AN ECONOMIC ANALYSIS OF LOW-INPUT AGRICULTURE AS A GROUNDWATER PROTECTION STRATEGY

by

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(ABSTRACT)

The unique characteristics of agricultural contamination of groundwater requires an innovative solution, such as the voluntary use of low-input agriculture (LIA) practices. This study was conducted to identify potential barriers to LIA adoption, analyze the effectiveness of agriculture and natural resource policies designed to remove the barriers to LIA adoption, and to determine the effectiveness of LIA practices in reducing the amount of chemicals released into the environment.

A survey of Richmond County, Virginia farming operations and attitudes identified current practices, potential LIA practices for the Northern Neck region of Virginia, and perceived barriers to LIA adoption. A 15 year nonlinear mathematical programming model was used to determine optimal farming practices, among 34 low-input and conventional practices, under various agronomic and policy scenarios. Two non-point simulation models, CREAMS and GLEAMS, were used to estimate the nitrogen and chemical loadings of runoff,

groundwater, and sediment; and the soil erosion from each of these scenarios.

The model shows that yields, labor requirements, and variable costs, individually have a weak influence on the adoption of low-chemical and organic production activities. The price of the organic nitrogen source, poultry litter, was strongly related to the use of LIA practices. The most cost effective policy for reducing Aatrex (atrazine) contributions to groundwater was a one-third reduction in surface application of Aatrex. However, there were many tradeoffs between chemical, nitrogen, and soil contributions to runoff, percolation, and sediment. The only policies which reduced all of these factors were land retirement policies. The tax level required to promote the use of a LIA practice was too high to be politically feasible, and the use of green-manure crops would require a 100 percent annual subsidy of those crops. A proposed base flexibility program caused more intensive use of conventional chemicals because of the limited number of eligible crops.

Low-input agriculture has promised reductions in chemical contamination of groundwater and runoff. This study's results showed that although that is indeed the case, there are tradeoffs between reduced chemical contamination and nitrogen and soil losses which should be considered when examining the cost effectiveness of using LIA practices as a groundwater protection strategy.

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CHAPTER 1

INTRODUCTION

Groundwater Contamination

Groundwater is a vital source of drinking water in the United States, with nearly 74 million citizens supplied with drinking water drawn from aquifers (Nielson and Lee); that is, about half of the United States drinking water is groundwater. The majority of this groundwater consumption occurs in rural America, where 97 percent of tap water is groundwater (Nielson and Lee). Protection of the quality of groundwater is thus of primary importance to local, state, and federal agencies.

Until the late 1970's and early 1980's, little was known about groundwater quality or quantity nor did they generate much public concern. Scientists and the general public held the belief that subsurface water supplies were protected from surface activities by impervious layers of rock, soil, and clay (Crutchfield). Discoveries of groundwater contamination in the late 1970s initiated a re-evaluation of the previous "out-of-sight, out-of-mind" attitude.

The earliest documented source of groundwater contamination resulted from the disposal of manufacturing waste below the surface level directly into aquifers or into adjoining areas where natural seepage moved contaminants into groundwater supplies (EPA 1987). Since then, many more sources of groundwater contamination have been identified. Recent studies suggest agriculture's contribution to non-point[1] pollution has been increasing (National Research Council, U.S. Department of Agriculture; Nielson and Lee; Pionke and Urban; Pye, Patrick and Quarles; O'Hare et. al; Cohen et. al). The U.S. Environmental Protection Agency (EPA) has determined that agriculture is the largest U.S. source of surface water contamination (National Research Council).

Agricultural Chemicals and Groundwater Contamination

Documented cases of groundwater contamination by agricultural use of pesticides[2] and fertilizers have been increasing since 1980. In at least 32 states, nitrogen contamination in excess of current U.S. health standards has been located (O'Hare et al.). Figure 1.1 shows that areas of potentially high nitrate concentrations are found in the Central Great Plains; the Palouse and the Columbia Basin in Washington; and parts of Arizona, the Corn Belt, Delaware, Maryland, Montana, and Pennsylvania (Nielson and Lee). The EPA reports that 77 pesticides have been found in the groundwater of 39 states (William, Holden, Parsons, and Lorber). Major regions of pesticide contamination potential, as shown in Figure 1.1, include the Atlantic Coastal Plain, the Mississippi Delta, the Northern Corn Belt, and California's Central Valley (Nielson and Lee). Many of the reported contamination detections have not been confirmed, and

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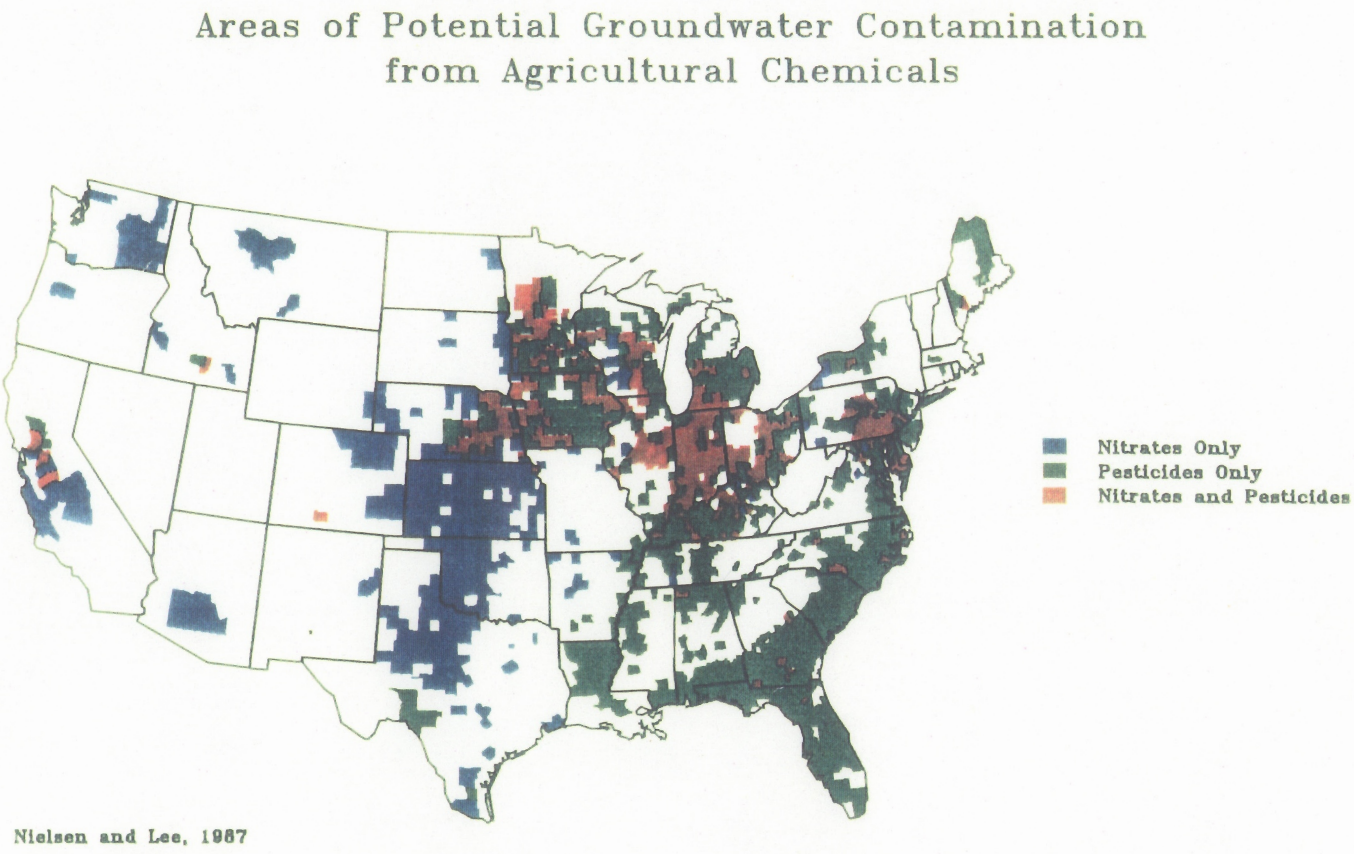
[1] Non-point pollution is pollution caused by sediment, nutrient, and organic and toxic substances originating from land-use activities and/or from the atmosphere, which are carried to lakes and streams by runoff (U.S. EPA, 1987) as well as percolating to undergraound water sources.

[2] The term pesticides in this study includes three classes of agrichemicals: insecticides, herbicides, and fungicides.



Areas of Potential Groundwater Contamination from Agricultural Chemicals

Nielsen and Lee, 1987

Figure 1.2. The study area, Richmond County, Virginia.

some contamination has resulted from unknown sources. The EPA has confirmed the detection of forty-six types of pesticides in groundwater (Williams, Holden, Parsons, Lorber).

Direct links between various land use practices, such as agrichemical application, and groundwater contamination are not easily established, but the rising use of agrichemicals per acre increases the potential for agriculturally caused groundwater contamination. The management of agrichemical contributions to groundwater contamination is, however, a complex issue. According to Batie, Cox, and Diebel, there are at least five reasons why the management of agricultural chemical groundwater contamination requires special attention:

* Agricultural sources are "non-point" and therefore difficult and expensive to manage,

* The pollution potential of agrichemicals and the preventative measures for agrichemical contamination are site-specific,

* Monitoring and testing procedures are expensive,

* The health and safety implications of contaminated groundwater are not well documented, and

* There is considerable resistance to traditional "polluter pays" regulations.

Agriculture as a Non-point Source of Pollution

The management of pollution associated with agricultural chemicals is difficult because agrichemicals are a non-point source of contamination, and thus are typically spread over wide expanses of land. Furthermore, non-point pollution from agricultural sources may not involve excessive or illegal actions; pollution is typically a result of generally accepted agricultural practices and chemical application according to label instructions (Zinn). Consequently, records of amount or location of pesticides and fertilizers used for agricultural purposes are practically nonexistent in most states.

Site-Specific Conditions

Whether an agrichemical will become a groundwater pollutant is dependent on the leachability of the chemical, weather, irrigation scheduling, and soil properties, as well as the hydrology and geology of the area. These factors vary widely across chemicals, regions, and time. Thus, testing of chemical dissipation must be conducted across a wide variety of sites and under different soil and climatic conditions to provide adequate information on potential contamination risks. However, delineation and testing of all susceptible areas would impose a considerable technical challenge that would severely tax the expertise and resources of any agency (Batie, Cox, and Diebel).

Since site conditions, pesticides, cropping patterns, and agricultural practices vary widely, no specific farming practices can be recommended that reduce the risk of pesticide contamination, and that are appropriate for all site conditions. This variability indicates that Best Management Practices (BMPs)[3] are not universal solutions to environmental

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[3] Best Management Practices are coordinated, judicious timing of activities and use of vegetation and materials, including some structures, as components within a total land management system. BMPs are usually associated with the prevention of soil erosion and contamination of water sources by agrichemicals.

problems. There is an uncertainty associated with the efficiency of BMPs due to the site-specific nature of environmental factors.

Expensive Monitoring and Testing

The detection of pesticides and nutrients in groundwater can require costly monitoring and testing procedures. According to Nielson and Lee, the monitoring of a single private well for pesticides can cost $100 to $300. Multiresidue screening techniques for agrichemicals have reduced the costs of detection. The EPA has developed five multiresidue analytical methods to detect a total of 120 pesticides, but costs are still high (Barles and Kotas). Nielson and Lee estimate that each test for pesticide residues costs an average of $84. Even with the available multiresidue tests, more than one test is frequently required. The testing procedure for nitrates is much simpler, and average costs are only $16 per test (Nielson and Lee).

Health and Safety Implications

Everyone in the U.S. probably consumes small amounts of pesticides daily in their food and water. Nearly 100 percent of the U.S. population has some pesticide residue in the fatty tissue of their body (Kutz, Strassman, and Yobs). However, the evidence connecting any health problems to long term exposure to agrichemicals is generally inconclusive.

There are several reasons why the evidence on human health risks associated with agrichemicals is often contradictory. Low-dose, extended exposure toxicities are very difficult to evaluate. Some health effects may take years or decades to develop. Also, there are synergistic effects of combined chemical exposures that cannot be analyzed easily. Finally, the method of exposure varies from skin absorption to ingestion (Nielson and Lee).

Nitrates in drinking water have been known to cause potentially fatal methemoglobinemia, or blue-baby syndrome, in infants. Nitrite (a by-product of nitrate) exposure has also been found to cause lower motor activity, increased aggression, and thinning and ballooning of the cardiac vessels in some laboratory animals (Fraser and Chilvers). Though carcinogenic effects of nitrites have been investigated, a more direct link to cancer can be found when nitrites combine with other substances (Nielson and Lee).

Epidemiology studies of pesticides effects are inconclusive. A few adverse health affects have been directly linked to pesticide exposure. Herbicide usage has been linked to cancerous lymphomas, but the extent to which this disease had been caused by water contamination is uncertain. Registration of the nematicides, ethylene dibromide (EDB) and dibromochloropropane (DBCP), was canceled by the Environmental Protection Agency because of evidence that they cause genetic mutations, reproductive disorders, and cancer in research animals. Several herbicides are suspected of causing nervous disorders and other chronic effects (Fleming).

In light of the medical uncertainty of pesticide effects, it is not surprising to find very few pesticides have drinking water standards or maximum contaminant levels (MCL). Six pesticide standards were mandated under the 1986 Safe Drinking Water Act. In June of 1987 six more pesticides were added. The largest addition of pesticide contaminant standards was completed in January 1989, when the EPA recommended 21 new pesticide standards. Yet another set of drinking water standards, including several pesticides, is to be activated by 1991 (U.S. EPA 1988).

Resistance to Regulation

In the past, when agriculture has detrimentally affected environmental quality, the problem has been managed through voluntary programs and cost-sharing. Thus, traditional water quality strategies which emphasize regulation generally are met with strong resistance from agriculturalists. The agricultural community tends to see the groundwater pollution problem as a need for more information, more farmer education, more financial assistance for the adoption of BMPs, and better pesticide labeling. In general, they do not see a need for regulations that restrict their use of current farming practices or which assign them liability for contamination (Batie, Abdalla). Yet many, including the general public, criticize voluntary programs as ineffective.

These five reasons as to why the management of agricultural chemical groundwater contamination requires special attention, also imply the need for special solutions. Low-input agriculture is an innovative, voluntary tool being proposed as a possible solution to agricultural contamination of groundwater.

Low-Input Agriculture

The terms "alternative agriculture," "organic farming," and "low-input agriculture" have all come to be used in roughly synonymous ways (Buttel et al.). For the purposes of this study, the term low-input agriculture (LIA) will be used to define a spectrum of production practices between conventional, chemical intensive practices and organic, non-synthetic chemical practices. The LIA acronym has been chosen instead of the more popular acronym LISA (Low-Input Sustainable Agriculture) to avoid the confusion associated with LISA. To some, LISA indicates more than a selection of agricultural practices; that is, it includes certain belief-structures (Batie and Taylor). To others, LISA means nothing more than the use of certain BMPs.

LIA is defined as a farming system in which the direct or indirect use of petroleum and petroleum-based inputs are reduced relative to conventional agriculture (Batie and Taylor). LIA is more comprehensive than the use of BMPs because LIA systems reflect a concern for reduced input use as well as environmental protection. The terms alternative and sustainable agriculture are used interchangeably in this study and are defined to include more philosophical concepts as well as the practical aspects of LIA and BMPs.

Farmers may adopt LIA for one or a combination of reasons. Environmentally concerned farmers may view LIA as a corrective measure for conventional farming's damage of soil, water, air, and wildlife. Lower expenditures may also be achieved through controlled chemical use such as appropriate timing, and reduction of quantities and varieties of chemicals. The cost of substituting management and labor for petroleum products in most situations is not accurately known. Despite the advantages of reduced health hazards, improved environmental quality, and reduction of costly inputs; LIA has not been adopted on a wide-scale.

Much of the current research on LIA is examining the possible barriers to LIA adoption within the current agricultural structure. The most commonly cited barrier is federal agricultural commodity programs (National Research Council). There have been recommendations to completely abolish commodity programs in hopes of raising the LIA adoption rate. The 1990 Farm Bill is most likely to contain some changes in the commodity programs which will allow the use of a greater variety of crops on base acreage.

This study, however, questions the effectiveness of using agricultural policy, alone, in promoting wide-spread adoption of LIA. Agricultural policy may be only one of many factors which influence the adoption of LIA. Nevertheless, if the appropriate mechanisms to remove the barriers to LIA adoption can be identified, then LIA may be used by federal and state governments as a groundwater protection strategy.

The identification of barriers to LIA adoption and the analysis of the environmental effects of LIA adoption are best suited to a case study analysis. A case study approach recognizes the site specific characteristics of non-point pollution and uses data directly related to agricultural practices as well as soil and weather conditions of the study area. Barriers to LIA adoption may also be dependent on the type of crops grown, and the location of the study area to crop and input markets. Policies can be mandated at the national level but the application, use, and effects of these policies are not generally the same for all parts of the country.

Objectives

To determine the relationship of a variety of policies to LIA adoption and LIA's effectiveness as a groundwater protection strategy, the objectives of this study are as follows:

1. To identify the conventional farming practices in Richmond County which are representative of cash grain farming in Virginia's Coastal Plain region.
2. To identify the possible barriers to LIA adoption.
3. To identify the low-input practices available to cash grain farmers in Virginia's Coastal Plain region.
4. To obtain information on the potential pesticide and nitrogen loading of groundwater from the conventional and low-input activities identified for Virginia's Coastal Plain region.
5. To determine the agricultural practices which maximize profits when both conventional and appropriate low-input agricultural activities are available for cash grain farming in Virginia's Coastal Plain region.
6. To analyze the efficacy of a variety of policies in promoting LIA adoption. Policies will include: cost-sharing green manure crops, restriction and taxation of chemicals, chemical loading restrictions, land use controls, and a base flexibility policy within the commodity programs.
7. To determine the impacts of the policies imposed on land use, net returns, labor requirements, potential runoff, percolation, sediment contamination, and soil erosion.
8. To evaluate the feasibility of using LIA as a groundwater protection strategy.

Methods

The Study Area

The study area is located in the Coastal Plain area of Virginia. The Coastal Plain consists of a layered sequence of sand and gravel aquifers separated by silt and clay confining beds. The aquifer system is divided into an unconfined aquifer, which is known as the Columbia aquifer, and underlying confined aquifers, which provide the largest water yields. In the eastern part of the Coastal Plain, water from the unconfined Columbia aquifer is suitable for most uses; however, because the aquifers frequently occur close to the land's surface the aquifer is extremely susceptible to contamination by bacteria, fertilizer, and pesticides (Meng, Harsh, and Kull).

The Coastal Plain can be further differentiated into the Eastern Shore Peninsula, the Northern Neck, and Southeastern Virginia. Both the Eastern Shore Peninsula and the Northern Neck border the Chesapeake Bay. The water quality of the Chesapeake Bay is a major concern to commercial fisheries, environmentalists and recreationalists in Virginia, Pennsylvania, Maryland and the District of Columbia. In recent years the Bay has suffered serious declines in quality and productivity (U.S.EPA, 1983). In 1987, the Chesapeake Bay Agreement was confirmed by all the concerned states[4], the EPA, and the Chesapeake Bay Commission with the

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[4] In December of 1987, Virginia, Maryland, Pennsylvania, the District of Columbia, the U.S. Environmental Protection Agency, and the Chesapeake Bay Commission formally signed the Chesapeake Bay Agreement.

charge to establish specific goals and mechanisms to clean-up and prevent further degradation of the Bay. The water quality goal of the Chesapeake Bay Agreement is the "reduction of point and non-point sources of pollution to attain a water quality condition necessary to support the living resources of the bay (Chesapeake Bay Commission, p. 3)." A specific objective of this goal is groundwater management and the control of agricultural discharges of contaminants. Groundwater from local aquifers may seep directly into the Bay or into adjoining streams where it joins additional chemicals deposited from surface runoff.

The county selected for this study is Richmond County, the second largest county in the Northern Neck. The location of Richmond County is denoted in Figure 1.2. While Richmond County does not front directly on the Bay, it does lie above a large aquifer which meets the Bay, and it fronts the Rappahannock River, a major freshwater tributary of the Bay. In 1987 Richmond County had 31.7 percent of its total land in farms[5], a 3.45 percent drop from 1982. Pasture and woodlands make up a very small percentage of farmland. Nearly 68 percent of Richmond County's farmland is cropland. The largest portion of the cropland is in soybeans, corn and small grains. Corn, which is the major grain crop, declined to 2,546 harvested hectares[6] (6,303 acres) in 1987, a 41 percent drop from

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[5] A farm is any place from which over $1,000 or more of agricultural products were produced and sold.

[6] All of the inputs and results of this study are reported in metric units. Conversion factors for domestic units are found in Appendix A. Where referred to in the text, the domestic units are given in parenthesis alongside the metric units. In addition, several of the Appendices referred to in the text contain the original data in domestic units.

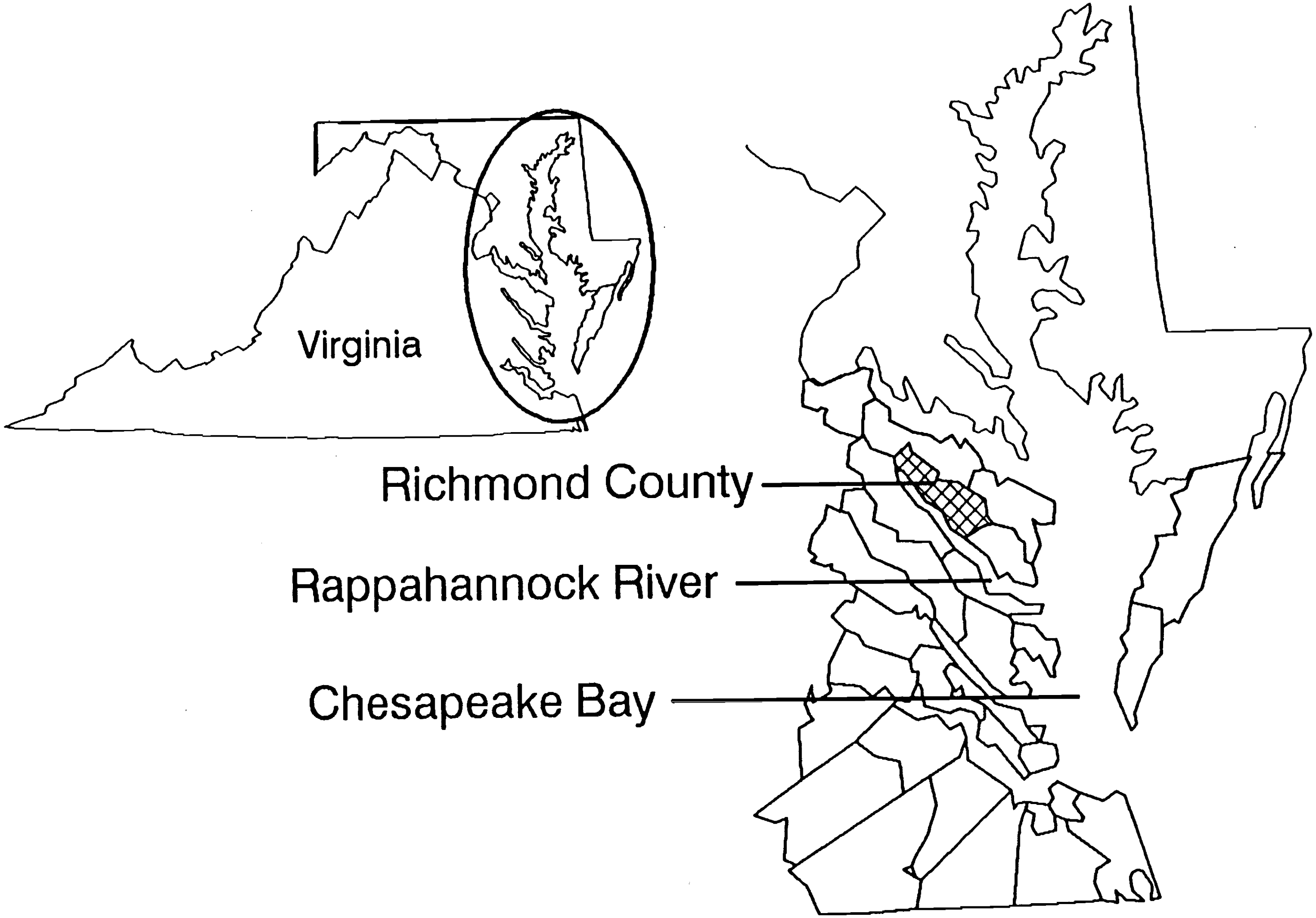

Figure 1.2. The study area, Richmond County, Virginia.

harvested corn acreage in 1982. Harvested wheat hectares in 1987, 2,028 hectares (5,021 acres), were 30 percent less then in 1982. Soybean acreage fell 19 percent from 1982; 4,684 hectares (11,593 acres) of soybeans were harvested in 1987 (U.S. Dept. of Commerce 1988, U.S. Dept. of Commerce 1983). Potatoes and other vegetables are found in smaller amounts. The fluctuations between 1982 and 1987 individual crop hectares may be attributed to loss of farmland, idle cropland, cropland under commodity acreage adjustment programs, and cropland under the Conservation Reserve Program. The county is also experiencing a transition from corn to small grain and soybean production as its' major source of income (Liddington). This transition is in part due to the variability of corn yields due to changing temperature and moisture conditions. The variable costs associated with corn production and the risk of complete crop loss are becoming too high for many farmers in the county (Liddington, Alley).

Richmond County farmers use a number of pesticides in an attempt to keep crop yields high. The two largest classes of pesticides used in Richmond County are insecticides and herbicides. In 1987, 3,589 hectares (8,883 acres) were treated with insecticides. That is over twice as many hectares as were treated in 1982. Acreage treated with herbicides increased 15 percent from 1982, with 5,058 hectares (12,520 acres) treated in 1987. Despite this increasing trend in pesticide use, the acreage treated with commercial fertilizers fell by nearly 22 percent from 1982, with 7,217 hectares (17,865 acres) treated in 1987 (U.S. Dept. of Commerce 1988, U.S. Dept. of Commerce 1983). These statistics are, however, based on sales data and may not accurately reflect the actual use of agrichemicals in the county. A Richmond County producer survey (VPI & SU, Dept. of Agric. Economics) noted problems with collecting accurate information from farmers on their rate of agrichemical use, in part because the state of Virginia does not require producers to keep records of chemical use.

Structure of the Study

To achieve the previously listed objectives, this study was divided into two steps; the identification of possible barriers to LIA adoption; and the development of an economic optimization model which incorporated the results of a groundwater simulation model. The initial step was to identify the possible sources of barriers to LIA adoption. A historical look at the evolution of current agricultural structure revealed many forces influencing adoption. Agricultural structure includes characteristics such as farm size, farm numbers, operator characteristics, and common practices. The adoption of LIA requires compatibility with the current structure and consideration of the complicated interaction of more "global " forces of influence such as ethics, education, and agricultural and natural resource policies.

The economic analysis used a multiperiod, nonlinear dynamic optimization model which maximized net returns to the county by selecting production activities which met the policy and physical restrictions imposed upon the model. Production activities were developed from a Richmond County survey of producers and the recommendations of county and state extension specialists. The practices included in the model represented a continuum from conventional agriculture, to organic agriculture. The practices were based on the conventional rotations of Richmond County to which different fertilization rates and weed control practices were applied. The multiperiod dynamic programming model optimizes over a fifteen year period. Annual decisions were made within the limitations imposed by previous decisions, such as nutrient carry-over and commodity program restrictions.

Groundwater loading coefficients were incorporated into the model to allow examination of a variety of policies. The simulation models CREAMS (Chemical, Runoff, and Erosion from Agricultural Management Systems) and GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) were used to provide the loading estimates of agrichemicals into groundwater and surface water, as well as the amount of soil erosion and its' nitrogen and chemical content. The simulation models rely heavily on the physical characteristics of the study area. The primary focus of the economic model was to estimate the effects of LIA adoption and of the policies on net return, labor requirements, land use and potential chemical pollution.

Organization of the Dissertation

This dissertation is organized to reflect the two parts of the study: the barriers to LIA adoption, and the economic model with the physical simulation model results. In Chapter 2 of this dissertation, LIA adoption barriers related to agricultural policy and other forces are identified.

In Chapter 3, the economic-physical model is developed. First, the framework for farm behavior, the theory of the firm, is discussed in relation to the selection of alternative production activities and the profits created by them. The price and yield series, along with chemical and nutrient budgets, are developed next. Then, the structure of the economic-physical model is presented in a generalized matrix form. Lastly, the simulation methods for chemical and nitrogen contributions to surface water, groundwater, and sediment are explained from a mass balance perspective. The mass balance approach attempts to account for all pathways of diffusion for chemical and nutrient applications. In Chapter 4 the results from three types of analysis are presented. First, the results from five general scenarios are presented. The general scenarios are constrained to basic agronomic practices in order to establish a basis for further analysis. Secondly, sensitivity analysis is done on the poultry litter price, labor requirements, and yields of organic and low-chemical production activities. The third type of analysis is the policy analysis. Several agricultural and natural resource policies are introduced to a general scenario to determine their effectiveness in promoting LIA adoption and reducing potential chemical contaminants.

A summary of this study, its overall implications for LIA adoption and policy-formulation, its limitations, and suggestions for future research are presented in the final chapter, Chapter 5.

CHAPTER 2

BARRIERS TO ADOPTION OF LOW-INPUT AGRICULTURE

Chapter One alluded to the influence of agricultural structure on groundwater contamination and on LIA adoption. Examination of the characteristics of agricultural structure and the factors which affect it provides a perspective for analyzing the potential of wide-spread use of LIA as a tool for controlling groundwater contamination. Major characteristics of U.S. agricultural structure include the concentration of agriculture in fewer but larger farms, mechanization and chemical dependency, limited labor supply, and absentee ownership.

Conventional Agricultural Structure

Farm Size

On average, the size of U.S. farms, in acres, has more than doubled since 1950 (Hallberg). However, this average size represents less than 25 percent of all farms (OTA). Smaller farms, of less than 50 acres, have persisted and represent almost 30 percent of U.S. farms (Hallberg). The significance of these changes in scale of operation may be reflected better by gross sales distribution. A small number of farms are making the bulk of agriculture's contribution to the national income. In 1987, 47.4 percent of gross farm sales were captured by only 4.3 percent of the largest farms (Hallberg). A bimodal distribution of farms, in acres, and the "disappearance" of mid-sized farms has been suggested by some observers. Hallberg refutes the bimodal idea, arguing that an acre measurement disguises the fact that the supposed "disappearing" mid-sized farms have actually moved into larger sales categories due to more intensive resource management.

Mechanization

Until the mid 1800's, farm size and productivity was constrained by the labor available to work the land. In the mid-to-late 1800's, a revolution of tools powered by draft animals significantly reduced the hours of labor required on the farm. By 1905, the gasoline-engined tractor was developed, and by 1910, assembly line tractors were in full production. The post-World War I period had a record number of tractor purchases and, as a result, one of the more significant changes in farm structure was occurring as a consequence, the substitution of capital for labor (Cochrane). Cochrane has attributed the preeminent position of mechanization in conventional agricultural structure to:

* the low price of petroleum,
* single man operation of machinery,
* convenient and easy use of machinery, and
* physical comfort of the farmer.

The historic substitution of capital for labor in U.S. agriculture has had many critics; a widely reported example of such capital was the invention and diffusion of the tomato harvester. This invention ultimately led to court proceedings. California Judge Raymond L. Marsh ruled that research on the tomato harvester, conducted by a land grant university, the University of California, assisted in the mechanization of agriculture. The judge found the University to be in violation of the Hatch Act because one of the consequences of the harvester was to displace farm laborers and family farms (Batie).

Labor

The number of available farm workers decreased as the industrial revolution took hold. After the Civil War, many soldiers traveled to the cities to find factory jobs rather than returning to the farm. According to Meeks, this influx of labor spurred more industrialization and a more volatile economy. However, as recessions and periods of unemployment loomed in the cities, agriculture resumed its role as the nation's primary employer. By the turn of the century, farming employed about 70 percent of the work force (Hallberg).

Today, only about 2 percent of employed workers are in primary agriculture (National Research Council). Many forces may be responsible for the decreasing availability and use of labor on the farm. Mechanization, a strong influence, has tended to be mostly labor-saving in nature. In addition, non-farm wages have been rising, requiring higher wages on farms to attract workers to agriculture (Evenson and Kramer). In 1985, only 5.6 million people, or 2.4 percent of the U.S. population, lived on farms (Galston).

Absentee Ownership

About 55 percent of the farms in the U.S. are operated by full owners, but only slightly more than one-third of the acreage is operated by full owners (Hallberg). The number of full owners has declined continuously during the past 30 years (Schertz). Part owners, owners in partnership, now operate about 30 percent of U.S. farms and over half of the U.S. farm acreage (Hallberg). Some of these part owners are family members. Lewis and Boxley report a corresponding increase in the proportion of land which is rented. Evidence exists for and against the idea that absentee ownership increases the use of environmentally degrading agricultural practices which (Held and Clawson; Lee; Buttel and Gertler).

Chemicals

Just as machinery has been used as a substitute for labor, agrichemicals have been used as substitutes for land. As land became more expensive, was used for development, or had its natural productivity depleted, agrichemicals were used to increase yields on the available land. This land substitution began to take place in the 1930's, undoubtedly encouraged to some degree by the federal government's land diversion programs (Batie and Taylor; Evenson and Kramer; Flora and Flora). The greatest expansion in the use of commercial nitrogen and chemical pesticides occurred during the 50's, 60's, and 70's.

Commercial nitrogen use doubled between 1940 and 1950, tripled between 1950 and 1960, and doubled again between 1960 and 1970. Since

1960, the percentage of acres treated with herbicides has grown, with over 95 percent of corn and soybean acres and over 60 percent of wheat acres treated by 1987 (Daberkow and Reichelderfer). Nitrogen use in 1987 averaged approximately 132 pounds per acre on 96 percent of corn acres (Daberkow and Reichelderfer). The attractiveness of agrichemicals was fostered by falling agrichemical prices, relative crop prices (Heady and Yeh), and wage and farm machinery prices (Daberkow and Reichelderfer).

The heavy use of synthetic, inorganic fertilizers has resulted in problems of eutrophication and pollution of water supplies. The use of pesticides has been associated with poisoning of humans, animals, soil, and water with toxic residues (Pimental et al.). Advances in the knowledge of agrichemical toxicity and in the ability to detect the presence of agrichemical residues may be contributing to the slowly reversing trend of high chemical use. Buttel et al. found 7.3 percent of New York State farmers used no pesticides or chemical fertilizers. The study also indicated that, nationally, 52 percent of wheat; 42 percent of sorghum; and 50 percent of rye, oats, and barley (in aggregate) are produced without pesticides. Although these are just point statistics, they are indicative of nationally declining chemical use levels.

Summary

This brief historical look at the evolution of current agricultural structure reveals many influencing forces. The repercussions of these structural characteristics on issues such as groundwater quality have contributed to rising social disenchantment with the structure itself.

LIA practices have been promoted as potentially desirable components of the solution to this social discontent. However, LIA is not being introduced onto a "clean slate." The effectiveness of LIA promotion will be influenced by the existing agricultural structure, economic conditions, and social perceptions.

Low-input Agriculture

The LIA characteristics of reduced chemical dependency and adapted mechanization could improve the relationship between agriculture and the environment without heavy regulation of production. However, the innovation of LIA cannot be introduced into the current agricultural system with expectations of wide-spread adoption simply because of these environmental benefits. The adoption of LIA is a complicated process involving a mixture of factors, of which any single factor or combination of factors may be a barrier to LIA adoption.

Innovation Characteristics

First, there are factors which influence the basic adoption process. Rogers' theory of adoption involves a temporal process influenced by the characteristics of the innovation and the adopter. Figure 2.1 displays Rogers' five innovation characteristics (relative advantage, compatibility, complexity, trialability, observability) which are used as a framework to further investigate the forces acting as barriers to LIA adoption. As part of the adoption process these characteristics are shown

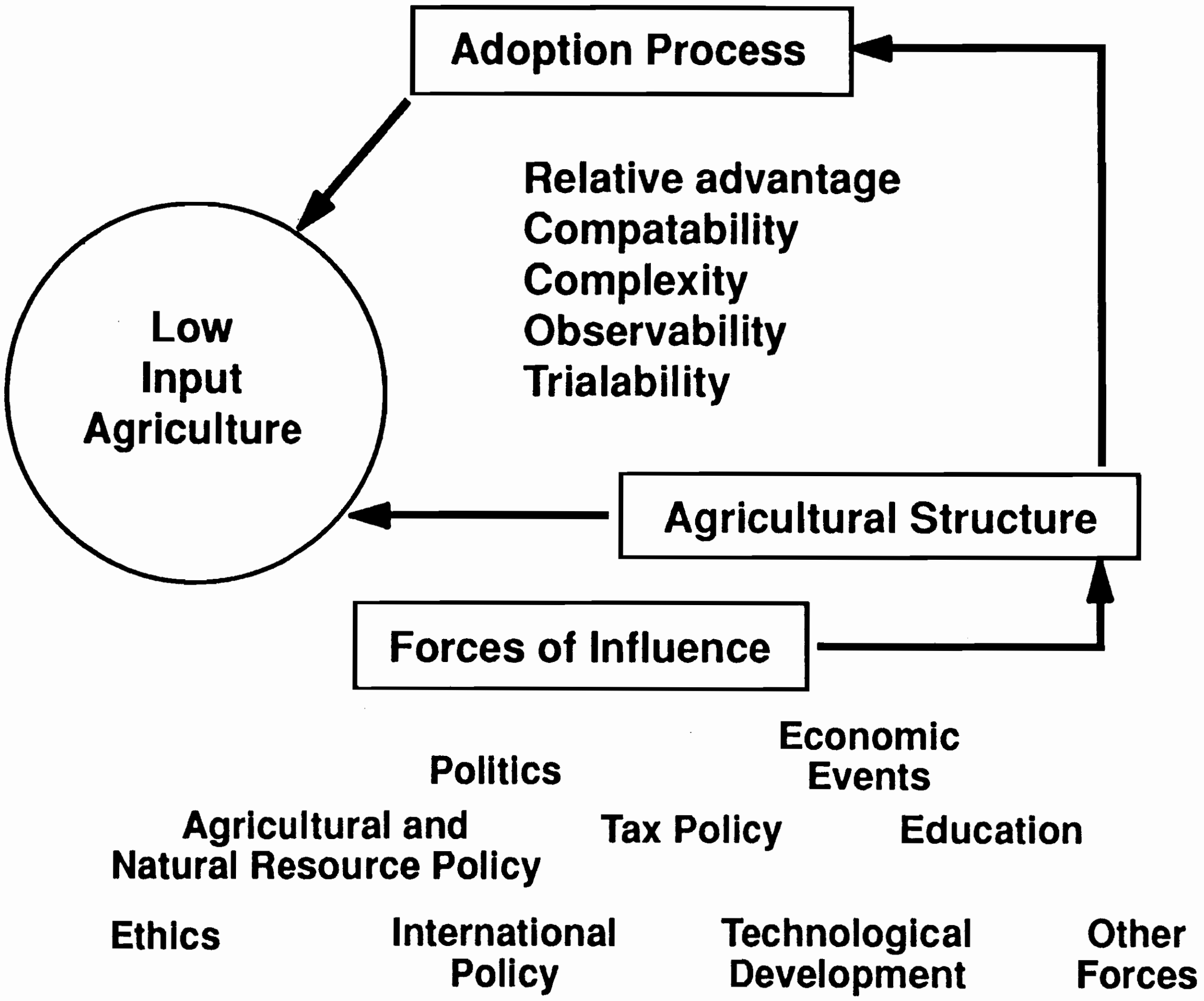

Figure 2.1. The factors influencing low-input agriculture adoption.

in Figure 2.1 to influence LIA adoption and are influenced by agricultural structure. Agricultural structure provides both direct and indirect influences on LIA adoption. Figure 2.1 indicates that there are other forces of influence which affect agricultural structure.

Relative Advantage

The first innovation attribute is relative advantage, or the degree to which an innovation is perceived as better than the idea it supercedes. The degree of relative advantage may be measured in economic terms, such as profits, or in measures of ease or comfort. Many new ideas are evaluated by relative profit advantage because they tend to involve a technology or series of technologies which result in reduced costs of production.

The singular goal of profit maximization is often challenged but remains prominent in economic thought (see Griliches; Haven and Rogers; Dixon). Despite the amount of research on LIA profitability, there is little agreement. Lockeretz, Shearer, Kohl, and Klepper conducted a five year study comparing organic farming to conventional farming across five states. In all five years, production was lower on organic farms, but the farms also consistently had lower costs of production. On average the savings in operating expenses offset the lower value of production, and the net incomes per hectare were about equal for LIA and conventional practices.

Dabbert and Madden studied the transition from conventional to LIA systems. Their study hypothesized that the shift would entail yield penalties and therefore they would experience revenue losses in the first few years, but soon thereafter, revenues would be restored to their former levels. Their linear programming analysis found that, even without imposing severe yield penalties, net income fell by 13 percent in the first year. The net income rose in the following five years, leveling off approximately 7 percent below the conventional systems' profit level. Oelhaf, and Power and Doran found similar results in their studies.

Norris also used linear programming to analyze alternative low-nitrogen input systems in Virginia, over 10 years. Three of Norris' LIA systems were found to have higher profits then the conventional systems, after the systems had stabilized. Taylor suggests that although field data is necessary to confirm these results, the comparison of the Norris study results to the results of other studies shows the potential for regional differences in LIA profitability. Climate, soil, precipitation, and other characteristics of a region may reduce risk and insure better profits with LIA adoption. Norris' study in Virginia may indicate that the region is better suited for LIA than the area in Pennsylvania studied by Dabbert and Madden.

Goldstein and Young studied the potential yields, costs, and net returns for LIA crop rotations which used self-seeding legumes that do not compete excessively with cash crops. The conventional system had considerably higher gross returns than the LIA system. The higher returns were in part due to more frequent crop harvests under conventional rotations. The profitability of each system was dependent on the price of crops. During Goldstein and Young's analysis, market prices favored the LIA system crops, while commodity program target prices favored conventional crops.

Discrepancies over the relative profitability of LIA are often attributed to differences in evaluation methods (Buttel et al.) and aggregation levels (Crosson and Ekey; Madden 1988b; and Buttel et al.). Another criticism of these studies may be their inability to account for all on farm benefits. For example, LIA systems are generally more diverse and protect soil structure, allowing better production consistency. Norris' profit results largely resulted from accounting for nutrient carry-over benefits, an added on-farm benefit.

The idea of relative advantage under LIA encompasses more than just simple economic profitability. The relative advantage of LIA may be greater than that of conventional agriculture when the long-term benefits of LIA are accounted for; such as improved soil structure, nitrogen carryover, and water quality.

Compatibility

The second characteristic of innovations is compatibility, the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters. An idea that is more compatible is perceived as being less uncertain for a risk adverse individual. The widespread adoption of LIA depends on its compatibility with the current structure of agriculture.

The compatibility of LIA and the structure of conventional agriculture involves the type of mechanization and agrichemical dependency as well as size and ownership of farms. There appears to be little recent research to support the idea that conventional farm characteristics have a negative influence on LIA adoption. Taylor suggests that there are very large scale as well as small scale organic farms. There are full- and part-time LIA farmers just as there are full-and part-time conventional farmers. Buttel, Gillespie and Power found no strong pattern between farm size and part-time farming status with their survey of LIA practice users.

Madden (1988a) found that the adoption of LIA by some very large farms might be difficult and impractical. However, it is not the size of the operation but the ability to substitute knowledge and managerial skills for some inputs which is the limiting factor. Madden speculates that widespread adoption of LIA would reverse the trend for fewer and larger farms--but only in areas with low labor availability and poor custom services. In areas with plentiful labor supplies, LIA adoption would not restrict the operation size.

Recall that some researchers believe absentee ownership promotes environmentally degrading practices. If this is so, and the evidence is mixed, part-owners may not adopt LIA. A survey by Blobaum found some landlords insisted on conventional practices, while most surveyed LIA farmers avoided this problem by renting from relatives. Overall, there is a reluctance to adopt LIA practices on rented land without assurances that the land could be kept long enough to realize all the benefits of LIA (Buttel and Gertler).

Mechanization, although often disassociated with LIA, can be compatible with the LIA system under certain labor constraints. For example, on the Kirschenmann farm in North Dakota there are only two laborers, for a 100 head cow-calf operation. The Kirschenmann farm has organic practices on 3,000 acres of grains (Taylor). Here mechanization plays a key role in the operation, allowing more time for crop production. Machinery comparable to conventional farm machinery was used by 82 percent of surveyed organic farmers in Lockeretz and Wernick's study of organic farmers in the Corn Belt. The difference between conventional and LIA mechanization tends to be in the way machinery is used. LIA involves a minimization of machinery impacts on the soil.

Excessive use of agrichemicals, on the other hand, is not compatible with LIA practices. Lockeretz and Wernick found that most LIA farmers are not abstaining from all chemicals, but they do avoid chemicals which are suspected of environmental damage.

Complexity

Complexity is the third characteristic of innovation and refers to the degree to which an innovation is perceived as difficult to understand and use. The influence of complexity is usually only surpassed by relative advantage in empirical studies. Generally, those new ideas requiring little additional learning investment on the part of the receiver will be adopted more rapidly than innovations requiring the adopter to develop new skills and understanding.

Coleman cites the complexity of the natural system and biological cycles as being a strong force behind the limited adoption of LIA. LIA works on the premise of prevention rather than remediation. Remedial methods, such as the use of agrichemicals, requires the identification of a disease or pest which may already be present in the crops. Prevention on the other hand, requires a deeper understanding of the biological nature of plants, insects, and the causes of infestations. Education and information need to be continually updated to keep complexity from becoming a barrier to adoption. The recent advent of on-farm computers and software which can assist the farmer in making preventative management choices has given, and will continue to give, farmers the ability to deal with more complex practices.

Trialability

Trialability refers to the degree with which an innovation may be used on a limited, experimental basis. New ideas which can be tried on an installment basis will generally be more quickly adopted than those which are not divisible. Although demonstration farms and a neighbor's successful adoption are influential, farmers recognize that caution is still required when translating these results to their own situation (Nowak). Due to the site-specific nature of the physical limitations of agriculture, and the personal constraints of management skills, the farmer may adopt successful practices in stages and may be required to "patch" together pieces of several systems by trial.

LIA may be based on a systems or holistic approach. However, the line between conventional and LIA becomes unclear as farmers use various components of BMPs on all or part of their acreage. The adoption of BMP components may or may not lead to complete LIA adoption as the adoption of BMPs does not insure the adoption of the more philosophical concept of sustainability. Time also prevents "perfect" trialability. LIA requires long-term investment and patience for payoffs. The ability to make a short-term, small investment -just to get one's feet wet - is not a strong attribute of LIA.

Observability

Finally, observability is the degree to which the results of an innovation are visible to others. This innovation characteristic is biased toward the physical component of new ideas. Therefore if the conceptual component dominates, innovations have relatively slower rates of adoption. Observability, except at demonstration farms, is difficult to achieve with agricultural technologies. LIA is the type of innovation which has few benefits which are highly observable. The limited observable characteristics of LIA are negative, such as larger weed populations. The adoption of LIA will not necessarily cause sudden changes in the agricultural scenery. For the most part LIA changes will be slow and unobtrusive.

"Global" Forces

Each of the adoption characteristics identified by Rogers is influenced by the same forces which acted to form the current agricultural structure as depicted in Figure 2.1. There are many forces, but several can be thought of as "global" in that they heavily influence both the agricultural structure and all of the innovation characteristics of LIA. Agricultural and natural resource policy, tax policy, ethics, and education are the "global" forces possibly influencing LIA's relative advantage, compatibility, complexity, trialability, observability. The single-hatched area of Figure 2.2 represents the influence of these "global" forces on LIA adoption. Each circle represents an area of influence by a global force, agricultural structure, and LIA. Areas where these circles overlap represent areas where one force influences the other and interactions take place. The shaded area is the area discussed previously where agricultural structure alone influences LIA adoption. The single-hatched area is where global forces influence LIA. The double-hatched area is where agricultural and natural resource policies affect LIA adoption. If another dimension could be attached to the overlapping areas it would measure the degree of influence, or the amount of overlap, each global force and agricultural structure have on LIA adoption.

Agricultural and Natural Resource Policy

Agricultural and natural resource policies influence both the relative advantage and compatibility of LIA. Agricultural commodity programs tend to negatively affect LIA adoption, by providing economic incentives for production of certain crops. Natural resource policy, specifically groundwater protection policy, has mixed effects on LIA

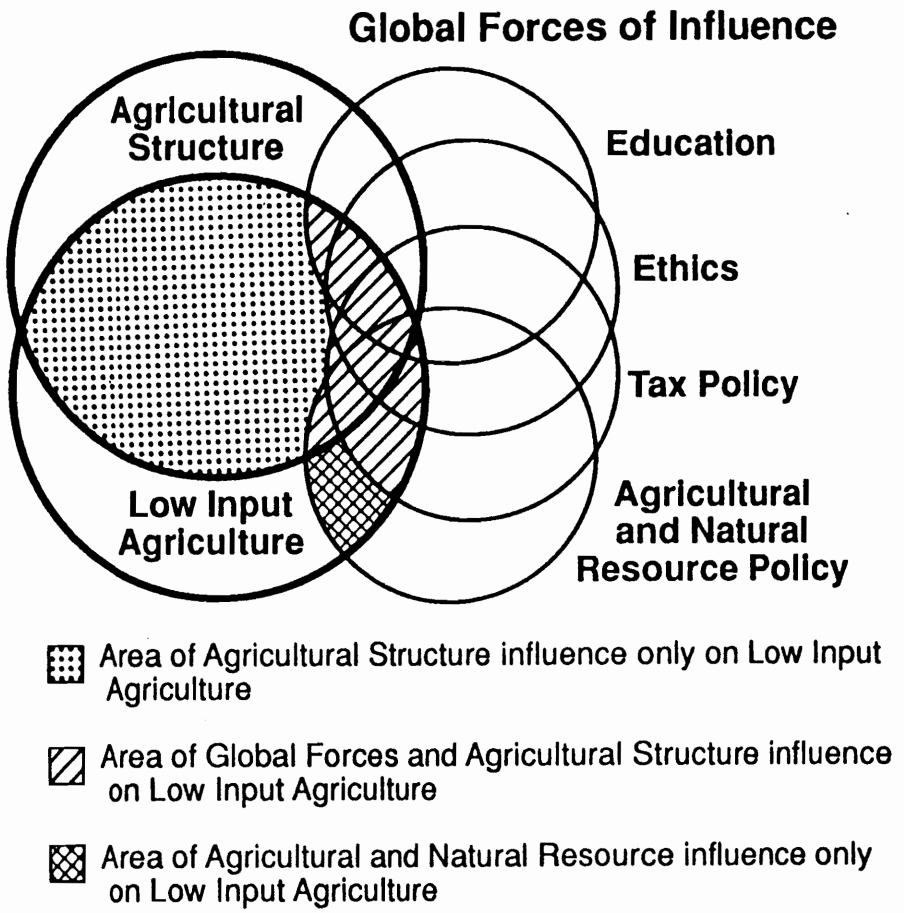

Figure 2.2. The influence of global forces and agricultural structure on low-input agriculture. Each circle represents an area of influence, overlapped circles create an area of interaction between global forces, agricultural structure, or LIA.

adoption. Most regulation of agricultural practices tends to work against LIA adoption, while programs with economic incentives for use of conservation practices improve LIA compatibility.

Commodity Programs. Commodity programs provide two major forms of aid to farmers. Non-recourse loans are provided to farmers to enable them to hold their crops for sale at some later date. The second type of support is a deficiency payment. This payment is the difference between what the farmer receives on the market for his crops and the target price set by the federal government. The farmer can only receive payment for the allowable planted portion of his base, and payment is based on an established historical yield. The crop base is a moving five year average of the program crop acreage, and the established yield is a moving five year average of the historical yield. Since 1985, however, the established yields have been frozen at their 1985 level.

Only eligible farmers can collect either program benefit. To be eligible, farmers must participate in acreage reduction programs and comply with the Conservation Compliance provisions. The Conservation Compliance provisions require farmers to file and over time implement conservation plans for highly erodible lands. Acreage reduction programs use the crop base to establish the amount of land to be diverted from production. Each of the two types of land diversion is calculated by a federally set percentage of base acreage. The first is required set-aside: this land is devoted to conservation uses, and no crop production is allowed. The second type is paid land diversion, the land is treated the same as set-aside, but the farmer receives a payment for this acreage. The farmer is paid for land diversion based on the established yield and a fixed price.

These programs affect the relative advantage and compatibility of LIA. The primary focus of relative advantage may be profitability. Commodity programs can cause a preference for monocultural production, in order to establish and maintain base. Young and Goldstein suggest that commodity programs pose a constraint on LIA adoption, not only because price supports are limited to a few crops, but also because payments for these crops are tied to historical production. If, for example, base requirements were more flexible, Young and Goldstein would expect more fields to be turned over to LIA rotations, which may depend heavily on nonprogram crops or may require the intermittent use of legumes to revitalize the soil nutrients.

Fleming sees direct links between commodity price support programs and slippage.[7] Slippage may promote the excessive use of chemicals, thereby dismissing LIA type practices, because inputs are not reduced but transferred to the land under production. Fleming speculates that farmers will use excessive amounts of inputs on the available cropland to insure an adequate crop, rather than cut costs by using less inputs. Young and Goldstein as well as Buttel et al., feel commodity policies not only shape

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[7] Slippage is the difference between the fraction of cropland that is idled and the resulting fractional decrease in total crop production. Most slippage is caused by idling the least productive land (Fleming) and by using remaining cropland more intensively.

today's agricultural policy but also shape tomorrow's agriculture because they work against the relative advantages of LIA.

Commodity programs affect the compatibility of LIA in a similar fashion. The structure of agriculture evolved with forces of commodity policy and its features reflect commodity policy. For example, mechanization is intensive and usually serves large fields with monocultural practices best. This type of machinery may not fit the needs of a more diverse LIA rotation. The incompatibility of LIA with some elements of agricultural structure reveals an incompatibility with the forces of commodity programs as well.

Groundwater Policy. Agricultural non-point pollution has received the explicit attention of policy-makers since the 1972 amendments of the Federal Water Pollution Control Act. The amendments require states to identify critical non-point pollution problem areas, select suitable BMPs for reducing pollution, and appoint agencies responsible for monitoring and controlling non-point pollution. The Environmental Protection Agency (EPA) Ground-Water Protection Strategy of 1984 identified pesticides and fertilizers as potential groundwater contaminants requiring special national attention (Batie, Cox, and Diebel). More recently, the Agricultural Chemicals in Ground Water Strategy was released by the EPA in February of 1988. This strategy calls for the states to work closely with the federal government to draft management plans. Federal government programs tend to be restricted to recommending action for states to take. For example, the federal government supports the use of cost-sharing incentives for adoption of preventative measures; only under the strictest conditions does it mandate farm adoption of preventative measures.

The effects of groundwater policy on relative advantage are mixed. There are arguments that groundwater policies which regulate the production activities of the farmer put the U.S. farmer at a relative economic disadvantage in the world market. U.S. agriculture competes with other countries where resources may not be as well protected, or the liability for groundwater contamination may not be placed on the producer. Relative economic disadvantage can also exist between producers acting under different state or regional restrictions. However, many economic incentives exist in groundwater policy which can boost the relative advantage of LIA. Cost-sharing of conservation practices is popular and may lead to the complete conversion of a farm to LIA.

Tax Policy

The characteristics of the conventional tax structure pertinent to agriculture can be difficult to evaluate because of the tax structure's broad design. There are a variety of general tax provisions which may affect agriculture in a way which prevents LIA adoption. Ward, Benfield, and Kinsinger have uncovered three specific tax codes which may be barriers to LIA adoption:

* cash accounting,
* accelerated depreciation, and
* fertilizer and lime deductions.

The special benefits of using cash accounting, instead of accrual accounting, provides a lucrative subsidy for conventional farmers. Cash accounting allows expenses for income collected in a given year to be deducted in a previous year. Producers who purchase large amounts of inputs will stock up on inputs during a good year to offset an expected high income. LIA producers have less inputs and will receive less relative advantage benefits from this ability to average income. Accelerated depreciation gives advantage to practices which utilize large machinery. Farmers converting to LIA would only benefit from accelerated depreciation if the transition required purchasing new machinery. The fertilizer and lime deductions[8] allow conventional farmers to claim ordinary business expense deductions for fertilizer and lime application. Farmers using this deduction can operate at less than real costs, are rewarded for the use of chemicals, and LIA farmers are penalized. Without this special deduction, such expenditures would be written off in increments over the lifetime of the investment. If LIA non-chemical practices, which build up long-run soil fertility and structure, were recognized under this deduction clause to "enrich, neutralize or condition the land (IRC Section 180)," then LIA users could benefit from immediate operating expense deductions. Most non-chemical weed control practices, such as cultivation, do not include costs which can be deducted.

A current tax benefit which could enhance LIA's relative advantage is conservation easement donations. Conservation easements are designed to preserve natural settings and unique physical features. In many cases,

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[8] Farmers may claim ordinary business expense deductions for fertilizer and lime applications, irrespective of whether productivity benefits extend over more than one year (IRC Section 180, 1988). Lime and fertilizer use is more of an investment than operating cost if benefits are extended past one year.

easements provide preservation with lower acquisition and administrative costs. The easements are claimed by the taxpayers as a charitable contribution and may be deducted. Ward, Benfield and Kinsinger have suggested that conservation easements be used for the preservation of farmland for farming. The Internal Revenue Service has already ruled favorably on several donations of farmland easements which were located in highly "stressed" development areas (Ward, Benfield and Kinsinger; p.90). The Internal Revenue Code (IRC) specifically includes "the preservation of open space (including farmland and forestland)...for the scenic enjoyment of the general public, or in keeping with the twin test of (a) being pursuant to a clearly delineated Federal, State or local governmental conservation policy, and (b) providing significant public benefit (IRC Section 170 (h)(4)(A))."

All tax-deductible conservation easements must be made "exclusively for conservation purposes (IRC 170(h)(1)(c))." This clause prevents the use of poor stewardship on land designated as a conservation easement: including use of pesticides where ecosystems may be damaged, and the abusive cropping of highly erodible land. Conservation easements have already been used to retire severely eroding farmland from crop production and to protect susceptible groundwater from abusive surface activities (Ward, Benfield, and Kinsinger).

Ethics

A large part of LIA's incompatibility may result from the influence of ethics. While LIA represents a set of alternative production practices, it may also imply a change in thinking for the agricultural sector. Conventional agriculture embodies a philosophy which incorporates the values of an industrialized society; that is, increased production is good; profit orientation is appropriate (Batie and Taylor). These are deeply-rooted and fundamental beliefs. In particular, man's relationship with nature has developed into one where farmers must "defeat" and "destroy" pests and weeds that "ravage" their crops (Coleman). This attitude toward nature is also reflected in pesticide names such as Blazer, Pounce, and Roundup. Although some of this desire to dominate over nature has disappeared, Taylor suggests that most farmers probably still harbor some of this feeling.

Besides the attitude of the adopter himself, a large compatibility problem is the attitude of peers. Lockeretz and Madden found that outright hostility is not common among neighbors of organic farmers, but indifference or skepticism is common. Many LIA farmers have experienced neighborly criticisms. In Wisconsin, a survey found that farmers anticipated criticisms before switching to LIA, but did not perceive them as deterrents to adoption (Brusko).

Education

Education is a "global" force which affects the compatibility and complexity characteristics of LIA. There have been changes in the higher education system which lessens its influence as a barrier to LIA adoption. However, education changes slowly for the most part, and there still exist forces within educational institutions which are incompatible with LIA adoption. Higher educational institutions have historically supported the dominance of man over his environment, focusing research in the area of more intensive agricultural practices and labor-saving technologies. The public sentiment that shaped the mission of colleges of agriculture in the past, and the need for reliable supplies of high quality, reasonably priced food is changing. The focus of university agricultural research programs is beginning to follow this lead. Many universities have initiated special studies and degrees in low-input agriculture. The consequences of this change will include the removal of the barriers of educational incompatibility. These barriers include the misinterpretation of LIA terms and practices, lack of field research on LIA practices, the lack of accessible LIA information and experts for farmers, and the reeducation of extension agents.

Information and education are the primary modes of overcoming the complexity of LIA. Coleman cites the complexity of the natural system and biological cycles as being a strong force behind the diminutive adoption rate of LIA. Advances by educational institutions and extension services in promoting the adoption of computers has enhanced the ability to cope with LIA complexities.

Summary

Recent literature on LIA adoption has focused on these "global" forces, especially agricultural policy, as barriers. The recommendations of these studies emphasize the need to modify or eliminate current agricultural policy. Reichelderfer and Phipps hypothesize that the abandonment of all commodity programs, with the retention of current conservation provisions, would result in environmentally beneficial relocation and mix of production activities, with less intensive and less damaging use of agrichemicals on expanded acreage. However, the preceding review of conventional agricultural structure included many characteristics, not all of which are heavily influenced by agricultural policy. Many of the agricultural structure characteristics were already in place before agricultural policies were initiated (Cochrane). Little evidence exists to support the idea that agricultural policy changes alone can influence all the other forces which work against LIA adoption, and cause widespread LIA adoption.

Other Characteristics of Agricultural Structure

There are other characteristics of agricultural structure which may not be influenced by changes in agricultural policy. The shaded area of Figure 2.2 represents these influences on LIA. These characteristics still influence the adoption of LIA and may remain as barriers to adoption despite supporting agricultural policies. These characteristics include technology, individual and regional farm characteristics, and farmer (adopter) characteristics.

Technology

Technology, such as mechanization and agrichemicals, is a characteristic which cannot be completely controlled by the global forces discussed in this section. Technology is heavily influenced by activities in other areas of the economy such as aerospace engineering or chemical engineering. In addition, certain forms of mechanization and chemical use have become an intricate part of the agricultural structure and agribusiness network; their complete removal may be economically, physically, and philosophically impossible. The gasoline-engined tractor and combine will probably never disappear from the agricultural scene, unless all gasoline-engined vehicles are banned. The persistence of these technologies and the promise of new technologies may prevent widespread adoption of LIA practices, unless the technologies reflect the new agricultural attitude toward protecting the environment. Under this scenario new technologies promise more efficient use of petroleum and the ability to use LIA despite a diminishing labor supply.

Individual and Regional Farm Characteristics

National policy-makers have always had to confront the problem of individual and regional differences when trying to develop a national level policy. Agriculture is particularly subject to these inconsistencies because of its site-specific nature. LIA addresses both environmental damage and the excessive use of inputs by agriculture. Environmental conditions can be very similar across a large region or vary between neighboring farms. The inputs used by a farmer are closely related to the natural properties of the environment on his farm. LIA's relative advantage varies with site characteristics and, therefore, adoption rates may be greater in one part a country than another. There are other regional characteristics which can similarly influence LIA adoption, such as commodity program participation (Ligon et al.), distance from markets, and relative prices.

Farmer Characteristics

Farmer or adopter characteristics are a fairly independent element of agricultural structure. Adopter characteristics have been studied extensively. Rogers lists five categories of adopters of innovations: innovators, early adopters, early majority, late majority, and laggards. The classification is based on the innovativeness, or the degree to which an individual will adopt new ideas earlier than others. The relative innovativeness is associated with certain individual characteristics including: socioeconomic characteristics, personality variables, and communication behavior. Each of these in turn reflects the adopter's objectives, access and ability to use information on innovations, their attitudes toward risk, and their need for and access to additional inputs (Norris).

Innovators can best be described by the term venturesome. Their need to try new ideas, even those with hazardous or risky outcomes, isolates these adopters from local communication networks. They tend to be wealthy, since substantial financial resources are necessary to absorb the cost of failures. A high degree of education and intellectual prowess must be present in order to apply complex technical knowledge. The early adopter is the most influential adopter. Unlike innovators, early adopters are highly respected and deeply integrated into society. The early adopter is well educated, and has a financially sound base to work from, but carefully invests both time and money in innovations. The early majority is the closest peer to the early adopter and follows the early adopters advise closely. Their adoption usually occurs long after the innovation is introduced because they wait to discover the consequences of the early adopters' decisions. Late majority adopters are usually pressured by their peers and economic necessity. They approach innovations with skepticism and usually perceive that they cannot afford the new technology when early adopters are implementing the innovation. Eventually they are moved by the perception that they cannot afford not to adopt. Laggards are the last to adopt an innovation. Their primary barriers to adoption are access, both to finances and general knowledge or exposure. While the late majority "perceive" themselves in a poor financial situation, the laggard definitely has limited resources. They tend to be suspicious, not critical, of innovations because they lack the knowledge base to understand the conceptual basis of the innovation. These characteristics are closely tied to the temporal process of adoption. LIA advocates must continually evaluate which type of adopter has grasped LIA and design further campaigns for adoption for the next group's characteristics.

Summary

The issue of barriers to LIA adoption is complicated by the many interacting forces involved. LIA is attempting to fit itself into the current agricultural structure which was developed under very different approaches to production. It has been proposed that agricultural policy change are the best way to force LIA type practices into mainstream agriculture. Within the dynamic scenario presented in this chapter, how important is agriculture policy? Can the modification of agriculture policy alone create an environment which compels widespread adoption of LIA? How important are natural resource policies? To determine the importance of agricultural policy in LIA adoption and consequent effectiveness in controlling groundwater contamination, an economic model is constructed in Chapter Three, in which producers select between conventional agricultural practices and a variety of LIA practices. The LIA practices vary from simply reducing chemical use to completely organic practices. A variety of agriculture and natural resource policies are then introduced to determine if they move the system into LIA production and what their effect is on groundwater quality.

CHAPTER 3

A Mathematical Model Evaluating the Potential Benefits of Low-Input Agriculture as a Groundwater Protection Strategy

A comprehensive analysis of low-input agriculture as a groundwater protection strategy requires analysis of at least the following three components:

- * farmer behavior
- * potential tradeoffs between possible pollutants
- * potential impacts of pollutants on groundwater and surface water quality

Mathematical modelling can assist in evaluating these components and many of the influential forces affecting each component. Two types of modelling were combined in this study. Nonlinear mathematical programming was used to model the farm operator decision process. Simulation analysis was used to model the physical nature of non-point pollution, and its results were incorporated into the mathematical programming model.

The Farm Operator Decision Model

Theoretical Basis

The economic theory of the firm provides the basic framework for analysis of decision-making on the farm. A firm is a technical unit which produces commodities; in this study all the farms in Richmond County are aggregated into a single firm. The "farm operator" of this single firm decides both crop mix and production methods, and gains the profits or bears the losses which result from his decisions. The farm operator transforms inputs into outputs, subject to the technology inherent in his production function. The final choice of input mixes and output levels depends primarily on the operators' objectives and his resource constraints. Modelling the decision process of the farm operator, under the theory of the firm, relies on a set of key assumptions concerning the production process and the firms objectives.

Assumptions

Several key assumptions concerning the production process are made within the theory of the firm. First, the theory assumes that the goal of the firm operator is to maximize profit while a farm operator's objective may be heavily influenced by the previously identified forces, such as government policy and ethics. These and other influential forces are often addressed by imposing constraints on the production process.

Second, the operator is assumed to have perfect information about his production function as well as product and input prices. It is evident that agriculture is highly susceptible to unknown variables such as weather. Stochastic forces can be incorporated into mathematical programming through the use of probability estimates in chance constrained programming or through the use of quadratic and MOTAD (minimization of total absolute deviation) programming. This study incorporated risk by accounting for yield and price variability over the study period as they related to historical weather patterns. Sensitivity analysis, an analysis of the affect of small changes in a parameter value on the optimal solution, identified which of the parameters require more precision in their estimation.

A third assumption is that inputs are homogeneous, that is, equivalent in quality and infinitely divisible. This assumption is easily made for inputs such as fertilizer, it is more difficult to apply divisibility to inputs such as machinery and to apply constant quality to inputs like labor.

Lastly, it is assumed that technology and tastes and preferences are constant throughout the study period. In this study, historical yield data was detrended and used to estimate yields based on 1988 production technology.

Profit Maximization

The farm operator is free to vary both cost and output through the choice of production practices, with the ultimate goal of maximizing profit. For a single year, a two input production process can be represented in a production function such as:

$$Y = f(X_1,X_2) \tag{3.1}$$

which represents the mix of two inputs X_1 and X_2 required for output level Y. Inputs X_1 and X_2 are available at prices P_1 and P_2. This simple production function can be extended to include multiple outputs and a multi-year planning horizon. The total revenue of the farm operator in a perfectly competitive market is the output level, Y, multiplied by its fixed unit price, P_y.

Profit (π) is then the difference between total revenue, P_yY, and total cost, $P_1X_1 + P_2X_2$ as follows:

$$\pi = P_yY - (P_1X_1 + P_2X_2) \tag{3.2}$$

or

$$\pi = P_yf(X_1,X_2) - P_1X_1 - P_2X_2 \tag{3.3}$$

Profit, as a function of X_1 and X_2, is maximized with respect to these variables.

Setting the partial derivatives of π with respect to X_1 and X_2 equal to zero results in the following two first order conditions:

$$\frac{\delta\pi}{\delta X_1} = P_y * f_1 - P_1 = 0 \tag{3.4}$$

$$\frac{\delta\pi}{\delta X_2} = P_y * f_2 - P_2 = 0 \tag{3.5}$$

where

$$f_i = \frac{\delta f(X_1,X_2)}{\delta X_i} \quad \text{for } i = 1,2 \tag{3.6}$$

is the marginal product of the inputs X_1 and X_2. The marginal product of an input indicates the change in output resulting from a one unit change in input i. Rearranging terms:

$$P_yf_1 = P_1 = VMP_1 \tag{3.7}$$

$$P_yf_2 = P_2 = VMP_2 \tag{3.8}$$

The value of the marginal product (VMP or P_yf_i) is the rate at which the farm operators' revenue would increase with the addition of another unit of input X_i. The first-order conditions for profit maximization thus require that each input be used until the value of its marginal product equals its price.

Application of the Theory of the Firm to Mathematical Programming

These classical concepts underlie the use of mathematical programming for economic analysis. Linear programming, the simplest form of mathematical programming, is a method of determining profit maximizing combinations of production practices that are feasible with respect to a set of constraints (Hazell and Norton). Linear programming does impose restrictive conditions on the production function. All production functions in linear programming are linear and thus exhibit constant returns to scale; this characteristic is also referred to as a fixed-proportion production function. The fixed-proportion production function represents production of a given level of output using a specific production process with specified levels of inputs. The more production processes included in the model with different levels of output and inputs, the closer the model approximates the continuous production function of neoclassical theory.

After methods of production are selected for inclusion in the model, budgets are developed to determine the resource requirements and costs of the production process. These resource requirements are converted to technical production coefficients, expressing the fixed resource requirements per unit of output. Each production method or process that is possible for the production of a given product defines a different fixed-proportion production function. These alternative methods of production are called activities. Unlike the general theory of the firm, in linear programming there are only a finite number of activities from which the operator may select.

Linear programming also requires that outputs and inputs be infinitely divisible, the assumption of divisibility, and that the combined output never exceed the sum of the output from each activity, the assumption of additivity. Complementary and substitution relationships between inputs in any one production process can thus not be modeled. The additional assumption of certainty requires that all the parameters affecting the operator's decision, such as technical coefficients, revenues, and costs, are known to the operator before a decision is made. Proportionality is the assumption that each resource is used in proportion to the level of activity, that is there is no initial or start-up charge and that this proportional relationship holds over the entire range of activity levels. Proportionality prohibits the modeling of economies of size. The objective function of linear programming can parallel the profit maximizing assumption of the theory of the firm, or the dual to profit maximization, which is cost minimization.

General acceptance of mathematical programming as an analytical method has made it a popular form of analysis in agricultural economics. The analysis of the adoption of different agricultural practices is commonly conducted with mathematical programming, linear and other types. James; Domanico, Madden, and Partenheimer; and Halstead used single year linear programming models to evaluate selection of alternative agricultural activities. Dabbert and Madden, and Norris included multiple years in their linear programming models. Mixed integer programming, another form of mathematical programming, was used by Holloway to evaluate the effects of federal programs on agricultural practices. There are relatively few studies employing mathematical programming models which aggregate the impacts of alternative practices above the farm level. Olson is one of the few to use programming on a national, interregional level to analyze the adoption of organic farming. Dynamic optimization modelling is the newest form of programming being used to analyze agricultural activities (Segarra et al., Kennedy et al.).

This study examined the profits and impacts of low-input adoption at the county level in order to examine the effects of widespread use of existing and low-input agricultural activities. The model had a linear objective function and both linear and nonlinear constraints.

The Mathematical Programming Model

The farm operator decision model used in this study is a fifteen year, multiperiod model. The initial year of the analysis was 1988. The model included the dynamics of annual carryover of chemical and nutrient residues and changes in commodity program base acreage and yields. All cropland in the study area, not just a single representative farm was included in the model. Evaluating the management of all the cropland in Richmond County facilitated the analysis of the possible effects of widespread adoption of low-input agriculture and the impacts of policy alternatives. The results of this model are post-transition, the transition process itself is not considered.

The general model had three elements: production activities representing alternative agriculture practices, including organic to high chemical use production; resource constraints and technical coefficients; and a linear objective function with its net returns coefficients.

Production Systems

The production activities in the mathematical model differed by weed control practices, fertilization (rates and sources), tillage, and crop rotations. Few insecticides were used in Richmond County on a regular basis; therefore, the pesticides emphasized in this study were herbicides. The production activities were built using information collected by a survey of Richmond County farm operators during the summer of 1989 (VPI & SU, Dept. of Agric. Economics), and Virginia Cooperative Extension Service recommendations by both the Richmond County Farm Management Extension Agent (Liddington) and an Extension Service Weed Specialist (Hagood). Four basic crop rotations were developed for use in the model. Different fertilization levels and sources, organic and inorganic, and herbicide treatments were then considered for the four rotations resulting in 34 production activities, including organic alternatives. Each rotation was first subject to the usual Extension Service recommended fertilization rates and weed control practices. A major consideration in developing alternatives to these extension recommendations was designing activities which were thought to be agronomically viable in Richmond County. The production activities represented a broad spectrum of choices for the farm operator. The two extremes of the spectrum were high chemical and fertilization rates and strictly organic activities. There were, in total, three organic activities and 31 other activities. The 34

Table 3.1. Summary description of the cropping activities available in the mathematical model[a].

Production Activities[b]	**Crop Rotation**[c]	**Special Characteristics**
1	C/SG-DC(2 yr)	med. chemicals/nutrients
1L	"	med. chemicals/nutrients poultry litter
2	"	high chemicals/nutrients
2L	"	high chemicals/nutrients poultry litter
3	"	low chemicals/nutrients
3L	"	low chemicals/nutrients poultry litter
4	"	med. chemicals/nutrients split nitrogen application
5L	"	no chemicals poultry litter
6	"	no Aatrex
6L	"	no Aatrex poultry litter
7	"	no Dual(metolachlor)
7L	"	no Dual poultry litter
17	"	no Gramoxone(paraquat)
17L	"	no Gramoxone poultry litter
8	C/SG-DC-RYE(2 yr)	med. chemicals/nutrients mowed rye
8L	"	med. chemicals/nutrients mowed rye poultry litter
9	"	no Aatrex(atrazine) mowed rye
9L	"	no Aatrex mowed rye poultry litter

[a] See Appendix B for more a detailed description.
[b] A suffix L indicates poultry litter is the source of nitrogen.
[c] C=corn, SG=small grains (wheat and barley), DC=double-cropped soybeans, FS=full season soybeans, MIX=rye and crimson clover.

Table 3.1, continued.

Production Activities[b]	**Crop Rotation**[c]	**Special Characteristics**
10	"	no Dual mowed rye
10L	"	no Dual mowed rye poultry litter
11L	"	no chemicals mowed rye poultry litter
18	"	no Gramoxone mowed rye
18L	"	no Gramoxone mowed rye poultry litter
12	C/SG-DC/FS/SG-DC(4 yr)	med. chemicals
12L	"	med. chemicals poultry litter
13	"	no Aatrex
13L	"	no Aatrex poultry litter
14	"	no Dual
14L	"	no Dual poultry litter
19	"	no Gramoxone
19L	"	no Gramoxone poultry litter
15	C/SG-DC-MIX(2yr)	med. chemicals/nutrients clover/rye plowed under
15L	"	med. chemicals/nutrients clover/rye plowed under poultry litter
16L	"	no chemicals clover/rye plowed under poultry litter

[b] A suffix L indicates poultry litter is the source of nitrogen.

[c] C=corn, SG=small grains(wheat and barley), DC=double-cropped soybeans, FS=full season soybeans, MIX= rye and crimson clover.

activities aresummarized in Table 3.1; further descriptions can be found in Appendix B. An activity having the suffix L used poultry litter shipped from Rockingham County in the Shenandoah Valley as its' source of nitrogen. It should be noted, at the time of this study, poultry litter was not being shipped from the Shenandoah Valley for use in Richmond County. However, poultry litter disposal is a growing concern in Virginia, and the potential transport of litter to farms for use as fertilizer is currently being studied (Napit, Norris).

The number of an activity as shown in Table 3.1 indicates crop rotation, and chemical and nutrient attributes. Therefore activities 1 and 1L were the same except that 1L used poultry litter as an organic nitrogen source whereas activity 1 used inorganic nitrogen. In this study, the notation 1(L) was used to indicate both activities 1 and 1L for purposes of summarizing common attributes of both rotations. The three organic activities only used poultry litter and are therefore, always referred to as 5L, 11L, and 16L, with no corresponding 5, 11, and 16 activities. Activity 4 occurred only with the use of inorganic nitrogen; no 4L exists.

In order to represent the various stages of each rotation within a single year, a composite hectare was created. For example, a system may have used a two year rotation which implies a hectare of corn in one crop year, followed by a hectare of double-cropped small grains and soybeans the second year, as in activities 1(L) through 7(L) and 17(L) in this study. On a composite hectare basis, this rotation was represented by one-half hectare of corn and one-half hectare double-cropped small grains and soybeans in one year, in the next year the crops are reversed on each half hectare. The one-half hectare of small grains was further divided into .275 hectare of wheat and .225 hectare of barley (Norris, VPI & SU, Dept. of Agric. Economics). Thus, a composite hectare of rotations 1(L)-7(L) and 17(L) included:

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare soybeans.

This sequence was a common rotation of cash grain operators in the study area (Norris, VPI & SU, Dept. of Agric. Economics). In Activity 1(L), corn and small grains were planted using moldboard plowing, while double-cropped soybeans were no-till planted.

Chemical weed control and nutrients were used at extension recommended rates. Activity 2(L) used higher chemical application rates to control weeds in no-till corn, as was found to be done by several operators in the study area (VPI & SU, Dept. of Agric. Economics). Minimum levels of chemicals are used in Activity 3(L) as well as minimum tillage for corn. The use of commercial nitrogen is split into two applications in all inorganic nitrogen systems, as was the practice of all the farm operators surveyed in Richmond County (VPI & SU, Dept. of Agric. Economics). Application of fertilizer in split applications allowed smaller fertilizer applications to be made at critical points of crop growth. For wheat, maximum uptake of nitrogen does not occur until late February to early March (Alley et al.). Split applications also reduce the accumulation of nitrogen in the soil which may be subject to leaching or denitrification before it is removed by the plant (Norris). Activity

4 further split the small grain inorganic nitrogen application, so that three applications were made. Organic nitrogen, such as that in poultry litter, is released much slower than inorganic nitrogen and cannot be applied once the crop has emerged, except through sidedressing, therefore only a single application was made of all poultry litter.

All agrichemicals and inorganic nutrients were removed from Activity 5L; cultivation was the primary form of weed control. Cultivation, a shallow turning of the topsoil to remove weeds among crops, was the primary weed control practice in low-input activities replacing the use of deep pre-plant tillage and herbicides (Klein et al., Regnier and Janke, King and Kramer). Activities 6(L),7(L) and 17(L) were similar to Activity 1(L), except that individual chemicals were removed from each and replaced by cultivations and/or other chemicals. Aatrex (atrazine), Dual (metolachlor), and Gramoxone (paraquat) were removed from some activities due to their leachability, persistence, and toxicity (EPA, 1988a; Pesticide Action Network; Royal Society of Chemists). Activities 6(L), 9(L), and 13(L) used no Aatrex, Activities 7(L), 10(L), and 14(L) used no Dual, and Activities 17(L), 18(L), and 19(L) used no Gramoxone.

The two year rotation in Activities 8(L),9(L),10(L),11L and 18(L) was corn, then double-cropped small grain followed by soybeans, followed by a custom aerially applied rye winter cover crop. The primary sources of weed control in this group of production systems, except Activity 11L, were chemicals and a mowed rye cover crop. Activity 11L was organic. In these nine activities, a rye winter cover was combined with a reduced tillage method for soil erosion and water quality control. A rye cover crop has been well established as an excellent soil erosion control practice (Domanico, Madden, and Partenheimer; Lockeretz; Peters, and McKee; Smith, Frye,Corak,and Bargo; Papendick, Elliot, and Power; Hoyt and Hargrove). Legumes have become an important type of cover crop because they add nitrogen to the soil (Doran et al.; Ott and Hargrove; Power, 1987a; Power, 1987b; Frye and Blevins) and are used in activities 15(L) and 16L. Rye has also been recommended by several studies as an important cover crop because of its' ability to store organic nitrogen and release it when plowed under (Williams and Wicks). If the rye is mowed and not turned under, however, most of the stored nitrogen can be lost (Bartholomew; Peters and Mckee; Williams and Wicks; Papendick et al.). Rye residues left on the surface have also been found to decrease crop growth by deterring stand establishment (Eckert). A mowed rye crop has been used for weed control because of its allelopathic properties (Barnes, and Putman; Liddington; Putman and DeFrank; Barnes). The allelopathic properties referred to here are chemical properties of plants which can affect the growth of other plants. Rye residues have the allelopathic potential to suppress weed growth. The evidence of beneficial allelopathic properties is however, mixed. Some research has found that yields of crops following rye are reduced (Peters and Mckee; Eckert).

Another common rotation used in the study area was a four year rotation of corn, double-cropped small grains and soybeans, followed by full-season soybeans, and in year four double-cropped small grain and soybeans. Activities 12(L),13(L),14(L) used this rotation under a variety of chemical regimes for weed control. There was no organic alternative using this rotation. Elimination of all chemicals from a rotation which has soybeans followed by soybeans would be difficult (Liddington, Hagood). Activities 15(L), and 16L used the potential nitrogen from a rye winter cover mixed with clover, which also reduced the soil erosion potential. Activities 15(L) and 16L used a simple two year rotation of corn, then double-cropped soybeans, followed by a mixed cover crop of rye and crimson clover. Activity 15(L) used chemicals for weed control, while Activity 16L was organic.

Resource Constraints and Technical Coefficients

The constraints and technical coefficients were developed to emulate the site specific qualities of Richmond County. The land constraints insured that all of the total cropland in Richmond County, 13,056 hectares (32,316.8 acres), was used for either planting, Conservation Reserve Program enrollment, buffer strip enrollment, or accounted for as idled cropland (U.S. Dept. of Commerce, 1989; Brown). Idled cropland was only used when other resource constraints prevented the entry of land into one of the other uses. The amount of available field hours for full-time and part-time operators was calculated from data published in Virginia Agricultural Statistics (Virginia Cooperative Crop Reporting Service) on the average monthly number of days suitable for fieldwork in Virginia. In Table 3.2 a composite number of available hours was calculated given the percent of full-time (53%) and part-time (47%) operators in Richmond County (U.S. Dept. of Commerce; Appendix C). The summer months, June

Table 3.2. A summary of the available field hours for full and part-time operators in Richmond County, Virginia.

Month	Full Time Hours/Month Weighted(53%)[a]	Part Time Hours/Month Weighted(47%)[a]	Aggregate Weighted Hours/Month (148 operators)
March[b]	82.68	31.53	16,903.0
April	82.68	31.53	16,903.0
May	87.98	33.55	17,986.0
June	138.50	62.49	29,746.0
July	117.66	50.08	29,265.0
August	112.89	48.05	23,819.0
September	149.46	63.62	31,536.0
October	111.30	42.44	22,753.0
November	106.53	40.62	21,778.0
December[c]	106.53	40.62	21,778.0
January[c]	106.53	40.52	21,778.0
February[c]	106.53	40.62	21,778.0

[a] The available full time labor was calculated by weighting the reported available field hours (Virginia Agricultural Statistics Service) and the estimated part time available labor (Appendix C) by the percentage of the total number of operators in the full or part time category (U.S. Dept. of Commerce).

[b] Days suitable for field work were not listed for March, the April figure was used as a proxy.

[c] Days suitable for field work were not listed for December, January and February, the November figure was used as a proxy.

through September, had the highest available field hours for both part-time and full-time operators. The total aggregate available field hours was highest in September, 31,536 hours. The spring months March-May had the least field hours, ranging from 16,903 to 17,986 aggregate available field hours. The model calculated the amount of hired labor and the amount of on-farm labor used by subtracting available operator labor from the total labor used.

The federal commodity program, as mandated by the 1985 Food Security Act, for grains (wheat, corn, and barley in this study) uses a combination of market price floor (loan rates), price guarantees to producers (target prices), and deficiency payments that make up the difference between the target and market prices. The incorporation of these payments in this study, as they relate directly to revenues, are discussed in the Objective Functions and Net Returns Coefficients section. However, provisions of the commodity program affected the land use constraints of this study. Total payment to an operator is the payment rate multiplied by the eligible production, not to exceed $50,000. Payments were not limited in the model because net returns were polled over all producers. To determine eligible production, an operator must file official base hectares and established yield for all commodity crops. The base hectares are the average hectares planted and considered planted hectares for the previous five years or the previous two years whichever is smaller. Established yields are the average yields for the previous five years, where high and low yields may be disregarded. The established yields were frozen by the federal government at 1985 levels but a five year moving average was used in this analysis to evaluate the possible effects of such as restriction on LIA adoption. A five year moving average was also used for established yield calculations.

The Acreage Reduction Program (ARP) requires that a percentage of the base hectares of each crop be diverted from planting but protected from weed infestations and soil erosion. This acreage is "considered planted" for base hectare calculations. An operator can not plant more than his registered base hectares less the ARP requirement for any crop if he intends to participate in the commodity program. Table 3.3 shows a comparison of the land use and yields possible under participation and nonparticipation. The participating operator in Table 3.3 has 10 percent less available land because of ARP requirements. His actual yield per hectare, 3,674 kg, is the same as the nonparticipating operator but his program yield, 3,130 kg, is lower due to lower yields being included in the average. However, Table 3.3 does not show that the participating operator has been assured at least the target price for his production, while the nonparticipating operator is vulnerable to variation in market prices. The ARP requirement was also set at the 1988 levels; 10 percent of corn, wheat, and barley base hectares (Brown).

Other government programs affecting land use which were included were the federal Conservation Reserve Program (CRP) and state buffer strip requirements of the Chesapeake Bay Local Assistance Board (CBLAB). The CRP program hectares in the study area were initially restricted to the total enrolled hectares in 1989, 58.58 hectare (145 acres) of trees and 577.40 hectares (1429.21 acres) of grassland (Brown). Grassed CRP

Table 3.3. A comparison of the land use and yields for an operator participating in federal commodity programs and an operator not participating.

	Participating Operator	Nonparticipating Operator
Base Hectares	40.40	40.40
ARP (10%)	- 4.04	
Permitted Planted Hectares	36.36	40.40
Planted Hectares	36.36	40.40
Actual Yield (kg/acre)	3,674.00	3,674.00
Total Production	133,587.00	148,430.00
Program Yield(kg) (5 year average)	3,130.00	
Program Production	113,807.00 (Planted Hectares * Program Yield)	

land became available for crops when the ten year required entry period expired. Table 3.4 shows that re-entry started in year 9 of the model with 12.12 hectares (30 acres) and continued through year 13. The greatest amount of land came back into production in year 12, 231.17 hectares (573 acres). In years 13 through 15, only those hectares planted in trees remained out of production, 55.48 hectares. CRP enrollment was frozen at the time of this study so it was assumed that no more land would be admitted and currently enrolled land would not be supported beyond the 10 year period in most scenarios. The forested CRP land is assumed to remain in trees. The CBLAB legislation of 1989 required buffer strips along waterways in counties surrounding the Chesapeake Bay and its major tributaries. The width of buffer strips depends on the operator's use of approved conservation practices. If a soil and water quality conservation plan, as approved by the local Soil and Water Conservation District, was implemented on adjacent land, then a 7.6 meter (25 foot) buffer strip is required. The buffer area was increased to 15.2 meters (50 feet) if the adjacent land is enrolled in a federal, state or locally-funded agricultural best management practices program. A 30.4 (100 foot) buffer was required in all other cases (Chesapeake Bay Local Assistance Board). A summary of the total land area that would be encompassed within these buffer strips is found in Table 3.5. The 7.6 meter buffer strip required of every operator in the county was initially used in this model, encompassing 76.76 hectares (190 acres), while the 30.4 meter buffer strip would require 307 hectares (760 acres).

Table 3.4. Schedule of reentry of Conservation Reserve land assuming only grassland returns to eligible cropland after ten years of conservation use.

Year of Sign-up	Total Hectares	Hectares of CRP in Grass	Hectares of CRP in Trees	Year of Exit
1986	13.29	12.12	1.17	9
1987	95.10	87.87	7.23	10
1988	171.56	165.72	5.74	11
1989	267.81	231.17	36.64	12
1990	88.32	80.52	7.80	13

Table 3.5. Summary of the land area in Richmond County, Virginia encompassed by the three possible levels of buffer strips required under Virginia law.

Buffer Strip Width	**Cropland Area Hectares**
7.6 meters	76.76 hectares
15.2 meters	153.52 hectares
30.4 meters	307.00 hectares

Technical Coefficients

This section briefly describes the elements within the matrix tableau in Figure 3.1; a more detailed description is available in the noted appendices. Definitions of the tableau notation are found in Table 3.6. The coefficients in row $\mathbf{NRT_t}$ are costs and revenues associated with each production activity. These coefficients are directly related to the objective function of this model and are therefore described in the next section: Objective Function and Net Returns.

The coefficients **dd** split each hectare of a production activity proportionally into the rotation's respective crops (Appendix B). The yield coefficient **f** for each crop was estimated from the residuals of detrended annual Richmond County yields (Virginia Cooperative Crop Reporting Service). The purpose of detrending yield data was to remove the effects of technological progress with the remaining fluctuations assumed to be primarily due to weather. These fluctuations were captured in the residuals of an Ordinary Least Squares regression and then added to 1988 average yields. The estimates listed in Table 3.7 reflect yields given current technology but the same weather and random occurrences as in 1970 through 1985 (Appendix D). The time period 1970 through 1985 was used for all historical data, as it was the period for which weather data was also available. Using historical data results in prescriptive not predictive conclusions. Year 6 had the highest corn yields at 6,273.8 kg per hectare (99.8 bushels per acre), while year 8 had very low yields at 2,032.0 kg per hectare (32.3 bushels per acre). Wheat and barley both attained their highest yield in year 14 at 4,245.62 and 4,264.37 kg perre

	NRTTt	Ait	AitL	BUFt	CRPt	kBit	kBitL	kNitL	kNitL	kAt	kPt	kBPt	TYkt-m	TYkt	TOTkBt-m	TOTkBt	kAYt	KtT	RkAyt	ACRkt	Nktg
RET	-1																				
NRTt	-a	b	bl		c						d	db						dt		1	dn
LANDt		1	1	1	1																
RCRPt					1																
RBUFt				1																	
STkit		dd				-1		-1													
STkitL			dd				-1		-1												
Ykt								f	f		-1										
YBkt						f	f					-1									
kALt						1	1	1	1	-1											
Tkt											1	1		-1							
SBkt						1	1									-1					
AYkt														1/kAt			-1				
AVkt													g						-1		
Dkt																RkAYt		-1			
ACRkt						h	h													-1	
NQktg						n		n													-1
LQktg							p														
PRQt						q		q													
KRQt						r		r													
LPRQt							ql		ql												
LKRQt							rl		rl												
CjQt						s	s	s	s												
LNt						t	t	t	t												
Ljt						u	u	u	u												
RNt						v	v	v	v												
Rjt						z	z	z	z												
ERDt						hh	hh	hh	hh												
LABt						nn	nn	nn	nn												
AAkt															aa	-1					

Figure 3.1. The general tableau form of the mathematical model used to evaluate the potential benefits of low-input agriculture as a groundwater protection strategy.

	Lktg	PPt	KKt	Pkg	Kkyg	Cjt	LTNt	LjTt	RNTt	RTjt	STNt	SjTt	ERDTt	Ofkt	RHS
RET															=0
NRTt	dl	dp	dpp			dc								do	<x
LANDt															=zz
RCRPt															=bb
RBUFt															=0
STkit															=0
STkitL															=0
Ykt															=0
YBkt															=0
kALt															=0
Tkt															=0
SBkt															=0
AYkt															=0
AVkt															<0
Dkt															=0
ACRkt															=0
NQktg															=0
LQktg	-pp														=0
PRQt		-1													=0
KRQt			-1												=0
LPRQt	-qq			-1											<0
LKRQt	-rr				-1										<0
CjQt						-1									=0
LNt							-1								=0
Ljt								-1							=0
RNt									-1						=0
Rjt										-1					=0
SEDNt											-1				=0
SEDjt												-1			=0
ERDt													-1		=0
LABt														-1	=0
AAkt															<0

Figure 3.1, continued.

Table 3.6. Notation used in the general tableau form of the mathematical model used to evaluate the potential benefits of low-input agriculture as a groundwater strategy.

Subscripts

f = month of the year, January-December.
g = groups of production activities with similar rotations, A-D.
i = production activity, 1-19.
j = chemical identification number, 1-15.
k = crop: corn,wheat,barley,double-cropped soybeans, full season soybeans.
m = previous years used for a five year moving average calculation, 1-5.
t = time periods, 1-15.

Rows (Constraints)

RET = sum of discounted annual net returns.
NRT_t = discounted annual net returns
$LAND_t$ = available cropland.
$RCRP_t$ = Conservation Reserve land enrollment.
$RBUF_t$ = buffer strip land enrollment.
ST_{kit} = allocation of the portion of one hectare of activity **i** (inorganic nitrogen) to crop **k**, base and nonbase.
$ST_{kit}L$ = allocation of the portion of one hectare of activity **i** (organic nitrogen) to crop **k**, base and nonbase.
${}_kAL_t$ = hectares of crop **k**.
Y_{kt} = transformation of nonbase hectares of crop **k** to bushels.
YB_{kt} = transformation of base hectares of crop **k** to bushels.
SB_{kt} = total base hectares of crop **k**.
T_{kt} = yield of crop **k**.
AY_{kt-m} = averaging of previous five years' yields of crop **k**.
D_{kt} = bushels of crop **k** available for commodity program enrollment.
ACR_{kt} = transformation of hectares of crop **k** set-aside to dollars of variable cost savings.
NQ_{ktg} = nitrogen requirements of crop **k** in rotation **g** using inorganic nitrogen.
LQ_{ktg} = nitrogen requirements of crop **k** in rotation **g** using organic nitrogen.
PRQ_{tg} = phosphorus requirements of crop **k** in rotation **g** using inorganic nitrogen.
KRQ_{tg} = potassium requirements of crop **k** in rotation **g** using inorganic nitrogen.
$LPRQ_{tg}$ = phosphorus requirements of crop **k** in rotation **g** using organic nitrogen.
$LKRQ_{tg}$ = potassium requirements of crop **k** in rotation **g** using organic nitrogen.
C_jQ_t = chemical j requirements.
LN_t = accounting of nitrogen percolated through soil.
L_{jt} = accounting of chemical j percolated through soil.

Table 3.6, continued.

Rows (Constraints), continued.

RN_t = accounting of nitrogen carried off surface of soil.
R_{jt} = accounting of chemical j carried off surface of soil.
ERD_t = accounting of soil erosion.
$SEDN_t$ = accounting of nitrogen carried off the surface in sediment
SED_{jt} = accounting of chemical j carried off the soil in sediment
LAB_{ft} = labor requirements in month f.
AA_{kt} = restriction of crop k base acres to previous five year average of base hectares in crop k.

Columns (Variables)

NRTT = transfer of annual net returns to objective function
A_{it} = production activity using inorganic nitrogen (hectare).
$A_{it}L$ = production activity using organic nitrogen (hectare).
BUF_t = buffer strip (hectare).
CRP_t = Conservation Reserve (hectare).
${}_kB_{it}$ = crop k registered as base, using inorganic nitrogen (hectare).
${}_kB_{it}L$ = crop k registered as base, using organic nitrogen (hectare).
${}_kN_{it}$ = crop k, nonbase, using inorganic nitrogen (hectare).
${}_kN_{it}$ = crop k, nonbase, using organic nitrogen (hectare).
${}_kAL_t$ = crop k planted (hectare).
${}_kP_t$ = crop k sold, nonbase (bushels).
${}_kBP_t$ = crop k sold, base (bushels).
TY_{kt} = total yield of crop k (bushels).
TOT_kB_t = total crop k planted, base (hectare).
${}_kAY_t$ = average yield for crop k (bushels/hectare).
${}_kT_t$ = total crop k receiving deficiency payments (bushels).
R_kAY_T = previous five year average yield of crop k (bushels/hectare).
ACR_{kt} = savings from land required idled (dollars).
N_{ktg} = total inorganic nitrogen purchased for activities with rotation g (kg).
L_{ktg} = total organic nitrogen purchased for activities with rotation g (kg).
PP_t = total phosphorus purchased for activities using inorganic nitrogen (kg).
KK_t = total potassium purchased for activities using organic nitrogen (kg).
P_{ktg} = total phosphorus purchased for activities with rotation g using organic nitrogen (kg).
K_{ktg} = total potassium purchased for activities with rotation g using organic nitrogen (kg).
C_{jt} = total chemical j purchased (kg or liters).
LTN_t = total nitrogen percolated through soil (kg).
L_jT_t = total chemical j percolated through soil (kg).
RNT_t = total nitrogen carried off surface of the soil (kg).

Table 3.6, continued.

Columns (Variables), continued.

R_jT_t = total chemical j carried off the surface of the soil (kg).
STN_t = total nitrogen carried off the surface in sediment (kg).
SjT_t = total chemical j carried off the surface in sediment (kg).
$ERDT_t$ = total soil erosion (metric tons).
O_{kft} = total labor used in month f (hours).

Technical Coefficients

a = discount factor.
b = variable cost of production activity, using inorganic nitrogen ($/hectare).
bl = variable cost of production activity, using organic nitrogen ($/hectare).
c = Conservation reserve enrollment payment ($/hectare).
d = market price of crop, nonbase ($/bushel).
db = market price of crop, base ($/bushel).
dt = commodity program deficiency payment ($/bushel).
dn = market price of inorganic nitrogen ($/kg).
dl = market price of organic nitrogen ($/kg).
dp = market price of phosphorus ($/kg).
dpp = market price of potassium ($/kg).
dc = market price of chemical ($/kg or $/liter).
do = opportunity cost or market price for labor ($/hour).
dd = percent of a hectare of production activity (i) planted in a crop (k).
f = yield of crop (bushels/hectare).
g = year t's contribution to a five year average of a crop (k) yields (percent).
h = percent of a hectare of crop base which must be idled (percent).
n = crop inorganic nitrogen requirements (kg/hectare).
p = crop organic nitrogen requirements (kg/hectare).
pp = amount of nitrogen available in a unit of poultry litter (percent).
q = crop phosphorus requirements of production activities using inorganic nitrogen (kg/hectare).
r = crop potassium requirements of production activities using inorganic nitrogen (kg/hectare).
ql = crop phosphorus requirements of production activities using organic nitrogen (kg/hectare).
rl = crop potassium requirements of production activities using organic nitrogen (kg/hectare).
qq = amount available phosphorus in one unit of poultry litter (percent).
rr = amount available potassium in one unit of poultry litter (percent).
s = crop chemical requirements (kg/hectare or liters/hectare).

Table 3.6, continued.

Technical Coefficients, continued.

t = amount of nitrogen percolated through soil surface (kg/hectare).
u = amount of chemical (j) percolated through soil surface (kg/hectare).
v = amount of nitrogen carried off soil surface (kg/hectare).
z = amount of chemical (j) carried off soil surface (kg/hectare).
hh = amount of soil carried off the soil surface (metric tons/hectare).
hv = amount of nitrogen carried off surface in sediment (kg/hectare).
hz = amount of chemical (j) carried off surface in sediment (kg/hectare).
nn = monthly crop labor requirements (hours/hectare).
aa = year t's contribution to a five year average of base planted in a crop (k) (percent).
x = total cropland available.
zz = total cropland in Conservation Reserve Program.
bb = total cropland in buffer strips.

hectare (64 and 78 bushels per acre) respectively. Soybeans yields were the highest in year 9, double-cropped yields were 2,095.6 kg per hectare (31 bushels per acre) and full season yields were 2,558.3 kg per hectare (37.9 bushels per acre). An aggregate soybean residual was estimated from OLS because full-season and double-cropped soybean yields were aggregated in the historical data. However, in Richmond County the yields from these two types of soybeans differ slightly (Liddington; VPI & SU, Dept. of Agric. Economics). The aggregate residual was added to the separate 1988 average yields for double-cropped and full-season soybeans (Liddington; VPI & SU, Dept. of Agric. Economics), producing slightly different estimated yields between the soybean rotations.

The variable costs which the operator did not accrue, due to the set-aside requirements of ARP, are added back into the net returns through coefficient **h**. The coefficients in the $\mathbf{NQ_{ktg}}$ and $\mathbf{LQ_{ktg}}$ rows are the nitrogen requirements for individual crops. The requirement for inorganic nitrogen is $\mathbf{NQ_{ktg}}$, while $\mathbf{LQ_{ktg}}$ are the requirements for organic nitrogen from poultry litter. The **pp** coefficient in the $\mathbf{LQ_{ktg}}$ row transforms poultry litter into nitrogen, with 2.9 percent of poultry litter consisting of nitrogen (Givens; Halstead; Norris). The nitrogen application rates summarized in Table 3.8 were based on the Richmond County operator survey (VPI & SU, Dept. of Agric. Economics) and Virginia Cooperative Extension Service recommendations (Liddington; Perkinson; Appendix E). Two sets of nitrogen requirement coefficients were used in this study under individual scenarios. The first set of nitrogen requirements did not account for any nitrogen available from the residue

Table 3.7. Crop yields estimated from detrended historical yield variations (1970-1985) and 1988 average yields for Richmond County, Virginia, in kilograms per hectare.

Year	Corn	Wheat	Barley	Double-Cropped Soybeans	Full Season Soybeans
1	5,003.80	3,619.66	3,728.65	1,360.78	1,823.44
2	4,191.00	4,082.33	3,921.51	1,823.44	2,286.10
3	4,724.40	3,919.03	3,621.50	1,469.64	1,932.30
4	4,927.60	3,837.39	4,007.22	1,769.01	2,231.67
5	5,080.00	4,082.33	4,007.22	1,469.64	1,932.30
6	6,273.80	3,701.31	3,792.93	1,551.28	2,013.95
7	4,749.80	3,674.09	4,242.94	1,415.21	1,905.09
8	2,032.00	3,674.09	3,364.35	925.33	1,387.99
9	5,156.20	3,674.09	3,514.36	2,095.59	2,558.26
10	5,537.20	3,755.74	3,514.36	1,986.73	2,449.40
11	3,479.80	3,837.39	3,535.79	870.90	1,333.56
12	5,765.80	4,354.48	4,264.37	1,823.44	2,313.32
13	6,705.60	3,919.03	4,071.51	1,986.73	2,449.40
14	2,489.20	4,245.62	4,285.80	979.76	1,469.64
15	6,146.80	3,592.45	3,985.79	1,741.79	2,231.67

of previous crops (Appendix E). The second set of coefficients did account for this organic source of nitrogen (Appendix E). The requirements shown in Table 3.8 are composite requirements of one hectare of a complete rotation. The requirements for phosphorus and nitrogen did not change as the nitrogen requirements did under the unaccounted crop residue and accounted crop residue categories. Total nitrogen required was the least, 69.03 kg per hectare (61.35 lb per acre) under Activities 12(L), 13(L), 14(L), and 19(L) and when crop residue nitrogen was accounted for. The reduction in required nitrogen under these activities was due to the use of full season soybeans. Activity 3(L), a low-chemical activity, used the low rates of application under both the unaccounted crop residue nitrogen and accounted categories, 95.11 and 83.53 kg per hectare (84.57 and 74.2 lb per acre). The current conventional approach to nutrient management is to apply the total Extension recommended nutrient levels to meet plant needs and achieve maximum economic yield. Any excess nitrogen, such as soil residues, is subject to leaching or runoff. LIA nutrient management accounts for soil nitrogen, reducing the total nitrogen application by that amount. In this study the largest amount of nitrogen available from crop residues was 20 kg per hectare (17.7 lb per acre).

Yields were not different between those activities which accounted for nitrogen from crop residuals and those rotations which did not account for nitrogen from crop residuals. Little field data was available to provide a relationship between nitrogen and yields in Richmond County, therefore the results of this study were somewhat limited. The and

Table 3.8. Summary of nutrient application rates for production activities, in kilograms per hectare[a].

Production Activity[b]	Total Nitrogen	Total Phosphorus	Total Potassium
CROP RESIDUE NITROGEN NOT ACCOUNTED FOR			
1(L),4,6(L),7(L), 17(L),15(L),16L	114.33	42.75	78.31
2(L)	143.37	20.25	44.56
3(L)	95.11	42.75	78.31
5L	112.35	45.01	70.87
8(L),9(L),10(L), 11L,18(L)	114.33	20.25	44.56
12(L),13(L), 14(L),19(L)	117.14	39.94	74.94
CROP RESIDUE NITROGEN ACCOUNTED FOR[c]			
1(L),4,6(L),7(L), 17(L)	102.40	42.75	78.31
2(L)	131.43	20.25	44.56
3(L)	83.53	42.75	78.31
5L	100.41	45.01	70.87
8(L),9(L),10(L), 11L,18(L)	163.15	20.25	44.56
12(L),13(L), 14(L),19(L)	69.03	39.94	74.94
15(L),16L	105.95	42.75	78.31

[a] See Appendix E for a more detailed description.

[b] A number with (L) following indicates two production activities, for example 1(L) indicates both production Activity 1 with inorganic nitrogen and 1L with poultry litter (organic nitrogen).

[c] For the detailed calculation of nitrogen from crop residue see Appendix F.

relationship between increased nitrogen fertilizer applications improved yields can be very strong (Brann; Peterson and Frye). In this study the yields used were based on the common practice of adding the total plant nitrogen needs, regardless of the soil nitrogen content. Therefore the question arises: would yields fall when up to 20 kg per hectare (18 lb per acre) of nitrogen are withheld, such as when soil nitrogen is accounted for? The literature suggests that, on average, 50 percent of applied fertilizer is actually taken up by crops (Keeney). The timing, soil moisture, temperature, and form of nitrogen fertilizer are often the limiting factors in efficient nitrogen use (Liddington; Keeney; Peterson and Frye). Since split applications of nitrogen are used, the crop nitrogen needs are met, and since corn and wheat do not benefit from large application of nitrogen fertilizer at planting, the reduction in commercial fertilizer does not suggest a change in yields (Brann; Liddington; Peterson and Frye). A survey of Richmond county farmers also showed there were no differences among farmers who added reduced amounts of commercial nitrogen (VPI & SU, Dept. of Agric. Economics). The current nitrogen management practices may provide too much nitrogen in the early stages of growth for efficient uptake, in which case the yield estimates used in this study underestimate the possible yields from accounting for soil nitrogen (Liddington). The reader should also keep in mind that soil tests used for estimating soil nitrogen content are not exact and there have been studies which show the recommendations for nitrogen applications from these tests vary by a greater degree than the 20 kg difference in these two nitrogen application schedules (Hallberg).

The coefficients **q,r** and **q1,r1** are the phosphorus and potassium requirements respectively, for individual crops of each production activity using inorganic or organic nitrogen respectively. The organic nitrogen production activities used the phosphorus and potassium available from poultry litter before purchasing any required commercial supplements. The **qq** and **rr** coefficients are the percentage of phosphorus and potassium available in poultry litter. Two percent of poultry litter is phosphorus and 1.5 percent is potassium (Givens, Norris).

The crop residue nitrogen was calculated from the total nitrogen content of crop residue biomass (Appendix F). The nitrogen content was subject to decay rates by which organic nitrogen is released and made available for crop uptake (Martin et al.; Bartholomew). A decay rate of .02, .05, .03 was used for corn, wheat, and barley; that is, 2 percent of nitrogen in these crops became available in the period following harvest, 5 percent and 3 percent of the residue nitrogen becomes available in the second and third year, respectively (Norris; Gilbertson; Bartholomew). The decay rate for soybeans was .33, .05, and .03 (Norris; Gilbertson), rye and clover decayed at the rate of .6, .1, .1, and .05 (Bartholomew; Allison, Peters and McKee; Norris; Appendix F). When rye was mowed followed by no-till corn, the nitrogen source was forgone since incorporation is critical to obtain the maximum amount of nitrogen from the residues. Residues with substantial nitrogen content left on the surface are exposed to weathering forces which may cause rapid denitrification and volatilization (Bartholomew; Peters and McKee). The residual nitrogen is calculated for each crop and subtracted from the nitrogen requirement within each individual production activity. These coefficients for residual nitrogen were calculated assuming a continuous rotation. When rotations were switched during the 15 years of this analysis then these coefficients produced residual amounts which are slightly high or low, depending on the two rotations involved.

The chemical requirements for each crop within a production activity are represented by the coefficient **s** in row $\mathbf{C_jQ_t}$. Table 3.9 identifies each chemical by the number used in the model and lists 1988-89 chemical prices provided by the Southern States Cooperative in Warsaw, Virginia. Harmony Extra was the most expensive chemical at $404.8 per kg ($890.6 per lb), but its application rate was very low. Aatrex was the most inexpensive at $2.87 per liter ($10.8 per gallon). The chemical requirements of each crop were assigned given the complete rotation and tillage operation (Hagood; Liddington; Appendix G). A summary of the total amount of chemical types used in each activity is found in Table 3.10. Activities 5L, 11L, and 16L are organic and have no chemicals. Activity 3(L) used only three chemicals, Aatrex, Gramoxone, and Fusulade. A wide variety of chemicals were used by the remaining activities, especially those with full season soybeans, Activities 12(L)-14(L) and 19(L). Only the high chemical use rotation, 2(L), used chemical #6 Banvel. The application rates were similar across rotations, for example #8 Pydrin was always used at .875 kg per hectare (.77 lb per acre).

The coefficients **u, z, hz,** and **hh** are the leaching, runoff, and sediment loadings of chemicals (Appendix H) and the soil erosion (Appendix I), from a hectare of each crop planted under a production activity.

Table 3.9. Chemical product prices (Southern States Cooperative, Inc.).

Chemical Number	**Chemical Product**	**Dollars/ Liter**	**Dollars/ Kilogram**
1	Blazer	14.08	
2	Lasso	6.06	
3	Aatrex	2.87	
4	Gemini		36.12
5	Bladex	5.18	
6	Banvel	17.97	
7	Harmony Extra		404.80
8	Pydrin	28.14	
9	Fusulade	21.57	
10	Roundup	20.25	
11	Lorox	14.78	
12	Dual	14.42	
13	Gramoxone	9.34	
14	Treflan	7.15	
15	2-4D	3.28	

Table 3.10. A summary of the total per hectare chemical requirements of each production activity. Units are liters except for chemicals 4 (Gemini) and 7 (Harmony Extra) which are in kilograms.

Production Activity	Total Chemical Used[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1(L),4			1.75	.175			.02	.255	.875			1.16	.875		
2(L)	.875		3.21			.29	.20	.255		1.17	.58	1.75	.875		.29
3(L)			1.75						.875				.30		
5,11,16	NONE														
6(L)				.175	1.86		.02	.255	.875			1.16	.875		.58
7(L)		4.7	1.75	.175			.02	.255	.875				.875		
15(L)	.875		1.75				.02	.255	.875		.58	2.05	.875		
17(L)			1.75	.175			.02	.255	.875	1.75		1.16			
18(L)	.875		1.75				.02	.255	.875	1.75	.58	2.05			
13(L)	.875			.09	.93		.02	.255	.875	.59	.58		.875	.44	.93
14(L)	.875	4.69	.87				.02	.255	.875	.59	.58		.875	.44	
10(L)	.875	4.68	1.75				.02	.255	.875		.58		.875		
12(L)	.875		.87	.09			.02	.255	.875	.59	.58	1.47	.875	.44	
8(L)	.875		2.33				.02	.255	.875		.58	1.75	1.75		
9(L)	.875				1.86		.02	.255	.875		.58	2.05	.875		.58
19(L)	.88		.87	.09			.02	.255	.875	2.34	.58	1.61		.44	

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[a] See Appendix G for a more detailed description of the chemical requirements of each activity.

[b] The total amount of chemicals used per activity was calculated by weighting the application rate per hectare for each crop by the percentage of a hectare planted in that crop for a composite activity.

[c] Units are kilograms.

Coefficients **t**, **v**, and **hv** are the leaching, runoff, and sediment concentration coefficients for nitrogen (Appendix J). The details of estimating these coefficients is contained in the physical simulation model section of this chapter. Note, however, that small grains do not have coefficients in these rows. The coefficients are annual loadings per hectare, because of the restrictions of the simulation models used the loadings are combined for all crops grown within one year on a single hectare. Therefore the loadings for small grains were included with corn and double-cropped soybean loadings because they follow or proceed those crops.

Labor requirements of each crop within an alternative production activity are calculated from an operation schedule and machinery budgets (Appendix C). Hours of labor are assigned to the individual crop within each rotation by coefficient nn. Table 3.11 shows the labor required by organic activities, 5L, 11L, and 16L were the highest. Activities using poultry litter have a smaller labor requirement, noted in parenthesis, due to the single application of poultry litter. Commercial nitrogen was applied at twice per crop, and three times in Activity 4. Organic activities had the highest labor requirements; for example, Activity 11L at 6.02 hours per hectare (2.4 hours per acre). The least labor was required by activities which included full season soybeans because soybeans require relatively less labor than corn. For instance, the total hours required for Activity 12L was 4.05 per hectare (1.6 hours per acre).

Table 3.11. A summary of the total composite labor requirements of each production activity, in hours per hectare.

Production Activity[a]	Total Labor Requirements For A Hectare of Activity[b]
1(L),6(L),7(L),17(L)[c]	4.99 (4.72)
2(L)	4.60 (4.33)
3(L)	4.95 (4.68)
4	5.12
5L	5.97
8(L),9(L),10(L),18(L)	5.34 (5.07)
11L	6.02
12(L),13(L),14(L),19(L)	4.48 (4.05)
15(L)	5.10 (4.83)
16L	5.97

[a] See Appendix C for a more detailed description.

[b] The total labor hours are calculated by weighting the hours required for each crop in the rotation by the percentage of a hectare planted in that crop for a composite rotation.

[c] A number with (L) following indicates two production activities, for example 1(L) indicates both production Activity 1 with inorganic nitrogen and 1L with poultry litter (organic nitrogen). The labor requirements for poultry litter activities are noted in parenthesis.

The Objective Function and Net Returns Coefficients

The objective function in this model was the summation of fifteen annual net returns discounted to present value, row **RET**. The net returns were specifically the returns to land, management, and capital. Within each of the fifteen years, net returns were calculated and discounted in row $\mathbf{NRT_t}$. The coefficient **a** in the net return equation is the discount factor applied to the net returns from each year. Barry suggests a 5 percent discount rate to reflect real returns to capital assets in agriculture over the long run. Randall recommends a real discount rate of 4-6 percent when evaluating the present value of natural resources. A 6 percent discount rate was initially used in the this study; therefore, for each year t, the **a** coefficient was:

$$\begin{matrix}\textbf{Discount}\\ \textbf{Factor}\end{matrix} = \mathbf{a} = (1+.06)^{t-1} \quad \text{for} \quad t=1...15 \qquad (3.9)$$

and annual net returns were:

$$\mathbf{a * Net\ Returns = a * (Total\ Revenue - Total\ Variable\ Costs)}\ . \qquad (3.10)$$

Total revenues were calculated from the marketing and government payment activity coefficients. The composite variable costs, excluding labor, in Table 3.12 were calculated from the production and purchasing coefficients. All costs and prices were expressed in 1988 dollars. Discounted net returns were then transferred to the objective function by row **RET**. The variable costs were calculated based on a composite production budget, which included the variable costs of seed, lime, machinery, and custom services, specifically chemical applications and aerial overseeding when appropriate. Using crop production budgets (Perkinson; Dunford, Judy and Vines) costs were calculated on a hectare basis (Appendix K). The values in Table 3.12 are composite because the variable cost of each crop in the activity was weighted by the proportion of a hectare allocated to that crop. Variable costs were highest for activities with winter cover crops, for example Activity 8 had variable costs of $240.81 per hectare ($97.3 per acre), and those which used cultivations in addition to some chemical application for weed control,such as 9(L) which had variable costs of $246.99 per hectare ($99.7 per acre). The lowest variable costs were under Activity 5L, an organic activity, at $182.74 per hectare ($73.8 per acre).

The purchasing coefficients include the price of commercial or inorganic nitrogen (**dn**), potassium (**dp**), phosphorus (**dpp**), agrichemicals (**dc**), poultry litter (**dl**), and labor (**do**). The price of commercial nutrients in 1988 dollars were: nitrogen $.55 per kilogram, potassium $.35 per kilogram, and phosphorus $.62 per kilogram (Perkinson). The price of poultry litter was calculated on the basis of current research on the marketing of poultry litter (Weaver et al; Napit). The purchase price to a broker was $8.8 per metric ton. The cost of loading, transporting was added by the broker in addition to a $1.1 per metric ton profit margin. The total cost to the operator for litter delivered was $.03 per kilogram (Appendix L). The costs of agrichemicals included in the production activities were shown previously in Table 3.8.

Off-farm labor could be purchased at $4 to $5 per hour, according to a survey of farmers in Richmond County (VPI & SU, Dept. of Agric.

Table 3.12. Variable costs[a], for composite production activities, per hectare, in 1988 dollars[b].

Alternative Production System[c]	**Total Variable Costs**[d]
1(L),7(L),17(L)	209.55 (207.97)
6(L)	215.73 (211.65)
2(L)	209.98 (208.40)
3(L)	183.26 (181.67)
4	210.34
5L	(182.74)
8(L),10(L),18(L)	240.81 (239.23)
11L	(214.32)
9(L)	246.99 (245.41)
12(L),14(L),19(L)	204.05 (202.86)
13(L)	207.14 (205.96)
15(L)	223.11 (221.54)
16L	(205.44)

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[a] Variable costs exclude labor, nitrogen and chemical sources.

[b] See Appendix K for a more detailed description.

[c] A number with (L) following indicates two production activities, for example 1(L) indicates both production Activity 1 with inorganic nitrogen and 1L with poultry litter (organic nitrogen).

[d] The value in parenthesis is the variable costs for the organic nitrogen activity (L), unless the activity uses only organic nitrogen then only one number is reported and it is for a L activity.

Economics). The costs associated with operator labor were considered opportunity costs. Opportunity cost is the value of the operator's time with respect to the next best use of his time, assumed here to be an off-farm job. The survey of operators in Richmond County (VPI & SU, Dept. of Agric. Economics) showed that $4.5 per hour, on average, would be required for the operator to take a part-time off-farm job. Both operator and off-farm labor were assigned a wage of $4.5 per hour.

Total revenue was composed of revenue from marketing crops and revenue from government commodity programs and CRP enrollment rent. Crop prices were adjusted annual averages of the weekly cash prices in the Northern Neck of Virginia, for the period 1970 through 1985 (Virginia Department of Agriculture and Consumer Service). Northern Neck regional prices were used for several reasons. First, they reflect the prices received by the operators in Richmond County better than state average prices. Second, the usual markets for these crops may be in surrounding counties not just Richmond County, and some operators may work land in other counties, and would be influenced by other prices. Several years of weekly cash price data was missing for wheat and barley. The missing data was estimated using linear price equations, constructed by Ordinary Least Squares Regression. In the regression, corn prices were used as predictors of wheat and barley prices (Groover). Three years of available weekly cash prices for wheat and barley were regressed onto corn prices. The time period 1970-1985 was used because it matches the available weather data used in the physical simulation model. Crop prices were adjusted by indexing with 1988 as the base, see Table 3.13 and Appendix M.

Table 3.13 shows crop prices in dollars per kilograms. Soybeans consistently had the highest prices. Corn prices were frequently below those of wheat. Except for soybeans, there was little variation in the crop prices. Corn ranged from $.09 to $.11 per kg ($2.28 to 2.79 per bushel). Wheat had a price range similar to corn but barley prices were lower, ranging from $.06 to $.09 per kg ($1.31 to $1.98 per bushel). Soybeans had a wider range of prices, varying from $.17 to $.30 per kg ($4.6 to $8.17 per bushel).

Commodity program deficiency payments were calculated as the difference between the revenue received at market prices and the revenue possible at target prices. Target prices were adjusted to 1988 dollars in the same manner as market prices. If the market price was above the target price, no deficiency payment was received. The deficiency prices in Table 3.14 are the difference between the adjusted target price and the adjusted market price in the Northern Neck Region of Virginia for the period 1970 through 1985, in 1988 dollars (Appendix M). Deficiency payments for corn were zero except in years 3 and 13 where $.01 per kg ($.25 per bushel) was received. Wheat had the highest overall deficiency payments in year 3, $.13 per kg ($3.54 per bushel), while barley deficiency payments varied from $.01 to $.04 per kg ($.22 to $.88 per bushel). There were no non-recourse loans considered in this model. The requirements to receive these program payments were discussed in the resource constraints section. CRP enrolled land received the average bid for the region in 1989, $173 per hectare ($70 per acre) (Brown). This bid

Table 3.13. Crop Prices in the Northern Neck of Virginia, 1988 dollars per kilogram (Virginia Dept. of Agriculture and Consumer Services)[a].

Year	Corn	Wheat	Barley	Soybeans
1	0.11	0.09	0.07	0.19
2	0.10	0.10	0.09	0.20
3	0.10	0.09	0.08	0.24
4	0.10	0.13	0.09	0.27
5	0.10	0.11	0.07	0.18
6	0.09	0.10	0.06	0.17
7	0.09	0.11	0.08	0.19
8	0.10	0.09	0.07	0.30
9	0.10	0.12	0.08	0.26
10	0.10	0.15	0.07	0.26
11	0.10	0.12	0.09	0.22
12	0.10	0.10	0.07	0.21
13	0.09	0.11	0.07	0.21
14	0.10	0.13	0.08	0.20
15	0.10	0.11	0.08	0.20

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[a] For a detailed description of the estimation of these prices see Appendix M.

Table 3.14. Deficiency Prices[a], per kilogram, in 1988 dollars (USDA)[b].

Year	Corn	Wheat	Barley
1	0.00	0.11	0.03
2	0.00	0.10	0.01
3	0.01	0.13	0.03
4	0.00	0.02	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.02	0.04
9	0.00	0.02	0.04
10	0.00	0.00	0.04
11	0.00	0.00	0.01
12	0.00	0.02	0.03
13	0.01	0.04	0.04
14	0.00	0.00	0.01
15	0.00	0.02	0.02

[a] Deficiency price was the market price subtracted from the target price, in 1988 dollars. If the market price was greater than the target price then a zero deficiency price was noted.

[b] For a more detailed description of the estimation of deficiency prices see Appendix M.

price was higher than previous average bid prices and therefore the income from CRP land may be an overestimate.

The Physical Non-Point Pollution Simulation Models

The Mass Balance Approach

Agricultural pollutants are a byproduct of producing food and grain crops. Only recently has society realized that the byproducts of production activities were generally pervasive, that is, not trivial or an exceptional phenomenon. The inclusion of these by-products and the costs associated with their loss, prevention and removal, into economic analysis follows a materials balance approach (Ayers and Kneese). The principles of the conservation of matter and the physical sciences' mass balance approach to the creation of and breakdown of matter served as the origins for the expanded economic analysis (Seneca and Taussig; Ayers and Kneese). Because physical matter cannot be destroyed, any economy will eventually have the same amount of material to dispose of as it initially used as inputs.

Applied to agricultural non-point pollution of groundwater, the mass balance approach requires the accounting of all possible pathways of dispersal for inputs such as nitrogen and pesticides. The transportation of nitrogen and agrichemicals by sediment, runoff, and percolation are the primary sources of water contamination. Although an agricultural practice may control the percolation of chemicals, the "balance" of the chemical residuals must also be disposed of, possibly as another form of non-point pollution such as surface runoff. Figure 3.2 shows the possible routes of nitrogen and pesticides applied on an agricultural field.

Chemicals and nutrients can be carried off the surface, leached through the soil, taken up into plant tissue to be stored or released, broken down within the soil or released from the surface to the atmosphere. The chemicals and nutrients left after plant use or chemical breakdown are common sources of agricultural non-point pollution (EPA, 1987a and 1987b). The characteristics of these potential pollutant pathways are determined by agricultural practices, soil characteristics, chemical and nutrient characteristics, and weather patterns. Controlling these variables in field experiments is difficult. There is a paucity of extensive field data on the fate of chemicals and nutrients; however, these physical movements can be traced through the use of simulation models.

Several simulation models have been built for the specific purpose of estimating non-point pollution loadings from agricultural activities, such as CREAMS (Knisel), AGNPS (Young et al), GLEAMS (Leonard, Knisel, and Still), LEACHMP (Wagnet and Hutson), and PRZM (Carsel et al.). The models used in this study were CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems) and GLEAMS (Groundwater Loading Effects of Agricultural Management Systems). The models were very similar, but the nitrogen movement modelled by CREAMS was not available from GLEAMS at the time of this study, and GLEAMS modelled pesticides travelling through the root zone more accurately than CREAMS.

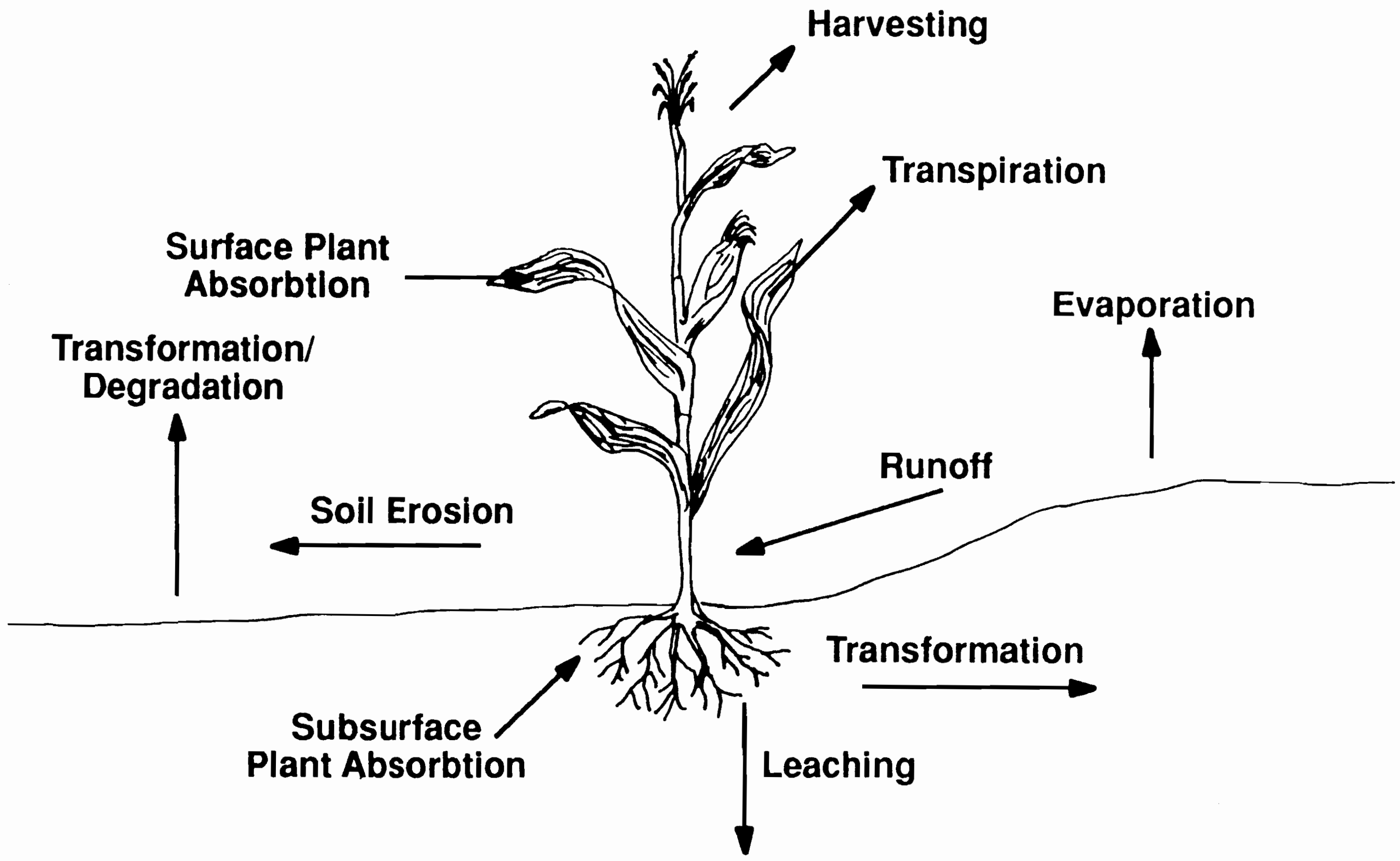

Figure 3.2. The potential pathways for dispersal of nitrogen and pesticides applied to an agricultural field.

The potential non-point pollution coefficients in this study were estimated by Davis. Further explanations of the simulation models, initial value selections, and simulation process can be found in Davis.

CREAMS

The CREAMS model was selected to predict nitrate movement in this study because of its accessibility, existing data base, and its ability to estimate soil erosion and both surface loss and subsurface loss of nitrogen. CREAMS was developed with the objective of evaluating the impacts of management practices on field scale non-point source pollution. The primary focus of CREAMS is soil erosion, nitrogen content of erosion, and surface runoff pollutant loads, but CREAMS also provides an estimate of nitrate leaching to the root zone, where chemicals or nutrients are considered potential groundwater pollutants (Heatwole, Diebel and Halstead). The model has been used in a variety of studies including varying climatic and diverse agricultural management scenarios (Crowder and Young; Del Vecchio and Knisel; Dickey; Dumper; Nicks et al.; Williams and Nicks; Halstead; Crowder et al.) as well as forest management (Dumper et al.) and landfill site evaluation (Lane).

CREAMS consists of three separate parameter sets: hydrology, erosion, and nutrient/chemical. The hydrology component requires parameters for soil, crops, weather, and slope. Fifteen years, 1970 through 1985, of precipitation and temperature data from the Warsaw, Virginia weather station, located in Richmond County, were used for the simulation process (Appendix N).

Another hydrology parameter is soil type. There are six general soil types in Richmond County. A Virginia Geographical Information Systems Map and the Soil Survey of Richmond County (USDA 1982) were used to select the prominent soil types under agricultural use (Shanholtz). Suffolk sandy loam covers 19.2 percent of Richmond County and is the primary soil type used for agricultural purposes. Suffolk sandy loam has a moderate to medium permeability, surface runoff is slow to medium, this soil can be acidic in unlimed areas, and the surface layer is low in organic matter. A major hazard to cropping on Suffolk sandy loam is moderate soil erosion. Suffolk sandy loam ranges between one and six percent slope in Richmond County. In this study, a three percent slope was used.

The erosion submodel of CREAMS uses a modified Universal Soil Loss Equation to estimate detachment which occurs when sediment is less than transport capacity. The submodel also estimates transport occurring after surface saturation and deposition occurring when sediment load exceeds transport capacity. Total soil loss predictions are available by storm, month, or year. Annual cumulative soil loss was used in this study for soil loss coefficients in the mathematical programming model (Appendix I). The information necessary for prediction of erosion included soil characteristics, erodibility, slope, dates of tillages, and years of rotation. Soil parameters included the fraction of clay (15%), silt (25%), and sand (60%) in the surface soil layer. The soil erodibility, or K factor, of 0.44 metric tons per hectare (.2 tons per acre) was used. The erosion component uses information from the hydrology submodel and then passes it to the chemistry component.

The nutrient/chemical component gives the user estimates of nitrogen and phosphorus losses at a field scale. Inputs include soil survey data, solubility of nutrients and coefficients which relate nitrogen content ofthe plant to various stages of plant growth. The study assumed initial values of 20 kg per hectare (17.76 lb per acre) of nitrate at the root zone, and .002 kg per hectare (.0018 lb per acre) of soil nitrogen in the top centimeter of soil. A more detailed listing of some of the critical hydrology, erosion and chemical parameters can be found in Appendix O and in Davis.

In this study, the nitrogen in crop residues was an important source of nitrogen for crops and a potential non-point pollution source. CREAMS does not recognize the availability of nitrogen from crop residues. However, residue nitrogen was manually accounted for and then inserted into CREAMS every year as additional available organic nitrogen for scenarios which did account for residual nitrogen. The average crop residue nitrogen for the 15 year period was used for simplicity (Appendix F). In the case where poultry litter was used as an organic source of nitrogen, nitrogen exists in the litter in two states inorganic and organic, and were both accounted for by CREAMS. This study did not account for phosphorus losses. The build up of phosphorus in soil is an environmental concern nationwide but not specifically in Richmond County or the Chesapeake Bay. The three outputs used by this study from CREAMS were the nitrogen content of annual soil erosion, and surface runoff and percolation (Appendix J).

GLEAMS

Increasing demands to predict the transportation of agrichemicals beyond the root zone to the aquifer, motivated the development of GLEAMS (Leonard, Knisel and Still). GLEAMS was developed form CREAMS and uses three submodels similar to CREAMS: hydrology, erosion, and pesticides. Much of the parameter data was interchangeable between CREAMS and GLEAMS. There are several differences in each of the submodels of GLEAMS from its' parallel submodel in CREAMS. The basic concepts of pesticide movement of GLEAMS are the same as CREAMS with some additions that enable the estimation of movement within and trough the root zone (Leonard, Knisel, and Still). Therefore GLEAMS creates more accurate accounts of potential groundwater contamination than CREAMS.

Pesticide solubility and the partition coefficient (K_{oc}) are the most important additional parameters required by GLEAMS because the calculations for separating pesticide losses into surface runoff, erosion, and percolation depend on these. Pesticide solubility is measured as the milligrams of chemical dissolved in a liter of water (mg/L). The partition coefficient estimates the ratio of pesticide concentration in solution, water phase, (mg/L) and concentration in soil, organic carbon phase, (mg/kg) (Leonard, Knisel and Still). Another important factor is the half-life of a pesticide, both on the plant foliage and in the soil. The half-life is a measurement of the days required to breakdown one-half of a pesticide application into secondary metabolites or degradates. Table

3.15 displays the solubility, half-life, and partition coefficient for the chemicals in this study. Gramoxone (paraquat) is the most persistent chemical in soil at 3600 days. Persistency is important in determining the potential hazards from a chemical. 2-4D is the least persistent, at 10 days, but has a higher lethal dose in research animals, LD_{50} of 300-1200 (Virginia Cooperative Extension Service, Appendix Q). More parameters are listed in Appendix O. The output used from GLEAMS simulation was the annual soil erosion, the chemical content of annual soil erosion, runoff, and percolation (Davis; Appendix H).

Using the mass balance approach to estimate the potential chemical and nitrogen contributions from agricultural practices allows analysis of the tradeoffs between each of the non-point pollution pathways. In this study, the effect of policies on chemical and nitrogen contributions to runoff, percolation and sediment were considered. The amount of soil erosion was also estimated. Other paths, such as volatilization, plant uptake and degradation, were accounted for in the simulation process but the values were not used in the mathematical programming model. These other paths and phosphorus and potassium were not important components of the non-point pollution problem in Richmond County, at the time of the study.

Focus of the Analysis

The complete mathematical programming model combines the economic forces of farm management decisions and the environmental impacts which

Table 3.15. The solubility, half-life (on plant foliage and in soil), and partition coefficient of pesticides used in this study. All the chemicals listed are herbicides except for Pydrin which is an insecticide (Wauchope; Verschueren).

Product Name	Active Ingredient(s)	Solubility (mg/L)	Half-Life Soil (days)	Half-Life Foliar (days)	K_{oc}[a]
Aatrex	Atrazine	33.0	60.0	2.0	160.0
Dual	Metolachlor	530.0	20.0	3.0	200.0
Gemini	Chlorimuron	500.0	50.0	3.0	20.0
	Linuron	75.0	60.0	3.0	863.0
Gramoxone	Paraquat	1.0E6	3600.0	3.0	1.0E5
Harmony	DPXM-6316	2400.0	12.0	0.5	10.0
2,4-D	2,4-D	900.0	10.0	9.0	74.0
Lasso	Alachlor	242.0	14.0	3.0	190.0
Bladex	Cyanazine	171.0	20.0	2.0	168.0
Fusilade	Fluazifop-P	2.0	20.0	3.0	3000.0
Pydrin	Fenevalerate	0.1	50.0	7.0	1.0E5
Blazer	Acifluorfen	9.0E5	30.0	3.0	139.0
Banvel	Dicamba	8.0E5	14.0	9.0	2.0
Roundup	Glyphosphate	1.0E6	30.0	2.5	1.0E4
Treflan	Trifluralin	0.3	60.0	20.5	1400.0
Lorox	Linuron	75.0	60.0	3.0	863.0

[a] The partition coefficient estimates the ratio of pesticide concentration in solution (water) phase (mg/L) and concentration in soil (organic carbon) phase (mg/kg).

occur as a result of those decisions. The model was then used to analyze the relative attractiveness of low-input agricultural systems over conventional systems and the contributions of each to non-point pollution. The sensitivity of the low-input systems and their contributions to erosion, leaching, and runoff contamination under various scenarios were examined. Among the scenarios analyzed were the use of chemical regulations, loading restrictions, agricultural policies intended to promote the use of legumes and crop rotations, and changes in yields, chemical amounts and cultural practices. The sensitivity analysis of low-input agricultural practices is particularly important given the lack of field data on these relationships. A brief outline of the scenarios analyzed are presented in Table 3.16. The results of these scenarios are found in the following chapter.

Table 3.16. A summary of the scenarios to be analyzed by the mathematical programming model developed in Chapter 3.

SCENARIO	RESIDUE NITROGEN[a]	LITTER[a]	ALL ACTIVITIES[a]	PRODUCTION, AND AGRICULTURAL AND NATURAL RESOURCE POLICY MODIFICATIONS
FIVE GENERAL SCENARIOS				
CURRENT PRACTICES	0	0	0	ONLY ACTIVITY 3t
NO LITTER	0	0	X	NONE
NO LITTER-X	X	0	X	NONE
UNRESTRICTED	0	X	X	NONE
UNRESTRICTED-X	X	X	X	NONE
SENSITIVITY ANALYSIS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES (USING UNRESTRICTED AND UNRESTRICTED-X SCENARIOS)				
LITTER PRICE	0	X	X	PRICE OF LITTER RAISED BY 30 PERCENT
LITTER PRICE-X	X	X	X	PRICE OF LITTER RAISED BY 30 PERCENT
REDUCED YIELD-A	0	X	X	ORGANIC YIELDS DROPPED A5tL 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-XA	X	X	X	ORGANIC YIELDS DROPPED A5tL 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-B	0	X	X	ORGANIC AND LOW-CHEMICAL YIELDS DROPPED A5tL, A3t(L) 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-XB	X	X	X	ORGANIC AND LOW-CHEMICAL YIELDS DROPPED A5tL, A3t(L) 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-C	0	X	X	ORGANIC AND LOW-CHEMICAL YIELDS DROPPED NOT IN SOLUTION,40% DROP
REDUCED YIELD-XC	X	X	X	ORGANIC AND LOW-CHEMICAL YIELDS DROPPED UNTIL NOT IN SOLUTION,40% DROP
OPERATOR LABOR-X	X	X	X	AVAILABLE OPERATOR LABOR REDUCED UNTIL NOT IN SOLUTION, NO CRITICAL VALUE
LABOR REQ.	0	X	X	LABOR REQUIREMENTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES RAISED NOT IN SOLUTION,
LABOR REQ.-X	X	X	X	LABOR REQUIREMENTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES RAISED NOT IN SOLUTION,
VARIABLE COST	0	X	X	VARIABLE COSTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES NOT IN SOLUTION,
VARIABLE COST-X	X	X	X	VARIABLE COSTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES NOT IN SOLUTION,

[a] An "X" indicates that the option was applied to the scenario, a "0" indicates that the option was not applied to the scenario.

Table 3.16, continued.

SCENARIO	RESIDUE NITROGEN[a]	LITTER[a]	ALL ACTIVITIES[a]	PRODUCTION, AND AGRICULTURAL AND NATURAL RESOURCE POLICY MODIFICATIONS
POLICY ANALYSIS WITH POULTRY LITTER (USING THE BASE POLICY SCENARIO)				
BASE POLICY	X	X	X	10% LABOR REQUIREMENT PENALTY, YIELD PENALTIES OF THE REDUCED YIELD-B SCENARIO, LITTER PRICE OF LITTER PRICE-X SCENARIO
COST-SHARE	X	X	X	100 % COST-SHARE OF ANNUAL GREEN MANURE ESTABLISHMENT COSTS
NO AATREX	X	X	X	NO AATREX USED IN PRODUCTION
1/3 AATREX	X	X	X	AATREX USE REDUCED BY 1/3
CHEMICAL TAXATION	X	X	X	CHEMICALS TAXED BY 300 PERCENT
40% PERCOLATION REDUCTION	X	X	X	PERCOLATION CHEMICAL LOADINGS REDUCED BY 40%
40% PERCOLATION/RUNOFF REDUCTION	X	X	X	PERCOLATION AND RUNOFF CHEMICAL LOADINGS REDUCED BY 40%
CRP	X	X	X	ALL ELIGIBLE LAND ENROLLED IN CRP
BUFFER STRIP	X	X	X	MAXIMUM REQUIRED AREA PUT UNTO BUFFER STRIP
BASE FLEXIBILITY	X	X	X	20% OF BASE PLANTED IN FULL SEASON SOYBEANS
POLICY ANALYSIS WITHOUT POULTRY LITTER (USING THE BASE POLICY SCENARIO)				
COST-SHARE	X	0	X	100 % COST-SHARE OF ANNUAL GREEN MANURE ESTABLISHMENT COSTS
NO AATREX	X	0	X	NO AATREX USED IN PRODUCTION
1/3 AATREX	X	0	X	AATREX USE REDUCED BY 1/3
40% PERCOLATION REDUCTION	X	0	X	PERCOLATION CHEMICAL LOADINGS REDUCED BY 40%
40% PERCOLATION/RUNOFF REDUCTION	X	0	X	PERCOLATION AND RUNOFF CHEMICAL LOADINGS REDUCED BY 40%

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[a] An "X" indicates that the option was applied to the scenario, a "0" indicates that the option was not applied to the scenario.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

The General Algebraic Modeling System (GAMS) was used to solve the mathematical programming model in this study (Brooke, Kendrick, and Meeraus). GAMS is adapted to interact with MINOS 5.2 (Murtagh and Saunders) to solve nonlinear models. Most nonlinear problems are solved easier if initial values are provided for the nonlinear variables; initial values also assist in the solving of very large models. Initial values were especially important in this model when five year moving averages were calculated to avoid division by zero. Initial values were provided for yield and hectare variables used in this calculation. A range was also set for these variables to prevent the nonlinear constraints from becoming infeasible or unbounded. This feature of the GAMS program does, however, allow the variables to vary, within the range, between constraints. Therefore, some solutions are identical except for small variations in variable levels. For example, total net returns, activity selection, and land use may be identical in two different solutions but the actual harvested yields may vary slightly because of the range set for their value. A listing of the initial values is provided in Appendix P.

The mathematical programming model in this study contained 4,745 equations and 6,976 variables. There were 180 nonlinear equations.

Another important part of the solution process was the GAMS/MINOS options file. The performance of GAMS/MINOS is controlled by a number of parameters or "options." Each option has a default value, which can be modified for the size and desired accuracy of a model. The option file used in the solution of this model is in Appendix P.

Steps in Analysis

The basic analysis of the mathematical programming model was conducted through five scenarios which reflected both current practices and potential changes in available agronomic practices. The second phase of the analysis was a sensitivity analysis focusing on the organic, low-chemical, and poultry litter activities. Sensitivity analysis determines the relationship between a change in a parameter's value and the effect of these changes on the optimal solution. Parameters tested included poultry litter price, farm labor availability, and the labor requirements and yields of organic and low-chemical production activities. The third phase involved the evaluation of agriculture and natural resource policies, using a scenario developed as a result of the sensitivity analysis. In the final phase the policy scenarios which used poultry litter were re-estmated without poultry litter.

Data Analysis Focus

For each optimal solution to a scenario, the resulting levels of five variables were compared:

- land use,
- labor,
- net returns,
- net present value (NPV) per hectare,
- potential nitrogen, chemical, and soil contributions to surface and groundwater.

A detailed listing of the results of each scenario is included in Appendices R through U; only the summary values are discussed in this chapter. The results of this analysis cannot be considered as predictions or goal prescriptions for Richmond County operators. Instead, these scenarios were a basis for comparing the potential tradeoffs to farmers and society of adopting a LIA production system.

Tradeoffs included costs of policies, and nutrient, chemical, and soil loadings to surface and groundwater. Neither the CREAMS nor GLEAMS models simulate the exact movement of nutrients, chemicals, or soil, instead they estimate movements off the field's surface. Therefore, these estimates are measurements of "potential" contamination. That these estimates are "potential" contaminants is one reason that "harmful" levels of nutrients, chemicals, and soil erosion were not specified. Another reason is that if contaminants reach a water body, their concentration within the water body is unknown and subsequently their "harmfulness" was unknown. Even if concentrations of chemicals in water are known, it cannot always be determined whether or not these concentrations are important to human health.

Toxicity based on lethal dosage (LD_{50}) is relative to the concentration of an active ingredient and the body weight of the victim. Toxicity is the quality, state, or degree of being poisonous. The toxicities of the chemicals used in this study, listed in Appendix Q, are oral toxicities. Oral LD_{50} (mg/kg) designates the dosage of milligrams per kilogram of body weight required to kill 50 percent of test animals when given a single dosage by mouth. The lower the LD_{50}, the higher the toxicity. LD_{50}'s are for technical grade, 100 percent concentration compounds; few marketed products are sold or applied at 100 percent concentration. However, concentration build-ups can occur in depositories such as surface and groundwater. Most any chemical can be lethal if the concentration level is high enough. Some chemicals products have warnings on their labels which are not related to LD_{50}'s because chemicals can be lethal due to extreme allergic reactions. Such chemicals may also have high LD_{50}'s indicating low toxicity.

When registering pesticides, the EPA uses acute LD_{50} values to determine the appropriate labeling. However, considerable controversy surrounds the accuracy and appropriateness of using LD_{50} values. The reliability of tests based on work with research animals is often questioned. Many feel that these results cannot be directly linked to human victims. There are two opposing schools of thought concerning this issue. Some feel that zero risk is the only solution and completely disclaim research done on lab animals. Others feel that LD_{50} values based on laboratory animals are too strict a test and that the ratings may be unnecessarily alarming to potential users. The LD_{50} classification of various chemicals are mentioned in this text only for comparative purposes.

A Note on Commodity Program Participation

The decision to enroll crops in the commodity program involved the comparison of yields, costs of production, and future prices and target prices. Although current prices may have been adequate for current costs, if target prices are needed in the future, crops have to be enrolled in advance to insure a large base for maximum use of high target prices. Faced with uncertainty, operators may consistently enroll in the commodity program as insurance against low yields and prices. Survey results indicate that 47 percent of the Richmond County farmers surveyed maintained base in case of poor prices in the future but were generally not currently participating in the commodity programs with respect to collecting deficiency payments (VPI & SU, Dept. of Agric. Economics).

Changes in activity selection in this model caused changes in chemical and nutrient costs which may be relevant to the future need of income subsidization in the form of deficiency payments. Another element of crop enrollment was the necessity to set-aside 10 percent of the enrolled land. If the yields on that land would increase total yield higher than the five year average yield used by commodity programs, then commodity program enrollment may fall. It could be rational in some years to have a negative income in order to insure adequate base in later years.

The Five General Scenarios

Current Practice Scenario

The Current Practice Scenario restricted the model's choice to use only one activity. The only production activity allowed was Activity 1, a two year corn/small grain-double crop soybean rotation with a medium or "conventional" chemical and nutrient budget. This activity is used by the majority of Richmond County farmers. A poultry litter market does not currently exist in Richmond County, therefore, the poultry litter alternative, Activity 1L, was not permitted. There was no accounting of nitrogen from crop residues in the nitrogen requirement budgets of this scenario, based on behavior observed in a Richmond County farm operator survey (VPI & SU, Dept. of Agric. Economics).

Land Use

Table 4.1 shows that most corn hectares were not enrolled in the commodity program in the optimal solution of the Current Practice Scenario. Only 12,333 hectares (30,527 acres) were enrolled over the 15 year period. Wheat and barley base enrollment was the largest portion of land planted to those crops. All barley was enrolled, totalling 41,658 hectares (103,114 acres) and a total of 46,843 hectares (115,948 acres) of wheat were enrolled. Under the assumptions of this model, the operator has perfect knowledge of future yields and prices.

Table 4.1. The value of annual minimum and maximum, and 15 year total crop hectares enrolled in the federal commodity program in the Five General Scenarios.

	Base Enrolled Hectares		
Scenario Crop	Annual Minimum	Annual Maximum	15 year Total
Current Practices			
corn	0	6,172	12,333
wheat	0	3,394	46,843
barley	2,777	2,777	41,658
No Litter			
corn	0	0	0
wheat	0	3,394	46,843
barley	2,777	2,777	41,658
No Litter-X			
corn	0	0	0
wheat	0	3,394	46,843
barley	2,777	2,777	41,658
Unrestricted			
corn	0	6,172	12,333
wheat	0	3,394	46,843
barley	2,777	2,777	41,658
Unrestricted-X			
corn	0	6,172	12,333
wheat	0	3,394	46,843
barley	2,777	2,777	41,658

Labor

No hired labor was required to meet the total labor requirements, 777,435 hours over the 15 year period as shown in Table 4.2. The annual maximum hours required was 63,639, and the minimum was 57,149. Since all the operator labor in Richmond County was pooled for this study, there were few scenarios where labor became restrictive and forced the hiring of additional labor. Labor became restrictive only when numerous operations were required in a single month. Under Activity 1 the month requiring the most labor was September, due to small grain seed bed preparation, planting and corn harvesting activities. However, labor required in September never rose above 55 percent of the operator labor available for that month.

Net Returns and NPV per Hectare

The optimal solution of the Current Practice Scenario produced a 15 year discounted net return of $29,284,960. Table 4.3 shows that the annual minimum and maximum net returns differed by $3,312,460. The magnitude of this difference was due to the inclusion of drought years: 8, 11, and 14 (Appendix O). In these years, yields were low; many Richmond County operators may have received state or federal emergency disaster aid to compensate for their crop losses. This emergency program was not included in the model. The NPV per hectare was calculated by dividing the 15 year discounted net returns by the total land available for agriculture (including CRP and buffer strips): 13,056 hectares (32,248 acres). This value is an over estimate of NPV per hectare because it includes the

Table 4.2. Annual minimum and maximum, and 15 year total labor hours required for the Five General Scenarios.

SCENARIO	HOURS OF LABOR Annual minimum	Annual maximum	15 year total
Current Practices	57,149	63,639	777,435
No Litter	59,130	63,108	900,312
No Litter-X	59,130	63,108	900,312
Unrestricted	68,740	76,342	1,088,823
Unrestricted-X	68,740	76,342	1,088,823

Table 4.3. Annual minimum and maximum, and 15 year total net returns (discounted) and the NPV per hectare for the Five General Scenarios.

SCENARIO	Net Returns[a] (1988 Dollars)			
	Annual minimum	Annual maximum	15 year total	Net Present Value[b] ($/ha)
Current Practices	208,154	3,520,614	29,284,960	2,243
No Litter	766,434	4,215,867	39,253,783	3,007
No Litter-X	805,856	4,316,928	40,075,933	3,070
Unrestricted	791,553	4,404,198	39,821,151	3,050
Unrestricted-X	861,331	4,531,511	41,276,313	3,161

[a] Discounted at 6 percent.
[b] NPV per hectare = 15 year total net return divided by total land available.

return to capital and management as well as land. The NPV per hectare is used only for comparison purposes between scenarios. The value was $2,243 per hectare ($900 per acre).

Potential Pollutants

All chemical contributions to runoff, percolation, and sediment were higher in years with greater precipitation, such as years 3, 6, 10, and 15. Variations within the other years may have been due to the timing of nutrient and chemical applications with respect to precipitation. Some years, for instance year 9, had high pollutant levels, but did not have extremely high total annual precipitation. Rainfall did however, follow the application of chemicals. The nitrogen loadings in Table 4.4 were consistently greater in percolating water than in runoff or sediment. The 15 year total of nitrogen runoff was 129,081 kg (283,978 lb). The minimum annual contribution to runoff was 3,086 kg (6,789 lb). The total nitrogen leached was over 50 times more, at 7,432,948 kg (16,352,486 lb). Over the 15 year period, 2,710,443 kg (5,962,975 lb) of nitrogen were removed in sediment. The minimum annual sediment loading was 52,829 kg (116,224 lb), and the maximum annual loading was 512,660 kg (474,452 lb).

Table 4.5 shows Gramoxone (paraquat) and Fusulade (fluazifop-P) levels were the highest chemical levels in runoff, 823,615 g (1,812 lb) and 84,652 g (186 lb) total respectively. Fusulade also appeared in potential percolation at 5,100 g (11.22 lb) (Table 4.6), while Gramoxone did not. Gramoxone is considered a moderately toxic chemical, while Fusulade is a slightly toxic chemical (Virginia Cooperative Extension

Table 4.4. Annual minimum, maximum, and 15 year total of nitrogen carried off the field in runoff, percolation, and sediment for the Five General Scenarios.

SCENARIO	**NITROGEN IN RUNOFF (kg)**		
	Annual minimum	Annual maximum	15 year total
Current Practice	3,086	20,531	129,081
No Litter	1,234	13,688	72,475
No Litter-X	1,234	14,310	70,628
Unrestricted	1,738	14,310	88,380
Unrestricted-X	1,173	14,310	79,419

SCENARIO	**NITROGEN IN PERCOLATION (kg)**		
	Annual minimum	Annual maximum	15 year total
Current Practice	112,756	801,695	7,432,948
No Litter	125,284	698,689	6,288,610
No Litter-X	85,786	604,742	4,618,708
Unrestricted	138,306	848,473	7,125,329
Unrestricted-X	106,090	828,098	6,998,475

Table 4.4, continued.

SCENARIO	NITROGEN IN SEDIMENT (kg)		
	Annual minimum	Annual maximum	15 year total
Current Practice	52,829	512,660	2,710,443
No Litter	41,350	411,870	2,137,122
No Litter-X	41,350	411,870	2,053,019
Unrestricted	42,090	440,489	2,244,407
Unrestricted-X	49,373	440,089	2,244,663

Table 4.5. Annual minimum, maximum, and 15 year total of chemicals carried off the field in runoff for the Five General Scenarios.

SCENARIO chemicals	**CHEMICALS IN RUNOFF (g)** Annual minimum	 Annual maximum	 15 year total
Current Practice			
Aatrex	161	4,270	26,546
Gemini[a]	226	19,706	47,018
Pydrin	11	5,170	15,298
Fusulade	0	30,833	84,652
Dual	91	22,496	71,667
Gramoxone	17,799	154,159	823,615
No Litter			
Aatrex	88	37,342	51,723
Fusulade	0	24,977	65,090
Gramoxone	5,024	44,292	225,276
No Litter-X			
Aatrex	88	37,342	51,723
Fusulade	0	24,977	65,099
Gramoxone	5,024	44,292	225,276
Unrestricted	0	0	0
Unrestricted-X	0	0	0

[a] Linuron

Table 4.6. Annual minimum, maximum, and 15 year total of chemicals carried off the field in percolation and sediment for the Five General Scenarios.

SCENARIO	**CHEMICALS IN PERCOLATION (g)**		
chemicals	Annual minimum	Annual maximum	15 year total
Current Practice			
Aatrex	28	139,570	597,245
Gemini[a]	0	15,620	36,176
Harmony Extra	0	5,021	7,644
Fusulade	0	2,777	5,100
Dual	0	5,496	19,712
No Litter			
Aatrex	43	162,179	690,097
No Litter-X			
Aatrex	43	162,179	690,097
Unrestricted	0	0	0
Unrestricted-X	0	0	0

[a] Chlorimuron

Table 4.6, continued.

SCENARIO chemicals	CHEMICALS IN SEDIMENT (g) Annual minimum	 Annual maximum	 15 year total
Current Practice			
Aatrex	6	4,270	11,835
Gemini[a]	6	463	1,280
Pydrin	105	12,568	43,348
Fusulade	0	2,777	8,273
Dual	0	160	476
Gramoxone	76,419	564,131	3,180,748
No Litter			
Aatrex	0	19	125
Fusulade	0	2,543	7,122
Gramoxone	20,150	158,178	857,219
No Litter-X			
Aatrex	0	19	125
Fusulade	0	2,543	7,122
Gramoxone	20,150	158,178	857,219
Unrestricted	0	0	0
Unrestricted-X	0	0	0

[a] Linuron

Service). Definitions of toxic classifications are in Appendix Q. Table 4.6 shows Aatrex (atrazine) and Gemini (chlorimuron) were the most significant percolation contaminants at 597,245 g (1,314 lb) and 36,176 g (80 lb) over the 15 year period. The chlorimuron component of Gemini appeared in percolation, while the linuron component appeared in runoff and sediment. Aatrex was a significant contaminant in runoff and sediment. Both Aatrex and Gemini are moderately toxic (Virginia Cooperative Extension Service). Pydrin (fenvalerate), the only insecticide used, appeared in sediment at high amounts with Gramoxone and Aatrex. The Pydrin level over the 15 years was 43,348 g (95 lb); the Gramoxone level was 3,180,748 g (6,998 lb); and the Aatrex level was 11,835 g (26 lb). Total Gramoxone and Pydrin levels in sediment were higher than their levels in either runoff or percolation, whereas the Aatrex levels in sediment were lower than in the other two sources.

As seen in Table 4.7, the annual soil erosion from the Current Practice Scenario varied between 15,522 metric tons (17,105 tons) and 160,767 metric tons (176,844 tons). The 15 year total was 791,412 metric tons (870,553 tons).

Summary

The Current Practice Scenario required the model to use an activity representative of current agronomic practices in Richmond County. Activity 1, the specified activity, used only inorganic nitrogen, a medium chemical budget, a two year corn/small grain-double cropped soybeans rotation, and did not account for nitrogen from crop residuals. Enrollment

Table 4.7. Annual minimum and maximum, and 15 year total soil erosion (metric tons) for the Five General Scenarios.

SCENARIO	**SOIL EROSION (metric tons)**		
	Annual minimum	Annual maximum	15 year total
Current Practices	15,522	160,767	791,412
No Litter	11,479	125,552	589,140
No Litter-X	11,479	125,552	589,140
Unrestricted	12,090	134,760	644,052
Unrestricted-X	12,090	134,760	644,052

of cropland in the commodity programs, over the 15 year period, was usually limited to wheat and barley hectares. Corn market prices were consistently higher than target prices, and given that the operator knew future prices, the farmer produced as much corn as possible by avoiding the ARP requirements of the commodity programs. Labor requirements were not binding over the county as a whole. Potential pollution was largest from Gramoxone and Aatrex. Gramoxone had the highest total chemical level in runoff, while Aatrex appeared at a high total level in percolation.

No Poultry Litter Scenarios

The two No Litter Scenarios were similar in their restrictions except that the No Litter-X Scenario accounted for nitrogen from crop residues in its nutrient budgets. Both scenarios were restricted to only an inorganic nitrogen source. The "X" notation was used to indicate scenarios with the same restrictions except for accounting for the residual nitrogen, which is indicated by the addition of an "X" to the scenario label. The absence of an "X" indicated that nitrogen from crop residues was not taken into account when calculating nitrogen requirements. Under these two scenarios any production activity not using poultry litter as a nutrient source was permitted, thus these scenarios differ from the Current Practice Scenario which restricted the model to only one activity.

Land Use

Under both No Litter Scenarios production Activity 3 was used in all 15 years. Activity 3 had a low-chemical budget and used the same rotation as the Current Practice Scenario, corn/small grain-double crop soybean. Table 4.1 shows the enrollment of wheat and barley base hectares was identical between the two No Litter Scenarios. The only difference in land use between the no poultry litter scenarios and the Current Practice Scenario was that no corn hectares were enrolled in the commodity program under the No Litter and No Litter-X Scenarios, a drop of 12,333 hectares (30,527 acres) planted to corn.

Labor

Table 4.2 show that a total of 900,312 hours were needed over the 15 year period for both scenarios. The labor requirements were 122,877 hours higher under the No Litter Scenarios than under the Current Practice Scenario because Activity 3 used more labor and less chemicals for weed control. The annual minimum and maximum hours were the same for the No Litter and the No Litter-X Scenarios at 59,130 and 63,108 hours, respectively.

Net Returns and NPV per hectare

The total discounted net return for the No Litter-X Scenario was $822,150 higher than that of No Litter Scenario, and it was $10,790,793 higher than the total net return under the Current Practice Scenario as shown in Table 4.3. Most of these savings were from the reduced nitrogen needs of the No Litter-X Scenario, which accounted for nitrogen from crop residues and had the same yields as the No Litter Scenario. The No Litter-X Scenario's annual net returns were consistently higher than the No Litter Scenario. There is, however, greater range between the minimum, $805,856, and maximum, $4,316,928, annual net returns of the No Litter-X than either the No Litter or Current Practice Scenarios. Although the total net returns were greater under these scenarios, Richmond County farmers are not currently using this type of production system. Farmers may not be using Activity 3, a low-chemical activity, because of the possibility of yield penalties, which are discussed later.

The NPV per hectare reflects the rise in net returns. The No Litter-X Scenario's NPV per hectare was $63 per hectare ($25.45 per acre) higher than the No Litter Scenario, and $827 per hectare ($334.10 per acre) higher than the NPV per hectare of the Current Practice Scenario. NPV per hectare was raised under both No Litter Scenarios because of the reduction in chemicals.

Potential Pollutants

Table 4.4 shows that the minimum and maximum nitrogen contributions to runoff and percolation of both No Litter Scenarios were less than those of the Current Practice Scenario. The minimum runoff contribution of the No Litter Scenarios were nearly half that of the minimum under the Current Practice Scenario, or 1,852 kg (4,074 lb) less. The 15 year total of nitrogen contributions to runoff were 72,475 kg (159,445 lb) and 70,628 kg (155,382 lb) for the No Litter and No Litter-X Scenarios, respectively.

The minimum nitrogen contributions to percolation of the No Litter Scenario and the Current Practice Scenario were very similar, but the maximum contribution under the No Litter Scenario is less by 103,000 kg (226,000 lb) than the Current Practice's maximum. The maximum annual contributions from the No Litter-X Scenario, 604,742 kg (1,330,432 lb), are even less than the No Litter Scenario, due to the reduced nitrogen requirements when accounting for nitrogen in crop residues. The difference in the nitrogen loadings of the No Litter Scenarios and the Current Practice Scenario were due to reduced application rates under Activity 3. The total amount of nitrogen leached from the No Litter and No Litter-X Scenarios over the 15 years were 6,288,610 kg (13,834,942 lb) and 4,618,708 kg (10,161,158 lb), respectively. Once again the nitrogen content of sediment was high. The 15 year total nitrogen content of sediment for the No Litter and No Litter-X Scenarios were 2,137,122 kg (4,701,668 lb) and 2,053,019 kg (4,516,642 lb) respectively. These were both less than the Current Practice Scenario by over 500,00 kg (1,100,000 lb). The total No Litter-X Scenario nitrogen loading of sediment was 657,424 kg (1,446,333 lb) less than the Current Practice Scenario.

Activity 3 had very low-chemical requirements. Table 4.5 and 4.6 show the levels of chemicals used which appeared as potential runoff, groundwater, and sediment pollution. Table 4.5 shows that Gramoxone (paraquat) level was the highest chemical 15 year level in runoff. The application of Gramoxone in Activity 3 was partially replaced in the No Litter Scenarios by cultivation. The reduced application rate resulted in a lower 15 year total of Gramoxone in runoff, 225,276 g (496 lb) in both

No Litter Scenarios; this amount was 598,339 g (1,316 lb) less than the Current Practice Scenario's 823,615 g (1,812 lb). As in the Current Practice Scenario, Gramoxone was not found in percolation. Aatrex was the only chemical appearing in percolation with 15 year totals of 690,097 g (1,518 lb) in both the No Litter and No Litter-X, Scenarios. The level of Aatrex in percolation shown in Table 4.6 was 13 times, or over 536,449 g (1,180 lb) greater than the level of Aatrex in runoff, under both No Litter Scenarios. Both Gramoxone and Aatrex appeared in sediment. Gramoxone was at a total level of 857,219 g (1,886 lb), Fusulade at 7,122 g (16 lb) and Aatrex at 125 g (.28 lb). The potential for groundwater contamination from Aatrex was even greater than the potential for Gramoxone in runoff but not as great as the Gramoxone content of sediment.

The soil erosion figures in Table 4.7 were the same for both the No Litter Scenarios, 589,140 metric tons (648,054 tons). The erosion from these scenarios was 202,272 metric tons (222,499 tons) less than the erosion under the Current Practice Scenario. The differences in soil erosion from the Current Practice Scenario were due to tillage practices. Activity 1 used in the Current Practice Scenario used moldboard plowing for corn seed bed preparation, while Activity 3 in the No Litter Scenarios used chisel plowing. Moldboard plowing disturbs the soil to a greater and deeper extent than chisel plowing, thereby exposing more soil to precipitation and wind. Chisel plowing is often part of a soil conservation plan.

Summary

The two No Litter Scenarios produced nearly identical results, except for the reduced costs of inorganic nitrogen purchases under the No Litter-X Scenario. The recognition of nitrogen from crop residuals produced a discounted 15 year increase in income of $822,150. The savings in input costs was relatively small due to the low estimates of nitrogen available from crop residuals. Total net returns were also higher than those generated under the Current Practice Scenario because of the use of Activity 3, which had a low-chemical budget.

The nitrogen and chemical contributions to runoff, percolation, and sediment decreased under these scenarios due to a decrease in nitrogen levels. The Current Practice Scenario's available nitrogen level was 19.22 kg per hectare (17.08 lb per acre), while 18.87 kg per hectare (16.77 lb per acre) was available in the No Litter and No Litter-X Scenarios. Activity 3 required more labor in order to achieve the low-chemical contamination levels, but the effect of pooling labor over the entire county prevented the purchasing of any hired labor. This assumption may exaggerate the availability of labor in Richmond County, but, according to a Richmond County Extension Agent, the average farm operator in the county is retired and does not work the land intensively (Liddington). Because the land is not worked intensively, there is a surplus of operator labor which could be used by practices which are more labor intensive.

Unrestricted Scenarios

The Unrestricted Scenarios were the least restricted of all five of the general scenarios. In these scenarios, the optimal decision could include any activity and both poultry litter and commercial nitrogen as a source of nutrients. The nitrogen from crop residues was accounted for in the Unrestricted-X Scenario whether poultry litter or commercial nitrogen was used.

Land Use

In the Unrestricted and Unrestricted-X Scenarios, production activity 5L was used throughout the fifteen years. Activity 5L was an organic activity; no chemicals are used, and poultry litter is the only source of nitrogen. The same rotation, corn/small grain-double crop soybean, was used as in the previous three scenarios . Note that there were no yield penalties for organic activities at this step of the analysis.

As indicated in Table 4.1 the enrollment of corn, wheat, and barley hectares for commodity base were the same for either Unrestricted Scenario and the same as under the Current Practice Scenario. Only 12,333 hectares (30,527 acres) of corn were enrolled over the 15 year period; while nearly all wheat, 46,843 hectares (115,948 acres) and barley, 41,658 hectares (103,114 acres) were enrolled. The target prices for corn were often below market prices. Under high market prices the farmer's income would be higher with fewer hectares enrolled in base because of the set-aside requirements. Wheat and barley target prices were above market prices more often than corn target prices.

Labor

Despite the more intensive use of cultivations to replace chemicals for weed control, the pooled labor supply was not exhausted. The annual amount of labor required in the Unrestricted Scenarios was consistently higher than the previous three scenarios. Still, the Unrestricted Scenarios still used only 13 percent of the total available labor over the 15 year period. Table 4.2 shows the maximum annual labor requirement was 76,342 hours in the Unrestricted Scenarios. Unlike the previous scenarios, the Unrestricted Scenarios did not have any labor requirements in February. February labor was used for spreading the second application of commercial nitrogen in a split application method. This labor is not required when using poultry litter because it was applied only once. There are, however, additional labor requirements in July not needed by the other scenarios. July labor is needed to cultivate soybeans, instead of using chemicals.

It is common among low-input agriculture systems to require more labor than conventional activities. The Unrestricted Scenarios both required 1,088,823 hours over the 15 year period. This total was 311,388 hours more than required under the Current Practice Scenario. The sensitivity of the labor requirements of LIA was examined in the sensitivity analysis which immediately follows this section.

Net Returns and NPV per hectare

The 15 year discounted total net return of the Unrestricted Scenario was $10,5336,191 higher than the Current Practice Scenario, but it was $1,455,162 less than the Unrestricted-X and $254,782 less than the No Litter-X Scenarios. The accounting for nitrogen from crop residuals, combined with the use of poultry litter as a source of nitrogen, phosphorus, and potassium, and absence of chemicals pushed the total net return of the Unrestricted-X Scenario to $41,276,313. The minimum annual net return shown in Table 4.3 of the Unrestricted-X Scenario was $55,475 higher than the minimum of the No Litter-X Scenario. The Unrestricted Scenario's minimum and maximum net returns, $791,553 and $4,404,198, respectively, were lower than the minimum and maximum net returns if the No Litter Scenario.

The NPV per hectare in Table 4.3 rose by $43 per hectare ($17 per acre) from the No Litter to the Unrestricted Scenario, and $91 per hectare (36.7 per acre) from the No Litter-X to the Unrestricted-X Scenarios. The NPV per hectare of the Unrestricted Scenario, $3,050 per hectare ($1,232 per acre), did not surpass that of the No Litter-X and Unrestricted-X Scenarios due to the small but important savings from accounting for nitrogen from crop residuals. The Unrestricted-X Scenario had the highest net return of all five scenarios, and consequently it had the highest NPV per hectare, $3,161 per hectare ($1,277 per acre).

Potential Pollutants

The fifteen year total nitrogen contributions to runoff for the Unrestricted and Unrestricted-X Scenarios were, respectively, 88,380 kg (194,436 lb) and 79,419 kg (174,722 lb). These nitrogen contributions to runoff, listed in Table 4.4, were 40,701 kg (89.542 lb) and 49,662 kg (109,256 lb) less than the levels in the Current Practice Scenario which used commercial nitrogen. The nitrogen level in the Current Practice Scenario was only slightly higher, 2 kg more nitrogen on a composite hectare (1.8 lb per acre), than in the Unrestricted Scenarios. The runoff contributions of the Unrestricted Scenarios were, in total, over 15,905 kg (34,991 lb) more than those generated under the No Litter Scenarios because the application rate of commercial nitrogen in the No Litter Scenarios was 17.24 kg less on a composite hectare (15.3 lb per composite acre) than the rate of poultry litter application in the Unrestricted Scenarios.

The nitrogen contributions to percolation under the Unrestricted Scenarios showed a greater change from previous scenarios than runoff. The largest minimum and maximum annual contributions to percolation of 138,306 kg (304,273 lb) and 848,473 kg (1,866,641 lb), respectively, occurred under the Unrestricted Scenario. The fifteen year total contributions to percolation were higher in the Unrestricted Scenario, 7,125,329 kg (15,675,724 lb). In general, the Unrestricted Scenarios, which used only organic nitrogen and cultivated more frequently, had higher nitrogen contribution to runoff and percolation than the No Litter Scenarios, but were contributions were less than those of the Current

Practice Scenario. The differences between the nitrogen contributions to runoff and percolation between scenarios were equally due to differences in application rates, and to the difference in the pollution potential of commercial nitrogen and poultry litter. The nitrogen content of sediment was higher in the Unrestricted Scenarios than the No Litter Scenarios but approximately 2,485,780 kg (5,468,716 lb) less than the Current Practice level. The Unrestricted-X Scenario had the higher total of the two total sediment nitrogen levels at 2,224,663 kg (4,894,259 lb) over the 15 year period. Nitrogen in sediment over all five scenarios was less than nitrogen in percolation but more than in runoff.

Since Activity 5L was organic, there were no chemical contributions to runoff, percolation or sedimentation. The soil erosion in the Unrestricted Scenarios was in between that of the No Litter Scenarios, and the Current Practice Scenario. Table 4.7 shows approximately 644,052 metric tons (708,457 tons) contributed by the Unrestricted Scenarios for the 15 year period. The minimum, 12,090 metric tons (13,323 tons), and the maximum, 134,760 metric tons (148,236 tons) were also midway between the No Litter Scenarios and the Current Practice Scenario.

Summary

In the Unrestricted Scenarios an organic activity, 5L, was selected throughout the 15 year period. An organic activity such as 5L is not currently in use in Richmond County. The results of these scenarios show that, if there was an accessible and inexpensive source of organic nitrogen and there were no yield penalties, activity 5L would provide large chemical savings and increase income. There may be barriers to the use of this type of activity which have thus far been unidentified in the model. Yield penalties, greater labor requirements, and lack of an organic nitrogen supply were not modelled and may actually exist, providing effective barriers to the adoption of activity 5L. These type of barriers will be modelled in the sensitivity analysis which will provide insights as to why farmers are not currently adopting LIA activities such as 5L.

The environmental effects of the Unrestricted Scenarios were mixed. Chemical loadings were zero but nitrogen loadings were high. Poultry litter as a source of organic nitrogen was found to have greater potential levels of percolation than commercial nitrogen in the long run.

Summary of the Five General Scenarios

Table 4.8 compares the critical parameters of each of the five general scenarios by ranking each parameter on a scale of 1 to 5. A ranking of 1 indicated the highest parameter level; 5 indicates the lowest level. The five general scenarios all used the same rotation. However, each scenario differed in many of the agronomic aspects of the production activity used, and by any restrictions placed upon the scenario. Some questions of the viability of an organic activity, such as that selected in the Unrestricted Scenarios were investigated through sensitivity analysis, and discussed in the next section.

Table 4.8. Summary of the five general scenarios. Each critical parameter is ranked on a scale of 1 to 5, where 1 indicates the highest level and 5 the lowest.[a]

SCENARIO	BASE HA.	LABOR	NET RETURN	POTENTIAL POLLUTANTS						SOIL EROSION
				NITROGEN			CHEMICALS			
				RUNOFF	PERCOL.	SEDIMENT	RUNOFF	PERCOL.	SEDIMENT	
Current Practices (A1)	1	5	5	1	1	1	1	1	1	1
No Litter (A3)	3 (-)	4 (+)	4 (+)	4 (-)	4 (-)	3 (-)	2 (-)	3 (-)	2 (-)	4 (-)
No Litter-X (A3)	4 (-)	3 (+)	2 (+)	5 (-)	5 (-)	4 (-)	2 (-)	2 (-)	3 (-)	3 (-)
Unrestricted (A5L)	2 (-)	1 (+)	3 (+)	2 (-)	2 (-)	2 (-)	4 (-)	4 (-)	4 (-)	2 (-)
Unrestricted-X (A5L)	2 (-)	1 (+)	1 (+)	3 (-)	3 (-)	2 (-)	2 (-)	4 (-)	4 (-)	2 (-)

[a] A tie in parameter values of scenarios may cause the ranking of 5 to be missing. A "+" or "-" sign designates the direction of change and potential tradeoffs between the types of pollution, with respect to the Current Practices Scenario.

Land Use

The production activities of each scenario are indicated below the scenario label in Table 4.8 with notation such as A1, indicating Activity 1. Base hectares were ranked according to their 15 year total of corn, wheat, and barley hectares enrolled in the commodity program. The Current Practice Scenario and Unrestricted Scenarios had the same enrollment totals, while the No Litter Scenario had the least, as no corn hectares were ever enrolled.

Labor

Labor requirements were ranked according to the total labor required for the entire 15 year period. Unrestricted Scenarios used the most labor, due to the substitution of cultivations for chemical weed control. Indeed, the labor used by the organic activity in the Unrestricted Scenarios may have been underestimated. This possibility is explored in the sensitivity analysis.

Net Returns and NPV per hectare

Net returns were ranked based upon the 15 year discounted net return. NPV per hectares were calculated using this total net return divided by the total cropland hectares and were ranked the same as net returns. The Unrestricted-X Scenario had the highest net return and NPV per hectare. The scenarios which accounted for nitrogen in crop residues had the highest net returns. The Unrestricted-X Scenario also had an economic advantage of zero chemical purchases.

Potential Pollutants

Ranking nitrogen contributions to runoff and percolation was based on the 15 year totals. The No Litter-X Scenario ranked the lowest in nitrogen contribution to both runoff, percolation and sediment. The inorganic nitrogen source and low application rates of the No Litter Scenarios caused them to be ranked lower than the Unrestricted Scenarios which used an organic source of nitrogen.

Chemical contributions were ranked in aggregate form. The 15 year totals of similar chemicals were compared across scenarios, as was the number of chemical substances found in runoff and percolation. For example, the Current Practice Scenario was ranked highest in all categories of chemical pollution because this scenario had the greatest number of chemicals and the 15 year totals of those chemical residuals which appeared in all five scenarios were at their highest level in the Current Practice Scenario. Note that the No Litter-X Scenario ranked second highest in chemical contributions to runoff and percolation but the lowest in nitrogen contributions.

Erosion was ranked on the 15 year totals. The Current Practice Scenario had the worst erosion, due primarily to its use of moldboard plowing. The disk tillage method and number of cultivations used for weed control were responsible for the Unrestricted Scenarios being ranked second in soil erosion.

The No Litter-X Scenario and Unrestricted-X Scenario had the best overall environmental rankings. The No Litter-X Scenario had better nitrogen management only because the rates of application were slightly less than under the Unrestricted-X Scenario. Using an organic activity caused the Unrestricted-X Scenario to use organic nitrogen which tended to cause more percolation contamination than commercial nitrogen. If the primary concern was chemical contamination of groundwater the Unrestricted-X Scenario would be best. Tradeoffs existed in these scenarios between nitrogen management and the reduction of non-point chemical pollution and soil erosion.

Sensitivity Analysis of Organic and Low-Chemical Activities

The Unrestricted Scenarios were used for a sensitivity analysis of low-chemical and organic activities. Parameter value changes were introduced, usually by percentages, and the model was re-solved. The Unrestricted Scenarios were selected for the sensitivity analysis because their preference for the organic Activity 5L presented the opportunity to test the affects of possible barriers to LIA adoption, such as yield and labor penalties. Because 5L used poultry litter as a nitrogen source, the Unrestricted Scenarios also allowed the testing of the viability of a poultry litter market through a sensitivity analysis of its price. This analysis worked backwards to reveal the possible barriers to LIA adoption; that is, LIA adoption is assumed and possible barriers are introduced to cause conversion away from LIA activities.

Because there were few differences between the Unrestricted and Unrestricted-X Scenario results, except for the savings from lower nitrogen purchases, only the results from the sensitivity analyses using the Unrestricted-X Scenario are presented in detail. Summaries of the results of sensitivity analyses, using both the Unrestricted and Unrestricted-X Scenarios, are included in Appendix S.

Litter Price Scenario

Currently, poultry litter is not used as a source of nitrogen in Richmond County, Virginia. However, in other parts of Virginia the use of poultry litter and animal manures is increasing. The average Northern Virginia poultry producer has a contract with a national poultry firm which provides all of the operators' inputs. The poultry producers do not usually produce their own feed. The disposal of poultry litter has only just begun to present itself as a problem to most contractors. In southern Virginia, the location of the poultry industry has been convenient to agricultural land, and a poultry litter market has begun to establish itself (Kenyon). Richmond County is not convenient to a litter source and therefore would require the transporting of litter long distances. Additional hauling costs and scheduling problems due to the bulk of poultry litter compared to commercial nitrogen could prevent the establishment of such a market.

In the Unrestricted Scenarios, poultry litter was the preferred source of nutrients. In these scenarios, poultry litter was priced at \$.03 per kilogram (\$27.50 per ton). The price included transportation conversion to Activity 3 over all 15 years occurred at a 30 percent increase in poultry litter price, that is to \$.039 per kg (\$35.45 per ton). The poultry litter price was exceptionally sensitive; only nine thousandths of a cent per kg (\$.004 per lb) forced poultry litter as a nutrient source out of the optimal solution. This price increase could easily be accounted for by a slightly low initial estimation of transportation costs or brokers' margin used in the poultry litter price estimation. On the other hand, the sensitivity of the use of poultry litter as an organic source of nitrogen may be over estimated. If a competitive market for poultry litter was to develop it is also possible that the price of poultry litter would be lower than the estimate used in this study. Another possible scenario would be the distribution of poultry waste for free to farm operators. This could be caused by increased requirements on poultry operators to dispose of their waste in an environmentally sound manner and by the surplus of waste in area of concentrated poultry litter operations.

The results of the Litter Price-X Scenario, after the change in litter price, were very similar to those under the No Litter Scenarios. A close comparison of critical variable values of the Unrestricted-X Scenario and the Litter Price-X Scenario was made to determine specific changes caused by the removal of poultry litter. Tables 4.9 to 4.14 contain the changes between the critical variables of the Litter Price-X Scenario from the Unrestricted-X Scenario.

Land Use

The crop rotation, corn/small grain-double crop soybeans, did not change in the move from Activity 5L to Activity 3. Table 4.9 shows enrollment of corn hectares in the federal commodity program fell by 12,333 hectares (3,052 acres) under the Litter Price-X Scenario. Wheat and barley enrollment over the 15 year period totaled 46,842 hectares (115,946 acres) and 41,658 hectares (103,114 acres), respectively.

Labor

Labor requirements were far less under the Litter Price-X Scenario than the Unrestricted-X Scenario. Table 4.10 shows a 15 year total difference of 187,613 hours between the Litter Price-X and Unrestricted-X Scenarios. Activity 5L used non-chemical methods of weed control which required more labor, and therefore explained the higher labor totals with the Unrestricted-X Scenario. No hired labor purchases were necessary with either scenario.

Net Return and NPV per hectare

The 15 year discounted total net return was over $1 million lower in the Unrestricted-X Scenario, Table 4.11, than in the Litter Price-X Scenario. The NPV per hectare accordingly dropped by $91 per hectare ($36.76 per acre). The difference in net returns was due to the addition of a chemical budget when activity 5L left the solution for activity 3. The Litter Price-X Scenario had a 15 year net return of $40,075,933, $1,200,380 lower than the Unrestricted-X Scenario.

Table 4.9. Annual minimum, maximum and the 15 year total crop hectares enrolled in the federal commodity program in the Litter Price-X Scenario, and change from the Unrestricted-X Scenario.[a]

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	0(-6,172)	0(-12,333)
wheat	37(-298)	3,394(0)	46,842(-1)
barley	2,777(0)	2,777(0)	41,658(0)

[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

Table 4.10. The annual minimum, maximum, and the 15 year total hours of labor required in the Litter Price-X Scenario, and change from the Unrestricted-X Scenario.[a]

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
59,130(-9,610)	63,108(-13,234)	901,210(-187,613)

[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

Table 4.11. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the Litter Price-X Scenario, and from the Unrestricted-X Scenario.[a]

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	Annual Total (Change)	**Net Present Value ($/ha)** (Change)
805,856 (-55,475)	4,316,928 (-214,583)	40,075,933 (-1,200,380)	3,070 (-91)

[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

Potential Pollutants

The removal of poultry litter caused large changes in the concentration of nitrogen in runoff and percolating water. Table 4.12 shows the 15 year total of nitrogen in runoff was 8,791 kg (19,340 lb) lower in the Litter Price-X Scenario, however the minimum level was higher, by 61 kg (134 lb), than in the Unrestricted-X Scenario. The 15 year total of nitrogen leaching potential under the use of poultry litter in the Unrestricted-X Scenario was approximately 50 percent more, 2,379,767 kg (5,235,487 lb) more, than that of the commercial nitrogen used in the Litter Price-X Scenario. Both the minimum and maximum annual contributions were lower under the Litter Price-X Scenario, as well. The minimum and maximum annual loadings of sediment with nitrogen fell with the removal of poultry litter less than percolation loadings. The minimum nitrogen level in sediment was 9,875 kg (21,725 lb) less than the Current Practice Scenario, while the maximum was 28,220 kg (62,084 lb) less. The total nitrogen content of sediment was 2,053,019 kg (4,516,642 lb) which was 191,644 kg (421,617 lb) less than the Unrestricted-X Scenario.

The result of the switch from an organic source of nitrogen to an inorganic source, although at low rates of application, indicates that the benefits of reduced chemicals from a completely organic activity must be weighed against the increase in potential groundwater pollution from the use of organic nitrogen. Lower levels of inorganic nitrogen reduced nitrogen contributions to groundwater more than organic nitrogen use.

Table 4.12. The annual minimum, maximum, and the 15 year total nitrogen content of runoff, percolation and sediment in the Litter Price-X Scenario, and change from the Unrestricted-X Scenario.[a]

Nitrogen Content of Runoff (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,234(+61)	14,310(0)	70,628(-8,791)

Nitrogen Content of Percolation (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
85,786(-20,304)	485,171(-221,525)	4,618,708(-2,379,767)

Nitrogen Content of Sediment (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
39,498(-9,875)	411,869(-28,220)	2,053,019(-191,644)

[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

The rise in poultry litter prices prevented the use of all three organic activities. Therefore the operator's decision was limited to activities with chemical weed control. Activity 3 has the lowest chemical budget of the remaining activities. Table 4.13 indicates the change in chemical contributions to non-point pollution between the Unrestricted-X Scenario (Activity 5L) and the Litter Price-X Scenario (Activity 3). All levels of chemicals were increased since the prior production activity, 5L, was organic. Fusulade and Gramoxone appeared in runoff at the highest levels, 65,098 g (143 lb) and 225,277 g (496 lb) over the 15 year period. Gramoxone appeared annually at the highest levels, with its' minimum annual contribution at 5,024 kg (11.05 lb). Chemical contributions to leaching only appeared for Aatrex, for a 15 year total of 863,118 g (1,899 lb). Gramoxone and Fusulade were not carried through the soil by percolation. They were, however, carried off the field in sediment. The Gramoxone level was the highest in sediment at a total of 1,052,614 g (2,316 lb), with the minimum annual contribution rising by 27,130 g (60 lb). Throughout this study Gramoxone was not leached, its' effects were strictly in runoff and sediment while Aatrex appeared in all three pathways of dispersal.

The differences in soil erosion shown in Table 4.14 show a 54,912 metric ton (60,403 ton) total reduction in soil erosion under the Litter Price-X Scenario. The minimum and maximum annual soil erosion fell by 611 metric tons (672 tons) and 9,208 metric tons (10,129 tons) under the Litter Price-X Scenario. Although the litter used in the Unrestricted-X Scenario would have contributed to soil structure the number of

Table 4.13. The annual minimum, maximum, and the 15 year total chemical content of runoff, percolation and sediment in the Litter Price-X Scenario, and change from the Unrestricted-X Scenario.[a]

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Aatrex	88(+88)	37,342(+37,342)	51,722(+51,722)
Fusulade	0(0)	24,977(+24,977)	65,098(+65,098)
Gramoxone	5,024(+5,024)	44,292(+44,292)	225,277(+225,277)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Aatrex	43(+43)	192,246(+192,246)	863,118(+863,118)

Chemical Content of Sediment (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Aatrex	0(0)	19(+19)	156(+156)
Fusulade	0(0)	2,543(+2,543)	9,278(+9,278)
Gramoxone	27,130(+27,130)	179,834(+179,834)	1,052,614(+1,052,614)

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[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

Table 4.14. The annual minimum, maximum, and the 15 year total soil erosion in the Litter Price-X Scenario, and from the Unrestricted-X Scenario.[a]

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
11,479(-611)	125,552(-9,208)	589,140(-54,912)

[a] The Litter Price-X Scenario had a poultry litter price of $.039, a 30 percent increase.

cultivations caused more soil erosion than the Litter Price-X Scenario which used few cultivations.

Summary

A \$.009 per kg (\$.004 per lb) rise in poultry litter price caused the removal of poultry litter from the optimal solution. The savings which originally caused a preference for activities using poultry litter was not derived from the nutrients it provided but from slight savings in labor and machinery costs. The savings were quite small and therefore the use of poultry litter was sensitive to changes in its price.

The price change lead to the selection of Activity 3 under the Litter Price-X Scenario, which reintroduced chemicals, at low levels. The potential pollution from nitrogen in groundwater was much lower, over 2,000,000 kg (4,400,000 lb), after poultry litter was removed from the optimal decisions. Poultry litter had greater leaching potential than inorganic nitrogen because of the slower release of nitrogen from the organic matter. Thus, chemical pollutants increased; nitrogen pollutants decreased as the solution moved from a completely organic activity to an activity using reduced amounts of nitrogen and chemicals.

Reduced Yield Scenario

One of the identified barriers to low-input agriculture adoption was the anticipation of lower yields. There is mixed evidence on the ability of organic, low-chemical, and low-tillage practices to produce the same yields as do the more chemical intensive practices. Organic and low-chemical practices, however, present areas of savings such as lower nutrient and chemical expenditures which may allow tradeoffs between costs and revenues to produce similar net returns.

The sensitivity analysis of organic and low-chemical yields was done in several stages. The first stage reduced only organic activity yields based on extension expert recommendations (Reduced Yield-XA); the second stage reduced organic and low-chemical activity yields (Reduced Yields-XB) based on extension recommendations. The third stage reduced organic and low-chemical activity yields until these activities were not used in the optimal solution (Reduced Yield-XC).

Initially, the yields of organic activities 5L, 11L, and 16L were reduced by percentages suggested by expert opinion (Hagood). Corn and soybean yields were penalized by 20 percent under activity 5L. Activities 11L and 16L had yield penalties of 20 percent for corn and 25 percent for soybeans. The change in yields caused the low-chemical activity 3L to be selected rather than the organic Activity 5L selected under the Unrestricted-X Scenario. Activity 3L brought in the use of chemicals and used the same crop rotation, corn/small grain-double crop soybeans or activity 5L.

In the second stage of analysis, Activities 3 and 3L were assigned the same yield penalties as Activity 5L, a 20 percent yield penalty for corn and soybeans. The other yield penalties penalties remained the same. The impact of the low-chemical budget ion the yields of Activities 3(L) was even more questionable than activity 5L, depending on the annual conditions. It could be possible to maintain yields under low-chemical activities given good weather conditions (Liddington; Hagood; VPI & SU, Dept. of Agric. Economics). The results of Yield Reduction-XB began to show a preference toward several other activities, including Activities 4, 1, 14L, and 12. Activities 4 and 1 used a two year corn rotation. Activity 4 split nitrogen requirements into three applications, while Activity 1 used the conventional nitrogen management plan. Activities 14L and 12 used the more complex four year rotation with full season soybeans. Activity 14 did not use Dual in it chemical budget, while Activity 12 used the conventional chemical budget, including Dual. However, the occurrences of these activities was sporadic and insignificant compared to the use of the primary activity, activity 5L. The 15 year discounted total net return declined further. The Yield Reduction-XB Scenario's net return of $31,932,935 was over $9 million less than the net return of the Unrestricted-X Scenario. Thus, the use of low-chemical or organic activities seemed fairly insensitive to changes in their yields, although the reductions in income may be too severe for profitable operation. A further reduction in yields was modelled since yield penalties are one of the most cited barriers to low-chemical and organic production activity adoption.

The final stage of the sensitivity analysis of yields was to find the yield penalty which caused the abandonment of any low-chemical or organic activity. Equal yield penalties were assigned to the low-chemical activities 3 and 3L, and the organic activities 5L, 11L, and 16L. The yield penalties were raised until none of these activities appeared in the solution, Yield Reduction-XC Scenario. Solutions between the original penalties assigned and the critical penalty value contained large amounts of annual variation between the use of Activities 5L and 3; the Activities 12 and 14L appeared regularly as secondary activities; and Activity 1 appeared irregularly as a primary activity.

At a 40 percent yield penalty on corn and soybeans, all low-chemical and organic activities were left out of the solution. The primary activity was Activity 1. Activity 14L, 12, and 4 were secondary activities, appearing irregularly. Tables 4.15 through 4.30 contain summary figures of the final Yield Reduction-XC Scenario and the change from the initial values in the Unrestricted-X Scenario using Activity 5L.

Land Use

There was a greater variety among production activities selected in the Yield Reduction-XC Scenario than all the previous scenarios. Activity 1, medium chemical use and with a 2 year corn/small grain-double cropped soybeans rotation, was the primary activity. A primary activity was an activity which appeared regularly in the 15 year period and was used on the largest percentage of cropland throughout the 15 year period. This primary activity was the same activity used in the conventional or Current Practice Scenario. There were, however, five years where Activity 1 did not appear at all. Activity 14L was used in three of those five years; the other two years used Activity 12. Activity 12 and 14L included a 4 year corn.small grain-double cropped soybeans/full season soybeans/small grain-double cropped soybeans rotation.

Enrollment of cropland in the commodity program under the Yield Reduction-XC Scenario was the same as the Unrestricted-X Scenario. Table 4.15 shows the 15 year total corn, wheat, and barley enrolled as base were 12,333 hectares (30,527 acres), 46,843 hectares (115,948 acres), and 41,658 hectares (103,114 acres) respectively. Minimum and maximum annual enrollment figures also showed no change from the Unrestricted-X Scenario.

Labor

Table 4.16 shows that total labor needed under the Yield Reduction-XC Scenario, 893,250 hours, was considerably less, 195,573 hours, than the Unrestricted-X Scenario. The Yield Reduction-XC Scenario required less labor annually as well. The difference in hours was primarily due to moving away from a non-chemical labor intensive weed control practice, to a practice which used chemicals.

Net Return and NPV per hectare

The 15 year total net return for the Yield Reduction-XC Scenario was $30,867,389 which Table 4.17 shows was over $10 million less than the net return in the Unrestricted-X Scenario. The NPV per hectare also fell by $797 per hectare ($322 per acre). Both the net return and production activity selection were influenced by the assumption of perfect knowledge of prices and yields. For instance, the use of Activities 14L and 12 coincided with years of relatively high soybean prices. Activity 14L and 12 both used a rotation which substituted a full season of soybeans for a season of corn.

Table 4.15. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	6,172(0)	12,333(0)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

Table 4.16. The annual minimum, maximum, and the 15 year total labor hours required in the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
57,149(-11,591)	63,567(-12,775)	893,250(-195,573)

[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

Table 4.17. The annual minimum, maximum, and the 15 year total net return and the NPV per hectare of the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha) (Change)**
327,696 (-533,635)	3,586,646 (-944,886)	30,867,389 (-10,408,924)	2,364 (-797)

[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

Potential Pollutants

The yield penalties forced the model to switch away from poultry litter use, which was previously found to be sensitive to price changes. Although litter price did not change its relative value fell in organic and low-chemical activities because yields were penalized. The potential nitrogen pollution contributed by the Yield Reduction-XC Scenario is shown in Table 4.18. The total nitrogen content of runoff rose by 29,910 kg (65,802 lb) total compared to the Unrestricted-X Scenario because the highly dissolvable form of inorganic nitrogen lends itself to being carried off the field in runoff more than percolation. While the total contributions to percolation fell by over 2 million kg (909,091 lb). The minimum and maximum annual contributions to runoff and percolation followed the fall and rise in their total contributions. In the previous Litter Price-X Scenario, the change from poultry litter to commercial nitrogen caused declines in nitrogen content of both runoff and percolation. The total level of nitrogen in sediment was 582,236 kg (1,280,919 lb) above the nitrogen level in sediment with the Unrestricted Scenario. This change was due in part to the conversion to a more intensive tillage practice, for this reason soil erosion in Table 4.20 also increased. The increase in potentially erodible soil in turn increased the amount of nitrogen moved off the field in sediment. The greatest chemical contributions to runoff with the Yield Reduction-XC Scenario were Gramoxone and Fusulade as shown in Table 4.19. Total Gramoxone contributions to runoff were 850,606 g (1,871 lb); Fusulade contributions were 86,145 g (189 lb). The annual contributions of each

Table 4.18. The annual minimum, maximum, and the 15 year total nitrogen content of runoff, percolation, and sediment in the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

Nitrogen Content of Runoff (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
2,777 (+1,604)	16,798 (+2,488)	109,329(+29,910)

Nitrogen Content of Percolation (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
83,317(-22,773)	627,298(-200,800)	4,893,235(-2,105,240)

Nitrogen Content of Sediment (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
52,829(+3,456)	545,945(+105,856)	2,826,899(+582,236)

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[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

varied. Annual Gramoxone contributions covered a range of 149,824 g (330 lb) in runoff. Aatrex was found in percolation, over the 15 year period, at 456,710 g (1,005 lb). Gramoxone and Roundup total levels in sediment were 4,491,387 g (9,894 lb) and 85,950 g (189 lb), respectively. The levels of Roundup in sediment were promoted by the increased use of full season soybeans.

No cultivations were used in the Yield Reduction-XC Scenario for weed control, but seed bed preparation was more intense, suggesting the potential for high soil erosion. Table 4.20 shows that total soil erosion did rise by 179,963 metric tons (197,959 tons) relative to the Unrestricted-X Scenario. Annual minimum and maximum contributions also rose by 3,432 metric tons (3,775 tons) and 3,624 metric tons (39,865 tons) respectively. The 15 year total of 824,015 metric tons (906,416 tons) of soil erosion was the highest thus far of all the scenarios. The magnitude of soil erosion was due to the deep cultivations of the production activities and the addition tillage needed for full season soybeans under Activities 12 and 14L.

Table 4.19. The annual minimum, maximum, and the 15 year total chemical content of runoff, percolation, and sediment in the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[c]	0(0)	2,501(+2,501)	3,102(+3,102)
Lasso[c]	0(0)	5,127(+5,127)	7,577(+7,577)
Aatrex	161(+161)	4,270(+4,270)	24,357(+24,357)
Gemini[d]	34(+34)	19,706(+19,706)	43,389(+43,389)
Pydrin	11(+11)	5,599(+5,599)	16,031(+16,031)
Fusulade	0(0)	30,833(+30,833)	86,145(+86,145)
Roundup[c]	0(0)	46,715(+46,715)	57,436(+57,436)
Lorox[c]	0(0)	11,616(+11,616)	16,076(+16,076)
Dual	0(0)	18,682(+18,682)	66,711(+66,711)
Gramox.	17,709(+17,709)	167,533(+167,533)	850,606(+850,606)
Treflan[c]	0(0)	28,881(+28,881)	40,552(+40,552)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[c]	0(0)	7,920(+7,920)	8,278(+8,278)
Lasso[c]	0(0)	3,713(+3,713)	7,066(+7,066)
Aatrex	28(+28)	75,777(+75,777)	456,710(+456,710)
Gemini[e]	0(0)	15,620(+15,620)	36,771(+36,771)
Harmony	0(0)	4,704(+4,704)	7,321(+7,321)
Fusulade	0(0)	2,777(+2,777)	4,782(+4,782)
Dual	0(0)	5,496(+5,496)	11,506(+11,506)

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[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

[c] These chemicals are used by secondary activities only. Secondary activities did not appear in every year, therefore their minimum was zero.

[d] Linuron

[e] Chlorimuron

Table 4.19, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Lasso[b]	0(0)	96(+96)	174(+174)
Aatrex	3(+3)	4,270(+4,270)	9,279(+9,279)
Gemini[c]	0(0)	463(+463)	1,291(+1,291)
Pydrin	105(+105)	27,601(+27,601)	72,544(+72,544)
Fusulade	0(0)	3,441(+3,441)	12,786(+12,786)
Roundup[b]	0(0)	53,394(+53,394)	85,950(+85,950)
Lorox[b]	0(0)	610(+610)	1,101(+1,101)
Dual	0(0)	160(+160)	455(+455)
Gramox.	76,419(+76,419)	1,114,910(+1,114,910)	4,491,387(+4,491,387)
Treflan[b]	0(0)	3,994(+3,994)	6,797(+6,797)

[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

[c] These chemicals are used by secondary activities only. Secondary activities did not appear in every year, therefore their minimum was zero.

[d] Linuron

[e] Chlorimuron

Table 4.20. The annual minimum, maximum, and the 15 year total soil erosion in the Yield Reduction-XC Scenario[a], and change from the Unrestricted-X Scenario.[b]

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
15,522 (+3,432)	171,001 (+36,241)	824,015 (+179,963)

[a] These are also the results of the Labor Requirement-X Scenario (600 percent increase in labor required by organic and low-chemical production activities) and the Variable Cost-X Scenario (50 percent increase in variable costs of organic and low-chemical activities).

[b] The Yield Reduction-XC Scenario had a 44 percent yield penalty on corn and soybeans of organic and low-chemical production activities.

Summary

After reducing only organic activity yields, the yields of low-chemical activities were also lowered. The yield penalties suggested by Extension experts caused no change in activity selection. A 40 percent decrease in yields was necessary in the Yield Reduction-XC Scenario to cause the removal of all low-chemical and organic activities from the optimal solution. Activity 1 was the primary activity in the Yield Reduction-XC Scenario, the same activity used in the Current Practice Scenario. The 40 percent yield penalty, was a heavy penalty and therefore it seemed the use of low-chemical organic activities in this model were not highly sensitive to yield fluctuations and may not be as large a barrier to LIA adoption as perceived. However, certain aspects of yield penalties for organic activities were not considered, such as:

* under poor weather conditions yields of organic or low chemical activities may be more, in the case of a wet year, or else in the case of a dry year, severely affected than other production activities,

* yield penalties may be more severe for one crop than another,

* yield penalties may not be permanent.

If incorporated in the model these issues might moderate or exaggerate the results found in the Yield Reduction-XC Scenario.

Operator Labor-X Scenario

In no scenario, thus far, was hired labor required in the optimal solution. The amount of available operator labor reflected a common pool of labor hours assigned not to any particular farm or allotment of hectares but to the entire amount of cropland in the county. The constraints of labor due to farm size and travelling distance between cropland were not accounted for in this model. Thus the sensitivity of production activity selection to available operator labor may be important.

To test the sensitivity of available operator labor, the available labor was reduced in intervals from the levels available in the Unrestricted-X Scenario. The critical value would be where any organic or low-chemical activity was no longer present in the optimal solution. At a 45 percent decrease in available operator labor, Activity 3L began to be used in intermittent years and the amount of idled hectares increased. The 15 year discounted net return at this point was still fairly high, $39,507,199. Land was idled due the lack of labor. Over 14,000 hectares (34,653 acres) were idled. Essentially the restrictions on operator labor also included restricted hired labor because both types of labor were assigned the same wages. At a 50 percent decrease in operator labor, a third activity entered, Activity 12, but as a secondary activity. Secondary activities were used infrequently and on a small percentage of the total cropland available over the 15 year period. As the analysis continued, Activity 5L was never ever absent from the final solution. The hectares used under Activity 3L did not increase significantly as the labor dropped; instead, larger amounts of land were idled. No critical value was determined to exist; the profits from Activity 5L dominated those from the other activities.

The selection of Activity 5L was determined to be insensitive to diminishing labor. The labor demand of an organic activity such as 5L may be quite high as labor is substituted for chemicals. However, in this study the labor required by Activity 5L, although higher than the other activities, was not enough to offset its other economic advantages.

Labor Requirement-X Scenario

It was previously shown that the operator labor supply was not a critical parameter for the selection of Activity 5L under the Unrestricted-X Scenario. The question of labor as an influential factor in low-input agriculture adoption was further investigated through the sensitivity analysis of the labor requirements of individual organic and low-chemical activities. These labor requirements were heavily influenced by two factors; non-chemical weed control practices and the spreading of poultry litter. All of the organic and low-chemical activities required several cultivations for weed control, Activity 5L required three cultivations of corn and soybeans. Poultry litter was used by all organic activities and one of the low-chemical activities. The use of poultry litter may be more labor intensive due to the difficulty in handling a substance of such bulk and the estimates in this model may have been low. In addition, the possibility existed that the number of cultivations for these activities was underestimated; weather conditions might dictate more cultivations or the labor for poultry litter spreading was underestimated. The continued sensitivity analysis of the labor requirements of organic and low-chemical activities specifically next increased the labor requirements of the low-chemical and organic activities 3, 3L, 5L, 11L, and 16L equally by increments until none of these activities appeared in the solution.

The change in labor requirements began at a 20 percent increase in labor requirements using 5 percent increments. No change in the primary activity, 5L, occurred until a 300 percent increase was imposed. At this value, Activity 5L was substituted for by the low-chemical Activity 3L. Hired labor had begun to be purchased at a 70 percent increase in labor requirements but was no longer necessary when Activity 5L was abandoned. At 5.5 times the original labor requirements, or 550 percent, the optimal management decision included Activity 1 as the primary production activity. The optimal solution at this point was essentially the same as the solution found under the Yield Reduction-XC Scenario, where yields of organic and low-chemical activities were reduced by 44 percent. There were small differences which were accounted for by rounding and the flexibility required by the model to solve nonlinear equations, as initial values in these equations were allowed a small range to move within. Tables 4.15-4.20 for the Yield Reduction-XC Scenario can be referred to for the variable values of the Labor Requirement-X Scenario.

Labor appeared fairly stable when tested from the aspect of labor required by organic and low-chemical activities, as well as under the previous test of available operator labor. A 550 percent increase was a substantial parameter change. The change in activities resulting from the increased labor requirements did show a preference for production activities which included the currently used rotations of Richmond

County: corn/small grain-double crop soybeans (2 year) and corn/small grain-double crop soybeans/full season soybeans/small grain-double crop soybeans (4 years).

Variable Cost-X Scenario

The final sensitivity test of organic and low-chemical production activities increased the variable costs of Activities 3,3L,5L,11L, and 16L until none appeared in the solution. The sensitivity of the inclusion of these activities relating to their variable costs would indicate their viability with fluctuating prices and changing requirements of inputs such as seed, fuel, and machinery repair. The variable costs were raised in 5 percent intervals starting at a 5 percent increase; once a switch in activities was achieved a 1 percent change was used to determine the specific value. Little change in the production activity selection occurred until the costs were raised by 40 percent. At a 40 percent increase, Activity 12 became an even more prevalent secondary activity, but the primary activity was still Activity 5L. At a 45 percent level all but one year's primary activity was switched to Activity 3. A complete switch of activities came at a 51 percent increase in variable costs. The resulting parameter values were again essentially the same as those in the Yield Reduction-XC Scenario and the Labor Requirement-X Scenario, Table 4.15 through 4.20, as the variable cost penalties caused a switch to Activity, 1. Relative to the Unrestricted-X Scenario the switch in production activities caused increases in chemical use and pollution, and increases in nitrogen pollution except to groundwater. The conversion to inorganic nitrogen always reduced the amount of groundwater loading.

Summary of the Sensitivity Analysis

There are many perceived economic and agronomic barriers to LIA adoption. This study considered the sensitivity of the use of organic and low-chemical activities to penalties on organic nitrogen price, and crop yields, labor requirements, and variable costs of organic and low-chemical activities. Only the price of poultry litter appeared highly sensitive. A $.009 increase in poultry litter price prevented the use of any organic or litter based activity.

The other identified barriers; crop yields, required labor, and input costs were all relatively insensitive to parameter changes. Large penalties were required before organic and low-chemical activity use was prevented. Because Activity 1 was the primary activity selected under the yield, labor, and variable cost penalties the conclusion was drawn that this activity should be prevalent, if all the penalties held true. Activity 1 is, in fact, the most widely used production practice in Richmond County. The severity of these individual penalties is hard to accept as realistic. However, the possibility exists that, in combination, these barriers may work together at more reasonable levels to prevent LIA adoption. Such a scenario, presented next, was used for the policy analysis of this study.

Agriculture and Natural Resource Policy Analysis

The sensitivity analysis determined critical value[9] of important parameters in the organic and low-chemical production activities used under the Unrestricted-X Scenario. The parameter values tested were important factors influencing the attractiveness, or unattractiveness of low-chemical and organic production activities. Another group of forces influencing in the adoption process were agriculture and natural resource policies. In this study, analysis of the following policies was considered: cost-sharing green manure crops, chemical restrictions and taxation, land retirement programs, and a base flexibility modification of the current commodity programs. Each policy scenario was evaluated for its water quality effects as well as its economic viability and its promotion of LIA activity use. However, only the Cost-Share policy was specifically designed to require the use of a LIA activity. The critical parameter values under each policy scenario were compared to a Base Policy Scenario, full summaries of the scenario results are found in Appendix X.

Base Policy Scenario

The scenario constructed for use for the policy analysis, the Base Policy Scenario, was a combination of several previous sensitivity analysis scenarios. The Unrestricted-X Scenario was not used because of its preference for strictly

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[9] The critical value of a parameter was the value, determined by sensitivity analysis, which caused all organic and low-chemical production activities to be excluded from the optimal solution.

organic activities which are not in use in the study area. The Base Policy Scenario was constructed using the critical price of poultry litter determined in the Litter Sensitivity Scenario, $.039 per kg, and the extension recommended yield penalties of the Yield Sensitivity Scenario-B. Poultry litter was included, despite the results of the sensitivity analysis, in order to accommodate the use of organic activities. The sensitivity of organic activity use to the price of litter would also probably have changed when used in combination with the other penalties of this scenario. After the initial policy analysis, a second analysis was done in which those policy scenarios, except chemical taxation, which used litter were rerun without the availability of litter. Activities 3, 3L, and 5L had a 20 percent penalty on corn and soybeans, while Activities 11L and 16L had a 20 percent penalty on corn and a 25 percent penalty on soybeans. A labor requirement penalty of 10 percent for organic and low-chemical activities was also included. The Base Policy Scenario assumed operators accounted for nitrogen from crop residuals through soil and plant biomass testing, since this is recommended by extension specialists.

These penalties and restrictions reflected possible barriers to the use of low-input agriculture in Richmond County. The use of organic and low-chemical activities was thus not prevented in the first set of policy analyses, only penalized in terms of yields, labor requirements, and the cost of organic nitrogen.

Land Use

The rotation selected in the Base Policy Scenario was a 2 year corn/small grain-double cropped soybean type which used inorganic nitrogen, Activity 1. Secondary activities included Activity 3 which used the same rotation and a low-chemical budget, and Activity 12 which used a 4 year, full season soybean rotation. Table 4.21 shows base enrollment for corn was low, 12,618 hectares (31,233 acres) in the Base Policy Scenario, while wheat and barley enrollment were near 100 percent. Corn market prices were generally greater than the target prices, and, since the farmer knew the target prices in advance, he choose not to enroll corn hectares in the commodity programs.

Labor

No labor was purchased due to the pooling of labor in the county. The highest labor needs occurred in years where Activity 3, which used cultivation for weed control, was selected. Activities 12 and 3 required more labor than Activity 1 but were not used frequently enough to warrant off-farm labor purchases. Table 4.22 shows a maximum annual labor requirement of 69,211 hours. The total labor required was 922,756 hours.

Net Returns and NPV per hectare.

The 15 year total net return for the Base Policy Scenario was $31,199,006. The net return was less than all of the five general scenarios, with the exception of the Current Practice Scenario. The ability to use Activity 3's low-chemical budget allowed net returns to be

Table 4.21. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program under the Base Policy Scenario.[a]

	Base Enrolled Hectares		
Crop	Annual Minimum	Annual Maximum	15 year Total
corn	0	6,172	12,618
wheat	0	3,394	46,843
barley	2,777	2,777	41,658

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[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

Table 4.22. The annual minimum, maximum, and the 15 year total labor required under the Base Policy Scenario.[a]

Hours of Labor		
Annual Minimum	Annual Maximum	15 year Total
57,149	69,211	922,756

[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

above those of the Current Practice Scenario which was restricted to using Activity 1 only. The penalties on the organic, low-chemical and poultry litter using activities prevented the net returns from the Base Policy Scenario from being as high as the other four general scenarios. Table 4.23 shows the range of the minimum and maximum annual net returns was similar to that of all the previous scenarios. The NPV per hectare shown in Table 4.23 of $2,390 dollars per hectare ($966 per acre), is well below those of the previous scenarios, except the Current Practice Scenario.

Potential Pollutants

The non-point pollution levels of the Base Policy Scenario were not clearly better or worse than previous scenarios. The total nitrogen in runoff, percolation, and sediment shown in Table 4.24, 108,220 kg (238,084 lb), 4,619,946 kg (10,163,921 lb), and 2,650,084 kg (5,830,185 lb) respectively, were lower than the under the Current Practice Scenario and similar to the results of the other four general scenarios. Runoff had the lowest annual levels of nitrogen of any scenario, thus far; the minimum annual contribution was 1,887 kg (4,151 lb), and the maximum annual contribution was 19,909 kg (43,800 lb). The mixed use of a medium nitrogen application activity, Activity 1, and a low nitrogen application activity, Activity 3, moderated the nitrogen contributions to water contamination.

The chemical contributions were also moderated by Activity 3's low-chemical budget. However, Gramoxone and Aatrex remained the chemicals found in runoff and groundwater, respectively, in the largest amounts.

Table 4.23. The annual minimum, maximum, and the 15 year total net returns under the Base Policy Scenario.[a] .

Net Returns (1988 Dollars)			
Annual Minimum	Annual Maximum	15 year Total	NPV ($/ha)
515,150	3,586,646	31,199,006	2,390

[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

Table 4.24. The annual minimum, maximum, and the 15 year total of nitrogen content of runoff, percolation, and sediment under the Base Policy Scenario.[a]

Nitrogen Content of Runoff (kg)

Annual Minimum	Annual Maximum	15 year Total
1,887	19,909	108,220

Nitrogen Content of Percolation (kg)

Annual Minimum	Annual Maximum	15 year Total
83,317	632,739	4,619,946

Nitrogen Content of Sediment (kg)

Annual Minimum	Annual Maximum	15 year Total
48,425	512,659	2,650,084

[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

Activity 3's low-chemical budget relied primary on Aatrex and Gramoxone. In Table 4.25 runoff is seen to contain large total amounts of both of these chemicals: Gramoxone 671,760 g (1,477 lb), Aatrex 23,447 g (10,658 lb). Aatrex was only the fifth highest chemical level in runoff. Fusulade, Dual, and Gemini levels in runoff followed behind Gramoxone, then Aatrex. The 15 year total of Aatrex percolation in Table4.25, was 555,967 g (123,127 lb). Aatrex also appeared in the chemical content of sediment at 6,953 g (14 lb) total, but Gramoxone had the highest sediment level at 2,775,538 g (6,106 lb). The consistent appearance of Aatrex did not necessarily indicate a harmful condition. The concentration of the chemical in the surface water or groundwater would need to be known before a level of risk can be estimated. However the large amounts may be a signal of potential danger from continued use of these production activities.

The soil erosion estimates in Table 4.26 indicate a higher total loss of soil under this scenario, 131,869 metric tons (145,056 tons) more than under the Unrestricted-X Scenario but 15,491 metric tons (17,040 tons) less than under the Current Practice Scenario. The 15 year total loss was 775,921 metric tons (855,065 tons).

Summary

The Base Policy Scenario established a set of parameter values which reflected perceived barriers to low-input agriculture in Richmond County. The optimal solution of the scenario indicated that these barriers were restrictive enough to prevent organic production use but were not severe

Table 4.25. The annual minimum, maximum, and the 15 year total of chemical content of runoff, percolation, and sediment under the Base Policy Scenario.[a]

Chemical Content of Runoff(g)

Annual Chemical	Annual Minimum	Annual Maximum	15 year Total
Blazer[b]	0	407	593
Aatrex	88	4,270	23,447
Gemini[c]	0	19,706	55,263
Pydrin	0	5,170	11,159
Fusulade	0	16,338	78,818
Roundup[b]	0	5,394	10,699
Lorox[b]	0	2,351	4,448
Dual	0	22,496	67,176
Gramoxone	4,584	154,159	671,760
Treflan[b]	0	10,739	22,397

Chemical Content of Percolation(g)

Annual Chemical	Annual Minimum	Annual Maximum	15 year Total
Blazer[b]	0	179	429
Aatrex	28	139,570	555,967
Gemini[d]	0	15,620	32,521
Harmony	0	5,021	6,872
Fusulade	0	1,383	1,680
Dual	0	5,496	13,955

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[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

[b] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[c] Linuron

[d] Chlorimuron

Table 4.25, continued.

	Chemical Content of Sediment(g)		
Annual Chemical	Annual Minimum	Annual Maximum	15 year Total
Aatrex	0	4,270	6,953
Gemini[c]	0	463	1,118
Pydrin	0	12,568	32,174
Fusulade	0	2,543	8,044
Roundup[b]	0	2,601	5,844
Lorox[b]	0	62	173
Dual	0	160	453
Gramox.	21,273	564,131	2,775,538
Treflan[b]	0	527	805

[b] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[c] Linuron

Table 4.26. The annual minimum, maximum, and the 15 year total of soil erosion under the Base Policy Scenario.[a]

Soil Erosion (metric tons)		
Annual Minimum	Annual Maximum	Annual Total
13,345	160,767	775,921

[a] The Base Policy Scenario had a 20 percent yield penalty on corn and soybeans and a 10 percent penalty on the labor requirements on organic and low-chemical activities, and a 30 percent penalty on the price of poultry litter.

activity. The results of this scenario were consistent with the type of production activities currently found in Richmond County (VPI & SU, Dept. of Agric. Economics).

In order to promote better water quality and/or low-input agriculture use many agriculture and resource policies have been proposed and some have already been implemented at the state level. The effect of some of these policies was analyzed by imposing them, individually, on this Base Policy Scenario.

Cost-Share Scenario

The ability to obtain significant nitrogen contributions from crops depends on the ability to establish a healthy stand and on the timing of their incorporation. There is a critical time where nitrogen content is high and the crop should be turned into the soil. Green manure crops may be substituted for a crop or added to a rotation as a winter cover. The latter was done in this study. Green manure crops added as winter cover are also beneficial for preventing soil loss, and absorbing residual chemicals over the winter season. Activities 15(L) and 16L contained a rotation which used a crimson clover/rye mix as a winter cover crop and as a green manure source. The potential nitrogen available from clover and rye in this study was estimated to be 12.5 kg and 22.5 kg per hectare (11.1 lb and 19.98 lb per acre), respectively. These were conservative estimates due to evidence that it is difficult to establish a high yielding clover crop in Richmond County because early spring freezes and other poor winter weather conditions often prevent the establishment of a good clover crop. The timing of turning a green manure crop into the soil is critical and the spring weather in Richmond County often prevents the farmer from entering the field at the optimal time to disk his crop into the soil (Liddington).

Neither activity using green manure crops had been selected in an optimal solution thus far in this study. The absence of any green manure activities was due to the inability of a rye/clover mix to provide large amounts of nitrogen in the Richmond County area. A cost-share program was thus designed to provide an economic incentive to use these production activities. Cost-sharing is a common economic incentive used to promote the use of desirable agriculture practices. Many states including North Carolina and Virginia, support the use of winter cover crops and green manure crops through subsidization of their establishment (Batie, Cox and Diebel). The amount of subsidization needed was determined by subtracting the variable costs of establishment (seed, aerial application, and fuel and machinery), $54.36 per hectare ($21.96 per acre), from the savings in nitrogen purchases, $4.61 per hectare ($1.86 per acre). An annual subsidization of at least 92 percent of the variable costs would be needed to have one of the green manure activities appear in the optimal solution. A 100 percent annual cost-share of the variable costs of establishment was incorporated into the Base Policy Scenario in order to analyze the effects of a green manure crop on potential pollutants.

Land Use

The 15 year period was nearly equally divided between Activities 16L and 15L. Activity 16L was an organic activity using the clover/rye green manure crop. Activity 15L used the same rotation but under a medium chemical budget. There was no pattern to the appearance of one production activity over the other. Activity 16L was affected by imposed yield, labor, and poultry litter price penalties.

The enrollment of crop hectares, shown in Table 4.27, in the commodity program did not change from the Base Policy Scenario except for corn enrollment. The Cost Share Scenario had an additional total of 7,782 hectares (19,262 acres) of corn enrolled in base over the 15 year period. The added costs of both activities warranted the price guarantee of the commodity programs.

Labor

The addition of the winter crop, which must be disked in the spring, raised the level of labor needed to 986,287 total hours, as indicated in Table 4.28. Activity 16L required even more labor than activity 15L because labor was used instead of chemicals for weed control. Seven percent more total labor, 63,531 hours, was needed in the 15 year period under the Cost Share Scenario as seen in Table 4.28. The requirements were not high enough to induce off-farm labor purchases.

Table 4.27. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the Cost-Share Scenario, and the change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	6,172(0)	20,400(+7,782)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

Table 4.28. The annual minimum, maximum, and the 15 year total labor requirements the Cost-Share Scenario, and change from the Base Policy Scenario.

	Hours of Labor	
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
53,618(-3,521)	81,263(+12,052)	986,287(+63,531)

Net Returns and NPV per hectare

The total net return shown in Table 4.29 for the Cost Share Scenario was $6,468,129 higher than the total net return under the Base Policy Scenario. Note that this was generally due to the annual government subsidy of $54 per hectare ($22 per acre) of clover/rye mix planted. Operator's economic benefits in this scenario were made possible only by government subsidization.

Potential Pollutants

The use of green manure crops did provide a reduction in the nitrogen content of runoff, Table 4.30. The annual amounts in Table 4.30, as well as the 15 years totals were at lower levels than under the Base Policy Scenario. Over 42,000 kg (92,400 lb) of nitrogen were removed from runoff by the use of Activities 15L and 16L. In part, this was due to both the reduction in nitrogen applied and the uptake and storage of residual soil nitrogen by the clover/rye crop. The nitrogen content of percolation did not fall. Rather, total nitrogen leaching increased by 2,366,229 kg (5,205,704 lb), mostly due to the use of poultry litter which has been shown to leach more nitrogen than inorganic sources of nitrogen. The 15 year nitrogen content of sediment decreased by 1,264,177 kg (2,781,189 lb), the decrease was in part due to the retention of soil by the winter cover.

Table 4.31 shows a similar result for chemical contributions to runoff and leaching. Blazer, Lasso, and Lorox contributions to runoff and sediment increased but the other chemical levels fell, including

Table 4.29. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the Cost-Share Scenario, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
905,197	4,979,590	37,667,135	2,885
(+390,047)	(+1,392,944)	(+6,468,129)	(+495)

Table 4.30. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the Cost-Share Scenario, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,173(-714)	11,198(-8,711)	65,422(-42,798)

Nitrogen Content of Percolation (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
15,469(-67,848)	920,178(+287,439)	6,986,175(+2,366,229)

Nitrogen Content of Sediment (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
32,092(-16,333)	261,307(-251,352)	1,385,907(-1,264,177)

Table 4.31. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the Cost-Share Scenario, and change from the Base Policy Scenario.

Chemical Content of Runoff(g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Blazer	0(0)	1,748(+1,341)	4,181(+3,588)
Lasso	0(0)	872(+872)	872(+872)
Aatrex	0(-88)	1,656(-2,614)	6,093(-17,354)
Gemini[a]	0(0)	0(-19,706)	0(-55,263)
Pydrin	0(0)	4,087(-1,083)	6,359(-4,800)
Fusulade	0(0)	12,113(-4,225)	31,163(-47,655)
Lorox	0(0)	40,634(+38,283)	68,126(+63,678)
Dual	0(0)	16,425(-6,071)	42,777(-24,399)
Gramoxone	0(-4,584)	122,348(-31,811)	369,664(-302,096)
Roundup	0(0)	0(-5,394)	0(-10,699)
Treflan	0(0)	0(-10,739)	0(-22,397)

Chemical Content of Percolation(g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Blazer	0(0)	18,453(+ 18,274)	34,002(+ 33,573)
Aatrex	0(-28)	262,154(+122,584)	817,133(+261,166)
Gemini[b]	0(0)	0(-15,620)	0(-555,967)
Harmony	0(0)	8,517(+3,496)	12,246(+5,374)
Roundup	0(0)	6(+6)	6(+6)
Lorox	0(0)	12(+12)	24(+24)
Dual	0(0)	15,468(+ 9,972)	52,352(+38,397)

[a] Linuron

[b] Chlorimuron

Table 4.31, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum	Annual Maximum	15 year Total
Lasso	0(0)	6(+6)	13(+13)
Aatrex	0(0)	6(+6)	31(+6,922)
Pydrin	0(0)	8,380(-4,188)	13,066(-19,108)
Fusulade	0(0)	1,046(-1,496)	3,250(-4,794)
Lorox	0(0)	260(+198)	712(+539)
Dual	0(0)	93(-67)	130(-323)
Gramoxone	0(-21,273))	281,906(-282,225)	855,945(-1,919,593)

Gramoxone. On the other hand, all the chemical levels in percolation increased. The increase in the total level of Dual in percolation, 52,352g (115 lb) was almost four times the level under the Base Policy Scenario. Total Aatrex levels in percolation increased by nearly 50 percent or 261,166 g (575 lb). Application rates of Dual were higher under Activity 15L, but Gramoxone rates were the same as Activity 1, which was used extensively in the Base Policy Scenario. Gramoxone in sediment fell by 1,919,593 g (4,223 lb), in total, from the Base Policy Scenario. The increases in percolation under the Cost-Share Scenario were due to the retention characteristics of the winter cover crop which reduced runoff and soil erosion. An evaluation of the tradeoffs between chemicals must be made when considering potential chemical pollution. Is a decrease in Aatrex and an increase in Blazer and other chemicals a good tradeoff? This evaluation requires the weighting of the characteristics of each chemical, such as toxicity, persistence, and the chemicals' value in agricultural production.

As expected, Table 4.32 shows a large decrease in soil erosion under the Cost-Share Scenario. Approximately 432,000 metric tons (475,200 tons) were saved using the production activities which incorporate a winter cover crop.

Summary

The cost of production activities using green manures and winter cover crops had been too expensive up until this point in the analysis to appear in any optimal solution. A 100 percent subsidization of the annual

Table 4.32. The annual minimum, maximum, and the 15 year soil erosion of the Cost-Share Scenario, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
1,289(-12,056)	45,880(-114,887)	352,874(-432,047)

establishment costs of the clover/rye cover crop was needed to bring these activities into the optimal solution. For this policy to be viable, its costs would need to be offset by the environmental benefits of a winter cover crop. Runoff contamination levels were reduced over all, but potential leaching increased for both chemicals and nutrients. The establishment of a winter cover crop prevented movement of soil and chemicals, normally lost on winter idled land. However, plant biomass and soil retention of chemicals and nutrients created a greater potential for the movement of chemicals and nutrients down through the soil toward groundwater supplies.

Chemical Restrictions and Taxation

Although no general program for groundwater quality protection has been adopted at the federal level, many management tools have been adopted at the state level. The management tools directed toward agriculture include limiting chemical applications, banning of particularly obtrusive chemicals, land use control,[10] chemical taxation, and loading restrictions. Each of these tools has benefits but may be difficult to enforce or may cause tradeoffs with other environmental factors such as soil erosion or surface water quality.

The major groundwater contamination concern in the Base Policy Scenario was the consistently large amounts of Aatrex (atrazine) found in percolating water. Aatrex is a common herbicide used in Richmond County. Aatrex is a "slightly toxic" chemical (Virginia Cooperative Extension Service, Appendix Q) and is

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[10] Land use restrictions are included in later scenarios which incorporate CRP and buffer strip programs and a base flexibility constraint.

listed by the EPA among chemicals with greater leaching potential. Aatrex (atrazine) was downgraded by the EPA in 1988 from a class "B", probably human, to a class "C", possible human, carcinogen. The EPA maintains that the evidence of oncogenic and mutagenic effects were not strong enough for a class "B" label (National Coalition Against the Misuse of Pesticides). Aatrex is used throughout the United States. Restrictions on atrazine use have been used mostly in the midwest where constant heavy use has caused the increased appearance of atrazine in drinking wells (Canter).

Two water quality policies were analyzed which specifically restricted the application of Aatrex. The first, the No Aatrex Scenario, was a complete ban of the herbicide. The second policy, the 1/3 Aatrex Scenario, was a one-third reduction in the amount of Aatrex used in the production activities from the Base Policy Scenario. In anticipation of these type of policies activities were included in the model which excluded Aatrex or had reduced Aatrex levels. In these activities, other chemicals and/or cultivations were substituted for chemical weed control (Hagood).

No Aatrex Scenario

The complete removal of Aatrex was an extreme case of restriction. The results showed limited alternatives as depicted in this model were available to Richmond County operators in such a situation. That is, Aatrex was used by all activities with chemicals except for three which were specifically designed not to use Aatrex. The alternative activities substituted Blazer and 2-4D for Aatrex. These specially designed activities and organic activities are the only choices available to the farmer who chooses not to use Aatrex.

Land Use. The primary activities in the No Aatrex Scenario were activities 6 and 5L. Activity 6 and 5L used the same 2 year corn/small grain-double cropped soybeans rotation as Activity 1, in the Base Policy Scenario. Activity 5L was organic, using labor instead of chemicals for weed control. Activity 6 substituted 2-4D and Bladex (cyanazine) for Aatrex in its chemical budget. Table 4.33 shows little change in land use, since the rotation did not change from the Base Policy Scenario. Corn base hectare enrollment increased by a total of 1,574 hectares (3,896 acres), while wheat and barley stayed at 46,843 and 41,658 hectares (115,948 and 103,114 acres) respectively.

Labor. The use of activity 5L, an organic activity, on a more frequent basis raised the amount of labor required from the Base Policy Scenario. However, no labor was purchased outside of the pooled operator labor, even with the 10 percent labor penalty on activity 15L. Table 4.34 shows a difference of 70,920 hours between the 15 year total labor requirements of the No Aatrex Scenario, 993,676 hours, and the Base Policy Scenario.

Table 4.33. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex			
corn	0(0)	6,172(0)	14,192(+1,574)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)
1/3 Aatrex			
corn	0(0)	6,172(0)	19,262(+6,644)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

Table 4.34. The annual minimum, maximum, and the 15 year total labor requirements the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

	Hours of Labor	
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex		
57,644(+495)	79,076(+ 9,865)	993,676(+70,920)
1/3 Aatrex		
57,395(+246)	79,163(+ 9,952)	970,529(+47,773)

Net Returns and NPV per hectare. Net returns are shown in Table 4.35 to decrease relative to the Base Policy Scenario. The 15 year total for the No Aatrex Scenario, $29,847,705, was $1,351,301 less than the Base Policy Scenario's net returns. The difference was due to increased commercial chemical application services and increased operator labor for the organic activity and changes in chemicals. Bladex and 2-4D were both more expensive per unit then Aatrex. The NPV per hectare was accordingly less at $2,286 per hectare ($923 per acre), a $104 per hectare ($42 per acre) decline.

Potential Pollutants. Total nitrogen found in runoff over the 15 year period dropped by 2,337 kg (5,141 lb). Table 4.36 shows a noticeable increase in nitrogen found in percolation of 888,081 kg (1,953,778 lb) in total. The nitrogen content of sediment also increased. The minimum annual nitrogen contributions to sediment decreased to 42,090 kg (92,598 lb) and the maximum annual contributions rose by 33,286 kg (73,229 lb). The tradeoff between the slow breakdown of organic nitrogen which is susceptible to leaching with a reduction in potential runoff with poultry litter was illustrated again.

The chemicals Bladex and 2-4D replaced Aatrex in Activity 6, and were found at high levels in runoff. Table 4.37 shows that the Bladex contribution to runoff was a 15 year total of 25,933 kg (57 lb) and the 2-4D total level was 31,286 g (69 lb). Gramoxone was found in the largest amount, 457,802 g (1,007 lb) followed by Treflan. Most of the other chemicals which appear in both the No Aatrex Scenario and the Base Policy

Table 4.35. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
No Aatrex			
443,929	3,458,250	29,847,705	2,286
(-71,221)	(-128,396)	(-1,351,301)	(-104)
1/3 Aatrex			
467,260	3,522,514	30,340,973	2,324
(-47,890)	(-64,132)	(-848,033)	(-66)

Table 4.36. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex	1,173(-714)	20,220(+311)	105,883(-2,337)
1/3 Aatrex	1,879(-8)	20,220(+311)	108,174(-46)

Nitrogen Content of Percolation (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex	98,746(+15,429)	787,990(+155,251)	5,508,027(+888,081)
1/3 Aatrex	98,499(+15,182)	690,046(+57,307)	5,004,332(+382,386)

Nitrogen Content of Sediment (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex	42,090(-6,335)	545,945(+33,286)	2,732,587(+82,503)
1/3 Aatrex	45,670(-2,755)	545,945(+33,286)	2,721,814(+71,730)

Table 4.37. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex			
Blazer[a]	0(0)	2,501(+2,094)	3,094(+2,501)
Aatrex	0(-88)	0(-4,270)	0(-23,447)
Gemini[b]	0(0)	7,128(+2,858)	19,977(-35,286)
Bladex	0(0)	19,706(+19,706)	25,933(+25,933)
Pydrin	0(0)	2,839(-2,331)	10,771(-388)
Fusulade	0(0)	14,096(-2,242)	33,331(-75,487)
Roundup[a]	0(0)	18,603(+13,209)	29,301(+18,602)
Lorox[a]	0(0)	46,653(+44,302)	51,100(+46,652)
Dual	0(0)	22,057(-439)	71,329(-4,153)
Gramoxone	0(-4,584)	105,575(-48,584)	457,802(-213,958)
2-4D	0(0)	28,949(+28,949)	31,286(+31,286)
Treflan[a]	0(0)	167,533(+156,794)	189,930(+167,533)
1/3 Aatrex			
Blazer[a]	0(0)	2,501(+2,094)	3,147(+2,554)
Aatrex	29(-59)	1,423(-2,847)	8,535(-14,912)
Gemini[b]	0(0)	19,706(0)	33,420(-21,843)
Bladex	0(0)	1,858(+1,858)	5,257(+5,257)
Pydrin	0(0)	4,897(-273)	12,722(-1,563)
Fusulade	0(0)	18,603(+2,265)	61,709(-17,109)
Roundup[a]	0(0)	46,694(+41,300)	64,942(+54,243)
Lorox[a]	0(0)	14,342(+11,991)	30,405(+25,957)
Dual	0(0)	22,057(-439)	77,055(-9,879)
Gramoxone	0(-4,584)	167,533(+13,374)	646,224(-25,536)
2-4D	0(0)	303(+303)	1,379(+1,379)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

Table 4.37, continued.

	Chemical Content of Percolation (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex			
Blazer[a]	0(0)	8,076(+7,897)	8,822(+8,393)
Aatrex	0(-28)	0(-139,570)	0(-555,967)
Gemini[c]	0(0)	15,620(0)	32,873(+352)
Bladex	0(0)	6,751(+6,751)	10,466(+10,466)
Harmony	0(0)	4,707(-317)	6,253(-619)
Fusulade	0(0)	0(-1,383)	0(-6,872)
Lorox[a]	0(0)	6(+6)	6(+6)
Dual	0(0)	5,858(+362)	18,768(+4,813)
2-4D	0(0)	9,232(+9,232)	25,421(+25,421)
1/3 Aatrex			
Blazer[a]	0(0)	7,973(+7,794)	8,690(+8,261)
Aatrex	9(-18)	42,123(-97,447)	183,765(-372,202)
Gemini[c]	0(0)	15,620(0)	34,465(+1,944)
Gemini[b]	0(0)	139(+139)	139(+139)
Bladex	0(0)	4,427(+4,427)	7,169(+7,169)
Harmony	0(0)	4,704(-317)	6,356(-516)
Fusulade	0(0)	442(-941)	542(-1,138)
Lorox[a]	0(0)	4(+4)	4(+4)
Dual	0(0)	5,858(+362)	18,491(+4,536)
2-4D	0(0)	6,054(+6,054)	12,565(+12,565)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.37, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex			
Blazer[a]	0(0)	12(+12)	12(+12)
Aatrex	0(0)	0(-4,270)	0(-6,953)
Gemini[b]	0(0)	463(0)	998(-120)
Bladex	0(0)	23(+23)	101(+101)
Pydrin	0(0)	13,165(+597)	32,230(+56)
Fusulade	0(0)	1,698(-845)	5,352(-2,692)
Roundup	0(0)	26,697(+23,096)	32,547(+26,703)
Lorox[a]	0(0)	305(+243)	465(+292)
Dual	0(0)	154(-6)	499(+46)
Gramoxone	0(-21,273)	609,107(+44,976)	2,578,344(-197,194)
Treflan	0(0)	1,997(+1,470)	2,802(+1,997)
2-4D	0(0)	6(+6)	6(+6)
1/3 Aatrex			
Blazer[a]	0(0)	12(+ 12)	12(+12)
Aatrex	0(0)	1,423(-2,847)	2,402(-4,551)
Gemini[b]	0(0)	463(0)	894(-218)
Bladex	0(0)	15(+15)	60(+60)
Pydrin	0(0)	13,688(+1,120)	33,284(+1,110)
Fusulade	0(0)	1,382(-1,161)	6,304(-1,740)
Roundup	0(0)	26,697(+24,096)	37,708(+31,864)
Lorox[a]	0(0)	389(+327)	858(+685)
Dual	0(0)	156(+4)	557(+104)
Gramoxone	7,076(-14,197)	609,107(+44,976)	2,652,645(-122,893)
Treflan	0(0)	1,997(+1,470)	2,920(+2,115)
2-4D	0(0)	4(+4)	4(+4)

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

Scenario were decreased under the No Aatrex Scenario. The exceptions were Roundup and Treflan which were used heavily on full season soybeans.

The total chemicals leached, Table 4.37, were usually higher in the No Aatrex Scenario than in the Base Policy Scenario. The higher level of chemicals was due to changes in application amounts in order to compensate for the loss of Aatrex, weather conditions, and the fact that 2-4D is a heavy leacher. The total level of 2-4D in groundwater, 25,421 g (56 lb), was below Aatrex levels in the Base Policy Scenario. Furthermore, the chemical 2-4D is not as persistent as Aatrex in soil at 3 weeks for 2-4D, 52 weeks for Aatrex, but its lethal dosage is lower (Appendix Q). The chemical content of sediment showed only traces of 2-4D but there was an increased total amount of Roundup at 32,547 g (72 lb). The total sediment content of Gramoxone decreased by 197,194 g (434 lb) from the Base Policy Scenario. The removal of Aatrex from production systems leads the substitution of an equally or more toxic chemical, 2-4D.

Table 4.38 shows soil erosion occurred at a lower minimum value than the Base Policy Scenario, 12,090 metric tons (13,299 tons), but the maximum, 171,001 metric tons (188,101 tons), and the 15 year total, 797,964 metric tons (877,760 tons), appeared at higher levels than the Base Policy Scenario. More soil erosion was the result of heavy use of cultivation in the organic activities although tillage practices were minimal.

Summary. The removal of a potentially harmful chemical, Aatrex, resulted in the use of 2-4D and Bladex, higher application rates for other

Table 4.38. The annual minimum, maximum, and the 15 year soil erosion of the No Aatrex and 1/3 Aatrex Scenarios, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex		
12,090(-1,255)	171,001(+ 10,234)	797,964(+ 22,043)
1/3 Aatrex		
13,234(- 111)	171,001(+ 10,234)	793,434(+ 17,513)

chemicals, and the intermittent use of an organic production activity. The use of Aatrex appeared to be critical for the production of corn in Richmond County; restricting its use left operators with few choices. The substitution of other chemicals in the model (based on Extension Service recommendations) resulted in contributions to runoff and groundwater of a possibly more dangerous chemical, 2-4D. The use of an organic activity was made viable in this scenario. However, it was used intermittently with a chemical activity. The use of both organic and inorganic activities would not occur if organic certification were desired. Certification programs require soil tests and plant material tests for inorganic substances. Certification can not occur until all residual inorganic substances are removed from the soil, a process which may take years. If the chemical alternative was selected over the organic activity, then the benefits and costs of the hazards to human and animal health from potential Aatrex contamination must be weighed against those of 2-4D.

1/3 Aatrex Scenario

The 1/3 Aatrex Scenario reduced Aatrex use from the levels in the Base Policy Scenario by one-third. This policy was based on a recent policy adopted in Iowa. The Iowa Department of Agriculture announced rules in December of 1989 to reduce statewide use of atrazine by 25 percent. Under this policy, atrazine application rates must be reduced (National Governors' Association). In this study, application rates remained the same; however, the total purchase of Aatrex was reduced. The use of surface level restrictions, as opposed to using contamination levels or loading restrictions, avoids the need for expensive monitoring equipment but may require a large enforcement staff in addition to extensive recordkeeping. A one-third drop in Aatrex use was introduced to the Base Policy Scenario to determine the policy's effectiveness in curbing groundwater and surface water contamination, as well as its affect on production activity choices. The results were compared to those achieved under the No Aatrex Scenario.

Land Use. A variety of production activities appeared over the fifteen year period. There was no clear-cut primary activity. Activity 5L and 6 each appeared in 5 years. These were the same alternatives selected under the No Aatrex Scenario. Activity 5L was organic, and Activity 6 used no Aatrex. Unlike the No Aatrex Scenario, both Activity 5L and 6 appeared consistently with a secondary activity. The most common secondary activity was Activity 1, a medium chemical use activity using the same rotation as Activities 5L and 6. Activities 12 and 13 also appeared, usually together in the same year. Activity 12 was a four year full season soybean rotation with medium chemical use. Activity 13 was the same as Activity 12 with the exception that no Aatrex was used. The pattern of activities was for an activity which did not use Aatrex to be coupled with an activity which did use Aatrex. The activities without Aatrex were generally the primary activities. Primary activities were used on the majority of available hectares.

Base enrollment of small grains in the 1/3 Aatrex Scenario did not change from the Base Policy Scenario. Table 4.33 shows that corn enrollment did increase by 6,644 hectares (16,495 acres), a greater increase than under the No Aatrex Scenario. More corn hectares were enrolled and subjected to ARP set-aside requirements in order to assist in production cost increases associated with the reduction of Aatrex, which was used exclusively on corn.

Labor. Although an organic activity did appear in the 1/3 Aatrex Scenario, it did not appear frequently enough to require off-farm labor. In Table 4.34, the 15 year total labor hours are shown to have increased by 47,773 hours from the Base Policy Scenario. The annual minimum and maximum labor requirements, 57,395 and 79,163 hours respectively, in the 1/3 Aatrex Scenario were higher than under the Base Policy Scenario due, in part, to the use of the organic activity.

Net Returns. The annual net returns in the 1/3 Aatrex Scenario were consistently less than those of the Base Policy Scenario, as shown in Table 4.35. The difference in income seen in Table 4.35 was due to the additional labor costs of the organic Activity 5L, and the higher variable costs and chemical costs of both Activity 6 and 13, the no Aatrex alternatives. NPV per hectare fell by $66 per hectare ($27 per acre) a relatively moderate decline. NPV per hectare was based on the 15 year total net return which was $848,033 less in the 1/3 Aatrex Scenario than in the Base Policy Scenario but $493,268 higher than the No Aatrex

Scenario. Both the total net return and NPV per hectare of the 1/3 Aatrex Scenario were higher than the more severe case, the No Aatrex Scenario.

Potential Pollutants. Table 4.36 shows the nitrogen runoff loading in the 1/3 Aatrex Scenario were much less than the Base Policy Scenario based on their 15 year total. The total nitrogen in runoff was at 108,174 kg (237,983 lb), only 46 kg (101 lb) less than the Base Scenario. The increase in nitrogen percolation, in the 1/3 Aatrex Scenario, was due in part to the introduction of more minimum tillage activities and poultry litter in the 1/3 Aatrex Scenario as opposed to the Base Policy Scenario. Minimum tillage does not breakup the soil structure as much as deeper tillage does. Less tillage does not provide pockets for the collection of percolating substances, and movement of water and chemicals tends to go straight down. Over 5,000,000 kg (11,000,000 lb) of nitrogen were percolated over the 15 year period but the total was 503,695 kg (1,108,129 lb) less than in the No Aatrex Scenario. This reduction in nitrogen percolated was due to less organic nitrogen use. The increase in nitrogen carried in sediment was less under the 1/3 Aatrex Scenario than the No Aatrex Scenario and the Base Policy Scenario. A 15 year total of 2,721,814 kg (5,987,990 lb) of nitrogen was trapped in sediment, 71,730 kg (157,806 lb) less than in the Base Policy Scenario.

As illustrated in Table 4.37, the one-third restriction on Aatrex did not keep Aatrex from being used. It did cause a 14,912 g (33 lb) and 372,202 g (819 lb) drop in the Aatrex content of runoff and percolation, respectively. The Aatrex content of sediment fell the least, by 4,551 g

(10 lb) total. The 1/3 Aatrex Scenario, had 7 chemicals appearing in runoff, percolation, and sediment at higher levels than under the Base Policy Scenario. Because the 1/3 Aatrex did not use organic activities as extensively as the No Aatrex Scenario there were less reductions in potential chemical pollutants.

The soil erosion levels in Table 4.38 show there was little change in the soil erosion between the scenarios restricting Aatrex. The total soil erosion was 793,434 metric tons (872,777 tons) in the No Aatrex Scenario and 797,964 metric tons (877,760 tons) in the 1/3 Aatrex Scenario. Both scenarios had soil erosion levels over 17,000 metric tons (18,700 lb) greater than the Base Policy Scenario, although their minimum annual values were less than those of the Base Policy Scenario.

Summary. A one-third reduction in the surface application of Aatrex resulted in nearly a one-third reduction in Aatrex loadings of both runoff and percolation. The cost of this reduction in net return terms was $493,268 less than the cost of the No Aatrex Scenario, and it was $848,033 less than the Base Policy Scenario, over the 15 year period. Society will make the final decision whether the benefits of complete removal of Aatrex (atrazine) was worth the lost net returns to farm operators. The impact of this change in the net returns should be weighed against the value of the additional reductions in Aatrex contamination. A restriction of the surface application of chemicals may not always result in the same reduction in loadings as occurred in this study. But the 1/3 surface chemical application restriction was fairly effective in reducing targeted pollutants but introduced new chemical use such as 2-4D.

Chemical Taxation Scenario

Economic incentives as a groundwater management tool usually translate into the use of either financial subsidies to encourage preventative measures, as in the Cost-Share Scenario, or into taxes to discourage excessive use or misuse of harmful inputs (Batie, Cox, and Diebel). Many different fees and taxes are used by states in their groundwater protection plans. A pesticide fee based on the leachability of a chemical could be a preferable policy, creating prices which better reflect the true cost to society of agrichemical use, but the administration of such a policy would be difficult. No states have taxed agrichemicals directly for the purpose of regulating their use.

To determine the viability of using a sales tax on chemicals to limit their use, the cost of all chemicals were raised by percentages until all chemicals were abandoned. The result was a switch from the activities used under the Base Policy Scenario to an organic activity, 5L, at a 300 percent tax rate. Table 4.39 shows the new price of chemicals under the 300 percent tax. Except for Harmony Extra and Gemini, which were measured in kilograms, the prices remained below $100 per liter.

Land Use. Production activity 5L was selected from the three available organic activities because its overall costs were less than the other organic activities. The enrollment of corn hectares into base changes dramatically. Table 4.40 reveals nearly all corn hectares were enrolled in the commodity program, an increase of 73,785 hectares (182,636 acres). The change in corn base was caused by the increased costs of production per kilogram of yield, labor, and poultry litter price penalties.

There were two years with idled hectares, years 11 and 14. This land was left out of production due to three factors. The first factor was the re-entry of CRP land into cropland starting in year 9. The extra hectares released from CRP could not go into base because of the five year moving average restriction. Secondly, the market price and poor yields did not cover the variable costs of planting this additional land without commodity program support, therefore the land was idled. Finally, no crop could enter the solution singly; all crops were tied to an entire rotation. The use of rotations prevented the planting of the additional land in a single profitable crop, such as soybeans. Each hectare of extra land would need to be divided into the appropriate proportions of each crop in the selected rotation. For instance, if soybeans were profitable at the market price, corn, a more expensive crop, would also have to be brought in at the following ratio under Activity 5L:

.5 hectare corn,
.275 hectare wheat,
.225 hectare barley,
.5 hectare double-cropped soybeans.

Because the cost of planting land involved an entire rotation, not just a single crop, the composite costs under Chemical Taxation were too high to justify planting.

Table 4.39. The Chemical Taxation Scenario imposed a 300 percent sales tax on the initial chemical prices in order to completely remove chemicals from use.[a]

Chemical # and Product Name	Initial 1988 Price	1988 Price with 300 Percent Tax
1. Blazer	14.08	42.24
2. Lasso	6.06	18.18
3. Aatrex	2.87	8.61
4. Gemini[b]	36.12	108.36
5. Bladex	5.18	15.54
6. Banvel	17.97	53.91
7. Harmony Extra[b]	404.80	1,214.40
8. Pydrin	28.14	84.40
9. Fusulade	21.57	84.40
10. Roundup	20.25	60.75
11. Lorox	14.78	44.34
12. Dual	14.42	43.26
13. Gramoxone	9.34	28.02
14. Treflan	7.15	21.45
15. 2-4D	3.28	9.84

[a] The tax percentage was applied to the individual chemical prices in 1988 dollars per liter except where noted. The prices were discounted in the net return calculation done each year by the model.

[b] This chemical price is per kilogram.

Table 4.40. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the Chemical Taxation Scenario, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	6,172(0)	86,403(+73,785)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

Labor. Off-farm labor did have to be purchased in the Chemical Taxation Scenario. The inflated labor requirements and extensive use of Activity 5L required the purchase of 103,066 hours annually for years 1-8, and up to 126,592 hours annually in years 9-15. Table 4.41 shows the large increase in hours required on both an annual and total basis. The labor required over the 15 year period was 4,202,773 hours. The minimum and maximum annual labor required were 274,958 hours and 302,169 hours, respectively.

Net Returns and NPV per hectare. The net returns in the Chemical Taxation Scenario were quite different from previous scenarios. Table 4.42 shows that a negative net return of $138,542 was received in year 8. The operator was forced to produce at a loss in that year in order to keep his base enrollment up for deficiency payments needed in later years. The actual loss would have been greater if fixed costs were accounted for in the model.

The total net return of $18,539,973 was $12,659,213 lower in the Chemical Taxation Scenario than the net returns of the Base Policy Scenario. The NPV per hectare of $1,420 per hectare ($574 per acre) was a fall of $970 per hectare ($861 per acre) from the Base Policy Scenario. Taxation, like most of the previous scenarios, lowered the value of the operators land for agricultural purposes.

Pollution Potential. Although nitrogen in runoff was reduced by fairly large amounts, nitrogen found in percolation was increased by even larger

Table 4.41. The annual minimum, maximum, and the 15 year total labor requirements the Chemical Taxation Scenario, and change from the Base Policy Scenario.

	Hours of Labor	
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
274,958(+217,809)	302,169(+232,958)	4,202,773(+3,280,017)

Table 4.42. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the Chemical Taxation Scenario, and change from the Base Policy Scenario.

Net Returns (Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
-138,542 (-653,692)	2,688,178 (-898,468)	18,539,973 (-12,659,213)	1,420 (-970)

Table 4.43. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the Chemical Taxation Scenario, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,173(-714)	13,569(-6,340)	75,534(-32,686)
Nitrogen Content of Percolation (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
106,090(+22,773)	776,874(+144,135)	6,023,763(+1,403,817)
Nitrogen Content of Sediment (kg)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
42,090(-6,335)	417,778(-94,881)	2,143,025(-507,059)

amounts. The 15 year total amount of nitrogen, Table 4.43, found in percolation was 6,023,763 kg (13,252,279 lb), almost 1,500,000 kg (3,300,300 lb) more than under the Base Policy Scenario. The use of litter represents the only potential contaminant in the chemical taxation scenario, as no chemicals were used. The nitrogen content of sediment and runoff fell by 507,059 kg (1,115,530 lb) and 32,686 kg (71,909 lb) respectively. The reductions in chemical non-point pollution, caused by zero chemical use, levels from the Base Policy Scenario are contained in Table 4.44.

Reduction in soil erosion was another environmental benefit of this scenario. Erosion dropped by 160,557 metric tons (176,613 tons). Table 4.45 shows that the minimum and maximum annual levels of soil erosion were also lower than under the Base Policy Scenario. The use of an organic activity alone may prevent soil loss unlike previous policy scenarios where the organic activity was combined with other activities which used deeper tillage practices.

Summary. The Chemical Taxation Scenario revealed that, in order to remove or restrict the use of chemicals by taxation, a large (300 percent in this study) tax would be required. The 300 percent tax was deemed a politically unacceptable alternative, but the process of finding the appropriate tax level to remove all chemicals indicated that moderate taxation did not cause changes in production activities. Chemicals were such an intricate part of rotations that moderate chemical production

Table 4.44. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the Chemical Taxation Scenario, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Blazer	0(0)	0(-407)	0(-593)
Aatrex	0(-88)	0(-4,270)	0(-23,447)
Gemini[a]	0(0)	0(-19,706)	0(-55,263)
Pydrin	0(0)	0(-5,170)	0(-11,159)
Fusulade	0(0)	0(-16,338)	0(-78,818)
Roundup	0(0)	0(-5,394)	0(-10,699)
Lorox	0(0)	0(-2,351)	0(-4,448)
Dual	0(0)	0(-22,496)	0(-67,176)
Gramoxone	0(-4,584)	0(-154,159)	0(-671,760)
Treflan	0(0)	0(-10,739)	0(-22,397)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Blazer	0(0)	0(-179)	0(-429)
Aatrex	0(-28)	0(-139,570)	0(-555,967)
Gemini[b]	0(0)	0(-15,620)	0(-32,521)
Harmony	0(0)	0(-5,021)	0(-6,872)
Fusulade	0(0)	0(-1,383)	0(-1,680)
Dual	0(0)	0(-5,496)	0(-13,955)

[a] Linuron
[b] Chlorimuron

Table 4.44, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Aatrex	0(0)	0(-4,270)	0(-6,953)
Gemini[b]	0(0)	0(-463)	0(-1,118)
Pydrin	0(0)	0(-12,568)	0(-32,174)
Fusulade	0(0)	0(-2,543)	0(-8,044)
Roundup	0(0)	0(-2,601)	0(-5,844)
Lorox	0(0)	0(-62)	0(-173)
Dual	0(0)	0(-160)	0(-453)
Gramoxone	0(-21,273)	0(-564,131)	0(-2,775,538)
Treflan	0(0)	0(- 527)	0(-805)

[a] Linuron

[b] Chlorimuron

Table 4.45. The annual minimum and maximum, and the 15 year soil erosion of the Chemical Taxation Scenario, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
12,090(-1,255)	127,515(- 33,252)	615,364(-160,557)

activities were not abandoned until the tax was very high, and then a complete conversion to organic agriculture occurred.

40% Loading Reduction Scenarios

Another possible method to control the contribution of chemicals to groundwater is a loading constraint. Loading constraints require a reduction in the actual pollutant contribution to groundwater or surface water. Such policies are often designed to reduce the total contamination level of an aquifer or surface water body within a set time period. Loading restrictions are difficult to enforce for several reasons. In particular, the enforcement of these constraints requires expensive field monitoring equipment and a large staff to identify and monitor the sources of contamination. The second reason restrictions are difficult to administer is that agricultural pollution is directly linked to weather. Poor weather conditions, either too wet or too dry, can cause unanticipated chemical contributions even at reduced application rates.

A 40 percent reduction from the Base Policy Scenario's chemical contributions to percolation was imposed in the 40% Percolation Reduction Scenario. The possibility of tradeoffs between the potential contaminants of runoff, and groundwater, exist when only groundwater loadings are restricted. Therefore, a second scenario was estimated which reduced both groundwater and runoff chemical contributions by 40 percent, the 40% Percolation/Runoff Reduction Scenario.

Land Use

The change in land use under the 40% Percolation Reduction Scenario and the 40% Percolation/Runoff Reduction Scenario were similar. Under both scenarios the medium chemical use, 2 year corn/small grain-double cropped soybeans rotation, of activity 1, remained the primary activity. The most frequent secondary activity was Activity 6, a two year rotation which used no Aatrex. The 40% Percolation/Runoff Reduction Scenario had a greater mix of secondary activities due to the more severe nature of the chemical loading restriction. Crop hectare enrollment did not change under the 40% Percolation Reduction Scenario from the Base Policy Scenario. There was a 4,529 hectare (11,210 acres) increase in corn enrollment under the 40% Percolation/Runoff Reduction Scenario as shown in Table 4.46. Again the change in enrollment was due to the severity of the restriction and the need to build up base for deficiency payments. More expensive chemicals were substituted for Aatrex in Activity 6.

Labor

Table 4.47 contains the changes in labor requirements for both loading restriction scenarios. Total labor requirements were increased by 400,578 hours and 698,729 hours under the 40% Percolation Reduction Scenario and the 40% Percolation/Runoff Reduction Scenario from the Base Policy Scenario. The 40% Percolation/Runoff Reduction Scenario used more labor hours, 1,621,485 hours, over the 15 year period than the 40% Percolation Reduction Scenario because of the appearance of the organic Activity 5L in several years. Both scenarios required the purchase small amounts of off-farm labor during planting and harvesting months, April and November generally, but only under the use of Activity 3 and 5L. The additional labor requirements of organic and low-chemical activities along with the 10 percent labor penalty assessed were enough to finally force the model into a labor purchasing situation. The amount of hours was small overall because Activities 3 and 5L were used extensively only in two years of each scenario.

Net Returns and NPV per hectare

Annual net returns were consistently lower in both the 40% Percolation Reduction Scenario and the 40% Percolation/Runoff Reduction Scenario than in the Base Policy Scenario. The more restrictive scenario's total net return was over $3,000,000 less than the Base Policy Scenario's total net return, Table 4.48. Total net return under the 40% Percolation Reduction Scenario was $29,490,387 and $28,130,220 under the 40% Percolation/Runoff Reduction Scenario. The NPV per hectare's shown in Table 4.48 with the net returns decreased as well, but remained above $2,000 per hectare ($808 per acre). The decline in net returns for these scenarios was due to the inclusion of more labor intensive activities, including low-chemical and organic activities. The restriction on both runoff and groundwater chemical contributions caused more extensive shifts in production activities causing a lower level of net return.

Table 4.46. The the annual minimum, ma
hectares enrolled in the federal commod
Reduction and 40% Percolation/Runoff Re
the Base Policy Scenario.

	Base Enrolled Hecta	
Crop	Annual Minimum(Change)	Annual Maximum(Chang
40% Percolation Reduction Scenario		
corn	0(0)	6,172(0)
wheat	0(0)	3,394(0)
barley	2,777(0)	2,777(0)
40% Percolation/Runoff Reduction Scenar		
corn	0(0)	6,172(0)
wheat	0(0)	3,394(0)
barley	2,777(0)	2,777(0)

Table 4.47. The the annual minimum, maximum, and the 15 year total labor requirements in the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios, and change from the Base Policy Scenario.

Hours of Labor Annual Minimum(Change)	 Annual Maximum(Change)	 15 year Total(Change)
40% Percolation Reduction Scenario		
57,149(0)	183,567(+114,356)	1,323,334(+ 400,578)
40% Percolation/Runoff Reduction Scenario		
57,395(+246)	289,938(+220,727)	1,621,485(+ 698,729)

Table 4.48. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
40% Percolation Reduction Scenario			
-250,914	3,561,480	29,490,387	2,259
(-264,236)	(-25,166)	(-1,708,619)	(-131)
40% Percolation/Runoff Reduction Scenario			
251,347	3,407,142	28,130,220	2,154
(-263,803)	(-179,504)	(-3,068,786)	(-236)

Potential Pollutants

The changes in nitrogen contributions to runoff, percolation, and sediment shown in Table 4.49 were mixed. The level of nitrogen in runoff under the 40% Percolation/Runoff Reduction Scenario declined by 306 kg (673 lb) but increased by 2,141 kg (4,710 lb) under the 40% Percolation Reduction Scenario. The 15 year level of nitrogen leached rose by over 1,000,000 kg (2,200,00 lb) in the 40% Percolation Reduction Scenario and by over 400,000 kg (880,00 lb) in the 40% Percolation/Runoff Reduction Scenario. The increased use of low-chemical activities and full season soybean rotations in the 40% Percolation/Runoff Reduction Scenario moderated the nitrogen leaching. The total nitrogen content of sediment was greater under the 40% Percolation Reduction Scenario at 2,679,712 kg (5,895,366 lb) than under the 40% Percolation/Runoff Scenario. Nitrogen in sediment followed the same pattern as nitrogen in runoff, that is the level of nitrogen was reduced under the 40% Percolation/Runoff Reduction Scenario and increased under the other scenario. The annual minimum nitrogen contributions to sediment were the same for both loading reduction scenarios, 52,829 kg (116,224 lb), but the maximum annual contribution was 33,398 kg (73,476 lb) higher under the 40% Percolation Reduction Scenario.

Restricting only the chemicals leached did not produce any large opposing increases in runoff contributions. Generally the chemicals which were found at reduced levels in percolation, Table 4.50, were also found in reduced amounts in runoff. The 40% Percolation Reduction Scenario had 6 chemical levels in runoff increase, of those only 3 were chemicals

Table 4.49. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Scenario	2,971(+1,084)	16,901(-3,008)	110,361(+2,141)
40% Percolation/Runoff Reduction Scenario	2,777(+890)	14,310(-5,599)	107,914(-306)

Nitrogen Content of Percolation (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Scenario	83,317(0)	1,310,109(+677,730)	5,981,964(+1,362,018)
40% Percolation/Runoff Reduction Scenario	98,746(+15,429)	828,098(+195,359)	5,020,627(+400,618)

Nitrogen Content of Sediment (kg)

	Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)
40% Percolation Reduction Scenario	52,829(+4,404)	473,887(-38,772)	2,679,712(+29,628)
40% Percolation/Runoff Reduction Scenario	52,829(+4,404)	440,489(-72,170)	2,586,876(-63,208)

Table 4.50. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios, and change from the Base Policy Scenario.

	Chemical Content of Runoff (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Scenario			
Blazer[a]	0(0)	120(-287)	247(-346)
Lasso	0(0)	1,826(+1,826)	1,826(+1,826)
Aatrex	0(-88)	3,845(+425)	18,769(-4,678)
Gemini[b]	0(0)	19,706(0)	38,731(-21,532)
Bladex	0(0)	1,858(+1,858)	2,895(+2,895)
Pydrin	11(+11)	2,393(-2,777)	11,700(+541)
Fusulade	0(0)	14,096(-2,242)	85,585(+6,767)
Roundup[a]	0(0)	5,394(0)	9,375(-1,324)
Lorox[a]	0(0)	2,351(0)	3,726(-722)
Dual	0(0)	18,571(-3,925)	50,374(-16,802)
Gramox.	17,709(+13,125)	105,944(-48,215)	710,639(+38,879)
Treflan	0(0)	10,739(0)	19,024(-3,373)
2-4D	0(0)	961(+961)	1,020(+1,020)
40% Percolation/Runoff Reduction Scenario			
Blazer[a]	0(0)	250(-157)	356(-237)
Lasso	0(0)	333(+333)	383(+383)
Aatrex	0(-88)	2,604(-1,666)	14,066(-9,381)
Gemini[b]	0(0)	13,743(-5,963)	33,153(-22,110)
Bladex	0(0)	1,995(+1,995)	5,120(+5,120)
Pydrin	0(0)	1,196(-3,974)	6,694(-4,465)
Fusulade	0(0)	14,096(-2,242)	47,290(-31,528)
Roundup[a]	0(0)	3,315(-2,079)	6,419(-4,280)
Lorox[a]	0(0)	1,445(-906)	3,810(-638)
Dual	0(0)	18,787(-3,709)	52,887(-14,289)
Gramox.	0(-4,584)	83,471(-70,688)	567,672(-104,088)
Treflan	0(0)	6,599(-4,140)	12,698(-9,699)
2-4D	0(0)	959(+959)	2,097(+2,097)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.50, continued.

	Chemical Content of Percolation (kg)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Scenario			
Blazer[a]	0(0)	120(-59)	257(-172)
Lasso	0(0)	3,716(+3,716)	3,716(+3,716)
Aatrex	0(0)	81,355(-58,215)	333,580(-222,387)
Gemini[c]	0(0)	3,916(-11,704)	19,513(-13,008)
Bladex	0(0)	7,523(+7,523)	8,890(+8,890)
Harmony	0(0)	2,323(-2,698)	4,122(-2,750)
Fusulade	0(0)	645(-740)	1,008(-672)
Dual	0(0)	5,407(-89)	8,950(-5,005)
2-4D	0(0)	2,531(+2,531)	3,551(+3,551)
40% Percolation/Runoff Reduction Scenario			
Blazer[a]	0(0)	130(-49)	258(-171)
Lasso	0(0)	9(+9)	9(+9)
Aatrex	0(-28)	74,933(-64,637)	333,579(-222,388)
Gemini[c]	0(0)	13,045(-2,575)	19,512(-13,009)
Gemini[b]	0(0)	4,753(+4,753)	4,753(+4,753)
Bladex	0(0)	7,510(+7,510)	8,573(+8,573)
Harmony	0(0)	1,137(-3,884)	2,054(-4,818)
Fusulade	0(0)	938(-420)	1,293(-387)
Dual	0(0)	4,861(-635)	11,920(-2,035)
2-4D	0(0)	6,499(+6,499)	9,201(+9,201)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.50, continued.

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
		Chemical Content of Sediment (kg)	
40% Percolation Reduction Scenario			
Lasso	0(0)	22(+22)	22(+22)
Aatrex	0(0)	1,273(-2,997)	4,160(-2,793)
Gemini[b]	0(0)	463(0)	1,047(-71)
Bladex	0(0)	19(+19)	27(+27)
Pydrin	106(+106)	6,971(-5,594)	33,892(-1,718)
Fusulade	0(0)	2,777(+234)	7,273(-771)
Roundup[a]	0(0)	2,601(0)	5,228(-616)
Lorox[a]	0(0)	62(0)	142(-31)
Dual	0(0)	120(-40)	313(-140)
Gramox.	76,419(+55,146)	483,303(-80,828)	2,751,709(-23,829)
Treflan	0(0)	528(+1)	634(-171)
2-4D	0(0)	6(+6)	6(+6)
40% Percolation/Runoff Reduction Scenario			
Lasso	0(0)	3(+3)	4(+4)
Aatrex	0(-28)	1,261(-3,009)	3,284(-3,669)
Gemini[b]	0(0)	323(-140)	928(-190)
Bladex	0(0)	19(+19)	54(+54)
Pydrin	0(0)	3,727(-8,841)	21,734(-10,440)
Fusulade	0(0)	1,731(-812)	5,616(-2,428)
Roundup[a]	0(0)	1,392(-1,209)	2,981(-2,863)
Lorox[a]	0(0)	38(-24)	96(-77)
Dual	0(0)	134(-26)	328(-125)
Gramox.	0(0)	376,365(-187,766)	2,267,484(-508,054)
Treflan	0(0)	324(-203)	597(-208)
2-4D	0(0)	6(+6)	13(+13)

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

present in the Base Policy Scenario. Only the three new chemicals: Lasso, Bladex, and 2-4D, increased in the runoff and sediment of the 40% Percolation/Runoff Scenario and in the percolation and sediment of the 40% Percolation Reduction Scenario. Aatrex was most heavily affected by the 40% leaching reduction. This result was expected given the results of the 1/3 Aatrex Scenario. The total reductions in Aatrex were 4,678 g (10 lb), 222,387 (489 lb), and 2,793 (6 lb) under the 40% Percolation Reduction Scenario. When both runoff and percolation were restricted, Aatrex contributions were further reduced in runoff, however, percolation levels remained the same, given rounding errors. Gramoxone contributions to runoff and sediment were reduced in the 40% Percolation/Runoff Reduction Scenario by 104,088 g (229 lb) and 508,054 g (1,118 lb) in total. There were 3 increased chemical levels in sediment under both Aatrex reduction scenario: Lasso, Bladex, and 2-4D. These 3 chemicals were not present under the Base policy Scenario, they were introduced because of the restriction on Aatrex and Dual loading levels.

Soil erosion was higher in the 40% Percolation Reduction Scenario than in the Base Policy Scenario. Table 4.51 shows a 214,199 metric ton (235,619 ton) total increase in soil erosion under the 40% Percolation Reduction Scenario. The variety of production activities used in the 40% Percolation/Runoff Reduction Scenario combined to effectively reduce soil erosion by 33,707 metric tons (37,078 tons) from the Base Policy Scenario.

Table 4.51. The annual minimum, maximum, and the 15 year soil erosion of the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Scenario		
15,522(+2,177)	239,026(+78,259)	990,120(+214,199)
40% Percolation/Runoff Reduction Scenario		
15,522(+2,177)	134,760(+26,007)	742,214(-33,707)

Summary

Except for Gramoxone in runoff, there were few tradeoffs between the chemical amounts found in runoff versus leaching under the two chemical restriction scenarios. One possibly significant difference was the appearance of 2-4D under the more restrictive 40% Percolation/Runoff Reduction Scenario. The same tradeoff between the control of Aatrex and the introduction of other possibly more dangerous chemicals which was presented under the No Aatrex and 1/3 Aatrex Scenarios appeared under a general chemical loading reduction because Aatrex played such an important role in crop production. The more restrictive policy, 40% Percolation/ Runoff Reduction had less potential nitrogen pollution than the 40% Percolation Reduction Scenario. Percolation of nitrogen increased under both scenarios but the increase was smaller under the 40% Percolation/ Runoff Scenario and was coupled with declines in both runoff and sediment nitrogen content. The 40% Percolation/Runoff Scenario had better nitrogen and soil erosion management practices. Potential chemical pollution was decreased for the most part, because of the loading restrictions. However, there were chemicals left unrestricted because they did not appear in the Base Policy Scenario. Some of these unrestricted chemicals were used as substitutes for restricted chemicals and others appeared because of new production activities in the solution. The potential harm from these chemicals at there respective levels needs to be weighed against the reductions achieved in other chemical levels.

Land Use Policies

Two types of land use policies were considered in this study. Both the federal Conservation Reserve Program and a state buffer strip set-aside policy were used in Richmond County. In the previous scenarios CRP land was assumed to be "frozen"; and no new hectares could be added and those already enrolled as grassland were converted back to cropland after their ten year enrollment period was over. The mandatory 7.6 meter (25 foot) buffer strips, under the ruling of the Chesapeake Bay Local Assistance Board, were removed from eligible cropland in all the previous scenarios.

The CRP program initiated in the 1985 Farm Bill was focused on the reduction of soil erosion. Only highly erodible land could be enrolled. The 1990 Farm Bill may bring a revitalization of CRP with a new focus including water quality improvement. Possible modifications to the CRP program include a broader eligibility ruling, which would allow enrollment of cropland where agricultural practices threaten current or future uses of surface water, and cropland constituting recharge areas for groundwater (Ervin et. al; Ervin). The CRP Scenario enrolls all of the eligible cropland in Richmond County as determined by the current soil erosion requirements for the entire 15 year period. There are 3,334 hectares (8,252 acres) of eligible land in the county (Shanholtz). The land was enrolled at the 1988-89 average bid rate for the county of $173 per hectare ($70 per acre), which may rise if a new bid period opened. The focal point of the CRP Scenario was to determine the potential water quality benefits from a larger enrollment of CRP land.

Buffer strips were mandated in Richmond County to reduce runoff into the numerous tributaries of the Chesapeake Bay. The maximum width of the buffer strips is 30.4 meter (100 feet) taking approximately 307 hectares (760 acres) of cropland out of production. This maximum buffer strip area was set-aside in the Buffer Strip Scenario without any financial payments, as is now the case. The two land use scenarios were examined together to compare their impacts, but were not combined under a single scenario.

Land Use

There was no change in the production activities selected under the CRP and Buffer Strip Scenarios from the Base Policy Scenario. Activity 1, a medium chemical budget activity using the 2 year corn/small grain-double cropped soybean rotation was the primary activity.

Fewer hectares were put into base under the land use scenarios but the reductions shown in Table 4.52 were due strictly to the removal of cropland hectares by CRP and buffer strip programs. Under the Buffer Strip mandate, a total of 1,887 hectares (4,671 acres) of base was lost; 22,103 hectares (54,710 acres) of base was lost under the CRP Scenario. The largest total loss was in hectares of wheat base under both the CRP and Buffer Strip Scenarios, 10,240 hectares (25,347 acres) and 874 hectares (2,163 acres) respectively. Since these policies only reduced available hectares and since there was no change in production activities, the only reason for a shift in base enrollment was the reduction in available land..

Table 4.52. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
Buffer Strip Scenario			
corn	0(0)	6,057(-115)	12,382(-236)
wheat	0(0)	3,331(-63)	45,969(-874)
barley	2,725(-52)	2,725(-52)	40,881(-777)
CRP Scenario			
corn	0(0)	3,858(-2,314)	9,860(-2,758)
wheat	0(0)	3,331(-63)	36,603(-10,240)
barley	2,170(-607)	2,170(-607)	32,553(-9,105)

Labor

Labor requirements declined paralleling the land removed from production, Table 4.53. The 15 year total labor requirements under the Buffer Strip and CRP Scenarios were 711,782 and 907,756 hours. The Buffer Strip labor requirement was a 15,000 hour decrease from the Base Policy Scenario. The CRP Scenario required 210,974 less hours than the Base Policy Scenario.

Net Returns and NPV per hectare

Net returns were generally lower under both the CRP and Buffer Strip Scenarios than under the Base Policy Scenario. Table 4.54 shows that the total net returns were $1,240,391 less under the CRP Scenario than the Buffer Strip Scenario, despite the federal payments received annually. The fact that net returns fell under the CRP Scenario indicated that the $173 per hectare bid rate did not cover the lost income from the cropland. However, the minimum annual net return was $137,300 higher under the CRP Scenario than under the Base Policy Scenario due to the subsidy. The Buffer Strip Scenario included no subsidization for retired land, but the total land area removed from production was less than that removed under the CRP Scenario, so the total net return, $30,639,062, did not decline as sharply from the Base Policy Scenario. The decreases in net returns caused the declining NPVs per hectare found in Table 4.54.

Table 4.53. The annual minimum, maximum, and the 15 year total labor requirements the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

	Hours of Labor	
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
CRP Scenario		
44,657(-12,492)	51,632(-17,579)	711,782(-210,974)
Buffer Strip Scenario		
56,083(-1,066)	67,632(-1,579)	907,756(-15,000)

Table 4.54. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
CRP Scenario			
652,450	3,239,329	29,398,671	2,251
(+137,300)	(-347,317)	(-1,800,335)	(-139)
Buffer Strip Scenario			
506,030	3,521,569	30,639,062	2,346
(-9,120)	(-65,077)	(-559,944)	(-44)

Potential Pollutants

Table 4.55 shows that there were large declines in the levels of nitrogen in both runoff and percolation with both land use scenarios. The nitrogen content of runoff fell by 24,728 kg (54,402 lb) to a total of 83,492 kg (183,682 lb) with the CRP Scenario. The Buffer Strip Scenario caused a less dramatic change in the total nitrogen content of runoff; there was a 1,909 kg (4,200 lb) reduction to 106,311 kg (233,884 lb). The 15 year total reduction in nitrogen leached from the Base Policy Scenario was large under the CRP Scenario, 1,071,162 kg less (2,356,556 lb). The reductions in nitrogen in sediment were not as high as percolation reduction, but the CRP Scenario did produce a 587,735 kg (1,293,017 lb) total decrease from the level of nitrogen under the Base Policy Scenario. All chemical contributions were also reduced. The reduction in chemical contributions was strictly a factor of the reduction of productive hectares, since there was no change in production activities nor their chemical budgets. Total Gramoxone levels in runoff were reduced by 20 percent, 144,589 g (318 lb), with CRP Scenario. Table 4.56 shows that Gramoxone in runoff was reduced by 2,585 g (5 lb) total, in the Buffer Strip Scenario. The 127,618 g (281 lb) total reduction in Aatrex percolation in the CRP Scenario, Table 4.56, was over 20 percent. Once again the Buffer Strip Scenario had a smaller reduction, 1.5 percent, decline in Aatrex levels in percolation. The reductions of Gramoxone levels in sediment were the largest of the chemical reductions in sediment, for both the CRP and Buffer Strip Scenarios. The CRP

Table 4.55. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
CRP Scenario	1,444(-443)	15,432(-4,492)	83,492(-24,728)
Buffer Strip Scenario	1,853(-34)	19,541(-368)	106,311(-1,909)

Nitrogen Content of Percolation (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
CRP Scenario	65,105(-18,212)	490,460(-142,279)	3,548,784(-1,071,162)
Buffer Strip Scenario	14,627(-68,690)	621,032(-11,707)	4,312,164(-307,782)

Nitrogen Content of Sediment (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
CRP Scenario	37,558(-10,867)	397,382(-115,277)	2,062,349(-587,735)
Buffer Strip Scenario	48,204(-221)	503,176(-9,483)	2,613,412(-36,672)

Table 4.56. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
CRP Scenario			
Blazer[a]	0(0)	218(-189)	363(-230)
Aatrex	67(-22)	336(-3,934)	18,126(-5,321)
Gemini[b]	0(0)	15,399(-4,307)	33,066(-22,197)
Pydrin	0(0)	4,008(-1,162)	8,655(-2,504)
Fusulade	0(0)	19,517(-3,179)	60,702(-18,116)
Roundup	0(0)	4,215(-1,179)	8,358(-2,341)
Lorox[a]	0(0)	1,837(-514)	3,475(-973)
Dual	0(0)	17,578(-4,918)	52,206(-14,970)
Gramox.	5,018(+434)	119,495(-34,665)	527,172(-144,589)
Treflan	0(0)	8,391(-2,348)	17,496(-4,901)
Buffer Strip Scenario			
Blazer[a]	0(0)	400(-7)	582(-11)
Aatrex	86(-2)	4,190(-80)	23,015(-432)
Gemini[b]	0(0)	19,338(-368)	41,763(-13,500)
Pydrin	0(0)	5,075(-95)	10,686(-473)
Fusulade	0(0)	24,511(+8,173)	87,868(+9,050)
Roundup	0(0)	5,293(-101)	10,499(-200)
Lorox[a]	0(0)	2,308(-43)	4,365(-83)
Dual	0(0)	22,076(-402)	65,930(-1,246)
Gramox.	6,440(+1,856)	103,968(-50,191)	669,176(-2,585)
Treflan	0(0)	10,538(-201)	21,979(-418)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.56, continued.

	Chemical Content of Percolation (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
CRP Scenario			
Blazer[a]	0(0)	140(-39)	335(-94)
Aatrex	22(-6)	108,186(-31,384)	428,349(-127,618)
Gemini[c]	0(0)	12,206(-3,414)	25,345(-7,176)
Harmony	0(0)	3,892(-1,129)	5,295(-1,577)
Fusulade	0(0)	1,032(-326)	1,264(-416)
Dual	0(0)	4,295(-1,099)	10,870(-3,085)
Buffer Strip Scenario			
Blazer[a]	0(0)	176(-3)	421(-8)
Aatrex	28(0)	139,570(0)	547,324(-8,643)
Gemini[c]	0(0)	15,329(-291)	32,073(-448)
Harmony	0(0)	5,021(0)	6,838(-34)
Fusulade	0(0)	1,358(0)	1,650(-30)
Dual	0(0)	5,394(-102)	12,747(-208)

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.56, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
CRP Scenario			
Aatrex	0(0)	3,336(-934)	5,484(-1,469)
Gemini[b]	0(0)	362(-101)	868(-250)
Pydrin	0(0)	9,742(-2,826)	25,012(-7,162)
Fusulade	0(0)	1,987(-556)	6,192(-1,852)
Roundup	0(0)	2,030(-571)	4,565(-1,279)
Lorox[c]	0(0)	48(-14)	135(-38)
Dual	0(0)	125(-35)	352(-101)
Gramox.	16,536(-4,737)	437,280(-126,851)	2,157,974(-617,564)
Treflan	0(0)	412(-115)	629(-176)
Buffer Strip Scenario			
Aatrex	0(0)	4,190(-80)	6,949(-4)
Gemini[b]	0(0)	454(-9)	1,098(-20)
Pydrin	0(0)	12,335(-233)	31,641(-533)
Fusulade	0(0)	2,543(0)	7,944(-100)
Roundup	0(0)	2,552(-49)	5,735(-109)
Lorox[a]	0(0)	61(-1)	170(-3)
Dual	0(0)	157(-3)	445(-8)
Gramox.	21,223(-50)	553,695(-10,436)	2,737,754(-37,784)
Treflan	0(0)	518(-9)	790(-15)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Scenario had the largest total Gramoxone reduction of 617,564 g (1,359 lb), and reductions in the minimum and maximum annual contributions of 4,737 g (10 lb) and 126,851 kg (279 lb) from the Base Policy Scenario.

The model in this study accounted for reduced non-point pollution strictly due to decreased or changed agricultural activity on the surface. Buffer strips are designed to work as a filter for contaminants traveling towards surface water or groundwater sources from other parcels of land. These environmental benefits are not accounted for in this model.

Soil erosion was also impacted by the reduced cropland under these land use scenarios. The reductions shown in Tale 4.57 were largest for the scenario where more land was idled, the CRP Scenario. A 176,085 metric ton (193,694 ton) total reduction in soil erosion occurred with the CRP Scenario; and a 14,318 metric ton (15,750 ton) total reduction occurred with the Buffer Strip Scenario. Reductions in soil erosion may have been even greater if more than one topographic and soil profile for the county was used. Since CRP land would have been highly erodible land, the magnitude of change in soil erosion may have been larger than estimated by this model.

Summary

The enrollment of potential cropland into CRP or as buffer strips, such as in these scenarios, reduced potential soil, nutrient, and chemical contributions to surface and groundwater. These reductions might

Table 4.57. The annual minimum, maximum, and the 15 year soil erosion of the CRP and Buffer Strip Scenarios, and change from the Base Policy Scenario.

	Soil Erosion (metric tons)		
	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
CRP Scenario			
	10,208(-3,137)	124,617(+36,150)	599,836(-176,085)
Buffer Strip Scenario			
	13,101(-244)	157,792(+2,975)	761,603(-14,318)

have been larger if the filtering effect of the buffer strips and the highly erodible classification of CRP land had been captured in the model. The widespread enrollment of land in either program did not cause a change in agricultural practices. The environmental benefits determined within this model were strictly due to reduced production activities.

Base Flexibility Policy

Base flexibility is a market oriented approach to agricultural policy which aims to restore the influence of market prices on farm production decisions through the liberalization of crop selection (McCormick and Algozin). Base flexibility allows operators with base to select crops without affecting income support levels or base acreage, unlike current provisions. Many forms of base flexibility have been proposed for the 1990 Farm Bill (Fowler; Boschwitz; Ervin; Ervin et al.). All of the proposals for base flexibility include the following factors in some form:

1. Operators may maintain base hectares eligible for commodity program benefits while choosing to plant a variety of non-program crops on flexible hectares. without program penalty.
2. Program payments are no longer tied to production yield and base hectare limitations for flexible hectares.

The expected outcome of this policy is that farmers will plant crops in response to market signals, rather than being encouraged to select only commodity crops. They also could use rotations which promote improved soil structure, use green manures, and other less chemical and nutrient intensive practices.

The environmental benefits of a base flexibility policy are anticipated to be a dislodging of existing incentives for monocultures and non-land input substitutions. On farms where operators have accumulated a large crop base relative to the remaining cropland, the maintenance of base is suspected to impede practices which can reduce chemical and nutrient applications (Ervin; Powell; Fleming). Results of a recent study estimating the reductions in potential chemical and nutrient contamination from the use of a base flexibility policy produced mixed results. Ervin et al. found that declines in the total number of hectares treated and shifts in crop mix toward crops requiring lower levels of chemical and fertilization application resulted in a national decline in chemical and nutrient use as well as leaching. However, reductions in leaching potential varied regionally. The declining chemical loading coincided with the use of hay and soybeans on flexible hectares combined with a decline in the hectares harvested. Not all areas of the country moved toward this combination.

In this study, the base flexibility policy was designed based on the most recent proposal being considered in Congress (Ervin). The following factors were included:

1. Up to 20 percent of pooled base hectares could be planted to full season soybeans.
2. Established yields for deficiency payments were frozen at the estimated 1988 yields of Richmond County.
3. Deficiency payments were maintained on the full base enrolled.
4. ARP set-aside requirements were maintained at 10 percent.
5. Base hectares were not frozen at 1989 levels.

Only full season soybeans were allowed on flexible hectares because the most recent proposal restricted the crops allowed on flexible hectares to oil-seed and industrial crops. Full season soybeans, with medium chemical budgets, were the most likely crop in these two categories to be grown in Richmond County. These constraints for base flexibility were added to the Base Scenario for a Base Flexibility Scenario.

Land Use

The base flexibility policy did not promote a move toward more low-chemical or organic activities. Activity 1, a two year corn rotation with medium chemical use, was the primary activity. All of the annual crop hectares were put into base under this scenario. This increase in base shown in Table 4.58, facilitates the largest possible amount of base flexibility hectares. The full 20 percent of base was planted annually to a medium or conventional chemical soybean activity. Corn enrollment was the most noticeable change with a 15 year total increase of 81,260 hectare (201,139 acres). A total of 187,756 crop hectares (464,743 acres) were enrolled in base over the 15 year period. Full season soybeans were planted on the base flexibility hectares independently from any rotation. The rotations in this model fixed the proportion of crops which could be grown for every hectare of cropland. For example, full season soybeans could normally not be planted without the full set of crops in the 4 year full season soybean rotation being planted in these proportions:

Table 4.58. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the Base Flexibility Scenario, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	6,172(+6,172)	6,460(+288)	93,878(+81,260)
wheat	3,394(+3,394)	3,553(+159)	51,633(+4,790)
barley	2,777(0)	2,907(+130)	42,245(+587)

.25 hectare corn,
.25 hectare full season soybeans,
.275 hectare wheat,
.225 hectare barley,
.5 hectare double cropped soybeans.Therefore in this

study, and as being proposed in Congress, the base flexibility disrupted the crop rotation schedules, instead of enhancing the use of rotations to take advantage of their reduced chemical requirements.

Labor

The total labor requirement shown in Table 4.59 was reduced by 39,543 hours from the Base Policy Scenario. Two forces produced this effect. Because more hectares were enrolled as base, more land was set-aside under the ARP requirements. In addition the full-season soybeans used on flexible hectares required less intensive labor then corn or small grains. The minimum and maximum annual labor requirements moved closer together, at 56,448 and 66,610 hours respectively.

Net Returns and NPV per hectare

After the selection of base flexibility hectares was made, the variable planting cost of the displaced corn and small grains were added back into net returns. In the model, base hectares were pooled and then 20 percent removed for base flexibility hectares, therefore the exact hectares of each crop displaced were unknown. A weighted average based on the enrolled hectares was used to calculate the production savings. The income from the removed corn and small grain harvests were also calculated and removed from the net returns. Total net return under the Base

Table 4.59. The annual minimum, maximum, and the 15 year total labor requirements the Base Flexibility Scenario, and change from the Base Policy Scenario.

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
56,448(-701)	66,610(-2,601)	883,213(-39,543)

Table 4.60. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the Base Flexibility Scenario, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
1,601,147	114,369,081	456,828,996	34,990
(+1,085,997)	(+110,782,435)	(+425,629,990)	(+32,599)

Flexibility Scenario of $456,828,996 was over 14 times greater than the total net return under the Base Policy Scenario, Table 4.60. The smallest annual net return was $1,085,997 higher than the smallest annual net return under the Base Policy Scenario. The Base Flexibility Scenario produced very attractive net returns because soybeans, a crop with higher market value and with lower costs than a complete rotation, was introduced.

Potential Pollutants

The effect of the base flexibility policy on potential nitrogen pollution was a large reduction in leaching, but only a small decrease in runoff. As shown in Table 4.61, the total nitrogen contributions to runoff were reduced by only .9 percent,or 990 kg (2,178 lb), while nitrogen leached was reduced by approximately 14 percent, 651,44 kg (1,433,177 lb). The sediment nitrogen content was unlike the other nitrogen results. Total nitrogen in sediment rose by 516,371 kg (1,130,016 lb) from the Base Policy Scenario. The substitution of a nitrogen fixing crop, such as full season soybeans, for crops requiring large applications of nitrogen, resulted in a reduction in the potential movement of nitrogen to surface and groundwater. The nitrogen content of sediment did not fit the pattern of the other nitrogen contributions.

On the other hand, chemical contributions were generally increased. Soybeans grown in Richmond County were produced using large amounts of a variety of chemicals. Only the chemicals linked to current commodity crops, such as Aatrex, were reduced, as Table 4.62 shows. The chemicals

Table 4.61. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the Base Flexibility Scenario, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,926(+39)	11,689(-8,220)	107,230(-990)

Nitrogen Content of Percolation (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
82,576(-741)	565,822(-66,917)	3,968,502(-651,444)

Nitrogen Content of Sediment (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
64,382(+15,957)	597,038(+84,379)	3,166,455(+516,371)

Table 4.62. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the Base Flexibility Scenario, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[a]	0(0)	0(-407)	0(-593)
Aatrex	62(-26)	3,376(-894)	18,618(-4,829)
Gemini[b]	11(+11)	19,968(+262)	47,013(-8,250)
Pydrin	4(+4)	5,197(+7)	10,216(-943)
Fusulade	0(0)	30,834(+14,496)	83,101(+4,283)
Roundup[a]	0(0)	91,227(+85,833)	207,545(+196,846)
Lorox[a]	0(0)	0(-2,531)	0(-4,448)
Dual	9(+9)	22,496(0)	69,900(+2,724)
Gramox.	10,081(+5,497)	160,341(+6,182)	749,982(+78,222)
Treflan	0(0)	46,235(+35,496)	153,867(+131,470)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[a]	0(0)	422(+243)	688(+259)
Aatrex	23(-5)	107,230(-32,346)	514,839(-41,128)
Gemini[c]	0(0)	158,405(+142,785)	190,542(+158,021)
Harmony	0(0)	5,021(0)	7,205(+333)
Fusulade	0(0)	2,777(+1,394)	4,772(+3,092)
Dual	0(0)	6,560(+1,064)	18,261(+4,306)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.62, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Aatrex	0(0)	4,177(-93)	9,869(+2,916)
Gemini[b]	0(0)	478(+15)	1,322(+204)
Pydrin	18(+18)	12,763(+195)	31,391(+783)
Fusulade	0(0)	2,777(+234)	8,192(+148)
Roundup[a]	695(695)	64,659(+62,058)	159,883(+154,039)
Lorox[a]	0(0)	12(-50)	12(-161)
Dual	0(0)	179(+19)	522(+69)
Gramox.	38,727(+17,454)	652,350(+88,219)	3,397,584(+622,046)
Treflan	0(0)	3,755(+ 3,228)	12,621(+ 11,816

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

used on full season soybeans were greatly increased. In runoff, the 15 year total of Roundup (glyphosate) was 207,545 g (457 lb), approximately 20 times the level which appeared in the Base Policy Scenario. Roundup is not considered a highly toxic chemical nor is it persistent, but as its concentration rises the potential for animal or human health effects increases. The leaching chemical levels shown in Table 4.62 indicate that the potential for contamination of groundwater also increased under the Base Flexibility Scenario. Four out of the five chemicals in percolation were at higher levels than under the Base Policy Scenario. Chlorimuron, the chemical in Gemini which leached, was increased to 190,542 g (419 lb), 6 times the Base Policy Scenario level. In both runoff and leaching as well as the no chemical, except Gramoxone, increased its minimum annual contribution more than 11 g (.02 lb) from the Base Policy Scenario. Gramoxone's minimum annual contribution to percolation increased by 5,497 g (12 lb). The maximum annual contributions of chemicals used on full season soybeans; such as Treflan, Gemini, Roundup, and Dual increased compared to the Base Policy Scenario. Total Aatrex levels in sediment increased by 2,916 g (6.4 lb). The total Gramoxone level in sediment rose by 622,046 g (1,368 lb) from the Base Policy Scenario; this was the greatest chemical level increase in sediment under the Base Flexibility Scenario.

Soil erosion followed the same trend as the chemical pollutants, rising over 8 percent, 64,584 metric tons (71,042 tons), from the Base Policy Scenario level. The annual minimum and maximum levels were raised by 3,258 metric tons (3,584 tons) and 9,623 metric tons (10,585 tons), as shown in Table 4.63.

Summary

Base flexibility policies have been proposed in order to free the farm operator from the restrictions of the commodity program and for its potential environmental benefits. The ability to plant oats, hay, or legumes was a critical factor in achieving any environmental benefits under this policy. With the proposed restriction to oil-seed and industrial crops, the trend will be to plant more or equally intensive crops on the available base flexibility hectares, rather than less intensive crops. In this study, full season soybeans were planted on base flexibility hectares. Nitrogen use and contributions to runoff and percolation declined due to the ability of soybeans to fix nitrogen and due to the reduced hectares planted to corn and small grains. However, chemical contributions to surface and groundwater as well as soil erosion were greatly increased. The only chemical reductions were of those chemicals used intensively by the corn, such as Aatrex. The value of a tradeoff between a reduction in the contributions of a chemical with documented hazardous health effects and the increase of numerous other slightly less toxic chemicals must be determined before a final decision is made on the value of base flexibility as it is currently proposed. Because base was not frozen at any level the farmers had the option of enrolling more land into commodity programs. If eligible base hectares were frozen the scenario results would include less flexible hectares, but

4.63. The value of and the change between the annual minimum, maximum, and the 15 year soil erosion of the Base Flexibility Scenario and the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
16,603(+3,258)	170,390(+9,623)	840,505(+64,584)

it is likely that farmers would still take advantage of as much flexible hectares as possible and plant the optional crops.

The Non-Poultry Litter Policy Scenarios

Whether or not a poultry litter market would ever develop between the grain belt of the Commonwealth and the Shenandoah Valley is a question which cannot be answered at this time. In the event that the answer turns out to be no, the policy scenarios which resulted in poultry litter use as a nutrient source would be irrelevant. Furthermore, the uncertainty surrounding the viability of a poultry litter market is enhanced by its price sensitivity. In this section therefore, most of the policy scenarios which used any poultry litter were conducted again without poultry litter available as a nutrient source. The chemical tax scenario was not redone here because that policy was designed to force farmers to organic production. That is, organic production with poultry litter, was the only option available when taxes were raised high enough to discourage all chemical use. Under this policy scenario an activity which does not use poultry litter and chemicals was not available. Complete result summaries of the non-poultry litter scenarios are found in Appendix U.

Cost-Share Without Litter Scenario

In the previous Cost-Share Scenario two activities which included a green manure were used, one being organic the other using chemicals. Both used poultry litter. In this Cost-Share Without Litter Scenario litter was removed as a nutrient source. Only one activity using green manures remained, Activity 15. Activity 15 used a two year corn/small grain-double cropped soybeans-rye/clover rotation. The rye/clover crop served as a green manure and winter cover crop. One hundred percent of the cost of the cover crop was subsidized. The chemical use in Activity 15 was based on Extension recommendations.

Land Use

Activity 15 was the primary activity in the Cost-Share Without Litter Scenario. Activity 12, a full season soybean rotation, appeared in two years. The enrollment of cropland in commodity programs was not different than the enrollment in the Base Policy Scenario. As shown in Table 4.64, a total of 12,620 hectares (31,238 acres) of corn, 46,843 hectares (115,948 acres) of wheat, and 41,658 hectares (103,114 acres) of barley were enrolled over the 15 year period. The figures in Table 4.64 are unchanged from the Base Policy Scenario because the annual rotations used were the same, except for the addition of the rye/clover green manure crop of Activity 15. Land use in the Cost-Share Scenario Without Litter was similar to that of the litter using Cost-Share Scenario, except for the appearance of the full season soybean activity and of course the absence of any activities using poultry litter. The full season soybeans rotation appeared because the of the additional cost of chemicals. The differences in the variable costs of each activity began a series of tradeoffs designed to maximize income. Tradeoff conditions were set by

Table 4.64. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	6,172(0)	12,620(+2)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

parameters such as set-aside requirements, target prices, market prices, labor requirements, and chemical requirements.

Labor

No hired labor was needed in the Cost-Share Without Litter Scenario. The minimum annual labor needed, 52,881 hours, declined by 4,268 hours from the Base Policy Scenario because of the use of Activity 12. In Activity 12, full season and double-cropped soybeans require less labor than other crops. Table 4.65 shows that the total labor required, 899,176 hours, was 23,580 hours less than that required by the Base Policy Scenario. The labor needed by the Cost-Share Scenario Without Litter over the 15 year period, was 87,111 hours less than the total hours required by the original Cost-Share Scenario. The use of an organic activity under the Cost-Share Scenario required more labor than the chemical and inorganic nitrogen based activities of the Cost-Share Without Litter Scenario.

Net Returns and NPV per hectare

The total discounted net return for the Cost-Share Without Litter Scenario was $32,549,333, an increase of $1,350,327 from the Base Policy Scenario. This increase was subsidized by the annual 100 percent cost-share of establishing a green manure crop. The annual minimum and maximum net returns, in Table 4.72, were $515,150 and $3,713,076, respectively. The net return for the 15 year period was $5,117,802 lower than the total net return realized under the Cost-Share Scenario using poultry litter.

Table 4.65. The annual minimum, maximum, and the 15 year total labor requirements the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
52,881(-4,268)	69,214(+3)	899,176(-23,580)

Table 4.66. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
515,150 (0)	3,713,076 (+126,430)	32,549,333 (+1,350,327)	2,493 (+103)

The difference in net returns between the Cost-Share Scenarios was attributable to the additional cost of chemicals. The NPV per hectare, including returns to capital and management, was \$2,493 per hectare (\$1,007 per acre), a \$103 per hectare (\$42 per acre) decrease from the Base Policy Scenario and a \$392 per hectare (\$158 per acre) decline from the original Cost-Share Scenario.

Potential Pollutants

The Cost-Share Scenario Without Litter reduced nitrogen in runoff and sediment while increasing nitrogen in percolation, as shown in Table 4.67. The green manure/winter cover crop retained moisture and nutrients, causing more leaching of nitrogen than runoff and sediment movement of nitrogen. The absence of poultry litter caused an increase in runoff and a decrease in percolation of nitrogen compared to the results of the Cost-Share Scenario using poultry litter. The minimum annual nitrogen contribution to runoff decreased by 714 kg (1,571 lb) to 1,173 kg (2,581 lb) from the Base Policy Scenario, and the maximum annual contribution declined by 7,466 kg (16,425 lb) to 12,443 kg (27,375 lb). Over the 15 year period the nitrogen contribution to runoff was 74,812 kg (164,586 lb), a 33,408 kg (73,498 lb) decline from the Base Policy Scenario. The minimum annual contribution to percolation declined by 61,099 kg (134,418 lb) but the maximum contribution rose by 188,515 kg (414,733 lb) from the Base Policy Scenario level. The total nitrogen contribution to percolation, over the 15 year period, was 5,175,887 kg (11,386,951 lb). This was a 555,941 kg (123,070 lb) increase from the nitrogen percolation

Table 4.67. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,173(-714)	12,443(-7,466)	74,812(-33,408)

Nitrogen Content of Percolation (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
22,218(-61,099)	821,254(+188,515)	5,175,887(+555,941)

Nitrogen Content of Sediment (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
24,563(-23,862)	261,307(-251,352)	1,710,157(-939,927)

of the Base Policy Scenario and a 1,810,288 kg (3,982,634 lb) decline from the level in the Cost-Share Scenario using poultry litter. The nitrogen content of sediment declined, over the 15 year period, by 939,927 kg (2,067,839 lb) from the Base Policy Scenario. The minimum and maximum annual contributions also declined to 24,563 kg (54,039 lb) and 261,307 kg (574,875 lb), respectively. Total nitrogen contributions to runoff and sediment were 9,390 kg (20,658 lb) and 324,250 kg (713,350 lb) higher in the Cost-Share Scenario Without Litter than in the original Cost-Share Scenario.

Table 4.68 shows that the contributions of chemicals to runoff, percolation, and sediment were mixed. In runoff five chemical levels were reduced, two remained about the same, and four increased from the Base Policy Scenario. Total levels of Aatrex and Gramoxone in runoff declined to 11,618 g (25 lb) and 617,727 g (1,359 lb), respectively, from their Base Policy levels due to the retention ability of the green manure crop. The 15 year totals of Blazer, Lasso, Pydrin, and Lorox in runoff increased from the Base Policy Scenario. The chemical contributions to percolation were less mixed, with most chemical levels rising from the Base Policy Scenario level. Table 4.68 shows that the level of Gemini (chlorimuron) and Fusulade declined from the Base Policy Scenario. The total amount of Gemini, the chlorimuron element specifically, declined by, 31,870 g (70 lb) to a 15 year total of 651 g (1.4 lb) in percolation. Total Aatrex percolation levels increased by the greatest amount from the Base Policy Scenario, rising 350,594 g (771 lb) to a level of 906,561 g (1,994 lb). Four of the nine chemicals found in sediment in the Cost-Share Without

Table 4.68. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[b]	0(0)	1,748(+1,341)	6,134(+5,541)
Lasso	0(0)	872(+872)	872(+872)
Aatrex	0(-88)	1,742(-2,528)	11,618(-11,829)
Gemini[a]	0(0)	1,382(-18,324)	1,583(-53,680)
Pydrin	0(0)	4,087(-1,083)	11,234(+75)
Fusulade	0(0)	23,236(+6,898)	67,776(-11,042)
Roundup[b]	0(0)	5,394(0)	10,698(-1)
Lorox	0(0)	40,634(+38,283)	86,358(+81,910)
Dual	0(0)	16,425(-6,071)	55,203(-11,973)
Gramox.	6,560(+1,976)	122,348(-31,811)	617,727(-54,033)
Treflan[b]	0(0)	10,739(0)	22,397(0)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[b]	0(0)	18,453(+18,274)	37,118(+36,689)
Aatrex	1,018(+990)	262,154(+122,584)	906,561(+350,594)
Gemini[b,c]	0(0)	407(-15,213)	651(-31,870)
Harmony	0(0)	8,517(+3,496)	11,999(-18,871)
Fusulade	0(0)	1,383(0)	1,382(-298)
Lorox	0(0)	12(+12)	24(+24)
Dual	0(0)	15,084(+9,588)	40,761(+26,806)

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[a] Linuron

[b] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[c] Chlorimuron

Table 4.68, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Aatrex	0(0)	103(-4,167)	177(-6,776)
Gemini[ab]	0(0)	45(-418)	56(+1,062)
Pydrin	0(0)	8,380(-4,188)	37,125(+4,951)
Fusulade	0(0)	2,108(+435)	8,192(+148)
Roundup[b]	0(0)	2,601(0)	5,928(+84)
Lorox	0(0)	858(+796)	2,318(+2,145)
Dual	0(0)	99(-61)	381(-72)
Gramox.	38,853(+12,580)	303,525(-260,606)	2,146,288(-629,250)
Treflan[b]	0(0)	528(-1)	805(0)

[a] Linuron

[b] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[c] Chlorimuron

Litter Scenario increased from the Base Policy Scenario. The largest increase was in the total Pydrin level which rose by 4,951 g (11 lb). The maximum annual and 15 year total contributions of Gramoxone and Aatrex declined by large amounts. The maximum annual level of Aatrex in sediment declined by 4,167 g (9 lb) and the 15 year total was 177 g (.4 lb), a 6,776 g (15 lb) decline from the Base Policy Scenario. The maximum annual and 15 year total Gramoxone levels were 303,525 g (668 lb) and 2,146,288 g (4,722 lb).

The majority of the chemical levels in percolation, runoff, and sediment were higher under the Cost-Share Scenario Without Litter than in the original Cost-Share Scenario because an organic activity could not be used in the Cost-Share Scenario Without Litter. Gramoxone and Aatrex runoff levels, over the 15 year period, were 248,063 g (546 lb) and 5,525 g (12 lb) higher, respectively, in the Cost-Share Without Litter than in the Cost-Share Scenario. The Aatrex level in percolation was 89,428 g (197 lb) higher in this scenario, with no organic activities, than in the original Cost-Share Scenario, which used organic activities. The use of green manures and winter cover crops resulted in mixed chemical and nitrogen pollution. Percolation of nitrogen and chemicals tended to increase due to the retention of moisture by the winter crop and the slow release of nitrogen by green manures at times when the crop was not actively using nitrogen.

The soil erosion under the Cost-Share Scenario Without Litter declined in every respect from the Base Policy Scenario. The minimum annual erosion was 6,369 metric tons (7,006 tons), a decline of 6,976 metric tons (7,674 tons) from the Base Policy Scenario, Table 4.69. The maximum annual erosion was 56,306 metric tons (61,937 tons) and the total over the 15 year period was 437,880 metric tons (481,668 tons), a decline of 338,041 metric tons (371,845 tons) from the Base Policy Scenario. The erosion is however, greater than that under the Cost Share Scenario, which used only poultry litter. The 85,006 metric ton (93,507 tons) erosion difference Between the Cost-Share Without Litter Scenario and the original Cost-Share Scenario was due to the infrequent use of Activity 12 which deeply plowed the soil before full season soybean planting. The green manure/winter cover crop provided resistance to soil erosion lowering the annual and 15 year total erosion from the Base Policy Scenario, which had no winter cover crop.

Summary

The Cost-Share Scenario Without Litter received the same subsidy as the original Cost-Share Scenario. Only one activity using green manures was available without litter, Activity 15. Activity 12 which included full season soybeans was used infrequently. The absence of poultry litter caused a change in activities when full season soybean prices were high. In the original Cost-Share Scenario, which used poultry litter, the full season soybeans were not as cost effective in the poultry litter based green manure activities. The Cost-Share Scenario Without Litter resulted in less nitrogen in runoff than if litter had been used. The absence of litter also prevented the use of an organic activity and therefore chemical levels in runoff and percolation were higher than under the Cost-

Table 4.69. The annual minimum, maximum, and the 15 year soil erosion of the Cost-Share Scenario Without Litter, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
6,369(-6,976)	56,306(-104,461)	437,880(-338,041)

Share Scenario. Overall, the absence of poultry litter under this policy created a situation with few production alternatives. Those activities chosen were generally caused more non-point pollution because of the additional chemicals required, when compared to the same scenario using poultry litter.

Surface Application Restrictions Without Poultry Litter.

Both the No Aatrex and the 1/3 Aatrex Scenarios were re-estimated without the use of poultry litter. The original scenarios had used the organic Activity 5L, with a two year corn/small grain-double cropped soybeans rotation, to assist in the reduction of Aatrex use. It was noted then that the intermittent use of an organic activity would not be realistic if a farmer wanted to have organic certification. In the No Aatrex Without Litter and the 1/3 Aatrex Without Litter Scenarios there were several choices including reduced Aatrex level activities and activities which did not use Aatrex at all. The organic activities were not available. With the additional restriction of no poultry litter these two scenarios became very similar, using the same activities and resulting in almost identical variable values.

Land Use

The No Aatrex Without Litter Scenario used Activity 6 almost entirely. A secondary activity, Activity 13, was used in years 4, 8, 9, and 10 when soybean prices were high. Activity 13 is a four year rotation with a season of corn replaced by full season soybeans. The less stringent surface application restriction caused a wider range of activities to be used. The 1/3 Aatrex Without Litter Scenario also used activities 6 and 13, but almost every year was split between one of these activities and a secondary activity which never covered more than 33.5 percent of the cropland available. In the 1/3 Aatrex Without Litter Scenario, activities 6 and 13 were the primary activities each year, paired with one secondary activity, such as 1,3, or 12. The primary activities, 6 and 13, did not use Aatrex. Activity 1 is the conventional activity with the two year corn/small grain-double cropped soybeans rotation and medium chemical use. Activity 3 is a low-chemical activity using the same rotation as Activity 1. Activity 12 was the same as Activity 13, except that it used Aatrex.

The enrollment of cropland in base was the same under the No Aatrex and 1/3 Aatrex Without Litter Scenarios. Table 4.70 shows that the 15 year total hectares, minimum and maximum annual hectares of corn, wheat and barley did not change from the Base Policy Scenario. The total amount of corn enrolled, 12,618 hectares (31,233 acres), was 1,574 hectares (3,896 acres) less than that enrolled under the No Aatrex Scenario and 6,644 hectares (16,445 acres) less than that enrolled under the 1/3 Aatrex Scenario. The difference in the corn enrollment under the No Aatrex Without Litter Scenario and the No Aatrex Scenario was, in part, due to the consistent use of Activity 6 as opposed to the frequent changes in activities under the original scenario.

Labor

The 1/3 Aatrex Without Litter Scenario used the most labor of the two Aatrex restriction scenarios, as shown in Table 4.71. The 1/3 Aatrex Without Litter Scenario required 907,224 hours over the 15 year period, while the No Aatrex Without Litter Scenario required 899,561 hours. The minimum annual hours required under both scenarios were the same as under the Base Policy Scenario but the maximum annual hours were less than in the Base Policy Scenario. The maximum annual hours required by the No Aatrex Without Litter Scenario was 62,749 hours, 6,462 hours less than the Base Policy Scenario, and by the 1/3 Aatrex Without Litter Scenario was 64,723 hours, 4,488 hours less than the Base Policy Scenario. The reduction in labor hours required was due to the intermittent use of Activities 12 and 13 which used less labor on a composite hectare basis than Activities 1 or 3, both of which were used in the Base Policy Scenario. Despite the increase in labor associated with the use of an inorganic source of nitrogen these labor hours were less than those under the original No Aatrex and 1/3 Aatrex Scenarios. The hours of labor required decreased by 94,115 hours in the No Aatrex Without Litter Scenario and by 63,305 hours in the 1/3 Aatrex Without Litter Scenario, from their corresponding scenarios using poultry litter. This difference was due to the absence of organic, labor intensive activities.

Table 4.70. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter			
corn	0(0)	6,172(0)	12,618(0)
wheat	0(0)	3,394(0)	46,847(+4)
barley	2,777(0)	2,777(0)	41,656(-2)
1/3 Aatrex Without Litter			
corn	0(0)	6,172(0)	12,618(0)
wheat	0(0)	3,394(0)	46,843(0)
barley	2,777(0)	2,777(0)	41,658(0)

Table 4.71. The annual minimum, maximum, and the 15 year total labor requirements the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter		
57,149(0)	62,749(-6,462)	899,561(-23,195)
1/3 Aatrex Without Litter		
57,149(0)	64,723(-4,488)	907,224(-15,532)

Net Returns and NPV per hectare

The net returns over the 15 year period were $29,417,912 and $30,050,142 for the No Aatrex and 1/3 Aatrex Without Litter Scenarios, respectively. Total net returns declined under both scenarios from the Base Policy Scenario as can be seen in Table 4.72. The loss in income was $1,781,094 in the No Aatrex Without Litter Scenario and $1,148,864 in the 1/3 Aatrex Without Litter Scenario. The NPV per hectare per hectare also decreased in these scenarios from the Base Policy Scenario. The NPV per hectare in the No Aatrex Without Litter Scenario was $2,253 and in the 1/3 Aatrex Without Litter Scenario the NPV per hectare was $2,302 per hectare. The No Aatrex Without Litter Scenario's total net return was $429,793 less than that of the No Aatrex Scenario, and the 1/3 Aatrex Without Litter Scenario's total net return was $290,831 less than that of the 1/3 Aatrex Scenario. The loss in net return in each case was attributed to the inability to selected an activity that used no chemicals. The difference in net returns was not excessive because the organic activities were used originally only as secondary activities.

Potential Pollution

In the No Aatrex Scenario the nitrogen content of runoff was 113,687 kg over the 15 year period. The 1/3 Aatrex Without Litter Scenario had a 15 year total nitrogen level of 114,691 kg (252,320 lb) in runoff, Table 4.73. These levels were 5,467 (12,0127 lb) and 6,471 kg (14,236 lb), respectively, more than the Base Policy Scenario, due to the use of

Table 4.72. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
No Aatrex			
269,504	3,458,250	29,417,912	2,253
(-245,646)	(-128,396)	(-1,781,094)	(-137)
1/3 Aatrex			
348,368	3,501,047	30,050,142	2,302
(-166,782)	(- 85,599)	(-1,148,864)	(-88)

Activity 3 in the Base Policy Scenario, which had a reduced nitrogen application budget. The total nitrogen level in percolation was 4,662,763 kg (10,258,079 lb) in the No Aatrex Without Litter Scenario, a 42,817 kg (94,197 lb) increase from the Base Policy Scenario. In the 1/3 Aatrex Without Litter Scenario the total nitrogen level in percolation was 4,580,503 kg (10,077,107 lb), a 39,443 kg (86,775 lb) reduction from the Base Policy Scenario. The minimum annual level of nitrogen percolation in each scenario was 83,317 kg (183,297 lb), the same as under the Base Policy Scenario. The maximum annual contribution were also the same 627,298 kg (1,380,056 lb), a reduction of 5,441 kg (11,970 lb) from the maximum in the Base Policy Scenario.

The 15 year total nitrogen content of sediment, as shown in Table 4.73, was 2,870,403 kg (6,314,887 lb) and 2,650,759 kg (5,831,670 lb) for the No Aatrex Without Litter and 1/3 Aatrex Without Litter Scenarios, respectively. Because the maximum annual nitrogen contribution to sediment, in the 1/3 Aatrex Without Litter Scenario decreased by 122,867 kg (270,307 lb) the total nitrogen content of sediment was only 675 kg (1,485 lb) greater than the total level of the Base Policy Scenario. The increases in nitrogen contributions to runoff, percolation, and sediment were due to activity selection, keeping in mind the Base Policy Scenario used Activity 3, a reduced nitrogen activity, intermittently.

Compared to the original Aatrex restriction scenarios, which used poultry litter activities, the nitrogen in runoff was higher, as expected from the switch to an inorganic source of nitrogen, and the percolation

Table 4.73. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter	2,777(+890)	20,220(+311)	113,687(+ 5,467)
1/3 Aatrex Without Litter	2,732(+845)	20,220(+311)	114,691(+ 6,471)

Nitrogen Content of Percolation (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter	83,317(0)	627,298(-5,441)	4,662,763(+ 42,817)
1/3 Aatrex Without Litter	83,317(0)	627,298(-5,441)	4,580,503(- 39,443)

Nitrogen Content of Sediment (kg)

	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter	52,829(+4,404)	545,945(- 33,286)	2,870,403(+220,319)
1/3 Aatrex Without Litter	52,829(+4,404)	389,792(-122,867)	2,650,759(+675)

levels were lower in the Without Litter Scenarios. Even in the No Aatrex Without Litter Scenario, where percolation rose from the Base Policy Scenario, the level of percolating nitrogen was 845,264 kg (1,859,581 lb) less than in the original No Aatrex Scenario. The differences are due to the characteristics of organic and inorganic nitrogen release and application. The sediment content of nitrogen was 137,816 kg (303,195 lb) higher in the No Aatrex Without Litter Scenario than in the original No Aatrex Scenario. The nitrogen level in sediment in the 1/3 Aatrex Without Litter Scenario was less than the original 1/3 Aatrex Scenario.

Overall, chemical levels in runoff, percolation, and sediment increased from the Base Policy Scenario, with the exception of Aatrex and Gemini. There was, of course, no Aatrex in runoff or percolation in the No Aatrex Without Litter Scenario and a reduced amount in the 1/3 Aatrex Scenario. More importantly, Table 4.74 shows there was a 15 year total of 2,164 g (5 lb) and 32,150 g (71 lb) of 2-4D in the runoff of the 1/3 Aatrex and No Aatrex Without Litter Scenarios, respectively. The appearance of 2-4D was tied to the use of Activity 13 in which the chemicals 2-4D and Bladex were used to substitute for Aatrex, according to Extension recommendations. The level of 2-4D in percolation was greater, 16,590 g (36 lb) and 26,055 g (57 lb), in the 1/3 Aatrex and No Aatrex Scenarios, respectively. Only the Fusulade level, in addition to Aatrex, in percolation was reduced either scenario. The higher chemical levels in the 1/3 Aatrex Without Litter Scenario was due to the presence of a low-chemical activity in the Base Policy Scenario. For example, total

Table 4.74. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

	Chemical Content of Runoff (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
No Aatrex Without Litter			
Blazer[a]	0(0)	2,501(+2,094)	3,772(+3,179)
Aatrex	0(-88)	0(-4,270)	0(-23,447)
Gemini[b]	0(0)	19,706(0)	42,824(-12,439)
Bladex	0(0)	2,833(+2,833)	11,377(+11,377)
Harmony	0(0)	315(+315)	315(+315)
Pydrin	11(+11)	3,166(-2,004)	15,343(+4,184)
Fusulade	0(0)	30,833(+14,495)	69,386(-9,432)
Roundup[a]	0(0)	18,603(+13,209)	31,155(+20,456)
Lorox[a]	0(0)	46,653(+44,302)	52,140(+47,652)
Dual	151(+151)	17,575(-49210)	78,450(+11,274)
Gramox.	6,782(+2,198)	105,944(-48,215)	697,014(-25,254)
Treflan[a]	0(0)	167,533(+156,794)	192,553(+170,156)
2-4D	0(0)	28,949(+28,949)	32,150(+32,150)
1/3 Aatrex Without Litter			
Blazer[a]	0(0)	2,501(+2,094)	3,554(+2,961)
Aatrex	29(-59)	1,423(-2,847)	8,186(-15,261)
Gemini[b]	13(+13)	19,706(0)	41,900(-13,363)
Bladex	0(0)	1,889(+1,889)	7,436(+7,436)
Pydrin	11(+11)	4,897(-273)	15,643(+4,484)
Fusulade	0(0)	18,603(+2,265)	85,689(+6,871)
Roundup[a]	0(0)	46,694(+41,300)	58,651(+47,952)
Lorox[a]	0(0)	11,616(+9,265)	16,769(-12,321)
Dual	101(+101)	22,057(-439)	72,403(+5,227)
Gramox.	17,709(+13,125)	167,533(+13,374)	804,121(+132,361)
Treflan[a]	0(0)	42,907(+32,168)	67,084(+44,687)
2-4D	0(0)	627(+627)	2,164(+2,164)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.74, continued.

	Chemical Content of Percolation (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
No Aatrex Without Litter			
Blazer[b]	0(0)	8,076(+7,897)	9,239(+8,810)
Aatrex	0(-28)	0(-139,570)	0(-555,967)
Gemini[c]	0(0)	15,620(0)	36,692(+4,171)
Bladex	5(+5)	21,169(+21,169)	35,429(+35,429)
Harmony	0(0)	4,704(-317)	8,648(+1,776)
Fusulade	0(0)	0(-1,383)	0(-1,680)
Lorox[a]	0(0)	6(+6)	6(+6)
Dual	0(0)	5,858(-362)	21,182(+7,227)
2-4D	0(0)	9,232(+9,232)	26,055(+26,055)
1/3 Aatrex Without Litter			
Blazer[b]	0(0)	7,973(+7,794)	8,855(+8,426)
Aatrex	9(-19)	42,123(-97,447)	164,237(-391,725)
Gemini[c]	0(0)	15,620(0)	35,445(+2,924)
Bladex	0(0)	14,112(+4,112)	23,459(+23,459)
Harmony	0(0)	4,704(-317)	7,973(+1,101)
Fusulade	0(0)	442(-941)	536(-1,144)
Lorox[a]	0(0)	4(+4)	4(+4)
Dual	0(0)	5,858(+362)	19,819(+5,864)
2-4D	0(0)	6,154(+6,154)	16,590(+16,590)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.74, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
No Aatrex Without Litter			
Blazer[a]	0(0)	12(+12)	31(+31)
Aatrex	0(0)	0(-4,270)	0(-6,953)
Gemini[b]	0(0)	463(0)	1,284(-166)
Bladex	0(0)	23(+23)	151(+151)
Pydrin	105(+105)	14,964(+2,396)	60,018(+27,844)
Fusulade	0(0)	2,777(+234)	11,279(+3,235)
Roundup[a]	0(0)	52,989(+50,388)	86,845(+81,001)
Lorox[a]	0(0)	305(+243)	822(+649)
Dual	6(+6)	154(-6)	689(+236)
Gramox.	76,419(+55,146)	853,355(+289,224)	4,273,139(+1,497,601)
Treflan[a]	0(0)	3,988(+3,461)	7,007(+6,202)
2-4D	0(0)	6(+6)	13(+13)
1/3 Aatrex Without Litter			
Blazer[a]	0(0)	12(+12)	29(+29)
Aatrex	2(+2)	1,423(-2,847)	2,425(-4,528)
Gemini[b]	0(0)	463(0)	1,110(-8)
Bladex	0(0)	15(+15)	99(+99)
Pydrin	105(+105)	14,415(+1,847)	55,928(+23,754)
Fusulade	0(0)	2,699(+156)	10,457(+2,413)
Roundup[a]	0(0)	2,601(0)	11,529(+5,685)
Lorox[a]	0(0)	305(+243)	855(+682)
Dual	4(+4)	156(-4)	557(+104)
Gramox.	76,419(+55,146)	500,606(+ 63,525)	3,593,665(+818,127)
Treflan[a]	0(0)	528(+1)	965(+160)
2-4D	0(0)	4(+4)	9(+9)

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Gramoxone levels in runoff increased by 132,361 g (291 lb) in the 1/3 Aatrex Without Litter Scenario. All chemicals increased in sediment in the No Aatrex Without Litter Scenario and 1/3 Aatrex Without Litter Scenario, except for Aatrex and Gemini (linuron). The Aatrex and Gemini 15 year total levels declined from the Base Policy Scenario by 6,953 g (15 lbs) and 166 g (.4 lb),respectively. The Gramoxone levels, of all the chemicals in sediment, increased by the largest amount, 1,497,601 g (3,295 lb) and 818,127 g (1,800 lb) in the No Aatrex and 1/3 Aatrex Without Litter Scenarios, respectively.

The original No Aatrex and 1/3 Aatrex Scenarios had much more favorable chemical levels for runoff, percolation, and sediment. Chemical levels were lower than the Base Policy Scenario levels because of the use of organic activities. In the No Aatrex and 1/3 Aatrex Without Litter Scenarios no zero chemical levels were available except for a the targeted chemical, Aatrex. The realism of using an organic activity intermittently, as in the original No Aatrex and 1/3 Aatrex Scenarios, has been questioned. However, in this model it is possible that the intermittent use of an organic activity could be seen as a tendency toward organic production use by a small number of farmers in the entire county. The results of this model do not portray this situation exactly, but the results indicate that further research is needed to measuring how large of an effect in chemical and nitrogen pollution the use of organic activities by a limited number of farmers can make on an entire watershed's water quality. The absence of any poultry litter or organic activities under these restrictions resulted in better nitrogen management but generally increased chemical pollution levels. The question of whether 2-4D at these levels was worse than Aatrex at its former levels is unknown.

The total soil erosion was nearly the same for both the No Aatrex and 1/3 Aatrex Without Litter Scenarios, 837,490 metric tons (921,239 tons) and 820,667 metric tons (902,734 tons), respectively. These figures are shown in Table 4.75 to be 61,569 metric tons (67,726 tons) and 44,746 metric tons (49,221 tons) greater then the levels in the Base Policy Scenario for the No Aatrex and 1/3 Aatrex Without Litter Scenarios, respectively. The minimum and maximum annual erosion contributions were the same for both Without Litter Scenarios, 15,522 metric tons (17,074 tons) and 171,001 metric tons(188,101 tons), respectively. The soil erosion of the original No Aatrex and 1/3 Aatrex Scenarios was only slightly less, on an annual basis, than the erosion under the No Aatrex and 1/3 Aatrex Without Litter Scenarios.

Summary

The land use in the No Aatrex and 1/3 Aatrex Without Litter Scenarios was similar to that of the original No Aatrex and 1/3 Aatrex Scenarios, except for the absence of the organic activity 5L, and less use of the low-chemical Activity 3. Chemical pollution was not necessarily less under the No Aatrex and 1/3 Aatrex Scenarios. Reductions in Aatrex loadings were accompanied by the introduction of 2-4D and Bladex, as well as increases in many other chemicals. The level and toxicity of each chemical would have to be weighed and the final concentrations estimated

Table 4.75. The annual minimum, maximum, and the 15 year soil erosion of the No Aatrex and 1/3 Aatrex Without Litter Scenarios, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
No Aatrex Without Litter		
15,522(+2,177)	171,001(+10,234)	837,490(+61,569)
1/3 Aatrex Without Litter		
15,522(+2,177)	171,001(+10,234)	820,667(+44,746)

before one scenario could be designated more harmful than another. The nitrogen and erosion contributions were increased from the Base Policy Scenario. However, nitrogen management was overall better with the absence of litter than with litter. The No Aatrex and 1/3 Aatrex Without Litter Scenarios were very limited in their protection of the environment because chemicals were present in every available activity and because the removal or restriction of Aatrex caused the substitution of possibly more dangerous types and amounts of other chemicals.

Loadings Restriction Without Litter Scenarios

The prevention of the use of poultry litter was expected to have a similar, although less pronounced, effect on the loading restriction scenarios as on the surface restriction scenarios. The original 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios used very little poultry litter. The 40% Percolation Reduction Scenario used poultry litter in only 1 year; the 40% Percolation/Runoff Scenario used litter in 2 years. The organic activity 5L was used infrequently in order to meet the loading restrictions. The ability to use an activity with no chemicals allowed more freedom in other years to use activities with chemicals in large amounts. The dependency of each year upon the other for base enrollment, nitrogen carryover, and pollution loadings caused more changes in the activity selection than just the removal of activity 5L in the reduction scenarios without litter. The results of the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Without Litter Scenarios were the same except for rounding errors. Only one set of values, those of the 40% Percolation Reduction Without Litter Scenario, are presented in the text and tables.

Land Use

The 40% Percolation Reduction Without Litter Scenario used such a variety of activities that a primary activity was not determined. Activity 1 and Activity 6 each appeared in four years as the rotation covering the most cropland. Activity 1 is the conventional two year corn/small grain-double cropped soybeans rotation with medium chemicals use. Activity 6 used the same rotation under a chemical budget with no Aatrex. The next most frequently used activity was 3, a low-chemical activity. The other activities included 2, 10, 12, 13, and 14.

The most significant land use change was the presence of idled hectares. Cropland was idled in several years in order to meet the chemical loading restrictions. Since the restrictions were not annual but over the 15 year period the model was free to select years where the idled hectares would lose the least amount of income for the operator. Idled hectares were not needed under the original 40% Reduction Scenarios because an organic activity could be selected in those years where it would cause the most reduction in pollution loadings. In these scenarios, without litter, the same decision was made but idled hectares was the only alternative to completely remove chemical use. In year five, 9,655 hectares (23,898 acres) were idled; in year eight, 2,780 hectares (6,881 acres) were idled; and in year ten, 4,850 hectares (12,005 acres) were idled. This loss of hectares caused some disruption in the base enrollment figures, relative to the base policy scenario.

Table 4.76 shows that enrollment of crops into the commodity programs changed from the Base Policy Scenario. Corn enrollment increased by 1,574 hectares (3,896 acres) over the 15 year period from the Base Policy Scenario, while wheat and barley enrollment decreased by 10,272 and 9,365 hectares (25,426 acres and 23,181 acres), respectively. Barley enrollment fluctuated for the first time in any scenario, with the minimum annual enrollment falling to 605 hectares (1,498 acres) in year five. These fluctuations caused limited enrollment later in the 15 year period when base hectares were needed but could not be enrolled because of the moving five year average. The minimum annual enrollments for both wheat and barley occurred in the year with the largest amount of idled hectares. This was a very different enrollment schedule then the enrollment schedule of the 40% Reduction Scenario using poultry litter. Under the original loading restriction scenarios base enrollment did not vary from the levels under the Base Policy Scenario, except for an increase in corn enrollment under the more restrictive 40% Percolation/Runoff Reduction Scenario.

Labor

Labor was hired under the loading restriction scenarios, without litter. Additional labor was required in years 6, 7, and 14. In these years the low-chemical activity 3 was used on the majority of cropland. Activity 3 is a reduced chemical activity and was therefore more labor

Table 4.76. The annual minimum, maximum, and the 15 year total crop hectares enrolled in the federal commodity program in the 40% Percolation Reduction Without Litter Scenario, and change from the Base Policy Scenario.

	Base Enrolled Hectares		
Crop	Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
corn	0(0)	6,172(0)	14,192(+1,574)
wheat	0(0)	3,394(0)	36,571(-10,272)
barley	605(-2,172)	2,777(0)	32,293(- 9,365)

intensive than either Activity 1 or 6. Labor and machinery was substituted for chemicals in weed control practices. The amount of labor purchased was 72,391, 78,889, and 92,038 hours in years 3, 7, and 14, respectively. As shown in Table 4.77, the total amount of labor required over the 15 year period was 1,415,494 hours, a 492,738 hour increase from the Base Policy Scenario. The minimum annual hours required decreased by 43,841 hours because of the idled land. The maximum annual hours increased by 178,962 hours due to the low-chemical activity. Compared to the 40% Percolation Reduction Scenario with poultry litter, the total required hours were 92,160 hours more under the 40% Percolation Reduction Without Litter Scenario. To get potential pollution results similar to those obtained with an organic activity, the 40% Percolation Reduction Without Litter Scenario used the low-chemical activity more often than the 40% Percolation Reduction Scenario had used the organic activity. This resulted in higher labor requirements.

Net Returns and NPV per hectare

The total discounted net return was $25,984,184 in the 40% Percolation Reduction Without Litter Scenario, as shown in Table 4.78. This was a $5,214,822 decrease from the net return level of the Base the Policy Scenario. The minimum annual net return fell to $129,881 and maximum annual net return decreased by $128,396 to $3,458,250. Interestingly, the years with idled cropland did not have the lowest annual net returns. The lowest annual net returns were caused by yield penalties on the low-chemical activity. The NPV per hectare decreased by

Table 4.77. The annual minimum, maximum, and the 15 year total labor requirements the 40% Percolation Reduction Without Litter Scenario, and change from the Base Policy Scenario.

Hours of Labor		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
13,308(-43,841)	248,173(+178,962)	1,415,494(+492,738)

$400 per hectare ($162 per acre) from the Base Policy Scenario. The net return figures were exactly the same for the 40% Percolation/Runoff Reduction Without Litter Scenario. The total net returns over the 15 year period in the original 40% Percolation Scenario was $3,506,203 more than that of the 40% Percolation Reduction Without Litter Scenario. The increased use of a low-chemical activity with yield penalties and the appearance of idled hectares combined to reduce the net return in the 40% Percolation and 40% Percolation/Runoff Without Litter Scenarios.

Potential Pollutants

The conversion from poultry litter to inorganic nitrogen and the use of a low-chemical activity combined to reduce the nitrogen content of runoff, percolation, and sediment, as shown in Table 4.79. The minimum and maximum annual nitrogen contributions to runoff were 1,075 kg (2,365 lb) and 11,679 kg (25,694 lb), respectively. The total over the 15 year period was 89,417 kg (196,717 lb), 18,803 kg (41,367 lb) less than the level in the Base Policy Scenario. The reduction in runoff nitrogen was cause by the use of low-chemical (low-nitrogen) activities and idled hectares. The total amount of nitrogen found in percolation over the 15 year period was 4,352,206 kg (9,574,853 lb) which was 267,740 kg (589,028 lb) less than that of the Base Policy Scenario. The minimum and maximum annual contributions to percolation were decreased by 57,382 (126,240 lb) and 5,441 kg (11,970 lb), respectively, from the Base Policy Scenario.

Table 4.78. The annual minimum, maximum, and the 15 year total net returns and NPV per hectare of the 40% Percolation Reduction Without Litter Scenario, and change from the Base Policy Scenario.

Net Returns (1988 Dollars)			
Annual Minimum (Change)	Annual Maximum (Change)	15 year Total (Change)	**Net Present Value ($/ha)** (Change)
129,881 (-385,269)	3,458,250 (-128,396)	25,984,184 (-5,214,822)	1,990 (-400)

Table 4.79. The annual minimum, maximum, and the 15 year nitrogen content of runoff, percolation, and sediment of the 40% Percolation Reduction Without Litter, and change from the Base Policy Scenario.

Nitrogen Content of Runoff (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
1,075(-812)	11,679(-8,230)	89,417(-18,803)

Nitrogen Content of Percolation (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
25,935(-57,382)	627,298(- 5,441)	4,352,206(-267,740)

Nitrogen Content of Sediment (kg)

Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
52,829(+4,404)	307,864(-204,795)	2,139,263(-510,821)

The change in percolation loadings was attributed, in part, to the use of an inorganic source of nitrogen rather than poultry litter. The slow release of poultry litter often occurs when plants do not need nitrogen and is usually leached, whereas inorganic nitrogen is in a highly soluble form and is more likely to be carried off the field in runoff before it has a chance to leach. Although the minimum annual nitrogen contribution to sediment rose by 4,404 kg (9,689 lb) from the Base Policy Scenario, the 15 year total of nitrogen in sediment declined by 510,821 kg (1,123,806 lb) to 2,139,263 kg (4,706,379 lb). The decline of nitrogen in sediment was due to the idled hectares required to met the chemical loading constraint and the use of low-nitrogen activities.

The 15 year total percolation, runoff and sediment levels of nitrogen were lower under the 40% Percolation Reduction Without Litter Scenario than in the 40% Percolation Reduction Scenario, which used poultry litter. The reduction from the original levels in the 40% Percolation Reduction Scenario were 20,944 kg (46,077 lb), 1,629,758 kg (3,585,468 lb), and 540,449 kg (1,188,988 lb) for runoff, percolation, and sediment, respectively. The cause of these reductions included a mixture of low-nitrogen activities, idled acreage, and the conversion from poultry litter to inorganic nitrogen.

Chemical loadings of those chemicals present under the Base Policy Scenario were reduced by, at least, the required 40 percent. Although the 40% Percolation/Runoff Without Litter Scenario was more severe, affecting both surface and groundwater loading, the chemical reductions were the same. This can be in part attributed to the use of Aatrex, which when restricted was the limiting factor in terms of the remaining activity choices. In order to meet the Aatrex reduction in percolation, along with the other reductions, the model was forced to reduced surface loadings. The largest reductions came from the largest contributors under the Base Policy Scenario, Gramoxone, Fusulade, Dual, and Gemini in runoff; Aatrex, and Gemini (chlorimuron) in percolation; and Gramoxone, Aatrex, and Pydrin in sediment. In runoff, percolation, and sediment there were 3 chemicals not found in the Base Policy Scenario. The chemicals were Lasso, Lorox, 2-4D, and Bladex, as shown in Table 4.80. Gramoxone was found in runoff at the highest total level, 543,019 g (1,195 lb), among the chemicals in runoff, despite a 128,741 g (283 lb) decrease from the Base Policy Scenario. The Aatrex level in runoff was reduced by 9,377 g (21 lb) from the Base Policy Scenario. The 15 year total level of Aatrex was the highest in percolation, at 303,103 g (667 lb), a 252,864 g (556 lb) decrease from the Base Policy Scenario. 2-4D levels were not the highest of the three new chemicals in percolation, Bladex at 25,581 g (56 lb), over the 15 year period, was the highest. The total 2-4D level in percolation was 16,018 g (35 lb) for the 15 year period. Overall the reduction in percolating chemical levels was greater than increase from the introduction of new chemicals. Safety levels for drinking, recreational use, or for wildlife habitat have not been determined. The level of Bladex in leaching was high but not as high as Aatrex levels, even after a 40 percent reduction. Table 4.79 shows that 9 of the 12 chemicals found in sediment were at lower levels than in the Base Policy

Table 4.80. The annual minimum, maximum, and the 15 year chemical content of runoff, percolation, and sediment of the 40% Percolation Reduction Without Litter Scenario, and change from the Base Policy Scenario.

Chemical Content of Runoff (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[a]	0(0)	221(+186)	356(-237)
Lasso[a]	0(0)	1,538(+1,538)	1,871(+1,871)
Aatrex	0(-88)	3,137(-1,133)	14,070(-9,377)
Gemini[b]	0(0)	19,706(0)	33,154(-22,109)
Bladex	0(0)	2,833(+2,833)	5,084(+5,084)
Pydrin	0(0)	2,721(-2,449)	6,695(-4,464)
Fusulade	0(0)	14,096(-2,242)	47,291(-31,527)
Roundup[a]	0(0)	2,930(-2,464)	6,419(-4,280)
Lorox[a]	0(0)	2,077(-274)	4,529(+81)
Dual	0(0)	17,574(-4,922)	37,865(-29,311)
Gramox.	10,491(+5,907)	105,944(-48,215)	543,019(-128,741)
Treflan[a]	0(0)	5,833(-4,906)	11,357(- 11,040)
2-4D	0(0)	664(+664)	1,056(+1,056)

Chemical Content of Percolation (g)

Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Blazer[a]	0(0)	130(-49)	258(-171)
Lasso[a]	0(0)	101(+101)	110(+110)
Aatrex	0(-28)	70,219(-69,351)	303,103(-252,864)
Gemini[c]	0(0)	4,453(-11,167)	13,588(-18,933)
Bladex	0(0)	18,009(+18,009)	25,581(+25,581)
Harmony	0(0)	2,642(-2,379)	3,934(-2,938)
Fusulade	0(0)	941(-442)	1,008(-672)
Dual	0(0)	4,599(-897)	9,209(-4,746)
2-4D	0(0)	9,232(+9,232)	16,018(+16,018)

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[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Table 4.79, continued.

	Chemical Content of Sediment (g)		
Chemical	Annual Minimum(Change)	Annual Maximum(Change)	Annual Total(Change)
Lasso[a]	0(0)	6(+6)	15(+15)
Aatrex	0(0)	1,273(-2,997)	2,966(-3,987)
Gemini[b]	0(0)	463(0)	917(-201)
Bladex	0(0)	23(+23)	55(+55)
Pydrin	0(0)	8,052(-4,516)	28,463(-3,711)
Fusulade	0(0)	2,050(-493)	6,509(-1,535)
Roundup[a]	0(0)	1,230(+1,371)	3,176(-2,668)
Lorox[a]	0(0)	58(-4)	201(-28)
Dual	0(0)	110(-50)	232(-221)
Gramox.	40,344(-19,071)	483,303(-80,828)	2,567,049(-208,489)
Treflan[a]	0(0)	287(-240)	558(-247)
2-4D	0(0)	6(+6)	6(+6)

[a] These chemicals are used by secondary activities only. Secondary activities did not appear in every year.

[b] Linuron

[c] Chlorimuron

Scenario. The total Gramoxone levels, over the 15 year period, in sediment decreased by 208,489 g (459 lb), Aatrex decreased by 3,987 g (9 lb), and total Pydrin levels decreased by 3,711 g (8 lb). The chemicals 2-4D, Lasso, and Bladex were found in sediment at low levels. These new chemicals, introduced to replace Aatrex, were the only chemicals found in sediment at higher rates than in the Base Policy Scenario.

The 40% Percolation Reduction Without Litter Scenario achieved the same results as the 40% Percolation/Runoff Reduction Without Litter Scenario. Both resulted in reductions in the majority of chemicals and in nitrogen loadings. The loading restrictions, without litter, appeared to give the best potential protection for groundwater and surface water quality. Some of the reduction in nitrogen and chemical loading was, however, attributed to cropland idled in order to meet the restrictions. Compared to the original 40% Percolation Reduction Scenario the 40% Percolation Reduction Without Litter Scenario exceeds the original chemical and nitrogen reductions. Overall this scenario benefitted from the removal of poultry litter, unlike the other non-poultry litter policy scenarios whose impacts were less clear-cut with the removal of poultry litter.

The minimum and maximum annual soil erosion were 12,766 metric tons (14,043 tons) and 113,555 metric tons (124,910 tons), respectively. The total erosion contribution for the 15 year period was 618,672 metric tons (680,539 tons), as shown in Table 4.81. This total erosion contribution benefitted from the idled hectares so that the total was a decline of 157,249 metric tons (172,974 tons) from the erosion level of the Base

Policy Scenario. The soil erosion of the 40% Percolation Reduction Without Litter Scenario was also less than that of the original 40%Percolation Reduction Scenario, which used more cultivations under the organic activity than the low-chemical activity used.

Summary

Overall, the 40% Percolation Reduction Without Litter Scenario performed the best of the No Litter Policy Scenarios. Since the results were the same for the less restrictive scenario and the more restrictive, 40% Percolation/Runoff Without Litter Scenario, the less restrictive one would be selected based on reduced administrative costs and enforcement time. The 40% Percolation Reduction Without Litter Scenario did present the possibility of idling sections of land in order to meet watershed loading restrictions. An administrative problem would be deciding how the idled land is to be distributed within the county. Following the pattern of the Conservation Reserve Program and state groundwater regulations, the land most eligible for this role would be that land most susceptible to erosion, runoff, leaching, and land serving as a recharge area for aquifers. Designating these areas has been too expensive a groundwater strategy for many states (Batie, Cox, and Diebel).

Summary

The re-estimation of those policy scenarios which used poultry litter activities revealed several issues. First, this process has emphasized the tradeoffs between runoff and percolation of nitrogen

Table 4.81. The annual minimum, maximum, and the 15 year soil erosion of the 40% Percolation Reduction Without Litter Scenario, and change from the Base Policy Scenario.

Soil Erosion (metric tons)		
Annual Minimum(Change)	Annual Maximum(Change)	15 year Total(Change)
40% Percolation Reduction Without Litter		
12,766(-579)	113,555(-47,212)	618,672(-157,249)

depending on the source of nitrogen. Poultry litter leached worse than inorganic nitrogen and inorganic nitrogen was found in runoff in larger amounts than nitrogen from litter. Second, the absence of any activity which does not use chemicals but uses inorganic nitrogen severely limited the selection process of these scenarios. However, realistically there may be few farmers which would turn to completely organic activities when chemicals are restricted. With the consistent use of chemicals several of these policies did not appear to have as many environmental benefits as when they included the intermittent use of organic activities. The interpretation of chemical levels in runoff, percolation, and sediment was not as clear as in the scenarios using poultry litter. The surface application restrictions, in particular, did not appear to be better policies than the loading restrictions. The loading restrictions without litter were better environmental protection scenarios than when evaluated with the use of poultry litter.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Summary of Methods and Results

Groundwater provides half of the United States drinking water. Until recently, the contamination of groundwater by surface activities was well hidden under layers of rock and soil. Since the 1970s, evidence of contaminated groundwater has been increasing; among the many sources of contaminants is the agricultural use of chemicals. The management of agrichemical contributions is a complex issue because agricultural sources are non-point, the pollution potential of agrichemicals are site specific, monitoring and testing are expensive, the health implications are uncertain, and farm operators resist regulation of their practices. These special problems require an innovative solution, such as the adoption of Low-Input Agriculture to reduce agrichemical contributions.

Low-Input Agriculture includes a spectrum of practices which reduce the direct or indirect use of petroleum and petroleum-based inputs relative to conventional agriculture. LIA, in this study, is a set of tools from which farmers can select practices which may improve their current situation. LIA as described does not reflect a different philosophy of life. Many farmers realize the environmental benefits of LIA but perceive barriers which prevent their adoption of LIA. One barrier is agricultural and natural resource policies. This study analyzed the potential effectiveness of both agricultural and natural resource policies to promote LIA and to reduce nitrogen and chemical contributions to surface water, groundwater, nitrogen and chemicals in sediment, and soil erosion. The study was conducted in a case study area.

The identification of barriers to LIA adoption and the analysis of the environmental effects of LIA adoption are well suited to a case study approach. Richmond County, Virginia, located in the Northern Neck of Virginia, was selected as the case study area. Richmond County is a cash grain farming area where chemicals are considered necessary for production by many operators. The county also encompasses several major tributaries of the Chesapeake Bay and is situated above the Columbia aquifer which seeps into the tributaries and the Chesapeake Bay.

Identification of Conventional Farming Practices

A personal survey of thirty Richmond County farm operators was conducted in the summer of 1989 to collect general agronomic practice information (VPI & SU, Dept. of Agric. Economics). The information assisted in identifying farming practices of Richmond County farmers , the first objective of this study. Based on this information four primary crop rotations emerged: (1) corn/small grain-double cropped soybeans (2 years), (2) corn/small grain-double cropped soybeans/full season soybeans/small grain-double cropped soybeans (4 years), (3) corn/small grain-double cropped soybeans-rye (2 years), and (4) corn/small grain-double cropped soybeans-rye and clover (2 years). The amount of chemicals used on each of these rotations were classified as moderate and farmers tended to follow Extension Service recommendations. The majority of chemicals used were herbicides. Only three operators were classified as low-input farmers.

Identification of Barriers to LIA Adoption

In order to identify what barriers may have kept operators from adopting LIA, an extensive search of current literature on the possible barriers to LIA and published surveys of farmers opinions toward LIA was conducted. The literature search added to the information gathered through the results of the Richmond County survey. Identification of barriers was the second objective of this study. Two immediate forces were found to be influencing LIA adoption: (1) the current agricultural structure and (2) the adoption process itself. Current agricultural structure supports a concentrated farming sector, large farm sizes, the substitution of capital for labor, and significant absentee ownership. This is the setting into which LIA has been introduced for adoption and the setting which proponents of LISA expect it to change. LIA was considered to be similar to all other innovations and subject to a temporal process of adoption influenced by characteristics of the innovation and the adopter. LIA's characteristics of relative advantage, compatibility, complexity, trialability, and observability gave a mixture of impediments and complements for the adoption of LIA. Relative advantage, in terms of profits, was the most frequently studied attribute of LIA. Perceptions of decreased yields, increased variable costs, increased labor costs, and reduced net returns were the larger immediate barriers identified.

These immediate forces acting upon LIA adoption were determined to be influenced, in turn, by more "global" forces of education, ethics, as well as tax, agriculture, and resource policies. It was these global forces which were determined to have the greatest influence on LIA adoption and therefore needed more explicit attention upon their direct and indirect relationships with LIA adoption. Agriculture and natural resource policies were identified as the forces most frequently manipulated by federal and state policy-makers to change agricultural practices and control environmental pollution, the goals of LIA. To determine the importance of agricultural and natural resource policies on LIA adoption and consequent effectiveness of controlling groundwater contamination, an economic model was constructed in which producers selected between conventional and a variety of LIA practices.

Identification of Potential LIA Practices

Identification of potential LIA practices for Richmond County, Virginia, was the third objective of this study. Thirty-four activities were constructed using the four initial rotations identified by the Richmond County survey and were included in a mathematical programming model. In the model, different fertilization rates, chemical types and application rates, nitrogen sources, and non-weed control practices were added to the initial rotations. The advice of the Richmond County Farm Management Extension Agent and a Cooperative Extension Service weed specialist were used in the construction of the model's activities. The production activities are summarized in Table 5.1. An activity having the

Table 5.1. Summary description of the cropping activities available in the mathematical model[a].

Production Activities[b]	**Crop Rotation**[c]	**Special Characteristics**
1	C/SG-DC(2 yr)	med. chemicals/nutrients
1L	"	med. chemicals/nutrients poultry litter
2	"	high chemicals/nutrients
2L	"	high chemicals/nutrients poultry litter
3	"	low-chemicals/nutrients
3L	"	low-chemicals/nutrients poultry litter
4	"	med. chemicals/nutrients split nitrogen application
5L	"	no chemicals poultry litter
6	"	no Aatrex
6L	"	no Aatrex poultry litter
7	"	no Dual(metolachlor)
7L	"	no Dual poultry litter
17	"	no Gramoxone(paraquat)
17L	"	no Gramoxone poultry litter
8	C/SG-DC-RYE(2 yr)	med. chemicals/nutrients mowed rye
8L	"	med. chemicals/nutrients mowed rye poultry litter
9	"	no Aatrex(atrazine) mowed rye
9L	"	no Aatrex mowed rye poultry litter

[a] See Appendix B.1 for more a detailed description.

[b] A suffix "L" indicates poultry litter is the source of nitrogen.

[c] C=corn, SG=small grains (wheat and barley), DC=double-cropped soybeans, FS=full season soybeans, MIX=rye and crimson clover.

Table 5.1, continued.

Production Activities[b]	Crop Rotation[c]	Special Characteristics
10	"	no Dual mowed rye
10L	"	no Dual mowed rye poultry litter
11L	"	no chemicals mowed rye poultry litter
18	"	no Gramoxone mowed rye
18L	"	no Gramoxone mowed rye poultry litter
12	C/SG-DC/FS/SG-DC(4 yr)	med. chemicals
12L	" poultry litter	med. chemicals
13	"	no Aatrex
13L	"	no Aatrex poultry litter
14	"	no Dual
14L	"	no Dual poultry litter
19	"	no Gramoxone
19L	"	no Gramoxone poultry litter
15	C/SG-DC-MIX(2yr)	med. chemicals/nutrients clover/rye plowed under
15L	"	med. chemicals/nutrients clover/rye plowed under poultry litter
16L	"	no chemicals clover/rye plowed under poultry litter

[b] A suffix "L" indicates poultry litter is the source of nitrogen.

[c] C=corn, SG=small grains(wheat and barley), DC=double-cropped soybeans, FS=full season soybeans, MIX= rye and crimson clover.

suffix L used poultry litter, shipped from the Shenandoah Valley, as its source of nitrogen. The number of an activity indicates a crop rotation and attendant chemical and nutrient regimes. Therefore activities 1 and 1L were the same except 1L used poultry litter as an organic source of nitrogen whereas 1 used commercial nitrogen fertilizer. The notation 1(L) indicates both activities 1 and 1L. There were three organic activities: 5L, 11L, and 16L.

Potential Chemical and Nitrogen Pollution

To complete Objective 4, to obtain information on chemical and nitrogen loading of groundwater from the production activities, the results of Davis were used. Davis used two simulation models: CREAMS (Chemical, Runoff, and Erosion from Agricultural Management Systems) and GLEAMS (Groundwater Loading Effects of Agricultural Management Systems). A mass balance approach to the estimation of chemical loading was facilitated by the ability of these two models to account for virtually every dispersal path of chemicals and nitrogen. Simulation was over the 1970 through 1985 weather period, using hydrological, topographical, and soil profiles from Richmond County. Four major paths of non-point pollution were selected for use in this study: surface runoff, percolation, sediment content, and soil erosion. Percolation provides potential groundwater contaminants. The other three non-point estimates were included because of their direct relationship with water quality and

possible indirect relationships with the level of chemicals in groundwater. The Chesapeake Bay is a potential depository for all four paths. Tradeoffs between the contaminant levels of each path under different policies were analyzed based on these loading estimates.
The loading estimates were then incorporated into the mathematical programming model.

Estimation of Profitable Production Practices

Estimation of profitable practices for Richmond County, Objective 5, was completed using a multi-period, nonlinear mathematical programming model. The mathematical programming model in this study contained 4,745 equations and 6,976 variables. There were 180 nonlinear equations which calculated the moving average of yield and base hectares. The model accounted for several dynamic aspects of production activities, including nitrogen and chemical residue carry-over, as well as the dynamic aspects of base and yield calculations under the federal commodity programs. The objective of the model was the maximization of net returns over variable costs for a 15 year period, starting in 1988, using a 6 percent discount rate. The model produced a post-transition analysis of production choices. A summary of the 33 scenarios analyzed under this objective is contained in Table 5.2. An initial estimation of five general scenarios provided a basic profile of profitability and chemical and nitrogen contributions against which the other four scenarios were rated. The set of activities available did not vary by yields; the possibility of yield penalties was introduced through sensitivity analysis.

Table 5.2. A summary of the scenarios analyzed by the mathematical programming model developed in Chapter 3.

SCENARIO	RESIDUE NITROGEN[a]	LITTER[a]	ALL ACTIVITIES[a]	PRODUCTION, AND AGRICULTURAL AND NATURAL RESOURCE POLICY MODIFICATIONS
<u>FIVE GENERAL SCENARIOS</u>				
CURRENT PRACTICES	0	0	0	ONLY ACTIVITY 3t
NO LITTER	0	0	X	NONE
NO LITTER-X	X	0	X	NONE
UNRESTRICTED	0	X	X	NONE
UNRESTRICTED-X	X	X	X	NONE
<u>SENSITIVITY ANALYSIS OF ORGANIC AND Low-chemical ACTIVITIES</u> (USING UNRESTRICTED AND UNRESTRICTED-X SCENARIOS)				
LITTER PRICE	0	X	X	PRICE OF LITTER RAISED BY 30 PERCENT
LITTER PRICE-X	X	X	X	PRICE OF LITTER RAISED BY 30 PERCENT
REDUCED YIELD-A	0	X	X	ORGANIC YIELDS DROPPED A5tL 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-XA	X	X	X	ORGANIC YIELDS DROPPED A5tL 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-B	0	X	X	ORGANIC AND Low-chemical YIELDS DROPPED A5tL, A3t(L) 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-XB	X	X	X	ORGANIC AND Low-chemical YIELDS DROPPED A5tL, A3t(L) 20% DROP CORN AND SOYBEAN A11tL, A16tL DROP 20% CORN AND 25% SOYBEAN
REDUCED YIELD-C	0	X	X	ORGANIC AND Low-chemical YIELDS DROPPED NOT IN SOLUTION,40% DROP
REDUCED YIELD-XC	X	X	X	ORGANIC AND Low-chemical YIELDS DROPPED UNTIL NOT IN SOLUTION,40% DROP
OPERATOR LABOR-X	X	X	X	AVAILABLE OPERATOR LABOR REDUCED UNTIL NOT IN SOLUTION, NO CRITICAL VALUE
LABOR REQ.	0	X	X	LABOR REQUIREMENTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES RAISED NOT IN SOLUTION,
LABOR REQ.-X	X	X	X	LABOR REQUIREMENTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES RAISED NOT IN SOLUTION,
VARIABLE COST	0	X	X	VARIABLE COSTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES NOT IN SOLUTION,
VARIABLE COST-X	X	X	X	VARIABLE COSTS OF ORGANIC AND LOW-CHEMICAL ACTIVITIES NOT IN SOLUTION,

[a] An "X" indicates that the option was applied to the scenario, a "0" indicates that the option was not applied to the scenario.

Table 5.2, continued.

SCENARIO	RESIDUE NITROGEN[a]	LITTER[a]	ALL ACTIVITIES[a]	PRODUCTION, AND AGRICULTURAL AND NATURAL RESOURCE POLICY MODIFICATIONS
POLICY ANALYSIS WITH POULTRY LITTER (USING THE BASE POLICY SCENARIO)				
BASE POLICY	X	X	X	10% LABOR REQUIREMENT PENALTY, YIELD PENALTIES OF THE REDUCED YIELD-B SCENARIO, LITTER PRICE OF LITTER PRICE-X SCENARIO
COST-SHARE	X	X	X	100 % COST-SHARE OF ANNUAL GREEN MANURE ESTABLISHMENT COSTS
NO AATREX	X	X	X	NO AATREX USED IN PRODUCTION
1/3 AATREX	X	X	X	AATREX USE REDUCED BY 1/3
CHEMICAL TAXATION	X	X	X	CHEMICALS TAXED BY 300 PERCENT
40% PERCOLATION REDUCTION	X	X	X	PERCOLATION CHEMICAL LOADINGS REDUCED BY 40%
40% PERCOLATION/ RUNOFF REDUCTION	X	X	X	PERCOLATION AND RUNOFF CHEMICAL LOADINGS REDUCED BY 40%
CRP	X	X	X	ALL ELIGIBLE LAND ENROLLED IN CRP
BUFFER STRIP	X	X	X	MAXIMUM REQUIRED AREA PUT UNTO BUFFER STRIP
BASE FLEXIBILITY	X	X	X	20% OF BASE PLANTED IN FULL SEASON SOYBEANS
POLICY ANALYSIS WITHOUT POULTRY LITTER (USING THE BASE POLICY SCENARIO)				
COST-SHARE	X	0	X	100 % COST-SHARE OF ANNUAL GREEN MANURE ESTABLISHMENT COSTS
NO AATREX	X	0	X	NO AATREX USED IN PRODUCTION
1/3 AATREX	X	0	X	AATREX USE REDUCED BY 1/3
40% PERCOLATION REDUCTION	X	0	X	PERCOLATION CHEMICAL LOADINGS REDUCED BY 40%
40% PERCOLATION/ RUNOFF REDUCTION	X	0	X	PERCOLATION AND RUNOFF CHEMICAL LOADINGS REDUCED BY 40%

[a] An "X" indicates that the option was applied to the scenario, a "0" indicates that the option was not applied to the scenario.

Five General Scenarios

Table 5.3 compares the results of the five general scenarios which were optimized with different agronomic assumptions. The characteristics are ranked 1 to 5. A ranking of 1 indicates the highest parameter value; 5 indicates the lowest value. Chemical pollution was ranked according to the loading levels of similar chemicals and the number of chemicals used. Additional notations of "+" and "-" were used to note the general change in these variables from their level under the Current Practice Scenario.

<u>Current Practice Scenario.</u> The Current Practice Scenario was restricted to the use of only the most common production activity in Richmond County, Activity 1. Activity 1 was a corn/small grain-double cropped soybeans rotation, with a medium chemical use budget. Total net returns over the 15 year period were the lowest of all the general scenarios at $29,284,960 for the entire county. Labor requirements were also lowest at 777,435 hours. Potential pollution levels for all paths of dispersal were at their highest 15 year total level under this scenario. Runoff carried a total of 129,081 kg (283,978 lb) of nitrogen and six different chemicals. Gramoxone (paraquat) appeared at the highest level, totalling 823,615 g (1,812 lb). In total, percolating water carried 7,432,948 kg (16,352,486 lb) of nitrogen and 597,245 g (1314 lb) of Aatrex (atrazine) and four other chemicals. The 15 year total content of sediment included 2,710,443 kg (5,962,975 lb) of nitrogen and 3,180,748 g (6,998 lb) of Gramoxone. Soil erosion was 791,412 metric tons (870,553 tons) over the

Table 5.3. Summary of the five general scenarios. Each critical parameter is ranked on a scale of 1 to 5, where 1 indicates the highest level and 5 the lowest.[a]

SCENARIO	BASE HA.	LABOR	NET RETURN	POTENTIAL POLLUTANTS NITROGEN			CHEMICALS			SOIL EROSION
				RUNOFF	PERCOL.	SEDIMENT	RUNOFF	PERCOL.	SEDIMENT	
Current Practices (A1)	1	5	5	1	1	1	1	1	1	1
No Litter (A3)	3 (-)	4 (+)	4 (+)	4 (-)	4 (-)	3 (-)	2 (-)	3 (-)	2 (-)	4 (-)
No Litter-X (A3)	4 (-)	3 (+)	2 (+)	5 (-)	5 (-)	4 (-)	2 (-)	2 (-)	3 (-)	3 (-)
Unrestricted (A5L)	2 (-)	1 (+)	3 (+)	2 (-)	2 (-)	2 (-)	4 (-)	4 (-)	4 (-)	2 (-)
Unrestricted-X (A5L)	2 (-)	1 (+)	1 (+)	3 (-)	3 (-)	2 (-)	2 (-)	4 (-)	4 (-)	2 (-)

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[a] A tie in parameter values of scenarios may cause the ranking of 5 to be missing. A "+" or "-" sign designates the direction of change and potential tradeoffs between the types of pollution, with respect to the Current Practices Scenario.

15 year period. The Current Practice Scenario established baseline levels of net income, labor, base enrollment, and potential nitrogen and chemical pollution, and soil erosion against which the other four general agronomic scenarios could be compared.

No Litter Scenarios. In the No Litter Scenario the model was prevented from using poultry litter as a nitrogen source. The scenario did not account for nitrogen from crop residues, and was free to select any non-poultry litter using activity. The No Litter Scenario had a net return of $39,253,783 over a 15 year period and a low total labor requirements of 900,312 hours, using production activity 3. Activity 3 used the same 2 year corn rotation as Activity 1 but with a reduced chemical budget. The chemical and nitrogen contributions to non-point pollution were the second lowest of the five scenarios. All levels of potential contaminants were reduced from the current practices scenario. Nitrogen levels for the 15 year period in runoff, percolation, and sediment were 72,475 kg (159,445 lb), 6,288,610 kg (13,834,942 lb), and 2,137,122 kg (4,701,668 lb), respectively. Chemical applications were reduced, consequently only three chemicals appeared in runoff and sediment, and one chemical appeared in percolation. Gramoxone appeared at the highest total levels in runoff and sediment at 225,276 g (469 lb) and 963,016 g (2,119 lb) for the county. Aatrex was the only contributor to percolation at a total of 588,172 g (1,294 lb). Soil erosion was cut to 588,070 metric tons (646,877 tons) for the county over 15 years.

The No Litter-X Scenario was identical to the No Litter Scenario except for the accounting of nitrogen available from crop residues (noted by the "X" suffix). The No Litter-X Scenario also used low-chemical Activity 3. The total net return for the entire county was moderate at $40,075,933 over the 15 year period, a $10,790,973 rise from the Current Practice Scenario. Total nitrogen contributions to runoff and percolation were at the lowest levels of the five scenarios. Chemical contributions, nitrogen contributions to sediment, and soil erosion were not at the lowest total levels among the five general scenarios. The 15 year total nitrogen content of runoff was 70,628 kg (155,382 lb), a 58,453 kg (128,600 lb) drop from the Current Practice Scenario. Nitrogen in percolation was also at its lowest total level of 4,618,708 kg (10,161,158 lb). Total chemical contributions were the same as under the No Litter Scenario except the Aatrex contribution in percolation was 97,925 g (215 lb) more. However, Aatrex in sediment declined to 125 g (.27 lb) over the 15 year period. Total soil erosion was only 1,070 metric tons (1,177 tons) higher than the lowest level under the No Litter Scenario.

Both the No Litter and the No Litter-X Scenarios resulted in lower potential nitrogen and chemical pollution, and soil erosion than under the Current Practice Scenario. The No Litter Scenarios had higher net returns over the 15 year period than the Current Practice Scenario. The low-chemical production activity selected under these scenarios proved that LIA practices can be profitable, although there were no penalties assigned to LIA practices in this part of the analysis. The No Litter-X Scenario had a higher total net return than the No Litter Scenario due to lower fertilizer purchases caused by accounting for the nitrogen from crop residuals. The reduction in nitrogen purchases of, at the maximum, 20 kg per hectare (17.76 lb per acre), created an economic advantage for the low-chemical activity in addition to the reduced chemical purchases. Lower commercial applications of nitrogen caused lower nitrogen pollution than the No Litter Scenario. No other differences in production practices existed between the No Litter and No Litter-X Scenarios.

Unrestricted Scenarios. In the Unrestricted Scenario, the model could select any activity and any source of nitrogen. The accounting of nitrogen from crop residues was excluded. Total net return was fairly high at $39,821,151, despite being tied for the highest labor requirement of 1,088,823 hours over the 15 year period. An organic activity selection, 5L, compensated for the labor requirements by excluding any chemical costs. Soil erosion and nitrogen contaminants were high to moderate. Total nitrogen in runoff, 88,380 kg (194,436 lb) was only lower than the Current Practice Scenario, as was nitrogen in sediment at 2,244,407 kg (4,937,695 lb). Total nitrogen in percolation was at a mid-range level of 7,125,329 kg (15,675,724 lb). Soil erosion was just below the Current Practice Scenario at 644,051 metric tons (708,456 tons) over the 15 year period.

The Unrestricted-X Scenario, unlike the Unrestricted Scenario, accounted for the nitrogen available from crop residues. The Unrestricted-X Scenario had the highest total net return of $41,276,313, and shared the highest total labor requirements of 1,088,823 hours, but maintained the zero chemical contributions by using an organic production activity, 5L. Nitrogen contributions to percolation and soil erosion, in contrast, were at very high levels. Total nitrogen percolation was 6,998,475 kg (15,396,645 lb), this amount was over 2,379,767 kg (5,235,487 lb) higher than the lowest nitrogen percolation level under the No Litter-X Scenario. Total soil erosion was nearly the same level as the Unrestricted Scenario, 644,052 metric tons.

The Unrestricted and Unrestricted-X Scenarios had higher total discounted net returns than the No Litter and No Litter-X Scenarios, respectively. The Unrestricted Scenarios resulted in the use of an organic production activity. The selection of this type of production system as opposed to the low-chemical system hinged on the ability to use an organic nitrogen source. In this study poultry litter was used as the organic nitrogen source. As anticipated, the use of an organic production activity reduced potential chemical pollution the most of any of the five general scenarios, since no chemicals were used. However, the use of poultry litter as a source of nitrogen resulted in increased potential nitrogen pollution of groundwater from the No-Litter and No Litter-X Scenarios. This increase was caused by the slower release of nitrogen in a form usable by plants. Normally this slower release is thought to reduce potential nitrogen pollution problems. The slower release of nitrates, however, often leads to the release of nitrogen when plant uptake is low, thus causing nitrogen leaching. This study shows that, although the use of poultry litter reduces potential nitrogen runoff and has little effect on the nitrogen content of sediment, there is a potential increase in leaching. The potential pollution was less under the scenario which accounted for crop residuals because less litter was added. Sensitivity analysis of the most unrestricted scenario was conducted to test some of the identified barriers to LIA adoption.

Sensitivity Analysis

A sensitivity analysis was conducted on the Unrestricted-X Scenario by imposing several perceived barriers to LIA adoption at increasing levels until the organic and low-chemical activities of the model did not appear in the solution. The Unrestricted-X Scenario was used because an organic activity, a possible extreme LIA production system, was selected throughout the 15 year period as the most profitable activity.

Litter Price Scenarios. The price of an organic nitrogen source must be competitive with the market price of inorganic nitrogen and the subsidies provided inorganic fertilizer users under current tax codes. The relationship between the price and use of poultry litter was determined by increasing the litter price until it no longer occurred in the optimal solution. In this case the low-chemical activities were allowed in the optimal solution if they did not use litter. At a 30 percent increase in price, a \$.009 per kg (\$.004 per lb) increase, litter was no longer competitive with the inorganic source. The resulting scenario was identical to the No Litter-X Scenario except for rounding errors. Net returns and labor requirements fell from their Unrestricted-X levels. The levels of these variables were previously discussed under the No Litter-X

Scenario. The use of an organic production system was very sensitive to the price of poultry litter, the inorganic nitrogen source. There was no production activity which used no chemicals and inorganic nitrogen.

Thus, it was vital to have poultry litter in the analysis, despite its price sensitivity. The price of poultry litter used in this analysis was an estimated cost based on transaction costs, transportation, and broker's fees. If the demand for poultry litter or another form of organic nitrogen Richmond County rose due to increased interest in LIA activities, transaction and transportation costs could fall as a more complete and competitive market structure formed. Another possible scenario would include increased requirements of poultry operations to dispose of their waste products in an environmentally sound manner. These requirements may lead to poultry operators paying a farmer to remove the waste or at least free distribution of waste products to farmers.

Yield Penalties Scenarios. Yield penalties resulting from the adoption of LIA were another perceived barrier to LIA adoption tested by sensitivity analysis. A reduction in the yields of corn and soybeans of the organic activities were based on extension recommendations. The reduction resulted in a conversion from the organic activity 5L to the low-chemical activity 3L. An additional penalty was recommended by extension specialists for the low-chemical activities, 3 and 3L. The penalties consisted of a 20 percent yield penalty on corn and soybeans of Activities 3, 3L, and 5L, and a 20 percent penalty on corn and 25 percent penalty on soybeans for activities 11L and 16L. Imposing these penalties caused a shift back to the original 5L activity at reduced net returns. Finally, the penalties assigned were increased equally until all organic and low-chemical activities were removed from the solution. At a 40 percent yield penalty in all the LIA rotations on corn and soybeans, Activity 1 became the primary production activity with several secondary activities appearing inconsistently throughout the 15 year period. Under this Yield Reduction-XC Scenario total labor requirements fell by 195,573 hours and the 15 year total net return by $10,408,924 from the Unrestricted-X Scenario. Total nitrogen percolation was reduced by 2,105,240 kg (4,613,528 lb) due to the conversion from litter to inorganic nitrogen, which also caused a total 29,910 kg (65,802 lb) rise in nitrogen in runoff over the 15 year period. All total chemical levels were increased since the Unrestricted-X Scenario had been organic. Eleven chemicals were found in runoff, 7 in percolation, and 10 in sediment over the 15 year period. Gramoxone was found at the highest total levels in runoff and sediment, while Aatrex total levels were the highest in percolation respectively. Runoff carried a total of 850,606 g (1,871 lb) of Gramoxone, sediment carried 4,491,389 g (9,881 lb); while percolation carried 456,710 g (1,005 lb) of Aatrex off the fields over the 15 year period. Total soil erosion rose under the yield penalties to 824,015 metric tons (906,417 tons). The selection of a LIA activity was less sensitive to yield penalties, in this study, than much literature and other studies conclude. The insensitivity of organic production practices alone was not enough to provide a large barrier to LIA adoption.

Labor Availability and Requirements. The third barrier to LIA adoption considered was related to labor: either its declining availability or the larger requirements of LIA systems. There was no critical value found which led to conversion from organic and low-chemical activities to one of the other available activities. Therefore another approach was used which put a labor penalty specifically on the labor requirements of the low-chemical and organic production activities. At a 600 percent increase in required labor hours the model converted to the same production scheme as in the optimal solution under the Yield Reduction-XC Scenario. That such an extremely large increase in labor was necessary to make the LIA system less profitable, suggests that labor is not a strong barrier to LIA adoption.

Likewise, a sensitivity analysis considering the relationship between variable input costs of organic and low-chemical activities and their selection resulted in conversion to the same production system as the Yield Reductions-XC Scenario. At a 51 percent increase in variable costs low-chemical and organic activities were abandoned for more conventional activities. This perceived barrier also seemed to have a weak relationship to the selection of LIA production activities.

The sensitivity of several economic and agronomic barriers to LIA adoption was estimated in this study. Only one barrier appeared highly sensitive, poultry litter price. The use of an organic activity was very sensitive to the price of poultry litter, the only available source of organic nitrogen. However, the production activity selected under a high poultry litter price was another type of LIA activity using low-chemical an nutrient applications. Poultry litter is not currently available in the study area and estimates of poultry litter costs may be inaccurate and cause some of the sensitivity found in the poultry litter price. The sensitivity of poultry litter price may also have been caused by treating litter as a market good. In the future environmental legislation may place greater requirements on poultry operations to dispose of the waste in a biologically sound manner. This could lead to poultry litter being a free good to farmers.

The barriers of reduced yields, increased labor requirements, and increased variable costs individually did not prove, individually, to be strong barriers to LIA adoption. The absence of widespread adoption of LIA activities indicates that some type of barrier must exist. It was suspected that in reality farmers face a combination of barriers which may dissuade them from LIA adoption. A combination of these penalties at low levels did result in a barrier to LIA adoption, as shown under the Base Policy Scenario.

Estimation of the Effects of Imposed Policies

Objectives 6 and 7 were achieved by the creation of a Base Policy Scenario which used several of the penalties explored under the sensitivity analysis and then imposed a variety of agricultural and natural resource policies. The polices imposed individually were: a cost-share program for green manures, surface chemical application restriction, chemical taxation, restriction of chemical loading of non-point pathways, land use restrictions, and a base flexibility option in the federal commodity programs. The cost-share, surface chemical restriction, and chemical loading restriction policies were imposed under two different scenario conditions: with poultry litter available and without poultry litter.

Policies With Poultry Litter

Summary Table 5.4, ranks the important variable levels of each policy scenario (with poultry litter) on a scale of 1 to 10. A ranking of 1 indicates the highest level; 10 the lowest level. The second set of symbols under each variable, "+" or "-", indicates the change for each scenario variable, from the Base Policy Scenario levels. Because of the diversity in chemical types and contaminant levels a numerical ranking of chemicals was omitted. For each policy scenario, the 15 year change in chemical loadings, from the Base Policy Scenario, were summed within transportation routes; the sign of this summation is used for comparison of policy scenarios in Table 5.4. This aggregate ranking was useful for summary purposes but did not reflect the variety of chemical use across scenarios.

Base Policy Scenario. The Base Policy Scenario was constructed by imposing the litter price of \$.039 per kilogram (\$.018 per lb) from the Litter Price-X Scenario, the yield penalties recommended by extension specialists under the yield reduction scenarios, and a labor requirement penalty of 10 percent on organic and low-chemical activities. Operators were assumed to account for nitrogen from crop residues because this is a

Table 5.4. A ranking of some of variable values of the policy scenarios, with poultry litter, analyzed.[a]

SCENARIO	LAND USE	LABOR	NET RETURNS	POTENTIAL POLLUTANTS						SOIL EROSION
	TOTAL BASE HECTARES			NITROGEN			CHEMICALS			
				RUNOFF	PERCOL.	SEDIMENT	RUNOFF	PERCOL.	SEDIMENT	
Base Policy (A1)	8	7	3	2	6	5				5
Cost-Share (A15L)	3 (+)	5 (+)	2 (+)	10 (-)	1 (+)	2 (+)	(-)	(+)	(-)	10 (-)
No Aatrex (A5L,A6)	6 (+)	4 (+)	6 (+)	7 (-)	3 (+)	3 (+)	(-)	(+)	(-)	3 (+)
1/3 Aatrex (A6,A5L)	4 (+)	6 (+)	5 (+)	3 (-)	5 (+)	8 (-)	(+)	(-)	(-)	4 (+)
40% Percolation Reduction (A1,A6)	9 (+)	3 (+)	7 (+)	1 (+)	2 (+)	10 (-)	(+)	(-)	(-)	1 (+)
40% Percolation Runoff Reduction (A1,A3,A6L)	5 (+)	2 (+)	9 (+)	4 (-)	4 (+)	4 (+)	(-)	(-)	(-)	7 (-)
Chemical Taxation (A1,A6)	2 (+)	1 (+)	10 (+)	9 (-)	3 (+)	7 (-)	(-)	(-)	(-)	8 (-)
CRP (A1,A6)	10 (+)	10 (+)	8 (+)	8 (-)	9 (-)	9 (-)	(-)	(-)	(-)	9 (-)
Buffer Strip (A1,A6)	7 (+)	8 (+)	4 (+)	6 (-)	7 (-)	6 (-)	(-)	(-)	(-)	6 (-)
Base Flexibility	1 (+)	9 (+)	1 (+)	5 (-)	8 (-)	1 (+)	(+)	(+)	(+)	2 (+)

[a] Each variable is ranked on a scale of 1 to 10. A ranking of 1 indicates the highest level; 10 the lowest level. A "+" or "-" indicates the direction of change, and potential tradeoffs between types of pollution, relative to the Base Policy Scenario level. Chemicals are not given a numerical ranking because comparisons were too difficult to make given the variety of chemical quantities and numbers across scenarios.

practice highly recommended by extension and an important part of any LIA system. The use of any organic or low-chemical activity was not prevented, only made more costly by the penalties. The optimal solution of the Base Policy Scenario selected Activity 1 over the majority of hectares and years. Total net return was $31,199,006 and 922,756 hours of labor were required over the 15 year period. The production practices of the Base Policy Scenario caused a greater total amount of nitrogen to be found in percolation, 4,619,946 kg (10,163,881 lb), than runoff, 108,220 kg (238,084 lb). The nitrogen content of sediment was 2,650,084 kg (5,830,185 lb). However, relative to the other policy scenarios the percolation level was low and runoff level high.

Ten chemicals were found in runoff, the Gramoxone level was 671,760 g (1,478 lb) over the 15 year period. Only six chemicals appeared in percolating waters, Aatrex was found at the highest 15 year level, 555,967 g (1,223 lb), in this scenario. Sediment carried nine chemicals in this scenario, total Gramoxone was the highest at 2,775,538 g (6,106 lb). Although subsequent policies were implemented to reduce agrichemical use, some chemical levels in the Base Policy Scenario were surpassed by other policy scenarios. Soil erosion was moderate at 775,921 metric tons (853,513 tons) over the 15 year period. The possibility of a sensitive relationship between LIA activities selected under the policy scenarios and the price of poultry litter still exists. Those policy scenarios which did select activities which use poultry litter were later evaluated assuming the availability of poultry litter.

Green Manure Cost-Share Program. The benefits of using green manures as a nitrogen source and winter cover, such as reduction in purchased nitrogen, did not provide the profits needed for inclusion in the optimal solution of any scenario, thus far. It was calculated that a 100 percent subsidization of the annual variable input costs of establishing the green manure was necessary in order for it to enter the solution. A high subsidization was required for adoption because of the low estimated nitrogen levels received from this particular green manure in Richmond County. A rye/clover crop was used as the green manure crop and was disked under in early spring, Activity 15L. Total net returns rose by $6,468,129 from the Base Policy Scenario due to the 100 percent subsidization.

Runoff of nitrogen, over the 15 year period, was reduced from the Base Policy Scenario level by a total of 42,798 kg (94,156 lb) and five out of the eight chemical levels under the Base Policy Scenario in runoff were reduced. The total Gramoxone level in runoff fell by 302,096 g (665 lb). Total Aatrex levels in percolation increased by nearly 50 percent or 261,166 g (575 lb). The total nitrogen content of sediment fell by 1,120,823 kg (2,465,811 lb) as did 5 out of the seven chemical levels found in sediment. The total Aatrex level fell in sediment by 6,922 g (15 lb). The 15 year total soil erosion level was the lowest level of all policy scenarios at 352,874 metric tons (388,161 tons), a 432,047 metric ton (475,252 tons) drop from the Base Policy Scenario level. However, not all of the environmental effects of the green manure crop were positive. Percolation of both nitrogen and chemicals increased from their levels under the Base Policy Scenario due to the retention of chemical residues by the winter cover. Total nitrogen levels in percolation rose by 2,366,229 kg (5,205,704 lb). All chemical levels in percolation rose; Aatrex levels rose in total by 261,166 g (575 lb). Using a green manure as a winter cover crop provided nitrogen for the following crop, and it reduced runoff and soil erosion. The tradeoff for the reduction in surface movement was an increase in percolation of both chemicals and nitrogen due to the retention of moisture under these crops. The amount of nitrogen provided by these green manures, based on weather conditions and yields in Richmond County, was fairly low. The larger benefits of this scenario, reduced runoff and soil erosion, were attributed to the use of a winter cover crop. The smaller benefit of reduced purchased nitrogen requirements was not large enough to induce the use of green manures without 100 percent subsidization.

Surface Application Restrictions. Two scenarios were analyzed which restricted the use of Aatrex, the chemical found consistently at the highest levels in groundwater in this study. A complete removal of Aatrex from production practices was imposed in the No Aatrex Scenario. A less severe one-third reduction was imposed in the second scenario, 1/3 Aatrex Scenario. Application rates were not changed; restrictions applied to the total use of Aatrex in the county. Activities 6 and 5L were selected in the No Aatrex Scenario; both activities used the same 2 year corn rotation, neither used Aatrex; 5L was organic. The 1/3 Aatrex Scenario also used these two activities but depended less on the organic activity and included several activities at low levels which used Aatrex. The total net return of the No Aatrex Scenario was more severely reduced, by $1,351,301, than was the 1/3 Aatrex Scenario which had a reduction of $848,033 from the Base Policy Scenario. Nitrogen contributions to runoff were reduced under both the No Aatrex and 1/3 Aatrex Scenario by 2,337 kg (5,141 lb) and 46 kg (101 lb) respectively over the 15 year period. Nitrogen carried by percolation increased in both scenarios relative to the Base Policy Scenario, by totals of 888,081 kg (1,953,778 lb) under the No Aatrex Scenario and 382,386 kg (841,249 lb) under the 1/3 Aatrex Scenario. The nitrogen content of sediment was lower under the No Aatrex Scenario, at a 15 year total of 2,732,587 kg (6,011,691 lb).

The limitation of Aatrex induced the substitution of higher levels of currently used chemicals and the introduction of 2-4D and Bladex. Under the No Aatrex Scenario, all Aatrex was removed, but a total of 25,421 g (56 lb) and 31,286 g (69 lb) of 2-4D were added to percolation and runoff. Less 2-4D was added to percolating water under the 1/3 Aatrex Scenario since there was some flexibility to use low levels of Aatrex. Under the 1/3 Aatrex Scenario, a 15 year total of 12,565 g (28 lb) of 2-4D and 183,765 g (404 lb) of Aatrex were found in percolation; 1,379 g (3 lb) of 2-4D and 8,535 g (19 lb) of Aatrex were found in runoff. The chemical 2-4D was not carried in sediment movement. In both scenarios the levels of over two-thirds of the other chemicals rose in runoff, percolation, and sediment.

The banning of Aatrex from surface application was more costly, in terms of total discounted net returns, than the 1/3 reduction in Aatrex use. Which scenario was more cost-effective is examined in the conclusions section of this scenario. The tradeoffs between these scenarios, in addition to differences in net returns, include the introduction of 2-4D and Blazer as substitutes for Aatrex. The removal or reduction of a target chemical did not induce widespread LIA practices; instead, a combination of LIA practices and activities which substituted other, potentially more harmful chemicals resulted.

Chemical Taxation. A commonly used economic incentive to discourage excessive use or misuse of harmful inputs is taxation. Taxation is used to raise the costs of inputs until they better reflect their true costs to society. By raising the price of all chemicals by an equal percentage the level of tax was determined which would "force" the conversion to a chemical free, organic activity. A 300 percent tax on all chemicals was needed before this conversion occurred. At this point, the organic 2 year corn rotation activity, 5L was selected. The total net return under this activity was the lowest of all the policy scenarios, falling $12,659,213 from the Base Policy Scenario. The labor required, over the 15 year period, was the highest level of all the policy scenarios at 4,202,773 hours over the 15 year period.

Chemical use was nonexistent and therefore at the lowest level of all policy scenarios. Nitrogen levels in runoff decreased in total by

32,686 kg (71,909 lb), while total levels in percolation increased by 1,403,817 kg (3,088,397 lb). The total nitrogen level in sediment fell by 507,059 kg (1,115,530 lb). Soil erosion benefits, over the 15 year period, were high under the chemical taxation scenario. The level of soil erosion fell by 160,557 metric tons (176,613 tons) under this scenario from the Base Policy Scenario.

The chemical tax required to prevent the use of chemicals was so large that it became politically unrealistic. Taxation is not commonly used to prevent the use of fertilizer or chemicals because such high tax levels are required. Feasible tax levels on chemicals may be set to create funds for research but not to prevent the use of chemicals with higher environmental and health risks.

Loading Restrictions. The final restriction on chemical use were the two policies which restricted the loading of chemicals into non-point pollutant pathways. The first scenario, 40% Percolation Reduction Scenario, restricted all chemical levels in percolation to less than 40 percent of their total level under the Base Policy Scenario over the 15 year period. The second policy restricted both runoff and percolation chemical contributions to less than 40 percent of their initial levels. These type of restrictions are politically popular but are expensive to enforce and are often shrouded by debate over the time period within which the goal should be reached. The primary activities selected under both scenarios were Activity 1 and Activities 6(L). The presence of activities 6(L) indicated that Aatrex was a limiting chemical as activities 6(L) were specifically designed without Aatrex. Net return over the 15 year period was higher under the 40% Percolation Scenario than the 40% Percolation/ Runoff Scenario at $29,490,387 and $28,130,220 respectively. Both net returns were lower than the net return under either surface application restriction policy.

All 15 year total nitrogen levels increased under these scenarios except for the nitrogen content of runoff under the 40% Percolation/Runoff Scenario which decreased by 306 kg (673 lb). The nitrogen level in percolation under the 40% Percolation Scenario rose the most, totalling 1,362,018 kg (2,996,440 lb), under these two scenarios. Nitrogen in sediment was the highest under the 40% Percolation Scenario at a 15 year total of 2,679,712 kg (5,895,366 lb). All chemicals which were in the initial Base Policy Scenario meet or exceeded their 40 percent reduction, under each scenario. The restriction on Aatrex again forced the introduction of 2-4D and Bladex at unrestricted levels. Their levels were unrestricted because they did not appear in the Base Policy Scenario. Under the 40% Percolation Scenario the total contribution of six chemicals to runoff rose, including Gramoxone at 710,639 g (1,563 lb) level. Only Lasso and Bladex levels in runoff rose under the 40% Percolation/Runoff Reduction Scenario from the Base Policy Scenario. Total percolation levels decreased under the 40% Percolation Scenario except for the addition of 3,551 g (8 lb) of 2-4D, 3,716 g (8 lb) of Lasso, and 8,890 kg (19 lb) of Bladex. Two of these chemical levels were higher under the 40% Percolation/Runoff Scenario: 9,201 g (20 lb) of 2-4D and 8,573 g (19 lb) of Bladex. Only a small amount, approximately 6 g (.01 lb), of 2-4D was carried in sediment in either case.

Soil erosion results under the two loading restriction scenarios were mixed. Total soil erosion under the 40% Percolation Scenario attained the highest level of the policy scenarios at 990,120 metric tons (1,089,132 tons). On the other hand, soil erosion under the 40% Percolation/Runoff scenario was reduced by 33,707 metric tons (37,078 tons). The use of a variety of secondary activities under the 40% Percolation/Runoff Scenario provided the combination of tillages needed to reduce soil erosion over the 15 year period. The 40% Percolation Reduction Scenario was not as severe and therefore fewer secondary activities were used. The restriction of potential chemical levels in both runoff and groundwater caused more severe losses in net returns than the reduction in a targeted chemical's surface use.

Tradeoffs under the 40% Percolation and 40% Percolation/Runoff Reduction Scenarios were similar to those of the No Aatrex and 1/3 Aatrex Scenarios in that 2-4D and Blazer were introduced as substitutes for Aatrex and that nitrogen levels in runoff, percolation, and sediment increased. Surface application restrictions appeared to be less costly than the loading restrictions, while the reductions in chemicals were smaller under the loading restrictions.

Land Use. Two land use policies were evaluated. Under the CRP Scenario, all eligible land, 3,334 hectares (8,252 acres), was put into the CRP program at a $173 per hectare ($70 per acre) bid rate. The Buffer Strip

Scenario forced the maximum amount of land, 307 hectares (760 acres) potentially required to be put out of production so as to serve as buffers to major waterways under the mandate of the Chesapeake Bay Local Assistance Board. This set-aside land was in 30.4 meter (100 ft) parcels along the major tributaries of the Chesapeake Bay. The land use policies were designed to reduce non-point pollution by reducing productive land and providing filtering areas for water traveling across the surface. The results of these scenarios only accounted for the benefit from removal of productive land, as the filtering effect was not modelled. Total net return was very low ($29,398,671) under CRP Scenario because the bid rate did not cover the lost income from the land enrolled in CRP over the 15 year period. The less extensive removal of buffer strip land reduced total net return by only $559,944 to $30,639,062.

All potential pollutants were reduced. The reduction in potential pollutants was directly due to the retirement of cropland which decreased chemical and nutrient input use as well as reduced tillage. The CRP Scenario produced some of the largest reductions from Base Policy Scenario levels because of the amount of land removed from cropland. Of the nitrogen reduction in the CRP Scenario, percolation levels were reduced the most, decreasing by a total of 1,071,162 kg (2,356,556 lb) from the Base Policy Scenario. Total Gramoxone runoff was reduced by 144,588 g (318 lb), while total Aatrex levels in percolation fell by 127,618 g (281 lb) under the CRP Scenario. Total soil erosion under the CRP Scenario was 161,767 metric tons (177,944 tons) less than erosion under the Buffer

Strip Scenario, and 176,085 metric tons (193,694 tons) less than the Base Policy Scenario level.

The retirement of productive land was the only policy to produce overall reductions in potential pollutants. The level of reduction was dependent on the amount of land removed. The enrollment of all eligible land into the CRP program produced large reductions in potential pollutants but was very costly to the government because of subsidies provided to the farmer, even then the farmer's cost of lost production was not completely reimbursed. Land retirement programs involving smaller amounts of land could provide significant reductions in potential pollutants without severe costs to farmer or the government.

Base Flexibility Scenario. A base flexibility policy was designed, based on the most recent proposal being considered in Congress (Ervin). The flexibility policy included the following: up to 20 percent of pooled base hectares available for planting in alternative crops, base enrollment frozen at the levels set in the initial year, established yields for deficiency payments frozen at 1988 yields, deficiency payments available for the entire base, and ARP requirements maintained at 10 percent. Only full season soybeans were allowed to be planted on the flexible hectares because the most recent proposal restricted alternative crops to oil-seed and industrial crops. Full season soybeans were the most likely crop in these two categories to be grown in Richmond County.

The activity selection did not change from the Base Policy Scenario, but the maximum number of hectares of corn, wheat, and barley were enrolled as base for the first time, in order to take advantage of the base flexibility policy. The full 20 percent of pooled base was planted to a full season soybean crop, using a medium chemical budget. Total discounted net returns were the highest in this scenario at $456,828,996, a rise of $425,629,990 from the Base Policy Scenario. This increase in income was due to the increased production of soybeans, a high valued crop, and the deficiency payments received on the flexible hectares planted to soybeans.

Nitrogen contributions to non-point pollution were reduced, over the 15 year period, because nitrogen application on the 20 percent of base planted to full season soybeans was reduced. However, chemical contributions were generally higher due to the dependency of full season soybeans on a variety of chemicals. Total Aatrex contributions to runoff and to percolation were decreased by 4,829 g (11 lb) and 41,128 g (90 lb) respectively, from their Base Policy levels due in part to displaced corn hectares. The 15 year total Aatrex level in sediment increased by 2,916 g (6.4 lb) from the Base Policy Scenario, due to the increased movement of soil across the field. Roundup levels in runoff rose from their Base Policy Scenario levels by the largest amount, in total a 1,196,846 g (2,633 lb) increase. Gemini, chlorimuron in particular, was carried by percolation at the highest level, in total 190,542 g (419 lb), a 158,021 g (348 lb) increase from the Base Policy Scenario. Both Roundup and Gemini were used on full season soybeans. The total soil erosion level rose from the Base Policy Scenario by 64,584 metric tons (71,042 tons). This was the second highest level of erosion under the policy analysis.

On an annual basis, the Base Policy Scenario produced greater soil erosion than the Base Flexibility Scenario when a full season soybean rotation was used on all the cropland. This indicates that full season soybeans are associated with higher soil erosion. This was also supported by the higher total soil erosion under the Base Flexibility Scenario where full season soybeans are planted every year on 20 percent of the cropland.

The Base Flexibility Policy had no incentives for LIA adoption. The restricted selection of crops eligible for flexible hectares provided incentives for continued use of conventional type practices including the expansion of full season soybeans. Full season soybeans in Richmond County require intensive chemical use. The chemicals used on soybeans were increased from their Base Policy Scenario while chemicals used on conventional commodity crops were reduced slightly due to their displacement by soybeans. In order for the Base Flexibility Scenario to promote LIA adoption crops such as grasses, hays, and legumes which are less chemical intensive and have other nutrient benefits, should be the only options for flexible hectares.

Policies Without Poultry Litter

In the event that a poultry litter market does not develop between the grain belt of the Commonwealth and the Shenandoah Valley, those policy scenarios which resulted in the use of poultry litter as nutrient source would be irrelevant. Therefore the Cost-Share, No Aatrex, 1/3 Aatrex, 40% Percolation Reduction, and 40% Percolation/Runoff Reduction Scenarios were estimated without the availability of poultry litter. Without poultry litter no activity was available which did not use chemicals.

Summary Table 5.5, ranks the important variable levels of each policy scenario (without poultry litter) on a scale of 1 to 10. A ranking of 1 indicates the highest level; 10 the lowest level. The second set of symbols under each variable, "+" or "-", indicates the change for each scenario variable, from the Base Policy Scenario levels. For each policy scenario, the 15 year change in chemical loadings, from the Base Policy Scenario, were summed within transportation routes; the sign of this summation is used for comparison of policy scenarios in Table 5.5.

Cost-Share Without Litter Scenario. In the Cost-Share Without Litter Scenario there was only one activity available which used a green manure, Activity 15. This activity used a 2 year corn/small grain-double cropped soybean rotation. With a 100 percent annual variable cost subsidy this activity was selected, but not in every year. Activity 12, which used a 4 year corn/small grain-double cropped soybeans/full season soybeans/small grain-double cropped soybeans rotation, was selected in several years because of the high price of soybeans. No hired labor was necessary in this scenario, the total labor requirement over the 15 year period was 899,176 hours. The 15 year net return in the Cost-Share Without Litter Scenario was $32,549,333, an amount higher than the Base Policy Scenario net returns but less than the net returns under the original Cost-Share Scenario.

The potential pollution levels from nitrogen were less than under the Cost-Share Scenario using poultry litter, but the chemical levels were

Table 5.5. A ranking of some of variable values of the policy scenarios, without poultry litter, analyzed.[a]

SCENARIO	LAND USE	LABOR	NET RETURNS	POTENTIAL POLLUTANTS						SOIL EROSION
	TOTAL BASE HECTARES			NITROGEN			CHEMICALS			
				RUNOFF	PERCOL.	SEDIMENT	RUNOFF	PERCOL.	SEDIMENT	
Base Policy (A1)	8	7	3	2	6	5				5
Cost-Share Without Litter (A15L)	3 (-)	5 (+)	2 (+)	10 (-)	1 (+)	2 (-)	(-)	(+)	(-)	10 (-)
No Aatrex Without Litter (A5L,A6)	6 (+)	4 (+)	6 (+)	7 (-)	3 (+)	3 (+)	(+)	(-)	(+)	3 (+)
1/3 Aatrex Without Litter (A6,A5L)	4 (+)	6 (+)	5 (+)	3 (-)	5 (+)	8 (-)	(+)	(-)	(+)	4 (+)
40% Percolation Reduction Without Litter (A1,A6)	9 (+)	3 (+)	7 (+)	1 (+)	2 (+)	10 (-)	(-)	(-)	(-)	1 (+)
40% Percolation Runoff Reduction Without Litter (A1,A3,A6L)	5 (+)	2 (+)	9 (+)	4 (-)	4 (+)	4 (+)	(-)	(-)	(-)	7 (-)

[a] Each variable is ranked on a scale of 1 to 10. A ranking of 1 indicates the highest level; 10 the lowest level. A "+" or "-" indicates the direction of change, and potential tradeoffs between types of pollution, relative to the Base Policy Scenario level. Chemicals are not given a numerical ranking because comparisons were too difficult given the variety of chemical quantities and numbers across scenarios.

higher. The percolation of nitrogen totaled 55,941 kg (123,070 lb) higher than the Base Policy Scenario because of the retention of moisture and nutrients by the winter green manure crop. However, the percolation was less over the 15 year period than in the original Cost-Share Scenario. Sediment and runoff nitrogen contributions, over the 15 year period, were less than levels in the Base Policy Scenario, by 33,408 kg (73,498 lb) and 939,927 kg (2,067,839 lb), respectively. Chemical levels in runoff, percolation, and sediment were mixed if compared to the Base Policy Scenario and more than the levels under the Cost-Share Scenario, since the Cost-Share Scenario used organic activities. Four of the eleven chemicals found in runoff increased from their Base Policy levels. Reductions in Gramoxone and Aatrex levels in runoff were 11,829 g (26 lb) and 54,033 g (119 lb) over the 15 year period. Only two chemical levels decreased in percolation. This was again due to the runoff retention characteristics of using a winter green manure crop, thus presenting more opportunity for leaching. The Aatrex level in percolation increased in total by 350,594 g (771 lb) from the Base Policy level. Chemical levels in sediment increased by relatively small amounts, except for Aatrex, Dual, and Gramoxone levels which declined. The total Gramoxone level in sediment decreased the greatest of these three chemicals, by 629,250 g (1,394 lb). As expected soil erosion over the 15 year period declined by 338,041 metric tons (371,845 tons) from the Base Policy Scenario. The absence of poultry litter and the nitrogen made available from the green manure in the Cost-Share Without Litter Scenario gave this scenario nitrogen management benefits over the original Cost-Share Scenario and over the

Base Policy Scenario. However, because chemicals could not be avoided, chemical levels in runoff, percolation, and sediment were higher than in the Cost-Share Scenario. There were large decreases in chemicals in runoff and soil erosion in the Cost-Share Without Litter Scenario,compared to the base Policy Scenario because of the ability of a winter green manure crop to retain these substances on the field.

Aatrex Application Restrictions Without Litter Scenarios. The No Aatrex and 1/3 Aatrex Scenario, using poultry litter, both used organic activities frequently to meet the surface level application restrictions. Both the No Aatrex Without Litter and the 1/3 Aatrex Without Litter Scenarios used activity 6 in a majority of the 15 years. Activity 6 used the 2 year corn/small grain-double cropped soybeans rotation and had a chemical budget which did not include Aatrex. The 1/3 Aatrex Without Litter Scenario was less restrictive and therefore Activity 6 in conjunction with the conventional chemical budget Activity 1, was used in most of the 15 years of the model. There was no significant change in the enrollment of cropland in the commodity programs in the No Aatrex and 1/3 Aatrex Without Litter Scenarios from the Base Policy Scenario. Less labor was needed over the 15 year period of each of these scenarios than in the Base Policy Scenario because of the intermittent use of a 4 year corn/small grain-double cropped soybeans/full season soybeans/small grain-double cropped soybeans rotation, which required less labor on a composite hectare than the production activities used in the Base Policy Scenario. A total of 907,224 hours were required by the 1/4 Aatrex Without Litter

Scenario and 899,561 hours were required by the No Aatrex Without Litter Scenario. Total net returns were $29,417,912 and $30,050,142 over the 15 year period in the No Aatrex and 1/3 Aatrex Without Litter Scenarios, respectively. The total discounted net returns of both scenarios were less than that of the Base Policy Scenario and of the original, litter using No Aatrex and 1/3 Aatrex Scenarios. The loss of returns between the policy scenarios with and without litter was due to the inability to select an activity without any chemical use.

All nitrogen contributions to non-point pollution were greater than the levels in the Base Policy Scenario, except for percolation in the 1/3 Aatrex Scenario. The increase in total nitrogen contributions from the Base Policy Scenario were all less than 10 percent. Except for reducing the percolation of nitrogen in the 1/3 Aatrex Without Litter Scenario, these surface application restrictions did not create better nitrogen management. As was found in the original surface application restriction policies the 1/3 Aatrex Scenario Without Litter resulted in nearly the same decrease in Aatrex loadings as the No Aatrex Without Litter Scenario. For example, the total level of Aatrex in runoff decreased by 23,447 g in the No Aatrex Without Litter Scenario and by 15,261 g in the 1/3 Aatrex Without Litter Scenario. The total percolation and sediment loadings between scenarios followed a similar Aatrex reduction pattern. The tradeoff for Aatrex reduction was the introduction of 2-4D, Bladex, and increases of those chemicals used on the full season soybeans of activity 13. Only traces of 2-4D were found in sediment, while the largest amount, 32,120 g, was found in the runoff of the No Aatrex Without Litter

Scenario. The largest total quantity of Bladex was in the percolation of the No Aatrex Without Litter Scenario, 35,429 g (78 lb). The 1/3 Aatrex Without Litter Scenario also had 2-4D and Bladex loadings but at anywhere from 40 to 95 percent less than the levels in the No Aatrex Without Litter Scenario. The total Gramoxone level in sediment was the largest increased chemical level in sediment. Pollution levels were considerably worse in the surface restriction without litter scenarios than the with litter scenarios because of poor nitrogen management and the substitution of other chemicals for Aatrex. Although percolation may have been higher in the original No Aatrex and 1/3 Aatrex Scenarios, the overall environmental effects were too detrimental in the No Aatrex and 1/3 Aatrex Scenarios to be considered good non-point pollution policies. The absence of an organic nitrogen source in this case was detrimental. The conventional situation, as in the Base Policy Scenario, was in many ways more attractive.

Loading Restrictions Without Litter Scenarios. The 40% Percolation and Percolation/Runoff Scenarios had used very little poultry litter. The organic activity 5, using a 2 year corn/small grain-double cropped soybean rotation, was used intermittently to allow the loading constraints to be meet. The removal of organic activities caused the 40% Percolation and 40% Percolation/Runoff Without Litter Scenarios to have the same solutions. The most important result of these loading constraint scenarios without litter was that cropland had to be idled in order to meet the 40% reduction constraints. Apparently, the infrequent use of an organic activity in the original loading reduction scenarios provided just enough chemical reduction to meet those constraints. Activities 1 and 6 were used in the 40% Percolation and Percolation/Runoff Reduction Without Litter Scenarios. Both activities were based on the 2 year corn/small grain-double cropped soybean rotation. Activity 6 used no Aatrex, and was selected because Aatrex was the limiting chemical when facing loading or application restrictions. Activity 1 used the conventional or medium chemical budget. Since the loading restriction was not annual but over the entire 15 year period, idled hectares were selected in the most cost-effective years, or when the greatest reduction in chemicals could be achieved for the least loss in income. In year 5, 9,655 hectares (6,881 acres) were idled; in year 8 2,780 hectares (6,881 acres); and in year 10, 4,850 hectares (12,005 acres) were idled. Base enrollment figures dropped because of this idled land. Once land was idled the enrollment in following years was limited by the change in the moving five year average of eligible base hectares. Additional labor was required in three other years because of the use of the labor intensive secondary activity 3. Activity 3 was a low-chemical activity which increased the labor required for weed control and decreased chemical use. The amount of labor purchased in those three years totaled 243,318 hours. The total labor hours required over the 15 year period was 1,415,494, a 492,738 hour increase from the Base Policy Scenario. Total discounted net returns suffered because of the idled land and increased labor needs. Total net returns were $5,214,822 less than under the Base Policy Scenario and

$3,506,203 less than in the 40% Percolation Reduction Scenario using poultry litter.

The potential pollution from this scenario benefitted from the reduction in productive land, conversion to inorganic nitrogen, and the use of a low-chemical and low-nitrogen activities. All nitrogen contributions were decreased from their Base Policy levels. The greatest change was in the total nitrogen content of sediment, which decreased by 510,821 kg (1,123,806 lb) from the Base Policy level. Only three of the thirteen chemicals appearing in runoff were at higher 15 year levels than in the Base Policy Scenario; Lasso Bladex, and 2-4D. Those same three chemicals accounted for the only increased chemical levels in percolation and sediment, also. There should be concern over the possible toxicity of these chemicals, particularly 2-4D. The 15 year total levels of 2-4D were not as large as in many of the other scenarios which had limited Aatrex use. The total 2-4D levels in runoff, percolation, and sediment were 1,056 g (2 lb), 16,018 g (35 lb), and 6 g (.01 lb), respectively. Soil erosion also decreased in the 40% Percolation Reduction and 40% Percolation/Runoff Reduction Without Litter Scenarios. The maximum annual soil erosion decreased by 47,212 metric tons (51,933 tons), and the 15 year total decreased by 157,249 metric tons (172,974 tons) from the Base Policy Scenario levels. The loading reduction scenarios appeared more attractive than the surface restriction scenarios when poultry litter was unavailable. This is directly due to the lack of a production activity which used no chemicals and inorganic nitrogen. The reduced percolation of nitrogen from inorganic nitrogen use, the use of production activities with no Aatrex or generally reduced chemical budgets, and the retiring of productive land in those years were pollution potential was the greatest provided an optimum outcome. The limitation of this scenario was the inability of a farmer, policy-maker, or scientist to predict those when the critical time is to remove land from production and when to use low-chemical budget production activities.

Summary

Objectives 1 through 7 were met through the use of a survey, literature review, non-point pollution simulation models, and a multi-period, nonlinear mathematical programming model. The final objective, Objective 8, was to evaluate the general effectiveness of LIA as a groundwater protection strategy. This objective is met in the next section through the use of cost-effectiveness comparisons of the previous scenarios.

Conclusions

The implications of this study are twofold: (1) implications for the potential adoption of low-input agriculture in Richmond County, Virginia and (2) the implications for groundwater protection, as well as other environmental concerns. The ability of policies to promote LIA adoption are evaluated based on the conversion to LIA activities from conventional practices and the direct cost to society and the farmer to achieve that change. In evaluating the environmental effectiveness of the LIA practices, the cost of conversion to LIA is broken down further into the costs per unit of environmental loading reductions, such as the cost per gram of Aatrex reduction in groundwater. These conclusions, and the limitations of this particular study, indicate future research needs in the area of low-input agriculture as a groundwater protection strategy.

Implications for the Adoption of LIA

The implications for the adoption of LIA can be drawn from three areas of this study; the Unrestricted Scenario solutions, the Sensitivity Analysis, and the ability of the agricultural and natural resource policies to promote LIA selection in their optimal solutions.

The Unrestricted-X Scenario

Under the Five General Scenarios examined, the Unrestricted-X Scenario, which accounted for nitrogen from crop residuals and allowed the use of any activity including poultry litter activities, selected an organic activity as the production system throughout the 15 year period. Since the objective of the mathematical model in this study was the maximization of net returns over variable costs, the organic activity was the most profitable production activity available in this study to the farm operators in Richmond County. Discounted net returns were the highest under this scenario of the five general scenarios including Current Practices.

It cannot, however, be concluded from this solution that all operators in Richmond County should be using organic methods and would thereby be earning more profits than under their current practices. If this were the case, enterprising farmers in the county would be using such production practices. A Richmond county farmer survey (VPI & SU Dept. of Agric. Economics) found only 3 low-input farmers. The selection of this LIA activity within the model, was due, in part, to the assumptions of perfect knowledge of future prices and yields, a pooled labor supply, the existence of a poultry litter market, and no yield or labor penalties on LIA activities. The farmer in Richmond County does not have easy access to a poultry litter market, does not know future prices, target prices, and yields, nor does the farmer have access to a communal county labor supply. Furthermore, the actual yields and labor requirements of LIA practices are not known.

Despite these unrealistic assumptions, this scenario allows the analysis of other conditions which may be preventing LIA activities from being adopted. The conditions which cause this unrestricted scenario to approach reality can be explored through sensitivity analysis. Barriers to adoption, such as yield and labor penalties, have been identified by other studies as critical barriers to LIA adoption. The sensitivity analysis on the Unrestricted-X Scenario in this study identified the strength of these barriers in Richmond County.

Sensitivity Analysis

The potential barriers of labor requirements, yield penalties, variable cost penalties, and organic litter price were investigated through sensitivity analysis. The use of low-input agricultural practices were found to be generally insensitive to these barriers, with the exception of the price of the inorganic nitrogen source. The use of organic activities was very sensitive to the price of poultry litter. This barrier was significant in that poultry litter was the only source of organic nitrogen, except for small amounts from crop residuals and legumes. This sensitivity may be, in part, the result of using estimates for the costs of transportation, transactions, and broker's fees. If, in fact, a competitive poultry litter market was to develop in Richmond County, the price of poultry litter could decrease. The other potential scenario is that poultry litter waste becomes such an environmental problem in those areas where the poultry industry is located that poultry operators pay farmers to haul off their litter. In either case, the price of poultry litter could decrease and be further from its critical value found in the sensitivity of LIA activity use to analysis. It should be noted that no activity in the model used no chemicals and commercial nitrogen.

Substantial and perhaps unrealistic penalties on labor requirements, variable costs, and yields were required to make LIA systems unattractive to farmers. The insensitivity of organic activity use to labor requirements can be partially attributed to the effects of a pooled labor supply. However, extension specialists note that the labor supply in Richmond County is at a surplus level because of farmer characteristics and their production habits (Liddington). Many farmers in Richmond County are at or above the retirement age and do not work their land with the most labor intensive methods because they do not depend on a large farm income for their livelihood. There was one important caveat to the conclusion that labor and yields and variable costs are not significant barriers to LIA adoption. The occurrence of a single barrier, except at high levels, may not limit LIA adoption, but a combination of these barriers may act together to prevent LIA adoption.

A combination of barriers, at low levels, was used in the Base Policy Scenario and caused a switch to conventional practices. Poultry litter was later removed from those policy scenarios which had litter use. The Base Policy Scenario presented the most realistic situation in which to evaluate the influence of policies to promote LIA adoption.

Policies and the Promotion of LIA Adoption

The Cost-Share policy was the only policy designed specifically to promote LIA adoption. The remaining policies were targeted toward improving groundwater quality; a byproduct of which may have been LIA adoption. Some policies which may induce the use of LIA activities cost less than others. Costs were also shared by different parties under each scenario. Land use policies failed to change farming practices, although environmental benefits were still created from reductions in cultivated land. Table 5.6 will be used to evaluate the effectiveness of these policies in inducing conversion to LIA. Table 5.6 allocates the aggregate change in net returns to the farmer or government as costs or benefits.

Cost-Share and Base Flexibility Scenarios. Only three scenarios had increases in their net income from the Base Policy Scenario: the Cost-

Table 5.6. The change in 15 year discounted net returns; the total cost or benefit to the farmer, the total cost or benefit to the government and the occurrence of conversion to low-input practices under each of the policy scenarios.[a]

Policy Scenario	**Change in Net Return from Farming**	**Cost or Benefit to Farmer**	**Cost or Benefit to Government**[b]	**Occurrence of LIA Conversion**
		(1988 dollars)		
Cost-Share	+6,468,129	+6,468,129	-6,468,129[c]	conversion
No Aatrex	-1,351,301	-1,351,301	0	conversion
1/3 Aatrex	-848,033	-848,033	0	conversion
Chemical Taxation	-12,659,213	-12,659,213	+12,659,213[d]	conversion
40% Percolation Reduction	-1,708,619	-1,708,619	0	partial
40% Percolation/ Runoff Reduction	-3,068,786	-3,068,786	0	partial
CRP	-1,800,335	-1,800,335	-5,937,961	none
Buffer Strip	-559,944	-559,944	0	none
Base Flexibility	+425,629,990	+425,629,990	-420,190,470	none

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[a] Cost or benefits were determined by who paid for and/or received the change in net return. Unless otherwise indicated poultry litter was available as a nutrient source.

[b] No administrative, enforcement or transaction costs are included in the costs to farmers and the government.

[c] Government transfers to the farmer, like taxes, can be viewed as direct transfers with no net effect on the economy.

[d] The tax collected could be transferred back to the farmer as a form of subsidy. Part of this tax collection would be taken up by administrative costs.

Table 5.6, continued.

Policy Scenario	Change in Net Return from Farming	Cost or Benefit to Farmer	Cost or Benefit to Government[a]	Occurrence of LIA Conversion
		(1988 dollars)		
Cost-Share Without Litter	+1,350,327	0	+1,350,327	partial
No Aatrex Without Litter	-1,781,094	-1,781,094	0	partial
1/3 Aatrex Without Litter	-1,148,864	-1,148,864	0	partial
40% Percolation Reduction Without Litter	-5,214,822	-5,214,822	0	partial
40% Percolation/ Runoff Reduction Without Litter	-5,214,822	-5,214,822	0	partial

[a] No administrative, enforcement or transaction costs are included in the costs to farmers and the government.

Share Scenario, the Cost-Share Scenario Without Litter and the Base Flexibility Scenario. The use of green manures provided too little additional nitrogen to offset the costs of establishing the rye/clover mix. The cost of this policy was high to the government which shouldered a 100 percent variable cost subsidy. Based on the change in the 15 year discounted net return under the Cost-Share Scenario from the Base Policy Scenario, the farmers received a $6,468,129 benefit supported entirely by the government over the 15 years. The Cost-Share Without Litter Scenario was less costly, $1,350,327, because the inability to use poultry litter limited the production activity selection and a complete conversion to green manures did not occur. Neither Cost-Share Scenario had government costs as high as the Base Flexibility Scenario, which was the most expensive scenario.

The Base Flexibility Scenario is based on a policy that has been promoted as a way to move farmers away from dependency on the government for subsidies by freeing them of some of the constraints of the federal commodity programs. However, as can be seen in Table 5.6, the government was estimated to be paying a total of $420,190,470 in income subsidy, due to the increased participation in the commodity programs under the base flexibility policy used in this study. The government cost of the Base Flexibility Policy was calculated as the portion of the change in total discounted net return remaining after the total discounted value of the full season soybeans grown on flexible hectares was subtracted. With flexibility, farmers maintain their deficiency payments on base hectares while also getting market value for soybeans on 20 percent of that base.

If base yields are frozen, base enrollment will increase in order to take advantage of this subsidy.

The base flexibility policy, in this study, does not promote LIA adoption for two reasons. First, a farmer who is using rotations will need time to develop a new rotation which uses one of the alternative crops allowed on the flexible hectares; until then, the use of this policy interrupts his rotations. Rotations are one of the simplest LIA characteristics to incorporate. Second, the alternative crops currently proposed for use on the flexible hectares are limited to oil-seed and industrial crops. These crops exclude any legumes, except soybeans, grasses, and hay which would be beneficial to a LIA system.

Both the Cost-Share and the Base Flexibility Scenarios caused an increase in farmer net returns over the 15 year period at the government's cost. The cost of either one of these policies if projected on a regional or national basis would prohibitive. Environmentally, the Base Flexibility Scenario achieves small reductions in potential pollutants because it does not cause conversion to a LIA activity. The cost and the lack of environmental benefits eliminates the Base Flexibility Scenario as a useful scenario for either LIA adoption or groundwater protection. The cost-share policy is attractive to farmers because of the increase in net returns. Groundwater protection benefits, however, did not exist in the Cost-Share Scenarios. Furthermore, although surface runoff and soil erosion was reduced under the cost-share policy, hydrologically the groundwater and surface water meet and one pollutes the other. Coupling the cost of the cost-share policy with the lack of groundwater protection benefits makes the cost-share policy quite unattractive.

The Chemical Taxation Scenario. The Chemical Taxation Scenario was the only scenario to cause complete conversion to LIA activities and resulted in a loss of net returns. The total discounted net return fell by $12,659,213. This loss was a cost borne strictly by the farm operators. However, this tax is a revenue to the government, and the costs of this scenario actually depend on the use of this tax. The tax could be returned to farmers in the form of cost-share programs or other economic incentives. The money could also be "earmarked." In Iowa, a fertilizer tax is "earmarked" for research in the area of low-input agriculture. However, the severity of the Chemical Taxation Scenario tax appears to be unrealistic, as a 300 percent tax would probably not be politically feasible. A chemical taxation policy at lower levels would induce the use of different chemicals but not eliminate chemical use.

The Aatrex Restriction Scenarios. Eight scenarios produced a loss in total net return and only partial conversion to LIA activities: the No Aatrex Scenario, the 1/3 Aatrex Scenario, the 40% Percolation Reduction Scenario, and the 40% Percolation/Runoff Scenario and their Without Litter re-estimations. The No Aatrex and 1/3 Aatrex Scenarios usually used a combination of an organic activity and an activity which substituted other chemicals for Aatrex. The cost of removing Aatrex from farm production was $1,351,301 over the fifteen year period, compared to the cost of reducing Aatrex by 1/3 which was only $848,033. Because an activity which did not use chemicals was unavailable the No Aatrex and 1/3 Aatrex Without Litter Scenarios resulted in higher costs to the farmer of, $1,781,094 and $1,148,864, respectively. The cost of these scenarios was paid by the farmer; no government costs were involved except for administration and enforcement.

The environmental effects, which are valued in the next section, indicate that the No Aatrex and 1/3 Aatrex Scenarios are similar except for nitrogen in runoff. The more extensive use of chemical based activities caused the No Aatrex and 1/3 Aatrex Without Litter Scenarios to potentially cause large nitrogen, chemical and soil erosion pollution problems. The Without Litter Scenarios of surface application restriction did not adequately promote LIA practices and caused lost income to the farmer.

<u>The Loading Restriction Scenarios.</u> The 40% Percolation Reduction and 40% Percolation/Runoff Reduction Scenarios and Without Litter Scenarios also caused only partial conversion to LIA activities. In the 40% Percolation and 40% Percolation/runoff Scenarios the LIA activities were used just enough to meet the loading restrictions. The cost of the 40% Percolation/Runoff Scenario was the highest of the four scenarios using poultry litter and causing partial conversion. The 40% Percolation/Runoff Scenario cost the farmer $3,068,786 over the 15 year period. The cost to the farmer of the 40% Percolation Reduction Scenario was $1,708,619 which was also above the cost of either application restriction scenario. The

40% Percolation and Percolation/Runoff Reduction Scenarios Without Litter were more costly to the farmer at $5,214,822.

The environmental benefits from the Without Litter loading restriction scenarios were better than those from the loading restriction with poultry litter. However, much of these benefits were caused not by conversion to LIA but through the idling of land at the critical times for pollution. As LIA promotion policies only, the 40% Percolation and 40% Percolation/Runoff Reduction Without Litter Scenarios were expensive and only caused partial conversion. Restricting the amount of Aatrex found in groundwater in this manner is difficult and expensive to enforce.

Although these four scenarios did not cause complete conversion to LIA activities they were less costly than all but one of the policy scenarios. Their major environmental benefit was the reduction in the largest potential chemical pollutants, Gramoxone and Aatrex. The tradeoffs for these reductions were higher nitrogen contributions to non-point pollution, more soil erosion, and the introduction of substitute chemicals. The 1/3 Aatrex Scenario reduced the contributions of Aatrex, the leading groundwater chemical contaminate in this study, at a relatively low cost. If Aatrex contamination was targeted as the most important water quality problem, a policy like the 1/3 Aatrex Policy could be effectively used.

The Land Use Scenarios. Finally, the two land use policies did not achieve conversion to LIA activities. Instead, land was idled or enrolled into the CRP program. The CRP Scenario cost the farm operators $1,800,335 but cost the government $5,937,961 in bid payments, over the 15 year period. The sum of these provided an estimate of the total cost of this program, excluding administrative costs. The loss in farm income, despite the government subsidy, indicates why total enrollment in CRP cannot be expected at the current average bid rate for Richmond County. The Buffer Strip Scenario cost the government nothing and the farm operator only $559,944 total. This difference was based strictly on the smaller land area affected by the Buffer Strip Policy. The results of the study indicate that the CRP and Buffer Strip policies cannot be used to promote LIA adoption. However, in the following section the environmental benefits of retiring productive land are valued without concern for the adoption of LIA activities. With this evaluation it appears that land retirement policies can be effectively used for groundwater protection.

Summary

Left unrestricted, the optimal solution to the mathematical programming model of this study was exclusive use of an organic activity. The selection of an organic activity as the most profitable production activity was based on conditions which do not currently exist in Richmond County. However, the selection of the organic activity promoted the examination of the many reasons why this production activity does not exist in Richmond County. The typical barriers cited (such as yield penalties, labor requirements, and variable cost penalties) were individually found not to be significant barriers. The absence of LIA activities in Richmond County can be attributed to the general perception that these barriers exist, and that the identified barriers work in combination with existing characteristics of the county, its farmers, and with each other to create a multi-faceted barrier to LIA adoption. The general misconceptions of LIA practices can only be eliminated by more field research. The interaction of barriers and area characteristics can be examined through case study analyses such as this and through the analysis of adoption of LIA by innovative farmers.

The most cost-effective policies for inducing the adoption of LIA activities, in a scenario of mixed low level penalties on low-chemical and organic activities and poultry litter availability, were surface application restrictions. A reduction in surface application of a targeted chemical was less costly than a complete ban, still promoted conversion to LIA practices, and reduced groundwater loadings of the most prevalent chemical. Groundwater loading restrictions, in contrast, were more expensive and present administrative problems. The monitoring of groundwater and surface water loadings is labor intensive and requires expensive equipment. At the national level this cost could be prohibitive. When litter became unavailable the surface restriction scenarios did not perform as well. This was largely due to the limited number of policies using inorganic nitrogen and reduced or zero chemical levels. The combination of organic nitrogen and low chemical levels is often ignored by LIA literature because of the advocacy of animal manures, however, this analysis had shown that better inorganic nitrogen management may perform better than poultry litter use.

Cost-share programs promoted conversion to LIA and provided profits for the farmer but at a prohibitive cost to the government. Chemical taxation was unattractive because of the severity of the tax required to obtain conversion to LIA practices. Land use policies, whether subsidized or not, did not produce changes in production practices, only changes in the total land in production. Finally the proposed Base Flexibility policy did little toward inducing LIA adoption but raised farmer incomes, partially at the expense of the government. The cost of the cost-share policies and other policies found to be cost prohibitive should also be compared to the existing costs of federal commodity subsidies. The costs of some of these policies, including administrative costs, may be less than the subsidies program and result in the use of LIA practices. However, it should be noted that the purpose of the commodity subsidy program is a stable food supply not the promotion of certain agricultural practices or environmental benefits.

Implications for Groundwater and Environmental Quality

The focus of many new proposals for the 1990 Farm Bill and other recent agricultural and natural resource policies is the increasing desire by farmers, government, and society for protection of the environment from non-point pollution from such sources as agricultural chemicals, nitrogen, and soil erosion. Each policy considered in this study cannot only be evaluated on its effectiveness for LIA adoption but also for its effectiveness in reducing non-point pollution. Table 5.7 is used for this

Table 5.7. The change in 15 year discounted net return; change in nitrogen contributions to runoff, percolation, and sediment; change in Aatrex contributions to runoff, percolation, and sediment; and changes in soil erosion under each of the policy scenarios.[a]

Scenario (source)	Cost (dollars)	Nitrogen (kg)				Aatrex (g)				2-4D (g)				Soil Erosion (metric tons)
		Runoff	Percol.	Sediment	Total	Runoff	Percol.	Sediment	Total	Runoff	Percol.	Sediment	Total	
Cost-Share (government)	+6,468,129	-42,798 (+151)	+2,366,229 (-3)	-1,264,177 (+5.1)	-1,069,254 (+6.1)	-17,354 (+373)	+261,166 (-25)	-6,922 (+934)	+236,890 (-27.3)					-432,047 (+15)
No Aatrex (farmer)	-1,351,301	-2,337 (+578)	+88,081 (-15)	+82,503 (-16)	+168,247 (-8)	-23,447 (+58)	-555,967 (+2.4)	-6,953 (+194)	-586,367 (+2.3)	+31,286 (-43)	+25,421 (-53)	+6 (-225,217)	+56,713 (-24)	+22,043 (-61)
1/3 Aatrex (farmer)	-848,033	-46 (+18,436)	+382,386 (-2.2)	+71,730 (-12)	+454,070 (-1.8)	-14,912 (+57)	-372,202 (+2.3)	-4,551 (+186)	-391,665 (+2.2)	+1,378 (-615)	+12,565 (-67)	+12 (-70,669)	+13,947 (-61)	+17,513 (-48)
Chemical Taxation (farmer)	-12,659,213	-32,686 (+387)	+1,403,817 (-9)	-507,059 (+25)	+864,072 (-15)	-23,447 (+540)	-555,967 (+23)	-6,953 (+1,821)	-586,367 (+22)					-160,557 (+79)
40% Percolation Reduction (farmer)	-1,708,619	+2,141 (-798)	+1,362,018 (-1.25)	+29,628 (-58)	+1,393,787 (-1.22)	-4,678 (+365)	-222,387 (+8)	-2,793 (+612)	-229,858 (+7)	+1,020 (-1,675)	+3,551 (-481)	+6 (-284,770)	+4,577 (-373)	+214,199 (-8)
40% Percolation/ Runoff Reduction (farmer)	-3,068,786	-306 (+10,087)	+400,618 (-8)	+63,208 (-49)	+463,520 (-7)	-9,381 (+329)	-222,388 (+14)	-3,699 (-830)	-231,762 (+13)	+2,097 (-1,472)	+9,201 (-335)	+13 (-237,445)	+11,311 (-273)	-33,707 (+91)
CRP	-1,800,335	-24,728	-1,071,162	-587,735	-1,683,625	-5,321	-127,618	-1,469	-134,408					-176,085
(farmer)		(+73)	(+2)	(+3)	(+1.1)	(+338)	(+14)	(+1,225)	(+13)					(+10)
(government)	(-5,937,961)	(+240)	(+6)	(+10)	(+3.5)	(+1,116)	(+46)	(+4,042)	(+44)					(+34)
total		(+313)	(+8)	(+13)	(+4.6)	(+1,454)	(+60)	(+5,267)	(+57)					(+44)

[a] A positive number in parenthesis indicates a cost-effectiveness measure of a reduction in potential pollutant levels. A negative number essentially represents a payment which made to increase the level of a potential pollutant.

Table 5.7, continued.

Scenario (source)	Cost (dollars)	Nitrogen (kg)				Aatrex (g)				2-4D (g)				Soil Erosion (metric tons)
		Runoff	Percol.	Sediment	Total	Runoff	Percol.	Sediment	Total	Runoff	Percol.	Sediment	Total	
Buffer Strip (farmer)	-559,944	-1,909 (+293)	-307,782 (+2)	-36,672 (+15)	-346,363 (+1.6)	-432 (+1,296)	-8,643 (+65)	-4 (+139,986)	-9,079 (+62)					-14,318 (+39)
Base Flexibility (government)	-420,190,470	-990 (+424,435)	-651,444 (+645)	+516,371 (-814)	-135,733 (+3,096)	-4,829 (+87,014)	-41,128 (+10,217)	+2,916 (-144,098)	-43,041 (+9,762)					+64,584 (-6,506)
Cost-Share Without Litter (government)	+1,350,327	-33,408 (+40)	+555,941 (-2.4)	-939,927 (+1.4)	-417,394 (+3.2)	-11,829 (+114)	+350,594 (-3.8)	-6,776 (+199)	+331,989 (-4.1)					-338,041 (+4)
No Aatrex Without Litter (farmer)	-1,781,094	+5,467 (-326)	+42,817 (-42)	+220,319 (-8.1)	+268,603 (-6.6)	-23,477 (+76)	-555,967 (+3.2)	-6,953 (+256)	-586,397 (+3.1)	+32,150 (-55)	+26,055 (-68)	+13 (-137,007)	+58,218 (-31)	+61,569 (-29)
1/3 Aatrex Without Litter (farmer)	-1,148,864	+6,471 (-178)	-39,443 (+29)	+675 (-1,702)	-32,297 (+36)	-15,261 (+75)	-391,725 (+2.9)	-4,528 (+254)	-411,514 (+2.8)	+2,164 (-531)	+16,590 (-69)	+9 (-127,651)	+18,763 (-61)	+44,746 (-26)
40% Percolation Reduction Without Litter (farmer)	-5,214,822	-18,803 (+277)	-267,740 (+19)	-510,821 (+10)	-797,364 (+6.5)	-9,377 (+556)	-252,864 (+21)	-3,987 (+1,308)	-266,288 (+20)	+1,056 (-4,938)	+16,018 (-326)	+6 (-869,137)	+17,080 (-305)	-157,249 (+33)
40% Percolation/ Runoff Reduction Without Litter (farmer)	-5,214,822	-18,803 (+277)	-167,740 (+19)	-510,821 (+10)	-759,758 (+6.9)	-9,377 (+556)	-252,864 (+21)	-3,987 (+1,308)	-266,288 (+20)	+1,056 (-4,938)	+16,018 (-326)	+6 (-869,137)	+17,080 (-305)	-157,249 (+33)

evaluation and comparison of the various policies. The variable changes listed in Table 5.7 are based on the change from the Base Policy Scenario.

A standard approach in this type of cost-effectiveness comparison is to divide the cost of a policy by the achieved reduction in a targeted pollutant. In this analysis, however, many pollutants are being affected by the various policies. This cost-effectiveness analysis is further complicated by the fact that, in some scenarios, some pollutants decrease, while others increase. A relative cost-effectiveness measurement was determined by dividing the total cost of each policy by the total, 15 year, change in individual pollutants. It would have been attractive to have some physical measure by which to aggregate the pollutants to determine an overall cost per unit of reduction. Unfortunately, considering just the units of soil loss, metric tons, and the units of chemical loss, grams, demonstrated the folly of such an attempt at aggregation. Further, it is more than just units, but factors such as active ingredients, toxicity, and persistence, which influence the overall effectiveness of a policy. As in the case of physical units, these factors are not easy to combine in one overall measurement. The cost-effectiveness measurement in this study is biased because each pollutant reduction is divided into the entire cost of the policy, when in fact if aggregation was done each pollutant would bear a smaller proportional share of the cost. Estimates of cost-effectiveness are therefore high, and they serve only as a relative comparison within a pollutant type across scenarios.

In Table 5.7, the cost-effectiveness measure represents the cost per unit of pollutant reduction. A positive sign on that unit cost indicates that policy did reduce the pollutant. A negative sign on the cost-effectiveness measure indicates that the policy increased the pollutant and a payment was made by government and/or farmer per unit of the increase. All chemicals could have been evaluated in this manner. However, because of the variety of chemicals Aatrex was examined, along with its common substitute 2-4D, because of its consistent appearance in runoff, percolation, and sedimentation. Note that these costs do not include the costs of clean-up, health effects, or detection--only direct costs to the income of the government and farm operator.

The Cost-Share Scenarios

The Cost-Share Scenario, Cost-Share Without Litter resulted in a large cost to the government. The cost of using the rye/clover cover crop under the Cost-Share Scenario was completely subsidized by the government. Under this premise, Table 5.6 shows that it cost the government $151 per kg ($69 per lb) of nitrogen removed from runoff and $3 per kg ($1.4 per lb) of nitrogen removed from percolation, and $5.1 per kg ($2.3 lb) of nitrogen removed from sediment.

The reduction of Aatrex in runoff cost $373 per g ($169,528 per lb) and the reduction in sediment cost $934 per g ($424,545 per lb). The total change in Aatrex loadings reflect the fact the percolation loadings increased by more than the reductions in runoff and sediment, therefore, a payment for increasing overall loadings, of $27.3 per g ($12,409 per lb) was made. The cost of soil erosion reductions was \$15 per metric ton (\$14 per ton). Overall the Cost-Share Scenario did not get adequate reductions in potential pollutant levels for its cost. The Cost-Share Without Litter was not very cost-effective, either. The total cost of nitrogen reduction was \$3.2 per kg (\$1.45 per lb) but Aatrex and soil erosion were not reduced. Aatrex levels rose, in total, by 331,989 g (730 lb) and soil erosion rose by 338,041 metric tons (371,845 tons). The cost-effectiveness figures in these cases had negative signs indicating that a payment to increase the level of a contaminant was necessary. Note that if the increase in a contaminant is large the payment is small, which is not realistic since payment should rise as more contaminant is found in the environment. This problem is strictly a function of the mathematical derivation of these cost-effectiveness figures. Therefore the payments are not used for comparison as much as the positive cost-effectiveness figures.

The Base Flexibility Scenario

The Base Flexibility Scenario also had large government costs. The reduction in nitrogen cost \$424,435 per kg (\$192,925 per lb) in runoff, \$645 per kg (\$293 per lb) in percolation, and \$3,096 per kg (\$1,407 per lb) total. Payments for increases in nitrogen to sediment of \$814 per kg (\$370 per lb) off set some of the reduction benefits. Aatrex use was reduced under the Base Flexibility Scenario because of displaced corn base; however, the costs were high to the government: \$87,014 per g (\$39,551,818 per lb) in runoff, \$10,217 per g (\$4,644,090 per lb) in percolation. Aatrex loadings increased in sediment, but the total effect was a reduction in Aatrex loadings, costing $9,762 per g ($4,47,273 lb). The reductions in nitrogen and Aatrex contamination were costly under the Base Flexibility Scenario. Although Aatrex loadings of groundwater were reduced, the cost was prohibitive. Furthermore, the payments which would be estimated for the increases in other potential chemical contaminants under this scenario make Base Flexibility as currently proposed a poor tool for groundwater protection.

Aatrex Restriction Scenarios

The surface application policies of the No Aatrex and 1/3 Aatrex Scenarios and No Aatrex and 1/3 Aatrex Without Litter Scenarios were generally less costly per unit of reduction than the other scenarios. Nitrogen reductions in runoff cost $578 per kg ($263 per lb) for the 1/3 Aatrex Scenario and $18,436 per kg ($8,380 per lb) for the No Aatrex Scenario. The No Aatrex Scenario had the most costly nitrogen in runoff reduction of the policy scenarios because of the small size of the reduction, 46 kg (101 lb). Percolation and sediment nitrogen content increased under both the 1/3 Aatrex and No Aatrex Scenarios. The reductions in runoff nitrogen were masked by the increased levels of nitrogen in percolation and sediment, so that the total change in nitrogen loadings was an increase of 168,247 kg (370,143 lb) for the No Aatrex Scenario and 454,070 kg (998,954 lb) for the 1/3 Aatrex Scenario. The total nitrogen in the No Aatrex Without Litter Scenario also increased and a payment of $6.6 per kg ($4 per lb) were calculated. On the other hand, the 1/3 Aatrex Without Litter had a large decrease in nitrogen in percolation which caused the total nitrogen contributions to be negative. The nitrogen reduction in the 1/3 Aatrex Without Litter Scenario cost $36 per kg ($16 per lb), the second highest cost for a scenario which reduced total nitrogen contributions.

Reduction of Aatrex in percolation costs between $2 and $3 per g ($909 and $1,364 per lb) for both scenarios using poultry litter. Reduced Aatrex levels in runoff cost about $58 per gram ($26,361 per lb) for both scenarios, and the reduction of Aatrex in sediment cost $194 and $186 per g ($88,182 and $84,545 per lb) in the No Aatrex and 1/3 Aatrex Scenarios respectively. The total change in Aatrex contributions was negative for both scenarios. The total cost of Aatrex reduction was $2.3 per g ($1,045 per lb) for the No Aatrex Scenario and $2.2 per g ($1,000 per lb) in the 1/3 Aatrex Scenario. There was a substitution of 2-4D for Aatrex in these scenarios, which required a payment of $24 per g ($10,909 per lb) in the No Aatrex Scenario and $61 per g ($4,545,454 per lb) in the 1/3 Aatrex Scenario to increase loadings. Both the No Aatrex and 1/3 Aatrex Without Litter Scenarios were less cost-effective at reducing total Aatrex loadings, the cost was $3.1 per g ($1,409 per lb) and $2.8 per g ($1,273 per lb), respectively. Each individual loading reduction, that is runoff, percolation, and sediment, were more expensive in the Without Litter Scenarios.

Soil erosion was increased under all four surface application reduction scenarios. A payment value of $61 per metric ton ($55 per ton) and $48 per metric ton ($44 per ton) was calculated for the No Aatrex and

1/3 Aatrex Scenarios respectively. The payment values were less under the No Aatrex and 1/3 Aatrex Without Litter Scenarios due to the larger increases in soil erosion. The cost of Aatrex reduction under the No Aatrex and 1/3 Aatrex Scenarios were similar and the least costly of all the policy scenarios. Based on the cost for Aatrex reduction and the increases in other areas, the 1/3 Aatrex Scenario is the most viable groundwater protection tool of the scenarios examined. The same scenarios without the use of poultry litter, the No Aatrex and 1/3 Aatrex Without Litter Scenarios, proved to be less cost-effective at reducing Aatrex because of the lack of organic activities. However, even at these higher costs the No Aatrex and 1/3 Aatrex Without Litter Scenarios were less costly than the remaining scenarios and could also be considered as a cost-effective tool for groundwater management.

The Chemical Taxation Scenario

The Chemical Taxation Policy was expensive to the farmer, but produced fairly large reductions in chemical levels, without reducing total nitrogen loss. The reduction of nitrogen in runoff and sediment, costing \$387 and \$25 per kg (\$176 and \$11 per lb), was not enough to offset the rise in nitrogen percolation resulting in a total expenditure of \$15 per kg (\$6.8 per lb) to increase nitrogen loadings. The reduction of Aatrex in runoff was the most expensive of all the policy scenarios at \$540 per g (\$245,430 per lb), while its costs of reduction in percolation and sediment were \$23 and \$1,821 per g (\$10,454 and \$827,727 per lb). While the chemical costs of Aatrex reduction to groundwater and in total were high but not the highest of all the scenarios. Soil erosion reduction costs were not extremely high under the Chemical Taxation Scenario at \$79 per metric ton (\$72 per ton). As a groundwater protection policy, the Chemical Taxation Scenario fails to keep nitrogen out of groundwater. The potential tradeoffs between surface and groundwater, and between chemicals and nitrogen, keep the Chemical Taxation Scenario from being an effective groundwater protection policy.

The Loading Restriction Scenarios

The loading restriction scenarios were generally less cost-effective at containing chemical non-point pollution than the surface restrictions. The total change in nitrogen contributions was positive; therefore a total payment of \$1.22 per kg (\$.55 per lb) and \$7 per kg (\$3.2 per lb) of nitrogen were required under the 40% Percolation Reduction and 40% Percolation/Runoff Scenarios. Nitrogen contributions were increased with payments (per kg of nitrogen) of \$798 per kg (\$363 per lb) in runoff, \$1.25 per kg (\$.57 per lb) in percolation, and \$58 per kg (\$26 per lb) in sediment in the 40% Percolation Scenario. The 40% Percolation/Runoff Scenario had reductions in nitrogen content of runoff at \$10,087 per kg (\$4,585 per lb), while payments were made for increased contributions to percolation at \$8 per g (\$3,636 per lb) and to sediment at \$49 per g (\$22,273 per lb). The total payments for nitrogen pollution were less than those required under the surface level restriction scenarios. The 40% Percolation Reduction and 40% Percolation/Runoff Reduction Without Litter Scenarios reduced nitrogen contributions instead of increasing them as the 40% Percolation and 40% Percolation/Runoff Scenarios did. Total nitrogen contributions were reduced by 759,758 kg (1,671,468 lb) at a cost of $6.9 per kg ($3.1 per lb). The 40% Percolation and Percolation/Runoff Reduction Without Litter Scenarios had was the third highest cost of nitrogen reduction of the six scenarios which reduced nitrogen contributions.

The Aatrex reductions were less in the loading restriction scenarios using litter than under the surface application reduction scenarios. The cost of total Aatrex reduction was $72 per g ($32,727 per lb) and $13 per g ($5,909 per lb) for the 40% Percolation and 40% Percolation/Runoff Scenarios. The chemical 2-4D was found at lower levels under the 40% Percolation and 40% Percolation/Runoff Reduction Scenarios than under the No Aatrex or 1/3 Aatrex Scenarios because of the use of more production activities which reduced all chemicals. Total payments required for the introduction of 2-4D were $373 per g ($169,545 per lb) under the 40% Percolation Reduction Scenario and $273 per g ($124,091 per lb) under the 40% Percolation/Runoff Scenario.

The cost of the reduction of Aatrex in runoff under the 40% Percolation Reduction Scenario was higher than under the 40% Percolation/ Runoff Scenario, at $365 per g ($165,893 per lb) compared to $329 per g ($149,545), because the 40% Percolation Reduction Scenario reduced Aatrex in runoff by less. The cost of reducing Aatrex levels in percolation and sediment were $8 and $612 per g ($3,636 and $278,182 per lb) under the 40% Percolation Reduction Scenario. The 40% Percolation/ Runoff Reduction

Scenario produced a small increase in Aatrex content of sediment, while the reduction in Aatrex in percolation cost $14 per g ($6,364 per lb).

The 40% Percolation and 40% Percolation/Runoff Without Litter Scenarios achieved an additional 43,536 g (96 lb) of reduction in total Aatrex levels, but the cost per gram was $7 ($3,636 per lb) more than in the 40% Percolation/Runoff Reduction Scenario using poultry litter. At $20 per g ($9,091 per lb) of Aatrex removed from the environment, the 40% Percolation Reduction Without Litter Scenario was more cost-effective than the Chemical Taxation Scenario, the land use scenarios, and the Base Flexibility Scenario.

The cost of reducing soil erosion was fairly high under the 40% Percolation/Runoff Scenario, $91 per metric ton ($83 per ton); there were no soil erosion reductions under the 40% Percolation Scenario. The 40% Percolation Reduction Without Litter Scenario was not as cost-effective in reducing soil erosion, at $33 per metric ton ($30 per ton), as the original 40% Percolation Reduction Scenario, at $8 per metric ton ($7 per ton).

Based only on the cost-effectiveness of protecting groundwater, the 40% Percolation and the 40% Percolation/Runoff Scenarios, with and without litter, were the second best type of policies for Aatrex reduction and nitrogen reduction. The total cost for reducing nitrogen, chemical, and soil loading was less attractive in the No Aatrex and 1/3 Aatrex Scenarios, with and without litter. The 40% Percolation Reduction Without Litter Scenario could be considered the best groundwater strategy of the loading restriction scenarios. This scenario combined cost-effective nitrogen management with a relatively cost-effective Aatrex reduction. The key to the value of the 40% Percolation Reduction and Percolation/ Runoff Reduction Scenarios was the use of idled land, just as was used under the land use policies.

Land use restrictions were shown to have low environmental impacts. A potentially valuable groundwater protection policy indicated by this analysis is the idling of land which does not meet certain loading restrictions. The reduction of potential pollutants through loading restrictions can be a cost-effective measure for groundwater protection but not necessarily for overall environmental protection, especially if the costs of implementing such a program on a national scale are considered.

Land Use Scenarios

The land use policies resulted in reductions of all potential pollutants because of the retirement of productive land. The Buffer Strip Scenario had the highest cost to the farmer for total Aatrex reduction of all the scenarios experiencing declines in net returns. The high cost to farmers indicates that the Buffer Strips may be less cost-effective at reducing Aatrex levels than other policies, due to the lack of compensation for the land's productivity and because the reductions in chemical levels are minimal. Aatrex reductions cost $1,296, $65, and $139,986 per g ($589,032, $29,543, and $63,630,000 per lb) in runoff, percolation, and sediment. The cost of nitrogen reductions were $293 per kg (133 per lb) in runoff, $2 per kg ($.90 per lb) in percolation, and

$152 per kg ($69 per lb) in sediment for a total cost of $1.6 per kg ($.70 per lb). These nitrogen reductions were the second most inexpensive reductions among the policy scenarios.

The CRP Scenario had two cost-effectiveness values calculated: the upper value is the cost to the farmer based on his lost income, the second is the cost to the government based on the compensation paid for CRP enrollment. These costs are totaled in the third entry under the CRP Scenario. The costs were higher to the government per unit of non-point pollution reduction than the farmer. For example, the government paid nearly four times the farmers' cost for Aatrex reductions in runoff, $1,116 per gram ($507,222 per lb). The government paid $46 per g ($20,909 per lb) of Aatrex reduction in percolation and $4,042 per g ($1,837,273 per lb) in sediment, while the farmer paid $14 per g ($6,364 per lb) and $1,225 per g ($556,818 per lb) for Aatrex reductions in percolation and sediment. The difference between farmer costs and government costs were not as large for the reduction of nitrogen contaminants. The government paid $240 per kg ($109 per lb), $6 per kg ($2.7 per lb), and $.90 per kg ($.41 per lb) for reduced levels of nitrogen in runoff, percolation, and sediment. Farmer costs for reduced nitrogen content of runoff, percolation, and sediment were $73, $2, and $3 per kg ($33, $.9, and $1.4 per lb) respectively.

Soil erosion reductions were inexpensive to the farmer in both land use scenarios: $10 per metric ton ($9 per ton) to the farmer and $34 per metric ton ($31 per ton) to the government under the CRP Scenario, and $39 per metric ton (35 per ton) to the farmer under the Buffer Strip Scenario.

All potential pollutants were reduced under the Buffer Strip and CRP Scenarios, the farmer paid all the policy costs in the Buffer Strip Scenario while the government paid almost five times as much of the policy costs as the farmer under the CRP Scenario. Land use policies which retire productive land result in the most complete reduction in potential pollutants. The costs of nitrogen reductions was the second lowest of all the policy scenarios, but the cost of Aatrex reduction was among the highest. The advantage of land use policies is the lack of any opposing increases in potential pollutants from another pollutant. Although some per unit costs of nitrogen and chemical reduction were high, the CRP and Buffer Strip Scenarios were attractive as groundwater protection strategies not only for their reductions in groundwater loading but reductions in all other aspects of pollution studied.

Summary

Although groundwater quality was the focus of this study, other non-point pollution contributions from farming practices must be considered to find a generally cost-effective policy.

Only the CRP and Buffer Strip Scenarios resulted in reductions of all pollutants. Land retirement programs may be attractive to farmers attempting to meet conservation compliance requirements depending on the extent of land needed to be set aside. The costs of all policies are high per unit of pollutant reduction but, the reader is reminded that these estimates are biased upward. In cases where increases as well as decreases in pollutants were observed, several policies may have to be combined to obtain reductions in all pollutants. For example, the Cost-Share Scenario had inexpensive reductions in nitrogen and soil erosion but chemical reductions were mixed, in particular, Aatrex leaching increased. In this case, a Cost-Share program and/or an Aatrex surface application restriction could be employed. Even then, the result of this combination of policies on pollutant levels is unknown, and the cost per unit of pollutant reduction would probably increase. A single policy which is cost-effective at reducing groundwater loadings while minimizing other environmental effects is the desirable option.

The 1/3 Aatrex Scenario produced less Aatrex reductions at nearly the same cost per unit as a complete removal of Aatrex under the No Aatrex Scenario. General banning of a targeted chemical may be cost-effective but the possibility exists for substitutions of other chemicals, such as 2-4D for Aatrex. The toxicity, persistence, and cost of the substitute chemical must be considered. The surface application restrictions on the whole were more cost-effective than loading restrictions. The relative cost of surface restrictions would have been greater if the expense of monitoring for loading restrictions were included in its per unit cost. Restrictions on chemical loading and chemical surface application produced the desired effects for groundwater contamination but overall environmental quality may not improve under these scenarios.

Except under land retirement policies, reductions in chemical contributions to groundwater were often associated with large increases in nitrogen losses and soil erosion. Organic and low-chemical activities were shown to have non-point pollution characteristics, as do conventional practices. One of the most prominent tradeoffs in the use of organic activities was the reduction in potential chemical pollution and the possibility of increased nitrogen pollution. Most LIA activities include the use of organic sources of nitrogen, such as poultry litter, which have the potential to pollute as much as or more than inorganic sources of nitrogen. In this study, poultry litter leached more than inorganic nitrogen on a consistent basis due to the physical characteristics of nitrogen in litter. Using poultry litter as a starter fertilizer, followed by later applications of commercial nitrogen, might prove to be a more environmentally benign practice. Other cultural practices in LIA activities which should be carefully managed to minimize environmental effects are cultivations, and the monitoring of nutrient levels building up in the soil. The use of numerous cultivations for weed-control under organic and low-chemical activities can add to soil erosion just as excessive tillage does. The simple reduction of chemicals from production does not guarantee general reductions in pollution. However, the potential pollution from organic nitrogen sources and non-chemical weed control could be minimized with careful management.

The Base Flexibility Policy as currently proposed does little for the adoption of LIA practices but does show potential for reducing the nitrogen and chemicals associated with base commodities. Table 5.6 shows soil erosion rose under the Base Flexibility Scenario, which is related to the introduction of full season soybeans. Table 5.6 does not show the associated increase in all chemicals used on soybeans. Because commodities currently proposed as eligible to be planted on flexible hectares have eliminated the use of low-input crops, such as grasses and legumes, potential pollutant reductions have been diminished. It is possible that the use of legumes and grasses soil erosion and nitrogen reductions could be greater, as under the Cost-Share Scenario.

LIA has promised reductions in chemical contamination of groundwater and runoff. This study showed that although that is indeed the case, there are tradeoffs between reduced chemical contamination and nitrogen losses and soil erosion. There are in some instances tradeoffs within chemical reductions because sediment content and runoff levels may not move in the same direction as percolation levels. All tradeoffs should be considered when examining the cost-effectiveness of any policy or LIA practices. Comparisons are not straight forward due to varying measurement units, toxicity levels, and the uncertainty of contamination concentrations in depository water bodies. However, a cost-effectiveness measurement, such as the one used in this study, brings attention to the complexity of the problem and the sometimes contradictory solutions created by a single policy.

Based on this study, LIA adoption in general would provide significant reductions in the chemical loading of groundwater. However, a blanket adoption of LIA practices does not insure reductions in nitrogen contamination of groundwater, nor does it consider the hydrological links between surface and groundwater flows. The use of organic nitrogen has proven to cause increased nitrogen leaching. The control of this problem under LIA adoption requires more sophisticated management of fertilization practices. Combination of organic and commercial nitrogen will probably be the best practice under LIA adoption. This recommendation means that the recent rise in consumer desire for completely organic products may work against the consumer desire for environmentally benign agricultural practices. Perhaps the most important caveat to the recommendation of LIA practices as groundwater protection strategies is that agriculture is a site-specific process and so are the environmental loadings created from agricultural practices. A national endorsement of a limited number of LIA practices would be too restrictive; federal support for LIA's use as a groundwater strategy should include research and presentation of results of many different combinations of practices under varying physical conditions. The state level enforcement of LIA adoption policies is more feasible.

If LIA is not the best solution than what is the alternative? What is needed to solve the unique problems of agricultural pollution of groundwater is an information intensive approach to production. This alternative does not abandon the idea of LIA but enhances the scope of LIA. All LIA practices should be associated with the same type of information program as Integrated Pest Management. Nutrient needs should be based on regularly tested soil and plant tissue tests, and pesticide needs should be based on pest and weed population counts. This type of program will require more labor hours to be spent in management of the farm, assisted by many computer programs which are designed to assist the farmer in this task. Additional research will also be needed to develop better procedures for testing soil and plant tissue for nutrient levels and prescribing actions needed to the farmer.

Although the retirement of productive land did not promote the use of LIA practices, it could be also be useful tool for groundwater protection. There have been proposals to change the emphasis in the CRP legislation from strictly soil erosion to groundwater management. This study shows that the enrollment of land in the CRP program provides not only soil erosion benefits but large runoff and groundwater protection benefits as well. Land retirement programs were not the most cost-effective measure for protecting groundwater, especially if the farmer is subsidized for his land. But the costs may not be deemed unreasonable considering the ability to get reductions in all areas of non-point pollution. LIA adoption could be easily paired with the retirement of small parcels of land in order to compensate for any non-point pollution not reduced under LIA.

Limitations of the Study

Three major limitations in the mathematical model concerned the assumption of perfect knowledge, yields used within the study, and the loading coefficients.

Perfect Information

The assumption of perfect knowledge could not be made under normal circumstances. The effect of perfect knowledge about future prices and yields was particularly noticeable in the enrollment of base. Knowledge of future target prices, market prices, and yields allows 15 years of planting to be planned at the start of this analysis. This planning horizon caused an upward bias in net returns because, in reality, the farmer must estimate what his deficiency payment needs will be in the future and plan his commodity program enrollment based on this uncertainty. In addition, loading restriction policy results were biased by the ability of the farmer to know what the future loadings of chemicals would be based on weather patterns. Farmers selected activities using less chemicals in years where the weather conditions promoted more runoff or leaching. The annual optimal decisions were not only optimal for the current year but also for the 15 year period based on complete knowledge of the conditions in all 15 years. The assumption of perfect knowledge is a problem in this multi-period model, but the problem can be diminished by introducing risk and uncertainty to the model as is discussed in the future research section of this chapter.

Yield Variability

If yield response function could be incorporated in this study, the model would take on even more dynamic aspects. Allowing yields to respond directly to either weather or chemical use would create more potential for evaluating the possible barriers to LIA adoption. Yield response functions could be incorporated in the algorithm currently used. There are, however, large data gaps in yield response research, and obtaining enough verified data to create functions for the Richmond County area would be difficult. More demonstration farms and large test plots which are subject to an entire LIA production system are needed to obtain this data.

Loading Coefficients

The third model limitation involves the lack of diversity within the types of land used in the model. A single soil type was used in this model based on the percentage of soil types making up cropland. However, if lands had been varied by erosion factors, then differentials would have appeared in which lands should be enrolled in the CRP program. These differentials may have contributed more to the potential reductions of non-point pollution from those areas. In addition, no method was available to incorporate the filtering affects of buffer strips. Increases in buffer strip hectares may have had more significant impacts on runoff than suggested in this study. The simulation models used for pollution loading only predicted field level movement, and the final destination of the materials moved by water over or through the soil can not be estimated.

Other Limitations

One aspect of low-input agriculture which was not considered and limited the scope of the optimal solutions reached in this study was the inclusion of animal production. Animal production is advocated for LIA practices as a local source of manure. Such a source may have been less costly than transporting poultry litter from the Shenandoah Valley. There are, however, few animals in the county now, and large initial fixed costs would be associated with establishing animal production. Possible broiler operations are being planned for the Richmond County area.

This study also represented the cost side of LIA as a groundwater protection strategy but not all of the benefits. The benefits are perhaps more difficult to estimate because of many of the data gaps mentioned throughout this study, especially data on the toxicity and harmful levels of agrichemicals in the water supply. Not only should human health benefits from reductions in contamination be measured, but existence values for pristine waters and wildlife should be estimated as well.

LIA was defined in this study to be the reduction of petroleum-based inputs in agricultural production. Although the focus of this study included commercial fertilizers and chemicals, the analysis should have also considered the use of fuel by machinery. Many LIA practices rely on increased cultivations, a practice which requires more trips over the field with a tractor and therefore increases fuel consumption. The tradeoffs between the benefits of decreased chemical and commercial fertilizer use should be compared to the costs of increased fuel consumption. The use of machinery in LIA practices has not been investigated to a great extent. This type of research could be collected from LIA demonstration farms and large test plots, but would require the early commitment to record all field work and its fuel consumption.

Finally, this study did not consider the impact of new technologies on either groundwater quality nor agrichemical use. Increased regulation on groundwater quality and chemical use has lead to more research in the area of biological defenses against pests and weeds as opposed to synthetic chemical defenses. Within the 15 years of this study many new biological chemicals may become available (National Research Council).

Thus, the results of this study are less accurate as they are projected further into the future.

Future Research

There is much future research called for by the results of this study. Among the most needed research would be the creation of more diverse production alternatives; the introduction of uncertainty into the model; the enlargement of the mass balance approach; the evaluation of even more complex policies which combine nutrient, chemical, sediment, and soil loss with surface use restrictions; and the estimation of related regional costs from the impacts of the scenarios estimated in this study.

More diverse production systems would be difficult to develop but would significantly enrich this model. Vegetable production, either conventionally or organically, and its affects on the value of land because of vegetables' high value would be an interesting option to consider in this type of study. Also, as mentioned previously, the introduction of more animal production systems would allow a broader representation of LIA activities. For example, hog operations, alfalfa, and other crops in more complex crop rotations merit study. If commodity programs are to be phased out at some future date, or substantially reduced, the study of the impacts of such a change would be valuable.

The introduction of uncertainty through stochastic programming would remove the assumption of perfect knowledge which strongly influenced the planting decisions made under this model. Because the farmer knew future prices and yields, the optimal decisions were made for base enrollment, insuring the needed amount of base at some future time. Perfect knowledge also affected the decisions made under the chemical loading restriction policies. The operator knew future weather and potential loadings so the optimal decisions could be made in advance of weather, such as severe wet periods, which otherwise may have caused increased non-point pollution.

Enlarging the mass balance approach taken in this model could account for every gram of chemicals and nutrients applied on an agricultural field. The cost of controlling all the possible dispersals of agrichemicals may be too expensive, but the accounting would provide valuable tradeoff information. An expanded mass balance approach would also account for nutrients besides nitrogen, such as phosphorus, which is an important water contaminant in some areas. It would be useful if a simulation model which accounted for the build-up of residual nitrogen from applications and crop residues could be developed as CREAMS and GLEAMS were unable to do this.

Using this basic model with more complex policies would provide information to policy-makers concerned with the tradeoffs between all forms of non-point pollution from agricultural practices. This model is particularly useful for policy analysis because commodity programs are included, and the use of individual crops is tied directly to a rotation. By not allowing crops to enter individually, the model is forced to simultaneously evaluate all tradeoffs of pollution, cost, and revenues for the crops in a rotation. Rotations reflect the farmers planting schedule over a long period of time and promote a simple agronomic practice which can be an intricate part of LIA.

Finally, future research will estimate the initial impacts of adopting low-input agriculture and enforcement of those policies proposed to induced LIA adoption on the economy of the county and state. Sectoral output multipliers will indicate the relative impact of changing final demand for various products due to agrichemical regulation, changes in farm practices, and income of the county and state.

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APPENDIX A

CONVERSION FACTORS FOR METRIC TO DOMESTIC UNITS

Table A.1. Conversion Factors for Metric Units to Domestic Units.

COLUMN 1 METRIC	COLUMN 2 TO CONVERT COLUMN 1 TO COLUMN 3 MULTIPLY COLUMN 1 BY	COLUMN 3 DOMESTIC
HECTARE	2.47	ACRE
KILOGRAM	2.2 35.2	POUND OUNCE
GRAMS	0.0022	POUND
LITER	0.265 33.78	GALLON OUNCE
METRIC TON	1.102	TON
KILOGRAMS (WHEAT, SOYBEANS)	0.0367	BUSHEL (WHEAT, SOYBEANS)
KILOGRAMS (CORN)	0.0394	BUSHEL (CORN)
KILOGRAMS (BARLEY)	0.0455	BUSHEL (BARLEY)
METER	3.28	FOOT

APPENDIX B

PRODUCTION ACTIVITY OPERATION SCHEDULES

Table B.1. Production Activities 1,1L: Conventional Chemical Use.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare DC soybean

Operation Schedule

March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant corn	(10)Corn:Aatrex,Dual - 4,6
May	(10)Corn:N - 3,5**
June(10-25)Small Grains:combine DC soybeans:tllage-3 plant	(10-25)DC Soybeans:Gramoxone, Dual,Gemini - 1,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.(20)Corn:combine	(1)DC Soybean:Pydrin - 3,2
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 1L poultry litter is used and applied only at this time.
** For System 1L this N application does not occur.

Tillages
1: Moldboard
2: Disk
3: No-till
4: Chisel

Nutrient/Chemical Application Timing
1:preplant
2:pre-emergence
3:postemergence
4:at planting

Nutrient/Chemical Application Method
1:aerial
2:ground spray
3:scout/target
4:ground broadcast
5:trickle
6:with seed

Table B.2. Production Activities 2, 2L: High Chemical Use.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn	.225 hectare barley
.275 hectare wheat	.5 hectare DC soybean

<u>Operation Schedule</u>

March	(25)Corn:N,P,K - 1,4* Gramoxone,Aatrex,Dual - 1,2
April(10)Corn:tillage-3 plant	
May	(10)Corn:N - 3,5**
June(10-25)Small Grain:combine DC Soybean:tillage-2 plant	(10-25)DC Soybean:Gramoxone, Lorox,Dual - 1,2
July	(5)DC Soybean:Roundup,Blazer - 2,2
Sept.	(1)DC Soybean:Pydrin - 3,2
(20)Corn:combine	
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony, Banvil,2-4D - 3,2**

* For System 2L poultry litter is used and applied only at this time.
** For System 2L this N application does not occur.

Table B.3. Production Activities 3,3L: Low Chemical Use.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn	.225 hectare barley
.275 hectare wheat	.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-4	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant	(10)Corn:Aatrex - 4,6
May(15)Corn:cultivate	(10)Corn:N - 3,5**
June(10-25)Small Grain:combine	(10-25)DC Soybean:Gramoxone - 1,2
DC Soybeans:tillage-3	
plant	
Aug.	(1) DC Soybean:Fusulade - 3,2(3)
Sept.(20)Corn:combine	
(27)Corn:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N - 3,2**

* For System 3L poultry litter is used and applied only at this time.

** For System 3L this N application does not occur.

Table B.4. Production Activity 4: Split Nitrogen Application.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March	(20)Small Grain:N - 3,5
(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4
April(10)Corn:plant	(10)Corn:Aatrex,Dual - 4,6
May	(10)Corn:N - 3,5
June(10-25)Small grain:combine DC Soybean:tillage-3	(10-25)DC Soybean:Gramoxone, Dual,Gemini - 1,2
Aug.	(1) DC Soybean:Fusulade - 3,2(3)
Sept.	(1) DC Soybean:Pydrin
(20)Corn:combine	
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2

Table B.5. Production Activity 5L: Organic.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March (25)Corn:tillage-2	(25)Corn:Litter,P,K - 1,4
April (10)Corn:plant corn	
(30)Corn:cultivate 2X	
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine	
DC Soybean:tillage-3	
plant	
July(1-30)DC Soybean:cultivate 3X	
Sept.(20)Corn:combine	
(27)Small Grain:tillage-1	(27)Small Grain:Litter,P,K - 1,4
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	

Table B.6. Production Activities 6,6L: AAtrex Removed.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn	.225 hectare barley
.275 hectare wheat	.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant	(10)Corn:Bladex,Dual - 4,6
May	(10)Corn:N,2-4D - 3,5**
June(10-25)Small grain:combine DC Soybeans:tillage-3 plant	(10-25)DC Soybean:Gramoxone, Dual,Gemini - 1,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.(20)Corn:combine	(1)DC Soybean:Pydrin - 3,2
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

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* For System 6L poultry litter is used and applied only at this time.

** For System 6L this N application does not occur.

Table B.7. Production Activities 7,7L: Dual Removed.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn	.225 hectare barley
.275 hectare wheat	.5 hectare DC soybean

<u>Operation Schedule</u>	<u>Nutrient/Chemical Applications</u>
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant	(10)Corn:Aatrex,Lasso - 4,6
May	(10)Corn:N - 3,5**
June(10-25)Small grain:combine DC Soybean:tillage-3 plant	(10-25)DC Soybean:Gramoxone, Lasso, Gemini - 1,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.(20)Corn:combine	(1)DC Soybean:Pydrin - 3,2
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 7L poultry litter is used and applied only at this time.

** For System 7L this N application does not occur.

Table B.8. Production Activities 17,17L: Gramoxone Removed.

Corn/Small Grain - DC Soybean (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant	(10)Corn:Aatrex,Dual - 4,6
May	(10)Corn:N - 3,5**
June(10-25)Small Grain:combine DC Soybean:tillage-3 plant	(10-25)DC Soybean:Roundup, Dual, Gemini - 1,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.(20)Corn:combine	(1)DC Soybean:Pydrin - 3,2
(27)Small Grain:tillage-1	(27)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 7L poultry litter is used and applied only at this time.
** For System 7L this N application does not occur.

Table B.9. Production Activities 8,8L: Mowed Cover Crop.

Corn/Small Grain - DC Soybean-Rye (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley

.5 hectare soybean
.5 hectare rye

Operation Schedule	Nutrient/Chemical Applications
April(5)Rye:mow	
(15)Corn:tillage-3	(15)Corn:N,P,K,AAtrex,Dual - 4,6*
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine	(10-25)Corn:N - 3,5**
DC Soybean:tillage-3 plant	DC Soybean:Gramoxone, Dual,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.	(1)DC Soybean:Pydrin - 3,2
(15)Rye:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 8L poultry litter is used and applied only at this time.
** For System 8L this N application does not occur.

Table B.10. Production Activities 9,9L: Mowed Cover Crop, Aatrex Removed.

Corn/Small Grain - DC Soybean-Rye (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley

.5 hectare soybean
.5 hectare rye

Operation Schedule	Nutrient/Chemical Applications
April(5)Rye:mow	
(15)Corn:tillage-3 plant	(15)Corn:N,P,K,Bladex,Dual - 4,6*
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine DC soybean:tillage-3 plant	(10-25)Corn:N,2-4D -3,5** DC Soybean:Gramoxone, Dual,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.	(1)DC Soybean:Pydrin - 3,2
(15)Rye:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 9L poultry litter is used and applied only at this time.
** For System 9L this N application does not occur.

Table B.11. Production Activities 10,10L: Mowed Cover Crop, Dual Removed.

Corn/Small Grain - DC Soybean-Rye (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare soybean
.5 hectare rye

Operation Schedule	Nutrient/Chemical Applications
April(5)Rye:mow	
(15)Corn:tillage-3 plant	(15)Corn:N,P,K,AAtrex,Lasso - 4,6*
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine DC Soybean:tillage-3 plant	(10-25)Corn:N - 3,5** DC Soybean:Gramoxone, Lasso,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.	(1)DC Soybean:Pydrin - 3,2
(15)Rye:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 10L poultry litter is used and applied only at this time.
** For System 10L this N application does not occur.

Table B.12. Production Activities 18,18L: Mowed Cover Crop, Gramoxone Removed.

Corn/Small Grain - DC Soybean-Rye (2years)

.5 hectare corn
.275 hectare wheat
.225 hectare barley
.5 hectare soybean
.5 hectare rye

Operation Schedule	Nutrient/Chemical Applications
April(5)Rye:mow	
(15)Corn:tillage-3 plant	(15)Corn:N,P,K,AAtrex,Dual - 4,6*
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine	(10-25)Corn:N - 3,5**
DC Soybean:tillage-3 plant	DC Soybean:Roundup, Dual,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.	(1)DC Soybean:Pydrin - 3,2
(15)Rye:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 10L poultry litter is used and applied only at this time.
** For System 10L this N application does not occur.

Table B.13. Production Activities 11L: Mowed Cover Crop, Organic.

Corn/Small Grain - DC Soybean-Rye (2years)

.5 hectare corn	.5 hectare soybean
.275 hectare wheat	.5 hectare rye
.225 hectare barley	

Operation Schedule	Nutrient/Chemical Applications
April(5)Rye:mow	
(15)Corn:tillage-3 plant	(15)Corn:Litter,P,K - 4,6
(30)Corn:cultivate 2X	
May(15)Corn:cultivate 1X	
June(10-25)Small Grain:combine DC soybean:tillage-3 plant	
July(1-30)DC Soybeans:cultivate 3X	
Sept.(15)Rye:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	30)Small Grain:Litter,P,K - 1,4
Oct. (5-20)Small grain:plant	
Nov. (15)DC Soybeans:combine	

Table B.14. Production Activities 12,12L: Full Season Soybeans.

Corn/Small Grain-DC Soybean/FS Soybean/Small Grain-DC Soybean (4years)

.25 hectare corn
.275 hectare wheat
.225 hectare barley

.25 hectare FS soybean
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant(yr1)	(10)Corn:Aatrex,Dual - 4,6
May	(10)Corn:N - 3,5**
(13)FS Soybean:tillage-1	(13)FS Soybean:N,P,K - 1,6*
(20)FS Soybean:plant(yr3)	(20)FS Soybean:Dual,Gemini - 4,6
June	(1)FS Soybean:Roundup - 2,2
(10-25)Small Grain:combine (yr2,4) DC Soybean:tillage-3 plant(yr2,4)	(10-25)DC Soybean:Gramoxone, Dual,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)FS Soybean:Treflan - 3,2(3) DC Soybean:Fusulade - 3,2(3)
Sept.(27)Corn:combine(yr1)	(1)DC Soybean:Pydrin - 3,2
(30)Small grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small grain:plant(yr1)	
(18-25)FS soybean:combine(yr3)	
(25-30)Small Grain:tillage-1 plant(yr3)	(25-30)Small Grain:N,P,K - 1,4*
Nov.(15)DC Soybean:combine(yr2,4)	
Feb.	(20)Small Grain:N,Harmony(yr1,3) - 3,2**

* For System 12L poultry litter is used and applied only at this time.
** For System 12L this N application does not occur.

Table B.15. Production Activities 13,13L: Full Season Soybeans,No Aatrex.

Corn/Small Grain-DC Soybean/FS Soybean/Small Grain-DC Soybean (4years)

.25 hectare corn
.275 hectare wheat
.225 hectare barley

.25 hectare FS soybean
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1 *
April(10)Corn:plant(yr1)	(10)Corn:Bladex,Dual - 4,6
May	(10)Corn:N,2-4D - 3,5**
(13)FS Soybean:tillage-1	(13)FS Soybean:N,P,K - 1,6*
(20)FS Soybean:plant(yr3)	(20)FS Soybean:Dual,Gemini - 4,6
June	(1)FS Soybean:Roundup - 2,2
(10-25)Small grain:combine (yr2,4)	(10-25)DC Soybean:Gramoxone, Dual,Lorox - 1,2
DC Soybeans:tillage-3 plant(yr2,4)	
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)FS Soybean:Treflan - 3,2(3)
	DC Soybean:Fusulade - 3,2(3)
Sept.(27)Corn:combine(yr1)	(1)DC Soybean:Pydrin - 3,2
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant(yr1)	
(18-25)FS Soybean:combine(yr3)	
(25-30)Small Grain:tillage-1 plant(yr3)	(30)Small Grain:N,P,K - 1,4*
Nov.(15)DC Soybean:combine(yr2,4)	
Feb.	(20)Small Grain:N,Harmony(yr1,3) - 3,2**

* For System 13L poultry litter is used and applied only at this time.
** For System 13L this N application does not occur.

Table B.16. Production Activities 14,14L: Full Season Soybeans,No Dual.

Corn/Small Grain-DC Soybean/FS Soybean/Small Grain-DC Soybean (4years)

.25 hectare corn	.25 hectare FS soybean
.275 hectare wheat	.5 hectare DC soybean
.225 hectare barley	

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant(yr1)	(10)Corn:Aatrex,Lasso - 4,6
May	(10)Corn:N - 3,5**
(13)FS Soybean:tillage-1	(13)FS Soybean:N,P,K - 1,6*
(20)FS Soybean:plant(yr3)	(20)FS Soybean:Lasso,Gemini - 4,6
June	(1)FS Soybean:Roundup - 2,2
(10-25)Small Grain:combine (yr2,4)	(10-25)DC Soybean:Gramoxone, Lasso,Lorox - 1,2
DC Soybean:tillage-3 plant(yr2,4)	
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)FS Soybean:Treflan - 3,2(3)
	DC Soybean:Fusulade - 3,2(3)
Sept.(27)Corn:combine(yr1)	(1)DC Soybean:Pydrin - 3,2
(30)Small grain:tillage-1	(30)Small Grain:N,P,K,-1,4*
Oct.(5-20)Small Grain:plant(yr1)	
(18-25)FS Soybean:combine(yr3	
(25-30)Small Grain:tillage-1 plant(yr3)	(30)Small Grain:N,P,K,-1,4*
Nov.(15)DC Soybean:combine(yr2,4)	
Feb.	(20)Small Grain:N,Harmony(yr1,3) - 3,2**

* For System 14L poultry litter is used and applied only at this time.

** For System 14L this N application does not occur.

Table B.17. Production Activities 19,19L: Full Season Soybeans,No Gramoxone.

Corn/Small Grain-DC Soybean/FS Soybean/Small Grain-DC Soybean (4years)

.25 hectare corn
.275 hectare wheat
.225 hectare barley

.25 hectare FS soybean
.5 hectare DC soybean

Operation Schedule	Nutrient/Chemical Applications
March(25)Corn:tillage-1	(25)Corn:N,P,K - 1,4*
April(10)Corn:plant(yr1)	(10)Corn:Aatrex,Dual - 4,6
May	(10)Corn:N - 3,5**
(13)FS Soybean:tillage-1	(13)FS Soybean:N,P,K - 1,6*
(20)FS Soybean:plant(yr3)	(20)FS Soybean:Dual,Gemini - 4,6
June	(1)FS Soybean:Roundup - 2,2
(10-25)Small Grain:plant (yr2,4)	(10-25)DC Soybean:Roundup, Dual,Lorox - 1,2
DC Soybean:tillage-3 plant(yr2,4)	
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)FS Soybean:Treflan - 3,2(3)
	DC Soybean:Fusulade - 3,2(3)
Sept.(27)Corn:combine(yr1)	(1)DC Soybean:Pydrin - 3,2
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant(yr1)	
(18-25)FS Soybean:combine(yr3)	
(25-30)Small Grain:tillage-1 plant(yr3)	(30)Small Grain:N,P,K - 1,4*
Nov.(15)DC Soybean:combine(yr2,4)	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 19L poultry litter is used and applied only at this time.

** For System 19L this N application does not occur.

Table B.18. Production Activities 15,15L: Green Manure.

Corn/Small Grain - DC Soybean-Mix(Rye/Crimson Clover) (2years)

.5 hectare corn .5 hectare soybean
.275 hectare wheat .5 hectare mix(rye/clover)
.225 hectare barley

Operation Schedule	Nutrient/Chemical Application
April(5)Mix:disk under	
(15)Corn:tillage-2	(15)Corn:N,P,K - 1,4*
(25)Corn:plant	(25)Corn:Aatrex,Dual - 4,6
June(10-15)Small Grain:combine	(10)Corn:N - 3,5**
DC Soybean:tillage-3 plant	(10-15)DC Soybean:Gramoxone, Dual,Lorox - 1,2
July	(5)DC Soybean:Blazer - 2,2
Aug.	(1)DC Soybean:Fusulade - 3,2(3)
Sept.	(1)DC Soybean:Pydrin - 3,2
(15)Mix:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(30)Small Grain:N,P,K - 1,4*
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	
Feb.	(20)Small Grain:N,Harmony - 3,2**

* For System 15L poultry litter is used and applied only at this time.
** For System 15L this N application does not occur.

Table B.19. Production Activities 16L: Green Manure, Organic.

Corn/Small Grain - DC Soybean-Mix(Rye/Crimson Clover) (2years)

.5 hectare corn	.5 hectare soybean
.275 hectare wheat	.5 hectare mix(rye/clover)
.225 hectare barley	

Operation Schedule	Nutrient/Chemical Applications
April(5)Mix:disk under	
(15)Corn:tillage-2	(15)Corn:Litter,P,K - 1,4
(25)Corn:plant	
May(1-39)Corn:cultivate 3X	
June(10-15)Small Grain:combine	
DC Soybean:tillage-3	
plant	
July(1-30)DC Soybean:cultivate 3X	
Sept.(15)Mix:aerial overseed	
(27)Corn:combine	
(30)Small Grain:tillage-1	(10)Small Grain:Litter,P,K - 1,4
Oct.(5-20)Small Grain:plant	
Nov.(15)DC Soybean:combine	

APPENDIX C

LABOR AVAILABILITY AND REQUIREMENTS OF PRODUCTION ACTIVITIES

Table C.1. Full Time Operator Available Field Hours.

Month	Days	Hours per Day	Full Time Field Hours per Month
March*	15.6	10	156
April	15.6	10	156
May	16.6	10	166
June	25.2	11	277
July	20.2	11	222
August	19.4	11	213
September	25.6	11	282
October	21.0	10	210
November	20.1	10	201
January**	20.1	10	201
February**	20.1	10	201

* Days suitable for fieldwork were not listed for March, April figure was used as a proxy.
** Days suitable for fieldwork were not listed for February, November figure was used as a proxy.

Available work days per month are based on "Average Number of Days Suitable for Fieldwork, 1984-1988," as reported by the Virginia Agricultural Statitics Service, 1988. Hours per day are assumed (Norris).

For part-time farmers it was assumed that 40 hours a week, 8 hours per day, were worked off the farm. A percent of full time available labor was calculated by dividing the part-time available hours per month by the full time available hours per month. These percentages were then multiplied by the number of field days available per month.

Table C.2. Part-Time Operator Available Field Hours.

Month	Full Time Hours/Month	Percent of Full Time	Part-time Hours per Month
March*	156	.43	67.08
April	156	.43	67.08
May	166	.43	71.38
June	277	.48	132.96
July	222	.48	106.56
August	213	.48	102.24
September	282	.48	135.36
October	210	.43	90.30
November	201	.43	86.43
January**	201	.43	86.43
February**	201	.43	86.43

* Days suitable for fieldwork were not listed for March, April figure was used as a proxy.

** Days suitable for fieldwork were not listed for February, November figure was used as a proxy.

Table C.3. County Operator Available Labor Hours.

Month	Full Time Hours/Month Weighted(53%)	Part Time Hours/Month Weighted(47%)	Total Hour/Month (148 operators)
March	82.68	31.53	16903.0
April	82.68	31.53	16903.0
May	87.98	33.55	17986.0
June	138.5	62.49	29746.0
July	117.66	50.08	29265.0
August	112.89	48.05	23819.0
September	149.46	63.62	31536.0
October	111.3	42.44	22753.0
November	106.53	40.62	21778.0
January	106.53	40.62	21778.0
February	106.53	40.62	21778.0

According to the 1988 Census of Agriculture for 53 percent of the farm operators in Richmond County, Virginia farming is their primary occupation. The other 47 percent of farm operators are considered part-time, having another primary occupation. The total amount of farm operator labor avilable in Richmond County was then calculated for each month by multiplying the number of farm operators (148) (U.S. Dept. of Commerce) times the weighted full-time labor availability and part-time labor availability.

Table C.4. LABOR REQUIREMENTS OF FARM MACHINERY OPERATION.

Operation	Hours per Hectare	+10 Percent Effeciency
Chisel	.673	.74
Disk	.648	.71
Moldboard	1.094	1.20
Plant, Conventional	.757	.83
Plant, No Till	1.136	1.25
Combine, Corn	.945	1.44
Combine. Small Grain	1.312	.72
Cultivator	.656	.38
Nitrogen Applicator	.242	.27
Mower	.990	1.10

Source: Dunford, Judy and Vines;Perkinson;Norris

Hours of labor required per operation are based on machinery hours required for operations. A ten percent efficiency margin was added to adjust labor hours for variablility in effeciency of operator.

Table C.5. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production Systems 1(L),6(L),7(L),17(L)	
Corn	March	Tillage	1.20
		N Applic.	.27
	April	Plant	.83
	May	N Applic.	.27*
	Sept.	Combine	1.44
		TOTAL	4.01 (3.74)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
	Production Systems 2(L)		
Corn	March	N Applic.	.27
	April	Plant	1.25
	May	N Applic.	.27*
	Sept.	Combine	1.44
		TOTAL	3.23 (2.96)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
DCSoyb.	June	Tillage	.71
		Plant	1.25
	Nov.	Combine	1.44
		TOTAL	3.40

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production Systems 3(L)	
Corn	March	Tillage	.74
		N Applic.	.27
	April	Plant	.83
	May	Cultivate 1X	.38
		N Applic.	.27*
	Sept.	Combine	1.44
		TOTAL	3.93 (3.66)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29 (3.02)
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production Systems 4	
Corn	March	Tillage	1.20
		N Applic.	.27
	April	Plant	.83
	May	N Applic.	.27
	Sept.	Combine	1.44
		TOTAL	4.01
Wheat	March	N Applic.	.27
	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27
		TOTAL	3.56
Barley	March	N Applic.	.27
	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27
		TOTAL	3.56
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production System 5L	
Corn	March	Tillage	1.42
		N Applic.	.27
	April	Plant	.83
		Cultivate 2x	.76
	May	Cultivate 1x	.38
	Sept.	Combine	1.44
		TOTAL	**5.10**
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
		TOTAL	**3.02**
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N-Applic.	.27
	Oct.	Plant	.83
		TOTAL	**3.02**
DCSoyb.	June	Plant	1.25
	July	Cultivate 3x	1.14
	Nov.	Combine	1.44
		TOTAL	**3.83**

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production Systems 8(L),9(L),10(L),18(L)	
Rye	April	Mow	1.10
		TOTAL	1.10
Corn	April	Plant	1.25
		N Applic.	.27
	June	N Applic.	.27*
	May	Cultivate 1x	.38
	Sept.	Combine	1.44
		TOTAL	3.61(3.34)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
Production System 11L			
Rye	April	Mow	1.10
Corn	April	Plant	1.25
		N Applic.	.27
		Cultivate 2x	.76
	May	Cultivate 1x	.38
	Sept.	Combine	1.44
		TOTAL	5.20
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
		TOTAL	3.02
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
		TOTAL	3.02
DCSoyb.	June	Plant	1.25
	JUly	Cultivate 3x	1.14
	Nov.	Combine	1.44
		TOTAL	3.83

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
Production System 12(L),13(L),14(L),19(L)			
Corn	March	Tillage	1.20
		N Applic.	.27
	April	Plant	.83
	May	N Applic.	.27*
	Sept.	Combine	1.44
		TOTAL	4.01(3.74)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69
FSSoyb.	May	Tillage	1.20
		Plant	.83
		N Applic.	.27
	Oct.	Combine	1.44
		TOTAL	3.74

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.3, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production Systems 15(L)	
Mix	April	Disk	.71
		TOTAL	.71
Corn	April	Tillage	.71
		Plant	.83
		N Applic.	.27
	June	N Applic.	.27*
	Sept.	Combine	1.44
		TOTAL	3.52(3.25)
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
	Feb.	N Applic.	.27*
		TOTAL	3.29(3.02)
DCSoyb.	June	Plant	1.25
	Nov.	Combine	1.44
		TOTAL	2.69

* This operation does not occur when using poultry litter. This entry is omitted for the total in parenthesis, which is the labor requirement for activities using poultry litter(L).

Table C.5, continued. LABOR REQUIREMENTS FOR PRODUCTION ACTIVITIES.

Crop	Month	Operation	Field Hours
		Production System 16L	
Mix	April	Disk	.71
		TOTAL	.71
Corn	April	Tillage	.71
		Plant	.83
		N Applic.	.27
	May	Cultivate 3x	1.14
	Sept.	Combine	1.44
		TOTAL	4.39
Wheat	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
		TOTAL	3.02
Barley	June	Combine	.72
	Sept.	Tillage	1.20
		N Applic.	.27
	Oct.	Plant	.83
		TOTAL	3.02
DCSoyb.	June	Plant	1.25
	July	Cultivate 3x	1.14
	Nov.	Combine	1.44
		TOTAL	3.83

APPENDIX D

CROP YIELDS FOR RICHMOND COUNTY, VIRGINIA

Table D.1. ACTUAL CROP YIELDS.

Richmond County, Virginia Crop Yields,
1970-1988, Bushels Per Acre

Year	Corn	Wheat	Barley	Soybean
1970	79.0	55.0	55.0	18.0
1971	76.0	52.0	55.0	27.0
1972	90.0	43.0	48.0	23.0
1973	95.0	37.5	55.0	28.0
1974	97.0	39.5	55.5	24.0
1975	114.0	34.0	52.5	25.0
1976	87.0	34.0	62.5	23.0
1977	41.0	34.5	48.0	15.0
1978	88.0	35.5	52.0	32.0
1979	92.0	38.0	53.0	30.0
1980	58.0	40.0	54.0	13.0
1981	94.0	48.0	68.0	26.5
1982	109.0	42.0	64.0	28.5
1983	43.0	46.5	68.0	14.0
1984	102.5	38.0	62.0	25.0
1985	94.0	31.0	52.5	23.5
1986	43.5	51.0	52.5	20.0
1987	80.5	47.5	54.0	17.0
1988	76.0	57.0	71.5	23.0

Average annual Virginia Crop yields, 1970-1985 (Virginia Cooperative Crop Reporting Service), were detrended by regressing crop yield data on time:

$$\text{crop yield} = \text{intercept}+b_1(\text{time})+b_2(\text{time})^2+b_3(\text{time})^3+b_4(\text{time})^4+\text{residual}$$

Detrending in this manner captures the technologiical trends in the b coefficients of time (Maddala, Kramer). The residuals of the 1970-1985 regression equations are added to the 1988 yields to obtain yields 15 years beyond 1988 that are reflective of the weather and economic patterns of 1970-1985, but not reflective of technological trends.

Table D.2. Estimated Crop Yields for Virginia, for 15 Years starting in 1988, Bushels Per Hectare.

Year	Corn	Wheat	Barley	DC Soybean	FS Soybean
1	197	133	174	50	67
2	165	150	183	67	84
3	186	144	169	54	71
4	194	141	187	65	82
5	200	150	187	54	71
6	247	136	177	57	74
7	187	135	198	52	70
8	80	135	157	34	51
9	203	135	164	77	94
10	218	138	164	73	90
11	137	141	165	32	49
12	227	160	199	67	85
13	264	144	190	73	90
14	98	156	200	36	54
15	242	132	186	64	82

APPENDIX E

NUTRIENT REQUIREMENTS FOR PRODUCTION ACTIVITIES

Table E.1. Nutrient requirements, crop residue nitrogen unaccounted.

Production Activities
1(L),4,6(L),7(L),17(L),15(L),16L

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	146.26	45.0	67.5
Wheat	90.01	40.5	81.01
Barley	73.13	40.5	81.01

Production Activity
2(L)

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	168.77	0.0	0.0
Wheat	131.64	40.5	81.01
Barley	101.26	40.5	81.01

Production Activity
3(L)

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	112.51	45.0	67.5
Wheat	85.51	40.5	81.01
Barley	69.76	40.5	81.01

Table E.1, continued. Nutrient requirements, crop residue nitorgen unaccounted.

Production Activity
5L

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	146.26	45.0	67.50
Wheat	85.51	45.0	67.50
Barley	69.76	45.0	67.50

Production Activities
8(L),9(L),10(L),11L,18(L)

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	146.26	0.0	0.0
Wheat	90.01	40.50	81.01
Barley	73.13	40.50	81.01

Production Activities
12(L),13(L),14(L),19(L)

Crop	Nitrogen (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	146.26	45.00	67.50
Wheat	90.01	40.50	81.01
Barley	73.13	40.50	81.01
FS Soybean	11.25	33.75	54.01

Source: Perkinson; Liddington; VPI & SU, Dept. of Agric. Economics.

Table E.2. Nutrient requirements, crop residue nitrogen accounted.

Production Activities
1(L),4,6(L),7(L),17(L)

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	127.15	19.11	45.0	67.5
Wheat	85.25	4.76	40.5	81.01
Barley	68.37	4.76	40.5	81.01

Production Activity
2(L)

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	149.66	19.11	0.0	0.0
Wheat	126.88	4.76	40.5	81.01
Barley	96.50	4.76	40.5	81.01

Production Activity
3(L)

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	93.40	19.11	45.0	67.5
Wheat	80.75	4.76	40.5	81.01
Barley	65.00	4.76	40.5	81.01

Table E.2, continued. Nutrient requirements, crop residue nitrogen accounted.

Production Activity
5L

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	127.15	19.11	45.0	67.50
Wheat	80.75	4.76	45.0	67.50
Barley	65.00	4.76	45.0	67.50

Production Activities
8(L),9(L),10(L),11L,18(L)

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	139.92	6.34	0.0	0.0
Wheat	86.16	3.85	40.5	81.01
Barley	69.28	3.85	40.5	81.01

Production Activities
12(L),13(L),14(L),19(L)

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	139.92	6.34	45.0	67.5
Wheat	75.70	3.85	40.5	81.01
Barley	58.82	3.85	40.5	81.01
FS Soybean	0		33.75	54.01

Table E.2, continued. Nutrient requirements, crop residue nitrogen accounted.

Production Activities
15(L),16L

Crop	Nitrogen (kg/hectare)	Residue N (kg/hectare)	Phosophorus (kg/hectare)	Potassium (kg/hectare)
Corn	139.11	7.15	45.0	67.5
Wheat	80.41	14.31	40.5	81.01
Barley	63.53	14.31	40.5	81.01

Source: Perkinson; Liddington; VPI & SU, Dept. of Agric. Economics.

APPENDIX F

CROP RESIDUE NITROGEN

Table F.1. Nitrogen Content of Crop Grains and Straw.

Crop	Yield*	Nitrogen** Content	Percent Nitrogen	Source
Corn(grain)	371	151.9	1.61	Gilbertson et al
(stover)	4.96	112.5	1.11	Gilbertson et al
Wheat(grain)	99	56	2.08	Gilbertson et al
(straw)	1.7	22	.67	Gilbertson et al
Barley(grain)	99	39	1.82	Gilbertson et al
(straw)	1.1	17	.75	Gilbertson et al
Soybean(grain)	56	169	6.25	Gilbertson et al
(straw)	3.1	34	.54	Donahue et al

* bushels per hectare
** kilograms per hectare

Harvest Index = Grain Weight / Total Biomass (Shibles et al)

Corn Harvest Index	.55	(Norris)
Wheat Harvest Index	.55	(Norris)
Barley Harvest Index	.5	(Norris)
Soybean Harvest Index	.3	(Shibles et al)

Total (above ground) biomass of plant = Grain + Straw

To calculate Nitrogen content of crop residues (Norris):

For Corn:
(corn yield(bu/h) x 136 kg/bu)/.55 = total biomass weight(kg/h)
total biomass x .0135 = total Nitrogen in crop(kg/h)
crop yield(kg/h) x .016 = Nitrogen in grain(kg/h)
(Nitrogen in crop - Nitrogen in grain) = Nitrogen in residue

For Wheat:
(wheat yield(bu/h) x 60 kg/bu)/.55 = total biomass weight(kg/h)
total biomass x .0152 = total Nitrogen in crop(kg/h)
crop yield(kg/h) x .0208 = Nitrogen in grain(kg/h)
(Nitrogen in crop - Nitrogen in grain) = Nitrogen in residue

For Barley:
(barley yield(bu/h) x 48 kg/bu)/.50 = total biomass weight(kg/h)
total biomass x .0128 = total Nitrogen in crop(kg/h)
crop yield(kg/h) x .0182 = Nitrogen in grain(kg/h)
(Nitrogen in crop - Nitrogen in grain) = Nitrogen in residue

For Soybean:
(soybean yield(bu/h) x 60 kg/bu)/.3 = total biomass weight(kg/h)
total biomass x .0275 = total Nitrogen in crop(kg/h)
crop yield(kg/h) x .0625 = Nitrogen in grain(kg/h)
(Nitrogen in crop - Nitrogen in grain) = Nitrogen in residue

For Rye:

The rye cover, if left to mature would yield between 45 kg (Norris) and 70 kg of Nitrogen per hectare (Rodale). If the rye is plowed under in early April, it will have taken up 50-55 percent of the total Nitrogen required at maturity (Norris) or 22.5 - 35 kg per hectare. This study used 22.5 kg per hectare. If the rye is mowed, not plowed under, in early April little to none of the nitrogen content of the residue is recaptured (Peters and McKee). This study allowed no recapture of nitrogen from mowed rye.

For Clover:

A good clover stand plowed under in early April yields 112.5 kg (Hargrove; Wagger) to 225 kg of Nitrogen per hectare (LaRue and Patterson; Power, 1987b). This study used 112.5 kg of Nitrogen per hectare.

Crop residuals were calculated for a fifteen year period using the estimated crop yields and weather patterns for 1970-1985. This study used the average crop residuals over the sixteen year period because of the inability to easily inject new and varying amounts of organic nitrogen into the CREAMS simulation model on an annual basis.

Table F.2. Nitrogen content of crops.

Year	Nitrogen in Crop Residue (kg/hectare) Corn	Wheat	Barley	DC Soybean	FS Soybean
0	42.78	24.74	28.17	39.55	53.33
1	35.86	28.00	29.48	53.41	67.19
2	40.56	26.84	27.27	43.06	56.84
3	42.24	26.26	30.13	51.53	65.32
4	43.58	27.98	30.25	43.12	56.91
5	53.79	25.37	28.55	45.17	58.95
6	40.72	25.14	31.96	41.71	55.50
7	17.49	25.17	25.39	26.70	40.48
8	44.18	25.16	26.49	61.02	74.80
9	47.38	25.66	26.52	57.93	71.72
10	29.71	26.27	26.70	25.26	39.04
11	49.30	29.78	32.21	53.51	67.30
12	57.22	26.90	30.65	58.03	71.81
13	21.32	29.11	32.36	28.99	42.77
14	52.72	24.71	30.05	51.10	64.88
15	48.35	20.93	26.44	49.63	63.42
Average	41.70	26.13	28.91	45.61	59.39

Table F.3. Percent of Residue Nitrogen Available to Crops Requiring Nitrogen.

	Crop Residues Providing Nitrogen						
	Corn	Wheat	Barley	DCSoyb.	FSSoyb.	Rye	Mix
	Production Activities 1(L)-7(L),17(L)						
Crops Receiving Residue Nitrogen							
Corn	.03	.05	.05	.33			
Wheat	.02	.03	.03	.05			
Barley	.02	.03	.03	.05			
	Production Activties 8(L)-11L,18(L)						
Corn	.03	.05	.05	.05			
Wheat	.02	.03	.03	.03			
Barley	.02	.03	.03	.05			
	Production Activities 12(L)-14(L),19(L)						
Corn		.03	.03	.05	.33		
Wheat	.02			.03	.05		
Barley	.02			.03	.05		
FSSoyb.	.33	.05	.05	.33			
	Production Activities 15(L),16L						
Corn	.03	.05	.05	.05			.6
Wheat	.02	.03	.03	.03			.1
Barley	.02	.03	.03	.03			.1

Decay Rates

Corn, Wheat and Barley (t_1=.02,t_2=.05,t_3=.03): Corn and wheat stubble decay very littlke to none the first year and a small amount in subsequent years (Martin et al; Bartholomew).

Soybeans (t_1=.33, t_2=.05, t_3=.03): Soybeans give approximatley 15 lb/acre of nitrogen the first year, which is approximatly 33 percent of the total nitrogen in soybean residual (Virginia Tech Soil Testing and Plant Analysis Laboratory Procedures; Norris).

Rye (t_1=.6, t_2=.1, t_3=.1, t_4=.05): (Allison, Peters and McKee; Bartholomew;Norris)

Clover (t_1=.6, t_2=.1, t_3=.1, t_4=.05): (Bartholomew;Gilbertson et al).

APPENDIX G

PESTICIDE FORMULATIONS AND PRODUCTION ACTIVITY REQUIREMENTS

Table G.1. Chemical Formulations.

Product Number	Product Name	Active Ingrediant	Formulation (AI/Product)
1	Blazer	acifluorfen	2 lbs/gallon
2	Lasso	alachlor	4 lbs/gallon
3	Aatrex	atrazine	4 lbs/gallon
4	Gemini(a)	chlorimuron	2.04 lbs/gallon
	(b)	linuron	4 lbs/gallon
5	Bladex	cyanazine	4 lbs/gallon
6	Banvel	dicamba	4 lbs/gallon
7	Harmony Extra	DPX M6316	.75 oz/oz
8	Pydrin	fenvalerate	2.4 lbs/gallon
9	Fusulade	fluazifop-P	1.04 lbs/gallon
10	Roundup	glyphosate	4 lbs/gallon
11	Lorox	linuron	4lbs/gallon
12	Dual	metolachlor	8lbs/gallon
13	Gramoxone	paraquat	2.5lbs/gallon
14	Treflan	trifluralin	4lbs/gallon
15	2-4D	2-4D	4lbs/gallon

Source: Virginia Cooperative Extension Service 1988b;
Royal Society of Chemists

Table G.2. Chemical requirements.

Corn, Moldboard Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activitiy #
AAtrex	3.49	1.69	1(L),4,17(L), 19(L)
Dual	1.16	1.13	
Bladex	3.72	1.80	6(L)
2-4D	1.16	.56	
Dual	1.16	.56	
AAtrex	3.49	1.69	7(L)
Lasso	4.70	2.25	
AAtrex	3.49	1.69	12(L)
Dual	2.33	2.25	
Bladex	3.72	1.80	13(L)
2-4D	1.16	.56	
Dual	2.33	2.25	
AAtrex	3.49	1.69	14(L)
Lasso	4.70	2.25	

*Product is in liters unless otherwise noted as kilogram(kg) units.

Table G.2, continued. Chemical requirements.

Corn, No Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
AAtrex	4.65	2.25	2(L)
Dual	1.75	.32	
Gramoxone	1.75	.32	
AAtrex	3.49	1.69	8(L),18(L)
Dual	2.33	2.25	
Bladex	3.72	1.80	9(L)
2-4D	1.16	.56	
Dual	2.33	2.25	
AAtrex	3.49	2.25	10(L)
Lasso	4.65	1.69	
None			11L

*Product is in liters unless otherwise noted as kilogram(kg) units.

Corn, Disk Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare	Production Activity #
AAtrex	3.49	1.69	15(L)
Dual	2.33	1.13	
None			5L,16L

*Product is in liters unless otherwise noted as kilogram(kg) units.

Corn, Chisel Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
AAtrex	3.49	1.69	3(L)

*Product is in liters unless otherwise notes as kilogram(kg) units.

Table G.2, continued. Chemical requirements.

Wheat, Moldboard Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
Harmony Extra	.035 kg	.03	1(L),4,6(L), 7(L),8(L),9(L) 10(L),12(L),13(L), 14(L),15(L), 17(L),18(L),19(L)
Harmony Extra Banvel 2-4D	.035 kg .586 .586	.03 .28 .28	2(L)
None			3(L),5L,11L,16L

*Product is in liters unless otherwise noted as kilogram(kg) units.

Barley, Moldboard Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
Harmony Extra	.035 kg	.03	1(L),4,6(L), 7(L),8(L),9(L), 10(L),12(L),13(L), 14(L),15(L),17(L), 18(L),19(L)
Harmony Extra Banvel 2-4D	.035 kg .586 .586	.03 .28 .28	2(L)
None			3(L),5L,11L,16L

*Product is in liters unless otherwise noted as kilogram(kg) units.

Table G.2, continued. Chemical requirements.

Double-Cropped Soybean, No Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity#
Dual	1.16	1.13	1(L),4,6(L)
Gramoxone	1.75	.53	
Gemini	.35 kg	.195(.017)	
Fusulade	1.75	.22	
Pydrin	.51 kg	.15	
Dual	1.75	1.69	2(L)
Gramoxone	1.75	.53	
Lorox	1.16	.56	
Roundup	2.33	1.13	
Blazer	1.75	.42	
Pydrin	.51	.15	
Gramoxone	.59	.16	3(L)
Fusulade	1.75	.20	
Lasso	4.70	2.25	7(L)
Gramoxone	1.75	.53	
Gemini	.35 kg	.195(.017)	
Fusulade	1.75	.22	
Pydrin	.51	.15	
Dual	1.75	1.69	8(L),9(L),12(L), 13(L),15(L)
Gramoxone	1.75	.53	
Lorox	1.16	.56	
Blazer	1.75	.42	
Fusulade	1.75	.22	
Pydrin	.51	.15	
Lasso	4.70	2.25	10(L),14(L)
Gramoxone	1.75	.53	
Lorox	1.16	.56	
Blazer	1.75	.42	
Fusulade	1.75	.22	
Pydrin	.51	.15	
Dual	1.16	1.69	17(L)
Roundup	3.49	1.13	
Gemini	.35 kg	.195(.017)	
Fusulade	1.75	.22	
Pydrin	.51	.15	

*Product is in liters unless otherwise notes as kilogram(kg) units.

Table G.2, continued. Chemical requirements.

Double-Cropped Soybean, No Tillage, continued

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
Dual	1.75	1.13	18(L),19(L)
Lorox	1.16	.56	
Roundup	3.49	1.13	
Blazer	1.75	.42	
Fusulade	1.75	.22	
Pydrin	.51	.15	
None			5L,11L,16L

*Product is in liters unless otherwise notes as kilogram(kg) units.

Full Season Soybean, Moldboard Tillage

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
Dual	1.75	1.69	12(L),13(L),19(L)
Gemini	.35 kg	.195(.017)	
Treflan	1.75	.85	
Roundup	2.33	1.13	
Lasso	4.65	2.25	14(L)
Gemini	.35 kg	.195(.017)	
Treflan	1.75	.85	
Roundup	2.33	1.13	

*Product is in liters unless otherwise noted kilogram(kg) units.

Table G.2, continued. Chemical requirements.

Rye, Overseed

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
None			8(L),9(L),10(L), 11L,18(L)

*Product is in liters unless otherwise noted as kilogram(kg) units.

Rye/Clover Mix, Overseed

Chemical Product	Product* (per hectare)	Active Ingrediant (kg per hectare)	Production Activity #
None			15(L),16L

*Product is in liters unless otherwise noted kilogram(kg) units.

Source: Hagood; Liddington; Virginia Cooperative Extension Service, 1988a

APPENDIX H

ANNUAL CHEMICAL LOADING COEFFICIENTS

Table H.1. Chemical Content of Sediment, in grams per hectare.

Production Activity 1

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.227/0	.004/.001	.752/0	.001/0	.13/0	.007/0	.178/0	.001/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.008	0/.021	0/.075	0/.002	0/.012	0/.033	0/.006	0/.001
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.019/0	.034/.245	.081/.442	.039/.251	.036/.271	.072/.651	.086/1.044	.006/.539
9	0/0	0/.006	0/.044	0/.015	0/.450	0/.025	0/.046	0/.039
12	.001/.001	.002/.001	.004/.016	0/0	0/.001	.002/.024	.001/.005	0/0
13	8.966/4.313	19.81/10.42	52.927/29.61	6.983/9.191	23.526/18.64	28.862/20.96	24.904/21.56	9.019/8.136

Production Activity 2

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
3	.001/0	003/0	.003/0	.001/0	.014/0	.01/0	.001/0	0/0
6	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.011/0	.018/.161	.04/.266	.026/.131	.016/.16	.038/.349	.063/.617	.004/.329
10	0/1.962	.002/.184	.002/.438	.004/.319	.001/3.464	.005/1.091	.007/.699	0/.448
11	0/.017	0/.022	0/.133	0/.003	0/.025	0/.034	0/.002	0/.003
12	0/0	.001/.005	.001/.009	0/0	.004/.001	.002/.012	0/0	0/0
13	10.399/4.953	23.304/10.18	54.664/32.0	48.24/10.439	28.586/20.25	34.599/19.65	32.871/27.21	12.263/8.387
15	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 3

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.001/0	.002/0	.003/0	0/0	.001/0	.003/0	.001/0	0/0
9	0/0	0/.006	0/.039	0/.010	0/.412	0/.015	0/.037	0/.036
13	1.985/1.28	4.579/2.837	12.134/9.07	21.832/2.564	6.295/5.598	7.155/5.661	7.267/6.537	2.517/2.554

Table H.1, continued. Chemical Content of Sediment.

Production Activity 1, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.42/0	.005/0	.043/0	.005/0	.003/0	.003/0	.197/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.002	0/.016	0/.003	0/.008	0/.007	0/.002	0/.01
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.079/.041	.075/1.945	.007/.238	.03/.227	.015/.05	.036/.261	.1/.056
9	0/.051	0/.246	0/.007	0/.166	0/.214	0/.008	0/.004
12	.002/0	.002/.003	0/0	.002/.003	0/.001	.003/0	.001/.005
13	17.795/11.89	51.802/38.87	7.199/5.031	16.479/7.824	11.962/7.906	14.163/12.38	18.577/19.895

Production Activity 2, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/0	0/0	0/0	0/0	0/.001
3	.014/0	.002/0	0/0	.001/0	0/0	.001/0	.03/0
6	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.043/.017	.045/1.185	.002/.164	.015/.151	.007/.017	.021/.143	.087/.008
10	.005/.202	.007/2.57	0/.171	.001/.964	0/1.237	.003/.165	.014/.147
11	0/.002	0/.026	0/.002	0/.010	0/.014	0/.001	0/.004
12	.004/0	0/.002	0/0	0/.001	0/0	0/0	.010/.001
13	19.411/11.36	67.294/44.43	10.593/5.563	18.517/7.806	13.033/7.288	17.486/12.70	31.945/26.504
15	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 3, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.002/0	.003/0	0/0	.002/0	.001/0	.001/0	.001/0
9	0/.029	0/.202	0/.007	0/.14	0/.197	0/.007	0/0
13	3.878/3.004	13.231/12.19	1.938/1.497	3.668/2.129	2.682/2.121	3.776/3.397	5.556/5.624

Table H.1, continued. Chemical Content of Sediment.

Production Activity 4

chemical	year 1 corn/soyb	2 corn/soyb	3 corn/soyb	4 corn/soyb	5 corn/soyb	6 corn/soyb	7 corn/soyb	8 corn/soyb
3	.003/0	.004/0	.007/0	.001/0	.002/0	.007/0	.002/0	.001/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.008	0/.021	0/.075	0/.002	0/.012	0/.033	0/.006	0/.001
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.019/0	.034/.245	.081/.442	.039/.251	.034/.271	.072/.651	.086/1.044	.006/.539
9	0/0	0/.006	0/.044	0/.015	0/.045	0/.025	0/.046	0/.039
12	.001/.001	.002/.009	.004/.016	0/0	0/.011	.002/.024	0/.005	0/0
13	8.966/4.313	19.810/10.42	52.927/29.61	6.983/9.191	23.526/18.64	28.862/20.96	24.904/21.569.01	9/8.136

Production Activity 6

chemical	year 1 corn/soyb	2 corn/soyb	3 corn/soyb	4 corn/soyb	5 corn/soyb	6 corn/soyb	7 corn/soyb	8 corn/soyb
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.008	0/.021	0/.075	0/.002	0/.012	0/.033	0/.006	0/.001
5	.001/0	.002/0	.004/0	0/0	0/0	.003/0	.001/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.019/0	.034/.245	.081/.442	.039/.251	.034/.271	.072/.651	.086/1.044	.006/.539
9	0/0	0/.006	0/.044	0/.015	0/.45	0/.025	0/.046	0/.039
12	.001/.001	.001/.009	.02/.016	0/0	0/.001	.001/.024	0/.005	0/0
13	8.966/4.313	19.81/10.422	52.927/29.61	6.983/9.191	23.526/18.64	28.862/20.96	24.904/21.56	9.019/8.136
15	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 7

chemical	year 1 corn/soyb	2 corn/soyb	3 corn/soyb	4 corn/soyb	5 corn/soyb	6 corn/soyb	7 corn/soyb	8 corn/soyb
2	.001/.001	.002/.012	.005/.022	0/0	0/.001	.002/.033	.001/.007	0/0
3	.003/0	.004/0	.007/0	.001/0	.002/0	.007/0	.002/0	.001/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.008	0/.021	0/.075	0/.002	0/.012	0/.033	0/.006	0/.001
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.019/0	.034/.245	.081/.442	.039/.251	.034/.271	.072/.651	.086/1.044	.006/.539
9	0/0	0/.006	0/.044	0/.015	0/.45	0/.025	0/.046	0/.039
13	8.966/4.313	19.81/10.422	52.93/29.62	6.983/9.191	23.526/18.64	28.862/20.96	24.904/21.	569.019/8.136

Table H.1, continued. Chemical Content of Sediment.

Production Activity 4, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
3	.004/0	.005/0	.001/0	.005/0	.001/0	.003/0	.002/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.002	0/.016	0/.003	0/.008	0/.007	0/.002	0/.01
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.079/.041	.075/1.945	.007/.238	.03/.221	.015/.05	.036/.261	.1/.056
9	0/.051	0/.246	0/.007	0/.166	0/.214	0/.008	0/.004
12	.002/0	.002/.003	0/0	.002/.002	0/.001	.003/0	.001/.005
13	17.795/11.89	51.802/39.87	7.199/5.031	16.479/7.824	11.962/7.906	14.163/12.38	18.577/19.895

Production Activity 6, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.002	0/.016	0/.003	0/.008	0/.007	0/.002	0/.01
5	.003/0	.002/0	0/0	.003/0	0/0	.003/0	.001/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.079/.041	.075/1.945	.007/.238	.03/.227	.015/.05	.036/.261	.1/.056
9	0/.051	0/.246	0/.007	0/.166	0/.214	0/.008	0/.004
12	.001/0	.001/.003	0/0	.001/.002	0/.001	.001/0	.001/.005
13	17.795/11.89	51.802/28.87	7.199/5.031	16.479/7.824	11.962/7.906	14.163/12.38	18.577/19.895
15	.001/0	0/0	0/0	.001/0	0/0	.001/0	0/0

Production Activity 7, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
2	.003/0	.002/.003	0/0	.003/.003	0/0	.004/0	.001/.005
3	.004/0	.005/0	.001/0	.005/0	.001/0	.003/0	.002/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.002	0/.016	0/.003	0/.008	0/.007	0/.002	0/.01
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.079/.041	.075/1.9456	.007/.238	.03/.227	.015/.05	.036/.261	.1/.056
9	0/.005	0/.246	0/.007	0/.166	0/.214	0/.008	0/.004
13	17.795/11.9	51.802/29.87	7.1985/5.031	16.479/7.824	11.962/7.906	14.163/12.38	18.577/19.895

Table H.1, continued. Chemical Content of Sediment.

Production Activity 8

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
3	0/0	.001/0	0/0	0/0	0/0	.001/0	0/0	0/0
8	.004/0	.005/.126	.01/.25	.005/.12	.007/.114	.01/.308	.018/.583	.002/.321
9	0/0	0/.004	0/.027	0/.007	0/.32	0/.008	0/.022	0/.027
11	0/.013	0/.024	0/.121	0/.002	0/.024	0/.033	0/.001	0/.003
12	0/0	.001/.005	0/.012	0/0	0/.001	0/.012	0/0	0/0
13	2.1099/2.96	5.64/4.886	9.892/17.683	2.005/4.89	8.686/11.591	9.596/10.109	11.054/13.75	5.222/4.099

Production Activity 9

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/.011	0/0	0/0	0/0	0/0	0/0
5	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.004/0	.005/.126	.01/.215	.005/.12	.007/.114	.01/.308	.018/.583	.003/.32
9	0/0	0/.004	0/.027	0/.007	0/.32	0/.008	0/.022	0/.027
11	0/.013	0/.024	0/.121	0/.002	0/.024	0/.033	0/.001	0/.003
12	0/0	.001/.005	0/.012	0/0	0/.001	0/.012	0/0	0/0
13	2.109/2.96	5.64/4.886	9.892/17.683	2.005/4.89	8.686/11.591	9.596/10.109	11.054/13.75	5.222/4.099
15	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 10

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.011	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
2	0/0	0/.005	0/.011	0/0	0/0	0/.011	0/0	0/0
3	0/0	.001/0	0/0	0/0	0/0	.001/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.004/0	.005/.126	.01/.215	.005/.12	.007/.114	.01/.308	.018/.583	.003/.321
9	0/0	0/.004	0/.027	0/.007	0/.32	0/.008	0/.022	0/.027
11	0/.013	0/.024	0/.121	0/.018	0/.024	0/.033	0/.001	0/.003
13	2.109/2.96	5.64/4.886	9.892/17.683	2.005/4.89	8.686/11.591	9.596/10.109	11.054/13.75	5.222/4.099

Table H.1, continued. Chemical Content of Sediment.

Production Activity 8, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/0	0/.001]	0/0	0/0	0/0	0/0	0/0
3	0/0	.001/0	0/0	.001/0	0/0	0/0	0/0
8	.007/.003	.016/1.267	.002/.135	.005/.147	.003/.011	.005/.087	.017/.002
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
9	0/.038	0/.154	0/.004	0/.112	0/.152	0/.004	0/0
11	0/.005	0/.031	0/.001	0/.009	0/.011	0/.001	0/.006
12	0/0	0/.003	0/0	.001/.001	0/0	0/0	0/.02
13	2.486/4.696	20.185/25.52	5.272/2.774	5.029/4.458	3.112/4.231	4.363/4.495	3.687/11.576

Production Activity 9, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/0	0/0	0/0	0/0	0/0	0/0	0/0
5	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.007/.003	.016/1.267	.002/.135	.005/.147	.003/.011	.005/.087	.017/.002
9	0/.038	0/.154	0/.004	0/.112	0/.152	0/.004	0/0
11	0/.005	0/.031	0/.001	0/.01	0/.011	0/.001	0/.006
12	0/0	0/.003	0/0	.001/.001	0/0	0/0	0/.002
13	2.486/4.696	20.185/25.53	5.272/2.774	5.029/4.458	3.112/4.231	4.364/4.495	3.687/11.576
15	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 10, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
2	0/0	0/.002	0/0	0/.001	0/0	0/0	0/.001
3	0/0	.001/0	0/0	.001/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.007/.003	.016/1.267	.002/.135	.005/.147	.004/.011	.005/.087	.017/.002
9	0/.038	0/.154	0/.004	0/.112	0/.152	0/.004	0/0
11	0/.005	0/.031	0/.001	0/.009	0/.011	0/.001	0/.006
13	2.486/4.696	20.185/25.52	5.272/2.774	5.029/4.458	3.112/4.231	4.364/4.495	3.678/11.576

Table H.1, continued. Chemical Content of Sediment.

Production Activity 12

	year							
chemical	1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
3								
corn	0.002	0.003	0.006	0.001	0.002	0.006	0.002	0.001
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.005	0.003	0.007	0.001	0.006	0.006	0.003	0.001
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.016	0.032	0.093	0.06	0.057	0.101	0.118	0.009
dcsoy	0	0.306	0.508	0.336	0.304	0.823	1.266	0.638
fssoy	0.026	0.045	0.108	0.049	0.045	0.09	0.111	0.008
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041

Table H.1, continued. Chemical Content of Sediment.

Production Activity 12, continued

	year							
chemical	1	2	3	4	5	6	7	8
10								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	3.359	1.671	29.102	0.313	4.654	4.654	2.575	0.734
dcsoy	0	0.001	0.002	0.003	0.003	0.003	0.009	0
11								
corn	0	0	0	0	0	0	0	0
dcsoy	0.026	0.065	0.231	0.008	0.037	0.106	0.024	0.01
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.025	0.061	0.222	0.008	0.037	0.097	0.024	0.01
12								
corn	0.001	0.003	0.008	0.001	0	0.004	0.002	0
dcsoy	0.001	0.015	0.028	0.001	0.001	0.04	0.01	0.001
fssoy	0.005	0.003	0.005	0	0.001	0.009	0.002	0
dcsoy	0.001	0.014	0.024	0.001	0.001	0.036	0.01	0.001
13								
corn	8.254	16.909	56.022	12.3	30.469	31.209	30.439	10.814
dcsoy	4.823	11.327	31.099	10.428	19.057	22.373	22.851	8.618
fssoy	10.808	20.855	56.827	7.768	24.121	29.209	27.151	9.315
dcsoy	4.824	11.263	30.365	10.401	18.338	22.404	22.665	8.608
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0.036	0.247	0.086	1.69	0.17	0.377	0.171
dcsoy	0	0.001	0	0.001	0.001	0	0.001	0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 12, continued

	year						
chemical	9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0.001	0.001	0.001	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0	0	0.001	0.001
3							
corn	0.006	0.004	0.001	0.004	0.002	0.005	0.002
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.002	0.009	0	0.003	0.003	0	0.002
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.133	0.088	0.018	0.209	0.029	0.053	0.156
dcsoy	0.065	2.259	0.285	0.282	0.074	0.349	0.096
fssoy	0.109	0.108	0.012	0.04	0.032	0.051	0.123
dcsoy	0.05	2.031	0.246	0.239	0.057	0.296	0.071
9							
corn	0	0	0	0	0	0	0
dcsoy	0.059	0.273	0.008	0.173	0.242	0.009	0.005
fssoy	0	0	0	0	0	0	0
dcsoy	0.054	0.273	0.008	0.173	0.37	0.009	0.005

Table H.1, continued. Chemical Content of Sediment.

Production Activity 12, continued

	year						
chemical	9	10	11	12	13	14	15
10							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.83	8.452	0.445	3.37	0.399	0.399	0.328
dcsoy	0.012	0.013	0	0	0.003	0.003	0.014
11							
corn	0	0	0	0	0	0	0
dcsoy	0.008	0.053	0.013	0.028	0.033	0.009	0.034
fssoy	0	0	0	0	0	0	0
dcsoy	0.007	0.044	0.013	0.024	0.025	0.007	0.025
12							
corn	0.008	0.002	0	0.003	0.002	0.008	0.003
dcsoy	0.001	0.005	0.001	0.004	0.003	0.001	0.009
fssoy	0.002	0.01	0	0.005	0.001	0.001	0.004
dcsoy	0.036	0.002	0.001	0.003	0.001	0	0.004
13							
corn	22.523	57.994	9.355	13.854	12.433	20.491	25.343
dcsoy	13.639	41.968	5.499	8.658	9.27	14.634	21.19
fssoy	21.187	53.776	8.06	18.398	14.226	17.092	20.085
dcsoy	13.594	42.066	5.521	8.486	8.813	14.511	21.242
14							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.234	0.64	0.111	0.755	1.204	0.067	0.028
dcsoy	0.001	0.002	0	0	0	0	0.001

Table H.1, continued. Chemical Content of Sediment.

Production Activity 13

chemical	year 1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.005	0.003	0.007	0.001	0.006	0.006	0.003	0.001
dcsoy	0	0	0	0	0.007	0	0	0
5								
corn	0.001	0.002	0.005	0.001	0	0.002	0.001	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.016	0.032	0.093	0.06	0.057	0.101	0.118	0.609
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562
fssoy	0.024	0.037	0.089	0.043	0.039	0.079	0.096	0.007
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041

Table H.1, continued. Chemical Content of Sediment.

Production Activity 13, continued

	year							
chemical	1	2	3	4	5	6	7	8
10								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	3.359	1.671	29.1	0.313	4.654	7.921	2.575	0.734
dcsoy	0	0.001	0.002	0.003	0.003	0.007	0.009	0
11								
corn	0	0	0	0	0	0	0	0
dcsoy	0.026	0.065	0.231	0.008	0.037	0.106	0.024	0.01
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.025	0.061	0.222	0.008	0.037	0.097	0.024	0.01
12								
corn	0.001	0.003	0.008	0.001	0	0.004	0.002	0
dcsoy	0.001	0.015	0.028	0.001	0.001	0.04	0.01	0.001
fssoy	0.005	0.003	0.005	0	0.001	0.009	0.002	0
dcsoy	0.001	0.014	0.024	0.001	0.001	0.036	0.01	0.001
13								
corn	8.254	16.909	56.022	12.3	30.469	31.209	30.439	10.814
dcsoy	4.823	11.327	31.099	10.428	19.057	22.373	22.851	8.618
fssoy	10.808	20.855	56.827	7.768	24.121	29.209	27.751	9.315
dcsoy	4.824	11.263	30.365	10.401	19.338	22.404	22.665	8.608
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0.036	0.247	0.086	1.69	0.17	0.377	0.171
dcsoy	0	0.001	0	0.001	0.001	0.001	0.001	0
15								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 13, continued

chemical	year 9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0.001	0.001	0.001	0.002
fssoy	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0	0	0.001	0.001
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.002	0.009	0	0.004	0.003	0	0.002
dcsoy	0	0	0	0	0	0	0
5							
corn	0.005	0.001	0	0.002	0.001	0.005	0.001
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.133	0.088	0.018	0.201	0.029	0.053	0.156
dcsoy	0.049	2.031	0.246	0.239	0.057	0.295	0.071
fssoy	0.096	0.082	0.011	0.035	0.027	0.04	0.104
dcsoy	0.049	2.031	0.246	0.239	0.057	0.296	0.071
9							
corn	0	0	0	0	0	0	0
dcsoy	0.059	0.273	0.008	0.173	0.242	0.009	0.005
fssoy	0	0	0	0	0	0	0
dcsoy	0.054	0.273	0.008	0.173	0.231	0.009	0.005

Table H.1, continued. Chemical Content of Sediment.

Production Activity 13, continued

	year						
chemical	9	10	11	12	13	14	15
10							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.83	8.452	0.445	3.37	7.222	0.399	0.328
dcsoy	0.012	0.013	0	0	0.001	0.003	0.014
11							
corn	0	0	0	0	0	0	0
dcsoy	0.008	0.053	0.013	0.028	0.033	0.009	0.034
fssoy	0	0	0	0	0	0	0
dcsoy	0.007	0.044	0.013	0.024	0.025	0.007	0.025
12							
corn	0.008	0.002	0	0.004	0.002	0.008	0.003
dcsoy	0.001	0.005	0.001	0.004	0.003	0.001	0.009
fssoy	0.002	0.01	0	0.005	0.001	0.001	0.004
dcsoy	0	0.002	0.001	0.003	0.01	0	0.004
13							
corn	22.523	57.994	9.355	13.854	12.433	20.491	25.343
dcsoy	13.639	41.968	5.499	8.658	9.27	14.634	21.19
fssoy	21.187	53.776	8.06	18.398	14.226	17.092	20.085
dcsoy	13.594	42.066	5.521	8.486	8.813	14.511	21.242
14							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.234	0.64	0.111	0.755	1.204	0.067	0.028
dcsoy	0.001	0.002	0	0	0	0	0
15							
corn	0	0	0	0.001	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 14

	year							
chemical	1	2	3	4	5	6	7	8
1								
corn	0	0.003	0	0	0	0	0	0
dcsoy	0.001	0	0	0	0.001	0.002	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0	0.002	0	0
2								
corn	0.001	0.002	0.006	0.001	0	0.002	0.001	0
dcsoy	0.001	0.013	0.025	0	0.001	0.038	0.01	0.001
fssoy	0.005	0.003	0.005	0	0	0.009	0	0
dcsoy	0.001	0.012	0.022	0	0.001	0.034	0.01	0.001
3								
corn	0.002	0.003	0.006	0.001	0.002	0.006	0.002	0.001
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.005	0.003	0.007	0.001	0.006	0.006	0.003	0.001
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.016	0.032	0.093	0.06	0.057	0.101	1.118	0.009
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562
fssoy	0.024	0.037	0.089	0.043	0.039	0.079	0.096	0.007
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562

Table H.1, continued. Chemical Content of Sediment.

Production Activity 14, continued

chemical	year 1	2	3	4	5	6	7	8
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0	0.018	0.471	0.003	0	0.041
fssoy	0	0	0.175	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0	0.003	0.05	0.004
10								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	3.359	1.671	29.102	0.313	4.654	7.921	2.575	0.734
dcsoy	0	0.001	0.002	0.003	0.003	0.007	0.009	0
11								
corn	0	0	0	0	0	0	0	0
dcsoy	0.026	0.065	0.231	0.008	0.037	0.106	0.024	0.01
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.0254	0.061	0.222	0.008	0.037	0.097	0.024	0.01
13								
corn	8.254	16.909	56.022	12.3	30.469	31.209	30.439	10.814
dcsoy	4.823	11.327	31.099	10.428	19.057	22.373	22.851	8.618
fssoy	10.808	20.855	56.827	7.768	24.121	29.209	27.751	9.315
dcsoy	4.824	11.263	30.365	10.401	19.338	22.404	22.665	8.608
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0.036	0.247	0.086	1.69	0.17	0.377	0.171
dcsoy	0	0.001	0	0.001	0.001	0.001	0.001	0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 14, continued

chemical	year 9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0.002	0
dcsoy	0	0.002	0	0.001	0.001	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0	0	0.001	0.001
2							
corn	0.005	0.001	0	0.002	0.002	0.006	0
dcsoy	0	0.003	0	0.003	0.002	0	0.007
fssoy	0.002	0.011	0	0.005	0.001	0.001	0.004
dcsoy	0	0.001	0	0.003	0.001	0	0.003
3							
corn	0.006	0.004	0.001	0.004	0.002	0.005	0.002
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.002	0.009	0	0.004	0.003	0.002	0
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.133	0.088	0.018	0.021	0.029	0.053	0.156
dcsoy	0.049	2.031	0.246	0.239	0.057	0.295	0.071
fssoy	0.096	0.082	0.011	0.035	0.027	0.04	0.104
dcsoy	0.049	2.031	0.246	0.239	0.057	0.296	0.071

Table H.1, continued. Chemical Content of Sediment.

Production Activity 14, continued

	year						
chemical	9	10	11	12	13	14	15
9							
corn	0	0	0	0	0	0	0
dcsoy	0.054	0.273	0	0.173	0.237	0.009	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0.273	0.008	0.173	0	0.009	0.005
10							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.83	8.452	0.445	3.37	7.222	0.399	0.328
dcsoy	0.012	0.013	0	0	0.001	0.002	0.014
11							
corn	0	0	0	0	0	0	0
dcsoy	0.0086	0.053	0.013	0.028	0.033	0.009	0.034
fssoy	0	0	0	0	0	0	0
dcsoy	0.007	0.244	0.013	0.024	0.025	0.007	0.025
13							
corn	22.523	57.994	9.355	13.854	12.433	20.491	25.343
dcsoy	13.639	41.968	5.499	8.658	9.21	14.634	21.19
fssoy	21.187	53.776	8.06	18.398	14.226	17.092	20.085
dcsoy	13.594	42.066	5.521	8.486	8.813	14.511	21.242
14							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.234	0.64	0.111	0.755	1.204	0.067	0.028
dcsoy	0.001	0.002	0	0	0	0	0.002

Table H.1, continued. Chemical Content of Sediment.

Production Activity 15

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
3	.001/0	.001/0	.001/0	0/0	.001/0	.001/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.005/0	.007/.135	.020/.239	.005/.123	.008/.152	.011/.348	.203/.601	.002/.338
9	0/0	0/.004	0/.031	0/.007	0/.334	0/.009	0/.023	0/.028
11	0/.014	0/.03	0/.139	0/.003	0/.025	0/.142	0/.011	0/.033
12	0/0	.001/.007	0/.016	0/0	0/.001	0/.015	0/0	0/0
13	2.767/2.995	7.348/5.560	16.902/19.01	2.317/5.043	10.376/12.40	9.918/11.866	9.43/14.116	4.682/4.387

Production Activity 17

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.003/0	.004/0	.007/0	.001/0	.002/0	.007/0	.002/0	.001/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.008	0/.021	0/.075	0/.002	0/.012	0/.033	0/.006	0/.001
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.019/0	.034/.245	.081/.442	0.039/.251	.034/.271	.072/.651	.086/1.044	.006/.539
9	0/0	0/.006	0/.044	0/.015	0/.45	0/.025	0/.046	0/.039
10	0/2.317	.003/1.472	.004/15.26	.003/.642	.003/4	.007/3.169	.007/1.091	0/.543
12	.001/.001	.002/.009	.004/.016	0/0	0/.001	.002/.024	.001/.005	0/0

Production Activity 18

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.001	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
3	0/0	.001/0	0/0	0/0	0/0	.001/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.004/0	.005/.126	.01/.215	.005/.12	.007/.114	.01/.308	.018/.583	.003/.321
9	0/0	0/.004	0/.027	0/.007	0/.32	0/.008	0/.022	0/.027
10	0/1.085	0/.426	0/6.975	0/.153	0/1.884	0/1	.001/.305	0/.238
11	0/.013	0/.024	0/.121	0/.002	0/.024	0/.033	0/.001	0/.003
12	0/0	.001/.004	0/.008	0/0	0/.001	0/.008	0/0	0/0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 15, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
1	0/0	0/.001	0/0	0/0	0/0	0/0	0/.001
3	0/0	.001/0	0/0	.001/0	0/0	0/0	.001/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.014/.003	.018/1.329	.002/.138	.006/.151	.004/.013	.006/.101	.022/.002
9	0/.055	0/.167	0/.004	0/.113	0/.161	0/.005	0/0
11	0/.007	0/.036	0/.001	0/.011	0/.012	0/.001	0/.013
12	0/0	.001/.003	0/.001	.001/.001	0/0	0/0	0/.003
13	4.789/5.973	18.236/27.07	5.59/.2.84	4.809/4.73	4.153/4.552	4.956/5.313	5.346/12.528

Production Activity 17, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
3	.004/0	.005/0	.001/0	.005/0	.001/0	.003/0	.002/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.002	0/.016	0/.003	0/.008	0/.007	0/.002	0/.01
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.079/.041	.075/1.945	.007/.238	.03/.227	.015/.05	.036/.261	.1/.056
9	0/.051	0/.246	0/.007	0/.166	0/.214	0/.008	0/.004
10	.007/.428	.01/3.913	0/.375	.001/1.393	0/1.494	.004/.308	.011/.719
12	.002/0	.002/.003	0/0	.002/.002	0/.001	.003/0	.001/.005

Production Activity 18, continued

chemical	year 9 corn/soyb	10 corn/soyb	11 corn/soyb	12 corn/soyb	13 corn/soyb	14 corn/soyb	15 corn/soyb
1	0/0	0/.001	0/0	0/0	0/0	0/0	0/0
3	0/0	.001/0	0/0	.001/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.007/.003	.016/1.267	.002/.135	.005/.147	.003/.011	.005/.087	.017/.002
9	0/.038	0/.154	0/.004	0/.112	0/.152	0/.004	0/0
10	0/.198	.001/1.742	0/.066	0/.497	0/.635	0/.048	.001/.071
11	0/.005	0/.031	0/.001	0/.009	0/.011	0/.001	0/.006
12	0/0	0/.002	0/0	.001/.001	0/0	0/0	0/.001

Table H.1, continued. Chemical Content of Sediment.

Production Activity 19

	year							
chemical	1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.001	0	0.003	0	0.001	0.002	0	0
3								
corn	0.002	0.003	0.006	0.001	0.002	0.006	0.002	0.001
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0.003	0.007	0.001	0	0.006	0.003	0.001
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.016	0.032	0.093	0.598	0.057	0.101	0.118	0.009
dcsoy	0	0.252	0.452	0.287	0.271	0.705	1.127	0.562
fssoy	0.024	0.037	0.089	0.043	0.039	0.079	0.096	0.007
dcsoy	0	0.252	0.452	0.287	0.27	0.705	1.127	0.562
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0.006	0.045	0.018	0.471	0.031	0.05	0.041

Table H.1, continued. Chemical Content of Sediment.

Production Activity 19, continued

chemical	year 1	2	3	4	5	6	7	8
10								
corn	0	0.003	0.004	0.003	0.004	0.007	0.007	0
dcsoy	1.77	1.12	10.639	0.493	2.773	2.82	0.841	0.44
fssoy	3.36	1.673	29.105	0.315	4.657	7.926	2.58	0.734
dcsoy	1.727	1.063	10.538	0.496	2.777	2.713	0.849	0.44
11								
corn	0	0	0	0	0	0	0	0
dcsoy	0.026	0.065	0.231	0.008	0.037	0.106	0.024	0.01
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.025	0.061	0.222	0.008	0.037	0.097	0.024	0.01
12								
corn	0.001	0.001	0.004	0.001	0	0.002	0.001	0
dcsoy	0.001	0.01	0.018	0	0.001	0.027	0.006	0.001
fssoy	0.005	0.003	0.005	0	0.001	0.009	0.002	0
dcsoy	0.001	0.009	0.016	0	0.001	0.024	0.006	0.001
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0.036	0.247	0.086	1.69	0.17	0.377	0.171
dcsoy	0	0.001	0	0.001	0.001	0.001	0.001	0

Table H.1, continued. Chemical Content of Sediment.

Production Activity 19, continued

	year						
chemical	9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0.001	0.001	0.001	0.002
fssoy	0	0	0	0	0	0	0
dcsoy	0	0.002	0	0	0	0.001	0.001
3							
corn	0.006	0.004	0.001	0.004	0.002	0.005	0.002
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0.009	0	0.004	0	0	0.002
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.133	0.088	0.018	0.021	0.029	0.053	0.156
dcsoy	0.049	2.031	0.246	0.239	0.057	0.295	0.071
fssoy	0.096	0.082	0.011	0.035	0.027	0.04	0.104
dcsoy	0.049	2.031	0.246	0.239	0.057	0.296	0.071
9							
corn	0	0	0	0	0	0	0
dcsoy	0.059	0.273	0.008	0.173	0.242	0.009	0.005
fssoy	0	0	0	0	0	0	0
dcsoy	0.054	0.273	0.008	0.173	0.237	0.009	0.005

Table H.1, continued. Chemical Content of Sediment.

Production Activity 19, continued

chemical	year 9	10	11	12	13	14	15
10							
corn	0.01	0.012	0.001	0.001	0.002	0.004	0.011
dcsoy	0.332	2.818	0.319	1.093	1.204	0.262	0.599
fssoy	0.836	8.46	0.445	3.371	7.224	0.401	0.335
dcsoy	0.318	2.804	0.32	0.003	1.111	0.239	0.53
11							
corn	0	0	0	0	0	0	0
dcsoy	0.008	0.053	0.013	0.028	0.033	0.009	0.034
fssoy	0	0	0	0	0	0	0
dcsoy	0.007	0.044	0.013	0.024	0.025	0.007	0.025
12							
corn	0.004	0.001	0	0.002	0.001	0.004	0.001
dcsoy	0	0.003	0	0.003	0.002	0	0.006
fssoy	0.002	0.01	0	0.005	0.001	0.001	0.004
dcsoy	0	0.001	0	0.002	0.001	0	0.003
14							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.234	0.64	0.111	0.755	1.204	0.067	0.028
dcsoy	0.001	0.002	0	0	0	0	0.001

Table H.2. Chemical Content of Runoff, in grams per hectare.

Production Activity 1

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.227/0	.422/0	.752/0	.054/0	.13/.001	.547/0	.178/0	.073/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.409	0/.719	0/3.193	0/.042	0/.382	0/1.155	0/.174	0/.041
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.002/0	.006/.095	.014/.092	.011/.073	.007/.049	.016/.216	.031/.482	.001/.186
9	0/0	0/.081	0/.278	0/.146	0/4.996	0/.215	0/.678	0/.496
12	.065/.1	.161/1.39	.387/2.671	.027/.021	.003/.117	.135/3.51	.083/.578	.008/.007
13	1.126/1.856	4.112/3.574	8.308/9.523	2.153/1.965	3.887/4.963	5.266/6.136	7.699/7.355	2.176/2.486

Production Activity 2

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.226	0/0	0/.281	0/.005	0/.05	0/.03	0/.001	0/.003
3	.078/0	.404/0	.501/0	.153/0	2.47/0	1.407/0	.122/0	.029/0
6	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.001/0	0.004/0.065	.01/.05	.008/.044	.004/.023	.01/.132	.024/.371	.001/.131
10	0/9.453	0.005/0.734	.006/1.103	.013/.795	.002/10.995	.015/5.416	.03/4.379	0/1.927
11	0/.939	0/1.303	0/7.738	0/.074	0/.781	0/1.943	0/.145	0/.154
12	.003/.099	.06/1.167	.066/2.328	0.031/0.013	0.574/0.108	.269/2.901	.017/.001	.001/.008
13	1.494/2.344	5.515/4.021	12.89/13.06	2.78/2.12	5.331/5.818	6.378/6.331	11.806/10.03	.049/2.915
15	0/0	0/0	0/0	0/0	0/0	0/.001	0/0	0/0

Production Activity 3

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.147/0	.288/0	.468/0	.026/ 0	.084/0	.282/0	.112/0	.045/0
9	0/0	0/.061	0/.185	0/.098	0/4.047	0/.134	0/.566	0/.40
13	.291/.523	1.088/.918	2.412/2.796	.559/.493	1.037/1.326	1.314/1.52	2.277/2.125	.578/.669

Table H.2, continued. Chemical Content of Runoff.

Production Activity 1, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.421/0	.475/0	.043/0	.432/0	.025/0	.36/0	.196/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.042	0/.583	0/.05	0/.282	0/.214	0/.035	0/.261
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.021/.006	.018/.813	.002/.101	.004/.103	.002/.008	.01/.051	.036/.006
9	0/.264	0/2.626	0/.096	0/1.406	0/2.182	0/.053	0/.014
12	.219/.018	.141/.437	.007/.02	.163/.325	.013/.0612	.225/.018	.084/.585
13	3.820/2.348	11.668/13.1	1.776/2.052	2.613/2.526	1.721/2.099	3.667/2.918	5.931/3.977

Production Activity 2, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.002	0/.258	0/0	0/0.007	0/.013	0/.001	0/.057
3	2.344/0	.167/0	.009/0	.134/0	.035/0	.107/0	5.114/0
6	0/0	0/0	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.012/.003	.64/.013	0/.072	.003/.074	.001/.003	.006/.026	.026/.001
10	.014/.253	.023/11.71	0/.733	.002/2.804	0/3.743	.008/.258	.043/.246
11	0/.033	0/1.289	0/.076	0/.434	0/.412	0/.021	0/.074
12	.553/.005	.006/.409	0/0	.009/.227	.001/.041	.017/.001	1.394/.069
13	4.505/2.514	18.281/17.4	2.658/2.496	3.508/2.841	2.131/2.111	4.382/3.531	8.814/5.585
15	0/.001	0/.01	0/0	0/0	0/0	0/.001	0/.002

Production Activity 3, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.231/0	.312/0	.014/0	.247/0	.058/0	.181/0	.12/0
9	0/.107	0/2.034	0/.075	0/1.035	0/1.635	0/.032	0/.001
13	.935/.538	3.392/3.727	.481/.561	.682/.645	.424/.5	.719/.907	1.633/1.052

Table H.2, continued. Chemical Content of Runoff.

Production Activity 4

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
3	.227/0	.422/0	.752/0	.054/0	.13/.001	.547/0	.178/0	.073/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.409	0/.719	0/3.193	0/.042	0/.382	0/1.155	0/.174	0/.041
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.002/0	.006/.095	.014/.092	.011/.073	.007/.049	.016/.216	.031/.482	.001/.186
9	0/0	0/.081	0/.278	0/.146	0/4.996	0/.215	0/.678	0/.496
12	.065/.1	.161/1.39	.387/2.671	.027/.021	.003/.117	.135/3.51	.083/.578	.008/.007
13	1.126/1.856	4.112/3.574	8.308/9.523	2.153/1.965	3.887/4.963	5.266/6.136	7.699/7.355	2.176/2.486

Production Activity 6

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.409	0/.719	0/3.193	0/.042	0/.382	0/1.155	0/.174	0/.041
5	.075/0	.19/0	.499/0	.033/0	.006/0	.184/0	.093/0	.009/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.002/0	.006/.095	.014/.092	.011/.073	.007/.049	.016/.216	.031/.484	.001/.186
9	0/0	0/.081	0/.278	0/.146	0/4.996	0/.215	0/.678	0/.496
12	.031/.01	.08/1.39	.192/2.671	.014/.021	.001/.117	.064/3.51	.041/.578	.004/.007
13	1.126/1.856	4.112/3.574	8.308/9.523	2.153/1.965	3.887/4.963	5.266/6.136	7.699/7.355	2.176/2.486
15	.01/0	.062/0	.063/0	0/0	0/0	.028/0	.001/0	0/0

Production Activity 7

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
2	.056/.105	.166/1.89	.55/3.863	.039/.019	0/.089	.138/5.225	.103/.908	.009/.001
3	.227/0	.422/0	.752/0	.054/0	.13/.001	.547/0	.178/0	.073/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.409	0/.719	0/3.193	0/.042	0/.382	0/1.155	0/.172	0/.041
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.002/0	.006/.095	.014/.092	.011/.073	.007/.049	.016/.216	.031/.482	.001/.186
9	0/0	0/.081	0/.278	0/.146	0/4.996	0/.215	0/.678	0/.496
13	1.126/1.856	4.112/3.574	8.308/9.523	2.153/1.965	3.89/4.96	5.266/6.136	7.699/7.355	2.176/2.486

Table H.2, continued. Chemical Content of Runoff.

Production Activity 4, continued

chemical	year 9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
12	.219/.018	.141/.437	.007/.02	.163/.325	.013/.061	.225/.018	.084/.585
3	.421/0	.475/0	.043/0	.432/0	.095/0	.36/0	.196/0
8	.021/.006	.018/.813	.002/.101	.004/.103	.002/.008	.051/.01	.036/.006
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.042	0/.583	0/.05	0/.282	0/.214	0/.035	0/.261
9	0/.264	0/2.626	0/.096	0/1.406	0/2.182	0/.053	0/.014
13	3.82/2.348	11.668/13.1	1.776/2.052	2.613/2.526	1.721/2.099	3.667/2.918	5.931/3.97
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0

Production Activity 6, continued

chemical	year 9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.042	0/.583	0/.05	0/.282	0/.214	0/.035	0/.261
5	.283/0	.153/0	.01/0	.201/0	.014/0	.288/0	.104/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.021/.006	.018/.813	.002/.101	.004/.103	.002/.008	.01/.051	.036/.006
9	0/.264	0/2.626	0/.096	0/1.406	0/2.182	0/.053	0/.014
12	.109/.018	.069/.437	.004/.02	.081/.325	.006/.061	.111/.018	.042/.585
13	3.82/2.348	11.668/13.1	1.776/2.052	2.613/2.526	1.721/2.099	3.667/2.918	5.931/3.977
15	.111/0	.008/0	.018/0	.144/0	.001/0	.149/0	.006/0

Production Activity 7, continued

chemical	year 9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
2	.3/.013	.121/.428	.007/.02	.179/.469	.01/.048	.349/.018	.108/.691
3	.421/0	.475/0	.043/0	.432/0	.095/0	.36/0	.196/0
4a	0/0	0/0	0/0	0/0	0/0	0/0	0/0
4b	0/.042	0/.583	0/.51	0/.282	0/.214	0/.035	0/.261
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.021/.006	.018/.813	.002/.101	.004/.103	.002/.008	.01/.051	.036/.006
9	0/.264	0/2.626	0/.096	0/1.406	0/2.182	0/.053	0/.014
13	3.82/2.348	11.668/13.1	1.776/2.052	2.613/2.526	1.721/2.099	3.667/2.918	5.931/3.977

Table H.2, continued. Chemical Content of Runoff.

Production Activity 8

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.166	0/0	0/.176	0/.003	0/.035	0/.025	0/0	0/.002
3	.073/0	.159/0	.129/0	.002/0	0/.049	.122/0	.015/0	.025/0
8	.001/0	.002/.056	.008/.039	.006/.039	.002/.017	.007/.111	.017/.341	.001/.114
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
9	0/0	0/.046	0/.115	0/.075	0/3.368	0/.086	0/.464	0/.315
11	0/.661	0/.949	0/5.849	0/.042	0/.626	0/1.291	0/.091	0/.108
12	.046/.003	.143/.9	.12/2.085	0/.008	.006/.086	.053/1.968	.018/.001	0/.006
13	.54/1.271	2.303/2.03	5.918/7.1	1.185/1.129	2.104/3.125	2.688/3.22	5.183/5.38	1.313/1.527

Production Activity 9

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.166	0/0	0/.176	0/.003	0/.035	0/.025	0/0	0/.002
5	.026/0	.081/0	.077/0	0/0	.003/0	.034/0	.009/0	0/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.001/0	.002/.056	.008/.039	.006/.039	.002/.017	.007/.111	.017/.341	.001/.114
9	0/0	0/.046	0/.115	0/.075	0/3.368	0/.086	0/.464	0/.315
11	0/.661	0/.949	0/5.849	0/.042	0/.626	0/1.291	0/.091	0/.108
12	.046/.003	.143/.9	.12/2.085	0/.008	.06/.086	.053/1.968	.018/.001	0/.006
13	.539/1.271	2.303/2.031	5.918/7.1	1.185/1.129	2.104/3.125	2.688/3.22	5.183/5.38	1.313/1.527
15	0/0	.009/0	.017/0	0/0	0/0	.087/0	0/0	0/0

Production Activity 10

	year							
chemical	1	2	3	4	5	6	7	8
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.166	0/0	0/.176	0/.003	0/.035	0/.025	0/0	0/.002
2	.021/.001	.078/.815	.081/2.014	0/.005	0/.042	.021/1.958	.012/0	0/0
3	.073/0	.159/0	.129/0	.002/0	.049/0	.122/0	.015/0	.025/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.001/0	.002/.056	.008/.039	.006/.039	.002/.017	.007/.111	.017/.341	.001/.114
9	0/0	0/.046	0/.115	0/.075	0/3.368	0/.086	0/.464	0/.315
11	0/.661	0/.949	0/5.849	0/.042	0/.626	0/1.291	0/.091	0/.108
13	.539/1.271	2.303/2.03	5.918/7.097	1.185/1.29	2.104/3.125	2.688/3.22	5.183/5.38	1.313/1.527

Table H.2, continued. Chemical Content of Runoff.

Production Activity 8, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.007	0/.23	0/0	0/.006	0/.008	0/0	0/0
3	0.06/0	.154/0	.013/0	.188/0	.026/0	.034/0	.076/0
8	.007/.002	.011/.593	0/.064	.002/.065	.001/.002	.005/.02	.02/.001
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
9	0/.187	0/1.711	0/.058	0/.799	0/1.253	0/.017	0/0
11	0/.091	0/1.165	0/.037	0/.315	0/.29	0/.008	0/.206
12	.085/.015	.122/.39	0/0	.162/.171	.008/.025	.044/0	.061/.249
13	1.611/1.265	8.313/9.522	1.309/1.344	1.499/1.423	.833/1.077	1.817/1.629	3.524/2.805

Production Activity 9, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.007	0/.230	0/0	0/.006	0/.008	0/0	0/0
5	.043/0	.06/0	0/0	.098/0	.003/0	.03/0	.033/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.007/.002	.011/.593	0/.064	.002/.065	.001/.002	.005/.02	.02/.001
9	0/.187	0/1.711	0/.058	0/.799	0/1.253	0/.017	0/0
11	0/.091	0/1.165	0/.037	0/.315	0/.290	0/.008	0/.206
12	.085/.015	.122/.390	0/0	.162/.171	.008/.025	.044/0	.061/.249
13	1.611/1.265	8.313/9.522	1.309/1.344	1.499/1.424	.833/1.077	1.817/1.629	3.524/2.805
15	0/0	0/0	0/0	.004/0	0/0	0/0	0/0

Production Activity 10, continued

	year						
chemical	9	10	11	12	13	14	15
	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb	corn/soyb
1	0/.007	0/.23	0/0	0/.006	0/.008	0/0	0/0
2	.054/.008	.058/.258	0/0	.094/.164	.002/.013	.037/0	.029/.206
3	.06/0	.154/0	.013/0	.188/0	.026/0	.034/0	.076/0
7	0/0	0/0	0/0	0/0	0/0	0/0	0/0
8	.007/.002	.011/.593	0/.064	.002/.065	.001/.002	.005/.02	.02/.001
9	0/.187	0/1.711	0/.058	0/.799	0/1.253	0/.017	0/0
11	0/.091	0/1.165	0/.037	0/.315	0/.290	0/.008	0/.206
13	1.611/1.265	8.313/9.522	1.309/1.344	1.499/1.424	.833/1/077	1.817/1.629	3.524/2.805

Table H.2, continued. Chemical Content of Runoff.

Production Activity 12

chemical	year 1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.433	0.008	0.876	0.015	0.102	0.488	0.004	0.066
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.416	0.008	0.875	0.015	0.102	0.439	0.004	0.066
3								
corn	0.28	0.593	0.94	0.085	0.161	0.724	0.223	0.104
dcsoy	0	0.001	0	0	0.001	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.075	0.049	0.118	0.011	0.108	0.087	0.056	0.031
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.003	0.007	0.015	0.013	0.008	0.019	0.033	0.002
dcsoy	0	0.13	0.123	0.099	0.068	0.289	0.592	0.235
fssoy	0.003	0.009	0.015	0.014	0.009	0.021	0.038	0.002
dcsoy	0	0.107	0.109	0.085	0.06	0.249	0.526	0.207
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.092	0.335	0.175	5.532	0.245	0.744	0.551
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0.092	0.335	0.175	5.45	0.265	0.744	0.551

Table H.2, continued. Chemical Content of Runoff.

Production Activity 12, continued

chemical	year 1	2	3	4	5	6	7	8
10								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	4.281	2.46	41.063	0.675	7.281	10.558	4.966	1.748
dcsoy	0	0.002	0.003	0.006	0.004	0.012	0.014	0
11								
corn	0	0	0	0	0	0	0	0
dcsoy	1.284	2.488	10.071	0.186	1.252	3.971	0.841	0.381
fssoy	0	0	0	0	0	0	0	0
dcsoy	1.255	2.161	9.499	0.185	1.252	3.423	0.841	0.381
12								
corn	0.159	0.44	0.945	0.074	0.015	0.369	0.199	0.022
dcsoy	0.177	2.545	4.828	0.042	0.213	6.468	1.35	0.135
fssoy	0.318	0.257	0.332	0.008	0.055	0.571	0.109	0.012
dcsoy	0.175	2.157	3.962	0.042	0.213	5.342	1.35	0.135
13								
corn	1.282	4.711	9.076	2.46	4.376	6.132	8.328	2.473
dcsoy	1.995	4.121	10.376	2.285	5.513	7.056	8.067	2.84
fssoy	1.405	4.589	9.029	2.17	4.275	5.891	8.105	2.281
dcsoy	2	4.071	10.096	2.299	5.596	7.01	8.008	2.836
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	1.018	2.928	1.714	20.815	1.848	6.781	3.48
dcsoy	0	0.009	0.003	0.01	0.007	0.015	0.014	0

Table H.2, continued. Chemical Content of Runoff.

Production Activity 12, continued

	year						
chemical	9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0.016	0.461	0.021	0.293	0.155	0.117	0.212
fssoy	0	0	0	0	0	0	0
dcsoy	0.014	0.014	0.021	0.021	0.021	0.094	0.129
3							
corn	0.564	0.591	0.064	0.547	0.192	0.481	0.262
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.023	0.16	0.005	0.065	0.043	0.006	0.045
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.026	0.021	0.002	0.005	0.004	0.011	0.04
dcsoy	0.01	0.978	0.13	0.134	0.014	0.076	0.011
fssoy	0.03	0.027	0.003	0.006	0.005	0.014	0.046
dcsoy	0.007	0.88	0.112	0.114	0.011	0.064	0.008
9							
corn	0	0	0	0	0	0	0
dcsoy	0.352	0.352	1.621	0.108	1.621	0.067	0.021
fssoy	0	0	0	0	0	0	0
dcsoy	0.351	0.326	1.615	0.108	1.615	0.067	0.021

Table H.2, continued. Chemical Content of Runoff.

Production Activity 12, continued

chemical	year 9	10	11	12	13	14	15
10							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	1.021	14.997	0.82	4.631	9.917	0.568	0.36
dcsoy	0.016	0.021	0	0.001	0.002	0.006	0
11							
corn	0	0	0	0	0	0	0
dcsoy	0.162	2.074	0.297	1.075	1	0.175	1.017
fssoy	0	0	0	0	0	0	0
dcsoy	0.146	1.661	0.298	0.907	0.727	0.147	0.679
12							
corn	0.568	0.337	0.024	0.406	0.121	0.587	0.216
dcsoy	0.039	0.796	0.046	0.643	0.395	0.044	1.223
fssoy	0.157	0.757	0.004	0.332	0.06	0.033	0.347
dcsoy	0.036	0.29	0.046	0.536	0.107	0.015	0.601
13							
corn	4.462	12.752	2.026	2.987	2.105	4.236	6.542
dcsoy	2.806	14.328	2.293	2.921	2.51	3.507	4.456
fssoy	4.619	12.483	1.948	3.079	2.162	4.207	6.62
dcsoy	2.806	14.303	2.302	2.856	2.365	3.483	4.414
14							
corn	0	0	0	0	0	0	0
dcsoy	0	6.781	0	0	0	2.023	0
fssoy	2.047	9.282	0	7.732	11.68	0.808	0.001
dcsoy	0.005	0.024	0	0	0.0014	0.004	0.011

Table H.2, continued. Chemical Content of Runoff.

Production Activity 13

chemical	year 1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.433	0.01	0.877	0.015	0.102	0.49	0.004	0.066
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.416	0.01	0.875	0.015	0.102	0.44	0.004	0.066
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.075	0.049	0.118	0.011	20.815	0.087	0.056	0.031
dcsoy	0	0	0	0	0.007	0	0	0
5								
corn	0.092	0.275	0.616	0.045	0.007	0.253	0.112	0.013
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.003	0.007	0.015	0.013	0.249	0.019	0.033	0.002
dcsoy	0	0.107	0.109	0.085	0.06	0.033	0.527	0.207
fssoy	0.003	0.008	0.015	0.013	0.008	0.019	0.207	0.002
dcsoy	0	0.107	0.109	0.085	0.06	0.249	0.526	0.026
9								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0.092	0.335	0.175	5.532	0.265	0.744	0.551
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0.092	0.335	0.175	5.545	0.265	0.744	0.551

Table H.2, continued. Chemical Content of Runoff.

Production Activity 13, continued

	year						
chemical	9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0.016	0.461	0.021	0.294	0.156	0.117	0.212
fssoy	0	0	0	0	0	0	0
dcsoy	0.014	0.014	0.021	0.022	0.038	0.094	0.129
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.023	0.16	0.005	0.065	0.043	0.006	0.045
dcsoy	0	0	0	0	0	0	0
5							
corn	0.372	0.186	0.016	0.253	0.083	0.381	0.135
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.879	0.021	0.002	0.005	0.014	0.011	0.04
dcsoy	0.007	0.002	0.112	0.114	0.011	0.039	0.008
fssoy	0.026	0.021	0.114	0.005	0.004	0.011	0.717
dcsoy	0.007	0.88	0.112	0.004	0.011	0.064	0.008
9							
corn	0	0	0	0	0	0	0
dcsoy	0.352	2.99	0.108	1.621	2.488	0.067	0.021
fssoy	0	0	0	0	0	0	0
dcsoy	0.356	2.997	0.108	1.615	2.397	0.067	0.021

Table H.2, continued. Chemical Content of Runoff.

Production Activity 13, continued

chemical	year 9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0.016	0.461	0.021	0.294	0.156	0.117	0.212
fssoy	0	0	0	0	0	0	0
dcsoy	0.014	0.014	0.021	0.022	0.038	0.094	0.129
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0.023	0.16	0.005	0.065	0.043	0.006	0.045
dcsoy	0	0	0	0	0	0	0
5							
corn	0.372	0.186	0.016	0.253	0.083	0.381	0.135
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
7							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
8							
corn	0.879	0.021	0.002	0.005	0.014	0.011	0.04
dcsoy	0.007	0.002	0.112	0.114	0.011	0.039	0.008
fssoy	0.026	0.021	0.114	0.005	0.004	0.011	0.717
dcsoy	0.007	0.88	0.112	0.004	0.011	0.064	0.008
9							
corn	0	0	0	0	0	0	0
dcsoy	0.352	2.99	0.108	1.621	2.488	0.067	0.021
fssoy	0	0	0	0	0	0	0
dcsoy	0.356	2.997	0.108	1.615	2.397	0.067	0.021

Table H.2, continued. Chemical Content of Runoff.

Production Activity 13, continued

chemical	year 9	10	11	12	13	14	15
10							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	1.021	14.997	0.82	4.631	9.917	0.568	0.36
dcsoy	0.016	0.021	0	0.001	0.002	0.006	0.026
11							
corn	0	0	0	0	0	0	0
dcsoy	0.162	2.074	0.297	1.075	1	0.175	1.017
fssoy	0	0	0	0	0	0	0
dcsoy	0.146	1.661	0.298	0.907	0.727	0.147	0.679
12							
corn	0.568	0.337	0.024	0.406	0.121	0.587	0.216
dcsoy	0.039	0.796	0.046	0.643	0.395	0.044	1.223
fssoy	0.157	0.757	0.004	0.332	0.06	0.033	0.349
dcsoy	0.036	0.29	0.046	0.536	0.107	0.015	0.601
13							
corn	4.462	12.752	2.026	2.987	2.105	4.236	6.542
dcsoy	2.806	14.328	2.293	2.921	2.51	3.507	4.456
fssoy	4.619	12.483	1.948	3.079	2.162	4.207	6.62
dcsoy	2.806	14.303	2.3	2.856	2.365	3.483	4.414
14							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	2.047	9.282	2.023	7.732	11.68	0.808	0.442
dcsoy	0.005	0.024	0	0.001	0.004	0.004	0.011
15							
corn	0.147	0.01	0.03	0.18	0.001	0.214	0.008
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0

Table H.2, continued. Chemical Content of Runoff.

Production Activity 14

	year							
chemical	1	2	3	4	5	6	7	8
1								
corn	0	0	0	0	0	0	0	0
dcsoy	0.433	0.008	0.876	0.015	0.102	0.488	0.004	0.066
fssoy	0	0	0	0	0	0	0	0
dcsoy	0.416	0.008	0.875	0.015	0.102	0.439	0.004	0.066
2								
corn	0.069	0.238	0.673	0.052	0	0.197	0.123	0.013
dcsoy	0.125	2.314	4.674	0.026	0.108	6.442	1.418	0.09
fssoy	0.33	0.246	0.323	0.004	0.022	0.565	0.088	0.004
dcsoy	0.124	1.959	3.824	0.026	0.108	5.305	1.418	0.09
3								
corn	0.28	0.593	0.94	0.085	0.161	0.724	0.223	0.104
dcsoy	0	0.001	0	0	0.001	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
4b								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0.075	0.049	0.118	0.011	0.108	0.087	0.056	0.031
dcsoy	0	0	0	0	0	0	0	0
7								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
8								
corn	0.003	0.007	0.015	0.013	0.008	0.019	0.033	0.002
dcsoy	0	0.107	0.109	0.085	0.06	0.249	0.527	0.207
fssoy	0.003	0.008	0.015	0.013	0.008	0.019	0.207	0.002
dcsoy	0	0.107	0.109	0.085	0.06	0.249	0.526	0.206

Table H.2, continued. Chemical Content of Runoff.

Production Activity 14, continued

year chemical	1	2	3	4	5	6	7	8
9								
corn	0	0	0	0	0.265	0	0	0
dcsoy	0	0.092	0.335	0.175	5.532	0	0.744	0.551
fssoy	0	0	0.175	0	0	0	0.551	0
dcsoy	0	0.092	0.335	0	5.545	0.265	0.744	0
10								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	4.281	2.46	41.063	0.675	7.281	10.558	4.966	1.748
dcsoy	0	0.002	0.003	0.006	0.004	0.012	0.014	0
11								
corn	0	0	0	0	0	0	0	0
dcsoy	1.284	2.488	10.07	0.186	1.252	3.971	0.841	0.381
fssoy	0	0	0	0	0	0	0	0
dcsoy	1.255	2.161	9.499	0.185	1.252	3.423	0.841	0.381
13								
corn	1.282	4.711	9.076	2.46	4.376	6.132	8.328	2.473
dcsoy	1.995	4.121	10.376	2.285	5.513	7.056	8.067	2.84
fssoy	1.405	4.589	9.029	2.17	4.275	5.891	8.105	2.281
dcsoy	2	4.071	10.096	2.279	5.596	7.01	8.008	2.836
14								
corn	0	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0	0
fssoy	0	1.018	2.928	1.714	20.815	1.848	6.781	3.48
dcsoy	0	0.009	0.003	0.01	0.007	0.015	0.014	0

Table H.2, continued. Chemical Content of Runoff.

Production Activity 14, continued

	year						
chemical	9	10	11	12	13	14	15
1							
corn	0	0	0	0	0	0	0
dcsoy	0.016	0.461	0.021	0.293	0.155	0.117	0.212
fssoy	0	0	0	0	0	0	0
dcsoy	0.014	0.344	0.021	0.021	0.036	0.094	0.129
2							
corn	0.391	0.146	0.012	0.223	0.088	0.459	0.141
dcsoy	0.019	0.518	0.03	0.62	0.268	0.028	0.969
fssoy	0.164	0.812	0.002	0.345	0.046	0.027	0.38
dcsoy	0.017	0.173	0.03	0.514	0.057	0.008	0.493
3							
corn	0.564	0.591	0.064	0.547	0.192	0.481	0.262
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4							
corn	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
fssoy	0	0	0	0	0	0	0
dcsoy	0	0	0	0	0	0	0
4b							
corn	0	0	0	0	0	0	0
dcsoy	0						

APPENDIX I

ANNUAL SOIL EROSION COEFFICIENTS

Table I.1. Annual Soil Erosion Loadings

Alternative Production Systems 1,6,7,17

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	1.95	3.38	13.13	1.03	6.18	6.41	6.34	2.22	3.16	14.98	1.46	3.76	2.46	2.33	3.63
soyb	0.76	1.93	6.32	2.31	3.99	4.37	6.32	1.97	2.62	10.86	1.25	1.84	1.57	3.38	6.20

Alternative Production System 2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	1.07	1.95	6.50	0.60	3.54	3.67	4.28	1.41	1.03	9.77	0.98	2.10	1.19	1.52	3.76
soyb	0.40	1.10	3.34	1.39	2.37	2.44	4.57	1.16	1.05	6.70	0.81	0.92	0.81	1.81	4.01

Alternative Production System 3

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	1.23	1.88	7.57	0.74	4.57	4.30	5.11	1.75	1.57	10.91	1.05	2.28	1.46	1.84	2.89
soyb	0.63	1.48	5.46	1.75	3.29	4.43	5.69	1.68	1.59	9.27	1.07	1.25	1.14	2.60	4.93

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	1.95	3.38	13.13	1.03	5.51	6.41	6.34	2.22	3.16	14.98	1.45	3.76	2.46	2.40	3.63
soyb	0.76	1.93	6.32	2.31	3.99	4.37	6.32	1.97	2.55	10.86	1.25	1.61	1.57	3.38	6.20

Alternative Production System 5

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	1.41	2.19	8.15	0.87	5.06	5.26	5.53	1.93	1.97	11.74	1.23	2.60	1.79	2.06	2.71
soyb	0.69	1.68	5.85	1.95	3.07	3.92	6.00	1.86	2.08	9.92	1.87	1.25	0.98	2.93	5.49

Alternative Production Systems 8,9,10,18

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	0.45	0.81	2.02	0.18	2.10	2.04	2.75	1.30	0.29	5.98	0.96	1.25	0.56	0.76	0.63
soyb	0.47	0.85	3.58	1.21	2.26	2.02	4.08	0.87	0.76	6.36	0.63	0.90	0.78	1.19	3.70

Alternative Production System 11

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	0.74	1.32	3.83	0.36	2.84	3.09	3.38	1.54	0.98	7.35	1.32	1.66	0.90	1.12	1.05
soyb	0.56	1.14	4.19	1.54	4.97	2.58	4.52	1.03	1.48	7.30	0.69	1.14	0.96	1.63	4.59

Alternative Production Systems 12,13,14,19

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	2.28	3.92	14.13	1.34	6.65	6.54	7.28	2.46	3.87	15.45	1.72	4.23	3.09	3.38	4.08
soyb	.85	2.24	6.88	2.71	4.48	4.86	6.70	2.10	3.20	11.60	1.34	1.93	1.81	3.96	6.94
fsoyb	1.57	2.98	14.45	2.98	7.91	7.28	8.89	2.46	5.49	16.78	2.40	3.43	2.73	5.04	6.45
soyb	0.83	2.10	6.56	2.53	4.19	4.48	6.70	1.81	2.89	11.15	1.34	1.90	1.75	3.29	6.79
ave soyb	0.84	2.20	6.72	2.62	4.33	4.67	6.70	1.95	3.04	11.37	1.34	1.91	1.78	3.62	6.86

Alternative Production System 15

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	0.58	1.01	3.96	0.27	2.62	2.13	2.10	1.07	0.74	2.24	1.12	1.03	0.78	0.83	0.94
soyb	0.51	1.01	3.87	1.32	2.53	2.26	4.26	0.94	1.07	6.81	0.65	1.01	0.85	1.43	4.10

Alternative Production System 16

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
corn	0.81	1.28	3.58	0.49	2.98	2.66	2.55	1.28	1.21	5.33	1.41	1.28	0.98	1.19	1.03
soyb	0.63	1.30	4.52	1.68	1.75	2.96	4.75	1.21	1.81	7.84	0.78	0.90	0.63	1.86	5.08

The annual soil erosion was simulated for the fifteen year period under the same weather conditions as 1970-1985. The nonpoint pollution model CREAMS was used to obtain these loading coefficients. All coefficients are in metric tons per hectare.

APPENDIX J

ANNUAL NITROGEN COEFFICIENTS FOR SEDIMENT, RUNOFF, AND PERCOLATION

Table J.1. Nitrogen Content of Sediment.

Scenario: Nitrogen Credits in Residue Recognized

Alternative Production Systems 1(L),6(L),7(L),17(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	6.4	12.6	32.7	4.7	19.8	24.8	19.6	8.0	13.0	45.1	5.0	13.1	9.1	9.8	13.5
Soybean	2.8	8.3	19.8	8.7	14.5	18.4	20.1	7.3	11.5	37.3	4.6	6.3	6.5	13.2	21.0

Alternative Production System 2(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.0	7.7	18.1	2.9	12.8	15.4	14.0	5.4	7.5	31.1	3.6	8.1	4.7	6.5	13.8
Soybean	1.5	5.0	11.7	5.4	9.3	10.7	14.8	4.9	5.5	24.3	3.2	3.8	3.3	7.3	14.2

Alternative Production System 3(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.3	7.7	20.4	3.2	15.2	17.3	16.1	6.5	7.1	34.5	3.8	8.3	5.5	7.2	11.3
Soybean	2.4	6.3	17.2	6.5	12.1	14.5	18.3	6.5	7.6	31.7	4.0	4.9	4.9	10.1	16.7

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	6.4	12.6	32.7	4.7	19.8	24.8	19.6	8.0	13.0	45.1	5.0	13.1	9.1	9.8	13.5
Soybean	2.8	8.3	19.8	8.7	14.5	18.4	20.1	7.3	11.5	37.3	4.6	6.3	6.5	13.2	21.0

Alternative Production System 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.8	8.9	22.4	4.0	17.0	20.7	17.6	7.0	9.2	36.8	4.3	9.4	6.9	8.4	11.1
Soybean	2.5	7.3	18.4	7.3	11.8	16.3	19.1	7.0	9.7	34.0	4.4	5.1	4.2	11.1	18.5

Alternative Production System 8(L),9(L),10(L),18(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	1.9	3.7	7.1	1.2	8.2	8.9	8.9	5.0	1.6	20.3	3.5	4.8	2.7	3.4	3.2
Soybean	1.8	4.2	10.9	4.5	8.5	9.3	13.5	3.5	4.4	22.9	2.6	3.7	3.3	4.9	12.8

Alternative Production System 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	2.9	5.7	12.1	2.0	10.6	13.4	11.5	5.8	4.4	24.9	4.5	6.5	4.0	4.9	4.9
Soybean	2.3	5.1	13.4	5.5	10.4	11.7	15.0	4.2	7.3	26.4	2.8	4.6	4.2	6.3	16.0

Alternative Production System 12(L),13(L),14(L),19(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	7.3	14.4	35.7	6.0	21.1	25.8	22.6	9.0	15.7	46.9	6.0	14.7	10.8	13.5	15.2
Soybean	3.1	9.6	21.9	9.9	16.0	20.2	21.5	7.8	13.7	39.8	5.0	7.5	7.7	15.2	23.5
FSoybean	5.2	11.7	35.9	11.1	25.1	28.4	27.7	8.9	21.9	50.2	8.5	12.4	10.2	19.4	22.5
Soybean	3.1	9.2	20.7	9.4	15.0	19.0	21.5	6.9	12.6	38.6	5.0	7.5	7.4	13.2	22.9

Alternative Production System 15(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	2.2	4.6	12.0	1.5	9.9	9.5	7.9	4.4	3.6	17.3	4.0	4.4	3.4	3.8	4.2
Soybean	2.0	4.9	12.1	4.9	9.6	10.4	13.9	3.8	5.6	24.7	2.6	4.0	3.7	6.0	14.3

Alternative Production System 16(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	3.0	5.4	11.7	2.5	10.8	11.6	9.6	5.2	5.3	19.5	4.8	5.3	4.2	5.3	5.1
Soybean	2.5	6.0	14.7	5.8	7.5	13.2	15.6	4.8	8.4	27.5	3.2	3.9	3.3	7.7	17.5

Scenario: Nitrogen Credits in Residue Not Recognized

Alternative Production Systems 1(L),6(L),7(L),17(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	6.4	12.6	32.7	4.7	19.8	24.8	19.6	8.0	13.0	45.1	5.0	13.1	9.1	9.8	13.5
Soybean	2.8	8.3	19.8	8.7	14.5	18.4	20.1	7.3	11.5	37.3	4.6	6.3	6.5	13.2	21.0

Table J.1, continued. Nitrogen Content of Sediment.

Scenario: Nitrogen Credits in Residue Not Recognized

Alternative Production System 2(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.0	7.7	18.1	2.9	12.8	15.4	14.0	5.4	7.5	31.1	3.6	8.1	4.7	6.5	13.8
Soybean	1.5	5.0	11.7	5.4	9.3	10.7	14.8	4.9	5.5	24.3	3.2	3.8	3.3	7.3	14.2

Alternative Production System 3(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.3	7.7	20.4	3.2	15.2	17.3	16.1	6.5	7.1	34.5	3.8	8.3	5.5	7.2	11.3
Soybean	2.4	6.3	17.2	6.5	12.1	14.5	18.3	6.5	7.6	31.7	4.0	4.9	4.9	10.1	16.7

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	6.4	12.6	32.7	4.7	19.8	24.8	19.6	8.0	13.0	45.1	5.0	13.1	9.1	9.8	13.5
Soybean	2.8	8.3	19.8	8.7	14.5	18.4	20.1	7.3	11.5	37.3	4.6	6.3	6.5	13.2	21.0

Alternative Production System 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	4.8	8.9	22.4	4.0	17.0	20.7	17.6	7.0	9.2	36.8	4.3	9.4	6.9	8.4	11.1
Soybean	2.5	7.3	18.4	7.3	11.8	16.3	19.1	7.0	9.7	34.0	4.4	5.1	4.2	11.1	18.5

Alternative Production System 8(L),9(L),10(L),18(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	1.9	3.7	7.1	1.2	8.2	8.9	8.9	5.0	1.6	20.3	3.5	4.8	2.7	3.4	3.2
Soybean	1.8	4.2	10.9	4.5	8.5	9.3	13.5	3.5	4.4	22.9	2.6	3.7	3.3	4.9	12.8

Alternative Production System 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	2.9	5.7	12.1	2.0	10.6	13.4	11.5	5.8	4.4	24.9	4.5	6.5	4.0	4.9	4.9
Soybean	2.3	5.1	13.4	5.5	10.4	11.7	15.0	4.2	7.3	26.4	2.8	4.6	4.2	6.3	16.0

Alternative Production System 12(L),13(L),14(L),19(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	7.3	14.4	35.7	6.0	21.1	25.8	22.6	9.0	15.7	46.9	6.0	14.7	10.8	13.5	15.2
Soybean	3.1	9.6	21.9	9.9	16.0	20.2	21.5	7.8	13.7	39.8	5.0	7.5	7.7	15.2	23.5
FSoybean	5.2	11.7	35.9	11.1	25.1	28.4	27.7	8.9	21.9	50.2	8.5	12.4	10.2	19.4	22.5
Soybean	3.1	9.2	20.7	9.4	15.0	19.0	21.5	6.9	12.6	38.6	5.0	7.5	7.4	13.2	22.9

Alternative Production System 15(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	2.2	4.6	12.0	1.5	9.9	9.5	7.9	4.4	3.6	17.3	4.0	4.4	3.4	3.8	4.2
Soybean	2.0	4.9	12.1	4.9	9.6	10.4	13.9	3.8	5.6	24.7	2.6	4.0	3.7	6.0	14.3

Alternative Production System 16(L)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	3.0	5.4	11.7	2.5	10.8	11.6	9.6	5.2	5.3	19.5	4.8	5.3	4.2	5.3	5.1
Soybean	2.5	6.0	14.7	5.8	7.5	13.2	15.6	4.8	8.4	27.5	3.2	3.9	3.3	7.7	17.5

Table J.2. Nitrogen Content of Runoff.

Scenario: Nitrogen Credits in Residue Recognized

Alternative Production Systems 1,6,7,17

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	0.9	0.8	0.2	0.3	0.5	0.7	0.2	1	1.3	0.2	0.7	0.3	0.4	0.7
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.3	1.4	0.1	0.2	0.2	0.3	0.5

Alternative Production System 2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.2	0.6	0.6	0.1	0.4	0.3	0.5	0.1	0.7	0.9	0.1	0.4	0.2	0.2	0.8
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.1	1	0.1	0.1	0.1	0.2	0.3

Alternative Production System 3

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.3	0.3	0.5	0.1	0.3	0.9	0.1	0.2	0.1	0.2	0.5
Soybean	0.1	0.2	0.5	0.1	0.3	0.4	0.4	0.1	0.2	1.1	0.1	0.1	0.1	0.2	0.3

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	0.9	0.8	0.2	0.3	0.5	0.7	0.2	1	1.2	0.1	0.7	0.3	0.4	0.7
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.6	0.2	0.3	1.2	0.1	0.2	0.2	0.6	0.6

Alternative Production System 8,9,10,18

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	0.2	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.7	0.1	0.2	0.1	0.2	0.3
Soybean	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.2	0.9	0.1	0.1	0.1	0.1	0.3

Alternative Production System 12,13,14,19

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	1	0.8	0.2	0.3	0.5	0.7	0.2	1.1	1.3	0.2	0.7	0.3	0.4	0.8
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.3	1.3	0.1	0.2	0.2	0.3	0.5
FSoybean	0.1	0.4	0.6	0.1	0.3	0.4	0.6	0.2	0.3	1	0.1	0.3	0.1	0.3	0.5
Soybean	0.2	0.3	0.7	0.1	0.4	0.5	0.5	0.1	0.2	1.3	0.1	0.2	0.2	0.3	0.5

Alternative Production System 15

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.7	0.1	0.2	0.1	0.2	0.3
Soybean	0.1	0.1	0.5	0.5	0.3	0.2	0.4	0.5	0.2	0.2	0.1	0.2	0.1	0.1	0.3

Alternative Production Systems 1L,6L,7L,17L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.5	0.7	0.2	0.3	0.5	0.7	0.3	0.4	1.1	0.2	0.3	0.2	0.3	0.6
Soybean	0.1	0.2	0.6	0.1	0.3	0.4	0.5	0.1	0.2	1	0.1	0.2	0.1	0.2	0.4

Alternative Production System 2L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.4	0.3	0.6	0.1	0.3	0.8	0.1	0.2	0.1	0.2	0.7
Soybean	0.1	0.1	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.7	0.1	0.1	0.1	0.1	0.2

Alternative Production System 3L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.6	0.1	0.4	0.3	0.6	0.1	0.3	0.8	0.1	0.2	0.1	0.2	0.6
Soybean	0.1	0.2	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.8	0.1	0.1	0.1	0.2	0.3

Table J.2, continued. Nitrogen Content of Runoff.

Scenario: Nitrogen Credits in Residue Recognized, continued

Alternative Production System 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.6	0.2	0.2	0.9	0.1	0.2	0.1	0.2	0.4
Soybean	0.1	0.2	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.8	0.1	0.1	0.1	0.2	0.3

Alternative Production System 8L,9L,10L,18L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	0.2	0.4	0.1	0.1	0.2	0.4	0.1	0.1	0.7	0.1	0.1	0.1	0.2	0.3
Soybean	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.3

Alternative Production System 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.8	0.3	0.2	0.1	0.1	0.3	0.3	0.2	0.1	0.8	0.8	0.2	0.1	0.2	0.2
Soybean	0.1	0.1	0.5	0.5	0.3	0.2	0.4	0.5	0.2	0.2	0.1	0.2	0.1	0.1	0.3

Alternative Production System 12L,13L,14L,19L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.4	0.7	0.2	0.3	0.4	0.7	0.2	0.4	1	0.1	0.3	0.2	0.2	0.5
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.2	1	0.1	0.2	0.2	0.2	0.4
FSoybean	0.1	0.4	0.6	0.1	0.3	0.4	0.6	0.2	0.3	1	0.2	0.3	0.2	0.3	0.5
Soybean	0.1	0.2	0.6	0.1	0.3	0.4	0.5	0.1	0.2	1	0.1	0.2	0.1	0.2	0.4

Alternative Production System 15L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.4	0.1	0.2	0.8	0.1	0.2	0.1	0.2	0.3
Soybean	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.1	0.7	0.1	0.1	0.1	0.1	0.3

Alternative Production System 16L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.5	0.2	0.2	0.8	0.2	0.2	0.1	0.2	0.4
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.2	0.8	0.1	0.1	0.1	0.2	0.3

Scenario: Nitrogen Credits in Residue Not Recognized

Alternative Production Systems 1,6,7,17

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	1	0.9	0.2	0.4	0.6	0.7	0.3	1.1	1.3	0.2	0.8	0.4	0.5	0.8
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.3	1.4	0.1	0.2	0.2	0.3	0.5

Alternative Production System 2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.2	0.7	0.6	0.1	0.2	0.3	0.5	0.2	0.8	1	0.1	0.5	0.2	0.2	0.6
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.1	0.9	0.1	0.1	0.1	0.2	0.3

Alternative Production System 3

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.4	0.6	0.1	0.4	0.3	0.6	0.2	0.3	0.9	0.1	0.3	0.1	0.2	0.6
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.1	1	0.1	0.1	0.1	0.2	0.3

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	1	0.9	0.2	0.4	0.6	0.7	0.3	1.1	1.3	0.2	0.8	0.4	0.5	0.8
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.6	0.2	0.3	1.2	0.1	0.2	0.2	0.6	0.6

Alternative Production System 8,9,10,18

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.4	0.5	0.1	0.2	0.2	0.4	0.1	0.6	0.8	0.1	0.2	0.1	0.1	0.4
Soybean	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.1	0.8	0.1	0.1	0.1	0.1	0.3

Table J.2, continued. Nitrogen Content of Runoff.

Scenario: Nitrogen Credits in Residue Not Recognized, continued

Alternative Production System 12,13,14,19

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.3	1	0.8	0.2	0.3	0.6	0.7	0.2	1.1	1.3	0.2	0.8	0.3	0.4	0.8
Soybean	0.2	0.3	0.8	0.2	0.4	0.6	0.5	0.2	0.3	1.4	0.1	0.3	0.2	0.3	0.5
FSoybean	0.1	0.4	0.6	0.1	0.3	0.4	0.6	0.2	0.3	1	0.1	0.3	0.2	0.3	0.5
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.3	1.4	0.1	0.2	0.2	0.3	0.5

Alternative Production System 15

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.5	0.5	0.1	0.2	0.3	0.5	0.2	0.7	0.9	0.2	0.4	0.1	0.2	0.5
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.2	1	0.1	0.1	0.1	0.2	0.4

Alternative Production Systems 1L,6L,7L,17L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.5	0.7	0.2	0.3	0.5	0.7	0.3	0.4	1.1	0.2	0.4	0.2	0.4	0.6
Soybean	0.1	0.2	0.6	0.1	0.3	0.4	0.5	0.1	0.2	1	0.1	0.2	0.1	0.2	0.4

Alternative Production System 2L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.5	0.2	0.2	0.8	0.1	0.2	0.1	0.2	0.4
Soybean	0.1	0.1	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.7	0.1	0.1	0.1	0.1	0.2

Alternative Production System 3L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.5	0.2	0.2	0.9	0.1	0.2	0.1	0.2	0.4
Soybean	0.1	0.2	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.8	0.1	0.1	0.1	0.2	0.3

Alternative Production System 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.6	0.1	0.3	0.3	0.5	0.1	0.2	0.9	0.1	0.2	0.1	0.2	0.4
Soybean	0.1	0.2	0.5	0.1	0.2	0.3	0.4	0.1	0.1	0.8	0.1	0.1	0.1	0.2	0.3

Alternative Production System 8L,9L,10L,18L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	0.2	0.4	0.1	0.2	0.2	0.4	0.1	0.1	0.7	0.1	0.2	0.1	0.1	0.3
Soybean	0.1	0.1	0.4	0.1	0.2	0.2	0.4	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.3

Alternative Production System 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.8	0.3	0.2	0.1	0.1	0.3	0.3	0.2	0.1	0.8	0.8	0.2	0.1	0.2	0.2
Soybean	0.1	0.1	0.5	0.5	0.3	0.2	0.4	0.5	0.2	0.2	0.1	0.2	0.1	0.1	0.3

Alternative Production System 12L,13L,14L,19L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.4	0.7	0.2	0.3	0.4	0.7	0.2	0.4	1	0.1	0.3	0.2	0.3	0.5
Soybean	0.2	0.3	0.7	0.2	0.4	0.5	0.5	0.2	0.2	1	0.1	0.2	0.2	0.2	0.4
FSoybean	0.1	0.4	0.7	0.1	0.3	0.4	0.6	0.2	0.3	1	0.2	0.3	0.2	0.3	0.5
Soybean	0.1	0.2	0.6	0.1	0.3	0.4	0.5	0.1	0.2	1	0.1	0.2	0.1	0.2	0.4

Table J.2, continued. Nitrogen Content of Runoff.

Scenario: Nitrogen Credits in Residue Not Recognized,continued

Alternative Production System 15L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.5	0.2	0.2	0.8	0.2	0.2	0.1	0.2	0.3
Soybean	0.1	0.2	0.4	0.1	0.2	0.3	0.4	0.1	0.1	0.7	0.1	0.1	0.1	0.1	0.3

Alternative Production System 16L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0.1	0.3	0.5	0.1	0.2	0.3	0.5	0.2	0.2	0.9	0.2	0.3	0.1	0.2	0.4
Soybean	0.1	0.2	0.5	0.1	0.3	0.3	0.4	0.1	0.2	0.9	0.1	0.1	0.1	0.2	0.3

The loading of nitrogen into runoff or surface water was simulated for the fifteen year period under the same weather conditions as 1970-1985. The nonpoint pollution model CREAMS was used to obtain these loading coefficients. In the first scenario (Nitrogen Credits in Residue Recognized) the farm operator has adjusted his application of nitrogen, in either inorganic or poultry litter form, to account for the available nitrogen in crop residues. The second scenario (Nitrogen Credits in Residue Not Recognized) the farm operator has applied the total recommended application of nitrogen, either inorganic or poultry litter, in addition to nitrogen available from crop residues. All coefficients are in kilograms per hectare.

Table J.3. Nitrogen Content of Percolation.

Scenario: Nitrogen Credits in Residue Recognized

Alternative Production Systems 1,6,7,17

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	15.8	77.3	67.8	17.6	36.4	42.9	33.8	44.5	63.4	65.8	22.6	67.3	23.3	50.9	61.3
Soybean	0	0.8	42.8	0.3	11.2	48.1	10.1	15.8	27.2	37.9	0	0	13.1	46.3	47.2

Alternative Production System 2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	19.4	112	95.1	30.1	55.8	59.8	60.5	76.5	84.5	86.5	32.2	87	35.8	76.2	80
Soybean	0	3.8	52.8	0.3	17.6	59	19	24.6	35.3	49.9	0.6	2.2	18.6	60.8	61.1

Alternative Production System 3

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	14	65.9	54.4	11.5	24.3	37.1	24.9	26.2	53	59.4	19.9	58.8	19.8	48.8	47.5
Soybean	0	0.8	40.3	0.3	11.7	44.3	6.4	11.3	25.6	35.4	0	1.1	12.7	39.9	43.7

Alternative Production System 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	15	55.9	54.2	9.7	19.3	36.8	24.8	38.6	56.8	54.6	17.1	54.5	17.1	45.3	50.4
Soybean	0	0.3	35.9	0.2	8.5	33.8	5.1	10.3	24.4	22.9	0	0	7.7	28.2	40

Alternative Production System 8,9,10,18

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	69.9	58.4	18.7	37.3	52.6	47	75.2	41.2	72.3	28.7	30.7	34.4	65.7	31.2
Soybean	1.8	7.1	50.9	0.5	18.4	58.1	12	18	31.7	50.1	0	6.8	23.3	40.8	57.4

Alternative Production System 12,13,14,19

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	16.2	70.1	68.4	19.1	26.4	41.8	30.5	42.3	54.4	62	21.7	61.8	23	47.9	61.5
Soybean	0	0.7	37.8	1.8	16.6	61.5	3.8	15.1	31.4	31.5	1.1	0	17.3	45.9	42.4
FSoybean	8.2	35.5	29.2	8.1	15.5	18.6	14.1	14.3	29.6	24.9	9.6	38.4	10.4	27.9	23.6
Soybean	0	0.8	0.1	8.3	37.5	4.1	4.3	21.2	27	0	0	8.2	35.6	35.7	0.4

Alternative Production System 15

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	75.4	63.3	19.3	39.4	49.6	46.8	72.7	36.6	56.1	25.7	32.2	22.7	68.4	30.7
Soybean	1.5	9	52.2	0.6	18	59.4	14.9	22.4	31	52.6	0	6.7	26.4	45.3	56.1

Alternative Production Systems 1L,6L,7L,17L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	23	72.2	89.4	36.5	36.8	67.6	63	75.8	71.8	87.7	35.9	50.6	33.4	95.1	74.5
Soybean	0	1.8	25.8	0.5	2.7	24.2	1.5	8.4	8.4	15.9	0	0	4.7	20.1	9.1

Alternative Production System 2L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	20.9	88.6	96.3	44.3	41.8	73.6	78.6	84.9	75	107	40.3	58	37.3	116	81.4
Soybean	0	2.3	31.5	0.6	4.8	34.3	2.1	9.8	10.4	23	0.3	1.1	9.5	29.7	12.4

Alternative Production System 3L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	13.3	52.2	61.9	30.2	28.4	49.3	54.6	53.6	51.6	73	28.1	34.6	24.2	80.5	50.9
Soybean	0	1.7	24.4	0.5	2.9	22.7	1.3	7.6	8.1	15.6	0	0.5	4.5	15.8	9.4

Table J.3, continued. Nitrogen Content of Percolation.

Scenario: Nitrogen Credits in Residue Recognized, continued

Alternative Production System 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	19.6	64.4	73.9	36.4	37.3	60.8	62.1	60.7	65.4	85.2	34.2	44.5	29.9	93.1	65.3
Soybean	0	1.9	26.2	0.5	3.3	24.4	1.5	8.3	8.7	17.1	0	0.6	5.1	19.5	10.1

Alternative Production System 8L,9L,10L,18L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	64.8	82	23.9	30.6	60	48.4	67.1	58.3	84.6	24.9	22.7	30.5	94.8	55.2
Soybean	1.3	5.3	30.1	1	6.3	31.7	1.6	3.8	11.4	27.7	0.1	4	11.9	15.9	18

Alternative Production System 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	7.9	70.4	6	26.3	1	66.1	31.3	76.5	3.8	84.9	26.8	23.8	3.4	96.4	15.9
Soybean	0.7	0	29.5	89.5	5.6	31.1	1.6	56	11	61	0.1	27.8	13.2	32.5	17

Alternative Production System 12L,13L,14L,19L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	18.1	44.2	56.3	28.5	29.4	44.4	36.7	39.6	61.8	58.8	26.6	36.1	22.3	69.3	59.4
Soybean	0	1.5	47.4	9.6	16	56.4	17.4	21.3	34.6	43.1	5.6	0	23.3	50.8	38.5
FSoybean	13.1	60.2	52.6	12.8	22.6	35.3	26.4	33.5	41.4	48.2	15.9	50	17.1	53.2	39.9
Soybean	0	1.5	20.3	0.2	3	18.9	1.6	7	6.4	10	0	0	2.4	12.6	6.3

Alternative Production System 15L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	71.2	86.4	25.7	32.1	64.6	53.6	74	55.6	83.5	27.1	24.7	31.8	93.7	58.2
Soybean	1.1	6.3	31.5	1	6.6	33.5	1.7	4.4	11.8	29.8	0.1	4	15.5	19.9	18.6

Alternative Production System 16L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	70.8	86	25.5	31.8	64.5	53.4	73.6	55.4	82.9	26.7	23.6	31.1	93.5	58
Soybean	0.7	5.9	31.2	1	6.1	33.3	1.7	4.5	11.6	29.2	0.1	3.7	15.6	20	18.1

Scenario: Nitrogen Credits in Residue Not Recognized

Alternative Production Systems 1,6,7,17

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	21.9	99.6	98.8	29.2	38.8	67.7	61.8	78.4	74.3	83.6	33.4	77.3	34.3	80.9	76.9
Soybean	0	0.8	40.2	0.3	10.3	45	7.4	12.8	25.2	34.6	0	0	12	41.8	43.5

Alternative Production Systems 2

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	24.5	128.	139	43.8	46.4	92.2	102	117	73.2	114	45.5	84.3	45.8	118	81.4
Soybean	0	6	40.2	0.3	23.6	66.5	5.5	10.3	25.3	36.8	0.4	1.9	21.2	44	42.9

Alternative Production Systems 3

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	21.4	75.9	84.2	22.8	21.6	55.9	45.5	55.9	65.7	76.1	29	65	29.4	65.7	67
Soybean	0	0.8	33.3	0.3	8.7	35.9	0.5	4.5	20.1	27.7	0	0.9	9.6	28.7	33.7

Alternative Production Systems 4

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	21.9	99.5	98.8	29.2	38.7	67.7	61.8	78.4	74.3	83.6	33.4	77.2	34.3	80.9	78.4
Soybean	0	0.8	39.6	0.3	9.6	40.7	7.3	12.7	24.2	28.5	0	0	10	39.6	40.3

Table J.3, continued. Nitrogen Content of Percolation.

Scenario: Nitrogen Credits in Residue Not Recognized, continued

Alternative Production Systems 8,9,10,18

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	97.6	111	31.3	40.6	77.3	76.2	101	80.4	91.2	35.8	45.8	39.8	99.4	90
Soybean	1.7	9.5	49.5	0.5	17.1	54.4	8.1	16.8	29.3	45.8	0	6.2	29.6	45	52.6

Alternative Production Systems 12,13,14,19

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	17.4	81.1	72.3	21.1	35.2	45	34.6	50.9	62.7	64.9	23.5	69.7	24.7	51.9	67.4
Soybean	0	4.2	49.9	4	22.7	80.4	15.1	27	44.8	43.8	2.4	0	27.1	65.5	57.1
FSoybean	10.3	58.2	46.7	8.7	26.9	23.8	17.5	22.5	43.4	33	11.6	52.2	18	36.7	32.6
Soybean	0	0.8	39.8	0.1	10	43.2	9.3	9.9	24.9	32.6	0	0	9.8	44.4	42.6

Alternative Production Systems 15

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	118	143	39.4	51.6	90.2	91.5	120	92.4	108	42.4	51.2	48.4	120	103
Soybean	1.4	22.9	53.5	0.6	21.7	68.6	12.5	23	30.2	50	0	6.4	48.2	53.2	54.1

Alternative Production Systems 1L,6L,7L,17L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	25.5	80.7	98.6	42	41.4	75.7	73.6	86.7	79.1	95.2	40.4	56.6	37.7	103	83.2
Soybean	0	2	27.2	0.5	2.9	25.6	1.7	8.9	8.8	17.2	0.1	0	5.1	23	9.6

Alternative Production Systems 2L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	30.9	113	131	56.4	56.1	95.8	102	116	91.5	117	51.7	72.3	48.4	130	101
Soybean	0	6.6	32.9	0.7	9.1	46.1	2.3	10.4	10.9	24.6	0.4	1.2	17.9	35	12.9

Alternative Production Systems 3L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	21.4	63.9	80.5	31.8	32.8	59.7	54.2	63.8	66.1	79.9	32.6	45.9	30	85.8	66.9
Soybean	0	1.7	24.6	0.5	2.9	22.8	1.3	7.8	8.2	15.7	0	0.5	4.5	16	9.5

Alternative Production Systems 5L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	26.3	80.6	98.7	42.5	42.5	49.4	47.4	43.3	58.8	85.5	35.1	52.8	36.2	102	81.6
Soybean	0	2	27.6	0.5	3.6	24.8	0.2	3.5	6.3	10.4	0	0.5	5.2	20.3	10.5

Alternative Production Systems 8L,9L,10L,18L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	81.3	111	37	39.7	83.5	79.4	102	77.9	103	36.9	34	42.2	119	97.9
Soybean	1.3	10.8	34	0.9	7.9	32.2	1.5	10.3	11.4	26.1	0.1	3.8	22.5	26.2	17.3

Alternative Production Systems 11L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	7.9	70.4	6	26.3	1	66.1	31.3	76.5	3.8	84.9	26.8	23.8	3.4	96.4	15.9
Soybean	0.7	0	29.5	89.5	5.6	31.1	1.6	56	11	61	0.1	27.8	13.2	32.5	17

Alternative Production Systems 12L,13L,14L,19L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	17.9	42.7	54.3	27.9	28.6	42.7	35.3	37.6	61.1	56.4	25.9	31.4	21.4	67.4	58.9
Soybean	0	1.5	46.7	9.7	15.8	55	16.6	20.7	34.7	42.1	5.6	0	22.7	48.9	38.6
FSoybean	14	63.7	57.7	13.2	21.8	39.4	28.7	38.3	42.5	48.6	16.9	50.8	18.4	58.3	40.7
Soybean	0	1.3	17.5	0.1	3.3	16	1.7	6.3	5.4	8.4	0	0	1.7	11	5.3

Table J.3, continued. Nitrogen Content of Percolation.

Scenario: Nitrogen Credits in Residue Not Recognized, continued

Alternative Production Systems 15L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	104	143	45.1	48.6	95.9	94.9	118	86	116	43.6	39.9	50.9	139	110
Soybean	1.6	24.2	38.3	1.1	16.1	52.7	1.8	13	12.6	31.1	0.1	5	4	35.6	19.1

Alternative Production Systems 16L

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Corn	0	95.8	124	35.8	44.9	81.6	74.4	94.8	71.4	97.5	36	32.3	42.2	119	72.4
Soybean	0.9	20.6	34.2	1.2	11.5	52.9	4.3	9.7	12.7	33.5	0.1	4.3	35.5	27.2	19.8

The loading of nitrogen into the root zone was used as a proxy for percolation potentially reaching groundwater. The loading coefficients were simulated for the fifteen year period under the same weather conditions as 1970-1985. The nonpoint pollution model CREAMS was used to obtain these loading coefficients. In the first scenario (Nitrogen Credits in Residue Recognized) the farm operator has adjusted his application of nitrogen, in either inorganic or poultry litter form, to account for the available nitrogen in crop residues. The second scenario (Nitrogen Credits in Residue Not Recognized) the farm operator has applied the total recommended application of nitrogen, either inorganic or poultry litter, in addition to nitrogen available from crop residues. All coefficients are in kilograms per hectare.

APPENDIX K

VARIABLE OPERATING COSTS, IN 1988 DOLLARS

Table K.1. Farm Machinery Operating Costs.

Operation	$/hectare	$/hour	hectares/ hour	Total $/hectare
Chisel	.40		1.49	.40
(+tractor*)		11.81		7.92
				8.32
Disk	1.29		1.54	1.29
(+tractor*)		11.81		7.67
				8.96
Moldboard	3.26		.91	3.26
(+tractor*)		11.81		12.93
				16.21
Planter,	6.58		1.32	6.58
Conventional				
(+tractor**)		5.65		4.28
				10.87
PLanter,	12.60		.88	12.60
No Till				
(+tractor**)		5.65		6.41
				19.01
Planter,	4.38		1.06	4.38
Drill		5.65		5.33
				9.73

*125 Horse Power Tractor

**70 Horse Power Tractor

Table K.1. Farm Machinery Operating Costs.

Operation	$/hectare	$/hour	hectares/ hour	Total $/hectare
Cultivator				4.95
(+tractor)				**4.95**
Combine,	31.81		1.89	31.81
Corn Head				**31.81**
Combine,	11.88		3.78	11.88
Grain Head				**11.88**
Fertilizer	.20		4.11	.20
Spreader				
(+tractor**)		5.65		1.38
				1.58
Mow	3.22		1.00	3.22
(+tractor**)		5.65		5.65
				8.87

*125 Horse Power Tractor
**70 Horse Power Tractor

Source: Dunford, Judy, and Vines; Perkinson

Table K.2. Variable cost crop budgets.

CORN, MOLDBOARD TILLAGE
PRODUCTION ACTIVITIES
1(L),4,7(L),12(L),14,17(L),19(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**			TOTAL	**157.12** **(155.54)**

PRODUCTION ACTIVITIES
6(L),13(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	2.00	24.75
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**			TOTAL	**169.49** **(167.91)**

* Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

Table K.2, continued. Variable cost crop budgets.

CORN, NO TILLAGE
PRODUCTION ACTIVITIES
2(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				149.05 (147.47)

PRODUCTION ACTIVITIES
8(L),10(L),18(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
CULTIVATE	HECTARE	4.95	1.00	4.95
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				154.00 (152.42)

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[*] Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

Table K.2, continued. Variable cost crop budgets.

CORN, NO TILLAGE
PRODUCTION ACTIVITIES
9(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
APPLIC. N	HECTARE	1.58	2.00	3.16[*]
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	2.00	24.75
CULTIVATE	HECTARE	4.95	1.00	4.95
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
***************************************TOTAL				**166.37** **(164.79)**

[*] Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

PRODUCTION ACTIVITY
11L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
APPLIC. N	HECTARE	1.58	1.00	1.58
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	0.00	0.00
CULTIVATE	HECTARE	4.95	3.00	14.85
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
***TOTAL				**149.65**

Table K.2, continued. Variable cost crop budgets.

CORN, CHISEL OR DISK TILLAGE
PRODUCTION ACTIVITIES
3(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
CHISEL	HECTARE	8.32	1.00	8.32
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
***TOTAL				129.29 (127.71)

* Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

PRODUCTION ACTIVITY
5L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	2.00	17.87
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	1.00	1.58
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	0.00	0.00
CULTIVATION	HECTARE	4.95	3.00	14.85
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
***TOTAL				139.74

Table K.2, continued. Variable cost crop budgets.

CORN, MOLDBOARD TILLAGE
PRODUCTION ACTIVITIES
15(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	1.00	8.94
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				129.91 (128.34)

* Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

PRODUCTION ACTIVITY
16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	75.00	0.74	55.69
LIME	KG	0.03	900.09	27.00
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	1.00	8.94
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	1.00	1.58
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	0.00	0.00
CULTIVATION	HECTARE	4.95	3.00	14.85
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				130.81

Table K.2, continued. Variable cost crop budgets.

CLOVER, NO TILLAGE
PRODUCTION ACTIVITIES
15(L),16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	0.58	54.46	31.58
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	1.00	8.94
OVERSEED,AERIAL	HECTARE	14.85	1.00	14.85
***			TOTAL	55.38

Table K.2, continued. Variable cost crop budgets.

RYE, NO TILLAGE
PRODUCTION ACTIVITIES
8(L),9(L),10(L),11L,18(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	7.95	3.09	24.60
PRODUCTION MACHINERY-VARIABLE COSTS				
MOW	HECTARE	8.86	1.00	8.86
OVERSEED,AERIAL	HECTARE	19.80	1.00	19.80
**TOTAL				53.26

PRODUCTION ACTIVITIES
15(L),16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	7.95	3.09	24.60
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	1.00	8.94
OVERSEED,AERIAL	HECTARE	19.80	1.00	19.80
**TOTAL				53.34

Table K.2, continued. Variable cost crop budgets.

DOUBLE CROP SOYBEANS, NO TILLAGE
PRODUCTION ACTIVITIES
1(L),4,6(L),7(L),15(L),17(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	2.97	44.55
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	3.00	37.13
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				149.38

PRODUCTION ACTIVITY
2(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	2.97	44.55
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
DISK	HECTARE	8.94	1.00	8.94
PLANT	HECTARE	19.01	1.00	19.01
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	3.00	37.13
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				158.32

Table K.2, continued. Variable cost crop budgets.

DOUBLE CROP SOYBEANS, NO TILLAGE
PRODUCTION ACTIVITIES
3(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	2.97	44.55
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
CUSTOM APPLIC.				
CHEMICALS	HECTARE	12.38	2.00	24.75
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				137.00

PRODUCTION ACTIVITIES
5L,11L,16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	2.97	44.55
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
CUSTOM APPLIC.				
CHEMICALS	HECTARE	12.38	0.00	0.00
CULTIVATION	HECTARE	4.95	3.00	14.85
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				127.10

Table K.2, continued. Variable cost crop budgets.

DOUBLE CROP SOYBEANS, NO TILLAGE
PRODUCTION ACTIVITIES
8(L),9(L),10(L),12(L),13(L),14(L),18(L),19(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	2.97	44.55
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
PLANT	HECTARE	19.01	1.00	19.01
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	4.00	49.50
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				161.76

Table K.2, continued. Variable cost crop budgets.

FULL SEASON SOYBEAN, MOLDBOARD TILLAGE

PRODUCTION ACTIVITIES
12(L),13(L),14(L),19(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	15.00	1.98	29.70
LIME	KG	0.03	675.07	20.25
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	10.87	1.00	10.87
APPLIC. N	HECTARE	1.58	1.00	1.58
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	3.00	37.13
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	31.81	1.00	31.81
**TOTAL				110.42

Table K.2, continued. Variable cost crop budgets.

WHEAT, MOLDBOARD TILLAGE
PRODUCTION ACTIVITIES
1(L),2(L),6(L),7(L),8(L),9(L),10(L),
12(L),13(L),14(L),15(L),17(L),18(L),19(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	10.50	4.95	51.98
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
***TOTAL				122.21 (120.63)

PRODUCTION ACTIVITIES
3(L),5L,11L,16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	10.50	4.95	51.98
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	0.00	0.00
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
***TOTAL				109.84 (108.26)

[*] Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

Table K.2, continued. Variable cost crop budgets.

WHEAT, MOLDBOARD TILLAGE
PRODUCTION ACTIVITY
4

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	10.50	4.95	51.98
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	3.00	4.74
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				123.80

Table K.2, continued. VARIABLE COST CROP BUDGETS.

BARLEY, MOLDBOARD TILLAGE
PRODUCTION ACTIVITIES
1(L),2(L),6(L),7(L),8(L),9(L),10(L),12(L),
13(L),14(L),15(L),17(L),18(L),19(L)

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	4.95	6.19	30.63
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				100.86 (99.28)

PRODUCTION ACTIVITIES
3(L),5L,11L,16L

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	4.95	6.19	30.63
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	2.00	3.16*
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	0.00	0.00
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				88.49 (86.91)

* Production activities using poultry litter(L) have only one application of nitrogen. One application of nitrogen is omitted from the total in parenthesis.

Table K.2, continued. Variable cost crop budgets.

BARLEY, MOLDBOARD TILLAGE
PRODUCTION ACTIVITY
4

INPUT	UNIT	PRICE	QUANTITY	TOTAL
SEED	SEED	4.95	6.19	30.63
LIME	KG	0.03	562.56	16.88
PRODUCTION MACHINERY-VARIABLE COSTS				
MOLDBOARD	HECTARE	16.21	1.00	16.21
PLANT	HECTARE	9.73	1.00	9.73
APPLIC. N	HECTARE	1.58	3.00	4.74
CUSTOM APPLIC. CHEMICALS	HECTARE	12.38	1.00	12.38
HARVEST MACHINERY-VARIABLE COSTS				
COMBINE	HECTARE	11.88	1.00	11.88
**TOTAL				102.45

Source: Perkinson; Liddington; Dunford, Judy, and Vines.

Table K.3. Composite variable cost budgets.

Production Activities 1(L),7(L),17(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System(L)
Corn	.5	157.12	155.54	78.56(77.77)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCsoyb.	.5	149.38		74.69(74.69)
			TOTAL	**209.55(207.97)**

Production Activity 6(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System(L)
Corn	.5	169.49	162.91	84.74(81.45)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCsoyb.	.5	149.38		74.69(74.69)
			TOTAL	**215.73(211.65)**

Production Activities 2(L)

Crop	Hectare	Cost per Hectare	Cost per System L	Cost per System(L)
Corn	.5	149.05	147.47	74.52(73.73)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCsoyb	.5	158.32		79.16(79.16)
			TOTAL	**209.98(208.40)**

Production Activities 3(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	129.29	127.71	64.64(63.85)
Wheat	.275	109.84	108.26	30.21(29.77)
Barley	.225	88.49	86.91	19.91(19.55)
DCsoyb.	.5	137.00		68.50(68.50)
			TOTAL	**183.26(181.67)**

Table K.3, continued. Composite variable cost budgets.

Production Activity 4

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	157.12		78.56
Wheat	.275	123.80		34.04
Barley	.225	102.45		23.05
DCsoyb.	.5	149.38		74.69
			TOTAL	**210.34**

Production Activity 5L

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	139.74		69.87
Wheat	.275	108.26		29.77
Barley	.225	86.91		19.55
DCsoyb.	.5	127.10		63.55
			TOTAL	**182.74**

Production Activities 8(L),10(L),18(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	154.00	152.42	77.00(76.21)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCSoyb.	.5	161.76		80.88(80.88)
Rye	.5	53.26		26.63(26.63)
			TOTAL	**240.81(239.23)**

Production Activity 11L

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	149.65		74.82
Wheat	.275	108.26		29.77
Barley	.225	86.91		19.55
DCsoyb.	.5	127.10		63.55
Rye	.5	53.26		26.63
			TOTAL	**214.32**

Table K.3, continued. Composite Variable Cost Budgets.

Production Activity 9(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	166.37	164.79	83.18(82.39)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCsoyb.	.5	161.76		80.88(80.88)
Rye	.5	53.26		26.63(26.63)
			TOTAL	**246.99(245.41)**

Production Activities 12(L),14(L),19(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Crop per System (L)
Corn	.25	157.12	155.54	39.28(38.88)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCSoyb.	.5	161.75		80.87(80.87)
FSSoyb.	.25	110.42		27.60(27.60)
			TOTAL	**204.05(202.86)**

Production Activities 13(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.25	169.49	167.91	42.37(41.98)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCSoyb.	.5	161.76		80.87(80.87)
FSSoyb.	.25	110.42		27.60(27.60)
			TOTAL	**207.14(205.96)**

Table K.3, continued. Composite variable cost budgets.

Production Activities 15(L)

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Cost per System (L)
Corn	.5	129.91	128.34	64.95(64.17)
Wheat	.275	122.21	120.63	33.61(33.17)
Barley	.225	100.86	99.28	22.69(22.34)
DCsoyb.	.5	149.38		74.69(74.69)
Rye	.25	53.34		13.33(13.33)
Clover	.25	55.38		13.84(13.84)
			TOTAL	223.11(221.54)

Production Activity 16L

Crop	Hectare	Cost per Hectare	Cost per Hectare L	Crop per System (L)
Corn	.5	130.81		65.40
Wheat	.275	108.26		29.77
Barley	.225	86.91		19.55
DCsoyb.	.5	127.10		63.55
Rye	.25	53.34		13.33
Clover	.25	55.38		13.84
			TOTAL	205.44

APPENDIX L

POULTRY LITTER

Table L.1. Poultry litter nutrient contents.

One ton of poultry litter = 58 lbs Nitrogen

40% of poultry litter = inorganic nitrogen
60% of poultry litter = organic nitrogen

One kilogram of Nitrogen = 2.2 lbs of Nitrogen
= 34 kilograms of poultry litter
One kilogram of poultry litter
= .029 kilograms of Nitrogen

One kilogram of Phosphorus = 2.2 lbs of Phosophorus
= 48 kilograms of poultry litter
One kilogram of poultry litter
= .021 kilograms of Phosphorus

One kilogram of Potassium = 2.2 lbs of Potassium
= 66 kilograms of poultry litter
One kilogram of poultry litter
= .015 kilograms of Potassium

Source: Norris, Givens

Table B.2. Poutlry litter price.

Assume $2.00 per loaded mile

170 miles from Harrisonburg, Virginia to Tappahonnock, Virginia

Transport by a 20 ton capacity truck

($2.00 / mile x 170 miles) / 20 tons = $17.00 / ton

Assume the poultry litter broker pays the following:

To purchase litter from poultry producer	$8.00 / ton
To rent front end loader and load litter	$1.50 / ton
To transport litter	$17.00 / ton
Broker pays	$26.50 / ton
Profit margin for broker	$1.00 / ton
Total cost to producer for litter delivered	$27.50 / ton ($.03 / kg)

Source: Weaver et al, Showalter, Napit, Norris

APPENDIX M

CROP PRICES AND COMMODITY PROGRAM TARGET PRICES, IN 1988 DOLLARS

Table M.1. Base Crop Prices in the Northern Neck Region of Virginia, 1970-1988, Per Bushel.

Year	Corn	Wheat	Barley	Soybean
1970	1.36	1.26	.77	2.63
1971	1.40	1.45	1.00	2.93
1972	1.26	1.27	.87	3.20
1973	1.98	2.91	1.52	5.99
1974	2.97	3.60	1.75	6.13
1975	2.73	3.07	1.54	5.31
1976	2.49	3.08	1.84	5.41
1977	2.16	2.00	1.34	6.87
1978	2.31	3.02	1.50	6.40
1979	2.66	4.01	1.63	6.99
1980	3.02	3.88	2.24	6.78
1981	3.06	3.25	1.82	6.94
1982	2.43	3.04	1.62	5.96
1983	3.30	4.25	2.29	6.96
1984	3.27	3.80	2.18	6.95
1985	2.55	2.87	1.74	5.54
1986	2.10	2.42	1.41	5.08
1987	1.67	2.49	1.10	5.17
1988	2.52	3.25	1.62	7.44

Base crop prices are annual averages of the weekly cash prices in the Nothern Nech Region of Virginia, 1970-1988 (Virginia Department of Agriculture and Consumer Services). Several years of weekly cash price data was missing for wheat and barley. The missing data was estimated using linear price equations, constructed by Ordinary Least Squares Regression. In the regression corn prices were used as a predictor of wheat and barley prices (groover). Three years of available weekly cash prices for wheat and barley were regressed onto corn prices.

These crop prices were then adjusted to 1988 dollars. A feed grain index, where 1988 = 100, was used to adjust the prices. A 1988 = 100 index was created by dividing a set of 1977 =100 (USDA) indices by the 1988 index. Each price was then divided by the new index.

Table M.2. Feed Grain Index (1977=100), Feed Grain Index (1988=100) and Adjusted Crop Prices, Per Bushel.

Year	Index (1977=100)	Index (1988=100)	Corn	Wheat	Barley	Soybean
1	59	50.43	2.70	2.50	1.53	5.21
2	62	52.99	2.64	2.74	1.89	5.53
3	58	49.57	2.54	2.56	1.75	6.45
4	94	80.34	2.46	3.62	1.89	7.46
5	143	122.22	2.43	2.94	1.43	5.01
6	133	113.67	2.40	2.70	1.35	4.67
7	123	105.13	2.37	2.93	1.75	5.15
8	100	85.47	2.53	2.34	1.57	8.04
9	104	88.89	2.60	3.40	1.69	7.20
10	117	100.00	2.66	4.01	1.63	6.99
11	135	115.13	2.62	3.36	1.94	5.88
12	145	123.93	2.47	2.62	1.47	5.60
13	120	102.56	2.37	2.96	1.58	5.81
14	146	124.79	2.64	3.41	1.83	5.56
15	148	126.45	2.58	3.00	1.72	5.50
16	122	104.27	2.44	2.75	1.67	5.31
17	96	82.05	2.56	2.95	1.72	6.19
18	81	69.23	2.41	3.60	1.59	7.47
19	117	100.00	2.52	3.25	1.62	7.44

Target prices for each of the crops covered by federal government commodity programs (ASCS) were adjusted in the same manner as market crop prices.

Table M.3. Adjusted Commodity Program Target Prices (1988=100), Per Bushel.

Year	Target Price			Adjusted Target Price		
	Corn	Wheat	Barley	Corn	Wheat	Barley
1	1.35	2.82	1.15	2.68	5.59	2.28
2	1.35	2.93	1.15	2.55	5.53	2.17
3	1.41	3.02	1.15	2.84	6.10	2.32
4	1.64	3.39	1.27	2.04	4.22	1.58
5	1.38	2.05	1.13	1.13	1.68	.92
6	1.38	2.05	1.13	1.21	1.80	.99
7	1.57	2.29	1.28	1.49	2.18	1.22
8	2.00	2.47	2.15	2.34	2.89	2.51
9	2.10	3.40	2.25	2.36	3.82	2.53
10	2.20	3.40	2.40	2.20	3.40	2.40
11	2.35	3.63	2.55	2.03	3.15	2.21
12	2.40	3.81	2.60	1.93	3.07	2.10
13	2.70	4.05	2.60	2.63	3.95	2.53
14	2.86	4.30	2.60	2.29	3.45	2.08
15	3.03	4.28	2.60	2.39	3.46	2.05
16	3.03	4.28	2.60	2.90	4.10	2.49
17	3.03	4.28	2.60	3.69	5.22	3.17
18	3.03	4.28	2.60	4.38	6.18	3.75
19	2.93	4.23	2.51	2.93	4.23	2.51

APPENDIX N

ANNUAL AND MONTHLY PRECIPITATION DATA

Table N.1. Annual and monthly precipitation data.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
						(inches)							
51	1.47	1.69	2.68	3.07	3.04	4.66	5.23	2.91	2.68	2.19	5.27	3.87	38.76
52	5.40	2.87	3.99	4.67	3.28	2.92	2.62	2.61	3.44	2.53	4.58	3.46	42.37
53	3.94	3.28	4.38	3.31	4.25	1.40	1.33	4.73	1.50	2.77	1.68	2.68	35.25
54	3.86	1.20	2.86	2.08	3.58	0.52	2.60	3.29	0.63	2.21	2.67	2.92	28.42
55	0.98	2.90	4.23	4.20	3.06	5.92	2.86	11.90	5.47	2.63	1.97	0.82	46.94
56	2.23	3.30	2.94	3.08	2.39	2.78	6.48	2.24	8.01	5.02	6.58	2.94	47.99
57	3.23	3.41	3.70	2.60	1.96	4.68	1.16	6.24	3.22	6.40	3.80	5.48	45.88
58	3.81	4.52	5.87	5.10	4.78	4.15	4.75	7.85	2.41	4.78	3.29	4.37	55.68
59	1.22	1.57	2.79	3.92	0.71	1.10	12.21	1.93	2.29	5.20	7.50	2.89	43.33
60	2.08	3.73	2.61	3.34	6.97	1.07	5.63	6.02	7.97	3.13	1.18	3.01	46.74
61	3.49	5.16	4.65	2.26	6.33	5.49	2.39	2.82	3.56	8.48	1.61	5.12	51.36
62	4.92	3.45	4.32	4.08	2.44	5.81	4.39	4.45	3.95	0.78	6.85	2.88	48.32
63	1.81	1.83	6.05	0.14	2.59	6.88	0.66	1.57	2.52	0.00	5.98	1.98	32.01
64	3.48	4.97	2.60	4.88	0.73	3.93	3.63	6.08	3.38	2.65	2.28	2.84	41.45
65	2.38	2.01	3.48	2.26	1.25	5.31	7.24	2.40	3.36	1.10	0.43	0.37	31.59
66	3.20	3.70	0.83	3.41	2.91	3.79	3.18	1.36	11.17	5.19	1.45	3.15	43.34
67	1.88	2.41	2.38	1.20	4.26	0.90	6.36	6.48	1.47	1.41	2.01	5.08	35.84
68	2.63	0.51	5.38	1.49	4.33	6.34	2.97	4.23	1.21	1.89	2.87	1.84	35.69
69	3.28	3.02	3.16	3.52	4.35	2.18	5.75	11.25	3.59	1.28	1.63	6.25	49.26
70	1.16	1.92	3.27	2.72	3.37	4.33	5.36	0.57	1.27	1.70	0.00	2.63	28.30
71	2.61	3.37	1.92	1.73	8.24	3.74	3.32	4.11	1.26	8.68	3.60	0.81	43.39
72	2.38	5.27	2.18	3.31	7.43	10.46	5.10	2.00	3.92	4.59	5.20	3.68	55.52
73	2.29	3.30	2.16	4.44	3.14	1.76	4.56	2.97	2.61	3.14	1.43	5.17	36.97
74	3.70	1.36	4.90	1.87	3.93	2.23	4.99	7.07	5.01	0.55	1.30	4.10	41.01
75	4.31	2.53	5.98	2.84	3.51	6.10	8.11	3.38	11.30	3.87	3.02	3.34	58.29
76	4.85	1.04	2.34	0.97	5.33	3.13	3.49	2.27	9.00	7.94	1.46	1.97	43.79
77	1.99	1.15	1.88	1.61	3.50	1.26	2.32	2.36	5.16	5.56	3.05	5.90	35.74
78	7.61	0.44	4.78	4.03	9.31	3.42	2.07	4.97	0.48	0.48	3.20	3.87	44.66
79	5.79	5.40	2.57	3.09	6.47	3.34	6.23	8.80	12.28	2.97	5.12	1.98	64.04
80	3.04	0.84	4.32	3.48	2.74	1.03	4.37	0.96	1.58	6.87	2.63	0.61	32.47
81	0.26	3.03	1.34	3.37	5.98	3.55	4.79	3.10	4.42	2.27	0.98	3.22	36.31
82	3.35	3.58	2.81	2.90	1.47	4.15	3.83	6.55	2.11	2.29	4.38	2.67	40.09
83	1.45	2.24	5.98	7.22	5.21	3.36	1.61	2.21	4.27	5.11	4.72	5.36	48.74
84	4.06	2.35	10.57	4.12	7.07	1.89	3.77	2.88	0.87	2.94	3.78	1.30	45.60
85	2.57	3.26	1.01	0.30	3.62	2.31	2.14	11.42	8.35	4.83	5.74	0.54	46.09
Average	3.05	2.76	3.63	3.05	4.10	3.60	4.21	4.46	4.16	3.53	3.24	3.12	42.89

Table N.1, continued.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
						(centimeters)							
51	3.73	4.29	6.81	7.80	7.72	11.84	13.28	7.39	6.81	5.56	13.39	9.83	98.45
52	13.72	7.29	10.13	11.86	8.33	7.42	6.65	6.63	8.74	6.43	11.63	8.79	107.62
53	10.01	8.33	11.13	8.41	10.80	3.56	3.38	12.01	3.81	7.04	4.27	6.81	89.54
54	9.80	3.05	7.26	5.28	9.09	1.32	6.60	8.36	1.60	5.61	6.78	7.42	72.19
55	2.49	7.37	10.74	10.67	7.77	15.04	7.26	30.23	13.89	6.68	5.00	2.08	119.23
56	5.66	8.38	7.47	7.82	6.07	7.06	16.46	5.69	20.35	12.75	16.71	7.47	121.89
57	8.20	8.66	9.40	6.60	4.98	11.89	2.95	15.85	8.18	16.26	9.65	13.92	116.54
58	9.68	11.48	14.91	12.95	12.14	10.54	12.07	19.94	6.12	12.14	8.36	11.10	141.43
59	3.10	3.99	7.09	9.96	1.80	2.79	31.01	4.90	5.82	13.21	19.05	7.34	110.06
60	5.28	9.47	6.63	8.48	17.70	2.72	14.30	15.29	20.24	7.95	3.00	7.65	118.72
61	8.86	13.11	11.81	5.74	16.08	13.94	6.07	7.16	9.04	21.54	4.09	13.00	130.45
62	12.50	8.76	10.97	10.36	6.20	14.76	11.15	11.30	10.03	1.98	17.40	7.32	122.73
63	4.60	4.65	15.37	0.36	6.58	17.48	1.68	3.99	6.40	0.00	15.19	5.03	81.31
64	8.84	12.62	6.60	12.40	1.85	9.98	9.22	15.44	8.59	6.73	5.79	7.21	105.28
65	6.05	5.11	8.84	5.74	3.18	13.49	18.39	6.10	8.53	2.79	1.09	0.94	80.24
66	8.13	9.40	2.11	8.66	7.39	9.63	8.08	3.45	28.37	13.18	3.68	8.00	110.08
67	4.78	6.12	6.05	3.05	10.82	2.29	16.15	16.46	3.73	3.58	5.11	12.90	91.03
68	6.68	1.30	13.67	3.78	11.00	16.10	7.54	10.74	3.07	4.80	7.29	4.67	90.65
69	8.33	7.67	8.03	8.94	11.05	5.54	14.61	28.58	9.12	3.25	4.14	15.88	125.12
70	2.95	4.88	8.31	6.91	8.56	11.00	13.61	1.45	3.23	4.32	0.00	6.68	71.88
71	6.63	8.56	4.88	4.39	20.93	9.50	8.43	10.44	3.20	22.05	9.14	2.06	110.21
72	6.05	13.39	5.54	8.41	18.87	26.57	12.95	5.08	9.96	11.66	13.21	9.35	141.02
73	5.82	8.38	5.49	11.28	7.98	4.47	11.58	7.54	6.63	7.98	3.63	13.13	93.90
74	9.40	3.45	12.45	4.75	9.98	5.66	12.67	17.96	12.73	1.40	3.30	10.41	104.17
75	10.95	6.43	15.19	7.21	8.92	15.49	20.60	8.59	28.70	9.83	7.67	8.48	148.06
76	12.32	2.64	5.94	2.46	13.54	7.95	8.86	5.77	22.86	20.17	3.71	5.00	111.23
77	5.05	2.92	4.78	4.09	8.89	3.20	5.89	5.99	13.11	14.12	7.75	14.99	90.78
78	19.33	1.12	12.14	10.24	23.65	8.69	5.26	12.62	1.22	1.22	8.13	9.83	113.44
79	14.71	13.72	6.53	7.85	16.43	8.48	15.82	22.35	31.19	7.54	13.00	5.03	162.66
80	7.72	2.13	10.97	8.84	6.96	2.62	11.10	2.44	4.01	17.45	6.68	1.55	82.47
81	0.66	7.70	3.40	8.56	15.19	9.02	12.17	7.87	11.23	5.77	2.49	8.18	92.23
82	8.51	9.09	7.14	7.37	3.73	10.54	9.73	16.64	5.36	5.82	11.13	6.78	101.83
83	3.68	5.69	15.19	18.34	13.23	8.53	4.09	5.61	10.85	12.98	11.99	13.61	123.80
84	10.31	5.97	26.85	10.46	17.96	4.80	9.58	7.32	2.21	7.47	9.60	3.30	115.82
85	6.53	8.28	2.57	0.76	9.19	5.87	5.44	29.01	21.21	12.27	14.58	1.37	117.07
Average	7.74	7.01	9.21	7.74	10.42	9.14	10.70	11.32	10.58	8.96	8.22	7.92	108.95

APPENDIX O

CREAMS/GLEAMS PARAMETER SUMMARIES

Important parameters used in the CREAMS and GLEAMS hydrology and erosion sub-models are listed and defined in the following tables. The values selected for the final runs for each rotation are included. Many of the values were obtained from tables in Appendix A and B of User's Guide for the CREAMS Computer Model (USDA-SCS). Some values were obtained from the soil survey of Richmond County for Suffolk sandy loam. Dashes indicate that the values are the same for each rotation. Erosion parameters that are duplicates of hydrology parameters are not included in the table of erosion parameters.

Table O.1. Hydrology parameters.

PARA-METER	DEFINITION	VALUE FOR PRODUCTION ACTIVITY[a]									
		1	2	3	4	5	8	11	12	15	16
DACRE	Drainage area (acres)	-	-	-	-	-	1.0	-	-	-	-
RC	Effective saturated hydraulic conductivity (in/hr)	-	-	-	-	-	0.28	-	-	-	-
FUL	Fraction of pore space filled at field capacity. CREAMS only	-	-	-	-	-	0.44	-	-	-	-
CONA	Soil evaporation parameter	-	-	-	-	-	3.5	-	-	-	-
POROS	Soil porosity (in/in)	-	-	-	-	-	0.40	-	-	-	-
BR15	Wilting point (in/in)	-	-	-	-	-	0.08	-	-	-	-
	CREAMS only										
CN2	SCS curve number for moisture condition II	80	77	78	80	79	76	78	81	77	79
CHS	Field slope (ft/ft)	-	-	-	-	-	0.03	-	-	-	-

[a] Only production activities where there may be differences in parameter values are noted. Otherwise activities with the same rotation or using litter will use the same parameters as those activities listed.

Table O.1, continued. Hydrology parameters.

PARAMETER	DEFINITION	VALUE FOR PRODUCTION ACTIVITY[a]									
		1	2	3	4	5	8	11	12	15	16
WLW	Watershed length to width ratio	-	-	-	-	-	1.5	-	-	-	-
RD	Effective rooting depth (in)	-	-	-	-	-	30	-	-	-	-
UL(1-7)	Total soil water storage (in) for each of seven soil layers. CREAMS only	UL(1) UL(2) UL(3-7)			= = =		0.27 1.33 1.60	- - -	- - -	- - -	- - -
NOSOHZ	Number of soil horizons in the rootzone GLEAMS only	-	-	-	-	-	2	-	-	-	-
BOTHOR	Depth to bottom of each soil horizon (in)	-	-	-	-	18 and 30			-	-	-
POR	Porosity of each soil horizon (in^3/in^3)	-	-	-	0.40 and 0.40				-	-	-
FC	Field capacity of each soil horizon	-	-	-	0.22 and 0.22				-	-	-
BR15	Wilting point of each soil horizon (in/in)	-	-	-	0.08 and 0.08				-	-	-
OM	Organic matter content of each soil horizon (% of soil mass)	-	-	-	1.0 and 1.0				-	-	-
LDATE	Dates (Julian days)	Varies with crops grown, and planting and harvest dates for each rotaion									
AREA	Leaf area index for the crops grown	Varies with LDATE for each rotaion									

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[a] Only production activities where there may be differences in parameter values are noted. Otherwise activities with the same rotation or using litter will use the same parameters as those activities listed.

Table O.2. Erosion parameters.

PARAMETER	DEFINITION	VALUE FOR PRODUCTION ACTIVITY[a]									
		1	2	3	4	5	8	11	12	15	16
SOLCLY	Fraction of clay in surface soil layer	-	-	-	-	-	0.15	-	-	-	-
SOLSLT	Fraction of silt in surface soil layer	-	-	-	-	-	0.25	-	-	-	-
SOLSND	Fraction of sand in surface soil layer	-	-	-	-	-	0.60	-	-	-	-
SSCLY	Specific surface area of clay particles (m^2/g)	-	-	-	-	-	20.0	-	-	-	-
SSORG	Specific surface area of organic matter (m^2/g)	-	-	-	-	-	1000.0	-	-	-	-
SLNGTH	Slope length (ft)	-	-	-	-	-	200.0	-	-	-	-
KSOIL	Soil erodibility factor (t/ac)	-	-	-	-	-	0.20	-	-	-	-
NYEARS	# of years in this rotation	2	2	2	2	2	2	2	4	2	2
CDATE	Julian days on which	Varies with cropstage and tillage practices									
CFACT	Soil loss ratio of overland flow segment	Varies with CDATE									
PFACT	Contouring factor	1.0 on all CDATES, all rotations. Indicating no contouring or terraces used									
NFACT	Manning's n (surface roughness coeff.)	Varies with CDATE									

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[a] Only production activities where there may be differences in parameter values are noted. Otherwise activities with the same rotation or using litter will use the same parameters as those activities listed.

An initial comparison of predicted hydrology and erosion output of the two models enabled correction of discrepancies in the respective parameter files. For example, when the root depth (RD) was changed from 39 to 30 inches in CREAMS, and the corresponding decreases in water storage for soil layers (UL1-7) was made so that greater percolation would be predicted, a change in root depth in GLEAMS required a corresponding change in the depth of the last soil horizon (BOTHOR) to 30 inches. After that change was made, the differences in hydrology output from the two models were minor. Good agreement in erosion output for a given rotation was also achieved after a mistaken slope length in the GLEAMS erosion files was corrected to the 200 feet used in CREAMS.

CREAMS and GLEAMS initially predicted 35-year average runoff from 2.8 to 4.1 cm/yr or 3 to 4 % of average annual precipitation. An effort to validate the hydrology output with reported observations from Coastal Plain areas having soils similar to the Suffolk sandy loam in Richmond County, led to the decision to increase runoff (and decrease percolation) by increasing the SCS curve number by 2 or 3, depending on specific differences in tillage and cultivation practices that were not initially recognize. These changes increased runoff to 3.4 to 5.6 cm/yr or 3 to 5 % of average annual precipitation. Data from the Nomini Creek Watershed Pre-BMP Evaluation Final Report enabled separation of surface runoff from observed total runoff (base flow plus surface runoff) at two watershed gauging stations, QN1 and QN2. QN2 is located at a 225-hectare sub-watershed stream outlet; and QN1 is at the stream outlet of the entire 1500-hectare Nomini Creek watershed. In 1987, 11.9 cm of surface runoff was observed at QN2 which was 12.7% of recorded precipitation. In 1988, QN2 received 6.4 cm of runoff or 6.6% of precipitation. Surface runoff at QN1 was 4.8 and 6.9 cm or 5.2 and 7.0 % of precipitation in 1987 and 1988, respectively (Mostaghimi et al., 1989). A 0.34 ha watershed study under a rotation of winter rye, sweet corn, and pearl millet at Tifton Georgia reports runoff of 7 cm/yr or 6% of precipitation (Hubbard and Leonard, 1989). In that study, CREAMS was used, and its predictions for runoff were less than what actually occured. Surface crusting of the sandy Coastal Plain soil, a process not represented by CREAMS, may account for the greater actual runoff (Hubbard and Leonard, 1989).

Initial predictions for average annual soil loss were thought to be too low for all rotations (personal communication, Heatwole, Tim, Mostaghimi). The Universal Soil Loss Equation predicted losses of 1.34 and 2.68 t/ac/yr from continuous no-till corn and continuous conventional-till corn, respectively. Graphically depicted VIRGIS data for cropland in Richmond County showed annual soil losses ranging from 2 to 6 t/ac. To predict more valid soil loss, the slope was increased from 2%, to 3%. The result was predictions of average annual soil loss ranging from 1.12 to 2.60 t/ac over 10 simulations using precipitaion data.

Table 0.3 is a summary of the important nutrient parameters used in CREAMS. Duplicated parameters from the hydrology and erosion parameter files are not included.

Table 0.3. Nutrient parameters.

PARAMETER	DEFINITION	VALUE FOR PRODUCTION ACTIVITY[a] 1	2	3	4	5	8	11	12	15	16
SOLN	Soluble nitrogen (kg/ha) in surface 1 cm	-	-	-	-	-	0.2	-	-	-	-
NO3	Nitrate (kg/ha) in root zone at start of sim.	-	-	-	-	-	20.0	-	-	-	-
SOILN	Total soil nitrogen (kg/kg) in surface 1 cm	-	-	-	-		0.002	-	-	-	-
EXKN	Extraction coefficient for nitrogen	-	-	-	-	-	0.07	-	-	-	-
AN	Enrichment coefficient for nitrogen	-	-	-	-	-	7.4	-	-	-	-
AP	Enrichment exponent for nitrogen	-	-	-	-	-	-0.2	-	-	-	-
RCN	Concentration (ppm) of nitrogen in rainfall	-	-	-	-	-	0.08	-	-	-	-

[a] Only production activities where there may be differences in parameter values are noted. Otherwise activities with the same rotation or using litter will use the same parameters as those activities listed.

GLEAMS PESTICIDE PARAMETERS

The following table summarizes the properties required in the use of GLEAMS for each pesticide. Pesticide solubility and the partition coefficient (Koc) are perhaps the most important parameters because calculations for separating pesticide losses into surface runoff, sediment, and percolation depend on these. The "USDA-ARS Interim Pesticide Properties Database, Version 1.0" was the most extensively used source of values (Wauchope, 1988). The Handbook of Environmental Data on Organic Chemicals (Verschueren, 1983) and the database in Appendix B of the GLEAMS User Manual, Version 1.8.55 (USDA-ARS, 1990) provided some missing data. If there were different reported values from the three sources for a given pesticide property, the first source listed above had priority. Values marked with a "^" are absent from the literature cited. No data on the plant uptake parameter (COFUP) was available, so a relative ranking was created based on pesticide solubilities.

Table 0.4. Chemical Parameters.

			HALF-LIFE		WASHOFF		
TRADE NAME	COMMON NAME	SOLUBILITY	SOIL	FOLIAR	FRAC.	Koc	COFUP
Aatrex	Atrazine	33.0	60.0	2.0	0.50	160.0	0.3^
Dual	Metolachlor	530.0	20.0	3.0	0.65	200.0	0.5^
Gemini	Chlorimuron	500.0	50.0	3.0^	0.50^	20.0	0.5^
	+Linuron	75.0	60.0	3.0^	0.50^	863.0	0.3^
Gramoxone	Paraquat	1.0E6	3600.0	3.0	0.40	1.0E5	1.0^
Harmony	DPXM-6316	2400.0	12.0	0.5	0.50^	10.0	0.8^
2,4-D	2,4-D	900.0	10.0	9.0	0.45	74.0	0.6^
Lasso	Alachlor	242.0	14.0	3.0	0.40	190.0	0.4^
Bladex	Cyanazine	171.0	20.0	2.0	0.60	168.0	0.4^
Fusilade	Fluazifop-P	2.0	20.0	3.0^	0.50^	3000.0	0.0^
Pydrin	Fenvalerate	0.1	50.0	7.0	0.40	1.0E5	0.0^
Blazer	Acifluorfen	9.0E5	30.0	3.0^	0.50^	139.0	1.0^
Banvel	Dicamba	8.0E5	14.0	9.0	0.65	2.0	1.0^
Roundup	Glyphosphate	1.0E6	30.0	2.5	0.65	1.0E4	0.9^
Treflan	Trifluralin	0.3	60.0	20.0	0.40	1400.0	0.0^
Lorox	Linuron	75.0	60.0	3.0^	0.50^	863.0	0.3^

Validation of nutrient and pesticide output from this simulation study with reported observations was limited by the availability and format of data from the literature. Differences in predicted and observed results due to geographic location, crop rotations, tillage, and fertilizer and pesticide application amounts, also made quantitative validation difficult.

Data for validating GLEAMS predictions for all 15 pesticides used in these rotations are not available. However, there is value in the predictions. They show the most probable partitioning of pesticides into surface runoff, sediment, and percolation under normal rainfall conditions (Hubbard et al., 1989).

APPENDIX P

GAMS OPTIONS FILE AND INITIAL VALUES

Table P.1. The GAMS Options file which sets the default values of the program.

```
BEGIN GAMS/MINOS OPTIONS

   MAJOR ITERATIONS  500

   ROW TOLERANCE 1.0E-4

   MAJOR DAMPING PARAMETER .1

   PENALTY PARAMETER 10

   FEASIBILITY TOLERANCE 1.0E-4

END GAMS/MINOS OPTIONS
```

Table P.2. The Initial Values used in the GAMS programming language. Initial values provided useful information for nonlinear equation solving and for solving a large model, as in this study.

```
PARAMETER WO1(O)
/NRTT1 1/
PARAMETER ZO1(OO)
/TYC1 5980.467,TYW1 3054.957,TYB1 2499.510/
PARAMETER ZO11(OO)
/TYC1 6173,TYW1 3055,TYB1 2700/
PARAMETER ZR1(R)
/CAY1 195,WAY1 130,BAY1 170/
PARAMETER ZR11(R)
/CAY1 197,WAY1 135,BAY1 175/
PARAMETER ZR111(R)
/CAY1 197,WAY1 135,BAY1 175/
PARAMETER ZII1(II)
/TOTCB1 197,TOTWB1 133,TOTBB1 175/
PARAMETER ZII11(II)
/TOTCB1 197,TOTWB1 133,TOTBB1 175/
PARAMETER ZII111(II)
/TOTCB1 197,TOTWB1 133,TOTBB1 175/
PARAMETER ZZI1(II2)
/TOTCB2 197,TOTWB2 133,TOTBB2 175/
PARAMETER ZZI11(II2)
/TOTCB2 197,TOTWB2 133,TOTBB2 175/
PARAMETER ZZI111(II2)
/TOTCB2 197,TOTWB2 133,TOTBB2 175/
PARAMETER ZII2(II2)
/TOTCB2 165,TOTWB2 150,TOTBB2 183/
PARAMETER ZII21(II2)
/TOTCB2 165,TOTWB2 150,TOTBB2 183/
PARAMETER ZII211(II2)
/TOTCB2 165,TOTWB2 150,TOTBB2 183/

PARAMETER WO2(O2)
/NRTT2 1/
PARAMETER ZO2(OO2)
/TYC2 5554.467,TYW2 3054.957,TYB2 2499.510/
PARAMETER ZO21(OO2)
/TYC2 6173,TYW2 3395,TYB2 2778/
PARAMETER ZR2(R2)
/CAY2 165,WAY2 150,BAY2 183/
PARAMETER ZR21(R2)
/CAY2 165,WAY2 150,BAY2 183/

PARAMETER WO3(O3)
/NRTT3 1/
PARAMETER ZO3(OO3)
/TYC3 2777,TYW3 3054.957,TYB3 2499.510/
PARAMETER ZO31(OO3)
/TYC3 6173,TYW3 3395,TYB3 2778/
PARAMETER ZR3(R3)
/CAY3 187,WAY3 145,BAY3 170/
PARAMETER ZR31(R3)
/CAY3 187,WAY3 145,BAY3 170/
PARAMETER ZZI3(II3)
/TOTCB3 100,TOTWB3 100,TOTBB3 100/
PARAMETER ZZI31(II3)
/TOTCB3 190.4,TOTWB3 136.4,TOTBB3 172.9/
PARAMETER ZZI311(II3)
/TOTCB3 190.6,TOTWB3 136.4,TOTBB3 176.6/
```

Table P.2, continued.

```
PARAMETER WO4(O4)
/NRTT4 1/
PARAMETER ZO4(OO4)
/TYC4 5554.467,TYW4 3054.957,TYB4 2499.510/
PARAMETER ZO41(OO4)
/TYC4 6173,TYW4 3395,TYB4 2778/
PARAMETER ZR4(R4)
/CAY4 194,WAY4 141,BAY4 187/
PARAMETER ZR41(R4)
/CAY4 194,WAY4 141,BAY4 187/
PARAMETER ZZI4(II4)
/TOTCB4 100,TOTWB4 100,TOTBB4 100/
PARAMETER ZZI41(II4)
/TOTCB4 188.4,TOTWB4 138.6,TOTBB4 175.4/
PARAMETER ZZI411(II4)
/TOTCB4 188.4,TOTWB4 138.6,TOTBB4 175.4/

PARAMETER WO5(O5)
/NRTT5 1/
PARAMETER ZO51(OO5)
/TYC5 5554.467,TYW5 3054.957,TYB5 2499.510/
PARAMETER ZO511(OO5)
/TYC5 6173,TYW5 3395,TYB5 2778/
PARAMETER ZR5(R5)
/CAY5 200,WAY5 150,BAY5 187/
PARAMETER ZR51(R5)
/CAY5 200,WAY5 150,BAY5 187/
PARAMETER ZZI5(II5)
/TOTCB5 100,TOTWB5 100,TOTBB5 100/
PARAMETER ZZI51(II5)
/TOTCB5 187.8,TOTWB5 140.2,TOTBB5 177.8/
PARAMETER ZZI511(II5)
/TOTCB5 187.8,TOTWB5 140.2,TOTBB5 177.8/

PARAMETER WO6(O6)
/NRTT6 1/
PARAMETER ZO61(OO6)
/TYC6 5554.467,TYW6 3054.957,TYB6 2499.510/
PARAMETER ZO611(OO6)
/TYC6 6173,TYW6 3395,TYB6 2778/
PARAMETER ZR6(R6)
/CAY6 247,WAY6 136,BAY6 177/
PARAMETER ZR61(R6)
/CAY6 247,WAY6 136,BAY6 177/
PARAMETER ZZI6(II6)
/TOTCB6 100,TOTWB6 100,TOTBB6 100/
PARAMETER ZZI61(II6)
/TOTCB6 188.4,TOTWB6 143.6,TOTBB6 180.2/
PARAMETER ZZI611(II6)
/TOTCB6 188.4,TOTWB6 143.6,TOTBB6 180.2/

PARAMETER WO7(O7)
/NRTT7 1/
PARAMETER ZO7(RR7)
/CA7 5554.467,WA7 3054.957,BA7 2499.510/
PARAMETER ZO71(OO7)
/TYC7 5554.467,TYW7 3054.957,TYB7 2499.510/
PARAMETER ZO711(OO7)
/TYC7 6173,TYW7 3395,TYB7 2778/
PARAMETER ZR7(R7)
/CAY7 187,WAY7 135,BAY7 198/
PARAMETER ZR71(R7)
/CAY7 187,WAY7 135,BAY7 198/
```

Table P.2, continued.

```
PARAMETER ZR711(R7)
/CAY7 187,WAY7 135,BAY7 198/
PARAMETER ZZI7(II7)
/TOTCB7 100,TOTWB7 100,TOTBB7 100/
PARAMETER ZZI71(II7)
/TOTCB7 198.7,TOTWB7 144.2,TOTBB7 180.6/
PARAMETER ZZI711(II7)
/TOTCB7 198.7,TOTWB7 144.2,TOTBB7 180.6/
PARAMETER WO8(O8)
/NRTT8 1/
PARAMETER ZO8(RR8)
/CA8 5554.467,WA8 3054.957,BA8 2499.510/
PARAMETER ZO81(OO8)
/TYC8 5554.467,TYW8 3054.957,TYB8 2499.510/
PARAMETER ZO811(OO8)
/TYC8 6173,TYW8 3395,TYB8 2778/
PARAMETER ZR8(R8)
/CAY8 81,WAY8 136,BAY8 158/
PARAMETER ZR81(R8)
/CAY8 81,WAY8 136,BAY8 158/
PARAMETER ZZI8(II8)
/TOTCB8 100,TOTWB8 100,TOTBB8 100/
PARAMETER ZZI81(II8)
/TOTCB8 204,TOTWB8 141.2,TOTBB8 183.6/
PARAMETER ZZI811(II8)
/TOTCB8 204,TOTWB8 141.2,TOTBB8 183.6/

PARAMETER WO9(O9)
/NRTT9 1/
PARAMETER ZO9(RR9)
/CA9 5554.467,WA9 3054.957,BA9 2499.510/
PARAMETER ZO91(OO9)
/TYC9 5554.467,TYW9 3054.957,TYB9 2499.510/
PARAMETER ZO911(OO9)
/TYC9 6873,TYW9 3400,TYB9 2781/
PARAMETER ZR9(R9)
/CAY9 203,WAY9 135,BAY9 164/
PARAMETER ZR91(R9)
/CAY9 203,WAY9 135,BAY9 164/
PARAMETER ZZI9(II9)
/TOTCB9 100,TOTWB9 100,TOTBB9 100/
PARAMETER ZZI91(II9)
/TOTCB9 181.6,TOTWB9 139.4,TOTBB9 181.2/
PARAMETER ZZI911(II9)
/TOTCB9 181.6,TOTWB9 139.4,TOTBB9 181.2/

PARAMETER WO0X(O0X)
/NRTT0X 1/
PARAMETER ZO0X(RR0X)
/CA0X 5554.467,WA0X 3054.957,BA0X 2499.510/
PARAMETER ZO0X1(OO0X)
/TYC0X 5554.467,TYW0X 3054.957,TYB0X 2499.510/
PARAMETER ZO0X11(OO0X)
/TYC0X 6918,TYW0X 3426,TYB0X 2802/
PARAMETER ZR0X(R0X)
/CAY0X 218,WAY0X 138,BAY0X 164/
PARAMETER ZR0X1(R0X)
/CAY0X 218,WAY0X 138,BAY0X 164/
PARAMETER ZZI0X(II0X)
/TOTCB0X 100,TOTWB0X 100,TOTBB0X 100/
PARAMETER ZZI0X1(II0X)
/TOTCB0X 183.4,TOTWB0X 138.2,TOTBB0X 176.6/
PARAMETER ZZI0X11(II0X)
/TOTCB0X 183.4,TOTWB0X 138.2,TOTBB0X 176.6/
```

Table P.2, continued.

```
PARAMETER WO1X(O1X)
/NRTT1X 1/
PARAMETER ZO1X(RR1X)
/CA1X 5554.467,WA1X 3054.957,BA1X 2499.510/
PARAMETER ZO1X1(OO1X)
/TYC1X 5554.467,TYW1X 3054.957,TYB1X 2499.510/
PARAMETER ZO1X11(OO1X)
/TYC1X 7002,TYW1X 3473,TYB1X 2845/
PARAMETER ZR1X(R1X)
/CAY1X 137,WAY1X 141,BAY1X 165/
PARAMETER ZR1X1(R1X)
/CAY1X 137,WAY1X 141,BAY1X 165/
PARAMETER ZZI1X(II1X)
/TOTCB1X 100,TOTWB1X 100,TOTBB1X 100/
PARAMETER ZZI1X1(II1X)
/TOTCB1X 187,TOTWB1X 135.8,TOTBB1X 172/
PARAMETER ZZI1X11(II1X)
/TOTCB1X 187,TOTWB1X 135.8,TOTBB1X 172/

PARAMETER WO2X(O2X)
/NRTT2X 1/
PARAMETER ZO2X(RR2X)
/CA2X 5554.467,WA2X 3054.957,BA2X 2499.510/
PARAMETER ZO2X1(OO2X)
/TYC2X 5554.467,TYW2X 3054.957,TYB2X 2499.510/
PARAMETER ZO2X11(OO2X)
/TYC2X 7119,TYW2X 3538,TYB2X 2900/
PARAMETER ZR2X(R2X)
/CAY2X 227,WAY2X 160,BAY2X 199/
PARAMETER ZR2X1(R2X)
/CAY2X 227,WAY2X 160,BAY2X 199/
PARAMETER ZZI2X(II2X)
/TOTCB2X 100,TOTWB2X 100,TOTBB2X 100/
PARAMETER ZZI2X1(II2X)
/TOTCB2X 165,TOTWB2X 136.8,TOTBB2X 169.6/
PARAMETER ZZI2X11(II2X)
/TOTCB2X 165,TOTWB2X 136.8,TOTBB2X 169.6/
PARAMETER WO3X(O3X)
/NRTT3x 1/
PARAMETER ZO3X(RR3X)
/CA3X 5554.467,WA3X 3054.957,BA3X 2499.510/
PARAMETER ZO3X1(OO3X)
/TYC3x 5554.467,TYW3x 3054.957,TYB3x 2499.510/
PARAMETER ZO3X11(OO3X)
/TYC3X 7160,TYW3X 3561,TYB3X 2918/
PARAMETER ZR3x(R3x)
/CAY3x 264,WAY3x 144,BAY3x 190/
PARAMETER ZR3x1(R3x)
/CAY3x 264,WAY3x 144,BAY3x 190/
PARAMETER ZZI3X(II3X)
/TOTCB3x 100,TOTWB3x 100,TOTBB3x 100/
PARAMETER ZZI3X1(II3X)
/TOTCB3x 173,TOTWB3x 141.2,TOTBB3x 169.8/
PARAMETER ZZI3X11(II3X)
/TOTCB3x 173,TOTWB3x 141.2,TOTBB3x 169.8/
```

Table P.2, continued.

```
PARAMETER WO4X(O4X)
/NRTT4X 1/
PARAMETER ZO4X(RR4X)
/CA4X 5554.467,WA4X 3054.957,BA4X 2499.510/
PARAMETER ZO4X1(OO4X)
/TYC4X 5554.467,TYW4X 3054.957,TYB4X 2499.510/
PARAMETER ZO4X11(OO4X)
/TYC4X 7160,TYW4X 3561,TYB4X 2918/
PARAMETER ZR4X(R4X)
/CAY4X 98,WAY4X 156,BAY4X 200/
PARAMETER ZR4X1(R4X)
/CAY4X 98,WAY4X 156,BAY4X 200/
PARAMETER ZZI4X(II4X)
/TOTCB4X 100,TOTWB4X 100,TOTBB4X 100/
PARAMETER ZZI4X1(II4X)
/TOTCB4X 209.8,TOTWB4X 143.6,TOTBB4X 176.4/
PARAMETER ZZI4X11(II4X)
/TOTCB4X 209.8,TOTWB4X 143.6,TOTBB4X 176.4/

PARAMETER WO5X(O5X)
/NRTT5X 1/
PARAMETER ZO5X(RR5X)
/CA5X 5554.467,WA5X 3054.957,BA5X 2499.510/
PARAMETER ZO5X1(OO5X)
/TYC5X 5554.467,TYW5X 3054.957,TYB5X 2499.510/
PARAMETER ZO5X11(OO5X)
/TYC5X 7160,TYW5X 3561,TYB5X 2918/
PARAMETER ZR5X(R5X)
/CAY5X 242,WAY5X 132,BAY5X 186/
PARAMETER ZR5X1(R5X)
/CAY5X 242,WAY5X 132,BAY5X 186/
PARAMETER ZZI5X(II5X)
/TOTCB5X 10,TOTWB5X 10,TOTBB5X 10/
PARAMETER ZZI5X1(II5X)
/TOTCB5X 188.8,TOTWB5X 147.8,TOTBB5X 183.6/
PARAMETER ZZI5X11(II5X)
/TOTCB5X 188.8,TOTWB5X 147.8,TOTBB5X 183.6/
```

Table P.2, continued.

```
X81.LO(OO)=.5;
X81.L(OO)=ZO1(OO);
X81.UP(OO)=ZO11(OO);
X131.LO(R)=ZR1(R);
X131.L(R)=ZR11(R);
X131.UP(R)=ZR111(R);
X131.LO(II)=ZII1(II);
X131.L(II)=ZII11(II);
X131.UP(II)=ZII111(II);
X131.LO(II2)=ZZI1(II2);
X131.L(II2)=ZZI11(II2);
X131.UP(II2)=ZZI111(II2);

X82.LO(OO2)=.5;
X82.L(OO2)=ZO2(OO2);
X82.UP(OO2)=ZO21(OO2);
X132.LO(R2)=.5;
X132.L(R2)=ZR2(R2);
X132.UP(R2)=ZR21(R2);
X132.LO(II2)=ZII2(II2);
X132.L(II2)=ZII21(II2);
X132.UP(II2)=ZII211(II2);


X83.LO(OO3)=.5;
X83.L(OO3)=ZO3(OO3);
X83.UP(OO3)=ZO31(OO3);
X133.LO(R3)=.5;
X133.L(R3)=ZR3(R3);
X133.UP(R3)=ZR31(R3);
XR13.LO(II3)=ZZI3(II3);
XR13.L(II3)=ZZI31(II3);
XR13.UP(II3)=ZZI311(II3);

X84.LO(OO4)=.5;
X84.L(OO4)=ZO4(OO4);
X84.UP(OO4)=ZO41(OO4);
X134.LO(R4)=.5;
X134.L(R4)=ZR4(R4);
X134.UP(R4)=ZR41(R4);
XR14.LO(II4)=ZZI4(II4);
XR14.L(II4)=ZZI41(II4);
XR14.UP(II4)=ZZI411(II4);

X85.LO(OO5)=.5;
X85.L(OO5)=ZO51(OO5);
X85.UP(OO5)=ZO511(OO5);
X135.LO(R5)=.5;
X135.L(R5)=ZR5(R5);
X135.UP(R5)=ZR51(R5);
XR15.LO(II5)=ZZI5(II5);
XR15.L(II5)=ZZI51(II5);
XR15.UP(II5)=ZZI511(II5);

X86.LO(OO6)=.5;
X86.L(OO6)=ZO61(OO6);
X86.UP(OO6)=ZO611(OO6);
X136.LO(R6)=.5;
X136.L(R6)=ZR6(R6);
X136.UP(R6)=ZR61(R6);
XR16.LO(II6)=ZZI6(II6);
XR16.L(II6)=ZZI61(II6);
XR16.UP(II6)=ZZI611(II6);
```

Table P.2, continued.

```
X87.LO(RR7)=.5;
X87.L(RR7)=ZO7(RR7);
X87.LO(OO7)=.5;
X87.L(OO7)=ZO71(OO7);
X87.UP(OO7)=ZO711(OO7);
X137.LO(R7)=.5;
X137.L(R7)=ZR7(R7);
X137.UP(R7)=ZR71(R7);
XR17.LO(II7)=ZZI7(II7);
XR17.L(II7)=ZZI71(II7);
XR17.UP(II7)=ZZI711(II7);

X88.LO(RR8)=.5;
X88.L(RR8)=ZO8(RR8);
XR18.LO(II8)=ZZI8(II8);
XR18.L(II8)=ZZI81(II8);
XR18.UP(II8)=ZZI811(II8);
X88.LO(OO8)=.5;
X88.L(OO8)=ZO81(OO8);
X88.UP(OO8)=ZO811(OO8);
X138.LO(R8)=.5;
X138.L(R8)=ZR8(R8);
X138.UP(R8)=ZR81(R8);

X89.LO(RR9)=.5;
X89.L(RR9)=ZO9(RR9);
X89.LO(OO9)=.5;
X89.L(OO9)=ZO91(OO9);
X89.UP(OO9)=ZO911(OO9);
X139.LO(R9)=.5;
X139.L(R9)=ZR9(R9);
X139.UP(R9)=ZR91(R9);
XR19.LO(II9)=ZZI9(II9);
XR19.L(II9)=ZZI91(II9);
XR19.UP(II9)=ZZI911(II9);

X80X.LO(RR0X)=.5;
X80X.L(RR0X)=ZO0X(RR0X);
X80X.LO(OO0X)=.5;
X80X.L(OO0X)=ZO0X1(OO0X);
X80X.UP(OO0X)=ZO0X11(OO0X);
X130X.LO(R0X)=.5;
X130X.L(R0X)=ZR0X(R0X);
X130X.UP(R0X)=ZR0X1(R0X);
XR10X.LO(II0X)=ZZI0X(II0X);
XR10X.L(II0X)=ZZI0X1(II0X);
XR10X.UP(II0X)=ZZI0X11(II0X);

X81X.LO(RR1X)=.5;
X81X.L(RR1X)=ZO1X(RR1X);
X81X.LO(OO1X)=.5;
X81X.L(OO1X)=ZO1X1(OO1X);
X81X.UP(OO1X)=ZO1X11(OO1X);
X131X.LO(R1X)=.5;
X131X.L(R1X)=ZR1X(R1X);
X131X.UP(R1X)=ZR1X1(R1X);
XR11X.LO(II1X)=ZZI1X(II1X);
XR11X.L(II1X)=ZZI1X1(II1X);
XR11X.UP(II1X)=ZZI1X11(II1X);

X82X.LO(RR2X)=.5;
X82X.L(RR2X)=ZO2X(RR2X);
X82X.LO(OO2X)=.5;
```

Table P.2, continued.

```
X82X.L(OO2X)=ZO2X1(OO2X);
X82X.UP(OO2X)=ZO2X11(OO2X);
X132X.LO(R2X)=.5;
X132X.L(R2X)=ZR2X(R2X);
X132X.UP(R2X)=ZR2X1(R2X);
XR12X.LO(II2X)=ZZI2X(II2X);
XR12X.L(II2X)=ZZI2X1(II2X);
XR12X.UP(II2X)=ZZI2X11(II2X);

X83X.LO(RR3X)=.5;
X83X.L(RR3X)=ZO3X(RR3X);
X83x.LO(OO3x)=.5;
X83X.L(OO3X)=ZO3X1(OO3X);
X83X.UP(OO3X)=ZO3X11(OO3X);
X133x.LO(R3x)=.5;
X133x.L(R3x)=ZR3x(R3x);
X133x.UP(R3x)=ZR3x1(R3x);
XR13x.LO(II3x)=ZZI3x(II3x);
XR13x.L(II3x)=ZZI3x1(II3x);
XR13x.UP(II3x)=ZZI3x11(II3x);

X84X.LO(RR4X)=.5;
X84X.L(RR4X)=ZO4X(RR4X);
X84X.LO(OO4X)=.5;
X84X.L(OO4X)=ZO4X1(OO4X);
X84X.UP(OO4X)=ZO4X11(OO4X);
X134X.LO(R4X)=.5;
X134X.L(R4X)=ZR4X(R4X);
X134X.UP(R4X)=ZR4X1(R4X);
XR14X.LO(II4X)=ZZI4X(II4X);
XR14X.L(II4X)=ZZI4X1(II4X);
XR14X.UP(II4X)=ZZI4X11(II4X);

X85X.LO(RR5X)=.5;
X85X.L(RR5X)=ZO5X(RR5X);
X85X.LO(OO5X)=.5;
X85X.L(OO5X)=ZO5X1(OO5X);
X85X.UP(OO5X)=ZO5X11(OO5X);
X135X.LO(R5X)=.5;
X135X.L(R5X)=ZR5X(R5X);
X135X.UP(R5X)=ZR5X1(R5X);
XR15X.LO(II5X)=ZZI5X(II5X);
XR15X.L(II5X)=ZZI5X1(II5X);
XR15X.UP(II5X)=ZZI5X11(II5X);
```

APPENDIX Q

PESTICIDE TOXICITIES

Table Q.1. The LD_{50} classification of the chemicals used in this study are associated with 5 taxic catagories. An LD_{50} is the oral dosage required for 50 percent of research animals to be killed from a single dose. The toxic classifications are:I-highly toxic(0-50), II-moderately toxic(50-500), III-slightly toxic(500-5000), IV-almost no toxicity(5000+). For comparison the toxicity of aspirin is listed.

Chemical	Toxic Classification	LD_{50}
Asprin	III	750
1. Blazer	III	1300
2. Lasso	III	1800
3. Aatrex	III	1780
4. Gemini	III	4000
5. Bladex	II	334
6. Banvel	III	2900
7. Harmony Extra	IV	5000
8. Pydrin	II	451
9. Fusulade	III	3328
10. Roundup	III	4300
11. Lorox	III	2900
12. Dual	III	2780
13. Gramoxone	II	150
14. Treflan	IV	10000+
15. 2-4D	II-III	300-1200

APPENDIX R

SUMMARIES OF THE FIVE GENERAL SCENARIOS

Table R.1. Scenario: Current Practice.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
29,284,960

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,150,837	3,269,114	3,520,614	3,147,617	1,425,350	1,595,279	1,111,786	208,154	2,791,096	2,698,313	459,964	1,803,220	2,257,547	288,250	1,557,819

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2243.03

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt	Alt

Table R.1, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					988					198	40	
NONB		6,172	1,234	6,172	6,172	6,172	6,172	5,184	6,178	6,222	6,305	6,420	6,263	6,421	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,260	6,460	6,460
FS SOYBEAN															
BASE															
NONB															

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	-0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,535	1,567	1,578	1,699	1,596
MAR	8,165	9,072	8,347	9,072	9,072	9,072	9,072	8,927	9,081	9,146	9,268	9,438	9,468	9,491	9,497
APR	4,610	5,122	4,713	5,122	5,122	5,122	5,122	5,041	5,128	5,164	5,233	5,329	5,346	5,359	5,362
MAY	1,500	1,666	1,533	1,666	1,666	1,666	1,666	1,640	1,668	1,680	1,702	1,733	1,739	1,743	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	17,052	17,052	17,052	17,052	16,910	17,070	17,198	17,439	17,775	17,864	18,386	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table R.1, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	19,385	21,539	19,816	21,539	21,539	21,539	21,539	21,194	21,560	21,714	22,003	22,406	22,478	22,533	22,547
CHEM 4*	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,160	2,162	2,178	2,207	2,247	2,261	2,261	2,261
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	194	194	194	195	196	199	203	205	216	207
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,175	3,175	3,148	3,151	3,173	3,215	3,274	3,295	3,295	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12	13,602	14,318	13,745	14,318	14,318	14,318	14,318	14,204	14,332	14,317	14,626	14,895	14,965	14,983	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	4,012	10,492	12,319	3,086	5,554	10,492	9,875	3,664	11,738	20,531	3,152	8,988	5,802	8,395	10,983
PERCOL	112,756	469,044	689,124	220,944	311,667	801,695	436,951	534,518	612,827	800,101	216,874	321,646	352,072	785,242	767,487
SED.	52,829	128,986	307,864	82,699	211,685	266,613	245,012	93,636	151,354	512,660	60,523	124,549	100,601	148,548	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	20,613	62,765	66,530	78,133	25,640	35,707	160,767	17,085	35,952	25,987	36,879	63,505

Table R.1, continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,261	31	4,270	6	802	43	1,098	6	2,595	31	271	32	97	19	1,272
CHEM 4															
CHEM4B	49	129	463	12	74	204	37	6	12	99	19	51	45	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	1,790	1,895	4,462	6,974	3,363	741	12,568	1,545	1,650	420	1,918	1,008
CHEM 9		37	271	93	2,777	154	284	241	315	1,530	44	1,066	1,382	52	26
CHEM 10															
CHEM 11															
CHEM 12	12	18	121		6	160	37		12	31		13	6	19	39
CHEM 13	76,419	186,579	483,303	99,819	260,256	307,493	133,066	104,984	183,434	564,131	77,104	156,027	128,117	171,471	248,540
CHEM 14															
CHEM 15															

Table R.2. Scenario: No Litter.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS, DOLLARS)

39,253,783

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,215,867	4,178,991	4,213,496	3,957,415	2,189,589	2,316,108	1,791,947	840,791	2,296,764	3,274,054	1,010,278	2,337,835	2,758,632	766,434	2,005,579

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,007

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t

Table R.2, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYB															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,177	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,595
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,284	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,329	5,362	5,362	5,362
MAY	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,016	4,044	4,098	4,173	4,199	4,199	4,199
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,070	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,059	9,078	9,245	9,303	9,303	9,303
DEC															

Table R.2, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,356,314	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
SOYBEANS															
BASE															
NONB	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	456,062	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,131,122	1,139,511	1,155,332	932,400	1,185,088	1,214,113	1,190,893

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
502,679	502,679	502,679	502,679	502,679	502,679	502,679	502,679	503,197	506,954	514,038	523,921	527,363	541,110	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
866,552	866,552	866,552	866,552	866,552	866,552	866,552	866,552	867,452	873,977	886,283	903,448	909,427	936,925	914,927

Table R.2, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,713	22,003	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8*															
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,720	3,788	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	4,320	8,640	1,851	4,937	5,554	7,406	1,852	4,324	13,688	1,891	3,210	1,938	3,230	8,398

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL.	125,284	419,054	646,787	187,618	234,522	636,295	330,799	432,631	560,934	698,689	195,439	303,027	299,759	591,766	626,006

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIM.	41,350	86,402	232,052	39,498	168,485	196,257	212,303	80,231	90,812	411,869	49,175	168,849	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	27,613	50,520

Table R.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	278	1,427	37,342	88	1,586	375	1,169	775
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		376	1,142	605	24,977	827	3,493	2,469	661	12,655	466	6,645	10,563	207	7
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,024	12,380	32,142	6,493	14,584	17,490	27,168	7,696	9,100	44,292	6,569	8,519	5,969	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	19,225	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM 4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table R.2, continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	18		6	18	6		12	19		45		7	7
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,543	93	228	222	179	1,257	44	899	1,273	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,150	45,769	130,874	27,130	73,399	79,095	40,344	31,296	42,515	158,178	21,656	143,014	31,029	46,340	722,267
CHEM 14															
CHEM 15															

Table R.3. Scenario: No Litter-X.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

40,075,933

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,316,928	4,253,905	4,284,144	4,024,089	2,252,512	2,348,990	1,847,948	893,589	3,446,631	3,321,457	1,055,589	2,381,856	2,799,984	805,856	2,042,455

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,070

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t

Table R.3, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	22	60	112	130	130	130
DC SOYB															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,596
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,284	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,329	5,392	5,362	5,362
MAY	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,016	4,044	4,098	4,173	4,199	4,199	4,199
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,332
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,070	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table R.3, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,356,314	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
SOYBEANS															
BASE															
NONB	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
985,586	985,586	985,586	985,586	985,586	985,586	985,586	985,586	986,599	993,939	1,007,781	1,027,091	1,033,817	1,061,227	1,039,299

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
502,679	502,679	502,679	502,679	502,679	502,679	502,679	502,679	503,197	506,954	514,038	523,921	527,363	541,110	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
866,552	866,552	866,552	866,552	866,552	866,552	866,552	866,552	867,452	873,977	886,283	903,448	909,427	936,925	914,927

Table R.3, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,714	22,003	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,720	3,788	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	4,320	8,023	1,851	4,320	5,554	6,789	1,852	3,707	14,310	1,891	3,210	2,584	3,876	7,106
PERCOL	85,786	305,496	465,958	122,198	156,759	469,044	199,961	211,687	385,488	604,742	139,329	213,788	235,156	485,171	538,146
SED.	41,350	86,402	232,052	30,498	168,485	196,257	212,303	80,231	90,812	411,870	49,175	84,745	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	28,684	50,520

Table R.3, continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	18		6	18	6		12	19		13		6	6
CHEM 4															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,542	92	228	222	179	1,257	44	899	1,273	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,151	45,768	130,875	27,130	73,398	79,095	40,344	31,296	42,514	158,178	21,656	37,217	31,029	46,339	72,226
CHEM 14															
CHEM 15															

Table R.3, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	277	1,427	37,342	88	1,586	375	1,169	775
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		376	1,142	605	24,977	827	3,493	2,469	661	12,655	475	6,645	10,563	207	6
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,024	12,380	32,142	6,493	14,584	17,490	27,168	7,696	9,099	44,292	6,569	8,519	5,971	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	19,225	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table R.4. Scenario: Unrestricted.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
39,821,151

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,153,263	4,226,376	4,404,198	3,999,588	2,229,389	2,353,648	1,827,370	881,514	3,428,307	3,304,045	1,038,957	2,365,712	2,788,288	791,553	2,028,945

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,050

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL

Table R.4, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					988					198	40	
NONB		6,172	1,234	6,172	6,172	6,172	6,172	5,184	6,178	6,222	6,305	6,420	6,263	6,421	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	22	60	112	130	130	130
DC SOYB															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB															
MAR	9,387	10,430	9,596	10,430	10,430	10,430	10,430	10,263	10,440	10,515	10,655	10,850	10,885	10,911	10,918
APR	8,832	9,813	9,028	9,813	9,813	9,813	9,813	9,656	9,823	9,892	10,024	10,208	10,241	10,266	10,272
MAY	2,111	2,345	2,158	2,345	2,345	2,345	2,345	2,308	2,348	2,364	2,396	2,440	2,447	2,453	2,455
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL	7,036	7,036	7,036	7,036	7,036	7,036	7,036	7,036	7,043	7,093	7,187	7,319	7,365	7,365	7,365
AUG															
SEP	16,164	17,052	16,341	17,052	17,052	17,052	17,052	16,910	17,070	17,198	17,439	17,775	17,864	18,386	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table R.4, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097					46,924	3,484	
NONBASE		1,018,319	229,585	1,197,296	1,234,326	1,524,393	1,154,095	414,734	1,254,071	1,356,314	863,714	1,457,356	1,653,389	629,242	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		332,603
NONBASE									449	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,865	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONBAS	308,582	413,499	333,268	401,156	333,268	438,692	320,925	209,835	475,682	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
43,034,191	46,146,821	44,130,762	46,146,821	46,146,821	46,146,821	46,146,821	45,648,800	46,193,771	46,534,165	47,176,138	48,071,652	48,283,969	49,364,531	48,583,749

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
224,660	224,660	217,549	224,660	224,660	224,660	224,660	224,660	224,905	226,682	230,033	234,708	236,336	248,821	238,833

Table R.4, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,738	5,554	8,862	3,086	4,937	6,789	8,640	3,056	3,707	14,310	1,891	3,852	3,224	7,105	11,629
PERCOL	138,306	470,895	790,759	329,565	377,704	685,668	344,377	336,951	470,740	760,905	246,505	283,125	413,412	848,473	627,944
SED.	42,090	99,980	240,742	49,370	177,737	228,349	226,498	85,712	116,758	440,489	54,849	93,091	71,573	125,943	191,225

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	23,884	82,379	17,404	50,175	56,656	71,159	23,199	25,020	134,760	19,544	24,717	17,860	32,229	52,975

Table R.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table R.4, continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table R.5. Scenario: Unrestricted-X.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
41,276,313

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,282,265	4,359,233	4,531,511	4,117,832	2,340,981	2,458,901	1,926,684	973,892	3,516,744	3,388,112	1,119,311	2,443,773	2,861,427	861,331	2,094,318

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,161

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL

Table R.5, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					988					198	40	
NONBASE		6,172	1,234	6,172	6,172	6,172	6,172	5,184	6,178	6,222	6,305	6,420	6,263	6,421	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBAS	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB															
MAR	9,387	10,430	9,596	10,430	10,430	10,430	10,430	10,263	10,440	10,515	10,655	10,850	10,885	10,911	10,918
APR	8,832	9,813	9,028	9,813	9,813	9,813	9,813	9,656	9,823	9,892	10,024	10,208	10,241	10,266	10,272
MAY	2,111	2,345	2,158	2,345	2,345	2,345	2,345	2,308	2,348	2,364	2,396	2,440	2,447	2,453	2,455
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL	7,036	7,036	7,036	7,036	7,036	7,036	7,036	7,036	7,043	7,093	7,187	7,319	7,365	7,365	7,365
AUG															
SEP	16,164	17,052	16,341	17,052	17,052	17,052	17,052	16,910	17,070	17,198	17,439	17,775	17,864	18,386	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,245	9,303	9,303	9,303
DEC															

Table R.5, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097					46,924	3,484	
NONB		1,018,319	229,585	1,197,296	1,234,326	1,524,393	1,154,095	414,734	1,254,071	1,356,314	863,714	1,457,356	1,653,389	629,242	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	24,684	25,983	24,164
DC SOYB															
BASE															
NONB	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
38,462,291	41,168,230	39,003,478	41,168,230	41,168,230	41,168,230	41,168,230	40,735,280	41,210,123	41,514,424	42,088,194	42,888,570	43,080,763	44,095,199	43,356,386

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
247,960	249,029	248,173	249,029	249,029	249,029	249,029	248,857	249,300	251,261	254,960	260,119	261,883	275,231	264,581

Table R.5., continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	4,937	8,862	3,086	4,937	6,789	8,640	3,056	4,324	14,310	1,891	3,852	2,580	4,521	6,460
PERCOL	106,090	385,727	647,750	295,621	324,011	728,252	483,856	482,715	555,992	828,098	243,353	223,418	377,357	789,072	527,163
SED.	45,053	99,980	240,741	49,373	177,742	228,349	226,498	85,712	116,758	440,489	54,849	93,091	71,573	12,500	191,225

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	23,884	82,379	17,404	50,175	56,656	71,159	23,200	25,020	134,760	19,544	24,717	17,860	32,229	52,975

Table R.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table R.5, continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

APPENDIX S

SUMMARIES OF THE SENSITIVITY ANALYSIS SCENARIOS

Table S.1. Scenario: Litter Price ($.039 PER KG).

TOTAL NET RETURNS, DISCOUNTED (15 YEARS, DOLLARS)
39,253,783

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,215,867	4,178,991	4,213,496	3,957,415	2,189,589	2,316,108	1,791,948	840,791	3,396,764	3,274,054	1,010,278	2,337,835	2,758,632	232,572	2,005,579

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,007

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t

Table S.1, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYB															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,177	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,596
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,239	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,239	5,392	5,362	5,362
MAY	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,016	4,044	4,098	4,173	4,199	4,199	4,199
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,069	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table S.1, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,356,314	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	7,410	24,164
SOYBEANS															
BASE															
NONB	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,129,965	1,131,122	1,139,511	1,155,332	1,177,401	1,185,088	1,214,113	1,190,893

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
502,679	502,679	502,679	502,679	502,679	502,679	502,679	502,679	503,197	506,953	514,038	523,921	527,363	541,110	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
866,552	866,552	866,552	866,552	866,552	866,552	866,552	866,552	867,452	873,977	886,283	903,448	909,427	936,925	914,927

Table S.1, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,714	22,003	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,720	3,788	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	4,320	8,640	1,851	4,937	5,554	7,406	1,851	4,324	13,688	1,891	3,210	1,938	3,230	8,398
PERCOL	125,284	419,054	646,787	187,618	234,522	636,295	330,799	432,631	560,934	698,689	195,439	303,027	299,759	591,766	626,006
SED.	41,350	86,402	232,052	39,498	168,485	196,257	212,303	80,231	90,812	411,870	49,175	84,745	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	28,684	50,520

Table S.1, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	278	1,427	37,342	88	1,586	374	1,169	775
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9	376	1,142	605	24,977	827	3,493	2,469	661	12,655	473	6,645	10,563	207	7	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,023	12,380	32,142	6,493	14,584	17,490	27,168	7,996	9,099	44,292	6,569	8,519	5,969	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	19,225	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM 4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table S.1, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	18		6	18	6		12	19	19	13	13	6	6
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,543	93	228	222	179	1,257	1,301	899	2,171	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,150	45,767	130,875	27,130	73,399	79,095	40,344	31,296	42,515	158,178	179,834	37,217	68,246	46,340	7,226
CHEM 14															
CHEM 15															

Table S.2. Scenario: No Litter-X ($.039 PER KG).

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

40,075,933

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,316,928	4,253,905	4,284,144	4,024,089	2,252,512	2,348,990	1,847,948	893,589	3,446,631	3,321,457	1,055,589	2,381,856	2,800,810	805,856	2,042,455

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,070

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t	A3t

Table S.2, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,715
NONB									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	22	60	112	130	130	130
DC SOYB															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,187	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB															

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,596
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,284	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,329	5,362	5,362	5,362
MAY	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,016	4,044	4,098	4,173	4,199	4,199	4,199
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,070	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,244	9,303	9,303	9,303
DEC															

Table S.2, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONB	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,356,314	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		323,484
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
SOYBEANS															
BASE															
NONB	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	454,179	201,743	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
985,586	985,586	985,586	985,586	985,586	985,586	985,586	985,586	986,599	993,939	1,007,781	1,027,091	1,033,817	1,061,226	1,039,299

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
502,679	502,679	502,679	502,679	502,679	502,679	502,679	502,679	503,197	506,954	514,038	523,921	527,363	541,110	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
866,552	866,552	866,552	866,552	866,552	866,552	866,552	866,552	867,452	873,977	886,283	903,448	909,427	936,925	914,927

Table S.2, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,713	22,003	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9	108,000	108,000	108,000	108,000	108,000	108,000	108,000	108,000	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,719	3,788	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	4,320	8,023	1,851	4,320	5,554	6,789	1,852	3,707	14,310	1,891	3,210	2,584	3,876	7,106

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	85,786	305,496	465,958	122,198	156,759	469,044	199,961	211,687	385,488	604,742	139,329	213,788	235,156	485,171	538,146

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SED.	41,350	86,402	232,052	39,498	168,485	196,257	212,303	80,231	90,812	411,870	49,175	84,745	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	28,684	50,520

Table S.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	278	1,427	37,342	88	1,586	375	1,169	775
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		376	1,142	605	24,977	827	3,493	2,469	661	12,655	473	6,645	10,563	207	7
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,024	12,380	32,142	6,493	14,584	17,490	27,168	7,696	9,100	44,292	6,569	8,519	5,971	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	192,246	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table S.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	18		6	18	6		12	19	19	13	13	6	6
CHEM 4															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,543	93	228	222	179	1,257	1,301	899	2,171	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,150	45,767	130,875	27,130	73,399	79,095	40,344	31,296	42,515	158,178	179,834	37,217	68,246	46,340	72,226
CHEM 14															
CHEM 15															

Table S.3. Scenario: Yield Reduction-A.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
39,273,144

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,215,867	4,180,570	4,214,984	3,958,820	2,190,915	2,317,359	1,793,128	841,903	3,397,816	3,275,064	1,011,421	2,339,098	2,762,112	767,622	2,006,465

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,008

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(Percentage of Cropland Split)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3t	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL

Table S.3, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,254	6,460
FS SOYBEAN															
BASE															
NONBASE															

CROPLAND IDLED (HECTARES)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500														
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,284	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,329	5,362	5,362	5,362
MAY	4,012	2,345	2,345	2,345	2,345	2,345	2,345	2,345	2,348	2,364	2,396	2,440	2,455	2,455	2,455
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,282	12,527	12,331
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,070	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table S.3, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONBASE	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,335,544	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONBASE									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,865	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONBASE	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	457,688	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,169,333	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POULTRY LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	38,964,320	38,964,320	38,964,320	38,964,320	38,964,320	38,964,320	38,964,320	39,004,218	39,293,481	39,839,021	40,600,019	40,865,086	41,865,965	41,065,262

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
502,679	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
866,552	282,088	282,088	282,088	282,088	282,088	282,088	282,088	282,389	284,575	287,890	292,937	296,451	308,936	298,948

Table S.3, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,713	22,003	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,720	3,788	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	3,703	8,023	1,851	3,703	5,554	7,406	1,852	3,707	13,065	1,891	1,586	1,938	1,938	4,522
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL.	125,284	527,057	707,886	264,763	289,449	667,770	427,694	508,542	568,348	765,882	232,005	190,676	383,744	717,097	531,685
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SED.	41,350	86,402	232,052	39,498	168,485	190,702	202,367	80,231	90,811	411,870	49,175	84,745	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	28,684	50,520

Table S.3, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	278	1,427	37,342	88	1,586	375	1,169	775
CHEM 4															
CHEM 4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		376	1,142	605	24,977	827	3,493	2,469	661	12,655	473	6,645	10,563	207	7
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,024	12,380	32,142	6,493	14,584	17,490	27,168	7,697	9,100	44,292	6,569	8,519	5,971	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	19,225	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table S.3, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	19		6	19	6		12	19	19	13	13	6	6
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,543	96	228	222	179	1,257	1,301	899	2,171	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,150	45,769	130,975	27,130	73,399	79,095	40,344	31,296	42,514	158,178	179,834	37,217	68,246	46,230	72,226
CHEM 14															
CHEM 15															

Table S.4. Scenario: Yield Reduction-XA.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

40,579,692

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4,362,413	4,296,815	4,324,611	4,062,279	2,288,554	2,409,452	1,880,025	923,832	3,475,196	3,348,622	1,081,731	2,407,405	2,826,278	828,794	2,063,686

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

3,108

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(Percentage of Cropland Split)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL	A3tL

Table S.4, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,209	6,460
FS SOYBEAN															
BASE															
NONBASE															

CROPLAND IDLED (HECTARES)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB															
MAR	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,233	6,240	6,284	6,368	6,484	6,525	6,525	6,525
APR	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,122	5,128	5,164	5,233	5,329	5,362	5,362	5,362
MAY	2,345	2,345	2,345	2,345	2,345	2,345	2,345	2,345	2,348	2,364	2,396	2,440	2,455	2,455	2,455
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,052	17,070	17,198	17,439	17,775	17,892	18,391	17,992
OCT	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,610	4,615	4,652	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,245	9,303	9,303	9,303
DEC															

Table S.4, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE															
NONBASE	1,215,811	1,018,319	1,147,923	1,197,296	1,234,326	1,524,393	1,154,095	493,730	1,254,071	1,356,314	863,714	1,457,356	1,705,527	633,112	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONBASE									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,865	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONBASE	308,582	413,499	333,268	401,156	333,268	351,783	320,925	209,835	475,682	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POULTRY LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
33,985,730	33,985,730	33,985,730	33,985,730	33,985,730	33,985,730	33,985,730	33,985,730	34,020,640	29,186,740	34,751,078	35,416,937	35,648,866	36,594,029	35,837,898

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.0

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
356,766	356,766	356,766	356,766	356,766	356,766	356,766	356,766	357,143	359,870	364,208	370,684	374,694	388,014	377,358

Table S.4, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,539	21,560	21,713	22,002	22,406	22,547	22,547	22,547
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,641	3,645	3,671	3,720	3,879	3,812	3,812	3,812
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,234	4,320	8,023	1,851	4,937	5,554	7,406	1,852	4,324	12,443	1,891	3,210	1,938	3,230	7,752
PERCOL.	80,848	323,393	606,054	259,208	274,638	642,467	439,420	443,740	464,562	743,484	206,157	177,836	332,707	701,592	439,949
SED.	41,350	86,402	232,052	217,242	168,485	190,702	212,303	80,231	90,812	411,870	49,175	84,745	67,187	111,763	180,888

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11,479	20,737	80,416	15,367	48,509	47,707	66,654	21,169	19,522	125,552	13,366	22,663	16,797	28,684	17,346

Table S.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	907	1,777	2,888	160	518	1,740	691	278	1,427	37,342	88	1,586	375	1,169	775
CHEM 4															
CHEM 4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9	376	1,142	605	10,905	827	3,493	2,469	661	12,655	473	6,645	10,563	207	7	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	5,023	12,380	32,142	6,493	6,400	17,490	27,168	7,696	9,100	44,292	6,569	8,519	5,971	10,505	17,346
CHEM 14															
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1															
CHEM 2															
CHEM 3	43	23,162	95,265	10,461	2,685	83,515	58,624	19,225	99,523	162,179	7,811	2,080	3,689	69,623	52,212
CHEM 4															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table S.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	6	12	18		6	18	6		12	19	19	13	13	6	6
CHEM 4															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9		37	241	62	2,543	92	228	222	179	1,257	2,558	899	2,171	45	
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13	20,150	45,758	130,875	128,889	34,548	79,095	40,344	31,296	42,515	158,178	255,694	37,217	68,246	46,340	72,226
CHEM 14															
CHEM 15															

Table S.5. Scenario: Yield Reduction-B.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
30,745,797

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,240,837	3,267,615	3,593,893	3,356,566	1,489,439	1,595,279	1,201,413	534,683	2,976,676	2,698,313	655,046	1,803,220	2,260,155	514,841	1,557,819

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,355

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A5tL	A5tL	A12t	A5tL	A1t	A5tL	A14tL	A14tL	A1t	A5tL	A1t	A1t,A1tL (95.0/5.0)	A5tL	A1t

Table S.5, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172	6,172	6,172				2,469	1,728			839		514	271	
NONBASE				3,086	6,172	6,172	3,703	1,358	3,089	6,222	5,465	6,420	5,947	6,190	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,715
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBAS	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB				3,086				3,086	3,089						

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB				1,500		1,500				1,513		1,567	1,500		1,596
MAR	9,387	9,387	9,387	4,536	10,430	10,572	10,013	4,282	4,541	9,146	10,513	9,437	9,421	10,872	9,497
APR	8,832	8,832	8,832	2,561	9,813	5,122	9,420	2,418	2,564	5,164	9,891	5,329	5,319	10,229	5,362
MAY	2,111	2,111	2,111	7,931	2,345	1,666	2,251	7,097	7,104	1,680	2,364	1,733	1,660	2,445	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,975	12,203	12,282	12,527	12,331
JUL	7,036	7,036	7,036		7,036		7,036				7,187			7,365	
AUG															
SEP	16,164	16,164	16,164	12,609	17,052	17,052	16,697	12,360	12,622	17,198	17,318	17,775	17,818	18,352	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	4,652	4,720	4,816	4,850	5,131	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table S.5, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384	733,190	826,505				332,379	124,420			82,793		122,003	19,091	
NONB				598,648	987,461	1,524,393	553,966	108,621	627,036	1,356,314	598,980	1,457,356	1,569,968	485,278	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		356,386
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
DC SOYB															
BASE															
NONB	246,865	330,799	266,614	654,193	266,614	351,783	256,740	367,212	766,034	454,179	161,395	430,145	471,604	186,058	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	943,813	0	1,360,428	44,901,769	0	0	1,371,861	0	1,417,240	1,357,141	0	1,432,557

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
43,034,191	43,034,191	43,508,236	0	46,146,821	0	0	31,673,724	32,578,940	0	46,752,819	0	2,130,885	49,247,994	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	467,964	0	502,679	0	80,205	80,283	506,953	0	523,921	501,668	0	530,112

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
224,660	224,660	224,660	824,925	224,660	866,552	224,660	361,901	362,279	873,977	230,033	903,448	876,116	248,821	914,927

Table S.5, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811						
CHEM 2								42,698	43,553						
CHEM 3				10,769		21,539		24,515	25,143	21,714		22,406	22,367		22,546
CHEM 4*				1,080		2,160		1,080	1,081	2,178		2,247	2,261		2,261
CHEM 5															
CHEM 6															
CHEM 7*				194		107		194	195	196		203	204		206
CHEM 8				3,148		3,148		3,148	3,151	3,173		3,274	3,294		3,295
CHEM 9				10,800		10,800		10,800	10,811	10,888		11,235	11,305		11,305
CHEM 10				7,190				7,190	7,197						
CHEM 11				7,159				7,159	7,166						
CHEM 12				23,390		14,318				14,434		14,895	14,928		14,988
CHEM 13				10,800		10,800		10,800	10,811	10,888		11,235	11,305		11,305
CHEM 14				5,400				5,400	5,405						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,728	5,184	8,764	2,777	4,937	10,492	8,443	3,034	5,560	20,531	1,875	8,988	5,677	7,095	10,982
PERCOL.	138,306	424,978	777,996	115,101	377,704	801,695	333,243	288,353	456,840	800,101	243,660	321,645	354,495	846,049	767,487
SED.	42,090	94,487	237,977	112,632	177,742	266,613	1,283,051	99,351	197,684	512,660	54,488	124,550	100,314	125,749	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	22,533	81,373	29,500	50,175	66,530	69,794	26,792	47,692	160,767	19,441	35,952	25,909	32,181	63,505

Table S.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

RUNOFF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				93				407	93						
CHEM 2								605	1,826						
CHEM 3				262		3,376		303	1,742	2,955		2,773	160		1,266
CHEM 4															
CHEM 4b				34		7,178		96	71	3,627		1,810	1,382		1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8				651		1,432		1,287	204	5,170		687	64		271
CHEM 9				1,080		1,327		1,697	11,330	16,338		9,026	14,096		90
CHEM 10				2,101				5,394	3,203						
CHEM 11				1,145				2,351	951						
CHEM 12				512		22,496				3,596		3,133	477		4,322
CHEM 13				28,371		70,369		31,758	45,384	154,159		32,993	24,590		64,009
CHEM 14				5,320				10,739	6,317						
CHEM 15															

PERCOLATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				130				120	90						
CHEM 2								6	3,713						
CHEM 3				4,471		73,239		30,494	34,607	139,570		1,682	3,088		48,220
CHEM 4						15,620		244	25	8,461			407		
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7						278				5,021			103		1,137
CHEM 8															
CHEM 9													1,382		25
CHEM 10															
CHEM 11															
CHEM 12				9		2,734		12		2,800		90	39		316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22						
CHEM 3				3		43		3	18	31	31	32	128		1,273
CHEM 4															
CHEM 4b				3		203		3		99	99	51	96		65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8				2,256		4,462		3,516	1,010	12,568	12,568	1,650	2,069		1,008
CHEM 9				111		154		253	167	1,530	1,530	1,066	2,448		26
CHEM 10				978				2,265	2,601						
CHEM 11				49				62	49			13	13		
CHEM 12				9		160				31	31	13	19		39
CHEM 13				126,203		307,493		113,402	219,133	564,131	564,131	156,028	283,768		248,541
CHEM 14				271				528	6						
CHEM 15															

Table S.6. Scenario: Yield Reduction-XB.

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

31,932,035

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,369,839	3,389,315	3,719,102	3,418,338	1,601,031	1,669,497	1,307,789	598,941	3,042,896	2,753,904	734,248	1,847,240	2,301,456	583,745	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,446

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A5tL	A5tL	A12t	A5tL	A4t	A5tL	A14tL	A14tL	A14tL	A5tL	A1t	A1t,A1tL	A5tL (95.0/5.0)	A1t

Table S.6, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172	6,172	6,172					1,234			247		296	109	
NONBASE				3,086	6,172	6,172	6,172	1,851	3,089	3,111	6,058	6,420	6,164	6,352	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,715
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB				3,086				3,086	3,089	3,111					

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB				1,500								1,567	1,500		1,596
MAR	9,387	9,387	9,387	4,536	10,430	1,500	10,430	4,355	4,541	4,573	10,613	9,437	9,453	10,900	9,497
APR	8,832	8,832	8,832	2,561	9,813	10,572	9,813	2,459	2,564	2,582	9,985	5,329	5,337	10,255	5,362
MAY	2,111	2,111	2,111	7,031	2,345	5,122	2,345	7,097	7,104	7,155	2,386	1,733	1,666	2,451	1,744
JUN	11,714	11,714	11,714	11,714	11,714	1,666	11,714	11,714	11,726	11,812	11,975	12,203	12,282	12,537	12,331
JUL	7,036	7,036	7,036		7,036	11,714	7,036				7,187			7,365	
AUG															
SEP	16,164	16,164	16,164	12,609	17,052	17,052	17,052	12,431	12,622	12,718	17,403	17,775	17,850	18,376	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	9,131	4,720	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,302	9,303
DEC															

Table S.6, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384	733,190	826,505					88,871			24,351		70,386	7,664	
NONB				598,648	987,461	1,524,393	923,276	148,119	627,036	678,157	663,915	1,457,356	1,627,320	497,974	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
DC SOYB															
BASE															
NONB	246,865	330,799	266,614	654,193	266,614	351,783	256,740	367,212	766,034	734,152	161,395	430,145	471,604	186,058	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	810,049	0	1,216,049	0	0	0	0	0	1,266,931	1,215,953	0	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
38,462,291	38,462,291	38,462,291	0	41,168,230	0	41,168,230	27,254,429	20,690,288	28,083,842	41,979,956	0	1,912,279	44,064,893	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	467,964	0	502,679	0	104,146	104,249	104,990	0	523,921	502,645	0	530,112

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
247,960	247,960	247,960	824,925	249,029	866,552	249,029	420,969	421,411	424,609	254,917	903,448	878,742	275,219	914,297

Table S.6, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888					
CHEM 2								42,930	43,553	43,862					
CHEM 3				10,769		21,539		24,688	25,143	25,322		22,406	22,443		22,546
CHEM 4*				1,080		2,160		1,080	1,081	1,089		2,247	2,261		2,261
CHEM 5															
CHEM 6															
CHEM 7*				194		107		194	195	196		203	204		207
CHEM 8				3,148		3,148		3,148	3,151	3,173		3,274	3,294		3,295
CHEM 9				10,800		10,800		10,800	10,811	10,888		11,235	11,305		11,305
CHEM 10				7,190				7,190	7,197	7,248					
CHEM 11				7,159				7,159	7,166	7,217					
CHEM 12				23,390		14,318						14,894	14,954		14,988
CHEM 13				10,800		10,800		10,800	10,811	10,888		11,235	11,305		11,305
CHEM 14				5,400				5,400	5,405	5,444					
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	4,629	8,764	2,777	4,937	9,257	8,640	2,864	5,560	16,798	1,886	2,772	5,072	4,518	10,336
PERCOL.	106,090	348,265	637,961	98,746	324,011	344,377	483,856	281,278	445,720	530,394	242,538	242,036	253,048	788,405	627,298
SED.	42,090	94,487	237,977	112,632	177,742	266,613	226,498	99,795	197,684	545,945	54,743	124,550	100,511	125,885	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	22,533	81,373	29,500	50,175	66,530	71,159	26,913	47,692	171,001	19,514	35,952	25,962	32,215	63,505

Table S.6, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501					
CHEM 2								606	1,826	5,127					
CHEM 3				262		3,376		308	1,742	1,838		2,773	160		1,266
CHEM 4															
CHEM 4b				34		7,178		96	71	498		1,810	1,382		1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8				651		1,432		1,287	204	5,599		686	64		271
CHEM 9				1,080		1,327		1,697	11,330	9,320		9,027	14,096		90
CHEM 10				2,101				5,394	3,203	46,715					
CHEM 11				1,145				2,351	951	11,616					
CHEM 12				512		22,496						3,133	478		4,322
CHEM 13				28,371		70,369		31,880	45,384	167,533		32,993	24,627		64,009
CHEM 14				5,320				10,739	6,317	28,881					
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				120	90	7,920					
CHEM 2								6	3,713	3,248					
CHEM 3				4,471		73,239		30,612	34,607	48,606		1,682	3,091		48,220
CHEM 4						15,620		244	25	8,838			407		
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7						278				4,704			103		1,137
CHEM 8															
CHEM 9													1,382		26
CHEM 10															
CHEM 11								12		6					
CHEM 12				9		2,734						90	39		316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.6, continued.

CHEMICALS REMOVED (GRAMS) BY:															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22	50	96				
CHEM 3				3		43		3	18	12	12	32	128		1,273
CHEM 4															
CHEM 4b				3		204		3		28	56	51	96		65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8				2,256		4,462		3,517	1,010	13,165	26,056	1,650	2,069		1,008
CHEM 9				111		154		253	167	1,698	3,397	1,066	2,448		26
CHEM 10				978				2,265	2,601	26,697	53,394				
CHEM 11				50				62	49	305	610	13	13		
CHEM 12				9		160						13	19		39
CHEM 13				126,203		307,494		113,935	219,133	609,107	1,037,806	156,028	284,027		248,541
CHEM 14				271				528	6	1,997	3,994				
CHEM 15															

Table S.7. Scenario: Yield Reduction-C (41% Penalty).

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
29,999,054

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2,150,837	3,269,114	3,520,614	3,356,566	1,425,350	1,595,279	1,111,786	526,816	2,976,676	2,698,190	459,687	1,803,220	2,258,559	288,416	1,557,819

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2221.12

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A1t	A1t	A14tL	A14tL	A1t,A12t (98.6/1.4)	A1t	A1t	A1t,A1tL (95.0/5.0)	A1t	A1t

Table S.7, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987			197		237	87	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	6,177	6,107	6,420	6,224	6,373	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,715
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089	45					

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500			1,513	1,536	1,567	1,500	1,669	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	9,081	9,238	9,437	9,462	9,484	9,496
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	5,127	5,216	5,329	5,342	5,355	5,362
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	1,770	1,697	1,733	1,666	1,742	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,975	12,203	12,282	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	17,133	17,410	17,775	17,858	18,379	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	4,716	4,720	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table S.7, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			24,351		56,309	7,664	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	1,346,586	836,658	1,457,356	1,642,962	624,596	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914	6,851	323,763
NONB									450	3,795	10,302	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	458,195	201,743	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,270,162	1,360,428	1,288,215	943,813	1,360,428	1,360,428	1,360,428	0	0	1,365,836	1,387,920	1,417,240	1,360,428	1,455,729	1,432,557

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	32,047,240	32,578,940	0	0	0	2,156,964	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	80,205	80,283	506,452	513,150	523,920	502,679	540,719	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	361,901	362,279	873,375	884,949	903,448	877,632	936,339	914,927

Table S.7, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	156					
CHEM 2								43,046	43,553						
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	21,558	21,934	22,406	22,464	22,516	22,546
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	2,162	2,260	2,247	2,261	2,261	2,261
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	204	216	206
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,294	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 10				7,190				7,190	7,197	104					
CHEM 11				7,159				7,159	7,166	104					
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318			14,656	14,603	14,894	14,960	14,978	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,305	11,305	11,306
CHEM 14				5,400				5,400	5,405	78					
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	4,012	10,492	12,319	2,777	5,554	10,492	9,875	3,056	5,560	20,536	3,146	8,988	5,692	8,390	10,982
PERCOL.	112,756	469,044	689,124	115,101	311,667	801,695	436,951	291,071	456,840	796,120	216,248	321,645	355,439	784,840	767,487
SED.	52,829	128,986	307,864	112,632	211,686	211,686	266,613	245,012	100,018	197,684	513,141	60,424	124,550	148,502	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	160,914	17,056	35,952	25,977	36,868	63,505

Table S.7, continued.

CHEMICALS REMOVED (GRAMS) BY:

RUNOFF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				93				407	93	36					
CHEM 2								607	1,825						
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	2,939	270	2,773	161	2,323	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71	3,582	315	1,810	1,382	226	1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,181	649	687	64	394	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	16,370	605	9,027	14,096	342	90
CHEM 10				2,101				5,394	3,203	670					
CHEM 11				1,145				2,351	951	167					
CHEM 12	978	9,572	18,682	512	741	22,496	4,079			3,642	170	3,133	478	1,568	4,322
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	154,351	24,098	32,993	24,637	42,509	64,009
CHEM 14				5,320					6,320	718					
CHEM 15															

PERCOLATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				130				120	90	114					
CHEM 2								6	3,713						
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	138,480	7,172	1,682	3,091	58,078	48,220
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,467			407	245	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				5,016			103	439	1,137
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		26
CHEM 10															
CHEM 11															
CHEM 12		284	5,496	9	19	2,734	210	12		2,844	6	90	38	2,342	316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.7, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22						
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	31	301	32	129	19	1,273
CHEM 4															
CHEM4B	49	130	463	3	74	204	37	3		98	118	51	96	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256	1,895	4,462	6,974	3,517	1,010	12,588	14,137	1,650	2,069	1,918	1,008
CHEM 9		37	271	111	2,777	154	284	253	167	1,533	1,577	1,066	2,448	52	26
CHEM 10				978				2,265	2,601	383	760				
CHEM 11				49				62	49	4	4	13	13		
CHEM 12	12	18	121	9	6	160	37			31	32	13	19	19	39
CHEM 13	76,419	186,580	483,303	126,203	260,256	307,494	133,066	114,203	219,133	564,780	644,140	156,028	284,097	171,404	248,541
CHEM 14				271				528	6	29	57				
CHEM 15															

Table S.8. Scenario: Yield Reduction-XC (40% Penalty)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
30,867,389

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,586,646	3,418,338	1,488,273	1,669,497	1,167,786	596,440	3,042,896	2,753,904	505,275	1,847,240	2,300,917	327,696	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2364.23

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A4t	A1t	A14tL	A14tL	A14tL	A1t	A1t	A1t,A1tL (95.0/5.0)	A1t,A14tL (99.0/1.0)	A1t

Table S.8, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987					197	40	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	3,111	6,305	6,420	6,262	6,381	[illegible]
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		[illegible]
NONB									3	28	73	137	160	3,555	[illegible]
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	[illegible]
NONB									3	23	60	112	130	129	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,459	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089	3,111				40	

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500				1,536	1,567	1,500	1,648	[illegible]
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	4,573	9,268	9,438	9,468	9,433	[illegible]
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	2,582	5,233	5,329	5,346	5,326	[illegible]
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	7,155	1,702	1,733	1,666	1,814	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	[illegible]
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	12,718	17,439	17,775	17,864	18,329	[illegible]
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	89,063	9,131	4,721	4,816	4,850	5,18	[illegible]
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	[illegible]
DEC															

Table S.8, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097				46,924		3,784	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	678,157	863,714	1,457,356	1,653,389	625,371	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	[illegible]
NONB										3,690	9,864	22,248	24,684	25,983	[illegible]
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	734,152	201,744	430,145	471,604	234,704	[illegible]

NUTRIENTS PURCHASED (KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NITROGEN	1,137,577	1,216,049	1,153,272	810,049	1,216,049	1,216,049	1,216,049			0	1,243,259	1,266,931	1,216,049	1,287,925	1,280,964
LITTER								27,372,848	27,875,288	28,083,842			1,952,269	356,040	
PHOSPHORUS	474,907	502,679	480,461	467,964	502,679	502,679	502,679	104,146	104,249	104,990	514,038	532,921	502,679	355,689	[illegible]
POTASSIUM	824,894	866,552	833,226	824,925	866,552	866,552	866,552	420,969	421,411	424,609	886,283	903,448	878,809	930,943	[illegible]

Table S.8, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888				138	
CHEM 2								43,046	43,553	43,862				538	
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	25,322	22,002	22,406	22,477	22,578	[illegible]
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	1,089	2,206	2,247	2,261	2,247	[illegible]
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	205	216	[illegible]
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,295	[illegible]
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	[illegible]
CHEM 10				7,190				7,190	7,197	7,248				92	
CHEM 11				7,159				7,159	7,166	7,217				92	
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318				14,626	14,895	14,965	14,805	[illegible]
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,305	11,305	[illegible]
CHEM 14				5,400				5,400	5,405	5,444				69	
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,937	9,257	9,257	2,846	5,560	16,798	3,152	7,704	5,076	7,730	[illegible]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	209,835	344,377	257,357	282,234	445,720	530,394	153,199	242,037	253,365	519,843	[illegible]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	211,686	266,613	245,012	100,018	197,684	545,945	60,523	124,550	100,601	149,075	[illegible]

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	171,001	17,085	35,952	25,987	37,042	[illegible]

Table S.8, continued.

CHEMICALS REMOVED (GRAMS) BY:

RUNOFF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				93				407	93	2,501				8	
CHEM 2								607	1,825	5,127				19	
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	1,838	271	2,773	161	2,314	[illegible]
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71	498	315	1,810	1,382	224	[illegible]
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,599	649	686	64	395	21
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	9,320	605	9,026	14,096	341	90
CHEM 10				2,101				5,394	3,203	46,715				23	
CHEM 11				1,145				2,351	951	11,616				13	
CHEM 12	978	9,572	18,682	512	741	22,496	4,079				170	3,132	477	1,551	[illegible]
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	167,533	24,134	32,992	24,645	42,614	[illegible]
CHEM 14				5,320					6,320	28,881				32	
CHEM 15															

PERCOLATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				130				120	90	7,920				4	15
CHEM 2								6	3,713	3,248				22	78
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	48,606	7,174	1,682	3,092	57,737	[illegible]
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,838			407	245	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				4,704			103	439	[illegible]
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		24
CHEM 10															
CHEM 11										6					
CHEM 12		284	5,496	9	19	2,734	210	12			6	90	38	2,316	[illegible]
CHEM 13															
CHEM 14															
CHEM 15															

Table S.8, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22	50	96				
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	12	283	32	129	19	15
CHEM 4															
CHEM4B	49	130	463	3	74	204	37	3		28	75	51	97	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256	1,895	4,462	6,974	3,517	1,010	13,165	27,601	1,650	2,070	1,922	[illegible]
CHEM 9		37	271	111	2,777	154	284	253	167	1,698	3,441	1,066	2,448	52	26
CHEM 10				978				2,265	2,601	26,697	53,395			16	
CHEM 11				49				62	49	305	610	13	13	1	
CHEM 12	12	18	121	9	6	160	37					12	19	19	39
CHEM 13	76,419	186,579	483,303	126,203	260,256	307,494	133,066	114,203	219,134	609,108	1,114,910	156,028	284,145	171,999	[illegible]
CHEM 14					271				528	6	1,997	3,994			
CHEM 15															

Table S.9. Scenario: Labor Requirements (5.5X)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

29,999,054

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,150,837	3,269,114	3,520,614	3,356,566	1,425,350	1,595,279	1,111,786	526,816	2,976,676	2,698,313	459,687	1,803,220	2,258,559	288,417	1,557,819

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2297.72

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A1t	A1t	A14tL	A14tL	A1t	A1t	A1t	A1t,A1tL	A1t (95.0/5.0)	A1t

Table S.9, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987			197		237	87	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	6,222	6,107	6,420	6,223	6,373	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500			1,513	1,536	1,567	1,500	1,669	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	9,146	9,239	9,438	9,462	9,484	9,497
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	5,164	5,216	5,329	5,342	5,355	5,262
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	1,680	1,697	1,733	1,666	1,742	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	17,198	17,410	17,775	17,858	18,379	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	4,652	4,721	4,816	4,850	5,132	9,303
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,245	9,303	9,303	9,303
DEC															

Table S.9, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097	153,348		24,351		56,309	7,664	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	1,356,314	836,658	1,457,356	1,642,962	624,597	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	454,179	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,270,162	1,360,428	1,288,215	943,813	1,360,428	1,360,428	1,360,428	0	0	1,371,861	1,387,920	1,417,240	1,360,429	1,455,729	1,432,557

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	32,047,240	32,578,940	0	0	0	2,156,964	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	80,205	80,283	506,954	513,150	523,921	502,679	540,719	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	361,901	362,279	873,977	884,950	903,448	877,633	936,339	914,927

Table S.9, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811						
CHEM 2								43,046	43,553						
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	21,714	21,934	22,406	22,464	22,516	22,547
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	2,178	2,207	2,247	2,261	2,261	2,261
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	205	216	206
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,295	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10				7,190				7,190	7,197						
CHEM 11				7,159				7,159	7,166						
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318			14,434	14,603	14,894	14,961	14,978	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 14				5,400				5,400	5,405						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	4,012	10,492	12,319	2,777	5,554	10,492	9,875	3,056	5,560	20,531	3,146	8,988	5,692	8,391	10,983
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	112,756	469,044	689,124	115,101	311,667	801,695	436,951	291,071	456,840	800,101	216,248	321,646	355,439	784,840	767,487
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	2,111,686	266,613	245,012	100,018	197,684	512,659	60,424	124,550	100,565	148,502	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	160,767	17,056	35,952	25,977	36,868	63,505

Table S.9, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93						
CHEM 2								607	1,825						
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	2,955	270	2,773	160	2,323	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71		315	1,810	1,383	226	1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,170	649	686	64	393	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	16,338	605	9,026	14,096	342	90
CHEM 10				2,101				5,394	3,203						
CHEM 11				1,145				2,351	951						
CHEM 12	978	9,572	18,682	512	741	22,496	4,079			3,596	170	3,133	478	1,568	4,322
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	154,159	24,099	32,993	24,638	42,509	64,009
CHEM 14				5,320					6,320						
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				120	90						
CHEM 2								6	3,713						
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	139,570	7,173	1,682	3,092	58,078	48,220
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,461			407	245	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				5,021			103	439	1,137
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		26
CHEM 10															
CHEM 11															
CHEM 12		284	5,496	9	19	2,734	210	12		2,800	6	90	39	2,341	316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.9, continued.

CHEMICALS REMOVED (GRAMS) BY:

SEDIMENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	31	301	32	129	19	1,273
CHEM 4															
CHEM4B	49	130	463	3	74	204	37	3		99	118	51	96	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256	1,895	4,462	6,974	3,517	1,010	12,568	14,112	1,650	2,069	1,918	1,008
CHEM 9		37	271	111	2,777	154	284	253	167	1,530	1,575	1,066	2,448	52	26
CHEM 10				978				2,265	2,601						
CHEM 11				49				62	49			13	13		
CHEM 12	13	18	121	9	6	160	37			31	31	13	19	19	39
CHEM 13	76,419	186,580	483,303	126,203	260,256	307,494	133,066	114,203	219,133	564,131	641,093	156,028	284,097	171,404	248,541
CHEM 14				271				528							
CHEM 15															

Table S.10. Scenario: Labor Requirement-X (5.5X)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
30,867,389

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,586,646	3,418,338	1,488,273	1,669,497	1,167,786	596,440	3,042,896	2,753,904	505,275	1,847,240	2,300,917	327,696	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2364.23

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A4t	A1t	A14tL	A14tL	A14t	A1t	A1t	A1t,A1tL	A1t,A14tL (95.0/5.0)	A1t (97.0/3.0)

Table S.10, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987					198	40	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	3,111	6,304	6,420	6,263	6,382	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	129	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089	3,111				40	

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500				1,536	1,567	1,500	1,648	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	4,573	9,268	9,238	9,468	9,433	9,297
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	2,582	5,233	5,329	5,346	5,326	5,362
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	7,155	1,702	1,733	1,666	1,814	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	12,718	17,439	17,775	17,864	18,329	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	9,131	4,721	4,816	4,850	5,188	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,245	9,303	9,303	9,303
DEC															

Table S.10, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097					46,924	3,484	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	678,157	863,714	1,457,356	1,653,389	625,371	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	734,152	201,744	430,145	471,604	234,705	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,272	810,049	1,216,049	1,216,049	1,216,049	0	0	0	1,243,259	1,266,931	1,216,049	1,287,934	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	27,372,848	27,875,288	28,083,842	0	0	1,952,269	356,040	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	104,146	104,249	104,990	514,038	523,921	502,679	535,689	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	420,969	421,411	424,609	886,283	903,448	878,809	930,943	914,927

Table S.10, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888				138	
CHEM 2								43,046	43,553	43,862				538	
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	25,322	22,003	22,406	22,478	22,578	22,547
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	1,089	2,207	2,247	2,261	2,247	2,261
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	205	216	206
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,294	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10				7,190				7,190	7,197	7,248				92	
CHEM 11				7,159				7,159	7,166	7,217				91	
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318				14,626	14,895	14,965	14,804	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 14				5,400				5,400	5,405	5,444				69	
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,937	9,257	9,257	2,846	5,560	16,798	3,152	7,705	5,076	7,730	10,337

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	209,835	344,377	257,357	282,234	445,720	530,394	153,199	242,037	253,365	519,844	627,298

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	211,686	266,613	245,012	100,018	197,684	545,945	60,523	124,545	100,601	148,311	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	171,001	17,085	35,952	25,987	37,043	63,505

Table S.10, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501				8	
CHEM 2								607	1,825	5,127				19	
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	1,838	271	2,773	161	2,314	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71	498	315	1,811	1,382	224	1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,599	649	686	64	394	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	9,320	605	9,026	14,096	341	90
CHEM 10				2,101				5,394	3,203	46,715				23	
CHEM 11				1,145				2,351	951	11,616				13	
CHEM 12	978	9,572	18,682	512	741	22,496	4,079				170	3,133	478	1,551	4,322
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	167,533	24,134	32,993	24,645	2,614	64,009
CHEM 14				5,320					6,320	28,881				32	
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				120	90	7,920				5	
CHEM 2								6	3,713	3,248				22	
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	48,606	7,175	1,682	3,092	57,737	48,220
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,838			407	245	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				4,704			103	439	1,137
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		25
CHEM 10															
CHEM 11										6					
CHEM 12		284	5,496	9	19	2,734	210	12			6	90	39	2,316	316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.10, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22	50	96				
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	12	283	32	129	19	1,273
CHEM 4															
CHEM4B	50	130	463	3	74	204	37	3		28	75	51	96	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256	1,895	4,462	6,974	3,517	1,010	13,165	27,601	1,650	2,069	1,920	1,008
CHEM 9		37	271	111	2,777	154	284	253	167	1,698	3,441	1,066	2,448	52	26
CHEM 10				978				2,265	2,601	26,697	53,394				
CHEM 11				50				62	49	305	610	13	13	1	
CHEM 12	12	18	121	9	6	160	37					13	19	19	39
CHEM 13	76,419	186,580	483,303	126,203	260,256	307,494	133,066	114,203	219,133	609,107	1,114,910	156,028	284,145	171,326	248,541
CHEM 14				271				528	6	1,997	3,994				
CHEM 15															

Table S.11. Scenario: Variable Cost (1.55% Penalty)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

29,999,054

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2,150,837	3,269,114	3,520,614	3,356,566	1,425,350	1,595,279	1,111,786	526,816	2,976,676	2,698,313	459,687	1,803,220	2,258,559	288,416	1,557,819

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2221.13

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A1t	A1t	A 14tL	A14tL	A1t	A1t	A1t	A1t,A1tL	A1t (95.0/5.0)	A1t

Table S.11, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987			197		237	87	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	6,222	6,107	6,420	6,224	6,373	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,715
NONB									3	28	73	137	159	3,554	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500			1,513	1,536	1,567	1,500	1,669	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	9,081	9,238	9,437	9,462	9,484	9,497
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	5,127	5,216	5,328	5,342	5,355	5,362
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	1,770	1,697	1,733	1,666	1,742	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,975	12,203	12,282	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	17,133	17,410	17,775	17,858	18,379	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	4,716	4,720	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,244	9,303	9,302	9,303
DEC															

Table S.11, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			24,351		56,309	7,664	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	1,356,314	836,658	1,457,356	1,642,962	624,596	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		323,763
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	454,179	201,743	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,270,162	1,360,428	1,288,215	943,813	1,360,428	1,360,428	1,360,428			1,371,861	1,387,920	1,417,240	1,360,428	1,455,729	1,432,557

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	32,047,240	32,578,940	0	0	0	2,156,964	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	80,205	80,283	506,953	513,150	523,920	502,679	540,719	530,112

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	361,901	362,279	873,977	884,950	903,448	877,633	936,339	914,927

Table S.11, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811						
CHEM 2								43,046	43,553						
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	21,713	21,934	22,406	22,464	22,516	22,546
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	2,177	2,206	2,247	2,261	2,261	2,261
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	204	216	207
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,294	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,305
CHEM 10				7,190				7,190	7,197						
CHEM 11				7,159				7,159	7,166						
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318			14,434	14,603	14,894	14,960	14,978	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,032	11,235	11,306	11,305	11,306
CHEM 14				5,400				5,400	5,405						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	4,012	10,492	12,319	2,777	5,554	10,492	9,875	3,056	5,560	20,531	3,146	8,988	5,692	8,390	10,983
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	112,756	469,044	689,124	115,101	311,667	801,695	436,951	291,071	456,840	800,101	216,248	321,645	355,439	784,840	767,487
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	211,686	266,613	245,012	100,018	197,684	512,660	60,424	124,550	100,565	148,502	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	160,776	17,056	35,952	25,977	36,868	63,505

Table S.11, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93						
CHEM 2								607	1,825						
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	2,955	270	2,773	161	2,322	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71	3,627	315	1,810	1,382	226	1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,170	649	687	64	394	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	16,338	605	9,026	14,096	342	90
CHEM 10				2,101				5,394	3,203						
CHEM 11				1,145				2,351	951						
CHEM 12	978	9,572	18,682	512	741	22,496	4,079			3,596	170	3,133	478	1,568	4,322
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	154,159	24,098	32,993	24,638	42,509	64,009
CHEM 14				5,320					6,320						
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				120	90						
CHEM 2								6	3,713						
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	139,569	7,172	1,682	3,092	58,078	48,220
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,461			407	245	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				5,021			103	439	1,137
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		26
CHEM 10															
CHEM 11															
CHEM 12		284	5,496	9	19	2,734	210	12		2,799	6	90	39	2,342	316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.11, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	31	301	32	129	19	1,273
CHEM 4															
CHEM4B	49	130	463	3	74	204	37	3		99	118	51	96	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256	1,895	4,462	6,973	3,516	1,010	12,568	14,112	1,650	2,069	1,818	1,008
CHEM 9		37	271	111	2,777	154	284	253	169	1,530	1,574	1,066	2,448	52	26
CHEM 10				978				2,265	2,601						
CHEM 11				49				62	49			13	13		
CHEM 12	12	18	121	9	6	160	37			31	31	13	19	19	39
CHEM 13	76,419	186,579	483,303	126,203	260,256	307,494	133,066	114,203	219,133	564,131	641,093	156,028	284,097	171,404	248,541
CHEM 14				271				528	6						
CHEM 15															

Table S.12. Scenario: Variable Cost-X (1.51X)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
30,867,410

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,586,646	3,418,338	1,488,273	1,669,497	1,167,786	596,440	3,042,896	2,753,904	504,883	1,847,240	2,301,134	327,892	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2364.23

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A1t	A4t	A1t	A14tL	A14tL	A14t	A1t	A1t	A1t,A1tL	A1t,A14tL (95.0/5.0)	A1t (97.0/3.0)

Table S.12, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987			198		237	87	
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	3,111	6,107	6,420	6,223	6,287	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,555	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	129	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089	3,111				87	

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500				1,536	1,567	1,500	1,622	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,391	4,541	4,573	9,239	9,438	9,462	9,356	9,497
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	2,582	5,216	5,329	5,342	5,283	5,362
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,097	7,104	7,155	1,697	1,733	1,666	1,897	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,976	12,203	12,283	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	12,718	17,410	17,775	17,858	18,254	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	9,131	4,721	4,816	4,850	5,257	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,079	9,245	9,303	9,303	9,303
DEC															

Table S.12, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097	153,348		24,350		56,308	7,664	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	678,157	836,658	1,457,356	1,642,962	616,081	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	734,152	201,744	430,145	471,604	237,264	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,272	810,049	1,216,049	1,216,049	1,216,049	0	0	0	1,240,747	1,266,931	1,216,049	1,268,520	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	27,372,848	27,875,288	28,083,842	0	0	0	1,934,950	783,288

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	104,146	104,249	104,990	513,150	532,921	502,679	529,184	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	420,969	421,411	424,609	884,950	903,448	878,802	923,765	914,927

Table S.12, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888				304	
CHEM 2								43,046	43,553	43,862				1,184	22,547
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	24,774	25,143	25,322	21,934	22,406	22,464	22,617	2,261
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	1,089	2,207	2,247	2,261	2,230	
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	107	107	194	195	196	199	203	205	216	206
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,294	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 10				7,190				7,190	7,197	7,248				202	
CHEM 11				7,159				7,159	7,166	7,217				201	
CHEM 12	13,602	14,318	13,745	23,390	14,318	14,318	14,318				14,603	14,895	14,961	14,584	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 14				5,400				5,400	5,405	5,444				152	
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,937	9,257	9,257	2,846	5,560	16,798	3,146	7,704	5,074	7,704	10,337
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	209,835	344,377	257,357	282,234	445,720	530,394	152,762	242,037	253,236	519,588	627,298
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	211,686	266,613	245,012	100,018	197,684	545,945	60,424	124,550	100,565	147,974	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	171,001	17,056	35,952	25,977	37,228	63,505

Table S.12, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501				18	
CHEM 2								607	1,825	5,127				41	
CHEM 3	1,261	2,604	4,270	262	808	3,376	1,099	311	1,742	1,838	270	2,774	160	2,300	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	2,358	7,178	1,074	96	71	498	315	1,811	1,383	220	1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651	346	1,432	3,166	1,287	204	5,599	649	687	64	394	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	1,697	11,330	9,320	605	9,027	14,096	338	1,686
CHEM 10				2,101				5,394	3,203	46,715			2,327	49	90
CHEM 11				1,145				2,351	951	11,616				27	
CHEM 12	978	9,572	18,682	512	741	22,496	4,079				170	3,133	478	1,527	4,321
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	167,533	24,099	32,993	24,638	42,701	64,008
CHEM 14				5,320					6,320	28,881			2,741	70	
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				120	90	7,920				10	
CHEM 2								6	3,713	3,248				49	
CHEM 3	28	19,836	75,777	4,471	2,253	73,239	51,329	30,671	34,607	48,606	7,173	1,682	3,092	57,242	48,220
CHEM 4		488	7,276		130	15,620	3,499	244	25	8,838			407	244	
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278			4,704			103	438	1,137	
CHEM 8															
CHEM 9			272		2,777		284				44		1,382		25
CHEM 10															
CHEM 11										6					
CHEM 12		284	5,496	9	19	2,734	210	12			6	90	38	2,282	316
CHEM 13															
CHEM 14															
CHEM 15															

Table S.12, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2								6	22	15	28				
CHEM 3	1,261	31	4,270	3	802	43	1,098	3	18	12	283	32	129	19	1,273
CHEM 4															
CHEM4B	50	130	463	3	74	204	37	3		28	75	51	97	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,721	3,188	2,256	1,895	4,462	6,974	3,517	1,010	13,165	27,600	1,650	2,069	1,923	1,008
CHEM 9		37	271	111	2,777	154	284	253	167	1,698	3,441	1,066	2,448	52	26
CHEM 10				978				2,265	2,601	26,722	53,443				
CHEM 11				50				62	49	305	610	13	13	1	
CHEM 12	12	18	121	9	6	160	37			31	62	13	19	19	39
CHEM 13	76,419	186,579	483,303	126,203	260,256	307,494	133,066	114,203	219,133	441,821	780,195	156,028	284,097	171,079	248,541
CHEM 14				271				528	6	1,997	3,994				
CHEM 15															

APPENDIX T

SUMMARIES OF THE POLICY SCENARIOS

Table T.1. Scenario: Base Policy

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

31,199,006

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,586,646	3,418,338	1,492,012	1,669,497	1,210,764	574,340	3,022,487	2,745,717	655,338	1,847,240	2,298,996	515,150	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2389.63

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A3t	A4t	A3t	A12t	A12t	A1t	A3t	A1t	A3t	A3t	A1t

Table T.1, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
CORN																
BASE	6,172		4,937					987			197		237	87		
NONB		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	6,222	6,107	6,420	6,223	6,373	6,460	
WHEAT																
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716	
NONB									3	27	73	137	159	3,553	838	
BARLEY																
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	
NONB										3	23	60	112	130	130	130
DC SOYBEAN																
BASE																
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460	
FS SOYBEAN																
BASE																
NONB				3,086				3,086	3,089							

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,596
MAR	8,165	9,072	8,347	4,536	6,857	9,072	6,857	4,412	4,571	9,146	6,982	9,438	9,462	7,165	9,497
APR	4,610	5,122	4,713	2,561	5,635	5,122	5,635	2,479	2,564	5,164	5,738	5,329	5,342	5,890	5,362
MAY	1,500	1,666	1,533	7,931	4,413	1,666	4,413	7,904	7,938	1,680	4,494	1,733	1,738	4,613	1,744
JUN	11,714	11,714	11,714	11,714	12,885	11,714	12,885	11,714	11,726	11,812	13,173	12,203	12,282	13,780	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	18,757	17,052	18,757	12,466	12,622	17,198	19,151	17,775	17,858	20,217	17,992
OCT	4,610	4,610	4,610	9,054	5,071	4,610	5,071	9,054	9,063	4,652	5,193	4,816	4,850	5,645	4,906
NOV	8,887	8,887	8,887	8,887	9,776	8,887	9,776	8,887	8,896	8,959	9,986	9,245	9,303	10,233	9,303
DEC															

Table T.1, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			19,481		56,309	7,664	
NONB		1,018,319	229,585	598,648	987,461	1,524,393	923,276	167,868	627,036	1,356,314	669,326	1,457,356	1,642,962	499,677	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914	199,623	356,386
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,684	25,983	24,164
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	266,614	351,783	256,740	367,212	766,034	454,179	161,395	430,145	471,604	186,058	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,272	810,049	985,586	1,216,049	985,586	793,813	808,383	1,226,289	2,105,937	1,266,931	1,272,163	1,060,415	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	463,520	468,448	506,954	513,150	523,921	526,297	540,719	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	818,259	825,784	873,979	884,950	903,448	907,828	936,339	914,927

Table T.1, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811						
CHEM 2															
CHEM 3	19,385	21,539	19,816	10,769	21,539	21,539	21,539	10,425	10,780	21,713	21,934	22,406	22,464	22,516	22,547
CHEM 4*	2,160	2,160	2,160	1,080		2,160		1,080	1,081	2,178		2,247	2,261		
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194		107		194	195	196	199	203	205		
CHEM 8	3,148	3,148	3,148	3,148		3,148		3,148	3,151	3,173	3,215	3,274	3,295		3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10				7,190				7,190	7,197						
CHEM 11				7,159				7,159	7,166						
CHEM 12	13,602	14,318	13,745	23,390		14,318		23,160	23,413	14,434		14,895	14,960		14,988
CHEM 13	10,800	10,800	10,800	10,800	3,641	10,800	3,641	10,800	10,811	10,888	3,720	11,235	11,306	3,812	11,306
CHEM 14				5,400				5,400	5,405						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,320	9,257	6,789	3,046	9,267	19,909	1,887	7,704	5,156	3,874	10,337

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	156,759	344,377	199,961	193,700	324,946	632,739	138,942	242,037	246,886	484,724	627,298

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	159,104	266,613	212,297	100,018	197,684	512,660	48,425	124,550	100,565	111,698	214,159

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EROSION (METRIC TONS)	15,522	32,771	113,556	29,500	48,509	66,530	66,654	26,974	47,692	160,767	13,345	35,952	25,977	28,668	63,505

Table T.1, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93						
CHEM 2															
CHEM 3	1,261	2,604	4,270	262	518	3,376	691	311	1,742	2,955	88	2,773	161	1,168	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34		7,178		96	71	3,627		1,810	14,096		1,686
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	651		1,432		1,376	225	5,170		687	65		271
CGEM 9		500	1,716	1,080	24,977	1,327	3,493	3,401	2,094	16,338	473	9,027	14,096	207	90
CHEM 10				2,101				5,394	3,203						
CHEM 11				1,145				2,351	951						
CHEM 12	978	9,572	18,682	512		22,496		936	2,471	3,596		3,133	478		4,322
CHEM 13	17,709	47,435	105,944	28,371	4,584	70,369	27,168	31,941	45,384	154,159	6,560	32,993	24,638	10,497	64,009
CHEM 14				5,320				10,739	6,338						
CHEM 15															

PERCOLATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				130				120	179						
CHEM 2															
CHEM 3	28	19,836	75,777	4,471	2,685	73,239	59,624	8,163	42,234	139,570	7,808	1,682	3,092	69,537	48,220
CHEM 4		488	7,276			15,620		244	25	8,461			407		
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333			278				5,021			103		1,137
CHEM 8															
CHEM 9			272										1,383		26
CHEM 10															
CHEM 11															
CHEM 12		284	5,496	9		2,734		6	2,181	2,800		90	39		317
CHEM 13															
CHEM 14															
CHEM 15															

Table T.1, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,261	31	4,270	3	5	43	6	3	18	31		32	96	6	1,145
CHEM 4															
CHEM4B	49	130	463	3		204		3	6	99		51	45		65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,256		4,462		3,754	1,106	12,568		1,650	419		943
CHEM 9		37	271	111	2,543	154	228	253	352	1,530	44	1,066	1,382	45	26
CHEM 10				978				2,265	2,601						
CHEM 11				49				62	49			13			
CHEM 12	12	18	121	9		160		6	37	31		13	6		38
CHEM 13	76,419	186,580	483,303	126,203	69,514	307,494	40,342	114,203	219,133	564,131	21,273	156,028	128,070	46,306	236,539
CHEM 14				271				528	6						
CHEM 15															

Table T.2. Scenario: Cost-Share Green Manure (100%)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
37,667,135

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,801,459	3,764,478	4,979,590	3,623,017	2,108,043	2,190,413	1,759,404	1,012,362	3,291,139	3,173,576	1,113,311	2,244,245	2,674,705	905,197	1,926,192

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2953.98

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A16tL	A16tL	A15tL	A15tL	A15tL	A16tL	A16tL	A16tL	A15tL	A15tL	A16tL	A15tL	A15tL	A16tL	A15tL

Table T.2, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172	6,172	6,172					1,234			247		296	109	
NONB				6,172	6,172	6,172	6,172	4,937	6,178	6,222	6,058	6,420	6,164	6,352	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB															

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	1	0	0	ERR	0	0	ERR	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB															
MAR															
APR	13,250	13,250	12,244	13,362	14,479	13,362	14,479	14,233	13,375	13,470	14,741	13,899	13,932	15,134	13,987
MAY	6,965	6,965			7,739		7,739	7,584			7,875			8,088	
JUN	12,885	12,885	11,714	11,714	12,885	11,714	12,885	12,953	11,726	11,812	13,242	12,203	12,282	13,851	12,331
JUL	7,739	7,739			7,739		7,739	7,739			7,906			8,101	
AUG															
SEP	17,779	17,779	16,163	17,052	18,757	17,052	18,757	18,561	17,070	17,197	19,144	17,775	17,849	20,213	17,992
OCT	5,071	5,071	4,610	4,610	5,071	4,610	5,071	5,071	4,615	4,651	5,093	4,816	4,849	5,644	4,906
NOV	9,775	9,775	8,887	8,887	9,775	8,887	9,775	9,775	8,895	8,959	9,986	9,244	9,302	10,233	9,302
DEC															

Table T.2, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384	733,190	1,033,131					71,097			24,351		70,386	7,664	
NONB				1,197,296	987,461	1,524,393	923,276	315,987	1,254,071	1,356,314	663,915	1,457,356	1,627,320	497,974	1,563,399
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,571
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	24,683	25,983	24,164
SOYBEANS															
BASE															
NONB	231,436	310,124	333,268	401,156	249,951	351,783	240,693	157,376	475,682	454,179	151,308	430,145	471,604	174,429	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NITROGEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LITTER	40,599,513	40,599,513	40,599,513	43,559,980	36,381,247	36,381,247	36,381,247	35,932,548	36,418,492	36,688,518	37,108,035	37,908,159	38,047,910	39,057,297	38,343,834
PHOSPHORUS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POTASSIUM	240,772	240,772	240,772	240,772	320,832	320,832	320,832	319,231	321,173	323,648	327,995	334,825	336,708	350,332	339,768

Table T.2, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1			10,800	10,800		10,800			10,811	10,888		11,235	11,305		11,306
CHEM 2															
CHEM 3			19,385	21,539		21,539			21,560	21,713		22,406	22,443		22,546
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*			194	194		194			195	196		203	205		207
CHEM 8			3,147	3,147		3,148			3,151	3,173		3,274	3,293		3,295
CHEM 9			10,800	10,800		10,800			10,811	10,888		11,235	11,306		11,306
CHEM 10															
CHEM 11			7,159	7,159		7,159			7,166	7,217		7,447	7,493		7,494
CHEM 12			23,742	25,180		25,180			25,204	25,384		26,193	26,289		26,358
CHEM 13			10,800	10,800		10,800			10,811	10,888		11,235	11,306		11,306
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	4,629	6,418	1,851	4,320	4,937	8,023	3,048	2,471	11,198	2,516	1,926	1,289	6,456	5,168
PERCOL	30,858	399,366	792,375	272,168	362,275	917,104	455,466	589,387	15,469	920,178	217,515	139,315	521,026	823,280	530,393
SEDIMENT	32,092	67,023	141,330	39,498	112,940	122,815	155,524	61,074	56,835	261,307	50,317	53,929	45,868	65,837	119,515

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8,387	15,133	45,880	9,813	29,192	27,093	45,053	15,209	11,181	56,306	13,772	13,097	1,289	19,691	32,560

Table T.2, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1			1,660	25		191			61	1,748		45	64		387
CHEM 2															872
CHEM 3			1,066	18		1,327			432	1,331		1,656	263		
CHEM 4															
CHEM 4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8			352	327		864			74	4,087		481	19		155
CHEM 9			913	543		660			1,575	12,113		6,067	9,286		6
CHEM 10															
CHEM 11			40,634	364		10,183			766	8,542		2,760	2,229		2,648
CHEM 12			16,425	74		16,157			463	3,589		2,446	245		3,378
CHEM 13			81,891	16,509		43,874			21,819	122,348		21,944	14,629		46,650
CHEM 14															
CHEM 15															

PERCOLATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1			183	98		13,954			457	18,453		19	671		167
CHEM 2															
CHEM 3			140,564	22,421		147,008			157,456	262,154		2,535	15,405		69,590
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			67			537			37	8,517			368		2,720
CHEM 8															
CHEM 9															
CHEM 10			6												
CHEM 11			15,003			6				12					
CHEM 12						11,492			15,468	9,512		135	155		588
CHEM 13															
CHEM 14															
CHEM 15															

Table T.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1											6				6
CHEM 2															
CHEM 3			5			5				6		6			6
CHEM 4															
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8			302	790		2,216				105	8,380		1,008	110	155
CHEM 9				43		55			340	1,039		725	1,046		
CHEM 10															
CHEM 11				18		259			43	224		71	77		19
CHEM 12						92				25		13			
CHEM 13			94,739	45,423		134,442			66,484	281,907		61,241	56,237		115,471
CHEM 14															
CHEM 15															

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Table T.3. Scenairo: No Aatrex

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
29,847,705

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,108,133	3,196,037	3,458,250	3,352,481	1,379,669	1,537,385	1,108,613	526,095	2,973,232	2,687,672	575,562	1,760,347	2,218,233	443,929	1,522,069

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,286

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A6t	A6t	A13t	A5tL	A6t	A5tL	A13t	A13t	A13t	A5tL	A6t	A6t	A5tL	A6t

Table T.3, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937				987	1,185			435		324	152	
NONBASE		6,172	1,234	3,086	6,172	6,172	5,184	1,901	3,089	3,111	5,870	6,420	6,136	6,309	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	3,086	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONB				3,086				3,086	3,089	3,111					

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(0)	(0)	(0)	0	(0)	(0)	(0)	0	0	0	0	(0)	0	(0)	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB		1,500	1,500	1,500		1,500		1,500	1,501	1,513		1,567	1,578		1,596
MAR	10,326	9,072	8,347	4,536	11,473	9,072	11,290	4,381	4,572	4,604	11,639	9,438	9,449	11,982	9,497
APR	9,715	5,122	4,713	2,561	10,794	5,122	10,622	2,463	2,564	2,582	10,951	5,329	5,335	11,273	5,362
MAY	2,332	1,666	1,533	7,931	2,580	1,666	2,539	7,899	7,938	7,995	2,617	1,733	1,736	2,694	1,744
JUN	12,885	11,714	11,714	11,714	12,885	11,714	12,885	11,714	11,726	11,812	13,173	12,203	12,283	13,780	12,331
JUL	7,739				7,739		7,739				7,906			8,101	
AUG															
SEP	17,780	17,052	16,341	12,609	18,757	17,052	18,601	12,438	12,622	12,718	17,169	17,775	17,846	20,206	17,992
OCT	5,071	4,610	4,610	9,054	5,071	4,610	5,071	9,054	9,063	9,131	4,669	4,816	4,850	5,645	4,906
NOV	9,776	8,887	8,887	8,887	9,776	8,887	9,776	8,887	8,896	8,959	8,989	9,245	9,303	10,233	9,303
DEC															

Table T.3, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384		826,505				132,952	85,317			42,857		16,956	10,702	
NONB		1,018,319	229,585	598,648	987,461	1,524,393	775,552	152,069	627,036	678,157	643,352	1,457,356	1,620,021	494,599	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
DC SOYB															
BASE															
NONB	246,965	413,499	333,268	654,193	266,614	351,783	256,740	367,212	766,034	734,152	161,395	430,145	471,604	186,058	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1,216,049	1,153,272	810,049		1,216,049		791,065	808,383	814,431		1,266,931	1,271,058		1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
38,462,291				41,168,230		40,735,280				92,897,696			44,046,016	

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	502,679	480,461	467,964		502,679		462,632	468,448	471,957		523,921	525,906		530,113

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
247,960	866,552	833,226	824,925	249,029	866,552	248,858	816,926	825,784	832,012	254,884	903,448	907,241	275,211	914,927

Table T.3, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888					
CHEM 2															
CHEM 3															
CHEM 4*		2,160	2,160	1,080		2,160		1,080	1,081	1,089		2,247	2,261		2,261
CHEM 5		22,958	21,122	11,479		22,958		11,038	11,491	11,572		23,883	23,912		24,032
CHEM 6															
CHEM 7*		194	194	194		194		194	194	196		203	205		207
CHEM 8		3,148	3,147	3,148		3,148		3,148	3,151	3,173		3,274	3,295		3,295
CHEM 9		10,800	10,800	10,800		10,800		10,800	10,811	10,888		11,235	11,306		11,306
CHEM 10				7,190				7,190	7,197	7,248					
CHEM 11				7,159				7,159	7,166	7,217					
CHEM 12		14,318	13,745	23,391		14,318		23,114	23,413	23,580		14,895	14,950		14,988
CHEM 13		10,800	10,800	10,800		10,800		10,800	10,811	10,888		11,235	11,306		11,306
CHEM 14				5,400				5,400	5,406	5,444					
CHEM 15		7,159	6,586	3,580		7,159		3,442	3,583	3,609		7,447	7,456		7,494

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	9,257	11,183	2,777	4,937	9,875	8,561	3,038	5,270	20,220	1,883	7,704	5,152	4,516	10,337

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	106,090	341,291	504,222	98,746	324,011	559,767	477,990	192,942	324,947	432,092	241,919	242,037	246,686	787,990	627,298

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	42,090	1,238,986	307,864	112,632	177,742	266,613	224,761	99,840	197,684	545,945	54,662	124,550	100,486	125,849	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	32,771	113,556	29,500	50,175	66,530	70,613	26,925	47,692	171,001	19,491	35,952	25,955	32,206	63,505

Table T.3, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501					
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b		4,437	2,833	34		7,128		96	71	498		1,811	1,383		1,686
CHEM 5		1,173	19,706	139		1,136			1,149	579		1,290	90		672
CHEM 6															
CHEM 7															
CHEM 8		623	647	605		1,432		728	2,839	2,874		687	65		271
CHEM 9		500	1,716	1,080		1,327		3,401	2,094			9,027	14,096		90
CHEM 10				2,101				5,394	3,203	18,603					
CHEM 11				1,145				2,351	951	46,653					
CHEM 12		9,072	17,575	512		22,057		936	2,471	11,616		2,607	433		4,051
CHEM 13		47,435	105,944	28,371		70,369		31,892	45,384	6,782		32,993	24,623		64,009
CHEM 14				5,320				10,739	6,338	167,533					
CHEM 15		383	358			173			454	28,949		925	6		39

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				139				181	426	8,076					
CHEM 2															
CHEM 3															
CHEM 4		488	7,276			15,620		244		8,838			407		
CHEM 4b															
CHEM 5		1,345	6,751	37		315		24	25	653		315	13		988
CHEM 6															
CHEM 7			31			278				4,704			103		1,137
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11										6					
CHEM 12		142	4,599	9		2,685		6	5,270	5,858		39	39		123
CHEM 13															
CHEM 14															
CHEM 15		6,307	9,232			198			1,934	2,566		2,619	39		2,526

Table T.3, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	985	24	3,336	2	5	34	5	2	14	24		24	72	5	950
CHEM 4															
CHEM 4b	38	101	362	2		159		2	5	77		38	34		48
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	82	1,345	2,491	1,763		3,487		2,934	863	9,742		1,239	313		752
CHEM 9		29	212	87	1,987	120	178	198	275	1,186	34	800	1,032	34	19
CHEM 10				764				1,770	2,030						
CHEM 11				38				48	38			10			
CHEM 12	9	14	95	7		125		5	29	24		10	5		29
CHEM 13	59,715	145,797	377,662	98,617	57,355	240,281	31,525	89,240	171,067	437,280	16,536	117,204	95,594	34,567	185,535
CHEM 14				212				412	5						
CHEM 15															

Table T.4. Scenario: 1/3 Aatrex

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
30,340,973

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,146,675	3,223,012	3,522,514	3,374,435	1,417,118	1,581,424	1,140,317	578,858	2,989,649	2,718,671	602,466	1,788,312	2,244,953	467,260	1,545,309

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,324

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t,A5	A12t,A13t	A6t,A1	A12t,A13t	A5tL,A3t	A6t,A4t	A5tL,A3t	A12t	A13t,A12t	A13t,A12t	A5tL,A3t	A6t,A1t	A6t,A1t	A5tL,A3t	A6t,A1t
(33/67)	(74/26)	(66/34)	(33/67)	(67/33)	(67/33)	(67/33)		(63/37)	(37/63)	(65/35)	(67/33)	(67/33)	(67/33)	(67/33)

Table T.4, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,171	3,086	5,553				1,728	1,457			637		419	211	
NONBASE			617	3,086	6,172	6,171	4,443	1,629	3,089	3,111	5,667	6,420	6,042	6,249	6,460
WHEAT															
BASE	3,395	3,395	3,394	3,394	3,394	3,394	3,395	3,394	3,394	3,395	3,395	3,394	3,394		2,716
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,778	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBASE	6,171	6,171	6,172	6,171	6,171	6,171	6,171	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYB															
BASE															
NONBASE		3,086		3,086				3,086	3,089	3,111					

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	(0)	3	0	0	1	0	0	0	(0)	(0)	0	(0)	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	500	1,500	1,500	1,500	1,500	1,500	500	1,500	1,501	1,513	504	1,567	1,578	537	1,596
MAR	9,606	4,082	8,256	4,536	9,934	9,572	9,613	4,338	4,572	4,604	10,061	9,438	9,435	10,424	9,497
APR	8,013	2,305	4,661	2,561	9,074	5,122	8,772	2,440	2,564	2,582	9,193	5,329	5,327	9,534	5,362
MAY	2,047	7,847	1,516	7,931	3,191	1,666	3,118	7,891	7,938	7,995	3,220	1,733	1,733	3,306	1,744
JUN	12,494	11,713	11,714	11,714	12,885	11,714	12,885	11,714	11,726	11,812	13,173	12,203	12,283	13,780	12,331
JUL	5,159				5,159		5,159				5,323			5,509	
AUG															
SEP	17,241	12,164	16,252	12,609	18,757	17,052	18,483	12,399	12,622	12,718	19,082	17,775	17,832	20,197	17,992
OCT	4,917	9,053	4,610	9,054	5,071	4,610	5,071	9,054	9,063	9,131	5,193	4,816	4,850	5,645	4,906
NOV	9,479	8,887	8,887	8,887	9,775	8,887	9,775	8,887	8,896	8,959	9,986	9,245	9,303	10,233	9,303
DEC															

Table T.4, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	948,333	458,243	929,818				232,665	104,868			62,825		99,479	148,697	
NONBASE			114,792	598,648	987,461	1,524,393	664,759	130,345	627,036	678,157	621,166	1,457,356	1,594,995	489,938	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONBASE									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,865	22,248	21,436	25,983	24,164
DC SOYB															
BASE															
NONBASE	267,437	672,708	333,268	654,193	266,614	351,783	256,740	367,212	766,034	734,152	161,395	430,145	471,604	186,058	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
379,193	766,871	1,145,424	810,049	328,544	1,216,049	2,057,544	787,287	808,383	814,431	329,934	1,266,931	1,269,852	340,172	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
25,641,519				27,444,842		26,687,179				28,034,605			29,883,944	

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
158,302	454,077	477,684	467,964	167,568	502,679	167,568	461,409	468,448	471,957	168,316	523,921	525,479	173,516	530,113

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
440,270	804,095	829,059	824,925	454,878	866,552	454,578	815,093	825,784	832,012	468,653	903,448	906,601	487,240	914,927

Table T.4, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1		10,800		10,800				10,800	10,811	10,888					
CHEM 2															
CHEM 3	6,462	7,180	6,605	3,590	7,180	7,180	7,180	10,261	3,593	7,189	7,189	7,211	7,215	7,215	7,215
CHEM 4*	720	1,080	2,160	1,080		2,160		1,080	1,081	1,089		2,247	2,261		2,261
CHEM 5		2,678	13,851	7,652		15,305		11,038	7,661	3,909		16,196	16,186		16,342
CHEM 6															
CHEM 7*	64	194	194	194		165		194	194	196		203	205		207
CHEM 8	1,049	3,148	3,147	3,148		3,147		3,148	3,151	3,173		3,274	3,295		3,295
CHEM 9	3,600	10,800	10,800	10,800	3,600	10,800	3,600	10,800	10,811	10,888	3,605	11,235	11,306	3,618	11,306
CHEM 10		7,189		7,190				7,190	7,197	7,248					
CHEM 11		7,159		7,159				7,159	7,166	7,217					
CHEM 12	4,534	22,671	13,673	23,391		14,318		23,051	23,413	23,579		14,895	14,939		14,988
CHEM 13	3,600	10,800	10,800	10,800	1,214	10,800	1,214	10,800	10,811	10,888	1,215	11,235	11,306	1,220	11,306
CHEM 14		5,400		5,400				5,400	5,406	5,444					
CHEM 15		835	4,319	2,386		4,772			2,389	1,219		5,050	5,047		5,096

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,934	8,177	11,115	2,777	4,731	9,669	7,884	3,028	9,266	20,220	1,879	7,704	5,147	4,307	10,337

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	98,499	209,958	499,902	98,746	268,258	487,967	378,955	191,899	324,947	432,092	207,263	242,037	246,467	690,046	627,298

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	45,670	134,109	305,846	112,633	174,658	266,613	218,726	98,128	197,683	545,945	52,721	124,550	100,400	121,250	22,880

EROSION (METRIC TONS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	13,234	33,660	112,745	29,500	49,620	66,530	68,701	26,859	47,692	171,001	17,447	35,952	25,932	31,056	63,505

Table T.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1		53		93				407	93	2,501					
CHEM 2															
CHEM 3	420	1,222	1,423	87	173	1,125	230	306	581	1,217	29	893	51	374	405
CHEM 4															
CHEM 4b	841	151	19,706	34		7,145		96	71	498		1,811	1,383		1,686
CHEM 5		197	1,858	92		757			766	195		875	60		457
CHEM 6															
CHEM 7															
CHEM 8	4	757	646	620		1,432		1,376	1,968	4,897		687	65		271
CHEM 9		567	1,715	1,080	8,325	1,327	1,164	3,401	2,094	18,603	154	9,027	14,096	66	90
CHEM 10		7,549		2,101				5,394	3,203	46,694					
CHEM 11		14,342		1,145				2,351	951	11,616					
CHEM 12	326	16,535	17,931	512		22,057		936	2,471	6,782	2,146	2,775	447		4,137
CHEM 13	5,903	52,523	105,431	28,371	4,861	70,369	9,056	31,825	45,384	167,533		32,993	24,606	3,361	64,009
CHEM 14		3,169		5,320				10,739	6,338	42,907					
CHEM 15		59	234			115			303	11		627	4		26

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1		118		136				120	344	7,973					
CHEM 2															
CHEM 3	9	6,028	25,343	1,491	895	24,414	19,542	8,051	14,077	42,123	2,552	541	990	22,280	15,431
CHEM 4		2,055	7,276			15,620		244	25	8,838			407		
CHEM 4b		139													
CHEM 5		1,345	4,427	24		209		24	25	221		213	9		672
CHEM 6															
CHEM 7			134			278				4,704			103		1,137
CHEM 8															
CHEM 9			92										442		8
CHEM 10															
CHEM 11										4					
CHEM 12		509	4,890	9		2,701		6	4,240	5,858		55	39		185
CHEM 13															
CHEM 14															
CHEM 15		704	6,054			131			1,289	867		1,776	26		1,718

Table T.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1											12				
CHEM 2															
CHEM 3	420	6	1,423	1	2	14	2	3	6	8		10	96	2	407
CHEM 4															
CHEM 4b	16	9	463	3		204		3	6	28		51	45		65
CHEM 5		1	15	2		12			10	1		13			4
CHEM 6															
CHEM 7															
CHEM 8	35	1,900	3,183	2,145		4,462		3,753	1,042	13,688		1,650	419		1,008
CHEM 9		37	271	111	848	154	76	253	352	1,698	14	1,066	1,382	14	26
CHEM 10		5,162		978				2,265	2,601	26,697		4			
CHEM 11		389		49				62	49	305		4			
CHEM 12	4	110	114	9		156		6	37	62		13	6		39
CHEM 13	25,473	181,022	480,037	126,205	24,467	307,494	13,448	111,933	219,132	609,107	7,076	156,028	127,852	14,829	248,541
CHEM 14		117		271				528	6	1,997					
CHEM 15													4		

Table T.5. Scenario: Chemcial Taxation (300%)

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

18,539,793

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2,211,081	2,296,147	2,688,178	2,102,700	636,884	717,677	464,618	-138,542	1,900,860	1,831,127	74,987	1,109,520	1,642,574	31,716	970,267

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

1,420

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL	A5tL

Table T.5, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	
NONBASE									6	50		248	289		6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	27		137	159	3,394	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22		112	130	41	130
SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,172	6,420	6,460	6,172	6,460
FS SOYB															
BASE															
NONBASE															

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	0	0	266	0	0	536	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB															
MAR	37,548	37,548	37,548	37,548	37,548	37,548	37,548	37,548	37,589	37,886	37,548	39,228	39,500	37,548	43,672
APR	35,326	35,326	35,326	35,326	35,326	35,326	35,326	35,326	35,365	35,644	35,326	36,907	37,163	35,326	41,088
MAY	8,443	8,443	8,443	8,443	8,443	8,443	8,443	8,443	8,452	8,519	8,443	8,820	8,882	8,443	9,820
JUN	46,855	46,855	46,855	46,855	46,855	46,855	46,855	46,855	46,903	47,249	46,855	48,813	49,130	47,833	49,326
JUL	28,143	28,143	28,143	28,143	28,143	28,143	28,143	28,143	46,903	28,371	28,143	29,276	29,459	28,143	29,459
AUG															
SEP	64,654	64,654	64,654	64,654	64,654	64,654	64,654	64,654	64,725	65,236	64,654	67,546	68,015	66,650	71,969
OCT	18,441	18,441	18,441	18,441	18,441	18,441	18,441	18,441	18,461	18,607	18,441	19,266	19,399	19,568	19,625
NOV	35,549	35,549	35,549	35,549	35,549	35,549	35,549	35,549	35,584	35,837	35,549	36,980	37,212	35,549	37,212
DEC															

Table T.5, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384	733,190	826,505	862,053	888,715	1,097,563	830,948	355,486	902,045	968,699	608,770	1,008,691	1,173,103	435,470	
NONBASE									984	8,719		45,117	60,973	529,526	1,250,720
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		332,603
NONBASE									450	3,795	5,501	21,863	22,865	485,091	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	5,267	22,248	24,684	8,198	24,164
DC SOYB															
BASE															
NONB	246,865	330,799	266,614	320,926	266,614	281,426	256,740	167,868	380,546	363,343	157,994	344,116	488,523	177,743	330,769

NUTRIENTS PURCHSED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
38,462,291	38,462,290	38,462,290	38,462,290	38,462,290	38,462,290	38,462,290	38,462,290	38,504,253	38,808,483	38,462,290	40,182,630	40,461,413	39,407,454	43,356,386

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
247,960	247,959	247,959	247,959	247,959	247,959	247,959	247,959	248,230	250,191	247,959	259,050	260,847	261,280	264,581

Table T.5, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4*															
CHEM 5															
CHEM 6															
CHEM 7*															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	4,629	8,764	2,901	4,690	6,419	8,147	2,901	4,016	13,569	1,728	3,605	2,461	4,073	6,460
PERCOL	106,090	348,265	637,961	271,799	302,286	688,507	447,196	447,567	516,247	776,874	217,859	201,941	360,032	694,679	6,460
SEDIMENT	42,090	94,487	237,977	46,904	167,250	215,574	215,636	82,082	111,081	417,778	51,039	87,289	67,451	115,162	191,225

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,090	22,533	81,373	16,867	47,053	53,409	67,746	22,199	23,804	127,515	18,373	23,113	16,790	29,525	52,975

Table T.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

RUNOFF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

PERCOLATION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table T.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b															
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11															
CHEM 12															
CHEM 13															
CHEM 14															
CHEM 15															

Table T.8, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				91				400	91						
CHEM 2															
CHEM 3	1,237	2,556	4,190	257	509	3,313	678	305	1,710	2,901	86	2,724	158	1,147	1,244
CHEM 4															
CHEM 4B	2,477	4,355	19,338	33		7,044		94	70	3,560		1,778	1,358		1,656
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	11	612	635	639		1,405		1,350	221	5,075		675	63		
CHEM 9		491	1,684	1,060	24,511	1,302	3,428	3,337	2,055	16,036	464	8,865	13,845	203	89
CHEM 10				2,062				5,293	3,143						
CHEM 11				1,123				2,308	934						
CHEM 12	960	9,394	18,333	503		22,076		918	2,425	3,530		3,077	469		4,245
CHEM 13	17,379	46,550	103,968	27,842	14,312	69,056	26,661	31,345	44,539	151,307	6,440	32,401	24,199	10,310	62,868
CHEM 14				5,221				10,538	6,220						
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				127				118	176						
CHEM 2															
CHEM 3	28	19,466	74,364	4,388	2,635	71,873	57,531	8,011	41,447	139,570	7,666	1,652	3,037	68,298	47,361
CHEM 4		478	7,141			15,329		239	24	8,461			400		
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			327			273				5,021			101		1,117
CHEM 8															
CHEM 9			266											1,358	25
CHEM 10															
CHEM 11															
CHEM 12		279	5,394	9		2,683		6	2,140	2,800		88	38		311
CHEM 13															
CHEM 14															
CHEM 15															

Table T.6. Scenario: 40% Percolation Reduction

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

29,490,387

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,561,480	3,289,815	1,475,976	1,121,041	1,167,786	574,340	3,014,113	2,225,575	504,883	1,847,240	2,294,743	250,914	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2258.76

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A4t,A6t (89.8 /10.2)	A1t,A12t (63/37)	A4t	A3t,A4t (79/21)	A1t	A12t	A14t	A6t,A5tL (46/54)	A1t	A1t	A1t,A4t (47/53)	A6t	A1t

Table T.6, continued.

CROPLAND PLANTED - BASE/NONBASEASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					987			197		237	87	
NONBASE		6,172	1,234	5,029	6,172	6,172	6,172	2,098	3,089	6,222	6,107	6,420	6,223	6,373	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONBASE				1,142				3,086	3,089						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	701	1,536	1,567	1,578	1,669	1,596
MAR	8,165	9,072	9,694	7,393	10,572	21,915	9,072	4,412	4,571	26,828	9,239	9,438	10,289	9,484	9,497
APR	4,610	5,122	4,713	4,175	5,122	175,260	5,122	2,479	2,564	23,648	5,216	5,329	5,342	5,355	5,362
MAY	1,500	1,666	1,533	3,985	1,666	13,024	1,666	7,904	7,938	5,858	1,697	1,733	1,738	1,742	1,744
JUN	11,714	11,714	11,714	11,714	11,714	39,469	11,714	11,714	11,726	30,845	11,976	12,203	12,283	12,527	12,331
JUL										15,242					
AUG															
SEP	16,164	17,052	16,341	15,408	17,052	57,456	17,052	12,466	12,622	44,904	17,410	17,775	17,858	18,379	17,992
OCT	4,610	4,610	4,610	6,255	4,610	15,534	4,610	9,054	9,063	12,142	4,720	4,816	4,850	5,132	4,906
NOV	8,887	8,887	8,887	8,887	8,887	29,945	8,887	8,887	8,896	23,399	9,078	9,245	9,303	9,303	9,303
DEC															

Table I.6, continued.

MARKET SALES - BASE/NONBASEASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			24,351		56,309	7,664	
NONBASE		1,018,319	229,585	975,719	1,234,326	1,283,596	1,154,095	167,868	627,036	1,210,580	836,658	1,457,356	1,642,962	624,597	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONBASE									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONBASE	308,581	413,499	333,268	494,813	333,268	296,215	320,925	367,212	766,034	405,378	201,744	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,272	6,209,303	1,216,049	1,034,027	1,216,049	793,813	808,383	567,680	1,240,747	1,266,931	1,272,163	1,303,009	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
										22,296,598				

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	489,830	502,679	502,679	502,679	463,520	468,448	234,704	513,150	523,921	526,297	540,719	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	8,511,447	866,552	866,552	866,552	818,259	825,784	539,528	884,950	903,448	907,828	936,339	914,927

Table T.6, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				39,975				10,800	10,811						
CHEM 2															
CHEM 3	19,385	21,539	17,846	175,529	21,539	21,539	21,539	10,425	10,780		21,934	22,406	22,464		22,547
CHEM 4*	2,160	2,160	2,160	17,603	2,160	454	2,160	1,080	1,081	1,008	2,207	2,247	2,261	2,261	2,261
CHEM 5			2,100							10,710				24,000	
CHEM 6															
CHEM 7*	194	194	194	194	194	92	194	194	195	91	199	203	205	216	207
CHEM 8	3,148	3,148	3,148	3,148	3,148	662	3,148	3,148	3,151	1,468	3,215	3,274	3,295	3,295	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	5,038	11,033	11,235	11,306	11,306	11,306
CHEM 10				26,612				7,190	7,197						
CHEM 11				26,498				7,159	7,166						
CHEM 12	13,602	14,318	13,745	176,761	14,318	3,010	14,318	23,160	23,413	6,680	14,604	14,895	14,960	14,978	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	5,146	10,800	10,800	10,811	5,038	11,033	11,235	11,306	11,306	11,306
CHEM 14				19,988				5,400	5,405						
CHEM 15			646							3,340				7,484	

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,971	4,937	6,333	9,257	3,046	9,267	16,901	3,146	7,704	4,816	7,745	10,337
PERCOL	83,317	341,291	423,719	1,310,109	119,112	442,840	257,357	193,700	324,946	737,695	152,763	242,037	206,184	519,596	627,298
SEDIMENT	52,829	128,986	307,864	93,779	211,686	211,045	245,012	100,018	197,684	473,887	60,424	124,550	100,565	148,501	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	239,026	58,631	51,663	78,133	26,974	47,692	146,795	17,056	35,952	25,977	36,868	63,505

Table T.6, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				34				120	93						
CHEM 2									1,826						
CHEM 3	1,261	2,604	3,845	307	809	2,084	1,099	311	1,742		270	2,773	398		1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	176	2,358	1,509	1,074	96	71	1,679		1,810	1,383	226	1,686
CHEM 5			282							441	315			1,858	
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	568	346	301	3,166	1,376	204	2,393	649	687	65	394	271
CHEM 9		500	1,716	967	30,834	932	4,184	3,401	11,330	7,561	605	9,027	14,096	342	90
CHEM 10				778				5,394	3,203						
CHEM 11				424				2,351	951						
CHEM 12	978	9,572	18,571	376	741	4,728	4,079	936		1,457	170	3,133	478	832	4,322
CHEM 13	17,709	47,435	105,944	26,509	54,619	28,605	92,908	31,941	45,384	71,338	24,099	32,993	24,638	42,509	64,009
CHEM 14				1,969				10,739	6,317						
CHEM 15			36							23				961	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				48				120	90						
CHEM 2									3,716						
CHEM 3	28	19,836	68,209	7,634	2,253	81,355	51,329	8,163	34,607		7,173	1,682	3,092		48,220
CHEM 4		488	7,276		130	3,283	3,499	244	25	3,916			407	246	
CHEM4B															
CHEM 5			671							697				7,523	
CHEM 6															
CHEM 7			30		31	58				2,323			103	439	1,137
CHEM 8															
CHEM 9							284				44		654		26
CHEM 10															
CHEM 11															
CHEM 12		284	5,407	11	19	575	210	6		1,123	6	90	39	865	317
CHEM 13															
CHEM 14															
CHEM 15			918							2,531				103	

Table T.6, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2									22						
CHEM 3	1,261	31	36	5	12	24	1,098	3	18		270	32	96		1,273
CHEM 4															
CHEM4B	49	130	463	9	74	43	37	3		46	19	51	45	13	65
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	1,962	1,882	938	6,974	3,754	1,010	5,816	1,544	1,650	419	1,918	1,008
CHEM 9		37	271	99	2,777	105	284	253	167	708	44	1,066	1,382	52	26
CHEM 10				362				2,265	2,601						
CHEM 11				18				62	49			13			
CHEM 12	12	18	120	3	6	34	37	6		11		13	6	6	39
CHEM 13	76,419	186,580	483,303	109,586	260,256	127,102	133,066	114,203	219,133	261,056	76,961	156,028	128,070	171,404	248,541
CHEM 14				100				528							
CHEM 15															

Table T.7. Scenario: 40% Percolation/Runoff Reduction

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

28,130,220

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,287,683	3,407,142	1,090,155	1,555,025	677,631	434,481	2,851,117	1,858,136	504,251	1,758,899	2,291,871	251,347	1,594,695

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2154.58

TOTAL LAND AVAILABLE (HECTARE)

13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A3t,A6t (30/70)	A14t	A4t,A5tL, A6tL (28.5/38 /33.5)	A4t,A6t (16.5/83.5)	A3t	A1t,A13t, A14t (38.5/53 /8.5)	A4t,A6t A12t (83.6/4 /12.4)	A5tL	A1t	A1t,A2t A6t (3.7/3.4 /92.9)	A4t	A6t	A1t

Table T.7, continued.

CROPLAND PLANTED - BASE/NONBASEASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937		2,325		938	1,640			516		431	189	
NONBASE		6,172	1,234	3,086	3,847	6,172	5,234	2,635	5,798	6,222	5,789	6,420	6,029	6,271	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONBASE									3	27	73	136	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONBASE				3,086				1,897	380						

CROPLAND IDLE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	426	1,500	1,500	1,500	1,501		1,536	1,567	1,578	1,669	1,596
MAR	8,165	9,072	12,666	4,536	20,227	12,939	24,555	6,046	9,782	42,058	9,191	9,177	11,011	9,468	9,497
APR	4,610	5,122	8,898	2,561	16,499	7,656	20,178	3,412	4,812	39,570	5,189	5,419	5,326	5,346	5,362
MAY	1,500	1,666	5,449	7,931	3,656	4,037	15,802	5,472	2,439	9,457	1,688	1,733	1,732	1,739	1,744
JUN	11,714	11,714	22,348	11,714	24,950	17,507	46,855	11,714	11,726	47,249	11,975	12,357	12,283	12,527	12,331
JUL					10,600					28,371					
AUG															
SEP	16,164	17,052	31,015	12,609	34,982	25,485	67,669	14,085	16,523	68,791	173,465	17,775	17,830	18,364	17,992
OCT	4,610	4,610	8,796	9,054	9,820	6,890	18,441	7,341	5,162	18,607	4,721	4,816	4,850	5,132	4,906
NOV	8,887	8,887	16,955	8,887	18,930	13,282	35,549	8,887	8,896	35,837	9,078	9,245	9,303	9,303	9,303
DEC															

Table T.7, continued.

MARKET SALES - BASE/NONBASEASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		763,977		334,753		126,273	118,078			63,569		102,431	16,699	
NONBASE		1,018,319	229,585	598,648	769,392	1,474,135	78,972	210,828	1,176,987	1,085,051	793,082	1,457,356	1,591,715	614,558	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONBASE									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONBASE									447	3,690	9,864	22,248	21,435	25,983	24,164
SOYBEANS															
BASE															
NONBASE	308,581	413,499	313,098	654,193	308,162	340,185	256,740	306,547	511,377	363,343	201,743	430,145	471,604	232,572	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NITROGEN	1,137,577	1,216,049	1,089,834	810,049	347,271	1,178,058	976,827	942,202	1,167,016		1,236,703	1,278,769	1,269,695	1,301,706	1,280,964
LITTER				28,650,654						41,514,425					
PHOSPHORUS	474,907	502,679	480,461	467,964	143,552	502,679	498,459	473,966	498,925	0	511,718	514,147	525,423	540,258	530,113
POTASSIUM	824,894	866,552	833,226	824,925	421,100	866,552	860,222	829,901	862,329	251,261	882,803	888,788	906,517	935,647	914,927

Table T.7, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				6,637	1,329			380			
CHEM 2				57,859				4,807							
CHEM 3	19,385	21,539	5,866	10,770	13,426	21,539	21,212	9,197	19,357		21,882	1,831	22,368		22,547
CHEM 4*	2,160	2,160	1,506	1,080	1,346	1,804		1,496	2,029		2,207	2,171	2,261	2,261	2,261
CHEM 5			14,869					5,491	936			22,199		23,962	
CHEM 6												114			
CHEM 7*	194	194	136	194	121	104		194	195		199	203	205	216	207
CHEM 8	3,148	3,148	2,195	3,148	1,962	2,629		3,148	3,151		3,215	3,274	3,295	3,295	3,295
CHEM 9	10,800	10,800	10,800	10,800	6,732	10,800	10,800	10,800	10,811		11,033	10,855	11,306	11,306	11,306
CHEM 10				7,190				4,418	885			506			
CHEM 11				7,159				4,399	881			251			
CHEM 12	13,602	14,318	9,629		8,925	11,958		17,568	15,448		14,567	15,151	14,938	14,966	14,988
CHEM 13	10,800	10,800	8,634	10,800	6,732	9,620	3,641	10,800	10,811		11,033	11,615	11,306	11,306	11,306
CHEM 14				5,400				3,319	664						
CHEM 15			4,637					1,712	292			7,037		7,472	

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	10,137	2,777	4,844	8,647	6,733	3,020	11,409	14,310	3,136	7,614	4,500	7,737	10,337
PERCOL	83,317	341,291	484,538	98,746	257,731	364,928	197,710	234,255	417,005	828,098	152,059	245,425	169,174	519,053	627,298
SEDIMENT	52,829	128,986	282,334	112,632	194,951	255,019	210,795	96,932	157,050	440,489	60,265	122,922	100,388	148,401	222,880

EROSION (METRIC TONS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	15,522	32,771	102,604	29,500	55,666	63,427	66,174	26,290	36,819	134,760	17,010	35,392	25,929	36,844	63,505

Table T.7, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				250	11			2			
CHEM 2				333				50							
CHEM 3	1,261	2,604	787	262	502	3,106	681	200	2,389		268	130	609		1,266
CHEM 4															
CHEM 4B	2,524	4,434	13,743	34	673	5,994		156	236		315	1,749	1,382	226	1,686
CHEM 5			1,995						71			1,199		1,855	
CHEM 6															
CHEM 7															
CHEM 8	11	623	452	605	637	1,196		939	174		649	680	65	393	271
CHEM 9		500	1,542	537	11,303	1,245	3,493	3,128	1,688		605	8,721	14,096	342	90
CHEM 10				2,101				3,315	394			609			
CHEM 11				1,145	1,009			1,445	117			94			
CHEM 12	978	9,572	12,264	376	430	18,787		530	1,560		170	2,588	478	831	4,322
CHEM 13	17,709	47,435	83,471	28,371	44,237	61,652	26,954	30,464	38,999		24,042	33,255	24,604	42,471	64,009
CHEM 14				5,320				6,599	779						
CHEM 15			252						27			859		959	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				106	22						
CHEM 2				9											
CHEM 3	28	19,836	26,327	4,471	1,404	74,933	58,100	9,380	80,474		7,169	148	3,089		48,220
CHEM 4		488	5,074		81	13,045		169	3				407	246	
CHEM4B			4,753												
CHEM 5								13	758			292		7,510	
CHEM 6															
CHEM 7			22		121	232							103	439	1,137
CHEM 8															
CHEM 9					938				285		44				26
CHEM 10															
CHEM 11															
CHEM 12		284	3,212		12	2,283		5	4,861		6	39	39	863	317
CHEM 13															
CHEM 14															
CHEM 15			6,499						164			2,435		103	

Table T.7, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,260	31	5	3	274	39	6	3	23		270	1	96		1,273
CHEM 4															
CHEM4B	49	130	323	3	46	170		4	12		19	50	45	13	65
CHEM 5			16						1			18		19	
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	2,226	2,089	1,102	3,726		3,457	786		1,544	1,630	419	1,918	1,008
CHEM 9		37	262	111	1,731	144	228	248	319		44	1,029	1,382	52	26
CHEM 10				978	75			1,392	320			216			
CHEM 11				50				38	6			3			
CHEM 12	12	18	77		4	134		3	15			13	6	6	39
CHEM 13	76,419	186,580	376,365	126,203	113,188	269,847	40,344	109,874	187,824		76,733	156,469	127,837	171,259	248,541
CHEM 14				271				324	1						
CHEM 15													6		6

Table T.8. Scenario: Buffer Strip

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

30,639,062

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,165,678	3,283,587	3,521,569	3,356,299	1,465,807	1,639,889	1,189,627	564,991	2,967,420	2,695,908	644,025	1,814,201	2,257,762	506,030	1,566,266

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2346.74

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	307	307	307	307	307	307	307	307	307	307	307	307	307	307	307

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A3t	A4t	A3t	A12t	A12t	A1t	A3t	A1t	A1t	A3t	A1t

Table T.8, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,057		4,845					969			194		233	85	
NONBASE		6,057	1,211	3,028	6,057	6,057	6,057	2,059	3,031	6,107	5,996	6,305	6,113	6,260	6,345
WHEAT															
BASE	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331	3,331		2,665
NONBASE									3	27	73	137	159	3,490	825
BARLEY															
BASE	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725	2,725
NONBASE									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,057	6,057	6,057	6,057	6,057	6,057	6,057	6,057	6,063	6,107	6,189	6,305	6,345	6,345	6,345
FS SOYBEAN															
BASE															
NONBASE				3,028				3,028	3,031						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,472	1,473	1,485	1,508	1,539	1,550	1,640	1,568
MAR	8,013	8,903	8,191	4,452	6,729	10,375	6,729	4,330	4,486	8,977	6,855	9,268	9,293	7,040	9,327
APR	4,524	5,027	4,625	2,513	5,530	5,027	5,530	2,433	2,516	5,068	5,633	5,233	5,247	5,785	5,267
MAY	1,472	1,635	1,504	7,783	4,330	1,635	4,330	7,756	7,790	1,649	4,412	1,802	1,707	4,531	1,713
JUN	11,495	11,495	11,495	11,495	12,645	11,495	12,645	11,495	11,507	11,594	12,933	12,203	12,064	13,534	12,112
JUL															
AUG															
SEP	15,862	16,734	16,036	12,373	18,408	16,734	18,408	12,234	12,387	16,880	18,802	17,457	17,541	19,857	17,676
OCT	4,524	4,524	4,524	8,885	4,977	4,524	4,977	8,885	8,894	4,566	5,098	4,730	4,764	5,544	4,819
NOV	8,721	8,721	8,721	8,721	9,594	8,721	9,594	8,721	8,730	8,793	9,804	9,245	9,137	10,051	9,137
DEC															

Table T.8, continued.

MARKET SALES - BASE/NONBASEASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,073,819		811,088					69,771			19,481		55,259	6,017	
NONBASE		999,324	229,585	587,481	969,042	1,495,958	906,054	164,737	615,351	1,331,219	657,113	1,431,224	1,613,737	490,779	1,535,541
WHEAT															
BASE	398,730	429,255	431,708	422,714	449,696	407,724	404,726	404,726	404,726	413,720	422,714	479,676	431,708		316,586
NONBASE									450	3,795	10,303	21,863	22,865	544,419	108,900
BARLEY															
BASE	429,255	448,878	414,538	458,690	458,690	434,161	485,672	385,103	402,273	402,273	404,726	488,124	466,048	490,577	464,909
NONBASE									447	3,690	9,864	22,248	24,684	25,983	24,164
SOYBEANS															
BASE															
NONBASE	302,826	405,786	327,052	641,990	261,641	345,221	251,951	360,362	751,759	445,775	158,448	422,432	463,200	182,742	406,093

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,116,358	1,193,366	1,131,759	794,939	967,202	1,193,366	967,202	779,006	793,320	1,203,605	987,587	1,244,248	1,249,536	1,041,535	1,258,173

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
466,048	493,303	471,499	459,235	493,303	493,303	493,303	454,874	459,719	497,577	503,790	514,544	516,940	531,094	520,685

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
809,507	850,389	817,683	809,537	850,389	850,389	850,389	802,996	810,396	857,813	868,811	887,284	891,694	919,673	868,660

Table T.8, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,599				10,598	10,609						
CHEM 2															
CHEM 3	19,023	21,137	19,446	10,569	21,137	21,137	21,137	10,230	10,579	21,312	21,533	22,004	22,064	22,115	22,145
CHEM 4*	2,120	2,120	2,120	1,060		2,120		1,060	1,061	2,137		2,207	2,221		2,221
CHEM 5															
CHEM 6															
CHEM 7*	191	191	191	191		105		191	191	193		199	201		203
CHEM 8	3,089	3,089	3,089	3,089		3,089		3,089	3,092	3,114		3,216	3,236		3,236
CHEM 9	10,599	10,599	10,599	10,599	10,599	10,599	10,599	10,599	1,609	10,686	10,831	11,034	11,104	11,104	11,104
CHEM 10				7,056				7,056	7,063						
CHEM 11				7,026				7,026	7,033						
CHEM 12	13,349	14,051	13,489	22,954		14,051		22,728	22,977	14,167		14,627	14,694		14,721
CHEM 13	10,599	10,599	10,599	10,599	3,573	10,599	3,573	10,599	10,610	10,686	3,652	11,034	11,104	3,744	11,104
CHEM 14				5,299				5,299	5,305						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,392	9,085	10,974	2,725	4,320	9,085	6,662	2,989	9,094	19,541	1,853	7,566	5,065	3,808	10,152
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	81,763	334,925	494,817	96,904	153,835	337,953	196,231	190,087	318,891	621,032	136,405	14,627	242,487	476,087	616,120
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	51,844	126,581	302,122	110,532	159,104	261,641	208,344	98,152	194,003	503,176	48,204	122,317	98,773	109,710	218,909

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,232	32,160	111,437	28,950	47,604	65,289	65,410	26,471	46,803	157,792	13,101	35,308	25,514	28,157	62,373

Table T.8, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,237	30	4,190	3	5	42	6	3	18	30		31	95	6	1,250
CHEM 4															
CHEM4B	48	127	454	3		200		3	6	98		50	44		63
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	103	1,690	3,128	2,214		4,379		3,684	1,085	12,335		1,620	412		990
CHEM 9		36	266	109	2,543	151	224	248	345	1,502	43	1,047	1,358	44	25
CHEM 10				960				2,223	2,552						
CHEM 11				48				60	48			13			
CHEM 12	11	18	119	9		157		6	36	30		13	6		38
CHEM 13	74,994	183,100	474,290	123,850	69,714	301,759	39,591	112,072	215,052	553,695	21,223	153,230	125,788	45,482	244,112
CHEM 14				266				518	6						
CHEM 15															

Table T.9. Scenario: CRP

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

29,398,671

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,009,909	3,076,108	3,239,329	3,083,246	1,551,975	1,671,395	1,292,238	775,134	2,668,722	2,428,083	795,947	1,691,199	2,014,050	652,450	1,446,065

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2251.52

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334	3,334
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A12t	A3t	A4t	A3t	A12t	A12t	A1t	A3t	A1t	A1t	A3t	A1t

Table T.9, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	4,823		3,858					772			154		185	68	
NONBASE		4,823	965	2,411	4,823	4,823	4,823	1,640	2,411	4,823	4,668	4,823	4,637	4,755	4,823
WHEAT															
BASE	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652	2,652		2,122
NONBASE														2,652	531
BARLEY															
BASE	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170
NONBASE															
DC SOYBEAN															
BASE															
NONBASE	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823	4,823
FS SOYBEAN															
BASE															
NONBASE				2,411				2,411	2,411						

CROPLAND IDLE (HECTARE)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,244	1,186
MAR	6,380	7,098	6,522	3,545	5,358	8,261	5,358	3,448	3,569	7,089	5,341	7,089	7,067	5,350	7,089
APR	3,602	4,003	3,683	2,001	4,403	4,003	4,403	1,937	2,001	4,003	4,389	4,003	3,990	4,397	4,003
MAY	1,172	1,302	1,198	6,197	3,448	1,302	3,448	6,176	6,197	1,302	3,437	1,302	1,298	3,443	1,302
JUN	9,153	9,153	9,153	9,153	10,069	9,153	10,069	9,153	9,153	9,153	10,069	9,153	9,153	10,279	9,192
JUL															
AUG															
SEP	12,630	13,325	12,769	9,853	14,657	13,325	14,657	9,742	9,853	13,325	14,633	13,325	13,298	15,076	13,403
OCT	3,602	3,603	3,603	7,075	3,963	3,603	3,963	7,075	7,075	3,603	3,963	3,603	3,603	4,205	3,647
NOV	6,945	6,945	6,945	6,945	7,639	6,945	7,639	6,945	6,945	6,945	7,639	6,945	6,945	7,639	6,945
DEC															

Table I.9, continued.

MARKET SALES - BASE/NONBASEASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	855,051		645,845					55,557							
NONBASE		795,732	179,402	467,794	771,619	1,191,187	721,464	131,175	489,496	1,051,331	511,645	1,094,735	1,224,282	372,770	1,167,074
WHEAT															
BASE	317,497	358,080	343,756	336,595	358,080	324,659	322,272	322,272	322,272	329,433	336,595	381,952	343,756		252,088
NONBASE														413,781	70,024
BARLEY															
BASE	341,803	357,429	330,084	365,241	365,241	345,710	386,726	306,646	320,318	320,318	322,272	388,679	371,101	390,632	363,288
NONBASE															
SOYBEANS															
BASE															
NONBASE	241,131	323,116	260,422	511,198	208,337	274,889	200,621	286,946	598,005	352,051	123,459	323,116	352,051	138,891	308,648

NUTRIENTS PURCHASED (KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NITROGEN	888,923	950,242	901,187	632,986	770,154	950,242	770,154	620,299	631,033	950,242	768,713	950,242	947,888	790,939	954,765
LITTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHOSPHORUS	371,101	392,802	375,441	365,675	392,802	392,802	392,802	362,203	365,675	392,802	392,108	392,802	391,969	403,239	394,951
POTASSIUM	644,587	677,139	651,097	644,611	677,139	677,139	677,139	639,402	664,611	677,139	676,098	677,139	675,889	698,168	681,437

Table I.9, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				8,440				8,440	8,440						
CHEM 2															
CHEM 3	15,148	16,831	15,485	8,416	16,831	16,831	16,831	8,146	8,416	16,831	16,777	16,831	16,777	16,807	16,831
CHEM 4*	1,688	1,688	1,688	844		1,688		844	844	1,688		1,688	1,688		1,688
CHEM 5															
CHEM 6															
CHEM 7*	152	152	152	152		84		152	152	152		152	152		154
CHEM 8	2,460	2,460	2,460	2,460		2,460		2,460	2,460	2,460		2,460	2,460		2,460
CHEM 9	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440
CHEM 10				5,618				5,618	5,618						
CHEM 11				5,594				5,594	5,594						
CHEM 12	10,629	11,188	10,741	18,278		11,189		18,098	18,278	11,189		11,189	11,167		11,189
CHEM 13	8,440	8,440	8,440	8,440	2,845	8,440	2,845	8,440	8,440	8,440	2,845	8,440	8,440	2,845	8,440
CHEM 14				4,220				4,220	4,220						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	2,701	7,234	8,739	2,170	3,376	7,234	5,305	2,380	7,234	15,432	1,444	5,787	3,849	2,892	7,716

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	65,105	266,691	394,008	77,162	122,495	269,102	156,253	151,361	253,670	490,460	106,277	181,813	184,280	361,830	468,276

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	41,281	100,792	240,570	88,012	131,656	208,336	165,897	78,155	154,323	397,382	37,558	93,558	75,064	83,382	166,380

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12,129	25,608	88,734	23,052	37,906	51,988	52,084	21,078	37,231	124,617	10,208	27,006	19,390	21,400	47,406

Table I.9, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				72				218	72						
CHEM 2															
CHEM 3	985	2,035	3,336	205	405	2,638	540	243	1,360	2,291	67	2,083	120	872	945
CHEM 4															
CHEM 4B	1,972	3,468	15,399	27		5,609		75	56	2,812		1,360	1,032		1,259
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	9	487	506	509		1,119		1,075	176	4,008		516	48		203
CHEM 9		391	1,341	844	19,517	1,037	2,730	2,657	1,635	12,664	362	6,781	10,523	154	68
CHEM 10				1,642				4,215	2,501						
CHEM 11				895				1,837	743						
CHEM 12	764	7,480	14,598	400		17,578		731	1,929	2,788		2,353	357		3,226
CHEM 13	13,838	37,067	82,787	22,170	11,396	54,988	21,229	24,959	35,429	119,495	5,018	24,783	18,396	7,835	47,783
CHEM 14				4,157				8,391	4,948						
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				101				94	140						
CHEM 2															
CHEM 3	22	15,500	59,214	3,494	2,098	57,230	45,810	6,379	32,970	108,186	5,973	1,264	2,308	51,906	35,996
CHEM 4		381	5,686			12,206		191	19	6,559			304		
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			260			217				3,892			77		849
CHEM 8															
CHEM 9			212										1,032		19
CHEM 10															
CHEM 11															
CHEM 12		222	4,295	7		2,136		5	1,702	2,170		68	29		236
CHEM 13															
CHEM 14															
CHEM 15															

Table T.9, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	985	24	3,336	2	5	34	5	2	14	24		24	72	5	950
CHEM 4															
CHEM4B	38	101	362	2		159		2	5	77		38	34		48
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	82	1,345	2,491	1,763		3,487		2,934	863	9,742		1,239	313		752
CHEM 9		29	212	87	1,987	120	178	198	275	1,186	34	800	1,032	34	19
CHEM 10				764				1,770	2,030						
CHEM 11				38				48	38			10			
CHEM 12	9	14	95	7		125		5	29	24		10	5		29
CHEM 13	59,715	145,800	3,777,662	98,617	57,355	240,281	31,525	89,240	171,067	437,280	16,536	117,204	95,594	34,567	185,535
CHEM 14				212					412	5					
CHEM 15															

Table T.10. SCENARIO: BASE FLEXIBILITY

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

456,828,996

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
96,863,015	71,672,865	114,369,081	15,631,051	1,923,945	1,601,147	1,316,808	29,855,455	26,285,246	17,648,663	5,358,663	18,151,804	39,409,667	4,821,841	11,920,345

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

34989.97

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A1t	A1t	A1t	A4t	A3t	A3t	A1t	A1t	A3t	A1t	A1t	A3t	A1t

Table I.10, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
NONBASE															
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,398	3,422	3,468	3,531	3,553	3,553	3,553
NONBASE															
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,780	2,800	2,837	2,889	2,907	2,907	2,907
NONBASE															
DC SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,222	2,240	2,240	2,270	2,311	2,326	2,326	2,326
NONBASE															

CROPLAND IDLE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,166	1,166	1,166	1,166	1,166	1,166	1,166	1,166	1,168	1,176	1,192	1,213	1,221	1,221	1,221
MAR	6,351	6,351	6,351	6,351	6,351	7,517	6,857	4,800	6,357	6,402	4,903	6,606	6,648	5,024	6,648
APR	3,586	3,586	3,586	3,586	3,586	3,586	5,635	3,944	3,589	3,615	4,029	3,730	3,753	4,129	3,753
MAY	6,277	6,277	6,277	6,277	6,277	6,277	4,413	8,199	6,283	6,327	8,376	6,529	6,570	8,583	6,570
JUN	10,825	10,825	10,825	10,825	10,825	10,825	13,374	11,908	10,836	10,913	12,164	11,261	11,331	12,465	11,331
JUL															
AUG															
SEP	12,572	12,572	12,572	12,572	12,572	12,572	19,755	13,829	12,584	12,673	14,126	13,078	13,160	14,476	13,160
OCT	6,785	6,785	6,785	6,785	6,785	6,785	5,635	7,144	6,792	6,840	7,292	7,058	7,103	7,478	7,103
NOV	8,887	8,887	8,887	8,887	8,887	8,887	9,776	9,776	8,896	8,959	9,986	9,245	9,303	10,233	9,303
DEC															

Table T.10, continued.

MARKET SALES - BASE/NONBASEASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	875,384	733,190	826,505	862,053	888,715	878,050	664,759	284,389	902,931	976,546	497,500	1,049,296	1,227,980	364,673	1,125,648
NONBASE															
WHEAT															
BASE	325,047	366,595	351,931	344,599	366,595	332,379	329,935	329,935	329,935	339,999	352,017	406,776	368,394	399,093	337,694
NONBASE															
BARLEY															
BASE	349,931	365,928	337,934	373,927	373,927	353,931	395,922	313,938	328,258	330,592	337,038	413,940	397,698	418,629	389,325
NONBASE															
SOYBEANS															
BASE															
NONBASE	457,441	600,129	491,015	583,343	491,015	516,195	256,740	281,180	684,735	655,759	272,606	626,599	680,918	31,146	604,170

NUTRIENTS PURCHASED (KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NITROGEN	884,782	884,782	884,782	884,782	884,782	884,782	721,734	721,734	885,782	891,950	737,270	920,399	926,171	755,495	926,171
LITTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHOSPHORUS	444,357	444,357	444,357	444,357	444,357	527,674	444,357	444,357	444,357	447,957	453,923	462,245	465,144	465,144	465,144
POTASSIUM	761,583	761,583	761,583	761,583	761,583	916,549	761,583	761,583	761,583	767,752	777,977	792,241	797,209	797,209	797,209

Table T.10, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1															
CHEM 2															
CHEM 3	15,077	15,077	15,077	15,077	15,077	21,539	15,077	15,077	15,092	15,199	15,402	15,684	15,783	15,783	15,783
CHEM 4*	2,938	2,938	2,938	2,938	2,938	2,160	778	778	2,941	2,962	794	3,056	3,075	814	3,075
CHEM 5															
CHEM 6															
CHEM 7*	151	151	151	151	151	119			151	152		157	158		158
CHEM 8	3,148	3,148	3,148	3,148	3,148	3,148			3,151	3,173		3,274	3,295		3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,306	11,306
CHEM 10	5,177	5,177	5,177	5,177	5,177		5,177	5,177	5,182	5,219	5,288	5,385	5,419	5,419	5,419
CHEM 11															
CHEM 12	16,059	16,059	16,059	16,059	16,059	14,318	3,888	3,888	16,074	16,189	3,972	16,705	16,810	4,070	16,810
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	3,641	3,641	10,811	10,888	3,720	11,235	11,306	3,812	11,306
CHEM 14	3,888	3,888	3,888	3,888	3,888		3,888	3,888	3,892	3,920	3,972	4,045	4,070	4,070	4,070
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,407	8,147	11,689	2,975	5,085	9,257	7,455	1,926	9,637	19,835	1,967	6,703	4,664	4,458	10,026
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	82,576	283,266	474,277	128,530	204,318	344,377	185,519	190,987	402,427	107,230	122,685	199,703	226,112	450,673	565,822
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	64,382	147,205	383,590	104,461	255,233	314,401	2,563,911	95,993	192,028	597,038	66,071	144,798	118,624	152,230	266,487

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16,603	33,134	127,833	25,327	68,898	66,530	76,944	23,394	42,060	170,390	16,827	36,638	27,617	36,839	71,471

Table T.10, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1															
CHEM 2															
CHEM 3	981	1,823	3,249	233	568	3,376	484	194	1,821	2,069	62	1,941	113	819	886
CHEM 4															
CHEM 4B	2,691	4,546	19,968	284	2,598	7,178	124	69	311	3,986	11	1,961	1,483	14	1,791
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	15	623	671	529	353	1,432	84	4	195	5,197	7	693	72	33	309
CHEM 9		500	1,716	901	30,834	1,327	3,493	2,469	1,631	16,338	473	9,027	14,096	207	90
CHEM 10	9,512	566	91,227	1,500	16,177		11,033	3,884	2,271	33,590	1,861	10,703	23,064	1,321	837
CHEM 11															
CHEM 12	1,605	9,845	18,894	264	857	22,496	242	27	1,407	5,028	9	3,586	592	77	4,971
CHEM 13	19,441	50,018	114,725	26,250	56,920	70,369	40,959	11,694	41,297	160,341	10,081	35,076	26,371	18,531	67,910
CHEM 14		2,262	6,505	3,808	46,235		15,066	7,732	4,553	20,790		17,870	27,164	1,879	2
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1			7	49			422	11	31	11	154		2		
CHEM 2															
CHEM 3	23	13,891	62,323	9,348	2,155	73,239	48,269	14,154	75,285	107,230	7,545	1,177	2,862	50,478	46,861
CHEM 4	127	1,967	11,327		143	15,620	571	176	18	158,405	20	106	584	137	1,342
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			333		333	278				5,021			103		1,137
CHEM 8															
CHEM 9			272		2,777				315				1,383		26
CHEM 10															
CHEM 11															
CHEM 12	18	380	6,560	9	19	2,734	18		3,752	4,410	2	75	60	5	222
CHEM 13															
CHEM 14															
CHEM 15															

Table T.10, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2															
CHEM 3	1,261	28	4,177	5	722	39	5		2,335	28		29	87	6	1,145
CHEM 4															
CHEM4B	60	136	478	14	87	217	7	2	17	120		61	52		69
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	163	1,801	3,418	1,874	1,972	4,617	247	18	935	12,763	27	1,723	485	119	1,229
CHEM 9		37	271	92	2,777	154	228	222	315	1,530	44	1,066	1,382	45	26
CHEM 10	7,463	3,713	64,659	695	10,340	17,599	5,721	1,631	1,846	18,931	1,010	7,789	16,796	928	763
CHEM 11													11		
CHEM 12	23	24	132		8	179	4		15	53		24	9	2	47
CHEM 13	100,432	220,689	603,028	112,789	299,329	289,675	102,001	50,439	219,561	652,349	38,727	187,969	153,711	83,651	283,251
CHEM 14		80	549	191	3,755	378	838	380		1,433	252	1,745	2,800	156	65
CHEM 15															

APPENDIX U

SUMMARIES OF THE POLICY SCENARIOS WITHOUT POULTRY LITTER

Table U.1. Scenario: Cost-Share Green Manure (100%), Without Poultry Litter

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
32,549,333

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,665,131	3,486,980	3,713,076	3,418,338	1,693,828	1,848,507	1,350,728	574,340	3,022,487	2,900,557	655,338	1,990,967	2,298,996	515,150	1,714,909

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2516.03

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A15t	A15t	A15t	A12t	A15t	A15t	A15t	A12t	A12t	A15t	A3t	A15t	A1t	A3t	A15t

Table U.1, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					988			198		237	88	
NONB		6,172	1,235	3,086	6,172	6,172	6,172	2,098	3,089	6,222	6,107	6,420	6,223	6,373	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394		2,716
NONB									3	28	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONB									3	23	60	112	130	130	130
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,535	1,567	1,578	1,669	1,596
MAR				4,536				4,412	4,571		6,982		9,462	7,168	
APR	12,244	13,361	12,468	2,561	13,362	13,362	13,362	2,479	2,564	13,470	5,738	13,899	5,342	5,890	13,987
MAY	1,500	1,666	1,533	7,930	1,666	1,666	1,666	7,904	1,938	1,680	4,493	1,733	1,738	4,613	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	13,173	12,203	12,282	13,779	12,331
JUL															
AUG															
SEP	16,163	17,052	16,341	12,609	17,052	17,052	17,052	12,466	12,622	17,197	19,151	17,775	17,858	20,217	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	4,651	5,192	4,816	4,850	5,645	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,986	9,244	9,303	10,233	9,302
DEC															

Table U.1, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			19,481		56,309	6,131	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,035	1,356,314	669,326	1,457,356	1,642,962	499,677	1,563,399
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,571
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,864	22,248	21,436	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	643,193	333,268	351,783	320,925	367,212	766,033	454,179	161,395	430,145	471,604	186,057	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,177,124	1,251,205	1,194,295	810,048	1,055,056	1,055,056	1,055,056	793,812	808,383	1,063,967	1,005,936	1,099,336	1,272,163	1,060,415	1,111,971

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	502,679	502,679	502,679	463,520	468,448	506,954	513,149	523,921	526,297	540,719	530,112

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,225	824,925	866,552	866,552	866,552	818,259	825,784	873,977	884,950	903,448	907,827	936,339	914,927

Table U.1, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888		11,235			11,306
CHEM 2															
CHEM 3	19,835	21,539	19,816	10,769	21,539	21,539	21,539	10,425	10,780	21,713	21,934	22,406	22,443	22,516	22,546
CHEM 4*				1,080					1,081				2,261		
CHEM 5															
CHEM 6															
CHEM 7*	194	194	194	194	194	194	194	194	195	196		203	205		207
CHEM 8	3,147	3,147	3,147	3,147	3,147	3,147	3,147	3,147	3,151	3,173		3,274	3,295		3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 10				7,190				7,190	7,197						
CHEM 11	7,159	7,159	7,159	7,159	7,159	7,159	7,159	7,159	7,166	7,217		7,447			7,494
CHEM 12	23,742	25,180	24,030	23,390	25,180	25,180	25,180	23,160	23,413	25,384		26,193	14,960	3,811	26,358
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	3,720	11,235	11,305		11,306
CHEM 14				5,400				5,400	5,405						
CHEM 15															

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	1,173	3,086	7,677	2,777	3,703	5,554	6,789	3,046	9,266	12,443	1,887	2,568	5,156	3,873	5,814

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	22,218	154,869	578,948	98,746	320,925	764,048	330,799	193,700	324,946	821,254	138,942	142,525	246,885	484,724	552,358

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	24,563	58,630	142,811	112,632	120,346	122,815	134,541	100,018	197,685	261,307	49,100	53,929	100,565	111,701	119,516

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6,369	12,467	46,369	29,500	31,784	27,093	39,251	26,974	47,692	56,306	13,772	13,097	25,977	28,668	32,561

Table U.1, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1	1,234		1,660	92	271	191	6	407	93	1,748		45			387
CHEM 2															872
CHEM 3	600	1,345	1,090	263	426	1,327	111	310	1,742	1,331	88	1,656	161	1,168	
CHEM 4															
CHEM 4B				34				96	71			1,382			
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	5	418	353	651	154	864	2,401	1,376	225	4,087		481	64		155
CHEM 9		327	913	1,080	23,236	660	3,104	3,400	2,094	12,113	473	6,067	14,096	207	6
CHEM 10				2,101				5,394	3,203						
CHEM 11	4,604	7,356	40,634	1,145	4,555	10,183	629	2,351	951	8,542		2,760			2,648
CHEM 12	257	7,844	16,425	512	679	16,157	31	936	2,471	3,589		2,446	478		3,378
CHEM 13	12,333	31,321	83,683	28,371	36,993	43,874	71,190	31,941	45,384	122,348	6,560	21,944	24,638	10,497	46,650
CHEM 14				5,320				10,739	6,338						
CHEM 15															

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1			183	130	457	13,954	3,456	120	179	18,453		19			167
CHEM 2															
CHEM 3	1,018	42,467	143,011	4,471	7,739	147,008	95,734	8,163	42,234	262,154	7,808	2,535	3,092	69,537	69,590
CHEM 4								244					407		
CHEM4B															
CHEM 5															
CHEM 6															
CHEM 7			67		55	537				8,517			103		2,720
CHEM 8															
CHEM 9													1,382		
CHEM 10															
CHEM 11			6			6				12					
CHEM 12		1,105	15,084	9	228	11,492	383	6	2,181	9,512		135	39		588
CHEM 13															
CHEM 14															
CHEM 15															

Table U.1, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1	6		6							6	6				6
CHEM 2															
CHEM 3			6	3	6	6		3	19	6	6	6	103	6	6
CHEM 4															
CHEM4B				3				3	6				45		
CHEM 5															
CHEM 6															
CHEM 7															
CHEM 8	28	876	1,589	2,256	987	2,216	4,962	3,755	1,106	8,381	8,381	1,008	1,428		155
CHEM 9		25	191	111	2,061	56	142	253	352	1,039	1,083	725	2,108	45	
CHEM 10				978				2,265	2,601						84
CHEM 11	86	185	858	49	154	259	6	62	49	224	224	71	71		19
CHEM 12		49	99	9	6	93		6	37	25	25	13	19		
CHEM 13	33,853	79,663	213,314	126,203	140,595	134,442	87,118	114,203	219,133	281,907	303,525	61,241	189,311	46,307	115,471
CHEM 14				272				528	6						
CHEM 15															

Table U.2. Scenario: No Aatrex, Without Poultry Litter

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)
29,417,912

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,082,581	3,196,037	3,458,250	3,352,481	1,363,969	1,537,385	1,057,158	523,858	2,973,232	2,687,672	415,689	1,760,347	2,217,681	269,504	1,522,069

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,253

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A6t	A6t	A6t	A13t	A6t	A6t	A6t	A13t	A13t	A13t	A6t	A6t	A6t	A13t	A6t

Table U.2, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937					988			197		237	87	
NONBASE		6,172	1,234	3,086	6,172	6,172	6,172	2,098	3,089	3,111	6,107	6,420	6,223	3,143	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,394	3,395	3,394	3,394		2,716
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
SOYBEAN															
BASE															
NONBASE	6,172	6,172	6,172	3,086	6,172	6,172	6,172	6,172	6,178	6,222	6,305	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				3,086	3,089	3,111				3,230	

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,535	1,567	1,578	1,669	1,596
MAR	8,165	9,072	8,347	4,536	9,072	9,072	9,072	4,412	4,572	4,604	9,238	9,438	9,462	4,767	9,497
APR	4,610	5,122	4,713	2,561	5,122	5,122	5,122	2,479	2,564	2,582	5,216	5,329	5,342	2,674	5,362
MAY	1,500	1,666	1,533	7,931	1,666	1,666	1,666	7,904	7,938	7,995	1,697	1,733	1,737	8,299	1,744
JUN	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,714	11,726	11,812	11,975	12,203	12,282	12,527	12,331
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	17,052	17,052	17,052	12,467	12,622	12,718	17,410	17,775	17,858	13,727	17,992
OCT	4,610	4,610	4,610	9,054	4,610	4,610	4,610	9,054	9,063	9,131	4,720	4,816	4,850	9,783	4,906
NOV	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,887	8,896	8,959	9,078	9,245	9,303	9,303	9,303
DEC															

Table U.2, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			24,351		56,309	7,664	
NONB		1,018,319	229,585	598,648	1,234,326	1,524,393	1,154,095	167,868	627,036	678,157	836,658	1,457,356	1,642,962	308,040	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	333,268	351,783	320,925	367,212	766,034	734,152	201,743	430,145	471,604	407,001	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,576	1,216,049	1,153,272	810,049	1,216,049	1,216,049	1,216,050	793,812	808,383	814,431	1,240,747	1,266,931	1,272,163	871,778	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,910	502,679	480,461	467,964	502,679	502,679	502,679	463,520	468,448	471,957	513,150	523,921	526,297	504,380	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	866,552	866,552	866,552	818,259	825,784	832,012	884,950	903,448	907,827	892,764	914,927

Table U.2, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888				11,305	
CHEM 2															
CHEM 3															
CHEM 4*	2,160	2,160	2,160	1,080	2,160	2,160	2,160	1,080	1,081	1,089	2,206	2,247	2,261	1,130	2,261
CHEM 5	20,663	22,958	21,122	11,479	22,958	22,958	22,958	11,112	11,491	11,572	23,379	23,883	23,944	11,984	24,032
CHEM 6															
CHEM 7*	194	194	194	194	194	194	194	194	194	196	199	203	205	216	207
CHEM 8	3,147	3,148	3,147	3,148	3,148	3,148	3,148	3,148	3,151	3,173	3,215	3,274	3,295	3,295	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 10				7,190				7,190	7,197	7,248				7,526	
CHEM 11				7,159				7,159	7,166	7,217				7,494	
CHEM 12	13,602	14,318	13,745	23,391	14,318	14,318	14,318	23,160	23,413	23,580	14,603	14,895	14,960	24,464	14,988
CHEM 13	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 14				5,400				5,400	5,406	5,444				5,653	
CHEM 15	6,443	7,159	6,586	3,580	7,159	7,159	7,159	3,464	3,583	3,609	7,290	7,447	7,466	3,737	7,494

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,937	9,875	9,257	3,046	5,270	20,220	3,146	7,704	5,156	8,066	10,337
PERCOL	83,317	341,291	504,222	98,746	209,835	559,767	257,357	193,700	324,947	432,092	152,763	242,037	246,885	388,507	627,298
SEDIMENT	52,829	128,986	307,858	112,632	211,686	266,608	245,013	100,018	197,685	545,945	60,424	124,550	100,565	192,724	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,556	29,500	62,765	66,530	78,133	26,974	47,692	171,001	17,056	35,952	25,977	50,555	63,505

Table U.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501				678	
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b	2,524	4,437	2,833	34	2,357	7,128	1,074	96	71	498		1,811	1,383	19	1,686
CHEM 5	416	1,173	19,706	139	37	1,136	574	1,149	579	63	1,290	90	1,227	672	
CHEM 6															
CHEM 7											315				
CHEM 8	11	623	647	605	346	1,432	3,166	728	2,839	2,874	649	687	65	400	271
CHEM 9		500	1,716	1,080	30,833	1,327	4,184	3,401	2,094		605	9,027	14,096	433	90
CHEM 10				2,101				5,394	3,203	18,603				1,854	
CHEM 11				1,145				2,351	951	46,653				1,040	
CHEM 12	234	9,072	17,575	512	728	22,057	3,820	936	2,471	11,616	351	2,607	433	2,188	4,051
CHEM 13	17,709	47,435	105,944	28,371	54,619	70,369	92,908	31,941	45,384	6,782	24,098	32,993	24,638	49,814	64,009
CHEM 14				5,320				10,739	6,338	167,533				2,623	
CHEM 15	56	383	358			173	6		454	28,949	113	925	6	689	39

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				139				181	426	8,076				417	
CHEM 2															
CHEM 3															
CHEM 4		488	7,276		130	15,620	3,499	244		8,838			407	190	
CHEM 4b															
CHEM 5	5	1,345	6,751	37	21,169	315	339	24	25	653	19	315	13	3,431	988
CHEM 6															
CHEM 7			31		31	278				4,704			103	2,364	1,137
CHEM 8															
CHEM 9															
CHEM 10															
CHEM 11										6					
CHEM 12		142	4,599	9	18	2,685	160	6	5,270	5,858		39	39	2,236	123
CHEM 13															
CHEM 14															
CHEM 15	555	6,307	9,232		12	198			1,934	2,566	19	2,619	39	48	2,526

Table U.2, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1										12	12			6	
CHEM 2															
CHEM 3															
CHEM 4															
CHEM 4b	49	130	463	3	74	204	37	3	6	28	75	51	97		65
CHEM 5	6	12	23	3		19	6		15	3	3	19	19	16	6
CHEM 6															
CHEM 7															
CHEM 8	106	1,722	3,188	2,089	1,882	4,462	6,974	3,517	1,010	13,165	14,964	1,650	2,070	2,212	1,008
CHEM 9		37	272	111	2,777	154	284	253	352	1,699	1,743	1,066	2,448	58	26
CHEM 10				978				2,265	2,601	26,697	52,989	6	6	1,302	
CHEM 11				49				62	49	305	305			52	
CHEM 12	12	62	110	9	6	154	31	6	37	62	93	13	19	35	39
CHEM 13	76,419	186,580	483,294	126,203	260,256	307,488	133,066	114,203	219,133	609,107	853,355	156,028	284,097	215,368	248,541
CHEM 14				272				528	6	1,997	3,988			216	
CHEM 15												6			

Table U.3. Scenario: 1/3 Reduction in Aatrex Use

TOTAL NET RETURNS, DISCOUNTED (15 YEARS)

30,050,142

NET RETURNS, DISCOUNTED

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,129,640	3,245,369	3,501,047	3,374,435	1,406,652	1,581,424	1,108,362	574,340	2,989,649	2,718,671	494,764	1,788,312	2,243,798	348,368	1,545,309

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

2,302

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t,A6	A1t,A6t	A6t,A1	A12t,A13t	A3t,A6t	A4t,A6t	A3t,A6t	A12t	A12t,A13t	A12t,A13t	A3t,A6t	A1t,A6t	A1t,A6t	A3t,A13t	A1t,A6t
(33.3/66.7)	(33.3/66.7)	(31.8/68.2)	(33.3/66.7)	(33.3/66.7)	(33.3/66.7)	(33.3/66.7)		(33.3/66.7)	(66.2/33.8)	(33.0/67.0)	(32.2/67.8)	(33.3/66.7)	(33.3/66.7)	(33.3/66.7)

Table U.3, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,171		4,937					988			197		237	87	
NONBASE		6,171	1,234	3,086	6,171	6,171	6,171	2,098	3,089	3,111	6,107	6,420	6,223	4,181	6,461
WHEAT															
BASE	3,395	3,395	3,395	3,394	3,395	3,395	3,395	3,394	3,394	3,395	3,395	3,394	3,395		2,715
NONBASE									3	27	73	137	159	3,553	838
BARLEY															
BASE	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777	2,777
NONBASE									3	22	60	112	130	130	130
DC SOYBEAN															
BASE															
NONBASE	6,171	6,171	6,171	6,171	6,172	6,171	6,171	6,172	6,178	6,222	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONBASE				3,086				3,086	3,089	3,111				2,192	

CROPLAND IDLED (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,501	1,513	1,536	1,567	1,578	1,669	1,596
MAR	8,165	9,072	8,346	4,536	8,334	9,572	8,334	4,412	4,572	4,604	8,499	9,438	9,462	5,541	9,497
APR	4,610	5,122	4,713	2,561	5,293	5,122	5,293	2,479	2,564	2,582	5,387	5,329	5,342	3,707	5,362
MAY	1,500	1,666	1,533	7,931	2,582	1,666	2,582	7,904	7,938	7,995	2,613	1,733	1,738	7,112	1,744
JUN	11,714	11,714	11,714	11,714	12,104	11,714	12,104	11,714	11,726	11,812	12,371	12,203	12,282	12,930	12,331
JUL															
AUG															
SEP	16,163	17,052	16,341	12,609	17,621	17,052	17,621	12,466	12,622	12,718	17,984	17,775	17,858	15,813	17,992
OCT	4,610	4,610	4,610	9,054	4,764	4,610	4,764	9,054	9,063	9,131	4,877	4,816	4,850	8,254	4,906
NOV	8,887	8,887	8,887	8,887	9,183	8,887	9,183	8,887	8,896	8,959	9,378	9,245	9,303	9,602	9,303
DEC															

Table U.3, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505					71,097			19,481		56,309	6,131	
NONB		1,018,319	229,585	598,648	1,152,034	1,524,393	1,077,151	167,868	627,036	678,157	785,087	1,457,356	1,642,962	370,889	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	458,244	415,474	412,419	412,419	412,419	421,584	430,749	488,793	439,914		322,603
NONB									450	3,795	10,303	21,863	22,865	554,296	110,572
BARLEY															
BASE	437,414	457,410	422,417	467,408	467,408	442,413	494,903	392,423	409,920	409,920	412,419	497,403	474,907	499,902	464,909
NONB									447	3,690	9,865	22,248	21,436	25,983	24,164
DC SOYB															
BASE															
NONB	308,581	413,499	333,268	654,193	311,049	351,783	299,529	367,212	766,034	734,152	188,434	430,145	471,604	336,001	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,576	1,216,049	1,153,271	810,049	1,139,225	1,216,049	1,139,224	793,812	808,383	814,431	1,163,702	1,266,931	1,272,164	32,719	1,280,964

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,906	502,679	480,461	467,964	502,679	502,679	502,679	463,520	468,448	471,957	513,150	523,921	526,297	516,058	530,113

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,225	824,925	866,552	866,552	866,552	818,259	825,784	832,012	884,950	903,448	907,827	906,766	914,927

Table U.3, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				10,800	10,811	10,888				7,672	
CHEM 2															
CHEM 3	6,462	7,180	6,605	3,590	7,180	7,180	7,180	10,425	3,593	7,189	7,189	7,211	7,215	7,215	7,215
CHEM 4*	2,160	2,160	2,160	1,080	1,440	2,160	1,440	1,080	1,081	1,089	1,479	2,247	2,261	767	2,261
CHEM 5	13,775	15,305	14,081	7,652	15,305	15,305	15,305		7,661	3,909	15,716	16,196	16,186	8,154	16,342
CHEM 6															
CHEM 7*	194	194	194	194	130	165	129	194	194	196	133	203	205	146	207
CHEM 8	3,147	3,148	3,147	3,148	2,098	3,147	2,098	3,148	3,151	3,173	2,155	3,274	3,295	2,236	3,295
CHEM 9	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,800	10,811	10,888	11,033	11,235	11,306	11,305	11,306
CHEM 10				7,190				7,190	7,197	7,248				5,108	
CHEM 11				7,159				7,159	7,166	7,217				5,086	
CHEM 12	13,602	14,318	13,745	23,391	9,545	14,318	9,545	23,051	23,413	23,579	9,802	14,895	14,939	16,616	14,988
CHEM 13	10,800	10,800	10,800	10,800	8,414	10,800	8,414	10,800	10,811	10,888	8,620	11,235	11,306	8,897	11,306
CHEM 14				5,400				5,400	5,406	5,444				3,836	
CHEM 15	4,295	4,773	4,319	2,386	4,773	4,772	4,773		2,389	1,219	4,901	5,050	5,068	2,543	5,096

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	4,731	9,669	8,434	3,046	9,266	20,220	2,732	7,704	5,156	6,723	10,337
PERCOL	83,317	341,291	504,222	98,746	192,143	487,967	238,224	193,700	324,947	432,092	148,237	242,037	246,885	419,398	627,298
SEDIMENT	52,829	128,986	307,867	112,633	197,285	266,613	234,109	100,018	197,688	389,792	56,705	119,384	97,257	166,712	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,555	29,500	58,013	66,530	74,306	26,974	47,692	171,001	15,837	35,952	25,977	43,531	63,505

Table U.3, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				407	93	2,501				460	
CHEM 2															
CHEM 3	420	868	1,423	87	173	1,125	230	310	581	1,217	29	893	52	374	405
CHEM 4															
CHEM 4b	2,524	4,437	19,706	34	1,572	7,145	715	96	71	498	211	1,811	1,383	13	1,686
CHEM 5	277	782	1,889	92	25	757	383		766	195	42	875	61	835	457
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	620	230	1,432	2,110	1,376	1,968	4,897	435	687	65	272	271
CHEM 9		499	1,716	1,080	28,881	1,327	3,954	3,401	2,094	18,603	561	9,027	14,096	360	90
CHEM 10				2,101				5,394	3,203	46,694				1,258	
CHEM 11				1,145				2,351	951	11,616				706	
CHEM 12	482	9,239	17,944	512	485	22,057	2,547	936	2,471	6,782	101	2,775	447	1,488	4,137
CHEM 13	17,709	47,435	105,944	28,371	41,273	70,369	70,993	31,941	45,384	167,533	18,330	32,993	24,638	37,199	64,009
CHEM 14				5,320				10,739	6,338	42,907				1,780	
CHEM 15	37	255	238			115	4		303	11	76	627	4	469	26
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				136				120	344	7,973				283	
CHEM 2															
CHEM 3	9	6,612	25,089	1,491	895	24,414	19,542	8,163	14,077	42,123	2,574	541	990	2,287	15,431
CHEM 4		487	7,276		86	15,620	2,333	244	25	8,838			407	129	
CHEM 4b															
CHEM 5	4	897	4,500	24	14,112	209	226		25	221	13	213	9	2,335	672
CHEM 6															
CHEM 7			127		20	278				4,704			103	1,604	1,137
CHEM 8															
CHEM 9			86										442		8
CHEM 10															
CHEM 11										4					
CHEM 12		189	4,898	9	12	2,701	107	6	4,240	5,858		55	39	1,521	185
CHEM 13															
CHEM 14															
CHEM 15	370	4,205	6,154		8	131			1,289	867	13	1,776	26	33	1,718

Table U.3, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1										12	12			4	
CHEM 2															
CHEM 3	420	10	1,423	1	2	14	2	3	6	8	8	10	107	2	407
CHEM 4															
CHEM 4b	49	130	463	3	49	204	25	3	6		13	35	66		66
CHEM 5	4	8	15	2		12	4		10	1	1	13	13	11	4
CHEM 6															
CHEM 7															
CHEM 8	106	1,722	3,188	2,145	1,255	4,462	4,649	3,755	1,042	13,380	14,415	1,493	1,809	1,501	1,008
CHEM 9		37	272	111	2,699	154	265	253	352	1,699	1,743	723	2,070	54	26
CHEM 10				978				2,265	2,601	404	404	1,996	1,996	883	
CHEM 11				49				62	49	305	305	25	25	35	
CHEM 12	12	47	114	9	4	156	20	6	37	31	31	11	15	24	39
CHEM 13	76,419	186,580	483,308	126,205	197,967	307,493	102,157	114,203	219,137	441,831	500,606	155,990	272,101	161,125	248,540
CHEM 14				271				527	6	6	6			146	
CHEM 15												4	4		

Table U.4. Scenario: 40% Reduction in Chemcial Leached Over 15 Years, Without Poultry Litter

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)
25,984,184

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	3,458,250	3,407,141	389,574	1,008,289	687,592	305,117	2,671,250	1,590,230	484,894	1,543,489	2,178,396	129,881	1,562,290

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

1990.21

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A6t	A14t	A4t	A3t,A6t (94.8/5.2)	A3t	A3t,A13t (30.0/70.0)	A6t,A12t (96.7/3.3)	A3t,A6t (13.8/86.2)	A1t,A3t (93.1/6.9)	A2t,A10t (7.1/92.9)	A1t,A4t (68.1/31.9)	A3t	A1t

Table U.4, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937				987	1,185			435		324	152	
NONB		6,172	1,234	3,086	1,344	6,171	5,185	1,920	6,078	3,797	5,870	6,420	6,137	6,309	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	739	2,863	2,757	2,630	2,477	2,088	2,563	2,503	2,452		1,921
NONB						531	637		921		905	1,028	1,101	3,553	1,632
BARLEY															
BASE	2,777	2,777	2,777	2,777	605	2,343	2,256	2,152	2,026	1,708	2,096	2,048	2,006	1,977	1,967
NONB						435	521		754		740	841	901	930	940
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	1,344	6,171	6,172	4,781	6,178	3,797	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				1,676	99						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	9655	0	0	2780	0	4850	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	326	1,526	1,530	1,162	1,546	923	1,576	1,610	1,624	1,691	1,639
MAR	8,165	9,072	8,346	4,536	2,302	24,117	24,534	8,066	8,936	6,925	10,209	124	9,950	26,038	9,497
APR	4,610	5,122	4,713	2,561	1,115	19,699	20,162	6,036	5,045	4,453	6,170	16,193	5,335	21,398	5,362
MAY	1,500	1,666	1,533	7,930	363	15,307	15,789	7,990	1,869	2,243	2,602	2,389	1,735	16,757	1,744
JUN	11,714	11,714	11,714	11,714	2,550	45,257	47,189	17,209	11,846	10,182	14,558	14,255	14,205	50,338	12,447
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	3,713	66,005	68,321	22,468	17,172	14,823	21,012	18,013	18,097	73,948	18,228
OCT	4,610	4,610	4,610	9,054	1,004	17,971	18,825	9,187	4,897	4,008	5,820	4,951	4,992	20,792	5,039
NOV	8,887	8,887	8,887	8,887	1,935	34,177	35,549	13,057	8,896	7,726	10,955	9,245	9,303	37,211	9,303
DEC															

Table U.4, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505				132,952	85,317			42,857		76,956	10,702	
NONB		1,018,319	229,585	598,648	268,758	1,235,195	775,552	130,740	1,233,920	804,901	804,190	1,457,356	1,620,021	494,599	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	99,776	350,472	334,990	319,505	300,921	259,356	325,246	360,424	317,794		228,245
NONB						72,224	86,032		124,336		127,528	164,495	158,554	554,296	215,414
BARLEY															
BASE	437,414	457,410	422,417	467,408	101,772	373,196	401,988	304,013	299,098	252,180	311,406	366,773	343,073	355,899	329,340
NONB						76,907	103,238		123,583		122,101	167,392	148,644	185,986	174,797
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	72,565	285,045	256,740	238,337	485,013	269,531	198,963	430,145	471,604	186,057	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,272	810,048	264,778	1,004,680	984,898	565,044	1,216,917	728,587	1,234,714	1,385,667	1,284,362	1,065,010	1,293,272

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	109,452	506,590	502,928	365,239	508,838	309,245	518,205	241,582	532,844	543,668	536,609

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	188,680	874,374	869,273	640,714	879,630	533,098	895,595	483,224	921,120	942,383	927,922

Table U.4, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				5,867	347			11,235			
CHEM 2				57,859								55,746			
CHEM 3	19,385	21,539		10,769	4,690	20,431	21,194	4,986	346	1,824	21,851	22,937	22,433	22,494	22,547
CHEM 4*	2,160	2,160	2,160	1,080	470	111		587	2,127	1,146	2,054		2,261		2,261
CHEM 5			21,122			1,181		5,785	22,242	12,179					
CHEM 6												241			
CHEM 7*	194	194	194	194	42	95		106	200	103	191	209	210		212
CHEM 8	3,148	3,148	3,148	3,148	685	162		1,710	3,151	1,670	2,994	3,274	3,295		3,295
CHEM 9	10,800	10,800	10,800	10,800	2,352	10,800	10,800	8,367	10,811	6,644	11,033	10,434	11,306	11,306	11,306
CHEM 10				7,190				3,906	231			1,067			
CHEM 11				7,159				3,889	230			7,447			
CHEM 12	13,602	14,318	13,745		3,117	736		12,430	14,624	7,596	13,618	1,603	14,951		14,988
CHEM 13	10,800	10,800	10,800	10,800	2,352	4,009	3,641	6,710	10,811	6,038	10,529	12,036	11,306	3,811	11,306
CHEM 14				5,400				2,933	174						
CHEM 15			6,586			368		1,807	6,936	3,798		242			

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	1,075	5,777	6,729	2,057	11,060	11,679	3,057	2,155	4,946	3,872	10,337
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	25,935	473,710	197,591	151,734	449,911	383,777	151,391	156,766	222,126	484,391	627,298
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	46,092	199,875	210,714	72,320	152,844	304,380	59,576	56,127	100,486	111,655	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,555	29,500	12,766	48,675	66,149	19,393	36,092	95,149	16,783	14,201	25,955	28,656	63,505

Table U.4, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				92				221	3			2,155			
CHEM 2				333								39			
CHEM 3	1,261	2,604		263	176	1,651	680	65	56	3,137	258	1,538	304	1,167	1,266
CHEM 4												1,182			
CHEM 4B	2,524	4,434	19,706	34	513	367		52	253	1,909			1,382		1,686
CHEM 5			2,833			58				501	293				
CHEM 6									1,692						
CHEM 7															
CHEM 8	11	623	647	605	75	74		395	169	2,721	604	435	64		1271
CHEM 9		500	1,716	537	6,713	853	3,493	2,419	1,646	9,661	596	4,764	14,096	207	90
CHEM 10				2,101				2,930	103			1,285			
CHEM 11				1,145				1,277	30			2,077			
CHEM 12	978	9,572	17,574		161	1,134		507	839	1,657	158	108	478		4,322
CHEM 13	17,709	47,435	105,944	28,371	11,892	20,210	26,943	18,972	38,338	84,845	22,902	20,335	24,623	10,491	64,009
CHEM 14				5,320				5,833	204						
CHEM 15			358						664	26					

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				98	6			24			
CHEM 2				9								101			
CHEM 3	28	19,836		4,471	490	70,219	58,072	4,452	1,357	13,626	7,212	2,556	3,091		48,220
CHEM 4		488	7,276		28	803		132	1	4,453			407	69,473	
CHEM4B															
CHEM 5			6,751			16		13	18,009	792					
CHEM 6															
CHEM 7			31		7	14				2,642			103		1,137
CHEM 8															
CHEM 9											41		941		26
CHEM 10															
CHEM 11															
CHEM 12		284	4,599		4	138		3	2,641	1,277	6	1	39		317
CHEM 13															
CHEM 14															
CHEM 15			9,232			10			3,898	2,878					

Table U.4, continued.

CHEMICALS REMOVED (GRAMS) BY:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2												6	6		
CHEM 3	1,261	31		3	3	17	6		1	1	254	6	102	6	1,273
CHEM 4															
CHEM4B	49	130	463	3	16	10		2	12	52	70		45		65
CHEM 5			23			1			18	6	6				
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,089	409	229		1,909	753	6,613	8,051	982	1,401		1,008
CHEM 9		37	271	111	604	95	228	189	316	910	955	667	2,050	45	26
CHEM 10				978				1,230	83			442	442		
CHEM 11				49				33	1			58	58		
CHEM 12	12	18	110		1	8		3	7	13	13		7		39
CHEM 13	76,419	186,580	483,303	126,203	56,668	90,841	40,343	68,581	184,583	310,153	383,350	68,617	196,582	46,282	248,541
CHEM 14				271				286							
CHEM 15									5						

Table U.5. Scenario: 40% Reduction in Chemicals Leached and in Runoff Over 15 Years, Without Poultry Litter

TOTAL NET RETURNS, DISCOUNTED (15 YEARS,DOLLARS)

25,984,184

NET RETURNS, DISCOUNTED (DOLLARS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3,223,759	3,344,028	348,250	3,407,142	389,574	1,008,289	687,592	238,337	2,671,250	1,590,230	484,894	1,543,489	2,178,396	129,881	1,562,290

TOTAL (DISCOUNTED) VALUE OF AGRICULTURAL LAND (DOLLARS PER HECTARE)

1746.89

TOTAL LAND AVAILABLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056	13,056

CRP/BUFFER STRIP (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRP	636	636	636	636	636	636	636	636	624	536	370	139	59	59	59
BUFFER	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77

MAJOR ROTATION(S)
(PERCENTAGE OF CROPLAND SPLIT)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A1t	A1t	A6t	A14t	A6t	A3t,A6t (95.0/5.0)	A3t	A3t,A13t (30.0/70.0)	A6t,A12t (97.0/3.0)	A3t,A6t (14.0/86.0)	A1t,A3t (93.0/7.0)	A2t,A10t (7.0/93.0)	A1t,A4t (68.0/32.0)	A3t	A1t

Table U.5, continued.

CROPLAND PLANTED - BASE/NONBASE (HECTARE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	6,172		4,937				987	1,185			434		324	152	
NONB		6,172	1,234	3,086	1,344	6,171	5,184	1,920	6,079	3,797	5,870	6,420	6,137	6,309	6,460
WHEAT															
BASE	3,394	3,394	3,394	3,394	739	2,863	2,757	2,630	2,477	2,088	2,564	2,503	2,451		1,921
NONB						531	637		921		904	1,028	1,101	3,553	1,632
BARLEY															
BASE	2,777	2,777	2,777	2,777	604	2,343	2,256	1,509	2,026	1,708	2,097	2,048	2,007	1,977	1,967
NONB						435	522		753		740	841	901	930	
940															
DC SOYBEAN															
BASE															
NONB	6,172	6,172	6,172	6,172	1,344	6,171	6,172	4,781	6,177	3,797	6,304	6,420	6,460	6,460	6,460
FS SOYBEAN															
BASE															
NONB				3,086				1,676	99						

CROPLAND IDLE (HECTARE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	9657	0	0	3425	0	4850	0	0	0	0	0

LABOR USED (HOURS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
JAN															
FEB	1,500	1,500	1,500	1,500	326	1,526	1,531	1,162	1,546	923	1,576	1,610	1,624	1,691	1,639
MAR	8,165	9,072	8,346	4,536	2,302	24,117	24,534	8,066	8,936	6,925	10,209	124	9,950	26,038	9,497
APR	4,610	5,122	4,712	2,561	1,115	19,699	20,162	6,036	5,045	4,453	6,170	16,193	5,335	21,398	5,362
MAY	1,500	1,666	1,533	7,931	362	15,307	15,789	7,990	1,869	2,243	2,601	2,389	1,735	16,757	1,744
JUN	11,714	11,714	11,714	11,714	2,550	45,257	47,189	17,209	11,846	10,183	14,558	14,255	12,406	503,338	12,447
JUL															
AUG															
SEP	16,164	17,052	16,341	12,609	3,713	66,005	68,321	22,468	17,172	14,823	21,012	18,013	18,097	73,948	18,228
OCT	4,610	4,610	4,610	9,054	1,004	17,970	18,825	9,187	4,897	4,008	5,820	4,951	4,992	20,792	5,039
NOV	8,887	8,887	8,887	8,887	1,935	34,177	35,548	13,057	8,896	7,725	10,955	9,245	9,303	37,211	9,303
DEC															

Table U.5, continued.

MARKET SALES - BASE/NONBASE (BUSHELS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CORN															
BASE	1,094,230		826,505				132,952	85,317			42,857		76,956	10,702	
NONB		1,018,319	229,585	598,648	268,758	1,235,195	775,552	130,740	1,233,920	804,901	804,190	1,457,356	1,620,021	494,599	1,563,400
WHEAT															
BASE	406,309	458,244	439,914	430,749	99,776	350,472	334,990	319,504	300,921	259,356	325,246	360,424	317,794		228,245
NONB						72,224	86,032		124,336		127,528	164,495	158,554	554,296	215,414
BARLEY															
BASE	437,414	457,410	422,417	467,408	101,772	373,196	401,988	304,013	299,098	252,180	311,406	366,773	343,073	355,899	329,340
NONB						76,907	103,238		123,583		122,101	167,392	148,644	185,986	174,797
SOYBEANS															
BASE															
NONB	308,581	413,499	333,268	654,193	72,565	285,045	256,740	238,227	485,013	269,531	198,963	430,145	471,604	186,057	413,461

NUTRIENTS PURCHASED (KILOGRAMS)

NITROGEN

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1,137,577	1,216,049	1,153,271	810,049	264,778	1,004,679	984,898	650,344	1,216,917	728,587	1,234,714	1,385,667	1,284,362	1,065,010	1,293,272

LITTER

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PHOSPHORUS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
474,907	502,679	480,461	467,964	109,452	506,590	502,928	365,239	508,838	309,246	518,205	241,582	532,844	543,668	536,609

POTASSIUM

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
824,894	866,552	833,226	824,925	188,680	874,375	869,273	640,714	879,630	533,098	895,595	483,224	921,121	942,382	927,922

Table U.5, continued.

CHEMICALS PURCHASED (LITERS UNLESS NOTED OTHERWISE BY * THEN KILOGRAMS)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHEM 1				10,800				5,867	347			11,235			
CHEM 2				57,859								55,746			
CHEM 3	19,385	21,539		10,770	4,690	20,431	21,194	4,986	346	1,824	21,851	22,937	22,433	22,494	22,547
CHEM 4*	2,160	2,160	2,160	1,080	470	111		587	2,127	1,146	2,054		2,261		2,261
CHEM 5			21,122			1,180		5,785	22,242	12,179					
CHEM 6													241		
CHEM 7*	194	194	194	194	42	95		106	200	103	191	209	210		212
CHEM 8	3,148	3,147	3,147	3,148	685	162		1,710	3,151	1,670	2,994	3,274	3,295		3,295
CHEM 9	10,800	10,800	10,800	10,800	2,352	10,800	10,800	8,367	10,811	6,644	11,033	10,434	11,306	11,306	11,306
CHEM 10				7,190				3,906	231			1,067			
CHEM 11				7,159				3,889	230			7,447			
CHEM 12	13,602	14,318	13,745		3,117	736		12,430	14,624	7,596	13,628	1,603	14,950		14,988
CHEM 13	10,800	10,800	10,800	10,800	2,352	4,009	3,641	6,710	10,811	6,038	10,529	12,036	11,306	3,811	11,306
CHEM 14				5,400				2,933	174						
CHEM 15			6,586			368		1,807	6,936	3,798		242			

NITROGEN REMOVED BY (KILOGRAMS):

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF	3,456	9,257	11,183	2,777	1,075	5,777	6,729	2,057	11,060	11,679	3,057	2,155	4,946	3,872	10,337
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOL	83,317	341,291	504,222	98,746	259,535	473,710	197,591	151,734	449,911	383,777	151,391	156,766	222,126	484,391	627,298
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT	52,829	128,986	307,864	112,632	46,092	199,875	210,714	72,320	152,844	304,380	59,576	56,127	100,486	111,655	222,880

EROSION (METRIC TONS)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15,522	32,771	113,555	29,500	12,766	48,675	66,149	19,393	36,092	95,149	16,784	14,201	25,955	28,656	63,505

Table U.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RUNOFF															
CHEM 1				93				221	3			39			
CHEM 2				333								1,538			
CHEM 3	1,261	2,604		262	176	1,651	680	64	56	3,137	258	1,182	303	1,166	1,266
CHEM 4															
CHEM 4B	2,524	4,434	19,706	34	513	367		52	253	1,909	293		1,382		1,686
CHEM 5			2,833			58			1,692	501					
CHEM 6															
CHEM 7															
CHEM 8	11	623	647	605	75	74		395	169	2,721	605	435	65		271
CHEM 9		500	1,715	537	6,713	853	3,493	2,419	1,646	9,661	596	4,764	14,096	207	90
CHEM 10				2,101				2,930	103			1,285			
CHEM 11				1,145				1,277	30			2,077			
CHEM 12	978	9,572	17,574	376	161	1,134		507	839	1,657	158	108	478		4,322
CHEM 13	17,709	47,435	105,944	28,371	11,892	20,210	26,943	18,972	38,338	84,845	22,902	20,335	24,623	10,491	64,009
CHEM 14				5,320				5,833	204						
CHEM 15			357			9			664	26					

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PERCOLATION															
CHEM 1				130				98	6			24			
CHEM 2				9								101			
CHEM 3	28	19,836		4,471	490	79,219	58,072	4,452	1,357	13,626	7,212	2,556	3,090	69,473	48,220
CHEM 4		488	6,751		28	803		132	1	4,453			407		
CHEM4B															
CHEM 5						16		13	18,009	792					
CHEM 6															
CHEM 7			31		7	14				2,642			103		1,137
CHEM 8															
CHEM 9											41		941		26
CHEM 10															
CHEM 11															
CHEM 12		284	4,599		4	138		3	2,541	1,277	6	1	39		317
CHEM 13															
CHEM 14															
CHEM 15			9,232			10			3,898	2,878		2,435			

Table U.5, continued.

CHEMICALS REMOVED (GRAMS) BY:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SEDIMENT															
CHEM 1															
CHEM 2												6	6		
CHEM 3	1,261	31		3	3	17	6		1	1	254	6	102	6	1,273
CHEM 4															
CHEM4B	49	130	463	3	16	10		2	12	52	70		45		65
CHEM 5			23			1			18	6	6				
CHEM 6															
CHEM 7															
CHEM 8	105	1,722	3,188	2,089	409	229		1,909	753	6,613	8,051	982	1,401		1,008
CHEM 9		37	271	111	604	95	228	189	316	910	955	667	2,050	45	26
CHEM 10				978				1,230	83			442	442		
CHEM 11				49				33	1			58	58		
CHEM 12	12	18	110		1	8		3	7	13	13		7		39
CHEM 13	76,419	186,580	483,303	126,203	56,668	90,841	40,343	68,581	184,583	310,153	383,350	68,617	196,582	46,282	248,541
CHEM 14				271				286							
CHEM 15									5						

VITA

Penelope Louise (Brown) Diebel was born June 11, 1961, in Hutchison, Kansas. After graduating from Heritage High School in Littleton, Colorado, she attended Colorado State University, from which she received a B.S. degree in Outdoor Recreation Management in 1983. She worked for the Colorado State Parks and Recreation Department after graduating and married Ken E. Diebel in the summer of 1984. She returned to Colorado State University, receiving a M.S. degree in Agricultural and Natural Resource Economics in 1986. She and her husband continued their education at Virginia Polytechnic and State University, where she received a Ph.D. in Agricultural Economics in 1990. Penny currently resides in Manhattan, Kansas where she is an assistant professor in the Agricultural Economics Department of Kansas State University.

Penelope L Diebel