Effects of Agri-Environmental Payment Policies on Agricultural Trade

Joseph Cooper, Mark Peters, and Roger Claassen[1]

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[1] The first and third authors are economists in the Resource Economics Division, Economic Research Service (USDA), 1800 M Street, NW, Washington DC, 20036-5831, USA (E-mail: jcooper@ers.usda.gov and claassen@ers.usda.gov, respectively), and the second is an economist with the Agricultural Marketing Service, USDA, but was with ERS when he contributed to this paper. The views expressed are the authors' and do not necessarily represent policies or views of their respective institutions.

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Abstract

In many OECD countries, including the U.S., interest in developing agri-environmental payment programs is currently strong. In the future, the inclusion of an agri-environmental payment program into the WTO's "green box" could be more easily challenged by WTO member countries on the basis that it has more than "minimal" trade-distorting impacts on production. The goal of this paper is to conduct an *ex ante* analysis of the trade impacts of stylized examples of agri-environmental payment programs that have been proposed for implementation in the near future. To simulate the production and trade impacts of these programs, we use a partial equilibrium model of the U.S. agricultural sector in a sensitivity analysis across a range of design options for agri-environmental payments. For the three agri-environmental payment scenarios evaluated, the maximum change in exports ranges from a 7 percent *decrease* (wheat) to a 1 percent *increase* (soybeans). We do not expect the programs that decrease U.S. production, which would tend to have an upward pressure on world commodity prices, to be challenged before the WTO.

I. Introduction

Cooper, Johansson and Peters (2003) present an environmental assessment of agricultural trade liberalization. As outlined in that paper, interest in assessments of this type is strong, with numerous agencies and organizations around the world sponsoring or calling for such activities. However, scant attention has been paid to empirical assessments of the converse issue. Namely, what are the impacts of agri-environmental programs on agricultural trade?

The Uruguay Round Agreement on Agriculture (URAA) completed in 1994 under the auspices of GATT, differentiated domestic support policies into various "boxes" according to their effects on production and trade. "Green Box" policies, or domestic farm programs that meet certain criteria for causing minimal trade distortions, including many agri-environmental programs, were exempted from any expenditure limits.

Agri-environmental payment programs can improve the environmental performance of agriculture and provide an alternative source of farm income (Claassen and Horan; Batie; Lynch and Smith; Smith; Feather and Cooper). Programs that have both environmental and farm income objectives are sometimes referred to as "green payment" programs. The 2002 Farm Act creates a new program that can both improve environmental performance and provide some income support to producers. The Conservation Security Program (CSP) can provide payments that exceed the cost-sharing provided by existing programs (e.g., the Environmental Quality Incentives Program, or EQIP) for the adoption and/or maintenance of environmentally benign best management practices (BMPs). Beginning in 2003, producers participating in CSP could receive cost-sharing in amounts similar to that provided by EQIP for practice adoption, plus cost-sharing for the maintenance of previously adopted practices, plus other payments that will depend on the producer's overall level of conservation effort (i.e., the number of resource concerns addressed and whether these concerns are addressed on all or only part of the farm).

Unlike commodity program payments, agri-environmental programs meeting the design criteria for the WTO's 'green box' would not be subject to the World Trade Organization (WTO) limits on subsidizing production. The CSP is an example of such a program, and is essentially an analog to several types of EU agri-environmental subsidies allowed under their Reg. 2078/92.[2] Article 13 ("due restraint"), otherwise known as the "Peace Clause," of the WTO's Agreement on Agriculture, protects countries using subsidies that comply with the agreement from being challenged under other WTO agreements. Without this "peace clause", under the Subsidies and Countervailing Measures Agreement and related provisions, WTO-member countries would have greater freedom to take action against each others' subsidies. However, the peace clause is due to expire at the end of 2003. In the future, an agri-environmental payment program that meets the "basic criteria" and "specific criteria" required for its inclusion into the WTO's "green box" could nonetheless challenged by WTO member countries on the basis that it does not meet the "fundamental requirement" for inclusion in the green box.[3] Namely, after expiration of the peace clause, even agri-environmental programs that technically satisfy the "criteria" outlined in the green box text could be challenged if some country estimates that the program has more than "minimal" trade-distorting impacts on production.[4] On the other hand, the peace clause could be renewed. In any case, the concept of the green box is an economic concept, and policy instruments that fall into this category are supposed to be minimally trade-distorting (Josling, 2000).

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[2] EU agri-environmental programs are expatiated on in Bernstein, Cooper, and Claassen (2003) and <http://europa.eu.int/comm/agriculture/envir/programs/evalrep/text_en.pdf>.

[3] The "fundamental requirement" for domestic support programs is "that they have no, or at most minimal, trade-distorting effects or effects on production." Accordingly, all measures for which exemption is claimed shall conform to the following "basic criteria": "a) the support in question shall be provided through a publicly-funded government program (including government revenue foregone) not involving transfers from consumers; and, b) the support in question shall not have the effect of providing price support to producers."

In addition, payments under environmental programs must meet the following policy "specific criteria" and conditions: "a) Eligibility for such payments shall be determined as part of a clearly-defined government environmental or conservation programme and be dependent on the fulfilment of specific conditions under the government programme, including conditions related to production methods or inputs; and b) The amount of payment shall be limited to the extra costs or loss of income involved in complying with the government programs." (http://www.wto.org/wto/english/docs_e/legal_e/14-ag_02_e.htm).

[4] The peace clause is discussed at http://www.wto.org/english/tratop_e/agric_e/negs_bkgrnd10_peace_e.htm.

The goal of this paper is to conduct an *ex ante* analysis of the trade impacts of stylized examples of potential agri-environmental payment programs. As actual programs of the type we consider here are not yet implemented in the U.S., we consider several hypothetical programs that are discussed in the next section. To simulate the production and trade impacts of these programs, we use the USMP partial equilibrium model (see the appendix).

II. Agri-environmental Program Scenarios

To maintain consistency with other ERS research on agri-enviromental payments, we consider the trade impacts of the agri-environmental program scenarios considered in Claassen *et al.* (2001). We examine the impacts of the programs on exports of the three major grains (corn, wheat, and soybeans) for three scenarios that cover a range of conservation activities and farm income support objects. The two bases for conservation payments are *good performance* and *improved performance*. Good performance refers only to the state of environmental performance, without regard to when that performance was achieved, while improved performance refers only to actions undertaken in the context of program enrollment. In these hypothetical scenarios, the environmental objective is to reduce water quality damage due to sediment. Estimates of sediment damage, including that to freshwater recreation, ditch maintenance, municipal and industrial water uses, navigation, water storage capacity, and flooding, are roughly $287 million per year (Feather, Hellerstein, and Hansen, 1999; Ribaudo, 1989). At the farm level, soil conservation or erosion reduction is the focus of the program alternatives.

Our stylized scenarios do not precisely match any existing or pending program. We analyze some program designs that are relatively inefficient in terms of targeting, and as such, can be expected to have relatively large market impacts. Programs that are targeted toward farms that are best able to achieve the environmental objectives and in which payments are more carefully tailored to producer costs (even if payments exceed those costs by some modest amount) can be expected to produce greater environmental benefits, at a lower cost to the economy, and with less commodity market impact. Payments are based on erosion rates or erosion reductions and are not crop- specific. While different crops do have different erosion consequences, payments do not depend directly on crop choice. For each of our three scenarios, we look at a range of payment rates that result in programs that spend as much as $3 billion in agri-environmental payments to producers. The upper end of this range is as much, or more than, anticipated expenditures for the new Conservation Security Program (CSP), for which the Congressional Budget Office (CBO) estimates expenditures of $2 billion over 10 years. Moreover, the estimated potential to increase production, and decrease world prices, would most likely be larger for our scenarios than for CSP, given that CSP has stronger acreage limits than any scenario evaluated here.

The *good performance* base requires the farmer to use a “low rainfall erosion” production system, i.e., a production system with a rainfall erosion rate below that for a system using a predominant crop rotation in combination with conventional tillage on the same soil and in the same region. Essentially, this example was chosen as being representative of fairly basic environmentally benign production practices that many farmers already use. Payments per acre under our hypothetical program are equal to soil conserved (tons per acre) multiplied by a payment rate per ton of soil conserved. Soil conserved is the difference between: (1) the maximum erosion rate observed for any production system for a given soil in a given region (the reference level); and (2) the estimated rate of erosion for the "low rainfall erosion" system in use on the same soil in the same region. Payment rates used in the analysis range from $1 to $4 per ton of soil erosion reduction.[5]

The *good performance* base is further broken down into two policy scenarios – *sodbuster* and *no sodbuster* – that have potentially different implications for farm income and expansion of commodity production. *Good performance with the sodbuster* scenario is similar to sodbuster provisions of current commodity policy, and farmers in the program who bring previously uncropped highly erodible land (HEL) into production lose other farm program benefits. With the *good performance with no sodbuster* scenario, farmers in the program who bring previously uncropped highly erodible land (HEL) into production do not lose other farm program benefits. Hence, we would expect *a priori* that the *good performance with no sodbuster* program would be more likely to increase production than that with the *sodbuster* provision.

The *improved performance* base requires the farmer to reduce erosion from pre-program levels. Payments are based on actual erosion reduction from pre-program levels rather than erosion relative to the reference level. Payments per acre under our hypothetical program are equal to erosion reduction (tons per acre) multiplied *by* payment rate per ton of erosion reduction. Payment rates used in the analysis range from $4 to $14 per ton of erosion reduction[6]. Payment rates are higher than under the good performance standard because the

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[5] For the good performance base, payment to a specific production system is calculated as: $s_k \max(e_k^r - e_{ki}, 0)$ where *k* indexes regions (a geographic area/soil combination), s_k is the payment rate for region *k*, e_k^r is the "reference level" for region *k*, and e_{ki} is the erosion rate for system *i* in region *k*. The incentive is fixed so the program size (total government subsidy expenditure) is endogenous.

[6] For the *improved performance* base, payment to a specific production system is calculated as: $s_k(e_k^b - e_k)$ where s_k is the payment rate for region *k*, e_k^b is the erosion pre-program baseline, and e_k is erosion. Essentially each USMP region is treated as a representative farm. Again, the incentive is fixed so the program size (total government subsidy expenditure) is endogenous.

program budget (up to $3 billion) can support higher payment rates when funds are focused only on erosion reduction.

The simulation results of the *improved performance base* can serve as a useful comparison to those from the *good performance with sodbuster* as the former is reminiscent of the more economically efficient existing USDA programs that provide financial incentives to adopt BMPs only to farmers that do **not** currently use the BMPs. One would not expect *a priori* that this improved performance base program would lead to expanded crop production. In fact, the higher the payment, the more willing the farmer is to reduce erosion, and subsequently, the more likely production is to fall; the improved performance scenario requires that erosion be reduced throughout the farm, and hence, initiation of crop production on grass/forest land would count against the producer in terms of total erosion. Hence, the meeting of this expectation by the simulations serves as a check on the reliability of the model.

III. Results of the Analysis

For analyzing the impacts of the three programs on production and exports, the scenarios are integrated into the USMP model of the U.S. farm sector. The domestic impact of the alternative program designs are measured in three ways: water quality benefits, the change in farm income, and net costs to the economy. Water quality benefits per ton of soil erosion reduction vary spatially as shown in fig. 1 (see the appendix for a discussion of the derivation of the estimated dollar value of water quality damage per ton). Net economic cost is the change in total agricultural producer and consumer incomes that result from the subsidy program. These costs include the direct cost of changing production management or conservation practices to reduce erosion and indirect costs such as the loss of commodity output if producers shift to less erosive but less productive production systems[7]. Payments to producers are *not* a net cost to the economy, but rather a transfer from taxpayers to agricultural producers[8].

Water quality benefits are modest relative to net economic costs. The values the public places on reductions in soil erosion have been estimated for the following environmental amenities: municipal water use, industrial uses, irrigation ditch maintenance, road ditch maintenance, water storage, flooding, and soil productivity (Ribaudo *et al.*, 1990; Ribaudo, 1986), freshwater-based recreation (Feather *et al.*, 1999), and navigation (Hansen *et al.*, 2002). Of course, these represent only a subset of the environmental amenities affected by sediment. Among the amenities not included are increases in waterfowl populations, cleaner coastal and estuarine recreation areas, population survival of endangered species, and quality of commercial fisheries. Therefore, the values used here should be viewed as a minimum estimate of total environmental benefits. For the *improved performance* base, water quality benefits exceed net economic costs for programs of roughly $1.1 billon or less (fig. 2). For larger programs, net economic cost exceeds water quality benefits. For the *good performance with sodbuster* scenario, net economic costs are equal to or exceed water quality benefits over the full range of program sizes analyzed. For *good performance without sodbuster*, previously uncropped HEL land is eligible for subsidy payments, so crop production expands significantly onto uncropped HEL, resulting in a net *increase* in soil erosion and an increase in water quality damage.

[7] Government expenditures for program implementation are a real cost to the economy but could not be included in our modeling framework.

[8] Raising government funds through taxation to make these payments imposes real costs on the economy. The economic cost of taxation is the value of economic activity lost due to the tax. Taxes on productive resource will reduce the utilization of those resources. For example, an increase in the tax on labor income may prompt some workers to leave the workforce, reducing production. While the magnitude of these costs is unknown, reasonable estimates range from 20 and 50 cents for each dollar of additional tax revenue (Browning, 1987).

Farm income gains are significant across all policy designs analyzed (fig. 3). For the *improved performance* base, farm income gains exceed producer payments because commodity prices rise (and hence, consumers pay more), albeit modestly. Much of the payment also translates directly into farm income gains because some erosion reduction can be achieved at a cost lower than the payment offered. For example, for a payment of $5 per ton of erosion reduction, producers would take all erosion reduction actions that could be achieved for $5 per ton *or less*. For the *good performance* base, producers mostly collect payment for past conservation actions and do little to further reduce soil erosion. Commodity prices are largely unaffected, and hence, consumers are not affected. Payments pass through more-or-less directly to farm income.

Figures 4 through 6 present the changes in U.S. exports as a function of the agri-environmental payments by crop.[9] Note, however, that in the analysis, payments are not varied explicitly by commodity. The actual payment system splits the nation into 90 zones (45 USMP regions each with a non-HEL and an HEL soil). For all three commodities, the improved performance program leads to exports falling as agri-environmental payments increase, with a 7 percent fall in the case of wheat. Exports increase under the *good performance without sodbuster* provision scenario for all three commodities. Exports are essentially flat, with only slight increases under the *good performance with sodbuster* scenario for all commodities except wheat, which experiences a slight decrease. This decrease is due to some shifting of production from wheat to the other commodities as stewardship payments increase. This switching is likely a consequence of soil conserved varying by commodity, and hence, stewardship payments differing slightly by commodity. If

[9] In our partial equilibrium model for the U.S. agricultural sector, world prices move along the import and export functions as determined by the import and export demand and supply elasticities. Of course, as the model is otherwise limited to the U.S. sector, it cannot incorporate any more advanced game theoretic principles about how the other countries might react than what is contained in these elasticities in the import and export functions.

we consider the export increases in percentage terms, the maximum changes for the program with the maximum increase in exports – namely, *good performance with no sodbuster provision* – are very small. With increases of less than 0.5% in the case of corn and approximately 1% for the other two, we donot expect major impacts of the program on the world prices of the commodities, even with this particular program that actually lowers environmental benefits. The 7 percent fall in wheat exports associated with the *improved performance* scenario is a more notable impact on world trade, but one unlikely to be challenged by other WTO members.

IV. Conclusion

As a result of the Uruguay Round in 1995, WTO members agreed that funding for most domestic support policies (through the Aggregate Measure of Support) would have to be reduced. However, an exception was made for agricultural support policies that have a minimal impact on production and trade. Such policies are exempt from funding reductions and are commonly referred to as green box policies.

Given the current interest in the U.S. in expanding agri-environmental payment programs, an important question is whether or not some of these potential programs have more than a "minimal" impact on production and trade. We would expect *a priori* that cost sharing agreements that simply cover the cost difference per acre of adopting environmentally benign management practices would have a minimal impact on production and trade. However, addressing the question becomes more complex when the farm stewardship payments have the potential to increase income.

The results of our analysis of potential agri-environmental payment programs in the U.S. suggest that they would present minimal trade distortions. While "minimal" in the WTO definition is not defined and is open to interpretation (Nelson, 2002), the maximum increase in predicted exports, at around 1%, is relatively small.[10] In practice, within the WTO trade negotiations context, countries tend not to challenge programs that decrease production, as do some of the scenarios discussed here. As such, inclusion of these programs into the WTO ‘green box’ should draw little concern on the basis of their contribution to trade-distortion. On the other hand, the three programs considered here may not meet the specific “green box” criteria, which states that producers should not be compensated for more than their costs of adopting the practices, and could be challenged on that basis, at least after the Peace Clause expires in 2003. However, more carefully targeted and tailored policies may not be as easily challenged. Note that, as of August 2002, while many of the over 260 disputes brought before the WTO’s Dispute Settlement Body since its inception address agricultural issues, none specifically target agri-environmental programs.

A potentially interesting line of research would be to examine the production and trade implications of EU agri-environmental payment programs allowed under regulations EC 2078/92 and 1257/1999. Agri-environmental policy in the EU is in fact now a part of the EU’s policy on rural development. Due to this inclusion, it can be difficult to separately identify EU rural development programs (i.e., programs that generally address farm income issues) from agri-environmental programs. [11] For example, EU regulation (as embodied in EC 1257/99) allows for compensatory payments to farmers who produce in less-favored areas, such as mountainous areas, areas threatened with abandonment, or areas in which “the maintenance of agriculture is necessary to ensure the conservation or improvement of the environment, the management of the landscape, or its tourism value.”[12] [13]

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[10] In addition, an increase in production and consequent decrease in price as a result of an agri-environmental program could be of domestic policy concern in the extent that it increases the cost of traditional commodity programs such as price supports.

[11] See http://europa.eu.int/comm/agriculture/envir/index_en.htm for an example of the EU’s integration of rural development and conservation.

[12] See <http://europa.eu.int/comm/agriculture/envir/programs/evalrep/text_en.pdf> for more detail on EU agri-environmental programs.

A second implication of our analysis applies to potential policy responses to the environmental consequences of agricultural trade liberalization. For instance, it could be possible to respond to regional increases in environmental consequences by targeting those regions with higher levels of farm stewardship payments in order to increase conservation program adoption. Our results demonstrate that the effects of the farm stewardship payments on trade are likely to be small, and hence, bode well for devising a system of harmonization of trade and environmental policy, or perhaps more feasibly in the short run, for developing agri-environmental policy responses to trade-induced environmental consequences.

[13] EC 2078/92 is the forerunner to EC 1257/99.

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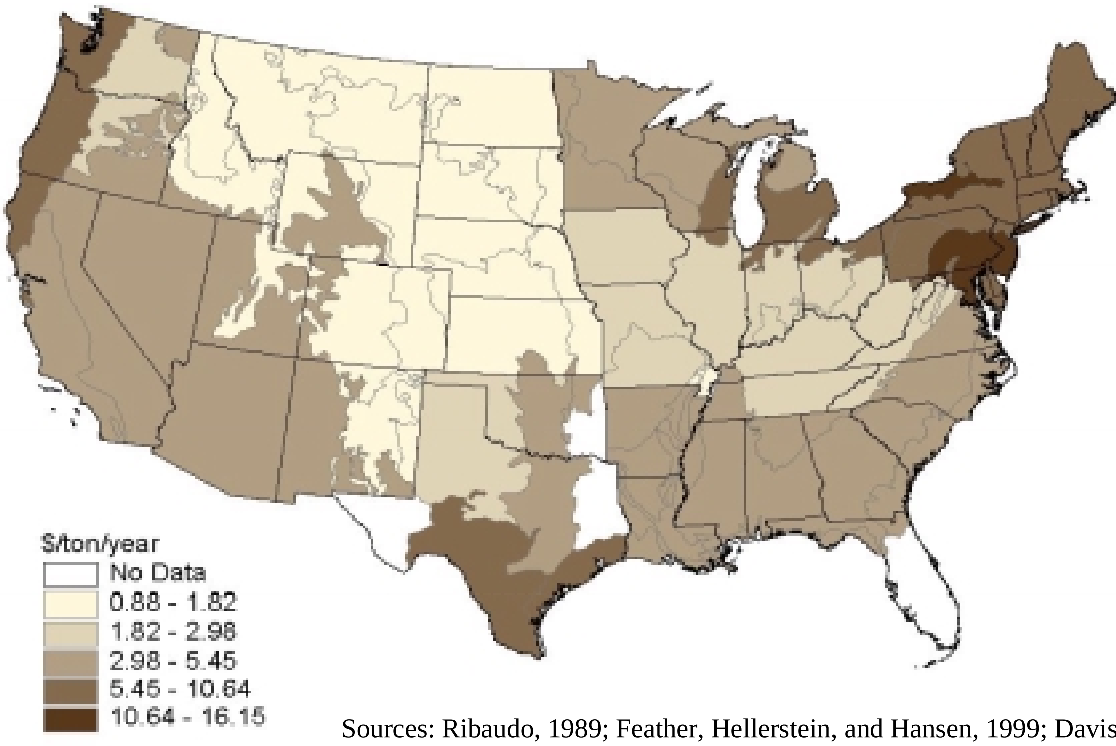
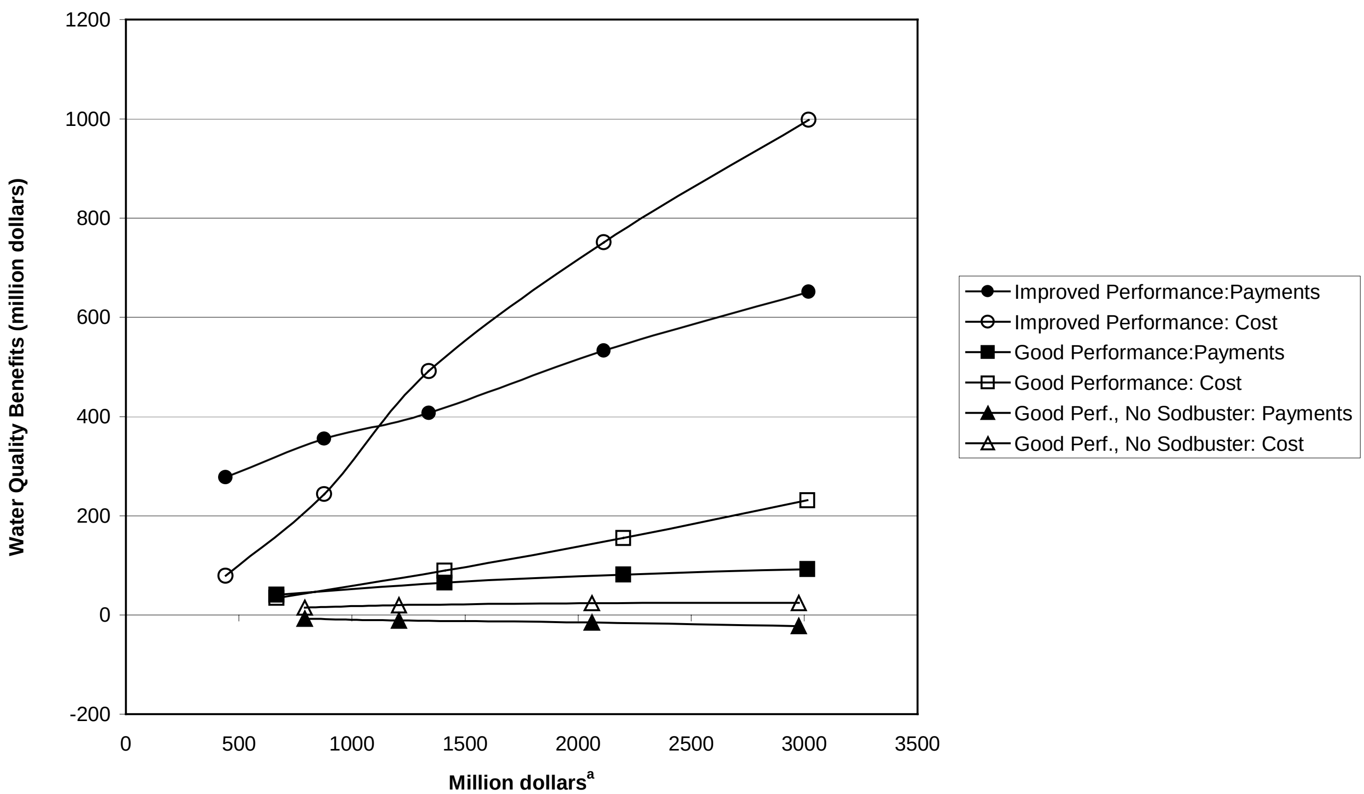
Fig1. Estimated Water Quality Damage from Soil Erosion



Sources: Ribaudo, 1989; Feather, Hellerstein, and Hansen, 1999; Davison and Hansen, 2000.

Fig. 2. Water Quality Benefits as a Function of Payments to Producers and of Net Economic Costs



[a] ***Producer payments*** are the government expenditure for payments to producers, excluding conservation planning, technical assistance, and enforcement costs. ***Measured cost*** reflects the change in total income in the economy required to produce the agri-environmental gains due to the subsidy program, including the direct cost of changing production management or conservation practices to achieve environmental gains and indirect costs such as the loss of commodity output if producer shift to less erosive but less productive production systems. The m*easured costs* reported here *do not include* (1) payments to producers, (2) government expenditures for program implementation, and (3) economic costs of raising taxes to fund government program expenditures. Producer payments are not included because they are transfers of income from taxpayers to agricultural producers rather than actual costs to the overall economy.

Fig. 3. The Relationship Between Farm Income and Conservation Program Payments for the Hypothetical Scenarios

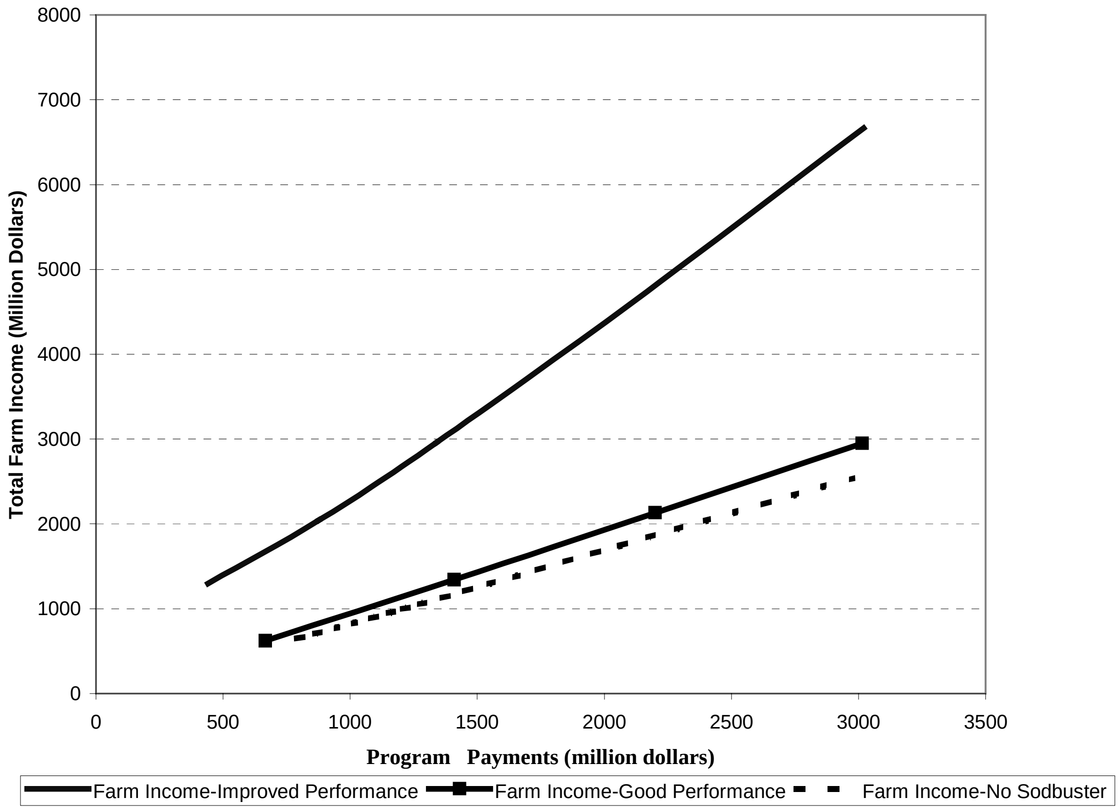
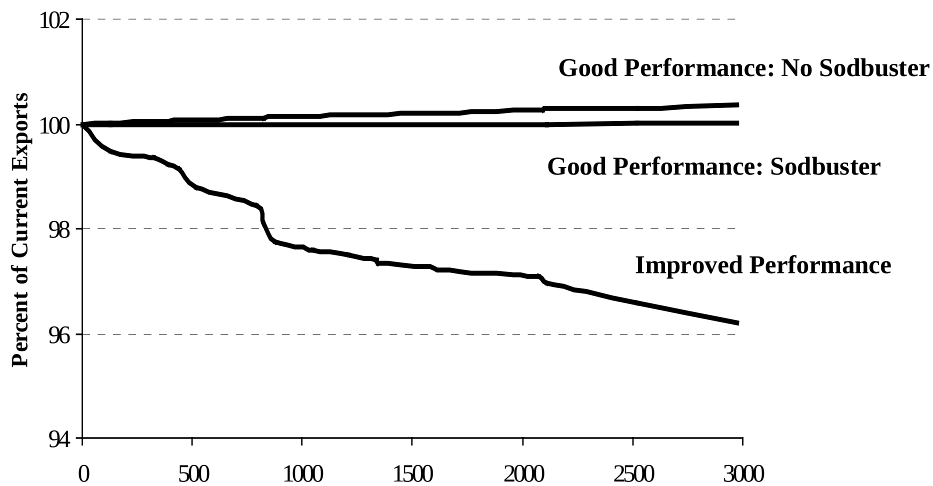


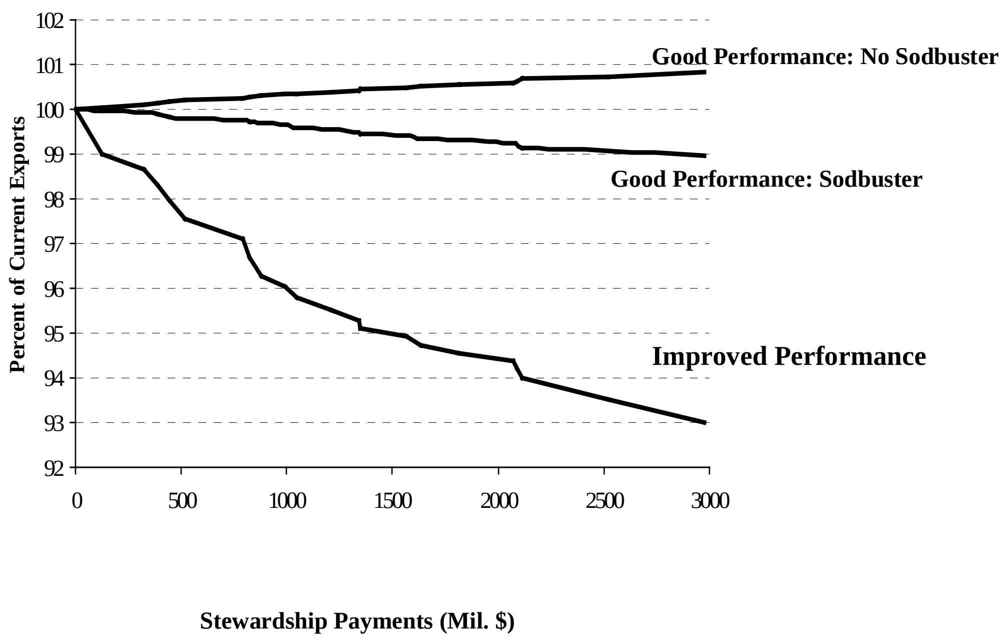
Fig. 4. Corn Exports and Stewardship Payments



Stewardship Payments (Mil. $)*

*Total payments to all cereals producers

Fig. 5. Wheat Exports and Stewardship Payments



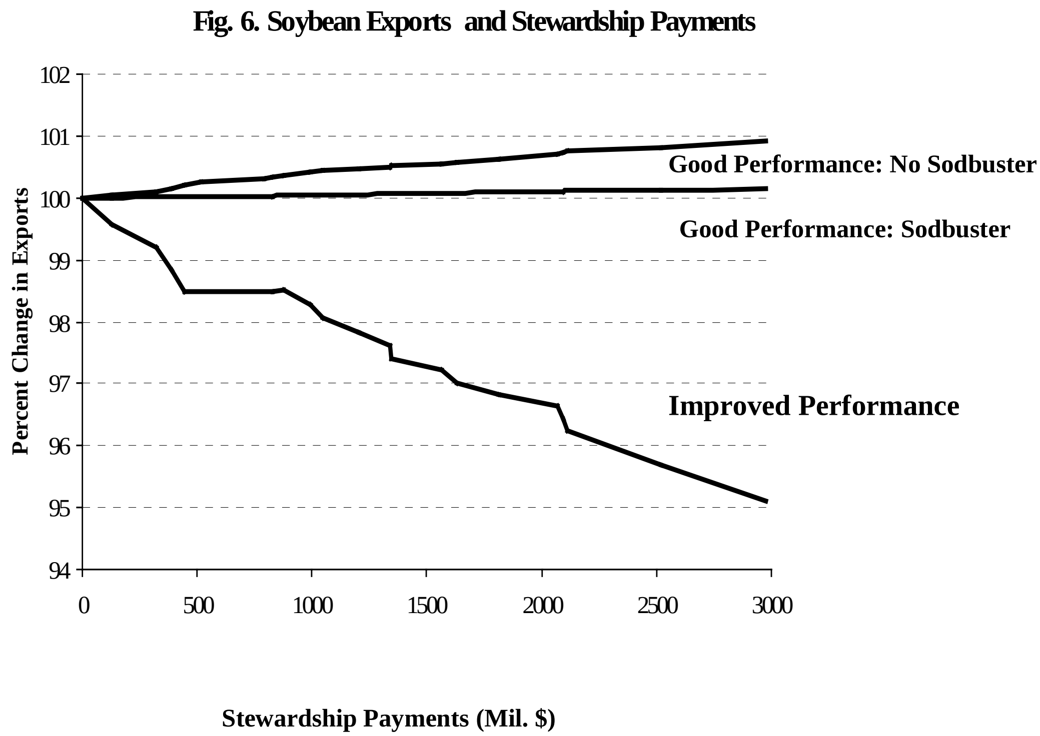


Fig. 6. Soybean Exports and Stewardship Payments
Percent Change in Exports
102
101
100
99
98
97
96
95
94
0
500
1000
1500
2000
2500
3000
Good Performance: No Sodbuster
Good Performance: Sodbuster
Improved Performance
Stewardship Payments (Mil. $)

Appendix. U.S. Mathematical Programming Model (USMP)

To consider the effects of alternative environmental policies on traded volumes and agriculture's environmental performance, we employ USMP, a regional model of the U.S. agricultural sector. USMP is a comparative-static, spatial and market equilibrium model of the type described in McCarl and Spreen (1980). The model incorporates agricultural commodity, supply, use, environmental emissions and policy measures (House, McDowell, Peters, and Heimlich, 1999). The model has been applied to various issues, such as design of agri-environmental policy (Claassen et. al., 2001), regional effects of trade agreements (Burfisher et al., 1992), climate change mitigation (Peters, et al., 2001), water quality (Johansson and Kaplan, 2003; Kaplan and Johansson, 2003; Ribaudo et al., 2001; Peters et al., 1997), irrigation policy (Horner, et al., 1990), ethanol production (House et al., 1993), wetlands policy (Heimlich et al., 1997; Claassen et al., 1998), and sustainable agriculture policy (Faeth, 1995).

USMP estimates equilibrium levels of commodity price and production at the regional level, and the flow of commodities into final demand and stock markets. Geographic units consist of 45 model regions within the United States based on the intersection of the 10 USDA Farm Production Regions and the 25 USDA Land Resource Regions (USDA, SCS, 1981). Within each region, highly erodible land (HEL) is distinguished from non-HEL. Twenty-three inputs (e.g., nitrogen fertilizer, energy, labor) are included as are 44 agricultural commodities (e.g., corn, hogs for slaughter) and processed products (e.g., soybean meal, retail cuts of pork). Crop production systems are differentiated according to rotation, tillage, and fertilizer rate. Production, land use, land use management (HEL, non-HEL, crop mix, rotations, tillage practices), and fertilizer applications rates are endogenously determined. Substitution among the production activities is represented with a nested constant elasticity of transformation function. Parameters of the nested-CET function are specified so that model supply response at the national level is consistent with supply response in the USDA's Food and Agriculture Policy Simulator (McDowell, Kramer, Randall, and M. Price) an econometric estimated national level simulation model of the U.S. agriculture sector. The version of the model used in the analysis has the same elasticities as the ERS/Penn State Model.

USMP explicitly models producer risk with respect to selection of nitrogen fertilizer application rates. Producer selection of nitrogen fertilizer application rates will depend on the expected returns and producers perception of risk to those returns. Producers' perceptions of risk are represented in USMP with a risk premium that increases exponentially with the reduction in nitrogen fertilizer application rates from the base application rate. While reducing nitrogen fertilizer application rates will reduce the variation in net returns it may also reduce the yield attainable under good growing conditions. Producers, however, are likely to be more concerned with making sure that yields are not constrained by lack of nitrogen to the plant under good growing conditions than they are with the costs associated with over application of nitrogen fertilizer under poor growing conditions. Consequently, producers will likely view the reduction of their nitrogen fertilizer application rates below that needed to achieve maximum yields under good growing conditions as risky, and will require a premium above that of the expected return for reducing their fertilizer application rates below what they believe to be needed to assure maximum yields under good growing conditions.

Major government agricultural programs, chiefly the Flexibility Contract Program (FCP), the Conservation Reserve Program (CRP), and conservation compliance are also represented. The most important of these for this analysis is conservation compliance, which limits expansion of production onto HEL by requiring producers to forego FCP and CRP payments when bringing new HEL into production without implementing an approved conservation system.

On the demand side, domestic use, trade, ending stocks and price levels for crop and livestock commodities and processed or retail products are determined endogenously. Trade is represented with excess demand and supply curves, with the assumption that there is no policy response by the rest-of-world to U.S. environmental policies. Hence, trade volumes respond to changes in prices. USMP allocates production practices regionally based on relative differences in net returns among production practices by region.

With data from U.S. Department of Agriculture (USDA) production practice surveys (Padgitt et al. , 2000), the USDA Long-Term Agricultural Baseline (USDA, WAOB, 1998), the National Resources Inventory (USDA, SCS, 1994), and the Erosion/Productivity Impact Calculator (Williams et al., 1990), USMP is used to estimate how changes in environmental or other policies affect U.S. input use, production, demand, trade, world prices, and environmental indicators.

Environmental indicators include soil erosion, losses of nitrogen and phosphorous to ground and surface water, volatilization and denitrification of nitrogen, nitrogen runoff damage to coastal waters and erosion damage.[14] [15] Environmental emissions for each crop production activity were obtained from simulations of the production activities using the Environmental Policy Integrated Climate model, or EPIC (formerly known as the Erosion Productivity Impact Calculator) (Williams et al., 1990). EPIC utilizes information on soils, weather, and management practices, including specific fertilizer rates, and produces information on crop yields, erosion, and chemical losses to the environment. For the

[14] Denitrification is the process by which nitrogen is released to the atmosphere due to bacterial action in wet and compact soils and volatilization occurs when fertilizer applied releases directly to the environment. The sum of these is the USMP indicator “nitrogen loss to the atmosphere.”

simulations management practices and initial fertilizer application rates were set consistent with agronomic practices for the 45 regions as reported in the USDA's Cropping Practices Survey. Yield and environmental indicators—such as, nitrogen losses and erosion—were then estimated by running each of the cropping systems represented in USMP through EPIC. Take, for example, the process of constructing USMP's erosion indicator. In the first step, yields were obtained by running EPIC for 7 years for each crop in the rotation with erosion rates set at zero and the distribution of rainfall and temperature set to match reported rainfall and temperatures for the seven-year period from 1989-1995 for each region. Erosion rates were set at zero to ensure that the yields were a function of weather and not of losses in soil productivity. Average yields by crop for each region were calculated from NASS county data for this same time period and used to evaluate EPIC's performance in simulating crop growth. EPIC based average yields by crop and region came within 10 percent of average reported yields for these crops and regions over the seven-year period. The environmental indicators were then obtained by running the systems through EPIC with erosion rates set at zero for a period of sixty years. This permitted the systems to be run through two complete cycles of the weather distribution, removing the effect of particular weather pattern on the results. For the estimation of nitrogen losses, a similar two-step process was repeated for nitrogen application rates representing 10-, 20-, 30-, 40-percent reductions from their initial values.

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[15] For information on the environmental impacts of agriculture, please see the ERS Briefing Room on Conservation and Environmental Policy (ERS, 2001) as well as the Briefing Room on Global Climate Change (ERS, 2000a).

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