Appendix 7-1

The U.S. Agriculture Sector Mathematical Programming Model (USMP)

To consider the effects of trade liberalization on U.S. agriculture's environmental performance 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. The model has been applied to study 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 (Salathe et al., 1982), an econometrically estimated national level simulation model of the U.S. agriculture sector.

Major government agricultural programs, chiefly the Production Flexibility Contract Program (PFCP), the Conservation Reserve Program (CRP), and conservation compliance also are 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.

For this analysis the USMP model is calibrated to projected crop and livestock supply, demand, production, acreage, government program, input cost and other conditions for 2005. U.S. agriculture sector conditions in 2005 come from the USDA Baseline. Costs of production for crop production activities and livestock enterprises are based on ERS 1996 cost-of-production budgets (USDA, ERS, 1996). The costs are then indexed to the USDA Baseline projections of variable costs for 2005.

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 Environmental Policy Integrated Climate model, or EPIC (formerly known as 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.[1 2] Environmental emissions for each crop production activity were obtained from simulations of the production activities using EPIC. 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 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 (a predecessor of the Agricultural Resource Management 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 county data from USDA's National Agricultural Statistical Service (NASS) 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 7-year period. The environmental indicators were then obtained by running the systems through EPIC with erosion rates set at zero for a period of 60 years. This permitted the systems to be run through two complete cycles of the weather distribution, removing the effect of particular weather patterns 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.

In USMP, economic values have been linked to several of the environmental indicators. With regards to onsite values, agricultural soil erosion results in agricultural productivity losses, polluted air from wind erosion, and off-site costs attributed to water pollution. The loss of productivity stems primarily from the loss of topsoil and nutrients. The USMP's soil-depreciation indicator is the discounted value of long-term yield changes due to this loss, and is based on current output prices.

Estimates of the monetary value of offsite damages are derived from sediment and nitrogen damage indexes developed by the USDA (Claassen et al., 2001; Ribaudo, 1986; Feather et al., 1999). Amenities included in the indexes are 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

[1] 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."

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

set of amenities is by no means an exhaustive list of all amenities affected by sediment and nitrogen runoff, let alone that the impacts of the other environmental indicators have not been monetized yet. Hence, the monetized estimates of offsite damage calculated by USMP here—the value of nitrogen loss to water and the value of sheet and rill erosion damages—should be viewed as a lower bound on total offsite damages.

Of course, while USMP does contain some of the important agri-environmental indicators, the set is by no means complete. One example of an omitted indicator is emissions of pollutants associated with fuel usage. Agricultural trade will be a significant component of overall FTAA trade (see chapter 1 of this report), and increased international commerce likely involves increased transportation and fuel usage. Thus, expanded agricultural trade 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). Another example of an omitted source of pollution is manure production, and its contribution to nitrogen and phosphorus production. However, the next version of USMP will contain these manure-related indicators. Finally, USMP cannot estimate environmental impacts associated with commodities not in the model, such as sugar and fruit and vegetables empirical evidence and lack of data for estimation, we specified the values of the fundamental parameters of the model to be equal across countries.