Flexibility and the Integration of Commodity and Environmental Policies

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ABSTRACT

Environmental and health risk concerns associated with the use of agricultural chemicals in the United States are increasing. In response, public policies designed to alter farming practices and the use of agricultural chemicals are being proposed and implemented. In addition, agricultural price stabilization and income support policies are being reviewed for environmental implications. This paper provides a farm-level analysis of the interrelationships between the current U.S. commodity program for corn and selected policies for controlling the use of corn rootworm insecticides. The farm modeled is for Chickasaw County, Iowa. Results show significant opportunities for coordinating agricultural commodity and environmental policies. Corn rootworm insecticide use can be reduced with only modest effects on certain equivalent farm income.

FLEXIBILITY AND THE INTEGRATION OF COMMODITY AND ENVIRONMENTAL POLICIES

There is broad evidence of increased concern for environmental and health risks associated with the use of chemicals in U.S. agriculture (Council on Environmental Quality 1991; Batie 1987; Hoyer et al. 1987). Regulating powers of the U.S. Environmental Protection Agency (USEPA) are being extended through re-registration of pesticides, drinking water standards, and other measures. Also, states are enacting laws limiting the use of agricultural chemicals, providing funding for research on alternative less chemically dependent cultivation practices, monitoring groundwater quality, and assessing health risks (Wise and Johnson 1990). It is somewhat surprising that the regulation of agricultural chemicals has progressed to the present point, without more comprehensive analyses of the interrelationships of chemical use, agricultural commodity programs for price stabilization and income support, and farm-level decisions (CARD and USEPA 1989).

The triple-base of the Food, Agriculture, Conservation and Trade Act of 1990—FACTA 90 —continued a trend toward flexibility that was initiated with the Food Security Act of 1985—FSA85 (Glaser 1986). The triple-base provision for commodities with target prices permits participating producers to plant 15 percent of their program base in an alternative crop in return for forfeiting the associated deficiency payment. The result is producer decisions at the margin are based on market, not policy, prices. Government cost reduction, increased producer discretion, and environmental concerns were the three major arguments for the introduction of the triple-base.

Environmental policies for agriculture have had a contrasting trend. Conservation compliance and regulation of agricultural chemicals are examples of limitations in flexibility characteristic of environmental policy. The result of the combination of more flexible commodity policy and more restrictive environmental policy is the significant modification of the decision space for producers. The result will change environmental and economic performance for farms and the agricultural sector.

Empirical assessments have been developed for the farm level impacts of U.S. agricultural commodity programs, extending the analysis to issues of uncertainty. Kramer and Pope (1981) analyzed commodity program participation using a stochastic dominance model for Kern County (California), demonstrating relationships among program parameters, risk attitudes, and farm size. Musser and Stamoulis (1981) evaluated commodity programs from the 1977 U.S. Farm Bill using a farm level quadratic risk programming model, and concluded that for risk averse Georgia farmers, commodity program participation dominated nonparticipation except at higher levels of expected net returns. An early study by Scott and Baker (1972) used quadratic programming to analyze risk-return trade-offs for Illinois farms, endogenizing commodity program participation.

Recently, farm-level studies have been expanded in scope, perhaps in response to concerns about environmental and commodity policy trade-offs. For example, Helms et al. (1987) used a whole farm simulation model to relate impacts of producer preferences to participation in commodity programs to the adoption of tillage practices. They found that a combination of commodity program participation with minimum and no-till practices dominated other alternatives for a typical Utah farm. The integration of commodity program participation and adoption of soil conservation practices within a risk framework was studied by McSweeny and Kramer (1986). Trade-offs between farm-level soil loss and nutrient (nitrogen and phosphorous) loss were also examined. Their findings suggested that cross-compliance between commodity and environmental programs would lead risk averse southern Virginia farmers to adopt improved soil and nutrient loss control practices.

This paper illustrates the importance of flexible commodity programs in integrating environmental and commodity policies for agriculture. The analysis is at the farm level and for a ban and a tax on use of corn root worm insecticide. Corn root worm is ranked as the most important corn insect pest in the Midwest (Foster et al. 1986). In crop rotations with one or more years of corn following corn, rootworm infestation is a problem requiring insecticides or other forms of control. A stylized treatment of triple-base program is used, anticipating a continuation of the flexibility trend that began in the FSA85. The results show that flexibility in commodity policy is important to the maintenance of farm income for producers that must comply with restrictive environmental policies.

The Integrated Modeling System

The integrated modeling system is a specialized version of the Comprehensive Economic Environmental Policy Evaluation System (CEEPES) (CARD and USEPA 1989) developed by the Center for Agricultural and Rural Development (CARD) and Office of Policy Analysis/USEPA. A unique feature of CEEPES is the use of biological, geophysical, and phenological process models as a system that includes their integration with economic decision and policy models. For analysis of corn rootworm insecticide regulation, and commodity program analysis, this system was specialized for farm-level decisions. The specialized version of CEEPES including policy, farm decision, and biological components is illustrated in Figure 1.

Policy Component

The policy component identifies the agricultural and environmental policy instruments and summarizes outcomes of key performance variables. The focus is on the interdependencies between the current U.S. commodity program for corn and alternative policies for regulating the use of corn rootworm insecticides. Under the FACTA 90, price and income support and stabilization for corn producers is provided through nonrecourse loans, deficiency payments, paid land diversions, and reduced acreage provisions (USHR 1990). The program parameters are set by the government prior to planting. Acreage eligible for enrollment in the program base is determined for each farm by a five-year moving average of acres planted plus set-aside under the program for corn. Given this rule, a reduction of corn acres planted and program idled in one year can reduce the base acres in the following year by one-fifth of the decrease. The base yield, used in the calculation of the deficiency payment, was frozen in the FSA85.

Two policies for limiting the use of corn rootworm insecticides were examined with the triple-base. The first was a complete ban. The second was a tax on the use (purchase) of corn rootworm insecticides levied on the producer. Flexibility in the commodity program was also examined as potentially reducing corn rootworm insecticide use. The emphasis in the analysis is on the interdependencies between commodity and environmental policies and opportunities for "win-win" or near "win-win" outcomes from more coordinated policy actions.

Biological Component

The biological component used an existing physiological process model, the Erosion Productivity Impact Calculator (EPIC) (Williams et al. 1984; Putman and Dyke 1987). EPIC is capable of simulating growth and yield for both annual and perennial plants, and can be operated in time steps by Julian day over an arbitrary number of years, permitting the simulation of crop rotations. This feature of EPIC was important for the analysis since diversified crop rotations are a way of controlling corn rootworm infestation, and the triple-base makes this practice more economically attractive. EPIC requires input data (weather, crop, tillage, and soil parameters) available from standard secondary sources.

For operating and calibrating EPIC, historical weather and actual yield data were utilized. Yields were simulated for commonly observed crop rotations. To account for corn yield reductions due to corn rootworm infestation, EPIC was modified to reflect root damage. The ranges and probabilities of damage were determined from experimental data and consultation with entomology specialists at Iowa State University (Tollefson 1989). Thus, the biological component was used to provide simulated yield distributions for the selected rotations and corn rootworm infestation levels. Actual weather data were used to estimate these distributions.

Farm-Level Decision Component

The farm-level decision component used quadratic risk programming (QRP) to model producer behavior under uncertainty. The formulation incorporating the commodity program provisions is similar to that of McSweeny and Kramer (1986). In matrix notation the standard QRP model can be represented as

$$\underset{\underline{X}}{MAX} \{\underline{C}^T \underline{X} - \alpha \underline{X}^T \Sigma \underline{X}\} \tag{1}$$

$$subject\ to\ A\ \underline{X} \leq \underline{b} \tag{2}$$

$$\underline{X} \geq 0 \tag{3}$$

where $\underline{X}$ is the vector of enterprise activity levels; $\underline{C}$ is the vector of expected net returns; Σ 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. The limitations for QRP are well known. However, the studies of Tsiang (1972), Levy and Markowitz (1979), and Meyer (1987) suggest that the mean-variance approach may closely approximate economic behavior based on a wider range of more plausible utility functions.

Representative Farm

The specialized version of CEEPES was applied to a 320 acre farm in Nashua, Iowa (Chickasaw County). Crops included in the farm level analysis were: corn (C), soybeans (S), oats (O), and alfalfa hay (L) grown in typical rotations observed in Iowa. Five crop rotations were included: 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 alfalfa hay (CSCOL); and 5) corn followed by oats followed by three years of alfalfa hay (COLLL).

Rotations with one or more years of corn following corn were assumed to be subject to rootworm infestation in the absence of application of corn rootworm insecticides. Following Foster et al. (1986), and after consulting with ISU entomologist J. 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 option to participate in the government's commodity program for corn was included. The opportunity to participate was packaged into a single activity that included mandatory paid land diversion, short-term nonrecourse loans and deficiency payments in return for idling land under the acreage reduction program. Program participation was modeled as an activity separate from the production activities, but program and production activities are linked by constraints on planted acres when program participation was selected. The constraint required corn to be grown on exactly the number of acres enrolled in the commodity program less the set-aside under the acreage reduction and paid land diversion programs. When base flexibility provisions were included, lower deficiency payments were included and the restrictions on planted acres were relaxed accordingly. Participation on every acre of program base was not required. However, less than full participation will reduce the producers commodity program base in future years. A penalty on less than full participation was used simulate the future loss of income in a static modelling framework.

Estimates of revenue uncertainty faced by producers include both yield and product price variability. Contributions to yield variability from weather and pest infestation were considered. Constraints on land and acreage base, as well as seasonal restrictions on machinery and labor, were incorporated in the farm decision model.

Model Specification, Data, and Assumptions

In this section the process models used for the analysis are reviewed and the structures required for the evaluations of the base flexibility, the ban and the tax on corn rootworm insecticide are developed.

EPIC

EPIC was calibrated to reflect farm-level yields and for simulating impacts of corn rootworm infestation. Historical daily weather data for the years 1955-87 coupled with plot level experimental data on rootworm infestations and outcomes for the years 1977-84 in Nashua on corn yield were used (Tollefson 1989). County average soybean, oat, and alfalfa hay yields for years 1977-87 were used to calibrate EPIC (Iowa Agricultural Statistics 1978-88). To the assess impacts of rootworms on corn yields, EPIC was applied to estimate yield reductions for selected levels of damage. 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).

Four rootworm infestation levels were selected using the ISU root-rating system.[1] Following Tollefson (1989), ranges of root damage with ratings (1-3, 3-4, 4-5, 5-6) were mapped into four infestation levels (None, Low, Moderate, Heavy) with annual probabilities (0.1, 0.4, 0.4, 0.1). The estimation of the discrete probability distribution for infestation levels was based on Turpin et al. (1972) and experimental data from Nashua County on observed infestations and yield reductions

(Tollefson 1989). These experimental data were used to calibrate EPIC, and to simulate corn yields for 33 years using the probabilities of infestation. Infestation levels were assumed temporally uncorrelated and independent of weather (Foster et al. 1986; Tollefson 1989).

QRP

The time series of yields from EPIC, together with the historical market prices, program parameters, and variable costs of production were used to estimate net returns per acre by production activity and alternative infestation levels. A list of the production and commodity program activities that are modeled can be found in Table 1. Recall that only corn following corn rotations were subject to rootworm damage. Estimates of net returns were:

$$RP_{ij} = \sum_{k=1}^{5} W_{jk} \, [YLD_{ijk} \, * \, MP_{ik} \, - \, VC_{ijk}] \tag{4}$$

where RP_{ij} is the net returns to production activity j in year i (dollars per acre); W_{jk} is the relative share of crop k in the total rotation $j(\sum_{k=1}^{5} W_{jk} = 1); YLD_{ijk}$ is the yield 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); and VC_{ijk} is the variable cost of crop k in rotation j in year i (dollars per acre). Expected net return for each of the production activities was approximated by taking the average over the 33 years.

Historical market prices for each crop year (1955-87) were obtained from Futrell (1988). Relevant corn program parameters for 1974-87 were from unpublished ASCS data (1989). Data on variable production costs for the crop sequences were from ISU Extension Budgets (Duffy 1987). All prices and costs were in 1987 dollars. Insecticide costs per acre were calculated using the price of Counter, the major corn rootworm insecticide in Iowa (Wintersteen and Hartzler 1987). The label rate of one pound per acre was used.

Since farmers know government program parameters before planting, the variability of net returns to enrollment derives from uncertainty about market prices and yields. Although expectations of market prices are likely conditioned upon the level of the program parameters, estimation of this relationship is beyond the scope of this farm level analysis. Following McSweeny and Kramer (1986), the variability of net returns to enrollment with certain program parameters, was approximated using the target price, loan rates, and paid land diversion payment rate for a single year (1987). These parameters were deflated and used to calculate net returns to enrollment for each year from 1974 to 1987. Acreage reduction rates were also from (or the same as) 1987.

The commodity program benefits include deficiency payments, nonrecourse loan benefits, and paid land diversion payments. Returns from the market are fully captured in the returns of the production activities and are not included in the calculation of benefits from the commodity program enrollment activities. The commodity program benefits were:

$$\begin{aligned} RE_{ij} + &\{(1-ARP-PLD) * YLD_{ij} * [MAX(LLR_i,MPC_i)-MPC_i]\} + \\ &\{(1-ARP-PLD) * [MAX(TGT_i-MAX(SAP_i,NLR_i),0)] * BYLD_{ij}\} + \\ &\{PLD * PLDP_i * BYLD_{ij}\}-(ARP + PLD) * CVC_i \end{aligned} \tag{5}$$

where RE_{ij} is the benefits received from participating in the corn program of sequence j in year i (dollars per acre of base); ARP is the 1987 set-aside required under the acreage reduction program (percent of total acres enrolled); PLD is the 1987 set-aside required under the voluntary paid land diversion program (percent of total acres enrolled); LLR_i is the 1987 local Chickasaw county loan rate for corn inflated to year i (dollars per bushel); MPC_i is the real local market price for corn in year i (dollars per bushel); TGT_i is the 1987 target price for corn inflated to year i (dollars per bushel); SAP_i is the real national season average market price used to determine the deficiency payments in year i (dollars per bushel); NLR_i is the 1987 national average loan rate for corn inflated to year i (dollars per bushel); $BYLD_{ij}$ is the base yield established by the producer in year i for crop sequence j (bushels per acre); $PLDP_i$ is the 1987 paid land diversion payment rate inflated to year i (dollars per bushel); and CVC_i is the real cost in year i of covering acres set-aside under the acreage reduction and paid land diversion programs (dollars per acre). Benefits vary by crop sequence only because yields and therefore program base yields vary by crop sequence. Expected net return to the enrollment activities was approximated by the average of all years.

Less than full participation in the commodity programs for corn means fewer acres of corn planted and, because program base is a five-year moving average of planted acres, the program base in future years will be lowered. The estimation of the distributions of lost benefits for situations in which the nonparticipation in commodity programs reduced the base required the evaluation of the variability of future losses from base acreage reduction. Producers are faced with uncertainty about which programs will be implemented and what the values of the associated parameters will be in future years. To approximate the variability in the net present value of the stream of future losses, both sources of uncertainty should be considered. In practice, however, it is difficult to predict if government commodity programs will change in future years. Thus, only the latter was estimated using the actual parameter values for 1974-87.

The net present value of annual benefits lost from a lower corn base was used to estimate the penalty for losing base. The lost benefits from an acre of established corn base was estimated as the return to an acre of corn in the program less the best nonprogram alternative:

$$\begin{aligned} BR_{ij} = {} & \{(1-ARP_i-PLD_i) * YLD_{ij} * MAX(MPC_i,LLR_i)\} + \\ & \{(1-ARP_i-PLD_i) * BYLD_{ij} * MAX[TGT_i-MAX(SAP_i,NLR_i),0]\} + \\ & \{PLD_i * PLDP_i * BYLD_{ij}\}-(ARP+PLD) * CVC_i-NBA_i \end{aligned} \tag{6}$$

where BR_{ij} is the return to an acre of corn base above that of the best nonprogram alternative for sequence j in year i (dollars per acre); and NBA_i is the return to the best nonprogram crop alternative in year i (dollars per acre). The penalty in (6) was calculated for each year as the net present value of the annual lost benefits (BR_{ij}) in the five succeeding years. The discount factor was 8 percent.

The values used to calculate the penalty reflect the current economic and political environment. Any policy changes may change the value of the penalty. Adding program base flexibility, for example, changes the stream of expected future benefits and therefore the penalty. Because the same penalty values were used in the model for evaluating each of the policies, the outcomes do not reflect the change in the penalty.

Machinery and labor requirements were subdivided into four seasons: (1) April and May, (2) June and July, (3) August and September, and (4) October and November, and were obtained from CARD/SCS budgets. Estimates of machinery and labor availability were based on typical numbers of workers and machines for a representative Iowa farm, and average number of working hours per season (Iowa Agricultural Statistics 1978-88). Constraints on the level of corn base eligible for participation in the farm program were dependent upon the assumed percentage of total acres established as base. A constraint on the amount of rootworm insecticide was also included to simulate the insecticide ban.

Using a third-degree polynomial, net returns of production, program benefits, and lost future program benefits were regressed on time to detrend the series for the production, enrollment, and penalty activities. The detrended data 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-term trend are considered random or unpredictable. The calculated variance-covariance matrix and the expected net returns for the production activities and selected enrollment and penalty activities are presented in Table 1.

Several observations can be made from Table 1. The rotations (CC) and (CCS) with insecticide applications dominate the same rotations without insecticides. Accounting for insecticide costs (\$8/acre for CC and \$2.33/acre for CCS), the expected net returns of (CC) and (CCS) with insecticides are higher by 35 percent and 7 percent than those without insecticides. Moreover, the variances of net returns for these rotations with insecticides are lower by 36 percent and 3 percent than those without insecticides. Consequently, (CC) and (CCS) without insecticides will be in the optimal QRP solution only if their insecticide using counterparts are constrained or made less profitable.

Net returns of the production and the participation activities are negatively correlated (Table 1). In general, the higher the share of corn in the rotation, the more negative the correlation. Thus, enrollment in the government program for corn leads to a reduction in risk.

The penalty activities are negatively correlated with the production activities and positively correlated with the program participation activities. This follows from the fact that higher returns to enrollment in the corn program are associated with higher opportunity costs for loss of base acres. The covariances among the program participation activities, which all included corn and were subject to the same weather conditions, were always positive. The rotations including alfalfa hay had relatively small covariances with the other rotations. They also had the lowest variances, which tended to increase their attractiveness as the level of risk aversion increased.

Empirical Findings and Policy Implications

The standard for comparison, the baseline, reflects the more inflexible corn program of the past. In the baseline, the target price was set at the 1987 level of $3.03 per bushel, while the acreage reduction rate (ARP) was 20 percent and the paid land diversion (PLD) was 10 percent. Also, 65 percent of the 350 total representative farm acres (228 acres), was assumed eligible for enrollment in the corn program. The cost of corn rootworm insecticide was $8.00 per pound of active ingredient.

To empirically investigate the role of risk aversion, nine levels of the Arrow-Pratt risk aversion coefficient, α, ranging from $\alpha = 0.0000$ (risk neutral) to $\alpha = 0.0004$ were simulated.[2] Sensitivity analyses were performed for the target price, the ARP set-aside rate and corn base acreage. Additional analyses involving the target price and ARP set-aside rate provided an opportunity to investigate the possibility of compensating producers for the insecticide ban by offering additional program benefits. Altogether, the QRP was solved 296 times.

Insecticide Ban

Figure 2 illustrates that a complete ban on rootworm insecticide application would substantially reduce the expected utility of the farmer and that the reduction would vary significantly depending on attitude toward risk. For a given constant level of expected return, the variability of returns under the ban increased relative to the baseline. This increase in variability holds for all levels of risk aversion, and is most notable at higher levels. For example, differences in expected utility between the ban and no ban with inflexible commodity programs and the ban and no ban with flexible commodity programs were 2.3 percent and 2.8 percent for a risk neutral farmer ($\alpha = 0.0$). Comparable values for a more risk averse farmer, with $\alpha = 0.0004$, are 16.7 percent and 21.7 percent (Figure 3).

The frontier in Figure 2 for the ban with the inflexible commodity program is clearly always on or above the frontier for the ban under the flexible commodity program. The position of frontiers in Figure 2 demonstrate how flexibility in the commodity programs reduced the negative impact of a corn rootworm insecticide ban. The extent of the reduction in expected utility varied from 0.5 percent for risk neutral producers to 7.7 percent for producers with the highest risk aversion coefficient (Figure 4). Clearly, the combination of inflexible commodity programs and a restrictive pesticide policy decreased producers' expected utility more than flexible commodity programs with the same policy, especially if risk aversion is high. This result suggests that increased flexibility might be tied with a ban or partial ban on the use of corn rootworm insecticides as a way of compensating farmers for associated income loss.

Producer responses to a ban under flexible and inflexible commodity programs are at least partially indicated by the changes in the mix of crops grown. The area planted to corn generally diminished and the area planted to other crops increased with the ban. And the magnitude of these changes was larger with flexible commodity programs. Corresponding to the reduction in corn acres, the change in commodity program participation fell more when the corn rootworm ban was imposed with flexible commodity programs than with inflexible programs. These outcomes would hold for all levels of risk aversion. For example, with the ban and $\alpha=0.0002$, the flexible base policy resulted in 11 percent (136 to 121 acres) fewer corn acres and about the same percentage reduction in corn enrolled in the program. This result is compared with no reduction under the inflexible commodity program.

Taxing Insecticides

In Figure 5, the E-V frontiers under a 100 percent tax with flexible and inflexible commodity programs are above the frontiers for the baseline, and flexible commodity program with no tax. But the observed change in expected utility was less than 3 percent for all levels of risk aversion. Moreover, a tax at either 50 or 100 percent was an ineffective policy instrument for reducing the use of insecticides. Likewise, the role of flexibility in the commodity program was limited in the case of the tax. With either tax level, the differences in the objective function values between flexible and inflexible commodity programs were never greater than 1.5 percent. Hence, taxes at these levels did not alter producer behavior or use of insecticides under either flexible or inflexible commodity programs. The taxes simply reduced the farmers' expected utility, a transfer of income that did not disturb allocation decisions.

Commodity Program Flexibility and Environmental Policy

To the extent that inflexibility in the commodity program for corn encourages chemically intensive corn production, flexibility may allow diversity and reduce the demand for chemicals. This outcome was not the case when the percentage of total acres and program parameters were set at the baseline levels. Figure 6 shows that the flexibility caused no change in insecticide use from the baseline. When, however, the farm was assumed to have 80 percent of the total crop land established as corn base, there was a 5 percent reduction (164 to 156 pounds) in insecticide use. In this case, the historically established base acreage available for participation (280 acres) was 3.7 percent greater than the optimal within the inflexible commodity programs (270 acres). When a target price of $2.50 per bushel was assumed, flexibility induced a 41 percent reduction (118 to 70 pounds) in insecticide use from the baseline. The available base acres for participation (228 acres) were larger than what was optimal with the lower target price and flexible commodity programs (187 acres). Thus, there are circumstances, in terms of base acres and target price, that make flexibility in the commodity programs effective in reducing the use of corn rootworm insecticides. Generally, the lower the target price and the higher the rate of base to total acres, the more effective flexibility options were in reducing rootworm insecticide use.

In addition to the potentially positive environmental impacts of the flexible base, the policy also relaxes a potentially significant constraint on producer decisions. Hence, increases in both producer expected utility and adjustments in the crop mix are likely.

Percentage changes in the optimal value of the objective function induced by a flexible base are summarized in Figure 4 across selected levels of risk aversion for baseline levels of program parameters and in Figure 7 for selected levels of program parameters at one level of risk aversion. It can be seen that base flexibility always left unchanged or increased the objective function value. Generally, the negative impact of the inflexibility on the farmer's expected utility increased with the risk aversion coefficient. For baseline levels of program parameters without a ban, there was no increase of expected utility except at the highest level of risk aversion where a 1.2 percent increase is observed. In Figure 7 positive differences of .2 and 2 percent are shown when 80 percent of cropland is assumed to be the established base and when the target prices is set to $2.50 per bushel. In general, flexibility had more of an impact on the objective function value when a higher percentage of cropland is established as base, the target price is lower and the ARP rate is higher. These results are also illustrated in Figures 2 and 8, which show the E-V frontiers for the inflexible commodity program situations overlay or are positioned above the frontiers with flexible commodity programs for the alternatives.

The gaps between the E-V frontiers under the inflexible and flexible commodity program alternatives increased with the level of risk aversion. In addition, the gaps, given the ban, were larger than when no ban was imposed. Comparisons of Figures 2 and 8 show that base flexibility increased producer expected utility more as the percent of total acres eligible for participation increased, especially under the ban. Flexible commodity programs were favorable with a relatively high levels of established base. When the target price was reduced to $2.50 per bushel, compared with the baseline of $3.03, the impact of flexible commodity programs for on expected utility also increased. A similar comparison between the baseline results and the lower ARP set-aside rate showed that the impact of flexibility was minimal.

Sensitivity of Results to Program Parameters

Comparison of Figures 2 and 8 demonstrates the interaction between commodity programs for different assumptions on the level of program base acres and corn rootworm policies. What is important for impacts of flexibility is not so much the absolute percentage of total cropland in the base, but the percentage relative to corn acreage the farmer would produce, given current circumstances. The level of established base may differ from the optimum with commodity program flexibility, because the base is established historically under a nonflexible program. In Figure 2, the frontier for the ban with the inflexible commodity program lies to the left and above the frontier for the ban with the flexible commodity program at most levels of risk aversion. The estimated reduction in expected utility from the ban was even greater with inflexible commodity programs than with flexible programs when 80 percent of cropland was corn base (Figure 8). The divergence is widest for producers with higher risk aversion.

As expected, the results demonstrate that insecticide applications followed corn acreage closely. As the returns to the commodity program increased and more corn was grown, more rotations with corn following corn (CC and CCS) were employed. The higher the level of base acres, the larger were the quantities of insecticides applied. With 50, 65, and 80 percent of total acres in the corn base, 65, 118, and 164 pounds of active ingredient were applied with inflexible commodity programs. These changes in the quantities of insecticides applied resulted from changes in acres treated at a constant rate.

As the target price was lowered from of $3.03 to $2.50 per bushel, area planted in corn under the flexible commodity program decreased from 148 to 121 acres, resulting in a decrease of insecticide applications from 118 to 70 pounds of active ingredient. The opposite was observed for the lower ARP or set-aside. As ARP was lowered from 20 to 10 percent, area planted to corn and the quantities of insecticides applied increased from 148 to 171 acres and from 118 to 140 pounds.

The sensitivity of impacts of the corn rootworm insecticide ban for expected utility given changes in base acres, target price, and ARP or set-aside was also examined. As expected, it was found that the greater the opportunity to take advantage of the commodity program (larger base), the greater the benefit of participating (higher target price), and the lower the costs of participating (lower ARP set-aside), the greater the adverse impact of the insecticide ban for farmer expected utility. The importance of corn base acreage is easily demonstrated. For $\alpha = 0.0002$, the impact of an insecticide ban on certainty equivalent farm income varied from 6.3 percent with 50 percent of the total acres as base, in both inflexible and flexible commodity program alternatives, to 20 percent and 12.8 percent with inflexible and flexible commodity programs and an 80 percent corn base. Comparisons of Figures 2 and 8 also demonstrates that the higher the base-to-total-acres ratio, the greater the impact of the insecticide ban on expected utility. The farmers with a higher share of base acres were penalized most, especially when commodity programs are inflexible.

The relationship of the target price to the ban and expected utility of farmers can be demonstrated by comparing the baseline ($3.03) to the lower target price ($2.50). For $\alpha = 0.0002$, the 5.1 and 9.9 percent reductions for the ban compared with no ban under the lower target price for the flexible and inflexible commodity program alternatives, are significantly smaller than the 11.8 and 15.1 percent reductions for the baseline. Increasing target prices increased expected utility at a slower rate when a ban is imposed compared to the baseline (Figure 9). A similar comparison between the baseline and assumed lower ARP rates showed that adverse impacts of the ban on expected utility decreased with the level of ARP. As the ARP set-aside requirement increased, expected utility declined at a slower rate when a ban was imposed compared to the baseline (Figure 10).

Comparisons of the total area planted for corn, the amount of insecticide applied, the expected utility under the baseline, and elimination of the program yielded notable results. When the commodity program was eliminated altogether, the total of corn acreage decreased further and the area planted to other crops increased. The percentage decrease in the area of corn grown from the baseline (148 acres) to no program (116 acres) was 22 percent. Similarly, the percentage reduction in the total amount of insecticides applied from the baseline to the no-program alternative was more than 70 percent (118 to 35 pounds). These results provide firm support for the argument that the government corn program encourages continuous cropping and use of rootworm insecticides. Note, however, that the variability of net returns increased sharply in the absence of the program (Figure 11). Similar to Musser and Stamoulis (1981), program participation dominated nonparticipation.

Conclusions

This analysis has shown a number of opportunities for coordinating commodity and environmental policy. Base flexibility relaxes a constraint for producer behavior and increases expected utility, especially with an insecticide ban. The policy implication is that increased base flexibility can be tied to a ban or a partial ban on corn rootworm insecticides as a way of compensating farmers for associated income loss. In this capacity, base flexibility is more beneficial to risk averse producers, and to producers with high corn base to the acreage ratio. The target price also can be increased to compensate farmers for an insecticide ban. Values of the target price and ARP that leave farmers equally well off with a corn rootworm insecticide ban can be determined easily.

The greater the opportunity to take advantage of the commodity program (larger established base), the greater the benefits of participating (higher target price) and the lower the cost of participating (lower ARP set-aside), the larger the quantities of insecticides applied. Because opportunities to use lower chemical application rates were not modeled, the amount of insecticide applied followed closely the acreage planted to corn. Flexibility reduced the use of corn rootworm insecticides. The impact was less noticeable with high base, high target prices, and a low ARP. If the government's commodity programs for corn were eliminated, insecticide use and corn acreage on the representative farm would drop significantly.

Attitude toward risk was a key variable influencing policy outcomes. Risk averse producers seem to benefit substantially more from higher commodity program benefits. These differences are of such magnitude that they should be considered in fashioning corn programs that encourage environmental restrictions, such as the flexibility target price ARP ban trade-off suggested above.

Clearly, there are opportunities for modifying the use of pesticide chemicals through the government's commodity programs. These opportunities will likely arise during the debate over the 1995 Farm Bill. The outcomes of this analysis suggest that exploring the interrelationships between U.S. government commodity programs and environmental policies and outcomes will be tremendously rewarding. The results presented here are for the farm level. Broader implications for commodity prices and other feedbacks to producer decisions are extensions of this work, and as foundations for a more solid basis for designing commodity programs to meet environmental, income, and stability targets for the U.S. agricultural sector.

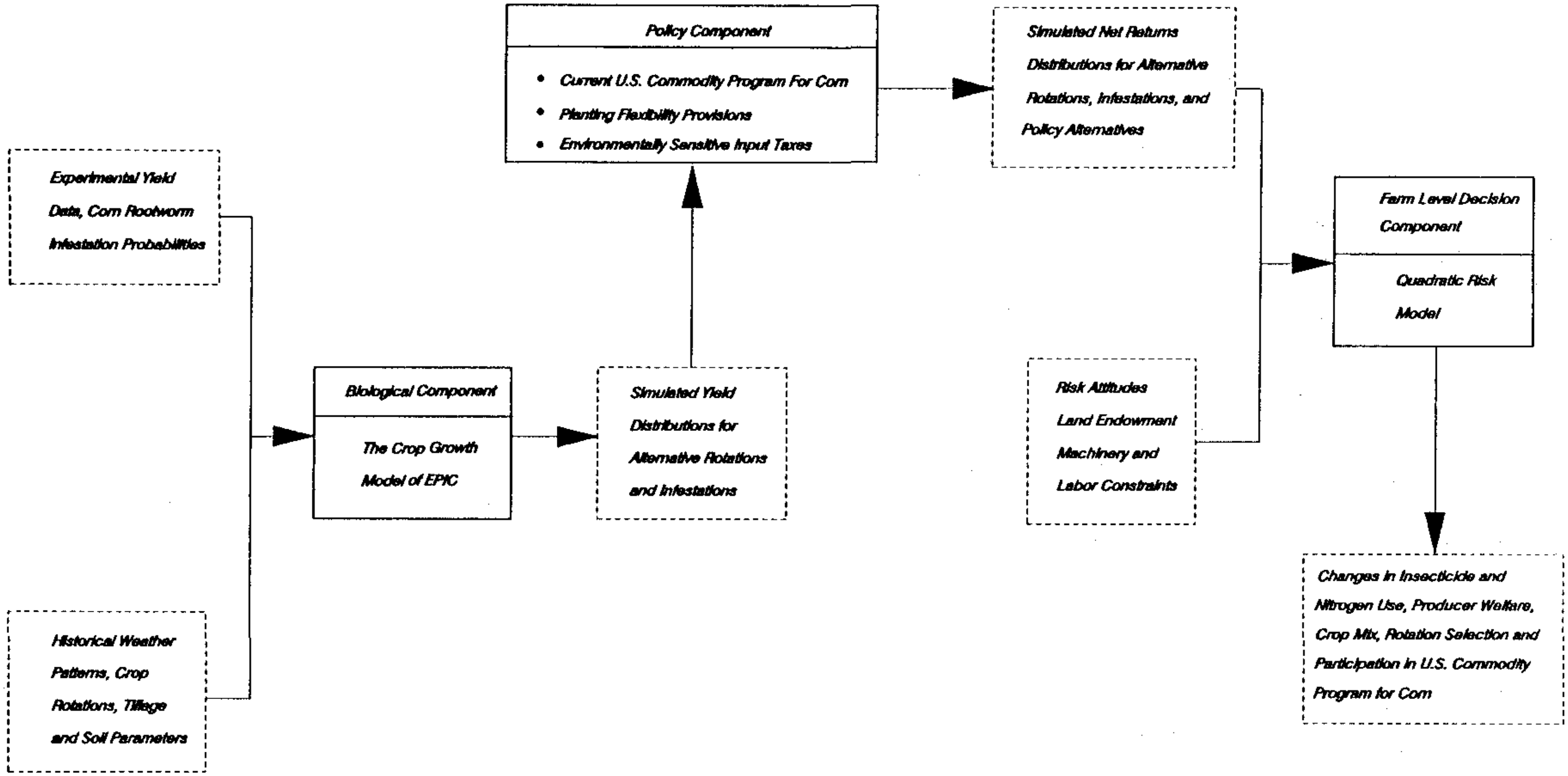


Figure 1. Representative Farm Simulation Model

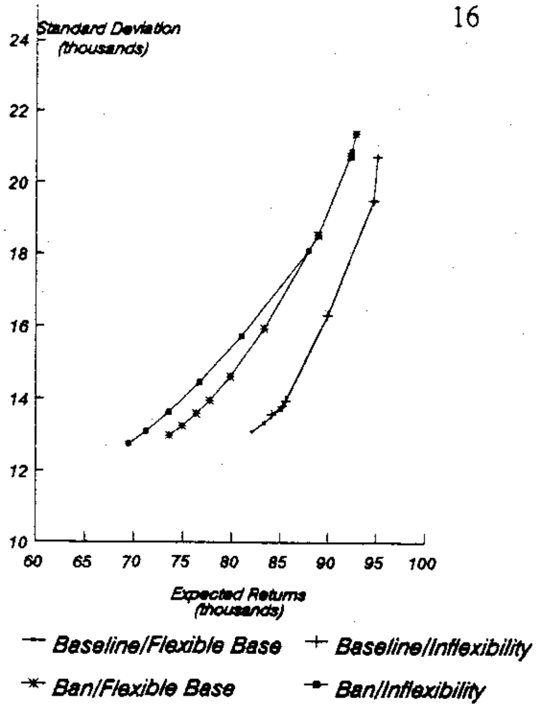


Figure 2. Comparison of E-V Frontiers: Baseline to Ban, with Flexible and Inflexible Commodity Programs

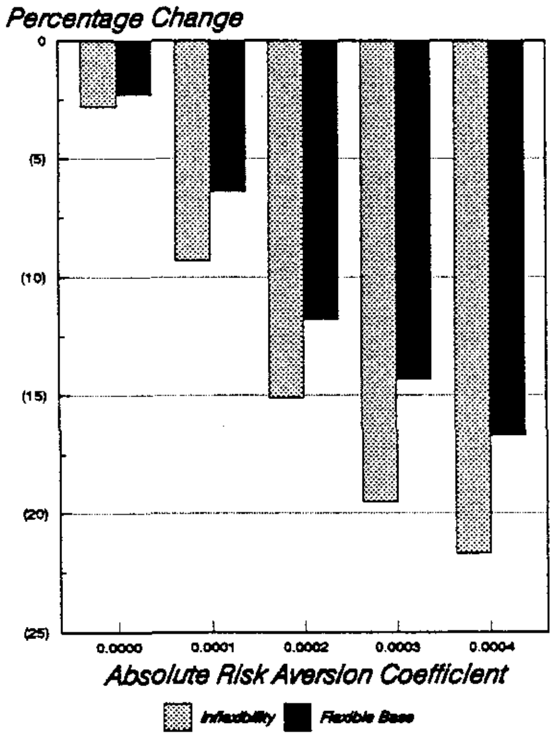


Figure 3. Percentage Change in Objective Function Value Induced by Ban on Corn Rootworm Insecticide

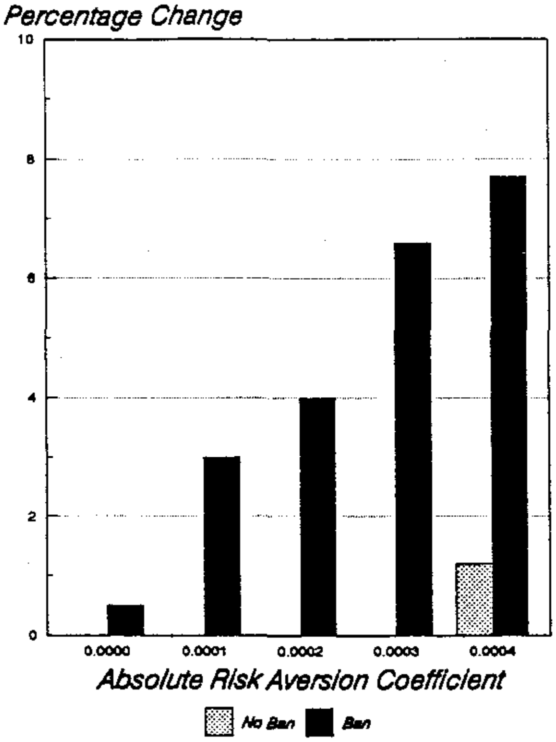


Figure 4. Percentage Change in Objective Function Value Induced by Introduction of Flexible Commodity Program

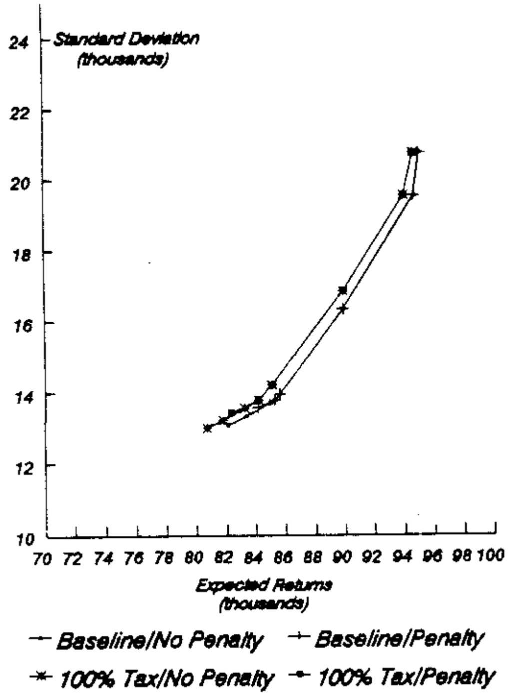
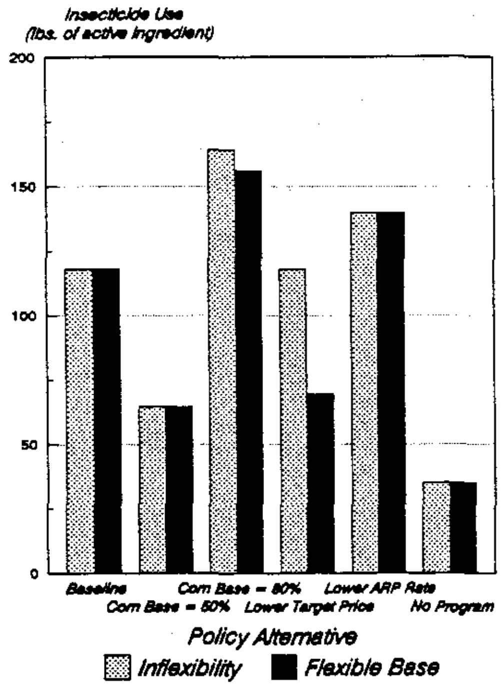
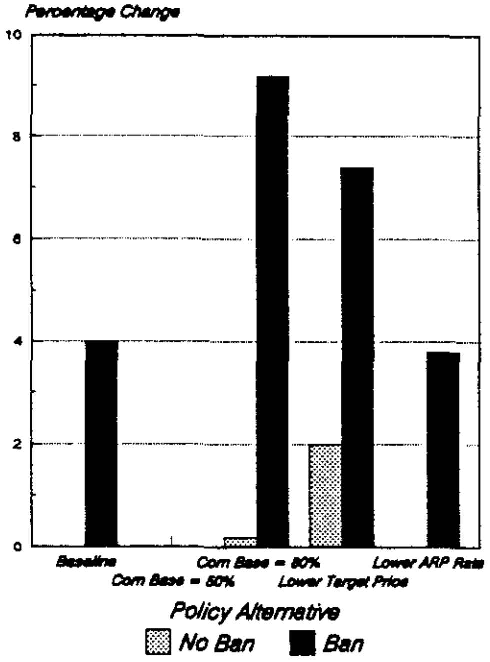


Figure 5. Comparison of E-V Frontiers: Baseline to 100 percent tax, with Flexible and Inflexible Commodity Programs



Absolute Risk Aversion Coefficient = 0.0002

Figure 6. Insecticide Usage with Flexible and Inflexible Commodity Programs for Selected Alternatives



Absolute Risk Aversion Coefficient = 0.0002

Figure 7. Percentage Change in Objective Function Value Induced by Introduction of Flexible Commodity Programs for Selected Alternatives

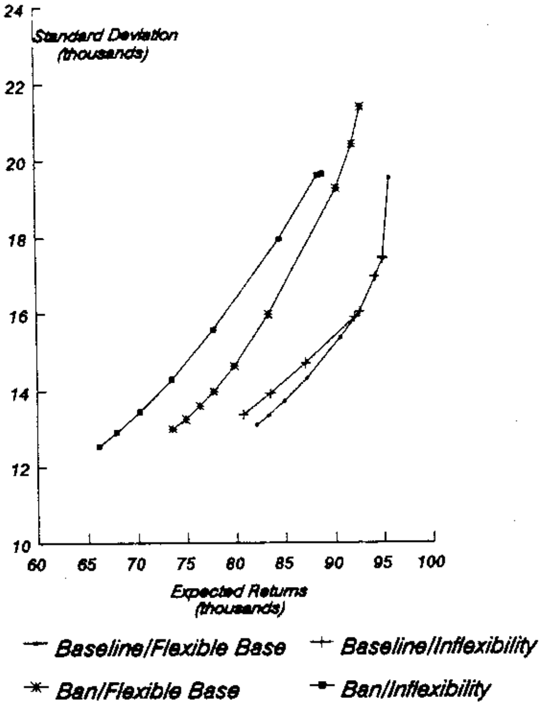


Figure 8. Comparison of E-V Frontiers: Baseline to 80 percent Base Assumed to Ban, with Flexible and Inflexible Commodity Programs

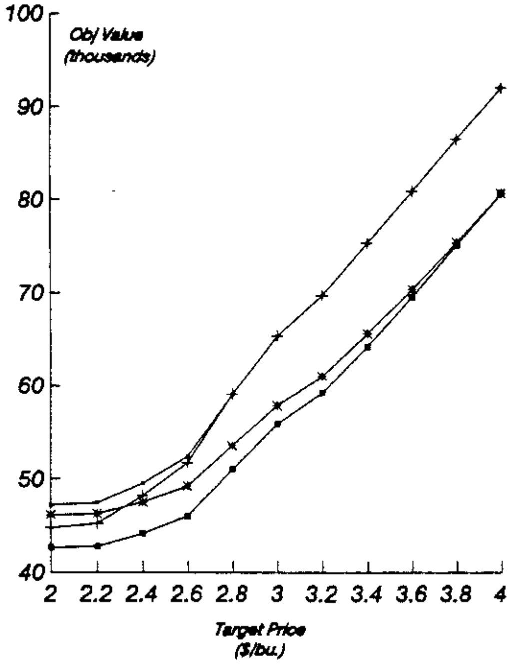


Figure 9. Objective Function Values for Baseline and Ban at Alternative Target Prices

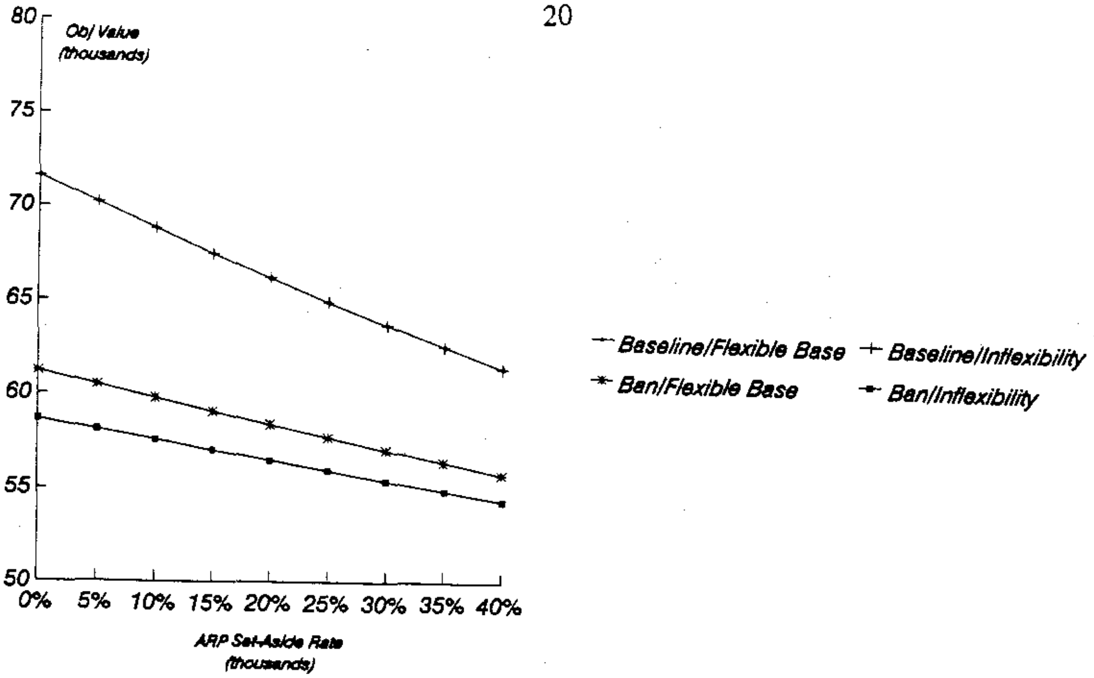


Figure 10. Objective Function Values for Baseline and Ban at Alternative ARP Set-Aside Rates

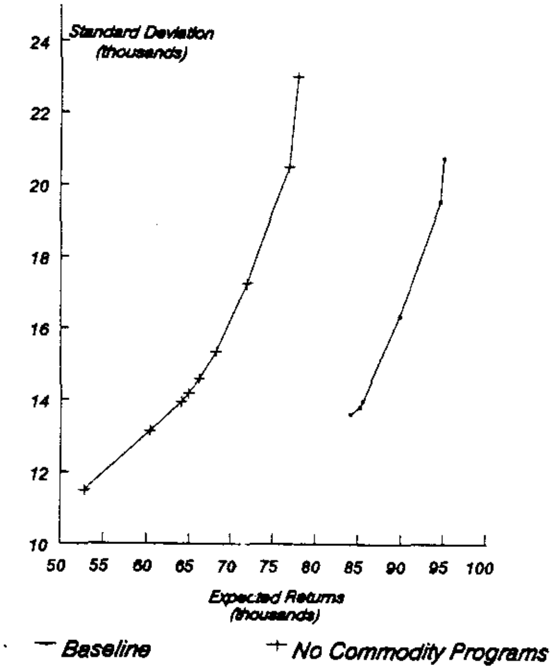


Figure 11. Comparison of E-V Frontiers: Baseline to No Program

Table 1. Variance-Covariance Matrix and Expected Net Returns for the Baseline

						Activity					
Activity #	1	2	3	4	5	6	7	8	9	10	11
Variance - Covariance											
	CC NO INF	CC INF	CCS NO INF	CCS INF	CS	CSOLL	COLLL	PROGRAM C FL S	PROGRAM C FL C NO INF	PENALTY C FL S	PENALTY C FL C NO INF
1	772										
2	8281	12154									
3	6433	6744	5829	6137							
4	6317	7730	5829	6137							
5	5895	6119	5749	5653	5811						
6	3665	3492	3519	3372	3547	2396					
7	1031	588	1262	1171	1422	1304	1530				
8	-1675	-2036	-1011	-1078	-700	-446	-17	1481			
9	-1681	-2039	-1014	-1080	-701	-448	-19	1486	1491		
10	-195	-42	-199	-194	-288	-216	-220	59	59	155	
11	-265	-284	-239	-272	-285	-208	-169	118	118	100	75
Expected Returns ($/Acre)											
	250.48	179.69	246.51	227.12	234.71	179.12	169.54	153.10	152.94	-76.68	-45.09

INF = Subject to insect infestation
FL = Following

C = Corn
S = Soybeans

O = Oats
L = Legume hay

ENDNOTES

1. Iowa State University has developed a root damage rating scale from 1 to 6 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. Due to seasonal constraints on labor and machinery, levels of $\alpha > 0.0004$ resulted in idled acreage beyond that required for government program enrollment. Since cropland is typically fully utilized in the study area, solutions for higher levels of α were not considered.

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