Some Domestic Environmental Effects of US Agricultural Adjustments under Liberalized Trade: A Preliminary Analysis

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Abstract

This paper analyzes the environmental impacts of agricultural trade liberalization on various indicators of environmental quality, including manure production, soil erosion, nitrogen and phosphorous loss to water, at the national and regional levels. We assess the environmental impacts of a hypothetical trade liberalization scenario involving the elimination of all agricultural policy distortions in all trading countries. We can view this extreme scenario as an upper bound on the possible effects of potential trade liberalization outcomes. The estimated changes in U.S. agricultural production, even in this scenario of full agricultural trade liberalization, are well within the bounds of average seasonal variation in U.S. agricultural commodity production seen over the last thirty five years. This general characterization of the results aside, we note that the estimated changes in commodity production and subsequent environmental impacts are not uniform across the landscape, with small increases in agricultural production and environmental quality in some regions and decreases in others.

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Executive Summary

This paper evaluates some of the environmental impacts on the U.S. of a trade liberalization scenario involving the elimination of all agricultural policy distortions (i.e., agricultural subsidies and tariffs) that were in place in the year 2000 in all trading countries (and no changes in environmental policies relative to 2000). This empirical simulation of a total trade liberalization scenario provides an upper bound on the possible market effects of more probable scenarios of partial trade liberalization. We find that, even for this extreme case scenario, the estimated changes in U.S. agricultural production are within the bounds of normal seasonal variation in U.S. agricultural commodity production as observed over the last thirty-five years. Therefore, the results of this analysis suggest that, for the U.S. as a whole, environmental impacts stemming from the hypothesized trade shocks will also most likely fall well within average seasonal variation. Note that we are not implying that there will likely be no increase in environmental effects, but simply that the estimated increases are likely to be small. This general characterization of the results aside, we note that the estimated changes in commodity production and the environmental impacts are not uniform across the United States, with increases in agricultural production and environmental indicators in some regions and decreases in others.

Regarding the highlights of the regional changes demonstrated by the numerical simulation, corn production is likely to increase in all U.S. regions, with most regional changes being marginal. The potential changes in wheat production are fairly homogenous across regions

and within plus or minus two percentage points. Soybean production is likely to fall marginally in all regions.

Changes in the livestock and feed sectors are also predicted to be marginal overall, with some variation at the regional levels. For example, while dairy production falls nationally, many regions exhibit increases in production. Swine production is likely to remain relatively unchanged following agricultural trade liberalization. The changes in the beef sector differ by region, with marginal decreases in some regions and marginal increases in others. Poultry production is predicted to increase marginally in most regions.

The potential national changes in environmental impacts are generally marginal, simply because the national changes in commodity production anticipated under agricultural trade liberalization are, as discussed above, also quite marginal. However, the changes in both production and environmental impacts at the national level are summations of the regional changes, which can be positive or negative, and hence the national changes may not necessarily be representative of changes at the regional level. For example, areas with the largest cropping increases are likely to have the largest potential increases in pesticide loading to ground and surface waters.

Assigning monetary values to these production and environmental changes is necessary to assess the costs and benefits of agri-environmental policies. However, research is still in the early stages of assessing the environmental impacts of agricultural activities beyond the edge of the field, and we were only able to assign monetary values to three environmental impacts (damages from nitrogen loss to water as well as from on-site and off-site soil erosion impacts). As expected, given the small changes in the physical quantities of the environmental impacts, the changes in the dollar value of the environmental damages attributed to these production changes, while increasing in the aggregate, are relatively small and less than one percent over the pre-trade liberalization baseline. The value of the increase in aggregate damages to the environment of the three externalities that we could value is approximately one percent of the expected net change in gross producer receipts and gross consumer expenditures for agricultural products. There is some regional variation in the change in the monetized environmental impacts, with several regions showing decreasing damages and others increasing damages. For instance, damages from soil erosion are predicted to increase in the Northeast and decrease in the Southeast.

Although the model used in this analysis is the most comprehensive agricultural sector model currently capable of analyzing the costs and benefits of U.S. agri-environmental impacts, the analysis does have some limitations. Localized impacts at scales smaller than the regional aggregations that we use in the presentation may be more variable than are apparent at the larger regional aggregations. In addition, while agricultural activity produces positive (depending on the previous use) environmental by-products, such as open space and scenic views, an empirical assessment of such goods with respect to trade liberalization is currently not feasible. Finally, we note that the analysis and interpretation of results do not take into consideration the effectiveness of regulatory and voluntary programs in mitigating the environmental consequences of increasing production.

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I. Introduction

U.S. legislation requiring formal environmental reviews, or environmental assessments, of major federal activities significantly affecting the environment date back thirty years. Within the last decade, nongovernmental organizations (NGOs) and other interested parties have called for extending these environmental reviews to trade agreements (WWF, 2001). In 2002, the first relatively in-depth environmental review of a trade agreement (U.S. – Chile Free Trade Agreement) was conducted for legislative review.[2] Many interest groups and policymakers may desire a more rigorous analysis for further-reaching trade agreements, such as that which might occur under multilateral trade liberalization between all WTO member nations. The goals of this paper are to discuss as well as quantify some of the possible U.S. environmental impacts of a hypothetical agricultural trade liberalization scenario in the WTO context.

To motivate this change in trade policy, consider the declaration on agricultural trade from the Fourth WTO Ministerial Conference held in Doha, Qatar in November 2001 (the ministerial is the highest level meeting of the WTO). Here the WTO affirms its commitment to "correct and prevent restrictions and distortions in world agricultural markets." The WTO commits itself "to comprehensive negotiations aimed at: substantial improvements in market access; reductions of, with a view to phasing out, all forms of export subsidies; and substantial reductions in trade-distorting domestic support."[3] Given that agriculture is the leading source of pollution in 57 percent of river miles, 30 percent of lake acres (excluding the Great Lakes), and 15 percent of estuarine waters that were found to be impaired in the U.S.(ERS, 2001), changing

[2] A draft of this review is available online at <www.ustr.gov/environment/environmental.shtml>.
[3] See <www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm> for text of the declaration.

agricultural production levels following a post-Doha trade agreement could have observable environmental effects in the U.S.

The next section of the paper provides a literature review of empirical assessments of the environmental impacts of agricultural trade liberalization. Next, we describe the modeling framework used in obtaining our results. The third section presents the results.

II. Trade Liberalization and Agriculture: Review of Empirical Evidence

A broad empirical literature examines trade and environment, although little of it is explicitly linked to agriculture. For example, Frankel and Rose (2002) statistically examine the impacts of trade liberalization on various air pollution measures. In their analysis, they found little evidence that trade had a detrimental effect on the levels of their indicators of air pollution in the U.S, and one indicator (sulfur dioxide, or SO_2) actually decreases significantly with increasing openness to trade. Another study, also using a statistical analysis (Antweiler, Copeland, and Taylor, 2001), finds that SO_2 levels exhibit net decreases with freer trade. However, it is uncertain whether or not lessons relevant to agriculture trade can be drawn from a literature that does not explicitly model the impacts of agriculture on the environment. Returning to an earlier example, Antweiler, Copeland, and Taylor observed that rural areas (including agricultural production regions) tend to be associated with lower SO_2 than urban areas, a finding that may be relevant to a discussion on the environmental (de)merits of agricultural trade liberalization. Hitherto, few empirical studies have specifically examined the environmental effects of agricultural trade liberalization. Several notable exceptions (detailed below) include research on the environmental effects of trade between OECD countries and on the potential environmental effects of NAFTA (US, Mexico, and Canada).

Using a simulation model, Abler and Shortle (1992) analyzed restrictions on agricultural chemicals in the United States and the European Community (EC) under various farm commodity policy scenarios. Their model had three regions (U.S., EC, rest of the world) and four commodities (wheat, maize, coarse grains, soybeans). Given the farm programs existing at the time of the analysis, U.S. farmland owners gained economically from chemical restrictions while EC farmland owners generally lost. Given bilateral elimination of farm programs, both U.S. and EC farmland owners benefited economically from restrictions on chemical use. They found that bilateral farm program elimination without chemical restrictions induced a shift in chemical usage from the EC to the United States.

Another detailed simulation analysis of 22 agricultural sub-sectors in Mexico indicates that unilateral trade liberalization by Mexico would decrease both agricultural output and pollution, as measured by 13 indicators of water, air, and soil effluents (Beghin, Dessus, Roland-Holst, and van der Mensbrugghe, 1997). Overall Mexican real GDP, however, increases significantly (*ibid*). Using a simulation model of the agricultural economy in conjunction with statistical analysis, Williams and Shumway (2000) examine the impact of NAFTA, economic growth, research investment, and farm policy. Due to the combined effects of these factors, real farm income is projected to increase in both the United States and Mexico, and dramatically so in the latter. Williams and Shumway's simulation model predicts that both fertilizer and pesticide usage in the United States will increase substantially and, although pesticide usage will decrease in Mexico, there will be substantial increases in Mexico's fertilizer usage.

The Commission for Environmental C

(NAAEC), also conducts original research on the environmental effects of NAFTA.[4] In particular, two case studies sponsored by CEC focus on the environmental impacts of NAFTA-induced changes in agricultural market structures. One of these agricultural case studies concerns Mexican corn production (Nadal, 1999). As corn producers in Mexico adjust to changing price dynamics, their responses could generate important environmental effects. Potential responses include the modernization of production techniques or the substitution of corn for other crops. Modernization involves capital-intensive production technologies such as irrigation, the intensive use of agro-chemicals, and the increased use of mechanized equipment. Many of these technologies are water-intensive. Thus, their adoption could place increased pressure on water resources that may already be imperiled by overuse. The study indicates some loss of crop genetic diversity, as farmers shift from local varieties of corn to hybrids with higher yields. This loss is limited by heterogeneous soil qualities, climates, and local pests, which degrade the performance of high-yield hybrids.

On the other hand, a shift from corn to feed grains (e.g., sorghum, barley) may have positive environmental outcomes, because plowing and water usage would most likely decrease. Since the implementation of NAFTA, total area harvested in Mexico has remained fairly stable, but the area devoted to sorghum production has reached record levels and the area devoted to barley has increased slightly. These increases in feed grains, however, have not come at the expense of corn area, which has fluctuated due to a series of droughts. In the case of sorghum, the increase in area planted may have been driven by increased beef production in Mexico. Trade liberalization undoubtedly reinforces a shift to crops for which a country possesses a

[4] The Commission on Environmental Cooperation (CEC) recently held a conference on this topic, “Assessing the Environmental Effects of Trade Liberalization: Lessons Learned and Future Challenges,” (see available papers at <www.cec.org/programs_projects/trade_environ_econ/>).

comparative advantage, but predicting this shift and its environmental impact poses a significant challenge.

Taken as a whole, the limited number of existing studies in conjunction with their limited scope do not allow us to draw generalizations from their results. As such, they certainly leave room for further empirical studies that provide a reasonably comprehensive examination of the environmental impacts of trade liberalization. Our empirical examination includes an integrated assessment of the major commodities in the agricultural sector to account for production, consumption, and price changes between commodities and regions. Such an integrated assessment is necessary to form a reasonably comprehensive assessment of the potential effects of trade policy on the environment.

III. Some Environmental Impacts of Agricultural Trade Liberalization on U.S. Agricultural Areas: Results of the Empirical Simulation

In this section, we simulate the environmental impacts on the U.S. of estimated agricultural production changes associated with the trade liberalization scenario. Our methodology employs three components: a trade equilibrium model for world agriculture, a spatial equilibrium model for U.S. agriculture (i.e., production is disaggregated regionally), and a spatial environmental simulation model based on U.S. agricultural production technologies (see Box 1 for graphical linking of the topics and models). Appendix 1 discusses the details of these models.

Trade Impacts

The first model component estimates the changes in world production resulting from lifting all trade restrictions on agricultural products between WTO member nations, including U.S.

production changes. To do this we employ the results from a multiple-commodity, multiple-country model of agricultural policy and trade, the ERS/PSU World Trade Model, which simulated the agriculture sector's response to a scenario in which all countries eliminate their border protections and trade-distorting domestic support for all commodities.[5] To do so, U.S. tariffs, fixed payments per unit of output and per unit of intermediate output, as well as any direct and whole-farm payments that are based on area or that otherwise affect crop mix were eliminated. Decoupled subsidies, such as production flexibility contracts, are not linked to production of specific crops, and therefore do not factor into this set of simulation models. In sum, all WTO blue and amber box forms of support (see Box 2) are excluded in both the model of U.S. agriculture and the world model.

We present the resulting production shocks and changes in gross returns in Table 1. For the most part, U.S. production marginally decreases with trade liberalization. Several notable exceptions are increases in corn production by 2.4 percent and substantial decreases in the production of several dairy commodities (e.g., butter, non-fat dry milk, and whole dry milk). Furthermore, many of these changes are accompanied by a countervailing price effect, which serves to temper the effects of reduced production on gross returns (price times quantity) and to augment the effects of production increases on gross returns. Estimated gross returns to agriculture increase by approximately $10.8 billion U.S., or 4.2 percent. However, because of higher prices, U.S. consumers would spend more (an estimated $12.2 billion) and get less (2.3 million metric tons less) of agricultural produce. On the other hand, costs on taxpayers of the subsidies will decrease.

[5] Preliminary documentation of the model can be found at <http://coldfusion.aers.psu.edu/wto/>. See appendix 1 of this paper for a brief overview of the model.

Placing these changes in the context of historical experience, we note from Figure 1 that these percentage changes in production levels are well within the bounds of past changes in production levels.[6] Nevertheless, the changes in production may be more pronounced at the regional production level, which is where we turn to next.

Regional Changes in U.S. Agricultural Production

The next step is to impose the aggregate U.S. production shocks from Table 1 into the spatial equilibrium model for the U.S. (the U.S. Regional Agricultural Programming Model - USMP).[7] This model uses a multi-commodity, spatial equilibrium approach of the type described in McCarl and Spreen (1980). USMP allocates production practices regionally based on relative differences in net returns among the production practices (differentiated by rotation, tillage, and fertilizer rates) by region. As such, USMP can be used to simulate how changes in agricultural trade policy (via production changes) will manifest themselves in a spatial equilibrium across 45 production subregions (for the tables, we aggregate the results up to the 10 USDA Farm Production Regions). Variables in the model include regional commodity supplies, commodity prices, commodity demands, farm input use, farm income, government expenditures, and participation in farm programs. In response to changes in economic incentives, the USMP model allows for scale effects, some composition effects, such as a changing product mix, and technique effects, such as changing management practices. For instance, nitrogen fertilizer use in USMP can be reduced by decreasing acreage planted (scale effect), shifting to production of

[6] The choice of yearly change in production as the standard for comparison is admittedly an arbitrary one, but little guidance exists to drive the choice of a standard for comparison.

[7] See appendix 1 for a brief overview of USMP.

crops that use less nitrogen fertilizer (composition effect), or by reducing nitrogen fertilizer application rates on a given crop mix (technique effect).

The estimated regional changes in primary crop and livestock resented in Tables 2a and 2b, corresponding to crop and livestock production, respectively. Corn production is predicted to increase in all regions, especially in the Lake, Corn Belt, and Northern Plains regions. The estimated changes in wheat production are fairly homogenous across regions. Soybean production is likely to fall in all regions. Other notab clude a predicted 9 percent increase in sorghum production in the Southern Plains and a 17 percent decrease in rice production in the Corn Belt.

Changes in the livestock and feed sectors are also expected to be marginal overall, with some variations at the regional levels. For example, while dairy production falls in general there are many regions that have potential increases in production: Northeast, Appalachia, Southeast, Southern Plains, Delta, and Mountain regions. Swine production is likely to remain relatively unchanged following agricultural trade liberalizati

region: decreases in the Northeast, Lake, Corn Belt, and Appalachia regions; increases in the Northern Plains, Delta, Mountain, and Pacific regions (zero changes are estimated for the Southeast and Southern Plains regions). Poultry production is expected to increase marginally in most regions (zero changes are estimated in the Delta and Mountain regions).

In addition to scale effects, we also note potential changes in technique effects in the cropping sectors (Table 2c). By and large, these changes are of the same magnitude as the scale effects discussed above. The Northern Plains region would experience the greatest changes in acreage and tillage practices: a 5.1 and 14.7 percent increase in conventional tillage and no-till acres respectively, and a 6.4 and 6.1 percent decrease in mulch tillage and ridge-till acres respectively. Total cropping acreage is likely to remain relatively constant following agricultural trade liberalization, with an increase of 0.770 million hectares, or 0.6 percent. At least at the national level, as the percent increase in total crop production is only slightly larger than the percent expansion in crop acreage, the increase in intensification of production appears minimal.

Change in physical environmental measures

As we noted above, the predicted percentage changes in production levels are well within the bounds of past changes in production levels. Because these percentage changes in production are quite small at the aggregate level, the corresponding changes in aggregate environmental indicators are also expected to be small. Note that we are not suggesting that there will likely be no increase in environmental effects, but simply that the estimated increases are likely to be small. We use the USMP model to assess the hypothesis that the environmental impacts are in fact small.

While the current version of USMP contains a range of environmental indicators that link agricultural production to environmental quality, only a small subset is presented here.[8]

discussed above, also quite marginal. However, regional changes in crop and livestock production will be associated with subsequent regional changes in the relevant environmental indicators. For example, cropping increases likely to occur in the Northern Plains result in potential increases in pesticide loading to ground and surface waters in that region (by 1.54 million kg). Other notable changes include reductions in pollutant loading to ground and surface waters observed in the Southern Plains region from crop production, but increases in the potential damages from livestock production (an increase in manure nitrogen and phosphorus production of 1.37 million kg and 0.59 million kg, respectively).

Monetary Valuation of Production and Environmental Changes

Assigning monetary values to these production and environmental changes is necessary to assess the costs and benefits of agri-environmental policies. However, while researchers are still in the early stages of assessing the environmental impacts of agricultural activities beyond the edge of the field, even fewer attempts have been made in assigning monetary values to these impacts. In USMP, economic values are linked to regional net returns in the cropping and livestock sectors and to several of the environmental indicators. These potential changes are expected to have differential effects across farm production regions. Agricultural productivity loss is an on-site cost of agricultural soil erosion. The loss of productivity stems primarily from the loss of topsoil and nutrients. The soil depreciation indicator is the discounted value of long-term yield changes due to this loss, and is based on current output prices. Wind erosion and water pollution are off-site costs of wind and soil erosion.

We derive estimates of the monetary value of off-site damages from sediment and nitrogen damage indices developed by the USDA (Claassen et al., 2001; Ribaudo, 1986; Feather et al., 1999; Hansen et al., 2002; and other work in progress at ERS). The monetized impacts include those on municipal water use, industrial uses, irrigation ditch maintenance, road ditch maintenance, water storage, flooding, and soil productivity, fresh water-based recreation, navigation, and estuary-based boating, swimming, and recreation. This set is by no means an exhaustive list of all activities affected by sediment and nitrogen runoff. Furthermore, the impacts of environmental indicators other than erosion and nitrogen loading remain to be monetized. Hence, the monetized estimates of off-site damage calculated by USMP here – the value of nitrogen loss to water and the value of sheet and rill erosion damages -- are viewed as a lower bound on total off-site damages. [9]

The monetary estimates of potential production and environmental changes resulting from liberalized agricultural trade are summarized across regions in Table 3a and Figure 3. We note in general that changes in the dollar value of the environmental damages attributed to these production changes are positive in the aggregate, albeit relatively small, less than 1%. However, several regions (Southeast, Southern Plains, and the Pacific) show environmental benefits, as denoted by negative signs in Table 3a and Figure 3. To put these changes in context, we note that the value of the aggregate damages to the environment for our narrow set of externalities exceeds $16 million, and represents approximately 1 percent of the expected gains from trade liberalization as measured by the net change in gross producer receipts and gross consumer expenditures for agricultural products.

[9] The interested reader can obtain the dollar per ton figures for off-site erosion and nitrogen loss to water for each region by dividing the base levels of the dollar values by the base levels of the physical values in table 3a.

VI. Conclusions

Agricultural trade liberalization under a post-Doha trade liberalization scenario is likely to affect the environment in a variety of ways, some positive and others negative. Trade liberalization will likely produce environmental impacts as a result of scale, technique, and composition effects in production. For the U.S., our preliminary analysis suggests that the environmental impacts would be small in aggregate at less than one percent, but with some potentially important variation across the ten U.S. subregions of our analysis. For example, sheet and rill erosion is likely to increase in the Northern Plains (1.6 percent) and Northeast (0.8 percent) regions, while decreasing in the Southern Plains (-0.8 percent), Southeast (-0.2), and Pacific (-0.1 percent) regions. In another example, nitrogen loss to water from crop production is likely to increase in the Northern Plains (1.7 percent), Southeast (0.1), and Northeast (0.5 percent) regions, while decreasing in the Southern Plains (-0.5 percent) and the Pacific (-0.1 percent) regions.

While our modeling framework does contain some of the important agri-environmental indicators, the set is by no means complete. Not included in this analysis are the damages due to greenhouse gas emissions, pesticide losses, manure nutrient and bacterial discharges, among others. One specific example of an omitted indicator is emissions of pollutants associated with fuel usage. Expanding agricultural trade leads to increasing international commerce, and the associated increases in transportation and fuel usage may contribute to increased emissions of pollutants. Increased ground transportation is often concentrated in a few border corridors, resulting in hotspots of localized environmental stress, such as the high traffic areas in and around Laredo, Texas, and Detroit, Michigan (Sierra Club and Holbrook-White, 2000). A recent study of the border corridors of Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey, and Tucson-Hermosillo concludes that NAFTA trade “contributes significantly to air pollution" in all five corridors (ICF Consulting, 2001). In addition, USMP cannot estimate environmental impacts associated with commodities not in the model, such as sugar and fruit and vegetables. Finally, USMP cannot estimate the value of changes in the level of environmental amenities (e.g., open space and scenic views) generated by agricultural activities. The amenities may not be highly correlated with agricultural production and may be quite site-specific as well.

In addition to the types of impacts modeled in our quantitative analysis, technological modernization, trans-boundary issues such as the importation of harmful, non-indigenous species (HNIS), environmental consequences of increased use of transportation, the creation of "pollution havens," and the development of environmentally friendly products are other examples under which expanded agricultural trade could have positive or negative effects on the environment. Although this paper focuses on impacts in the U.S., the environmental impacts of trade liberalization, and the assessments thereof, are of global interest. For instance, paragraphs 6 and 31-33 of the ministerial declaration of the Fourth WTO Ministerial Conference held in Doha, Qatar in November 2001 address trade and environment issues. These include "the efforts by members to conduct national environmental assessments of trade policies on a voluntary basis."[10] Finally, in Appendix 4, we provide some insights on issues outlined in the agenda of the CEC-sponsored symposium for which this paper was prepared.

[10] See http://www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm for text of the declaration.

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<u>Box 1. Methodology used to Map</u>
<u>the Impacts of Trade Liberalization on the Environment</u>

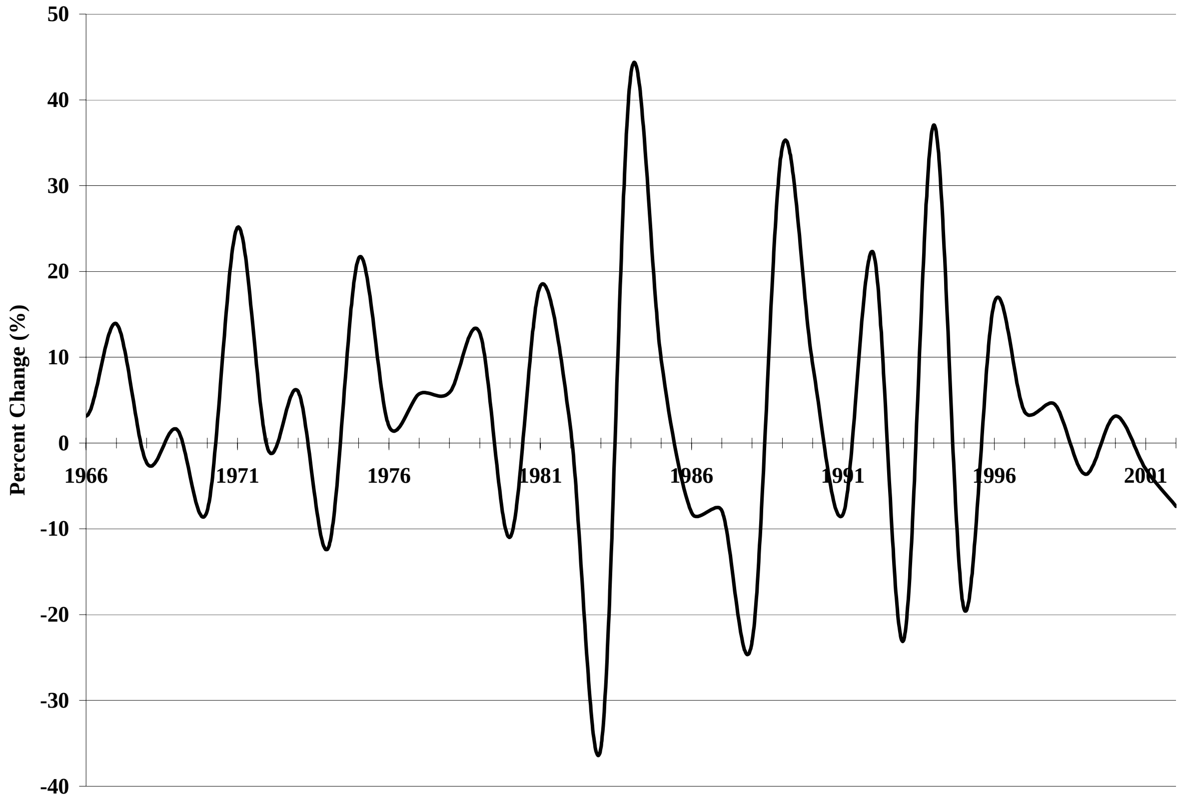
Agricultural Trade Liberalization
(post-Doha Scenario)
⇓
Change in world prices
(estimated by the ERS/PSU World Trade Model)
⇓
Changes in production practices, input use and outputs
(estimated by the U.S. Regional Agricultural Model [USMP])
⇓
Changes in physical measures of environmental impacts
(estimated by the U.S. Regional Agricultural Model [USMP])
⇓
Changes in economic measures of environmental impacts
(estimated by the U.S. Regional Agricultural Model [USMP])

Box 2. Treatment of domestic agricultural support in the Uruguay Round Agreement on Agriculture (URAA)

Category	General criteria	Examples of policies
Exempt support (green box)	Measures must be financed by the government rather than consumers and must not provide price support to producers Specific criteria are defined for general government services, public stockholding, domestic food aid, direct payments, payments under agri-environmental programs, and other programs	Green box programs include direct payments to farmers that do not depend on current production decisions or prices, disaster assistance, and government programs on research, extension, pest and disease control, and agri-environmental subsidy programs such as the Conservation Reserve Program and the Environmental Quality Incentives Program
Exempt direct payments (blue box)	Direct payments under production-limiting programs must be based on fixed area or yields, and cover 85 percent or less of the base level of production or head of livestock	Blue box policies are direct payments to producers, linked to production of specific crops, but which impose offsetting limits on output
Nonexempt support (amber box)	Market price support, nonexempt direct payments and any other subsidies not specifically exempted are subject to reduction commitments	Amber box policies include market price supports, and output and input subsidies

Source: Uruguay Round Agreement on Agriculture, WTO (with modifications by the authors).

Figure 1. Annual Aggregated Percentage Changes in Production from Previous Year: Corn, Soybeans, Rice, Wheat, Poultry, Pork (1966 – 2002)



Percentage Changes by Commodity						
Statistics	*Corn*	*Wheat*	*Soybeans*	*Rice*	*Poultry*	*Pork*
Mean % Change	4.91	1.53	4.39	4.34	4.14	1.06
Median	1.63	0.82	4.47	2.34	4.30	1.10
Range	133.11	61.49	62.46	74.30	13.22	33.16
Minimum	-49.31	-27.46	-25.32	-35.10	-2.32	-17.80
Maximum	83.80	34.03	37.15	39.20	10.89	15.36

Source: Derived from the USDA's Production, Supply, and Distribution database

(http://www.ers.usda.gov/data/psd/)

Table 1. Simulated Changes in U.S. Production and Gross Returns to Producers Resulting From the Elimination of all Agricultural Trade Distortions

Commodities	Change in Production (%)	Change in Consumer Price (%)	Change in Gross Returns (%)
Rice	-1.2	13.2	-0.8
Wheat	-0.1	4.8	2.5
Corn	2.4	16.5	13.9
Other coarse grains	1.7	13.5	10.9
Soybeans	-0.7	7.5	3.9
Cotton	0.0	4.5	2.1
Beef & veal	-0.1	10.6	8.1
Pork	0.0	7.5	5.0
Poultry meat	1.6	13.0	10.5
Butter	-15.0	-12.0	-12.0
Cheese	-0.6	-1.9	-1.9
Non-fat dry milk	-15.0	-1.6	-1.6
Fluid milk[a]	1.7	-1.2	-1.2
Whole dry milk	-31.6	-13.4	-13.4
Other dairy[a]	1.9	-1.1	-1.1
Total	0.27	9.19	4.23

[a]Not treated as an internationally traded commodity in the model.
Source: ERS/Penn State World Trade Model

Fig. 2. U.S. Regional Aggregations for the Trade and Environment Simulation (USDA Farm Production Regions)

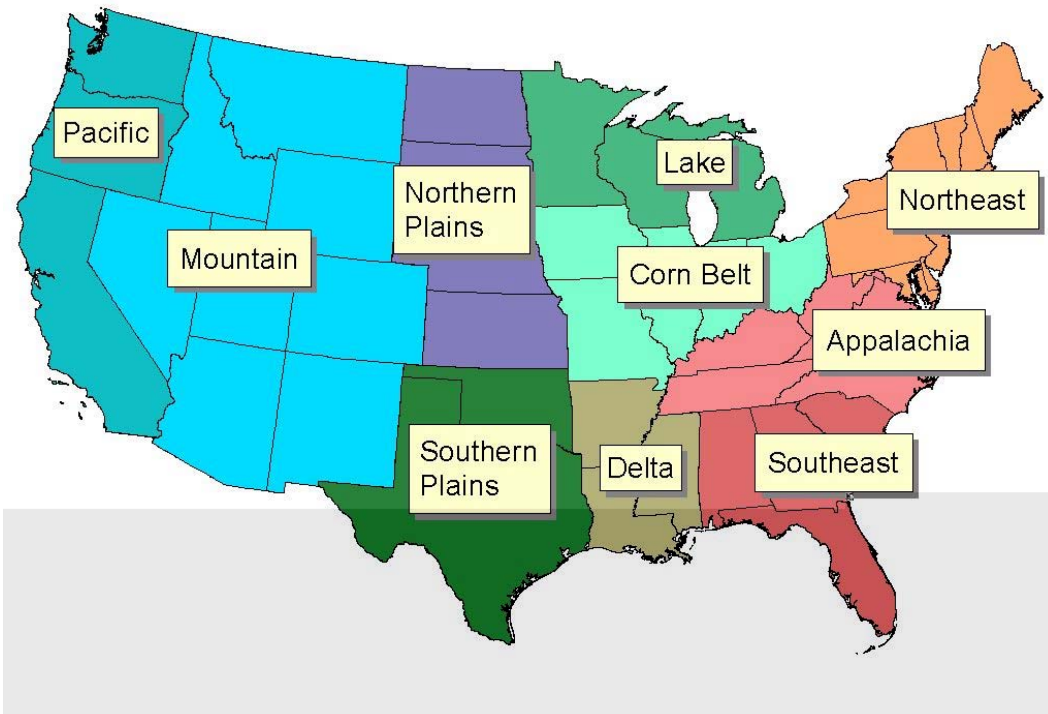


Table 2a. Simulated Regional Changes in U.S. Crop Production under the Agricultural Trade Liberalization Scenario

REGION [a]	NT	LA	CB	NP	AP	SE	SP	DL	MN	PA	US
					CORN (MILLION BU)						
BASE	377.4	1,467.0	6,285.7	1,939.9	538.5	195.2	63.8	146.1	161.6	60.1	11,235.4
NEW LEVEL	383.3	1,498.6	6,358.7	2,056.4	564.7	199.9	66.8	149.7	164.5	61.7	11,504.2
CHANGE	5.9	31.6	73.1	116.5	26.1	4.7	3.0	3.5	2.9	1.6	268.9
%CHANGE	1.6	2.2	1.2	6.0	4.8	2.4	4.7	2.4	1.8	2.6	2.4
					SORGHUM (MILLION BU)						
BASE	0.0	0.0	60.8	322.7	3.6	0.8	23.6	243.2	13.9	0.0	668.5
NEW LEVEL	0.0	0.0	60.7	330.0	3.5	0.8	25.7	245.5	13.9	0.0	680.1
CHANGE	0.0	0.0	-0.1	7.2	-0.1	0.0	2.2	2.3	0.1	0.0	11.6
%CHANGE	0.0	0.0	-0.1	2.2	-3.1	1.1	9.2	1.0	0.4	0.0	1.7
					BARLEY (MILLION BU)						
BASE	7.9	36.8	0.0	136.9	2.3	0.0	0.0	0.2	137.7	43.3	365.1
NEW LEVEL	7.9	37.0	0.0	140.1	2.3	0.0	0.0	0.2	140.8	43.2	371.4
CHANGE	0.0	0.2	0.0	3.1	0.0	0.0	0.0	0.0	3.1	-0.1	6.3
%CHANGE	-0.3	0.5	0.0	2.3	0.2	0.0	0.0	0.7	2.2	-0.1	1.7
					OATS (MILLION BU)						
BASE	8.1	51.2	48.8	37.0	1.7	0.0	0.0	2.6	0.0	0.6	149.9
NEW LEVEL	8.2	51.6	49.3	38.3	1.7	0.0	0.0	2.7	0.0	0.6	152.5
CHANGE	0.1	0.5	0.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	2.6
%CHANGE	1.0	1.0	1.2	3.8	0.8	0.0	0.0	1.7	1.1	1.1	1.7
					WHEAT (MILLION BU)						
BASE	33.2	155.3	347.7	903.3	68.3	14.2	16.9	560.9	312.4	133.1	2,545.1
NEW LEVEL	33.2	153.8	346.6	899.6	69.0	14.1	17.2	562.3	312.0	133.4	2,541.4
CHANGE	0.1	-1.5	-1.0	-3.7	0.7	0.0	0.3	1.5	-0.3	0.3	-3.7
%CHANGE	0.2	-1.0	-0.3	-0.4	1.0	-0.3	1.9	0.3	-0.1	0.2	-0.1
					RICE (MILLION CWT)						
BASE	0	0	1.8	0	0	0	141.9	9	0	41.5	194.2
NEW LEVEL	0	0	1.4	0	0	0	140	9	0	41.3	191.8
CHANGE	0	0	-0.3	0	0	0	-1.8	0	0	-0.3	-2.4
%CHANGE	0	0	-17.7	0	0	0	-1.3	-0.3	0	-0.6	-1.3
					SOYBEANS (MILLION BU)						
BASE	44.5	367	1908.7	361.2	205	95.4	251.9	11.3	0	0	3245
NEW LEVEL	44.2	365.9	1902.4	358.5	199.8	93.8	247.7	11.2	0	0	3223.6
CHANGE	-0.3	-1.1	-6.3	-2.7	-5.2	-1.6	-4.2	-0.1	0	0	-21.4
%CHANGE	-0.6	-0.3	-0.3	-0.7	-2.5	-1.7	-1.7	-0.8	0	0	-0.7
					COTTON (MILLION BALES)						
BASE	0	0	0.4	0	1.5	1.6	5	5.7	1.3	2	17.5
NEW LEVEL	0	0	0.4	0	1.5	1.6	5	5.7	1.3	2	17.5
CHANGE	0	0	0	0	0	0	0	0	0	0	0
%CHANGE	0	0	-0.1	0	0	0.1	0.2	-0.2	0.2	0	0

[a] Region definitions: NT = North East; LA = Lake States; CB = Corn Belt; NP = Northern Plains; AP = Appalachia; SE = South East; SP = Southern Plains; DL = Delta States; MN = Mountain; PA = Pacific; US = United States.

Table 2b. Simulated Regional Changes in U.S. Livestock and Feed Production under the Agricultural Trade Liberalization Scenario

REGION [a]	NT	LA	CB	NP	AP	SE	SP	DL	MN	PA	US
SILAGE (MILLION TONS)											
BASE	19.8	21.3	12.4	23.2	10.3	2.9	0.7	1.3	3.6	0	95.6
NEW LEVEL	20.2	21.7	12.6	23.5	10.5	3	0.7	1.4	3.7	0	97.3
CHANGE	0.4	0.4	0.2	0.4	0.2	0	0	0	0.1	0	1.7
%CHANGE	1.9	1.9	1.5	1.5	2	1.7	1.7	1.6	1.6	0	1.7
HAY (MILLION TONS)											
BASE	17.9	22.6	27.6	21.5	19.2	2.3	1.7	1.6	27.1	14.1	155.6
NEW LEVEL	17.9	22.5	27.4	21.9	19.1	2.3	1.7	1.6	27.1	14.1	155.7
CHANGE	-0.1	-0.1	-0.1	0.4	-0.1	0	0	0	0	0	0.1
%CHANGE	-0.3	-0.3	-0.5	1.8	-0.3	-0.1	0.1	-0.1	0.1	0	0.1
DAIRY (MILLION ANIMAL UNITS)											
BASE	1.800	2.536	0.930	0.315	0.608	0.224	0.109	0.439	0.920	1.780	9.661
NEW LEVEL	1.840	2.510	0.912	0.303	0.629	0.227	0.110	0.461	0.967	1.660	9.619
CHANGE	0.040	-0.026	-0.018	-0.012	0.021	0.003	0.001	0.022	0.047	-0.120	-0.042
%CHANGE	2.222	-1.025	-1.935	-3.810	3.454	1.339	0.917	5.011	5.109	-6.742	-0.435
SWINE (MILLION ANIMAL UNITS)											
BASE	0.541	2.110	6.136	2.457	7.961	0.156	0.163	0.357	0.341	0.112	20.334
NEW LEVEL	0.542	2.110	6.137	2.457	7.955	0.156	0.163	0.357	0.341	0.112	20.330
CHANGE	0.001	0.000	0.001	0.000	-0.006	0.000	0.000	0.000	0.000	0.000	-0.004
%CHANGE	0.185	0.000	0.016	0.000	-0.075	0.000	0.000	0.000	0.000	0.000	-0.020
BEEF (MILLION ANIMAL UNITS)											
BASE	0.060	1.383	3.905	14.113	0.199	0.000	0.104	9.368	5.259	1.852	36.243
NEW LEVEL	0.059	1.375	3.886	14.141	0.198	0.000	0.104	9.396	5.273	1.856	36.288
CHANGE	-0.001	-0.008	-0.019	0.028	-0.001	0.000	0.000	0.028	0.014	0.004	0.045
%CHANGE	-1.667	-0.578	-0.487	0.198	-0.503	0.000	0.000	0.299	0.266	0.216	0.124
POULTRY (MILLION ANIMAL UNITS)											
BASE	0.050	0.049	0.110	0.017	0.162	0.080	0.070	0.042	0.003	0.060	0.643
NEW LEVEL	0.051	0.050	0.112	0.017	0.165	0.081	0.071	0.042	0.003	0.061	0.653
CHANGE	0.001	0.001	0.002	0.000	0.003	0.001	0.001	0.000	0.000	0.001	0.010
%CHANGE	2.000	2.041	1.818	0.000	1.852	1.250	1.429	0.000	0.000	1.667	1.555

[a] Region definitions: NT = North East; LA = Lake States; CB = Corn Belt; NP = Northern Plains; AP = Appalachia; SE = South East; SP = Southern Plains; DL = Delta States; MN = Mountain; PA = Pacific; US = United States.

Table 2c. Simulated Regional Changes in Tillage Practices under the Agricultural Trade Liberalization Scenario

REGION [a]	NT	LA	CB	NP	AP	SE	SP	DL	MN	PA	US
CONVENTIONAL (MILLION ACRES)											
BASE	3.2	15.6	45.4	32.2	7.8	6.9	16.6	23.9	11.5	4.5	167.6
NEW LEVEL	3.2	15.7	45.7	33.9	8	6.9	16.6	23.9	11.6	4.5	170
CHANGE	0.1	0.1	0.2	1.6	0.2	0	0	0.1	0.1	0	2.4
%CHANGE	2.2	0.8	0.5	5.1	2	0	-0.1	0.3	1.2	0.1	1.4
MOLD-BOARD (MILLION ACRES)											
BASE	8.2	11.9	12.3	14.6	6.3	1.1	0.8	5.7	9	3.4	73.4
NEW LEVEL	8.2	12	12.4	14.4	6.3	1.1	0.8	5.7	9	3.4	73.3
CHANGE	0	0.1	0	-0.2	-0.1	0	0	0.1	0	0	-0.1
%CHANGE	0.1	0.8	0.3	-1.4	-0.9	-0.1	0.1	1.1	-0.2	0	-0.1
MULCH (MILLION ACRES)											
BASE	1.2	7.2	20.6	13.8	1.7	0	0	1.6	2.4	0.2	48.8
NEW LEVEL	1.2	7.4	20.8	12.9	1.8	0	0	1.6	2.4	0.2	48.3
CHANGE	0	0.1	0.2	-0.9	0.2	0	0	-0.1	0	0	-0.5
%CHANGE	-0.7	1.8	1.1	-6.4	9	0	0	-3.3	-1.8	-0.2	-1
NO-TILL (MILLION ACRES)											
BASE	2.1	3.2	20.7	4.7	3.4	0	0.7	0	0	0	34.8
NEW LEVEL	2.1	3.1	20.5	5.4	3.3	0	0.6	0	0	0	35
CHANGE	0	-0.1	-0.2	0.7	-0.2	0	-0.1	0	0	0	0.2
%CHANGE	-0.8	-2.3	-0.8	14.7	-4.9	0	-15.1	0	0	0	0.5
RIDGE-TILL (MILLION ACRES)											
BASE	0	0.1	0	1.3	0	0	0	0	0	0	1.4
NEW LEVEL	0	0.1	0	1.2	0	0	0	0	0	0	1.3
CHANGE	0	0	0	-0.1	0	0	0	0	0	0	-0.1
%CHANGE	0	-1.4	0	-6.1	0	0	0	0	0	0	-5.7
TOTAL (MILLION ACRES)											
BASE	14.6	38	99	66.7	19.3	7.9	18.1	31.2	22.9	8.1	326
NEW LEVEL	14.7	38.3	99.3	67.9	19.4	7.9	18	31.3	23	8.1	327.9
CHANGE	0.1	0.3	0.3	1.2	0.1	0	-0.1	0.1	0.1	0	1.9
%CHANGE	0.4	0.7	0.3	1.8	0.4	0	-0.6	0.3	0.3	0	0.6

[a] Region definitions: NT = North East; LA = Lake States; CB = Corn Belt; NP = Northern Plains; AP = Appalachia; SE = South East; SP = Southern Plains; DL = Delta States; MN = Mountain; PA = Pacific; US = United States.

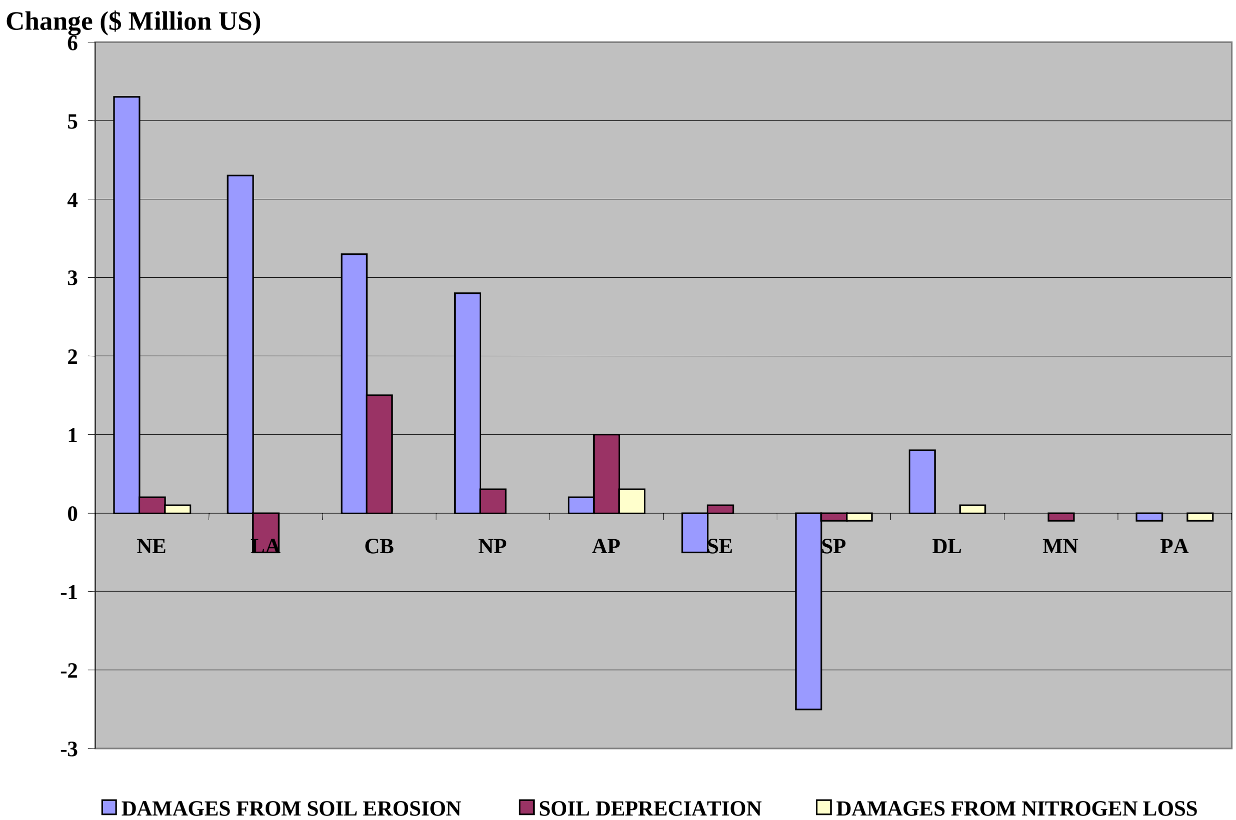
Table 3a. Simulated Environmental Changes and Some Associated Quantified Monetary Values under the Agricultural Trade Liberalization Scenario[a]

REGION [b]	NT	LA	CB	NP	AP	SE	SP	DL	MN	PA	US
SHEET AND RILL EROSION (MILLION TONS)											
BASE	46.17	92.11	424.51	152.82	71.73	49.98	92.28	70.26	54.22	35.60	1089.68
NEW LEVEL	46.55	92.67	425.78	155.20	71.79	49.87	91.56	70.44	54.23	35.58	1093.67
CHANGE	0.38	0.57	1.27	2.38	0.06	-0.12	-0.72	0.18	0.01	-0.02	3.99
%CHANGE	0.82	0.62	0.30	1.56	0.09	-0.24	-0.78	0.26	0.01	-0.06	0.37
OFF-SITE SHEET & RILL EROSION DAMAGES ($MILLION US)											
BASE	623.80	541.80	1040.80	216.00	233.10	190.90	328.80	258.50	84.50	110.50	3628.70
NEW LEVEL	629.10	546.10	1044.20	218.80	233.20	190.40	326.20	259.30	84.50	110.50	3642.40
CHANGE	5.30	4.30	3.30	2.80	0.20	-0.50	-2.50	0.80	0.00	-0.10	13.70
%CHANGE	0.85	0.79	0.32	1.30	0.09	-0.26	-0.76	0.31	0.00	-0.09	0.38
WIND EROSION (MILLION TONS)											
BASE	0.97	113.36	41.59	119.97	0.53	0.00	0.00	185.32	227.04	28.82	717.59
NEW LEVEL	0.97	112.39	41.96	131.23	0.54	0.00	0.00	185.48	225.97	28.79	727.34
CHANGE	0.00	-0.97	0.37	11.27	0.01	0.00	0.00	0.16	-1.07	-0.03	9.75
%CHANGE	0.34	-0.86	0.90	9.39	2.43	0.00	0.00	0.09	-0.47	-0.10	1.36
SOIL DEPRECIATION ($MILLION US)											
BASE	15.10	11.00	97.90	99.40	42.50	1.20	49.00	2.30	7.30	35.00	360.60
NEW LEVEL	15.30	10.50	99.30	99.70	43.40	1.30	49.00	2.30	7.20	35.00	363.10
CHANGE	0.20	-0.50	1.50	0.30	1.00	0.10	-0.10	0.00	-0.10	0.00	2.50
%CHANGE	1.32	-4.55	1.53	0.30	2.35	8.33	-0.20	0.00	-1.37	0.00	0.69
NITROGEN LOST TO WATER FROM CROP PRODUCTION (MILLION TONS)											
BASE	0.24	0.44	1.93	1.01	0.49	0.17	0.51	0.56	0.15	0.09	5.60
NEW LEVEL	0.24	0.45	1.93	1.03	0.50	0.17	0.51	0.56	0.15	0.09	5.64
CHANGE	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04
%CHANGE	0.51	2.31	0.27	1.72	0.56	0.12	-0.48	0.29	0.27	-0.40	0.65
NITROGEN LOSS TO WATER DAMAGES ($MILLION US)											
BASE	30.60	0.70	6.20	0.60	43.00	36.10	17.30	21.20	1.90	14.30	172.00
NEW LEVEL	30.70	0.70	6.20	0.60	43.40	36.20	17.20	21.30	1.90	14.20	172.50
CHANGE	0.10	0.00	0.00	0.00	0.30	0.00	-0.10	0.10	0.00	-0.10	0.50
%CHANGE	0.33	0.00	0.00	0.00	0.70	0.00	-0.58	0.47	0.00	-0.70	0.29

[a] Estimates of erosion, nutrient and pesticide losses are aggregate values to the edge-of-field simulated for predominant cropping practices over 67 years using the Environmental Policy Integrated Climate (EPIC) model. Manure values are estimated using Census of Agriculture (USDA/NASS, 1997) data for regional shares and nutrient availability coefficients from Kellogg et al. (2000).

Note: For the change in environmental effects, a minus sign indicates a decrease in damage and a positive sign an increase.

Figure 3. Change in Monetary Value of Selected Environmental Indicators



Note: Increasing the value of an indicator represents a decrease in environmental quality

Table 3b. Simulated Environmental Changes without Associated Quantification of Monetary Values under the Agricultural Trade Liberalization Scenario [a]

REGION [b]	NE	LA	CB	NP	AP	SE	SP	DL	MN	PA	US
PHOSPHORUS LOST TO WATER FROM CROP PRODUCTION (MILLION TONS)											
BASE	0.04	0.04	0.21	0.12	0.06	0.03	0.05	0.06	0.02	0.00	0.62
NEW LEVEL	0.04	0.04	0.22	0.12	0.06	0.02	0.05	0.06	0.02	0.00	0.62
CHANGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
%CHANGE	0.53	0.76	0.25	1.13	0.33	-0.07	-0.64	0.17	-0.12	-0.05	0.37
PESTICIDES LOST TO WATER FROM CROP PRODUCTION (MILLION TONS)											
BASE	12.53	43.72	144.47	50.10	27.78	12.41	50.27	18.62	9.79	8.33	378.02
NEW LEVEL	12.64	44.41	145.59	53.46	29.25	12.39	50.16	18.70	9.85	8.32	384.75
CHANGE	0.11	0.69	1.12	3.36	1.46	-0.02	-0.11	0.07	0.06	-0.01	6.72
%CHANGE	0.88	1.58	0.77	6.70	5.26	-0.18	-0.22	0.40	0.56	-0.13	0.02
MANURE PRODUCTION (MILLION TONS)											
BASE	38.74	59.05	73.31	65.20	65.72	23.28	18.66	46.24	32.65	39.65	462.50
NEW LEVEL	39.48	58.77	73.32	64.89	66.27	23.61	18.91	46.54	33.32	37.91	463.01
CHANGE	0.74	-0.28	0.01	-0.31	0.55	0.33	0.25	0.30	0.67	-1.74	0.51
%CHANGE	1.91	-0.47	0.01	-0.48	0.84	1.42	1.34	0.65	2.05	-4.39	0.11
MANURE NITROGEN (MILLION LBS)											
BASE	231.40	264.01	346.29	266.48	348.10	259.02	198.87	243.44	140.43	219.00	2517.03
NEW LEVEL	235.67	263.23	347.63	265.37	352.50	262.96	201.88	245.43	143.41	212.33	2530.41
CHANGE	4.27	-0.78	1.34	-1.11	4.40	3.94	3.01	1.99	2.98	-6.67	13.38
%CHANGE	1.85	-0.30	0.39	-0.42	1.26	1.52	1.51	0.82	2.12	-3.05	0.53
MANURE PHOSPHORUS (MILLION LBS)											
BASE	102.22	136.02	229.26	187.09	227.21	111.28	89.19	141.36	78.36	101.28	1403.25
NEW LEVEL	103.99	135.95	230.26	186.41	229.19	112.95	90.50	141.93	79.49	98.86	1409.54
CHANGE	1.77	-0.07	1.00	-0.68	1.98	1.67	1.31	0.57	1.13	-2.42	6.29
%CHANGE	1.73	-0.05	0.44	-0.36	0.87	1.50	1.47	0.40	1.44	-2.39	0.45

[a] Estimates of erosion, nutrient and pesticide losses are aggregate values to the edge-of-field simulated for predominant cropping practices over 67 years using the Environmental Policy Integrated Climate (EPIC) model. Manure values are estimated using Census of Agriculture (USDA/NASS, 1997) data for regional shares and nutrient availability coefficients from Kellogg et al. (2000).

Appendix 1. Agricultural Sector Models Used in the Analysis in the Main Text

For the simulation analyses in this paper, the world price and production shocks resulting from an elimination of agricultural policy distortions are modeled using the Economic Research State/Penn State University trade model. Given these results, the U.S. Regional Agricultural Model (USMP) models estimates detailed U.S. domestic production and environmental impacts. Before we turn to brief description of these models, we address their theoretical backgrounds.

Partial Equilibrium (PE) and Computable General Equilibrium (CGE) are the major modeling options used to investigate the impacts of trade policy (for an overview see Van Tongeren, van Meijl, and Surry, 2001 and Anania, 2001). The USMP and ERS/Penn State trade models have a PE framework. PE is essentially a supply and demand framework either for a single good, or for a set of goods, or even for a set of goods across countries. CGE models simultaneously represent multiple sectors in the national (world) economy to account for the sectoral (international) flows of goods and services and their consequent effects on domestic (world) prices and consumption.

Specifically, in a PE model such as the used in our analysis, the U.S. agricultural sector (primary and secondary product supply, consumption and trade) is independent of other the U.S. economic sectors (e.g., manufacturing and service). PE models could also link several sectors, e.g. agriculture and energy. Regardless, a defining feature of a PE model is that price and income impacts are limited to only those that occur between sectors in the model. In a CGE representation of the U.S. agricultural sector, the other U.S. sectors would be included on both the supply and demand sides. While a CGE model would seem favorable because it can account for changes in one industry impacting other industries, its overall complexity requires a rather simplistic representation of the various economic sectors. Furthermore, if the industry of interest has little potential for impact on other industries, then the advantage of CGE approaches are lessened. In general, PE models allow for a much greater level of sophistication when modeling a specific industry and regional environmental effects, such as changes in agricultural production resulting from trade policy.

A. ERS/Penn State trade model[11]

The ERS/Penn State trade model is an applied partial equilibrium, multiple-commodity, multiple-region model of agricultural policy and trade. It is a nonspatial model – meaning that it does not distinguish a region's imports by their source or a region's exports by their destination. It is a gross trade model that accounts for exports and imports of each commodity in every region.

The model is dynamic in that it allows for lags in adjustment over time in crop area, livestock production, dairy product production, and oilseed crushing. In this way, the model can trace a time path of adjustment to alternative trade liberalization scenarios. The model can also be used to compare different options for phasing in reductions in tariffs, export subsidies, or other agricultural trade policies.

Country and Commodity Coverage

The version of the model used in our analysis contains four countries/regions: the United States (US), European Union (EU-15), Japan, and the rest of the world (ROW). There are currently 21 commodities in the model: seven crops (rice, wheat, corn, other coarse grains, soybeans, other oilseeds, tropical oils, sugar), four oilseed products (soybean oil and meal, other oilseed oil and meal), four livestock products (beef and veal, pork, poultry, raw milk), and five processed dairy products (butter, cheese, nonfat dry milk, fluid milk, and other dairy products). The “other coarse grains” aggregate is primarily barley, sorghum, millet, and oats. The “other oilseeds” aggregate consists primarily of rapeseed and sunflower. The “other dairy products” aggregate includes ice cream, yogurt, and whey. In the model, raw milk, fluid milk, and other dairy products are nontraded commodities. Raw milk is used domestically in the production of the model's five processed dairy products. The other 18 commodities are all traded internationally.

Policy Coverage

A wide range of policies is incorporated into the model. The core set of policies for all countries includes both specific and ad valorem import and export taxes/subsidies, tariff-rate quotas (TRQs), and producer and consumer subsidies. In the case of the US, the model also includes loan rates for crops and marketing orders for dairy products. For Japan, the model includes “mark-ups” that are very high for rice and wheat.

Policy coverage for the EU is particularly extensive. The model includes intervention prices (which entail government purchases and then export subsidies), variable import levies, compensatory payments, acreage set-asides, and base area bounds (which limit the total area of grains and oilseeds by cutting off payments if the base area bound is reached). The EU component of the model also includes production quotas for raw milk and sugar.

Data and Base Year

The base year used in our analysis is 2000. Baseline data on area, yields, production,

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[11] This description is drawn from <http://coldfusion.aers.psu.edu/wto/>, from which a full description is also available.

consumption, stocks, and trade are drawn from USDA and country sources, including USDA's Production, Supply, and Distribution (PS&D) database. Tariffs, TRQs, and world prices are drawn from the Agricultural Market Access Database (AMAD).

Model Structure and Parameters

The model is a reduced-form economic model in which the behavior of producers, consumers, and other economic agents is represented by elasticities and other model parameters. The behavioral equations in the model are largely constant-elasticity in nature. Constant-elasticity functions were selected because of their ease of interpretation and well-behaved properties (provided the elasticities are chosen appropriately). The structure of the behavioral equations is the same for all countries in the model. The parameters of the equations and the values of variables in these equations vary from one country to another.

In assembling the parameter values for the model, the model draws on parameters in other trade models, including the European Simulation Model (ESIM), the ERS baseline projections model, the Food and Agricultural Policy Simulator (FAPSIM), AGLINK, SWOPSIM, as well as other sources in the trade literature. Adjustments were made to parameters in the process of testing the model when the test results did not appear reasonable. A number of restrictions were imposed on the model’s elasticities to ensure that requirements of economic theory were satisfied.

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

To consider the effects of alternative environmental policies on traded volumes, market prices and agriculture's environmental performance, as well as the effects of trade liberalization on the latter, 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 (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.[12] [13] 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

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[12] 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."

[13] 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).

practices, including specific fertilizer rates, and produces information on crop yields, erosion, and chemical losses to the environment. For the 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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Appendix 2. Coordination of Domestic Agri-Environmental Policies and Trade Liberalization

Agricultural support and protection rates are higher in developed than in developing countries (Burfisher, 2001; page 29). Reducing agricultural support with trade liberalization will likely decrease the return to agriculture most in those countries with the highest level of support. Diminished profitability then decreases the incentive to apply costly polluting inputs, so environmental stress from pesticide runoff and groundwater contamination would be reduced. Conversely, in countries that are better able to accommodate increased agricultural intensity because pesticide and fertilizer usage historically has been low, one might expect increased rates of chemical application as world prices rise in response to diminished domestic price supports and subsidies. On the other hand, the externalities associated with extensive methods of production may decrease. Thus, one might expect both positive and negative environmental impacts from trade liberalization. This possibility illustrates the potential to coordinate international trade and domestic environmental policies in order to benefit from trade liberalization's environmental improvements and efficiency gains while mitigating its potential to encourage specific negative environmental externalities. In other words, by coordinating domestic environmental policy with trade policy, a "win-win" outcome emerges.

Different countries employ various domestic agri-environmental policies that can combat suspected adverse environmental impacts of production increases that may result from trade liberalization. Some countries, particularly in the EU, employ various domestic agri-environmental policies designed to reduce the loss of desirable environmental by-products of agriculture that may be perceived to be under threat due to agricultural production decreases resulting from trade liberalization. In fact, the WTO recognizes the need for countries to protect their environment and to conserve natural resources. Under the WTO regulations set forth in the Agreement on Agriculture, member nations are required to reduce domestic support levels. However, the WTO allows domestic environmental and natural resource policies that meet certain criteria to be placed under the 'green box' exemption (see box 2), and therefore not are not subject to reductions in support. To qualify for the 'green box', a program:

- must affect trade and production only minimally,
- must not support prices or increase consumer costs, and
- must be financed by the government.

The potential use of generic agri-environmental programs, such as agri-environmental payment programs, to reduce the environmental impacts of agricultural production is demonstrated empirically in Claassen *et al.* (2001). However, an important question in terms of trade negotiations is what impacts these programs may have on production. On-going research at ERS suggests that agri-environmental programs may actually counter some of the production increases due to liberalized trade. This research also suggests that agri-environmental payment programs have minimal impacts on production.

Current U.S. Federal-level agri-environmental policy spans a wide range of programs, but unlike in the EU, these policies are targeted only at the potential negative consequence of agriculture, although that is changing to some extent with the introduction of the Grassland Reserve Program (GRP) and a revised Farmland Protection Program (FPP) in the 2002 Farm Bill.[14] USDA-administered programs that can be used to counter possible adverse environmental impacts of production increases that may result from trade liberalization include:[15]

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[14] Types of State and local programs that can be used to protect the amenities of agriculture are briefly covered in chapter 4.2 and are covered in detailed in Hellerstein et al. (2002).
[15] The budget data for these programs are derived from estimates supplied by the USDA's Office of Budget and Program Analysis.

- **Environmental Quality Incentives Program (EQIP) –** Through the use of technical assistance, education, cost-sharing, and incentives payments, EQIP assists farmers and ranchers in adopting management techniques that reduce nonpoint-source surface and groundwater pollution. Fiscal 2000 expenditures: US$174 million. Funding increases by 450% with the 2002 Farm Bill (comparing the six year period of the 2002 Farm Bill with the six year period of the previous Farm Bill), for around $9 billion in spending over 2002-2011.
- **Conservation Reserve Program (CRP)** - CRP provides rental payments to agricultural producers who retire environmentally sensitive cropland. Fiscal 2000 expenditures: US$1.6 billion. Near $2 billion in funding over 2002-2011 under the 2002 Farm Bill.
- **Farmland Protection Program (FPP)** - FPP allocates funds for purchase of conservation easements and other types of interest in land with prime, unique, or other highly productive soils. Although there were no fiscal 2000 expenditures, the 2001 budget requested US$65. Funding of $597 million is mandated for 2002-2007.
- **Wetland Reserve Program (WRP) –** WRP assists landowners in returning farmed wetlands to their original condition through easement payments and restoration cost-sharing. Fiscal 2000 appropriations: US$157. Near $2 billion in funding over 2002-2007 under the 2002 Farm Bill.
- **Conservation Security Program (CSP)** - Provides payments to farmers in return for their use of a wide range of environmentally benign land management practices. The program will have three "tiers" for participation; higher tiers require greater conservation effort and offer larger payments. Existing practices can be enrolled. This program is new under the 2002 Farm Bill, with $2 billion in funding over 2002-2011 (funding level forecasted in 2002).

- **Grassland Reserve Program (GRP) –** Using contracts or easements in conjunction with compensatory payments, up to 2 million acres of grassland will be protected from conversion to other uses. This program is new under the 2002 Farm Bill, with up to $254 million in funding available over 2002-2007.

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Appendix 3. Executive Order 13141 and The Environmental Review Process.

Recognizing the beneficial relationship between trade liberalization and environmental protection, President Clinton signed Executive Order 13141, "Environmental Review of Trade Agreements", on November 16, 1999 (64 Fed. Reg. 63169, Nov. 18, 1999). The Executive Order demonstrates the U.S. Government's commitment to the inclusion of ongoing environmental assessment and evaluation procedures in bilateral, multilateral, and natural resource sector free trade agreements. Under the direction of the U.S. Trade Representative and the Council on Environmental Quality, the effects of free trade agreements are to be evaluated, and when deemed appropriate, established in a written Environmental Review. The environmental review mechanism aims to "contribute to the broader goal of sustainable development" and "help identify potential environmental effects of trade agreements, both positive and negative." The Order establishes the fundamentals of the environmental review process, including essential elements of the process such as interagency collaboration, public participation, and transparency. To implement the Executive Order effectively, the President directed the United States Trade Representative and the Chair of the Council on Environmental Quality, in consultation with relevant foreign policy, environmental, and economic agencies, to develop Guidelines for the Environmental Review of Trade Agreements ("Guidelines"). These Guidelines, released in December 2000 (65 Fed. Reg. 79442, December 19, 2000), provide a detailed outline of the environmental review evaluation process and focus on the primary steps to complete an effective and timely environmental review. The Guidelines are centered on an ongoing and thorough scoping process, which serves as the keystone of the review. Throughout the scoping process, domestic, transboundary, and global environmental impacts of the free trade agreement are identified and analyzed, both qualitatively and quantitatively, as appropriate, in consultation with private and public entities.

Appendix 4. Discussion of Policy Issues Pertinent to the CEC Symposium

One of the goals of the CEC Symposium as outlined in its agenda is to receive insights on possible policy responses that mitigate negative environmental effects of trade. One issue in this context is the impact on trade of these policy responses themselves. Utilizing the same modeling approaches as used in this paper, on-going research at ERS empirically examines the trade impacts of three generic agri-environmental schemes that provide farmers with incentive payments to encourage farm management activities that reduce erosion. Why might the trade impacts of these programs be of interest? 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, 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.[16] We find that, for the three agri-environmental payment scenarios evaluated, the maximum change in exports range from a 7 percent *decrease* (wheat) to a 1 percent *increase* (soybeans) across the scenarios. With regards to the scenario predicting a decrease in production, the reality is that no country is likely to challenge agri-environmental programs (e.g., the Conservation Reserve Program in the U.S.) that decrease production.

Other topics of interest under the agenda of the CEC Symposium include approaches to integrating environment and trade policies, including specific institutional and governance responses, and approaches that engage the meaningful input of civil society in environment and trade policy integration. It is with the latter in mind that the on-going trade and environment research at ERS was conceived. The overall aim of this research is to lay out an analysis of the major trade and environment linkages in one document. The results of this research are intended to inform a wide audience, including policymakers, policy analysts, environmental groups, commercial agriculture interests, and others interested in exploring the linkages between agricultural trade and the environment. With regards to specific institutional and governance responses, the methodology laid out in this paper can serve as background information for potential future quantitative analysis that informs the official environmental review process in the U.S., a process required under U.S. Executive Order 13142 and the U.S. Trade Act of 2002.

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