An Economic and Environmental Evaluation of Farm Bill Policy Options Using the CEEPES-FAPRI Modeling System

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AN ECONOMIC AND ENVIRONMENTAL EVALUATION OF FARM BILL POLICY OPTIONS USING THE CEEPES-FAPRI MODELING SYSTEM

Congress is considering significant changes to current farm programs. Long-term trends that are driving change include increased trade opportunities with GATT, a continued decline in rural population, increased budgetary (fiscal) pressure, and growing environmental concerns over agricultural nonpoint source pollution. These issues are the primary reasons given for changing the programs. Problems with current commodity programs are also giving impetus to those who want to see change: they are costly, they encourage production of program crops, they disproportionately benefit large farms, they discourage crop rotation, they often do not provide farm income support during bad years when the support is most needed, and they reduce the share of U.S. cropland on which planting decisions are based on market signals. Lower budget costs, improved efficiency, increased planting flexibility, and continued farmer adoption of environmentally-friendly production practices are some of the objectives Congress is trying to achieve as it considers the 1995 Farm Bill.

Every five years, Congress adjusts farm policy and tries to undo some of its mistakes. One mistake that led to large increases in the cost of programs was tying program payments to actual yields and tying the payment rate to inflation. The policy trigger to reduce commodity payments started with the 1985 Food Security Act (1985 FSA). The 1985 FSA reduced the number of bushels per acre on which payments are based by shifting from actual yields to fixed program yields, and the 1990 Food, Agriculture, Conservation, and Trade Act (1990 FACTA) reduced the number of acres eligible to receive payments. The 1990 FACTA introduced the Normal Flex Acreage (NFA) program where producers do not receive deficiency payments on 15 percent of their program base acreage and were allowed to plant any other eligible crop. Besides the 15 percent NFA, producers can flex an additional 10 percent (Optional Flex) of their base into other eligible crops and give up the deficiency payments on those acres.

While the commodity title of the 1985 FSA aimed to reduce government outlays, the conservation title emphasized programs that encouraged soil conservation practices. The Conservation Reserve Program (CRP) and Conservation Compliance were the two major conservation titles introduced in that bill. Concerned by increased water quality problems from agriculture, the 1990 FACTA enlarged the scope of conserving practices to include water and wildlife habitat resources. The CRP, Conservation Compliance, and the conservation focus of the Normal and Optional Flex programs produced large gains in environmental quality. In particular, these programs resulted in an annual net saving of about 980 million tons of soil from reduced water and wind erosion (Kellogg, TeSelle, and Goebel 1994). Adoption of soil conserving technologies such as conservation tillage, strip cropping, terracing, and contouring increased during this time. There is evidence that conservation tillage sequesters soil organic carbon and helps reduce global warming potential (Lal et al. 1995).

The multiple objectives of farm policy make it imperative to conduct ex ante evaluations of the impact of alternative policies on both the economic welfare of producers and consumers and the environment. Congress often relies on estimates from FAPRI (Food and Agricultural Policy Research Institute) for guidance on the economic impacts of alternative policies. But Congress has no place to turn for comprehensive environmental analysis because of the inherent difficulties with estimating the environmental impacts from agriculture. But advancements in science and computer technology and the availability of site-specific data—for example, the 1992 National Resources Inventory (1992 NRI)—have made it possible to construct mathematical modeling systems to predict environmental consequences of alternative production systems.

CEEPES (Comprehensive Economic and Environmental Policy Evaluation System) is the state-of-the-art economic-environmental modeling system developed at the Center for Agricultural and Rural Development (CARD), Iowa State University. CEEPES integrates a watershed-level linear programming model of agricultural decision making with site-specific environmental process models to allocate resources, select profit-maximizing production systems, and predict site-specific impacts of those systems and resource use levels.

Reseachers at CARD have successfully linked the supply component of the FAPRI modeling system with the environmental prediction component of CEEPES. FAPRI forecasts crop acreage response and program participation under alternative policy options at the macro level (cost of production regions). Given the FAPRI estimates, profit-maximizing crop rotations and tillage systems are estimated using linear programming techniques for each watershed in the CEEPES study region. Specifically, the environmental baseline counterpart to the FAPRI baseline is obtained by disaggregating regional FAPRI estimates into state-level projections, which, in turn, will be further disaggregated into projections for the CEEPES watersheds. CEEPES then analyzes the environmental impacts of the profit-maximizing production systems within each watershed. The results are spatially disaggregated predictions of environmental impacts of alternative farm programs.

This report estimates the economic and environmental trade-offs of the 1995 Farm Bill policy options evaluated by FAPRI. Specifically, we evaluate the 1995 FAPRI baseline, 25 percent Normal Flex, and the Revenue Assurance program. We describe the modeling systems and the CEEPES-FAPRI linkage, describe the policy options and their likely economic and environmental impacts, and discuss predicted economic and environmental impacts of these policy options.

Modeling Systems and the Study Area

The FAPRI System

FAPRI is a large-scale econometric model of the U.S. and world agricultural sectors. The FAPRI system comprises domestic crop and livestock models, world trade model for grains and oil seeds, and satellite models that determine net farm income and the government cost of agricultural programs (Westhoff et al. 1990). There is perfect feedback from each of these models to one another on an iterative basis. Each of the FAPRI models is conditioned by assumptions about the general economy, agricultural policy, weather, and a number of other exogenous factors. FAPRI projects several economic indicators for the seven program crops (barley, corn, cotton, sorghum, oats, wheat, and rice), soybeans, and hay. These indicators are farm price, loan rate, target price, base acres, flex and ARP acres, acres planted, and program participation rates. Projections of these indicators are given by FAPRI at national or multistate regional levels.

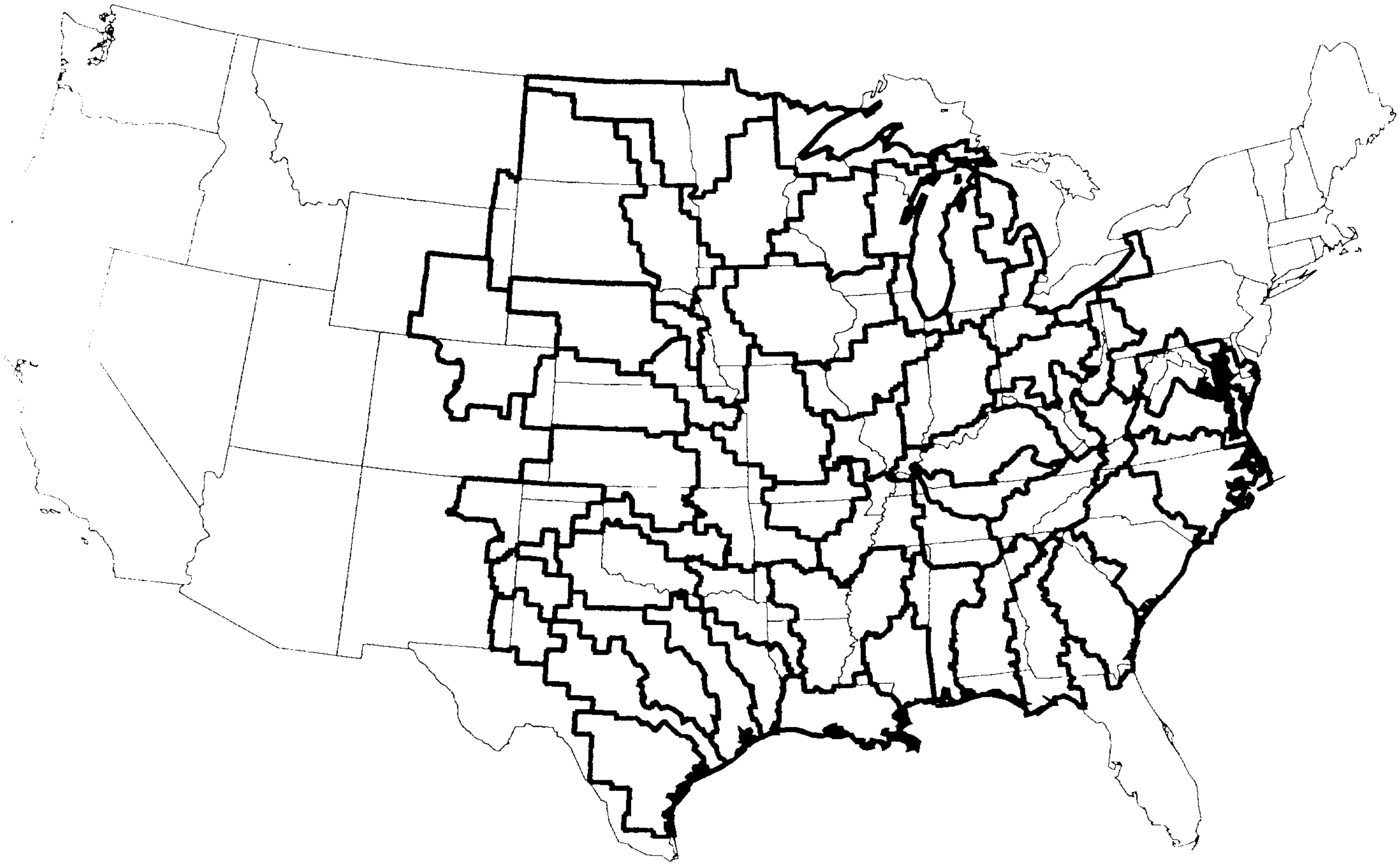
The CEEPES System

The CEEPES integrated modeling system consists of four major components: (1) an agricultural decision component, (2) an environmental fate component, (3) a policy component, and (4) a component for evaluating economic-environmental trade-offs. The agricultural decision component, which is the core of the CEEPES system, is a linear programing model that allocates resources to maximize short-run profits. This model is called the Resource Adjustment Modeling System (RAMS). RAMS is configured at the watershed level (Producing Area [PA]). Geographically defined PAs are the basic production units. PAs are hydrological unit areas defined by the Water Resources Council (WRC 1970). For this evaluation RAMS is configured for 57 PAs covering seven out of ten major USDA farm production regions. Figure 1 presents the boundaries of the watersheds that define the study area. This study area represents more than 90 percent of corn, sorghum, soybeans, and oats acreage and more than 80 percent of wheat and cotton acreage (Figure 2).

The environmental component consists of two major field-scale physical process models, the Erosion Productivity Impact Calculator (EPIC)/Water Quality Model and the Pesticide Root Zone Model (PRZM). The EPIC-Water Quality model is used to simulate the irrigation, tillage, conservation, and fertilizer management impacts on crop yield, nutrient runoff and percolation, wind erosion, sheet and rill erosion, and soil organic carbon for selected crop rotation practices. See Lakshminarayan et al. (1995) for a complete description of EPIC-Water Quality model simulation experiment. PRZM was used to simulate herbicide runoff and leaching potential. See Bouzaher et al. (1993) for a description of this methodology.

The RAMS System

We developed RAMS to determine optimal patterns of resource use and production practices, following traditional regional models (Taylor and Frohberg 1977; Burton and Martin 1987). However, we also incorporated a detailed weed control subsector linked to crop production through herbicide management practices, productivity response, and chemical cost. For this purpose, we use a novel approach to quantify the relationship between herbicide effectiveness (as determined mainly by target weed groups, weather patterns, and soil type) and crop yield response (Bouzaher et al. 1992). RAMS is constructed to interface with the fate and transport component of CEEPES and to incorporate a wide range of chemical policy and nutrient options. As such, RAMS takes a big step toward linking economic and environmental objectives. Finally, RAMS also includes a government subsector that incorporates the major rules and provisions of commodity programs and Conservation Compliance.



CEEPES Project Production Areas

0 200 400 MILES

0 200 400 KILOMETERS

Figure 1. Study Area

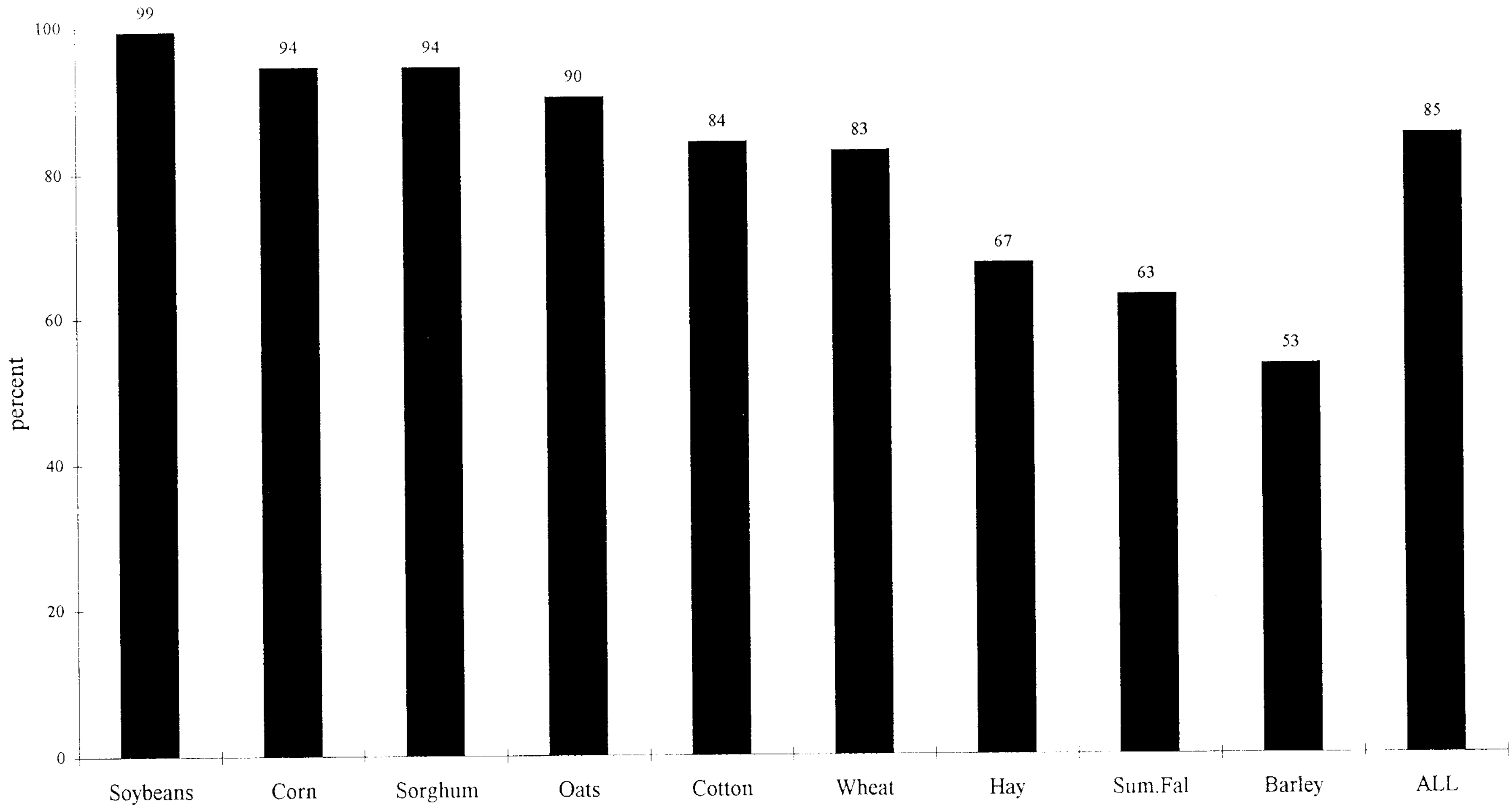


Figure 2. Crop coverage in the CEEPES study region

Within a PA we adopt a unique land-group definition representing aggregated Major Land Resource Areas (MLRAs). In addition, an MLRA is aggregated over major land groups defined from USDA land capability classes and subclasses. This aggregation process is carried through and reflected in the technological coefficients of RAMS, most importantly in the yield effects of weed control alternatives. We maintain a distinction between highly erodible and nonhighly erodible land, however, for purposes of modeling Conservation Compliance.

Theoretical Background and Key Assumptions in RAMS. The risk-neutral producer is assumed to operate a competitive multiproduct farm and select input and output levels to maximize profits. Both input and output prices are exogenous (i.e., the producer is a price taker). The input and output data in RAMS are assumed to be averages of a large number of relatively homogeneous farm firms, so that production and resource use are aggregated over a geographically homogeneous area.

We assume the farm produces both positive output (crops) and negative output (pollutants). The pollution process defines the "ultimate" ecological state having economic impact. The damage function to evaluate the economic impact of the pollutant is currently assumed to be exogenous to the firm.

RAMS is partially deterministic in that producers face a riskless market condition. However, weather uncertainty has a major influence on field-day availability, herbicide effectiveness, and crop productivity. Resolution of weather uncertainty is achieved by invoking a certainty equivalent criterion (Arrow 1965).

Finally, note that RAMS is susceptible to problems of aggregation bias. Aggregation bias exists when the microeconomic foundation of the RAMS model is transformed into aggregate market behavior. Since the data necessary for RAMS are mainly available only for aggregated producers, there is the potential bias for using microtheory to predict aggregate response. Given that aggregation bias is a common problem with regional modeling systems, our goal is to design RAMS to minimize this bias.

The activities defined in RAMS can be grouped into three major subsector groups.

The Crop Production Subsector. Activities are defined as acres of crop rotations, either dry or irrigated, on highly or nonhighly erodible land,[1] and under one of 16 combined tillage and conservation practices. We assume these activities represent current practices under full weed control; hence they are associated with base yields and production cost, derived from currently observed production data.

The Government Programs Subsector. All government program activities are defined in close relationship with the production subsector and are briefly summarized here.
For each PA, we distinguish these activities:

- A single conservation reserve activity with an associated average rental rate and Conservation Compliance on highly erodible lands

- Deficiency payment activities (and associated returns to participation) defined for each program crop and for both highly erodible and nonhighly erodible land

- Base loss penalty activities for each program crop, reflecting deviation from urrently maintained program bases

The Weed Control Subsector. This subsector includes two groups of activities:

- Herbicide activities represent acres of treated corn and sorghum under one of the alternative herbicide strategies. These activities are defined by tillage practice and are linked to production activities through restriction on adopted tillage and carryover effect on crops in rotation with corn and sorghum.

- Chemical activities represent amounts of individual chemicals (i.e., pounds of active ingredient) used in the different herbicide strategies. These activities are used for accounting for total chemical use, a main link to the fate and transport component of CEEPES; weighing individual chemical use to conform to current practices and minimize the lack of diversification introduced by LP solutions; and policy restriction modeling.

Constraints. The three subsectors previously described are interrelated through the use of resources and other restrictions that define the constraint set of RAMS. We distinguish three

[1] Note that in the current formulation, a distinction is made between highly and nonhighly erodible land activities for conservation compliance modeling purposes. However, it should be understood that the two sets of activities are mutually exclusive and form a complete partition of the set of rotation activities under all combinations of conservation, tillage, and irrigation practices.

types of constraints—physical constraints, transfer-row constraints, and flexibility constraints. Physical constraints impose restrictions on availability of total land, highly erodible land, CRP land retirement program, commodity program base acreage, surface water, and irrigation requirements. Transfer-row constraints are used for accounting purposes, between production and selling activities, between herbicide and chemical activities, and to account for labor, water, and fertilizer inputs. Flexibility constraints are used for calibration purposes. Given the well-known, highly specialized nature of linear programming solutions, the model is forced to conform to some minimum level of observed practices (as per 1992 NRI) for irrigation, contour crop, conventional tillage activities.

Performance Criterion. As we have described, RAMS is built to determine short-term regional agricultural economic performance under various policies. Therefore, its objective function measures short-run total net profit, which is equal to the difference between total returns from the government programs and the marketing subsectors and the total costs from the production, weed control, and buy inputs subsectors.

Mechanics of the FAPRI-CEEPES Linkage

The FAPRI modeling system provides national and regional market simulations of agricultural policy and decision variables for major crops. For these results to be useful in the CEEPES framework, they must be systematically disaggregated from the national or regional level to the watershed level. For most crops, this is accomplished in two stages. In the first stage, the FAPRI results for a particular region are broken down into estimates for each state within that region using econometrically estimated equations. For most variables, these equations are designed to capture the different responses producers in each state have to policy and market variables that may change from one scenario to another. For prices and loan rates, state estimates are based solely on national prices and loan rates. The regression parameters estimated over the historical data set are employed in combination with FAPRI projection data to form state-level estimates. In the second stage, these state-level estimates are disaggregated into estimates for each watershed within a state's borders using fixed, crop-specific shares.

Because sufficient time series data for these indicators do not exist at the watershed level, the final disaggregation from state to watershed must be accomplished using crop-specific fixed weights determined from the 1992 NRI database using the three-year (1990-92) average. It is hypothesized that, while each state's share of a region's production may change from scenario to scenario, the relationship between a given watershed and the states contributing to it will not substantially change due to the relative homogeneity of cropping patterns within watersheds. This is especially true when a watershed covers a large portion of a given state, as in the case of PA 41 in Iowa.

Finally, the RAMS LP model selected the profit-maximizing crop rotations, tillage practices and conservation practices for each PA for the years 1995 and 2004. The disaggregated FAPRI projections on planted acres and program base acres for 1995 and 2004 were treated as exogenous right-hand side variables by RAMS. Also taken from FAPRI were output prices, loan rates, ARP and participation rates. FAPRI's assumptions concerning annual productivity and cost increases were used to adjust RAMS yield and cost parameters. Thus a quasi-dynamic analysis was performed with the linked CEEPES-FAPRI system. Even though the yield and cost parameters in RAMS were adjusted for annual trend to be consistent with FAPRI's assumption, adoption of enviromentally friendly production systems were not adjusted for trend increases. Rather we let the RAMS model determine the levels of alternative production systems. The final output from RAMS under each policy option is the number of acres planted to corn, wheat, soybeans, sorghum, and hay for each PA by crop rotation, tillage, irrigation and conservation practice.

Policy Options

FAPRI, in consultation with congressional staff and other agency staff, evaluated the following policies: the 1995 Baseline, 20 and 25 percent NFA, Revenue Assurance, No-program, and a Marketing Loans program. This report summarizes CEEPES analysis of three FAPRI policy options—the 1995 FAPRI Baseline, 25 percent NFA, and Revenue Assurance. Baseline is considered as one of the policy options because it reflects a status quo scenario to compare alternative options including assumptions on fiscal programs that expire during the 1995 Farm Bill period.

The 1995 FAPRI Baseline

The FAPRI baseline represents continuation of all current programs and policies for the next 10 years. If these policies or programs contain provisions for annual change, then such changes are incorporated in the baseline. For example the ARP is assumed to continue. Furthermore, the FAPRI baseline embodies CBO (Congressional Budget Office) assumptions on fiscal programs that expire during the 1995 Farm Bill period. Adequate steps have been taken to calibrate the baseline to prevailing conditions and rules so that options can be evaluated against this baseline. The assumptions incorporated in the baseline are:

- Continuation of current policies in the United States and the other countries.

- WEFA (Wharton Econometric Foundation) projections on the growth of the domestic economy.

- Continuation of ARP, with the ARP rate for corn projected to be 5 percent through 1999-2000, falling to 2.5 percent in 2001 and 2002, and to zero percent thereafter. The ARP rates for sorghum, barley, and oats are set at zero percent. For cotton the ARP rate was set at zero percent for 1996-97 and raised to 10 percent for subsequent years.

- CBO rules on CRP, which include funding slightly over 17 million acres of CRP. CRP acres that came out of corn base and soybean acreage were renewed at 75 percent, cotton base CRP acres were renewed at 60 percent, sorghum and wheat base CRP acres were renewed at 40 to 45 percent, barley base CRP acres were renewed at 30 percent, and oat and rice base CRP acres were not renewed. Note that the LP model in CEEPES groups the total cropland into seven erodibility classes according to the erodibility index (EI). The acres of highly erodible land were adjusted to reflect the amount of CRP land coming back into production under these seven classes by using the 1992 NRI database.

Lower ARP rates and nonrenewal of 50 percent of CRP contracts is likely to increase total crop acreage. Feed grain acreage, corn, sorghum, barley, and oats should increase and stabilize by 2003. Assumptions on CRP acreage, combined with zero ARP rates for wheat, should increase wheat acreage significantly. Increased planting in the short term should depress feed and food grain prices and keep government costs higher. Over the long term, as acreage levels moderate and prices recover, government costs should decline. Soybean should continue to gain acreage because of the current NFA rate of 15 percent. Cotton acreage is expected to increase and to be supported initially by higher prices and zero ARP.

Increases in corn, sorghum, soybean, and cotton acreage are likely to increase soil erosion. But Conservation Compliance on highly erodible land (HEL) should offset such increases by increasing conservation tillage and other conservation practices. Chemical use should generally increase, but the producers who are likely to use the current planting flexibility option to its full extent to minimize market risk should result in more crop rotation, which will provide offsetting force to reduce chemical use.

25 Percent Normal Flex

Historically, the federal government used three key policy instruments to control program costs: (1) reduce the deficiency payment rate by setting a lower target price, (2) reduce program payment yields, and (3) reduce acres eligible for program payments. The NFA and OFA policy option is designed to provide the government with the third policy tool. Besides limiting payment acres, it enhances planting flexibility to the producers and allows a greater role for market signals to guide planting decisions.

These assumptions are incorporated in simulating the 25 percent NFA option:

- Increase NFA rate to 25 percent from the current 15 percent.
- OFA will remain at 10 percent. However, it is assumed that only half will be used by producers.
- The assumption on CRP is similar to the baseline.

By combining NFA and OFA, producers have 35 percent flexibility under this policy option. Increased planting flexibility should increase soybean acreage in line with past and current trends. Corn and wheat acreage should flex into soybeans. Increased soybean acreage may increase soil erosion because soybeans are more erosive than corn or wheat.

Revenue Assurance

Revenue assurance has been proposed as an alternative to current commodity programs by a group of Iowa farmers who believe current programs are an inefficient means of helping agriculture. Under this option, farmers would be guaranteed that their gross revenue would not fall below a certain percentage of normal revenue. Thus, payments would be received when they are needed most: when farmers are in financial stress.

The following assumptions were incorporated in simulating this policy option:

- Income support is provided to producers when crop revenue is less than 70 percent of normal crop revenue.

- The crops covered under this program include all major program crops and soybeans. Forage crops are excluded.

- Normal gross revenue is calculated on a five-year moving average of the product of county prices and an individual producer's yield.

- Transition payments would start at 80 percent of historic deficiency payments in 1996. These payments are phased out by 2000.

- Producers have total flexibility in their planting decisions without maintaining acreage base and set aside.

- Conservation compliance is assumed to continue and the CRP assumptions are similar to the baseline.

- Acreage control provisions, ARP and 0/50-85-92, are eliminated. However, it was assumed that only 50 to 60 percent of the set-aside acreage and 25 percent of the 0/50-85-92 acreage would return to production of major crops.

Recent research indicates that a revenue assurance program would have little impact on farmers' per acre use of inputs if revenue is assured at or below 85 percent of normal crop revenue (Babcock and Hennessy 1994). Thus, there should be little environmental change from changes in input use. But another study indicates that revenue assurance could have a significant impact on optimal crop mix by encouraging greater crop rotation (Hennessy, Babcock, and Hayes 1995). In the Corn Belt, greater use of a corn-soybean rotation would likely lead to less nitrogen fertilizer use and greater adoption of no-till (Babcock, Chaherli, and Lakshminarayan 1995). And in the Great Plains, increased use of wheat in a summer fallow rotation should increase adoption of conservation tillage practices on wheat (Babcock, Chaherli, and Lakshminarayan 1995).

Results

The CEEPES results of policy options for the FAPRI projection years 1995 and 2004 are shown as percentage changes from the FAPRI baseline estimates. The economic impacts include changes in total and per acre returns to crop production, crop rotation, crop mix, crop yields, crop prices, conservation and tillage practices, fertilizer and chemical use, total farm income, and government outlays. The CEEPES-FAPRI policy evaluation results are presented in two sections: the economic and production impacts and the environmental impacts. Tables 1 to 7 and Figures 3 and 4 summarize the economic impacts for the study region.

Economic and Production Impacts

Table 1 presents the baseline acreage and percentage changes in net returns and gross value of crop production. Because the revenue assurance program is gradually phased in starting in 1997, there is no change for this scenario in 1995. However, in 2004 total net returns to crop production, including insurance payouts, decrease by 1.64 percent. Increasing NFA to 25 percent decreases total net returns, including government program payments, by 4.7 percent in 1995 and by 3.3 percent in 2004. The returns decline from the loss of program payments on the additional 10 percent of NFA in exchange for planting flexibility.

Table 2 presents baseline crop rotation acreage and percentage changes under the two policy alternatives. Table 3 presents total crop acreage and percentage changes from the two policy alternatives. Under revenue assurance continuous corn acreage decreases slightly. Acreage in a corn-soybean rotation was expected to increase, but since there was a 2 percent decrease in overall corn acreage (Table 3), acreage in corn-soybean and corn-wheat rotations actually decreased. However, acreage in soybean-wheat and sorghum-soybean rotations increased significantly because of increased soybean, sorghum, and wheat production under the revenue assurance program (Table 3). Wheat-sorghum-fallow, the most profitable rotation in wheat production, increased by 7.5 percent. Furthermore, because 11 percent of summer fallow

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Table 1. Net Returns and Gross Value of Crop Production

	Baseline	Revenue Assurance	25% Flex
		Percent Change	
1995			
Total Net Returns	$34.95 billion	0.00	-4.72
Net Returns Per Acre	$118.05/ac	0.00	-3.52
Gross Value of Production	($/ac)		
Barley	83.45	0.00	-2.96
Corn	229.49	0.00	-0.62
Cotton	385.81	0.00	-1.76
Oats	71.44	0.00	0.67
Sorghum	85.56	0.00	-0.66
Soybeans	194.75	0.00	0.00
Spring Wheat	95.80	0.00	0.04
Winter Wheat	108.97	0.00	0.45
2004			
Total Net Returns	$33.78 billion	-1.64	-3.33
Net Returns Per Acre	$108.20/ac	-0.72	-2.28
Gross Value of Production	($/ac)		
Barley	83.29	4.10	4.22
Corn	232.63	-0.29	-0.08
Cotton	392.91	-2.79	4.02
Oats	74.22	0.18	-0.63
Sorghum	76.56	1.12	0.05
Soybeans	180.68	-1.37	-0.32
Spring Wheat	105.53	1.29	0.43
Winter Wheat	121.44	0.28	-0.50

Source: CARD 1995.

Table 2. Acreage Under Crop Rotations

Crop Rotation	Baseline	Revenue Assurance	25% Flex
1995	Acres	Percent Change	
continuous corn	14,540,047	0.00	-3.65
continuous cotton	2,604,165	0.00	-0.10
continuous hay	22,761,479	0.00	-10.60
continuous sorghum	2,882,193	0.00	11.52
continuous wheat	24,069,423	0.00	-4.87
corn-cotton	469,051	0.00	0.21
corn-sorghum	1,805,646	0.00	4.11
corn-soybean-wheat	10,423,611	0.00	-3.46
corn-soybeans	87,987,877	0.00	4.26
corn-wheat	16,136,151	0.00	0.57
cotton-sorg.-wheat	6,046,366	0.00	-12.50
cotton-soybeans	10,593,823	0.00	1.62
hay rotations	40,486,038	0.00	-2.60
sm. grain rotations	10,371,184	0.00	-10.90
sorghum-soybeans	4,561,098	0.00	-17.90
soybeans-wheat	12,834,087	0.00	-1.07
wheat-fallow	16,923,074	0.00	5.69
wheat-sorg.-fallow	5,230,431	0.00	2.50
other rotations	5,298,993	0.00	-15.70
2004			
continuous corn	15,423,446	-0.21	0.09
continuous cotton	2,576,744	-0.14	50.84
continuous hay	24,562,353	-9.41	-17.50
continuous sorghum	3,342,606	11.14	4.01
continuous wheat	25,330,828	13.90	-6.78
corn-cotton	627,520	2.80	1.75
corn-sorghum	1,973,218	0.64	15.48
corn-soybean-wheat	10,221,617	-3.16	-2.26
corn-soybeans	91,581,207	-1.72	1.45
corn-wheat	20,026,624	-15.50	-25.10
cotton-sorg.-wheat	6,473,291	-7.46	-13.80
cotton-soybeans	10,899,406	3.26	-0.63
hay rotations	40,602,933	-6.15	-5.54
sm. grain rotations	9,339,284	2.07	21.67
sorghum-soybeans	4,557,907	8.24	0.88
soybeans-wheat	14,412,660	39.26	-1.81
wheat-fallow	19,042,397	-18.80	35.82
wheat-sorg.-fallow	6,398,740	7.47	-0.05
other rotations	4,763,052	0.17	-12.20

Note: sm. grain are small grains representing barley and oats.

Source: CARD 1995.

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Table 3.Crop Acreage

Year/Crop	Baseline	Revenue Assurance	25% Flex
	Acres	Percent Change	
1995			
Barley	3,958,100	0.00	-2.10
Corn	76,075,100	0.00	1.25
Cotton	12,089,400	0.00	-1.90
Legume Hay	24,775,500	0.00	-10.01
Nonlegume Hay	20,459,600	0.00	1.98
Oats	5,702,220	0.00	-6.31
Sorghum	10,350,900	0.00	-3.47
Soybeans	62,274,700	0.00	-0.16
Summer Fallow	14,204,900	0.00	3.54
Spring Wheat	19,002,700	0.00	-0.29
Winter Wheat	41,501,500	0.00	-2.39
2004			
Barley	4,113,040	19.77	10.70
Corn	81,738,100	-2.03	-2.57
Cotton	12,241,600	-4.45	8.73
Legume Hay	27,090,200	7.57	-15.48
Nonlegume Hay	20,152,500	-21.57	-0.49
Oats	5,810,290	-3.63	-1.71
Sorghum	11,710,900	3.07	-0.67
Soybeans	63,863,100	2.81	-0.11
Summer Fallow	15,703,700	-10.77	12.52
Spring Wheat	20,518,500	1.21	-1.53
Winter Wheat	44,655,600	2.20	0.20

Source: CARD 1995.

Table 4.Crop Yields

Year/Crop	Baseline	Revenue Assurance	25% Flex
	Units	Percent Change	
1995			
Barley	51.43	0.00	-2.43
Corn	111.54	0.00	-0.62
Cotton	1.50	0.00	-1.39
Legume Hay	3.26	0.00	-0.75
Nonlegume Hay	2.23	0.00	-3.16
Oats	51.89	0.00	0.07
Sorghum	45.19	0.00	-0.68
Soybeans	35.84	0.00	0.00
Spring Wheat	29.97	0.00	0.05
Winter Wheat	34.18	0.00	0.42
2004			
Barley	53.20	2.21	2.22
Corn	113.06	-0.26	-0.05
Cotton	1.52	-2.19	4.68
Legume Hay	3.32	-2.50	-3.70
Nonlegume Hay	2.17	-2.25	-3.93
Oats	53.71	-0.12	-0.50
Sorghum	40.58	0.91	0.23
Soybeans	33.27	-1.43	-0.34
Spring Wheat	33.01	1.29	0.44
Winter Wheat	38.07	0.26	-0.49

Note: Units are in bu/acre: except for cotton (bales/acre) and hay (tons/acre).
Source: CARD 1995.

acreage was brought into production under the revenue assurance program, wheat-fallow rotation was substituted for continuous-wheat and wheat-sorghum-fallow rotation.

Under the 25 percent flex option continuous corn, continuous wheat, and continuous cotton acreage decreased. As expected, acreage under corn-soybean, corn-cotton, corn-sorghum, and wheat-fallow rotations increased. Because of increased flexibility, wheat production in summer fallow-based rotations, which is more profitable than continuous wheat, increased under the 25 percent flex option.[2] As a result, average wheat yields increase (see Table 4). In 1995 the small grain rotations decrease by 11 percent but over the long run the rotation increase significantly. The decline in small grain rotation in 1995 is due to increased net flex acreage out of barley (small grains) into other eligible crops.

The reduction in hay plantings, both in rotation and as continuous hay, is the result of an overall reduction in hay acreage (Table 3). The shift away from hay to other major crops may increase soil erosion. However, increased crop rotation should offset some of the soil losses and should certainly reduce chemical use which may enhance water quality. By combining the flex option with CRP targeting, overall soil loss reduction and water quality goals may be achieved.

Table 5 presents conservation and tillage practices and Table 6 presents agricultural chemical input use under the three policy scenarios. Because of Conservation Compliance, straight row production decreases and terracing increases in all scenarios. Acreage under no-till increases by 18 percent in 1995 under the flex option, of which one-third of the acreage was moved out of reduced tillage. Because of increased corn-soybean and wheat-fallow rotations, no-till becomes more attractive relative to reduced tillage (Babcock, Chaherli, and Lakshminarayan 1995). In addition to increased no-till, acres under terracing increase by 50 percent to meet the Conservation Compliance requirements on highly erodible land.[3] Even though no-till and reduced till acreage under flex option in 2004 decrease slightly, we should note the increase in no-till and reduced till acreage in the 2004 baseline compared to the 1995 baseline. With revenue assurance, adoption of soil conserving management practices increases.

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[2] Wheat-fallow rotation helps build soil moisture, which increases yield significantly (Williams, Llewelyn, and Barnaby 1990).

[3] According to FSA 1985 the conservation plans should be in place by 1995.

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Table 5. Acreage by Management Practices

Year/Management Practice	Baseline	Revenue Assurance	25% Flex
	Acres	Percent Change	
1995			
Conservation Practice			
Straight Row	215,974,000	0.00	-1.78
Contouring	45,175,900	0.00	-3.41
Strip Cropping	20,447,300	0.00	-29.05
Terracing	14,427,100	0.00	52.98
Tillage Practice			
Fall Tillage	89,162,100	0.00	-4.81
Spring Tillage	135,180,000	0.00	-1.93
Reduced Tillage	45,054,200	0.00	-3.68
No Till	26,628,400	0.00	18.31
2004			
Conservation Practice			
Straight Row	231,565,000	-4.82	-0.33
Contouring	46,131,600	4.60	-4.24
Strip Cropping	11,883,700	14.95	-7.18
Terracing	22,576,100	19.31	0.89
Tillage Practice			
Fall Tillage	96,245,600	6.26	3.49
Spring Tillage	133,802,000	-8.60	-4.51
Reduced Tillage	49,897,300	1.42	-0.91
No Till	32,210,800	5.81	-0.69

Source: CARD 1995.

Table 6.Fertilizer and Herbicide Use

Year/Chemical	Baseline	Revenue Assurance	25% Flex
	Units	Percent Change	
1995			
Fertilizer Use			
Nitrogen	7,902,450	0.00	-1.43
Phosphorus	4,873,660	0.00	-1.80
Potassium	3,133,400	0.00	-2.67
Corn/Sorghum Herbicide Use			
Atrazine > 1.5	12,760,400	0.00	4.09
Atrazine <= 1.5	36,026,600	0.00	2.62
Cyanazine	22,210,900	0.00	0.90
Metolachlor	21,040,000	0.00	-0.96
Alachlor	23,912,000	0.00	-1.64
Simazine	1,068,780	0.00	-12.30
2004			
Fertilizer Use			
Nitrogen	8,371,000	-3.32	0.11
Phosphorus	5,175,100	-0.88	-1.42
Potassium	3,295,020	-0.73	-3.42
Corn/Sorghum Herbicide Use			
Atrazine > 1.5	13,001,100	1.97	-5.42
Atrazine <= 1.5	37,772,800	-1.11	-0.44
Cyanazine	22,861,900	-0.48	-0.66
Metolachlor	21,467,200	0.32	-2.34
Alachlor	25,397,800	0.18	0.47
Simazine	1,197,320	-2.33	-12.22

Note: Fertilizer units are nutrient tons and herbicide units are pounds active ingredient.
Source: CARD 1995.

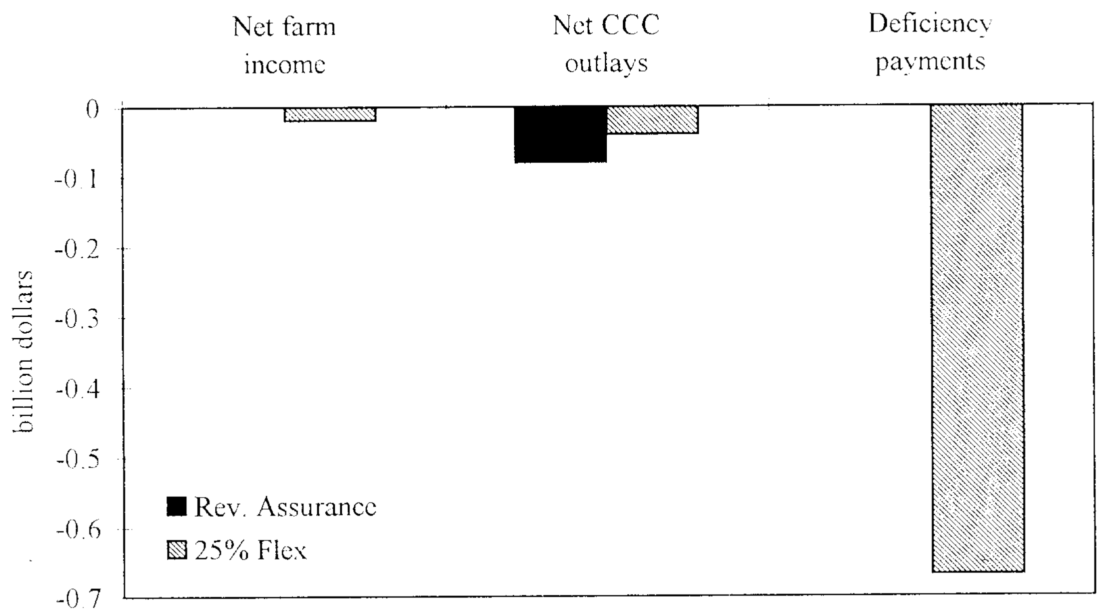

Figure 3. Changes in farm income and government outlays in 1995

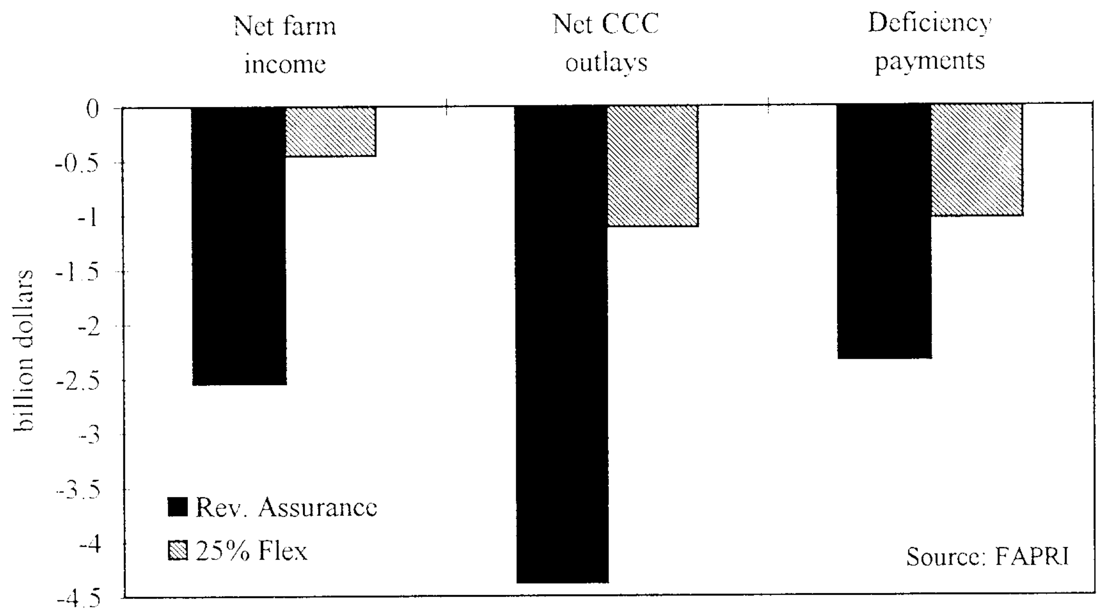

Figure 4. Changes in farm income and government outlays in 2004

Again as expected fertilizer use decreases in all scenarios, except for a small (0.1 percent) increase in nitrogen in 2004 under the flex option (Table 6). With 25 percent flex, nitrogen use decreases by 1.4 percent (roughly 113,000 tons) in 1995 because of increased crop rotation. With revenue assurance, the nitrogen use reduction is about 3.3 percent (roughly 276,000). In the long run, corn and sorghum herbicide use, particularly the triazines (atrazine, cyanazine, and simazine), decline under both policy options.

The changes in total net farm income (both crop and livestock income) and government outlays (net CCC outlay and deficiency payments) under revenue assurance and increased flex options, as projected by FAPRI, are shown in Figure 3 for 1995 and Figure 4 for 2004. With the revenue assurance program, government outlays decrease more than with the 25 percent Flex option. While the private farm income reduction was larger under revenue assurance compared to the 25 percent flex option. However, we realize that with revenue assurance, payments would be received by farmers when they are needed the most; that is, when farmers are in financial stress.

Environmental Impacts

Unlike the economic indicators, the environmental indicators cannot be easily aggregated because of spatial variability. Aggregating to larger geographical regions would fail to identify locations with unacceptable environmental quality. Therefore, environmental impacts (sheet and rill erosion, wind erosion, and nitrate runoff/leaching from corn, soybeans, sorghum, wheat, and hay) are aggregated only to the watershed (PA) level from the site-specific (NRI points) estimates. The site-specific environmental impacts of alternative policies depend upon the choice of site-specific production systems. So it is necessary to determine site-specific production impacts of alternative policies.

An important input into the metamodels that are used to predict pollution levels at each NRI point in the study region is the production system employed at each point. (A production system consists of a crop rotation, conservation practice, and tillage practice.) Predicted pollution levels in the CEEPES baseline are estimated from the actual production system employed at each NRI point in 1992. But policy changes can alter the production system employed at a point. In order to predict changes in pollution, we first have to predict changes in production systems.

Output from RAMS consists of the proportion of acreage in a PA allocated to each production system. The problem to overcome is how to allocate the PA-level distribution of production systems to the NRI points. The allocation should be consistent in the sense that reaggregation should return the original distribution of acreage in each PA. Previous versions of CEEPES assumed that each point in the PA utilized the same distribution of production systems that was predicted from RAMS. That is, there was no allocation of production systems to the point level. But clearly, the two most important factors influencing agricultural pollution are point-specific physical characteristics and point-specific production practices. The current version of CEEPES allocates the PA-level distribution of production systems to the NRI points in the PA by minimizing the number of NRI points on which changes in production systems must be made.

Under each policy and for each PA, RAMS takes the FAPRI-provided crop acreage levels and estimates the number of acres in a PA grown under each production system. The estimated acreage levels are compared to the actual acreage levels (from the 1992 NRI) under each production system in 1992. For each policy, if fewer acres are grown under a particular production system, then NRI points and their associated acreage amounts are reallocated to production systems in the PA that increase under the policy. NRI points are reallocated until the total number of acres under a particular production system is equal to the level predicted from RAMS. For those production systems that show an increase under a particular policy, all the NRI points that were operating under that production system in 1992 are assumed to continue operating under the same production system under the new policy. Additional NRI points are allocated to the production system until the total acreage in the PA is increased to the level predicted by RAMS.

A difficulty arises when the total number of acres cropped in a PA changes under a policy scenario. If total acreage increases, those NRI points that are most likely to return to production would have to be identified and allocated to a crop production system. Or, those NRI points that would have production expanded (i.e., an increased expansion factor) would have to be identified. If total acreage decreases, then those NRI points that would most likely leave production, or that would have a declining expansion factor, would have to be identified and taken out of production. Our modeling system does not, as yet, have this capability. Instead, before the RAMS distribution of cropping systems was allocated to the NRI points, we normalized the number of acres to equal the number of acres in production in 1992. This normalization rule implies that our environmental indicators are not suited for measuring total amounts of nitrate runoff and leaching and erosion because the total number of acres in production does not vary. Rather, our indicators should give good estimates of the per acre nitrate runoff and leaching and soil erosion across the study region.

Thus for all policies, including the 1995 FAPRI baseline, RAMS chooses an optimal allocation of crop acreage into alternative production systems at the PA level. The policy- and PA-specific acreage distribution are in turn allocated to the NRI points. Using the response functions (metamodels) and the site-specific data on production, weather, soil, and hydrologic properties we estimated long-term average nitrate runoff/leaching, sheet and rill erosion, and wind erosion for each of the 104,786 NRI sites in the Corn Belt, Lake States, and Northern Plains regions. The point-specific values were then aggregated to the PA levels and are reported in Tables 7 to 10.

Environmental effects from agriculture typically exhibit large yearly fluctuations. Here we are interested in measuring the long-term average effect of alternative production systems. This measurement requires that the crop production system be held constant for a long time. But the policy scenario implies that crop rotations will be changing from 1995 to 2004 because of changes in relative acreage for our crops. The changes in relative acreage are caused by CRP land coming back into production and by changes in ARP rates. To overcome this difficulty, we assume that acreage levels reach an equilibrium in 2004. We then use RAMS to allocate the 2004 acreage predictions from FAPRI to the various production systems and we hold the production systems constant for the 30-year environmental simulations. We use the CEEPES baseline calibrated to the 1992 NRI as the benchmark to measure the environmental changes introduced by the Farm Bill policy options—the 1995 FAPRI Baseline, Revenue Assurance, and 25 Percent Flex.

Tables 7 and 8 present CEEPES baseline average per acre loading of nitrate runoff and leaching and percentage changes from the two policy alternatives. The results clearly

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Table 7. Policy Impacts on Nitrate-N Runoff Loadings

PA	Dominant State (s)	CEEPES Baseline (1992 NRI)	FAPRI Baseline 2004	Revenue Assurance 2004	25% Flex 2004
		lbs/ac	**percentage change**		
22	MI/MN/WI	0.24	3.50	0.67	1.76
23	WI	1.17	-4.62	-14.66	-9.10
24	IL/IN/WI	2.94	-17.36	-20.04	-16.47
25	MI	1.97	6.96	6.73	9.01
26	MI	0.89	19.23	17.25	19.26
27	OH	2.78	15.75	14.40	14.49
28	OH	3.97	-37.72	-41.06	-36.51
31	OH	2.31	-67.18	-68.20	-67.01
32	OH	2.35	-7.60	-10.37	-6.14
34	IL/IN/OH	3.24	-17.80	2.80	3.42
35	IN	2.58	22.01	19.53	21.57
39	MN	1.76	-21.84	-27.57	-24.93
40	WI/MN	1.05	-36.79	-35.36	-39.92
41	IA	1.68	-41.86	-43.23	-40.85
42	IL	2.74	13.39	11.27	14.69
43	IL	4.40	-41.36	-40.77	-39.29
47	ND/MN	2.04	-7.36	-1.11	-12.92
52	ND/SD	2.36	-23.77	-25.09	-23.59
53	SD/ND	1.88	-3.47	-7.20	-7.10
55	NE	1.30	25.65	21.92	25.71
56	NE	2.12	-1.86	-3.17	-0.94
57	IA/NE	2.68	6.25	-0.72	7.82
58	KS	1.84	-11.07	-28.65	18.04
59	NE/KS	2.86	-16.43	-15.58	-11.39
60	MO	4.96	-25.72	-29.99	-25.28
63	KS	1.94	-20.92	-20.95	-13.52
64	KS	5.15	-13.67	-16.84	-10.28
Study Area		2.38	-10.57	-13.21	-8.16

Source: CARD 1995.

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Table 8. Policy Impacts on Nitrate-N Leaching

PA	Dominant State (s)	CEEPES Baseline (1992 NRI)	FAPRI Baseline 2004	Revenue Assurance 2004	25% Flex 2004
		lbs/ac	percent change		
22	MI/MN/WI	2.23	1.65	0.33	0.84
23	WI	1.76	-14.53	-14.53	-15.15
24	IL/IN/WI	4.53	37.10	35.55	37.53
25	MI	3.49	16.94	13.15	13.10
26	MI	2.57	-8.47	-9.72	-9.01
27	OH	3.47	4.45	1.28	-0.40
28	OH	2.72	43.20	41.34	43.26
31	OH	3.42	-26.65	-28.12	-26.40
32	OH	3.75	18.95	14.19	16.52
34	IL/IN/OH	3.57	2.42	49.30	48.60
35	IN	4.33	5.97	5.73	5.80
39	MN	1.17	18.24	28.46	23.10
40	WI/MN	1.24	25.99	16.19	30.45
41	IA	2.00	43.26	44.42	38.71
42	IL	2.95	10.60	11.36	7.81
43	IL	3.16	-19.12	-18.18	-19.22
47	ND/MN	0.60	21.85	17.16	18.70
52	ND/SD	0.40	-12.48	-17.86	-12.10
53	SD/ND	0.68	-9.09	-10.31	-7.72
55	NE	1.48	24.93	20.24	25.20
56	NE	0.99	-0.03	-5.74	-1.37
57	IA/NE	1.04	-2.13	-2.61	-3.25
58	KS	1.28	7.19	-23.46	49.07
59	NE/KS	1.03	-14.01	-19.17	-14.75
60	MO	1.06	-4.99	2.50	-3.96
63	KS	1.20	-7.59	-15.38	-3.64
64	KS	1.21	23.49	17.78	26.95
Study Area		1.95	11.10	9.38	12.29

Source: CARD 1995.

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Table 9. Policy Impacts on Sheet and Rill Erosion.

PA	Dominant State (s)	CEEPES Baseline (1992 NRI)	FAPRI Baseline 2004	Revenue Assurance 2004	25% Flex 2004
		tons/ac	**percentage change**		
22	MI/MN/WI	7.60	0.00	0.00	0.00
23	WI	5.65	-2.08	-8.36	-0.32
24	IL/IN/WI	5.50	-54.63	-53.93	-54.56
25	MI	4.69	-28.88	-35.25	-34.93
26	MI	2.12	-1.11	-0.38	-0.95
27	OH	2.23	-34.32	-32.76	-30.76
28	OH	5.58	-17.28	-18.42	-17.16
31	OH	6.86	8.31	8.31	8.31
32	OH	5.27	-17.27	-10.73	-10.44
34	IL/IN/OH	7.90	-12.23	-30.45	-29.83
35	IN	4.86	-48.06	-52.84	-49.10
39	MN	3.27	-14.15	-12.74	-8.74
40	WI/MN	6.15	-20.97	-19.81	-20.61
41	IA	7.57	-13.24	-14.67	-11.76
42	IL	6.31	-5.51	-2.68	-3.58
43	IL	7.30	-6.68	-19.56	-5.58
47	ND/MN	2.20	-19.19	-19.95	-15.11
52	ND/SD	4.30	-6.88	-5.47	-6.65
53	SD/ND	3.83	8.08	7.89	6.28
55	NE	5.77	5.57	5.40	5.54
56	NE	9.34	0.28	0.44	1.06
57	IA/NE	11.43	0.17	0.00	1.56
58	KS	3.98	3.09	-9.90	26.14
59	NE/KS	4.50	-1.10	1.18	1.73
60	MO	8.48	-8.31	-4.41	-7.61
63	KS	2.25	-26.69	-21.83	-27.25
64	KS	2.91	1.97	-0.94	-0.08
Study Area		5.32	-11.40	-12.48	-9.37

Source: CARD 1995.

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Table 10. Policy Impacts on Wind Erosion

PA	Dominant State (s)	CEEPES Baseline (1992 NRI)	FAPRI Baseline 2004	Revenue Assurance 2004	25 % Flex 2004
		tons/ac	**percentage change**		
22	MI/MN/WI	1.11	0.00	0.00	0.00
23	WI	0.71	-27.85	-33.52	-28.44
24	IL/IN/WI	0.76	-50.75	-45.00	-50.61
25	MI	0.65	-0.84	-3.83	-2.54
26	MI	0.57	23.38	24.26	23.45
27	OH	0.47	6.74	7.42	8.27
28	OH	0.28	3.34	1.98	3.84
31	OH	0.25	68.57	68.57	68.57
32	OH	0.31	-2.90	-2.58	-1.22
34	IL/IN/OH	0.44	23.34	-16.42	-15.45
35	IN	0.54	18.90	16.82	18.04
39	MN	2.57	-45.43	-58.58	-51.07
40	WI/MN	1.49	-46.22	-41.58	-48.53
41	IA	1.23	-54.75	-54.91	-52.44
42	IL	0.62	19.67	19.73	23.58
43	IL	0.50	-9.74	-9.28	-7.74
47	ND/MN	4.34	-16.56	-12.85	-21.82
52	ND/SD	6.66	-60.11	-56.83	-59.11
53	SD/ND	2.87	3.06	8.30	-3.20
55	NE	4.23	79.98	77.23	79.83
56	NE	2.58	7.59	0.94	8.05
57	IA/NE	1.05	14.85	10.01	14.87
58	KS	6.32	-26.27	-68.05	40.82
59	NE/KS	1.90	-20.38	-20.62	-18.45
60	MO	0.75	16.78	8.06	14.72
63	KS	6.18	-40.19	-37.51	-41.19
64	KS	1.44	-14.47	-8.00	-20.66
Study Area		2.45	-24.76	-31.63	-14.23

Source: CARD 1995

demonstrate spatial heterogeneity in the environmental impacts. In general there is reduced average per acre runoff loadings across all three policy options (Table 7). Note we have Conservation Compliance incorporated in all three policy options, which results in lower runoff and erosion. Because of the trade-off between runoff and leaching we generally see an increase in nitrate-N leaching across all three policy options (Table 8). The soil erosion results presented in Table 9 (sheet and rill erosion) and Table 10 (wind erosion) show a reduction in erosion rates attributeable to Conservation Compliance. As shown in Table 10, the only areas where wind erosion problems are predicted to get worse under the policy scenarios is PA 55 in Nebraska and PA 58 in Northwest Kansas under the 25 percent flex policy option

Spatial Distribution of Environmental Impacts

The point-specific values of the environmental indicators are linked to the NRI-based GIS (Geographical Information System) to demonstrate the spatial distribution of environmental impacts of alternative policies. Appendix A contains the maps of the three environmental indicators: nitrate-N runoff, nitrate-N leaching, and sheet and rill erosion. Figures A-1 through A-3 present the CEEPES baseline predictions of nitrate-N runoff, nitrate-N leaching, and sheet and rill erosion. Figure A-1 demonstrates that the largest per acre nitrate runoff levels (shown as the purple shaded areas) are located in Northern Missouri, Western Kansas, Southern Illinois, and in the Missouri River Valley in South Dakota. Areas with minimal potential nitrate runoff problems are in Michigan, Wisconsin, and parts of Nebraska. Figure A-2 shows that the areas where nitrate leaching potential is greatest is in Indiana, Ohio, Illinois, and parts of Iowa, Michigan, Wisconsin, and Nebraska. The sudden changes in estimated nitrate leaching that occur at certain state boundaries is a result of the state dummy variables in the metamodels. These unrealistic spatial discontinuities will be eliminated when the state dummies are replaced with latitude and longitude in the metamodels.

A comparison of Figures A-1 and A-2 shows that nitrate leaching and runoff are negatively correlated. Nitrogen that is not used by crops can either leach out or run off. Those areas with more permeable soils will lose a relatively larger percentage of nitrogen to leaching. Those areas that have more erosion potential or impermeable soils will have more runoff. Figure A-3 presents the baseline estimates of the spatial distribution of sheet and rill erosion. Average soil loss per acre is greatest in the Missouri and Mississippi River valleys. These areas are dark and light purple, and dark blue. Low sheet and rill erosion rates occur in large parts of the Dakotas, Kansas, and parts of Ohio, Minnesota, and Michigan.

The remaining figures in Appendix A show the percentage changes in the three environmental indicators under the three policy alternatives. Figures A-4, A-5, and A-6 present the percentage changes under the FAPRI baseline. One of the most striking results is the large areas where soil erosion will decrease in the future (Figure A-6). The assumption that Conservation Compliance plans are enforced explains much of this. Figure A-4 shows that the only large areas where nitrate runoff increases (the purple shaded areas) is in Central Illinois, Indiana, and Northwest Ohio. But as shown by Figure A-1, most of this area did not have high rates of nitrate runoff to begin with. Much of this same area also shows increased nitrate leaching. And nitrate leaching potential in this area was already relatively high (Figure A-2). The primary change in the production systems in this region relative to the baseline is that continuous corn and corn-corn-soybean rotations decrease while corn-soybeans increase. And it is well documented that a corn-soybean rotation is more susceptible to nitrate leaching than either continuous corn or corn-corn-soybeans (Kanwar et al. 1990).

Some of the areas in Northcentral Missouri with a high base level of nitrate runoff show significant improvements in the FAPRI baseline policies. The primary change in production in this region is a large increase in hay production, and a large decrease in row crop production. Figure A-5 shows that Southern Minnesota is the only area with relatively large percentage increases in nitrate leaching potential. Acreage under a continuous corn rotation is estimated to decrease substantially in this area while acreage under a corn-soybean rotation is up substantially. But this was an area that had low levels of baseline leaching (Figure A-2).

Figures A-7, A-8, and A-9 show the predicted percentage changes in environmental indicators once the revenue assurance program is fully implemented and Figures A-10, A-11, and A-12 show the estimated percentage changes under the 25 percent flex policy. What is most striking is the similarity to the changes shown under the FAPRI baseline. That is, there do not seem to be large environmental consequences (as measured by average per acre impacts) from either revenue assurance or the 25 percent flex policy. The most significant exception to this general finding is that runoff and soil erosion in Northwest Kansas under the 25 percent flex policy are substantially higher than under revenue assurance or the FAPRI baseline. The reason for this difference is that under the flex policy hay acreage subtantially decreases relative to the FAPRI baseline and revenue assurance policies, and both wheat and fallow acreage substantially increase. So some land that is estimated to be planted to hay under the FAPRI baseline is put into fallow, leading to increased soil erosion and, perhaps, increased nitrate runoff.

Concluding Remarks

Information on economic and environmental trade-offs of alternative Farm Bill policy options is crucial for making informed policy decisions. Because environmental impacts are spatially heterogeneous it is important to have a system that is capable of making site-specific environmental impact assessments. The CEEPES system is designed to make site-specific environmental impact assessments of economic and production choices made under alternative policy options. The FAPRI system makes macro-level forecasts of economic impacts and crop acreage changes under alternative policy options. By integrating these two systems we provide spatial predictions of economic and environmental trade-offs of the 1995 Farm Bill policy options—the FAPRI Baseline, Revenue Assurance, and 25 Percent Flex.

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APPENDIX A

Environmental Indicator Maps

Figure titles:

Figure A-1. Estimated Nitrate-N Runoff: CEEPES baseline.
Figure A-2. Estimated Nitrate-N Leaching: CEEPES baseline.
Figure A-3. Estimated Sheet and Rill Erosion: CEEPES baseline.
Figure A-4. Estimated Percent Change in Nitrate-N Runoff under the FAPRI Baseline.
Figure A-5. Estimated Percent Change in Nitrate-N Leaching under the FAPRI Baseline.
Figure A-6. Estimated Percent Change in Sheet and Rill Erosion under the FAPRI Baseline.
Figure A-7. Estimated Percent Change in Nitrate-N Runoff under Revenue Assurance.
Figure A-8. Estimated Percent Change in Nitrate-N Leaching under Revenue Assurance.
Figure A-9. Estimated Percent Change in Sheet and Rill Erosion under Revenue Assurance.
Figure A-10. Estimated Percent Change in Nitrate-N Runoff under 25 Percent Flex.
Figure A-11. Estimated Percent Change in Nitrate-N Leaching under 25 Percent Flex.
Figure A-12. Estimated Percent Change in Sheet and Rill Erosion under 25 Percent Flex.

Color copies of Figures A-1 through A-12 are available for $20 prepaid. Please make checks payable to Iowa State University. Send your order to Dr. Bruce Babcock, Iowa State University, 568D Heady Hall, Ames, Iowa 50011-1070.