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The Role of Irrigated Agriculture in a Changing Export Market

Gerald L. Horner
Daniel S. Putler
Susan E. Garifo

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THE ROLE OF IRRIGATED AGRICULTURE IN A CHANGING EXPORT MARKET. Gerald L. Horner, Daniel S. Putler, and Susan E. Garifo. Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C. 20250. June 1985. ERS Staff Report AGES850328.

ABSTRACT

Irrigated acreage in the United States would increase by 5.5 million acres if export demand for agricultural products increased by 90 percent, according to analytical research projections reported here. Ground water use would increase by 42 percent. This analysis of the effect of increased export demand for agriculture commodities on irrigated agriculture also projects substantial increases in ground water pumping costs for the Mountain and Northern Plains regions.

AUTHORS

Horner and Garifo are agricultural economists with the U.S. Department of Agriculture and Putler was a graduate research assistant with the University of California, Davis.

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The Role of Irrigated Agriculture in a Changing Export Market

Gerald L. Horner
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INTRODUCTION

Export demand for agricultural commodities can change substantially depending on world weather conditions, prices, incomes, exchange rates, and the political environment. Domestic production of principal export commodities is affected by the weather conditions, government commodity programs, off-farm input prices, and the amount and quality of labor and natural resources available. Knowing the effect of changes in the demand for export commodities on resource use can assist the Federal Government in short- and long-run resource planning.

This paper examines the current role of irrigation in the production of principal U.S. agricultural commodities and projects how dryland and irrigated cropping patterns could change under alternative export demand scenarios.

A spatial equilibrium mathematical programming model was used in this study which assumes perfectly competitive product and factor markets. The U.S. Mathematical Programming (USMP) model was acquired from the National Economics Division of the Economic Research Service, USDA.[1] The original model was initiated at Purdue University as a computerized model of the U.S. agricultural sector. [2] In the model, national crop and livestock commodity production was specified for 10 regions and commodity use was specified for national domestic, stock, and export market demands. Agricultural labor, crop, and pasture land were specified as price elastic factor supply activities.

The model was modified by including irrigated cropping activities and water supply functions, and by replacing the risk specification with a quadratic cost term that accounts for all unspecified production costs and returns. This modification allows the model to reproduce a base cropping pattern without the use of constraints placed on acreages. The price sensitive labor supply activity was respecified with average regional wage rates.

The original specification of the USMP did not separate dryland and irrigated crop production, or specify water as an explicit resource input. By including both production technologies and the supply of irrigation water as nonlinear regional activities in the national model, better estimates of irrigated agriculture production response and resource use can be made.

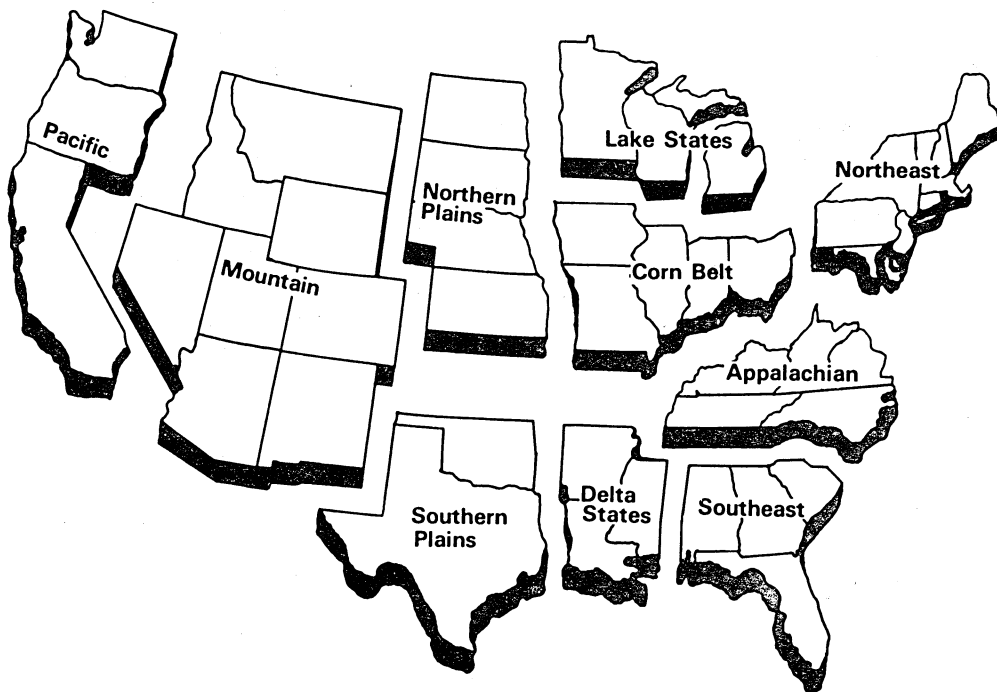
THE USMP MODEL SPECIFICATION

The USMP optimizes the net social payoff of national agricultural production. This is equal to the area under the demand functions less the area under the supply functions which is commonly defined in the economic literature as consumers' plus producers' surplus. The problem was specified as a quadratic programming model and solved using Minos.[3]

Three final demands were specified at the national level: domestic, export, and stocks. Commodity supply sources specified at the national level were imports, beginning commercial inventories, and government stock release. Crop and livestock production, labor, and land resource supply functions were specified for the 10 USDA crop production regions (fig. 1).

Figure 1.

Farm Production Regions



Source: U.S. Department of Agriculture

Primary and Secondary Commodity Activities

The USMP contained 36 of the major agricultural commodities produced in the United States. These commodities were divided into two categories: primary and secondary products. Primary commodities were defined as those produced on the farm and include the following:

<u>Crops</u>	<u>Livestock</u>
cotton	fed beef for slaughter
corn	nonfed beef for slaughter
soybeans	beef calves for slaughter
wheat	beef feeder yearlings
sorghum	beef feeder calves
rice	cull beef cows
barley	cull dairy cows
oats	cull dairy calves
silage	milk
hay	hogs for slaughter
	cull sows for slaughter
	feeder pigs
	poultry
	other livestock

There were 143 primary commodity production activities specified at the regional level. Elasticities of demand for the crops included in the model are the same elasticities used in the USMP. These elasticities were estimated by the Food and Agricultural Policy Branch, National Economics Division, Economic Research Service, USDA. The elasticities by commodity are as follows

<u>Crop</u>	<u>Elasticities of demand</u>		
	<u>Domestic</u>	<u>Stocks</u>	<u>Exports</u>
Cotton	-0.22	-1.96	-0.18
Corn	-.23	-3.25	-.33
Soybeans(oil)	-.14	-2.01	-.80
Wheat	-.07	-.90	-.35
Sorghum	-.01	-1.52	-.82
Barley	-.30	-.70	(1)
Oats	-.11	-1.30	(1)
Rice	-.09	-.63	-.46

(1)Not exported.

Secondary commodity production activities represent the processing of primary commodities into intermediate products or products that have an observable final demand. The following secondary commodity production activities were specified at the national level.

<u>Crops</u>	<u>Livestock</u>
soybean meal	fed beef
soybean oil	nonfed beef
livestock feed grain	veal
dairy protein supplement	pork
low protein swine feed	
high protein swine feed	
low protein cattle feed	
high protein cattle feed	

Factor Input Activities

The USMP model regionally specified the supply of land, labor, and miscellaneous factor inputs. Cropland and pasture land were specified with price-responsive supply functions. The supply elasticities of land used in this study were estimated to be 0.3 for cropland and 0.6 for pasture. These estimates were done in the original formulation of the model at Purdue University and no attempt was made to estimate regional elasticities.

Family labor was specified with perfectly elastic supply functions and constrained to 1978 levels. Hired labor was specified with price-responsive supply functions. Miscellaneous factor inputs were supplied in perfectly elastic national markets at fixed national prices without constraints.

Model Modifications

The USMP was modified to include regional irrigated crop production activities, ground and surface water supply functions, and a subroutine to eliminate the need for regional production constraints.

Irrigated Production Activities

With the exception of rice and cotton, most principal U.S. agricultural crops are not irrigated (table 1). The 31 million irrigated acres represent about 11 percent of the total acreage of those crops. However increased production of export commodities in response to a change in demand can come from irrigated areas. Increases in export demand relative to other irrigated crops would shift resource use from nonexport to export crops. The extent of the changes in cropping patterns would depend on the value of growing the export crops relative to other crops, and the flexibility of farmers to irrigate both export and other crops.

The original USMP model specified one crop production activity for each crop in a region. This specification incorporates both nonirrigated and irrigated cropping technologies into a single activity. By forming an additional activity to represent the irrigated technology, a more accurate commodity supply response to changes in commodity demand scenarios can be projected. Most of the U.S. irrigated crop production takes place in the four Western regions, the Mississippi River Delta, and Florida (table 1). About 50 percent of the principal crop acreage in the Pacific region and 42 percent of the Mountain region is irrigated. In 1978, most of the irrigated cotton was grown in the Southern Plains, Arizona (Mountain region), and California (Pacific region).

Table 1--Dryland and irrigated crop acreage by USDA crop reporting regions, USMP base solution, 1978

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Total
<u>Million acres</u>											
Cotton:											
Dryland			0.183		0.275	0.547	2.344	4.701			8.050
Irrigated							.128	2.343	0.694	1.521	4.686
Total			.183		.275	.547	2.472	7.044	.694	1.521	12.736
Corn:											
Dryland	2.674	11.184	35.740	5.559	4.205	2.644		.414	.040	.007	62.466
Irrigated				5.640		.234		.932	.911	.365	8.082
Total	2.674	11.184	35.740	11.199	4.205	2.878		1.346	.951	.372	70.548
Soybeans:											
Dryland	.926	4.864	21.596	3.043	3.495	4.944	10.697	.916			50.481
Irrigated				.220		.078	.591	.187			1.076
Total	.926	4.864	21.596	3.263	3.495	5.022	11.288	1.103			51.557
Wheat:											
Dryland	.372	2.908	3.249	24.234	.581	.228	.312	7.642	8.546	4.086	52.160
Irrigated				.531				.149	1.111	.511	2.302
Total	.372	2.908	3.249	24.765	.581	.228	.312	7.791	9.657	4.597	54.462
Sorghum:											
Dryland			.923	5.198			.206	3.983	.110	.004	10.424
Irrigated				.647				1.050	.219	.104	2.020
Total			.923	5.845			.206	5.033	.329	.108	12.444
Barley:											
Dryland	.208	1.009		3.063					1.597	.827	6.704
Irrigated									1.286	.641	1.927
Total	.208	1.009		3.063					2.883	1.468	8.631
Oats:											
Dryland	.788	3.839	2.993	4.638							12.258
Irrigated											0
Total	.788	3.839	2.993	4.638							12.258
Hay:											
Dryland	4.434	6.949	6.676	8.704	3.332	1.128	1.397	3.333	1.771	.818	38.542
Irrigated				.556		.023		.267	4.164	1.674	6.684
Total	4.434	6.949	6.676	9.260	3.332	1.151	1.397	3.600	5.935	2.492	45.226
Silage:											
Dryland	1.305	1.732	1.236	1.000	.614	.189	.068	.031	.023		6.198
Irrigated				.324		.015	.003	.097	.485	.204	1.128
Total	1.305	1.732	1.236	1.324	.614	.204	.071	.128	.508	.204	7.326
Rice:											
Irrigated			.025				1.895	.598		.485	3.003
Total:											
Dryland	10.707	32.485	72.596	55.439	12.502	9.680	15.024	21.020	12.087	5.742	247.282
Irrigated	0	0	.025	7.918	0	.350	2.617	5.623	8.870	5.505	30.908
Cropland	10.707	32.485	72.621	63.357	12.502	10.030	17.641	26.643	20.957	11.247	278.190

Sources: U.S. Dept. Agr., Agricultural Statistics, 1981, and U.S. Dept. Commerce, Bureau of the Census, 1978 Census of Agriculture, "Irrigation," Vol. 4, Feb. 1982.

Rice production was limited to Texas (Southern Plains), California (Pacific), and the Delta States. There is substantial acreage of dryland wheat and barley acreage in the Mountain and Pacific regions. These crops are usually grown as winter crops in the West where most of the rainfall occurs during the winter and, in some areas, no irrigation water is applied.

Surface Water Supply Functions

The USMP, as modified, requires the specification of a surface water supply function. Such a function must contain the amount of water that can be used on export crops and the price changes that will occur if the amount of water use changes.

About 54 percent of the total water used for irrigation in the United States is diverted from surface watercourses.[4] The remainder is pumped from ground water aquifers. Where surface water occurs in the arid West, agricultural development has, for the most part, thrived because of low capital investment requirements of the farmer and stable irrigation costs.

The pattern of water allocation in the West is based on court-determined arbitrary rights originating from the Riparian Doctrine and the Doctrine of Prior Appropriation. This means that a low probability of reallocating water from low-value agricultural uses to higher value agricultural and non-agricultural uses exists. Also, physical water requirements that are determined under the assumption of a lower than market determined water price will exceed existing supplies.

The U.S. Constitution delegated to the Congress the paramount authority to control the use of the Nation's navigable surface waters. Most Western States have declared that natural streamflow is the property of the public and therefore the property of the State in trust for the people. However this is subject to the authority of the U.S. Congress. As a result of rigid surface water allocation in the West, the surface water supply functions were specified in the USMP with a perfectly elastic price for each region. Quantities of surface water available for use were constrained by the amount of surface water applied in 1978 to the crops that were included in the model. The amount of surface water applied to crops included in this analysis and their average costs by region in 1978 were:

<u>Region</u>	<u>Surface</u>	<u>Average</u>
	<u>water use</u>	<u>cost</u>
	<u>Million acre-feet</u>	<u>\$/AF</u>
Northern Plains	1.738	4.78
Southeast	.113	4.45
Delta States	1.309	4.37
Southern Plains	2.217	8.18
Mountain	14.462	4.27
Pacific	13.126	9.46

Ground Water Supply Functions

Ground water has also played an important role in the irrigation of the West. With the development of the high-volume turbine pump, water could be

economically pumped from depths up to 700 feet for irrigating agricultural crops. Vast amounts of ground water are available in some areas of the United States that could be developed for irrigation. The following citation from a recent U.S. Geological Survey report supports the possibility of using greater amounts of ground water.

"The pumpage of fresh ground water in the United States in 1980 is estimated as approximately 88 billion gallons per day, which is on the order of 10 percent of the estimated natural flow through the Nation's ground water systems. From the national perspective, therefore, the resource is not overdeveloped; locally, however, the situation can vary widely, and a number of problems exist." -U.S. Geological Survey, Water-Supply Paper 2250, page 37.

Ground water aquifers, geological formations that have accumulated water over millions of years, are usually recharged naturally as water is removed. However the rate of pumping is sometimes greater than the rate of recharge and a temporary overdraft exists in several areas.

Ground water comprises about 46 percent of the total water used for irrigation in the Nation.[5] In 1978, about 29 million acres were irrigated with ground water. Overdrafting occurs in 11 of the major irrigated States and it directly affects agricultural production on 15 million acres.[6] Overdrafting is a rational procedure on the part of society if the financial returns from pumping are greater than the current costs of pumping plus the present value of future changes in pumping costs and environmental costs (user costs).[7] For example, benefits from pumping do exceed the pumping cost plus user costs for some aquifers in the San Joaquin Valley of California.[8] But, in other areas, the benefits from pumping are less than the pumping cost plus user costs. But overdrafting still occurs, however, as long as the user costs are not borne directly by the pumper. This is the case because ground water is a common property resource without exclusive rights being assigned to any one individual. Therefore future pumping and environmental costs are distributed among all of the users.

Some States have attempted to internalize user costs to the pumper by limiting the number or spacing of wells. For example, these policies slow the rate of extraction and bring private benefits and costs closer to presumed social benefits and costs. In areas of the country that have large ground water aquifers, overdraft could become a substantial but temporary source of irrigation water given stable energy costs and rising commodity prices.[9]

To accommodate the cost structure of ground water pumping in the USMP, we specified ground water supplies as price-responsive activities for each production region. The responsiveness of quantity supplied to changes in an output price sufficient to induce that level of output is referred to as the elasticity of supply of the product. Elasticity figures reflect the relative ease with which resources can be drawn into the production process. Supply is said to be inelastic (less than 1.0) if additional quantities are produced only at much higher costs (quantity is relatively unresponsive to output price). Conversely, supply is elastic (greater than 1.0) if more output produced is associated with very small cost increases (quantity is relatively responsive to output price). Time is a crucial element of supply elasticity: resources are

much more mobile in the long run than in the short run and therefore supply functions become more elastic over a longer time period.

The concept of supply elasticity as relates to water for irrigated agriculture applies in cases for which water production costs per unit rise. The most common example of increasing unit costs is that of water pumped from an overdrafted aquifer. Annual drawdown represents the magnitude of the decline in the water table for a given amount of overdraft (amount by which water withdrawals exceed recharge). Irrigators use pumps and irrigation equipment (fixed factors) and labor and energy (variable factors) to produce water for their own use in a vertically structured production process. Irrigators can be viewed as a suppliers of water because, in the absence of institutional barriers, irrigators would be able to sell the water to users who would be willing and able to pay the most for it.

Each additional acre-foot of water pumped from the aquifer results in cost increasing conditions brought about by the drawdown: water must be pumped a greater distance and well yields are decreased. In this analysis, energy prices, labor wages, and fixed costs are assumed constant so that water cost increases are associated with movements upward and along rather than leftward shifts in the water supply curve. Thus, for a given drawdown, input costs, and quantity of overdraft, an elasticity of ground water supply can be estimated. The following ground water supply cost and elasticities were developed from State-level information gathered by U.S. Geological Survey,[10] Farm and Ranch Irrigation Survey[11] and expert opinion.[12]

Region	Ground water use Million acre-feet	Average cost \$/AF	Supply elasticity
Northern Plains	8.077	12.77	0.6
Southeast	.423	14.39	1.5
Delta States	3.747	11.04	1.5
Southern Plains	5.624	18.74	.4
Mountain	2.735	16.54	.8
Pacific	2.192	18.99	.85

Positive Quadratic Programming

Duplicating actual regional cropping patterns with an unconstrained regional programming model is difficult to accomplish. The cause of this difficulty arises from the inability to estimate all costs and benefits from growing a particular crop. Economists have employed techniques to make regional programming models generate results closer to observed acreages. Day[13] and McCarl[14] have suggested procedures to estimate the magnitude of upper and lower bounds on regional crop acreages. One major deficiency of these approaches is the lack of data needed to implement these techniques in a national model.

Howitt and Mean[15] proposed an alternative to estimating the amount of "flexibility" in upper and lower bounds:

"This paper proposes a method to amend normative linear microeconomic models by a positive measure of the nonlinear part of

the cost function based on the actual action of the farmers. Using this positive approach the linear model can be exactly calibrated to observed outputs for a single year or calibrated with a least-squares criterion if actual crop acreages for several years are known. The resulting optimization problem incorporates a quadratic cost term for each regional crop grown and is constrained only by those fixed input constraints that can be empirically justified. The problem is solved as a quadratic programming problem, and being only moderately constrained, the model reaction to policy changes is a smooth trade-off based on changed comparative advantage."

The Positive Quadratic Programming (PQP) technique was originally applied to only nonmarginal crops (underspecialized crops)[16] in a model[17] and existing regional resource constraints limited the acreage of the marginal crops. The implementation of PQP in the USMP was different in that both underspecialized and overspecialized cropping activities were specified to base-year levels and regional resources were specified as cost-responsive supply functions.

One assumption underlying the USMP is that firms act as profit maximizers within perfectly competitive markets. Economic theory indicates that firms will succeed if they can equate their marginal cost of production with the price they receive for their output. This relationship can be expressed as:

$$P = MC \quad (1)$$

where P is the unit price of the output and MC is the marginal cost of production.

The production processes within the USMP model are described as Leontief production functions exhibiting constant returns to scale. That is, each unit of output requires fixed levels of inputs. Given these assumptions, the total cost of production for a specific region and crop can be expressed as a linear function of the form:

$$TC = cQ + C \quad (2)$$

where TC is the total cost of production, c is the variable cost per unit produced, Q is units of output, and C is the fixed cost of production.

The marginal cost of production is determined by differentiating the total cost function with respect to the quantity produced which in this case is:

$$MC = c \quad (3)$$

The price that producers receive for the commodities they produce is determined by a demand function for each commodity. The USMP assumes, for simplicity, that the industry faces a linear demand function of the following form:

$$P = a + bQ \quad (4)$$

where a is an intercept term and b is a slope coefficient.

The equilibrium condition for the production of each crop is determined by substituting equations (3) and (4) into (1) to obtain:

$$a + bQ = c \quad (5)$$

Rewriting the equation yields:

$$a + bQ - c = 0 \quad (6)$$

If the USMP is constrained to base period crop production levels, the constraints will be binding and take on a positive or negative dual value. A dual value indicates that the marginal costs of production estimated were not equal to the actual marginal costs of production that existed in the base year. Thus, the existence of dual values on these constraints indicates a violation of the basic assumption described by equation (6).

A positive dual value in the constrained run indicates that overspecialization of that crop occurred[18] and some of the costs associated with producing the crop were not measured. These unmeasured costs could be actual out-of-pocket costs such as transportation and insurance costs or costs not explicitly accounted for within the firm, such as risk.

A negative dual value in the constrained run indicates an underspecialization and that production costs were overestimated. Resource costs that could be overestimated are land rents and management costs. Positive externalities, such as the value of a crop in a rotational scheme, could also be present and would cause a negative dual value on a crop constraint.

The actual cost producers face can be defined as:

$$MCA = c + f(Q^*) \quad (7)$$

where $f(Q^*)$ is the negative of the dual value of a base-year level constraint on the respective crop activity. The value of $f(Q^*)$ also represents the unmeasured or overestimated marginal cost of producing that crop in the original normative USMP model.

Assuming that the unknown marginal cost function $f(Q)$ takes a linear form, then:

$$f(Q) = e + gQ \quad (8)$$

where e is an intercept term. When Q^* is equal to the base-year crop acreage levels, and

$$e + gQ^* = -RDG \quad (9)$$

with RDG representing the reduced gradient or dual value of the the base-year constraint on the crop-activity level in the quadratic programming model.

The g coefficients of the unknown marginal costs are always negative. Costs increase with quantity produced. Therefore, for crop production activities that are overspecialized (positive dual value on acreage constraint), the unknown marginal cost function would be calculated as:

$$e = 0, \text{ and} \quad (10)$$

$$g = - (RDG/Q^*) \quad (11)$$

Unknown marginal cost functions for underspecialized crop activities (negative dual values in the constrained run) will take the following form:

$$e = -2(RDG), \text{ and} \quad (12)$$

$$g = RDG/Q^* \quad (13)$$

Forming the total cost function yields the objective function for all crop activities

$$TC = (c + e + gQ)Q \quad (14)$$

that is quadratic in form and can be solved using the Minos optimization program.

The inclusion of the PQP technique in the USMP model will allow the model to duplicate base-year acreage levels without constraining the acreage levels. When policy changes or demand scenarios are introduced into the model, changes in the regional cropping pattern are determined entirely by the economic condition for general equilibrium which is that price equals marginal cost.

ALTERNATIVE EXPORT DEMAND LEVEL SIMULATIONS

The objective of this analysis was to determine the supply response of irrigated and dryland agriculture to changing export demand levels for agricultural commodities. This analysis was based on simulations made with the modified USMP.

Crops included in this study and their 1978 production and quantity exported are listed in table 2. Large proportions of the 1978 cotton, soybeans, wheat and

Table 2--Production and exports of major U.S. agricultural commodities, 1978

Crop	Production	Exported	Percentage
			exported Pct.
Cotton (1,000 bales)	10,478	5,850	56
Corn (million bu.)	7,268	2,133	29
Soybeans (million bu.)	1,869	753	40
Wheat (million bu.)	1,776	1,194	67
Sorghum (million bu.)	731	207	28
Barley (million bu.)	455	26	6
Oats (million bu.)	582	13	2
Hay (million tons)	144	0	0
Silage (million tons)	118	0	0
Rice (million cwt)	133	76	57

Source: U.S. Dept. of Ag., Agricultural Statistics, 1981.

rice crops were exported. Barley, oats, hay and silage were grown mainly for domestic consumption.

The alternative export demand levels selected for analysis were a reduction of 30 percent, and increases of 30, 60, and 90 percent. The range of export levels were chosen to cover possible declines and increases that may be possible in the 1980's.[19] It is assumed that these changes represent shifts in the export demand functions rather than changes in 1978 export demand elasticities.

The effects of changes in export demand levels were examined with respect to commodity production and price changes, regional cropping shifts, regional water use changes, and dryland and irrigated acreage changes.

Commodity Production and Prices

As one would expect, production of principal export commodities varied directly with changes in the export demand level (table 3). Variations in production levels as a result of a constant export demand level changes depended on the proportion of the crop that went into the export market, the elasticities of demand in the domestic and export markets, technical coefficients, stock of carryover, and the amount of and competition for land and water resources.

A decrease of 30 percent in export demand did not cause a serious decline in corn production (-7 percent) while sorghum, barley, oats, hay, and silage production increased due to increased use as livestock feed. Cotton, soybeans, wheat, and rice production declined significantly under this scenario.

Rice, cotton, and wheat production increased substantially more than corn or sorghum production under a 60- or 90-percent increase in export demand. Over half of the total U.S. production of wheat, rice, and cotton was exported in 1978. Therefore with a 90-percent increase in export demand, a large increase in production could be expected. Feed grains produced for domestic consumption decreased as land and water resources would be bid away by export crops.

Regional Cropping Shifts

A 90-percent increase in export demand caused U.S. cotton production to increase by 37 percent. Most of this increase was projected to occur in the Mountain States (1.9 million bales) and the Delta States (1.78 million bales) (table 4). A relatively small increase (120,000 bales) in cotton production was expected in California because water costs increased with additional water use as production expanded. This caused the region to lose its cost advantage over other regions growing dryland cotton. Cotton in the Pacific region was also grown in direct competition with rice production.

U.S. corn production increased by 18 percent under the 90-percent demand increase scenario. A substantial amount of that increase was projected for the Corn Belt (572 million bushels) and the Northern Plains (260 million bushels). A 61-percent increase was projected in corn production for Appalachia; slight decreases were projected in the Mountain and Pacific regions. Irrigated corn production was expected to decline in this type of scenario because of corn's high water requirement relative to other export crops.

Table 3--Effects of alternative demand levels on commodity production and prices

Crop and scenario	Price	Percentage change	Production	Percentage change
	<u>Per unit</u>	<u>Pct.</u>	<u>Unit</u>	<u>Pct.</u>
Cotton:				
1978 base	280.23		10.7	
Minus 30 percent	267.33	-5	9.3	-13
Plus 30 percent	294.00	5	12.1	13
Plus 60 percent	307.32	10	13.4	25
Plus 90 percent	319.83	14	14.7	37
Corn:				
1978 base	2.22		6848.2	
Minus 30 percent	2.10	-5	6363.8	-7
Plus 30 percent	2.35	6	7321.0	7
Plus 60 percent	2.48	12	7691.8	12
Plus 90 percent	2.59	17	8062.4	18
Soybeans:				
1978 base	6.74		1732.8	
Minus 30 percent	6.04	-10	1492.4	-14
Plus 30 percent	7.41	10	1939.9	12
Plus 60 percent	7.99	19	2109.5	22
Plus 90 percent	8.52	26	2256.2	30
Wheat:				
1978 base	3.03		1613.2	
Minus 30 percent	2.75	-9	1398.9	-13
Plus 30 percent	3.31	9	1793.0	11
Plus 60 percent	3.62	19	1992.3	23
Plus 90 percent	3.90	29	2172.9	35
Sorghum:				
1978 base	2.00		656.7	
Minus 30 percent	1.88	-6	803.9	22
Plus 30 percent	2.15	8	710.4	8
Plus 60 percent	2.30	15	730.5	11
Plus 90 percent	2.44	22	740.6	13
Barley:				
1978 base	1.92		413.5	
Minus 30 percent	1.78	-7	455.0	10
Plus 30 percent	2.07	8	361.2	-13
Plus 60 percent	2.24	17	348.9	-16
Plus 90 percent	2.40	25	337.1	-18
Oats:				
1978 base	1.23		600.0	
Minus 30 percent	1.16	-6	703.2	17
Plus 30 percent	1.34		523.6	
Plus 60 percent	1.49		506.3	
Plus 90 percent	1.64		486.5	
Hay:				
1978 base	61.02		98.1	
Minus 30 percent	56.95	-7	99.0	1
Plus 30 percent	65.58	7	97.4	-1
Plus 60 percent	69.96	15	97.0	-1
Plus 90 percent	73.90	21	96.7	-1
Silage:				
1978 base	34.60		98.5	
Minus 30 percent	34.14	-1	99.3	1
Plus 30 percent	35.15	2	97.7	-1
Plus 60 percent	35.76	3	97.2	-1
Plus 90 percent	36.31	5	96.8	-2
Rice:				
1978 base	8.16		133.7	
Minus 30 percent	7.71	-6	115.1	-14
Plus 30 percent	8.62	6	153.3	15
Plus 60 percent	9.06	11	170.9	28
Plus 90 percent	9.48	16	187.5	40

Units are: cotton, 1,000 bales; corn, soybeans, wheat, sorghum, barley, and oats, million bushels; hay and silage, million tons; and rice, million hundredweight.

Table 4--Effects of alternative export demand levels on regional commodity production in the United States, 1978

Region & export level	Cotton	Corn	Soybeans	Wheat	Sorghum	Barley	Oats	Hay	Silage	Rice
Percent change from base production										
Northeast:										
Base production ^{1/}	0	248.9	27.5	12.5	0	9.5	40.7	8.9	18.7	0
Minus 30 percent	-	-7.8	-12.7	-87.2	-	5.3	11.3	-3.4	.0	-
Plus 30 percent	-	8.6	11.6	77.6	-	-9.5	-7.1	4.5	.2	-
Plus 60 percent	-	15.3	20.7	172.8	-	-3.2	-4.9	6.7	.5	-
Plus 90 percent	-	21.6	28.7	266.4	-	3.2	-3.4	9.0	.8	-
Lake States:										
Base production ^{1/}	0	1,050.2	151.3	97.7	0	48.7	196.3	18.1	20.6	0
Minus 30 percent	-	-5.6	-12.0	-26.6	-	9.4	16.0	-5.5	0.8	-
Plus 30 percent	-	6.3	10.6	21.6	-	-11.3	-11.6	6.6	-.7	-
Plus 60 percent	-	10.6	18.8	47.5	-	-13.3	-14.4	11.6	-1.2	-
Plus 90 percent	-	14.7	26.0	73.8	-	-14.8	-17.6	15.5	-1.8	-
Corn Belt:										
Base production ^{1/}	0.2	3,760.0	969.7	118.9	67.1	0	151.7	15.4	18.7	1.0
Minus 30 percent	-58.6	-6.5	-12.5	-1.9	171.2	-	10.3	7.8	.5	-20.0
Plus 30 percent	44.2	5.5	10.7	-5.3	43.7	-	-10.3	-16.9	-1.1	10.0
Plus 60 percent	91.7	10.3	19.8	-3.0	68.9	-	-15.2	-30.5	-1.6	20.0
Plus 90 percent	142.0	15.2	27.8	.8	85.5	-	-19.7	-44.8	-2.1	30.0
Northern Plains:										
Base production ^{1/}	0	1,054.2	79.2	676.6	323.4	130.2	211.3	17.1	13.2	0
Minus 30 percent	-	-9.4	-13.3	-11.5	1.5	13.4	24.3	-4.7	1.6	-
Plus 30 percent	-	10.4	11.4	8.4	8.0	-19.1	-16.7	6.4	-1.4	-
Plus 60 percent	-	17.8	19.8	17.6	10.7	-18.4	-19.1	8.8	-2.8	-
Plus 90 percent	-	24.7	27.0	27.2	12.2	-17.3	-22.6	9.9	-4.0	-
Appalachia:										
Base production ^{1/}	.3	328.1	134.6	20.1	0	0	0	5.7	9.1	0
Minus 30 percent	-20.2	-22.6	-13.2	-100.0	-	-	-	42.1	0	-
Plus 30 percent	20.6	22.4	11.7	158.7	-	-	-	-49.1	.1	-
Plus 60 percent	40.8	41.4	21.7	158.7	-	-	-	-64.9	.6	-
Plus 90 percent	60.3	61.2	30.7	158.7	-	-	-	-82.5	1.1	-
Southeast:										
Base production ^{1/}	0.5	146.6	95.8	6.9	2.7	0	0	2.2	2.3	0
Minus 30 percent	-7.7	13.2	-32.2	62.3	0	-	-	9.1	2.1	-
Plus 30 percent	10.2	-10.5	27.9	-43.5	0	-	-	0	-1.5	-
Plus 60 percent	21.4	-20.0	49.4	-2.9	0	-	-	-4.5	-2.4	-
Plus 90 percent	32.6	-28.1	67.9	50.7	0	-	-	-4.5	-3.1	-
Delta States:										
Base production ^{1/}	2.5	0	253.7	11.1	11.4	0	0	2.2	.8	79.6
Minus 30 percent	-21.2	-	-13.1	-6.3	10.5	-	-	59.1	0	-13.3
Plus 30 percent	24.3	-	11.0	5.4	-2.6	-	-	-45.5	0	14.3
Plus 60 percent	49.6	-	20.0	18.9	-3.5	-	-	-86.4	0	27.5
Plus 90 percent	71.2	-	26.7	29.7	-7.9	-	-	-100.0	0	39.7
Southern Plains:										
Base production ^{1/}	4.1	119.5	21.2	180.8	223.2	0	0	6.1	1.9	27.8
Minus 30 percent	.5	-10.2	-24.1	-4.0	11.2	-	-	-49.2	1.0	24.8
Plus 30 percent	-4.0	11.4	20.3	.3	-.9	-	-	57.4	-.8	26.6
Plus 60 percent	-7.0	17.3	36.8	6.0	-3.1	-	-	106.6	-1.2	49.6
Plus 90 percent	-7.9	22.8	51.4	12.6	-5.4	-	-	145.9	-1.6	71.9
Mountain:										
Base production ^{1/}	1.3	98.4	0	287.3	21.5	149.8	0	14.0	8.9	0
Minus 30 percent	-51.1	2.3	-	-15.7	3.2	8.5	-	9.3	1.6	-
Plus 30 percent	52.5	-2.1	-	14.0	4.2	-9.5	-	-7.1	-1.5	-
Plus 60 percent	99.6	-5.9	-	31.5	6.0	-15.1	-	-17.1	-2.6	-
Plus 90 percent	146.4	-9.8	-	41.1	4.7	-21.3	-	-20.0	-3.8	-
Pacific:										
Base production ^{1/}	1.9	42.3	0	201.3	7.5	75.3	0	8.4	4.3	25.3
Minus 30 percent	-2.9	1.9	-	-14.2	6.7	8.2	-	-3.6	1.7	-3.6
Plus 30 percent	2.8	-1.7	-	14.1	-6.7	-9.0	-	6.0	-1.5	3.2
Plus 60 percent	4.3	-4.5	-	29.8	-12.0	-14.9	-	10.7	-2.7	4.7
Plus 90 percent	6.3	-7.1	-	44.6	-17.3	-20.2	-	13.1	-3.8	7.1

^{1/} Units are: cotton, 1,000 bales; corn, soybeans, wheat, sorghum, barley, and oats, million bushels; hay and silage, million tons; and rice, million hundredweight.

The projected increase in national soybean production of 30 percent was evenly distributed among the regions except the Southeast (68 percent) and the Southern Plains (51 percent). Most of the increase was projected for the Corn Belt (241 million bushels) where a substantial amount of soybean production currently exists. Moderate increases were projected for other soybean producing regions with the exception of the 68-percent increase in the Southeast and the 51-percent increase in the Southern Plains.

Increases in regional wheat production resulting from the 90-percent increase in export demand varied considerably. Large percentage increases occurred in the Northeast and Appalachia but relatively small increases were projected for the Corn Belt and the Southern Plains. Substantial increases in wheat production were projected for the Pacific and Mountain regions because of the crop's low water requirement relative to other irrigated crops.

The regional increase in sorghum production was even more diverse than the increase in wheat production. Production actually decreased in the Pacific region, Southern Plains, and the Delta States because of high water requirements and/or low returns to land and competition from other crops. A large part of the total increase was projected for dryland conditions in the Corn Belt and the Northern Plains.

As stated before, production of the non export feedstuffs declined under the export demand scenarios. With the exception of hay production, most of the decreases were fairly uniform across regions. Hay production declined substantially in the Corn Belt, Appalachia, and the Delta States. This was countered by an increase of 8.9 million tons in the Mountain region's hay production and smaller increases in the Lake States and Northern Plains.

Total rice production was projected to increase by 40 percent as a result of the 90-percent increase in export demand. Texas rice production (Southern Plains) was projected to almost double. California production increased only 9 percent due to the crop's high water requirement and the higher opportunity cost for water in competing export crops.

Regional Water Use

As stated before, regional surface water supplies were constrained to the amount of water from surface sources that was applied to the crops included in the study in 1978. Surface water applied to other agricultural crops was not included in the water supply because of the problem of physically reallocating surface water from other crops and because the crops not included in the model are usually higher valued crops.

The weighted average regional costs of surface water were substantially less than average ground water costs in all irrigated regions, but the use of surface water was constrained to 1978 levels and, as a result, changes in export demand levels did not change the use of surface water. However increases in export demand levels caused significant increases in the amount of ground water pumped and the per unit cost (table 5). Under a 90-percent increase in export demand, total ground water pumped increased over 42 percent from 22.8 million acre-feet to 32.5 million acre-feet.

Table 5--Effects of alternative export demand levels on regional
ground water pumping and costs in the United States, 1978

Region & export level	Quantity pumped	Percentage change	Cost per Acre-foot	Percentage change
	<u>Mil. acre-ft.</u>	<u>Pct.</u>	<u>Dollars</u>	<u>Pct.</u>
Northern Plains:				
1978 base	8.081		12.76	
Minus 30 percent	6.981	-13.6	9.86	-22.7
Plus 30 percent	9.277	14.8	15.91	24.7
Plus 60 percent	10.305	27.5	18.62	45.9
Plus 90 percent	11.258	39.3	21.13	65.6
Southeast:				
1978 base	.429		14.26	
Minus 30 percent	.393	-8.4	13.46	-5.6
Plus 30 percent	.469	9.3	15.15	6.2
Plus 60 percent	.504	17.5	15.93	11.7
Plus 90 percent	.536	24.9	16.66	16.8
Delta States:				
1978 base	3.754		11.03	
Minus 30 percent	2.913	-22.4	9.38	-15.0
Plus 30 percent	4.661	24.2	12.81	16.1
Plus 60 percent	5.530	47.3	14.51	31.6
Plus 90 percent	6.317	68.3	16.05	45.5
Southern Plains:				
1978 base	5.632		18.67	
Minus 30 percent	5.215	-7.4	15.20	-18.6
Plus 30 percent	6.055	7.5	22.19	18.9
Plus 60 percent	6.460	14.7	25.56	36.9
Plus 90 percent	6.800	20.7	28.87	54.6
Mountain:				
1978 base	2.744		16.47	
Minus 30 percent	2.165	-21.1	12.11	-26.5
Plus 30 percent	3.371	22.8	21.20	28.7
Plus 60 percent	3.970	44.7	25.71	56.1
Plus 90 percent	4.502	64.1	29.72	80.4
Pacific:				
1978 base	2.202		18.88	
Minus 30 percent	1.901	-13.7	15.83	-16.2
Plus 30 percent	2.535	15.1	22.26	17.9
Plus 60 percent	2.841	29.0	25.37	34.4
Plus 90 percent	3.125	41.9	28.25	49.6
Total:				
1978 base	22.842			
Minus 30 percent	19.568	-14.3		
Plus 30 percent	26.368	15.4		
Plus 60 percent	29.610	29.6		
Plus 90 percent	32.538	42.4		

The Northern Plains ground water pumping was projected to increase by 3.2 million acre-feet and the pumping cost to increase from \$12.76 to \$21.13 per acre-foot. The greatest percentage increase in regional pumping was projected for the Delta States (68 percent); but, due to the relative high elasticity of water supply, pumping cost was projected to increase by only 45.5 percent. Pumping cost for the eight-State Mountain region was projected to increase from \$16.47 to almost \$30.00 per acre-foot. This projected cost would be comparable to costs projected for the other western regions.

One of the overdraft problem areas is the Southern Plains where a substantial portion of the increase in ground water use (about 1.17 million acre-feet annually) was projected to occur. Southern Plains farmers in the pump most of their water from the Ogallala aquifer. Some areas of this aquifer have experienced substantial annual overdrafting. Increasing the overdraft by over 1 million acre-feet may quickly exhaust the economic water supply in the western part of the Southern Plains. These projections are based on ground water supply functions that existed in 1978; no attempt was made to estimate the change that may occur in those functions as a result of the export demand scenarios. A long-run increase in export demand would certainly change the nature of the water supply functions in critical ground water areas.

Dryland And Irrigated Production

Tables 6 through 9 present the change in regional dryland and irrigated crop acreages resulting from the four export demand scenarios. The percentage change in dryland and irrigated acreages by scenarios is presented in appendix tables 1-4.

As export demand decreased, total cropland use decreased by 14.7 million acres from 278 million acres (table 6). This decrease was distributed almost proportionately between dryland and irrigated acreage (app. table 1). As exports increased by 30, 60, and 90 percent, total cropland use increased by 15.9, 31.8, and 46.6 million acres (tables 7, 8, and 9). However irrigated acreage increased proportionally more than dryland acreage (app. tables 2, 3, and 4). Since irrigated yields are generally higher than dryland, the production response from irrigated agriculture was greater than dryland agriculture despite the higher ground water prices.

Irrigated wheat acreage was projected to increase by 1.135 million acres or 49 percent under the 90-percent increase in export demand (table 9 and app. table 4). About half of this increase (571,000 acres) was projected for the Northern Plains. This projected increase was expected because 67 percent of the total wheat production was exported in 1978. Dryland wheat acreage was projected to increase by only 32 percent from 54.4 million acres (app. table 4).

Soybean acreage was projected to increase by over 16 million acres under the 90-percent export increase scenario. Almost all of the increase is projected for dryland production because soybeans are not produced easily under irrigated conditions.

Corn acreage was projected to increase by 3 million acres under the high-export demand scenario with the irrigated acreage increasing by 21 percent and the dryland acreage increasing by 17 percent (app. table 4). Almost all of the

Table 6--Change in dryland and irrigated crop acreage due to a 30-percent decrease in exports, by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop total
Million acres											
Cotton:											
Dryland			-0.107		-0.056	-0.042	-0.440	-0.234			-0.878
Irrigated							.077	.183	-0.354	-0.044	-.293
Total			-.107		-.056	-.042	-.517	-.051	-.354	-.044	-1.171
Corn:											
Dryland	-0.208	-0.627	-2.310	-0.440	-.948	.398		-.092	0	0	-4.227
Irrigated				-.587		.002		-.072	.022	.007	-.629
Total	-.208	-.627	-2.310	-1.028	-.948	.401		-.164	.022	.007	-4.856
Soybeans:											
Dryland	-.119	-.584	-2.706	-.381	-.461	-1.578	-1.338	-.169			-7.336
Irrigated				-.048		-.032	-.120	-.080			-.280
Total	-.119	-.584	-2.706	-.429	-.461	-1.611	-1.458	-.249			-7.616
Wheat:											
Dryland	-.326	-.772	-.062	-2.597	-.580	.146	-.019	-.332	-1.497	-.614	-6.652
Irrigated				-.184				.012	-.123	-.056	-.351
Total	-.326	-.772	-.062	-2.781	-.580	.146	-.019	-.320	-1.620	-.670	-7.004
Sorghum:											
Dryland			1.578	.102			.021	.702	-.011	0	2.393
Irrigated				-.006				-.003	.020	.007	.018
Total			1.578	.096			.021	.699	.009	.008	2.411
Barley:											
Dryland	.012	.094		.412					.043	.044	.604
Irrigated									.154	.066	.220
Total	.012	.094		.412					.197	.109	.824
Oats:											
Dryland	.089	.616	.310	1.127							2.142
Irrigated											0
Total	.089	.616	.310	1.127							2.142
Hay:											
Dryland	-.151	-.366	.557	-.259	1.410	.087	.811	-1.948	.880	.041	1.061
Irrigated				-.085		-.001		-.032	.100	-.084	-.102
Total	-.151	-.366	.557	-.344	1.410	.086	.811	-1.980	.980	-.043	.959
Silage:											
Dryland	.001	.015	.011	.013	0	.004	.001	0	0		.045
Irrigated				.007		0	0	.001	.008	.003	.020
Total	.001	.015	.011	.020	0	.004	.001	.001	.008	.003	.065
Rice:											
Irrigated			-.006				-.251	-.149		-.017	-.423
Regional total:											
Dryland	-.701	-1.626	-2.729	-2.024	-.634	-.985	-.963	-2.073	-.585	-.529	-12.849
Irrigated	0	0	-.006	-.903	0	-.031	-.448	-.140	-.173	-.118	-1.819
Cropland	-.701	-1.626	-2.735	-2.927	-.634	-1.016	-1.411	-2.214	-.758	-.647	-14.699

Table 7--Change in dryland and irrigated crop acreage due to a 30-percent increase in exports, by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop total
<u>Million acres</u>											
Cotton:											
Dryland			0.082		0.056	0.057	0.500	0.157			0.851
Irrigated							.090	-.322			.175
Total			.082		.056	.057	.590	-.165	0.364	0.042	1.026
Corn:											
Dryland	0.228	0.701	1.973	0.488	.941	-.325		.062	0	0	4.068
Irrigated				0.645		.002		.099	-.020	-.007	.720
Total	.228	.701	1.973	1.132	.941	-.322		.161	-.020	-.007	4.788
Soybeans:											
Dryland	.106	.518	2.315	.333	.411	1.369	1.116	.137			6.304
Irrigated				.038		.028	.113	.074			.253
Total	.106	.518	2.315	.371	.411	1.397	1.228	.211			6.557
Wheat:											
Dryland	.288	.628	-.173	1.866	.920	-.099	.017	.074	1.299	.616	5.436
Irrigated				.148				-.035	.123	.054	.289
Total	.288	.628	-.173	2.014	.920	-.099	.017	.038	1.422	.670	5.725
Sorghum:											
Dryland			.402	.408			-.004	-.330	.029	0	.505
Irrigated				.059				.132	-.011	-.006	.173
Total			.402	.467			-.004	-.199	.018	-.006	.679
Barley:											
Dryland	-.018	-.115		-.585					-.047	-.044	-.809
Irrigated									-.172	-.074	-.246
Total	-.018	-.115		-.585					-.219	-.118	-1.055
Oats:											
Dryland	-.056	-.445	-.308	-.774							-1.582
Irrigated											0
Total	-.056	-.445	-.308	-.774							-1.582
Hay:											
Dryland	.203	.461	-1.113	.436	-1.619	-.030	-.650	2.216	-.683	-.036	-.814
Irrigated				.101		.001		.041	-.077	.111	.176
Total	.203	.461	-1.113	.537	-1.619	-.029	-.650	2.257	-.760	.075	-.638
Silage:											
Dryland	.002	-.011	-.012	-.011	.001	-.003	-.001	0	0		-.036
Irrigated				-.007		0	0	-.001	-.007	-.003	-.018
Total	.002	-.011	-.012	-.018	.001	-.003	-.001	-.001	-.007	-.003	-.054
Rice:											
Irrigated			.003				.271	.158		.015	.446
Regional total:											
Dryland	.753	1.736	3.167	2.161	.710	.969	.977	2.315	.599	.537	13.923
Irrigated	0	0	.003	.984	0	.032	.474	.146	.199	.132	1.969
Cropland	.753	1.736	3.169	3.144	.710	1.000	1.451	2.461	.798	.669	15.892

Table 8--Change in dryland and irrigated crop acreage due to a 60-percent increase in export demand, by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop total
<u>Million acres</u>											
Cotton:											
Dryland			0.168		0.111	0.117	1.016	0.305			1.717
Irrigated							.190	-.584	0.692	0.066	.363
Total			.168		.111	.117	1.206	-.279	.692	.066	2.080
Corn:											
Dryland	0.407	1.187	3.680	0.785	1.742	-.620		.075	0	0	7.256
Irrigated				1.137		.006		.160	-.054	-.017	1.232
Total	.407	1.187	3.680	1.922	1.742	-.615		.235	-.054	-.017	8.488
Soybeans:											
Dryland	.191	.915	4.270	.577	.761	2.422	2.006	.245			11.388
Irrigated				.066		.052	.211	.137			.466
Total	.191	.915	4.270	.643	.761	2.474	2.218	.382			11.854
Wheat:											
Dryland	.639	1.382	-.098	3.862	.920	-.005	.061	.497	2.973	1.287	11.517
Irrigated				.361				-.019	.261	.119	.722
Total	.639	1.382	-.098	4.223	.920	-.005	.061	.478	3.233	1.406	12.239
Sorghum:											
Dryland			.634	.505			-.007	-.713	.052	0	.471
Irrigated				.102				.246	-.025	-.012	.311
Total			.634	.607			-.007	-.467	.027	-.012	.781
Barley:											
Dryland	-.006	-.135		-.565					-.047	-.076	-.829
Irrigated									-.287	-.119	-.405
Total	-.006	-.135		-.565					-.333	-.194	-1.234
Oats:											
Dryland	-.040	-.553	-.454	-.887							-1.933
Irrigated											0
Total	-.040	-.553	-.454	-.887							-1.933
Hay:											
Dryland	.337	.802	-2.007	.446	-2.144	-.042	-1.193	4.114	-1.744	-.083	-1.514
Irrigated				.193		.002		.080	-.174	.206	.307
Total	.337	.802	-2.007	.638	-2.144	-.040	-1.193	4.194	-1.918	-.123	-1.207
Silage:											
Dryland	.006	-.022	-.019	-.022	.004	-.005	-.002	0	0		-.060
Irrigated				-.013		0	0	-.001	-.013	-.006	-.033
Total	.006	-.022	-.019	-.035	.004	-.005	-.002	-.001	-.013	-.006	-.092
Rice:											
Irrigated			.005				.521	.297		.024	.847
Regional total:											
Dryland	1.535	3.577	6.175	4.700	1.394	1.868	1.881	4.522	1.234	1.128	28.013
Irrigated	0	0	.005	1.846	0	.059	.922	.317	.400	.261	3.809
Cropland	1.535	3.577	6.180	6.546	1.394	1.927	2.803	4.839	1.633	1.389	31.822

Table 9—Change in dryland and irrigated crop acreage due to a 90-percent increase in export demand, by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop total
<u>Million acres</u>											
Cotton:											
Dryland			0.260		0.165	0.178	1.459	0.508			2.571
Irrigated							.274	-.773	1.016	0.095	.612
Total			.260		.165	.178	1.733	-.265	1.016	.095	3.183
Corn:											
Dryland	0.577	1.648	5.427	1.064	2.574	-.875		.116	-.001	-.001	10.530
Irrigated				1.600		.009		.203	-.090	-.026	1.695
Total	.577	1.648	5.427	2.664	2.574	-.866		.319	-.092	-.027	12.225
Soybeans:											
Dryland	.265	1.263	6.009	.788	1.075	3.328	2.657	.340			15.726
Irrigated				.088		.072	.300	.192			.652
Total	.265	1.263	6.009	.887	1.075	3.400	2.958	.532			16.378
Wheat:											
Dryland	.986	2.146	.028	5.924	.920	.119	.094	.993	3.734	1.922	16.865
Irrigated				.571				-.002	.386	.180	1.135
Total	.986	2.146	.028	6.494	.920	.119	.094	.991	4.119	2.102	18.000
Sorghum:											
Dryland			.789	.548			-.016	-1.051	.065	0	.335
Irrigated				.136				.339	-.040	-.018	.417
Total			.789	.684			-.016	-.712	.025	-.018	.752
Barley:											
Dryland	.008	-.149		-.528					-.085	-.016	-.860
Irrigated									-.396	-.160	-.557
Total	.008	-.149		-.528					-.481	-.266	-1.417
Oats:											
Dryland	-.028	-.675	-.589	-1.048							-2.340
Irrigated											0
Total	-.028	-.675	-.589	-1.048							-2.340
Hay:											
Dryland	.438	1.079	-2.986	.342	-2.734	-.058	-1.397	5.583	-1.771	-.131	-1.635
Irrigated				.270		.003		.111	-.300	.279	.364
Total	.438	1.079	-2.986	.612	-2.734	-.055	-1.397	5.695	-2.071	.149	-1.270
Silage:											
Dryland	.010	-.031	-.024	-.033	.007	-.008	-.002	0	0		-.083
Irrigated				-.018		0	0	-.002	-.019	-.008	-.047
Total	.010	-.031	-.024	-.051	.007	-.008	-.003	-.002	-.019	-.008	-.129
Rice:											
Irrigated			.007				.754	.431		.035	1.227
Regional total:											
Dryland	2.255	5.280	8.914	7.057	2.007	2.684	2.795	6.490	1.941	1.684	41.110
Irrigated	0	0	.007	2.647	0	.084	1.328	.499	.556	.377	5.499
Cropland	2.555	5.280	8.921	9.705	2.007	2.769	4.123	6.990	2.498	2.062	46.609

increase in irrigated acreage, 1.6 million acres, was projected for the Northern Plains where ground water cost was relatively low and other high-value crops such as rice and cotton were not competing for water.

About 2.5 of the 3.2 million acres of cotton projected to increase as a result of the high-export scenario were dryland. This increase is much more than the projected increase in irrigated cotton acreage of 13 percent. Most of the increase is projected for the Delta States. A switch from irrigated to dryland cotton is projected for about 500,000 acres in the Southern Plains.

The projected rice acreage increase of 1.2 million acres under the 90-percent export increase scenario was unevenly distributed among the rice producing areas (table 9). The largest projected regional increase was 431,000 acres (72 percent) in the Southern Plains. This is contrasted to the relatively low projected increase of 7 percent for the Pacific region (app. table 4). The regional differential in projected rice acreage can be explained in terms of the comparative advantage the Southern Plains has in growing rice due to lower water costs. Crops with high water requirements generally did not increase significantly in those regions with high water costs and high ground water supply elasticities.

With the exception of sorghum, feed grains grown mainly for domestic consumption declined under the increased export scenarios. The largest acreage decline was projected for oats (2.3 million acres). Hay, silage, and barley acreages were also projected to decline.

Irrigated agricultural production is projected to increase proportionality more than dryland production under the 90-percent increased export demand scenario. Some projected changes in regional irrigated and dryland acreages were also significant under this scenario. As one might expect, regions that had large cropland acreages in 1978 would have large projected increases in acreages. For example, total cropland acreage was projected to increase in the Northern Plains by 9.7 million acres of which 2.6 million acres would be irrigated (table 9). The projected increase in Northern Plains irrigated acreage was 33 percent (app. table 4). However, the largest projected percentage increase in irrigated acreage was 51 percent for the Delta States, a region with a relatively low ground water cost and a high elasticity of ground water supply. The largest projected increase in regional dryland acreage under the highest export demand scenario was 8.9 million acres in the Corn Belt.

SUMMARY AND CONCLUSIONS

Using a modified version of the USMP model that included irrigated cropping activities and water supply functions, we projected commodity production and regional cropping shifts under four export demand scenarios. Production of export commodities in irrigated regions would play a significant role in an expansion of export commodity demand. Under a 90-percent increase in export demand, irrigated acreage is projected to increase by 1.3 million acres or 51 percent in the Delta States. The Northern Plains can expect an increase of 2.6 million acres of irrigated land.

Ground water use was projected to increase by 42 percent under the 90 percent export demand increase scenario. Water use and costs were changed significantly

in some regions. Ground water pumping increased by 68 percent in the Delta States and 64 percent in the Mountain region. Water costs increased by 80 percent in the Mountain region to over \$28.00 per acre foot and by 66 percent in the Northern Plains to over \$21.00 per acre foot.

The results of this study are limited by the level of aggregation. In formulating a 10-region national model, one must make substantial aggregations in estimating production coefficients and specifying water supply functions. A good example is the Mountain region that includes such diverse agricultural areas as Montana and Arizona. Attempting to construct an irrigated wheat activity that would adequately represent the production of wheat from the Mountain region under various demand conditions is very difficult. The USMP model was developed to estimate national changes in income and agricultural production from changes in national policies. It serves that purpose very well. However, attempting to estimate regional changes in resource use as a result of those same policies needs to be done at a less aggregated level. A 48-state version of the USMP model is expected to be completed soon.

FOOTNOTES

1. Robert M. House, "USMP: A Mathematical Programming Model for Agriculture Sector Policy Analysis," forthcoming, U.S. Dept. Agr. Econ. Res. Serv.
2. Barbara L. Chattin, Bruce A. McCarl, and Harry Stephen Baumes, Jr. User's Guide and Documentation For A Partial Equilibrium Sector Model of U.S. Agriculture, Bulletin No. 414, Purdue Univ., Agr. Exp. Stat., Apr. 1983.
3. Bruce A. Murtagh and Michael A. Saunders, Minos 5.0 User's Guide, Tech. Rept. SOL 83-20, Systems Optimization Laboratory, Dept. of Operations Research, Stanford Univ., Dec. 1983.
4. Gordon Sloggett, Prospects For Ground water Irrigation: Declining Levels and Rising Energy Costs, AER-478, U.S. Dept. Agr., Econ. Res. Serv., Dec. 1981.
5. Sloggett, op.cit.
6. Sloggett, op. cit.
7. These costs are referred to as user costs in the economic literature
8. Richard E. Howitt, Is Overdraft Always Bad?, Proceedings of the Twelfth Biennial Conference on Ground Water, Sacramento, Calif., Nov. 1979, Univ. of Calif., Water Resources Center, pp. 50-61.
9. Optimal periods of overdraft can be determined quite easily. See Charles V. Moore, Ground water Overdraft Management: Some Suggested Guidelines, Giannini Foundation, Info. Series No. 84-1, Feb. 1984.
10. U.S. Geological Survey, Water Supply Paper 2250, 1984.
11. U.S. Bureau of the Census, 1978 Census of Agriculture, 1979 Farm and Ranch Irrigation Survey, Vol. 5, Special Reports, Part 8, 1980.
12. Oral communications with Gordon Sloggett, agricultural economist, U.S. Dept. Agr., Econ. Res. Serv., Oklahoma State Univ.
13. Richard H. Day, "Recursive Programming and the Production of Supply," Agricultural Supply Functions, Heady et al., Iowa State University Press, 1961.
14. Bruce A. McCarl, "Cropping Activities in Agricultural Sector Models: A Methodological Proposal," American Journal of Agricultural Economics 64:768-772, 1982.
15. Richard E. Howitt and Phillippe Mean, "A Positive Approach to Microeconomic Programming Models," Working Paper No. 83-6, Dept. of Agr. Econ., Univ. of Calif., 1983.
16. Nonmarginal or underspecialized crops are those that are "underproduced" in

a programming solution when compared to a base-year production.

17. Howitt and Mean, op. cit., p 16.

18. The cropping activity level in the unconstrained model is greater than the acreage level observed in the base year.

19. Robert M. House, "Agriculture and Uncertainty in the 1980's." unpublished, U.S. Dept. of Agr. Econ. Res. Serv., 1983.

Appendix table 1--Percentage in dryland and irrigated crop acres from 1978 base acreage due to a 30-percent decrease in export demand by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop change
<u>Percent</u>											
Cotton:											
Dryland			-58.4		-20.3	- 7.6	-18.8	- 5.0			-10.9
Irrigated							-60.3	7.8	-51.0	- 2.9	- 6.3
Total											- 9.2
Corn:											
Dryland	- 7.8	- 5.6	- 6.5	- 7.9	-22.5	15.1		-22.3	- .3	2.4	- 6.8
Irrigated				-10.4		.9		- 7.7	2.4	1.8	- 7.8
Total											- 6.9
Soybeans:											
Dryland	-12.9	-12.0	-12.5	-12.5	-13.2	-31.9	-12.5	-18.4			-14.5
Irrigated				-21.8		-41.7	-20.2	-42.8			-26.0
Total											-14.8
Wheat:											
Dryland	-87.5	-26.6	- 1.9	-10.7	-100.0	63.8	- 6.1	- 4.3	-17.5	-15.0	-12.8
Irrigated				-34.7				8.0	-11.1	-11.0	-15.2
Total											-12.9
Sorghum:											
Dryland			171.1	2.0			10.4	17.6	- 9.8	3.0	23.0
Irrigated				- 1.0				- .3	9.1	7.1	.9
Total											19.4
Barley:											
Dryland	5.9	9.3		13.4					2.7	5.3	9.0
Irrigated									12.0	10.2	11.4
Total											9.5
Oats:											
Dryland	11.4	16.0	.3	24.3							17.5
Irrigated											0
Total											17.5
Hay:											
Dryland	- 3.4	- 5.3	.6	- 3.0	42.3	7.7	58.0	-58.5	49.7	5.0	2.8
Irrigated				-15.3		- 2.6		-12.2	2.4	- 5.0	- 1.5
Total											2.1
Silage:											
Dryland	0	.8	.9	1.3	0	0	1.9	.5	.8		.7
Irrigated				2.3		1.8	2.3	1.1	1.7	1.7	1.8
Total											.9
Rice:											
Irrigated			-24.4				-13.3	-24.9		- 3.5	-14.1
Regional change:											
Dryland	- 6.5	- 5.0	- 3.8	- 3.7	- 5.1	-10.2	- 6.4	- 9.9	- 4.8	- 9.2	- 5.2
Irrigated	0	0	-24.0	-11.4	0	- 8.9	-17.1	- 2.5	- 2.0	- 2.1	- 5.9
Cropland	- 6.5	- 5.0	- 3.8	- 4.6	- 5.1	-10.1	- 8.0	- 8.3	- 3.6	- 5.8	- 5.3

Appendix table 2--Percentage in dryland and irrigated crop acres from 1978 base acreage due to a 30-percent increase in export demand by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop change
<u>Percent</u>											
Cotton:											
Dryland			44.6		20.5	10.3	21.3	3.3			8.7
Irrigated							70.7	-13.7	52.4	2.8	7.9
Total											8.4
Corn:											
Dryland	8.5	6.3	5.5	8.8	22.4	-12.3		15.0	.8	- .7	6.2
Irrigated				11.4		1.0		10.7	- 2.2	- 1.8	11.2
Total											6.8
Soybeans:											
Dryland	11.5	10.6	10.7	10.7	11.8	27.7	10.4	15.0			12.5
Irrigated				17.4		36.5	19.0	39.6			24.1
Total											12.8
Wheat:											
Dryland	77.5	21.6	- 5.3	7.7	158.6	-43.4	5.5	1.0	15.2	15.1	10.2
Irrigated				27.8				-23.6	11.0	10.5	16.3
Total											10.5
Sorghum:											
Dryland			43.6	7.9							
Irrigated				9.1			- 2.0	- 8.3	26.7	- .3	4.4
Total								12.5	- 5.1	- 5.7	10.2
Barley:											5.3
Dryland	- 8.9	-11.4		-19.1							
Irrigated									- 2.9	- 5.3	-12.6
Total									-13.4	-11.5	-11.6
Oats:											-12.4
Dryland	- 7.1	-11.6	- .3	-16.7							
Irrigated											-12.9
Total											0
Hay:											-12.9
Dryland	4.6	6.6	- 1.1	5.0	-48.6	- 2.7	- 46.5	66.6	- 38.6	- 4.3	- 2.5
Irrigated				18.1		4.8		15.3	- 1.9	6.6	3.4
Total											- 1.6
Silage:											
Dryland	.2	- .7	- 1.0	- 1.1	.1	0	- 1.5	- .4	- .6		- .7
Irrigated				- 2.1		- 1.1	- 2.0	- .9	- 1.5	- 1.5	- 1.4
Total											.8
Rice:											
Irrigated			11.0				14.3	26.4		3.1	14.8
Regional change:											
Dryland	7.0	5.3	4.3	3.5	5.6	10.0	6.8	9.3	4.5	9.2	5.4
Irrigated	0	0	12.0	15.2	0	8.0	15.1	9.2	2.8	2.6	8.2
Cropland	7.0	5.3	4.3	5.0	5.6	9.9	8.0	9.2	3.8	6.0	5.7

Appendix table 3--Percentage in dryland and irrigated crop acres from 1978 base acreage due to a 60-percent increase in export demand by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop change
	<u>Percent</u>										
Cotton:											
Dryland			91.8		40.4	21.5	43.4	6.5			21.3
Irrigated							148.3	-24.9	99.6	4.3	7.7
Total											16.3
Corn:											
Dryland	15.2	10.6	10.3	14.1	41.4	-23.5		18.0	- .3	- 6.7	11.6
Irrigated				20.2		2.4		17.2	- 6.0	- 4.6	15.2
Total											12.0
Soybeans:											
Dryland	20.6	18.8	19.8	19.0	21.8	49.0	18.8	26.7			22.6
Irrigated				29.8		66.3	35.8	73.4			43.3
Total											23.0
Wheat:											
Dryland	171.9	47.5	- 3.0	15.9	158.6	- 2.1	19.4	6.5	34.8	31.5	22.1
Irrigated				68.0				-12.6	23.5	23.2	31.4
Total											22.5
Sorghum:											
Dryland			68.8	9.7			- 3.6	-17.9	47.1	- 2.3	4.5
Irrigated				15.7				23.4	-11.3	-11.7	15.4
Total											6.3
Barley:											
Dryland	- 2.9	-13.4		-18.5					- 2.9	- 9.2	-12.4
Irrigated									-22.3	-18.5	-21.0
Total											-14.3
Oats:											
Dryland	- 5.0	-14.4	- .5	-19.1							-15.8
Irrigated											0
Total											-15.8
Hay:											
Dryland	7.6	11.5	- 2.0	5.1	-64.4	- 3.7	- 85.4	123.6	- 98.5	-10.2	- 3.9
Irrigated				34.6		10.1		29.9	- 4.2	12.3	4.6
Total											- 2.7
Silage:											
Dryland	.5	- 1.2	- 1.5	- 2.2	.6	0	- 2.5	- .5	- 1.0		1.0
Irrigated				- 3.9		- 1.5	- 3.3	- 1.3	- 2.7	- 2.7	- 2.9
Total											.4
Rice:											
Irrigated			21.1				27.5	49.7		4.9	28.2
Regional change:											
Dryland	14.3	11.0	8.5	8.5	11.2	19.3	12.5	21.5	10.2	19.6	11.3
Irrigated	0	0	20.0	23.3	0	16.9	35.2	5.6	4.5	4.7	12.3
Cropland	14.3	11.0	8.5	10.3	11.2	19.2	15.9	18.2	7.8	12.3	11.4

Appendix table 4--Percentage in dryland and irrigated crop acres from 1978 base acreage due to a 90-percent increase in export demand by USDA crop reporting region

Crop	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific	Crop change
<u>Percent</u>											
Cotton:											
Dryland			142.1		60.2	32.6	62.2	10.8			31.9
Irrigated							214.0	-33.0	146.4	6.2	13.1
Total											25.0
Corn:											
Dryland	21.6	14.7	15.2	19.1	61.2	-33.1		28.1	- 3.2	-12.7	16.9
Irrigated				28.4		4.0		21.8	- 9.9	- 7.2	21.0
Total											17.3
Soybeans:											
Dryland	28.6	26.0	27.8	25.9	30.8	67.3	24.8	37.2			31.2
Irrigated				40.1	92.3	50.8	102.5				60.6
Total											31.8
Wheat:											
Dryland	265.0	73.8	.9	24.4	158.6	52.2	30.2	13.0	43.7	47.0	32.3
Irrigated				107.4				- 1.2	34.7	35.3	49.3
Total											33.1
Sorghum:											
Dryland			85.5	10.5			- 7.7	-26.4	59.4	- 4.3	3.2
Irrigated				21.1				32.3	-18.2	-17.5	20.6
Total											6.0
Barley:											
Dryland	3.7	-14.8		-17.2					- 5.3	-12.8	-12.8
Irrigated									-30.8	-25.0	-28.9
Total											-16.4
Oats:											
Dryland	- 3.6	-17.6	- .6	-22.6							-19.1
Irrigated											0
Total											-19.1
Hay:											
Dryland	9.9	15.5	- 3.0	3.9	-82.1	- 5.1	-100.0	167.7	-100.0	-16.0	- 4.2
Irrigated				48.6		14.7		41.7	- 7.2	16.7	5.4
Total											- 2.8
Silage:											
Dryland	.8	- 1.8	- 2.0	- 3.3	1.1	0	- 3.6	- .5	- 1.7		- 1.3
Irrigated				- 5.5		- 1.8	- 4.7	- 1.8	- 3.8	- 3.8	- 4.2
Total											- 1.8
Rice:											
Irrigated			28.0				39.8	72.1		7.2	40.9
Regional change:											
Dryland	21.1	16.3	12.3	12.7	16.1	27.7	18.6	30.9	16.1	29.3	16.6
Irrigated	0	0	28.0	33.4	0	24.0	50.7	8.9	6.3	6.8	17.8
Cropland	21.1	16.3	12.3	15.3	16.1	27.6	23.4	26.2	11.9	18.3	16.8

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999	3000
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