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GOVERNMENTAL PROGRAMS AND THEIR EFFECT ON THE ADOPTION OF SUSTAINABLE AGRICULTURAL PRODUCTION PRACTICES: WITH SPECIAL EMPHASIS ON NITROGEN UTILIZATION.

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GOVERNMENTAL PROGRAMS AND THEIR EFFECT ON THE ADOPTION OF SUSTAINABLE AGRICULTURAL PRODUCTION PRACTICES: WITH SPECIAL EMPHASIS ON NITROGEN UTILIZATION.

By

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ABSTRACT

GOVERNMENTAL PROGRAMS AND THEIR EFFECT
ON THE ADOPTION OF SUSTAINABLE
AGRICULTURAL PRODUCTION PRACTICES:
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This research is an evaluation of how current commodity programs affect agricultural producers' cropping pattern decisions. This is of interest because the current commodity programs appear to contribute heavily to nitrogen use thus producing larger amounts of leaching than would be the case without the current commodity programs. To examine this hypothesis and how alternative farm programs might influence producers' cropping patterns, a linear programming model (LP) is developed. This model includes the current and proposed policies to study their effect on agricultural producers. The main aim of this thesis is to contribute workable solutions for consideration in the 1995 farm bill debate. This research found that by encouraging program crops such as corn the current farm programs result in greater nitrate leaching than would occur otherwise. An income support policy would continue to alleviate farm income volatility and reduce nitrate leaching, while allowing flexibility in crop planting decisions to farmers.

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Chapter 1

Introduction To This Research

INTRODUCTION:

The purpose of this research project is to examine how governmental policies affect the producer's production decisions in adopting various production styles. The conventional agricultural system refers to a high-intensity monoculture. As used here, an "alternative" production system is one that is not an energy and chemically intensive single crop farming system. The change is to a more diversified, sustainable system of food and fiber production. Profitability and environmental consequences directly related to practices employed in agricultural production, as influenced by governmental policies, will be specifically addressed. The primary focus of this research is on the agricultural practices relating to the nitrogen needs of crops and the manner in which nitrates are leached from the soil due to the agricultural producer's decisions. Government policies that affect producer's decisions will be tested within a mathematical programming model. Policy options will be tested to determine the one that will produce the highest return while encouraging more sustainable production practices. As both the private and the public sector become more concerned with environmental health, agricultural producers will increasingly come under fire to limit their negative impact on the environment. There is an urgency for agricultural producers to adopt practices that are more environmentally friendly. This concern over the quality of the environment is becoming a more popular mandate for the public. An example of this changing attitude is the increase of ground water monitoring we have witnessed in recent years. The information gathered heightens awareness of the environmental impact caused by modern agricultural practices (Fleming 1989).

OBJECTIVES:

The ultimate aim of research into making alternative agriculture economically viable should not necessarily result in elimination of all herbicides and other chemicals. The ultimate objective should be a system which is more competitive economically with the conventional system while simultaneously being significantly less dependent on chemicals and less environmentally harmful. This thesis is directed at a pragmatic solution acceptable to both the agricultural and environmental communities. Studies must be made to determine how changes in governmental agricultural policy affect producers' decisions regarding their cropping patterns. This outlines the main purpose of this research project. In particular, this paper will develop a mathematical programming model to study the effects these policies have on nitrogen sources comparing those obtained from legumes and other natural sources. One of the major influences on the environment, its treatment, and the economic stability of agricultural producers is the major farm policy legislation.

The 1990 Farm Bill (Food, Agriculture, Conservation and Trade Act of 1990; FACTA and the Omnibus Budget Reconciliation Act of 1990) will be examined to evaluate how it has influenced farmers' production decisions. In particular, the 1990 Farm Bill will be studied relative to specific effects on nitrate leaching producers' earnings.

Mainly, this thesis refers to the Farm Bills which set guidelines and restrictions on agricultural producers. As can be seen from the 1992 Michigan Agricultural Statistics Report, the USDA has started to pay more attention to water quality relative to fertilizer, herbicides and pesticides. The linear programming model will keep track of the amount of leaching that occurs with the various rotation options.

A linear program model will be designed for this thesis to determine the farm bill's effects on producer's decisions. The model will explore the nutrients that crop rotations can bring into crop production. The model will also be used to determine an approximate amount of leachate that is produced from the crop production. This leachate value will be a primary focus of this thesis as the concern over the quality of our ground water increases. To obtain some reduction in the amount of leaching that occurs, this model will explore three avenues for reduction: 1) The total elimination of the current farm programs. The representative farm, that will be described in detail below, will be operated with out the influence of current farm programs. These programs may have a distorting affect on the amount of nitrogen that is utilized on the farm (Antle 1991, Bovard 1989) 2) A tax credit for the use of resource conserving crops that incorporate compatible crops. Field work is timed so as to reduce the potential for leachate of nitrogen. And 3) A tax credit for the use of alternative forms of nitrogen. The information that is generated from the LP model will be used to evaluate the quality and effectiveness of the proposed policies.

Chapter 2

Literature Review of Sustainable Agriculture Research

DEFINITIONS OF SUSTAINABLE AGRICULTURE:

A wide range of meanings are associated with the term "sustainable agriculture": i.e. "alternative agriculture", "regenerative agriculture" and "organic farming". All seem to refer to similar yet not identical methods of agricultural production practices. The definition which the Rodale Institute has adopted is one of the more restrictive interpretations (Harwood 1984):

> "An organic system is one which is structured to minimize the need for off-farm soil or plant focused inputs. Because of lack of information on the disruptive effect of synthetic inputs, none are used. Natural sources of inputs are used with discretion."

On the basis of this definition, we can surmise self-sufficiency is the aim of any alternative agricultural production system. Self-sufficiency is a desirable goal because, ideally, it should enable an agricultural producer to maintain a level of production without enlisting outside help. This, in turn, should decrease the risk of environmental damage. This may not always hold because the use of green manure[1] as well as other forms of natural crop nutrients may themselves produce environmental damage. The work of Johnston (1982) is an excellent reference pertinent to the use of alternative forms of plant nutrients and how they affect environmental quality. He conducted a study of winter wheat plots which have had continuous corn grown on them for over 150 years in Rothamstad UK. These plots have either received mineral fertilizers or farmyard manure. He compared the organic content of the plots and found, even with significant difference in the soil structure, the yields obtained on the different plots were similar. Weeds, pests and diseases are all managed not through the use of man made chemicals but rather through crop rotations, cultivation and various biological controls. Thus, two modalities for sustainable nutrient management are acceptable under this strict definition of agricultural production: 1) crop rotations involving legumes and 2) return to the soil of crop residues, animal waste, sewage sludge and other forms of organic wastes.

A less restrictive definition of alternative agriculture is the one that allows some use of off-farm inorganic inputs such as synthetic fertilizers when nutrients available on the

[1] Green manure is primarily a low value crop that is planted to help control erosion, add nutrients back to the soil (esp nitrogen), and add biomas to increase water retention capabilities.

farm are in limited supply. Terms of this definition allow use of various agricultural chemicals to deal with any emergency outbreaks of weeds, disease and/or insect damage including any nutrient deficiency that may occur. The National Research Council has adopted this latter definition in their study of alternative agriculture (1989):

> "Alternative agriculture is any system of food or fiber production that systematically pursues the following goals:
>
> 1) More through the incorporation of natural processes such as nutrient cycles, nitrogen fixation and pest/predator relationships into the agricultural production processes.
>
> 2) Reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of the farm workers and consumers.
>
> 3) Greater productive use of the biological and genetic potential of plant and animal species.
>
> 4) Improvement of the match between cropping patterns and the productive potential and physical limitations of agricultural lands to insure long term sustainability of current production levels.
>
> 5) Profitable and efficient production with an emphasis on improved farm management and conservation of soil, water, energy, and biological resources".

In short, this definition portrays an agricultural production enterprise as one that does not produce any negative externalities beyond the area of operation and, at the least, leaves the productivity of the land at the same ecological level as it was at the beginning of production. Furthermore, this definition presents the possibility of actually improving the land base over some time frame while not eroding the farmer's profitability level. This is all accomplished through use of the least amount of conventional production inputs possible (i.e., chemical fertilizers, herbicides, pesticides, etc).

PROFITABILITY AND YIELD EFFECTS AND THE PRICES RECEIVED BY PRODUCERS:

Lockeretz, et al (1987) conducted a survey of the yields and operating costs of farms (both alternative and conventional) in the corn belt states. They concentrated on Illinois, Iowa, Nebraska, Minnesota and Missouri in this study. Fourteen (14) organic and conventional farms were selected and paired by size and soil type. Most of the organic farms had a livestock operation, and they had been run as "organic" for at least four (4) years prior to the study. These farms were operated using the Rodale Research Institute's definition of alternative farming cited above.

The results of the study showed that over the years, from 1974 to 1978, the organic farms had lower yields than their paired conventional farms. The organic farms also had lower financial outlays for fertilizer and pesticides which offset the increased cost of labor necessary to control weeds and pests. Thus, with lower yields and lower costs, the net income for the pairs ended up being approximately the same. At market, there was no significant difference in prices received between the organic and the nonorganic produce. This was due to the underdeveloped local market structure for organically grown produce. Yet, if a comparison of the markets were done now, one may find that the market demand for organically grown produce has grown.

In a recent study conducted by Lohr and Parks (1992) on the prices received by certified organic produce growers, it is demonstrated that growers can command a premium market price. They found that this certified "organically grown" produce can retail 25 to 35 percent above non-certified produce. In health food stores, this certified produce received as much as a 50 percent premium above other produce. From numerous other studies, it was found that organically grown food premiums ranged from 5 percent to as much as 100 percent higher than their non-organic counterparts depending on the base cost and risk perception. Oelhaf (1978) has demonstrated that alternatively grown crops do command a premium price as they enter the market. The data for this conclusion were collected from wholesalers of alternatively grown grains, soybeans, fruits and vegetables who were mostly located in California and the Northeast. Yet, unless these producers can effectively enter such a market, they will not be able to realize this premium price. Cacek and Langner

(1986) collated results from a survey of 213 organic field crop farmers in which 88 percent responded that their net farm income remained either constant or showed some increase when they reduced use of chemical inputs. The other 12 percent reported a decline in net income.

James (1983) used linear programming to compare the relative profitability of alternative and conventional farms in three (3) locations in central, western and southern Iowa. Data for this study was obtained from various sources to generate a picture of representative farms (both alternative and conventional) for the study area. The organic farms in the study did not use any inorganic fertilizers or pesticides thereby remaining consistent with the Rodale definition of alternative farming. James concluded, from his study, that "farming without commercial nitrogen and other chemicals is a viable alternative for some if not many Iowa farms". Yet, for those Iowa farmers and others as well who want to switch to an alternative crop production system, the transition will not be accomplished without some cost.

Dabbert and Madden (1986) used data from the Rodale Research center to study the transfer from a conventional to an alternative crop/livestock farming operation. No chemicals were used except for a small amount of fertilizer as start up. Weeds were controlled by mechanical means. From this study of the conversion, Dabbert and Madden concluded that there were no yield penalties as reported in other studies. This study also revealed to them that yields on their case farm were higher than the county average. The two researchers failed to give any justification for the reason their case farm fared so well.

Oelhaf (1978), in contradiction to Dabbert and Madden, stated that shifting to an alternative system of production from a conventional system usually results in a diminished yield from that realized on the land prior to the switch. This yield reduction has become to be known as a yield "penalty". The USDA study on organic farms (1980) also confirmed that during the first three or four years of transition a farmer will be likely to experience such a yield penalty. This substantiated Oelhaf's conclusion. Yet, after this period, yields should be restored to their pre-conversion level.

This report also states that a wide variety of factors exist which determine crop yields. These include soil fertility, seed varieties, climatic conditions, weed, pest, and disease control, availability of labor, harvesting methods and other management practices. In general, those crops that respond well to high levels of nitrogen fertilizer rates (corn and potatoes) will have lower yields under an organic system unless other sources of nitrogen can be utilized. Dabbert and Madden's study also found that there is a decline in total farm profitability contrary to the findings of Lockeretz et al. Again, they do not explain the reasons for this loss in total farm profitability identified during the early years of the transition. The main possible reason for this loss of profitability would be the inclusion of less profitable crops in the rotation (i.e., wheat, alfalfa).

As with conventional farms, organic farmers stated that weed control is one of their primary problems (USDA 1980). By adhering to Rodale's definition for alternative farming, no herbicides can be used on the land for purposes of weed control. Yet, in a continuous cereal-intensive rotation, weeds and disease are able to flourish because the pest has uninterrupted access to the susceptible host plant (Cook 1986)[2]. In order to maintain a continuous rotation of a single crop and insure proper crop health and production, large amounts of agricultural chemicals would be required. This view is supported by the findings of the Council for Agricultural Science and Technology (CAST 1980) which states the major advantage of herbicides is that they permit control of weeds in the crop row allowing for continuous cropping.

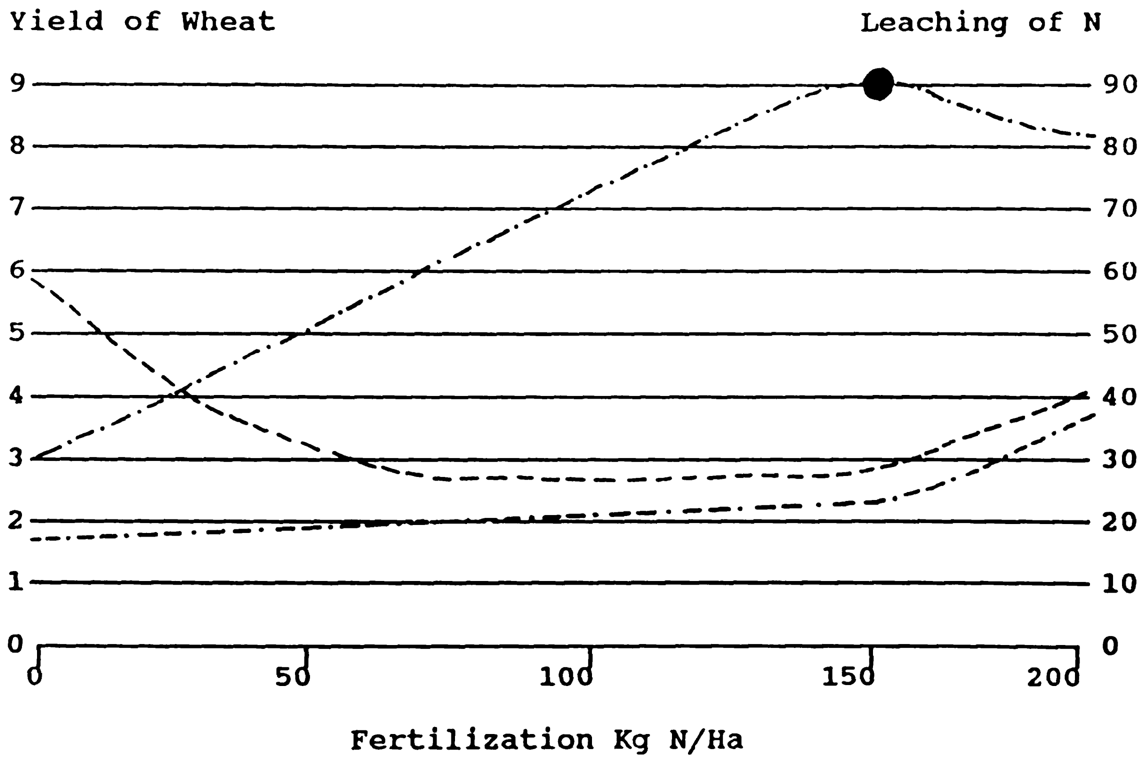
[2]The meaning of pest here, is any plant, animal, insect, disease or bacteria that has a detrimental effect on a desirable organism.

With the use of herbicides, crops can be planted earlier in the spring than would be the case if weed control depended primarily on cultivation. Use of herbicides also allows for higher seeding densities which, in turn, produce higher crop yields. This is due to the fact that the plants are closer together thus increasing the pressure between the crop and the unwanted plants. So by reducing the undesirable plants the wanted plants can utilize the available inputs to their fullest. This higher seeding rate may also contribute to either a larger yield penalty or the creation of the yield penalty in itself.

Dilz (1988) conducted a study on wheat yields and the amount of nitrogen leaching that occurred from various fertilizer applications. Dilz found that the amount of nitrate leaching climbs slowly compared with the rise in crop yield. This will progress to the point at which fertilizer rates produce the optimal yield.

Figure 2.1

Fertilizer Utilization



Economic optimal yield ●
Yield tonnes/ha
Leaching g N/10 kg of grain
Leaching Kg N/Ha

Yet, the use of legumes to supply nitrogen to subsequent crops does not reduce the possibility of excessive leaching. To help reduce leaching, regardless of the source of crop nutrients (synthetic fertilizers, crop residues, manure, etc), an agricultural producer must take into consideration several things. The ultimate amount of leaching that will occur on a particular soil depends on numerous factors in addition to the fertilizer rate; e.g. soil, crops, rotations, and weather patterns. Thus, by applying the following principles of good agricultural practice adapted to prevailing local conditions, nitrate leaching should be reduced to a practical minimum (Bockman et al 1990).

1) Fallow periods should be avoided. The soil should be kept under green cover for as much of the year as possible by early sowing of winter crops or intercropping.

2) Legumes should not be plowed down before winter. They should be preferably grown so that a subsequent crop, immediately following, can take up the nitrogen released by mineralization of the residues.

3) Grassland should not be plowed until shortly before the next crop can be established, and old grassland should preferably not be plowed. Where such plowing is necessary, rapid establishment of plants with high requirements for nitrogen is especially important.

4) Soil tillage should be minimized and preferably avoided in the autumn.

5) Straw should not be burned or removed but plowed in or used as mulch.

6) Slopes should be cultivated in such a way as to minimize surface runoff.

7) Manure should be evenly spread. Application in autumn or winter should be avoided.

8) Fertilizer nitrogen should not be applied in the autumn.

9) Fertilizer and manure should be applied at times and in amounts appropriate to the nutrient requirements of the crop taking into account the amount of available nitrogen already in the soil.

Nitrate leaching from the root zone usually takes place in the period between autumn and spring when precipitation exceeds evapotranspiration (German 1989). Thus, with the use of cover crops that are grown after harvest of the main crop, the cover crop can take up remaining mineral nitrogen and released nitrogen from soil humus.

Harwood (1992) conducted a study on the amount of leaching and runoff present with various cover crops and tillage practices. From his research, it was found, with a cover crop, runoff and nitrogen leaching amounts in the soil were reduced significantly compared to a situation in which land having no cover crops through the winter, was plowed in the fall. Yet, the effect that this cover crop has on nitrogen leaching depends upon both sowing time and crop type as well as climatic conditions. The earlier the date the cover is sowed the higher the amount of evapotranspiration and the lower amount of leachate. So, from this, it can be surmised that nitrate concentration is negatively affected by the reduction in the amount of leachate resulting from an increase in evapotranspiration by the cover crop.

NUTRIENTS FOR CROPS:

Power and Doran (1984) maintain that major sources of nutrients for crops in alternative agricultural production may be found in crop residues and livestock manure. Yet, they insist that the supply of these inputs be limited to the producers of the same inputs. In contrast to Power and Doran, Harwood (1984) stated the contribution of these inputs in, "meeting crop nitrogen needs from legumes in rotation has been grossly understated by American scientists". If his argument is correct, then Rodale's definition of organic agriculture (Harwood 1984), which was previously cited in this paper, would be feasible as there would be no nutrient deficiency for agricultural producers. It would be insured that agricultural producers could achieve self sufficiency in relation to crop nutrients. Yet, on the Rodale farm, corn yields which require large amounts of nitrogen were approximately 30% above the state average. This farm operated for over ten (10) years using few if any non-organic inputs.

Papendick et al. (1987) support the conclusions made by Harwood at the Rodale farm. They assert that all of the nitrogen requirements of the rotation can be satisfied by legumes grown on the farm. Papendick et al. fail to mention either the crop rotation pattern or its length. The crops which are in the rotation can play a major role in determining amounts of nitrogen available to plants in later years. This is illustrated in results accumulated from various studies throughout the United States. From these studies, it may be concluded that the fertilizer nitrogen equivalents of a 2 to 4 year old "good" alfalfa stand is at least 112 lbs of nitrogen per acre for the first succeeding crop and 38 lbs of nitrogen per acre for the second crop (Follett 1989). The programming model will examine how legumes can be used to reduce synthetic nitrogen use in crop production. This will be accomplished by applying a nitrogen credit for the legumes that are brought into the rotation. If agricultural producers should happen to experience a deficit, then other systems like green manure, erosion control to conserve soil nutrients, recycling of crop residues, manure and various other natural wastes may be enlisted to correct the shortfall.

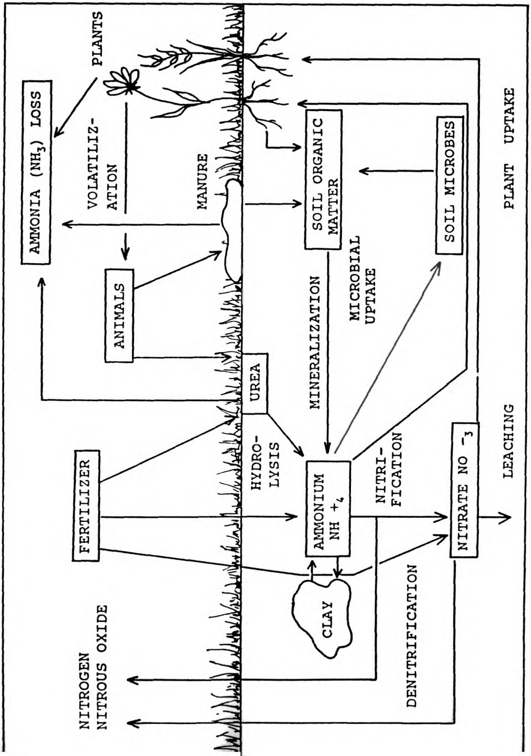
Olson et al (1982) came to a different conclusion than the two previous researchers cited above. They found that banning inorganic fertilizers in agricultural production would result in a substantially negative yield effect. Their base year for this conclusion was 1940. They assumed few, if any, inorganic fertilizers had been used. They then projected yields to 1970 assuming the only factor increasing crop yield was genetic improvements in plant cultivars. These projected yields were then used as economic comparisons to conventional and alternative agriculture. There is some question about this study as it only looks at advances in plant genetics while totally ignoring any and all new knowledge about crop production available since 1940. After 1940, crops were bred to be more responsive to fertilizers especially as the price of inorganic fertilizers dropped (particularly nitrogen) in relation to organic forms. If organic sources of nitrogen had stayed as relatively inexpensive as they were in the early 40's, then research on plant cultivars and farming practices probably would have been geared towards use of these organic sources.

NITROGEN IN SOIL ORGANIC MATTER:

Soil organic matter originates from living organisms (both plants as well as animal manure). This organic matter is a factor of importance in soil productivity because: 1) Nutrients are bound to soil organic matter and released upon its decomposition; 2) some of the organic matter acts as food to soil organisms; and 3) it stabilizes mineral soil aggregates. Thus, soil can contain large amounts of nitrogen reserves in the organic matter. An example of the level of nitrogen in soil's organic matter comes from a study of the United Kingdom's topsoil (Bockman et al 1990). The topsoil studied contained some 2,679 to 6,251 Lbs N/Ac for arable land and 10,716 to 17,860 Lbs N/Ac for old grassland. These reserves of nitrogen came from the organic matter in the soil formed from plant roots, residues and manure. The simple diagram below illustrates a representation of various forms and sources of nitrogen found in soil. Please refer to Figure 2.2, Cycle of Soil Nutrients.

Figure 2.2

Cycle of Soil Nutrients



For the evaluation of the nitrogen credit given to farmers who elect to use legumes, green manures etc, this information was important. In development of the model, this study gave a good foundation to the potential reserves of nitrogen found in legumes. This also highlights the need to have a green cover crop on the land to capture the unused crop nutrients applied during production.

LEACHING AS IT RELATES TO LAND MANAGEMENT AND CROPPING SYSTEMS:

According to Bockman et al (1990), plant nutrients are used in 5 primary ways: 1) The majority of nutrients are used by the plant for growth and other biological processes. 2) Another large part of the nutrients will be incorporated into the soil's organic matter. 3) Some of the plant nutrients will be converted into a minor form in the soil mainly clay ammonium complex. 4) Some of the nutrients will be lost through the action of denitrification and volatilization. 5) Finally, the remainder of fertilizer nitrogen is lost through the actions of leaching. This is the focus of this thesis.

Table 2.1
Fate of Soil Nutrients

Taken up by the crop (above ground parts)	40-60%
Incorporated in the soil's organic matter	20-50%
Miner form in soil (clay ammonium complex)	5-20%
Lost by denitrification and volatilization	2-30%
Lost by leaching	2-10%

There are many management practices that will have an effect on the amount of nitrogen that enters into each possible use of nitrogen outlined above. For instance, leaving land fallow for part of the year, will generate a greater level of leaching than that documented on land which is left under plant cover. This can be confirmed from a study done in Switzerland (German 1989).

Table 2.2
Field Usage of Nitrogen and How it Relates to the Amount of Leaching

Culture	Fallow	Maize	M+R	Grass
Fallow part	100%	Large	Small	0%
N-Fertilizer, Kg N/Ha	0	120	120	250
N-Leaching, Ka N/Ha				
Clay	100	72	27	8
Sand	167	60	24	9

Rotation: M+R = Maize and Rape (autumn sow). Alternative Agriculture 1989.

It can be inferred from the above information that it is imperative to leave fields with winter or catch crops[3] to the maximum extent possible (Bockman et al 1990, Harwood 1992). These cover crops are only truly effective in reducing leaching if they are given sufficient time to develop their root systems before the dormant season begins. In the case of grazed grassland, the agricultural producer will need to be careful because grazed land has a higher risk of leaching than a mown grassland. This is attributed to dung and urine deposits which create rich mineral nitrogen spots. These spots, in turn, contribute to higher levels of mineral nitrogen leaching. This even happens to old grassland in spite of the fact it has a very long growing season for nitrogen use as well as a very dense and extensive root system. Thus, along with grassland's ability to use and contain nitrogen, we have documented its very high potential of nitrate leaching once it has been ploughed under (Bockman et al 1990, Doran and Smith 1991, Harwood 1992).

A study of old, permanent grassland that has been ploughed down in Rothamstead England revealed extremely high levels of nitrate in the chalk beneath the field for several years after incorporation. Crop residues that are ploughed

[3] These are crops that are used to capture the unused soil nutrients after the main crop is harvested, thus limiting the amount of leaching and/or runoff of the nutrient.

into the soil can have an effect on the nitrogen content. Subsequently, agricultural producers could incorporate plant residues containing low levels of nitrogen into the soil. The plant's decomposition will temporarily immobilize mineral nitrogen as microbial biomass (Bockman et al 1990). Thus, those crops that are rich in nitrogen, once ploughed in, may contribute heavily to nitrate leaching.

SOIL EROSION:

Ploughing also increases soil erosion. This paper will not go into detail about soil erosion; yet, to totally ignore the subject, would be a serious omission. The main disadvantage that erosion has on production is that it will, over time, negatively effect the yields of crops grown on the field. Soil erosion also has a large detrimental effect on nearby water courses. This includes lowering the water quality not only through destruction of aquatic life but also through destruction of viability of the watercourse for navigation (Bockman et al 1990).

When erosion occurs, the physical and chemical composition of the soil will change. The process of erosion removes the fertile topsoil first. Then, through the process of ploughing, the less fertile soil layers beneath will be mixed with the remaining top soil thereby incorporated into the plant growing zone (Alt et al 1989). The table below, taken from the research of Alt et al, will give the reader a good idea of the scope of the erosion problem relating to production.

Table 2.3

Soil Erosion and Its Relation to the Area of the U.S. and the Cost of Fertilizer:

Region	Cropland Acres (Million)	Crop Yield Decrease From Erosion Percent[4]	Billion Dollars
Northeast	17.3	8.2	0.3
Lakestates	43.9	3.7	0.4
Corn Belt	92.4	3.7	1.0
United States	420.7	3.0	2.6

Region	Fertilizer Cost Increases From Erosion Percent	Combined Productivity Loss In 100^{TH} Year		Total Loss Over 100 Years[5]
			Billion Dollars	
Northeast	0.6	0.026	0.3	2.5
Lake States	0.4	0.043	0.4	3.3
Corn Belt	0.7	0.181	1.2	10.3
United States	0.6	0.519	3.1	28.1

From the above information, it can be concluded that crop yield, after 100 years of erosion, will be low and the

---

[4]Computed as the percent value of 100 year losses, discounted at 4 percent.

[5] The percentages relate to the current (1982) total value of crop production.

resultant need for fertilizer will increase. This trend is already apparent in agricultural production. Soil erosion is also greatly influenced by the management practices of the agricultural producer. The table below gives erosion losses from two Norwegian plots with identical slope but different soil types under varying operations (Bockman et al 1990).

Table 2.4
Soil Loss

Soil loss in different agricultural systems when the risk of erosion is high. Slope 1:8, mean values for 1982 - 1986.

System	Soil loss, tonnes/Ha Loam	Clay
Fallow	35.9	3.2
Spring Barley, Autumn Ploughed, Spring Harrowed	9.3	1
Spring Barley, Not Ploughed, Spring Harrowed	2.7	0.6
Meadow	0.2	0.02

The above discussion reveals the importance that soil erosion has on production. The recent farm bills have dealt with the issue of soil erosion through various programs. These include the Water Quality Protection Program (WQPP), Acreage Reduction Program (ARP) and the Integrated Farm Management Program Option (IFMPO.

COST COMPARISON:

Various studies, including Lockeretz (1984 and 1987), state that on the whole, alternative agriculture experiences smaller variable cost than that incurred with a conventional system. The primary reason for this cost difference lies in lower financial investment in fertilizers and pesticides on alternative farms. Oelhaf (1978) and Poincelot (1986) as well as Lockeretz et al (1984 and 1987) report that the alternative crop production system requires more labor than the conventional production system. In particular, Lockeretz et al reported that organic farms use approximately 12 percent more labor per unit of crop produced or 3 percent more per unit of land. They assert that this is not due to labor intensiveness but rather to the differences in crop mix and cultivation. Agricultural producers, on the whole, have not assumed responsibility for the environmental damage their production has caused. This damage is perpetuated by U.S. farm income support programs that discourage resource conserving production practices (Bovard 1989). "Resource conserving land" is land that is removed from production and is planted into annual, biennial, perennial grasses, or other soil conserving crops. These crops would also include forage legumes (alfalfa, clover, or combination). Thus, when soil related resource costs of agricultural production are added to the usual business accounting costs, conventional production is not cost effective (Boehlje and Eidman 1983).

MANAGEMENT:

The management needed to effectively operate a production system adopting more sustainable procedures is itself substantial. The organic manager will need to coordinate all the intricate relationships that make up a biological system. Madden (1987) finds that some of the key characteristics of successful organic farmers lie in "superb management". According to Madden, these farmers have complete knowledge of their total farming operation. This is in sharp contrast to conventional farming producers who need less understanding of the complex relationships between crops, weeds, insects, diseases, as well as the nutrient requirements of the crops grown on the field. Faeth (1993) states that in the United States the various restrictions and compliance requirements of agricultural programs provide farmers strong incentives to use production practices that will increase soil erosion and agro-chemical use. This is demonstrated by farmers who manage soil fertility and pests non-chemically growing non-program crops such as clover or alfalfa and who receive no government support for these programs. In affect, these farmers are being penalized for not enrolling in the government price support programs. Taking all of the above into consideration, the farmer who practices alternative farming methods will need to devote a considerably larger proportion of time and effort to management of his farm than a conventional farmer.

This could become both a formidable obstacle and serious consideration for agricultural producers who are weighing whether or not to switch to an alternative agriculture format. The time investment required to obtain the management skills necessary to make the switch from a conventional system to an alternative system would entail a substantial opportunity cost. This would be time that would have to be sacrificed from some other activity on the farm. Time needed to gain management knowledge, plus the opportunity cost of this knowledge acquisition would have to be taken from sources such as the off-farm job, recreation, quality family time and other pursuits that also have value and give utility to the agricultural producer. Farmers, whether conventional or alternative, do not have large blocks of time available to devote to such an endeavor.

Beyond considerations of time required to obtain new management skills, learn all the complex relationships that comprise the ecosystem, meet increased labor demand and decreased cost of inorganic fertilizer and other chemicals, another point deserves consideration. This is the yield penalty and its possible effect on food supplies produced from an alternative production system. This concern is noted by Adams (1990) in an article related to the increased acreage of land required to maintain the total amount of food production if there should be a widespread move to convert to an alternative farming system. He proposes that an organic farm system could never become a net exporter of produce without running down soil fertility! He asserts the lower yields realized will necessitate use of larger tracts of land possibly involving and destroying valuable wildlife habitat. However, it appears that the yield penalty is only temporary. In some cases, the ultimate yield may actually exceed that of the conventional farm. This makes Adams' concern about lower yields seem unjustified. With the adoption of rotations and lower value crops in an alternative production system, the consequence will be that fewer total acres of a crop will now be grown on the farm. Wide adoption of sustainable agricultural rotations, even with equivalent per acre yields, could be projected to reduce the total amount of commodity production for individual crops.

CONCLUSION:

There still needs to be continued research on the profitability of production conversion toward a more sustainable production system. This should include substantially more research on appropriate crop rotations and how such rotations will affect the various aspects of soil fertility. For instance, the amount of available nitrogen to the present crop, given the previous crops planted, should be a known entity. This amount is now being looked at and more information is being discovered. Yet, the variability from one study to the next can still be quite substantial. Soil erosion caused by the rotation employed and how it may affect soil nutrient content and availability of various other nutrient sources to the field is becoming more clearly understood.

In the literature, it was found that little mention has been made of how non-livestock producers would obtain extra organic material if needed (i.e., manure) and at what cost. Research needs to be conducted on the feasibility of organic material originating in surplus areas and subsequently being transferred to deficit areas. This could be handled by a transportation model in an LP frame work. Finally, farmers and agricultural producers need to be involved in both policy making and education to provide them updated information relative to alternative farming practices. Such a program would enlighten the producer's decision making and hopefully result in their ultimate decision to convert to an alternative farming method.

Chapter 3

1990 Farm Bill Analysis

INTRODUCTION TO FARM BILL ANALYSIS:

The Farm Bills, since their creation, have played a major role in decisions that agricultural producers make within each state across this country. Farm Bills are legislative actions that are created to aid agricultural producers with the returns they receive in the market, dictate what the producer can do given certain topographical scenarios and thus conserve soil resources. The numerous farm bills legislated in the past have been designed and implemented to correct what federally elected officials perceived as some wrong or problem in agriculture. For example, after World War I, Congress extended the wheat price support, established during the war, in spite of the fact that other countries such as Argentina and Australia were engaged in shipping The framers record amounts of this commodity. The USDA's reason for continuation of this artificially high price was to encourage farmers to continue production of large quantities of wheat as insurance that the U.S. would not become dependent upon other suppliers. Other examples include: 1) The government purchase of large quantities of grain to stimulate demand thereby raising the price for this commodity; 2) The government paying farmers to reduce the size of dairy herds so as to raise the price of milk. Farm bills have also served as vehicles to address various environmental concerns.

The farm programs laid their roots in the first part of this century. At the outset, the government effectively removed most, if not all, market incentives for production of most agricultural commodities (Bovard 1989). In their early stages, these policies continually set prices for various farm commodities not only above production costs but usually above prices existing on the world market. This practice creates an incentive for farmers to overproduce program crops leading these agricultural producers to push the upper limit of production obtainable from their soil. They accomplish this accelerated production through the use of chemical inputs (fertilizers, pesticides, herbicides, etc) (Bovard 1989). The framers of the most recent farm bills have endeavored to reintroduce more market incentives for agricultural producers.

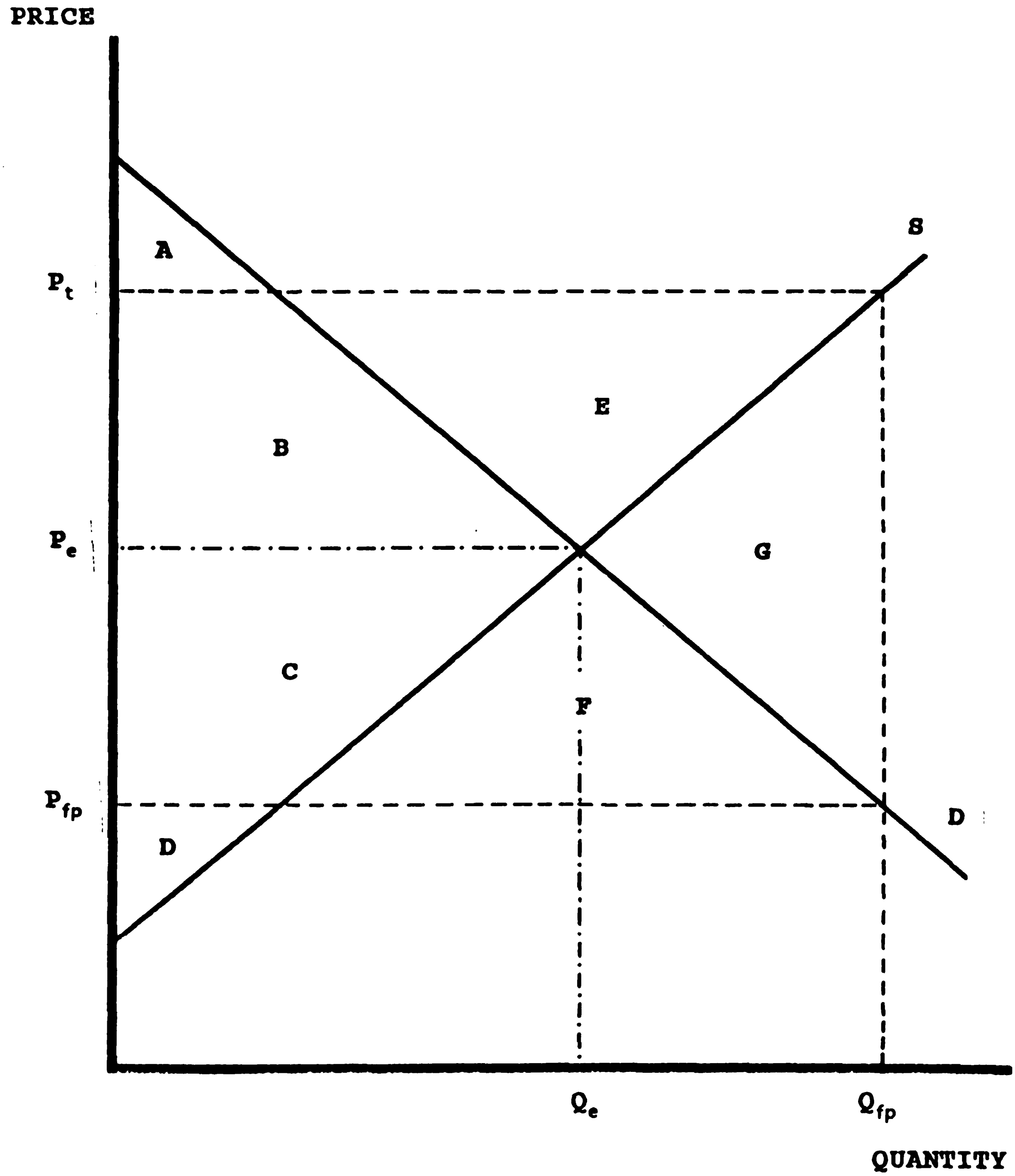
The artificial position of commodity prices that are sustained above those on the world market reduces the return that the Federal Government obtains from sales of commodities they purchased through their own commodity programs. This situation greatly reduces the comparative production advantages that farmers once enjoyed. These comparative advantages were gained through the increased sophistication of technological advancement farmers employed in production: 1) Better seed varieties both yielding more grain per plant and exhibiting more resistance to diseases, pests and climatic conditions; 2) Better and more sophisticated machinery allowing farmers to cultivate larger plots of land in a more labor and time efficient manner; and 3) New agricultural practices providing the farmer information on optimal planting and harvest time including not only the type and amount of chemicals recommended but also the optimal time for their application. As mentioned above, current farm bills have added incentives to elicit flexibility in planting decisions from farmers.

The study by Chang et al (1992) is not only an example of the effects that farm programs have on market prices and supply lines but also addresses the distributional effects of these programs. They used a mathematical programming model to study market distortions caused by price supports, target prices, program participation, deficiency payments and market loans. In summary, they found that the current farm programs promote a tendency to not only raise producer's prices but also to decrease consumer prices resulting in stimulation of production to excessive levels with higher consumption and exports. In Figure 3.1, P_t refers to the target price for the commodity program; S is the aggregate supply curve; D is the aggregate demand curve. Within an undistorted market P_e and

Q_e represent the equilibrium price and quantity. FP is when the farm program is in place. P_t is the price producers receive at production level Q_{fp}. The consumer price falls to P_{fp} while the government pays P_t-P_{fp}. From their analysis of the farm programs in place (1990 Farm Bill), Chang et al (Figure 3.1) found producer surpluses (area b+e+c+d) were larger than they would be at equilibrium. This conclusion held as well with consumer surplus (area a+b+c+f). These very surpluses produce a deadweight loss to society (area g). Under the present program, both the producer and the consumer can gain economic welfare but only at the expense of increasing governmental costs (area b+e+c+f+g). Thus, total social welfare is actually diminished because of the incurred increase in governmental cost.

Figure 3.1

Market Distortions From Farm Programs



The above assumes that the supply curve is static and will not shift due to any program effects.

Keeping the above in mind, the 1990 Farm Bill (Food, Agriculture, Conservation and Trade Act of 1990) will be examined to evaluate how it has influenced farmers' production decisions. In particular, the 1990 Farm Bill will be studied relative to specific effects on the quantity of the legume crops in proportion to the conservation practices agricultural producers are able to utilize. This thesis will also examine the ultimate effects on producers' earnings.

Most of the provisions that are contained in these farm bills are voluntary. Exceptions will be found in areas that are environmentally sensitive. One option open to all agricultural producers is not to enroll in the various farm programs. Non-enrollment would give farmers the freedom to grow any mix of crops determined most profitable and efficient for their individual farms. Farmers who do not enroll pass up a great safety net for reduction or elimination of a portion of the risk associated with production (Debertin 1986, Harsh et al 1981). These risks lie mainly in the area of output price. Farmers face situations daily in which outcomes are uncertain. Producers outside established farm programs assume undue risks to their operations when they elect non-enrollment thereby eliminating both government price support programs and also some risk insurance.

DEFICIENCY PAYMENTS IN THE FARM BILLS:[6]

Deficiency payments are made only to producers of wheat, feed grains (oats and corn), rice, or cotton. These payments are calculated on two different bases. The first is the difference between the target price (which is set by law) and the market price during a period specified by law. The second is the price per unit at which the government will provide non-recourse loans to farmers enabling them to hold their crops for later sale in a more profitable market. This loan rate program operated by the Commodity Credit Corporation (CCC) supports the price of feed grains, cotton, peanuts, and tobacco. The CCC is a federally owned and operated corporation within the U.S. Department of Agriculture. The CCC was created to stabilize, support, and protect both farm income and prices through loans, purchases, payments and other financial operations. The CCC functions as the financial institution through which all money transactions are handled for agricultural price and income support programs. The CCC also helps maintain balanced, adequate supplies of agricultural commodities and assists in their orderly distribution. Farmers who agree to comply with all commodity

[6] A farmer's deficiency payments are equal to the payment rate times the permitted acreage (base) times the county average yield. This holds unless the farmer can demonstrate a historical yield greater than that of the county.

program provisions may pledge a quantity of a commodity as collateral thereby obtaining a loan from the CCC. The borrower may elect either to repay the loan with intrest within a specified period regaining control of the collateral commodity or to default on the loan. In case of a default, the borrower forfeits, without penalty, the collateral commodity to the CCC. This program is the market loan, which was introduced in the 1985 Food Security Act. It was intended to address the rising budgetary cost resulting from accumulation of commodity stocks by the Federal Government. The market loan permits producers to repay their non-recourse loans at a rate below the loan rate created when world prices are lower than the loan rate. This is a payment that effectively covers the difference between the domestic support price and the world price[7]. This program should discourage agricultural producers from surrendering their commodities to the CCC.

MOTIVES AND INFLUENCES BEHIND THE 1990 FARM BILL:

This bill, as well as the previous Farm Bill, is a move in the direction of "decoupling" the commodity programs. It is a farm policy concept which, by separating farm program payments from the amount of production, would represent an

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[7] The world price often refers to the cost, insurance, and freight (c.i.f.) price of a commodity at the principle port of a major importing country or area.

alternative to current policies. Yet,the farm bills have not fully decoupled any commodity programs. Farmers would make planting decisions based on market prices but receive income-support payments independent of production and marketing decisions. This paper will not directly address the issue of decoupling, its logistics or any of the pros or cons on the issue. The 1990 Farm Bill also adds new environmental restrictions to farm practices.

The 1990 Farm Bill has three primary objectives: 1) To increase market orientation for farmers by emphasizing production flexibility. Payment to producers from such programs come from 13 different crops. These crops include the following: wheat, corn, barley, grain sorghum, oats, rye, extra long stable and upland cotton, rice, soybeans, tobacco, peanuts, and sugar. At present, production flexibility is hampered to some extent by the need to maintain base acreage in the commodity for which program payments are profitable. 2) To improve international competitiveness; and 3) To address various environmental concerns. The bill attempts to enhance the resource stewardship of American farmers through greater production flexibility. The 1990 Farm Bill also provides some incentives for farmers to change resource use in environmentally sensitive areas by detailing research and technical assistance.

BACKGROUND ON THE 1990 FARM BILL:

The 1990 Farm Bill developed the "50-92" program of the 1985 Farm Bill into the "0-92" provision. These provisions were designed to make agriculture more market orientated. The bill allows farmers to enroll up to 100 percent of their permitted acreage into conserving uses while simultaneously obtaining 92 percent of their deficiency payments. This permitted acreage is the maximum acreage of a crop which may be planted within the program. The permitted acreage is computed by subtracting the acreage reduction program (ARP)[8] requirements from the crop acreage base minus the diversion acreage (if applicable). For example, if a farm has a crop acreage base of 100 acres and 10 percent acreage reduction (ARP) is required, the permitted acreage is 90 acres. This provision improved an agricultural producer's ability to be more flexible in planting decisions. Flex options were also included in this farm bill as they were designed to allow the agricultural producer to grow a more varied crop mix. The producer will not receive deficiency payments for the crops in this flex acreage yet the base previously established will not be lost. The crops that may be planted on these flex acres include all program crops, all oilseed crops, all industrial or experimental crops and all other crops with the

[8] The acreage reduction program is also known as set aside. This is the percentage of a commodity program acreage base that must be idled in a given year. This is done to reduce commodity supplies and limit the cost of farm programs.

exception of fruits and vegetables. The 1990 Farm Bill offers two options for flex cropping. Under the normal flex option, the producer must use 25 percent of his crop acreage base as flex acres. By enrolling in the optional flex plan, the agricultural producer may plant up to an additional 10 percent of his crop acreage base into a flex crop.

SUSTAINABLE AGRICULTURE AND THE 1990 FARM BILL:

The 1990 Farm Bill encourages sustainable agricultural practices beyond what the 1985 bill did. The farm program payments that were adopted by the 1985 Food Security Act were based on a farmer's production of program crops. Those who elected to use certain sustainable agricultural production practices, under certain conditions, may have lost some program benefits.[9] The 1990 bill permits farmers to adopt specified rotation practices without loss of program benefits. These include the flex options, the 0/92 program, and the Integrated Farm Management Program Option.

INTEGRATED FARM MANAGEMENT PROGRAM OPTION:

The Integrated Farm Management Program Option (IFMPO) is a voluntary commodity program flexibility option designed to

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[9] Some of these production practices would include the use of crop rotation for pest control, fertilizer use reduction, and cover crops to name a few.

assist producers in adopting more sustainable farming production systems. These systems would incorporate more resource conserving crop (RCC) rotations.[10] Farmers would be allowed to plant at least 20 percent of their crop acreage base. This 20 percent would be spread over the life of the contract which would run between 3 and 5 years. An acceptable planting rotation for an RCC would be to grow 30 percent the first year and 25 percent for years two and three reserving 10 percent to be grown for years four and five.

When a resource conserving crop is added to a rotation, this crop should follow the provisions in the 1990 Farm Bill: reduce erosion, improve the soil fertility and/or tilth, interrupt the pest cycle developed in a monoculture production system and/or conserve water (Bockman et al 1990). The IFMPO was intended to help farmers utilize improved stewardship practices by providing farm program payments on resource conserving crops planted on paid acres and by allowing some harvest of set-aside acres. The law stipulates that up to 255 million acres may be enrolled in the program between 1991 and 1995. This program is intended to be most helpful to those

[10] Resource conserving crops, according to the 1990 Farm Bill, are: 1) forage legumes (clover alfalfa, vetch or medic). 2) any legume grown for use as a forage or green manure. 3) legume/small grain mixtures. 4) legume/grass mixtures. 5) legume/grass/small grain mixtures. Any bean crop that is to be harvested is not eligible. Malting barley and wheat are not eligible except when wheat is interplanted with a small grain and is destined for nonhuman consumption.

farmers who are converting base acres from program to non-program crops thereby enabling them to achieve a more diversified rotation. Even with the IFMPO's seemingly good business and ecological basis, few farmers are enrolling in the program (Hoefner et al 1991). This is due to the confusing details of the proposal and the varied interpretations of its provisions and requirements.

CONSERVATION RESERVE PROGRAM (CRP):

The CRP is a program authorized under the Food Security Act of 1985 that allows up to 45 million acres of highly erodible land to be planted into a 10-year reserve. Land in the reserve must be under grass or tree cover to protect it from erosion. It is not allowed to be used for hay production or livestock grazing.

Through 1993, the Conservation Reserve Program (CRP) reported having a total of 34 million acres enrolled. The present authorization level of approximately 40 million acres will be adequate to address additional environmental problems. It will also add some additional participation under current criteria which focus on highly erodible land. This leaves an additional 6 million acres to meet the full enrollment level. The Food Security Act of 1985 authorized the security to enter into contracts with producers to help conserve and improve soil and water resources through CRP.

Since its implementation, CRP has substantially reduced soil erosion improving water quality; thereby, not only protecting numerous wetlands but also bettering wildlife habitats as well as increasing land values. By enrolling in the CRP, an agricultural producer may actually realize an increase in the value of the enrolled acres (Shoemaker 1989). This is due to the possibility that the CRP payments may be substantially higher than those realized elsewhere. As a result, farmers having marginal, low productive land could conceivably receive the county average rents on their less desirable acreage.

Land enrolled in CRP, since its authorization, has fully established vegetation and has seen erosion reduced by an estimated 655 million tons annually. Agricultural records show that an excess of 2 million acres of trees and more than 7,000 acres of field wind breaks have also been established. In addition, some 49,000 acres of filter strips have been established near bodies of water. Two million acres of wildlife habitats have been created as well (Hoefner et al 1991). Uninterrupted opportunity for enrollment in the CRP should ensure continuation of these beneficial changes.

The 1990 Farm Bill is responsible for several areas which continue the conservation tradition established in the 1985 Food Security Act. The 1990 Farm Bill enables producers to reduce cropping on land where pollution of ground water is a critical concern. This is realized by extending the current CRP time periods for contracts entered into for the purpose of improving water quality. This land includes the following: 1) All crop land that is within 1,000 feet of a well within a state approved wellhead protection area; 2) Crop land that is on shallow karst areas, where sinkholes convey dangerous runoff directly into ground water;[11] 3) Filter strips that serve as natural barriers for control of erosion and runoff into nearby water courses.

If the agricultural producer leaves land in its protective cover of grass or trees, the crop base will extend beyond the contract's termination. Under the 1985 FSA, producers have the incentive to return the CRP land back to cropping at the end of the contract. Windbreaks and shelter belts may be entered into CRP without enrolling the entire field according to 1990 Farm Bill provisions. By enacting this provision, rental costs could be lower and long term

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[11] Karst terrain is one that has developed over thick limestone bedrock. The limestone is gradually dissolved in moving water and permits many major surface features to be worn away. Small solution holes (sink holes) are often visible at the surface.

benefits could also be created because producers will have the incentive to maintain these practices long after the contracts have expired (Bovard 1989).

A recent newsletter published by the Michigan Agricultural Stewardship Association (Lehnert 1993), made a critique of the IFMPO. In this article, it was revealed that Michigan was allotted 18,468 acres to be enrolled in the IFMPO program. Yet, at the time of the article, only 1,496 acres had been enrolled. It has been postulated that the main reason for this lack of participation is that the IFMPO is very similar to the current 0/92 program. The 0/92, in most cases, was superior to the IFMPO in providing benefits to agricultural producers. Under the 0/92 program, producers are guaranteed set deficiency payments at the time of enrollment. Under the IFMPO, the farmer will only receive the actual deficiency payments at the time of harvest which, in most cases, is at a reduced amount.

ENVIRONMENTAL CONCERNS ADDRESSED IN THE FARM BILLS:

The 1990 Farm Bill has put forth two changes in annual commodity programs designed to allow farmers to adopt practices that aim to encourage reduction of chemical use (IFMPO and flex plans). These program options are intended to enable agricultural producers to plant conserving crops and/or a combination of program crops without losing either program crop base acreage or deficiency payments. Permanent or annual cover crops can be established on some currently idle acreage. In order to improve water quality, wildlife habitat, reduce erosion and improve weed control.

WATER QUALITY:

The problem of agriculture and ground water pollution is still very much a concern in spite of various programs established in previous farm bills (Pierce et al 1990). According to data collected by state water agencies, non-point source pollution by agricultural producers may be responsible for 64 percent of all river degradation and 57 percent of all lake degradation. In some 609 counties, pesticide contamination was shown to have greatly effected some 4,916 water bodies. There was also significant nutrient contamination in 5,246 water bodies in 859 other counties(Doran and Smith 1991, Fleming 1989).

With higher levels of nitrate and trace amounts of pesticides being found in some aquifers, concern about ground water quality has increased. In 1988, some 46 pesticides had been found in ground water in 26 states directly resulting from normal agricultural operations. Of these 46 pesticides, 18 were at levels higher than those recommended by the Environmental Protection Agency (EPA) health advisory levels. It is also documented that some 1,254 existing public water systems are contaminated with nitrate (Hallberg 1987, Fleming 1989).

This new, alarming information on water contamination combined with recent scares over food contamination will increasingly place agricultural producers under the scrutiny of the public and regulators for their production practices. The future result could be tighter regulations and policies governing production practices. The consequences of these new regulations could be higher operating costs and lower profits for agricultural producers. These higher costs may include more labor allocated to weed control necessary because of diminished herbicide use. Higher costs would also be incurred as the farmer seeks to acquire management skills necessary to operate under the stricter regulations. The possibility of lower yields and/or fewer acres in production could result in less product on the market and/or payments from the government.

To help encourage producer adoption of a program directed toward water quality management, the 1990 Farm Bill created the Water Quality Protection Program (WQPP). This program offers incentives of up to $3,500 per year over a period of three to five years for creation and implementation of farm management plans which are established to protect both surface and ground water. This program will also provide cost savings, as high as 50 percent not exceeding $1,500 per farm, for agricultural producers who along with their WQPP create and install a plan that either enhances or preserves a wetland or wildlife habitat.

CONCLUSIONS:

This chapter has laid the ground work for developing alternative policies to be considered in the 1995 farm bill debate. It also provided information for development of the linear program model that will be used in the final design for proposed policy options. The upcoming debate on the 1995 Farm Bill will most probably be influenced by the same forces as the two proceeding farm bills: the continued budget deficit crisis, environmental quality issues, trade negotiations and barriers to creation of more flexibility in agricultural production.

The next chapter will examine in detail potential policies to be evaluated for inclusion during the 1995 farm bill debate. Subsequent chapters will discuss the design and the activities that will be included in the linear program model developed for this thesis. The policies that will be considered and analyzed will be developed in relation to major influences of past farm bills cited above. Those policy proposals will be evaluated based on considered economic and environmental criteria.

Chapter 4

Policy Proposals for
The 1995 Farm Bill Debates

INTRODUCTION TO POLICY ALTERNATIVES FOR THE 1995 FARM BILL DEBATE:

Based on the previous discussion concerning the farm bills, this thesis will continue with design of alternative agricultural policies for consideration in the 1995 Farm Bill debate. The policies proposed will be tested within a linear programming framework.

When formulating these alternatives, the factors which have influenced the outcome of past farm bills will be kept in mind. At the conclusion of chapter this chapter, the three most important points for consideration will be incorporated into the design of these policies policy alternative. These include: 1) Giving farmers more flexibility in their cropping decisions; 2) Making base acre restrictions and requirements more flexible; and 3) Freezing base acres while agricultural producers are in stages of rotational plans that do not utilize program crops. The mathematical programming model will identify the mix of restrictions, requirements and incentives that will maximize the return to the producer given the predetermined parameters. Below is the discussion of the various policy alternatives that will be tested in the linear programming model that this thesis will develop.

ALTERNATIVE POLICY PROPOSAL CONSIDERATIONS:

Some factors of influence considered in the design of the various policy proposals for this thesis were: 1) The rising budget deficit, 2) The desire to make agricultural markets more market responsive, and 3) Growing public concern over exposure to pesticides and other agricultural chemicals in or on food and groundwater. The GAO interviewed farmers and found them to believe that greater management requirements, lower yields and profits, increased weed problems and federal farm program constraints all combine to create significant barriers to the adoption of alternative agriculture practices (US GAO 1990). Established federal price and income support programs do not impose direct barriers; however, they do provide strong incentives for planting program crops and continuing to specialize in them year after year. One hypothesis that will be tested is whether or not the current federal farm programs encourage the continued production of program crops. Thus the over use of nitrogen for crop production (Bovard 1989, Fleming 1989, Hallberg 1987). The loss of program benefits resulting when non-program crops are planted in a diversified rotational system is a key economic disincentive.

Consideration should also be given to the idea proposing total elimination of base acreage payments and deficiency payments. This would meet the need to hold spending down on governmental farm programs thereby addressing concerns over the rising federal budget deficit. A proposed 10 percent reduction per year over a 5 year phase out in the deficiency payment schedule would be a way to eliminate these payments. This would only be a beginning gesture toward reaching world prices for agricultural commodities. It is important to note total elimination of deficiency payments for farmers may not be politically feasible. Yet, deficiency payment elimination is becoming an economic mandate as the federal deficit grows. At this point, even a small proposed reduction in the total deficiency payment is not guaranteed to survive the political process.

INCENTIVES FOR USING ALTERNATIVE AGRICULTURAL METHODS:

The 0/92 proposal enables farmers to employ a crop rotation program with non-program crops while still qualifying for deficiency payments. An alternative to this would be allowing producers to grow crops on the idle land that falls under the ARP (Acreage Reduction Plan). It would be necessary to place restrictions on the crops grown on this soil as it would usually be land that is environmentally sensitive (Helmers et al 1986). These restrictions include only planting crops that have the lowest potential for contributing to water and wind erosion. For every acre of program crops planted and harvested on such land, the producer should give up one acre of deficiency payments. Also, for each acre of experimental, conserving, or industrial crops planted and harvested, the producer will surrender one dollar of deficiency payments.

While the producer is growing the resource conserving crops, the base acres are not lost. Program payments that the producer is currently receiving cannot be reduced. Eligibility for simultaneous deficiency payments while growing an RCC rotation specifies that the producer must: 1) Not hay or graze the crop during the seven month period that haying and grazing is not allowed on acreage reduction program acres (ARP) (usually April 1 to October 31). 2) One half of a farmer's set aside land can be harvested at any time with no restrictions. 3) A plan that describes the rotation and the amount of the abase acres that will be used to plant the RCC must be filed with the local ASCS (Agricultural Stabilization and Conservation Service) office[12]. The plan will last for at least three years with the possibility for extension to, at the most, five years depending upon the total number of acres

[12] The ASCS is the U.S. Department of Agriculture agency responsible for administrating farm price- and income-support programs and some conservation and forestry cost-sharing programs.

enrolled. By allowing more flexibility in production decisions, farmers may begin to switch back and employ more sustainable rotations.

So far, the issue of how to motivate farmers into adopting sustainable agricultural practices has not been directly addressed. The IFMPO provision in the 1990 Farm Bill attempted to give farmers more options for crop rotations. Yet, this option did not go far enough in creation of necessary incentives for producers to eagerly incorporate sustainable agricultural practices. Mainly, the proposed program allows farmers to maintain their acreage base yields if non-program crops are grown on them. Furthermore, the program does not allow farmers to receive any deficiency payments on land if they harvest, hay or graze the RCC crops during the seven month period extending approximately from April 1 to October 31. This effectively reduces the profitability of bringing legumes into the rotation which, in turn, definitely reduces the agricultural producer's incentive to introduce these crops.

RCC'S AND DEFICIENCY PAYMENTS:

The actual amount of the deficiency payment will be determined through the mathematical model developed by this thesis. From the earlier model design, a range of prices was revealed that bring credit for using a rotation having one or more years in which a non-program crop is grown. This will be done so as to determine at what rate the outcome of the model will be altered thus producing a different result form the last.

ELIMINATION OF DEFICIENCY PAYOUTS:

A policy that calls for the total elimination of the base acreage programs should be considered. By doing this, the Federal Government could lower its total spending on commodity price supports. The production of agricultural commodities would become more market oriented. This has developed into a serious policy alternative as the federal deficit becomes a greater burden and the pressure to reduce it accelerates. Recognizing that farmers want to hold on to their base acreage programs, it will be important to educate them to understand that continuation of high deficit spending on all social programs, including agriculture, only robs from all of societies future to pay the approximate 2 percent of the populations present.

TAX CREDIT FOR LEGUMES BROUGHT INTO ROTATION:

A tax credit, nitrogen credit for legumes used in the rotation, could be awarded those producers using an alternative source of nitrogen (manure, green manure, legumes). These producers would be required to register their rotational plans with the option of altering them at the end of the stated rotation. These agricultural producers would also need to adopt practices that would minimize the potential leaching hazards of improper application and use of nitrogen sources. These production practices attempt to keep a cover on the fields and time field work and cultivation so as to avoid leaving the field without cover for extended periods.

The tax credit will depend upon the average national cost per acre of synthetic fertilizer nitrogen. Since there are a large number of synthetic nitrogen sources and cost can vary from region to region, this thesis will assume the cost to be based on dry nitrogen. This cost will be incorporated into the linear program model within the objective function as a sperate cost of production on a per pound of nitrogen rate. The cost of dry nitrogen, which is currently $0.19 per pound, used in this research is obtained from the Telfarm information gathered at Michigan State University. The amounts of nitrogen generated from various activities that will be available for subsequent crops are drawn from recent agricultural research (Bockman et al 1990, Follett 1989, Steenvoorden 1989).

SUMMARY OF PROPOSED POLICIES:

In conclusion, these policies will be evaluated in the context of a representative Michigan crop farm:

1) Current 1990 Farm Bill provisions

2) Allowing farmers to hay, graze, or harvest their RCC acreage and restricting them to receive a predetermined percent of their entitled payments for base crops if these were planted.

3) Providing tax incentives for the use of alternative sources of nitrogen.

4) A rotational credit paid to farmers who utilize rotations; involving one or more years of a resource conserving crop.

5) Total elimination of deficiency payments and commodity price supports.

Chapter 5

Linear Programming Model and Discussion of the Representative Farm

INTRODUCTION TO THE MODEL:

The focus of this work is on the representative farmer's planting decisions in the face of current and future policies. The effects of either current agricultural policies or those to be proposed later will not be evaluated relative to their impact on other firms and the economy as a whole. There will be no consideration of macroeconomic effects from either the current farm policies or those potential future agricultural proposals. Primary concern lies in the manner in which agricultural producers make decisions regarding crop rotations especially those relative to soil quality and leaching of nitrogen as a result of farm production practices. In the model, the amount of leaching which occurs with the use of cover crops was set to zero following Harwood (1992).

LINEAR PROGRAMMING AND WHY IT WAS USED FOR THIS STUDY:

A linear programming model was employed to determine the optimal mix of enterprises for the representative farm considered below. There are five reasons why a linear programming model was employed for this research (Anderson et al 1976, Boehlje and Eidman 1984, Hartley 1985). 1) The mathematical modeling procedure is applicable to virtually all resource allocation problems faced by a farm manager. 2) A linear programming model is capable of handling more complex problems than either budgeting or marginal analysis. With this model, we are able to designate a more complex, realistic problem without concern for the cost of or feasibility of obtaining an answer. 3) A linear programming model will not only provide data on the optimal mix of resources and the best production, marketing and/or financial plans; but it will also provide added information concerning the value of the resources employed within the model. This information will indicate which resources most limit maximum return for the operation, which resources are in excess supply, as well as the marginal value product for limiting resources (how much it would be worth to add additional units of those resources that are in limited supply). 4) A linear program will also furnish the sensitivity or stability of the farm plan. A mathematical model will facilitate evaluation of how the farm management analysis might change if variation occurred in product prices or technical efficiency. For this thesis, the linear programming model will examine how sensitive profit, maximizing a farmer's decisions, may be relative to changes in farm policies. 5) A final justification for using a linear programming model in farm management analysis lies in the ease with which it addresses the issues of opportunity cost[13]. Linear programming is one of the few techniques available that can solve a realistically defined farm management problem using mathematical procedures consistent with the economic concepts of marginal analysis.

Linear programs are mathematical techniques for solving a problem that exhibits certain characteristics. These characteristics are a function or objective to be maximized or minimized, where limited resources exist which may be employed to satisfy this objective, and numerous means of using those resources are available. Thus, this involves situations in which attempts are made either to maximize or minimize some set of linear constraints that will limit the degree to which the objectives can be pursued. This then gives rise to a general formula for a mathematical programming model:

Max profit = Sum of $c_j X_j$ where $j = 1$ to n
subject to.
Sum $a_{ij} X_j <= b_i$
for $i = 1....m$
$X_j >= 0$
for $j = 1....n$

[13] Opportunity cost is the cost of goods or service in terms of the lost opportunity to pursue the best alternative activity with the same time or resources. In this case, the opportunity cost of enrolling in various farm programs is of particular intrest.

Where:

X_j = The level of the j^{th} production process or activity.

c_j = The per unit return for the j^{th} activity.

a_{ij} = The amount of the i^{th} resource required per unit of the j^{th} activity.

b_i = The amount of the i^{th} resource available.

It will be necessary to identify data for the values in order to complete the model. For this farm, the manager will be faced not only with decisions of which specific crops to plant and their quantity; but will also have to be in compliance with rules and restrictions established by various federal and state farm programs.

CHARACTERISTICS OF THE REPRESENTATIVE FARM:

The representative cash crop farm used here consists of 500 acres of arable land. This figure was an average of all surveyed farms in Michigan within its class of cash crop farms (MASS 1992). The producer participates only in the corn program with 250 base acres of corn. Three different yields were incorporated into this model; a high yield of 120 bu per acre, a mid yield of 100 bu per acre and a low yield of 80 bu per acre. The farm is operated by an owner who can provide full time labor to the farm operation. The agricultural producer will hire any seasonal help that is required from local sources. This part time help is made up of either the owner's children or local individuals hired at $6.50 per hour. Key constraints are shown in Table 5.1; yields and costs used are given in Table 5.2. The base model linear program matrix is presented in appendix II.

Table 5.1

List of the Key Constraints for the Linear Program Model.

Activity	Sign	Size	Unit
LAND	<=	500	Acre
CRBASE	<=	250	Acre
SSIDE	<=	25	Acre
SPRLAB[14]	<=	520	Hours
SUMLAB	<=	750	Hours
FALLAB	=	390	Hours

In the early stages of the model development information from Bockman et al (1990), the amount of fertilizer uptake by various crops was reviewed. This, along with information obtained through the Crop Soil and Science (CSS) Department provided a good base for determination of the possible leaching of the applied nitrogen on the various soils and crops in the rotation. The model then, in turn, used this information to estimate the total amount of leaching on the farm. By holding leaching to a minimum, the environmental damage produced by agricultural production will be lessened.

[14] These are used to signify the main seasons in which productive activities take place on the farm.

The model also looks at how the inclusion of legumes in crop rotations reduce leaching and nitrogen fertilizer purchases. With the inclusion of legumes the amount of nitrogen fertilizer used on subsequent crops can be reduced. Yet the amount of leachate that is potentially generated depends on the timing of field operations as was explained earlier in this work. From the model, a percentage of the current deficiency payment to be awarded producers who grow a multi-year rotation will be determined. These rotations would involve growing non-program crops one or more seasons. This will be effected to make the adoption of sustainable rotations more economically attractive to agricultural producers.

The other commodities that the farmer will be able to produce include wheat, oats, clover, soybeans and canola.

Table 5.3

Overview of the Representative Farm:

Characteristic	Acres[15]	Base Acres	Yield /Acre	Cost /Acre
Land	500			
Corn		250	[16]	[17]
Wheat		0	60	85
Oats		0	70	50
Clover		Na	Na	25
Canola		Na	36	89
Soybeans		0	40	90
Oat/Clover		0	70	65
Wheat/Clover		0	60	100

TIME AVAILABLE FOR COMMODITY PRODUCTION:

Weather conditions limit time available for completion of field operations. Rosenberg et al (1982) estimated the number of field days available to a typical Southwest Michigan agricultural producer at an 80 percent probability. Rosenberg

[15] The amount of acres that will be grown of the various commodities and the rotations will be determined by the linear programing model. The acres on the land is a built in constraint so that the agricultural producer does not produce on more acres than is available to him.

[16] There are the yields developed in this model for comparison; high yield 120 bu per acre, mid yield of 100 bu per acre and a low yield of 80 bu per acre.

[17] There are three costs to the differing yields; High cost $123.00 per acre, Mid cost $108.00 per acre and a low cost at $100.00 per acre.

et al concluded from their study what percent of total time available was necessary, considering various crops included in the model provided, for field work. This study has also given the model some realism regarding the time available for agricultural producers to complete various field operations. This study was based on time available to the agricultural producer during certain times of the year and the inclusion of weather factors. This information will indicate the possible time limitations that may arise on the farm during the course of production. This will also provide data on the farmer's cost incurred when hiring more help, be it seasonable or full time. However because the crop season is divided into three seasons (Spring, Summer, Fall) for the model, the yield penalties due to untimely field operations are not included.

INCENTIVES FOR NITROGEN MANAGEMENT:

With the effect of legumes in the rotation, a nitrogen credit was included to portray what the various leguminous crops bring into the rotation. To test this within the linear program model, the value of nitrogen, on a per pound per acre basis, that the legumes bring into the rotation will be used as a credit against the cost of purchased nitrogen. The producers who utilize legumes for nitrogen will also be given a per pound credit to help offset the cost of growing legumes as both crops and nitrogen sources. The LP model will be testing whether or not the nitrogen program is feasible and, if so, at what level the credit should be applied. Again, the hypothesis is that as the amount of the credit rises so will the amount of alternative sources of nitrogen. The amount of leaching that results from the use of synthetic nitrogen should be negatively correlated to the amount of the nitrogen credit. Yet, eliminating synthetic nitrogen and using a "natural" alternative will not eliminate the possibility of nitrogen leaching. This is due to the fact that when the legume is ploughed down the nitrogen that was produced will be released into the surrounding soil thus producing the possibility for leaching. Thus, with the inclusion of this credit, one should see an impact on the amount of purchased nitrogen and the inclusion of legumes in a productive rotation.

The source of this "natural" nitrogen will be the legumes which are introduced into the rotation. Bringing legumes into the rotation reduces the need for purchased nitrogen fertilizers. Plants use nitrogen (mostly) and ammonium for their growth along with other biological processes and numerous other nutrients. The proportion of applied nitrogen that is taken up by the crop is affected by many factors including the crop species, climate and soil conditions (Bockman et al 1990). The rate of nutrient uptake also depends on the particular developmental stage of the plant. For an idea on the rate of fertilizer uptake and use, refer to the table 2.1 above.

As can be seen from examination of table 2.1's information, not all the fertilizers that are applied are used in the plant for growth. Thus, the fertilizer recommendations do have some leeway for change. Bockman et al conclude that an agricultural producer can reduce the amount of nitrogen in the soil thereby decreasing the amount of potential leaching through proper field management. This information gave the model a starting point from which to obtain information on the amount of leaching occurring in the cropping cycle.

The amount of nitrogen provided by various legumes is continually being researched and studied. One study revealed that in the year of plow down, alfalfa yielded approximately 112 lbs of nitrogen per acre. In the second year after plow down, this alfalfa field provided approximately 38 lbs of nitrogen per acre (Follett 1989). The model will be using the Follett information for nitrogen credits provided by various legumes to subsequent crops.

This nitrogen credit from the legumes will be used to apply the tax incentive for use of legumes. The amount of nitrogen brought into the rotation by previous legumes also affects the potential leaching; because even though a producer is lowering amounts of purchased synthetic nitrogen, the risk of nitrogen leaching is still present (Bockman et al. 1990).

ROTATIONS USED IN THE MODEL:

For the rotations, the model used a series of 4 year rotations that will include the following combinations:

Rotation one (ROTPL1):

Year 1) Oats/Clover[18]
Year 2) Corn
Year 3) Corn
Year 4) Soybeans

Rotation Two (ROTPL2):

Year 1) Oats/Clover
Year 2) Corn
Year 3) Wheat/Clover[19]
Year 4) Corn

Rotation Three (ROTPL3):

Year 1) Corn
Year 2) Corn
Year 3) Soybeans
Year 4) Wheat/Clover

The same rotations outside the government programs are called ROTPL4, ROTPL5, ROTPL6, respectively. There is a pair of one year rotations in the model to test the efficiency of the intercropped commodities above. These rotations are:

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[18] The oats/clover rotation is a one year rotation with the clover being interplanted with the oats and acting as a nitrogen source for the corn crop.

[19] The clover here will be frost seeded into the wheat crop and will be used as a green cover before the corn is planted and will be plowed down before planting the corn to utilize the clovers fixed nitrogen.

Oat/Clover
Wheat/Clover

Table 5.2

Reference to The Rotations and Crops Used in The Model

Year	Rotation /Crops	Government Program Yes/No	Nitrogen Credits Lbs/Ac
	ROTPL1	Yes	38
1	Oats/Clover		
2	Corn		
3	Corn		
4	Soybeans		
	ROTPL4	No	38
1	Oats/Clover		
2	Corn		
3	Corn		
4	Soybeans		
	ROTPL2	Yes	29
1	Oats/Clover		
2	Corn		
3	Wheat/Clover		
4	Corn		
	ROTPL5	No	29
1	Oats/Clover		
2	Corn		
3	Wheat/Clover		
4	Corn		
	ROTPL3	Yes	38
1	Corn		
2	Corn		
3	Soybeans		
4	Wheat/Clover		
	ROTPL6	No	38
1	Corn		
2	Corn		
3	Soybeans		
4	Wheat/Clover		

Use of the oat/clover intercropping is adopted to accomplish two goals: 1) to bring a legume/cover crop into the rotation so that it will provide nitrogen to the other legs of the rotation. and 2) the legume/cover crop will be used to capture some of the unused and still present nitrogen in the soil from the previous crops. This is done to limit the amount of leaching of nitrate that occurs in the fields during the fallow season.

The model designed for this thesis is a one year static model. Thus, to correctly portray the multi-year rotations in this single year frame work, some modifications were done. All yields, costs, time needed for production, nitrogen usage and credits were taken as percentages of that acre that each crop holds. Thus, for each crop in a particular rotation, the acre brought into production will be allotted in the temporal proportion that each crop has in the rotation.

DEFICIENCY PAYMENTS:

As mentioned above, a percentage of deficiency payments will be awarded to agricultural producers who use rotations. Deficiency payments will be paid to producers for the years they do not grow any program crop. The reason for employing this is to give the agricultural producer a positive economic incentive to adopt a more sustainable agricultural rotation.

Here, the main assumption is that the agricultural producer is not ready to give up the deficiency payments that have persuaded him to grow the program crops.

The manner in which this will be tested within the model is through creation of a transfer row that will take a percentage of the cropping acres and form a link with it to the deficiency payment column. The main assumption here is that the deficiency program will not be eliminated. The elimination of deficiency payments will be examined in another scenario.

This model will be run under seven different sets of assumptions. 1) A base run including only the current policy options available to the agricultural producer. This would consist of the commodity payment programs, flex options, the 0/92 and the IFMPO programs. 2) A run of the program with no government program or proposed options. Thus, the agricultural producer's decisions will be driven only by the cost of production of each activity and the individual return allocated to each activity. 3) The base run plus all proposed policy options that this thesis has outlined above. These would include the nitrogen credit and the partial reimbursement of deficiency payments for utilization of a multi-year rotation. 4) The base program with the nitrogen credit discussed above. 5) The base program with the partial deficiency payment option. 6) The sixth scenario will solely consider the nitrogen credit excluding all other programs government or proposed. The final model run will involve only the partial deficiency payments with no other, current or proposed, options considered.

LIMITATIONS OF THIS RESEARCH:

To achieve some simplification of the model, it is assumed that the farm participates in price stabilization programs only through it's 250 acre corn base. It is then evaluated on what effect this corn base has on the farm's participation in various policy programs. When a linear programming model is used, one can easily alter the model through the addition of new constraints. To change this model from one having 100 percent corn base to one which includes oats, wheat, barley base, etc one would only need to add the acreage constraints and force them into solution for the bases desired.

This model will also not evaluate a mixed crop/livestock farm within the linear program framework because of variabilities in the nutrient content of the livestock manure. Since one goal of this study is consideration of the effects that farm policies have on the use of alternative nitrogen sources, manure with its variability of nutrients is not a good candidate for inclusion. There are many reasons why it is difficult to find an accurate estimate for the nitrogen content of manure. This inconstancy makes the amount of nitrogen available to other crops difficult to determine. These include, but are not limited to, inaccurate and vague estimates by the farmer of the amount of manure applied; the wide variability in the nitrogen concentration of similar types of manure; variable amounts of nitrogen lost by ammonia volatilization following unincorporated surface applications; the uncertainty of the manure nitrogen that will become available for plant uptake; and the possibility that manure additions will increase nitrogen losses due to denitification in some soils (Bockman 1990, Laver et al 1976). Thus, the inclusion of a livestock operation was ruled out for the model.

MODEL YIELDS:

The yields and fertilizer recommendations used in the model were obtained from a Michigan State University publication (MSU 1992). For this model, only one soil type was considered. This was a loamy soil from the southwestern area of Michigan. This soil is predominantly loamy underlaid with sand and gravel (Kalamazoo-Oshtemo)[20]. For the small grains in rotation, it was found that in frost seeding of

[20] These are deep well drained loamy soils on nearly level to moderately slopping topography. They have moderate level of available water capacity. Kalamazoo and Oshtemo soils have moderate to rapid permeability.

alfalfa or red clover yields were not materially affected (Hesterman et al 1992). For a concise overview of the yields that are used in this model.

Chapter 6

Evaluation of The Model Under Differing Assumptions

INTRODUCTION TO THE MODEL EVALUATION:

The results of the analysis will be divided into two sperate parts. The first part will be were the current government programs are included for consideration for production decisions. The second part will be were the agricultural producer does not have the influence of the current government programs. The proposed policies that were developed for this thesis will also be evaluated both with and without the inclusion of the current farm programs. This will be done to determine what level of impact the proposed policies and the current programs.

BASE SCENARIO OF THE MODEL EVALUATES CURRENT GOVERNMENT FARM PROGRAMS:

The base model considered only the current governmental farm programs (0/92, Flex Options, Integrated Farm Management Program Option). One of the objectives of this study was to determine the level of leaching which occurs from the mix of production practices chosen by the agricultural producer. Under this base program, 10,906 pounds of total nitrogen leaching (LEACH) occurred as shown in Table 6.2. The agricultural producer earned $69,111.81. Since both income and leaching are major concerns any policy must improve income without increased leaching and/or reduce leaching without reduced income in order to be considered Pareto superior to the base case.

The dual value that is associated with a constraint is the marginal improvement in the optimal value of the objective function per unit increase in the constrained resource. For example, addition of one more acre of land to the model would improve the producer's income by $113.11. To see a complete accounting of the dual values please refer to Table 6.1 below.

Table 6.1

Dual Values From Base Model[21]

Variable	Dual Value
LAND	113.11
CRNBAS	26.58
SSIDE	159.18
GRGCRN	2.03
GRNCRN	2.32
GRWHT	2.95
GROATS	1.30
GRSOY	5.60
LECATE	0.00
NUSED	0.00
DRYCRN	-0.03
SPRLAB	6.5
SUMLAB	0.00
FALLAB	0.00
FLEXAC	0.00
DEFBUS	0.72
MFLXNO	-44.26
MFLXOP	0.00
MIFMPO	0.00
GRCANO	5.47

[21] For a full explanation of the definitions please refer to Appendix I at the end of this work.

Table 6.2

Base Model Information

Variable	Unit	Value	Value/ Unit
GCRHI	Acres	187.50	-123.00
SOYOUT	Acres	250.00	-90.00
SOYFLN	Acres	37.50	-90.00
SSIDE	Acres	25	-10.00
GCRN$	Bushels	22,499.60	2.03
SOY$	Bushels	11,500.20	5.6
DRYCRN	Bushels	22,499.60	-0.03
$DRY-N	Pounds	5,750.10	-0.19
$ANHYN	Pounds	26,249.60	-0.13
LEACH	Pounds	10,906.20	0.00
$LABSP	Hours	366.30	-6.50
$LABFL	Hours	63.90	-6.50
FLTOT	Acres	37.50	-6.50
DERATE	Dollars	22,499.60	0.72

An assumption that this model will test is whether the current governmental farm programs encourage the production of program crops; here, only corn is examined as a program crop. This assumption was confirmed because of the utilization of the high yield corn (187.50 acres). Another point of interest that needs special consideration from the output is the large positive dual value on the set aside (SSIDE) constraint. From an evaluation of the information in this table, it can be seen that considering the constraint of set aside land the utilization of it for production of cash crops could add positively to the producers' incomes. This data will be held in mind as the further scenarios are evaluated and a policy is finally recommended.

BASE SCENARIO WHEN ALL GOVERNMENT AND PROPOSED POLICIES ARE ELIMINATED:

This scenario was included so as to have a point of reference when the two proposed policies are added individually and in comparison with the other scenarios that will be subsequently examined. When all options are eliminated from the model, the optimal solution produces 500 acres of soybeans with a net return to the agricultural producer of $62,207.50. The leaching which occurs from growing continuous soybeans is approximately 4,000 pounds. This is a substantial reduction in the level of leaching which occurred in the previous scenario. This outcome was not expected since the production of soybeans over the entire productive acreage of the farm is not typical of Michigan farmers. This is somewhat unrealistic in part from the omission from the model of risk considerations and the yield penalty due to untimely field operations. If the price of corn were to raise to $2.28 a bushel from the current $2.03 price used in the model then soybeans would start to be switched over to the production of high yielding corn. For a detailed summary of the activities in solution and the range of optimality for this scenario, please refer to Tables 6.3 and 6.4 found below.

Table 6.3

Information From The Base Scenario Void of All Current and Proposed Policies

Variable	Value	Value/ Unit	Net Return
CROUTL	0.00	-19.27	-80.73
CROUTM	0.00	-56.67	-51.33
CROUTH	0.00	-91.77	-30.23
WHTOUT	0.00	-42.80	-42.21
SOYOUT	500.00	-90.00	0.00
OATOUT	0.00	36.78	-86.78
CANOUT	0.00	-43.70	-43.31
O/CLV	0.00	36.78	-101.78
W/CLV	0.00	-42.80	-57.21
CCSO-4	0.00	-69.73	-39.28
CWCO-5	0.00	-58.89	-61.11
CCSW-6	0.00	-90.13	-27.88
CRN$	0.00	2.03	0.00
WHT$	0.00	2.95	0.00
OAT$	0.00	1.30	0.00
SOY$	20,000.00	5.60	0.00
$CANOL	0.00	5.10	0.00
DRYCRN	0.00	-0.03	0.00
$DRY-N	10,000.00	-0.19	0.00
$ANHYN	0.00	-0.13	0.00
LEACH	4,000.00	0.00	0.00
$LABSP	445.00	-6.50	0.00
$LABSU	0.00	0.00	-6.50
$LABFL	0.00	0.00	-6.50

Table 6.4

Range of Optimality For Second Base Solution

Variable	Minimum	Maximum
CROUTL	NONE	-19.27
CROUTM	NONE	-56.67
CROUTH	NONE	-92.77
WHTOUT	NONE	-42.80
SOYOUT	-117.88	NONE
OATOUT	NONE	36.80
CANOUT	NONE	-43.70
O/CLV	NONE	36.78
W/CLV	NONE	-42.80
CCSO-4	NONE	-69.73
CWCO-5	NONE	-58.89
CCSW-6	NONE	-90.13
CRN$	0.00	2.28
WHT$	0.00	3.65
OAT$	0.00	2.54
SOY$	4.84	NONE
$CANOL	0.00	6.36
DRYCRN	NONE	0.22
$DRY-N	-1.70	0.38
$ANHYN	NONE	0.09
LEACH	-14.77	0.80
$LABSP	-36.01	0.00
$LABSU	NONE	0.00
$LABFL	NONE	0.00

NITROGEN CREDIT APPLIED TO THE CURRENT GOVERNMENTAL PROGRAMS:

At a credit of $0.31 a pound for fixed nitrogen the base model that was just evaluated was altered in the activities that are solution. 375 acres of rotation plan three (ROTPL3) was produced, 62 acres of soybeans was grown (SOYOUT), 37 acres were put into SOYFLO and 24 acres was placed into set aside. The leaching amount produced from the production of this cropping mix (10,550 lbs/acre) was not significantly reduced from the base model evaluated above (10,906 lbs/acre). Thus, this will not profoundly alter the potential contamination from nitrogen usage. From an evaluation of the nitrogen credit it can be seen that above $0.30 a pound for active nitrogen the base changes thus the potential for environmental damage can begin to be reduced. Also increasing this credit above the point at which the activities are altered, a heavier burden for the government's budgetary strain could be created. This is of importance as the current federal deficit grows and creates a heavier burden on federal law makers.

Table 6.5

Dual Values Under The Base and Nitrogen Credit Scenarios

Variable	Dual Value
LAND	113.11
CRNBAS	26.75
SSIDE	159.39
GRCORN	2.31
GGGCRN	2.03
DEFBUS	0.72
GRWHT	2.95
GROAT	1.30
GRSOY	5.60
GRCANO	5.10
LECATE	0.00
ANHY-N	0.13
DRYNIT	0.19
NUSED	0.00
DRYCRN	-0.03
SPRLAB	6.50
SUMLAB	0.00
FALLAB	6.50
MFLXNO	-44.46
MFLXOP	0.00
FLEXAC	0.00
MIFMPO	0.00
PLIFMP	-86.40
NCRYR1	0.31

The rotational plan that was developed in the model and that is part of the base (ROTPL3, corn, corn, soybeans, wheat/clover) is a large part of this scenario due to the large positive influence of the nitrogen credit developed for this thesis. The stability of the current government farm program options should also be noted. Managerial attention should be focused on those objective function coefficients that have a narrow range of optimality and coefficients near the endpoints of the range. These are the coefficients where a small change can necessitate modifying the optimal solution (Anderson et al. 1991). By doing this analysis a farm manager or policy maker can determine those activities that will produce the optimal outcome for the parties that will be directly effected by the program and society as a whole. The effects that alter social welfare will be evaluated in the concluding comments to this work.

As was explained above when the nitrogen credit drops below the current level for this scenario the activity levels would revert to those in the base model. Thus at a 163% income tax credit on nitrogen produces the changes that was desired when the policy alternative was developed. Yet at this level the cost to the government was higher than was originally desired. The cost the government would be $14,249.84 under the $0.31 nitrogen credit compared to $8,733.77 under the $0.19 tax credit. Even with this tax credit the behavior of the producer is not altered. This suggests that the amount of the credit must be raised to influence the producers production decisions. Thus the cost to the government would become prohibitive to the government if this policy were adopted.

From current estimates on the amount of leaching occurring within certain soil types and from various cropping patterns, this model showed that 10,055 pounds of nitrogen was leached. Legumes will produce nitrogen when plowed down and when no catch crop is started on the field in a timely fashion (Follett 1989, German 1989). An agricultural practice which will significantly reduce leaching of nitrogen is to maintain a cover crop or catch crop on the field during most of the year. This scenario will be evaluated in the next section. Another point that needs to be brought to the readers attention is the difference in the return that will be generated for the producer. Under the nitrogen credit scenario the producer generated $69,154, while under the tax on nitrogen the producer generated $62,983. Thus there is also a negative impact on the producer in the amount that can be realized from their efforts.

ROTATIONAL CREDIT AND THE CURRENT GOVERNMENT FARM PROGRAMS:

The purpose of adding a rotational credit to the model was encouragement for producers to utilize their rotations for conservation reasons. From an initial review of the information and activities in solution, this credit did not alter the outcome of the initial base solution until it was at approximately $24.00 per acre. One thing that has changed between this scenario and the last two is the income generated for the producer, see Table 6.7 below.

Table 6.6

Information From The Rotational Credit and Current Government Farm Programs

Variable	Value	Value/ Unit
SOYOUT	62.50	-90.00
SOYFLN	37.52	-90.00
SSIDE	24.98	-10.00
ROTPL3	375.00	-118.00
GCRN$	22,499.75	2.03
WHT$	5,624.94	2.95
SOY$	7,750.89	5.60
DRYCRN	22,499.75	-0.03
$DRY-N	2,000.47	-0.19
$ANHYN	6,862.42	-0.13
LEACH	10,550.08	0.00
$LABSP	231.29	-6.50
$LABFL	28.26	-6.50
FLTOT	37.52	0.00
DERATE	22,499.75	0.72
NCRED	14,249.84	0.00
NTAX	7,625.40	0.00

Table 6.7

Returns Under Scenario With Deficiency Payments

Base Scenario	$69,111.81
Nitrogen Credit Plus Current Government Programs	$69,154.65
Rotational Credit Plus Current Government Programs	$69,237.15
Nitrogen Input Tax Plus Current Government Programs	$62,983.00

The returns generated show that with the addition of the nitrogen credit as well as the rotational credit added positively to the producers income, as was expected and desired. Raising producer's returns is of importance; yet, lowering the burden of the federal deficit is of greater importance to social welfare. Thus, this could detract from the political feasibility of these two proposed policies. The rotational plans developed for this thesis did not come into the base solution, yet a small decrease in the cost to produce the rotation would bring each into the solution. From a quick summary of these scenarios, several conclusions can be drawn: 1) The two proposed policies within this thesis have had little influence on the decisions of the agricultural producer. As was mentioned above with a small increase in the nitrogen credit it would alter the outcome of the base scenario. This was also true for the rotational credit that was designed for this thesis. 2) The current government farm programs strongly influence decisions made by agricultural producers. This can also be seen by the returns that were generated by the policies. The base did not generate a substantially different return over the other options yet the range between them was insignificant. 3) These two policies do add to the producer's net return; yet, they will add to the government's financial burdens.

Table 6.8

Returns Generated Under
With out Deficiency Payments Scenario

No Commodity Program	$62,207.50
Nitrogen Credit Only	$62,207.50
Rotational Credit Only	$62,207.50

At this point the agricultural producer is still in the situation were no government programs are available that may alter his decision. To determine how sensitive this solution is to changes in the variable in the objective function, the price of soybeans was altered until a new solution comes into the model. A small adjustment downward in the market price of soybeans (to $4.84 or approximately 14% reduction) would altere the base solution when no options are available. The main point of encouragement is that the amount of leaching has been reduced to 4,000 pounds for the entire farm. This is a substantial amount over the previous scenarios considered. Since this is of concern in this research then it will remain an important point for consideration. As with all the previous runs of the model, the proposed policies have had little effect on the producers decisions. Yet, they did cost the government money due to the addition of the two policies. Since the two policies have had no effect on the production mix, the leaching has still been reduced.

NITROGEN CREDIT OPTION ONLY:

With the addition of the proposed 100% nitrogen credit option, the base solution just examined was not altered. Not until the nitrogen credit exceeded 162% of the base, Than the solution was changed to one growing ROTPL4. Both the leaching and amount of soybeans grown have remained constant. The dual value for the land is $117.66 thus increasing the value of one additional acre of land. Another important point to bring out is that the tax on leaching which could be developed now rises to $3.14 at which the solution would change. This high per pound tax would be infeasible to implement. This is due to the distorting effect it would have on the producers decisions. By having such a high tax producers would either stop using those sources of nitrogen that are being taxed or discontinue operation altogether. Both of these possible outcomes could decrease the amount of available commodities form their reduced production (Bovard 1989).

ROTATIONAL CREDIT OPTION EVALUATED:

This proposed $20 rotational credit still had no influence in changing the producer's cropping decisions. Only when the rotational credit reach $24 did the base change to

ROTPL4. This still will save the government money in its implementation. Since no rotations are grown, this produces no cost to the government. From the above evaluation, it has become apparent that the two proposed policies created for this thesis have had no effect on the production decisions generated. This reference is mainly the proposition that through development of a tax on nitrogen use the amount of leaching could be reduced and the fact that some of the activities on the boundary of the optimal range could be brought into the solution. These would include the rotations designed for this model in particular ROTPL3. This could be a more resource conserving cropping pattern thereby possibly reducing the amount of leaching generated. Yet as was shown above the inclusion of this rotation only slightly reduced the total amount of leaching that was generated.

Chapter 7

Final Remarks and Comments

The numerous runs of the linear program model have provided ample information on the current and proposed policies touched upon within this thesis. From information obtained, the current commodity programs are not nearly efficient enough to meet the limitations they place upon the agricultural decision makers. As was pointed out above, the federal deficit is still growing; and the Clinton administration is trying both to cut it and simultaneously implement new programs. Thus, this administration will be looking for ways to trim spending and direct realized savings to other areas of the economy. This will affect the final evaluation of the mix of programs that this thesis reviews. The research results from this thesis suggest a policy that meets the criteria: to help trim short run spending simultaneously maintaining agricultural producers' incomes.

As can be seen from Table 6.7 and Table 6.8, none of the LP model returns that do not include the current governmental program options yield as high a net return as realized when they are omitted from consideration. Thus, with this in mind, the current government program options need not be eliminated from consideration in future farm bills. Yet for the consideration of environmental consequences, the elimination of the current farm programs would cut federal outlays while reducing nitrate leaching, at least for the representative Michigan cash grain producer modeled here. Further research is needed in order to determine whether other areas of the country would have similar results. One such way to eliminate the use of agricultural supports is through "decupling" the price supports. In essence, this option would bring the producers' production decisions back in line with market forces. When the indirect costs of leaching are considered, mainly those costs of environmental damage to water bodies and wildlife habitat, the total cost of agricultural production would be higher (Bovard 1989, USDA 1990). Those options that include the current government programs potentially become too costly for society to endorse.

The three alternative policies that this thesis has developed all increase the producer's net income beyond that realized under current government programs, as was expected. This is taking into consideration current market prices and production costs. If the present commodity programs were abandoned, these prices and costs could be greatly affected. Yet, for the purposes of this thesis, no macroeconomic effects from taking any actions suggested here have been evaluated. One other area that this thesis did not combine in the model is the contribution that manure can bring to a rotation (Bockman et al 1990, Cook 1986, Dilz 1988, Doran and Scott 1991, Follett 1989). If manure application was taken into consideration for the nitrogen credit scenario, then both cost to the government and net return listed in Table 6.7 would be higher. The leachate amount might also be higher due to the farmer's potential overuse of the available nitrogen from both manure and legumes in the rotation. By adding the nitrogen introduced through manure application, the net return and cost to the government under the nitrogen credit program would rise. This discussion is not to discourage the use of all animal manure but to make a point that the amount of the available crop nutrients from the manure can vary widely.

The option that should hold greatest potential for meeting limitations put forth in this thesis is the total elimination of all payment or commodity support programs. However, this could result in a significant reduction in discretionary income, around 10% (see Tables 6.7 and 6.8). Although elimination of the commodity programs would reduce the federal budget deficit and potential nitrate leaching, farmers would be left exposed to the income volatility that the programs were originally designed to alleviate. In order to continue suppressing income volatility while reducing nitrate leaching we recommend an income support program which leaves farmers complete flexibility on cropping decisions.

Appendix I

Glossary For Variable Definitions

OBJECTIVE ROW:

	UNITS	
CORN	**BU**	The cost to grow an acre of corn. Low yielding corn (GCRLOW), Mid yield corn (GCRMID) and high yield corn (GCRHI). These each has a different cost per acre for production. These are produced out side government programs (..OUT) as well as within the flex options.
WHEAT	**BU**	The cost to grow one acre of wheat. The wheat is also produced in and out of the current government programs (this includes the flex options).
SOYBEANS	**BU**	This corresponds to the cost of producing one acre of soybeans this two has production in and outside of the current government programs.
OATS	**BU**	The production costs to grow one acre of oats. As with the three previous crops oats are grown in and out of the current government programs.
CANOLA	**LBS**	This relates to the cost to produce canola on one acre of crop land. As with the above crops this can be produced in and out of government programs.
SSIDE	**AC**	The cost to leave one acre out of production to meet governmental programs.
OAT/CLOVER	**AC**	This is the cost to produce this rotation on one acre in and out of the various government programs.
WHEAT/CLOVER	**AC**	Here this is the cost to produce one acre of this rotation in and out of government programs.

ROTPL1	AC	This is a four year rotation with the first year being oat/clover, two years of corn, one year of soybeans.
ROTPL2	AC	This is a four year rotation that has the first year in oat/clover, one year of corn, one year of wheat/clover and one more year of corn.
ROTPL3	AC	This is a four year rotation that has two years of corn, one year of soybeans and one year of wheat/clover.
ROTPL4	AC	This is the activity of growing the four year rotation(ROTPL1).
ROTPL5	AC	This is the activity of growing the four year rotation(ROTPL2).
ROTPL6	AC	This is the activity of growing the four year rotation(ROTPL3).
0/92CN	AC	This is the production of corn within the 0/92 option of the current government programs.
GCRN$	BU	This is the commodity price of corn grown on the farm.
CRN$	BU	This is the market price for corn the producer will receive for his output.
WHT$	BU	This is the market price for wheat that the producer will receive for his output.
OAT$	BU	This is the market price for oats that the producer will receive for his output.
SOY$	BU	This is the production cost to grow one acre of soybeans.
$CANOL		This is the commodity that the producer can receive for their out put.
DRYCRN	BU	This is the cost to the producer to dry one bushel of corn from the field to a suitable level for storage.
$DRY-N	LB	This is the average cost of one pound of dry nitrogen to the producer.
$ANHYN	LB	This is the cost of Anhydrous nitrogen.

LEACH	**LB**	This is a column that is used to keep track of the total amount of leaching that occurs on the farm.
LABOR	**HR**	This is the amount that the extra labor may be purchased for by the hour. There is spring labor ($LABSP), summer labor ($LABSU) and fall labor ($LABFL).
FLTOT	**AC**	This keeps a running total on the amount of flex acres that are being utilized.
IFMPO		This is the Integrated Farm Management Program Option.
DERATE	**BU**	This is the rate of deficiency payments made to program corn.
NTCRED	**LB**	This is the amount of the nitrogen credit that is proposed to be paid to farmers.
NCRED	**LB**	This is the per pound credit applied to the natural production of nitrogen by legumes in the crop rotation.
NTAX	**LB**	This is the per pound tax applied on the purchase of nitrogen.
ROTCRD	**AC**	This is the credit applied to the acres of non-program crops grown in a resource conserving rotation.

CONSTRAINTS:

LAND	**AC**	This is the total number of arable acres that this farm has at its disposal.
CRNBAS	**AC**	This is the total number of acres that are available to the producer to grow and receive corn deficiency payments on.
SSIDE	**AC**	This is the total number of acres that are enrolled as set-a-side for governmental programs.
GRCORN	**AC**	This signifies the yield and amount of corn that is grown at the government price.

GRG

DE

GR

G

G

GRGCRN	AC	This represents the yield and amount of corn that is grown at the market price.
DEFBUS	AC	This is the amount in bushels that is paid in deficiency payments.
GRWHT	AC	This is the yield and amount of wheat that is grown on the farm.
GROATS	AC	This is the grow oats activity on the farm.
GRSOY	AC	This represents the grow soybeans activity on the farm.
GRCANO	LB	This is the amount of production, in pounds, that an acre of canola will produce.
LECATE	LB	This is the amount, in pounds, that each crop or sequence of crops will leach of the applied nitrogen.
LECMAX	LB	This keeps track of the total amount of leaching that occurs from crop production.
ANHY-N	LB	This is the amount of anhydrous nitrogen utilized on the farm.
DRYNIT	LB	This is the amount of dry nitrogen being used on the farm for crop production.
NUSED	LB	This gives the amount of dry nitrogen, in pounds, that will need to be applied to each crop acre.
DRYCRN	BU	This is the activity where the corn that is grown on the farm is dried.
SPRLAB	HR	This is the available amount of labor to the farm for the planting of the various crops grown, given the hours needed per acre for each crop.
SUMLAB	HR	This is the available amount of labor to the farm to conduct summer crop operations, with the hours needed to preform the tasks on a per acre basis and for each crop.
FALLAB	HR	This gives the available amount of labor

available to the producer to do the harvesting of the various crops, with the appropriate hours given on a per acre

MFLXNO	AC	This is the total number of acres that can be grown in the normal flex program.
MFLXOP	AC	This puts a limit on the total number of acres that can be grown in the optional flex program. basis.
FLEXAC	AC	This is a transfer row for the flex acres out of the crop acre base land into the program.
MIFMPO	AC	This puts a limit to the total number of acres brought into the IFMPO program.
PLIFMP	AC	This is a control on the ifmpo program to bring it into solution.
NCRYR1	LB	This is the amount of nitrogen that will be available from the legume crop for the next two years.

MATRIX FOR LP MODEL

	GCRLOW	CROUTL	CRFLNL	CRFLOL	GCRMID	CROUTM	CRFLNM	CRFLOM	GCRHI	CROUTH	CRFLNH	CRFLOH	WHTOUT	WHFLXN
RETURN	-100	-100	-100	-100	-108	-108	-108	-108	-123	-123	-120	-123	-85	-85
LAND	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CRNBAS	1	1	1	1	1		1	1	1		1	1		1
SSIDE	.1111		.1111	.1111	.1111		.1111	.1111	.1111		.1111	.1111		.1111
GRCORN		-80.00	-80.00	-80.00		-100	-100	-100		-120	-120	-120		
GRGCRN	-80.00				-100				-120					
DEFBUS	-80.00				-100				-120					
GRWHT													-60	-60
GROATS														
GRSOY														
GRCANO														
LECATE	29.50	29.50	29.50	29.50	36.1	36.1	36.1	39.1	45.90	45.90	45.90	45.90	28.00	28.0
LECMAX														
ANNY-N	90.00	90.00	90.00	90.00					140.00	140.00	140.00	140.00		
DRYNIT													70.00	70.0
NUSED	73.80	73.80	73.80	73.80	125.00	125.00	125.00	125	114.80	114.80	114.80	114.80	70.00	70.0
DRYCRN	-80.00	-80.00	-80.00	-80.00	-100.00	-100.00	-100	-100	-120.00	-120.00	-120.00	-120.00		
SPRLAB	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	0.50	.50
SUMLAB	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.80	.8
FALLAB	1.23	1.23	1.23	1.23	1.28	1.28	1.28	1.28	1.33	1.33	1.33	1.33	0.30	.30
NFLXNO	-0.1765		1.00		-0.1765		1.00		-0.1765		1.00			1.0
NFLXOP	-0.3333			1.00	-0.3333			1.00	-0.3333			1.00		
FLEXAC			1.00	1.00			1.00	1.00			1.00	1.00		1.0
NIFNPO														
PLIFNP														
NCRYR1														
ROTPAY														
MINROT														

MATRIX FOR LP MODEL

	WHFLXO	SOYOUT	SOYFLN	SOYFLO	OATOUT	OATFLN	OATFLO	CANO92	CANOUT	CANFLN	CANFLO	SSIDE	OATFLN
RETURN	-85	-90	-90	-90	-50	-50	-50	-89	-89	-89	-89	-10	-65
LAND	1	1	1	1	1	1	1	1	1	1	1	1	1
CRNBAS	1		1	1		1	1	1		1	1	1	1
SSIDE	.1111		.1111	.1111		.1111	.1111	.1111		.1111	.1111	-1	.1111
GRCORN													
GRGCRN													
DEFBUS								-110.40					
GRWHT	-60												
GROATS					-70	-70	-70						-70
GRSOY		-40	-40	-40									
GRCANO								-36	-36	-36	-36		
LECATE	28.00	8.00	8.00	8.00	12.00	12.00	12.00	40.00	40.00	40.00	40.00		12
LECMAX													
ANNY-N													
DRYNIT	70.00	20.00	20.00	20.00	30.00	30.00	30.00	100.00	100.00	100.00	100.00		30.00
NUSED	70.00	20.00	20.00	20.00	30.00	30.00	30.00	100.00	100.00	100.00	100.00		30.00
DRYCRN													
SPRLAB	.50	1.93	1.93	1.93	.68	.68	.68	.50	.50	.50	.50	.13	.68
SUMLAB	.80	.87	.87	.87	.82	.82	.82	1.10	1.10	1.10	1.10	.13	.82
FALLAB	.30	.70	.70	.70								.13	
NFLXNO			1.00			1.00		-0.1765		1.00		-.1765	-.1765
NFLXOP	1.00			1.00			1.00	-0.3333			1.00	-.3333	-.3333
FLEXAC	1.00		1.00	1.00		1.00	1.00			1.00	1.00		
NIFMPO													
PLIFMP													1
NCRYR1													
ROTPAY													
MINROT													

MATRIX FOR LP MODEL

	OATFLO	OCLFLN	OCLFLO	WCLIFM	WCLVOT	WCLFLN	WCLFLO	ROTPL1	ROTPL2	ROTPL3	ROTPL4	R4FLXN	R4FLXO	ROTPL5
RETURN	-65	-65	-65	-100	-100	-100	-100	-109	-120	-118	-109	-109	-109	-120
LAND	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CRNBAS		1	1	1		1	1	.5	.5	.5		1	1	
SSIDE		.1111	.1111	.1111		.1111	.1111	.0555	.0555	.0555		.1111	.1111	
GRCORN											-60	-60	-60	-60
GRGCRN								-60	-60	-60				
DEFBUG								-60	-60	-60				
GRWHT					-60	-60	-60		-15	-15				-15
GROATS	-70	-70	-70					-17.5	-17.5		-17.50	-17.50	-17.5	-17.5
GRSOY								-10		-10	-10	-10	-10	
GRCANO														
LECATE	12	12	12	28	28	28	28	29	16	26	29	29	29	16
LECMAX														
ANHY-N								9.1	18.3	18.3	9.1	9.1	9.1	18.3
DRYNIT	30	30	30	70	70	70	70							
NUSED	30	30	30	70	70	70	70	7.5	15	15	7.5	7.5	7.5	15
DRYCRN								-60	-60	-60	-60	-60	-60	-60
SPRLAB	.68	.68	.68	.50	.50	.50	.50	1.53	1.17	1.48	1.53	1.53	1.53	1.17
SUMLAB	.82	.82	.82	.80	.80	.80	.80	.68	.67	.68	.68	.68	.68	.67
FALLAB				.40	.30	.30	.30	.84	.74	.92	.84	.84	.84	.74
NFLXNO		1		-.1765		1.00		-.0883	-.0883	-.0883		1		
NFLXOP			1	-.3333			1.00	-.1667	-.1667	-.1667			1	
FLEXAC		1	1			1.00	1.00					1	1	
NIFNPO														
PLIFNP				1										
NCRYR1								-38	-29	- 38	-38	-38	-38	-29
ROTPAY								-.50	-.5	-.5				
MINROT								1.00	1	1	1	1	1	1

MATRIX FOR LP MODEL

	R5FLXN	R5FLXO	ROTPL6	R6FLXN	R6FLXO	0/92	GCRNS	CRNS	WNTS	OATS	SOYS	SCANOL	DRYCRN	SDRY-N	SANNYN
RETURN	-120	-120	-118	-118	-118		2.03	2.03	2.95	1.3	5.6	5.1	-.03	-.19	-.13
LAND	1	1	1	1	1	1									
CRNBAS	1	1		1	1	1									
SSIDE	.1111	.1111		.1111	.1111	.1111									
GRCORN	-60	-60	-60	-60	-60			1							
GRGCRN							1								
DEFBUS						-110.40									
GRWNT	-15	-15	-15	-15	-15				1						
GROATS	-17.5	-17.5								1					
GRSOY			-10	-10	-10						1				
GRCANO												1			
LECATE	16	16	26	26	26										
LECMAX															
ANNY-N	18.3	18.3	18.3	18.3	18.3										-1
DRYNIT														-1	
NUBED	15	15	15	15	15										
DRYCRN	-60	-60	-60	-60	-60								1		
SPRLAB	1.17	1.17	1.48	1.48	1.48										
SUMLAB	.67	.67	.68	.68	.68										
FALLAB	.74	.74	.92	.92	.92										
MFLXNO	1			1		-.1765									
MFLXOP		1			1	-.3333									
FLEXAC	1	1		1	1										
NIFNPO															
PLIFNP															
NCRYR1	-29	-29	-38	-38	-38										
ROTPAY															
NINROT	1	1	1	1	1										

MATRIX FOR LP MODEL

	LEACH	SLABSP	SLABSU	SLABFL	FLTOT	IFNPO	DERATE	NCRED	NTAX	ROTCRED
RETURN		-6.5	-6.5	-6.5			.72			
LAND										
CRNBAS										
SSIDE										
GRCORN										
GRGCRN										
DEFBUS										
GRWHT						-6000	1			
GROATS										
GRSOY										
GRCANO										
LECATE	-1									
LECMAX	1									
ANHY-N										
DRYNIT										
NUSED										
DRYCRN									-1	
SPRLAB		-1								
SUMLAB			-1							
FALLAB				-1						
NFLXND										
NFLXOP										
FLEXAC					-1					
NIFNPO						1				
PLIFNP						-50				
NCRYR1										
ROTPAY										
MINROT										

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