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Regional Environment and Agriculture Programming Model

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Abstract

This bulletin presents the Regional Environment and Agriculture Programming Model (REAP), which was formerly known as USMP (U.S. Mathematical Programming Regional Agriculture Sector Model). This bulletin is a reference document for analysts and model users. It includes an outline of the objectives of REAP, describes the methodology used to achieve these objectives, and provides details on how REAP works. This bulletin provides the theoretical and modeling system specification, descriptions of the data used, and a guide for setting up and running model simulations. REAP is designed for spatial analyses of U.S. agricultural and environmental policies. REAP has been applied to soil conservation and environmental policy design, water quality, environmental credit trading, irrigation policy, climate change mitigation policy, trade and the environment, livestock waste management, wetlands policy, new or alternative fuels from agriculture products, crop and animal disease, and regional effects of trade agreements.

Keywords: Agriculture, environment, policy, mathematical programming, agricultural sector model.

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Contents

Summary

Development of the U.S. Mathematical Programming Regional Agricultural Sector Model (USMP) began in 1985 to augment economic and environmental policy analysis at the U.S. Department of Agriculture's Economic Research Service. Analysts needed a way to represent the interactions among product prices, choice of production practices, and demand for crop and livestock products when analyzing the potential effects of policies designed to address environmental issues associated with agriculture. The effects of environmental and energy policies were so widespread and the interaction among the various commodities so complex that it was impossible for analysts, using the available analytical tools and research results to project the ultimate effect of specified policies on agricultural producers or even to determine whether the policies would achieve their desired goals. This bulletin presents the current version of the USMP model—now the Regional Environment and Agriculture Programming Model (REAP)—its theoretical and modeling system specification, descriptions of the data used, and a guide for setting up and running model simulations.

What Are the Issues?

Many agricultural policy issues stem from agricultural production and its interface with the environment. Modeling efforts are important for informing policymakers on how these issues might influence the heterogeneous set of farms, farmers, and environmental resources that characterize U.S. agricultural production. Agricultural policy issues analyzed using REAP include soil conservation and environmental policy design, water quality, environmental credit trading, irrigation policy, climate change mitigation policy, trade and the environment, livestock waste management, wetlands policy, new or alternative fuels from agriculture products, crop and animal disease, and regional effects of trade agreements.

What Does the Model Do?

REAP is designed for general-purpose economic, environmental, technological, and policy analysis of the U.S. agriculture sector. REAP facilitates scenario—or "what if"—analyses by showing how changes in technology, commodity supply or demand, or farm, resource, environmental, or trade policy could affect a host of performance indicators important to decisionmakers and stakeholders. Analysts perform "what if" analyses by solving for a baseline, or status quo, economic equilibrium, then imposing specific policy, technology, trade, or other changes on the system and solving REAP again to compute a new economic equilibrium consistent with the scenario changes. Performance indicators include regional values for land use, input use, crop and animal production and prices, farm income, government expenditures, farm program participation, and environmental emissions such as erosion, nutrient and pesticide loadings, and greenhouse

gases. The scenarios analyzed do not predict a dated forecast or projection, but rather present the likely effect of proposed changes in policies, regulations, and markets on the agriculture sector's performance, holding constant all other conditions affecting the sector.

REAP is a price-endogenous mathematical programming model. As such, it incorporates the assumptions of neoclassical economics, supplemented by the best available estimated behavioral and biophysical relationships (e.g., for agricultural commodity supply and demand or nitrogen run off). Many regularly updated data sets—production practices surveys, multiyear baselines, macroeconomic trend projections, and regional resource and land databases—are applied to construct and update REAP. To generate a baseline scenario, disaggregated regional data are used to map the baseline data projections into REAP's smaller units of analysis. The relationships between production practices and environmental performance indicators represented in the model are derived by using biophysical models.

How Does the Model Work?

- REAP cropping enterprises, or activities that include rotation, tillage, and fertilizer choices, are linked to the Environmental Policy Integrated Climate Model (EPIC), a biophysical model of crop production. In addition to the effect of production practices on yields, EPIC is used to compute environmental indicators such as nitrogen loss and greenhouse gas emissions per acre for each REAP crop system, thereby augmenting economic analysis of "what if" scenarios with their environmental effects as well.

- Land use, crop mix, multiyear crop rotations, tillage practices, and nitrogen fertilizer application rates are all endogenously determined in REAP's 45 production regions. Scenario analysis explores the response of all these variables to "what if" changes in policy incentives, regulations, market conditions, technology, and so forth.

- Crop and livestock primary and secondary products are all integral parts of the model and interact in the solution process. Cattle, poultry, and swine feed rations are formed from activities that process crops into protein, energy, and trace elements necessary for the respective animal diets. Policy and market shocks that directly affect either the crop or livestock industry ultimately result in a market equilibrium that reflects the repercussions for agricultural industries and markets.

- REAP provides comparative static analysis from any base year in the historical/baseline data, which is approximately 1988-2015. REAP is typically calibrated to a current or future year selected from the 10-year USDA baseline. For example, REAP is to be calibrated to the 2010 baseline for scenario analysis of changes introduced in 2010. Near-term analyses of policy, market, or technology shocks reflect short- or medium-term sector responses; long-term analyses reflect longer run adjustments.

- The explicit linkages in REAP between production activities and environmental emissions indicators can be exploited to extend analysis to alternative environmental policy scenarios. For example, REAP was extended in 1999 to provide analysis of the effects of the Kyoto Protocol on U.S. agriculture. REAP has also been extended by the World Resources Institute to examine excess fertilizer nutrient (phosphorus) pollution in the Great Lakes, hypoxia, climate change, and point/nonpoint emissions trading.

- Data used are readily available. Most core model data are prepared and regularly updated by agencies of the U.S. Department of Agriculture. REAP applies USDA and ERS data and estimates to agriculture sector analysis. This includes ERS cost of production data, USDA acreage and production data, baseline data, and changes to commodity program policy instruments (e.g., fixed and counter-cyclical payments, target prices, loan rates, loan deficiency payments, and domestic agrienvironmental programs).