The Impact of Water Rights and Legal Institutions on Land and Water Use in 2000

CARD Report 70

THE CENTER FOR AGRICULTURAL
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578 EAST HALL
IOWA STATE UNIVERSITY
AMES, IOWA 50011

THE IMPACT OF WATER RIGHTS AND LEGAL INSTITUTIONS ON LAND AND WATER USE IN 2000

by

W. Arden Colette
Earl O. Heady
Kenneth J. Nicol

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Center for Agricultural and Rural Development
Iowa State University
578 East Hall
Ames, Iowa

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I. INTRODUCTION

During the past 15 years there has been increased pressure for a reallocation of water and a review of the system of water rights in the United States. In the Western States where water scarcity has long been a problem, population increases have expanded water requirements for urban and domestic uses. In the Eastern States contamination of lakes, rivers, and streams has brought about increased interest in pollution and water problems.

As the nation initially expanded and grew, legal and social institutions concerned with the ownership and use of water developed. Heady [9] points out that during this expansionary period the agricultural policy of the United States was growth-oriented. To obtain abundant food and to expand the farm sector, resources were made available to agriculture at low prices. In keeping with this policy a legal system that encouraged the construction of irrigation systems and the use of water in agriculture developed in the arid portions of the United States. Ownership, or the perpetual right to use water, became vested largely in agriculture. By the 1920s U.S. agriculture had exhausted its ability for further expansion in land area. Industrialization became the main method of national economic growth. Since World War II, population growth and rural to urban migration have combined to make urbanization and domestic water needs one of the major considerations in water allocation. The economy has shifted from an agricultural orientation through an industrial phase and now is becoming service oriented. Most of the laws and institutions that determine the ownership, allocation, and use of water were developed prior to 1900 when the nation had an agricultural growth orientation. In most areas these laws and institutional structures have not changed.

In several areas water right laws have been considered restrictive in the efficient allocation and use of water. Smith [27] reported that in California the appropriative water rights, their administration, and their legal status were condemned as not being conducive to the transfer of water from rural to urban uses. Radosevich, Vlachos, and Skogerboe [26] refer to the system of water rights as the "villian" in the inefficient use and management of water in the Western states. However, water right laws and institutions do change. Collette [3] reports that 15 states have made major revisions in their water rights systems since 1950. In an effort to improve the administration and reallocation of water, 14 states have incorporated permit system provisions into their water right systems.

Social Institutions

Patterns of behavior develop as individuals band together to form societies. These behavioral patterns become legitimized as social institutions and serve as the basis of social organization. The evolution of social institutions provides a definite, continuous, and organized pattern of regulations concerning the behavior of the individual in society. A definite normative ordering of society's goals support this pattern of

regulations and legitimizes the sanction for violations of the regulation. As the structure of society changes, the ordering and weighting of its goals change, with the result that social institutions must also change.

Laws and legal institutions are a statement of the regulations that society imposes on the behavior of the individuals making up that society. Laws reflect the value systems, ethics, and beliefs of society. Every society is faced with the universal problems of providing order, stability, and a degree of certainty of expectations. The laws of a society, both statute and common law, consist of society's attempt to solve these problems. Legal restrictions are not an external force that is imposed on individuals and society; they are not separate from society but are a reflection of society and social institutions.

Property

The social institution with the greatest effect on the distribution and use of water is the institution of private property. Property is not a physical concept but is the relationship between people and things. Property refers to the rights, obligations, privileges, and restrictions that govern the behavior of men toward the scarce resources in which society places value. Public property refers to a relationship in which society retains most of the rights and privileges associated with an object for the benefit of society as a whole. Private property describes the relationship in which the individual holds the rights and privileges associated with an object subject to certain restrictions and obligations to society. With the use of police power, the power of eminent domain, and the power of taxation, society retains certain control over property and its use. Zoning, land use restrictions, and other restrictive regulations have recently been added to the "reserved rights" of society. These "reserved rights" greatly reduce the individual's rights and control over property.

The development of water law and water right institutions is based on the concept of private property. The individual holds the rights to receive the income from his efforts and from the sale and management of the production emanating from the use of the resources. The individual also retains the right of possession over time and the right to transfer ownership. Two of the main goals of society in the development of water right institutions have been (a) to encourage the development of the water resources in the United States, and (b) to insure the availability of abundant low cost food. In order to encourage the individual to invest in the development of water resources, society endows water with the characteristics of private property. This guarantees the individual the return from his efforts and from his investment. It provides him with a measure of security and a planning horizon of sufficient length to guarantee the recapture of his investment. Public investment in the development of water resources has been combined with the concept of private property in an effort to guarantee the production of abundant food at low cost.

Analysis Goals

Many changes have taken place since the water right institutions were developed. The United States has become an urban society and relatively, agricultural expansion is a national goal of lower priority. However, the availability of abundant food at low cost is still a

national priority. It is not "a priori" clear that the best interest of society would be served by the elimination of existing water rights and priorities just because proponents of urban growth wish to obtain control of the water resources and divert them to urban and domestic uses. A review of the water right laws, Colette [3], has shown that flexibility in the allocation and use of water exists in all 50 states. One goal of the study reported here is to determine if sufficient flexibility exists to allow reallocation of water between agricultural and urban uses to satisfy both domestic and urban demands and the agricultural requirements for water in the year 2000. A second goal of this study is to establish a basis to evaluate if society would be better served by an elimination of the existing water right system or by a continuation of the present system.

Although all of the water right systems in the United States are based on one of the three basic doctrines--the Riparian, Appropriations, or Administrative Permit System--each state has a unique combination of water right laws and regulations. Because the laws are not uniform it is impossible to make specific statements that will apply to every state. To provide a basis for comparison and evaluation, Colette [3] has categorized states on the basis of their concepts of ownership and transferability of water and water rights. A sample survey conducted in 10 of the Western States indicates that the actual data on the distribution of water rights is not available, Colette [2, Appendix]. Because the actual legal allocation of water under water rights cannot be quantified, it is necessary to make an approximation. In the absence of an organized water market in which water can be transferred from owner to user, it can be assumed that the use of water is very closely related to the ownership of water. And, because the allocation and use of water does change over time the most recent data on the allocation of water would best reflect the ownership of water and water rights. The National Water Resources Council's estimate of 1975 water use in agriculture is used as a proxy for the ownership of water by agricultural producers and is used as a basis for making comparisons in the model of this study.

Specific study objectives

Comparison of four optimal solutions of the CARD-NSF[1] linear programming model of the national agricultural sector is used to estimate the impact of water right restrictions on the use of water, land, and other resources. Options with and without water right restrictions are compared at each of two export demand levels. The statistics which best indicate the economic impact on society include the differences in commodity supply prices; changes in product mix and the regional distribution of production; the redistribution of wealth and the cost of compensation required to maintain the utility level of all of the individuals in society; and changes in water use, land value, and land rent. The reserve productive capacity of American agriculture is used to indicate the flexibility of the agricultural sector. Changes in risk and the relative stability of agricultural prices and production also are estimated.

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[1]Center for Agricultural and Rural Development-National Science Foundation.

II. DELINEATION AND QUANTIFICATION OF THE BASIC MODEL

This study is conducted as a part of the Iowa State University, CARD-NSF effort in developing national environmental models of agricultural policy, land use, and water quality. A standard base model developed by the CARD staff working on the NSF project is utilized in order to ensure consistency in the various studies being conducted. The base model also is used in the modeling activities for the Second National Assessment of the Water Resources Council. This chapter includes only that information necessary for understanding and interpreting the alternatives presented. The reader who wishes more detailed information on the model is directed to Nicol and Heady [25] and to the documentation of the National Water Assessment Model, Meister and Nicol [19].

Model Delineation

Linear programming framework

A cost-minimizing linear programming framework is used to analyze the effects of policy alternatives on the agricultural sector. In matrix notation the model has the following form

$$\text{minimize } Z = C'X$$

$$\text{subject to } A_1X \geq D$$

$$A_2X \leq R$$

$$X \geq 0$$

In this formulation C is the vector of costs associated with the activities in the model. X is the vector of activities in the model.

These activities represent the acquisition of resources, production transformation, and commodity transportation alternatives. D is the set of regional and national commodity demands, and R is the set of resources available for use in satisfying the commodity demands. A_1 is the matrix of the interaction coefficients between the activities in X and the demands in D. A_2 is the matrix of resource use coefficients relating the activities in X to the resources in R.[2]

Delimitation of regions

The agricultural sector in the United States encompasses activities which are carried out under a wide range of climatic conditions, soil conditions, and differing farm structural arrangements. Since in a linear programming framework every unit of an activity must be considered identical, it is necessary to subdivide the U.S. agricultural sector into regions that are relatively homogenous for these characteristics. The regions must be consistent with the characteristics of the resources considered, the possible production techniques, and the alternatives to be considered.

With properly delimited regions the impact of alternative policies on a region and on a farm in a region can be analyzed. Interregional shifts in production patterns and relative commodity prices will be indicated by policies that affect the comparative advantage among

[2]A more complete discussion of linear programming can be found in Agrawal and Heady [1]; Dorfman, Samuelson, and Solow [6]; Hadley [8]; and Heady and Candler [10].

regions. The returns to resources in the form of "rent" as defined by Henderson and Quandt [14, p. 121] and Stonier and Hague [29] can be derived directly from the linear programming output.

Three sets of nested regions, producing regions, market regions, and major reporting regions, are defined in the model. One hundred and five producing regions have been delimited as relatively homogenous in resource availability, resource use, farm structure, technology, cropping patterns and productivity, Figure 1. To facilitate the development of water supplies, the producing regions are consistent with the 99 aggregated subareas defined by the Water Resources Council. Six of the aggregated subareas have been further divided to provide regions which more nearly reflect uniform climatic conditions or distinct agricultural production areas. Because the aggregated subareas are divisions of the 18 major river basins, Figure 2, subsets of contiguous producing regions are contained within the boundaries of the river basins. The major river basins and the enclosed producing regions are illustrated in Figure 3.

Because precipitation is a limiting factor in agricultural production in the western half of the United States and supplemental water application is necessary for successful production, activities involving irrigation have been included in the western producing regions. Water supplies for the producing regions in the Missouri, Arkansas-White-Red, Texas-Gulf, Rio Grande, Upper Colorado, Lower Colorado, Great Basin, Columbia-North Pacific, and California-South Pacific basins have been computed to allow evaluation of water availability

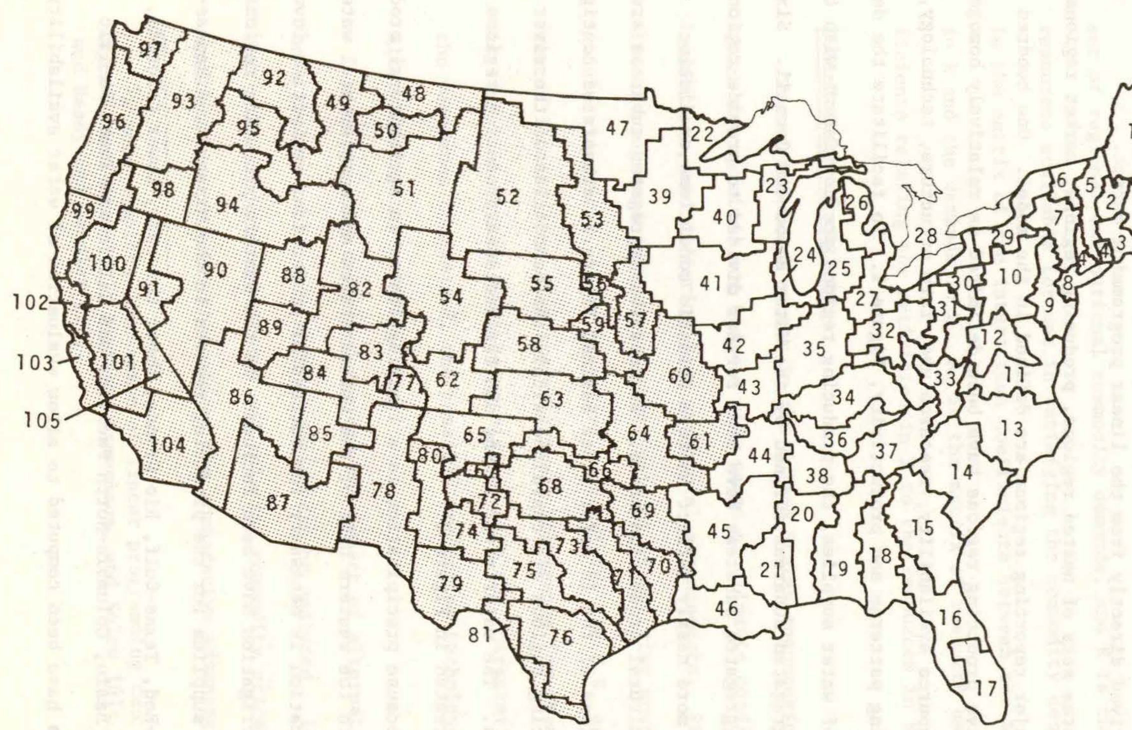

Figure 1. The 105 producing regions and the regions with irrigation activities (shaded).

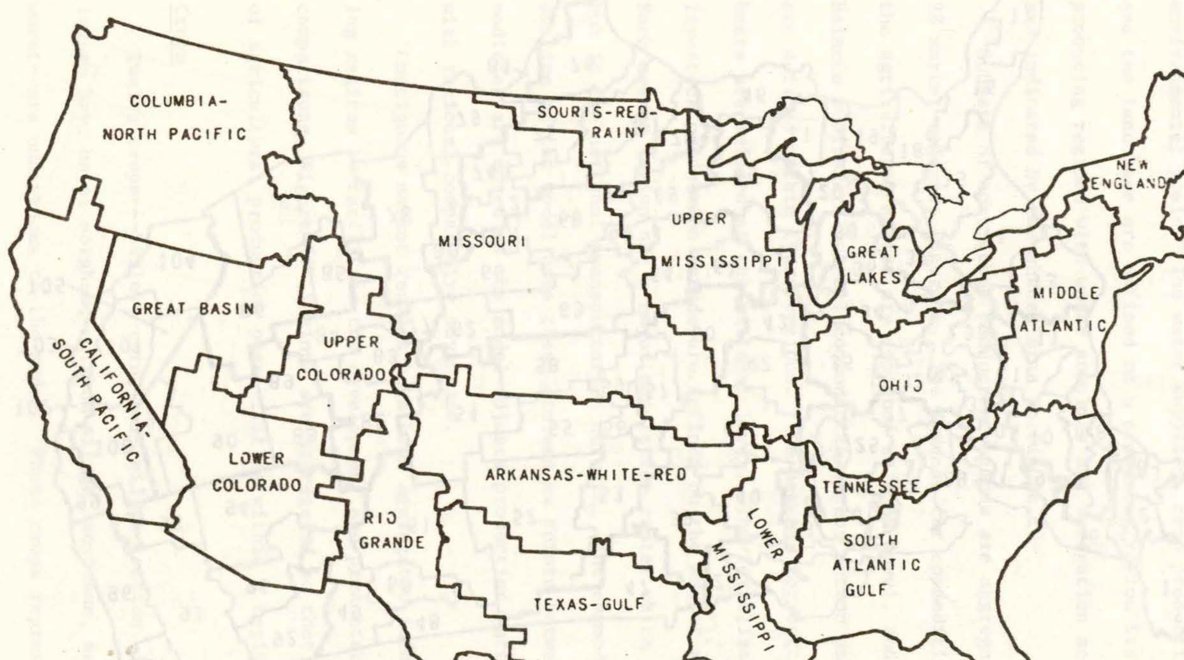

Figure 2. River basins with county boundaries

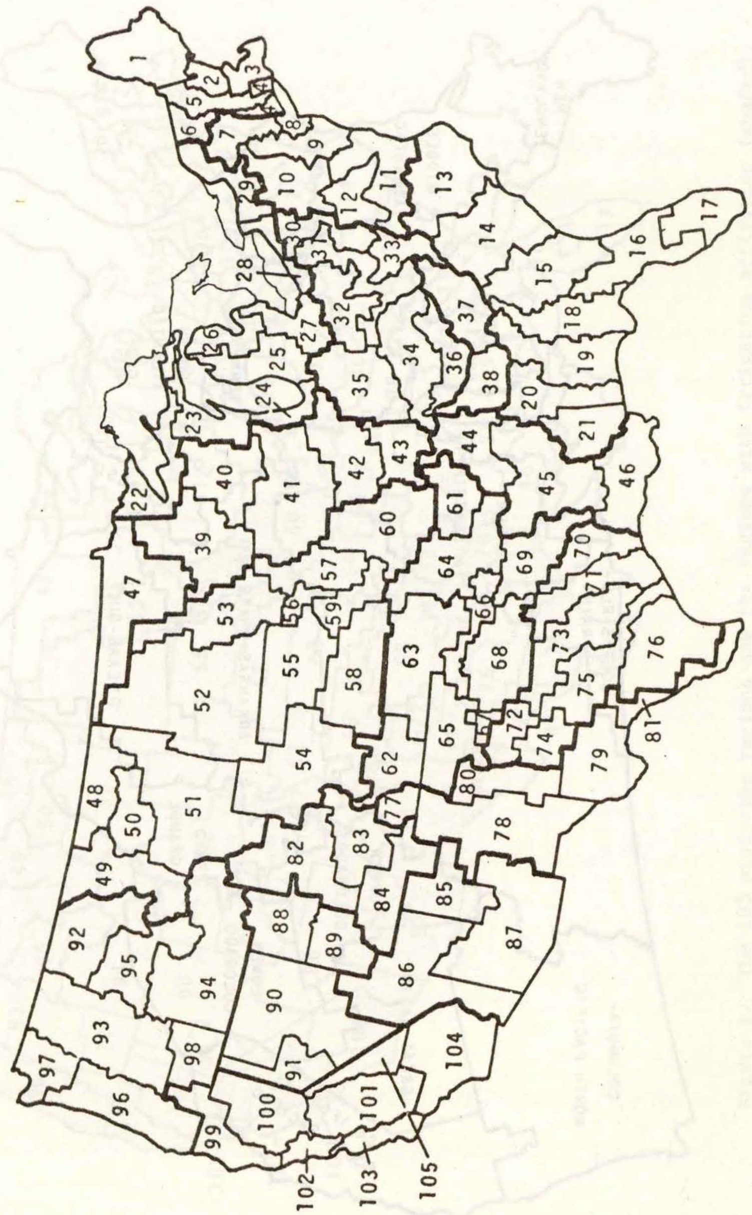

Figure 3. The major river basins and enclosed producing regions

in meeting demands of agriculture, muncipalities, industry, and environmental goals. The water supplies, crop production activities, and the land base are defined on a producing region basis. Those producing regions with water supplies and irrigation activities are indicated by the shaded area in Figure 1.

Subsets of contiguous producing regions are aggregated to delimit 28 market regions, Figure 4. The demands for commodities produced by the agricultural sector are computed at this level, and the market balance restraints for all commodities except cotton and sugar beets are defined within these regions. The demands for cotton and sugar beets are defined at the national level. The fertilizer balance and livestock production bounds are defined on the market region basis. Each market region has a major population center which serves as a hub in the national transportation network. The commodity transfer section of the model uses these centers as points between which commodities are moved as the model adjusts production patterns in accord with regional comparative advantage.

Contiguous market regions have been aggregated into seven reporting regions to facilitate the development and presentation of regional comparisons, Figure 5. Regions are aggregated so that the similarity of agricultural production possibilities within a region is maintained.

Crops

Twelve crops---barley, corn, corn silage, cotton, legume hay, nonlegume hay, oats, sorghum, sorghum silage, soybeans, sugar beets, and wheat--are endogenous to the model. These crops represent the principal

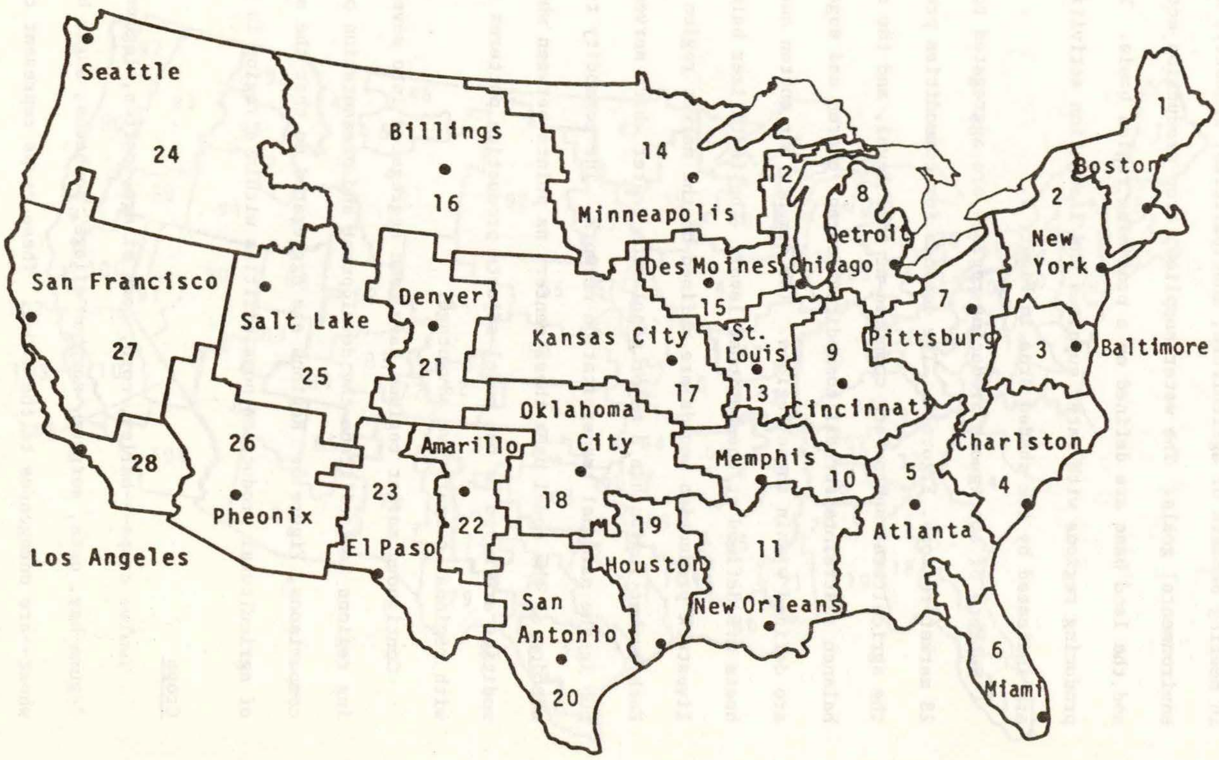

Figure 4. The 28 market regions

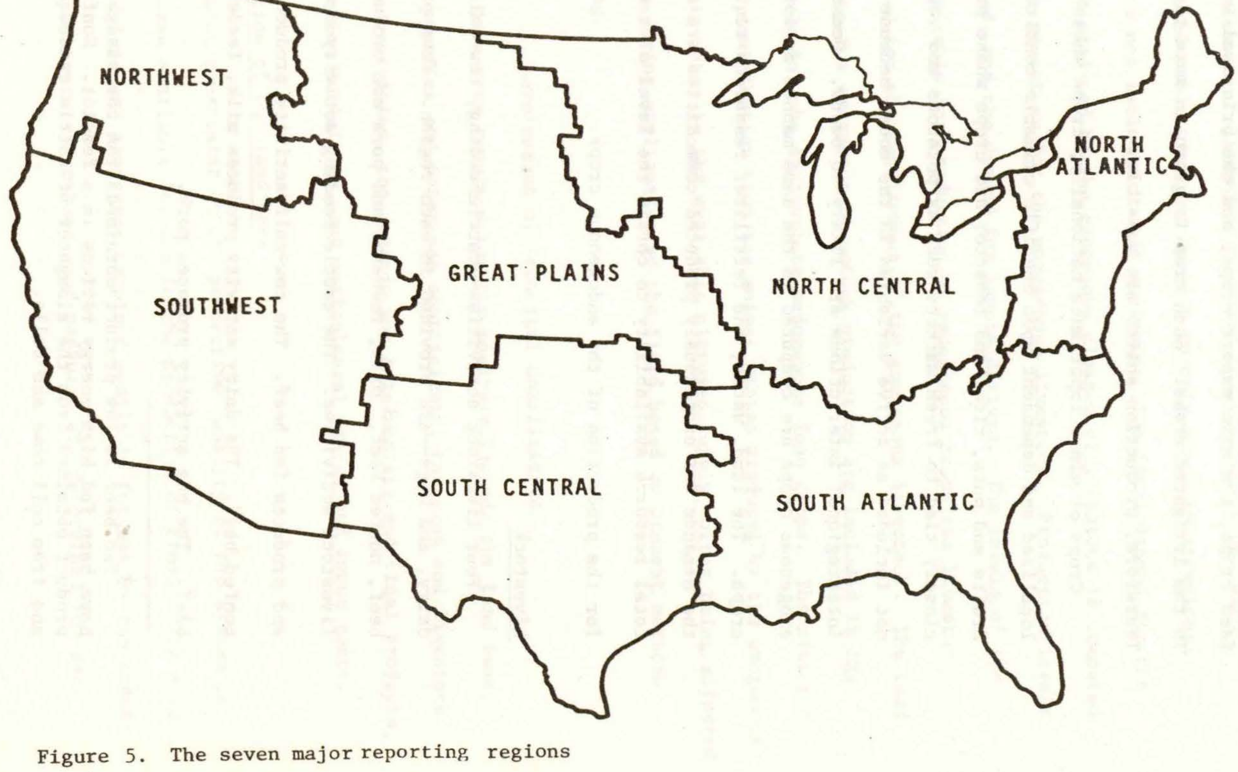

Figure 5. The seven major reporting regions

feed crops, the main export crops, and the principal water-using crops in the irrigated areas. Each crop is grown in more than one region. Therefore, production shifts are possible.

Crops of minor importance nationally; crops whose production is localized and dependent upon specific climatic conditions such as fruits and nuts, rice, and tobacco; and crops whose production is closely tied to fresh markets such as potatoes and vegetables, are not included as active variables in the model because only minor interregional interactions are likely to occur. Demands for these exogenous crops are computed in the same manner as for the endogenous crops. The land, water, and fertilizer resources required to satisfy the demands for exogenously produced commodities are subtracted from total resource availability to obtain the level of resources available for the production of the endogenous crops.

Livestock

Four livestock activities--cattlefeeding, cow-calf operations, dairy, and hogs--are provided in each region. Five products--fed beef, nonfed beef,[3] milk, feeders, and pork are produced by these livestock activities. The cattle feeding activity requires feeders and produces fed beef. The cow-calf activity produces feeders and nonfed beef. The dairy activity produces milk, feeders, and nonfed beef. The hog activity produces pork.

[3] Fed beef is the product obtained from the slaughter of cattle that have been fed high energy rations in a feedlot. Nonfed beef is the product obtained from the slaughter of cattle raised only on pasture and from cull cows and bulls.

Other classes of livestock of minor importance---those with more localized production and subject to only minor interregional shifts---are not included in the analysis. The final demand for the commodities produced by the exogenous classes of livestock is computed in the same manner as for the endogenous livestock. Production levels are computed, and the demand for inputs derived. The levels of resources available for production of endogenous crops and livestock are adjusted for the requirement of the exogenous livestock. The feed requirements for exogenous livestock production are included in the demand levels for the appropriate endogenous feed crops. The nitrogen fertilizer contribution from the animal wastes produced by the exogenous livestock is added to the available nitrogen supply after being adjusted for losses during application to the field based on present methods of handling.

Development of Technical Coefficients

Basic data sets required for the analysis include the land base, the water supplies and water use coefficients, the crop and livestock production activities, the demands for intermediate and final products, transportation activities, and agricultural prices and input costs.

Determination of the land base

The major constraint on the productive capacity of the system is the land base available for use in the production of crops. The acreages of dryland and irrigated cropland available for use by the endogenous crops, nonrotation hays, and pastures are determined for each on the nutrient requirements specified by the National Academy of Sciences [21, 22, 23]. The rations provide alternative levels of substitution among grains and between roughages and grains.[4]

Commodity Demand Sector

The commodity demand balance relationships are defined at the market region level. Demand is derived from two sources: first, the commodity demand generated within the model as one activity utilizes the product of another activity as an input into the production process; and second, the demand generated outside the model. The exogenously generated demand is represented in the model as a minimum requirement on production. Sufficient resources must be utilized in order to produce adequate quantities of the endogenous commodities to satisfy both the endogenous and exogenous demands. The exogenous demand is composed of domestic consumption of food and fiber, net exports, exogenous livestock feed requirements, and industrial and nonfood uses.

Domestic consumption

The projected demand for domestic consumption of food and fiber is obtained by multiplying projected per capita demands obtained from Meister and Nicol [9], Table 1, by the projected population reported in the OBERS projections [31]. The projected population for the

[4]As indicated in Nicol and Heady [25], various rations are included in the analysis. The nitrogen value of wastes for each class of livestock [20, 24] is adjusted for the efficiency of the handling system, the feeding time and the pattern of activity.

Table 1. Per capita demand of commodities for domestic consumption

Commodity	Unit	Quantity
Barley	bu.	.05
Corn	bu.	1.309
Oats	bu.	.212
Sorghum	bu.	-
Wheat	bu.	2.338
Oilmeal	cwt.	-0.0865[a]
Cotton	bales	.025
Beef and veal	lbs.[b]	150.7
Milk	lbs.[c]	456.6
Pork	lbs.[b]	71.5
Lamb and mutton	lbs.[b]	1.7
Turkey	lbs.[d]	12.8
Broilers	lbs.[d]	51.6
Eggs	Number	456.6

[a]Net supply, see text.

[b]Carcass weight.

[c]Fresh-milk equivalent.

[d]Ready-to-cook weight.

United States in the year 2000 is 262 million. The national demands are allocated to market regions using population "weights." No per capita consumption demand for sugar is reported. Total sugar demand, corrected for imports, is set at 39.9 million tons for 2000.

Net exports

The net export levels projected for OBERS E', Table 2, reflect the impact of the drastic change in international trade conditions during the 1971 to 1974 period. Projected export levels are significantly higher than previously projected exports, reflecting increased world demand for cereals. The high export level projections are based

Table 2. Net exports of commodities for projected normal and high export levels in the year 2000

Commodity	Unit	Exports Normal	High
		Million	
Barley	bu.	35.0	40.0
Corn	bu.	2,069.0	3,209.0
Oats	bu.	21.0	29.0
Sorghum	bu.	380.0	450.0
Wheat	bu.	919.0	1,479.0
Soybeans	bu.	1,475.0	1,700.0
Cotton	bales	4.2	4.6
Beef and veal	lbs.[a]	-2,924.0	-1,760.0
Milk	lbs[b]	-1,040.0	-1,040.0
Pork	lbs.[a]	-351.0	-351.0
Lamb and mutton	lbs.[a]	-247.0	-275.0
Turkey	lbs.[c]	80.0	80.0
Broilers	lbs.	253.0	253.0
Eggs	dz.	50.0	50.0

[a]Carcass weight.

[b]Fresh milk equivalent.

[c]Ready-to-cook weight.

on even greater demand for cereal grains as a result of increasing livestock production and consumption in the rest of the world. Grain and oilmeal exports are allocated to the market regions in the same proportion as the average export of each commodity from the major ports during the 1967 to 1969 period.

Feed for exogenous livestock and other uses

Feed requirements for sheep and lambs, turkeys, broilers, egg production, horses and mules, and other exogenous livestock are derived from the projected demands for the commodities produced by these classes of livestock. The projected demand for these livestock commodities is adjusted for export or import levels and the resulting demand is allocated to market regions on the basis of 1969 production. Market region demand is translated into feed demand by multiplying the number of units times the feed requirement of the livestock rations [19]. Miscellaneous uses such as seed production and alcholic beverages are projected by extrapolation of historical use patterns, Table 3.

Table 3. Demand of commodities for manufacturing and other uses in 2000

Commodity	Million bushels
Barley	205.7
Corn	287.1
Oats	48.5
Sorghum	15.2
Wheat	89.7
Soybeans	571.6

Exogenous oilmeal supplies

Part of the demand for oilmeal for feed is satisfied by exogenous supplies of peanut meal and linseed meal, expressed in soybean meal equivalents. A ratio relating the supply of oilmeal obtained to total production is computed based on the average of the 1968-70 period and is used to adjust the net demand for oilmeal.

Transportation Sector

Among market regions, transportation activities simulate the movement of production from surplus to deficit regions. The dual criteria for defining a market region are that the central city is a major metropolitan area and that it is a transportation center. The boundaries of the market regions are determined by the boundaries of the included producing regions.

Transportation routes are defined between each pair of contiguous consuming regions. Additional routes are defined to represent heavily used long-haul routes if they reduce the mileage by 10 percent over the accumulated short-haul routes. Two activities are defined for each commodity except hay and silage, over each route--one activity for shipment in each direction.

The cost associated with each activity is calculated by applying a uniform rate for each commodity over all routes. Ton-mile rates as functions of distance for various commodities are determined by least-squares regression from data given by the Carload Waybill Statistics [17]. The equations used in computing the rates are reported by Nicol and Heady [25].

Water Supplies

Water supplies are estimated for the 58 producing regions included in the nine river basins in the Western United States. The water supply projections include surface water, rechargeable ground water, and ground water depletion. The surface water estimates consider the physical relationship between precipitation, natural runoff, and reservoir storage. In estimating the contribution of ground water, pumping rates that are less than recharge rates are considered to be dependable supplies. Pumping rates in excess of recharge rates are dependent

upon the total availability of water in underground storage. On the basis of historical records of river discharge from the various producing regions and the relationship of reservoir storage to natural runoff in the maintenance of mean annual flow, the quantities of water indicated as available can be expected to be equaled or exceeded in 95 of every 100 years. The dependable water supply in each region, Table 4, consists of the surface water supply and that portion of ground water pumped from rechargeable aquifers. In those regions where ground water depletion is defined, the quantity of water available for depletion indicates either (a) the projected depletion rate in the year 2000, or (b) the present rate of depletion if the total water in storage as of 1975 is sufficient to maintain the present rate of depletion beyond the year 2000. In addition to the water naturally available in each region, water may be transferred between regions through natural river systems, man-made interbasin transfers, and man-made intrabasin transfers.

Agriculture is a residual water user. Nonagricultural demand for water, Table 5, must be satisfied before water can be made available for agricultural use. The dependable agricultural water supply is obtained by subtracting nonagricultural water requirements from the dependable water supply in each region. Ground water depletion is not included in the agricultural water supply but is an additional source of water which may be utilized at an additional cost. In the allocation of the agricultural water supply, the exogenous crop and livestock use, Table 5 is satisfied before any water can be allocated to crop or livestock activities included in the model. The water supplies have

Table 4. Dependable water supply and allowable ground water depletion by producing region for 2000

Producing region	Dependable supply			Allowable depletion
	Surface	Ground (1000 acre feet)	Total	
(Missouri Region)				
48	824.8	30.1	854.9	–[a]
49	3,031.0	37.9	3,068.9	–[a]
50	2,282.2	8.1	2,290.3	–[a]
51	4,901.8	124.0	5,025.8	–[a]
52	5,180.3	148.0	5,328.3	–[a]
53	791.1	152.4	943.5	–[a]
54	3,224.4	609.7	3,834.1	609.7
55	1,561.1	1,666.1	3,227.2	184.0
56	405.8	112.0	517.8	–[a]
57	2,556.8	263.6	2,820.4	–[a]
58	1,267.9	932.1	2,220.0	103.6
59	741.3	1,471.5	2,212.8	–[a]
60	5,473.0	215.4	5,688.4	–[a]
(Arkansas-White-Red)				
61	7,019.8	143.0	7,162.8	–[a]
62	685.7	169.3	855.0	–[a]
63	965.2	1,499.9	2,465.1	1,499.9
64	5,820.7	118.5	5,439.2	–[a]
65	705.1	232.2	937.3	1,896.5
66	857.5	43.0	900.5	672.2
67	16.4		16.4	333.6
68	2,328.0	257.0	2,585.0	167.7
69	5,866.6	88.0	5,954.6	–[a]
(Texas Gulf)				
70	4,158.8	177.4	4,336.2	–[a]
71	4,562.0	665.2	5,227.2	–[a]
72	23.9		23.9	1,678.0
73	2,134.6	500.0	2,634.6	1,489.6
74	29.8		29.8	713.5
75	1,417.0	347.9	1,764.9	24.9
76	1,141.3	953.1	2,094.4	–[a]

Source: [4].

[a]Ground water depletion not defined.

Table 4. (Continued)

Producing region	Dependable supply			Allowable depletion
	Surface	Ground (1000 acre feet)	Total	
(Rio Grande)				
77	318.5	679.3	997.8	–[a]
78	1,656.9	743.0	2,399.9	–[a]
79	390.0	631.5	1,021.5	–[a]
80	270.1	70.1	340.2	23.4
81	398.4	76.6	475.0	–[a]
(Upper Colorado)				
82	4,056.8	55.6	4,112.4	–[a]
83	3,218.2	452.9	3,671.1	–[a]
84	3,506.0	46.0	3,552.0	–[a]
(Lower Colorado)				
85	229.4	52.0	281.4	–[a]
86	382.3	399.2	781.5	133.1
87	1,624.0	1,531.3	3,155.3	2,866.9
(Great Basin)				
88	1,627.3	221.9	1,849.2	221.9
89	560.4	169.3	729.7	169.3
90	642.1	177.9	820.0	177.9
91	683.0	30.8	713.8	30.8
(Columbia-North Pacific)				
92	14,484.0	299.0	14,783.0	–[a]
93	13,038.6	607.3	13,645.9	–[a]
94	11,110.8	2,957.9	14,068.7	–[a]
95	14,331.3	118.9	14,450.2	–[a]
96	59,996.0	594.3	60,590.3	–[a]
97	25,023.7	171.7	25,195.4	–[a]
98	207.8	67.6	275.4	–[a]
(California-South Pacific)				
99	11,448.2	182.7	11,630.9	2,348.4
100	11,546.1	1,822.3	13,368.4	3,481.4
101	7,708.1	7,190.4	14,898.4	256.0
102	2,296.2	329.3	2,625.5	217.8
103	550.7	988.0	1,538.7	1,070.4
104	697.4	1,866.2	2,563.6	309.8
105	125.3	329.3	454.5	

Table 5. Water requirements to satisfy exogenous agricultural and nonagricultural demands by producing regions for 2000

Producing region	Exogenous agricultural	Nonagricultural demand
	(1000 acre feet)	
48	284.4	59.1
49	901.8	130.3
50	123.6	13.8
51	1,309.9	264.0
52	244.4	225.1
53	4.5	118.5
54	1,309.5	454.7
55	172.5	85.4
56	5.4	21.5
57	1.0	196.7
58	65.1	78.2
59	52.8	88.0
60	1.7	403.0
61	39.8	112.4
62	316.1	83.3
63	49.1	157.1
64	23.9	647.8
65	151.8	117.5
66	6.3	314.2
67	60.8	247.3
68	247.3	118.6
69	20.9	566.9
70	266.4	915.2
71	827.0	2,636.4
72	477.7	75.7
73	173.3	371.9
74	216.1	299.9
75	733.9	547.7
76	460.0	715.5
77	648.3	18.8
78	493.1	166.9
79	58.0	80.1
80	52.1	36.5
81	706.6	106.0
82	1,181.4	179.0
83	916.3	82.8
84	265.0	100.7

Source: [4].

Table 5. (Continued)

Producing region	Exogenous agricultural	Nonagricultural demand
	(1000 acre feet)	
85	31.4	65.4
86	284.7	290.9
87	560.2	644.2
88	556.6	1,035.4
89	161.8	120.0
90	1,570.1	137.9
91	663.0	409.4
92	597.2	141.3
93	1,820.2	526.7
94	2,858.8	172.3
95	361.6	109.1
96	264.0	1,323.1
97	21.1	450.1
98	235.3	111.8
99	386.0	294.2
100	4,576.8	621.9
101	2,029.1	911.5
102	439.8	990.7
103	676.9	245.4
104	2,310.2	2,686.5
105	299.1	63.6

been adjusted for normal conveyance losses. Hence, the supply indicates the total availability of water to farms or at the lower end of the producing region if the water is not utilized within the region of its origin.

The legal constraints incorporated into the analysis account for the quantities of water that must be delivered from the point of origin to some other location on the basis of legally binding interstate compacts, interbasin agreements, international agreements, and the existing ownership of water by agriculture under the present water right systems. Because data concerning the legal allocation of water under presently registered water rights are not available, the assumption is made that the allocation and use of water is a proxy for the ownership of water. The National Water Resource Council's estimates of the amount of water consumed by agriculture in each producing region in 1975, Table 6, are used as the best approximation of the ownership of water by agriculture. To eliminate the need for measuring return flow, all water demands are computed on the basis of consumptive use and not on the basis of withdrawal.

III. DISCUSSION AND COMPARISON OF SOLUTIONS

The impact of water rights on agricultural production is estimated by comparing four alternatives from the CARD-NSF linear programming model of the United States agricultural sector. The four alternatives represent unrestricted water allocation and water allocation under water right restrictions under each of two agricultural demand levels. Since domestic demand remains constant, the different demand levels reflect changes in export demand. The alternatives are designated to reflect demand levels under normal and high exports. Land use patterns, agricultural land rent, changes in product mix, commodity supply prices, adjustments in crop production patterns, water use, and changes in the marginal value product of water are selected as the best results for making comparisons and evaluating the impact of water rights. The unrestricted alternatives in this study will be used as the basis for comparison and for the computation of percentage changes.

Table 6. Estimated 1975 agricultural water consumption by producing region

Region	(100 acre feet)	Region	(1000 acre feet)
48	324.8	77	664.9
49	1,470.0	78	1,309.2
50	138.5	79	648.9
51	2,273.6	80	645.6
52	547.1	81	1,451.4
53	102.7	82	1,179.2
54	3,821.1	83	1,198.1
55	3,380.9	84	316.7
56	142.4	85	61.3
57	103.5	86	1,067.0
58	1,349.5	87	5,113.2
59	1,599.1	88	1,352.6
60	47.9	89	617.3
61	69.3	90	1,223.0
62	933.7	91	819.5
63	1,853.6	92	787.2
64	147.8	93	4,664.0
65	2,498.8	94	6,940.0
66	128.4	95	727.7
67	1,421.3	96	539.8
68	1,282.4	97	41.4
69	79.0	98	599.3
70	345.3	99	621.8
71	1,063.6	100	4,986.8
72	5,321.6	101	12,791.5
73	387.4	102	727.9
74	1,663.5	103	986.2
75	1,081.6	104	5,631.7
76	877.1	105	77.5

Source: [4].

Land Use Patterns

Normal export model

The water right restricted alternative requires slightly less land in production to meet the demands under normal export levels than does the unrestricted alternative, Table 7. Because pasture land is always assumed to be in use for forage, all land use adjustment occurs in cropland acreage. Dryland crop acreage is .8 percent (2.8 million acres) lower in the water right restricted option than in the unrestricted alternative. However, irrigated cropland use increases by 3.5 percent from 34.4 million acres to 35.6 million acres. Under unrestricted water conditions, 5.0 million acres of land available for irrigation is used as dryland. In the restricted alternative only 3.8 million acres of land available for irrigation is handled with dryland practices. The water right restriction alternative has 1.3 million more acres in irrigated pasture than does the unrestricted case. Even with water right restrictions, 2.5 million acres of pasture irrigated in 1975 are converted to dryland production. Under normal export demand levels, the model comparison indicates that water rights tend to slightly slow the development of new irrigated land.

Demands under normal export levels can be met without using all available cropland for crops under both the restricted and unrestricted alternatives.

Regional changes in land use patterns for normal export levels are indicated in the central and western regions. No changes in land use, cropland, dryland, dryland pasture, idle cropland

Table 7. United States agricultural land use, unused cropland, and land rent for the normal export alternative with and without water right restrictions for the year 2000

	Units	Unrestricted water allocation	Water right restrictions	Change	Percentage change
Total land use	100 ac.	1,299,664	1,298,128	-1,536	-.1
Cropland	"	360,210	358.674	-1,536	-.4
Dryland	"	325,779	323,028	-2,751	-.8
Irrigated	"	34,430	35,644	1,214	3.5
Nonirrigated[a]	"	5,010	3,833	-1,177	-23.5
Pasture land	"	939,454	939,454		
Dryland	"	934,180	932,875	-1,305	-.1
Irrigated	"	5,273	6,579	1,306	24.8
Nonirrigated[a]	"	3,852	2,547	-1,305	-33.9
Unused cropland	"	32,906[b]	34,442[c]	1,536	4.7
Dryland	"	31,286[b]	33,311[c]	2,025	6.5
Irrigated	"	1,619[b]	1,131[c]	-448	-30.1
Wetland development	"	4,729	4,729	0	0
Irrigation development	"	6,454	6,003	-451	-7.0
Total cropland rent	$1000	5,966,657	6,371,123	404,466	6.8
Dryland	"	5,171,494	5,127,086	-44,408	-.9
Irrigated	"	795,162	1,244,037	448,875	56.5
Land rent per acre	dol.	4.59	4.90	.31	6.8
Cropland	"	16.56	17.76	1.20	7.2
Dryland	"	16.12	16.06	-.06	-.4
Irrigated	"	20.16	31.51	11.35	56.3

[a] Nonirrigated refers to cropland or pasture land which is classified as irrigated but is farmed with dryland practices in this alternative solution.

[b] 8.4 percent of total cropland,
8.9 percent of nonirrigated cropland,
3.9 percent of irrigated cropland.

[c] 8.9 percent of total cropland,
9.4 percent of nonirrigated cropland,
2.8 percent of irrigated cropland.

or wetland development are indicated for either the North Atlantic region, Table 8, or the South Atlantic region, Table 9. One of the main effects of the water right restrictions is to encourage the continuation of irrigation in the developed irrigated areas of the West. When demand levels are constant and production under irrigation increases, production on dryland must decrease. The greatest impact from this substitution is in the North Central region, Table 10. Dryland cultivation is 2.1 million acres less under water right restrictions than otherwise. This results in an increase in land not used for crops from 8.7 million to 10.8 million acres. The North Central region has 27.8 percent of the nation's nonirrigated cropland not used for crops in the unrestricted option and 32.4 percent in the restricted option.

Table 8. Agricultural land use, unused cropland, and land rent in the North Atlantic region for normal and high export levels with and without water right restrictions for the year 2000

		Normal Export		High Export	
	Units	Unrestricted	Restricted	Unrestricted	Restricted
Total land use	1000 ac.	31,099	31,099	31,651	31,651
Cropland	"	12,750	12,750	13,402	13,380
Pasture land	"	18,348	18,348	18,249	18,271
Unused cropland	"	552	552	0	0
Wetland development	"	382	382	481	459
Total land rent	$1000	228,418	226,731	582,418	532,659
Land rent per acre	dol.	7.34	7.29	18.40	16.82
Cropland	"	17.91	17.78	43.45	39.80

Table 9. Agricultural land use, unused cropland, and land rent in the South Atlantic region for normal and high export levels with and without water right restrictions for the year 2000

		Normal Export		High Export	
	Units	Unrestricted	Restricted	Unrestricted	Restricted
Total land use	1000 ac.	130,791	130,791	133,124	133,124
Cropland	"	50,152	50,152	55,076	55,076
Dryland	"	50,093	50,093	55,017	55,017
Irrigated	"	59	59	59	59
Dryland pasture	"	80,639	80,639	78,047	78,047
Unused dryland		2,333	2,333	1	1
Wet land development	"	3,186	3,186	5,778	5,778
Total land rent					
Cropland	$1000	1,069,222	1,058,934	2,409,266	2,208,945
Dryland	"	1,068,770	1,058,495	2,407,331	2,207,205
Irrigated	"	451	438	1,935	1,740
Land rent per acre	dol.	8.17	8.09	18.09	16.59
Cropland	"	21.31	21.11	43.74	40.10
Dryland	"	21.33	21.13	43.75	40.11
Irrigated	"	7.59	7.37	32.54	29.25

Total cropland use in the South Central region, Table 11, decreases by only 12,000 acres under water right restrictions. However, the combination of dryland and irrigated cultivation changes drastically. Irrigated land use increases by 1.3 million acres while dryland use decreases by 1.3 million acres. This change in irrigated acreage has very little effect on the amount of unused cropland. The least-cost method of meeting demands for the unrestricted normal export option calls for the utilization of 4.5 million acres for dryland crops which were classified

Table 10. Agricultural land use, unused cropland, and land rent in the North Central region for normal and high export levels with and without water right restrictions for the year 2000

	Units	Normal Export Unrestricted	Normal Export Restricted	High Export Unrestricted	High Export Restricted
Total land use	1000 ac.	214,032	211,938	222,745	222,745
Cropland	"	138,531	136,437	150,265	150,164
Dryland	"	138,252	136,158	149,985	149,884
Irrigated	"	279	279	279	279
Dryland pasture	"	75,499	75,499	72,479	72,580
Unused dryland	"	8,713	10,807	0	0
Wetland development	"	1,160	1,160	4,180	4,079
Irrigation development	"	218	218	218	218
Total land rent					
Cropland	$1000	3,170,156	3,142,548	7,243,983	6,691,227
Dryland	"	3,153,175	3,125,534	7,223,415	6,671,024
Irrigated	"	16,980	17,014	20,567	20,202
Land rent per acre	dol.	14.81	14.82	32.52	30.03
Cropland	"	22.88	23.03	48.20	44.55
Dryland	"	22.80	22.95	48.16	44.50
Irrigated	"	60.68	60.80	73.50	72.20

as irrigated in the 1967 Conservation Needs Inventory [5]. When water right restrictions are imposed, cost minimization is attained with a shift of only 3.2 million acres to dryland crops. This difference of 1.3 million acres indicates a modest impact of water restriction on land use within the region.

The Great Plains region, Table 12, violates the trends in agricultural land use established in the other western regions and at the

Table 11. Agricultural land use, unused cropland, and land rent in the South Central region for normal and high export levels with and without water right restrictions for the year 2000

	Units	Normal Export Unrestricted	Normal Export Restricted	High Export Unrestricted	High Export Restricted
Total	1000 ac.	289,049	289,037	291,629	291,564
Cropland	"	62,652	62,640	66,219	66,153
Dryland	"	54,555	53,265	57,862	56,786
Irrigated	"	8,096	9,375	8,357	9,366
Nonirrigated[a]	"	4,458	3,174	4,419	3,352
Pasture land	"	226,396	226,396	224,423	224,423
Dryland	"	226,396	226,350	224,423	224,401
Irrigated	"		46		21
Nonirrigated[a]	"	496	450	496	475
Unused cropland	"	2,695	2,707	115	180
Dryland	"	2,505	2,505	114	148
Irrigated	"	189	201	0	32
Irrigation development	"	1,366	1,366	1,391	1,366
Total land rent					
Cropland	$1000	667,256	674,509	1,891,386	1,726,105
Dryland	"	411,902	407,743	1,326,750	1,201,465
Irrigated	"	225,354	267,065	564,636	524,640
Land rent per acre	dol.	2.30	2.33	6.48	5.92
Cropland	"	10.65	10.76	28.56	26.09
Dryland	"	8.22	8.13	24.82	22.48
Irrigated	"	20.33	21.28	44.19	41.24

[a] Nonirrigated refers to cropland pasture land which is classified as irrigated but is farmed with dryland practices.

national level. Dryland crop use increases and irrigation decreases under the water right restriction option. There is no unused irrigated land in the Great Plains region under either the restricted or unrestricted options.

Table 12. Agricultural land use, unused cropland, and land rent in the Great Plains region for normal and high export with and without water right restrictions for the year 2000

	Units	Normal Export		High Export	
		Unrestricted	Restricted	Unrestricted	Restricted
Total land use	1000 ac.	279,797	279,797	294,295	294,295
Cropland	"	68,864	68,864	83,822	83,786
Dryland	"	58,686	59,119	10,219	9,778
Irrigated	"	10,178	9,745	10,219	9,778
Nonirrigated[a]	"	122	107	122	82
Pasture land	"	210,932	210,932	210,012	210,506
Dryland	"	209,279	208,586	208,744	208,095
Irrigated	"	1,652	2,346	1,727	2,411
Nonirrigated[a]	"	1,574	881	1,500	815
Unused Dryland	"	14,497	14,497	0	0
Irrigation development	"	2,503	2,055	2,544	2,063
Total land rent					
Cropland	$1000	527,157	580,770	1,827,915	1,729,919
Dryland	"	250,581	250,767	1,312,743	1,194,046
Irrigated	"	276,576	330,002	515,172	535,873
Land rent per acre	dol.	1.88	2.07	6.21	5.87
Cropland	"	7.65	8.43	21.80	20.64
Dryland	"	4.27	4.24	17.86	16.15
Irrigated	"	26.85	33.49	49.81	54.34

In the cost minimization framework of the model, production capacity in excess of that necessary to fulfill demands is expressed as unused land resources. The unused resources occur in regions where the marginal cost of production plus transportation to points of demand is the greatest. The Great Plains region contains several marginal producing areas. At the normal export levels both restricted and unrestricted

alternatives have 14.5 million acres of unused cropland. This accounts for 44.1 percent of the unused cropland in the United States under the unrestricted option and 42.1 percent under the water right restriction.

Comparison of the results for the Northwest region, Table 3, indicates that dryland cultivation increases and irrigated land use decreases when water right restrictions are imposed. The only change in cropland utilization is an increase of 184,000 acres of irrigated land farmed with dryland practices under water right restrictions. This results in a shift of 184,000 acres from irrigation to dryland. Both options show 287,000 acres of unused dryland and no unused irrigated land. Irrigation development is one million acres under both options. Pasture increases slightly, 1.6 to 1.7 million acres, in the restricted option.

Total cropland use, dryland cultivation and irrigated land use all increase in the Southwest region, Table 14, under water right restrictions. Dryland use increases by only 16,000 acres but irrigated cropland use increases by 553,000 acres. Most of this increase results from changes in the amount of unused cropland. If water rights are in existence, irrigated pasture also is 505,000 acres larger than without the restrictions.

General shifts

Under normal export levels the following general shifts in agricultural land use are indicated by model solutions representing ongoing water rights or their absence. Land use in the eastern regions remains largely unchanged. Dryland production shifts out of the

Table 13. Agricultural land use, unused cropland, and land rent in the Northwest region for normal and high export with and without water right restrictions for the year 2000

	Units	Normal Export		High Export	
		Unrestricted	Restricted	Unrestricted	Restricted
Total land use	1000 ac.	104,852	104,852	105,139	105,139
Cropland	"	16,793	16,793	17,080	17,080
Dryland	"	10,550	10,734	10,811	10,756
Irrigated	"	6,242	6,058	6,269	6,324
Nonirrigated[a]	"	198	382	181	126
Pasture land	"	88,058	88,058	88,058	88,058
Dryland	"	86,429	86,367	86,429	86,429
Irrigated	"	1,629	1,690	1,629	1,629
Nonirrigated[a]	"	100	38	100	100
Unused dryland	"	287	287	0	0
Irrigation development	"	1,033	1,033	1,042	1,042
Total land rent					
Cropland	$1000	203,714	225,407	512,650	492,659
Dryland	"	58,630	57,449	194,043	173,172
Irrigated	"	144,787	167,957	318,606	319,486
Land rent per acre	dol.	1.94	2.14	4.87	4.68
Cropland	"	12.11	13.42	30.01	28.84
Dryland	"	5.66	5.54	18.25	16.29
Irrigated	"	22.48	26.07	49.39	49.52

[a]Nonirrigated refers to cropland or pasture land which is classified as irrigated but is farmed with dryland practices.

Table 14. Agricultural land use, unused cropland, and land rent in the Southwest region for normal and high export levels with and without water right restrictions for the year 2000

	Units	Normal Export		High Export	
		Unrestricted	Restricted	Unrestricted	Restricted
Total land use	1000 ac.	250,042	250,612	252,235	251,891
Cropland	"	10,464	11,034	12,657	12,313
Dryland	"	889	905	2,262	1,549
Irrigated	"	9,575	10,128	10,486	10,764
Nonirrigated[a]	"	231	168	503	44
Pasture land	"	239,577	239,537	239,537	239,577
Dryland	"	237,587	237,082	237,453	237,630
Irrigated	"	1,990	2,495	2,124	1,947
Nonirrigated[a]	"	1,681	1,176	1,546	1,724
Unused cropland	"	3,826	3,256	1,632	2,010
Dryland	"	2,396	2,327	1,271	1,559
Irrigated	"	1,429	929	361	450
Irrigation development	"	1,339	1,329	1,363	1,363
Total land rent					
Cropland	$1000	101,027	462,222	352,726	686,609
Dryland	"	15	664	6,029	6,410
Irrigated	"	101,011	461,557	346,696	680,198
Land rent per acre	dol.	.40	1.84	1.39	2.72
Cropland	"	9.65	41.88	27.86	55.76
Dryland	"	.02	.90	3.42	4.25
Irrigated	"	10.30	44.82	31.81	62.93

[a]Nonirrigated refers to cropland on pasture land which is classified as irrigated but is farmed with dryland practices.

North Central region as over two million acres of dryland are removed from production. Dryland production decreases in the South Central region but increases in the Great Plains, Northwest, and Southwest regions. Irrigated cropland use increases in the South Central and Southwest regions and decreases in the Great Plains and Northwest regions.

On a national basis, the decrease in total cropland devoted to crops is less than the increase in irrigated acreage. Total cropland use declines as prevailing water rights are lifted. Water rights tend to moderate shifts of land into and out of irrigation in response to short-run changes in commodity demand conditions. New irrigation development is evidently slowed down by the existing system of water right.

Because the national acreage of cropland devoted to crops decreases and regional shifts in crop production occur in response to water right restrictions, the proportion of the nation's cropland in each region changes, Figure 6. In the unrestricted water allocation option, 38.5 percent of U.S. cropland utilized is located in the North Central region, 19.1 percent in the Great Plains regions, 17.4 percent in the South Central region, 13.9 percent in the South Atlantic region, 4.7 percent in the Northwest region, 3.5 percent in the North Atlantic region, and 2.9 percent in the Southwest region.

When water right restrictions are implemented, five of the regions slightly increase their proportion of national cropland. The Southwest increases by 0.2 percent while the Great Plains, South Central, South Atlantic, and North Atlantic regions increases by 0.1 percent. The proportion in the Northwest region remains at 4.7 percent of the total. The North Central region slightly decreases its proportion. These are extremely small changes in the proportion of the nation's cropland allocated to each region as water right restrictions are in force.

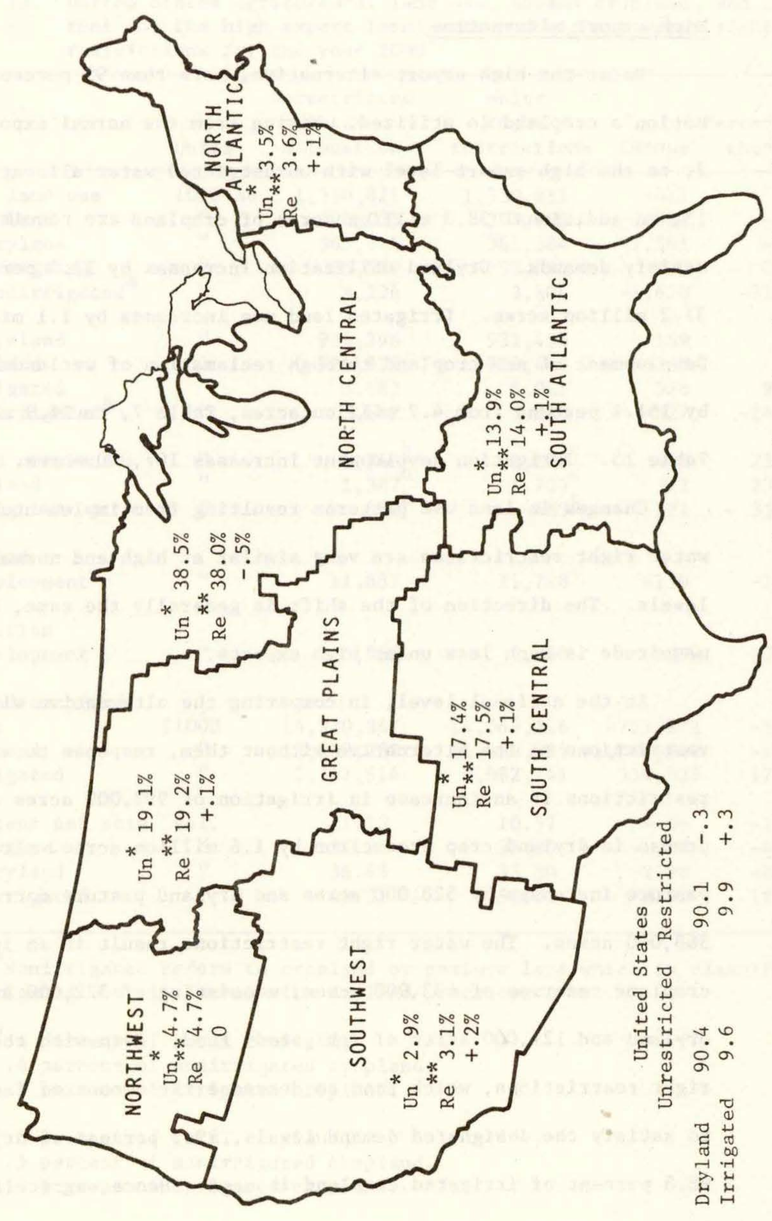

Figure 6. Proportion of national cropland utilization located in each major region and percentage change for the unrestricted water right restricted options at normal export levels (* unrestricted model, ** model with water rights restriction)

High export alternative

Under the high export alternative, more than 99 percent of the nation's cropland is utilized. Moving from the normal export, Table 7, to the high export level with unrestricted water allocation, Table 15, an additional 38.3 million acres of cropland are required to satisfy demands. Dryland utilization increases by 11.4 percent or 37.2 million acres. Irrigated land use increases by 1.1 million acres. Development of new cropland through reclamation of wetlands increases by 151.4 percent from 4.7 million acres, Table 7, to 11.9 million acres, Table 15. Irrigation development increases 107,000 acres.

Changes in land use patterns resulting from implementation of water right restrictions are very similar at high and normal exports levels. The direction of the shift is generally the same, but the magnitude is much less under high exports.

At the national level, in comparing the alternative with right restrictions to the alternative without them, response to water right restrictions is an increase in irrigation of 992,000 acres and a decrease in dryland crop produciton by 1.6 million acres. Irrigated pasture increases by 528,000 acres and dryland pasture decreases by 368,000 acres. The water right restrictions result in an increase in cropland reserves of 433,000 acres, consisting of 322,000 acres of dryland and 121,000 acres of irrigated land. Even with the water right restrictions, which tend to decrease the amount of land required to satisfy the designated demand levels, 99.5 percent of dryland and 98.8 percent of irrigated cropland is used. Hence, agriculture

Table 15. United States agricultural land use, unused cropland, and land rent for the high export level with and without water right restrictions for the year 2000

	Units	Unrestricted water allocation	Water right restrictions	Change	Percentage change
Total land use	1000 ac.	1,330,821	1,330,411	-411	.0
Cropland	"	398,525	397,956	-569	-.1
Dryland	"	362,945	361,384	-1,561	-.4
Irrigated	"	35,579	36,571	992	2.8
Nonirrigated[a]	"	5,226	3,606	-1,620	-31.0
Pastureland	"	932,296	932,455	159	.0
Dryland	"	926,812	926,444	-368	.0
Irrigated	"	5,483	6,011	528	9.6
Nonirrigated[a]	"	3,642	3,115	-527	-14.5
Unused cropland	"	1,749[b]	2,192[c]	443	25.3
Dryland	"	1,387[b]	1,709[c]	322	23.2
Irrigated	"	362[b]	483[c]	121	33.4
Wet land development	"	11,887	11,728	-159	-1.3
Irrigation development	"	6,561	6,054	-507	-7.7
Totland cropland rent	$1000	14,820,347	14,068,126	-752,221	-5.1
Dryland	"	13,052,732	11,958,984	-1,066,748	-8.2
Irrigated	"	1,767,614	2,082,141	314,527	17.8
Land rent per acre	dol.	11.13	10.57	-.56	-5.0
Cropland	"	37.18	35.35	-1.83	-4.9
Dryland	"	36.48	33.50	-2.98	-8.2
Irrigated	"	43.31	51.82	8.51	19.6

[a] Nonirrigated refers to cropland or pasture land which is classified as irrigated but is farmed with dryland practices.

[b] .4 percent of total cropland,
.4 percent of nonirrigated cropland,
.9 percent of irrigated cropland.

[c] .6 percent of total cropland,
.5 percent of nonirrigated cropland,
1.2 percent of irrigated cropland.

produces at full capacity in the sense of using all cropland. This does not imply that the United States would be within 1 percent of its ultimate or total capacity since it is possible to intensify production on the given land base. Also, additional land could be converted to cropland.

Land use adjustments occur in all regions as exports are increased from normal to high levels. In the North Atlantic region, Table 8, all available cropland is utilized and 1,000 acres of wetland is converted to cropland. The South Atlantic region, Table 9, increases land in crops by 4.9 million acres through the cultivation of 2.3 million acres not cropped at normal demand levels plus development of 2.6 million acres of wetland. Only 1,000 acres of cropland remains unused for crops. The North Central region, Table 10, increases cropland by 11.7 million, including wetland reclamation of 3 million acres. Unused cropland does not prevail in the North Central region under either the restricted or unrestricted alternatives. The high export alternative with water right restrictions utilizes 1,000 acres less cropland than the unrestricted option. (Wetland development decreases by 100,000 acres.)

Higher export levels result in an increase in both dryland and irrigated cropland use in the South Central region, Table 11. Dryland use increases by 3.3 million acres and irrigated cropland use increases by 261,000 acres. These shifts are accomodated by wetland development of 986,000 acres and a slight increase in irrigation development. Water right restrictions imposed under the high export alternative cause a

decrease of 1.1 million acres in dryland use and an increase of one million acres of irrigated cropland use. Wetland development remains constant, and irrigation development decreases by 25,000 acres.

In the Great Plains region, Table 12, larger exports have greater impact on dryland use. Cropped dryland increases by 14.9 million acres as all unused cropland is put into production. In addition, 459,000 acres of cropland are reclaimed from wetlands and 41,000 acres of irrigation development occurs. Water right restrictions under high exports bring about an increase in dryland use and a decrease in irrigated cropland. Wetland development decreases from 450,000 acres in unrestricted alternative to 424,000 acres under water right restrictions.

High export levels cause only small land use changes in the Northwest region, Table 13. Both dryland cultivation and irrigated cropland increases. Irrigation development also increases by 7,000 acres and all available cropland is utilized. The only major adjustment occurring at the high export level when water right restrictions are imposed is a shift of 55,000 acres from dryland to irrigated cropland use.

Comparing the unrestricted options under normal and high exports indicates that an additional 38.3 million acres of cropland must be brought into production to satisfy demands at high export levels. The Great Plains region increases cropland by 14.9 million acres, 38.9 percent of the national total. The North Central region increases by 11.7 million acres or 30.6 percent of the national total. Hence, the two regions account for 79.5 percent of the increase in cropland utilization required to satisfy demand at high export levels. The cropland increases in other regions thus are relatively modest as demand moves from the normal to the high export levels.

The distribution of increased cropland under high exports is not the same as the land utilization pattern existing under the normal export level alternative. Comparison of the regional distribution of the nation's cropland under unrestricted water allocation at normal and high export levels, Figures 6 and 7, indicates that two regions, the Great Plains and the Southwest, increase somewhat in relative importance as water right restrictions are removed.

Agricultural Land Rent

The rents reported for the United States and its major zones are weighted averages of the imputed values or shadow prices on land. Rent on cropland includes all dryland and irrigated cropland. Rent on dryland is the weighted average rent on land defined as dryland and land placed in cultivation through wetland development. Rent on irrigated land is the weighted average of the rent on all land that is defined as irrigated cropland. This includes land that is used in the production of irrigated crops, land which can be irrigated but is farmed with dryland practices, and land made available for irrigation through irrigation development. The acreage of irrigated land that is cultivated with dryland practices is included in the dryland acreage computation whereas the rent accruing to this land is included in the computation of rent on irrigated land.

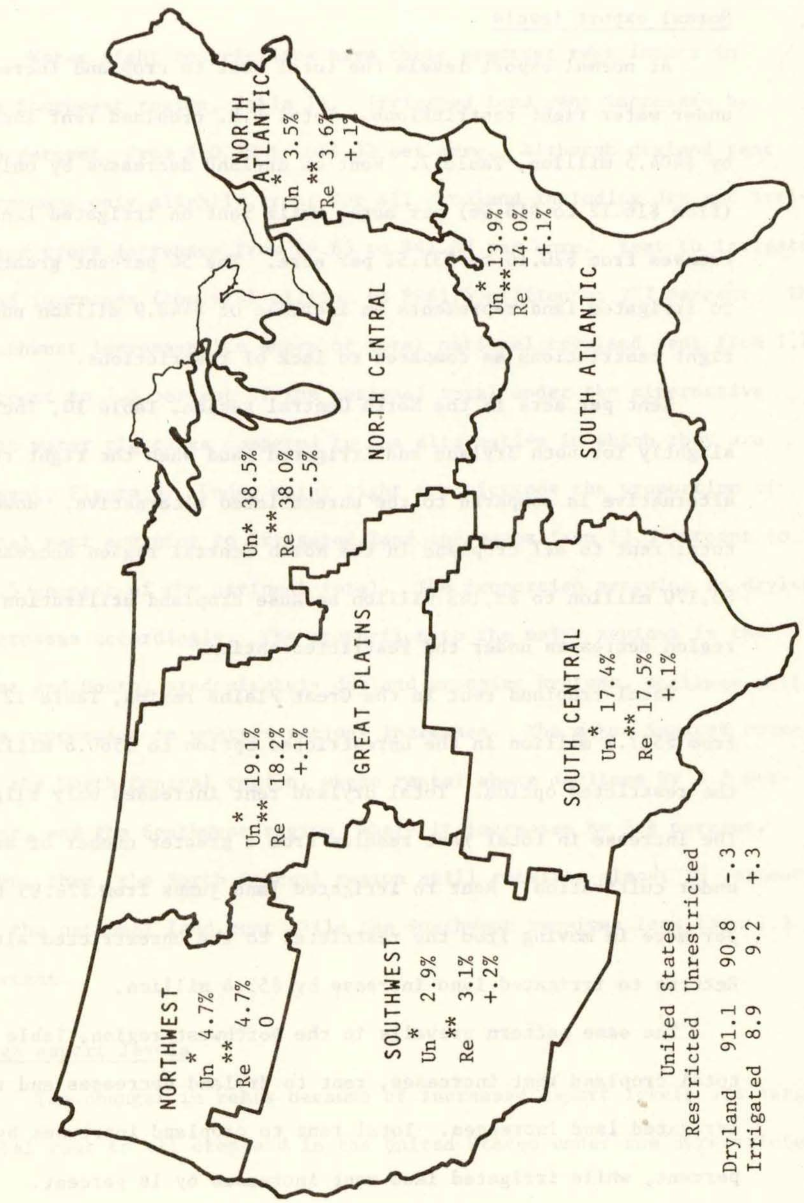

Figure 7. Proportion of national cropland utilization located in each major region and percentage change for the unrestricted and water right restricted options at high export demand levels (* unrestricted model, ** model with water rights restriction)

Normal export levels

At normal export levels the total rent to cropland increases under water right restrictions. Total U.S. cropland rent increases by $404.5 million, Table 7. Rent on dryland decreases by only $.06 (from $16.12 to $16.06) per acre, while rent on irrigated land increases from $20.16 to $31.51 per acre. The 56 percent greater rent to irrigated land represents an increase of $448.9 million under water right restrictions as compared to lack of restrictions.

Rent per acre in the North Central region, Table 10, increases slightly for both dryland and irrigated land when the right restrained alternative is compared to the unrestricted alternative. However, total rent to all cropland in the North Central region decreases from $3,170 million to $3,143 million because cropland utilization in the region decreases under the restricted option.

Total cropland rent in the Great Plains region, Table 12, increases from $527.2 million in the unrestricted option to $580.8 million in the restricted option. Total dryland rent increases only slightly. The increase in total rent results from a greater number of acres under cultivation. Rent to irrigated land jumps from $26.85 to $33.49 per acre in moving from the restricted to the unrestricted alternative. Returns to irrigated land increase by $53.4 million.

The same pattern prevails in the Northwest region, Table 13. The total cropland rent increases, rent to dryland decreases and rent to irrigated land increases. Total rent to cropland increases by 11 percent, while irrigated land rent increases by 16 percent.

Water right restrictions have their greatest rent impact in the Southwest region, Table 14. Irrigated land rent increases by 335 percent, from $10.30 to $44.82 per acre. Although dryland rent increases only slightly, rent for all cropland including dry and irrigated crops increases from $9.65 to $41.88 per acre. Rent to irrigated land increases from $101 million to $461.6 million or 357 percent. The Southwest increases its share of total national cropland rent from 1.7 percent to 7.3 percent of the national total under the alternative with water rights as compared to the alternative in which they are absent, Figure 8. Under water right restrictions the proportion of total rent accruing to irrigated land increases from 13.3 percent to 19.5 percent of the national total. The proportion accruing to dryland decreases accordingly. The proportion to the major regions in the East and South, predominately dryland cropping systems, declines while the proportion in western regions increases. The major impacts occur in the North Central region, where rental share declines by 3.8 percent, and the Southwest region, where it increases by 5.6 percent. Even, then, the North Central region still receives almost 50 percent of the national land rent while the Southwest receives less than 7.5 percent.

High export levels

The changes in rents because of increased export levels are large. Total rent to all cropland in the United States under the unrestricted

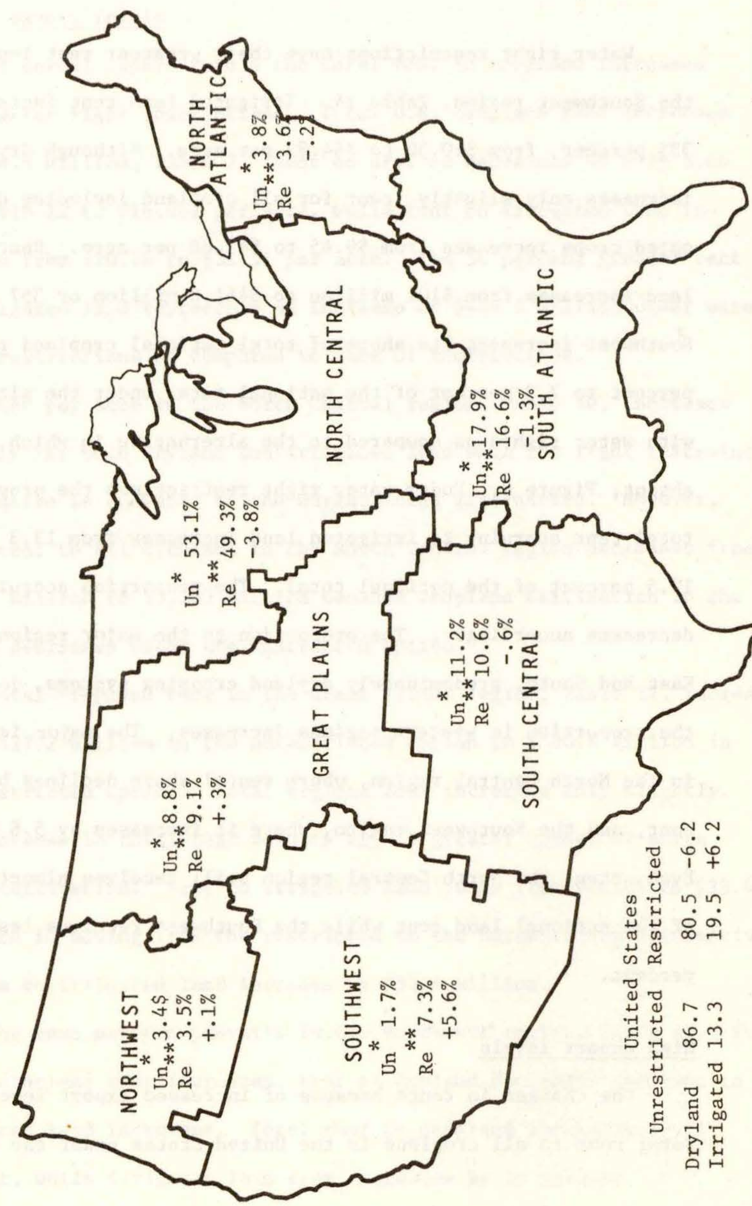

Figure 8. Proportion of national land rent accruing to cropland in each major region and percentage change for the unrestricted and water right restricted options at normal export levels (* unrestricted model, ** model with water right restriction)

alternative increases by $8.853.7 million or 148 percent because of greater exports, Tables 7 and 15. Rent to dryland increases 152 percent (from $5,171.5 million to $13,052.7 million) and to irrigated cropland by 122 percent, from $795.2 million to $1,767.6 million. Rent per acre of dryland increases by $20.36 per acre, and irrigated cropland rent increases by $23.15 per acre. Although the absolute change for irrigated land is greater, the percentage change is greater than for dryland. Dryland cultivation is more responsive to changes in export demand levels than irrigated cropland because it moves in and out of production of different crops with more flexibility than does irrigated land.

Under water right restrictions, high export levels produce effects different from those for normal export levels. With high exports, total irrigated cropland rent increases by 17.8 percent and dryland rent decreases by 8.2 percent in response to the water right restrictions. The decrease for the latter more than offsets the increase in rent for irrigated land. Rent on a per acre basis follows the same pattern as total rent. Irrigated cropland rent increases by 19.6 percent. At the high export level, the absence of water right restrictions allows the water to move where its marginal value productivity is greatest in meeting the higher demands.

Aggregate cropland rent in the North Central region under the unrestricted option, Table 12, increases by 128 percent for the high as compared to normal exports. Of course, dryland rent accounts for most of the region's rent received. Dryland rent per acre increases 111 percent while that for irrigated land increases 21 percent.

When water right restrictions are imposed under high exports, as compared to absence of restrictions, rent to both dryland and irrigated land declines in the North Central region. Aggregate dryland rent decreases by 7.6 percent and irrigated land rent declines by 1.8 percent. Rent accruing to all cropland decreases by 7.6 percent.

Shifting from the normal to the high export demand levels bring large increases in land returns for the Great Plains region, Table 12. Dryland rents increase by 423 percent while irrigated cropland increases by 86 percent. With exports at high levels, in both cases the imposition of water right restrictions, as compared to their absence, causes a redistribtuion of land rents between dryland and irrigated cropland. Rent to dryland decreases by 9 percent while the rent to irrigated cropland increases by 4 percent.

With water right restrictions in effect in both cases, a move up from normal to high exports increases rents to dryland and irrigated cropland in the Northwest region, Table 13. Rent to dryland increases by 231 percent and to irrigated cropland by 120 percent. With high exports in both cases, imposition of water right restrictions, as compared to no restrictions, brings a rent distribution similar to that in the Great Plains region. The aggregate return to dryland decreases by 10.8 percent while the total rent to irrigated land

increases by 0.3 percent. The total return to all cropland decreases by 3.9 percent.

Land rents in the Southwest region, Table 14, also increase as export demand levels increase. Comparing the normal export level and high export level under the unrestricted water allocation, total rent to all cropland increases by 249 percent with the higher exports. Aggregate dryland rent increases by $6 million and rent to irrigated land increases by 243 percent. Irrigated cropland rent increases by 208 percent per acre. The effect of water right restrictions on the Southwest region is unique. When water right restrictions are imposed under the high export level option, aggregate land rents and rents per acre for dryland and irrigated cropland increase. Total rent increases 94 percent for cropland--6.3 percent for dryland and 96 percent for irrigated land.

As exports move from the normal to the high level, total U.S. cropland rent increases by $8,537 million. This increase is not evenly distributed among all regions. The North Central region receives 46 percent of the total increase, the South Atlantic region 15 percent, the Great Plains region 15 percent, the South Central region 14 percent, the North Atlantic region 4 percent, the Northwest region 4 percent, and the Southwest region 3 percent. As exports move from the normal to the high level, the distribution of total returns to cropland changes among region. Imposition of water right restrictions under high exports causes an additional shift in the distribution of the national land rent among regions, Figure 9. The regional share of

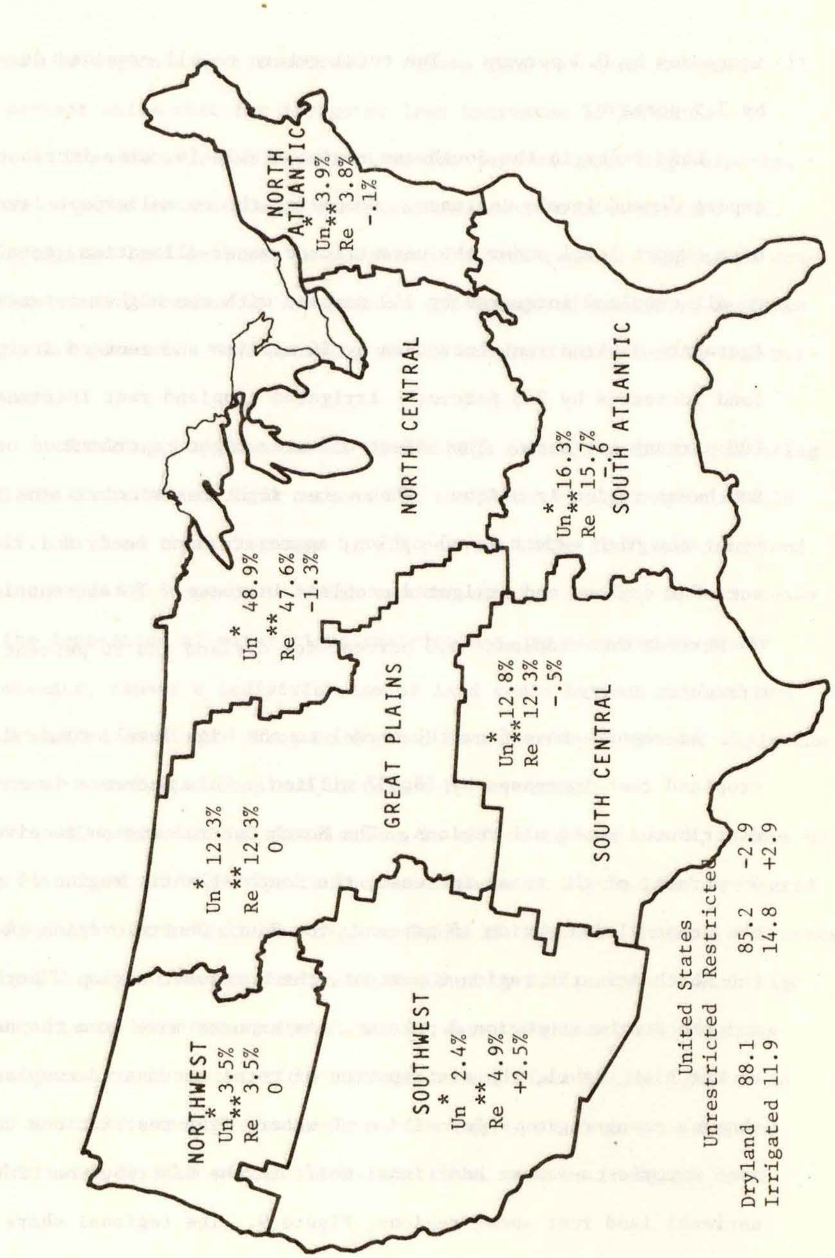

Figure 9. Proportion of national land rent accruing to cropland in each major region and percentage change for the unrestricted and water right restricted options at high export levels (* unrestricted model, ** model with water rights restriction)

aggregate rent decreases in the North Central, South Atlantic, South Central, and North Atlantic regions. The Great Plains and the Northwest regions have the same proportion of the national cropland rent as under absence of water right restrictions. Only the Southwest increases its share of the nation's aggregate land rent under water right restrictions. Even with these shifts, the North Central region still has over 47 percent of the nation's total cropland rent while the Southwest has less than 5 percent.

Commodity Mix

Production levels and commodity mixes are affected by both water right restrictions and export levels. Production levels under normal exports with unrestricted water allocation, Table 16, are used as a basis for comparison. Production levels under high export demands, Table 17, are compared with those for normal exports, Table 16, to indicate relative shifts in production with increases in export demand. The impact of water right restrictions is evaluated for both normal and high exports.

Impact of water right restrictions

Water right restrictions have an impact on most commodities produced under normal exports, Table 18. Production of corn, sorghum, legume hay, pasture, and nonfed beef increases while production of barley, oats, wheat, oilmeal, nonlegume hay, silage, feeders, and fed beef decline.

Table 16. Production of commodities produced endogenously under normal export alternative with unrestricted water allocation and with water right restrictions for year 2000

Commodity	Unit	Unrestricted water allocation	Water right restrictions
		(000 units)	
Corn	bu.	6,747,181	6,763,184
Sorghum	bu.	897,497	905,846
Barley	bu.	374,856	369,832
Oats	bu.	208,260	207,612
Wheat	bu.	1,671,952	1,669,897
Oilmeals	cwt.	1,763,599	1,760,963
Legume hay	tons	77,257	81,109
Nonlegume hay	tons	163,090	162,425
Silage	tons	753,218	739,074
Pasture	tons	150,321	150,819
Cotton	bales	10,767	10,767
Sugar beets	tons	39,908	39,908
Pork	cwt.	184,077	184,077
Milk	cwt.	1,187,534	1,187,534
Feeders	head	51,758	51,742
Fed beef	cwt.	308,021	307,926
Nonfed beef	cwt.	58,114	58,209
Fed-nonfed[a]	cwt.	65,471	65,376

[a]Indicates the amount of the demand for nonfed beef that is satisfied by the production of grain-fed cattle.

The change in production mix in response to the imposition of water right restrictions at high export demand levels, Table 17, is much different than the response at the lower export levels. Production of corn, oilmeal, nonlegume hay, pasture, and nonfed beef,

Table 16. Production of commodities produced endogenously under normal export alternative with unrestricted water allocation and with water right restrictions for year 2000

Commodity	Unit	Unrestricted water allocation	Water right restrictions
		(000 units)	
Corn	bu.	7,854,936	7,863,476
Sorghum	bu.	868,455	867,118
Barley	bu.	345,013	345,013
Oats	bu.	178,937	178,937
Wheat	bu.	2,229,897	2,229,897
Oilmeals	cwt.	1,862,981	1,873,132
Legume hay	tons	84,164	82,134
Nonlegume hay	tons	154,845	155,710
Silage	tons	812,821	811,804
Pasture	tons	148,473	148,746
Cotton	bales	11,163	11,163
Sugar beets	tons	39,908	39,908
Pork	cwt.	184,077	184,077
Milk	cwt.	1,187,534	1,187,534
Feeders	head	53,509	53,502
Fed beef	cwt.	318,502	318,465
Nonfed beef	cwt.	59,273	59,310
Fed-nonfed[a]	cwt.	65,476	65,439

[a]Indicates amount of demand for nonfed beef that is satisfied by production of grain-fed cattle.

increases while the production of sorghum, legume hay, silage, feeders, and nonfed beef decline in response to the water right restrictions.

Impact of increased export demand

When high exports prevail with the unrestricted water alternative, production of corn, wheat, oilmeal, legume hay, silage, cotton, feeders,

Table 18. Changes in production and national commodity mix in response to the imposition of water right restrictions and the increase in export demand levels for the year 2000

Commodity	Unit (1000)	Base: normal export unrestricted	Response to water right restrictions	Response to increase in export demand levels	Response to water right restrictions at high export levels
Corn	bu.	6,747,181	+16,003	+1,107,755	+8,540
Sorghum	bu.	897,497	+8,349	-29,042	-1,337
Barley	bu.	374,856	-5,024	-29,843	00
Oats	bu.	208,260	-648	-29,323	00
Wheat	bu.	1,671,952	-2,055	+557,945	00
Oilmeal	cwt.	1,763,599	-2,636	+99,382	+10,151
Legume hay	tons	77,257	+3,852	+6,907	-2,030
Nonlegume hay	tons	163,090	-665	-8,245	+865
Silage	tons	753,218	-14,144	+59,603	-1,017
Pasture	tons	150,321	+498	-1,848	+273
Cotton	bales	10,767	0	+396	00
Sugar beets	tons	39,908	0	0	00
Pork	cwt.	184,077	0	0	00
Milk	cwt.	1,187,534	0	0	00
Feeders	head	51,758	-16	+1,751	-7
Fed beef	cwt.	308,021	-95	+10,481	-37
Nonfed beef	cwt.	58,114	+95	+1,159	+37
Fed-nonfed beef	cwt.	65,471	-95	+5	-37

fed beef, and nonfed beef increases, Table 18. Production of sorghum, barley, oats, nonlegume hay, and pasture declines. Sugar beets, pork, and milk production remain unchanged.

Changed domestic commodity use is apparent under higher exports, Table 19. When corn supplies are adjusted to reflect the 1,140 million bushel increases in exports, domestic utilization of corn decreases by 32.2 million bushels. Production of feeders, fed beef, and nonfed

Table 19. Adjustments in production level, commodity mix, export demand, and net adjustment in commodity use in response to increased exports

Commodity	Unit (millions)	Change in production	Increase in export demand	Net adjustment in domestic commodity use
Corn	bu.	+1,107.8	1,140.0	-32.2
Sorghum	bu.	-29.0	70.0	-99.0
Barley	bu.	-29.8	5.0	-34.8
Oats	bu.	-29.3	8.0	-37.3
Wheat	bu.	+557.9	560.0	-2.1
Oilmeals	cwt.	+99.4	106.1	-6.7
Legume hay	tons	+6.9	0	+6.9
Nonlegume hay	tons	-8.2	0	-8.2
Silage	tons	+59.6	0	+59.6
Pasture	tons	-1.8	0	-1.8
Cotton	bales	+0.4	0.4	00
Sugar beets	tons	00	0	00
Pork	cwt.	00	0	00
Milk	cwt.	00	0	00
Feeders	head	+1.8	0	+1.8
Fed beef	cwt.	+10.5	0	+10.5
Nonfed beef	cwt.	+1.2	11.6[a]	+1.2

[a]Corresponds to a decrease in imports of beef and veal.

beef increases to compensate for reduced imports of beef. Among crops, only legume hay and silage production show a net gain in domestic use when exports are at high levels.

Total Production Costs

This analysis indicates that as more restrictions are placed on an economic system the system becomes less efficient. Excluding returns to land and water, production costs for satisfying total demands for the endogenous commodities are greater under water right restricted solutions than under unrestricted conditions. National production costs for normal export levels are $33.2 billion in the unrestricted solution and $34.1 billion in the water right restricted solution. At high export levels the production costs are $36.6 billion for the unrestricted solution and $37.5 billion for the water right restricted solution.

Water Use

Agricultural and nonagricultural water uses are computed only for those areas included in the nine river basins of the West. In the model specifications, water for municipal, industrial, recreation, fish and wildlife, electricity, and exogenous crop and livestock uses is fixed. These uses must be satisfied before water is available for the agricultural activities. In this context, agricultural activities are residual water users. Endogenous agricultural activities compete with each other for water but do not compete with exogenous crop and livestock uses or nonagricultural uses.

Although pasture production is exogenous, the model has the alternative of using water on irrigated pasture land in the production of roughage or of releasing this water for use by the endogenous activities. The three areas of water use that can vary are endogenous crop and livestock use and exogenous roughage use. The changes in consumptive use of water under the four model alternatives, Table 20, occur in these three categories.

Table 20. Total consumptive use (acre feet) and marginal value product of water for normal and high export levels with and without water right restrictions[a] for the year 2000

Demands	Normal Exports: Unrestricted water allocation	Normal Exports: Water right restrictions	High Exports: Unrestricted	High Exports: Water right restrictions
	(1000)			
Endogenous				
Crops	55,077	61,922	59,056	64,422
Livestock	1,894	1,877	1,953	1,946
Total	56,971	63,799	61,009	66,368
Exogenous				
Crops	16,445	16,445	16,445	16,445
Roughage	9,973	13,402	10,726	12,102
Livestock	59	59	59	59
Total exogenous agriculture	26,477	29,906	27,230	28,606
Total agriculture	83,448	93,705	88,239	94,974
Nonagricultural use	22,187	22,187	22,187	22,187
Total	105,635	115,892	110,426	117,161
Interregional transfer of water	7,827	12,802	7,983	12,775
Marginal value product (per acre-foot)	$11.92	$8.58	$12.71	$10.73

Agricultural water use adjustments

Water consumption in agriculture increases in response to both greater exports and water right restrictions. Under high exports, agriculture consumes 4.8 million acre-feet more of water than under normal exports, Table 20. This increase is allocated 4.0 million acre-feet to endogenous crops, 0.06 million acre-feet to livestock use and 0.8 million acre-feet to roughage on pasture land.

Under water right restrictions, agricultural water use increases for both normal and high exports. Under normal exports, total agricultural water consumption increases by 10.3 million acre-feet as compared to absence of restrictions. Consumption by endogenous crops increases by 6.8 million acre-feet and irrigated pasture by 3.4 million acre-feet. Livestock use decreases slightly. The same pattern prevails under high export levels but the magnitude of the shifts is lower. As compared to lack of restrictions, agricultural water consumption increases by 6.7 million acre-feet or 7.6 percent in response to imposition of water right restrictions at the high export demand levels. When export levels increase, water consumption for most of the crops increases, Table 21 and 22.

More water is used in the production of forages than in any other category of crops, Table 22. Under unrestricted water allocation at normal export levels, sorghum silage consumes 25 percent of all the water consumed by agriculture, Table 23, legume hay consumes 21 percent and pasture 12 percent. Water right restrictions result in a decrease in the proportion of water committed to the production of the small grain crops. On the other hand, water right restrictions increase the proportion of water allocated to production of high input-high profit crops such as cotton and sugar beets as compared to lack of water right restrictions. When evaluated on the basis of changes in the proportion of agricultural water used, the individual crops most responsive to water right restrictions are legume hay, pasture, cotton, corn silage, sorghum silage and wheat. The proportion of water used by legume hay, pasture,

Table 21. Water use by endogenous crops and livestock for normal export levels with and without water right restrictions for the year 2000

	Unrestricted water allocation	Water right restrictions	Change[a]	Change[a]
	(1000 acre-feet)			
Crops				
Barley	949	822	-127	-13.4
Corn	1,174	1,413	239	20.4
Corn silage	4,458	4,024	-434	-9.7
Cotton	2,919	4,507	1,588	54.4
Legume hay	17,549	21,776	4,227	24.1
Nonlegume hay	0	305	305	∞
Oats	249	239	-10	-4.0
Pasture	9,992	13,422	3,430	34.3
Sorghum	1,776	1,529	-247	-13.9
Sorghum silage	20,966	22,631	1,665	7.9
Soybeans	983	822	-161	-16.4
Sugar beets	0	136	136	∞
Wheat	4,049	3,713	-336	-8.3
Livestock				
Beef cows	1,161	1,162	1	.1
Beef feeding	597	577	-20	-3.3
Dairy	89	89	1	
Hogs	46	47	1	2.2

[a]From unrestricted to restricted.

and cotton increases, while the proportion used by corn silage, sorghum silage, and wheat decrease by the largest amounts.

Sources of Agricultural Water Supplies

An individual farmer can obtain his water supply from several sources. Water may be obtained from local dependable supplies such as streams,

Table 22. Water use by endogenous crops and livestock for the high export options with and without water right restrictions for the year 2000

	Unrestricted water allocation	Water right restrictions	Absolute change[a]	Percentage change[a]
	(1000 acre-feet)			
Crops				
Barley	565	569	4	.7
Corn	1,565	1,784	214	14.0
Corn silage	4,735	4,647	-88	-1.9
Cotton	3,015	4,647	1,632	54.1
Legume hay	20,453	23,209	2,756	13.5
Nonlegume hay	33	319	286	866.7
Oats	206	206		
Pasture	10,726	12,102	1,376	12.8
Sorghum	2,004	1,703	-301	-15.0
Sorghum silage	20,872	21,947	1,075	5.2
Soybeans	998	825	-173	-17.3
Sugar beets	322	386	64	19.9
Wheat	4,282	4,142	-140	-3.3
Livestock				
Beef cows	1,180	1,184	4	.3
Beef feeding	638	628	-10	-1.6
Dairy	93	93		
Hogs	41	40	-1	-2.4

reservoirs, and rechargeable ground water aquifiers which are fed by precipitation originating in that area. Water may be transferred from other areas by natural river flow. Man-made intrabasin transfers through canals and water coveyance structures that do not follow natural drainage systems are a potential source of supply, and interbasin transfers from one river basin to another through man-made structures provide another

Table 23. Percentage of total agricultural water consumption, by crop and livestock class, for normal and high export levels with and without water right restrictions for the year 2000

Crop or livestock class	Normal Exports: Unrestricted Water allocation	Normal Exports: Water right restrictions	High Exports: Unrestricted water allocation	High Exports: Water right restriction
	(percentage)			
Barley	1.1	0.9	0.6	0.6
Corn	1.4	1.5	1.8	1.9
Corn silage	5.3	4.3	5.4	4.9
Cotton	3.5	4.8	3.4	4.9
Legume hay	21.0	23.2	23.2	24.4
Nonlegume hay	0	0.3	0	0.3
Oats	0.3	0.3	0.2	0.2
Pasture	12.0	14.3	12.2	12.7
Sorghum	2.1	1.6	2.3	1.8
Sorghum silage	25.1	24.2	23.7	23.1
Soybeans	1.2	0.9	1.1	0.9
Sugar beets	0	0.1	0.4	0.4
Wheat	4.8	4.0	4.9	4.4
Beef cows	1.4	1.2	1.3	1.2
Beef feeding	0.7	0.6	0.7	0.7
Dairy	0.1	0.1	0.1	0.1
Hogs	0.1	0.1	0.0[a]	0.0
Exogenous crops	19.7	17.5	18.6	17.3
Exogenous livestock	0.0[a]	0.0[a]	0.0[a]	0.0[a]

[a]Less than 0.1 percent.

source of water. Ground water can also be pumped from underground aquifers in excess of the recharge rate until the reserve supplies are exhausted.

Under normal export demand levels and the unrestricted water allocation, 85.1 million acre-feet of water are needed to satisfy agricultural needs and to provide for conveyance losses, Table 24. Of this total 86.2 percent comes from local dependable sources, 3.4 percent from natural intrabasin transfers, 2.6 percent from man-made intrabasin transfers, 2.8 percent from interbasin transfers, and 5 percent from ground water depletion. When water right restrictions are imposed, the total water requirement for agricultural use and for the fulfillment of legally binding interstate compacts and international treaties increases by 14.1 percent to 97.2 million acre-feet. Seventy-eight and four-tenths percent of this is obtained from local dependable sources, 2.1 percent comes from natural intrabasin transfers, 1.6 percent from man-made intrabasin transfers, 9.2 percent from interbasin transfers, and

Table 24. Total agricultural water use and source of water supply for normal export option with and without water right restrictions for the year 2000

	Unrestricted water allocation	Water right restrictions	Absolute change	Percentage change
	(1000 acre-feet)			
Total agricultural water requirement	85,148[a]	97,195[a]	12,047	14.1
Source of supply				
Local dependable source	73,359	76,193	2,834	3.9
Natural intrabasin transfers	2,935	2,079	-856	-29.2
Man-made intrabasin transfers	2,256	1,526	-730	-32.4
Interbasin transfers	2,370	8,930	6,560	276.8
Ground water depletions	4,226	8,466	4,240	100.3

[a]Includes conveyance losses on interregional transfers.

and 8.7 percent comes from ground water depletion. Interbasin transfers, ground water depletions, and local dependable supplies play a much more important role under water right restrictions than they do when water allocation is unrestricted. Natural and man-made intrabasin transfers become less important.

The increase in interbasin transfers can be traced to the implementation of the required deliveries from the Upper Colorado Basin to the Lower Colorado and California basins. The increase in ground water depletion stems largely from the assumptions used in formulating the model alternatives. In the alternative with water right restrictions, a cost is associated with the cessation of irrigation and conversion of the land to dryland farming. A rational operator will continue to use ground water even from depletion as long as it is more profitable to use the water than to retire the land from irrigation. This retirement cost is not binding in the alternative without water right restrictions. The intrabasin transfers decrease in magnitude under water right restrictions. The water is utilized in the areas where the supplies were first developed and the water has been used historically. However, in the absence of water right restrictions water is transferred to other locations where its marginal value productivity under current practices is higher.

Under high export demand levels and unrestricted water allocation, 90 million acre-feet of water are required to meet agricultural demands and conveyance losses, Table 25. Of this total, 77.4 million acre-feet, or 86.1 percent, is obtained from local dependable supplies. Natural

Table 25. Total agricultural water use and source of water supply for the high export option with and without water right restrictions for the year 2000

	Unrestricted water allocation	Water right restrictions	Absolute change	Percentage change
	(1000 acre-feet)			
Total agricultural water requirement	89,977	98,417[a]	8,440	9.4
Source of supply				
Local depandable source	77,426	77,395	-31	.0
Natural intrabasin transfers	2,826	2,079	-747	-26.4
Man-made intrabasin transfers	2,880	1,529	-751	-32.9
Interbasin transfers	2,611	8,899	6,288	
Ground water depletions	4,832	8,513	3,681	76.2

[a]Includes conveyance losses on interregional transfers.

intrabasin transfers contribute 3.1 percent, man-made intrabasin transfers 2.5 percent, interbasin transfers 2.9 percent, and ground water depletions contribute 5.4 percent. The water requirement increases by 8.4 million acre-feet or 9.4 percent in response to imposition of water right restrictions at the high export levels. Interbasin transfers and ground water depletions become more important as sources of water supplies. Natural and man-made intrabasin transfers decline in importance. Local dependable sources supply 76.6 percent, natural intrabasin transfers 2.1 percent, and man-made intrabasin transfers 1.6 percent under high exports and water right restrictions. Interbasin transfers supply 9 percent and ground

water depletions 8.6 percent of the total water requirement under water restrictions at high export demand levels.

Regional adjustments

Only a small amount of irrigated land for use by endogenous crops is defined in the South Atlantic region. Water use in this region increases slightly in response to high export levels but is not responsive to water right restrictions. In the North Central region only one producing area contains irrigated land. Water use in this area also declines slightly in response to an increase in export levels but does not respond to water right restrictions. The entire agricultural water requirement is satisfied from local dependable sources.

In the South Central region water requirements increase by 43 percent in response to increased export demand and 15.6 percent and 11.9 percent in response to water right restrictions at normal and high export demand levels, respectively. The amount of water obtained from dependable surface sources and from natural transfers does not respond to the additional demand. Because only 29.4 percent of the dependable water supply in the region is utilized, the problem of unequal distribution within a major region is well illustrated. The excess water is not available elsewhere where it is needed. Interbasin transfers and ground water depletions become more important under these circumstances. Ground water depletion produces 17.3 percent of the water required at normal export levels with unrestricted allocation. This increases to 26.1 percent of the total requirement under water right restrictions. At high export demand levels the proportion of the total requirement satisfied by ground water depletion increases from 19.8 percent without restrictions to 26.1 percent with water right restrictions. Maximum allowable ground water depletion occurs in the producing areas which include the high plains regions of Texas, Oklahoma, and New Mexico.

Agricultural water use in the Great Plains region is relatively unresponsive to either changes in export levels or water right restrictions. Water use increases only 1.9 percent from 18.7 million acre-feet to 19.7 million acre-feet in response to high exports. In response to water right restrictions, water use increases by 0.4 percent at normal export levels and by 0.3 percent at high export levels. Local dependable sources contribute between 89 and 95 percent of the total water requirement. Although water right restrictions do not materially affect the total water requirement, they do cause large shifts in source of water and its place of use. As water right restrictions are imposed, more water is used near the location of the source and less is transferred through the natural water courses for use downstream. Interbasin transfers are greatly reduced and ground water depletion becomes the second most important source of water in the region. The greatest impact on natural transfers occurs in the Platte River Basin where transfers are reduced from 1.2 million acre-feet to 76,000 acre-feet as water right restrictions are imposed. The decrease in interbasin transfers is traced to the delivery requirement of the Colorado River Compact. The analysis indicates that, of water delivered from the Upper Colorado to the Lower Colorado Basin, over one million acre-feet is not required to

meet consumption needs. The delivery requirements in the Colorado River Compact, however, are at such a level that insufficient water is left in the Upper Colorado basin to allow continuation of interbasin transfers between the Upper Colorado and Missouri River basins. Interbasin transfers through the Colorado-Big Thompson project decrease from the upper limit of 660,000 acre-feet when water allocation is unrestricted to 34 thousand acre-feet at normal export levels with water right restrictions and zero delivery at high exports with water right restrictions. Ground water depletion enters as a source of agricultural water in the Platte River Basin as interbasin transfers decrease. Under normal export demand levels ground water depletions of 673,000 acre-feet are initiated in response to water right restrictions. At high export levels ground water depletions increase from 51,000 acre-feet when restrictions are absent to 702,000 acre-feet when water right restrictions are imposed. Only one producing area in the Great Plains region, the Arkansas River Basin in Colorado, is unable to satisfy its water demands at the 1975 use level. In this area, legal commitments for downstream deliveries and insufficient local dependable supplies indicate that by 2000 agriculture will have to release 288,000 acre-feet of water. This represents 31 percent of the total 1975 agricultural water use in the area.

Water requirements in the Northwest region respond little to either export demand levels or water right restrictions. Water use increases by 1.3 percent in response to an increase in export levels. Water use declines by only 1.1 percent, from 18.2 million to 18.0 million acre-feet at normal export levels when water right restrictions are imposed. All of the water requirements are met from local dependable sources. Two areas in the Northwest region, the Salmon-Lower Snake and the Oregon Closed Basin areas, do not have sufficient local dependable supply to satisfy both (a) the projected water needs for nonagricultural uses and (b) environmental, projected fish and wildlife requirements, and still continue agricultural water use at the 1975 level. At least 460,000 acre-feet of water must be released from agricultural uses in these areas or additional supplies must be developed if the sum of these uses is to be attained.

Water requirements increase by 11.6 percent in response to the high export levels in the Southwest region. With water right restrictions water requirements increase by 30 percent at normal export levels and by 18 percent at the high export demand levels. Local dependable sources provide 84 percent of the water under unrestricted water allocation and 68 percent under water right restrictions. There is a trade-off between man-made intrabasin transfers exemplified by the California Central Valley Project and interbasin transfers such as the California Aquaduct in conjunction with the Colorado River Compact. Intrabasin transfers decline and interbasin transfers increase in response to water right restrictions. Two areas in the Southwest region are unable to maintain their 1975 agricultural water use levels. In the Great Basin area there is insufficient water to satisfy the nonagricultural water needs and maintain the 1975 agricultural water use level. In the Southern California Coastal regions, the projected conversion of agricultural land

to urban development decreases the irrigated agricultural land base to an extent that the 1975 water use cannot be maintained on the remaining land. In the two areas, 688,000 acre-feet of water are diverted from agricultural uses.

Marginal Value Product of Water

The marginal value product per acre-foot of agricultural water in the United States is $12.71 under the high export demand level option and $11.92 under the normal export demand level option when water allocation is unrestricted. As water right restrictions are imposed, water use increases and the marginal value product of water decreases. The marginal value product decreases to $8.58 at normal export levels and to $10.73 at high export levels under water right restrictions.

The marginal value product of water in the South Atlantic and in the North Central regions is not affected by water right restrictions. In the South Atlantic region the marginal value product of water is $4.91 per acre-foot at normal export levels and $5.41 per acre-foot at high export levels under water right restrictions. In the North Central region the marginal value product is $2.91 at normal export levels and $2.80 at high export levels.

The marginal value product of water in the South Central region decreases from $15.77 to $15.28 per acre-foot at normal export levels but increases from $16.82 to $17.83 at high export levels in response to water right restrictions. At normal export levels the marginal value product declines as water use increases. This indicates that the additional water is applied to less efficient production units of the same crop or to the production of less valuable commodities.

In the Great Plains region the quantity of water used does not change significantly in response to water right restrictions. However, the marginal value product of water declines by 35 percent at normal export levels and by 62 percent at high export levels. The decrease in marginal value product is attributable to a reallocation of the water to the production of less valuable commodities and less productive areas within the region when right restrictions are in effect. Historically, water allocation and use were determined by the order of development and the proximity of the land to the location of the water supply, rather than in terms of the relative productivity of water.

The marginal value product of water in the Northwest increases from $.41 per acre-foot to $3.93 per acre-foot at both normal and high export levels under water right restrictions. In the Southwest the marginal value product of water decreases from $12.48 per acre-foot to $6.74 at normal export levels and from $12.38 to $9.46 per acre-foot at high export levels when water right restrictions are in effect. Although cropping patterns shift to more valuable crops such as cotton and sugar beets under irrigation, the increase in water use is much larger than needed by these crops. Hence, marginal units of water are used in production of other low valuable crops. The marginal value product of water declines accordingly under water right restrictions.

IV. SUMMARY AND POLICY IMPLICATIONS

A national policy that eliminates water rights and reallocates existing agricultural water supplies in terms of marginal value productivities would affect the agricultural land use pattern in the United States, the concentration and stability of production, and the interregional distribution of wealth. The agricultural commodity mix, commodity prices, and efficiency of resource utilization also would be affected.

Abolition of water rights would cause increased utilization of dryland for crops and decreased use of irrigated land for crops. The increase in required dryland acreage would be greater than the decrease in irrigated acreage, resulting in a net increase in the amount of land planted to crops. The increase in dryland acreage would be concentrated in the North Central and South Central regions. The importance of agriculture in the western regions would decrease both in absolute terms and relative terms. The eastern regions, although unaffected in absolute acreage, would become less important in relative terms because total dryland utilization increases. The South Central and Southwest regions would be the residual losers as the distribution of irrigated cropland adjusts in the West. A main effect of the abolition of water rights on agricultural land would be an increase in the dominance of the North Central region in American agriculture.

Existing water right institutions encourage the production of high value crops and diversification of agriculture in irrigated regions. In terms of model results, if the historical production pattern established under a system of water rights were eliminated, sugar beet production would concentrate mainly in the North Central region and cotton production would concentrate in the South Atlantic region. Cotton production would decrease 50 percent in the Southwest and by 33 percent in the South Central region. Production of other high value crops would also become more concentrated but not to the same degree as sugar beets and cotton.

The shift of production from irrigated cropland to dryland and the concentration and centralization of crops in more localized production areas could be justified on the basis of expected economic efficiency. However, the problem of stability of expected production is not as easily resolved. The variability of crop yields under irrigation generally is less than the variability under dryland conditions. Decreasing the contribution from irrigation and increasing the dependence on weather conditions and dryland cultivation would increase crop production variability. If dependence on annual weather conditions were increased, greater variability in output could cause greater commodity price oscillations and short-run instability.

Concentration of production into a smaller geographical area also increases the susceptibility of production to the effects of localized weather patterns, insect build-up, and disease epidemics. Weather at planting and harvest time becomes more critical and limitations on storage and transportation systems become more important. When production of a commodity is distributed over a wider area, the isolation effect protects major portions of the crop from disease and insect attacts which begin in other areas.

The study results indicate that the agricultural commodity mix would change if water rights were removed. Corn and sorghum production would decrease as silage becomes more important in livestock rations. Barley, oats, and wheat would increase in importance. More soybean oilmeal would be substituted for legume hay in livestock rations as added livestock production shifts from the Northwest, Southwest, and South Atlantic regions into the North Central, South Central, and Great Plains regions.

Less land is required to satisfy the needs of the United States under a system of water rights than in their absence. This is true because the acreage of irrigated crops with high yields is greater than under the alternative where right restrictions are not included. The institution of water rights conforms somewhat with the concept of a strategic cropland reserve which could be put into grain production under emergency conditions. Dryland not in crops can be placed in production more quickly and with lower costs than would be required for the reclamation and development of irrigated cropland. A policy that removed water rights would require a larger proportion of total land to be in crop production and would use land and water more fully in line with their comparative advantage. However, if potentially irrigable cropland, rather than dryland, were not used such a policy would decrease the flexibility of American agriculture and its ability to make short-run adjustments in production in response to major catastrophes affecting food production in any part of the world. The high cost of developing and maintaining irrigation systems makes it difficult to place cropland under irrigation for only a short period of time. Dryland is more easily moved into or out of production than irrigated land. The costs of this flexibility is represented in the greater national costs of producing the nation's crops and livestock.

Wealth as represented in agricultural land is the capitalized value of the income stream attributable to the use of the land. To avoid the problem of adjusting for original purchase price and subsequent capital gains, it is assumed that all capital gains have been extracted by previous owners and that the rents accruing to agricultural land represent the current rate of return on the investment which the present owner has in the land. On this basis any change in the income stream is directly proportional to the change in wealth. An increase in rent due to a change in policy can be interpreted as an annual increased return and can be capitalized to represent changes in present value at any desired rate of return. Under the condition that everyone must be at least as well off after a policy change as they were before, decreases in rents would represent the level of compensation that must be paid to those individuals who are placed in a less favorable position in order to maintain their level of income if water rights were modified.

Under these conditions at normal export levels, a policy eliminating water rights would reduce wealth of farmers who now have irrigated land. If compensation were paid to these farmers in an amount reflected in the shadow prices generated in this study, an annual payment of $449.7 million in compensation would be required. On the other hand, dryland farmers would realize an increased return of $45.3 million annually. The North Atlantic region would receive $1.7 million and the South

Atlantic region $10.3 million in increased returns. The North Central region would receive $27.7 million in increased returns and would require compensation payments of $34,000. Increased returns in the South Central region would be $4.5 million while compensation payment would be $11.7 million. No increased returns would accrue to the Great Plains region but compensation payments of $53.6 million would be required. The Northwest region would receive $1.2 million in increased returns and $24.4 million in compensation payments. Compensation payment in the Southwest region would be $361.2 million while no increased returns would accrue in the region.

Under high exports, in comparsion with normal exports, returns increase to $1,107.7 million while compensation payments decrease to $355.5 million annually if water rights are abolished and the nation's land and water are allocated optimally within this framework. This implies that as the nation's food producing capacity is approached, the limit of increased returns endowed by the policy would far exceed the compensation payments. Positive impacts would accrue to the North Atlantic, South Atlantic, and North Central regions while negative impacts would occur in the Northwest, Southwest, Great Plains, and South Central regions.

Implications for Water Development

With the existing system of water rights institutions and interstate compacts the analysis indicates that by the year 2000, 22 of the 58 irrigated producing regions will utilize all of their available dependable water supplies in meeting normal domestic and export demand levels. Eleven of these regions will be required to deplete their ground water supplies. Even with this depletion, eight regions will be unable to maintain their 1975 agricultural water use levels in 2000. (See Figure 10.)

The 22 regions that exhaust their water resources are not localized but are present in each of the nine river basins in the Western United States. The most severely affected regions are the Platte River, the Arkansas River, the Texas High Plains area, the Rio Grande River, the Upper and Lower Colorado River basins, and the Great Basin. Nineteen of the 22 water-short areas have the potential for increasing their dependable water supplies through reservoir construction. Additional interregional transfers also are a potential method of increasing water availability in these areas.

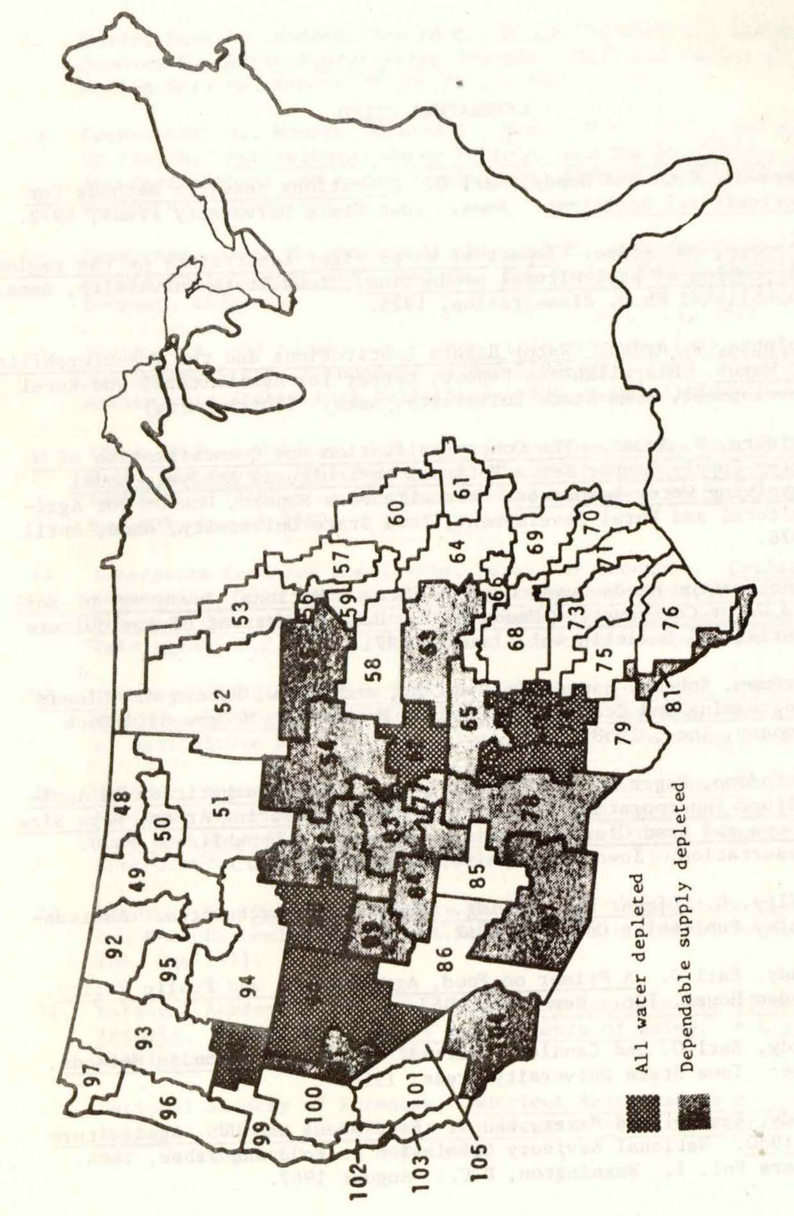

Figure 10. Producing regions that exhaust their dependable water supply under normal export demand levels

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