REGIONAL RESOURCE USE AND COMMODITY SUPPLY RESPONSE

By Richard M. Adams and Robert B. McKusick*

INTRODUCTION

Methodology for regional economic projections used in comprehensive planning and evaluation of water and related land resource use has been changing during the last 10 to 15 years. The changes have been occurring for several reasons:

- As a response to the economic, land, and water use information needs of the Water Resources Council (*33, 34*);[1]
- As a result of the National Water Commission study suggesting higher levies to resource users and beneficiaries (*15, 16*);
- In answer to questions regarding the consistent measurement of the value of goods and services to consumers and producers raised at the National Water Conference (*35*);
- As a result of a general concern for improved comprehensive agricultural forecasts and projections and more economic flexibility in water and land use policy and planning.

Abstract: The feasibility of quadratic programming as a means of integrating agricultural price-quantity relationships and regional resource availability is demonstrated for a California test case. Estimates are developed for producer's and consumer's surplus, values of vegetables and field crop production, and resource use considering alternative levels of commodity demand, functional price-quantity relationships, normalized prices, and OBERS production projections. The results of the study have implications for resource policy analysis, shortrun agricultural price forecast, resource situation and outlook work, commodity and resource projections, and an expanded role for regional river basin studies. Keywords: Quadratic programming, producer and consumer surplus, forecasts, projections, and resource planning, evaluation and policy.

The need exists for procedures which can be implemented at the regional level to develop: (1) a nationally consistent set of land (soil groups), water, production, and crop acreage projections for agriculture which can be used in river basin or regional studies; (2) a consistent set of prices to value alternative levels of production "with" and "without" program and projects, to determine national economic development benefits and costs;[2] and (3) intermediate projections (and methodology) based on shortrun cycles and longrun trends.[3]

The Economic Research Service (ERS) has the major responsibility for developing agricultural price, production, and resource use projections within USDA. Currently, applied methodology is lacking that ties commodity prices and quantities directly to regional resource use. In general, the river basin regional models of the Natural Resource Economics Division in ERS have traditionally been linear programming models, with commodity prices held constant, while "demand" restraints are imposed independent of prices. Prices and quantities tend to be developed exogenously, independent of the regional resource base.[4] Such models have been used to generate longrun projections (10-45 years) of land use and resource allocation.

Generally, national shortrun agricultural price-forecasting models which emphasize the interaction of prices and quantities ignore any interaction with the regional resource base and they do not consider regional comparative production advantages for crops. There is a need to incorporate these shortrun price-forecasting equations into regional programming models to endogenously determine regional production levels. Such methodology could enhance intermediate projections (2-5 years) through the expanded use of river basin regional programming models and improve regional shortrun forecasts of commodity prices and quantities and of resource use.

*Assistant Professor, Agricultural Economics, University of Wyoming, Laramie; Program Leader, Natural Resource Economics Division, Economic Research Service, Washington, D.C.

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

[2] For a discussion of the current multiple-objective planning and evaluation procedures, which involve the two objectives and four accounts used by Federal agencies, see (*14, 24, 27, 32-34*).

[3] This problem was recognized in a recent survey article in *Agricultural Economics Research* by Boutwell, and others, which pointed out that "longrun projections models generally fail to pick up shortrun variations just as shortrun forecasting models usually do not pick up longrun trends" (*7*, p. 41).

[4] In a strict sense, quantity is endogenously determined, but within predetermined bounds. While the optimum quantity produced in the linear programming model framework does not always equal the specified quantity restraint (because of other market and resource restraints), most market restraints are usually reached.

The output of this integrated effort (commodity price, quantity, and resource base) could be a valuable input into resource situation and outlook reports and the formulation and analysis of resource policy.

OBJECTIVES

This article demonstrates the feasibility of a quadratic programming model with the objective function specified to maximize producer's and consumer's surplus—as a means of integrating price-quantity relationships and intermediate-run regional resource availability at the State level. A set of results is compared for a quadratic programming model for California,[5] first incorporating price-forecasting equations for vegetables and field crops, and then inputing the normalized price series (*34*)[6] and OBERS (*29*)[7] production constraints for field crops, under alternative "demand" situations for 1980. The specific objectives are to:

- Compare the value of the objective function and the value of production for California field crops and vegetables under moderate and high levels of demand (price projections) and OBERS production levels.
- Compare resource use under the above conditions; and
- Provide insights into the feasibility of using the more general equilibrium framework provided by quadratic programming (which incorporates demand curves in the objective function) in resource evaluation and planning, compared with using OBERS quantity projections and normalized price series.

THE MODEL

The mathematical model is similar to those developed by Duloy and Norton (*8*), Hazell and Scandizzo (*9*), and Simmons and Pomerada (*18*). However, the study model uses a quadratic solution procedure similar to that suggested by Takayama and Judge (*19*).

The most notable feature of these models is that they include product demand relationships through the use of price-forecasting equations. The fact that prices are an endogenous variable and the nature of the maximand makes these models well suited to use in agricultural planning. The maximand of the quadratic programming problem may be equated to the area under the demand curves above supply costs at the relevant quantity levels (that is, the Marshallian concept of economic surplus). This feature is particularly meaningful from a policy standpoint in that aggregate distributional effects may be determined (see *8*).

The study model contains a quadratic objective function and a convex linear constraint set. Specifically, the objective function takes the form:

$$\text{Max } \pi = q' \, (q + .5\text{D}q) - c' \, (q)^{8} \qquad (1)$$

where π equals the sum of producer's and consumer's surplus; q equals a vector of aggregate activity levels in quantity units (for example, 100 cwt, or 1,000 tons); and a and D are elements of the linear demand structure ($\text{P} = a + \text{D}q$) where:

a = vector of intercept terms;
D = negative diagonal matrix of slope coefficients; and
c = vector of activity variable cost levels

As discussed by Duloy and Norton (*8*), maximizing the objective function is analogous to maximizing the sum of consumer's and producer's surplus; that is, a perfectly competitive solution in which price equals marginal cost. Disaggregation of the objective function into consumer's and producer's surpluses may be used to measure welfare distribution quantitatively under different policy parameters. Such a disaggregation, under varying assumptions about price-quantity relationships for the commodities studied is discussed in a later section.

The model objective function is bounded by a convex constraint set of the form:

$$\text{A}q \leqslant b \qquad (2)$$

where A is an M x N matrix of production coefficients; and b is an M x 1 vector of resource availability.

To simulate a linear programming (LP) outcome (horizontal demand curves or constant output prices) for certain commodities, the negative regional D matrix

[5] A detailed discussion of this model, as well as a set of analyses of alternative energy input prices and quantities, appears in (*1*) and (*2*).

[6] "Current normarlized prices" are the price standards used by Federal agencies in evaluating agricultural effects of alternative development and management plans for water and related land resources.

[7] Currently, agricultural production projections used by Federal agencies for water and related land resource planning are the OBERS series developed jointly by the Economic Research Service and the former Office of Business Economics (now Bureau of Economic Analysis), U.S. Department of Commerce.

[8] The scalar value (.5) in the objective function ensures a perfectly competitive solution (intersection of supply and demand, or P = MC) rather than the monopolistic solution (MR = MC). That is, the first-order conditions (for equation 1) result in the perfectly competitive equilibrium:

$$\text{P} = a + \text{D}q = c' \, (q)' = \text{MC}.$$

Without the .5 element, the first-order conditions result in the monopolistic situation: $a + 2\text{D}q = c'_. (q)' = \text{MC}$, where the left-hand term ($a + 2\text{D}q$) is marginal revenue (*8*).

elements (slope coefficients) corresponding to the field crop set were adjusted to approximate a horizontal ("perfectly elastic") slope. This approximation (rather than a slope of exactly zero) was necessary to facilitate the quadratic solution procedure; that is, the diagonal elements of the D matrix must be nonzero. This adjustment, together with adjustment of the field crop intercept terms to normalized price levels (while maintaining downward sloping demand relationships for vegetables), resulted in the set of objective function demand relationships used to approximate the LP outcome.

Algebraically, equation (1) takes the following heuristic form for field crops under the normalized price-OBERS projections.

$$\text{Max } \pi = a'q - c'q \tag{3}$$

Vegetable demand slopes and intercepts remain at original values (as estimated or derived from secondary sources), except for intercept modifications under alternative demand assumptions. OBERS production data were not available for vegetables.

Three alternative models are analyzed:

- model I - the basic quadratic form, with price-forecasting equations for both vegetables and field crops;
- model II - a quadratic form with field crops set at approximately zero slope and intercepts at normalized price levels; and
- model III - the same form as model II except that OBERS production levels are added as right-hand-side constraints.

The results presented later from these three forms show the usefulness of quadratic programming as compared to normalized prices and OBERS projections in a linear objective function.

Because the quadratic programming model and the two variants are exercises in normative economics, any claims as to their predictive accuracy would be misplaced. The model results are conditional upon the reasonableness of the price forecasting equations. More flexibility may be incorporated into projections of resource use through the use of commodity price-quantity relationships and into the forecast of regional prices through the use of regional resource programming models.

Commodity Demand

The quadratic programming methodology used in this study required the specification of linear demand functions of the form:

$$p = a + Dq \tag{4}$$

where p is an $n \times 1$ vector of prices, a is an $n \times 1$ vector of constants, D is a negative diagonal matrix of price-quantity slope coefficients, and q is an $n \times 1$ vector of quantities. These relationships are specified at the farm level. The diagonal D matrix means zero cross-effects for competing commodities at the farm level.

The general specification of the farm level price-forecasting equations includes variables for California production, production in other regions, and other variables, where:[9]

$$Pc_i = f\,(Qc_i,\ Qo_i, S_i, Y)$$

and

Pc_i = season average price received by farmers in California for commodity i
Qc_i = production in California
Qo_i = "other" U.S. production
S_i = existing U.S. stocks
Y = U.S. aggregate disposable personal income
and
f is a linear functional form.

Seasonal and annual price-forecasting estimates of 37 commodities (including seasonal subsets of the 18 model commodities) were required, 33 of which were obtained with the above price-forecasting equation.[10] Price-quantity relationships for the remaining four commodities where simultaneity was suspected were derived from more detailed econometric studies.[11] The employed price-forecasting equation slope and intercept values are published in (*1*) and (*2*).

OBERS Projections

Currently, the OBERS series represents the agricultural production projections used in water and related land resource planning at the Federal level. The projections of regional economic activity made for 190 water resource subareas include national production "requirements" to meet specific consumption, population, and import-export assumptions. Traditionally the regional production shares have been determined by historical trends.

These economic projections and supporting data base serve two purposes:

> First, they are an essential input for estimating the demands for water and related land. Second, they constitute a framework for estimating the economic effects of specified water constraints

[9] Econometrically, it appears reasonable to treat some annual crop production as predetermined within the crop year. Thus, quantity can be used as an independent variable in least squares price-forecasting equations to obtain unbiased statistical estimates.

[10] Independent variables other than "production in California" were evaluated at mean levels and added to the intercept terms in the objective function specification. The result was general price-forecasting equations of the form $Pc_i = a_i + d_iQc_i$. The addition of "other" explanatory variables to the intercept term is consistent with the model's emphasis on price prediction.

[11] The four commodities and the sources from which they were derived are: cotton (*6*), processing tomatoes (*12*), sugar beets (*4*), and safflower (*10*).

and of alternative programs for developing and managing the Nation's land and water resource (*30*, p. 5).

The conceptual basis underlying OBERS U.S. agricultural projections is supposed to be that of a general price equilibrium. According to the Water Resources Council, projected commodity per capita consumption is to be tied to a set of price-quantity relationships, in which national production projections reflect specified relationships between consumption and income, potentials for product substitution, and the price elasticity of product demand.

In the future, the OBERS production projection model will depend on these factors: baseline per capita consumption projections, price elasticities for all commodities, cross elasticities where appropriate, exports, enterprise budgets, and national interregional competition (7, p. 49). Such a model will generate regional production levels to be used as inputs in constrained regional optimizing models. But, even with these changes, the proposed model fails to recognize that regional demand influences price and regional supply is responsive to price changes. For resource planning and evaluation, consistency between regional production levels and national price levels will not be realized. That is to say, for resource planning and evaluation in the "principles" and "standards" framework of the Water Resources Council, the distinction between regional and national economic benefits and costs will still be unclear (*33, 34*).

Normalized Prices

"Current normalized prices" are the price standards used in evaluating agricultural effects of alternative development and management plans for water and related land resources. The current procedure uses an Almon polynominal distributed-lag method based on a 5-year period (*3, 17*). The resulting prices for planning purposes have been published by the Water Resources Council (*36*).

The current procedure, as with previous normalized price procedures (*25*) has not been integrated with OBERS production levels (or optimum production levels obtained from regional LP models) to determine the value of goods and services from a plan or project (for national economic development objective and account entries). It is questionable whether these quantities (production) and prices are in "equilibrium".

The study analyses for 1980 are based on the 1980 OBERS Series E production projections and normalized prices using the polynomical distributed-lag procedure for 1970-74 (table 1). New data have since been developed based on OBERS Series E -High Export, and normalized prices using 1971-75 data. These new data for California field crops show a slight decrease in prices (because of lower prices in 1975 and the weighting procedure of the distributed-lag approach). Projected production requirements for California field crops remained basically constant in 1980 except for increases in corn and grain sorghum.

DATA

Production Regions, Cropping Activities, and Resource Constraints

California is a major agricultural production region, producing a diverse, high-value, crop mix. Favorable climatic, soil, and water conditions have enabled the region to assume national dominance in the production of fruits and nuts, vegetables, and specific field crops. Changes in California production of these crops can significantly affect regional and national prices.

Table 1.—Normalized prices and 1980 OBERS production, California

Crop	Units	"Normalized" price (dollars per unit)[1]	1980 OBERS Series E production, California
			Thousands
Barley	Bushel	2.70	75,161
Beans, dry	Cwt	24.60	3,101
Corn, grain	Bushel	3.39	[2]23,987
Rice	Cwt	9.13	25,531
Sorghum, grain	Bushel	3.10	36,599
Sugar beets	Ton	32.62	7,839
Wheat	Bushel	3.16	[2]31,019

[1] Normalized price series is that obtained using the polynomial distributed lag procedure for 1970-74. [2] Corn and wheat data were not presented for California in the OBERS publication. Based on 1972-74 average production.

Source: ERS, Regional Projections Analytical System, preliminary prices and projections; and U.S. Water Resources Council, *1972 OBERS Projections Regional Economic Activity in the U.S., Series E Population Supplement* p. 59, table 2, May 1975.

Eighteen irrigated annual crops are included in the analysis: barley, beans (dry), broccoli, cantaloupes, carrots, cauliflower, celery, corn, cotton, grain sorghum, lettuce, onions, potatoes, rice, safflower, sugar beets, tomatoes (fresh and processed), and wheat. Perennials were not treated due to their complex time horizons. To account for seasonality of production (important for vegetables) and the diversity of California climatic zones, 14 production subregions and seasonal and annual cropping activities were specified.

Fixed resources (right-hand-side restraints) related to onfarm usage include land (of two quality types), irrigation water (ground and surface), fuel (gasoline and diesel), and nitrogen fertilizer. Institutional restraints, in the form of maximum processing capacities for processing tomatoes and sugar beets, were imposed. Market restraints in the form of OBERS production levels and normalized prices were imposed on models II and III.

EMPIRICAL RESULTS

The empirical results include the values of producer and consumer surplus, production levels and acreage for vegetables and field crops, and resource usage for California. Solutions for the three models[12] were obtained for both a moderate and high set of demand assumptions for 1980, resulting in a total of six model solutions.[13] The moderate and high demand assumptions apply only to the price-forecasting equations. The OBERS production levels and normalized prices were held constant.

Objective Function

The maximand of each model is analogous to maximizing the area under the crop demand curves less supply cost. Alternatively, this procedure may be compared with maximizing the sum of consumer's and producer's surplus. The slope and intercept of each price-forecasting equation affects the total value of the objective function as well as the respective components. The "flatter" or more elastic demand relationships may be expected to yield higher levels of producer's relative to consumer's surplus than more steeply sloped relationships. Therefore,the use of normalized prices (with "flat slopes") or perfectly elastic demand curves for field crops, with and without OBERS production restraints, will by definition tend to result in distributional and absolute changes in the objective function and resource use. The objective function values for each model, under respective demand assumptions, are presented in table 2.

The total value of the objective function under moderate demand, when compared with the quadratic solution (I), increased under both normalized-price, perfectly elastic demand (II), and normalized price-OBERS constraint models (III). Such an observation is consistent with the high level of field crop prices portrayed in the distributed-lag series, and the non-depressing effect on prices of horizontal slopes for these commodities. Thus, the use of normalized prices, even with OBERS constraints, tends to result in slightly higher objective function values than the base quadratic solution, under "moderate" demand adjustment. Model I shows the objective function to consist of about 65 percent producer's surplus and 35 percent consumer's surplus. Under the perfectly elastic (except vegetables) model II the percentages are about 90 and 10, compared with 78 and 22 for the constrained model III.

Under a high demand assumption (reflecting the high commodity price levels of 1973-74), the quadratic base solution (I) displays a higher value than the other models, partly because of a heavy mix of vegetable crops in the solution and field crop price intercepts (reflecting 1973-74 price levels) that exceeded the normalized price. The mix between producer's and consumer's surplus for each model output for which the measure is meaningful is roughly two-thirds and one-third. Consumer's surplus is greater than zero in models II and III only because of the downward-sloping demand relationship for vegetables.

Value of Production

The value of production (index numbers) of vegetables, field crops, and total production appears in table 3 (for moderate demand) and table 4 (for high demand).

Field crop production increased significantly under the conditions of model II, compared with the quadratic solution (model I), a result which is consistent with the nondepressing effect on prices of the horizontal slopes for field crops. This increase comes at the expense of vegetable production, which maintains the downward sloping demand relationships. When the OBERS production restraints are added to the horizontal demand curves for field crops (model III), field crop production decreases relative to that in model II, because of the constraining level of the OBERS projections.

With moderate demand adjustment for vegetables

[12] As noted, the comparative analysis across the three models discussed is not intended to provide evidence as to how well a normative model can predict. However, for comparative purposes, the quadratic model was selected as the logical base, given that models II and III represent progressively constrained versions of the quadratic. Additionally, the quadratic model has been fairly accurate in depicting selected field and vegetable crop production patterns for California in previous research (*1*).

[13] Variation in farm level price would be expected to affect production responses, for specific commodities and in the aggregate. To test sensitivity of the model solution to overall changes in commodity price levels, two demand assumptions (moderate and high) were incorporated. The moderate assumption involves an overall increase in prices (intercepts) of 50 percent above levels in 1972, while the high assumption reflects intercept adjustments for the price-forecasting equations corresponding to highest price levels observed in 1973-74 for each commodity.

Table 2.—Value of the objective function, producer's surplus, and consumer's surplus under alternative demand and model assumptions for 1980

Demand assumption and model	Objective function value	Producer's surplus[1]	Consumer's surplus[2]
	Thousand dollars		
Moderate Demand:[3]			
I. Base model, quadratic solution[5]	1,069.865	688.291 (64.3)	381.575 (35.7)
II. Perfectly elastic demand model, normalized field crop prices and no OBERS production restraints	1,304.108	1,163.196 (89.2)	140.912 (10.8)
III. Constrained, perfectly elastic demand model, normalized field crop price and OBERS production restraints	1,100.695	849.312 (77.2)	251.384 (22.8)
High demand:[4]			
I. Base model, quadratic solution[5]	1,789.705	1,183.981 (66.2)	605.724 (33.8)
II. Perfectly elastic demand model, normalized field crop prices and no OBERS production restraints	1,642.438	1,268.342 (77.2)	374.097 (22.8)
III. Constrained, perfectly elastic demand model, normalized field crop price and OBERS production restraints	1,536.866	1,013.677 (66.0)	523.189 (34.0)

Note: All models maintain the conventional downward-sloping price-forecasting equations for vegetables. Thus, there will be consumer's surplus values for models II and III, due primarily to vegetable production. Values in parenthesis are percentages.

[1] Producer's surplus, as used here, represents returns to land and management. [2] The model maximands are analogous to maximizing the sum of producer's and consumer's surplus; that is, area under the demand curve and above supply costs. Hence, the difference between the objective function and producer's surplus may be equated to consumer's surplus. [3] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972. [4] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-74, for each commodity. [5] Quadratic model incorporates price-forecasting equation for both vegetables and field crops, with no normalized price or OBERS considerations.

Table 3.—Index numbers of value of production for vegetables and field crops under models I, II, and III, moderate demand[1]

Production	Moderate demand adjustment for vegetables[2]					
	I. Base model—quadratic solution		II. Perfectly elastic demand model-normalized field crop prices and no OBERS production restraints		III. Constrained perfectly elastic demand model—normalized field crop price and OBERS production restraints	
	Index number	*Percentage change*	*Index number*	*Percentage change*	*Index number*	*Percentage change*
Vegetables	100	--	62	–38	84	–16
Field crops	100	--	209	+109	123	+23
Total	100	--	112	+12	97	–3

[1] Index numbers represent a Laspeyres price index developed using commodity prices from the models solutions as weights.
[2] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972.

Table 4.—Index numbers of value of production for vegetables and field crops under models I, II, and III, high demand[1]

Production	High demand adjustment for vegetables[2]					
	I. Base model—quadratic solution		II. Perfectly elastic demand model-normalized field crop prices and no OBERS production restraints		III. Constrained perfectly elastic demand model—normalized field crop price and OBERS production restraints	
	Index number	*Percentage change*	*Index number*	*Percentage change*	*Index number*	*Percentage change*
Vegetables	100	--	81	–19	89	–11
Field crops	100	--	129	+29	82	–18
Total	100	--	95	–5	87	–13

[1] Index numbers represent a Laspeyres price index using commodity prices from the models solutions as weights. [2] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-75, for each commodity.

(intercept term adjusted), field crop production exceeded that in the quadratic solution (I) (which is also moderate demand for both field crops and vegetables) under the assumptions of models II and III, while vegetable production decreased. In total, the OBERS constrained model under moderate demand revealed production levels somewhat similar to those in the base quadratic model. This similarity indicates that when adjustments in demand are gradual or moderate, normalized prices and OBERS constraints in an LP framework yield results somewhat consistent to those in the quadratic solution. There are disparities between vegetables and field crops, which indicate that OBERS production levels and normalized prices for field crops exceeded the estimated "equilibrium" price level relative to the quadratic solution.

Under a high demand adjustment for vegetables (and for all crops in the quadratic solution), the disparity between the quadratic solution (I) and the model II solution is reduced due to the increased comparative advantage of vegetables (high versus moderate demand). The value of the OBERS constrained solution (model III) for both field crops and vegetables was less than the value of the quadratic solution. The decrease in field crop production is expected due to the enhanced comparative advantage of vegetables. One would intuitively expect a relative increase in vegetable production under model III. However, because of regional production increases for selected field crops, particularly sugar beet production within the coastal valleys, resources are not available to expand vegetable production.

The results of the high demand assumption indicate that the LP framework, relative to the quadratic solution, lacks the flexibility to adjust to demand "shocks" such as the large price increase observed in 1973-74. Because of this inflexibility of prices and the fixed OBERS production restraints, the LP framework (compared with the quadratic) apparently has limitations for short and intermediate-run commodity supply response and resource use policy analysis and forecast.

Resource Use

Resource use generated from models I, II, and III appear in table 5. As a group, field crops are more land extensive than vegetables, their per acre water and fuel requirements are less, and their per acre fertilizer requirement is lower. Thus, any model which tends to favor production of one crop group over the other will result in differential rates of resource use. As a result, resource use depends on both total production and the commodity mix of production.

The demands placed on the land resource by the normalized price and OBERS models are consistent with the results presented in the production tables. The higher level of field crop production vis-a-vis vegetables is reflected in greater use of the land resource, compared with the base model. This is consistent with the more land extensive nature of field crops. Water demands are reduced in the normalized price-OBERS models (from base values) again consistent with the expanded field crop production and the generally lower water requirements of such crops. Fuel use tends to reflect the larger land area involved in the nonbase models.

Fertilizer usage displays no particular pattern in the various models, except for high demand model II. This behavior results from the highly differential rates of use among specific crops and the aggregate nature in which production is reported. For example, model II features an expanded production of dry beans, with a low per acre requirement for nitrogen fertilizer. This fact might not be obvious in terms of acreage if production of another field crop were reduced proportionately, but it

Table 5.—Aggregate resource use and index number for moderate and high demand levels, models I, II, and III

Resource	Unit	Moderate demand[1]			High demand[2]		
		I	II	III	I	II	III
		Million					
Land	Acres	2.142	2.480	2.229	2.178	2.506	2.295
Water	Acre feet	7.185	5.971	5.876	6.847	6.001	5.950
Fuel	Gallons	57.616	63.541	57.365	62.558	58.745	51.905
Fertilizer	Pounds	295.252	291.093	316.734	317.318	[3] 250.009	343.363
Resource use[4]		100	106	100	100	103	101

[1] Moderate demand refers to a uniform increase in commodity prices (intercepts) of 50 percent from levels in 1972. [2] High demand reflects an adjustment in commodity prices corresponding to the highest observed prices for 1973-75, for each commodity. [3] Decline in nitrogen fertilizer use is the result, in part, of substantial acreage increase in dry beans, a crop which uses relatively low amounts of such fertilizer. [4] Laspeyre's price index using approximate 1976 input costs as weighting mechanism.

would show up in a decline in overall nitrogen fertilizer use.

The OBERS constrained solutions, when compared with the quadratic solution, increased land use by only 100,000 acres but decreased water use by over 1 million acre feet. This results from the major shift to field crops.

RESEARCH AND POLICY IMPLICATIONS

The paper has discussed possible improvements in intermediate-term agricultural forecasting of price, production, and resource use by merging shortrun price-forecasting, intermediate-run income projections, and longer run regional programming models in an integrated system. A basic problem with current ERS forecasting and projections models is that commodity demand does not interact with the resource base and production relationships to determine regional equilibrium commodity prices and quantities. Once regional shares are determined, there is no corrective mechanism which allows for production adjustments based on changes in profitability or comparative advantage due to changes in the commodity price structure. This inflexibility to simultaneously vary price and quantity becomes even more important when major shifts occur in demand or regional production, as shown by the wide disparity between the results of model I and the normalized price results under high demand. Projections based on trend analysis would not anticipate these shifts.

ERS regional river basin models (in general, linear programming models) develop information which is basically resource related and emphasize production relationships and commodity supply. Current and projected regional information is developed for several factors: resource suitability and availability; crop suitability by land type or homogenous production area; crop yields and water coefficients by soils or production areas; and commodity production costs based on input levels, soils, methods of irrigation, resource problems (flooding, drainage, erosion, irrigation efficiency) and other resource use such as fertilizer, pesticides, gas, diesel, and labor. A weakness of such models is the lack of good demand restraints which consider both quantity and price in the derivation of regional commodity market shares. The idea of using aggregated demand projections as constraints for land and water projections is supported by the ERS Projections Task Force (*21*). But a critical aspect of these demand restraints is whether they will be developed exogenously or endogenously in regional models.

There is a need to merge the intermediate-run regional resource availability and productivity relationships of the river basin models with aggregate demand relationships. As pointed out by the ERS Projections Task Force (*21*, p. 13):

> Extended forecasts or outlook for events two, three, and four years hence are especially important for private investment decisions and public policy and program decisions. This is the period we should be focusing most heavily on because this is the period most meaningful to the crystal ball and tenure of policy makers and the period for which we have the most policy tools to use in altering undesirable outcomes. Immediate attention should be given to development of plans and responsibilities for a program of extended outlook (forecasts) to cover the period (one to four years) not now adequately covered by our short-term outlook program or the longer term projections program.

Commodity situation and outlook work should put more emphasis on resource availability and suitability as they affect commodity supply response. For example, the influence of weather (such as drought) on water availability in the West this year, and future landownership patterns in the West have raised questions as to the supply response of selected agricultural commodities. ERS should explore the possibility of resource situation and outlook work, in particular, the suitability and availability of land and water in the intermediate run for agricultural production. ERS might also consider a resource policy analysis program area which combines resource situation and outlook work and longrun research findings.

The results obtained from the various quadratic formulations have implications for resource evaluation. By introducing demand curves directly into the regional analysis, regional output or benefits are not developed as "needs" or "requirements." As a result, the derived demand for resources becomes a function of commodity demand and not fixed production levels. Resource demand is sensitive not only to product price but also to relative resource cost relationships among gas, diesel, fertilizer, pesticides, and other inputs. If commodity price is allowed to respond to potential supply conditions in projection models, resource repayment capacities for future conservation, development, management and use may be effected. Such effects may be particularly important for water resource planning and evaluation. For example, actual water demands are substantially higher under the quadratic "base" results than for normalized price and OBERS models. Thus, the normalized price and OBERS results might understate the true demand for irrigation water in California.

As previously discussed by McKusick, Adams, and Snyder (*13*), a more flexible approach to resource planning and evaluation should recognize the interaction of production and consumption through the use of commodity demand curves. If the use of consumer's surplus as a measure of welfare is accepted, then differential impacts on producer's and consumer's welfare can be quantified by quadratic programming. Water policy makers need to consider these differential impacts. Consistency among resource agencies in setting economic criteria for water and related land resource planning and evaluation would be enhanced if national (and, in certain cases, regional) demand curves are integrated with regional commodity production, costs, resource availability and suitability, resource production relationships, and regional derived demand curves for resources.

BIBLIOGRAPHY

(1) Adams, Richard M. *A Quadratic Programming Approach to the Production of California Field and Vegetable Crops Emphasizing Land, Water, and Energy Use*. Unpubl. Ph. D. disser., Univ. Calif., Davis, 346 pp., 1975.

(2) Adams, R. M., G. A. King, and W. E. Johnston. "Effects of Energy Cost Increases and Regional Allocation Policies on Agricultural Production." *Am. J. Agr. Econ.* Vol. 59, No. 3. Aug. 1977, pp. 444-455.

(3) Almon, S. "The Distributed Lag Between Capital Appropriations and Expenditures." *Econometrica*, Vol. 33, No. 1, pp. 178-198, Jan. 1965.

(4) Bates, Thomas H., and Andrew Schmitz. *A Spatial Equilibrium Analysis of the World Sugar Economy*. Calif. Agr. Expt. Sta., Giannini Found. Monog. 23, Berkeley, Univ. Calif., 1969.

(5) Best, M. J. *A Feasible Conjugate Direction Method to Solve Linearly Constrained Optimization Problems*. Dept. Combinatorics and Optimization, Waterloo, Res. Rpt. CORR 73-12, Ontario, Canada 1973.

(6) Blakley, Leo V. *Quantitative Relationships in the Cotton Economy with Implications For Economic Policy*. Okla. St. Univ. Expt. Sta. Tech. Bul. T-95, Stillwater, May 1962.

(7) Boutwell, Wayne, Clark Edwards, Richard Haidacher, Howard Hogg, William E. Kost, J. B. Penn, J. M. Roop, and Leroy Quance. "Comprehensive Forecasting and Projection Models in the Economic Research Service." *Agr. Econ. Res.* Vol. 28, No. 2, pp. 41-51, Apr. 1976.

(8) Duloy, J. H., and R. D. Norton. "CHAC, A Programming Model of Mexican Agriculture." L. Goreux and A. Manne, eds., *Multi-Level Planning: Case Studies in Mexico*, North-Holland Publ. Co., Amsterdam, 1973.

(9) Hazell, P. B. R., and P. Scandizzo. "Competitive Demand Structures Under Risk in Agricultural Linear Programming Models." *Am. J. Agr. Econ.* Vol. 56, No. 2, pp. 235-243, 1974.

(10) Houck, James P. "A Statistical Model of the Demand for Soybeans."*J. Farm Econ.* Vol. 46, pp. 366,374, 1964.

(11) Huang, Wen-Yuan and Howard C. Hoff, "Estimating Land Use Patterns: A Separable Programming Approach." *Agr. Econ. Res.* Vol. 28, No. 1, pp. 22-23, Jan. 1976.

(12) King, G. A., E. V. Jesse, and B. C. French. *Economic Trends in the Processing Tomato Industry*. Calif. Agr. Expt. Sta. Extens. Serv. Inf. Ser. Agr. Econ. No. 73-4, Univ. Calif. 1973.

(13) McKusick, R. B., R. M. Adams, and J. H. Snyder. "The Value of Goods and Services - Implications for a Flexible National Water Policy." *Water Resour. Bul.*, June 1977.

(14) McKusick, R. B., J. M. Kress, P. G. Ashton, and W. A. Bunter. "The Development of a Plan of Study—An Interagency Approach to Multiobjective

Planning and Evaluation of Water and Land Resource Use." *Water Resour. Bul.*, Vol. 9, No. 3, pp. 467-484, June 1973.

(15) National Water Commission. *New Directions in U.S. Water Policy Summary, Conclusions and Recommendations.* U.S. Gov't. Print. Off., Wash., D.C., 197 pp., 1973.

(16) ____________. *Water Policies for the Future.* Washington, D.C., 1973.

(17) Niehaus, Robert D. "Normalized" Prices for Project Evaluation." *Agr. Econ. Res.* Vol. 28, No. 2, pp. 82-84, Apr. 1976.

(18) Simmons, R. L., and C. Pomerada, C. "Equilibrium Quantity and Timing of Mexico Vegetable Exports." *Am. J. Agr. Econ.* Vol. 57, No. 3, pp. 472-479, Aug. 1975.

(19) Takayama, T., and G. G. Judge. "Equilibrium Among Spatially Separated Markets: A Reformulation." *Econometrica*, Vol. 32, No. 4, pp. 349-365, 1964.

(20) Takayama, T., and G. G. Judge. "An Interregional Activity Analysis Model for the Agricultural Sector." *J. Farm Econ.*, Vol. 46, No. 2, pp. 349-365, 1964.

(21) U.S. Department of Agriculture. *Report of the Projections Task Force.* Econ. Res. Serv., Memorandum from Quentin West, Wash., D.C., Aug. 13, 1976.

(22) ____________. *Issue Paper on Land Use Planning and Policy.* Econ. Res. Serv., Wash., D.C., 1975.

(23) ____________. *Implementation of the USDA Procedures for Planning Water and Related Land Resources.* Soil Conserv. Service, Memorandum from Kenneth E. Grant, Wash., D.C., Feb. 6, 1975.

(24) ____________. *USDA Procedures for Planning Water and Related Land Resources*, Econ. Res. Serv., For. Serv., Soil Conserv. Serv., Wash., D.C. 1974. *Population.* Vol. 1, Wash., D.C., 1972.

(25) U.S. Water Resources Council. *Guideline 2. Agricultural Price Standards for Water and Related Land Resources Planning.* Wash., D.C., Feb. 1974.

(26) ____________. *1974 OBERS Projections.* Vol. 1, Wash., D.C., 1974.

(27) U.S. Water Resources Council. "Water and Related Land Resources - Establishment of Principles and Standards." *Fed. Regis.*, Vol. 38, No. 1974, Part III, Wash., D.C., Monday, Sept. 10, 1973.

(28) ____________. *Summary and Analysis of Public Response to the Proposed Principles and Standards for Planning Water and Related Land Resources.* Wash., D.C., 135 pp., July 1972.

(29) ____________. *1972 OBERS Projections.* Vol. 1, Wash., D.C., 1972.

(30) ____________. *1972 OBERS Projections Regional Economic Activity in the U.S. Series E.* Wash., D.C., May 1975.

(31) ____________. *1972 OBERS Projections Regional Economic Population Supplemental Agricultural Projections.* Vol. 1, 3, and 4, Wash., D.C., May 1975.

(32) ____________. *Findings and Recommendations.* Wash., D.C., 8 pp., July 1970.

(33) ____________. *Principles for Planning Water and Related Land Resources.* Wash., D.C., 25 pp., July 1970.

(34) ____________. *Standards for Planning Water and Land Resources.* Wash., D.C., 55 pp., July 1970.

(35) ____________. *National Conference on Water: Panels, Issues, Papers.* Wash., D.C., Apr. 1975.

(36) U.S. Water Resources Council. *Guidelines - Agricultural Price Standards.* Wash., D.C., 1976.

In Earlier Issues

Exploration of the possibilities of increasing industrial utilization of both the basic and the waste products of agriculture is extensive. The possibilities in increased utilization of farm products on the farm are less spectacular but they are just as significant and considerable effort is being directed toward developing them. Wherever it is feasible to substitute forage crops on acres now producing corn, cotton, or wheat, and to utilize these crops profitably through livestock, there are opportunities to combat effectively the threat of so-called surplus production. Adjustments of this kind also work in the direction of improving the national diet, conserving soil resources, and lending greater stability to farm incomes.

Neil W. Johnson
Volume I, Number 2, p. 57
April 1949
