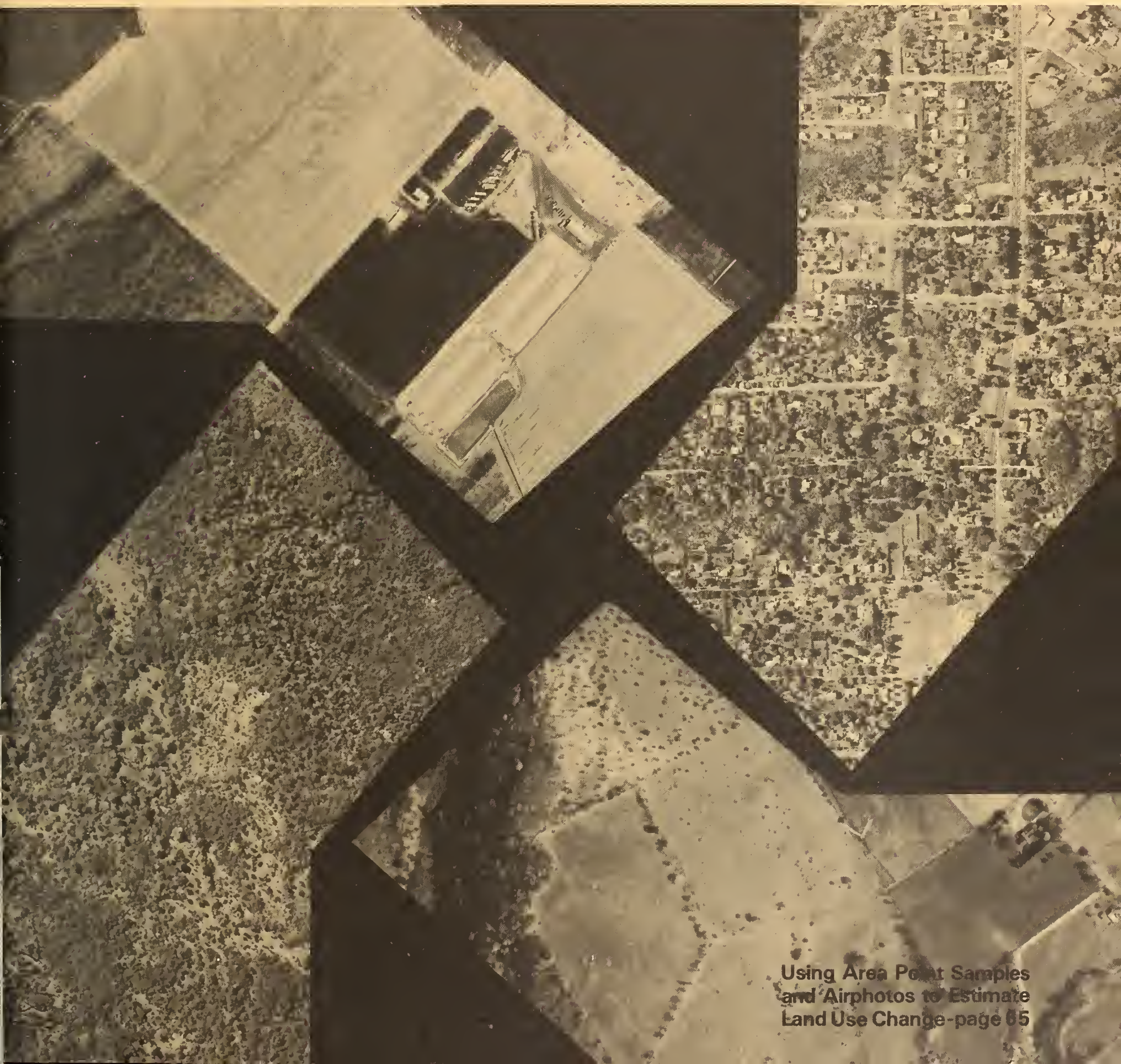
AGRICULTURAL ECONOMICS RESEARCH

A JOURNAL OF THE
U. S. DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE

APRIL 1976 VOL. 28 NO. 2



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AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the United States Department of Agriculture and Cooperating Agencies.

APRIL 1976 VOL. 28 NO.2

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COMPREHENSIVE FORECASTING AND PROJECTION MODELS IN THE ECONOMIC RESEARCH SERVICE

By Wayne Boutwell, Clark Edwards, Richard Haidacher, Howard Hogg, William E. Kost, J. B. Penn, J. M. Roop, and Leroy Quance *

ERS provides economic information on the near-term agricultural outlook and on longrun projections. Here is an overview of efforts to improve such information through comprehensive quantitative models. The various models incorporate intercommodity relationships within agriculture, aggregate farm price and income levels, interactions between the farm and nonfarm economies, natural resources, environmental considerations, and foreign markets.
Keywords: agricultural outlook, projections, forecasting, econometrics, models, systems.

"As for those economists who . . . have taken the stand that mathematics cannot possibly serve to elucidate economic principles, let them go their way . . . They can never prevent the theory of the determination of prices . . . from becoming a mathematical theory" (*36*, p. 47).[1] This observation by Leon Walras in 1874 applies to the forecasts and projections of agricultural prices and quantities by the Economic Research Service (ERS). It helps to explain why ERS, in its outlook and longer run projections programs, depends heavily on mathematical and statistical models. This article provides an overview of ERS efforts to improve its agricultural forecasts and projections through comprehensive econometric models. Other important forecast and projection efforts are also underway, but they are not the focus here.

ERS provides information on the near-term agricultural outlook and on longrun projections both to public and private decisionmakers. ERS specialists forecast prices, production, domestic use, and exports for individual commodities; and they make estimates for aggregates, such as farm income, the farm and retail price indexes, and food consumption. Commodity and aggregate agricultural sector forecasts and projections serve as the basis for the outlook program and as a major information source for public and private decisionmakers.

Recently, efforts have been made to improve the methodology used in agricultural forecasts and projections. The need stems from the continued difficulty of sorting out all interrelationships in U.S. agriculture and translating them into an accurate set of quantitative forecasts. The emergence of foreign markets as a dominant influence on U.S. agriculture has compounded the problem, and awareness has grown of the need for comprehensive models of the agricultural economy that include both domestic and foreign sectors. Another difficulty: longrun projections models generally fail to pick up shortrun variations, just as shortrun forecasting models usually do not pick up longrun trends. Shortrun cycles and longrun trends sometimes appear to conflict; thus, all researchers must be aware of the total activity. However, the two types of models do share common data sources and theories and they are complementary.

SHORTRUN AGRICULTURAL FORECASTS

Though shortrun forecasts are supported by modeling efforts throughout ERS, most of the work is concentrated in the three divisions in Food and Fiber Economics (FFE): Foreign Demand and Competition (FDCD), National Economic Analysis (NEAD), and Commodity Economics (CED) (fig. 1). Overall planning is done by the Deputy Administrator of FFE, the outlook and situation officer, and staff from CED, FDCD, and NEAD. This group is purposively composed so that it cuts across the administrative organization (shown in figure 1) to perform the forecasting function. The administrative organization has other purposes than forecasting. But to explain the forecasting function, we show the organizational setup as a background. The forecasting setup can be explained by showing how it differs from the organizational setup. Figure 2 indicates some of these cross-organizational linkages. Emphasis of this overview article is on function rather than organization. The three-division group reviews the current situation and makes basic assumptions for the forecast analyses. The assumptions usually involve the outlook for the general economy

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[1] Italic numbers in parentheses refer to items in References at the end of this article.

OUTLOOK AND FORECASTING
ORGANIZATIONAL STRUCTURE,
ECONOMIC RESEARCH SERVICE

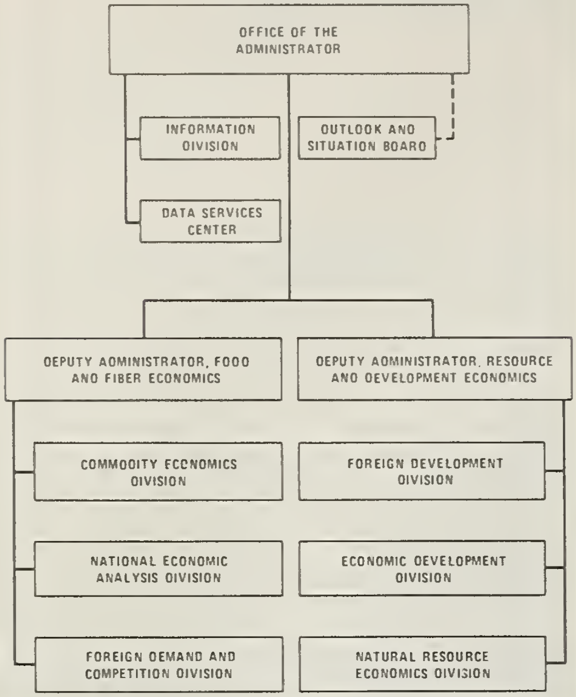


FIGURE 1

and alternative levels of world production and demand, and they sometimes involve estimates of U.S. crop production. Once the assumptions are specified, the analysis begins.

The area of responsibility for each division and the flow of forecast information are outlined in figure 2. Within ERS, FDCD has responsibility for export forecasts. The division's country and commodity analysts provide the primary information used to generate aggregate export forecasts for feed grains, food grains, soybeans, and cotton. These forecasts depend on the outlook and situation assumptions and on macrolevel forecasts of world population, income, and agricultural production. The import estimates made for countries are aggregated into exports for U.S. agricultural products.

Specific commodity forecasts are the responsibility of CED. Export forecasts from FDCD, situation and outlook assumptions, and macrolevel forecasts of the U.S. economy are used to develop domestic forecasts of prices, production, and use for the major commodity sectors: beef, pork, dairy, poultry, tobacco, fibers, oil crops, feed grains, and food grains.

NEAD has responsibility for aggregate agricultural forecasts. These are made for farm income, prices received by farmers, retail food prices, and per capita food consumption. CED's commodity price, production, and use forecasts provide part of the basis for NEAD's aggregate forecasts. However, aggregate models are also used. After results of the two approaches are compared, revisions may be made in some commodity forecasts as well as in the macrolevel forecasts for agriculture and for nonfarm income and consumer demand.

Outlook information is then coordinated, evaluated for overall consistency, and disseminated in ERS reports (fig. 2).

Underpinning the work described above is the Data Services Center (DSC) (fig. 1). Its primary function is to increase the use of computer technology to speed the flow of data into and throughout ERS. The Center acquires data used in ERS in automated forms, develops a data management and analysis system, and provides support through general systems analysis, programming, and scientific applications. DSC also helps to identify data gaps and to plan for filling these, and it helps articulate these needs to statistical agencies, other data suppliers, and other parts of the Federal statistical establishment.

Aggregate Forecasts

Forecasts of aggregate measures for U.S. agriculture, such as realized net farm income and prices received by farmers, depend on interrelations (1) between specific commodity forecasts and the U.S. economy and (2) between U.S. agriculture and the world economy as well as (3) among subsectors within agriculture. Accounting for these interrelations is essential in short-run forecasting.

Earlier models. In this overview, we chose to discuss aggregate models that treat agriculture as a subsector of a larger system. This focus eliminates some related and highly interesting work (*4, 18, 23*). A brief glance at earlier aggregate agricultural models will help in presenting the models currently used. The first agricultural sector model to interface with a macro model was that of Cromarty (*2*). Linkages to the macro-economy were direct; commercial demand for each commodity was a function of its own price, prices for substitutes, per capita disposable income, and the general price level. Feedback was likewise direct, because disposable income included net farm income after adjustments for taxes and transfers. Policy variables could be introduced through the Government demand equations, such as the equation for the amount of commodities going under loan or purchase agreement.

The Brookings quarterly model of the United States, as originally published (*3*), contained a submodel of the agricultural sector developed by Karl Fox (*6*). The agricultural sector submodel, with 15 equations, estimated domestic consumer demand for foods derived from crops and livestock, retail value of the market basket for crops and livestock, and farm-retail spreads. Identities determined the farm value of the market basket for crops and livestock. A final equation estimated the level

INFORMATION FLOWS IN THE SHORTRUN FORECASTING PROCESS

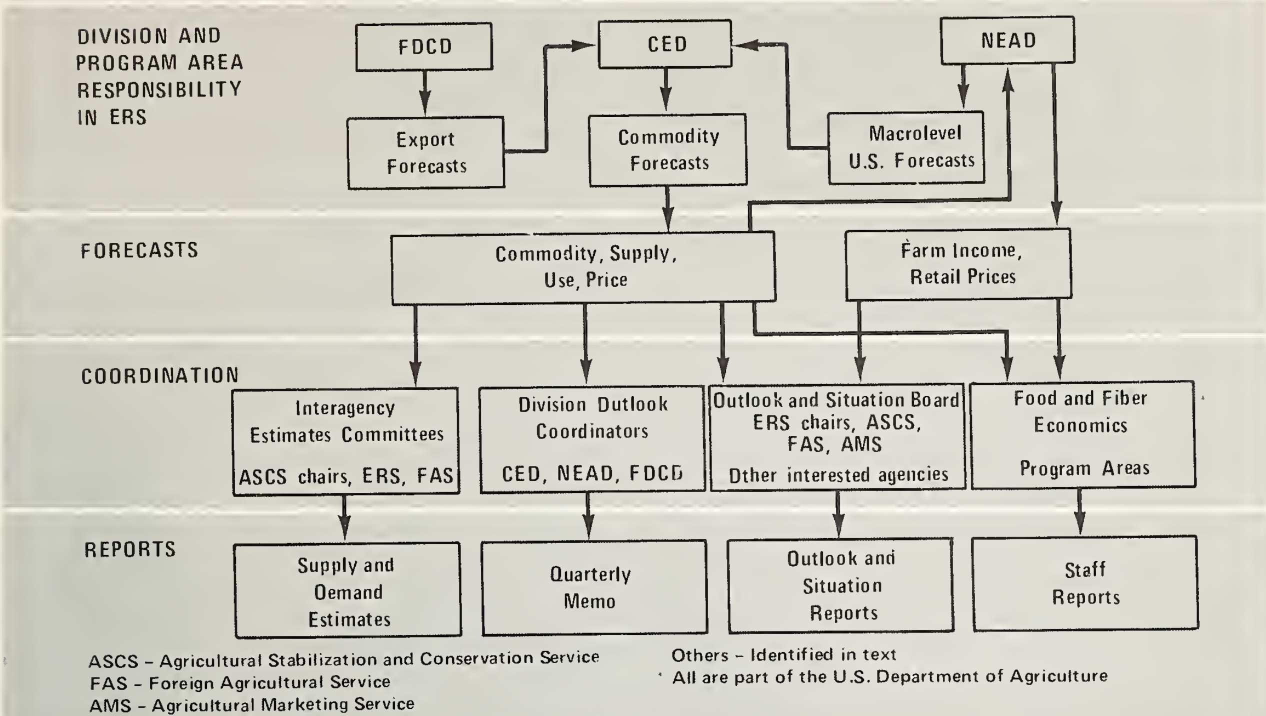


FIGURE 2

of prices received by farmers. Other endogenous variables included gross and net farm income, production expenses, depreciation, and net change in inventories. By the time the full Brookings model was operational, the agricultural sector had been reduced and reformulated by Fromm (*7*, p. 12). This reformulation is similar in linkages and structure to the Wharton model described below.

The Wharton model. ERS subscribes to the forecasting services of the Wharton Econometrics Forecasting Associates (WEFA). The Wharton Mark IV model has nearly 400 equations and identities and 17 sectors. The agricultural subsector is treated as any other industrial subsector would be; and several variables—fixed investment, an implicit price deflator, output originating in the sector, compensation per manyear, employment, and net proprietor's income—are all endogenously determined. The subsector setup allows for little alteration for the exploration of policy alternatives. Output originating in agriculture is seen unrealistically as a direct (same period) response to changes in consumer expenditures for food and beverages only. Agricultural output, in turn, helps determine employment, wage compensation, and investment in the total economy. The prime movers of the deflator for the agricultural sector and farm income are seen as prices received and paid by farmers, both of which are exogenous to the system.

However, the Mark IV linkages between the agricultural subsector and the remainder of the model are direct. Output originating in agriculture is a portion of aggregate supply, wage compensation and employment serve to determine the wage bill in agriculture, agricultural income is added in to arrive at national income, and investment is a component of aggregate demand. The implicit price deflator for agriculture enters into the estimation of the Consumer Price Index (CPI) and the Wholesale Price Index (WPI).

The feedbacks are also direct: interest rates in the economy help to determine agricultural investment; consumption expenditures for food determine output originating in agriculture; and the civilian unemployment rate and the CPI influence the rate at which manyears are compensated in agriculture.

ERS models. Two aggregate models were recently developed in ERS. In the first, described by Dale Heien in (*14*), a four-subsector (livestock, feed grain, food grain, and all other) annual agricultural sector is estimated as a submodel in a larger macroeconomic model that contains 47 equations and identities. This model has several limitations. Supply is considered fixed in any year after production, for example. Yet the results explicitly take into account the effect of changes in macropolicy instruments (such as interest and income tax rates) on a variety of agricultural sector variables: cash receipts, prices received, farm income, employment, and the like. Gerald Schluter takes another approach, quite different in concept (*29, 30*). After assuming answers to questions of final demand, he estimates the value of agricultural output required, using as much commodity detail as is desirable or available from an input-output (I/0) table. Schluter adjusts these output estimates to compensate for the fact that I/0 tables, with fixed coefficients, do not allow for technological change or shifts in relative prices. These adjusted estimates are clearly superior for forecasting purposes to unadjusted estimates of agricultural output.

Both the behavioral and I/0 approaches have their advantages. The behavioral approach better captures shortrun variations while the I/0 approach proves to be more suitable for examining longrun trends. And it can also be incorporated in the longrun projections models discussed in a later section. Current efforts in ERS use both approaches: behavioral for shortrun forecasting (3 months to 2 years) and I/0 for intermediate-term forecasting (2-5 years).

Two projects are underway in ERS to model the agricultural-macroeconomic interface. In the short-term behavioral project, economists are developing a more complete disaggregated submodel of the agricultural sector than is currently in use which can be substituted into the Mark IV model. Work should be completed and a report on it released soon.

The second project involves forecasting of income, prices, and other variables in the agricultural sector for the intermediate term (2-5 years). This effort uses the Wharton Annual and Industry Forecasting Model. Again, the main focus is on the interrelation of the agricultural sector and the macroeconomy; specifically, the impacts of macroeconomic policy on the agricultural sector and the effect of changes in the agricultural sector on the national economy. The WEFA annual and industry model has only two agricultural subsectors out of a total of 63 subsectors for the economy. Economists on the project are disaggregating these 2 subsectors into 16. In addition, nondurable manufacturing is being disaggregated further to identify the food processing subsectors. Final demands in the economy are disaggregated to separate out demands that are relevant to agriculture. Linking this macroeconometric model with an I/O model (with more detail in the agricultural and food processing subsectors) will allow forecasts of the effects of various macroeconomic scenarios on U.S. agriculture. Similarly, we will be able to forecast how changes in the agricultural sector will affect the macroeconomy. People on the intermediate-term project are using the 1967 I/O tables. Currently they are waiting for the Wharton staff to update its annual model with the newly published National Income and Product Account benchmark revisions (*33*).

Disaggregation Among Agricultural Commodities

The following models emphasize forecasts of commodity prices and quantities, but they can also be linked directly to the macroeconomy. Some obvious overlaps exist between the aggregate and disaggregated models; some aggregate models show commodity detail and some commodity models interact with the macroeconomy. But the commodity modeling discussed below emphasizes development of a system to provide consistent forecasts on *individual* commodities.

The Cross-Commodity Forecasting System (CCFS) in ERS provides a comprehensive analytical framework to support the outlook and situation process for which CED has responsibility. Basic components of CCFS are annual econometric models of the economic structure for individual commodities or commodity groups. CCFS is referred to as a *system* to distinguish it from the basic structural *model* components. These components are equilibrium models which contain—either explicitly or implicitly—demand, supply, and stock relationships and identities. The structural parameters are estimated individually for each commodity model. Once a commodity model is operational, it can be used separately to explain and forecast phenomena related to that commodity; it assumes answers to questions about other commodities are exogenous. The individual models are linked together via common variables which become endogenous in the linking process. The combined system of structural models is solved for the implied reduced-form system. A Gauss-Seidel procedure (*15*) is used to obtain the combined model solution and impact multipliers.

CCFS will eventually include:

beef	dairy products	barley	cotton
pork	eggs	soybeans	wool
chicken	corn	wheat	tobacco
turkeys	grain sorghum	rice	peanuts
lambs	oats	rye	fruits & vegetables

The current focus is on the feed grain-livestock-protein complex, in which a relatively strong economic interdependence exists. CCFS takes explicit account of the interdependencies.

Figure 3 illustrates the current composition of CCFS. It shows a decreasing level of aggregation—from system to sector to component to models. The approximate number of equations, including identities, appears in parentheses at each level. The figure also shows the progression of exogenous variables according to the level of disaggregation. For example, population is exogenous to the entire system. Feed price is exogenous to the livestock sector but endogenous to the system. Chicken prices are exogenous to the red meat component but endogenous to the livestock sector. Pork price is exogenous to the beef model but endogenous to the red meat component.

The livestock sector of CCFS, currently operational, contains models for beef, pork, chicken, turkey, eggs,

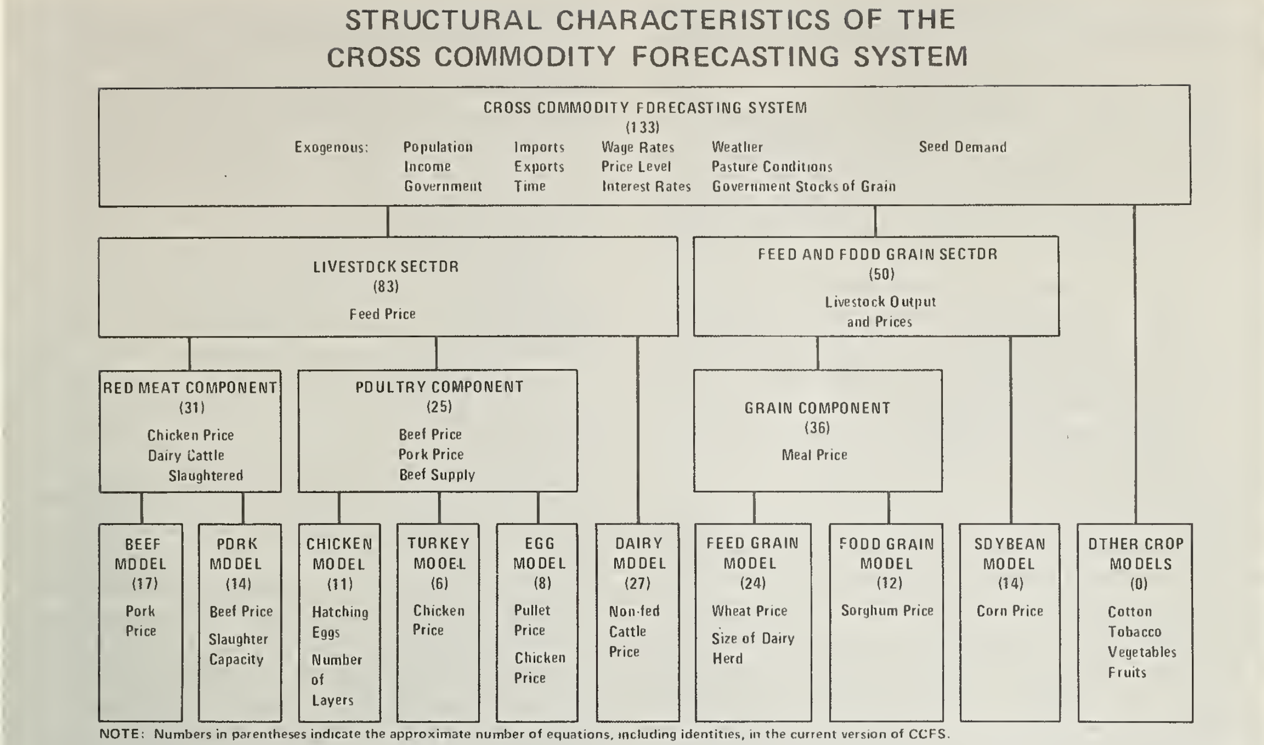


FIGURE 3

and dairy products. Individual commodity models are linked to form the sector. The information is used in the CED forecasting process and in various impact analyses.

The grain sector includes a model for feed grains—corn, sorghum, oats, and barley. This model is currently used to support the outlook and forecasting process. The wheat model is based on previous models, and it is the least developed of the models discussed thus far. For oilseeds, a soybean model has probably had the longest period of development and use. It is being reestimated and is currently operated separately. The livestock, feed grains, and soybean models are used, to a limited extent, in an iterative forecasting procedure. Plans are to link these three and the wheat model together. A previously estimated model for tobacco is being evaluated, and specification and estimation of a model for cotton is underway. Additional commodities will be added to CCFS.

When CCFS is completed, the system will comprise a comprehensive model of the agricultural sector with the capability of generating implied aggregates such as cash receipts, volume of marketings, prices received, and, given estimates of production expenses, farm income. In addition, because of the initial design of the overall agricultural sector framework, largely the work of Heien (*14*), the comprehensive model can be readily linked to a macromodel of the domestic U.S. economy, such as the Wharton (annual) model.

Forecasting Models of World Agriculture

FDCD is currently developing short-term forecasting models for world agriculture to help in this division's forecasting function. Such models, with their associated data base and explicit assumptions, help identify the important factors affecting foreign production, consumption, and trade. A primary concern is to develop objective forecast models that analysts will find not only helpful but also easy to use.

FDCD shortrun modeling efforts currently concentrate on forecasts for the grain-oilseed-livestock sectors of France, West Germany, Italy, the Netherlands, and Belgium-Luxembourg. These models are focused on wheat, several coarse grains, oilseeds, beef, veal, dairy, pork, poultry, and eggs. The models are recursive. Quantities are functions of prices, which are assumed to be set primarily by policies of the European Economic Community.

Each country model contains three submodels: production, feed consumption, and food consumption. The production submodel forecasts acreage and livestock numbers as well as productivity per unit. Total production is calculated by an identity. Major efforts are made to incorporate intercommodity relationships and price responsiveness. Feed consumption is forecast as a derived demand. Given feed conversion factors, the models calculate the feed required to support the forecasted number of animals. Food consumption is based on food demand equations used to estimate a matrix of price and income elasticities. This matrix, with exogenous price and income assumptions, is used to forecast food consumption.

Nonstructural forecast modeling is being experimented with. ERS staff members are evaluating autoregressive time series models for U.S. agricultural commodity exports. In addition, models built outside ERS are being examined for use in world agriculture forecasts. Our first such effort involves use of the Project LINK macroeconomic models and forecasts (*1*). These models provide a set of internationally consistent forecasts of macroeconomic variables for the major countries as well as a consistent set of aggregated world trade forecasts. This consistent set of forecasts can be used for variables treated as exogenous inputs in FDCD models. LINK includes the Wharton Mark IV model discussed earlier.

Modeling will become increasingly important in FDCD; it will involve continual updates and analyses of sets of integrated models. These modeling efforts will provide user-oriented, comprehensive data bases for foreign agriculture. It is envisioned that the models will be integrated with related work in other ERS divisions.

Some of the forecast modeling capabilities in other divisions already embrace the world situation. For example, CED has developed a national-level behavioral model of world rice trade. The model incorporates the following elements:

- Linear production and consumption functions containing both endogenous and exogenous variables
- Price relationships relating types of rice, marketing stages, and geographic locations
- Variables reflecting government policies.

The basic conceptual framework is a set of national and regional production and disappearance functions with price relationships to reflect those existing within and between countries. The world rice economy is divided into 38 countries or regions. (The United States is separated into long-medium grain and short-grain rice areas.) Using econometric techniques, analysts developed for each country a set of equations for estimating production, disappearance, and external and internal price relationships. Equation sets are solved with a linear programming algorithm (*11, 22*).

In time, a family or hierarchy of models may be developed, such as in Project LINK, to integrate information from existing models of the macroeconomy, each region's agriculture, world agricultural commodities, aggregate U.S. agriculture, and U.S. agricultural commodities. Access to Project LINK and the Wharton model is one step in this direction. Some shortrun forecasting capability may be provided by the world grain-oilseed-livestock model, discussed later, with some modifications. Lastly, a series of market demand studies has been initiated to develop agricultural market sector models for regions and commodities.

Related Models

ERS has other models that support the aggregate and disaggregated forecasting models described in preceding sections. Also, there are techniques used in the ERS forecasting process that resemble accounting frameworks more than analytic models. With these tools, the analysts relate individual forecasts of prices and quantities for agricultural commodities to aggregated forecasts of income and price levels.

One such tool is POLYSIM, a comprehensive computerized model of the agricultural sector of the economy (*25*). Used in policy analysis rather than forecasting, POLYSIM leaps from the assumptions which begin the forecasting process directly to the conclusions. In other words, it provides a shortcut method for assessing likely impacts of certain changes in assumptions. POLYSIM measures changes in commodity supplies, domestic use, exports, prices, farm income, and consumer expenditures—at the national level. Commodities covered are feed grains, wheat, soybeans, cotton, beef, hogs, lamb, turkey, broilers, eggs, and dairy products. The data are "baseline estimates" of the economic situation most likely to prevail over the next 5 years. The complex interactions of commodity loan rates, target prices, set-aside acreage, export controls, and Commodity Credit Corporation sales activities as policy instruments form an integral part of POLYSIM. The economic impacts of changes in these variables can be traced through important economic indicators in the agricultural sector.

POLYSIM has been used extensively during the past year to supplement other more traditional approaches to policy questions that need to be answered quickly. Analysts gain an integrated approach for measuring impacts among commodities in an internally consistent dynamic framework for several years into the future. Additional commodities are being incorporated into the model and a stochastic version of it (using probability distributions on yields and exports) has been developed. The model structure is documented and users' manuals are available (*26, 27*). Other policy oriented models are used in ERS, for example, the one discussed by Nelson (*23*). Such models are less closely allied than POLYSIM to the shortrun forecasting focus of the ERS models discussed earlier.

ERS is experimenting with a model to estimate the competitive equilibrium situation resulting from U.S. domestic and export food and fiber requirements, with technology, resource availability, and methods of production and marketing as given assumptions. The model's universe is the U.S. food and fiber industry, including farm input supplies, the farming sector, and the marketing and export sectors. Demand relationships express price as a function of quantity, and cross elasticities are included. Production and marketing activities are expressed in a linear programming format. The model estimates the competitive equilibrium by finding solutions in terms of prices and quantities that maximize net social benefits (*21*). When it becomes operational, the model will supplement other comprehensive models discussed earlier because its consistent estimates of prices and quantities for farm inputs and outputs can be used to estimate net farm income and prices received by farmers.

The Aggregate Income and Wealth (AIW) simulator model developed by Penson, Lins, and Baker (*24*) is another short-term model consisting of 53 ancillary relationships, 21 simultaneous equations, and 4 accounting identities. It forecasts components of the income accounts, balance sheet, and sources and uses of funds statement for the farm sector. The model takes as input the forecast of (1) prices received and (2) output for crops and livestock. Basic forecasts of aggregate income and wealth from the model are published in the annual Agricultural Finance Outlook of ERS. In addition, the model is used to compare basic forecasts with alternative policy situations.

Other related ERS models, such as the dairy policy model (*12, 13*), are less comprehensive and may focus on a single agricultural sector. A cotton-textile model is being developed. The Feed and Livestock Evaluating System (FALES) incorporates several models of the feed-livestock economy in a consistent fashion (*35*). A stochastic simulator of wheat and feed grains (STOCS) examines issues related to price stability and to grain reserves (*32*). A grains transshipment model primarily focuses on price differentials among regions (*17*). Finally, the Aggregate Crop Response Estimating model (ACRE) estimates regional supply response (*5*).

LONGRUN AGRICULTURAL PROJECTIONS

Longrun projections models for agriculture exist in most ERS divisions, though the major effort is concentrated in these: National Economic Analysis (NEAD) Foreign Demand and Competition (FDCD), and Natural Resource Economics (NRED) (fig. 1).

NEAD has overall responsibility for coordinating projections across ERS, and the division's Economic Projections and Analytical Systems Program Leader is the ERS Coordinator for Projections. The Agency program includes (1) a network of projection teams composed of analysts from ERS, other USDA agencies, universities, and foundations; (2) a centralized and automated National-Interregional Agricultural Projections (NIRAP) system; (3) a routinely revised set of core projections of alternative futures for U.S. agriculture; and (4) a series of publications: *Agriculture The Third Century*.

FDCD has an operational grain, oilseed, and livestock (GOL) model for projecting production, consumption, and trade of major agricultural commodities in and among major world countries and regions. The GOL model is used to provide constant price export projections for the NIRAP system and to conduct special studies on different aspects of the world food situation and the U.S. farm export market.

NRED uses a variety of models, including the NIRAP system and the Iowa State University's and various river basin linear programming models to generate projections to use in evaluating public investments in natural resource development and resource programs and policies.

The NIRAP System

NIRAP is a computerized simulation of U.S. agriculture that can be used to project and analyze alternative futures for U.S. agriculture based on differing scenarios and policy decisions. Through analysis of alternative futures, the range of possible adjustment paths for agriculture can be bracketed, an early warning of potential difficulties provided, and possible solutions to potential problems and tradeoffs between policy goals evaluated. These projections are revised periodically and analyzed to provide a check on major issues relating to the world food situation, agricultural productivity, the economic viability of the farm production sector, adequacy of land and water resources for food production, domestic food supplies and prices, agriculture and energy, and the environment.

The NIRAP system will never be fully developed; additional components will be added and existing components revised over time. For a specified scenario, the currently operational NIRAP system projects the following:

Agricultural productivity growth at the national and regional levels by aggregate farm output and crop and livestock aggregates;

Prices paid and received by farmers at the national level;

Gross farm income, production costs, and net farm income at the national level;

Individual commodity production, prices, and use at the national level (30 commodities);

Crop and livestock production, crop yields, and land use, by irrigation and nonirrigated practices at the national and regional levels;

Fertilizer and fuel input requirements by commodity and in the aggregate at the national and regional levels;

Environmentally related variables such as soil erosion and the use of pesticides and chemical fertilizers at the national and regional levels;

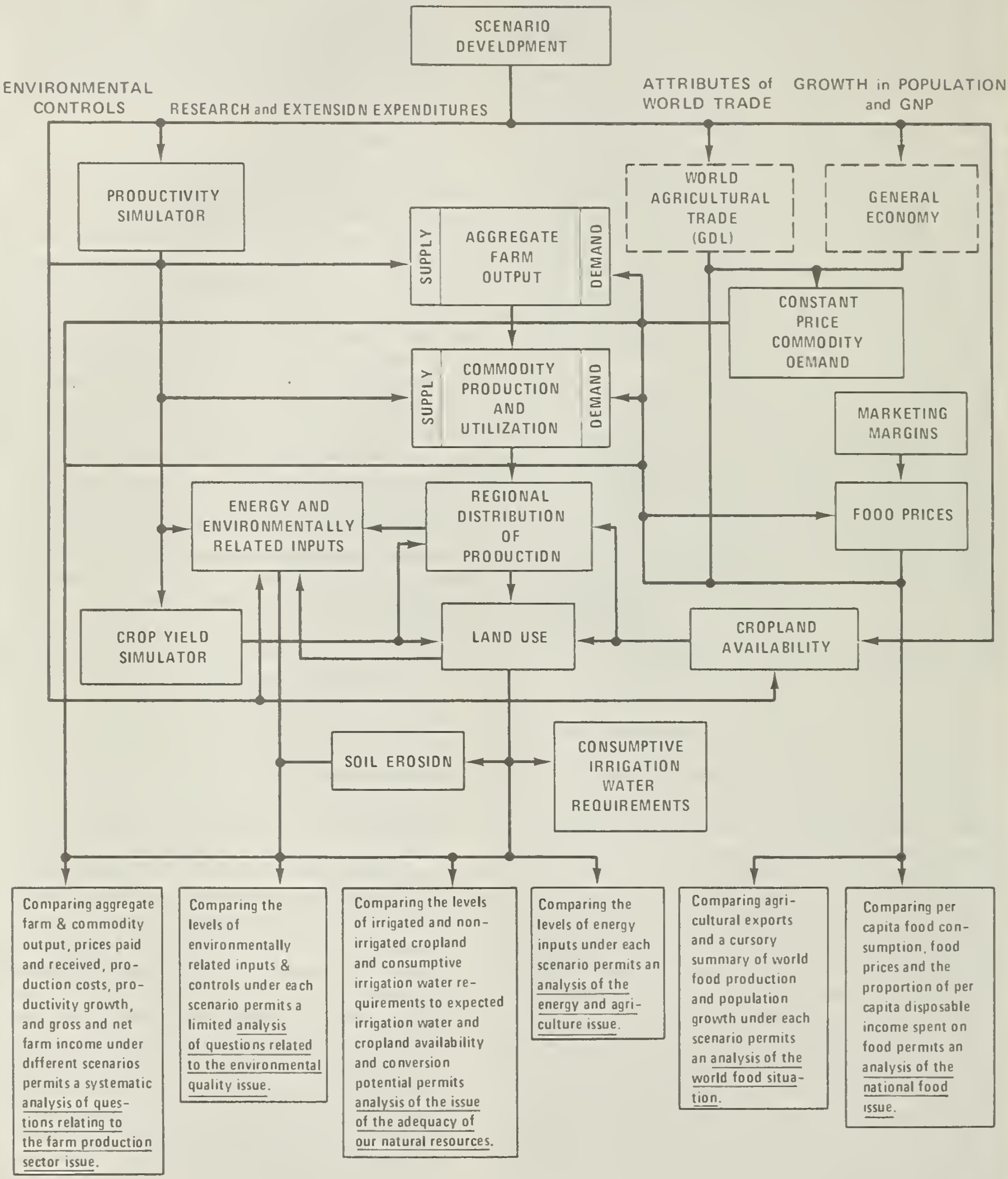
The consumer food price index at the national level;

Per capita food consumption, by commodity and in total, at the national level; and,

The percentage of per capita disposable income spent on food at the national level.

Figure 4 illustrates components of the NIRAP system and its use to project relevant relationships and indicators of change in food and agriculture for analysis of questions relating to the issues studied.

GENERALIZED FLOW CHART OF NATIONAL-INTERREGIONAL AGRICULTURAL PROJECTIONS (NIRAP) SYSTEM



NOTE: Dots on flow lines indicate lines connect.
— — — means no formal endogenous model.
——— means a formal endogenous model.

FIGURE 4

Modified Delphi workshops are conducted for scenario development. On the supply side, scenarios differ with respect to research and extension expenditures by the Federal and State governments, input price inflation, and environmental controls. On the demand side, scenarios differ with respect to domestic population and income growth, changes in tastes and preferences, and world trade. Quantified values of each scenario attribute provide shifts in the supply and demand functions in the aggregate farm output and commodity production and utilization components via scenario assumptions and the productivity simulator, world agricultural trade, and general economy components.

Farm prices and food consumption projections from the aggregate and commodity supply-demand models and marketing margins provide a basis for projecting food prices.

The crop yield simulator, cropland availability, and commodity production and utilization provide inputs for the regional distribution of production and land use components. National and regional commodity production, land use, and prices paid and received by farmers are used to project energy and environmentally related farm inputs. Land use projections are also determinants of projected soil erosion and consumptive irrigation water requirements.

Indicators projected by each NIRAP system component under appropriately paired scenarios are systematically analyzed to provide information for issue analysis as indicated at the bottom of figure 4. The issues are studied comparatively through the year 2025.

The world agricultural trade component is actually FDCD's GOL model rather than an integral NIRAP component, and the general economy components consist of scenario-determined exogenous population and GNP projections. All other components in the figure are endogenous NIRAP components in some significant stage of econometric development, and they are operational.

The OBERS Program

A major model requirement in NRED is development of agricultural output and resource use projections as part of the OBERS program. OBERS is an acronym which was devised when the Office of Business Economics (OBE) and ERS joined forces on longrun projections for use by the Water Resources Council (WRC). OBE, a unit in the U.S. Department of Commerce, was subsequently renamed the Bureau of Economic Analysis (BEA). NRED and the Regional Economics Analysis Division (READ) of BEA prepare periodic OBERS projections for the Council. Current plans call for a three-level set. The basic projection represents a continuation of current programs and policies. High and low projections related to such factors as restrictive environmental programs or expansionary export policies provide the two additional levels. NRED plans to use a national linear programming model to relate future demand and supply conditions in these projections.

Interagency planning teams use OBERS projections to prepare substate and regional resource development plans. The OBERS projections incorporate changes such as shifts in population, technology, land treatment, and interregional production, but not public resource development projects, such as irrigation, drainage, and flood protection. The linear programming framework was not available for use in the projections previously published (*34*) but plans call for its use in subsequent efforts. The OBERS projection model depends on information from NEAD, CED, or FDCD, including:

- Baseline per capita consumption projections
- Regional variations in consumption patterns
- Price elasticities for all commodities
- Cross elasticities where appropriate
- Exports
- Enterprise budgets

The NRED projection system explicitly recognizes interregional comparative advantage and resource availability at various product price-input cost levels. Regional level estimates from the national model are based on economic efficiency criteria and they are used to determine national implications of regional resource development plans (*8, 9, 10, 19, 20*) and to evaluate interregional impacts on commercial agriculture of policies and programs related to natural resources, including environmental issues. To measure primary interregional project and policy impacts, analysts use a constrained optimizing model, one that is consistent with the NRED regional projections models and compatible with the OBERS projections requirements. The system used for this purpose is a cost-minimizing model that meets a fixed national demand and does not allow price effects to influence demand. The NRED system projects for the following variables: commodity production, value of commodity output, costs of producing each commodity, land use by land class, water use, conservation tillage practices used, resources used in production, soil loss, and marginal unit costs.

FDCD Model

For longrun projections for the rest of the world, FDCD has developed a model of the world grain-oilseed-livestock economy. So that longer term world food prospects can be assessed, emphasis is placed on integration of the grain-oriented food sectors of the more developed regions. The model incorporates both intercommodity and interregional relationships. In the current version of the model, the focus is on a supply-demand equilibrium situation, solved by linear programming methods (*31*). The model does not contain spatial equilibrium elements. No projections are made concerning specific trade flows but evaluations of the net trade positions of regions can be made.

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The model incorporates information on population and income growth rates, demand and supply elasticities, physical input-output rates, and assumptions about underlying economic trends and policy constraints. Based on this information, the model projects equilibrium values for production, food and feed consumption, net trade, and prices for each commodity. Eleven commodities (wheat, rice, coarse grain, oilmeal, beef and veal, pork, lamb and mutton, poultry, milk, butter, and cheese) and 27 regions of the world are included. This work continues and expands the model reported on in *(28)*. Analysts have used the FDCD model to provide broad alternative future scenarios as well as to evaluate the long-term impact of specific policies.

AN ONGOING TASK

Since its reorganization in 1973, ERS has refocused and increased its modeling capability for forecasts and projections, and it will continue this work. In this overview article, we have attempted to inform people outside ERS of ongoing efforts in this area. This article can be considered the parent of a planned series of articles for this Journal which will provide a detailed look at the more comprehensive forecast and projections models.

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ECONOMIC CONSEQUENCES OF FEDERAL FARM COMMODITY PROGRAMS, 1953-72

By Frederick J. Nelson and Willard W. Cochrane*

Farm programs of the Federal Government kept farm prices and incomes higher than they otherwise would have been in 1953-65, thereby providing economic incentives to growth in output sufficient to keep farm prices lower than otherwise during 1968-72. The latter result differs significantly from findings in other historical free market studies. These conclusions stem from an analysis of the programs in which a two-sector (crops and livestock) econometric model was used to simulate historical and free-market production, price, and resource adjustments in U.S. agriculture. Supplies are affected by risk and uncertainty in the model, and farm technological change is endogenous.
Keywords: Government farm programs, farm income, risk, technological change, free market.

THE OBJECTIVE

Policy decisions affecting future production, consumption, and prices of food and fiber in the United States need to be made with as full knowledge as possible of the likely longrun and shortrun consequences. The quantitative analysis of past farm commodity programs described here can provide useful information for analyzing the consequences of future alternative programs.

How would agricultural economic development in the United States have been different if major farm commodity programs had been eliminated in 1953? To help answer the question, an econometric model was set up to simulate the behavior of selected economic variables during 1953-72.[1]

Farm programs of the Federal Government have, in various ways, supported and stabilized farm prices and incomes since 1933, when the first agricultural adjustment act was approved. Since then, dramatic long-term changes have occurred in (1) the resource structure of agriculture, (2) the productivity of measured agricultural resources, and (3) agricultural output levels. Such long-term changes did not occur independently of the farm programs. These programs were operated in a way that reduced risk and uncertainty for farmers, affected their expectations of future income potential from farm production activities, and influenced their willingness and ability to invest, to adopt cost-reducing technology, and to adjust output levels.

In considering effects of the programs, it is desirable to specify a model in which shortrun and longrun agricultural output responses are affected by investments, current input expenditures, and farm technological changes. These, in turn, should be influenced by price and income expectations and experiences, by the extent of risk and uncertainty, and by technological change. Such ideas were used in developing this model. A unique feature of the model is that it includes endogenous risk and resource productivity proxy variables.

Not much quantitative knowledge exists about intermediate and longrun supply adjustments under a sustained free-market situation. No claim is made however, that this model's results represent the definitive word in free-market analysis of the period studied. The estimates of longrun and shortrun effects of farm programs are extremely sensitive to changes in several assumptions that affect total supply and demand elasticities in the model. Further, ordinary least squares regression analysis (OLS) was used to estimate the coefficients of behavioral equations. Thus, the results should be considered preliminary and subject to revision if alternative estimation techniques later reveal substantial differences for important coefficients.

A central feature of the model—the disaggregation of agriculture into two sectors, crops and livestock—can be seen as both an advantage and a limitation. Use of two sectors instead of only one does allow analysis of important interrelationships between crops and livestock over time. But future research efforts should be aimed at a further extension to include specific commodities for two reasons. First, persons and organizations that might be the most interested in the type of information available from the model would want answers for specific commodities. Second, commodity specific equations might provide more accurate quantitative results. For example, measures of price variability for each commodity are the most logical proxy measures of the

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[1] A number of agricultural sector-simulation models developed in recent years can be used to quantify the total impact of farm commodity programs. Some of these models were reviewed in this study (*3, 8, 23, 24, 26, 30*). The basic framework for this model resembles that in (*30*) and in (*24*). However, following Daly (*2*), a two-sector approach was used instead of the one-sector approach of Tyner (*30*) or the seven-sector method of Ray (*24*).

extent of risk and uncertainty. But they were not used in the two-sector model.[2]

THE MODEL: ANALYTICAL FRAMEWORK, THEORY, AND SIMULATION PROCEDURE

The analysis centers around a comparison of two simulated time series for each of several variables in 1953-72. One series shows estimates of the variables' actual historical value with programs; the other, estimates in a free market without programs. The impact on a particular variable is the difference between its historical and free-market values, shown as a percentage change in table 4 and figure 1 (see p. 59).

As a measure of alternative impacts possible, several simulation results were obtained, based on differing assumptions about demand elasticities and resource adjustment responsiveness in a free market. This provided a test of the sensitivity of the model's results to such changes. Detailed discussion is limited primarily to one simulation set.

Overview

The simulation model consists of 59 equations (33 identities and 26 behavioral equations) and contains 51 exogenous variables.[3] A resource adjustment approach to crop and livestock output and supply response was used in designing the model. The simulation procedure for each year is as follows (the calculation for 1953 is used as an example):

- Current input levels are determined for the initial year (1953) based on beginning-of-year asset levels, current and recent price and income experiences, and farm programs in use
- Crop productivity and production are determined endogenously, based on the level and relative importance of selected inputs assumed to be primarily used for crop production
- Crop and livestock supply and demand components (including livestock production) and prices are simultaneously determined once crop production is known and Government market diversions under the farm programs are specified
- Given the above results, the model computes various measures of income, price and income variability, and aggregate agricultural productivity.
- Asset, investment, and debt levels, number of farms, and farmland prices are adjusted from the previous end-of-year levels, based on 1953 and earlier price and income experiences
- The above results are used to make similar calculations for 1954 and later years given the complete time series for those explanatory variables not determined within the model.

The data used to measure the variables are based on published and unpublished calendar year information from the Economic Research Service, and the Agricultural Stabilization and Conservation Service in the U.S. Department of Agriculture. However, only a few of these variables are published in the exact form used here. To facilitate analysis, assets, inputs, production, and use statistics were measured in 1957-59 dollars; for price indexes, 1957-59 equal to 100 was generally used.

Farm Program Variables

The farm programs covered include those involving price supports, acreage diversions, land retirement, and foreign demand expansion. Programs involving domestic demand expansion, marketing orders and agreements, import controls, and sugar are not explicitly included. The programs included have affected agriculture in the past two decades by:

- Idling up to 16 percent of cropland (6 percent of land in farms) through programs involving long- and short-term acreage diversions to control output
- Diverting up to 16 percent of crop output from the market into Government inventories or subsidized foreign consumption through price support and demand expansion activities
- Providing farmers with direct Government payments equal in value to as much as 29 percent of net farm income (7 percent of gross income).

Table 1 contains values of the exogenous farm program variables used. Table 2 shows the relative importance of some of these variables in the crop sector. The following three sections explain more about use of these variables and indicate the level for each program variable in the free-market simulation.[4]

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[2] Ray's disaggregation approach (*24*) is one alternative. Separate resource adjustment equations and production functions are included for livestock products, feed grains, wheat, soybeans, cotton, tobacco, and all other commodities. However, a procedure that places less strain on the available data would be one that uses commodity acreage and yield equations "controlled" by simulated aggregate resource and resource productivity adjustment estimates. See (*22*, p, 10; *34*).

[3] For a complete discussion of the theory, model, data, and simulation procedure, see (*19*). This information will also be available later in a planned USDA technical bulletin. A description of the variables and a list of the actual model equations are available from the senior author on request.

[4] An argument can be made in favor of making some or all program variables endogenous. For example, CCC inventory changes and acreage diverted by programs are complicated functions of announced price supports (loan rates), diversion requirements, and other supply and demand variables. Thus, exogenous price supports, instead of exogenous CCC inventory changes, could be used to represent the price support through acquisition and disposition activities of the CCC (as in (*3*)). Further, one might want to specify only policy goals (such as net income) as exogenous so that program operation rules would need to be endogenous to determine program details each year in

Table 1.—Government farm program variables, 1950-72

Year	Acres of cropland idled by programs (AD)	Percentage of land in farms not idled (PCT)	Percentage of acres planted with hybrid seed (PCTHB)	Net Government (CCC) inventory increases (1957-59 dollars)		Exports under specified Government programs (1957-59 dollars)		Government assisted crop exports (1957-59 dollars) (ASCX)	Direct Government farm program payments (GP)
				Crops (CCCD)	Livestock (CCLD)	Crops (GCX)	Livestock (GLX)		
	Millions	*Ratio*		*Billion dollars*					
1950	0.0	1.0000	0.1900	-0.765	0.035	a			0.283
1951	0.0	1.0000	.1960	-.446	-.122	a		a	.286
1952	0.0	1.0000	.2010	.351	0.0	0.386	a	0.426	.275
1953	0.0	1.0000	.2040	2.164	.315	.369	0.063	.353	.213
1954	0.0	1.0000	.2060	1.028	.127	.531	.127	.319	.257
1955	0.0	1.000	.2130	1.289	-.203	.759	.214	.316	.229
1956	13.6	.9983	.2160	-.312	-.149	1.268	.231	.543	.554
1957	27.8	.9765	.2200	-.919	.051	1.219	.170	.933	1.016
1958	27.1	.9772	.2370	1.350	-.089	.978	.122	.737	1.089
1959	22.5	.9806	.2790	.282	-.031	1.030	.076	.775	.682
1960	28.7	.9753	.2910	.261	.049	1.351	.046	1.098	.702
1961	53.7	.9538	.2490	-.087	.113	1.308	.067	.950	1.493
1962	64.7	.9439	.2570	.191	.172	1.220	.089	.675	1.747
1963	56.1	.9514	.2750	-.016	-.103	1.227	.153	.755	1.696
1964	55.5	.9511	.2590	-.249	-.191	1.377	.176	.935	2.181
1965	57.4	.9500	.2600	-.532	-.031	1.183	.105	.780	2.463
1966	63.3	.9443	.2660	-2.008	-.037	1.214	.063	.923	3.277
1967	40.8	.9635	.2800	-1.192	.143	.920	.108	.783	3.079
1968	49.3	.9561	.2630	1.521	-.011	.870	.116	.528	3.462
1969	58.0	.9477	.2700	1.028	-.061	.711	.093	.550	3.794
1970	57.1	.9483	.2740	-.928	.010	.723	.070	.942	3.717
1971	37.2	.9663	.2970	-.213	-.007	.687	.096	.987	3.145
1972	62.1	.9433	.2740	-.862	-.008	.701	.044	1.137	3.961

[a]Not available or not yet estimated.

Government market diversions. The Federal Government supports farm commodity prices through operations of USDA's Commodity Credit Corporation (CCC). The CCC helps farmers in three ways. It buys or sells commodities on the open market, and extends loans to farmers who have the option of repaying the loan or delivering their commodity to the CCC in lieu of repayment. Also, the CCC encourages domestic and foreign consumption by subsidizing food use or by giving commodities away. Five exogenous variables represent this activity in the model:

- CCCD is net stock change for crops owned by or under loan with the CCC
- CCLD is net stock change for livestock products owned by or under loan with the CCC
- GCX is crop exports under specified Government programs
- GLX is livestock exports under specified Government programs
- ASCX is crop exports assisted by the payment of export subsidies by the CCC

In the free-market simulation, these variables have a value of zero.

Acreage diversions and Government payments. Farm program operations aimed at controlling supply—to reduce the need for costly Government market diversions—include offering farmers some combination of direct cash payments and price support through CCC loan privileges in return for their idling of productive

the simulation. In the model, however, the procedure is to determine the impact of program operations, not policies, with such operations defined in a special way. The total impact of past program operations is the main goal rather than the effect of selected adjustments to specific annual policy variables or policy goals. See (*19*, pp. 139-149).

Table 2.—Farm program operations affecting crop output and marketings, 1950-72[a]

Year	Total Government market diversions[b]	Total acreage diversions	Crop-land plus diversions[c]	Total land in farms	Total crop production	Acres diverted as percentage of		Market diversions as percentage of production
						Land in farms	Crop-land	
	Billion dollars		*Million acres*		*Billion dollars*		*Percent*	
1950	d	0	377	1,202	17.0	0	0	d
1951	d	0	381	1,204	17.5	0	0	d
1952	1.2	0	380	1,205	18.4	0	0	7
1953	2.9	0	380	1,206	18.2	0	0	16
1954	1.9	0	380	1,206	17.9	0	0	11
1955	2.4	0	378	1,202	18.2	0	0	13
1956	1.5	14	383	1,197	18.3	1	4	8
1957	1.2	28	386	1,191	18.0	2	7	7
1958	3.1	27	382	1,185	19.9	2	7	16
1959	2.1	23	381	1,183	19.7	2	6	11
1960	2.7	29	384	1,176	20.8	2	7	13
1961	2.2	54	394	1,168	20.4	5	14	11
1962	2.1	65	396	1,159	20.7	6	16	10
1963	2.0	56	393	1,152	21.5	5	14	9
1964	2.1	56	391	1,146	20.7	5	14	10
1965	1.4	57	393	1,140	22.1	5	14	6
1966	0.1	63	395	1,132	21.6	6	16	1
1967	0.5	41	381	1,124	22.5	4	11	2
1968	2.9	49	384	1,115	23.2	4	13	13
1969	2.3	58	391	1,108	23.5	5	15	10
1970	0.7	57	389	1,103	22.6	5	15	3
1971	1.5	37	377	1,097	25.1	3	10	6
1972	1.0	62	398	1,093	25.3	6	16	4

[a]The information does not represent precise estimates of "excess capacity" in U.S. agriculture, but rather a summary of some relevant magnitudes. These do, of course, have implications for excess capacity analysis. [b]Government market diversions include the sum of net change in Government crop inventories (CCCD), Government crop exports (GCX), and assisted commercial crop exports (ASCX). [c]Includes acres of cropland harvested, crop failure acreage, cultivated summer fallow acres, plus acreage diverted by farm programs (AD). [d]Not available or not yet estimated.

cropland. The acreage idled under annual diversion and long-term land retirement programs (AD) is included as an explanatory variable in the equation for the use of cropland. The associated Government payments (GP) are included as part of gross and net farm income. In the free-market simulation, both of these variables have a value of zero. The percentage of total cropland not idled (PCT) is used in the analysis; its free-market value is, of course, 1.0 (100 percent).

Cropland planted with hybrid seed. The increased use of high-yielding corn and sorghum grain seed has been an important technological advance on American farms. The percentage of total cropland planted with hybrid seed (PCTHB) is used as an exogenous explanatory variable in the fertilizer and crop productivity behavioral equations. It was assumed that the upward trend in PCTHB was retarded in 1956 because acreage-idling programs began that year and they affected the relative importance of corn and sorghum acreage. Therefore, in the free-market simulation, PCTHB was assumed to increase a little faster from 1956 to 1959 than in actual history. The record level of PCTHB for 1971 (0.297) was assumed to have been achieved throughout 1961-72, after the high level achieved in 1960 (0.291.)[5]

[5] Following the theoretical ideas of Griliches (7), one could argue that the percentage of cropland planted with hybrid seed should be endogenous because the corn price level affects the profitability of adopting more expensive, higher yielding seed. An adequate consideration of this question will have to wait until commodity specific extensions are made. The percentage for all cropland depends on the relative importance and geographic location of corn and sorghum acreage as well as on prices received for corn and sorghum.

Special Features

Current input and asset adjustment. Behavioral equations representing the demand for assets were specified assuming asset adjustments occur in response to changes in (1) longrun profit expectations and (2) the extent of risk and uncertainty. Separate equations were included for the quantity of land and buildings, machinery and equipment, and livestock number inventories. The stock of an asset is determined by its level in the previous year, with adjustments for depreciation and for investments. A partial resource adjustment assumption was used in specifying demand equations for assets based on the Nerlovian distributed lag procedure. Longrun demand was explained by including as variables current and recent factor-factor price ratios, relative rates of return to farm real estate, and risk and uncertainty proxy indexes.

Current input expenditures depend on current and recent factor-product price ratios, asset levels, other input levels, and risk and uncertainty proxy indexes. The model contains behavioral demand equations for the following current inputs to agriculture: repair and operation of machinery, repair and operation of buildings, acres of cropland used for crops, fertilizer and lime, crop labor, livestock labor, hired labor, and miscellaneous inputs. The use of "other" input and asset levels as explanatory variables in current input demand functions is consistent with traditional profit-maximizing theory, because the marginal product of one factor depends on the quantity used of other factors. In the short run, current inputs adjust toward longrun levels as asset adjustments occur. Use of other current inputs as explanatory variables in the input demand functions resulted in a set of simultaneous equations.

Price and income expectations, and risk and uncertainty. Price and income expectations were represented by including current or lagged values of prices and income in input and asset adjustment equations. Simple averages of up to 5 years were sometimes used if more than one observed value was assumed relevant.

A major assumption was that an increase in commodity price variability specifically, and the elimination of farm programs generally, would increase the risk of investing in agriculture. Therefore the level of investment and current input expenditures for any given level of average price and income expectations would be reduced. The idea behind the assumption is that farmers will adjust to situations involving varying degrees of price and income uncertainty by sacrificing some potential profits to reduce the probability of financial disaster. Such adjustments depend on a farmer's psychological makeup and capital position, and they can take several forms:

- Adjusting the planned product mix to favor products with relatively low price and income variability
- Diversifying in a way that reduces net farm income variability
- Minimizing the probability that farm losses will lead to financial disaster by reducing the total amount of investment in the farm business which reduces the potential size of both profits and losses
- Increasing the firm's ability to survive loss experiences by increasing the share of total farm business investment held as financial reserves and operating with smaller amounts of borrowed capital.

(Elements of the first two adjustments may be involved when farmers choose to participate in specific voluntary price support-acreage diversion programs.) Because of the desire for financial reserves, an important interrelationship probably exists between annual investments, savings, family consumption, and risk and uncertainty. A realistic appraisal of the economic consequences of eliminating price stabilizing programs must consider this factor of farmers' risk aversion.[6]

Proxy indexes of the extent of risk and uncertainty were computed in the model as 5-year averages of the absolute annual percentage change in prices and in incomes. These indexes were included as explanatory variables in the behavioral equations for assets and inputs. Proxy indexes were computed for the following variables: (1) aggregate crop price index, (2) aggregate agricultural price index, (3) net income available for investment (net income plus depreciation allowances), and (4) the livestock-crop price ratio. Direct Government program payments to farmers (GP) were also used to explain resource adjustments; GP was assumed to represent a relatively certain source of net income for the coming year, once the annual program details had been announced by USDA.

Behavioral equations for the following variables contain one of the several risk and uncertainty proxy variables: repair and operation of machinery, fertilizer and lime, acres of cropland, repair and operation of buildings, miscellaneous inputs, buildings, land in farms, livestock number inventory, and farmland prices. Demand equations for machinery, labor, and onfarm crop inventories contain no risk proxies.

Crop input and productivity. Crop output is the product of three variables:

- Sum of four inputs (measured in 1957-59 dollar values) used primarily for crop production—fertilizer and lime, machinery inputs, acres of cropland for crops, and man-hours of crop labor
- Percentage of cropland harvested (exogenous)
- Output per unit of crop input

In specifying an output per unit of crop input equation,

[6] This explanation follows Heady's (*11*, pp. 439-583). Support also appears in (*6, 9, 15,* and *16*). And see the recent quantitative analysis of farmer investment and consumption behavior reported in (*5*). also an empirical test of the hypothesis that farmers' cropping patterns and total outputs are influenced by a consideration of risk as well as expected income in (*18*).

crop productivity increases specifically, and farm technological advances generally, were assumed to have occurred along with, or partly because of, the greater use of nonfarm produced inputs relative to the traditional inputs of land and labor.

Farm technological change can be seen as the longrun result of specialization of labor and the associated highly successful innovative effort and research investment by persons in both the public and private sectors. The farm input and public sectors of the economy have become specialized producers of a continuous stream of new improved products and technologies that are used by farmers. Farmers, in turn, have become specialists in organizing and using these products so that inputs of land and human capital have become more productive. These changes have resulted mainly in response to economic incentives and they involve dynamic adjustments in the demand and supply of technology. Farmers have demanded improved inputs and techniques to maximize profits. And suppliers have developed the new products and techniques desired. Farm technological change depends on resource substitutions and capital outlays by farmers in response to:

- Changes in factor and product price relationships
- Cost and availability of new inputs and techniques
- Expected benefit from adoption of new inputs and methods
- Farmers' liquid and capital assets position
- Extent and importance to farmers of risk and uncertainty[7]

The output per unit of crop input index was estimated as a linear function of several variables:

- Percentage of cropland planted with hybrid seed
- Ratio of nonfarm produced fertilizer and machinery inputs to crop labor and cropland inputs
- Crop inputs subtotal
- Squared interaction term between the first two items in this list.

(Input and output measures used are value aggregates based on 1957-59 average prices.) The hybrid percentage was assumed to increase productivity because of the tremendous yield-increasing effect of shifts to hybrid corn and sorghum seed. Productivity was assumed to decline as total inputs increased, because, for example, greater land use would likely extend to less productive cropland. The ratio of nonfarm inputs to land plus labor was assumed to increase productivity. In the analysis of farm program impacts, this crop productivity equation significantly helped to explain longrun price trends and cycles. Because of the method used to specify the crop productivity equation, financial losses and business disasters simulated in the free market were ultimately reflected in a reduced level of nonfarm purchased inputs relative to land and labor. As a result, aggregate crop resource productivity went down and crop and livestock prices increased over time. Further, as prices rose in the model, additional cropland and other crop inputs were pulled into the system. But average crop input productivity was further decreased, which tended to dampen the supply response and retard the expected downward pressure on prices. This illustrates the advantage of endogenously simulating productivity in preference to using a simple extension of past trends.

Supply, demand, and prices. Total supplies of crops and livestock were set as identically equal to current production, plus beginning-of-year private stocks, and imports (for livestock, minus exports). The associated demand components include feed, seed, domestic human consumption, commercial exports, exogenous exports assisted by export subsidies or other specified Government programs, exogenous CCC net inventory changes, and end-of-year private stocks. Measures of "open-market," or "commercial," supply were defined as total supply minus Government market diversions (CCC net inventory changes plus Government-aided exports). Given the level of crop production, the supply and demand equations are used to simultaneously determine livestock production, livestock and crop prices, and the endogenous components of demand. Each such component is, directly or indirectly, a function of beginning-of-year private stocks, population, disposable personal income per capita, a nonfood price index, the various exogenous Government market diversion variables, exogenous crop exports and crop imports, crop production, and a time trend.

Alternative simulation sets, or runs, discussed below, were based on the use of alternative demand equations for domestic human consumption (because these could not be successfully estimated by usual regression analysis) and the use, in one simulation, of a synthesized equation for the foreign demand for crops.[8]

Aggregate prices, incomes, and other equations. Detailed results from preceding components of the model are used to compute an index of agricultural prices, various measures of income (including gross and net farm income and the rate of return in agriculture relative to the market interest rate), and several measures of price and income variability assumed to reflect the extent of risk and uncertainty. The quantity of hired farm labor and the hired farm wage rate are determined simultaneously. From these results, farm production expenses for labor and a residually computed family labor input are derived. Farm prices and the nonfarm

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[7]These ideas are based on concepts in (*1, 10, 27,* and *6*). The quantitative procedure used was influenced by the work in (*17, 21,* and *32*).

[8]One set of domestic demand equations is based on the elasticity matrix of (*4*). Another set is derived using simple analysis of the relationship between income-deflated price and consumption, used in (*33*). Shortrun and longrun foreign demand elasticities for crops are based on (*28*).

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wage rate are two of the explanatory variables determining the wage rate for hired labor. Farm land values and the number of land transfers per 1,000 farms are determined simultaneously. Farm prices, aggregate agricultural productivity, and nonfarm price levels are three of the variables used to explain land values.[9]

Output per unit of input for the total agricultural sector is derived from estimates of crop and livestock production and from the inputs previously estimated.

Other equations included in the model compute (1) the number of farms, based on an estimate of average farm size, (2) gross farm capital expenditures, (3) farm debt, and (4) total quantity and current value of assets.

Simulation Procedures and Alternatives

Results for three alternative simulation sets are discussed below.[10] Each set includes a simulation of a free market situation and the actual historical situation. These alternatives were developed because of the difficulty of estimating theoretically correct demand equations for domestic human consumption and crop exports by usual procedures. The three sets appear in table 3, and its footnotes describe the procedure and sources briefly.[11]

[9] Equation specifications were influenced by (*31*) for hired labor and (*14*) for land prices.

[10] The computer simulation procedure uses the Gauss-Seidel algorithm to obtain a solution of this nonlinear system by an iterative technique (*13*). Bob Hoffman and Hyman Weingarten, ERS, made programming revisions needed to facilitate use of the Gauss-Seidel procedure.

[11] Six additional simulation alternatives appear in (*19*, p. 232, table 19). These are based on arbitrary revisions in the resource adjustment equations made to allow for possible additional effects of increased risk and uncertainty in a free market.

Table 3.—Simulation alternatives

Demand assumption	Number for[a]	
	Historical simulation	Free-market simulation
Least inelastic demand assumption[b]	13	14
Moderately inelastic demand assumption[c]	18	19
Most inelastic demand assumption[d]	9	10

[a]These numbers identify the alternative simulations in the text, table, and charts of this article. [b]Domestic demand equations were based on domestic demand for human consumption elasticities shown in (*4*, pp. 64-66 and 46-51). Own elasticities for domestic consumption of crops and livestock are -0.274 and -0.259 respectively. Commercial crop exports were made endogenous by using foreign demand elasticities based on those reported in (*28*). The foreign demand elasticities are -1.0 in the short run and -6.0 in the long run. [c]Same domestic demand parameters discussed in previous footnote, but commercial crop exports were made exogenous and equal actual historical levels. [d]Crop exports were considered exogenous, as in footnote three, but domestic demand functions were derived by graphic analysis of the relationship between income deflated price and per capita consumption during the period. (See (*33*, pp. 11-18), for example). Here, own elasticities are -0.11 or -0.15 for livestock and -0.07 or -0.13 for crops.

EFFECTS OF ELIMINATING FARM COMMODITY PROGRAMS IN 1953

What would have happened in American agriculture had farm programs been eliminated in 1953? Some possible answers to this question are provided by the results in table 4 and figures 1-8. One measure of the

Table 4.—Effects on selected variables of eliminating farm programs in 1953, five-year averages, 1953-72[a]

Item	Percentage change from historical value			
	1953-57	1958-62	1963-67	1968-72
Crop supply to open market (CSPLY)[b]	8.4	2.6	-4.3	-9.5
Livestock supply to open market (LSPLY)[b]	3.8	4.8	3.4	-3.9
Price index for crops (PC)	-28.2	-22.6	-8.1	31.7
Price index for livestock (PL)	-19.5	-25.8	-18.5	25.2
Price index for agriculture (PA)	-23.2	-24.4	-14.9	27.7
Total net income (TNI)	-42.0	-37.7	-19.7	40.3
Total agricultural productivity index (TLB)	1.5	3.7	2.4	-5.1
Price index for land and buildings (PLD)	-4.6	-12.4	-16.8	-16.5
Gross farm capital expenditures (GCE)	-20.9	-54.3	-47.3	-12.7
Total production assets at end of year (ASSET)	-1.7	-7.0	-10.0	-10.0
Agricultural price variability index (SPA)	52.7	7.2	36.1	150.0

[a]Based on results of simulations 18 and 19, which use demand parameters derived from demand matrix in (*4*). Exports are assumed to be exogenous. [b]Supply includes production minus Government market diversions plus beginning-year private stocks plus net private imports for livestock and gross imports for crops.

PERCENTAGE CHANGE IN AGRICULTURAL PRICE INDEX: HISTORICAL TO FREE-MARKET LEVEL

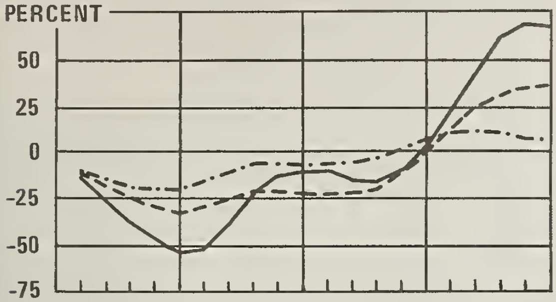

FIGURE 1

1952 '57 '62 '67 '72

SIMULATION	COMPARED WITH SIMULATION	INELASTIC DEMAND
—— 10	9	Most
– – 19	18	Moderately
—·— 14	13	Least

Note: See Table 3 for explanation of alternative simulations.

impact of farm programs on a variable is the difference between the simulated historical level and the simulated free-market level. Such differences are shown in figure 1 and table 4 as percentage changes from the historical to the free-market levels.

Alternative Impacts on Prices

The impacts of eliminating farm programs, on agricultural prices, for the three alternative simulation sets discussed in table 3, are shown in figure 1. The patterns of percentage impacts on prices for each demand alternative resemble one another to some extent. Each is initially negative and each grows over time until the largest negative impact occurs in 1957. Afterwards, the magnitude reduces gradually as the free-market price level becomes equal to and greater than the historical level by 1967. The largest positive impact occurs in 1969-71. However, the degree of impact differs importantly among the alternatives in most years, a behavior that highlights the important interrelationship between the assumed elasticity of demand and the estimated impacts of the farm programs.

Under all three demand alternatives, it is estimated that prices in the free market would have been lower than in actuality during 1953-65. By 1957, the reduction would have been 20 percent for the least inelastic demand assumption, 33 percent for the moderately inelastic demand assumption, and 54 percent for the

FERTILIZER AND LIME INPUTS: ACTUAL AND SIMULATED VALUES

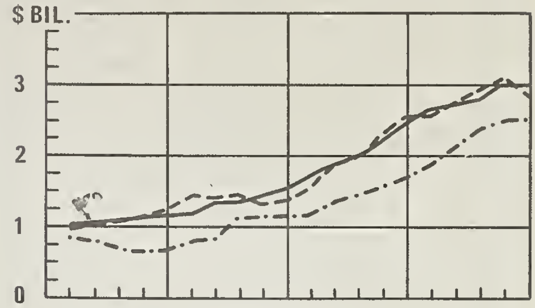

FIGURE 2

MACHINERY INPUTS: ACTUAL AND SIMULATED VALUES

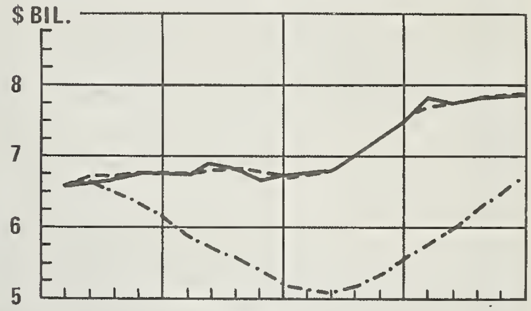

FIGURE 3

CROPLAND INPUT INDEX: ACTUAL AND SIMULATED VALUES

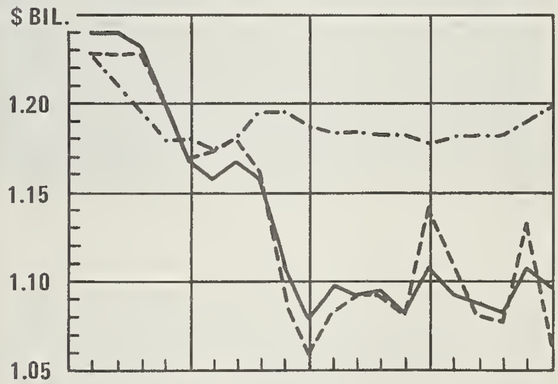

FIGURE 4

1952 '57 '62 '67 '72

—— ACTUAL
– – HISTORICAL*
—·— FREE-MARKET*

**Historical simulation 18 : free-market simulation 19.*

TOTAL AGRICULTURE PRODUCTIVITY INDEX: ACTUAL AND SIMULATED VALUES

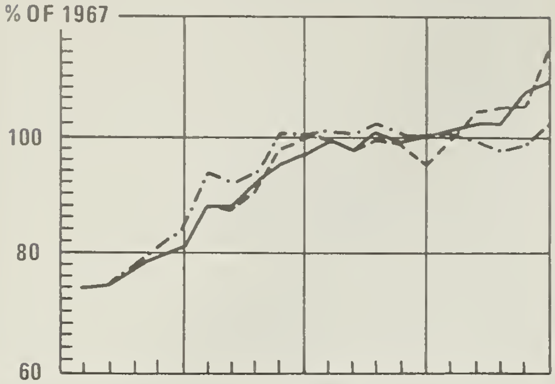

FIGURE 5

TOTAL NET INCOME INCLUDING NET RENT: ACTUAL AND SIMULATED VALUES

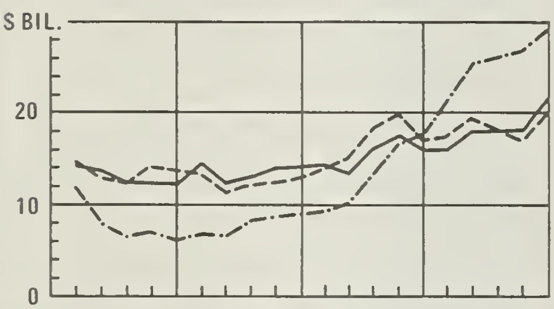

FIGURE 7

1952 '57 '62 '67 '72

— ACTUAL
– – HISTORICAL*
–·– FREE-MARKET*

**Historical simulation 18 : free-market simulation 19.*

PRICE INDEX FOR AGRICULTURAL PRODUCTS: ACTUAL AND SIMULATED VALUES

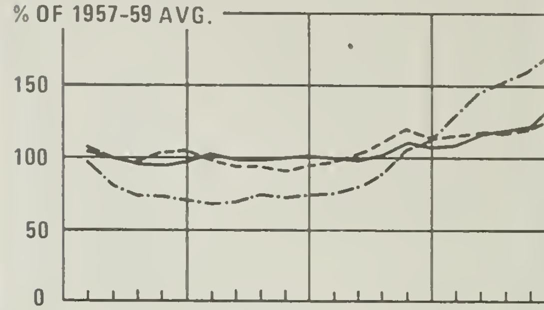

FIGURE 6

RELATIVE RATE OF RETURN TO FARM REAL ESTATE: ACTUAL AND SIMULATED VALUES

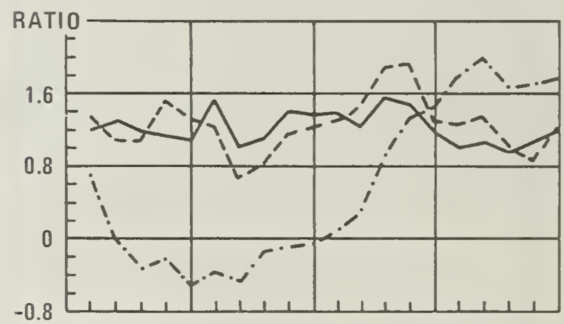

FIGURE 8

1952 '57 '62 '67 '72

— ACTUAL
– – HISTORICAL*
–·– FREE-MARKET*

**Historical simulation 18 : free-market simulation 19.*

most inelastic demand assumption. In all three cases, prices would have begun to recover after 1957, but would not have returned to their actual historical levels until around 1967, 10 years after the 1957 low and 14 years after the programs had been eliminated. Prices would have continued to increase, relative to the historical situation, until they peaked during 1969-71. Eliminating farm programs in 1953 would have raised 1972 farm prices 6 percent under the least inelastic demand assumption, 35 percent under the moderately inelastic demand assumption, and 68 percent under the most inelastic demand alternative. Thus, farm programs kept farm prices higher than they otherwise would have been during 1953-65, but the cumulative effect was to keep them lower than otherwise during 1968-72.

This latter result differs importantly from those in other historical free-market studies. For example, Ray and Heady report that low free-market prices would have depressed income and increased supplies throughout their period of analysis—1932-67 (*25*, p. 40). In Tyner and Tweeten's study, prices are lower in the free-market simulation than in the historical simulation for all periods reported—1930-40, 1941-50, and 1951-60 (*30*, p. 78). In both studies, the supply response in agriculture is never enough for free-market farm prices to recover fully. One explanation is that the rate of technological advance was exogenous in the previous models while in this model, such change is endogenous.

Results For Moderately Inelastic Demand Alternative

Effects of eliminating farm programs in 1953 are also presented in table 4 and figures 2-8. These results are based on a comparison of historical simulation 18 and free-market simulation 19.[12] This set of results is not necessarily the "best," or "most correct." It was selected primarily because the results represent a kind of mid-range between the alternatives, as indicated in figure 1. Presenting only one set of results facilitates understanding the dramatic and interrelated effects that would have occurred in the absence of the programs.

Supplies and prices. Changes in the aggregate farm price level for the free-market situation, compared to actual history, resulted primarily from changes in crop supply and price. As one might reasonably expect, crop price adjustments also determined eventual livestock price adjustments. Over time, livestock producers adjust their inventory and production levels in response to changes in the livestock-crop price ratio. Crop price changes were determined mainly by changes in open market crop supplies tempered by simultaneous adjustments in feed use and private end-of-year inventory levels.

Actual crop prices were significantly affected by large Government market diversions equal to over 10 percent of actual production in 1953-55. With price-supporting activities eliminated in 1953, crop prices would have fallen sharply as stocks increased in the short run. In a free-market situation, private crop stocks would have been 17 percent higher than the historical level in 1955, and crop prices, 36 percent lower. Open market crop supplies would have continued to exceed historical supply levels throughout 1955-64, because crop production decreases would not have been large enough to offset the effect of elimination of Government market diversions. Actual diversions, substantial in this period, ranged from 7 to 16 percent of actual crop production, though 4-16 percent of the cropland was idled by existing programs. After 1964, however, crop production decreases in a free market would have become larger than actual Government market diversions under the program. Thus, free-market crop supplies would have fallen below historical levels in 1965; and, by 1972, they would have been down 11 percent. Crop prices would have been 36 percent higher in 1972 than they actually were in that year.

The relative decrease in crop production after 1964 would have dramatically affected farm prices throughout 1964-72 (fig. 6). As a result, 8 percent more crop related inputs would have been used by 1972, in the free market. *But crop productivity would have dropped 19 percent below the actual historical level, cutting crop production 13 percent.*

Farm income. Total net farm income, in the free market, would have averaged 42 percent below historical levels in 1953-57. Such income would have been 20 percent below the actual level in 1953. By 1957, income would have dropped $8 billion, to equal 55 percent of actual income that year. Further, though net farm income would have remained more than $3 billion lower through 1966, it would have finally risen to a level nearly $10 billion higher than historical levels in 1971 and 1972. Such income would have climbed 58 percent above the historical level in 1971, to average 40 percent higher during 1968-72 (fig. 7).

Figure 8 shows the impact of eliminating farm programs on the rate of return to farm real estate (relative to market interest rates). Residual returns to real estate in a free market would have been negative in 1954-62, making estimated losses comparable to those in the depression years, 1930-33. As with price and net income, the rate of return in a free market would have been higher than its historical level after 1967. However, the highest free-market rate of return ratio (RATO=2.0 in 1969) would not have been as high as that for the war-influenced period of 1942-48, when the ratio varied from 2.1 to 3.8.

Assets, investments, and land prices. Assets, value of capital expenditures, and land prices would all have been lower in a free market than historically for 1953-72 (table 4). Low prices and incomes and increased risk and uncertainty would have immediately and subsequently affected the amount of assets farmers would have been willing and able to buy. Gross farm capital expenditures would have declined dramatically. Reaching a level 59 percent below actual historical levels by 1960, they would not have returned to a point near actual levels until 1971 and 1972. Total productive assets in a free market would have averaged 10 percent below actual historical levels during 1963-72, and farm land prices would have averaged 17 percent below actual values.

Agricultural productivity. The agricultural productivity index would have been somewhat higher in a free market than it actually was from 1955 to 1968, reaching a high of 7 percent more in 1958. However, the longer term effect of eliminating farm programs would have been to reduce the productivity index to a level 11 percent below the historical level by 1972. In 1961, the index would have been 101 (1967 = 100), never to exceed 102 in subsequent years of the free-market simulation (fig. 5).

Crop productivity in a free market would have fallen below actual historical levels for all years after 1958, and would have been down 19 percent by 1972. Most of this 19-percent decrease would have been attributable to the decline in use of nonfarm inputs (such as fertilizer

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[12] Historical simulation 18 can also be compared with the actual variable values plotted in figures 2-8. However, some equations have been adjusted to reproduce history more accurately than otherwise through use of regression error ratios. Such adjustment was considered desirable because the model is nonlinear. Thus, important disturbances in the equations could affect accuracy of the estimated program impacts.

and machinery) relative to cropland (figs. 2-4). The ratio of machinery and fertilizer to land and labor would have been 52 percent lower in the free market situation.[13] Also, the increased use of lower quality land would have reduced crop productivity; but an increase in the relative use of hybrid seed would have raised productivity. Decreased machinery inputs and increased use of cropland would have substantially raised labor inputs for 1957-72 in a free market.

Agricultural price variability. Absolute annual percentage changes in the agricultural price index would have averaged substantially above historical levels in a free-market situation. For the initial 5-year period, 1953-58, this index of variability would have averaged 53 percent higher. It would have continued above historical levels for all but 2 years. By 1968-72, the index would have averaged 150 percent higher.

Organization and structure. Several organizational and structural changes in agriculture would have occurred had farm programs been eliminated in 1953. Number of farms would have risen while the average size dropped. Land in farms relative to other assets would have increased, and cropland and labor would have been substituted for machinery and fertilizer inputs.

In the free market, the number of farms would have declined, but not as fast as it actually did. In historical simulation 18, number of farms declined at the average annual rate of 3.0 percent per year to a 1972 level of 2.7 million. In free-market simulation 19, the number of farms declined at the rate of 1.9 percent per year to 3.3 million in 1972. (The simulated number of farms was 4.7 million for 1953.) In 1972, there would have been 24 percent more farms than in actual history because the average size would have been 19 percent lower while total land in farms remained essentially unchanged. (Elimination of farm programs did affect land in farms prior to 1972.)

Average farm size in 1972 would have been much lower in a free market because agriculture would have been less mechanized, with more labor used per acre. A free market from 1953 on would have slowed the rate at which machinery and fertilizer and other nonfarm produced inputs were substituted for land and labor. Thus, farmers would have had less inducement to reorganize operations into larger sized units. In the historical simulation, the average size of farm increased at the average rate of 2.5 percent per year from 1953 to 1972. In the free market, this figure would have been 1.4 percent.

The share of total assets made up by land would have increased from 55 percent to 60 percent with a free market while shares for all other assets would have declined. Crop labor requirements would have risen from 7 to 15 percent of total current inputs. Cropland would have changed from 3 to 4 percent; livestock labor, from 4 to 5 percent. Other input shares would have declined.

Agricultural employment would have risen, with labor requirements 73 percent higher in 1972 than with farm programs. Most of the increased labor would have come from farm operators or their families. Family labor would have gone up 120 percent but hired labor inputs would have gained only 19 percent.

[13] A net decrease in crop productivity in this free-market simulation results mostly from the effect of reduced machinery relative to cropland and labor. The effect of less use of machinery offsets a technically inappropriate positive effect of reduced fertilizer. The fertilizer sign comes from a negative partial derivative of productivity with respect to fertilizer of -0.1 obtained for the crop productivity equation.

ASSESSMENT

The following summarizes results from simulations using demand relationships implying an aggregate domestic demand elasticity of around -.25 and assuming commercial crop exports are fixed at their actual historical levels in the free-market case (simulations 18 and 19). These results suggest that at least seven different impacts on the agricultural economy would have occurred had farm commodity programs of the Federal Government been eliminated in 1953:

- Farm prices would have dropped for several consecutive years until they averaged 33 percent below actual levels by 1957
- Aggregate farm prices would have been stable but low until after 1964, when they would have risen to a level averaging 35 percent above the actual figure in 1972
- Net farm income would have fallen 55 percent below the actual level by 1957 but it would have reached 58 percent above the actual level in 1971
- Residual returns to owners of farm real estate would have been negative in 1954-62
- Quantity of assets, value of capital expenditures, and farmland prices all would have been lower than actual levels throughout 1953-72, as a result of farmers' response to the initial and subsequently lower price and income experiences, lower expectations, and increased risk and uncertainty
- Land and labor inputs would have increased relative to other inputs, and the rate of decline in agricultural employment and number of farms during 1953-72 would have been reduced
- Crop resource productivity would have dropped under historical levels in all years after 1958, to be down 17 percent in 1972
- Agricultural productivity (crops and livestock combined) would have been 11 percent under actual levels in 1972.

Thus, farm programs had substantial and important effects on the developments in the agricultural sector during the period studied. In particular, the programs apparently worked to promote both long- and short-term price and income stability. Apparently, the potential exists for continuous long-term food and fiber price cycling because of the nature of agricultural supply responses in a free-market situation. This cycling would occur, as the domestic and world economies grow, because domestic agricultural supply cannot grow at exactly the same rate as demand. The growth rate for supply is affected by complex interrelationships that exist between (1) adjustments in agricultural assets and inputs, in response to price and income experiences, and (2) adjustments in crop productivity and livestock production. During 1953-72, farm commodity programs were operated in a way that mitigated aggregate farm price and income cycling over extended periods.

This study suggests that farm programs supported farm prices and incomes at levels substantially higher than they would have been otherwise during 1953-65. Feed and other crop prices were supported by programs that idled productive land and diverted marketable supplies into Government storage or that subsidized domestic and foreign use. This resulted in reduced livestock production and consumption, and higher livestock prices. Farmers responded to these developments by mechanizing, fertilizing, increasing farm size on the average, and generally adopting technologies that reduced costs, boosted resource productivity, and expanded productive capacity. Elimination of farm programs in 1953 would have slowed the rate at which these advancements took place, or reversed the trend temporarily. The result: in recent years (1968-72), farm price levels would have been higher in a free market than in actuality.

Farm prices in the free-market simulation eventually recovered, and finally exceeded actual historical levels, because elimination of farm programs in 1953 put agriculture through the "longrun wringer."[14] With free-market prices 10 to 30 percent below actual levels throughout 1953-66, and a negative rate of return to real estate for a number of years, gross capital expenditures and current input expenditures were greatly reduced, and agricultural productivity and output growth retarded. The eventual result in the free-market simulation was that farm prices increased dramatically as aggregate demand grew faster than aggregate supply. Farm commodity programs held farm prices and incomes *higher* than would have been true otherwise for 1953-65, which apparently provided the economic incentives to growth in output sufficient to hold farm prices *lower* than they otherwise would have been for 1968-72.

These results suggest that the national agricultural plant can and does respond to changes in economic incentives, given sufficient time. But because substantial time is required to change agricultural capacity, long periods of substantial disequilibrium and disruption can result in a free market. Without farm commodity programs, consumers would have enjoyed low farm product prices through 1964. Farmers, at the same time, would have suffered their worst financial crisis since the Depression. But these low prices would have been replaced by high farm prices, following a long period of rapid farm price increases after 1964. At the same time, farm incomes would have been improved greatly.

[14] Cochrane discussed how the "longrun wringer" could "correct" the surplus condition in agriculture in (*1*, pp. 134-136).

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USING AREA POINT SAMPLES AND AIRPHOTOS TO ESTIMATE LAND USE CHANGE

By Kathryn A. Zeimetz, Elizabeth Dillon, Ernest E. Hardy, and Robert C. Otte*

A two-stage sample of airphoto prints and point sampling was used to examine changes in land use patterns in 53 selected counties that had grown rapidly and substantially in population between 1960 and 1970. Point sampling, 20 points per square mile, was used on a sample of airphoto prints approximating 15 percent of the land area to study 12 categories of rural and urban land use. This approach evolved from experience with different scales of photos, areal samples of photos, random traverses, and point sampling in varying combination. This technique, an inexpensive one, resulted in data that satisfactorily correlated with comparable data from other sources and provided detail on the dynamics of land use change.
Keywords: Airphoto interpretation, remote sensing, point sampling, urbanization, land use inventory.

INTRODUCTION

Aerial photographs have proved to be a valuable source of data on land use, particularly in obtaining historical data that could not have been gained otherwise. The automated remote sensing techniques that are being developed hold promise as an inexpensive source of broad-scale data on land use and other resources. But for specific detailed studies of land use and land use change, conventional airphoto interpretation remains an important tool. Sampling is one way to make it more efficient and less costly. This article reviews some of the experience of Economic Research Service (ERS) staff and other researchers in interpreting aerial photos and developing a two-stage sampling technique to obtain detailed data on land use change in 53 selected counties. Though not without some statistical shortcomings, the approach appears to have specific advantages over other techniques, and the statistical weaknesses can be overcome by suitable randomization and probability sampling.

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HISTORICAL USE

Airphoto Interpretation

The late Francis J. Marschner, while in the Land Economics Division of USDA's Bureau of Agricultural Economics, pioneered in the use of aerial photos as a source of land use data. In the 1940's, he developed a land use map of the United States based in large part on airphotos (*13, 14*). Since then, his division, now the Natural Resource Economics Division of ERS, has used airphoto interpretation in various ways.

An important factor in expanding the application of aerial photo interpretation was its use by the military during World War II. After the war, persons trained in the technique adapted it for civilian purposes. One major application has been in local land use inventories and analyses of land use change made to accompany comprehensive land use planning at the local level. A more general application is Avery's study of land use change in Clark County, Georgia, which produced six-category inventories for 1944 and 1960 and a detailed land use map of the county (*4*).

An example of the use of airphoto interpretation in a statewide resource inventory is the New York LUNR project (Land Use and Natural Resources). LUNR was designed to "identify and record how the state's land resources are being utilized." Project staff relied heavily on aerial photo interpretation for data on land use and other resource characteristics. Data can be retrieved by computer through a statewide grid system with cells of 1 square kilometer. Gessaman and Hardy used this system when they analyzed historical land use change in a 2,086 square mile area of southern New York in which they employed 8 land use categories (*10*).[1]

The main source of photos for ERS has been USDA's Agricultural Stabilization and Conservation Service, which has had aerial photography produced for agriculturally important areas of the country at intervals of approximately 8 years since the late 1930's. Other sources are USDA's Forest Service and Soil Conservation Service, and the U.S. Geological Survey. These airphoto

[1] For a review and discussion of land classification schemes used with remote sensing, see (*1*) and (*3*).

archives contain a wealth of information on land use, as yet largely untapped.

Generally, the analyst has examined photos of an entire study area. Some variation in intensity of coverage is possible by use of photos of different scales. In some cases, the technique has been used to obtain a complete land use inventory of an area. Different categories of use are identified and circumscribed on the photos and measurement estimates are made either by planimeter or dot grid. A major use of the approach by ERS in earlier years was to determine land use by flood frequency zone as a basis for estimating flood damages in river basin studies.

However, most ERS airphoto interpretation has been used not to develop comprehensive inventories but to identify and measure specified changes between two points in time. For example, Anderson and Dill studied clearing and drainage in North Carolina between 1950 and 1957, using large-scale photography (1:20,000) (*2*). Dill and Otte focused on urbanization in Western States between 1950 and 1960, in which they used photo index sheets (uncontrolled mosaics) in a scale of 1:63,360 (*8*).

Area Point Sampling

ERS has used sampling on a limited scale. Nobe and Dill, with traverses, developed estimates of land use by flood stage zones in the flood plain of the Potomac River (*15*). In a study of urbanization of land in 96 counties in the Northeastern States, Dill and Otte used the sample plots of the Conservation Needs Inventory (*7*). This stratified sample of 100-acre plots comprises 2 percent of the rural, non-Federal land in each U.S. county. Dill and Otte identified change to urban use within each plot and measured the extent through aerial photography of 1:20,000 scale.

ERS first used point sampling for land use studies as a result of research with the Department of Geography at the University of Chicago on rural floodplain use during 1959-63. In a report on that work, Brian Berry examined various sampling methods for obtaining flood plain data, including the use of points (*5*).

Sloggett and Cook made the first major use of point sampling in ERS resource studies when they evaluated flood prevention benefits in small watershed projects in Oklahoma (*16*). They used aerial photos as maps to locate the sample points, and they gathered data on land characteristics and use through ground survey and from secondary sources.

Point Sampling and Airphoto Interpretation Combined

The first combined use of point sampling and aerial photo interpretation by ERS occurred in Frey and Dill's study of land use change in the lower Mississippi River alluvial plain (*9*). From the U.S. Air Force, they obtained airphoto coverage of the entire area for 1969 in a scale of 1:125,000. Earlier coverage—for 1950, on the average, but ranging from 1949 to 1953—came from ASCS photo index sheets in a scale of 1:60,000 or smaller.

Frey and Dill used a systematically aligned sample of points, one per square mile. The origin point for each print was randomly selected. Six land use categories were identified: (1) cropland, (2) grassland, (3) transitional land, (4) forest, (5) urban and buildup land, and (6) other. The basic objective was to obtain data on conversion of forest land to cropland. However, six-category inventories were developed for both 1950 and 1969, as was a matrix of change among all uses between the 2 years (table 1).

As the most important change, cropland increased from 9,963,000 acres to 13,710,000 acres. This increase resulted from conversion to cropland of 3,818,000 acres of forest land, 219,000 acres of grassland, and 61,000

Table 1.—Changes in land use, lower Mississippi alluvial plain, 1950-69

Major use, 1969	Major use, 1950						Total, 1969
	Cropland	Grassland	Transition	Forest	Urban	Other	
	1,000 acres						
Cropland	9,601	219	61	3,818	1	10	13,710
Grassland	186	686	13	209	0	1	1,095
Transition	93	22	24	18	0	0	157
Forest	20	20	28	7,386	1	2	7,457
Urban	46	9	2	28	362	0	447
Other	17	2	1	61	1	1,131	1,213
Total, 1950	9,963	958	129	11,520	365	1,144	24,079

Source: (*9*).

acres of transition land. (Also, an insignificant amount of urban-type use was eliminated.) Cropland lost 186,000 acres to grassland, 93,000 acres to transition use, 46,000 acres to urban use, and 17,000 acres to other uses.

This type of matrix can be used in Markov and other simulation techniques to make projections based on historical relationships. Burnham used Markov analysis on table 1 to project land use for the Mississippi Valley study area to 1988, 2007, 2026, and to equilibrium (*6*).

STUDY OF SELECTED URBANIZING COUNTIES

In mid-1973, ERS and the Department of Natural Resources at Cornell University developed a cooperative research project to measure and analyze land use change where urbanization is having maximum impact on previously rural areas. To identify such areas, both relatively and absolutely, analysts listed counties that showed at least a 30-percent population increase and an absolute increase of 20,000—for a U.S. total of 129 counties (*17*). From this list, 53 counties were selected that had complete airphoto coverage for 1 year as close as possible to 1960 and 1 year as close as possible to 1970. Thus, the period of observed land use change would be comparable to the two most recent population censuses (fig. 1).

A common scale of photography provides greater economy and more accuracy of interpretation by permitting development of procedures that can be uniformly and repetitively applied. Therefore, only ASCS photographs were used in the study. Though limiting the source of photography simplified the interpretation and sampling procedures, it introduced some bias into selection of counties. ASCS uses aerial photography in the operation of various farm programs; therefore, almost all U.S. cropland has been photographed. Counties with frequent full airphoto coverage by ASCS are generally those with a significant acreage of cropland distributed over most of the county.

Further, an area is rephotographed when it is deemed that significant changes in the cropland acreages and boundaries have occurred—on the average, at intervals of about 8 years. ASCS photographs of the counties sampled in the ERS study usually were not made in census years, and the intervals generally were not 10 years. The longest interval between photographs of the counties sampled was 18 years; the next longest, 13 years. For 14 counties, the interval was 6 years, the shortest period. For the study, the average year of

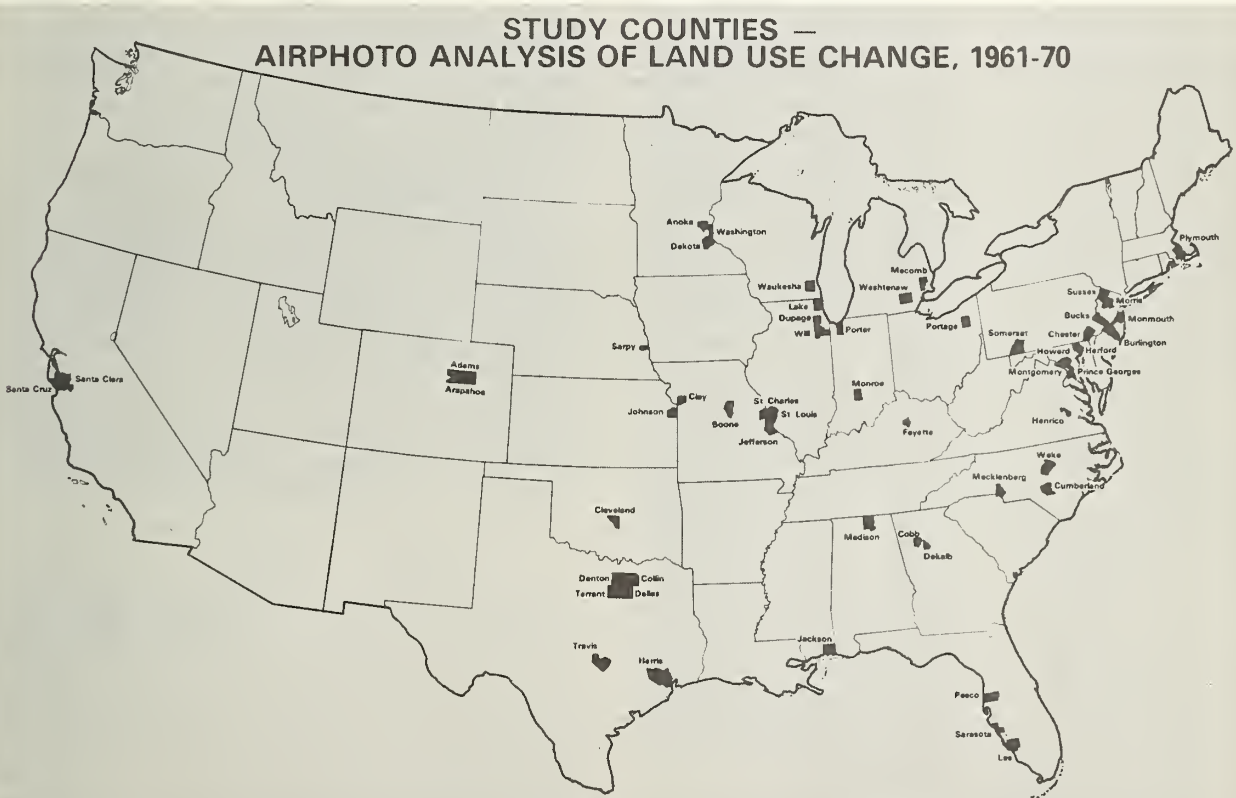

FIGURE 1

coverage was 1961 for the earlier reading and 1970 for the later one.

Sampling Procedure

Information on land use and changes in such use came from a two-step sampling procedure. First, areas were selected from county photos; second, points were chosen within each selected photo.

If aerial photography could have been obtained specifically for this study, the procedure might have been randomized as follows. A plane would fly at random across the county. Photos would be taken along each traverse at random locations sufficiently far apart to preclude overlap. However, because of the cost factor, existing ASCS photographs had to be used.

ASCS photographs are made with a 65-percent overlap along each flightline (traverse) and a 30-percent overlap from one flightline to the next—to provide stereoscopic coverage for any given point. Points near the center of each flightline appear on three separate photos. Points near the edge, where the flightlines overlap, may appear on six separate photos. Thus, specific points have different probabilities of being included in a sample of prints, which introduces a possible source of bias because all points in a selected photo were weighted equally in the ERS analysis.

A sample of prints was selected on a systematic, geographically stratified basis that would insure a cross section of each county and would preclude any point entering the sample more than once. The procedure produced a sample similar in appearance to one obtained with a specifically designed set of traverses and random photos.

The procedure used for each county was to pick photos from alternate flight strips on photo index sheets. Whether to start with the first or second strip was determined by flipping a coin. A number from 1 to 10 was picked randomly to specify the first photo of the selected flight strip. Starting from this photo, every tenth photo in each alternate row was chosen. Hence, the first photo was selected at random and the remaining photos were chosen systematically.

The original aim was to obtain an area sample of at least 10 percent or more of the surface area of each county. The number of photos required for this coverage was based on two calculations. Each photo was assumed to represent a usable area of 8 square miles. The average size of the counties being studied was 646 square miles; thus, about 80 photos per county would be needed. Photos from 2 different coverages overlapped about 65 percent. The effective area represented by each pair of photos was thus reduced to 5.2 square miles, which indicated 13 photos were needed for a 10-percent coverage. With this guideline, the goal of 10-percent coverage was exceeded and approximately 15 percent of the area was used for the second step, the point sample.

In this step, the interpreter sampled within each photo using (1) a random set of points, 20 per square mile, which has been selected from a random numbers table and (2) a piece of 9" by 9" graph paper with a mesh of 1/20 inch. Thus, any point representing an area on the ground 83 feet square had an equal chance of being selected. The points marked on the graph paper were transferred to a heavy acetate template.

Five templates were drawn up, each providing eight sample possibilities (four cardinal positions times two sides). The templates received a major number — I, II, III, IV, or V — and opposite sides of each template were labeled A and B. The template corners were subnumbered 1 through 4 in a clockwise direction. The template to be used was placed on the airphoto; the specified subnumber was at the top of the right-hand corner of the template (or left-hand corner if side B was selected). After the template had been placed on the most recent photo, the equivalent points were located on the older photo, and the land use could be interpreted on each photo. Interpreters used magnification as necessary and they interpreted all points monocularly. For some counties, early coverage was at a 1:20,000 scale while the later coverage was at 1:40,000. For these, the template was placed on the earlier photo and the equivalent points were located on the newer coverage.

The original goal, to average at least two points per square mile for the total sample area, was more than met in every county. The average sampling rate for all counties was 3.0 points per square mile. The point sample data were converted to acreage figures; each county's total surface area, as given in Census publications, was divided by the total number of points in the sample for that county. Thus, for each county, a point had a specific acre equivalent that provided a constant for conversion of all point data to acreage data.

County aggregates were achieved by summing the county acreage estimates.

Coefficients of variation were computed for the estimates of the area in each use category in 1967. (Table 2 shows these coefficients for a group of three counties in Illinois.) Analysts made the computations using point counts. However, they would have obtained nearly identical results using the conversion to acreage estimates.

With a random sample of photos and points assumed, variance for each category of use could be estimated through the following formula:[2]

$$v(\hat{\bar{y}}) = \frac{(1\frac{n}{N}) \sum^{n}\left(M_i p_i - \frac{\sum^{n} M_i p_i}{n}\right)^2}{n(n-1)} + \frac{n}{nN} \sum^{n} \frac{M_i p_i (1-p_i)}{(m_i-1)}$$

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[2] Formula adapted by Huddleston from (*11*, pp. 183-186, 206-208). Also see (*12*).

Table 2.—Land use change in Dupage, Lake, and Will counties, Illinois, 1961 and 1967

Land use in 1967	Land use in 1961											Land use in 1967	
	Crop-land	Pasture and range	Open idle land	Farm-stead	Forest land	Resi-dential land	Trans-porta-tion	Recrea-tion	Comm. Ind. Inst.[a]	Water bodies > 40 acres	Miscel-laneous use	Total	Coeffi-cient of variation
Cropland	550,876	3,618	1,704								186	556,384	9.0
Pasture and range	1,427	14,288										15,715	18.8
Open idle land	10,008	3,184	74,068						186	1,984	372	89,802	17.7
Farmstead				18,244	432							18,676	15.3
Forest land	372	1,240	1,641		80,163	216						83,632	15.0
Residential	5,362	248	2,105		434	110,794					402	119,345	21.0
Transportation	1,638	216				432	51,393				648	54,327	12.5
Recreation	432							11,284		248		11,964	27.9
Commercial, Industrial, Institutional	5,327		2,261			186			43,216		1,084	52,074	26.6
Waterbodies less than 40 acres	216		864							40,343		41,423	39.2
Miscellaneous[b]	216		1,178								16,376	17,770	16.5
Total, 1961	575,874	22,794	83,821	18,244	81,029	111,628	51,393	11,284	43,402	42,575	19,068	1,061,112	

[a]Commercial, industrial, and institutional land.
[b]Includes urban idle land.

Note: Blanks indicate zero quantities.

where:

$\hat{\bar{y}}$ = Estimated average number of points in specified land use per print

$$\frac{1}{n}\sum^{n} M_i p_i$$

N = Total number of prints in counties
n = Number of sampled prints in counties
M_i = Total number of points on ith print
m_i = Number of sampled points on ith print
p_i = Proportion of points in specified land use on ith print based on sample

The coefficient of variation was estimated using the following formula:

$$c.v.\,(\hat{\bar{y}}) = \frac{\sqrt{v(\hat{\bar{y}})}}{\hat{\bar{y}}}$$

Coefficients of variation (c.v.) for the 1967 inventory of the three Illinois counties ranged from 9.7 for cropland, 52 percent of the total area, to 39.2 for water bodies, which comprised 4 percent of total area and were concentrated within a relatively few sample prints (table 2). Some individual components of change would show very high c.v.'s. However, these components have some utility as evidence of a particular direction or shift, if viewed within the entire matrix.

Land Use Categories

The 12 categories selected covered most possibilities of urban and rural land uses:

Cropland. Even tone and texture. On occasion, distinct row patterns visible. Lack of natural vegetation, sharply defined boundaries, and, in some cases, machine tracks leading to the field.

Pasture and range. Up to 30-percent tree crown cover showing unmistakable signs of animal use, such as stock ponds, animal trails, and salt blocks. Usually lacked appearance of recent tillage. Frequently a regular shape with distinct boundaries.

Open idle land. Less than 10-percent crown cover and no evidence of other use. Uneven in texture and tone, often irregular in shape. Vegetation often uneven and shrubby in appearance.

Farmsteads. All farm buildings and farm facilities except farm residence. Included barns, silos, machinery sheds, farm lanes, exercise yards, watering points, and feed lots.

Forest land. Over 10-percent tree crown cover and no other visible uses. Areas of less than 10-percent tree crown cover with evidence of logging.

Residential. Houses and yards associated with them (including farm and rural dwellings), apartment complexes, mobile home sites, and urban residential streets.

Urban idle land. Unused or vacant land surrounded on three sides by urban activity. Construction sites where future use could not be determined. (In table 2, urban idle land was included in "miscellaneous.")

Transportation. Facilities and land areas associated with movement of people and goods. All highways and roads (except streets within residential areas), railroad lines and yards, clearly distinguishable rights-of-way, airports, and docks.

Recreation. Mainly forms of human-made activity associated with resident population. Camp grounds, golf courses, drive-in theatres, race tracks, ski facilities, and public swimming pools.

Commercial, industrial, and institutional. Institutions and land obviously associated with them, such as central business districts and churches, schools, hospitals, cemeteries, and shopping centers that are found in the central business district and other business areas.

Water bodies. Dams, reservoirs, and lakes greater than 40 acres. Streams and rivers wider than 200 feet from bank to bank.

Miscellaneous. Primarily streams or other bodies of water less than 40 acres, drainage ditches, irrigation ditches, and Commodity Credit Corporation storage bins. Used only as a last resort to avoid excessive use of a category which provides minimum information. (In table 2, urban idle land is in the "miscellaneous" category.)

FOCUS ON THREE ILLINOIS COUNTIES

Data on three Illinois counties illustrate the type of information obtained by the analysis (table 2). Dupage, Lake, and Will are typical of the 53 study counties; they are located at the periphery of a Standard Metropolitan Statistical Area (SMSA)—in this case, Chicago. Dupage county's population increased 178,000 from 1960 to 1970—56 percent. Lake county's rose 89,000 and Will's, 58,000—slightly over 30 percent for each. These counties, along with McHenry county, also in the Chicago SMSA, were the only Illinois counties with relative population increases of 30-plus percent and absolute increases of more than 20,000.

Airphoto coverage was available for 1961 and 1967. The sample contained 4,886 points, each representing an average of 217 acres. Table 2 presents a matrix of land use change for the three counties. The lowest row gives an inventory of land use in 1961 by 11 land use categories. The right-hand "total" provides a similar inventory for 1967.

When using the table, read up a column to determine the disposition, by 1967, of the acreage in a given use in 1961. For example, in 1961, the three counties contained an estimated 575,874 acres of cropland. Six years later, 5,362 acres of this land had changed to residential use, 5,327 acres had been developed for commercial, industrial, and institutional uses, and 10,008 acres had been idled. Smaller acreages had shifted to other uses; and 550,876 of the cropland acres in 1961 remained as such.

Read across the rows for the 1961 use of 1967 acreage in a given category. For example, an estimated 119,345 acres were in residential use in 1967. Of this total, 110,794 acres had been in this category in 1961. The new residential acreage came from cropland (5,362), open idle land (2,105) and pasture, forest, and miscellaneous use (small quantities).

Figure 2 shows graphically the shifts among major land use categories.

Conversion Coefficients

Assuming uniform population increases yearly between 1960 and 1970, the three counties gained a total of 195,000 people between 1961 and 1967. Urban acreage rose 20,000. Thus, an estimated 0.10 acre was converted to all urban uses for each unit of increase in population—about 0.04 for residential use and 0.06 for transportation, recreation, and commercial-industrial-institutional uses. In addition, another 0.03 acres per capita was added, on net, to open idle acreage.

Pool of Idle Land

From data for the three Illinois counties, we can identify land shifts from agricultural to urban-type uses. At the beginning of the period, 83,821 acres—a little under 8 percent—was used as open idle land. That is, it had less than 10-percent tree cover and no evidence of pasturage or any other use. By 1967, some of this land had added enough tree cover to be classed as forest, although probably little or no change occurred in actual use. An estimated 4,366 acres had been developed for residential and commercial-industrial-institutional uses, about half for each category by 1967. Also, some previously idle land had been brought under tillage.

In general, much open idle land is probably in transition to urban uses. Of the estimated 20,000 acres converted to urban use, about one-fourth came from open idle land. However, in the urbanization process, some land will likely be idled for long periods, possibly indefinitely, because of its isolation or other disadvantages compared with surrounding land that is being developed.

DATA SOURCES COMPARED WITH OTHER SOURCES

Two procedures were used to evaluate the data-generating technique chosen for the study. First, analysts subjected four counties (Dupage, Ill., Prince Georges, Md., Clay, Mo., and Tarrant, Tex.) to the same sampling and interpretation procedure twice for 1960, resulting in two sets of land use data for the same counties for the same year. The *t*-dependent tests of expanded acreage data were used to check the ability of the sampling procedure to replicate results (table 3).

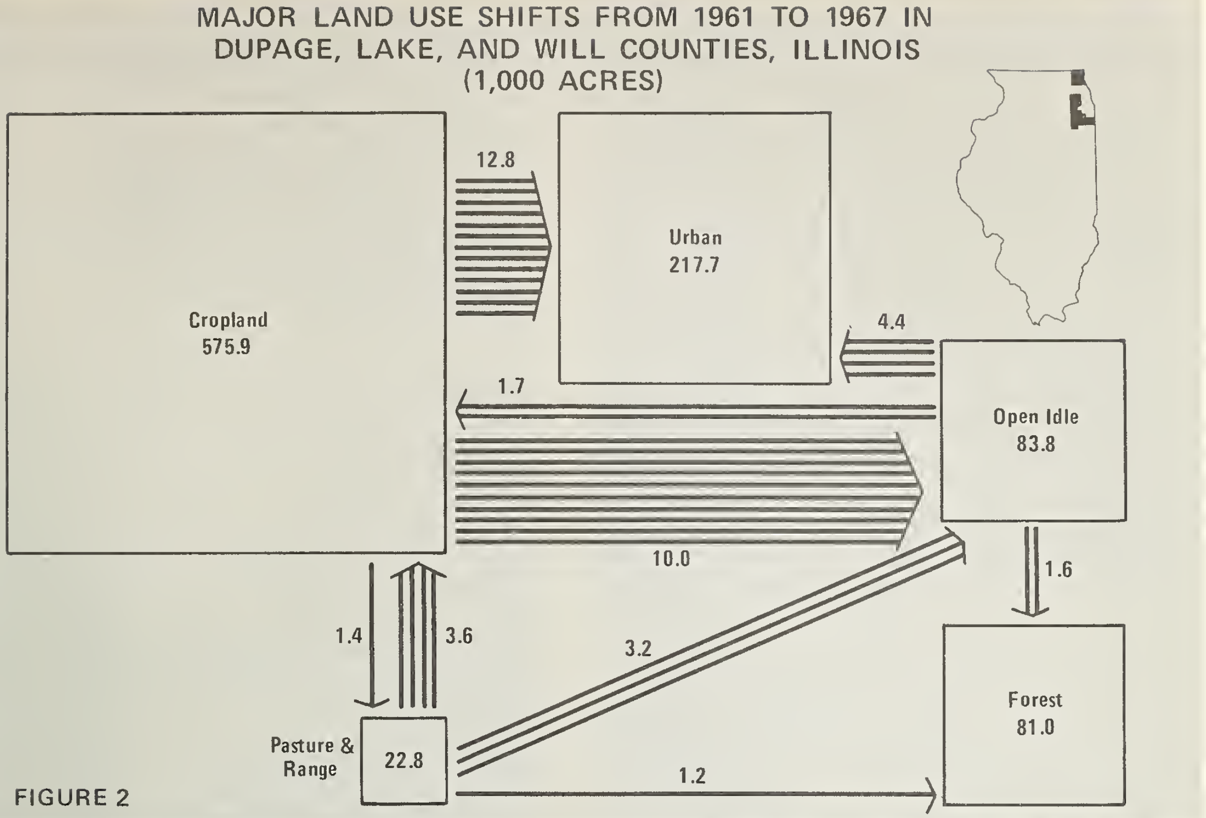


FIGURE 2

Thus, for example, the *t*-dependent was calculated based upon the cropland data for each of the two samples from each of the four counties. The same procedure was followed for the 11 other land use categories. The hypothesis being tested was that variation in the two inventories resulted from chance alone. In all cases, except for commercial-industrial-institutional use, *t* was not exceeded; thus, the hypothesis was verified.

Second, using simple regression analysis, analysts compared county land use data obtained from aerial photos in this study with county land use data from other sources. The correspondence was quite high (table 4 and fig. 3). In comparisons for cropland, forest, and water areas, the airphoto data tended to give slightly higher readings for small acreages of the observed variables and slightly lower readings for larger acreages compared with other data sources.

Differences with other sources could be expected because methods of data collection differed and, in some cases, category definitions varied between sources. For example, in the Census of Agriculture, the farmer respondents identify what part of their land is cropland. They may include pasture and idle land that has not been tilled for some years. In airphoto interpretation, identification of cropland hinges on evidence of recent tillage; thus, this method could be expected to be less inclusive than that of the census.

Surface area of many lakes and reservoirs varies both by season and between years; thus, some discrepancies would occur even with the same technique of measurement. Also, water area showed the highest coefficient of variation of any of the uses.

Acreage figures developed for pasture-range and open idle land could not be checked, for two reasons. No comparable data exist from other sources for the open idle land category. Also, significant acreages of land identified as open idle land in the airphoto study were probably included as pasture-range in the census and CNI. Urban areas could also not be compared because no suitable source of data exists.

A valuable feature of a point sample is that the resulting data are site-specific. Though study data were aggregated by county, they could be aggregated by river basin or other *ad hoc* geographic basis with the proviso that number of points be large enough for statistical reliability. Also, data on total land area probably would not be available. This lack could be remedied by measuring the study area on a map. Or the sampling procedure could be designed to give a precise number of points per square mile with a constant acreage value for each point. Simple expansion would become possible for any geographic configuration. The county was used as the unit for the study because most of the data we needed were available only by county. Also we could obtain statistics

Table 3.—Comparison of land use data derived in two separate point samples of four study counties for 1960

Land use	Average proportion of the four-county area	The t-dependent*
Cropland	29.4	2.30
Pasture range	14.9	0.06
Farmstead	1.1	0.84
Open idle	7.5	0.20
Forest	20.4	1.87
Residential	12.8	0.70
Urban idle	19	3.00
Transportation	4.9	0.26
Recreation	.9	1.56
Commercial-industrial-institutional	2.9	3.43
Water bodies over 40 acres	2.8	3.17
Miscellaneous	1.7	1.90

*At the point 0.05 level of significance, t equals 3.182.

on total areas of counties from other sources, so we did not attempt to estimate total area from the sample.

Another value of a point sample: attributes can be associated at a disaggregated level. Census and similar data are usually available by county. In examining land use shifts from this type of data, the analyst can only observe how one use increases as another decreases—for the county as a whole. For example, urban land use may have risen between 2 census years while that for cropland may have fallen. In effect, one must use associations at the aggregate level as a surrogate for associations at the individual level. However, a point sample permits observation at the site-specific level. Thus, the data become more amenable to Markov and similar analytical techniques requiring site-specific data.

Finally, a combination of point sample and airphoto interpretation costs relatively little when photographs obtained through secondary sources can be used. Drawing the sample and acquiring and interpreting photos totaled approximately $500 per county. Though types of data obtained by airphoto interpretation are limited to phenomena observable visually from the air (directly or by inference), they complement and supplement data obtained by other methods.

VALUE OF AIRPHOTO INTERPRETATION

Airphoto interpretation can provide helpful data on land use. The technique serves as a source of data on past uses that could not be obtained elsewhere. In some circumstances, use of a photo print sample can reduce cost and hold loss of precision to a tolerable level. For interpretation of a given print, a point sample serves two functions. First, further cost reduction results because areas with specific uses need not be circumscribed and measured. Second, variables can be associated at a site-specific level.

The resulting land use transition matrix provides three types of information:

- Land use inventories for two points in time
- Breakdown of the disposition in the later year of the acreage in each category for the earlier period
- Prior use of the acreage found in each category in the later period.

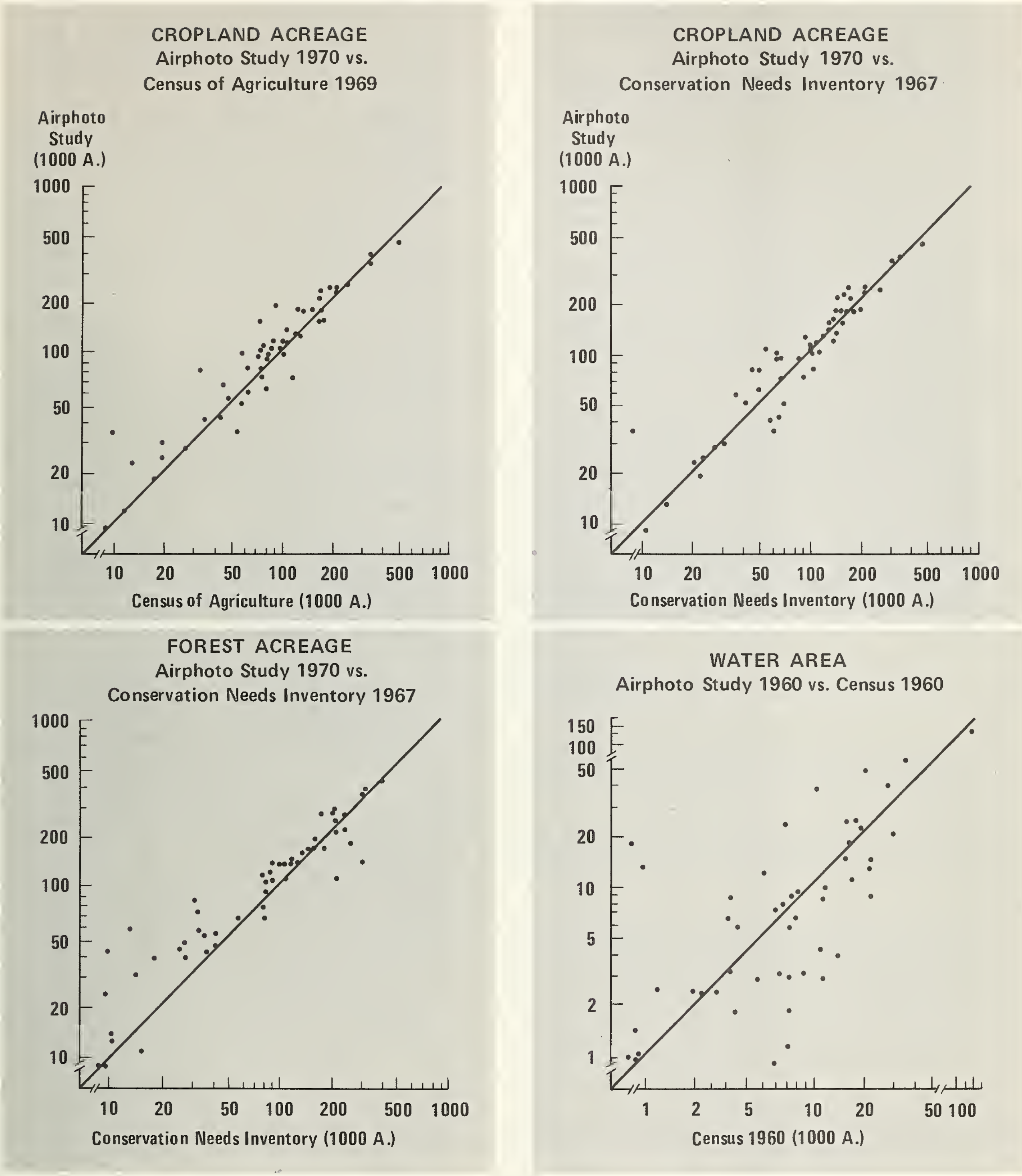
Thus, the analyst gains data on the dynamics of land use change which cannot be obtained by comparison of simple inventories of land use for two points in time.

Table 4.—Comparison of current study's land use data with data from other sources

Land use $\frac{X}{Y}$	Cases	Correlation coefficient (r)	Equation	t[a]
Cropland-				
Total, Census of Agriculture, 1969[b]				
Current study, 1970	54	0.97	$y = 0.94X + 16{,}000$	28.9
Total, CNI, 1967[c]				
Current study, 1970	52	.96	$y = .96X + 12{,}000$	24.6
Forestland:				
CNI, 1967[c]				
Current study, 1970	53	.94	$y = .86X + 24{,}000$	19.2
Water bodies over 40 acres:				
Area measurement reports, 1960[d]	54	.88	$y = .85X + 1{,}600$	13.3
Current study, 1960				

[a]All significant at the .001 level. [b]1969 Census of Agriculture. County Data Books, table 1. [c]1967 State Conservation Needs Inventories. [d]U.S. Dept. Commerce, Bur. of Census. Area Measurement Reports, by States, 1960.

FIGURE 3
AIRPHOTO DATA COMPARED
WITH OTHER SOURCES



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RESEARCH REVIEW

IN THIS ISSUE

"An excessive study of mathematics absolutely incapacitates the mind," according to Sir William Hamilton, the 18th century Scottish philosopher. "In mathematics, dullness is elevated to a talent," added Hamilton, "and talent degraded into incapacity." The three articles in this issue of *Agricultural Economics Research* depend heavily on mathematics, statistics, and computers. Whether these articles are evidence of dullness in ERS elevated to a talent, talent degraded into an incapacity, or neither of the above, we leave for the reader to determine.

An overview of comprehensive models used to support ERS forecasts and longrun projections of commercial agriculture forms the subject of the first article. This overview opens a series of articles planned for AER that will describe and explain ERS modeling efforts. In this issue, we focus on commercial agriculture. Other articles or series of articles are planned to appear later on rural growth, natural resource development, and progress in underdeveloped nations.

The authors of the second article use an econometric model to evaluate two decades of farm programs. The programs helped support farmers' income during the early part of the period, but they also provided economic incentives which stimulated output. As a result, farm prices during the latter part of the period were lower than they would otherwise have been.

An interesting problem raised in the third article is: "What is a random sample?" The authors take the position that observations randomly sampled from aerial photos warrant the same statistical treatment as if they had been randomly sampled from the ground. Reviewers of the article cautioned that the procedure was not valid; some points on the air photos had twice the probability of other points of entering the sample because of planned overlaps in the photo segments. The authors countered that all points on the ground had an equal probability of appearing twice as often in the photos. But the reviewers were also concerned that air photo coverage was not randomized before the photos were taken. The fine point of the argument appeared to turn on whether a sample must be purposively randomized or be simply unpredictable *a priori*. The issue was not resolved before we went to press, and the article appears as is so that you can make up your own mind.

Both this journal issue and the last one represent a new focus for AER involving changes in its essential components: content, style, and format. We intend a broader perspective, one that reflects the total ERS effort, that shows the work of ERS as an *Agency* in agricultural economics. The major articles will reflect this shift. The former Book Review section will too. Renamed Research Review, it carries important brief commentaries that do not fit into the article format.

Content is significant but it cannot be conveyed without language. The words, the style one chooses, must be clear and concise, freed of ambiguities, pared of padding. In an age of considerable division into specialized fields that require technical language, AER will continue to treat subjects technically. But we will avoid the use of "jargon" words as much as possible. Similarly, we will use only charts and tables that function with the text, not that detract from or duplicate it. Considerable time and care remain imperative in both the selecting and editing of Journal material.

Format, how the Journal "looks" to the eye, completes the essential set of components. We have made certain changes to facilitate the information flow from page to brain. For example, the abstract now flows spatially with the article. The tables and figures are shaded for clarity and ready separation from the text. We are treating the cover differently to capture both the realism and abstraction of agricultural economics. The journal that makes a statement by its content, style, and format will attract and sustain more reader interest.

We are also attempting to make AER more noticeable to a wider audience. Its circulation, at around 3,000, is small. Yet it carries articles whose content is both timely and timeless, whose subjects are important, and whose techniques can be both additive within the agricultural economics discipline and also perhaps applicable beyond it.

Finally, *Agricultural Economics Research* currently represents the sole quarterly research journal of the U.S. Department of Agriculture. Its continued usefulness depends on our efforts and on yours. We need and invite your support.

Clark Edwards
Judith Armstrong

FROM THE ST. CROIX TO THE POTOMAC

by Sherman E. Johnson. Big Sky Books, Montana State University, Bozeman, Montana 59715. 289 pages. 1974. $4.95 (paperback).

In times past when it was not déclassé to read the poems of Longfellow and Lowell, pupils recited how "lives of great men" promise that we too can leave footprints. Thereupon a dutiful scholar such as this reviewer read the autobiography of the swashbuckling Theodore Roosevelt and that of the "up-from-slavery" Booker T. Washington. There followed the works of the muckraking Lincoln Steffens, the "never-educated" Henry Adams, and the Plains pioneer Alvin Johnson.

And now we have the footprints of Sherman Johnson, sometime college professor and drought years' land planner and purchaser for the Resettlement Administration. Principally a career agricultural economist in the U.S. Department of Agriculture, Johnson rose to receive the President's Award for Distinguished Federal Civilian Service. If Johnson's footprints are not giant they are nonetheless sharply graved.

And graved with a purpose. In his autobiography, Sherman Johnson declares his message unabashedly. Primarily, he intends to exalt the role of the Government bureaucrat; secondarily, to advise him on deportment. With the unembellished directness that is his signature, Johnson upholds the worth of public service and testifies to his own pride in it. Far from being annoyed by "the invidious connotation of the word *bureaucrat,*" he is "proud of the appellation."

Johnson advocates dedication. For "success, and happiness in professional public employment, first one needs a spirit of service to fellowmen, second, one must place the opportunity for service above greater financial rewards." The theme is echoed in the book's closing line: "If young people become convinced they are truly serving the public welfare they will find professional public service a rewarding experience."

On careful reading, the autobiographical narrative divides three ways. First Johnson describes life in the Swedish lumbering and farming community of the St. Croix Valley of Minnesota, where he was born in 1896. He recounts the hardship and financial insecurity of farming in that territory, also the diversity of personalities who inhabited the place.

Second, we see traced the remarkable career of a man who as a youth scarcely could leave farmwork to attend school and who interrupted his schooling after the eighth grade. Although he lived only 27 miles from Minneapolis and St. Paul, he first visited those cities when his father, who admired Theodore Roosevelt, took his 16-year old son to hear the Bull Moose candidate for the Presidency. The one trip "whetted my appetite," Johnson writes. Thereupon, he enrolled in an agricultural academy in St. Paul and eventually in the university. He received his B.S. degree at age 28 and continued with graduate studies.

Once embarked on a professional career, Johnson moved among the landgrant institutions of Minnesota, Louisiana, Montana, and South Dakota. After study of the new farm programs from the vantage point of the Brookings Institution, he worked as land planner and purchaser in the Northern Plains. In 1936 Johnson moved permanently to Washington. He rose quickly to head the Division of Farm Management and Costs in USDA's Bureau of Agricultural Economics. Without disparaging his later War Food and international achievements, many of us who watched from near at hand believe that Johnson distinguished himself the most as a leader in farm management research. Later assignments include agricultural counseling in India and elsewhere, and election as President of the International Association of Agricultural Economists.

A third division of the autobiography contributes to agricultural history. Sherman Johnson was so involved in production policy for U.S. agriculture for 30 years that the story of his life is the story of that policy.

Each part of the Johnson saga will appeal to a separate readership. The account of life in the country will attract some readers out of nostalgia; others, from curiosity. Johnson's associates and friends, of whom there are many, will savor the personal story with deep appreciation. Absence of literary grace notes and of soul-in-torment drama will reduce its appeal to strangers. Stylistically, the book is written almost without inflection: crossing a stream by guiding a Model T Ford on two planks ranks equally with a conference with Nehru about India's food problem.

Modest man that he is, Sherman Johnson will not be dismayed if his most lasting message proves to be his insights into the history of agricultural programs. His career spanned exciting, yeasty years. Government and farm leadership pulled agriculture out of depression, encouraged it to produce full-blast during wartime, applied technology in postwar years while trying to mitigate income-depressing consequences, and finally taught a technological lesson worldwide.

A few evaluative reflections shine through. Johnson regrets the favoritism shown in farm programs toward the larger commercial farmers. He laments the disregard of smaller farmers, tenants, and especially hired farmworkers. "Society cannot afford to maintain a caste system in agriculture," he warns.

It is indeed some distance from the St. Croix to the Potomac. Johnson's footprints in spanning that distance and his testimony of gratification are worth heeding. As his autobiography reveals, Johnson wielded influence and won laurels not only without engaging in strategic maneuver, but without being capable of it. We can suspect that in governmental infighting his greatest resource was not technical skill but his known absolute candor. It was disarming. If intellectual display appears now to be in vogue, it may be refreshing to know that a competent economist attained the highest civilian recognition in the U.S. Government without imposture or pedantry.

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UNCLE SAM'S FARMERS: THE NEW DEAL COMMUNITIES IN THE LOWER MISSISSIPPI VALLEY

By Donald Holley. University of Illinois Press, Urbana, Illinois. 312 pages. 1975. $14.50.

The depression years of the early 1930's seem long ago. Cotton in the deep South sold for 6 cents a pound when a buyer could be found, working capital or "furnish" for family living and crop production was nearly impossible to obtain; tax and mortgage payments were in arrears; and jobs were almost nonexistent. Because of its rurality, the rural Mid-South perhaps did not have as high a jobless rate as did the more industrial East and Midwest. But poverty was more severe; it was the sharecroppers, the tenant farmers, and the sawmill workers who were dispossessed. These people were disadvantaged before the Great Depression; with it, their plight became almost hopeless.

But the period was also a time of experimentation in social and economic programs. Into the situation came the alphabet agencies of the New Deal attempting to alleviate, if not solve, the problem of rural poverty. In his book, Holley has elected to focus on these attempts of the Federal Government to decrease farm poverty. As he said, the idea was simple: "The government would take impoverished families off land too poor to yield a decent living and convert it to forest, recreational, or other nonagricultural uses. The displaced families would be resettled on productive soil and eventually they would become owners of their farms" (p.i.). Farm communities and subsistence homesteads command most of Holley's attention; rural rehabilitation (rehab farms) and tenant purchase farms are only incidentally treated. *Uncle Sam's Farmers* is more an account of the Agencies and the men of these Agencies, especially their operations in Arkansas and, to a much lesser extent, in Louisiana and Mississippi during 1933-46. The book provides a history of attempts at cooperative farm efforts.

Holley has performed a much needed service in his recapitulation and discussion of the times, the events, the Agencies, and the people involved in innovative programs which attacked rural poverty, particularly farm poverty. He is primarily concerned with the large costly projects, such as Dyess, Plum Bayou, Terrebonne, Transylvania, and Lake Dick but some of the references stem from the tenant purchase (Bankhead-Jones Act) and the farm rehabilitation programs. The book provides a detailed story of Region VI operations of the Resettlement Administration and the Farm Security Administration that concerned community farms. In many respects, Holley's work is also a defense of the men and their actions, the policies and the Agencies involved.

People like Rexford G. Tugwell, Harry L. Hopkins, Carl C. Taylor, W. R. Dyess, T. Roy Reid, E. B. Whitaker, Floyd Sharp, and T. B. Fatherree were some of the principal actors in the drama of the "war against poverty" in the 1930's. Some of these men were not known outside Region VI, but others operated at the national level. It is important to have their contribution documented.

But as the author says: "Although the government divested itself of control over the resettlement projects, the communities themselves remain monuments to the idealism of a nation fighting economic collapse. Some thirty five years later Dyess is occasionally mentioned as the place where Johnny Cash grew up, while projects like Plum Bayou and Terrebonne have fallen completely into obscurity" (p. 282).

An interpretation and an evaluation of the social and economic impact of the experiments would have contributed to the book. One major conclusion reached by Holley was that the small size of the farm units (usually less than 40 acres) contributed to the lack of longrun success of the projects as farming ventures. He also concluded that the selection of individual families for participation in the projects was less than optimum. Though the conclusions are probably correct, he presents no supportive evidence. Nor did he assess the economic and social impact of the projects on the farm families or on the region.

Holley's book provides an excellent history of the U.S. Government's attempt to solve poverty among a selected group of people in a restricted geographical area during a most adverse economic time. But the broader implications were not discussed, and in this sense the book is lacking.

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THE ECONOMICS OF NATURAL ENVIRONMENTS

By John V. Krutilla and Anthony C. Fisher. Studies in the Valuation of Commodity and Amenity Resources. For Resources of the Future, Inc. The Johns Hopkins University Press, Baltimore, Md. 21218. 292 pages. $16.95.

In a work which boldly tackles a difficult subject, Krutilla and Fisher have demonstrated the possibilities of theoretical and empirical economic analysis for practical problem solving. They present "operational models" for conducting quantitative analyses of the amenity value of environmental resources and conventional analyses of commodity resources.

The volume is divided into two basic sections (actually three if the advanced mathematics information is considered): one which lays an institutional and theoretical framework (four chapters) and one which applies the framework to five specific cases. Although much of the text draws upon Krutilla and Fisher's research, three of the cases represent a condensation from other research efforts of Resources of the Future, Inc. (RFF).

The authors set the tone in chapter one with an adequate introduction to management of natural environments, particularly public lands. Early on, they discuss the idea that land in its natural state is not necessarily unproductive. In perhaps their strongest point, the authors single out the critical importance of direct and indirect Government subsidy in the alteration of wild lands.

Chapter two presents a discussion of failure by markets to allocate efficiently the resources of natural environments. Topics covered include common property resources, public goods externalities on public lands, and the relationship between assignment of property rights and resource valuation.

The important issues of irreversibility and time are considered in chapters three and four. A very lucid discussion appears on society's potential attitude toward the risk associated with the irreversible (in a technical, polyperiod sense) conversion of natural environments to developmental purposes. Because of the existence of option value and newer interpretations of the possible gains from trade among generations, traditional benefit-cost analysis of a natural resource development project may be incomplete as a basis for a public decision. In a model using optimal control theory, the authors demonstrate that:

where benefits from development of a natural environment are decreasing over time relative to benefits from preservation, the instantaneous optimum level of development is also decreasing (p. 57).

In chapters five and six, the authors apply the theoretical framework to the hydroelectric power plant proposals for the Hell's Canyon reach of the Snake River. They demonstrate how a critical review of a natural resource project may reveal some of the social costs (accounting for asymmetrical technological change and adjusting for subsidies), exclusive of the environmental costs. After determining that one of three proposals demonstrated net economic benefits, they evaluated the amenity resources, using the ecological carrying-capacity concept. The amenity valuation established a case for preserving Hell's Canyon by demonstrating that "quantitative analysis can be very useful even in the absence of its capacity to capture all of the values potentially attributable to preserving rare natural environments" (p. 135).

In chapters seven and eight, Krutilla and Fisher apply the framework to the White Cloud Peaks case (in which a marginal molybdenum extraction and processing facility has been proposed) and to development in the Mineral King Valley (in which additional capacity has been proposed within an existing system of intensive recreation facilities). Once again, the authors show that strong arguments against development, based solely on private market criteria, can be developed. The optimal capacity concept was used, in both cases, to ascertain what recreational demand levels might occur.

The final two cases are less site-specific. Chapter nine addresses the problem of optimum allocation of prairie wetlands for breeding and habitat use by migratory waterfowl. The problem involves private and common property interests. In chapter ten, the authors evaluate alternatives for Alaskan oil exploitation and transportation systems.

Assessing this book is difficult enough because of the biases introduced through a raising of expectations, only to find that the problem remains as tough to crack as ever. However, a noticeable dent has been made towards the valuing of environmental resources. One can expect too much from people in an organization (RFF) which has continuously produced a rich body of knowledge on natural resource management. The amenity resource valuation work (recreational mainly) stems from the long line of research beginning with Marion Clawson in the fifties. Krutilla and Fisher attempt to value environmental costs, saying that "ultimately the environmental damages reckoned as economic costs will have to be assessed" (p. 279).

The feeling exists, after reading the volume, that environmental damages continue to be viewed mainly as uneconomic (except recreational), and that they represent an intangible (albeit important) value to society. Though this feeling may be an overreaction to the research caution (scientifically correct) of the authors, this reviewer remains ill at ease, given the influence of these two economists. For example, there are economic costs from the environmental damage of tidal marshland alteration, a specific not covered in the book. These costs include erosion and flood control plus waste assimilative capacity—to name a few. But the point is that ecology science disciplines may have knowledge beyond economics, which when given an economic interpretation (for example, the prairie wetland work discussed above), allow a management tool to be applied in the context of broad social efficiency. Though a wealth of additional scientific data already exists, I believe much more exists than is apparent, based on the dearth of major publications on social costs (other than health and recreation). While agreeing with the authors that environmental issues constitute a methodologically difficult front, this reviewer contends that analysis must be pushed forward beyond normal economic consideration. Like it or not, we are allocating resources that are scarce (in quantity and quality) and unique, the longrun effect of which is often irreversible.

These specific criticisms of the work perhaps stem from unfair expectations of a broader perspective. However, when considering the use of natural resources, one needs a broader brush analysis because of the possibility of future option foreclosure. When considering alternative energy sources, not only the *in situ* or direct production costs should be analyzed, but also the relative environmental costs. The environmental risk of a nuclear alternative was not even lightly considered in the Hell's Canyon case, although so-called ecocatastrophe issues were briefly discussed in the Alaskan Oil case. Damage to the Arctic tundra ecosystem would be hard to value in an economic sense, but damage to West Coast fisheries may occur and require economic evaluation. Similarly, in the bioeconomic optimum allocation of wetlands, the authors did not consider the increased cost of plowing around the potholes, the assertion of flood losses (though the wetlands are purported to control flood levels and ground water recharge), and the lost agricultural production. While increasing the complexity of already complex problems, ecological solutions to ecological problems require this expanded approach.

On balance, the book provides a useful view of the state of the art. It is well written and well referenced. Both authors and the other researchers involved should be commended for continuing to push the capabilities of the dismal (and too often conservative and provincial) science into policy areas requiring the analysis of tradeoffs.

Based on the book's preface statements that it represents an "early effort" and that the "volume doubtless raises more issues than it is capable of resolving satisfactorily," a final comment by RFF's Marion Clawson is appropriate. In their 1974 annual report, Clawson states: "The partial and piecemeal approach to environmental problems . . . ignored the maxims of ecology . . . everything in an ecosystem is related to everything else in that system."

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FOOD AID AND INTERNATIONAL GROWTH

By Earl O. Heady, Leo V. Mayer, Keith D. Rogers, and Uma K. Srivastava. Iowa State University Press, Ames, Iowa. 1975. 160 pages. $7.95.

The effects of food aid programs on producer and consumer welfare, agricultural progress, and fiscal structures in recipient countries are quantified by the methods reported in *Food Aid and International Economic Growth*. The presentation suffers somewhat from dated information. Statistical tables generally contain information only up to the late 1960's, excluding data on projections. Despite this shortcoming, the book is a very useful addition to the literature on food aid.

The authors use India as the reference country. They focus their analysis on conditions under which consumer welfare can be enhanced and farmers insulated from negative price impacts. According to some analysts, assert the authors, food aid has, through its effects on the market, dampened agricultural development of the low-income countries. Other analysts believe that the net effect of food aid has been positive.

Future usefulness of food aid, say the authors, will depend on the answers to the following critical problems that have reduced the efficiency of food aid as a tool for economic development:

- Negative price and production impact on domestic producers in recipient countries
- Hardening of the terms of food aid and lowering of the aid component in the shipments
- Problems associated with excess accumulation and use of counterpart funds from past aid agreements.

Their expressed objective is to solve these problems empirically and to provide some policy guidelines for both developed and developing countries to increase the effectiveness of food aid in economic development.

In the book's theoretical background, the authors present the necessary and sufficient conditions for preventing the food gap from becoming a constraint on the growth process. They examine the price disincentive effect of food aid by developing a theoretical model to test the hypothesis that the negative effect on prices and production is much less or else absent when markets are differentiated. If this hypothesis is correct, previous work which neglected the real-income effect on demand seems to have overstated the negative effect of P.L. 480. Of course, some earlier studies referred to by the authors are not strictly comparable. For example, the Mann study was based on 1952-63 while the authors' study, which changed the specification of various equations in the Mann study was based on 1956-67.

Using India's differential market system of commercial and "fair price" shops as an example, the authors concluded that the negative impact of P.L. 480 on domestic production and prices could be reduced to insignificant proportions if the commodities are distributed to create new demand. To ensure that their farmers experience no price dampening impacts, recipient countries should be required to channel aid supplies through differentiated markets, such as India's fair-price shops.

The authors state that the hardening of food aid terms has reduced the real-aid component of P.L. 480. Pricing food aid at world market prices has created a debt-servicing burden which threatens to cut through the foreign exchange resources of recipient nations in coming years. However, the inflationary impact of large accumulations of counterpart funds can be overcome. The writers maintain that, to solve this problem, surplus local currency counterpart funds should be given back to aid-recipient countries in the form of grants. They also estimate that food aid can be priced at lower levels with little additional net cost to the United States.

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Kent B. Smith
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TOWARD MORE ACCURATE FARMING DATA

The cornerstone for a new farm statistical structure in the United States was laid in 1966, when the Statistical Reporting Service (SRS) of the U.S. Department of Agriculture put a probability sampling scheme into operation in the 48 contiguous States. The scheme, a long time in the making, started with the master sample for agriculture originally developed at Iowa State University during World War II. SRS began experimenting with the application of this area sampling frame to crop and livestock estimating in 1953. In that year, the Congress authorized the Service to research alternative ways of making these estimates, following an obvious breakdown in estimation of cotton production in 1951.

Introduction of the new method was approached carefully and deliberately, because trouble was encountered at every step. Eight years of research and pilot operation preceded the initiation of probability surveys to collect data in 11 Southeastern and 4 Midwestern States where the master sample could be adapted with relatively little modification. Thereafter, SRS introduced the enumerative surveys in a few additional States each year after it had suitably modified the area sampling frame to allow for different farming conditions, such as those found in range areas, irrigated valleys, specialized fruit and vegetable growing areas, and areas of developing urbanization. The objective of this new survey system was to provide estimates for major crop and livestock items with a sampling error at the national level of 2 percent.

By 1969, with probability sampling a reality in 48 States, a revolutionary change occurred in SRS Crop Reporting Board procedures. A major hurdle was overcome: internal opposition among long-experienced statisticians. Before that time, national estimates had been derived by summing estimates for the individual States, estimates which had been arrived at by various sampling methods. To gain the real advantage of a national probability sample, necessarily small, statisticians had to determine the national estimate for a particular crop first, after which they scaled or adjusted individual State estimates to conform with the national estimate. SRS introduced this change in Board procedures only after much discussion of the likely benefits and risks. The new system soon clearly proved itself superior for wheat estimates and it was adopted for other crops and for livestock.

A major challenge to the new system arose in 1967. Results of the 1964 Census of Agriculture became available, and these indicated that total cattle estimates made by SRS needed to be increased 2 percent. Larger percentage adjustments would have to be made in the subdivisions of cattle numbers if the SRS projections were to be compatible with the Census benchmarks. Since the probability surveys were just being put into effect, they could hardly be held responsible, but they were held suspect. After all, the census method was an old established system, never challenged.

Three conclusions emerged from this experience. One, the area probability sample served better for estimating crops than for livestock. Acres did not move, but livestock did. Livestock numbers changed substantially seasonally; acreages, less so. Most important, very large numbers of livestock and poultry were often concentrated on small areas of land, causing large sampling errors in the estimates based on area samples.

Two, the goal of achieving a 2-percent standard error for national estimates of major crops or livestock would no longer be adequate for a rapidly changing agriculture. Cattlemen made it abundantly clear that a 2-percent deviation from the mark was too misleading for their planning. They had been led to believe by the analysts interpreting the estimates that the cattle cycle was on the down side and that price prospects were favorable. Consequently, these producers had retained more cattle than would be profitable to raise.

Three, a less costly method was needed than simply expansion of the size of the area probability sample, the usual method for gaining accuracy. As a method for data collection, mail surveys cost much less than the personal interview technique required for an area sample.

To achieve the benefits of a mail survey approach, SRS began using list sampling frames to supplement the area sampling scheme while retaining a probability survey design. With research help from Professor H. O. Hartley of Texas A & M University, Service analysts developed a methodology that combined these two sampling methods to get a single probability estimate. The result: "multiple-frame" sampling.

The approach was tried first with livestock, where improvement was most needed. Again adaptation was made cautiously and carefully. Hog and pig estimates from multiple-frame samples were introduced in five States in 1970. By 1975, they were being used in 23 States for 95 percent of the hog population. Simultaneously, cattle multiple-frame samples were introduced in 38 States for 96 percent of that population. The accuracy of results proved remarkably good, correctly calling the changes in direction of these populations during periods of rapidly changing growing and cultural practices that caused analysts to question these estimates repeatedly. A series of unexpected developments, unprecedented in recent times since the use of large-scale feeding has become prevalent, caused price and profit outlooks to change rapidly and drastically. Grower behavior in reaction to such events as inflation with unprecedented rises in feed and fuel prices, peacetime price ceilings, and a series of erroneous economic forecasts (especially of food prices and farm income) took unexpected, and, to older generations of analysts, unbelievable turns. Time after time, accuracy of hog and cattle inventory estimates was vindicated by the subsequent marketings, though such marketing occurred on different schedules than the analysts had anticipated.

Superiority of multiple-frame sampling had been clearly demonstrated. Then, as the need developed for more accurate estimates of farm data generally, because of urgent world food problems, SRS sought to adapt the method to other estimates. To do so, it needed as complete as possible a mailing list of farms, classified by enterprise and size, to serve as a list sampling frame. Research on how to get such a list indicated that no national list was available to serve as a good starting point. Many lists from various sources would have to be merged to attain a reasonably complete list. Because of the variation in sources, list sampling frames would best be compiled State by State. Two more difficulties became apparent: identifying the person able to give authentic, current information on each farm or establishment so that it appeared once and only once in the list, and keeping the list up to date. A multimillion dollar budget would be required for specialists to compile a suitable list in every State.

The SRS budget for 1976 contained an appropriation of $1,250,000 to get started. This amount allows analysts to prepare the foundation for a restructuring of the farm statistical system which will make the investment well worthwhile.

First to benefit from the availability of multipurpose list frames will most likely be the crop and livestock estimates. Very soon, however, a major beneficiary will be the economic estimates made for the Economic Research Service and other Federal and State agencies for which SRS collects data. Currently, analysts collect much of the economic data as part of the comprehensive national probability surveys made each year. The primary purpose of the June survey is to collect data on planted acreages of crops; the other, in December, is taken mainly for livestock data. A third survey is being introduced in 1976, basically to obtain economic data. Demand has grown for such data to be more current than now, obtained as they are through the quinquennial census of agriculture.

The flexibility of a system of annual sample surveys will allow most data to be collected on a more timely basis. Further, much duplication between long- and short-term surveys can be eliminated and, over a 5-year period, all data heretofore collected through the census can be acquired.

The principal distinguishing feature of the census of agriculture today is that it represents the main source of farm data by counties, because it is the largest sample taken. In the two most recent censuses, about 85 percent of the farms were covered. With a controlled probability sample, such as the one SRS is preparing to take nationally, about a 25-percent sample will probably yield county data of sufficient accuracy. Success with such a system would substantially reduce the overall reporting burden on farmers. The new system would, however, require the full cooperation of persons selected in each survey's samples.

The Office of Technology Assessment of the U.S. Congress has reported favorably on this proposed method for acquiring agricultural data. SRS is developing its list-building capabilities as rapidly as the new appropriations permit. By the time necessary changes in the laws have been made to authorize an integrated agricultural data system, SRS hopes to have developed the means to bring this system into being.

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A CRITIQUE OF THE FARM INCOME TASK FORCE REPORT

The magnitude of upward revisions made in the 1973 net farm income figures between January and July 1974 created both political and professional concern. As a result, the ERS Administrator set up in mid-1974 a Farm Income Task Force to provide an out-of-house evaluation of Service performance in this key area of estimates work. Some of the task force members were ERS economists; most were not.

The revisions turned out to have been necessary because, in a period of disruptive change, ERS had been using procedures designed for periods of gradual change. To find corrective solutions, the taskforce had three objectives:

- To recommend changes to reduce the magnitude of revisions possible in the future
- To integrate the figures more accurately with the national income and product accounts (NIP)
- To reflect more accurately the major organization changes which have occurred in the farm production sector.

The task force report contains a number of important observations and recommendations. As a major contribution, members integrated a set of concepts, emphasized the need for more accurate, complete data, and pinpointed these data deficiencies as the real "villains" in the 1973-74 faulty estimates. They found that the percentage revisions required for farm income were the largest of any component of national income, and that successive revisions regularly zeroed in on what became the final estimate. To reduce both frequency and magnitude of revisions, the task force proposed that substantial changes be made in data collection, handling, release, timing of revisions, accounting rules, and definitions. Task force members noted especially the problems created by organization change in the farming sector, and that some errors in the estimates result from use of concepts or definitions that fail to square with behavior in the real world.

"The most significant improvements are possible in the area of basic data," concluded the task force members. Certainly this conclusion holds if one emphasizes the minimization of revisions objective. I would argue that some of the suggested changes in concepts, discussed later, are more significant in achieving the other two objectives of the task force.

It is of particular importance to note that most of the data changes the task force recommends must be made by agencies other than ERS, especially SRS. The report calls for monthly quantity data on crop and livestock movements to parallel the monthly price data already collected. Availability of these additional statistics would eliminate reliance on historical monthly marketing patterns in making preliminary estimates. Use of such historical patterns was a major factor contributing to the need for revision in the 1973 estimates. Other priorities within the area of basic data collection, according to the task force, are more frequent statistics on production expenses and inventories of livestock and purchased inputs.

A second level of data improvements would support the objectives of improving comparability to the NIP accounts and of recognizing farm organizational change. Most importantly, the committee recommends adopting the "establishment basis" to replace the current mixture of establishment and product bases in the accounts. As a result, the definition of the farm sector would be closer to that used in the NIP accounts for other sectors. The farm sector would include all output of establishments whose primary business was farming, including ancillary products and services produced by them. Accompanying this basis change would be four other modifications:

- A shift to the concept of "income from farms" from the concept of "income of farm operators"
- An emphasis on gross value added or gross income originating in the sector rather than net value added or net income
- A more complete accounting of interfarm transfers
- The separation of capital formation from current production expense (procedures now treat breeding herds and construction as operating expenses).

These changes would shift emphasis from the farm as a consumption unit to the farm as a business, they would provide more complete measures of economic activity, and they would distinguish more clearly between production and investment activities. The conceptual changes yield a number of further data needs: interfarm movements, activity in secondary farm enterprises, and separation of breeding stock from fattening animals (especially onfarm or own-account capital flows).

There can be little question that the changes proposed by the task force would contribute in a major way to the three objectives. This reviewer has little to add within that context. The committee also suggests a few administrative changes to improve timing and to facilitate necessary revisions, but admittedly and by assignment gives only peripheral attention to improved techniques of program operation. The committee appears to accept uncritically that current staff are "at least fully occupied" on current operations and argues that ERS should give high priority to adding new staff to lead program development. Given the present size of this operation and the severe competition among ERS priorities, the current staff might have appreciated some suggestions on how to squeeze more out of what resources they now have.

As one who has read reports of earlier ERS task forces on the farm income and balance sheet, AAEA concept committees, and OMB task forces, and who has served on internal ERS study groups on farm income and balance sheet work, I cannot help being impressed by the extent to which the committee report is consistent with previous suggestions.

I am under the impression that the report is largely an original effort, though they obviously drew on various previous studies, such as that by the inhouse Farm Income Committee chaired by Eldon Weeks, as well as consultant expertise in developing it. Regardless of the source of inspiration, the task force has served a valuable function in assembling and rationalizing a set of proposals, as well as in validating prior internal ERS studies. It is a pity, and yet an undeniable fact, that legitimizing of staff ideas most often takes place by the stamp of outside approval.

What are the prospects for implementation of the ideas? Mixed, I suspect. A major portion of the improvement requires large infusions of budget to SRS to collect data more frequently. At least through the current budget crunch, I would anticipate only marginal shifts in current data instruments. Provided that we don't encounter another economic roller coaster of 1973 proportions, that will do for the short term. In a longer horizon, it is to be hoped that the suggestions will serve as a blueprint for shifting and for adding data resources. Once the budget situation is brighter, it behooves economic analysts to press for the resources required.

Events seem to be moving toward conceptual adjustments to recognize changes that have taken place in the farm sector. With the major initiatives being made in the 1974 census, I hope we can also look forward to the farm income accounts adjusting in the directions recommended. The existing system evolved by building bridges of assumptions over various data chasms. No less, the proposed system also could be constructed from available data, given some manpower devoted to it. As the assumption framework is developed, it needs to be thoroughly documented so that researchers outside the farm income group can participate in evaluating the work and making refinements, and so the new data base can substitute for assumptions as it becomes available. At the same time, the framework needs to be converted into a computerized program to improve operating efficiency and timeliness of the estimates. At least one economist and one programmer assigned full time would provide a start. Perhaps this is the groundwork to be laid while efforts to augment the data base are ripening to fruition. The latter requires SRS concurrence, and thus is not solely under the ERS Administrator's control.

The committee's adoption of the establishment basis and "net income of farms" begs a larger question on data, albeit one they were not assigned. Should not the Department collect economic data to enable aggregations by product and by persons classed as farm operators? The general answer is that USDA should and it does.

The derivative question becomes whether these accounts should not be planned in conjunction with the accounts reported by establishment. The task force recognized and noted that some of the commodity quantity data have parallel payoff in situation and outlook work. A product account basis is a natural way of organizing such data. Since commodity work consumes a major part of ERS resources, it would seem efficient to integrate commodity data by product account with the farm income work. The task force also could have noted that gathering data on ancillary farm activities goes some distance toward measuring personal accounts of farm operators, thereby addressing social welfare issues. Integrating data and accounts here with those for enterprise and product may offer further efficiencies. The ERS Administrator should examine the feasibility of integrating the task force recommendations with needs of other ERS areas of activity. We need look no further for a start than the report of the previous, inhouse Farm Income Committee study.

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"NORMALIZED" PRICES FOR PROJECT EVALUATION

INTRODUCTION

The economic evaluation of public investment projects requires a vector of product and factor prices to be used in the calculation of expected net returns to investment. The most important concern in the selection of this price vector is that it correspond as closely as possible to the prices that will prevail over the life of the project.[1]

Of course, because of uncertainty about the future and the absence of binding forward markets for all goods, one cannot know *a priori* what these future product and factor prices will be. Thus, current expectations of future prices are used. In addition, so that the merits of any particular public investment project may be judged relative to the merits of other projects, it is desirable to standardize the way in which these price expectations are formed. The U.S. Water Resources Council, which coordinates water and related land use

[1] It might be argued that the prices used should be those that *ought to*, rather than those that *will*, prevail. This normative point of view is crucial if society's preferences regarding distributional equity, public health and safety, and environmental quality (to mention three principal examples) are to be incorporated into the evaluation process. However, these general welfare values are currently not considered in terms of price, a convention that will be maintained here.

planning in the United States, has accomplished this task by determining:

> . . . relative price relationships and the general level of prices prevailing during the planning study will be assumed to hold generally for the future, except where specific studies and considerations indicate otherwise.[2]

Though the Council's assumption might be questioned, the meaning of its directive is beyond dispute: in general, future prices are to be approximated by using current prices.[3]

The Council does, however, recognize, in a systematic fashion, some exceptions to its directive. One exception concerns the evaluation of costs and returns to projects involving agricultural production. In general, the prices of agricultural commodities and inputs fluctuate widely because of such unpredictable or uncontrollable factors as changes in the weather or in Soviet grain purchases. In recognition of this variability, " . . . the Water Resources Council will periodically publish data on prices of agricultural and other goods and services for all planning activities" that indicate what prices would have been, had market forces been somehow "normal" in the current year.[4] Again, *current* prices are emphasized; the "abnormal" influences are netted out and only "normal" market forces prevail. These "normalized" product and factor prices are used to calculate a stream of constant normal net revenues which are discounted over the life of a project.

DEFINING NORMALIZED PRICES

It is a highly ambiguous idea that a normalized price is the price that would have prevailed in a market if supply and demand conditions had been "normal." The ambiguity is both theoretical and operational. Theoretically, the very existence of an objective set of normal market conditions is subject to debate. Use of the concept "normal" implies that each factor which influences prices must be seen as following a stochastic, rather than deterministic, time path.[5] That is, each influence would be viewed as random, with a characteristic probability distribution moving along some path over time. This concept implies that a fundamental ambiguity associated with the notion of probability exists in any discussion of normalized prices. This ambiguity relates to the objective-subjective spectrum along which the principal theories of probability may be roughly arranged.

At one extreme, the classical notion of probability implies that there exists some unique and objectively determined set of conditions (in our case, for a normal market), described by the mean of the probability distribution for each influence at each point in time. For our purposes, the normalizing procedure is used to estimate as accurately as possible the prices resulting from this set of conditions.

Elsewhere along the objective-subjective spectrum, such a unique, objectively determined set of normal conditions does not exist. Under either the Bayesian or Keynesian notions of probability, for example, no set of conditions (here, for a normal market) exists independently of what persons believe these conditions are. The purpose of a normalizing procedure becomes that of forming a consensus or common belief about what normal conditions are, and hence, what normal prices are.

In short, it is not theoretically clear that an objective set of normal market conditions exists. Attempts to compose a precise general definition of a set of normal conditions which may or may not objectively exist are therefore likely to fail. Further clarification of the meaning of "normal" can probably only come at an operational level.

There seem to be three types of procedural or operational ambiguities. First, it is not abundantly clear which causal market forces are relevant, or which are of first-order importance and which, of second-order importance. Second, even if it is agreed which influences are relevant, it is also necessary to agree on the values of these variables. Third, agreement must exist as to the quantitative impacts of these normal conditions on prices.

These definitional problems are great enough so that no precise general definition of normal conditions and prices can be made. Let us focus instead on two procedures for normalizing prices that are flexible enough to resolve these definitional ambiguities at an operational, rather than conceptual, level.

PRICE-NORMALIZING MODELS

The first procedure for normalizing prices is the use of a quantitative empirical model of the agricultural sector to simulate the level of current prices resulting from market forces agreed on as normal. This approach has two great conceptual advantages. By requiring the specific identification of model structure, normal exogenous variable values, and parameter estimates, the technique becomes an educational and analytical as well as price-normalizing tool. And it is inherently flexible enough to incorporate changes in the consensus about what constitutes normal conditions. The chief disadvantage is that this approach requires substantially greater funding than is currently allocated for price normalizing work. Yet the magnitude of quantitative empirical

[2] "Water Resources Council: Water and Related Land Resources–Establishment of Principles and Standards for Planning," Fed. Register, Monday, Sept. 18, 1973, p. 24783.

[3] It has been contended that use of long-term price forecasts is more appropriate than use of current prices. The magnitude of errors involved in such forecasts relative to the errors involved in using current prices is the principal argument in support of the Council's position. For an earlier statement of the price forecast contention, see M. L. Upchurch. "Price Levels for Use in Evaluating Irrigation Development: The Problem." In *Water Resources and Econ. Dvlpt. of the West, Direct and Indirect Benefits*, Conf. Proc., Committee on Econ. of Water Resources Dvlpt. of Western Agr. Econ. Res. Counc., Ogden, Utah, December 1951.

[4] *USDA Procedures for Planning Water and Related Land Resources*, U.S. Dept. Agr., March 1974, p. III-7. Since the publication of these procedures, the Water Resources Council has adopted the policy of updating these prices annually.

[5] Deterministic time paths must be ruled out because, in such an economic system, only one set of prices would be observed, and the need for normalizing prices would never arise.

research on agricultural price behavior by the agricultural economics profession makes this method a feasible option.[6]
research or agricultural price behavior by the agricultural economics professional makes this method a feasible option.[6]

$$P_t = P^n_t + u_t \qquad (1)$$

Where:

P_t is the observed price at time t; P^n_t is the normal price in time t which would have been observed if market conditions had been normal;

u_t is the short-term fluctuation component of observed price.

As time passes and prices change, a discrepancy may emerge between the current observed price and the price believed to be normal in the previous period. If so, the process of normalizing prices consists of incorporating some fraction of this discrepancy into one's beliefs about what normal prices are in the current period. Algebraically, this process can be expressed as:

$$P^n_t = P^n_{t-1} + \lambda(P_t - P^n_{t-1}) \qquad (2)$$

Where λ is a real number between zero and one, exclusive.

Equation (2) can be shown as equivalent to:

$$P^n_t = \lambda P_t + \lambda(1-\lambda)P_{t-1} + \lambda(1-\lambda)^2 P_{t-2} + \ldots \qquad (3)$$

That is, the normal price in each period is simply a weighted average of all previous actual prices, in which the weight distribution is identified by one parameter, λ. This series of weights declines; each successive earlier price contributes less to the current normal price than does each more recent price. The series is also infinite, and its sum is unity. The infinite nature of the series presents no practical problem, since the series may be truncated when it approaches sufficiently close to one. Equation 3 is used to calculate a single set of normalized product and factor prices for the current year. Use of the set yields normal annual net income from the project being evaluated. This income is assumed to remain constant over the project's life. In other words, equation 3 is not an autoregressive projection procedure. It is applied once in the current year. The constant normal income stream is projected, not the prices themselves.

Empirical implementation of this second approach requires that an estimate of the parameter λ be obtained. Such estimation is impossible using ordinary least squares' regression techniques, because the normalized price in each period is not an observable variable. ERS economists have used two methods to take care of this problem.

In the first of these—technique A—the weight coefficients, rather than the parameter λ, were estimated directly from the price time series for each commodity over 1950-74. The Almon polynomial distributed-lag method was used over a 5-year period, the weight distribution was approximated by a second-degree polynomial constrained to approach zero after the fifth year.[7] All regressions included a correction for serial correlation, made with the Cochrane-Orchutt iterative technique.[8] Each estimated coefficient was divided by the unconstrained series sum to make the coefficients sum to one.[9]

In the second approach—technique B—a value of λ was specified *a priori* for each commodity. The primary advantage is that normalized prices can be as responsive to the movement of actual prices as one desires. A value of λ close to one yields a highly responsive normalized price. A value of λ close to zero yields a less responsive normalized price. As a refinement, judgments of persons familiar with a commodity market could be included when determining the weight distribution for that commodity.

Each of these estimation techniques has yielded normalized-price series that are dampened images of the actual price series. Both techniques compare quite favorably to other normalizing procedures.[10] They represent a significant contribution to the available methodology. ERS has proposed use of technique A to normalize prices for future economic evaluations of development projects.

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IMPACTS OF HIGHER GASOLINE PRICES ON RURAL HOUSEHOLDS

Automobiles consume over half the energy used by the Nation's transportation sector. Efforts to curtail petroleum imports have focused on reducing gasoline consumption because private motor vehicles are viewed as significant, sometimes inefficient energy users. Also, adverse impacts on income and disruptions in lifestyle were thought to be minimized by concentrating on passenger transportation. Higher gasoline prices, increased taxes, and rationing have been discussed as methods of achieving this reduction, and of the three, higher prices seem to be the alternative adopted. The focus here will be on both the empirical and theoretical reasons for the belief that higher gasoline prices have a greater adverse

[6] See first article in this issue: "Comprehensive Forecasting and Projection Models in the Economic Research Service."

[7] See Almon, S., "The Distributed Lag Between Capital Appropriations and Expenditures." *Econometrica*, Vol. 33, No. 1, January 1965, pp. 178-196. Additional treatment appears in Johnston, J. *Econometrics*. 2nd ed., pp. 294-298.

[8] Cochrane, D., and G. H. Orcutt. "Application of Least-squares Regressions to Relationships Containing Auto-correlated Error Terms," *Jour. Amer. Statis. Assoc.*, Vol. 44, 1949, pp. 32-61.

[9] The full results of this estimation are available as a working paper by Niehaus, R. D. "A Suggested Methodology for Normalizing Prices for Resource Development Project Evaluation." Natural Resource Econ. Div., Econ. Res. Serv., U.S. Dept. Agr.

[10] *Ibid.*

impact on rural households than on urban ones.[1]
belief that higher gasoline prices have a greater adverse impact on rural households than on urban ones[1] [4,5].

Increases in gasoline prices adversely affect both household incomes and consumer welfare. The relative price change induces users to substitute less desired modes of transportation; the income effect reduces real purchasing power of households. The severity of the impact depends on several factors, including distance to jobs and shopping, the number of trips required by household needs, vehicle gas mileage, availability of alternative transport modes, and household income. Rural households potentially face relatively more severe impacts because the above characteristics generally involve more difficulties for them than for urban households.

Consider two households, one rural, the other urban, with similar preference patterns and net income (after job commuting costs have been subtracted). Initially, both households are in stationary equilibrium purchasing identical quantities of the goods. Both purchase two goods whose prices, for purpose of this analysis, consist of the market price plus the transportation costs associated with purchasing the item or service. This approach differs from other indifference analyses of gasoline pricing and rationing.[2]

Now introduce a rise in fuel prices which increases commuting costs and, thus the relevant prices of both goods. The price ratio may change if one of the goods has a larger transportation cost component associated with it. Different quantities of the goods are now purchased at a new equilibrium point. Both urban and rural households would adjust their use of transportation to offset some of the welfare loss from higher prices. Either household may switch to less fuel-intensive modes, reduce the traveling distance, or consolidate trips in attempting to offset the higher relevant prices of the goods. For example, carpooling or public transit may be used for work trips, which reduces commuting costs and increases the household's net income to purchase other goods. Consolidating trips and reducing travel distances would lower the absolute relevant prices and also increase net purchasing power.

The rural household perhaps cannot make substitutions as readily as the urban household can. For example, the rural household may find it difficult to reduce the transportation costs for obtaining food or medical care. Fewer alternatives to private motor vehicles, such as public transportation, normally exist in rural areas; and carpooling may be difficult to implement because of more scattered origins and destinations.

Urban households, on the other hand, may have more favorable options available among distances and modes. Thus, under energy conservation policies, the urban households would tend to suffer less loss of welfare and purchasing power than would the rural households. Additionally, public transit may receive preferred treatment through lower fuel prices or guaranteed quantities of fuel. Again, urban households would tend to benefit more, which further exacerbates the rural-urban differences.

Thus, higher fuel prices might mean losses of purchasing power because of fewer transport options for rural than for urban households. Data on rural-urban transportation characteristics are available for a preliminary evaluation of this hypothesis. However, some of the data rely on a residential classification—unincorporated areas and incorporated places—that does not exactly conform to the standard rural-urban designation, a limitation to keep in mind.

Private Vehicle Ownership and Alternative Modes Rural households depend more on private vehicles than do urban counterparts. In 1972, 96 percent of the nonmetropolitan households with incomes over $5,000 owned at least one automobile or light truck; the comparable urban figure was 85 percent. Nonmetropolitan households also tended to own more than one vehicle.[3]

Rural households rarely use modes other than private motor vehicles for work trips and, given the superior modal characteristics of private vehicles, the same pattern likely holds true for other trips. Only 1 percent of rural farm and nonfarm workers used public transportation, while 85-90 percent in each group either drove or rode in cars for home-to-work trips. In comparison, 12 percent of urban workers used public transportation and 80 percent traveled to work in cars.[4] Rural households would find themselves hard-pressed to substitute among modes in the short term.

Trips and Vehicle-miles

One-way automobile trip lengths for all trip purposes generally average longer in unincorporated areas, incorporated places of under 5,000 people, and incorporated places of 1 million or more population. There, trip lengths average approximately 10, 10½, and 11½ miles, respectively.[5] Intermediate-sized incorporated places with 5,000 to 1 million persons have shorter average trip lengths. Farmers and farm managers have the longest average trip lengths for family business trips, over 11 miles, more thnan double the length for other occupational groups.[6]

Persons from households in unincorporated areas make about 1,600 trips a year on the average. This total is almost 15 percent more than the national average of 1,400 trips and over twice the number made by household

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[1] Rupprecht, Erhardt O., Jr. "Impacts of Higher Gasoline Prices on Rural Households." Paper presented at annual meeting of Amer. Agr. Econ. Assoc., Columbus, Ohio, August 1975. "The Gas Price Hike: New Dilemma for Country Folks." *The Farm Index.* Vol. XIV, No. 9, September 1975.

[2] Edwards, Clark. "Exchangeable Coupon Gas Rationing," *Agr. Econ. Res.*, Vol. 26, No. 3, July 1974, p. 56.

[3] U.S. Bureau of the Census. *Current Population Reports, Consumer Buying Indicators, Household Ownership of Cars and Light Trucks: July 1972.* Series P-65, No. 44, U.S. Govt. Print. Off., Wash., D.C., February 1973, pp. 11-12.

[4] U.S. Bureau of the Census. *Census of Population*, 1970: U.S. Summary PC(1)C1, table 87.

[5] U.S. Department of Transportation. *Nationwide Personal Transportation Study: Purposes of Automobile Trips and Travel.* Rpt. 10, U.S. Govt. Print. Off., Wash., D.C., May 1974, p. 16.

[6] *Ibid*, p. 71.

occupants in the largest incorporated places. Household residents in unincorporated areas travel 15,400 vehicle-miles a year, averaging 42 vehicle-miles a day—more than households in any other residential grouping.[7]

Households in the smallest incorporated places have particularly interesting trip characteristics. They make next to the lowest average number of annual trips, about 1,050. Perhaps they meet some of their trip needs by walking. However, they have the fourth highest number of vehicle-miles because their average trip length is rather long. The highest number of annual trips, 1,900, and the second highest vehicle-mile figure, 14,700, were logged for households in incorporated places with 5,000-24,999 people.[8]

Household members in the largest incorporated places make the fewest automobile trips annually, 700. They also log the lowest annual vehicle-miles of all residential groupings at 8,200. As the population of the city increased, vehicle-miles of travel went down, perhaps partially explained by increased use and availability of public transportation. Over 50 percent of the vehicle-miles of households in the largest incorporated places were logged on work trips; in contrast, for residents of other jurisdictions, such trips accounted for only about 40 percent of the annual vehicle-miles.[9]

People in rural areas usually lack alternative transport modes.[10] They use their automobiles more, as shown by the trip and vehicle-mile figures currently available. In addition, a greater proportion of the miles are incurred for other than work trips, especially for family business trips such as shopping and medical care.

From the data on vehicle-mileage, some preliminary analysis can be made of the differential impact of higher fuel prices on urban and rural households. In a congested urban environment, motor vehicles have poorer gas mileage than on relatively open roads. For example, urban autos require approximately 8,100 British thermal units (Btu's) per passenger mile, more than all other modes except airplanes. Going between cities, however, cars are more than twice as efficient as they are within the city, requiring 3,400 (Btu's) per passenger mile.[11]

Using the above data on vehicle mileage and given that urban fuel consumption was 11.5 miles per gallon (mpg) while rural consumption was 15.5 mpg in 1974, we can estimate the gallons of gasoline consumed.[12] A household in an unincorporated area would use about 1,000 gallons while one in a larger incorporated place would use about 700 gallons. In these polar cases, the rural household consumes about 40 percent more gasoline but its members travel almost twice as many vehicle-miles as do those in the urban household.

Thus, a gasoline tax or price hike of 25 cents a gallon would increase the annual cost of transportation by $250 for the household in the unincorporated area. Householders in the largest urban area would pay only $175 more, assuming no change in travel habits. However, since the urban households probably have more opportunities to reduce travel distances or switch to alternative modes, welfare impacts would potentially be less than $175 for them. Even if a portion of the gasoline tax for a stipulated number of gallons was refunded through a tax rebate program, inequities could occur because of the welfare aspects of the substitution effect.

A goal of national energy policy could be to allocate the burden of conservation among the urban and rural population to minimize any excessive dislocation on either group. In this event, energy policies should account for rural-urban variations in transportation characteristics and vehicle efficiency. However, more specific data by income classes and travel requirements could help assure that policies are both efficient and equitable.

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LAND USE ADJUSTMENTS THROUGH COMPETITIVE BIDDING

For almost four decades, American agriculture was characterized by supply in excess of amounts that would clear the market at prices acceptable to farmers. Agricultural programs were developed which offered price supports and limited production either by restricting the acreage of certain crops or by removing land from production.

The programs proved relatively effective in meeting their objective. But they were very expensive to operate. The Federal Government spent billions of dollars in farmer payments and storage costs for the surplus commodities. All farmers were paid at the same rate, regardless of their production costs; and the rate was usually high enough to keep inefficient producers in operation. Thus, for the efficient producer, a portion of the payment represented pure profit or an income transfer above the amount actually required to continue production. Programs from the late fifties on were generally designed to remove land from production. Thus, great incentive existed to increase production per acre.

In the early seventies, the situation changed drastically. Poor weather conditions caused the Soviet Union to purchase large quantities of U.S. grain, as did several other countries. These purchases depleted U.S. surplus stocks. Food prices soared, and poor weather conditions

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[7] U.S. Department of Transportation, Federal Highway Administration. *Nationwide Personal Transportation Study: Household Travel in the United States.* Rpt. 7, U.S. Govt. Print. Off., Wash., D.C., December 1972, pp. 16-17.

[8] *Ibid.*

[9] *Ibid.*

[10] U.S. Senate, Committee on Agriculture and Forestry. *Prelude to Legislation to Solve the Growing Crisis in Rural Transportation: Part I, Transportation in Rural America.* U.S. Govt. Print. Off., Wash., D.C., Feb. 10, 1975, pp. 173-191.

[11] Hirst, Eric. *Energy Intensiveness of Passenger and Freight Transport Modes 1950-1970.* Oak Ridge National Lab., ORNL-NSF-EP-44, Oak Ridge, Tenn., April 1973, p. 32.

[12] Healy, Timothy J. *The Energy Use of Public Transit Systems.* Univ. Calif., Santa Clara, Calif., 1974, p. 41.

prevented stocks from being rebuilt. Also, there is much concern that population growth will soon cause food demand to outstrip U.S. ability to produce food sufficient to meet the needs of other countries. Thus, many people now think programs are needed to induce, rather than limit, agricultural production.

A Competitive Bid System

As a policy administration tool, a competitive bid system could be used to either limit or stimulate production at lower cost to the Government than with other approaches. In such a system, each farmer would specify the price at which he or she would take land out of production if needed.

This sytem can incorporate features which provide consideration of any number of factors before the final selection of bids is made. Development of these features would require coordination of several Agencies' research and specification of data on compatible terms.

In theory, a producer should be indifferent to choices if the returns are equal. Thus, producers should be willing to adjust cropland use if the compensation for adjustment equals the net profit they would have made from production without the adjustment. A producer's decision would be made based on expected net returns: expected revenue (normal yields times expected price) minus the expected variable cost of production (normal inputs times expected input prices).

A competitive bid system would allow farmers to specify the compensation rate they require to make a specified land use adjustment. The rate could be different for each producer. No income transfer would occur because no farmer would be paid more than was required to induce performance.

Evaluation of a Pilot Bid System

The competitive bid system concept has been discussed for several years. Research has indicated that, theoretically, the system is more efficient than other methods for land retirement.[1] A pilot program was tested in four States in the late fifties in which only whole farm units could be offered. Farmers were asked to submit a bid per acre that they would accept for participation in preference to a compensation level set by the Government. They submitted bids through the county Agricultural Stabilization and Conservation Service (ASCS) office, which sent bids to the State offices. The bid summaries were sent to the Soil Bank Division of ASCS in Washington for final approval.

J. Carrol Bottom and his associates analyzed some characteristics of these bids.[2] They also surveyed the participants to find out more characteristics. In the pilot program, the farms' bids per acre increased as the crop value per acre increased. However, as a percentage of crop value, bids declined as the crop value per acre rose. Of farmowners in Nebraska who were questioned about the program, 63 percent favored it while 29 percent did not. Persons other than farmers in the area reacted less favorably; 60 percent expected the farm families to move from the area and seek employment elsewhere, thus hurting the local economy.

The competitive bid program was not set up. Though no reasons were specified publicly, two were commonly advanced. First, compiling the bids would have been difficult. Second, some persons believed that the bidding system did not allow for a fair evaluation of the land. That is, the land would be retired based on the bid and not on an independent evaluation of the land's productivity.

If these were the actual reasons, computer technology can be used to overcome them. A computerized system can be designed that will adjust the bid based on productivity or any other desirable adjustment criterion, array the bids nationwide, and accept each based on a specified acceptance criterion. These steps can be completed rapidly and efficiently so that within a few weeks after bidding has closed, the bids could be analyzed and the successful bidders notified.

Operation of a Competitive Bid System

The basic premises of a bid system are these:

- A policy proposal can be specified in detail with definite adjustment objectives and constraints
- Producers, after evaluating performance requirements, can make a bid indicating the payment they require to comply
- After producer bids are received, they can be evaluated based on a prescribed adjustment criteria.

The policy proposal could be used to induce production or change production practices as well as reduce output. The program objective could be stated in terms of the number of acres to be adjusted—either through retirement or use in production. Total cost of the program could also be specified as a goal. The basis for operating the system would be the same for any objective. To reduce production, one would bid to take land out of production. To induce production, one would bid to change output, from the farmer's viewpoint, from a more profitable to a less profitable alternative. For instance, payments could be made for converting pasture land to cropland, cropland to pasture, conventional tillage to a specified alternative, one crop to another, or to use of specific crop rotations instead of certain fertilizer and pesticide applications.

The producer would determine a bid based on an evaluation of the program alternatives compared with all other enterprises on the farm plus an assessment of the risk involved in program participation. Producers would probably evaluate cost, returns, risk, labor requirements, and cash flow of the adjustment as they would do for

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[1] Carr, A. Barry and Luther G. Tweeten. *Comparative Efficiency of Selected Voluntary Acreage Control Programs in the Use of Government Funds*, Okla. State Univ. Agr. Expt. Sta. Rpt. P-696, June 1974. The author of this review has also made a more comprehensive study of this topic: "Land Use Adjustment Using Competitive Bidding," U.S. Dept. Agr., Econ. Res. Serv., Commod. Econ. Div. working paper, February 1976.

[2] Bottom, J. Carrol, John O. Dunbar, Richard L. Kohls, Donald L. Vogelsang, Gene McMurtry, and Sidney E. Morgan. *Land Retirement and Farm Policy*, Purdue Univ. Agr. Expt. Sta. Res. Bul. 704, September 1961.

any other enterprise. They would determine the value forgone by meeting the performance requirements of the adjustment program.

Following these evaluations, the producer would develop a gaming strategy for the bid to be sumitted. He or she would want it low enough to have reasonable assurance of acceptance but high enough not to feel discriminated against if other higher bids are also accepted. Thus, a producer's final bid would incorporate the income calculation of expected returns over variable costs but it would also include other factors and considerations.

Bid adjustment criteria could be varied. Major criticisms of past programs have been their costs and their inadequate consideration of intangible factors. Within a bid system, different combinations of criteria can be used to evaluate bids. For instance, bids could be evaluated on a cost per acre basis. The bid with the lowest per acre cost would be accepted first regardless of the land's location. However, concern might exist about the overall economic effect on a community, on conservation, on resource use, or other factors. In such cases, an index of the effect of these factors could be used to increase or decrease the relative value of each bid before the final selection was made.

A bid system would increase the possibility of meeting the specified objectives of the program. Specified Government cost, acres of adjustment, or quantity of production adjusted could be controlled by the level of bid acceptance.

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U. S. GOVERNMENT PRINTING OFFICE : 1976 O - 209-040

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The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget, through February 28, 1980.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. $1 a single copy, $3.85 a year domestic, $4.85 foreign.