Farm-Level Evaluation of Planting Flexibility Proposals for the 1990 Farm Bill

Effects on Use of Corn Rootworm Insecticides and Nitrogen

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Since the 1985 Food Security Act (1985 FSA), increased concern for environmental and health risks associated with the use of chemicals in U.S. agriculture has changed the focus of legislative debate. One of the major responses to these concerns has been discussion of ways to give farmers greater flexibility in planting. Those proposing more flexibility promote it as a means of encouraging crop rotations and other alternatives to intensive chemical use. This study investigates the effectiveness of such provisions for (1) shifting rotations and (2) reducing applications of corn rootworm insecticide and nitrogen on a case-study Iowa farm. A specialized version of the Comprehensive Economic and Environmental Policy Evaluation System (CEEPES), developed at the Center for Agricultural and Rural Development (CARD), was utilized for the empirical assessment.

The first alternative simulated, called option A, involves a total farm acreage base, determined from historical plantings, and the decoupling of deficiency payments from plantings in the current year. The second alternative, called option B, involves allowing resource-conserving crops to be counted as corn or other program crops when calculating governmental deficiency payments and maintaining base acreage for government commodity programs. (Under certain circumstances, resource-conserving crops may be grown on acres previously idled under the acreage reduction program.) Two additional options involved taxes on the use of nitrogen and corn rootworm insecticide. The taxes were modeled so that the outcomes from the planting flexibility options could be compared

with others more directly designed to reduce the use of corn rootworm insecticides and purchased nitrogen. Sensitivity of the outcomes to changes in expected relative crop prices was investigated to evaluate the flexibility of options A and B, as well as to estimate the effects of policy-induced supply shocks and price impacts on the initial results.

The results indicate that in most cases the planting flexibility proposals would encourage conversion to less corn-intensive rotations, reducing the use of corn rootworm insecticide and nitrogen. But, such reductions would not be guaranteed. In fact, under option A, insecticide and nitrogen use actually would increase significantly among less risk-averse producers. Changes in rotations planted would vary sharply, depending upon the policy alternative and the producer's attitude toward risk. At lower levels of risk aversion, a corn-corn-soybean (CCS) rotation would be used exclusively under option A, whereas under the baseline a corn-soybean (CS) rotation would be used on 25 percent of the acreage, with CCS on the remainder. Consequently, corn rootworm insecticide and nitrogen applications would be higher under option A. Under option B, a corn-oats-legume hay-legume hay-legume hay (COLLL) rotation would replace some of the CCS and CS rotations by the less-risk-averse farmers. That translates into lowered rootworm insecticide and nitrogen use.

At higher levels of risk aversion, continuous corn (CC) and COLLL dominated under all alternatives. Relative to the baseline, the COLLL rotation would be more prominent than the CC rotation in the optimal mix of rotations under both planting flexibility options. Compared to the baseline, use of corn rootworm insecticide and nitrogen would decrease under the planting flexibility alternatives at higher levels of risk aversion.

The impact of the planting flexibility alternatives on producer welfare, as measured by certainty equivalent income, was always positive but never larger than 7 percent. The impact of the insecticide and nitrogen taxes on producer welfare would be negative, with reductions up to 12 percent.

Adjustments in the optimal mix of crops and insecticide and nitrogen use, in response to changes in relative crop prices, would be higher under option A than option B. Adjustments under both planting flexibility alternatives would be higher than under the baseline. These adjustments, used as a measure of the flexibility offered by each alternative, suggest that option A would be more flexible than option B, and that both would be more flexible than the baseline. Finally, changes in relative commodity prices could result from implementation of the proposed planting flexibility provisions. These price changes could lessen the reduction--or even increase--the use of corn rootworm insecticides and nitrogen.

INTRODUCTION

The focus of debate over the 1990 farm bill has shifted substantially from that for the 1985 Food Security Act (1985 FSA). Broad evidence of increased concern for environmental and health risks associated with the use of chemicals in U.S. agriculture (Batie 1987; Hoyer et al. 1987; O'Hare et al. 1985) has not only increased the array of interest groups involved in the policy debate; it has altered the views and concerns of more traditional participants as well. Many have begun to question the role government commodity programs play in discouraging the adoption of agricultural practices with less reliance on those inputs responsible for the risks (NRC 1989). It often seems as if policies for agriculture and environmental regulation reflect a limited understanding of possible interdependencies (CARD and USEPA 1989). The newest calls are for more flexibility in planting decisions made by producers. Those proposing flexibility provisions are promoting them as a means of encouraging the use of rotations and other alternatives to intensive chemical use and as a means of increasing (or encouraging) plantings of oilseeds, oats, and other crops for which the U.S. has lost world market shares or for which increased domestic demand has not spurred domestic production. Senator Lugar, in a speech before the Senate, has stated why he believes planting flexibility is needed (Lugar 1989):

> When our rigid, crop-specific acreage base system encourages farmers to stick with crops in surplus, and avoid crops where market prices are at historically high levels--then our farmers need planting flexibility. When our policies for program crops, sensible as they may be, have the perverse result of exporting soybean acreage and soybean crushing capacity to South America--then our farmers need planting flexibility. And when

the National Research Council states unequivocally that our present acreage base system and related policies "economically penalize those who adopt rotations, apply certain soil conservation practices, or attempt to reduce pesticide applications"--then our farmers need planting flexibility, and they need it now.

This study investigates the effectiveness of such provisions for shifting rotations and reducing corn rootworm insecticide and nitrogen applications for a case-study Iowa farm. A specialized version of the Comprehensive Economic and Environmental Policy Evaluation System (CEEPES) developed at the Center for Agricultural and Rural Development (CARD) was used for the empirical assessment. The analysis consisted of estimating yield distributions with a well-tested plant process model, estimating the distribution of returns to various cropping activities, and solving a quadratic risk model to find the optimal mix of the activities under each of several policy alternatives. The measurement variables of most interest in the study were use of nitrogen and corn rootworm insecticide. The model design suggests that the selection of rotations is the single most important determinant of nitrogen and insecticide use. Rootworm is ranked as the most important corn insect pest in the Midwest (Foster et al. 1986) and is usually a problem only in crop rotations with one or more years of corn following corn. Applications of purchased nitrogen can be reduced significantly if credits for nitrogen fixation by legumes are given.

Certainty equivalent income in relation to the other measurement variables provides an indication of the trade-offs associated with each of the policy alternatives. To facilitate the comparison, government payments made to the farm were held constant under all policy alternatives, unless producers chose not to participate on all eligible acres.

The first planting flexibility alternative (option A) simulated is similar to proposals made by U.S. senators Richard Lugar/Patrick Leahy and Rudy Boschwitz and involves revitalizing the concept of a farm acreage base for determining eligibility for program benefits and decoupling deficiency payments from plantings in the current year. The second planting flexibility alternative (option B), similar to proposals by U.S. Senator Wyche Fowler and U.S. Representative Jim Jontz, would allow "resource conserving crops," including legumes, small grains, and grasses, to be counted as corn or other program crops for the purpose of calculating deficiency payments and maintaining program bases for individual crops. In addition, two policies designed to more directly reduce the use of insecticide and purchased nitrogen were simulated to compare the outcomes between them and the planting flexibility alternatives. Specifically, 200 percent taxes on the use of purchased nitrogen and corn rootworm insecticide were evaluated. Sensitivity of the outcomes to changes in expected crop prices was investigated to evaluate the inherent flexibility in the planting flexibility proposals and to estimate the effects of potential policy-induced supply shocks and price impacts on the initial results.

Section two discusses the current rules and provisions of the government commodity program for corn. Section three examines the flexibility provisions in legislation introduced by Senator Wyche Fowler of Georgia, senators Richard Lugar of Indiana and Patrick Leahy of

Vermont, and Representative Jim Jontz of Indiana, in addition to a proposal by Senator Rudy Boschwitz of Minnesota. In section four, the integrated modeling system approach is developed for the empirical assessment. Impacts of the two planting flexibility options and two input taxes on corn rootworm insecticide and nitrogen use and other measurement variables were estimated at the farm level.

Commodity Program for Corn under the 1985 Food Security Act

The 1985 FSA included the major provisions and rules established under the 1981 bill, with some modifications and new titles appearing. For feed grains, price support is still provided via commodity purchases and nonrecourse loans, but loan rates paid to farmers are lower. In addition, marketing loans and loan deficiency payments provide direct income support without artificially supporting prices. Income support through deficiency payments continued, but target prices were frozen through 1987 and reduced subsequently. Supply management is accomplished, as it was under the 1981 bill, through the acreage reduction program, paid acreage diversion, Commodity Credit Corporation purchases, and the farmer owned reserve. The secretary of agriculture retains some discretion in setting acreage reduction rates under the acreage reduction program.

The 1985 FSA also added the 50/92 program, accompanied later by the 0/92 program created in the 1987 Omnibus Budget Act. Resource conservation and environmental protection are provided through several provisions that originated in the 1985 FSA. The long-term Conservation Reserve Program, Sodbuster, Swampbuster, and conservation compliance all are designed for that purpose. Disaster assistance continues to be provided through disaster payments, crop insurance, and FmHA loans (Becker 1988).

The concept of individual crop bases as an important tool for administering the price and income support programs is carried over from the previous farm bill. Individual crop bases are calculated yearly for each of the feed grains. The bases are calculated for individual farms as the average of the acreage planted to each crop plus acreage considered planted in the five previous years on the farm. Acreage considered planted included any set-aside or diverted acreage, excluding Conservation Reserve Program acres, and acreage producers could not plant due to conditions beyond their control. Producers are allowed to increase their individual crop bases only by exiting the program for one or more years and planting more acres of the program crop than the established base (Glaser 1986). Base acres of individual crops would be lost if, in a given year, acreage planted plus acreage considered planted to that crop fell below the base established in the previous year.

For a producer to be eligible for program benefits, the sum of acres planted to each feed-grain crop and set-aside under the acreage reduction program or paid acreage diversion provisions may not exceed the crop base established for that crop and farm. Further, cross-compliance rules, when in effect, require participants in the program for some crops and not others to limit plantings of the non-enrolled program crops to the individual crop bases established for them.

Deficiency payments on each program crop are made to those who participate in the program on the acres planted to the crop. Program payment yields since 1986 have been based upon the average program payment yields established during the period from 1981 to 1985, excluding the years with the highest and lowest yields. Starting in 1988, the secretary of agriculture was authorized to change the calculation to the average of actual yields during the five preceding years, dropping the highest and lowest yields. Deficiency payments per bushel are calculated as the difference between the target price, set annually for each crop, and the higher of a seasonal average market price and the national loan rate, also set annually (Glaser 1986).

Planting Flexibility Proposals

The debate over the 1985 FSA focused on (1) the eroding financial strength of farmers, (2) the United States' declining share of agricultural commodity exports in world trade, (3) huge surpluses of grain and oilseeds in this country, and (4) agriculture's perceived impact on the environment and human health. In the debate on the 1990 farm bill, the first three of these concerns have been substantially weakened. The relative success of the 1985 legislation is at least partly responsible. Farmers' financial conditions began to improve in 1987 after several years of steady decline. Net cash income for farms has been rising irrespective of government payments. The U.S. share in world agricultural markets has generally increased under the 1985 FSA, contrasting with a previous three-year decline. Stocks of surplus agricultural commodities have generally declined (U.S. General Accounting Office 1989). Although environmental concerns were addressed by several provisions in the 1985 FSA, most dealt with control of soil erosion; water quality and the use of pesticides and fertilizers remained largely neglected.

Even with the perceived success of the 1985 FSA, more recent concerns have led to calls for more flexibility in planting decisions and for more attention to the potential impacts of agricultural practices on groundwater and surface water quality and the environment in general. Planting flexibility proposals have included expanded lists of eligible program crops and changes to the rules for establishment and maintenance of crop bases and the rules for calculation of program payments.

There are several explanations for the popularity of these planting flexibility provisions. Among them, concerns about the effects of continuous, intensive cropping practices on the soil, environment, and world trade of oats, soybeans, and other oilseeds, and the perceived connection between these practices and the current rules and provisions of the government's commodity programs. Proponents of planting flexibility argue that such provisions will allow farmers to respond more freely to world market signals and will remove disincentives to production practices that are less threatening to the environment.

Recent interest in more planting flexibility is not surprising, inasmuch as the farm program has become progressively less flexible under each farm bill since 1970 (Evans 1989). Moves toward more planting flexibility have occurred in recent years. The 10-25 planting flexibility option for oilseeds, mandated by the Disaster Assistance Act of 1988 for 1989 and the Budget Reconciliation Agreement of 1989 for the 1990 crop year, is an example. This option allows producers to plant from 10 to 25 percent of their crop-specific program bases to oilseeds with base protection. Deficiency payments are denied on those acres. In addition, changes in the government program for wheat allowed producers to plant up to 105 percent of their wheat base, accompanied by an offsetting loss of deficiency payments and forgiveness of acreage reduction requirements.

The process of developing the 1990 farm bill has yielded several proposals by U.S. Congressmen. Four of these will be outlined in the rest of this section. The purpose of this discussion is not to comprehensively outline all of the proposals that contained flexibility provisions; many have been made, including the Administration's and one by a coalition of environmental groups. Rather, it is meant to introduce some of the ideas being put forth for debate.

Two fundamental approaches were taken in the four congressional proposals. A bill sponsored by Senators Lugar and Leahy and a plan laid out in a speech before the Senate by Senator Boschwitz, both in November of 1989, followed one approach. The second approach was followed in bills sponsored by Senator Fowler and Representative Jontz, introduced in May and October of 1989, respectively.

The first approach is centered around changes in the rules for establishing base acreages and for making deficiency payments on those acres. Under this approach, a whole farm acreage base consisting of acreages of present program crops, oilseeds, and other crops would be calculated for every farm. This base would be the basis for determining eligibility for program benefits. Payments, once eligibility is established, would be made on a fixed, unchanging number of acres each year, in essence decoupling payments from current plantings. Under the Lugar-Leahy bill, the base would be called a "normal crop acreage farm base." It would be calculated as the average sum of acres planted, or considered planted, in the five previous years to (1) the current program crops and (2) soybeans, sunflower, canola, other specified oilseeds and industrial crops as designated by the secretary of agriculture. The Boschwitz plan defines the base as a "farm acreage base." It would be calculated as the sum of (1) the individual crop bases of the program crops established in 1989 and (2) the largest total number of oilseed crops planted on the farm in any of the five years from 1985 to 1989. To qualify for deficiency payments under the Lugar-Leahy bill, the total acreage of all the crops that compose the whole farm acreage base must not exceed the base established for them. The Boschwitz plan would impose a more restrictive rule that would require that only the crops that compose the whole farm acreage base be grown on the base established.

Under both proposals, a separate base upon which deficiency payments are to be made would be established. Lugar-Leahy defines this acreage as the "program payment base." In both cases, the base on which payments are to be made would be set at previously established crop bases for each program crop. Under Boschwitz's plan the program payment bases would be set at the individual crop bases established in 1989. Lugar-Leahy would set them at the 1990 level. Producers would not be allowed to change their payment base over the life of the new farm bill. The program payment yields for each year of the new farm bill would be frozen at the 1989 and 1990 levels under the Boschwitz and Lugar-Leahy proposals, respectively. Recall that, for the current program, the 1989 and 1990 payment yields are set at the five-year average of payment yields over the period 1981 to 1985, throwing out the highest and lowest yields. Payment yields for 1991 to 1995 therefore would reflect yields from a decade earlier.

The second approach would provide a new program option to producers. In return for developing a "five-year farm resource management plan," producers would be given certain privileges. These privileges, in effect, would offer flexibility to implement the plans and incentives to participate in the optional program. Five-year plans under both of these proposals would be based on technical guides. The creation of the guides is provided for in other sections of each bill. The emphasis of this approach is on reducing current program disincentives to the inclusion of "resource-conserving crops" into crop rotations. Presumably, rotations that include resource-conserving crops would rely less on purchased inputs and more on nitrogen-producing legumes, cropping sequences that reduce pest problems, and crops that reduce soil erosion. The concept of individual crop bases would be retained.

In return for filing a farm resource management plan, acreage reduction requirements under the acreage reduction program would be waived if plantings of program crops in the plans are lower than they would be if the farmer participates in the traditional program. Acres planted to resource-conserving crops, beyond that which might be planted on acres previously set aside under the acreage reduction program, would be eligible for deficiency payments and could be counted as if they were planted to a program crop for the purpose of maintaining base acreages for individual crops. Resource-conserving crops are defined by Jontz as legumes, legume-grass mixtures, legume-small grain mixtures, and legume-grass-small grain mixtures. Fowler defines them as legume and legume-small grain mixtures that are part of resource-conserving rotations. Jontz excludes malting barley and wheat, unless inter-planted with other small grains that are not intended for human consumption, and bean crops. Fowler defines resource-conserving rotations as those that fix nitrogen and reduce erosion and chemical use.

Requirements to be eligible for deficiency payments would remain unchanged from the current farm bill with one exception. Under the Jontz proposal, cross-compliance with other program crops would be waived to allow participants to diversify into other crops consistent with their farm management plans. Program payment yields under both proposals would not be allowed to decrease. Presumably payment yields would continue to be based upon the average program yield for the 1981 to 1985 period, dropping the highest and lowest years.

Several other features were included in the two bills to provide incentives for participation in the optional program, to provide more planting flexibility, or to address issues of equality and fairness. Fowler would offer the higher of the 1989 or 1990 target prices and a 15 percent reduction on federal crop insurance premiums to participants. Jontz includes a base-adjustment provision for producers with low established bases due to historical use of sustainable and resource-conserving rotations. Finally, Fowler would offer base protection to producers not participating in the optional program by allowing them to plant up to 40 percent of their base acres to the resource-conserving crops defined earlier without losing base acreage. Because of the potentially depressing effects on hay prices, the Jontz bill includes provisions granting the secretary of agriculture power to restrict hay harvesting by participants when it is believed that prices will be depressed. This provision could be a major deterrent to participation in the optional program, since producers would not know before enrollment if it would be implemented.

Fowler also would require the plans to be "site specific." Presumably farmers with several scattered plots would be required to compose a plan for each plot, adding to the burden of administering the program. Administration and certification would be provided by the secretary through the Agricultural Stabilization and Conservation Service, Agricultural Soil Conservation Service, and the Agricultural Extension Service. The Fowler bill calls upon the secretary of agriculture or the state soil conservation office and the state cooperative extension service, in consultation with the local soil conservation district, the local committees, and the secretary to provide assistance in formulating the plans for farmers.

The requirements for certification of the plans are laid out in very general terms by both proposals. The Fowler bill would require the plans to provide a "schedule to develop farming operations and practices designed to optimize the use of non-farm resources and minimize the use of production items and practices with known or potentially adverse impacts on health and the environment" (U.S. Congress, Senate 1989). And, among other things the farmer must describe in the plan "how the farming operations and practices could reasonably be expected to result in the reduction of soil erosion to a level that does not exceed the soil loss tolerance level (established by the secretary of agriculture) and in the use of agricultural chemicals being reduced to low levels" (U.S. Congress, Senate 1989). The Jontz bill requires the plans to provide a "schedule to develop sustainable agricultural production systems on the farm subject to the plan and describe the farming operations and practices to be implemented during the five-year period" (U.S. Congress, House 1989). And, "describe how the farming operations and practices could reasonably be expected to result in nondegradation of farmland soils, reductions in the use of fertilizers and pesticides to low levels, protection of water supplies from depletion and contamination, and significant reductions in the use of non-renewable natural resources and purchased production inputs" (U.S. Congress, House 1989).

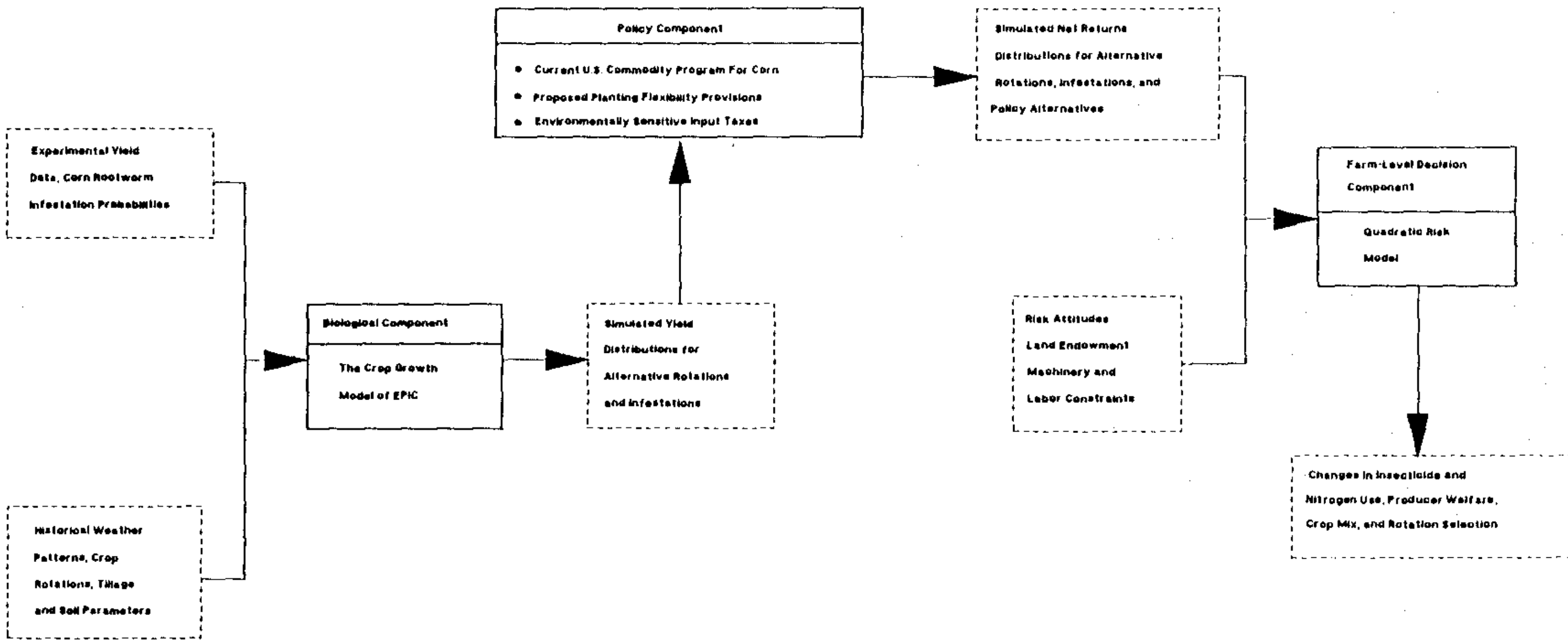
Empirical Analysis

In this section, the probable impacts of proposed planting flexibility rules and provisions are investigated by using an integrated modeling system. The integrated modeling system and the associated models are developed, and results from a case-study Iowa farm are discussed.

The Integrated Modeling System

The integrated modeling system applied was the Comprehensive Economic Environmental Policy Evaluation System (CEEPES), developed by the Center for Agricultural and Rural Development (CARD) and the U.S. Environmental Protection Agency (USEPA) (CARD and USEPA 1989). A unique feature of CEEPES is the use of biological, geophysical, and phenological process models as a system and their integration with economic-decision and policy models. For this analysis, the system was specialized for farm-level analysis. The specialized version of CEEPES, including policy, farm-decision, and biological components is illustrated in Figure 1.

Figure 1
Representative Farm Simulation Model



Biological Component. The biological component used an existing physiological process model, the Erosion Productivity Impact Calculator (EPIC). EPIC is capable of simulating growth and yield for both annual and perennial plants. EPIC can be operated in time steps by Julian day over an arbitrary number of years that permits simulation of crop rotations. This feature of EPIC was important for the present analysis because the planting flexibility provisions proposed are intended by design to encourage the adoption of crop-diverse rotations. EPIC was constructed so that required input data (weather, crop, tillage, and soil parameters) are realistically available to most model users. Documentation of EPIC is available in Williams et al. (1984) and Putman and Dyke (1987).

Thirty-three years of yields were simulated for five alternative crop rotations to estimate yield distributions. For operating and calibrating EPIC, historical weather and yield data were utilized. EPIC was previously modified to estimate reductions in corn yields as a function of quantifiable ranges of corn rootworm damage (CARD and USEPA 1988). Ranges of damage and probabilities that each would occur in any given year were determined from experimental data and consultation with Entomology specialists at Iowa State University (Tollefson 1990). Thus, the biological component was used to provide simulated yield distributions for the selected rotations and levels of corn rootworm infestation. The yield distributions were used to calculate distributions of net returns for the cropping activities in the farm-level decision component.

Researchers at the Center for Agricultural and Rural Development, in cooperation with the Agricultural Research Service's Grasslands Research

Lab in Temple, Texas, also are working on procedures to estimate the impact of weed competition on various crops (Gassman 1990). These estimates may be used in the future to include new production activities that do not use herbicide in the farm-level analyses.

Farm-Level Decision Component. The farm-level decision component used quadratic risk programming (QRP) to evaluate producer behavior under uncertainty. Among the alternative methods for explicitly modeling risk in farm decision problems, QRP (the mean-variance approach) probably has been the most popular. Freund (1956) was the first to apply QRP for an agricultural firm. Since then, QRP has been applied in many farm-level decision analyses, for example, Scott and Baker (1972), Jensen and Piedrahita (1979), Musser and Stamoulis (1981), and McSweeny and Kramer (1986).

In matrix notation the standard QRP model can be represented as

$$\max_{\underline{X}} \{\underline{C}^T \underline{X} - \alpha \underline{X}^T \textstyle\sum \underline{X}\}, \quad (1)$$

$$\text{subject to } A \underline{X} \leq b, \quad (2)$$

$$\underline{X} \geq 0, \quad (3)$$

where $\underline{X}$ is the vector of enterprise activity levels; $\underline{C}$ is the vector of expected net returns; $\sum$ is the variance covariance matrix of net returns; α is the coefficient of absolute risk aversion; $\underline{b}$ is a vector of the resource endowments; and A is the matrix of input-output coefficients.

It is well known that the quadratic objective function is compatible with the widely accepted expected utility theory only if the farmer's utility function is quadratic or if the farmer has a negative exponential utility function and the probability distribution of the net returns for the activities is multivariate normal (Freund 1956). However, the studies of Tsiang (1972), Levy and Markowitz (1979), and a recent paper by Meyer (1987) suggest that the mean-variance approach may closely approximate economic behavior based on a wider range of utility functions.

The specialized version of CEEPES was applied for a farm in Nashua, Iowa (Chickasaw County). The QRP model activities were developed for production, enrollment in the government program for corn, penalty for loss of corn base, insecticide supply, and nitrogen supply. The production activities were for the selected rotations, a single soil type, and a conventional tillage method. A single enrollment activity with set-aside requirements and deficiency payments was included in the simulations. A penalty for loss of corn base was specified. The insecticide and nitrogen supply activities were defined for recommended rootworm insecticide and nitrogen applications, respectively. The case-study farm was assigned 350 acres of land and was subject to seasonal limits on labor and machinery.

Crops included in the analysis were: corn (C), soybeans (S), oats (O), and legume hay (L), grown in typical rotations observed in Iowa. The five crop rotations included in the representative farm model were

1. continuous corn (CC);
2. corn following soybeans (CS);
3. two years of corn following one year of soybeans (CCS);
4. corn followed by soybeans followed by another year of corn followed by oats then legume hay (CSCOL); and

5. corn followed by oats followed by three years of legume hay (COLLL).

Production activities for each rotation were modeled with conventional usage of pesticides and fertilizers. In addition, production activities for those rotations subject to rootworm infestations were included, assuming no insecticide treatments. The latter activities were included to test the viability of nonconventional practices under the policy alternatives simulated. Rotations with one or more years of corn following corn were assumed to be subject to rootworm infestation in the absence of corn rootworm insecticides. Following Foster et al. (1986), and consultation with an ISU entomologist (Tollefson 1989), it was determined that corn root damage could be assumed negligible in all crop sequences other than corn following corn (i.e., the CC and CCS rotations).

The sources of risks considered were technical risk in yields due to weather and pest infestation and output price risk. These sources of risk were important for conditioning producer decision making in the representative farm model.

Policy Component. The policy component identified the agricultural policy instruments and summarized outcomes of key performance variables. The focus was on the current U.S. commodity program for corn under the 1985 FSA, proposed changes to introduce more flexibility in planting decisions, and taxes on environmentally sensitive inputs. The policy component provided incentives and restrictions to the farm-level decision component.

The standard for comparison in the analysis was a "baseline" defined to reflect 1989 economic conditions and policies for agriculture and the environment. In the baseline, deficiency payments are tied to plantings with the target price, national loan rate, and the acreage reduction rate for corn set at 1989 levels. The program corn base assigned to the representative farm was set at 65 percent of the 350 acres (228 acres) available for production. Program payment yields were based on yields estimated in the biogeophysical component of the modeling system. The cost of corn rootworm insecticide was $8.00 per pound of active ingredient and nitrogen was $0.15 per pound. A penalty for loss of base acreage was included to simulate the rules for establishment and maintenance of the corn base. Expected returns to the production activities and their variances were based on the distribution of returns estimated with 33 years of price, cost, and yield information. It was assumed that the producer would not participate in the commodity program for oats and that the cross-compliance rules between oats and corn were not in effect.

Option A. The first planting flexibility policy option simulated closely reflects the rule and provision changes to the current commodity program for corn proposed by Lugar-Leahy and Boschwitz. The key features simulated include determining the whole farm acreage base from historical plantings and decoupling deficiency payments from current plantings.

Several modifications to the baseline were made to reflect these features. The whole farm acreage base was computed as the sum of the corn base assigned to the farm and the soybean and oats plantings under the baseline. Because this summation yielded a different value for each level of risk aversion, the whole farm acreage base varied accordingly. To be eligible for deficiency payments, total plantings of corn, oats, and soybeans were constrained to be less than the whole farm acreage base. Payments were made in a lump sum amount on the program payment base, set equal to the corn base under the baseline, and did not depend upon current plantings. To facilitate the comparison to the baseline, set-aside according to the 1989 baseline acreage reduction rate of 10 percent of the base was made a condition for receiving payments. The penalty for loss of corn base was excluded because planting a sufficient amount of corn was no longer a condition for receiving payments in the future. The program payment yield and target price were held constant.

Option B. Option B closely reflects the planting flexibility provisions in proposals made by Jontz and Fowler. Adjustments in set-aside requirements and the rules for determining eligibility for deficiency payments are made to encourage planting of resource-conserving crops. Individual crop bases and the linkage between plantings and deficiency payments are retained. Under both proposals, the adjustments are offered as an option in exchange for development of five-year farm management plans that outline, among other things, crop and rotational shifts to reduce erosion, chemical and fertilizer applications, and other practices potentially hazardous to human health and the environment. A minimum requirement for eligibility in the optional program is not expressed. Rather broadly defined objectives the farm management plans should meet are enumerated. Examples include minimizing chemical use, conserving soil and water, and enhancing economic resilience. Implementation of such provisions might be accompanied by some minimum quantifiable reductions in chemical and fertilizer use, soil loss savings, and so forth. For the present analysis no minimum requirements were imposed.

Modifications made to the baseline to simulate the second planting flexibility option included allowing legume hay, which meets the criteria for a resource-conserving crop in both proposals, to be grown on acres previously idled under the acreage reduction program, as long as the acreage of corn planted does not increase relative to the baseline. In addition, legume hay, not planted on previously set-aside acres, may count as planted corn acreage for the purposes of calculating deficiency payments and maintaining the corn base. Deficiency payments are not made on legume hay planted to the acreage that was previously set aside. The program payment yield and target price were held constant.

Taxes on Environmentally Sensitive Inputs. Finally, a more direct means of reducing the use of corn rootworm insecticides and nitrogen was simulated. A 200-percent tax on the purchase price of each input was modeled by simply increasing the purchase price accordingly.

Sensitivity Analysis. Sensitivity of the outcomes to changes in expected relative crop prices was estimated. The sensitivity analysis was executed to evaluate the inherent flexibility in the planting flexibility proposals and to estimate the effects of potential policy-induced supply shocks and price impacts on the initial results. The analysis was performed by systematically varying the expected corn price and resolving the quadratic risk programming model. The changes in expected prices were assumed to change only expected returns, not the variability of returns.

For the baseline and each of the policy alternatives, participation in the program for corn was modeled. If it was suspected that nonparticipation would dominate participation, then the model was rerun, with the associated rows and columns used to simulate the corn program excluded.

Model Specification, Data, and Assumptions

In this section the models utilized for the analysis and the modifications required for the policy evaluation exercises are discussed.

EPIC. Calibration of EPIC was performed to reflect yield levels on the case-study farm and to simulate impacts of corn rootworm infestation. Historical data on daily weather for the years 1955-1987, plot-level experimental data on rootworm damage and corn yields for the years 1977-1984 at the Iowa State research farm in Nashua, Iowa (Tollefson 1990), and county average soybean, oat, and legume hay yields for years 1977-1987 (Iowa Agricultural Statistics, 1978-1988) all were used for the calibration.

To assess impacts of rootworms on corn yields, EPIC was applied to estimate yield reductions for four levels of damage. The levels of damage were expressed in quantifiable ranges. The ISU root-rating system was adopted as a measure of the damage.[1] Following Tollefson (1989), ranges of root damage with ratings (1-3, 3-4, 4-5, 5-6) were mapped into four damage levels: none, low, moderate, heavy. The probability of a damage level occurring in any year is 0.1, 0.4, 0.4, and 0.1, respectively. The estimation of the discrete probability distribution of damage levels was based on Turpin et al. (1972) and experimental data from Nashua on observed infestations (Tollefson 1990). The experimental data, which also included yield reductions under various levels of damage, were used to calibrate EPIC and to simulate corn yields for 33 years by using the probabilities of infestation. The rootworm damages were reflected in reduced daily water uptake. This approximation of damages was based on results of an EPA funded study on corn rootworm insecticides (CARD and USEPA 1989). It was assumed that the damage levels were temporally uncorrelated and independent of weather. Levels of damage were selected at random for each of the 33 years from the discrete probability distribution of infestation levels.

QRP. The tableau of the Quadratic Risk Programming model is shown in Figure 2. The five basic types of activities are production, enrollment, base loss penalty, and insecticide and fertilizer supply. Constraints on land, labor, machinery, government program bases, and inputs make up the bulk of the rows; transfer rows and balance equations used to reflect program provisions and chemical and fertilizer needs constitute the rest.

Production Activities. Production alternatives listed in Table 1 were modeled for the four crops (corn, soybeans, oats, and legume hay) and five rotations (CC, CCS, CS, CSCOL, and COLLL). The yields from EPIC for each crop were rotation dependent, as were the variable costs. In addition, activities for the CC and CCS rotations with and without the use of corn rootworm insecticides were included. Nonuse of insecticides was reflected in the variable costs and the yields.

The variable costs of production for the crop sequences were from ISU Extension Budgets (Duffy 1987). Historical market prices for each crop

Figure 2. Tableau of Quadratic Risk Programming Model

	Production Activities	Enrollment Activities	Penalty Activities	Insecticide and Nitrogen Supply Activities
Land Constraints				
Labor Constraints				
Machinery Constraints				
Program Base Constraints				
Input Constraints				
Commodity Program & Input Transfer Rows				

Table 1. List of Production Activities

Rotation	With Conventional Use of Corn Rootworm Insecticide
CC	Y
CC	N
C-S	N
C-C-S	Y
C-C-S	N
C-S-C-O-L	N
C-O-L-L-L	N

C = Corn
S = Soybeans
O = Oats
L = Legume Hay

year (1955-1987) were obtained from an Iowa State University Extension Publication (Futrell 1988). All prices and costs were inflated by the consumer price index and expressed in 1987 dollars.

The time series of yields estimated by using EPIC, together with the historical market prices and variable costs of production were integrated to estimate net returns of the production activities on a per-acre basis. The estimates of net returns were

$$RP_{ij} = \sum_{k=1}^{4} W_{jk}[YLD_{ijk} * MP_{ik} - VC_{ijk}], \tag{4}$$

where RP_{ij} is the net returns per acre to production activity j in year i (dollars per acre); W_{jk} is the relative share of crop k in rotation j($\sum_{k=1}^{4} W_{jk} = 1$); YLD_{ijk} is the yield per acre for crop k in rotation j in year i (bushels per acre); MP_{ik} is the market price of crop k in year i (dollars per bushel or ton); VC_{ijk} is the variable costs per acre of crop k in rotation j in year i (dollars per acre). Expected returns to the production activities were approximated by the average annual returns over 33 years.

Enrollment Activities. The specification of and returns to enrollment in the government's commodity program for corn were policy-option dependent. Under the baseline, option B, and the insecticide and nitrogen tax alternatives, the enrollment activity represented the set-aside and deficiency payments per acre of base enrolled in the program. For option A, the enrollment activity represented a lump sum deficiency payment and set-aside for all acres of corn base. The calculation of the deficiency payment per acre of base is described below.

For option A, this value was simply multiplied by the number of acres of corn base to arrive at the lump sum deficiency payment.

Estimation of the time series of returns from the enrollment activities to estimate expectations and variability required careful consideration of the sources of uncertainty about program costs and benefits prior to planting. Farmers have knowledge of government program parameters before planting, so the variability of net returns to enrollment derives from uncertainty about market prices and yields. Although expectations of market prices in a given year are likely conditioned upon the level of the program parameters, estimation of this relationship is beyond the scope of this analysis.

A procedure similar to the one used by McSweeny and Kramer (1986) was followed. Specifically, the variability of net returns to enrollment, with the target price and loan rates certain, was approximated by using the program parameters for a single year, 1989. The 1989 parameters were inflated by the consumer price index before being used to estimate the time series of returns to enrollment in the government program for corn. Consequently, the real values of the program parameters were held constant. The values of the parameters were obtained from unpublished ASCS data (ASCS 1989). Net returns to enrollment were calculated for each year from 1974 to 1987. The 1989 levels of program parameters were used as the basis for the values of the program parameters, even though yield data for 1988 and 1989 were unavailable to calculate returns in those years, so that expectations and variability of returns to enrollment would reflect those of the most recent commodity program. The set-aside rate under the acreage reduction program was set at the 1989 level as well.

The program payment yield was based on the average of program payment yields, dropping the highest and lowest yields, for the period from 1981 to 1985. The payment yields for each year from 1981 to 1985 were estimated as the average of the previous five years, dropping the highest and lowest yields. Payment yields under the 1985 FSA are based on the same calculation. A simple average of all corn crop sequences grown in each rotation was used to make the payment yield calculations.

The net returns per acre of corn base were calculated as

$$RE_i = \Big((1 - ARP - PLD)\ \{MAX[TGT_i - MAX(SAP_i, NLR_i), 0]\} * BYLD\Big) - CVC_i, \tag{5}$$

where RE_i is the return to participating in the corn program in year i (dollars per acre of base); ARP is the 1989 set-aside required under the acreage reduction program (percentage of total acres enrolled); TGT_i is the 1989 target price for corn inflated to year i (dollars per bushel); SAP_i is the real, national, season-average market price (September-January) used to determine the deficiency payments in year i (dollars per bushel); NLR_i is the 1989 national-average reduced loan rate (or Findley loan rate) for corn, inflated to year i (dollars per bushel); BYLD is the program payment yield established by the producer (bushels per acre); and CVC_i is the real cost in year i of covering acres set aside under the acreage reduction program (dollars per acre). In reality, the September through August season-average price and the basic loan rate also enter the calculation of deficiency payments (Evans and Price 1989). The additional complexities, however, would add little to the accuracy of the estimates and, thus, were excluded. The expected returns to the enrollment activities were approximated by the average annual returns over 14 years.

Penalty Activity. Under the current program, farms are assigned corn bases equal to a moving average of corn planted or considered planted in the five previous years. Consequently, maintaining a corn base requires a minimum level of corn production, regardless of the decision to enroll in the program. If planted acreage plus acreage considered planted falls short of the current established base, the farm's corn base will be smaller the next year by one fifth of the deficit. The future earning potential of these corn-base acres is lost. In short, the producer must use the base or lose it.

To account for this long-run loss of earnings in a short-run analysis, a penalty for loss of corn base in the current year was estimated. Theory suggests that the estimate of the penalty should reflect the market value of corn base acres and that the market value should reflect the value of the stream of expected returns to the corn base. Because the penalty is determined by a period from the present to infinity, the impact on the penalty of the returns to the corn base realized in any single year should have little, if any, impact on the actual value of the penalty. Consequently, the value of the penalty will not likely vary nor will it be correlated with either the production or enrollment activities.

To approximate the market value of the corn base, estimates of expected future benefits must be made. If, over the long run, the producer expects economic and political conditions to remain the same, the average annual historical benefits to base acres might be a reasonable estimator of benefits in the future. The QRP model of a risk neutral producer was used to estimate the average annual historical benefits of holding base acres over the period from 1974 to 1987. The QRP was run for two levels of base acres, one representing the loss of the first acre of base, the second representing the last possible acre of base lost. The shadow price on the corn base, which reflects the marginal return to an acre of base, was observed for each run. Assuming the relationship between the number of base acres lost and their annual benefit is approximately linear, the annual benefit was estimated as the average of the return to the first and last acre of base possibly lost. Finally, the estimate of the penalty was calculated as the net present value of an infinite stream of the average annual benefit to an acre of corn base.

Insecticide and Nitrogen Supply Activities. Corn rootworm insecticide and nitrogen costs were not directly included in the net returns to the production activities. Instead, the costs were introduced through separate activities to facilitate the introduction of the taxes. Accounting for the quantity of insecticides applied was done in pounds of active ingredients per acre. The rate of chemical application per acre on corn following corn was set at the recommended rate of one pound of active ingredient per acre. Opportunities to adjust rates were not included, largely because little information about the relationships between rates, rootworm infestations, weather, and other variables is available. Insecticide costs per acre were calculated by using the price of Counter, the major corn rootworm insecticide in Iowa (Wintersteen and Hartzler 1987). Nitrogen was measured in pounds. Rates of application and credits for legumes were based on Iowa State University Cooperative Extension recommendations (Voss 1982). The price per pound was taken from the 1987 Annual Summary of Agricultural Prices (Agricultural Statistics Board 1988). The costs of the insecticide and nitrogen purchases were assumed to be certain because producers know the costs before making planting decisions.

Transfer Rows and Constraints. Figure 2 illustrates the transfer rows and constraints on the levels of activities in the optimal outcome. Only one land type was included. Machinery constraints were specified for nine machinery groups, according to basic functions (e.g., primary tillage, secondary tillage, power, etc.). Both machinery and labor are seasonal constraints. Consequently, requirements and available amounts of these resources were specified for four seasons: (1) April and May; (2) June and July; (3) August and September; and (4) October and November. Machinery and labor requirements during all other months are typically negligible. Hourly machinery and labor requirements were obtained from CARD/SCS budgets. Estimates of machinery and labor availability were based upon assumptions about the number of workers and machines on a farm the size of the case-study farm and average working hours per season. The average working hours per season was based on assumptions about the number of hours worked per day, and historical information on average days fields were workable per season, obtained from "Planting to Harvest" (Iowa Agricultural Statistics Service 1988).

A number of equations were included to simulate the rules of the current government program for corn. Under the baseline, because production and enrollment activities were modeled separately and because deficiency payments are coupled with the production of corn, transfer rows between the two were included. The rows reflect the rules of the program that link deficiency payments with current production by requiring that one acre of corn production, less set-aside under the acreage reduction program, accompany one acre of corn enrolled in the program. Upper limits on the acreage of corn that can be enrolled in the program and the permitted acreage planted to corn were included to reflect the rules for eligibility of deficiency payments. The upper limits depended upon the level of program base established for the farm. Finally, a penalty transfer row was included to reflect planting requirements for maintaining the existing level of program base. If the level of corn production plus set-aside in any given run did not exceed the current level of the corn base, the penalty on loss of corn base was invoked by the penalty transfer row.

Modifications to the structure of the model to simulate option A involved the elimination of most of the transfer rows and constraints that were necessary to simulate the baseline. The transfer row between the production activities and the enrollment activity, the upper limit on corn acreage enrolled and permitted planted, and the penalty transfer row (along with the penalty activity) were eliminated. A whole-farm acreage base constraint was added to place an upper bound on the sum of corn, oats, and soybean acreages.

For option B, the fundamental rules and provisions of the program remain unaltered. Changes were made to the rows under the baseline to reflect the new rules that allow legume hay to be planted on previously set-aside acres or to be counted as corn plantings for purposes of collecting deficiency payments and calculating the corn base for the next year. The last set of equations is the insecticide and nitrogen transfer rows. The rows link the input buying activities with the production activities that require them.

Variance-Covariance Matrix

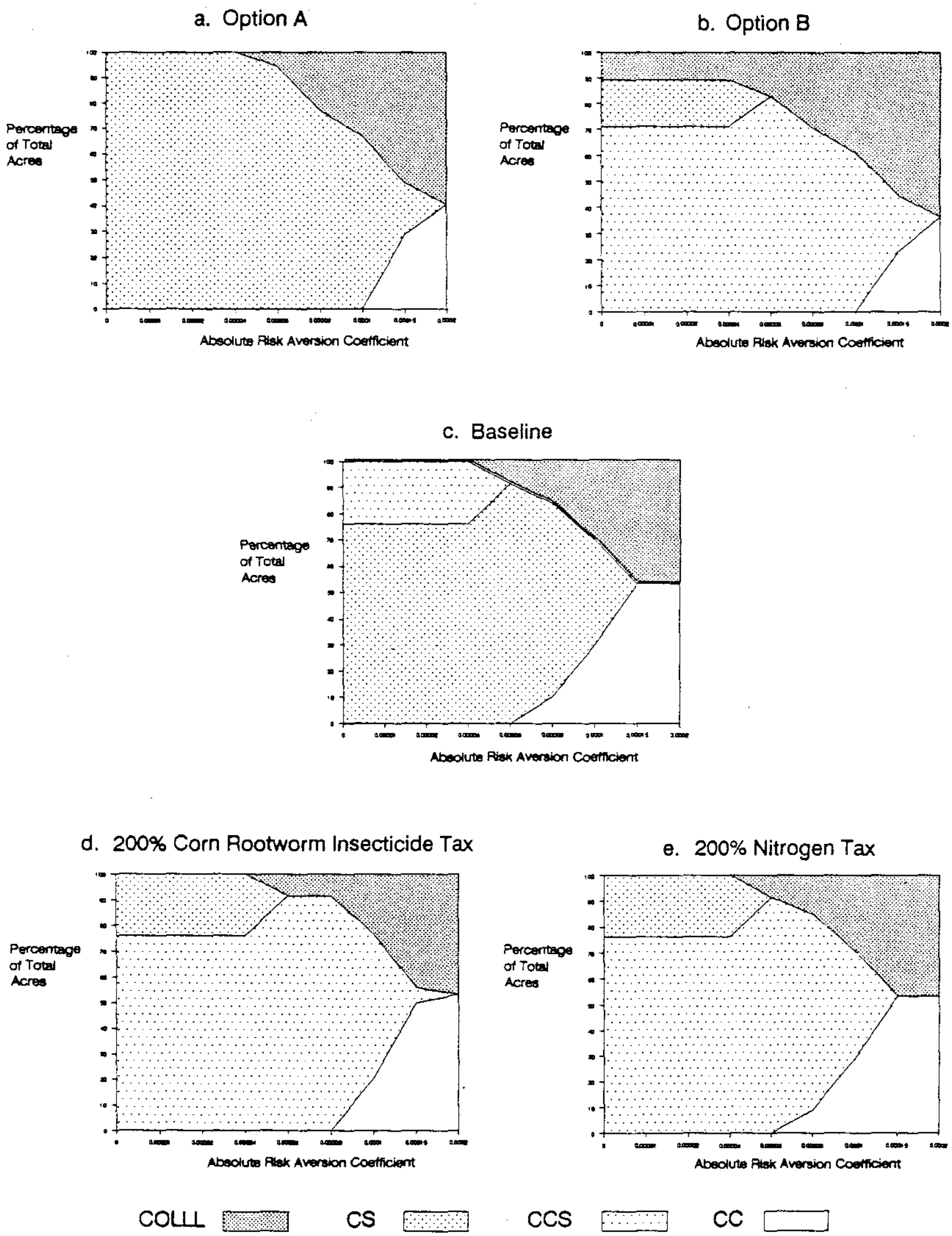
Using a third degree polynomial, net returns were regressed on time to detrend the series for the production and enrollment activities. These detrended net returns were used to estimate the variance-covariance matrix. Thus, it was implicitly assumed that, in practice, farmers are generally aware of long-run trends in net returns, and only the deviations from the long run are considered random or unpredictable. The variance-covariance matrices and the expected returns to the production and enrollment activities for the baseline and each of the policy alternatives are in Appendix A. By definition, the variance-covariance matrix and the expected returns do not change from the baseline for option B or either of the input tax alternatives. The variance-covariance matrix and vector of expected returns are different under option A only in that the program enrollment activity represents a lump sum payment instead of payments on a per-acre basis. The variance-covariance matrix and the expected returns for the baseline and all policy alternatives, except option A, are presented in Table A.1. of the appendix. They are presented for option A in Table A.2.

Empirical Findings

This section compares the outcomes of each policy alternative to that of the baseline. Rotation selection, nitrogen and corn rootworm insecticide use, crop mix, and certainty equivalent income as a measure of producer welfare were the measurement variables by which the alternatives were evaluated. Government payments made to the farm, by design, were held constant under all policy alternatives unless producers chose not to participate on all eligible acres. The measurement variables of most interest in the study were uses of nitrogen and corn rootworm insecticide. By construction, the selection of rotations is the single most important determinant of nitrogen and insecticide use. Certainty equivalent income in relation to the other measurement variables provides an indication of the trade-offs associated with each of the policy alternatives. In all cases, the policy outcomes are reported for several levels of risk aversion, ranging from risk neutral (absolute risk aversion coefficient equal to 0.0000) to risk averse (absolute risk aversion coefficient equal to 0.0002).

Rotations. A CCS rotation, with conventional use of corn rootworm insecticide, would be used most frequently under the baseline and all of the policy alternatives by producers at lower levels of risk aversion (Figures 3a-3e). This outcome reflects the favorable expected returns and variance of returns relative to CC and CS rotations (Appendix). Because a CCS rotation would be used more frequently under the planting flexibility options than it is under the baseline, the advantage of the rotation for less risk-averse producers seems independent of incentives to grow corn imbued in the commodity program for corn. In other words, for the the case-study farm, a CCS rotation would be heavily used even if the role of the market, as a determinant of production decisions, is increased as it would be under the planting flexibility alternatives.

Figure 3. Optimal Rotation Mix under Each Policy Alternative



A CS rotation would be the second most used rotation at lower levels of risk aversion, except under option A where CCS is grown exclusively. Under option B, some of the land would be devoted to COLLL at lower levels of risk aversion. The result is due to the provision under option B that would allow legume hay to be planted on acres previously set aside. Neither the insecticide nor the nitrogen tax had any impact on the rotations adopted at lower levels of risk aversion.

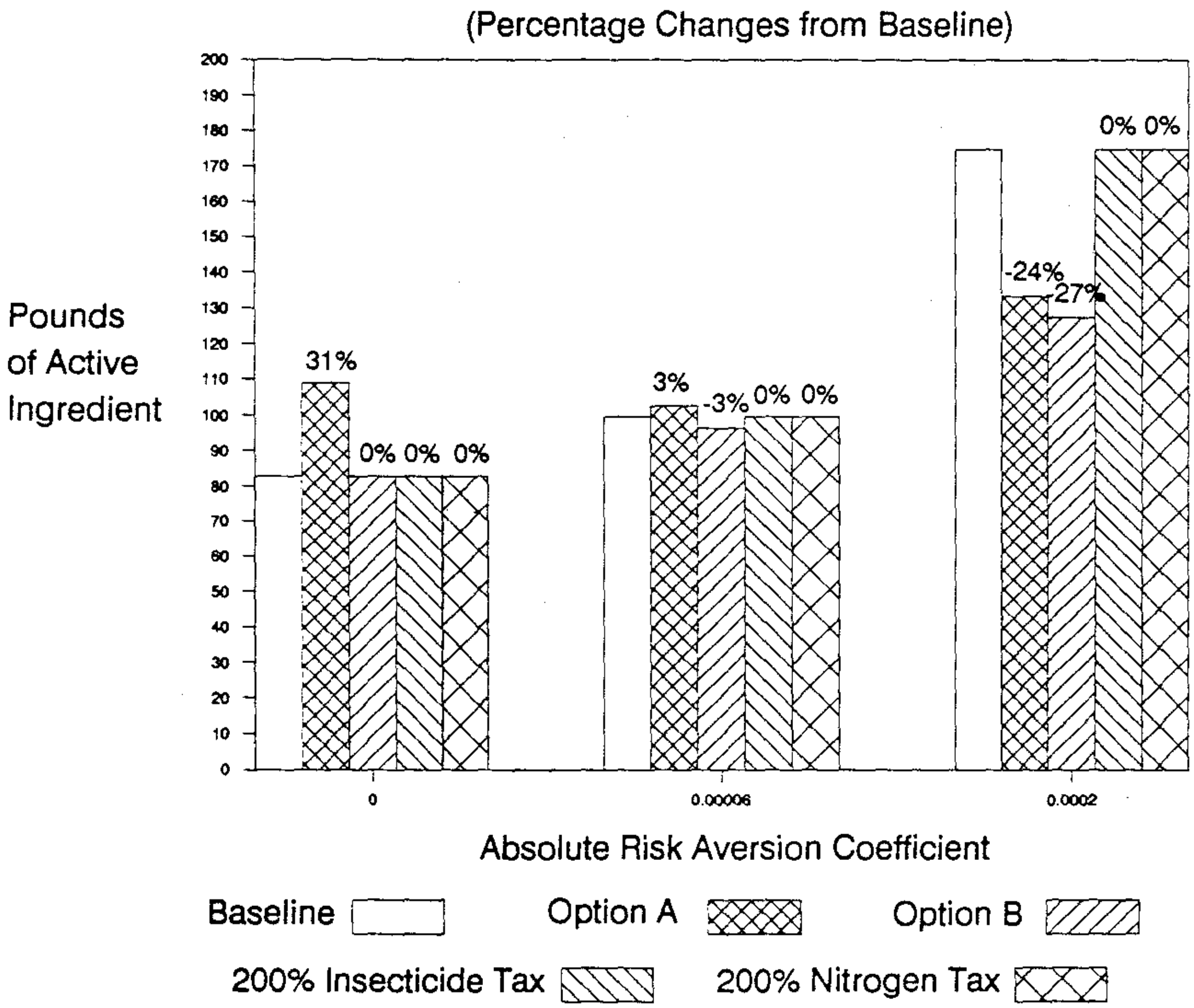
At higher levels of risk aversion, continuous corn, with conventional use of corn rootworm insecticide control, and a COLLL rotation would be used most frequently under the baseline and all policy alternatives. This outcome was determined by three factors. First, the variance of COLLL is relatively low. Second, CC, despite yielding a relatively high variance of returns, compared to other rotations has (1) a relatively small positive covariance with COLLL and (2) a relatively large negative covariance with the enrollment activity (Appendix). Third, the inflexibility of the current program dictates planting of a minimum level of corn to receive deficiency payments. Land devoted to continuous corn requires fewer acres to achieve that minimum level than a CS or CCS rotation. The rest of the land may be devoted to a COLLL rotation that yields relatively stable returns. Relative to the baseline, COLLL and a small area of CCS would replace continuous corn in the optimal mix of rotations under option A. A similar outcome occurred under option B, except that COLLL is adopted even more than under option A. Acreage devoted to continuous corn would be reduced significantly from the baseline and would slip below 40 percent of the total acreage at the highest level of risk aversion.

The results also revealed that without conventional use of corn rootworm insecticide, CC and CCS rotations did not occur under the baseline or any of the policy alternatives (Figures 3a-3e). Under the baseline and planting flexibility scenarios, CC and CCS rotations with conventional use of insecticide dominated, with higher expected returns and lower variances (Appendix Table A.1). It was initially thought that the 200-percent tax on rootworm insecticide and nitrogen might provide enough incentive to cause producers to discontinue use of insecticide on these rotations. Perhaps a higher tax could induce them to do so.

Insecticide Use. Figure 4 shows the optimal levels of corn rootworm insecticide use under the baseline and each policy option for selected levels of risk aversion. Insecticide use at lower levels of risk aversion would be unchanged from the baseline under option B, the insecticide tax and nitrogen tax alternatives. It would actually increase under option A. As risk aversion increases, insecticide use under options A and B would be significantly less (24 and 27 percent respectively at the highest level of risk aversion) than under the baseline. At higher levels of risk aversion, fewer acres relative to the baseline would be devoted to rotations with corn following corn, and less corn rootworm insecticide would be applied under option A. Corn, especially corn following corn, is subject to greater variability in returns, and plantings are less constrained under the option relative to the baseline.

The reduction in insecticide use under option B at higher levels of risk aversion is related to the relative stability of returns to legume hay rotations. Given the choice to substitute legume hay for corn to

Figure 4. Optimal Levels of Corn Rootworm Insecticide Use under Each Alternative at Selected Levels of Risk Aversion

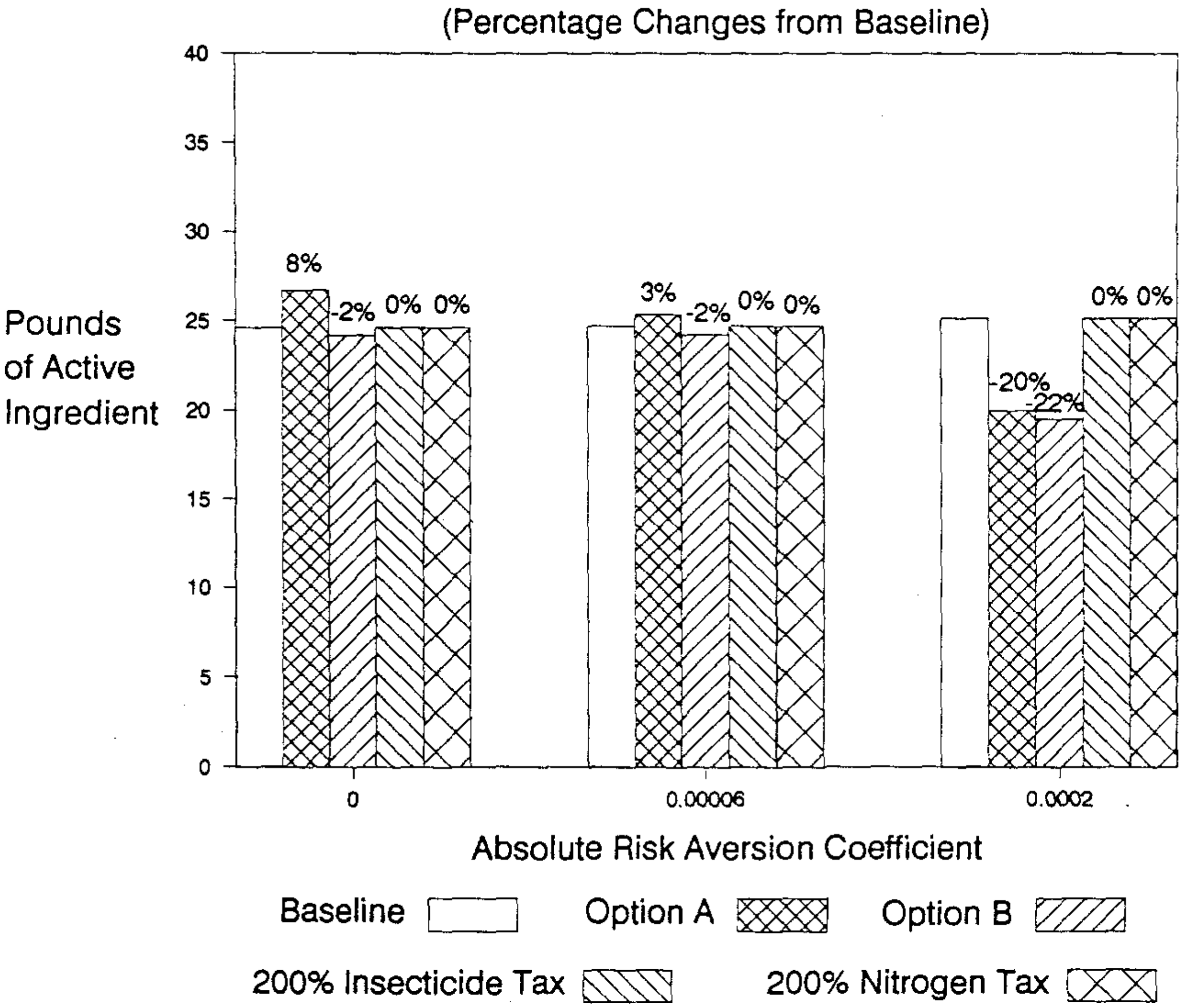


satisfy program constraints and receive deficiency payments, relatively risk-averse producers would do so, whereas less risk-averse producers would likely continue to plant corn. The insecticide tax and the nitrogen tax remain relatively ineffective at reducing corn rootworm insecticide use. Given the differences in expected returns and variances between each of the production activities, before and after the taxes are imposed, the relative ineffectiveness of the insecticide and nitrogen tax can largely be attributed to the inflexibility of the current program for corn.

The increase in insecticide use at lower levels of risk aversion under option A reflects the relative profitability advantage corn has had, based on 33 years of historical market prices, even without the program. The outcome also is heavily dependent on the level of corn base assumed for the case-study farm. Had the level of established base been higher, the amount of corn grown and insecticides used under the baseline would almost certainly have been higher and the change effected by option A would have been smaller, perhaps even negative.

Nitrogen Use. The pattern of nitrogen use under the various alternatives and levels of risk aversion, not surprisingly, closely followed that of insecticide use (Figure 5). Smaller changes in nitrogen use relative to changes in insecticide use would occur because some nonlegume nitrogen is required by all rotations. Corn rootworm insecticide use is limited to rotations where corn follows corn in one or more years. The ineffectiveness of either a 200-percent tax on insecticide or nitrogen in reducing the use of purchased nitrogen again demonstrates the inflexibility of the current programs.

Figure 5. Optimal Levels of Nitrogen Use under Each Alternative at Selected Levels of Risk Aversion

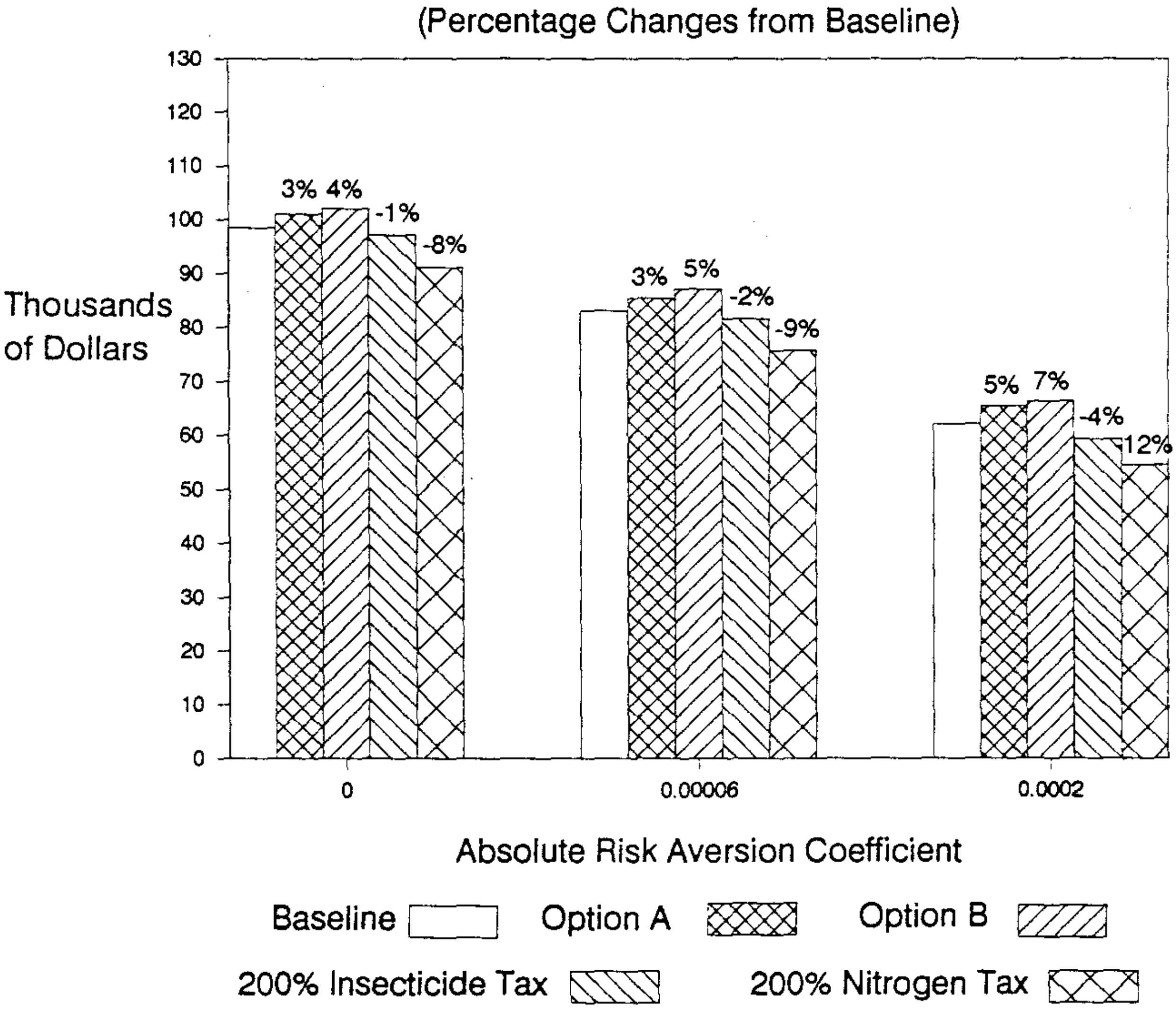


Certainty Equivalent Income. Certainty equivalent incomes under the planting flexibility proposals would typically be 3-7 percent higher than under the baseline (Figure 6). The largest percentage increases would occur for producers with higher levels of risk aversion. Increases in certainty equivalent income would occur because of freedom to adopt a more profitable combination of rotations afforded by the planting flexibility options with no loss of commodity program benefits. A portion of the increase under option B can be attributed to the provision that would allow producers to plant resource-conserving crops on acres previously set aside, which can be viewed as a reduction in the costs of enrolling in the program for corn. The results indicate that the flexibility provisions, assuming no commodity price impacts, would improve the welfare of participating producers, as measured by certainty equivalent income on the case-study farm at no additional expense to the government. Lacking estimates of impacts of planting flexibility alternatives on commodity crop prices, however, precludes making any stronger statements about the welfare effects.

Under the taxes on environmentally sensitive inputs, certainty equivalent income would clearly fall, and the decline is significantly larger for the nitrogen tax than for the insecticide tax. The difference is primarily because the nitrogen tax would be higher in absolute dollars than the insecticide tax since nitrogen costs make up a greater share of variable costs relative to corn rootworm insecticide costs.

Crop Mix. Figures 7a-7c show the optimal crop mix under the baseline and each policy option for selected levels of risk aversion. Under the baseline and both input tax options, the acreage of corn grown, as a

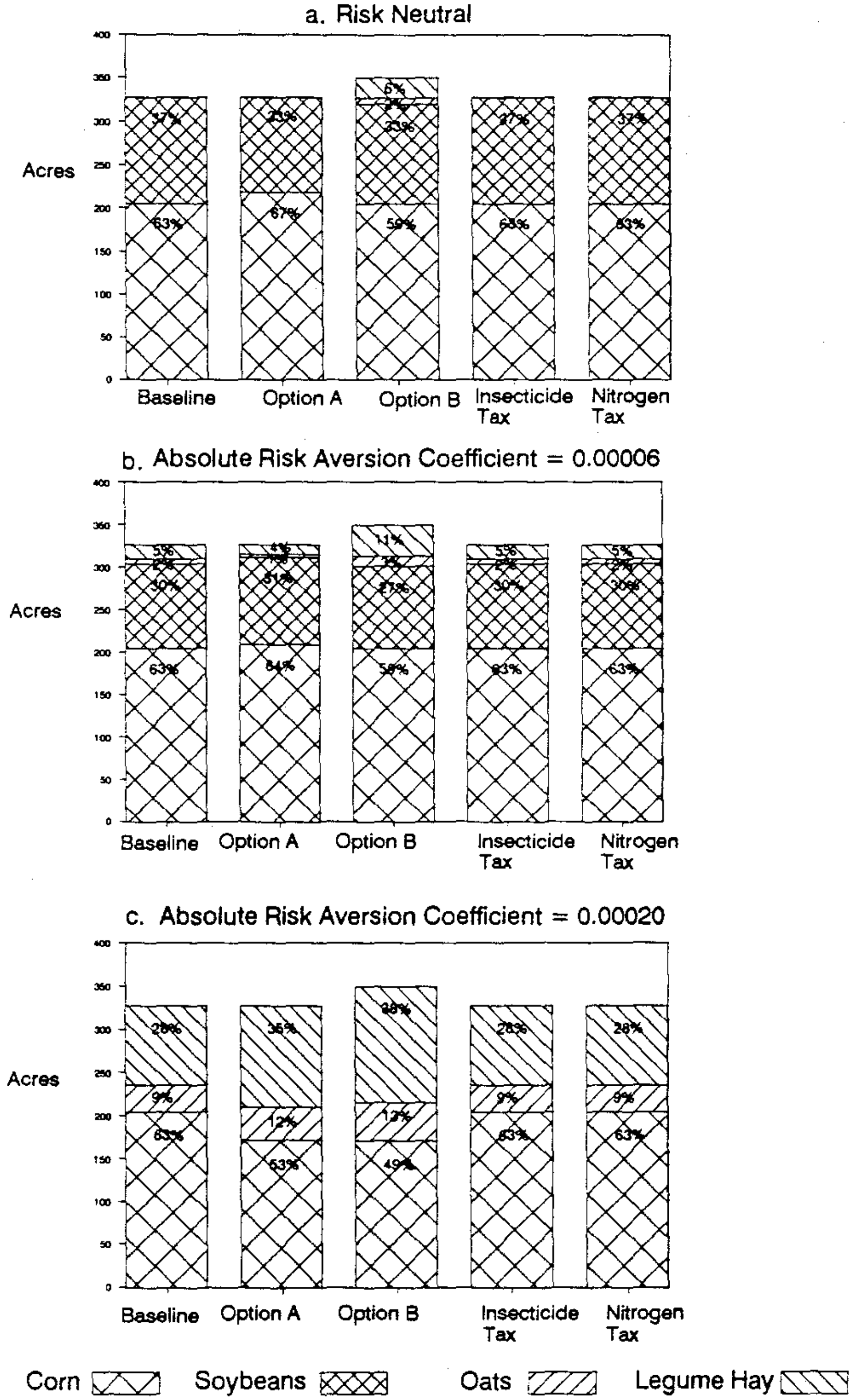
Figure 6. Certainty Equivalent Income under Each Alternative at Selected Levels of Risk Aversion



percentage of the total acres planted to crops on the farm, would remain at 63 percent for all levels of risk aversion. Under option A, for a risk neutral producer, the acreage devoted to corn would actually increase to 67 percent of the total acreage planted (Figure 7a). This outcome, as did the increase in insecticide use, reflects the relative profitability advantage corn has had historically in the market, even without the program and the level of corn base assigned to the representative farm. Under option B, acres of corn grown would remain unchanged from the baseline, but decrease as a percentage of total acres, from 63 to 59 percent, because acres previously set aside are now part of the total planted acres (Figure 7a). Under the baseline, option A, and both input tax options, soybeans make up the rest of the crop mix for the risk-neutral case. Relative to the baseline, soybean acreage planted and as a percentage of total cropland would decrease under both planting flexibility options for a risk-neutral producer (Figure 7a). The results cast some doubt on claims that planting flexibility will increase soybean acreage to recapture lost world soybean markets. Such an outcome is clearly not assured. Oats and legume hay would be grown by risk-neutral producers under option B. Legume hay is grown only on acres that must either be set aside or planted to a resource-conserving crop. This outcome reveals an unwillingness by represented producers who are risk neutral or relatively risk averse to plant legume hay as a resource-conserving crop in place of corn, even if given the flexibility to do so, when their expectations are based upon historical output prices and current target prices and loan rates.

Figure 7. Crop Mix under Each Alternative for Selected Levels of Risk Aversion

(Crop Grown as a Percentage of Total Acres Indicated)



At higher levels of risk aversion, oats and legume hay are substituted for soybeans under the baseline and all policy alternatives (Figures 7b and 7c). At the highest levels of risk aversion, corn, oats, and legume hay make up the entire crop mix (Figure 7c). And, corn acreage under options A and B is reduced by more than 25 acres from the baseline (Figure 7c). Nearly 42 more acres of legume hay would be grown under option B than under the baseline at that highest level of risk aversion.

Crop Price Sensitivity Analysis. Sensitivity of the measurement variables to changes in relative crop prices was estimated by systematically deviating the expected corn price. Expected returns of the production activities were consequently deviated, but the variance-covariance matrix was unaffected. Estimation of sensitivity to changes in crop price relationships, from the historical relationships, provides the opportunity to investigate the extent of the flexibility offered by the planting flexibility options and how policy-induced supply shocks and relative crop price impacts will affect the outcomes discussed in the previous section. The former investigation relates to adjustments that may occur given relative price changes independent of the policy implementation. The latter relates to adjustments in response to relative price shocks that might occur because of the implementation of the policy.

Planting Flexibility. Determination of the extent of flexibility inherent in options A and B was made by comparing adjustments in the measurement variables, given changes in relative crop prices, under the baseline and both options. Elasticities of change with respect to the corn price were calculated for the measurement variables. Large elasticities are associated with greater flexibility to adjust plantings and input decisions in response to relative price changes.[2] The elasticities are reported in Tables 2-7.

The results under both planting flexibility options, compared to the baseline, demonstrate that producers would have increased ability to make adjustments in response to changes in expectations about relative prices. Adjustments in insecticide and nitrogen use and crop mix would be greater under either planting flexibility proposal than they are under the baseline. Under the baseline, the selected measurement variables would be unchanged for most levels of risk aversion. Even the nonzero elasticities at higher levels of risk aversion would be relatively small.

Under option A, elasticities would be frequently nonzero and occasionally large. For example, elasticities of corn rootworm insecticide use and nitrogen use as high as 10 and 3.27, respectively, would occur at lower levels of risk aversion (Table 2). And, own-price elasticities for corn as high as 2.5 and cross-price elasticities for soybeans, oats, and legume hay of -5.02, -34.2, and -34.2, respectively, would occur for an absolute risk aversion of 0.00006 (Tables 4-7).

The elasticities would frequently be nonzero and occasionally large under option B but typically smaller than those that would be evident under option A, except at higher levels of risk aversion. The outcome at higher levels of risk aversion is related to the advantage of legume hay rotations at these levels of risk aversion and to the provisions that would allow planting legume hay without loss of government payments under option B.

Table 2. Comparison of elasticities of change for insecticide use with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	-0.20	-0.13	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	-0.20	-0.13	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	-0.20	-0.13	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	-0.20	-0.13	0.00	0.00
Option A	-10	10.00	10.00	10.00	4.29	2.08	1.90	1.76	5.47	3.12
	-5	0.00	0.00	0.00	0.00	2.08	1.90	1.76	5.47	2.65
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	1.21	2.94	12.59	5.47	1.63
	+10	5.89	5.89	5.89	4.37	4.56	8.59	12.87	4.99	1.63
Option B	-10	0.00	0.00	0.00	0.00	1.75	1.94	1.80	5.50	3.66
	-5	0.00	0.00	0.00	0.00	1.28	1.94	1.80	6.03	3.57
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	1.94	10.38	6.03	1.71
	+10	0.00	0.00	0.00	0.00	0.00	2.63	8.55	5.97	1.71

Table 3. Comparison of elasticities of change for nitrogen use with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	-0.01	-0.00	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	-0.01	-0.00	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	-0.01	-0.00	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	-0.01	-0.00	0.00	0.00
Option A	-10	3.27	3.27	3.27	1.40	1.79	1.60	1.44	2.84	1.93
	-5	0.00	0.00	0.00	0.00	1.79	1.60	1.44	2.84	1.75
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	1.05	1.88	4.31	2.84	1.35
	+10	1.92	1.92	1.92	1.42	1.80	3.42	4.39	2.68	1.35
Option B	-10	0.00	0.00	0.00	0.00	1.48	1.61	1.45	2.75	2.13
	-5	0.00	0.00	0.00	0.00	1.09	1.61	1.45	2.96	2.10
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	1.61	3.69	2.96	1.39
	+10	0.00	0.00	0.00	0.00	0.00	1.44	2.98	2.93	1.39

Table 4. Comparison of elasticities of change for corn acreage with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Option A	-10	2.50	2.50	2.50	1.07	1.43	1.22	1.07	2.07	1.42
	-5	0.00	0.00	0.00	0.00	1.43	1.22	1.07	2.07	1.29
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.83	1.43	3.08	2.07	1.01
	+10	1.47	1.47	1.47	1.09	1.39	2.53	3.13	1.96	1.01
Option B	-10	0.00	0.00	0.00	0.00	1.15	1.21	1.06	1.95	1.53
	-5	0.00	0.00	0.00	0.00	0.84	1.21	1.06	2.09	1.50
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	1.21	2.59	2.09	1.01
	+10	0.00	0.00	0.00	0.00	0.00	1.07	2.09	2.07	1.01

Table 5. Comparison of elasticities of change for soybean acreage with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	0.37	0.54	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	0.37	0.54	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	0.37	0.54	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	0.37	0.54	0.00	0.00
Option A	-10	-5.02	-5.02	-5.02	-2.15	2.08	1.90	1.76	-11.91	0.00
	-5	0.00	0.00	0.00	0.00	2.08	1.90	1.76	-11.91	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	1.21	1.26	-4.96	-11.91	0.00
	+10	-2.94	-2.94	-2.94	-2.18	-1.37	-2.24	-5.13	-10.00	0.00
Option B	-10	0.00	0.00	0.00	0.00	1.75	1.94	1.80	-8.77	0.00
	-5	0.00	0.00	0.00	0.00	1.28	1.94	1.80	-10.15	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	1.94	-3.51	-10.15	0.00
	+10	0.00	0.00	0.00	0.00	0.00	0.51	-3.06	-10.00	0.00

Table 6. Comparison of elasticities of change for oat acreage with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
Option	-10	0.00	0.00	0.00	0.00	-34.20	-6.43	-3.55	-0.73	-0.63
A	-5	0.00	0.00	0.00	0.00	-34.20	-6.43	-3.55	-0.73	-0.79
	0	-	-	-	-	-	-	-	-	-
	+5 +10	0.00	0.00	0.00	0.00	-20.00	-6.15	-1.79	-0.73	-1.12
		0.00	0.00	0.00	0.00	-10.00	-4.62	-1.75	-0.90	-1.12
	-10									
Option	-5	0.00	0.00	0.00	0.00	-8.36	-4.66	-2.81	-0.71	-0.44
B	0	0.00	0.00	0.00	0.00	-6.13	-4.66	-2.81	-0.64	-0.47
	+5	-	-	-	-	-	-	-	-	-
	+10	0.00	0.00	0.00	0.00	0.00	-4.66	-1.74	-0.64	-0.98
		0.00	0.00	0.00	0.00	0.00	-2.92	-1.27	-0.64	-0.98

Table 7. Comparison of elasticities of change for legume hay acreage with respect to corn price under the baseline and both planting flexibility options

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	-5	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
	+10	0.00	0.00	0.00	0.00	0.00	-0.71	-0.30	0.00	0.00
Option A	-10	0.00	0.00	0.00	0.00	-34.20	-6.43	-3.55	-0.73	-0.63
	-5	0.00	0.00	0.00	0.00	-34.20	-6.43	-3.55	-0.73	-0.79
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	-20.00	-6.15	-1.79	-0.73	-1.12
	+10	0.00	0.00	0.00	0.00	-10.00	-4.62	-1.75	-0.90	-1.12
Option B	-10	0.00	0.00	0.00	0.00	-8.36	-4.66	-2.81	-0.71	-0.44
	-5	0.00	0.00	0.00	0.00	-6.13	-4.66	-2.81	-0.64	-0.47
	0	-	-	-	-	-	-	-	-	-
	+5	0.00	0.00	0.00	0.00	0.00	-4.66	-1.74	-0.64	-0.98
	+10	0.00	0.00	0.00	0.00	0.00	-2.92	-1.27	-0.64	-0.98

Policy-Induced Price Impacts. Because evaluation of market level impacts was beyond the scope of the study, the next best alternative for evaluating potential policy-induced commodity price impacts was to estimate the sensitivity of the measurement variables to several alternative levels of relative crop prices. Comparison of corn rootworm insecticide use levels across policy options demonstrates the potential for widely varying outcomes, given changes in relative crop prices.

Table 8 reports corn rootworm insecticide use under the baseline and both planting flexibility options by risk-aversion and relative crop price assumptions. Under option A, the direction of the change in insecticide use from the baseline for less risk-averse producers would be reversed, with a 10-percent decrease in the relative corn price. Insecticide use would increase relative to the baseline under option A if no price impacts were assumed; a 10-percent decrease in the corn price would lead to zero use of insecticide use relative to the initial commodity price levels. Whereas it seemed initially that insecticide use would increase under option A, relative to the baseline, it is now clear that the outcome would be conditioned by policy-induced changes in relative commodity prices. Similarly, at higher levels of risk aversion, insecticide use under option A would not decrease as much, relative to the baseline (initial relative crop prices), if corn prices rose 5 or 10 percent relative to other crop prices. A 5-percent decrease would have no impact on less risk-averse producers but would further reduce insecticide use by as much as 27 percent from the initial result obtained for option A. The results are even more dramatic for a 10-percent decrease in the corn price.

Table 8. Comparison of corn rootworm insecticide use under the baseline and both planting flexibility options (pounds of active ingredient)

Policy Option	Percentage Change in Corn Price	Absolute Risk Aversion Coefficient								
		0.00000	0.00001	0.00002	0.00004	0.00006	0.00008	0.00010	0.00015	0.00020
Baseline	-10	82.95	82.95	82.95	82.95	99.66	116.54	143.58	174.70	174.70
	-5	82.95	82.95	82.95	82.95	99.66	115.42	142.69	174.70	174.70
	0	82.95	82.95	82.95	82.95	99.66	114.30	141.79	174.70	174.70
	+5	82.95	82.95	82.95	82.95	99.66	113.18	140.90	174.70	174.70
	+10	82.95	82.95	82.95	82.95	99.66	112.06	140.00	174.70	174.70
Option A	-10	0.00	0.00	0.00	62.26	81.40	68.08	60.09	52.81	91.66
	-5	108.96	108.96	108.96	108.96	82.06	76.08	66.49	84.74	115.61
	0	108.96	108.96	108.96	108.96	102.72	84.07	72.89	116.66	133.26
	+5	108.96	108.96	108.96	108.96	108.96	96.42	118.78	148.59	144.15
	+10	173.15	173.15	173.15	156.55	149.56	156.28	166.67	174.92	155.04
Option B	-10	82.95	82.95	82.95	82.95	79.58	66.26	58.27	47.61	80.81
	-5	82.95	82.95	82.95	82.95	90.23	74.25	64.66	73.89	104.76
	0	82.95	82.95	82.95	82.95	96.41	82.25	71.06	105.82	127.51
	+5	82.95	82.95	82.95	82.95	96.41	90.25	107.93	137.74	138.40
	+10	82.95	82.95	82.95	82.95	96.41	103.90	131.84	168.99	149.28

Under option B, changes in the relative corn price would not change insecticide use at lower levels of risk aversion. For more risk-averse producers, a 5- or 10-percent increase in the expected corn price would raise insecticide use but not to a level greater than that under the baseline (initial relative crop prices). Five- and 10-percent reductions in the expected corn price would result in insecticide use reductions of as much as 27 and 55 percent, respectively, from the outcome obtained for option B at initial relative crop prices. A pattern of adjustments for nitrogen use was very similar to that of corn rootworm insecticide use.

Policy Implications

The planting flexibility provisions would encourage conversion to less corn-intensive rotations that reduce corn rootworm insecticide and nitrogen use on farms like the one used for the case study. But such reductions would not be guaranteed. Because historical market price relationships for corn, soybeans, oats, and legume hay favor corn, insecticide and nitrogen use would actually increase significantly for less risk-averse producers under option A. The impact of the planting flexibility alternatives on producer welfare, as measured by certainty equivalent income, would be positive, but seldom very large. By definition, changes in government payments were constant across all policy options.

The taxes of 200-percent on corn rootworm insecticide and nitrogen had almost no effect on any of the measurement variables except producer welfare. The rules and provisions of the current program for corn dominate major changes in the relative input costs, imposed by the taxes on corn rootworm insecticide and nitrogen, as a determinant of insecticide and nitrogen use, crop mix, and rotations adopted. Given the relative inflexibility of the current program for corn, the taxes would essentially transfer income from producers to the government.

Using adjustments in corn rootworm insecticide and nitrogen use and crop mix in response to changes in relative crop prices as a measure of flexibility, it seems that option A would be more flexible than option B. Both would be more flexible than the current program modeled as the baseline. Finally, changes in relative corn prices of 10 percent or less, caused by implementation of the proposed planting flexibility provisions, would condition the eventual outcome of the planting flexibility provisions if implemented. The results of the analysis indicated that policy-induced commodity price impacts could lead to a situation where very little reduction, or an increase, in the use of corn rootworm insecticides and nitrogen from the baseline would result under either planting flexibility option.

Extensions of the Analysis

The conclusions drawn from this analysis are conditioned by the exclusion of nonconventional agricultural practices, with the exception of continuous corn and CCS rotations with no corn rootworm insecticide. The introduction of such practices has the potential to alter the outcomes of the policy alternatives analyzed. In addition, the exclusion of crop price impacts of each of the policy alternatives biased the comparison of each alternative to the baseline. The sensitivity analysis on the relative corn price provided an indication of the magnitude of the potential bias. Finally, the ability to adjust base acreage upwards over time under the baseline by staying out of the program was not considered. This omission may be particularly important for the sensitivity analysis, where expectations for lower corn prices may result in an optimal solution that involves staying out of the program for one or more years and increasing the corn base. Analysis of such relationships might require a dynamic approach. To the extent that current commodity price relationships deviate from historical relationships, conclusions about the near term may be biased. Adjusting crop prices to reflect more current relative prices would mean that near-term impacts could be estimated more accurately.

ENDNOTES

1. Iowa State University has developed a root damage rating scale from one to six for larval feeding. The rating scale is defined as follows: 1 when no damage or only a few minor feeding scars are evident; 2 when feeding scars are evident, but no roots have been eaten to within 1 1/2 inches of the plant; 3 when several roots have been eaten to within 1 1/2 inches of the plant, but the equivalent of an entire node of roots has not been destroyed; 4 when one node of roots has been completely destroyed; 5 when two nodes of roots have been completely destroyed; and 6 when three or more nodes of roots have been destroyed.

2. The outcomes from quadratic risk programming models such as the one used in this analysis ignore the dynamics of change and provide only a static solution at some single point in time. When alternative solutions reveal adjustments in rotations, crop mixes, and so forth, the adjustments do not occur instantaneously and require periods of transition. In this case, that period might be several years because producers cannot, for example, use a continuous corn rotation one year and the next switch to a COLLL sequence. Therefore, the estimates of flexibility in this analysis reflect adjustments that may be made over a period of several years in response to changes in expectations about relative prices.

Appendix

Table A.1. Variance-covariance matrix for baseline, planting flexibility option B and the input tax policy alternatives

Activity	CC	CC[a]	CCS	CCS[a]	CS	CSCOL	COLLL	Program
CC	**7790**	8296	6451	6336	5913	3680	1047	-2336
CC[a]	8296	**12167**	6760	7747	6135	3506	603	-2554
CCS	6451	6760	**5947**	5847	5765	3534	1276	-1466
CCS[a]	6336	7747	5847	**6155**	5670	3387	1185	-1443
CS	5913	6135	5765	5670	**5826**	3561	1435	-1091
CSCOL	3680	3506	3534	3387	3561	**2409**	1316	-668
COLLL	1047	603	1276	1185	1435	1316	**1540**	-15
Program	-2336	-2554	-1466	-1443	-1091	-668	-15	**2010**
Expected Returns	257	194	255	239	245	189	176	98

a Indicates rotation is subject to rootworm infestations because no insecticides were applied.
Variances are highlighted by bold print.

Table A.2. Variance-covariance matrix for planting flexibility option A

Activity	CC	CC[a]	CCS	CCS[a]	CS	CSCOL	COLLL	Program
CC	**7790**	8296	6451	6336	5913	3680	1047	-532649
CC[a]	8296	**12167**	6760	7747	6135	3506	603	-582442
CCS	6451	6760	**5947**	5847	5765	3534	1276	-334252
CCS[a]	6336	7747	5847	**6155**	5670	3387	1185	-329094
CS	5913	6135	5765	5670	**5826**	3561	1435	-248797
CSCOL	3680	3506	3534	3387	3561	**2409**	1316	-152395
COLLL	1047	603	1276	1185	1435	1316	**1540**	-3622
Program	-532649	-582442	-334252	-329094	-248797	-152395	-3622	**1.04E+08**
Expected Returns	257	194	255	238	244	189	175	20212

a Indicates rotation is subject to rootworm infestations because no insecticides were applied.
Variances are highlighted by bold print.

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