Environmental and Economic Impacts of Agricultural Policy Reform: An Interregional Comparison

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Abstract

Mathematical programming results revealed that moving toward more flexible agricultural policies would generate substantial economic and environmental gains in a North Carolina diversified cropping region. But in a Washington-Idaho dryland grains region, only the use of relatively new and sometimes problematic alternative cropping systems permitted environmental and economic gains under policy reform. In both regions, a recoupling policy, which links government payments to resource-conserving farming practices, was needed to protect environmental quality when market prices for program crops were high.

Key Words: agrichemical leaching, agricultural policy, alternative agriculture, erosion, mathematical programming.

Introduction

Agriculturally-related human health and environmental impacts have become increasingly important in the agricultural policy debate. Research on environmental and economic tradeoffs of production practices for a variety of crops, chemicals, climates, and regions is needed to inform the 1995 and subsequent Farm Bill debates on issues related to protection of human health, natural resources, and farm income.

Estimates of aggregate economic effects of agrichemical restrictions vary in magnitude and direction for different regions of the country (Taylor et al.). Environmental costs (benefits) associated with agrichemical pollution (abatement) differ by region as well. For example, in a contingent valuation study of willingness to pay for groundwater protection in a region with high pesticide contamination potential, willingness to pay was significantly correlated with the likelihood of groundwater contamination (Sun et al.). Thus, smaller benefits of groundwater protection would be expected in areas with low contamination potential, and also in less populated areas.

Studies have predicted that the South would be more adversely affected by national pesticide bans than other regions due to higher pest pressures (Taylor et al.; Richardson et al.). Foster attributes these results to insufficient modeling of substitution possibilities. The long growing season and moderate climate in the South might make adapting to chemical restrictions easier because more crop options are available. With respect to restrictions on inorganic nitrogen, the South has an advantage over cooler climates because green manure crops can be double-cropped with cash crops.

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Various studies have addressed the impacts of alternative policies on the private profitability of alternative and conventional production systems (Dobbs and Becker; Duffy and Chase; Faeth et al.). Few studies address broader measures such as impacts on the natural resource base, changes in taxpayer cost, and impacts on returns to land. As social scientists, we need to develop a more complete framework for evaluating the environmental and economic performance of the agricultural sector. While Faeth et al. presented a comprehensive natural resource accounting framework including erosion damage and farm subsidy costs, the study did not address impacts on groundwater quality. Moreover, the EPIC model Faeth et al. used for calculating erosion levels may not always perform well in new regions. This study uses hydrologic models to calculate relative leaching potential of different cropping systems and an erosion model (RUSLE) which has been calibrated for the region under study.

In this study, a large number of conventional as well as resource conserving cropping options were studied for representative farms in two contrasting farming regions, the North Carolina Coastal Plain and the Washington-Idaho Palouse. These two important production regions lie outside the Great Plains and Corn Belt regions, where much analysis has been done (Faeth et al., Dobbs and Becker, Lockeretz et al., Duffy and Chase, National Research Council). These two regions also represent contrasting environmental problems, climates, and population densities.

Farm-level, mixed integer programming models were used to project profit-maximizing farm manager behavior under a variety of farm policy scenarios (Painter). Crop prices prevailing under each policy scenario were estimated from a survey of agricultural sector modelers and outlook specialists. Agrichemical leaching and soil erosion were estimated using physical models that account for management practices, climate, and topography. Environmental and economic impacts for each policy scenario were calculated from the profit-maximizing cropping choices. Specifically, the impacts of profit-maximizing behavior by farm managers on farm profit, taxpayer cost in terms of government payments to farmers, erosion damage, and agrichemical leaching were estimated. Results were assessed both with and without resource-conserving cropping systems.

Assigning dollar values to environmental damage estimates in order to obtain a more comprehensive measure of policy impacts is difficult. Erosion-induced economic damage, both on-site and off-site, are determined for all production systems in the highly erodible Palouse region using documented measurement methods. As economic damage estimates from predicted agrichemical leaching rates are not available, physical leaching estimates are presented for each crop production system in the Coastal Plain region.

Aggregate Versus Farm-Level Approaches

The choice between national modeling and farm-level analysis in policy evaluation involves major tradeoffs. Aggregate modelers have measured selected components of social welfare using a variety of approaches (for example, see Smith et al.; Hertel; Langley et al; Tobey and Reinert). All aggregate studies suffer fundamental weaknesses related to the gross aggregation of production regions and lack of specificity in utilized data. The relationships in aggregate models are often based on historical data generated under policies and technologies different from the ex ante policies being modeled. Multiregional programming models typically include a limited activity set compared to actual practices. Environmental impacts are especially difficult to aggregate as they tend to be site-specific, varying by soil type, climate, hydrology, and human and wildlife population densities.

On the other hand, single-region, farm-level studies of the impacts of agricultural policies are rarely convincing. Cropping patterns, environmental vulnerabilities, and farm and community economic structure vary greatly from region to region. As a compromise, this study estimates detailed farm-level impacts of agricultural policies in two dissimilar regions using a uniform methodology and estimates of national prices by policy.

Methods

Mixed integer programming (MIP) models were developed for six policy scenarios (Figure 1).

Figure 1. Policy Scenarios Modeled for Representative Farms in Both Study Regions.

1990 FARM BILL: Farmers receive deficiency payments based on the difference between legislated target prices and average market prices for program commodities. In return, they must "set-aside" a certain portion of their historical base acreage for these commodities. 1990 provisions require farmers to forgo deficiency payments on an additional 15% of their crop acreage bases ("flex acres"). They may plant program crops, oilseeds, and specified nonprogram crops on "flex acres" while preserving base and yield history. Participating farmers also must comply with provisions protecting erodible land and wetlands enacted in the 1985 Farm Bill. Quota programs (dairy, peanuts, tobacco, etc.) would be continued unchanged in this and all other scenarios.

40% FLEX: In this scenario, the "flex acres" in the 1990 Farm Bill are increased to 40%. All other provisions remain identical.

ADMIN: The Bush Administration's original proposal for the 1990 Farm Bill provided for a whole farm base called the Normal Crop Acreage (NCA), which is the sum of the farms' program crop acreage bases plus historical oilseed plantings. Deficiency payments are based on historical program crop bases and yields. Basically, this represents 100% flexibility on base acreage plantings excluding set-aside requirements which remain in effect. Flex provisions are not included in this scenario.

DECUP: Farmers freely choose crops and farming practices while receiving annual lump sum payments equal to their average historical payment levels.

RECUP: Farmers collect subsidies based on estimated erosion reduction in the Palouse and on reduction of agrichemical use in the Coastal Plain.

NO PROG: Commodity programs are terminated unilaterally. Farmers receive no deficiency payments or lump sum payments for program crop production.

These scenarios include the status quo 1990 Farm Bill, a version with increased mandatory flex requirements (*40% FLEX*), a scenario with complete base flexibility modeled on the Bush Administration's 1990 proposal (*ADMIN*), a scenario in which government payments are based on historical levels and there are no planting restrictions (*DECUP*), a scenario with payments based on environmental criteria (*RECUP*), and a scenario with no government programs (*NO PROG*). MIP is useful for identifying profit-maximizing combinations of crop rotations subject to economic and physical constraints including crop prices, production costs, farm program rules, and resource endowments (Perry et al.). Binary farm program participation decisions and accompanying binary environmental and production restrictions are endogenized using zero-one integer variables. A sample MIP formulation for the 1990 Farm Bill in the North Carolina study area is available upon request from the authors. Detailed formulations for all policy scenarios are available in Painter.

The MIP models determine the profit-maximizing choice of cropping systems for the farm manager on each representative farm. In North Carolina, the representative Coastal Plain farm was developed using Census of Agriculture data (U.S. Dept. of Commerce) and advice from local Extension specialists. This 400-acre farm has a 40-acre tobacco allottment, 180 acres of corn base, and 120 acres of wheat base. Generally, a farm in this area would rotate corn with double-cropped wheat/soybeans and tobacco. Yield data were obtained from Census of Agriculture data. In Washington, the representative Palouse farm was constructed using survey data (Halvorson), as the study area comprises just one portion of a county. This 1275-acre dryland grain farm has 46 percent of the land in wheat base acreage and 21 percent in barley base. Base and yield data were obtained from Halvorson. Set-aside rates of 7 percent for wheat and 7.5 percent for corn and barley were used in this study, based on 1991-95 projections (Food and Agricultural Policy Research Institute).

Average industry-wide prices for program crops over the 1991-95 projection horizon were calculated as the mean response of a survey of agricultural outlook and policy specialists (Table 1). Market prices were predicted to be lower when set-aside programs were discontinued, such as for the No Programs and Decoupling scenarios. Policy scenarios which allowed more crop choice flexibility tended to increase price projections for wheat and corn, and decrease price projections for soybeans. In general, predicted price variation over policy scenarios was modest, possibly due to the assumption of *unilateral* changes in U.S. policy.

In the MIP models, net returns over total costs are maximized for each policy scenario. The land cost, either share-cropping (Palouse) or cash rent (Coastal Plain), represents an actual cost if farmland is rented or an opportunity cost if it is owned. Potential environmental damage, taxpayer cost, and returns to land are calculated from the profit-maximizing outcome. Policy impacts for farm managers and landowners are tallied separately. Almost two-thirds of the land in the Washington-Idaho study region and over one-half in the North Carolina study region is rented. Under share-cropping, farm policies may affect farm operators differently than landlords. Taxpayer costs include deficiency payments and decoupled or recoupled payments. Administrative costs and social welfare opportunity costs of financing government farm programs are not included due to a lack of information. Estimates of the direct social opportunity costs of subsidy payments vary widely, but might range from 20 percent to 50 percent of the subsidy itself (Alston and Hurd, p. 149). Environmental impacts measured in this study include on-site and off-site soil erosion damage estimates and agrichemical leaching estimates for all agrichemicals used in both study areas.

In the three-county North Carolina Coastal Plain study region (Pitt, Wayne, and Greene Counties), less than 2 percent of the land is classified as highly erodible compared to 88 percent of the land in the Washington-Idaho Palouse study region. No erosion damage was calculated for cropping systems in the North Carolina Coastal Plain due to the small percentage of highly erodible land. An off-site soil erosion damage value of $3.14 (1991 dollars) per ton of soil eroded is used for the Palouse study area based on Ribaudo's estimate for the Pacific region. Ribaudo includes estimates of damage from siltation in roadside ditches, flooding attributable to siltation, costs of dredging hydroelectric reservoirs and navigation channels, destruction of fish habitat, declining quality of recreation areas, and other water degradation effects.

On-site soil erosion damage estimates in the Palouse were calculated applying present value analysis to estimated functions which measure the effect of topsoil loss on current and future yields for wheat, barley, and peas (Walker and Young). A 4 percent real private rate of discount and a 75-year time horizon were used. This captures 95 percent of the present value of erosion damage into perpetuity. Topsoil depth is used as a proxy for soil properties such as organic matter content and bulk density that are correlated with topsoil depth and in turn with crop yields. On-site erosion damage by topsoil depth was weighted by the relative frequency of different depths in the study area.

Agrichemical leaching in both study areas was estimated using an attenuation factor method which accounts for differences in soil, climate, and agrichemical properties. The attenuation factor is a process oriented index which is useful for ranking the *relative* leaching potential of a solute under different management scenarios in a given area (Khan and Liang, 1989). The relative risk for leaching of agrichemicals was estimated as follows:

$$AF = \exp\left[-0.693 \left(\frac{L\ R\ \theta}{q\ T_{1/2}}\right)\right] \qquad (1)$$

Table 1. National Average Farm Level Price Predictions (Dollars per Bushel) by Crop for 1991-95 Under Six Policy Scenarios.

Policy	Corn		Soybeans		Wheat	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1990 Farm Bill	2.24	0.25	5.85	0.51	3.05	0.26
1990 Farm Bill, 40% Flex	2.28	0.24	5.85	0.55	3.08	0.23
Administration Proposal	2.27	0.26	5.69	0.52	3.09	0.16
Decoupling	2.14	0.21	5.67	0.45	2.99	0.29
Recoupling	2.20	0.21	5.85	0.41	3.06	0.26
No Programs	2.17	0.21	5.63	0.48	3.04	0.42

SOURCE: Painter and Young.

where L is depth to groundwater and R is the chemical retention factor, a measure of chemical adsorption in soil calculated from organic carbon partition coefficients and organic carbon content of soil. θ is field capacity soil water content, q is average daily net infiltration, and $T_{1/2}$ is the pesticide degradation half-life, a measure of pesticide persistence in soil. For nitrate-nitrogen, $T_{1/2}$ is adjusted to reflect losses in mobile nitrogen due to plant uptake, nitrification, and immobilization. A depth to groundwater value of 5.00 meters was chosen, as low water table levels range from 4.5 to 6 meters in the North Carolina Coastal Plain, which is the more vulnerable of the two study areas to agrichemical leaching (USDA, 1980; USDA, 1974*a*; USDA, 1974*b*). Fertilizer nitrate-nitrogen (NO_3 - N) and, to a lesser extent, Banvel herbicide were predicted to be highly likely to leach beyond a soil depth of five meters.[1] In the Palouse study region, virtually no agrichemicals were predicted to leach beyond a depth of five meters. Relatively high water tables, higher rainfall, and sandier soils result in a much higher potential for water quality damage in the North Carolina Coastal Plain. In addition, rural population density is 12 times higher in this region, which indicates a greater human threat from polluted groundwater.

In the North Carolina Coastal Plain, three resource-conserving cropping systems are modeled: low-input corn, low-input corn preceded by an Austrian winter peas cover crop, and low-input corn preceded by a vetch cover crop. Conventional systems in the North Carolina study region include conventionally tilled corn, no-till corn, soybeans, double-cropped winter wheat and no-till soybeans, wheat, and tobacco. In the Palouse, alternative cropping systems include a grain-rapeseed rotation, a wheat-dry pea-unharvested legume rotation, a wheat-barley-green manure clover rotation, and a bluegrass-lentil-small grains rotation. These alternative systems do have some limitations for use on a commercial basis: fluctuating grass seed and rapeseed markets can make those rotations unprofitable, and agronomic problems have been associated with the green manure and unharvested legume crops. Conventional systems for this region include wheat-dry peas and wheat-barley-dry peas.

Results: North Carolina Coastal Plain

Tables 2 and 3 present policy-induced economic and environmental impacts for both regions when returns to management are maximized using expected 1991-95 prices. Returns to management in column (1) of Tables 2 and 3 reflect the optimal solutions to the MIP models converted to a per acre basis. The remaining columns represent post-optimization calculations for these solutions.

In the North Carolina Coastal Plain, policy reform could achieve substantial economic and environmental gains as measured in this study (Table 2). Recoupling (*RECUP*) increases returns to management by $21/acre over the 1990 Farm Bill (*1990 FB*) with alternative crops and by $34/acre when alternative crops are excluded (see column (1)). Returns to management are also increased, to a lesser extent, under the 1990 Administration Proposal (*ADMIN*) and Decoupling (*DECUP*). A small decline in returns to management occurs under the 1990 Farm Bill plus 40% Flex (*40% FLEX*). Under No Programs (*NO PROG*), returns

Table 2. Predicted Average Economic and Environmental Indicators When Maximizing Returns to Management by Policy Scenario, 1991-95 Expected Prices, North Carolina Coastal Plain.

Policy/Rotations Available	(1) Returns to Management ($/ac/yr)	(2) Returns to Land ($/ac/yr)	(3) Taxpayer Cost ($/ac/yr)	(4) Nitrogen Leaching (lbs/ac/yr)
1. 1990 Farm Bill				
a. All Rotations	36	110	22	54
b. No Alt. Rotations	23	110	22	91
2. 1990 Farm Bill, 40% Flex				
a. All Rotations	31	110	14	51
b. No Alt. Rotations	21	110	6	24
3. 1990 Admin. Proposal				
a. All Rotations	52	110	26	27
b. No Alt. Rotations	41	110	24	6
4. Decoupling				
a. All Rotations	41	110	22	29
b. No Alt. Rotations	34	110	22	6
5. Recoupling				
a. All Rotations	57	110	39	6
b. No Alt. Rotations	57	110	39	6
6. No Programs				
a. All Rotations	15	110	0	29
b. No Alt. Rotations	11	110	0	6

Table 3. Predicted Average Economic and Environmental Indicators When Maximizing Returns to Managment by Policy Scenario, 1991-95 Expected Prices, Washington-Idaho Palouse

Policy/Rotations Available	(1) Returns to Management ($/ac/yr)	(2) Returns to Land ($/ac/yr)	(3) Tax-payer Cost ($/ac/yr)	(4) Erosion Rate (t/ac/yr)	(5) Off-site Erosion Damage ($/ac/yr)	(6) On-site Erosion Damage ($/ac/yr)
1. 1990 Farm Bill						
a. All Rotations	6	53	23	5.6	14.0	1.3
b. No Alt Rotations	-6	61	23	6.1	15.1	1.4
2. 1990 Farm Bill, 40% Flex						
a. All Rotations	2	46	15	4.1	10.1	1.0
b. No Alt Rotations	-8	58	16	6.1	15.1	1.4
3. 1990 Admin						
a. All Rotations	11	52	28	5.3	13.1	1.3
b. No Alt Rotations	1	57	28	6.5	16.2	1.6
4. Decoupling						
a. All Rotations	5	43	23	2.1	5.2	0.5
b. No Alt Rotations	-1	61	23	6.3	15.5	1.5
5. Recoupling						
a. All Rotations	15	43	36	2.1	5.2	0.5
b. No Alt Rotations	-5	61	23	6.3	15.5	1.5
6. No Programs						
a. All Rotations	-9	36	0	2.1	5.2	0.5
b. No Alt Rotations	-19	53	0	6.3	15.5	1.5

to management are approximately half of those under *1990 FB*. Short-run returns to land are not impacted by these policy provisions, as cash rent dominates in the North Carolina study region. In terms of taxpayer cost, measured as government payments to farmers, outlays are $17/acre higher under *RECUP* than under *1990 FB*. Government payments are $2-$4/acre higher under *ADMIN* than under *1990 FB*. Taxpayer cost declines relative to *1990 FB* under the remaining scenarios.

When alternative crops are not available, nitrogen leaching is estimated at just 6 lbs/acre/year under *ADMIN, DECUP, RECUP,* and *NO PROG*, compared to 91 lbs/acre/year under *1990 FB*. Complete planting flexibility encourages profitable soybean production. Under these alternative policies, North Carolina Coastal Plain farmers no longer plant relatively unprofitable corn and wheat in response to government payments. Since wheat and corn are high nitrogen users, the potential for environmental damage from nitrogen leachate declines.

Paradoxically, environmental damage as measured by the nitrogen leaching estimates is predicted to be higher for the Coastal Plain when alternative rotations are available than when they are excluded, except under *1990 FB*. This result can be explained by the profit-maximizing choice when alternative rotations are available: low-input corn preceded by a nitrogen-fixing cover crop. When alternative rotations are *not* available, profit-maximizing farmers replace corn with soybeans under scenarios with increased planting flexibility. While the low-input corn with a cover crop is predicted to leach just 43 percent of the fertilizer nitrate-nitrogen of conventionally grown corn, this amount of leaching still exceeds the level predicted for soybeans.

RECUP and *ADMIN* are predicted to have the highest policy-induced gains in economic and environmental indicators, both with and without alternative crops, in the Coastal Plain study region. *RECUP* is more costly to taxpayers than *ADMIN*, however. Low nitrogen leaching both with and without alternative crops is achieved only under *RECUP*, where farmer incentives are tied to reduction of nitrogen and Banvel use. Under *ADMIN*, complete base flexibility allows soybean production on wheat and corn bases. Since soybeans do not require nitrogen or Banvel, *ADMIN* performs well based on the environmental criteria in this study. Evidence that intensive soybean production is increasing in the South is provided by 1987 Natural Resource Inventory data which revealed that over 70 percent of southern farmers planning to plant soybeans were doing so on land that had been previously cropped to soybeans in at least two of the previous three years (Ikerd).

Price sensitivity was examined by increasing market prices for corn, wheat, and barley to target prices. In the North Carolina study region, only *RECUP* produced low leaching estimates under the assumption of strong world grain markets (Table 4). Under other policy scenarios, profit-maximizing farmers exit the government program to plant intensive grain rotations, which increases nitrogen leaching. By including modest taxpayer expenditures for agrichemical use reductions, *RECUP* was able to substantially reduce environmental damage.

Results: Washington-Idaho Palouse

In the Washington-Idaho Palouse, returns to management also increase under *RECUP* and *ADMIN* and decline under *40% FLEX* and *NO PROG* (Table 3). Under *DECUP*, returns increase only when no alternative rotations are available. However, in this region of fewer profitable crop alternatives, less dramatic change is achieved with policy reform. Returns to land show that alternative rotations yield lower profits to landlords. Several of the alternative rotations include green manure crops which yield no immediate crop share for landlords. Under current farm program provisions, program crops yield lucrative deficiency payments which are split with landlords along with the crop share. Conventional rotations have a higher concentration of these program crops. The immediate decline in landlord's share under many alternative rotations may be a barrier to greater use of alternative rotations.

As in the North Carolina study area, *RECUP* has the highest taxpayer cost in the Palouse when all rotations are available (Table 3). When alternative rotations are excluded, only *ADMIN* has slightly higher tax cost than *1990 FB* as the flex

Table 4. Predicted Average Economic and Environmental Indicators When Maximizing Returns to Management by Policy Scenario, Program Crop Prices Set Equal to Target Prices, North Carolina Coastal Plain.

Policy/Rotations Available	(1) Returns to Management ($/ac/yr)	(2) Returns to Land ($/ac/yr)	(3) Tax-payer Cost ($/ac/yr)	(4) Nitrogen Leaching (lbs/ac/yr)
1. 1990 Farm Bill				
a. All Rotations	51	110	0	74
b. No Alt. Rotations	42	110	0	107
2. 1990 Farm Bill, 40% Flex				
a. All Rotations	54	110	0	74
b. No Alt. Rotations	43	110	0	107
3. 1990 Admin. Proposal				
a. All Rotations	52	110	0	77
b. No Alt. Rotations	39	110	0	114
4. Decoupling				
a. All Rotations	67	110	22	74
b. No Alt. Rotations	59	110	22	107
5. Recoupling				
a. All Rotations	59	110	19	29
b. No Alt. Rotations	42	110	19	51
6. No Programs				
a. All Rotations	48	110	0	74
b. No Alt. Rotations	40	110	0	107

provisions requiring 15 percent reduction in deficiency payments are not enforced (Figure 1). Erosion increases slightly under *ADMIN* relative to *1990 FB*; complete planting flexibility allows planting of the most profitable and most erosive crop, winter wheat. When profitable, environmentally sound alternative rotations are included in the model, erosion rates decline substantially under alternative policy scenarios that remove traditional farm program incentives favoring winter wheat. Wheat/pea/green manure is the optimal choice for 100 percent of the representative farm under *DECUP, RECUP,* and *NO PROG* when all rotations are included. Smaller percentages of this soil conserving system are used under policies with traditional farm program incentives. Unfortunately, this rotation has had mixed success after the initial three years of successful field trials (Goldstein); further work on this particular system is needed before farmers can be expected to adopt it.

For the Palouse region, both *DECUP* and *RECUP* reduce erosion damage substantially when alternative rotations are available (Table 3). Under *RECUP,* farm managers would benefit at the expense of taxpayers, as both returns to management and taxpayer cost increase relative to the *1990 FB*. Under *DECUP,* taxpayer cost is set equal to that under *1990 FB* by design (see Figure 1). Returns to land are $10/acre lower for both *DECUP* and *RECUP,* however. The *40% FLEX* policy scenario reduces erosion by 1.5 tons/acre/year relative to *1990 FB* when alternative rotations are available and also reduces taxpayer outlays by $8/acre. Under this scenario, both returns to management and returns to land decline somewhat relative to *1990 FB*.

In both regions, taxpayer cost increased most (relative to *1990 FB*) under *RECUP* and *ADMIN,* and, as would be predicted, fell under *40% FLEX* and *NO PROG.* Taxpayer cost is comprised of program crop deficiency payments under *1990 FB*, *40% FLEX*, and *ADMIN*. As specified earlier for *DECUP*, the farm-wide subsidy is set equal to that of *1990 FB* (see Figure 1), but is not tied to production decisions. The subsidy for *RECUP* is based on average farm-wide environmental performance, either erosion rate (Palouse) or leaching of nitrate-nitrogen and Banvel (Coastal Plain), and is targeted to reward "good" environmental performance with subsidy levels equal to those under *1990 FB*.

As in the North Carolina study area, price sensitivity analysis for the Palouse revealed that *RECUP* had superior performance when crop prices rose high enough to remove traditional incentives for farm program participation (Table 5). Conservation compliance provisions under 40% *FLEX* and *ADMIN* provide environmental protection only when farmers choose to participate. When market prices rise above target prices, profit-maximizing farmers exit the government program and use profitable but erosive winter wheat systems. Only *RECUP*, which pays farmers to reduce soil erosion and nitrogen use, protected the environment under high grain prices. It did so at high cost to taxpayers, but associated reductions in environmental damage and increases in farmer profits more than offset the growth in taxpayer expenditures.

Implications for Research and Policy

Projected impacts for the North Carolina Coastal Plain and the Washington-Idaho Palouse diverge considerably. Reformist policies were projected to bring economic and environmental gains without the availability of alternative crops in the North Carolina study region. In the Palouse, limited crop choice diminishes the potential for economic and environmental gains using policy reform alone. The development and transfer of alternative crop rotations is vital to reducing environmental damage in this region. In addition, policy benefits need to be decoupled from wheat production. Divergent regional impacts highlight the importance of detailed evaluations of national policies in different regions. Both economic and environmental impacts of policies depend greatly on site-specific land, climate, and farm structure characteristics.

The robust projected performance of *RECUP* in protecting the environment during periods of high market prices highlights an important policy choice for policymakers. If society wants to avoid losing environmental gains during periods of strong demand and high prices, farm program payments based on environmental performance rather than market price levels and historical production of program crops should be considered. However, the gains to farmers and society from *RECUP* comes at increased cost to taxpayers. Under average market prices, gradual program elimination coupled with development of sustainable technology may be more cost effective in some regions. When world grain markets are strong, results of this study show that environmental degradation can be expected unless recoupled programs are adopted. Congress will need to balance the importance of budgetary reductions and environmental protection. Regionally specific environmentally recoupled policies might cost less than policies with uniform national standards. Further research and development to perfect environmentally sound and profitable sustainable farming technologies will improve the cost effectiveness of recoupled policies.

The results of this study strongly suggest that policy reform and technology development are both important to achieve an economically and environmentally sound agriculture. Policy reform without simultaneous investment in the development and extension of appropriate sustainable technology will have limited payoff in regions like the Palouse that lack profitable and environmentally sound cropping alternatives. However, in areas similar to the North Carolina Coastal Plain, policy reform could enhance economic and environmental performance with currently available cropping technology. Of course, caution should be exercised in generalizing the results from these two regional case studies nationally. Similar farm-level case studies of policy impacts are needed for other important production regions.

Table 5. Predicted Average Economic and Environmental Indicators When Maximizing Returns to Management by Policy Scenario, Program Crop Prices Set Equal to Target Prices, Washington-Idaho Palouse

Policy/Rotations Available	(1) Returns to Management ($/ac/yr)	(2) Returns to Land ($/ac/yr)	(3) Tax-payer Cost ($/ac/yr)	(4) Erosion Rate (t/ac/yr)	(5) Off-site Erosion Damage ($/ac/yr)	(6) On-site Erosion Damage ($/ac/yr)
1 1990 Farm Bill						
a. All Rotations	26	48	0	10.4	32.8	2.3
b No Alt. Rotations	26	48	0	10.4	32.8	2.3
2. 1990 Farm Bill, 40% Flex						
a. All Rotations	22	49	0	9.9	31.0	2 0
b No Alt. Rotations	22	48	0	10.4	32 8	2 1
3. 1990 Admin. Proposal						
a. All Rotations	27	49	0	10.4	32.8	2.3
b. No Alt. Rotations	27	49	0	10.4	32.8	2.3
4. Decoupling						
a All Rotations	30	64	23	5.7	18.0	1 1
b No Alt. Rotations	11	61	23	6.3	19.7	1.1
5. Recoupling						
a. All Rotations	50	69	54	2.1	6.6	0.5
b. No Alt. Rotations	34	75	35	6 2	19.4	1.3
6. No Programs						
a All Rotations	25	48	0	10.4	32.8	1.9
b. No Alt. Rotations	25	48	0	10.4	32.8	1.9

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Endnotes

1. Data were not available on mineralization of organic residues, thus leaching estimates predict movement of fertilizer nitrate-nitrogen only.