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U.S. Agricultural Production in Relation to Alternative Water, Environmental, and Export Policies

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THE CENTER FOR
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U.S. AGRICULTURAL PRODUCTION IN RELATION TO ALTERNATIVE WATER, ENVIRONMENTAL, AND EXPORT POLICIES

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PREFACE

This report presents analyses of alternative future scenarios relating to U.S. agriculture as defined for the National Water Assessment conducted under the auspices of the U.S. Water Resources Council. A large-scale, national-interregional programming model developed at the Center for Agricultural and Rural Development (CARD), Iowa State University, was used to evaluate water and land needs for the agricultural sector component of the National Water Assessment. A grant under the RANN program of the National Science Foundation (GI-32990) to CARD supported the development of the model. Specification of the model to be used specifically in the National Water Assessment was a cooperative undertaking between CARD personnel and the Agricultural Resources Assessment System (ARAS) Technical Committee representing the Water Resources Council. The ARAS Committee was also responsible for specifying the assumptions regarding future demands for agricultural commodities and alternative resource management strategies in the agricultural sector. The ARAS Committee included:

Roger Strohbehn, NRED of the Economic Research Service, U.S. Department of Agriculture, Chairman

R. Mack Gray, Soil Conservation Service, U.S. Department of Agriculture

Adrian Haught, Forest Service, U.S. Department of Agriculture

Alan P. Kleinman, Bureau of Reclamation, U.S. Department of Interior

Rodney W. Olsen, Fish and Wildlife Service, U.S. Department of Interior

Arden Weiss, Water Resources Council

Larry W. Tombaugh, Environmental Systems & Resources,
RANN Program of the National Science Foundation

Also, other presons served as advisors. Included in this group was a number of staff members from the Environmental Protection Agency, the Corps of Engineers of the Department of Army, and the Bureau of Economic Analysis of the Department of Commerce. A number of persons at Iowa State University either helped with or advised on the study. Included in this group were James Wade, Dan Dvoskin, Howard Madsen, Walter Thomas, Nancy Turner, and others. Analysts of the Economic Research Service, U.S. Department of Agriculture, who participated in the study included Paul Fuglestad, Marlin Hanson, Robert Niehaus, and Paul Rosenberry.

Although funds from the RANN program of the National Science Foundation were used to develop the basic model, the major part of the analysis representing the National Water Assessment was financed by the Economic Research Service, U.S. Department of Agriculture, and the Water Resources Council. The Department of Interior (Bureau of Reclamation and Fish and Wildlife Service) also provided financial support. The study was under the general guidance and direction of the Natural Resource Economics Division, ERS, as part of its obligation to analyze future water and land needs by the agricultural sector.

Selected alternative future scenarios defined for the National Water Assessment are analyzed in this report. Implications and conclusions presented in the report represent views of the authors and do not represent policy recommendations of the USDA or of the Water Resources Council.

A companion report was prepared by the Economic Research Service that analyzes in more detail all of the 13 alternative future scenarios specified for the study. The ARAS Committee reviewed the assumptions, findings, and implications of each of the alternative scenarios and selected a set of 1985 and 2000 projections to serve as the agricultural "bench mark" projections for use in analyses of total national water needs in the Assessment. This report of agricultural futures analysis will be published jointly by the USDA and the Water Resources Council.

The Authors

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report is based on the study completed in conjunction with the U.S. Department of Agriculture, Economic Research Service as a part of the 1975 National Water Assessment. The main objective of this part of the Assessment is to evaluate the nation's land and water resource capabilities relative to the future magnitude and trends of variables affecting agriculture and its domestic and international impacts under varying assumptions of technology and resource policy.

To accomplish this objective, a model capable of analyzing land and water resource use within the framework of interregional trade-offs is employed. The model incorporates 105 producing areas based on the U.S. Water Resources Council's aggregate subareas, 28 market regions reflecting demand centers and transportation hubs, 57 regions in the west consistent with the producing areas with irrigation water supplies defined, crop and livestock production activities in each producing area, and a transportation sector connecting the markets to complete the interregional competition aspect.

Resource adequacies are evaluated by running a base future incorporating most likely trends and several alternative futures where changes are made in one or more parameter sets to reflect an alternative trend or policy affecting the parameter sets involved. The base alternative represents a continuation of the present trends in yields, per capita food consumption, and exports. The alternative futures can be combined into three major investigative areas. The first group

analyzes changes in projected demand and export levels; the second deals with water quality, increased water use efficiency, and water requirements for energy development; and the third group deals with the enhancement of environmental quality as reflected in reduced gross field loss of soil, maintenance of wetlands, and increased stream flow for estuary and aquatic life needs.

The results of the analysis indicate that agriculture does have the capacity to meet future demands for output while contributing to increased flexibility in resource allocation and environmental parameters. The variation in the impact of alternative policies indicates that little impact on the consumer would be experienced unless large amounts of water were diverted for instream water requirements or if export levels became extremely high.

Differences in response between the base or trend situation and the other future alternatives indicate that land and water resources may only become critical during cases of extreme demand for agricultural products, especially in the near term (1985) alternatives studied. A greater time for farmer response, less rapid compounded increases in demand and the continuation of technological trends indicate a more flexible agricultural sector in the longer term (2000) analysis.

The decline in water availability as a result of ground water depletion reduces irrigated acreages possible in some areas especially the high plains region of Texas, Oklahoma, and New Mexico. Similarly, most regions experience water shortages if an environmental enhancement situation were to include increased stream flows to provide better wildlife habitat, increased flows for aquatic life, and to improve estuary conditions.

Considering the alternative that simulated a higher efficiency of water use and comparing the results with the alternative to enhance the environment, it is noted that the possible savings in water from the higher irrigation water efficiencies would more than offset the diversion for stream flow maintenance. This brings about an additional interaction that wildlife cover along the delivery and drainage ditches would be reduced as water seepage is eliminated.

As more pressure is placed on the agriculture's productive capacity more land is developed for irrigation, wet soils are drained, and forest land is cleared and utilized for cultivated crops. This development of new land resources reaches its highest level under the high export alternative in 2000. The increased pressure on capacity is also reflected by the land and water rental values increasing to reflect a greater marginal value product of the final units employed as commodity prices are increased. A high degree of pressure is put on the productive capacity for the 1985 high export alternative when essentially all available land is used and new land development has not had sufficient time to become widespread.

Even though the overall impacts on the agricultural sector may not be severe, the regional impacts could become significant. Restrictions on water use impact severely in the western United States and land conservation programs especially soil loss restrictions would impact on the high erosion areas of the Southeast and Central Mississippi Valley and Delta areas. These impacts indicate that utilizing a single variable national objective may encourage variation in regional impacts not necessarily desirable on a regional basis and even of concern from the national policy implications.

I. INTRODUCTION

Events of recent years have brought the world food problem into sharper focus and prominence, but the continued debate on its nature and resolution is characterized by diverse opinions and uncertainty. Uncertainty is compounded by the variety and nature of factors that have direct bearing on the problem. Some of these factors are population growth, affluence, availability of usable land and water, availability of such inputs as fertilizer and pesticides, availability and cost of energy, environmental concerns, and weather. Nevertheless, the importance of the problem in human and economic terms coupled with the United States' leadership in export of world food call for our best effort in understanding and coping with the role of the U.S. in world food needs.

With increasing population the demand for food, water, and land increases. The question asked repeatedly is "Will there be enough land and water resources to meet future food and fiber needs at a reasonable cost to consumers?" The adequacy of land and water resources to achieve U.S. goals for continued economic development and to provide desired living standards is a continuing concern.

This concern about resource adequacies is expressed in terms of three dimensions: quantity, time, and location. For water resources especially, a fourth dimension, quality, also has recently received much attention. Two types of factors exert influence on water quality: natural factors and man-made factors. Quality degradation by either of these two may be alleviated by appropriate treatment, but treatment costs and institutional incentives determine whether, and to what extent, this will be done.

Increasing agricultural production to meet future domestic and export demands and increasing development of energy resources will create conflicts. Production of food and development of energy sources affect the environment in either beneficial or adverse ways. If the effect is adverse, society may curtail or modify certain agricultural production activities through expressed policies or laws to maintain or improve the environmental aspect. The adequacies of land and water resources then have to be reconsidered.

In this report on land and water adequacy, emphasis is on the nation's water resources. Therefore, in the following sections water supplies and demands will be discussed. Particular emphasis will be placed on the agricultural industry as a major user of water and as an industry that interacts intensively with the environment.

Water--A Nationwide Perspective

The United States as a whole is abundantly endowed with water. Over the contiguous 48 states, renewable fresh water resources are derived from an annual average precipitation of 30 inches. About 70 percent of this precipitation is lost through evaporation and transpiration before it reaches streams and rivers. The remaining 30 percent becomes the annual natural runoff. For the contiguous states, runoff accounts for 1,200 billion gallons of fresh water per day. However, with

the current surface storage and because of the effects of floods and droughts, only 278 bgd (billion gallons per day) of the renewable surface waters (25 percent) are considered currently available in 98 of every 100 years. With additional surface storage development, a total of 700 to 800 bgd potentially could be made available [22].

In addition to the renewable surface waters, considerable amounts of both renewable and nonrenewable ground water currently are available or can be developed. For example, about 20 percent or 70 bgd of the nation's current fresh water withdrawal use comes from ground water sources. Much of this is taken from riverbed sands and constitutes a partial withdrawal from surface supplies. Therefore, in many cases, future increases in ground water use will reduce surface water availability.

Finally, huge amounts of saline and brackish waters are available, but only about 55 bgd of saline water are currently being used. The cost of the desalination process under present technology is still higher than the value of water to agriculture [2].

In 1965 fresh water withdrawal for all purposes averaged about 269 bgd, including substantial reuse. of flows, Table 1. Of this amount approximately 77 bgd were consumed through evaporation or incorporation into products. By 1985 the total national withdrawal of fresh water is estimated to reach 600 bgd, including reuse. Of this, between 116 and 154 bgd is expected to be consumed, depending upon the energy alternative implemented [20].

Table 1. Estimated daily water use in the United States.

Type of Use	1965 Withdrawals	Percent	1965 Consumption Use	Percent
	(million gallons)			
Rural Domestic	2,351	.87	1,636	2.10
Public Municipal	23,745	8.80	5,244	6.74
Industrial	46,405	17.21	3,764	4.83
Steam-Electric Power				
Fresh	62,738	23.26	659	.84
Saline	21,800	8.08	157	.20
Agriculture				
Irrigation	110,852	41.11	64,969	83.17
Livestock	1,726	.64	1,626	2.10
Total	269,617	100.00	77,782	100.00

Source: [22, p. 4-1].

The historic distribution of withdrawals among users is shown in Figure 1. This figure shows the rapid growth in the use of electricity in the United States in recent decades as reflected in increased water withdrawals for thermal-electric power. Figure 2, however, illustrates that water consumption by thermal-electric power plants is relatively small. As does Table 1, it also emphasizes the importance of agriculture as a water consumer.

From a nationwide viewpoint, the water supply potential seems sufficient to serve all the nation's needs. However, national totals give a false picture of the adequacy of this nation's water resources to meet

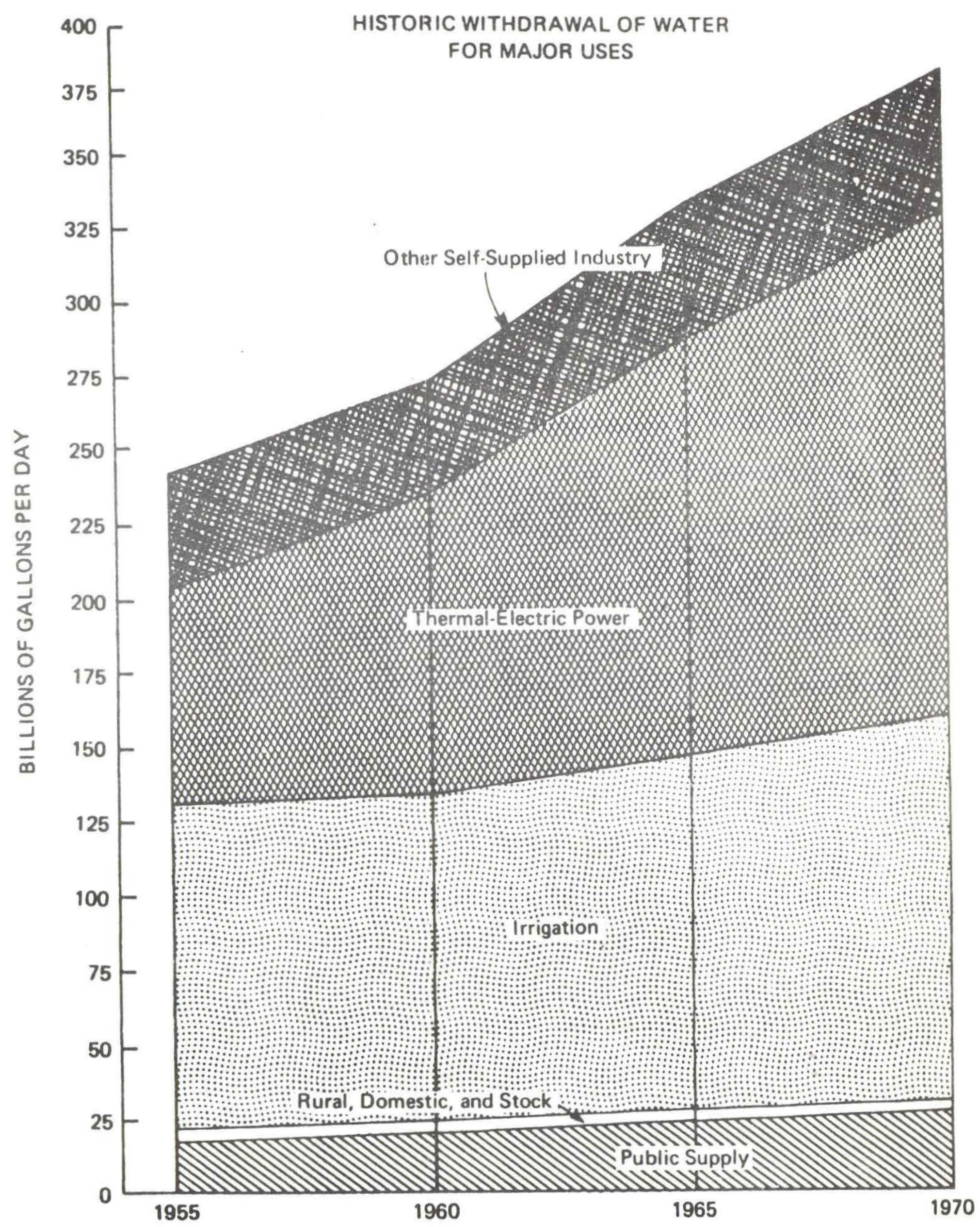


Figure 1. Source: [21].

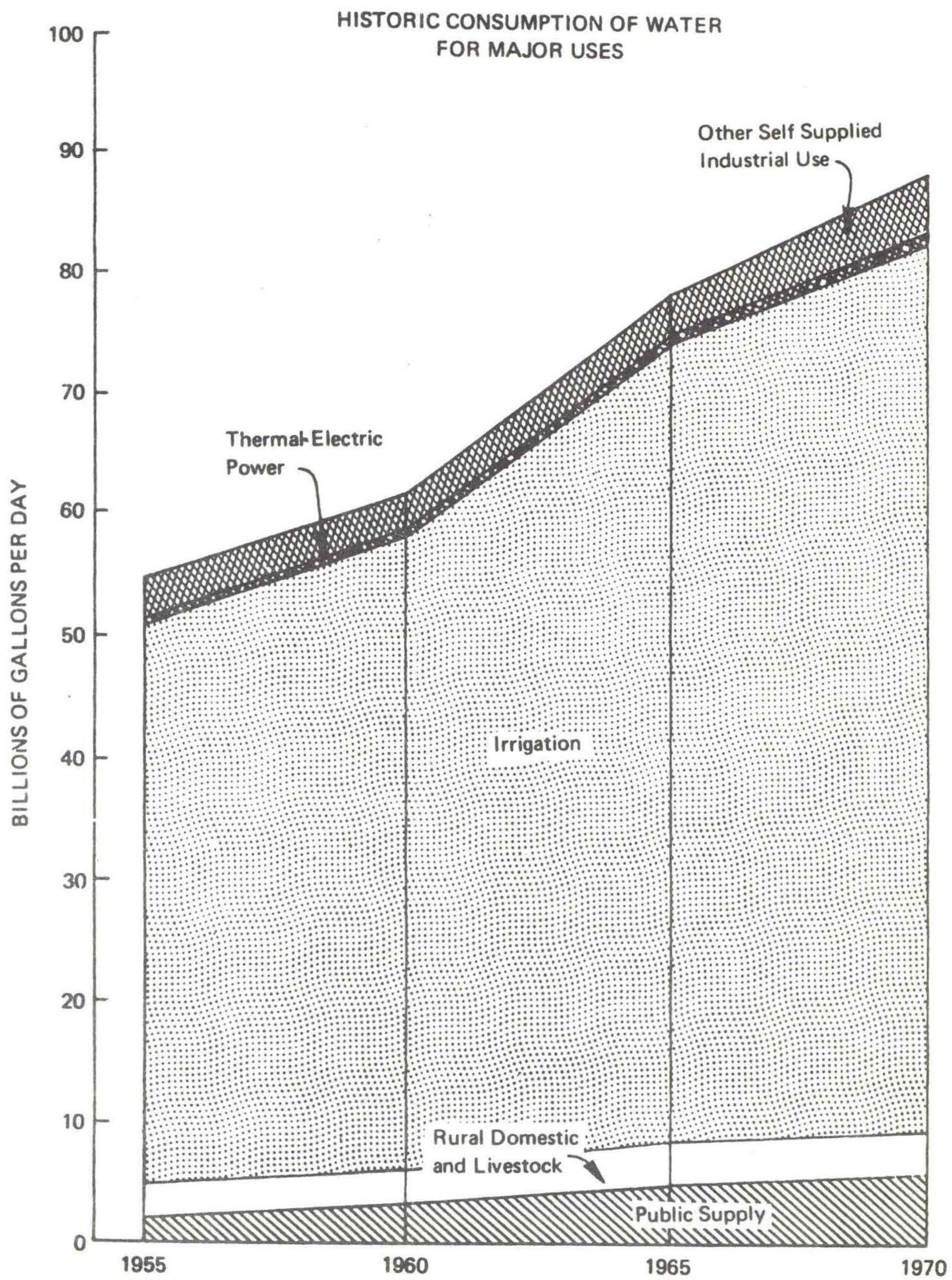


Figure 2. Source: [21].

future needs, both short- and long-term. Distribution and timing of water resource supplies vary widely among geographic regions. In addition to regional variations in annual precipitation, there are yearly and seasonal variations. This lack of uniformity in supply and in timing of availability between and within regions is one of the major water problems in the United States. These problems will become more critical when regional water demands are increased because of energy development and environmental legislation.

In many of the 48 contiguous states, agriculture accounts for at least half and, in some cases, for nearly all water consumption not counting evapotranspiration from nonirrigated crops, pasture, range, and forest land. Urban consumptive use predominates in the North Atlantic, Great Lakes, Ohio, and Tennessee regions, and gross withdrawals are primarily for urban uses in all eastern regions. In the western regions withdrawals are mostly for irrigation and other rural uses.

About 10 percent of the farmland and range land in the United States is irrigated. In the West, irrigation is often the difference between uncertain and stable production. In the humid East, irrigation can prevent crop failures, increase yields, and improve product quality even in average years.

This dominance of water use for irrigation is a reflection of past policies. Water resource development in the West was encouraged by the federal government to attract settlers in new territories. This served the national purpose to help populate the West. At present, 90 percent of the water used in the western states is for irrigation and in the opinion of some, quoting a recent Des Moines Register editorial [12]: "Much of this water costs more than its value for farm production." Until a few years ago, water development for irrigation took place at the same time that land was retired to avoid large crop surpluses. This conflicting set of policies for agriculture--development of new irrigated land on one hand and retiring land on the other--has been discussed by Heady and Madsen [6,8]. His analysis indicated that future water resource and irrigated land development beyond projects already authorized is unnecessary to maintain projected domestic demands and international needs in line with the levels of the late 1960s. This situation may no longer hold as environmental and energy policies interact to reduce the flexibility in the agricultural sector and the increasing concern over the world food situation creates the potential for an increased demand.

The agricultural sector may remain the principal consumptive user of water for many years, and management and development of water resources in the rural sector of the economy will continue to be important issues in public policies.

Agriculture and the Environment

In terms of land area and value of natural resources, agriculture occupies a large subset of the total environmental complex. Because of this coincidence, it is inevitable that agricultural processes affect the surrounding environment, whether beneficially or adversely. With

economic and technical development, agriculture has become an increasing source of nonpoint pollution. The decrease in the real cost of capital, relative to land and labor, has led to large and highly mechanized farms. This change in relative costs has also encouraged specialization in one or a few products since machinery and equipment are now highly oriented to a particular product. Examples of this trend can be found in the large-scale livestock breeding and feeding units and the duoculture of corn and soybeans in the Corn Belt.

Two types of technologies have been employed to meet the increasing levels of domestic and export demand of recent years: 1) more land has been brought into production, and 2) existing cropland has been cropped more intensively. The environmental problems with the use of more land are primarily those associated with wind and water erosion and loss of wildlife habitat (for example, drainage of wetlands). The problems with the more intensive use of land result primarily from heavy use of fertilizers and pesticides and increasing soil and water salinity because of irrigation. Another major pollutant in agriculture is animal wastes. Where in the past only hundreds of cattle were fattened or poultry housed, now thousands can be accommodated in the same area at the same time. This concentration has led to waste disposal problems. Runoff from feed lots and other large-scale livestock production units has become an increasing source of pollution of the rivers and lakes.

In a recent publication, Headley [5], summarized what has been agriculture's activity over the past decades:

> Adoption of industrialized technology is the method we chose to minimize the market value of resources devoted to agriculture. In that regard we have been effective. But the extra-market values sacrificed for cheap food and economic growth have not been as consciously economized, if at all. Our streams and lakes are muddy and contain a variety of man-made chemicals. Our ground water is suspect and the disposal of animal and processing wastes in certain localities impinges upon the natural environment in an unsatisfactory way. Communities have been depleted of their people as economic growth has spurred urbanization. At least part of our economic growth has been provided by living off the depreciation of both the countryside and the cities. Yet due to our method of measuring our material well-being, the maintenance activities required to correct the former shortsightedness results in increasing GNP.

To reduce the pollution of the rivers and lakes to levels determined acceptable by society, several costs are involved. In the language of economics, scarce environmental goods must be traded off against other scarce economic goods and services. The opportunity cost of obtaining more environmental quality for any society is the sacrifice of doing without other valuable commodities. These choices made now--either consciously or be default--will determine the quality of the environment we shall live in during this century and which our children will inherit [11].

Before environmental policy choices can be made, it is necessary to discuss the technical aspects of specific examples of environmental degradation, their causes, and ways to decrease their effects.

The sediment erosion problem

Concern about water erosion and sediment has been one of the basic elements of the conservation movement during the past four decades. But within that period a significant change in emphasis has taken place.

The soil conservation efforts that originated in the 1930s were first concerned with the physical destruction or waste of soils resulting from man-induced erosion. The intrinsic costs to present and future generations were expressed as reduced capacity for agricultural production, increased flood hazards, and adverse social and economic effects for landowners, communities, the states, and the entire nation [26]. It was estimated that more than 50 million acres of land had been ruined for crop production and another 125 million acres were largely stripped of topsoil. Today, the annual soil loss from land in the United States is estimated to be 4 billion tons annually of which 3 billion tons are lost from agricultural and forested lands [1].

More recently there has emerged a sense of urgency about sediment problems. In its first annual report, the Council of Environmental Quality [4] identified sediment as a source of water pollution. The report states that sediment carried by erosion represents the greatest volume of wastes entering surface waters. Agricultural development increases soil erosion rates four to nine times over erosion from land with natural cover.

The goal of meeting the national and international demand for food and fiber in a world of growing population and increasing affluence comes in direct conflict with the goals of conservation, land use, and water quality. More food requires more land or more intensive use of present land. Both alternatives lead to greater levels of erosion unless conservation practices are used. The National Inventory of Soil and Water

Conservation Needs [14] shows that 92 percent of all cropland has a major conservation problem, with erosion being a limitation on 55 percent of all cropland. Therefore, any increase in crop production will increase the sediment-erosion problem unless appropriate changes are made in land use patterns and crop management systems. In this study, soil loss legislation is simulated through means of a soil loss restraint imposed on the model under the assumption that the maintenance of the soil on the land will benefit the water resources with which the soil interacts [13].

Animal wastes

The change in confined animal production has resulted in a number of adverse environmental effects. The wastes are no longer randomly and broadly distributed over the land where they can be absorbed by nature with few difficulties. Confined animal production has caused large concentrations of wastes to accumulate in small areas. The development of these large-scale operations in the last 10 to 15 years has resulted in water and air pollution.

The nutrient enrichment of the streams from the wastes that reach it can cause pollution problems. It does not necessarily produce problems as long as the quantities are small enough and the stream flow in the waterways is large enough. However, when the quantities become too large, bacterial action can no longer break down the wastes because the BOD (biological oxygen demand) is too high. The sharp reduction in oxygen will lead to the killing of fish. The nutrients of the waste further

lead to huge algal "blooms" in lakes, which die off as fast as they grow, sinking into the lakes. This process is called eutrophication, or overfertilization, and lowers the recreational values of streams and lakes [3,7].

The land has been and will continue to be the ultimate disposal point of animal wastes from agricultural operations. Methods such as liquid and solid waste systems may be used to reduce the volume or quantity to be disposed of, but the land remains the disposal point for most of the treated and untreated wastes. The use of animal wastes on land for crop production results in benefits for both agricultural and urban interests, but the wastes and land must be managed carefully to achieve favorable results. Disposal of animal manure on land still remains the least expensive method of disposal as long as adequate land area is available adjacent to the animal production operation. A producer who fails to arrange for the availability of such land faces the possibilities of higher transportation costs, higher treatment and disposal costs, or the encroachment of residential and commercial neighbors who may not appreciate the wastes from his operation.

In this study, the nitrogen in the waste of animal production is accounted for and can be used in crop production. In the environmental enhancement alternative, a restriction is imposed on the model requiring that all animal waste be disposed of over land through use in crop production.

Protection of fish and wildlife and the development of new land

In years past, water development projects and water-related activities at both state and federal levels often went forward with little regard for damage caused to fish and wildlife resources. Thousands of miles of natural stream channels were relocated or altered, some streams were dried up, estuaries and marshes suffered from drainage and landfill operations, and estuarine habitat essential for shellfish and other species was destroyed by dredging and channel deepening. Water quality deterioration and water temperature alteration have also adversely affected fish and wildlife resources in both marine and fish water [10]. A rising level of population and affluence will, among other things, increase the demand for food and the demand for recreational areas with game for hunting and fishing. In terms of land and water resources development, these can be conflicting demands.

The aim of this study is to evaluate the magnitudes of some of the trade-offs between increased agricultural output and decreasing environmental quality. By restricting any further wetland or forest land development, it is possible to determine if this type of development is really necessary to meet future demands. Minimum stream flow levels are imposed on the model to assure maintenance of fish and wildlife habitats. Soil erosion is restrained to very low levels.

The problem of water pollution and environmental degradation is one that cannot be simply solved by the present pricing system. We are faced with a commonly owned resource that has a positive marginal opportunity cost but

which carries a zero marginal user charge for waste disposal. The task of the policy maker is to provide the pricing mechanism and institutions needed to allocate this common property resource in a manner consistent with the needs and desires of the community. The results obtained from this study can be used in making these decisions.

Objectives of This Study

This study is made to evaluate the nation's resource capabilities relative to future magnitudes of major variables such as international trade, land and water conservation, environmental enhancement, energy development, and subvariables that relate to them. Particular emphasis is placed on identifying national and regional resources that are in critical supply situations and which may require special programs of development or allocation under alternative future paths of the nation. This study in particular focuses on water resources used by and available to agriculture.

Critical supply situations will be more prominent when increased resource demands for energy development and environmental enhancement are taken into account. Environmental enhancement will require reductions in erosion levels and animal waste runoff and will demand land and water resources for fish and wildlife preservation. One of the objectives of this study is to evaluate the impacts and the trade-offs between present and more restrictive legislation (or policy) aimed at increasing environmental quality. It will not be possible to balance the cost and benefits and to come up with an overall conclusion about the magnitude of the total net benefit. To do so would require both the assumption of a welfare function and further analysis of benefits derived from increasing environmental quality. What can be achieved, however, is the quantification of some of the impact; for example, national and regional changes in land use patterns (with important implications on regional resource use and employment) and changes in the cost of food production to the consumers. These variables can provide important information for policy decision making.

An effective evaluation of water productivity, capacity, allocation possibilities, and needs cannot, however, be made apart from other resources and the technology generally available to agriculture. The value productivity of and demand for water in Arizona is interdependent with the amount of nitrogen used on corn in Iowa. Similarly, the need for irrigated pasture in Montana is interdependent with the use of land in Tennessee or the intensity of the grain/silage ration fed to beef cattle in Illinois. In general, reclaimed land in the Southeast serves as a substitute for water in the West and vice versa. Hence, a model or analytical device directed toward a detailed measurement of agricultural water problems and possibilities in the nation must deal with the interrelationships among regions whether or not they use water for irrigation and among all crop and livestock products, including all major technologies and resource combinations for them. Therefore, one of the objectives is to build such a model and evaluate its capabilities.

The model chosen for this study is a mathematical programming model. Although such models have limitations, they appear to be the most appropriate

for this type of analysis. Programming models allow great detail at regional levels while still retaining considerable flexibility for analyzing alternative futures.

In this study seven alternative futures are analyzed. Each alternative highlights a change in one or several policy variables. Before discussing these alternatives, however, the model will be described.

II. THE MODEL

This study uses a linear programming model developed for the nation's agricultural sector that encompasses 105 producing areas each having up to 9 different land-resource groups, 58 water regions and 28 market regions. Producing areas and water regions are contained in the different market regions, and the market regions are interconnected by a transportation sector. This set of regions together with the transportation network makes the model capable of analyzing the major effects of proposed environmental restrictions and other changes in policy parameters. The interregional linkages simulate the dependence that exists among the different areas and activities in the agricultural sector. A restriction on the use of water for irrigation in the West (because of higher demands by municipal and industrial uses or because of minimum stream flow restrictions for fish and wildlife) will affect the level of production in the Midwest and the East. Similarly, restrictions on soil loss will move production out of soil loss prone areas into other areas. It is this interdependence that makes the model a suitable analytical device for studying regional shifts in production and land use patterns resulting from changes in regional comparative advantage.

The model is a partial equilibrium model which, given assumptions about levels of consumption and export, will minimize the cost of producing this quantity of agricultural product demand within the restraints imposed on the model. The model also assumes a competitive equilibrium wherein all farm resources receive their market rate of return (except for land where return is determined endogenously in the model).

A complete and detailed description of the model is given in Meister and Nicol [9]. The sections that follow briefly summarize the model and emphasize some of its important features.

Regional Delineations

The model has three types of regions: producing areas (PA's), water supply regions (WR's) and market regions (MR's). The producing areas, Figure 3, are the 99 Aggregated Subareas (ASA's) defined by the Water Resources Council modified to 105 areas to be consistent with the agricultural patterns experienced in six of the ASA's. These producing areas consist of contiguous counties of the mainland and sum to both ASA's and major river basins. Crop production activities and the cropland base are defined within each one of these producing areas. The water supply regions, (PA48-105) consistent with the producing areas in the western United States are those in Figure 4. The 28 market

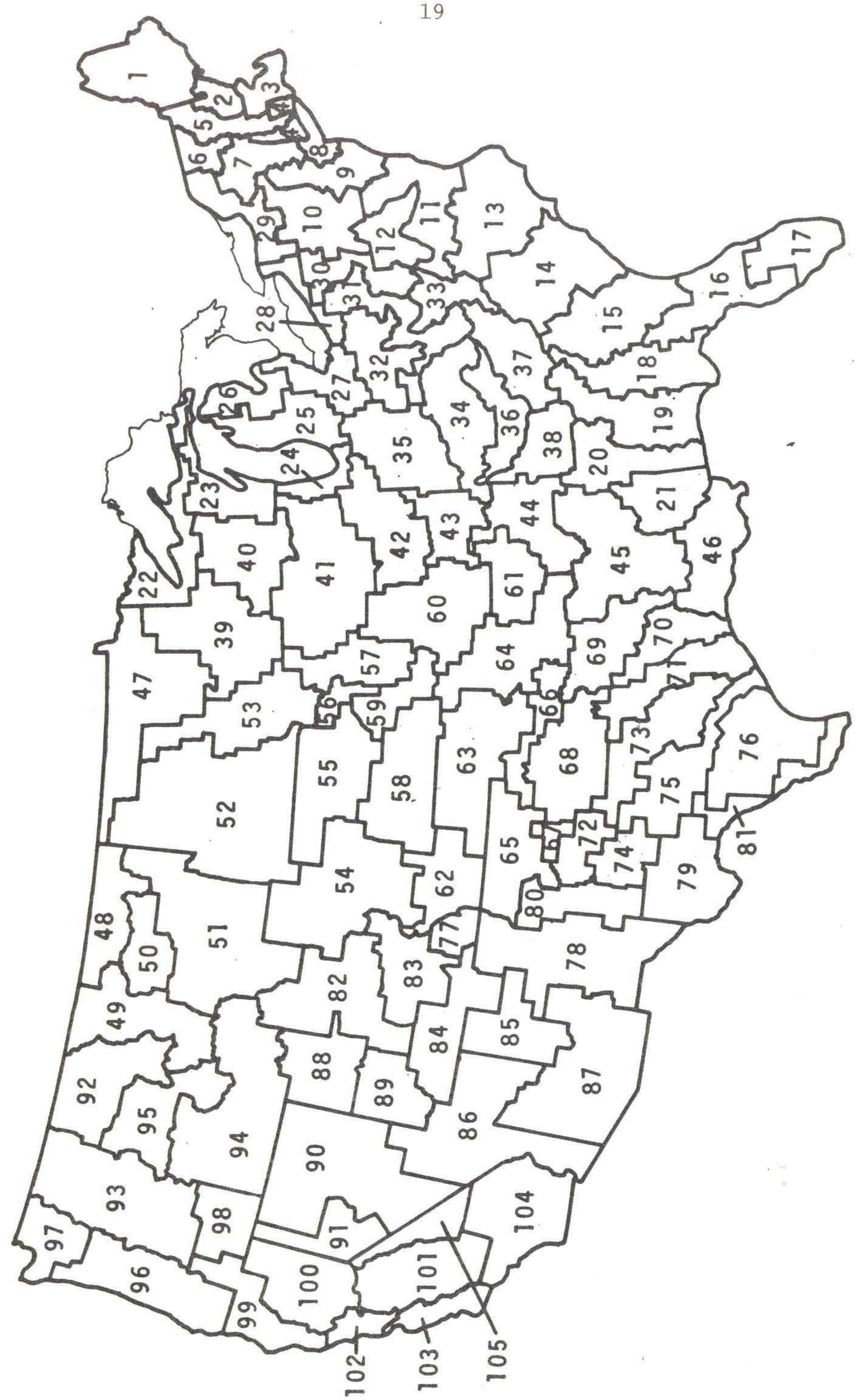


Figure 3. The 105 producing areas.

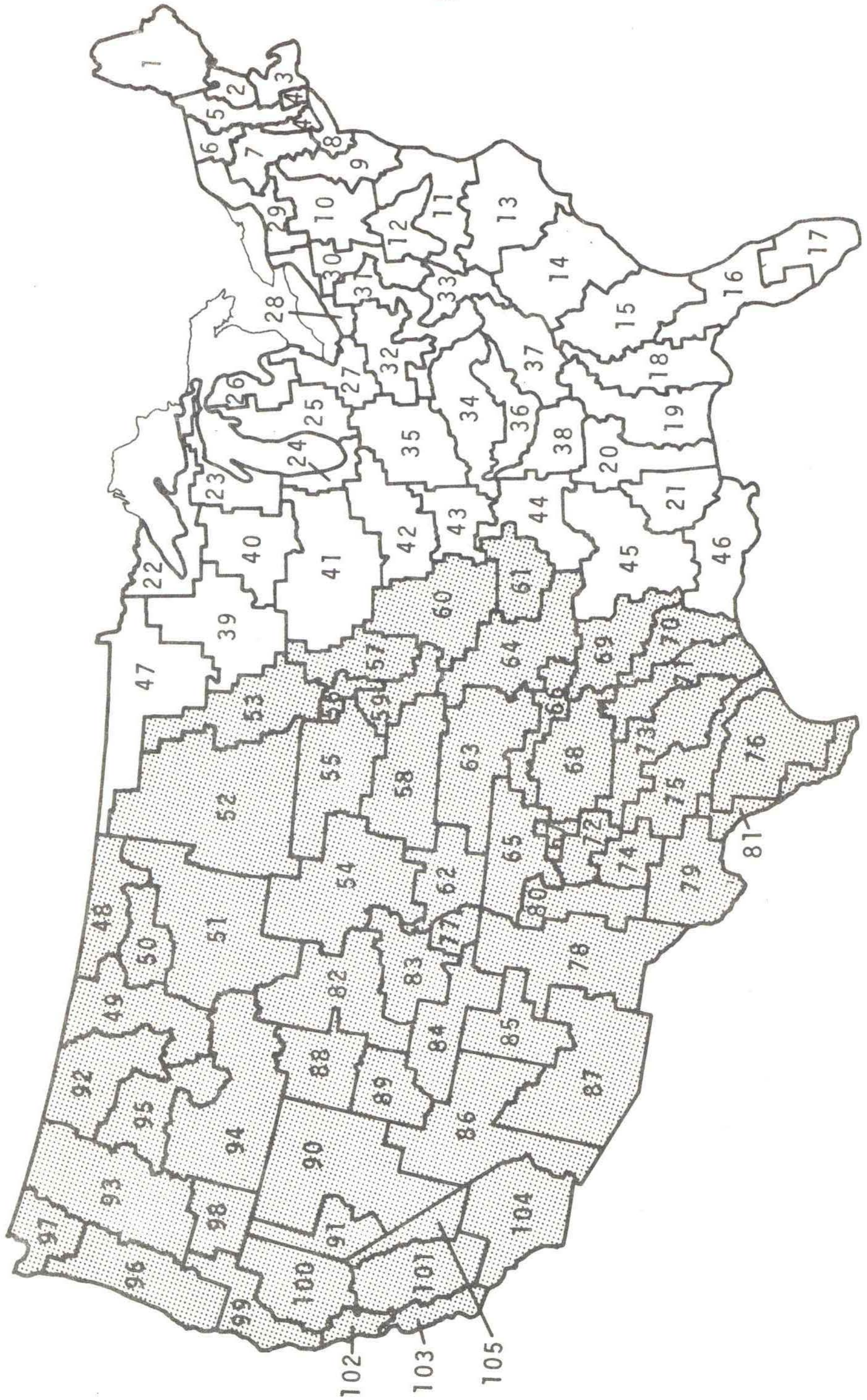


Figure 4. The producing areas with irrigated lands.

or consuming regions are those in Figure 5 with commodity demands in each reflecting domestic population, per capita incomes, and net exports from conventional ports. Livestock activities are defined at the market region level. For reporting purposes the 18 major river basins, Figure 6, will be used.

Major Sectors of the Model

The above description outlines the general nature of the model and in particular its regional characteristics. We now describe the major sectors in more detail. This additional detail is necessary to understand the changes that are made in parameters when analyzing different futures.

The land sector

The land base includes three major categories: cropland, permanent hayland, and permanent pasture land including public grazing lands and forest land grazed. The cropland sector is based on the 1967 National Inventory [14] cropland definition with an adjustment for wild hay as determined from the 1969 Agricultural Census [19]. The remaining lands incorporate the Conservation Needs Inventory (CNI) pasture, range, and forest land grazed with the additional public lands grazed determined from the Census to provide a base level of pasture production incorporated as available hay equivalents in the model.

The cropland base from the National Inventory is aggregated from the county level to the 105 producing areas, Figure 3, and from the 28

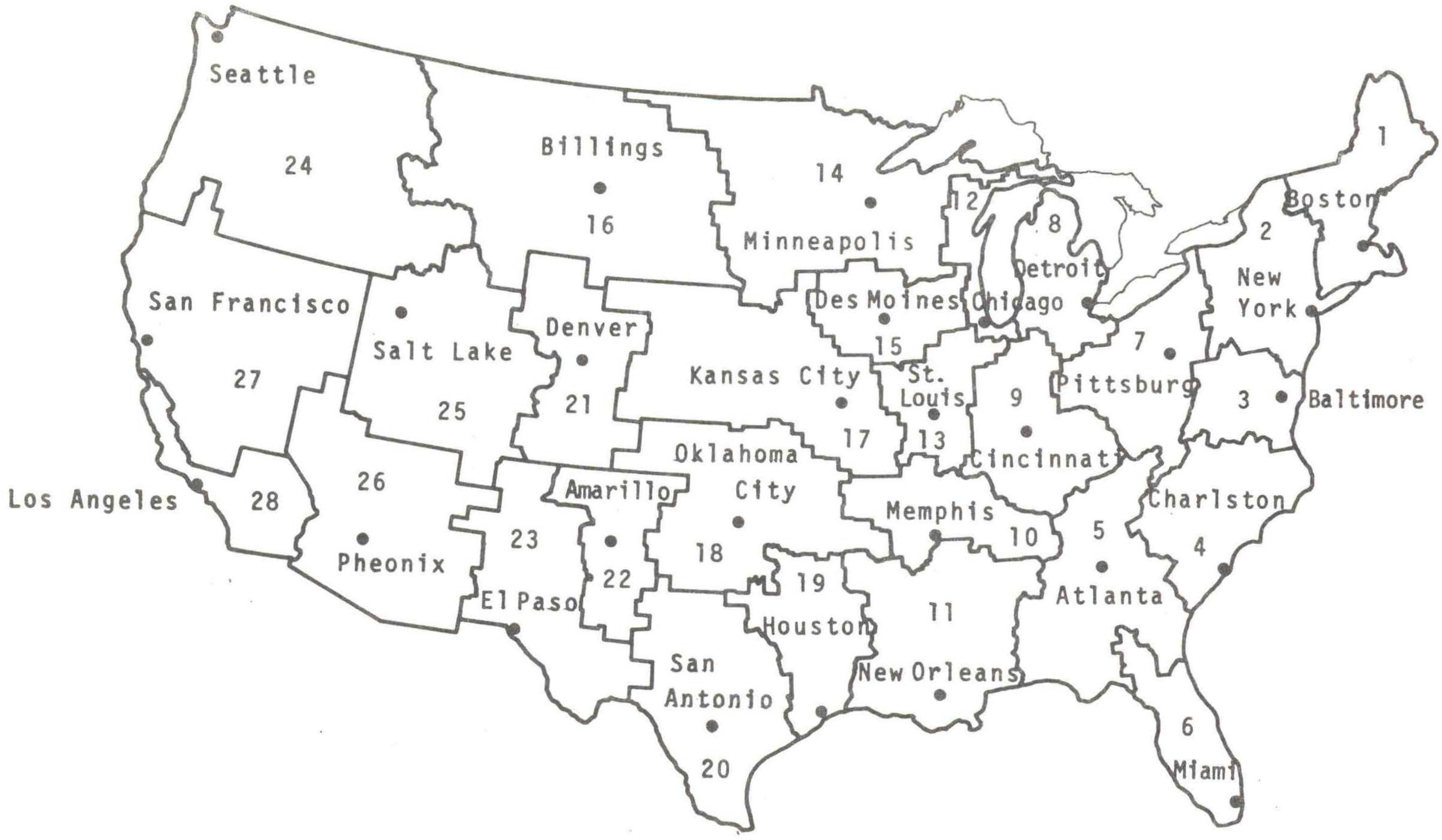


Figure 5. The 28 market regions with central cities indicated.

Figure 6. River basins with county boundaries

land classes defined to 9 land groups in each of the dryland and irrigated uses, Table 2. This land aggregation is adjusted to a 1974

Table 2. Land class and subclasses aggregated to the nine land groups.[a]

Land Groups	Inventory class-subclass	Land Groups	Inventory class-subclass
1	I	6	IVe
2	IIe	7	IVs, IVc, IVw
3	IIs, IIc, IIw	8	all of V
4	IIIe	9	all of VI, VII & VIII
5	IIIs, IIIc, IIIw		

[a] Inventory class and subclasses are as defined by the Soil Conservation Service for the National Inventory (15).

actual acreage by adding lands developed through drainage conversion from the Class IIw and IIIw wet soils to a Class I equivalent productive capacity. Adjustments in irrigated acres are made to reflect developments after 1967. Future conversions of each of these types are allowed and are restricted to estimated potential conversions.

The land base is adjusted for expected conversions to urban and other nonagricultural uses between 1967 and the target date of the analyses, 1985 or 2000. Adjustments in the land base also are made for crops not endogenous to the model.[1] This prior adjustment is justified

[1]The exogenous crops are: rye, rice, fruit and nuts, vegetables, flaxseed, peanuts, sugarcane, tobacco, Irish potatoes, sweet potatoes, dry beans, dry peas, and other crops.

on the basis that these crops are generally the higher value crops and would have the economic advantage in competition for land use.

The crop and soil loss sector

The crop sector represents the production of barley, corn, corn silage, cotton, legume hays, nonlegume hays, other hays, oats, cropland pasture, other pasture, sorghum, sorghum silage, soybeans, sugar beets, and wheat. These crops are combined in relevant rotations to provide alternative production possibilities in each producing area which provides a range of crop production possibilities to be evaluated under the various alternatives. The rotations are combined with 12 possible conservation tillage practices including the tillage alternatives: residue removal (generally fall plowing), residue management, and conservation or reduced tillage. The three tillage methods are combined with the four conservation alternatives: straight row cultivation, contouring, strip-cropping or terracing to provide a large variation in cropping intensity and soil loss, Table 3.

Gross soil loss as calculated represents the average annual tons of soil leaving the field. This measurement of soil loss does not represent the amount reaching the stream or bodies of water. Some soil particles settle out or are diverted as the runoff passes through grassed areas or onto flatter terrain, thereby changing the water's capacity to transport soil particles. Two separate procedures were used to determine the gross soil loss per acre. For the areas east of the Rocky Mountains the "Universal Soil Loss Equation" was used and for the area west of the

Table 3. Allowable conservation practices on the different land groups.[a]

Land groups	Row cropping	Contouring	Strip cropping	Terracing
1	X[b]			
2	X	X	X	X
3	X	X		
4	X		X	X
5	X	X		
6	X		X	X
7	X	X		
8	X			
9	X			

[a]Based on recommendations from the Soil Conservation Service.

[b]X = Practice allowed.

Rocky Mountains data derived from a Soil Conservation Service questionnaire were used to derive the soil loss coefficients for each management systems.[2]

The remaining crops are accounted for prior to model construction and adjustments are made in the land and water availability. Within the producing regions solution crop acreages[3] are restrained to be between prespecified upper and lower limits. The reason for these adjustment constraints is that regional shifts in production are gradual, not instantaneous, due to imperfect mobility of resources. Regional adjustment constraints are based on crop production patterns reported in the 1969

[2]For a detailed description of the calculations see Meister and Nicol [9]. An example of the SCS questionnaire is found in the reference.

[3]The crops involved are wheat, corn, silage (corn silage and sorghum silage), sorghum, soybeans, cotton, and sugar beets.

Census of Agriculture [19]. Acreages of individual crops are allowed to decrease to 70 percent of the 1969 Census acreage by 1985 and to 40 percent by the year 2000. Crop acreage is allowed to double from 1969 to 1985; no upper limit is set on year 2000 acreages.

The other endogenous crops (oats, barley, and nonlegume hay) are constrained at the market region level. These crop acreages are only required to satisfy a lower limit, calculated the same way as the PA adjustment limits. A final restraint in the model controls tne ratio between the acres of the legume and nonlegume hays. The active restraints in each of the PA's are shown in Table 3.11 in [9].

The livestock sector

This sector endogenously handles the beef cow, dairy, hogs, and beef feedlot activities in producing the livestock commodities: milk, fed beef, cull beef, pork, and feeders (an intermediate commodity used in the beef feedlot activities). The livestock activities are defined so that each of the four types of livestock demand that the commodities available for feed in alternative rations, which have previously been developed, reflect optimum feed inputs for alternative feed price ratios and commodity output levels. The feeders have 16 alternative rations, hogs and beef cows five each, and dairy has six. Linear combinations of the included rations for any livestock type provide an even larger number of possible rations for the livestock.

Regional livestock activity levels are restrained for reasons similar to the crop restraints. The 1985 restraints are set at 80 percent of 1969 for the lower limit and 250 percent of 1969 as the upper limit.

The lower restraint level for the year 2000 is set at 60 percent of 1969 with all 1969 levels determined from the Census of Agriculture livestock totals [19].

Livestock wastes historically have served as a ready source of plant nutrients. In line with the restrictions on animal waste runoff into the nation's waterways, all livestock activities considered in the model are developed with the possibility that their wastes, using the "conventional" system of handling, can be utilized as a fertilizer in the cropping sector.

The water sector

The water sector reflects the use of water with the agricultural sector as the sole user of the resource and is only defined in those areas west of the Mississippi except the Souris-Red-Rainy Basin, Figure 3. Direct competition for water with the other sectors is not included, thereby allowing only for complete evaluation of the possibilities available to agriculture. The water supply in each water supply region is derived in a manner consistent with the estimating procedure as outlined in the Volumetric Adequacy work statement of the Water Resources Council [25]. Producing area water supplies are calculated at present use levels plus seven-tenths of the remaining outflow from the region during the months when irrigation water is applied to crops.

The consumptive use of water for irrigation in 1975 is calculated by multiplying the 50 percent precipitation coefficients for irrigation and the 1971-73 average irrigated acres reported by the Statistical

Reporting Service or the NIRAP[4] projected acres for crops not reported by SRS. These water use estimates thus include irrigation from both surface and ground water. Depletion of ground water resources over time is accounted for in the final water supply available in the year 2000. Water supplies for the energy and environmental enhancement alternatives, to be explained later on, are the supplies of the base model reduced by the appropriate energy and environmental demands in 1985 and 2000. A comparison of the different supplies is presented in Table 4.

Table 4. Comparison of agricultural water supplies by major river basins for the base model and all alternative futures, with actual 1975 total use figures for comparison.

River basins	Water Use 1975	OBERS E' 1985	OBERS E' 2000	Environmental 1985	Environmental 2000	Energy 2000
Missouri	13.9	23.6	23.6	13.4	13.3	23.2
Ark-White-Red	7.4	11.7	11.2	5.7	5.2	11.2
Texas-Gulf	9.6	10.0	7.7	6.1	3.9	7.7
Rio Grade	4.4	4.4	4.4	3.8	3.7	4.4
Upper Colorado	2.4	3.0	3.0	.9	.9	2.7
Lower Colorado	6.1	5.9	5.5	5.7	5.7	5.4
Great Basin	3.5	3.5	3.5	2.7	2.7	3.5
Col-Nth-Pacific	12.3	76.5	76.5	9.1	9.1	76.4
California	24.1	30.6	30.6	21.3	21.3	30.5
Western basins[a]	83.5	169.4	166.1	68.7	65.8	165.1

[a]May not add because of rounding.

Water use coefficients for crop activities in the model represent the net diversion requirement to provide the crop with the amount of

[4]National Interregional Agricultural Projections Systems, USDA.

water needed for growth in addition to that provided from precipitation. The irrigation requirements of individual crops are based on current irrigation delivery and application practices with assumed rainfall at the 80 percent exceedance level.[5] Two sets of water use coefficients have been obtained from the Soil Conservation Service staff in Denver. The first set represents projected water use coefficients based on trend increases in water use efficiency. The second set represents high efficiency coefficients reflecting expected changes in delivery and application systems.

A water transportation network is developed that reflects natural flows and interbasin transfers, Figure 7. Water prices are acreage weighted average reimbursable costs of the Bureau of Reclamation projects [9, Table 3.12].

The supplies of water are adjusted for water use by the exogenous crops and irrigated hay land and range land prior to solving the model. However, the model is given the choice to return the irrigated exogenous pasture back to dryland pasture if this is economic. A change of irrigation pasture back to dryland pasture makes irrigation water available for use in other cropping activities. Hay yield of the exogenous pasture is adjusted accordingly if this activity takes place in the model.

The demand sector

Domestic and net export demands are estimated for each commodity based on projected per capita income, consumption, and relative future

[5] This represents a relatively dry year since more rainfall would be expected to occur in 8 out of 10 years.

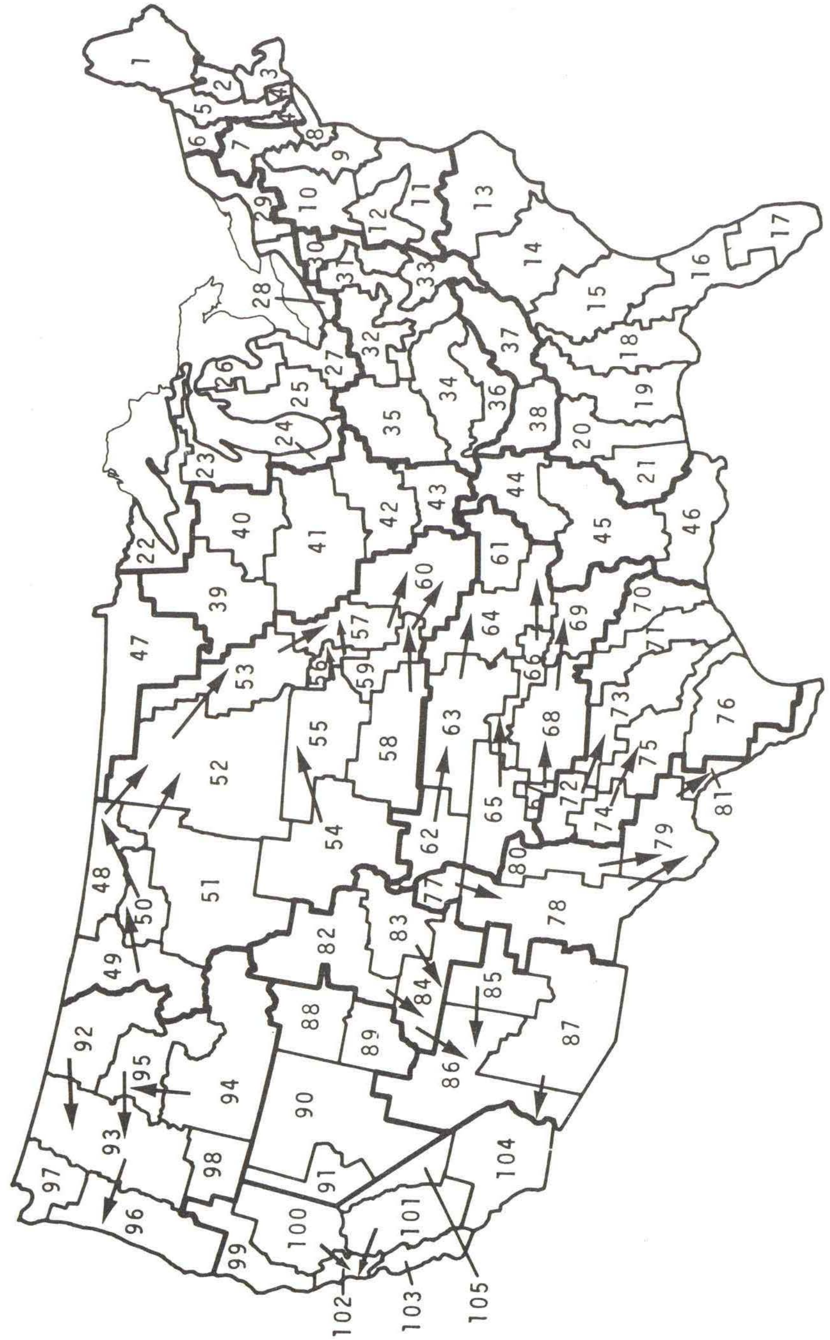


Figure 7. River basins with a schematic of the water flow network for the western basins.

prices. Exports are based on estimated international prices, expected governmental international agreements, and other demand factors estimated in the OBERS[6] projections [23,24]. Total demands include feed grains for exogenous livestock. Projected per capita demand levels and net export levels are shown in Tables 5 and 6.

The transportation sector

Interregional interdependence is created especially by a transportation submodel or sector. The transportation network is based on the 28 market regions and calculates the cost of transporting the commodities barley, corn, oats, sorghum, oilmeals, wheat, milk, fed and nonfed beef, pork, and feeders. Silages, hays, and livestock wastes are transported only within the market regions.

This last section concludes the description of the model. However, to show more clearly the overlapping nature of producing regions and market regions, the types of activities included in the model, and the way in which activities are restrained, a schematic representation is provided of the model in Figures 8 and 9. The schematic in Figure 8 shows how several producing areas (PA's) are contained within market region 1 (MR1). Further, the figure shows the major types of restraints--those in the left column, and activities--those on the top row. To further show how these different agricultural sectors are interrelated,

[6]OBERS stands for the Office of Business Economics (now Bureau of Economic Analysis) and Economic Research Service. The projections are prepared for the U.S. Water Resources Council.

Table 5. Projected per capita demand levels for 1985 and 2000 for the OBERS E' and E estimated and actual 1970-72.

Commodity	Unit	Average Consumption 1970-72	OBERS E' Consumption 1985[a]	2000[b]
Barley	bu.	.04	.042	.05
Corn	bu.	1.103	1.207	1.309
Oats	bu.	.219	.212	.212
Sorghum	bu.	.0	.0	.0
Wheat	bu.	2.52	2.472	2.338
Soybeans	bu.	NA[c]	NA[c]	NA[c]
Cotton	bales	.039	.029	.025
Beef & veal (carcass wt.)	lbs.	116.8	136.7	150.7
Milk (fresh equiv.)	lbs.	560.0	511.4	456.6
Pork (carcass wt.)	lbs.	68.9	68.1	71.5
Lamb & mutton (carcass wt.)	lbs.	3.2	1.8	1.7
Turkeys (R.T.C.)	lbs.	8.6	10.9	12.8
Chickens (R.T.C.)	lbs.	41.9	49.8	56.5
Eggs	doz.	26.0	25.0	38.0

[a]Projected U.S. population for 1985 is 233.1 million.

[b]Projected U.S. population for 2000 is 262.4 million.

[c]Not available.

Figure 9 presents a more detailed breakdown of market region 1 in Figure 8. In this figure the market region subscript has been omitted and the meaning of the restraints, ranges, and abbreviations are as follows:

Table 6. Projected net export levels, OBERS E and OBERS E', for 1985 and 2000, and actual 1970-72 data.

Commodity	Unit	Average 1970-72[a]	OBERS E 1985	OBERS E 2000[b]	OBERS-E' 1985	OBERS-E' 2000[c]	OBERS-E' (High) 1985	OBERS-E' (High) 2000[c]
		(million)						
Barley	bu.	43	93	96	20	35	25	40
Corn	bu.	663	1,118	1,275	989	2,069	1,889	3,209
Oats	bu.	14	5	4	10	21	19	29
Sorghum	bu.	160	202	217	160	380	270	450
Wheat	bu.	737	785	814	774	919	1,179	1,479
Soybeans	bu.	443	599	684	950	1,475	1,125	1,700
Cotton	bales	4.1	3.5	3.5	4.1	4.2	4.2	4.6
Beef & veal (carc. wt.)	lbs.	-1,740	-2,163	-2,909	-2,169	-2,924	-1,190	-1,760
Milk (fresh equiv.)	lbs.	-500	-500	-500	-680	-1,040	-680	-1,040
Pork (carc. wt.)	lbs.	-278	-275	-325	-307	-351	-307	-351
Lamb & mutton (carc. wt.)	lbs.	-117	-184	-203	-230	-274	-230	-275
Turkeys (R.T.C.)	lbs.	31	35	35	70	80	70	80
Broilers (R.T.C.)	lbs.	203	133	90	235	253	235	253
Eggs	doz.	40	43.9	50	44	50	43.9	50

[a]Source: [16].

[b]Source: [23].

[c]Source: [24].

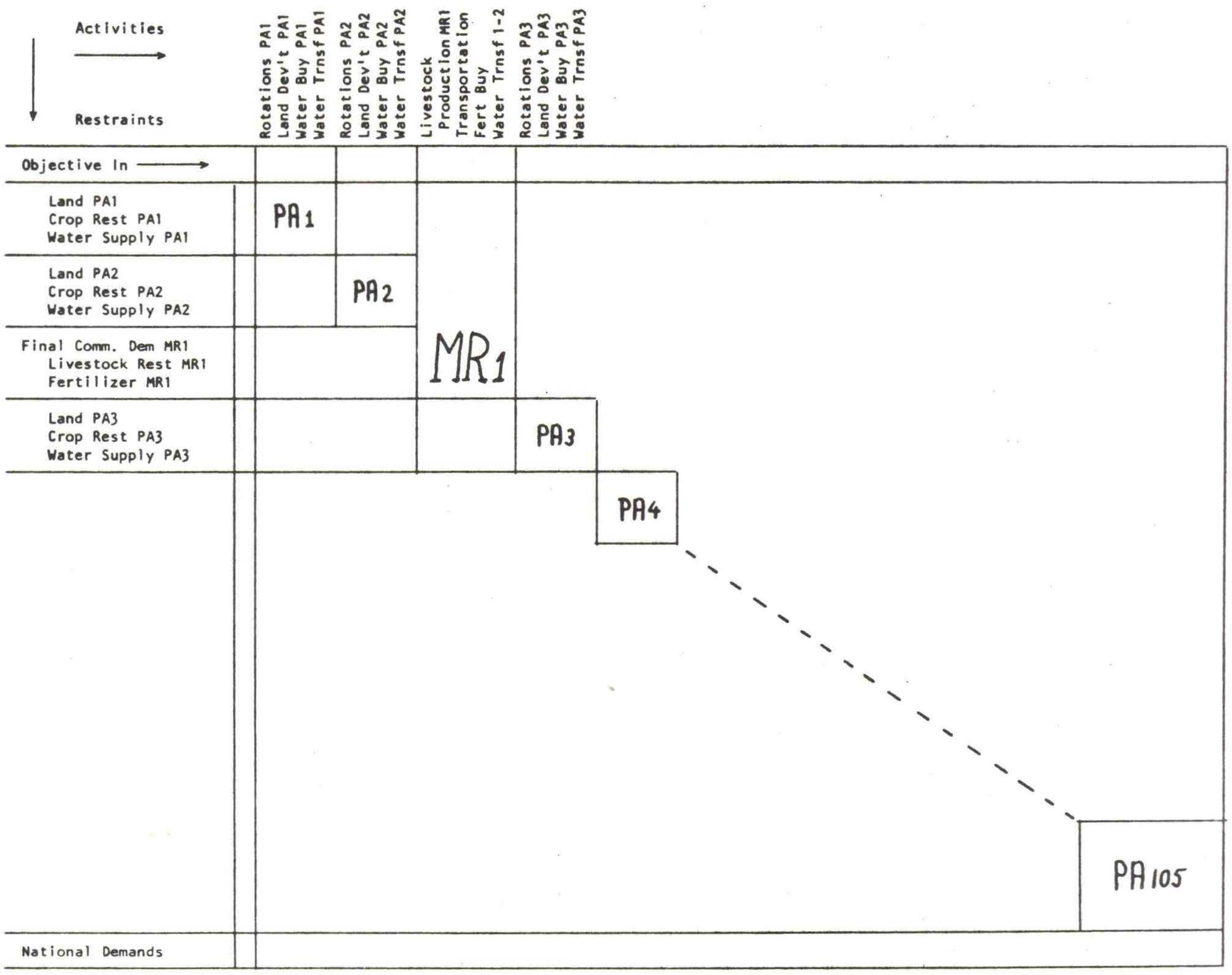


Figure 8. A schematic representation of the model showing the overlapping nature of producing and market regions.

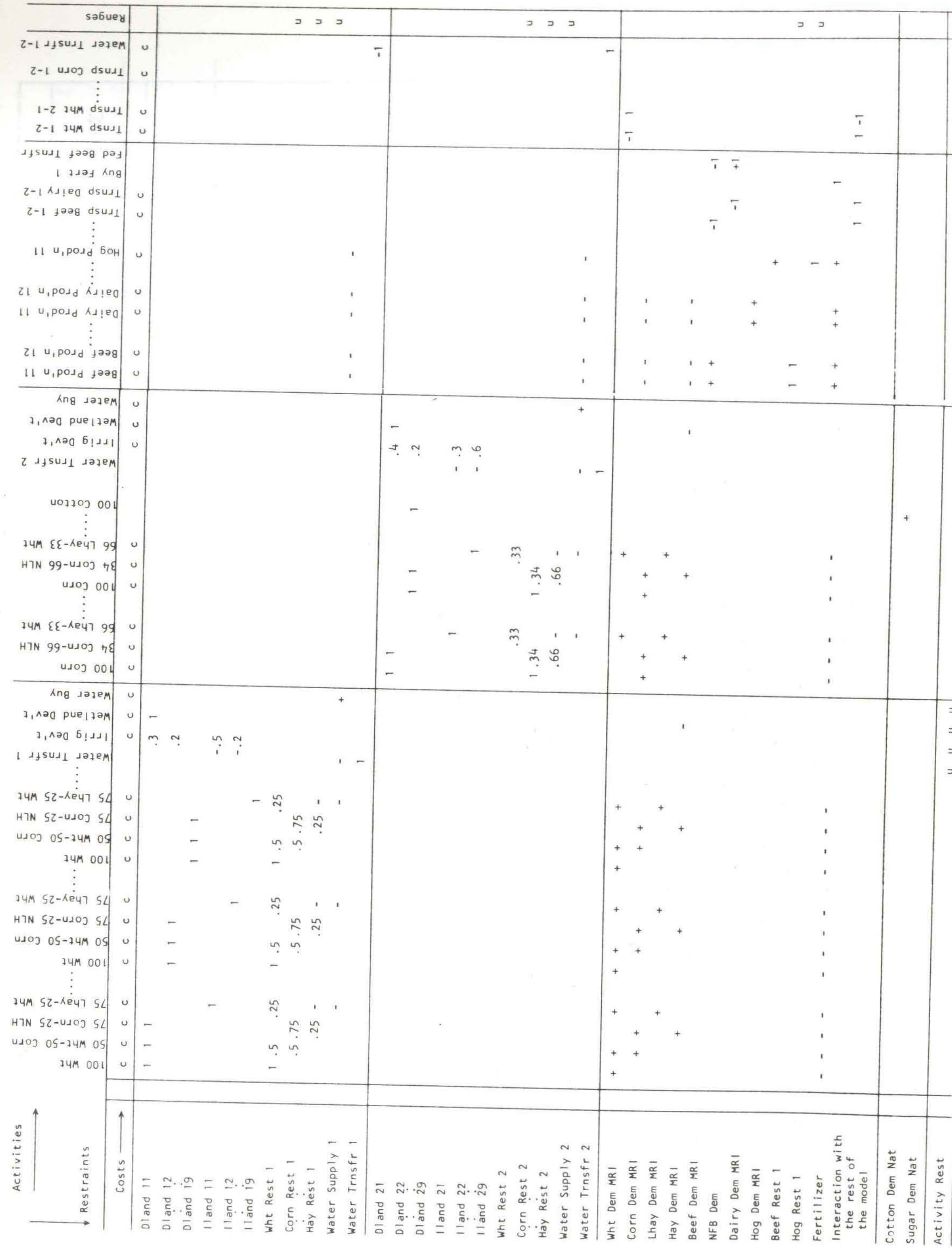


Figure 9. A detailed presentation of the interrelationships between agricultural activities in market

Restraints---

DLandij	is dryland available in the j-th group of the i-th producing area;
ILandij	is irrigated land available in the j-th land group of the i-th producing region;
Wht Resti	is the restriction on wheat production, expressed in number of acres, in the i-th producing region;
Wht Dem MR1	is the wheat demand row balancing wheat supply and demand at the market region level;
Cotton Dem Nat	is the cotton demand row balancing cotton supply and demand at the national level.

Activities---

50 Wht-50 Corn	is a 50 percent wheat and 50 percent corn rotation;
Beef Prod'n ij	is a beef producing activity using the j-th ration in the i-th producing area;
Trnsp Beef	is a transportation activity shipping beef from market region 1 to market region 2.

Activity Rest---

u an activity that is restricted by an upper bound on the maximum level of activity that can be attained.

Ranges---

u a restraint that has an upper bound.

Abbreviations other than those already explained---

TRNSF -- transfer
Lhay -- legume hay
NFB -- nonfed beef
NLH -- nonlegume hay
Fert -- fertilizer

Futures Analyzed

A number of alternative futures relating to resource demands, water supply conditions and efficiency, nonirrigated and irrigable land availability, environmental and conservation practices, adjustment flexibilities, preemptive water uses, and export levels are evaluated by the model. Evaluations are made for 1985 and 2000 (in some cases only 2000) with emphasis on the regional impacts as the system attains indicated domestic consumption and national export levels and regional efficiency in production under each of the scenarios.

The alternative futures evaluated are summarized by first stating the basic set of conditions that are incorporated into the base alternative. The remaining alternative futures will be developed by changing one or more of the assumptions in the base condition.

Basic conditions for OBERS E' runs

The base conditions include the following: the land base is that of the 1967 Conservation Needs Inventory (CNI) updating for drainage of wet soils and irrigation development over the period 1967-73. Land in Classes IIw and IIIw, forest land and pasture land, can be converted to Class I cropland up to a level of 90 percent of the total inventoried acres in these classes in the 1967 CNI. Land conversion costs are amortized over 20 years at Production Credit Association interest rates and, in conjunction with the O and M costs required to maintain these converted acres at a Class I capability, provide the annual per acre conversion cost for this activity. The 1967 CNI irrigated land base is

adjusted for irrigation development occurring between 1967 and 1974. The water supply represents the current (estimated 1975) water use in agriculture supplemented with the availability from region outflows during the major irrigation period of the year. The 1985 and 2000 water supplies are adjusted to reflect ground water depletion in areas of nonrechargeable aquifers, Table 4. Irrigation efficiency, except for projected general technological improvements, is held at present levels. Domestic demand, based on major variables representing population, per capita incomes, and time trends in food preferences is obtained from the OBERS E' projections [24]. For 1985, these variables include a 233 million population and a $5,400 per capita income (in 1967 dollars). By 2000, respective figures are 262 million and $8,100.

Soil loss is restrained to a maximum of 40 tons per acre or 10 times the t values.[7] No restriction is imposed on livestock waste disposal. Flexibility or production adjustment restraints are imposed to prevent extreme shifts among regions. On an individual crop and region basis, 1985 acreage is restrained within a range equal to .7 and 2.0 proportions of the 1969 acreage. Acreage in 2000 cannot be less than .4 of the 1969 acreage, but there is no upper limit. For livestock, 1985 regional production totals, in number of head for beef cows, beef feeding and dairy, and cwt. liveweight for hogs, are restrained within a range equal to .8 to 2.5 proportions of the corresponding 1969 totals.

---

[7]The t value is defined as that amount of erosion that can occur through time without lowering the soil's productivity.

For the year 2000 the restraints are set at .6 of the 1969 level and no upper limit is imposed. The model forces irrigated acreage to be at least equal to the 1969 level for endogenous crops. These assumptions form the basis for the OBERS E' runs for the year 1985 and 2000. The modifications for the alternative runs consist of changes in the application of some of these conditions. We now explain the variants or conditions of the other alternative futures examined.

OBERS-E or low demand alternative

This alternative is developed for 2000 only. The solution is constrained to the 1972 OBERS-E projections of domestic demands, export levels, and irrigated crop acres [23]. The domestic demand and export levels are generally lower than the OBERS E' series used in the base scenario. The two sets of projections are compared in Tables 5 and 6. All remaining assumptions are carried over from the OBERS E' runs.

The high export alternative

In this alternative, evaluated for both 1985 and 2000, all conditions and constraints of the OBERS E' run are retained except that higher levels of exports are used. Higher export levels may occur with rising affluence of less developed countries, improved diets, and a vigorous U.S. export policy to stabilize and improve the balance of trade. A comparison of export levels used is given in Table 6.

The land and water conservation alternative

For this alternative, evaluated for 1985 and 2000, all assumptions of the OBERS E' run are retained except that the solution is constrained

to cropping patterns and conservation practices that will achieve sustained long-run productivity. This policy constraint would conform with society's concern for maintaining a productive agricultural land base and reducing stream and lake sedimentation. It is attained by holding allowable soil loss at the "t value" as specified by the Soil Conservation Service for each region and land group. In addition, an accelerated adoption rate for irrigation water conserving technologies is incorporated.

The environmental enhancement alternative

Several changes are made in this alternative to reflect possible societal environmental concerns with maintaining water quality and protection of fish and wildlife. Solutions for 1985 and 2000 evaluate the impacts of such policies on the agricultural sector. In addition to retaining the restrictive soil loss assumption of the conservation run, three environmental assumptions are included: a) no further development of wet soils for cultivation is allowed beyond 1975, b) the water supply available for agricultural uses is reduced to allow minimum stream flows for maintenance of water quality and protection of aquatic life, and c) livestock wastes cannot accumulate at production sites but must be returned to the land.

The energy development alternative

By 2000, additional nonirrigated and presently irrigated lands may be withdrawn from agriculture as energy development efforts take priority.

Similarly, energy development activities increase demand for water and may cause diversions to meet this end. Water supplies are therefore adjusted to allow shale oil extraction and to transport and process coal for generation of electricity. No adjustment is made for projected stripmining of coal. The assumption is made that most land presently under stripmining again will be productive pasture land by the year 2000. With conversion of stripmined land back to pasture, the total area under stripmining will not change enough to cause any significant changes in the model solutions. A comparison of the available water supplies for the E', environmental and energy alternatives is given in Table 4.

Environmental enhancement, OBERS E alternative

Under this alternative, the assumptions of the environmental runs are combined with the OBERS E series demand assumptions for the year 2000. The alternative thus evaluates the impacts of a policy concerned with the environment which may limit exports to levels projected in the OBERS E series [23].

These runs form the basis for the initial phases of the 1975 National Water Assessment analysis. The alternative futures analyzed represent only a few of those possible. Several assumptions are held constant in all eleven alternatives; hence, the analysis of a restricted set of policy measures. Any changes in the conditions held constant among alternatives will change the solution results. In the following chapters the solutions of the runs will be discussed and analyzed.

III. THE BASE RUNS

The E' scenarios for the years 1985 and 2000 are the base runs against which future alternatives are compared to determine their impact on resource use and allocation, prices, and income. In this section the results of these two runs are discussed in detail. Reporting is done at national and riverbasin levels, Figure 6. Also, where possible, solution results are compared with 1971-73 average acreage and production totals derived from ERS statistical reports [16].

In the large-scale model used in this study not all results can be analyzed and reported. Choice of important variables to summarize must be made. In this report we concentrate on land and water use, prices and incomes, and environmental impacts.

First, a breakdown is given of total land use by crop and area. In discussing these results reference is made to yields, livestock production, and rations. Following the land use discussions, regional water supplies and consumptive use are discussed, followed by a discussion of conservation--tillage practices and soil loss. Partial equilibrium prices, which are part of the solution results, are then presented and discussed.

Total Acreage and Distribution of Dryland and Irrigated Crops

Compared with the average 1971-73 acreage, total endogenous crop acres used in 1985 increase by 4.8 percent while the increase is 7.3 percent by 2000, Table 7. The extra acreage required by the year 2000

Table 7. Endogenous crop acres for the United States for the OBERS-E' 1985 and 2000 alternatives.

Crop	1971-73[a] Average	OBERS-E' 1985	OBERS-E' 2000
		(thousand acres)	
Barley	10,124	17,299	8,322
Corn	60,956	54,116	57,619
Cotton	12,172	8,110	6,602
Oats	14,459	15,012	9,516
Sorghum	13,863	14,284	14,360
Roughages	72,822	66,718	75,043
Soybeans	48,185	69,445	87,219
Sugar	1,261	1,572	1,903
Wheat	47,942	48,608	41,962
Endogenous crop total	271,942	295,164	302,555
Percentage of acres irrigated	9.6	9.2	9.4

[a]Source: [16].

to meet increases in projected demand between 1985 and 2000 is small, only 6.8 million acres. This small increase between 1985 and 2000 can be explained as follows: a) the bounds on the production restraints are widened for the year 2000 to a lower bound of 40 percent of the 1969 crop acreage and no upper bound; b) the increase in projected yields, which leads to

a higher average crop yield in 2000, Table A.1, reduced the total number of acres required per unit of final crop demands. From a least-cost standpoint, widening of the production bounds allows more optimal production and resource use patterns than in the more tightly restrained 1985 solution. Irrigated acres increase from 26.9 million in 1971-73 to 27 and 28 million in 1985 and 2000, respectively, Table 8. The 1969 irrigated acreage of the endogenous crops was 22 million acres [19] and the model was restrained to at least have a solution with irrigated acreage equal to or greater than this 1969 level. In solutions for both years this restraint could not be met in some producing areas because of a shortage of either water or land. The regional impacts of these shortages are discussed later.

Irrigated acreages for the endogenous crops in 2000 are also presented by states, Figure 10, to show more clearly the regional distribution of these acres.

Land use at the national level is summarized in Table 9. Although the number of acres cultivated increased in 1985 and 2000, under the demand levels of this alternative there is still a substantial amount of surplus capacity in the United States. In 1985 there is 59.3 and in 2000, 60.1 million acres of unused cropland. This acreage represents the potential of U.S. agriculture to further increase total output at higher export levels. Of this unused cropland, close to 50 percent is classed as land in the land groups I-V, which is "good" to "average" quality land.

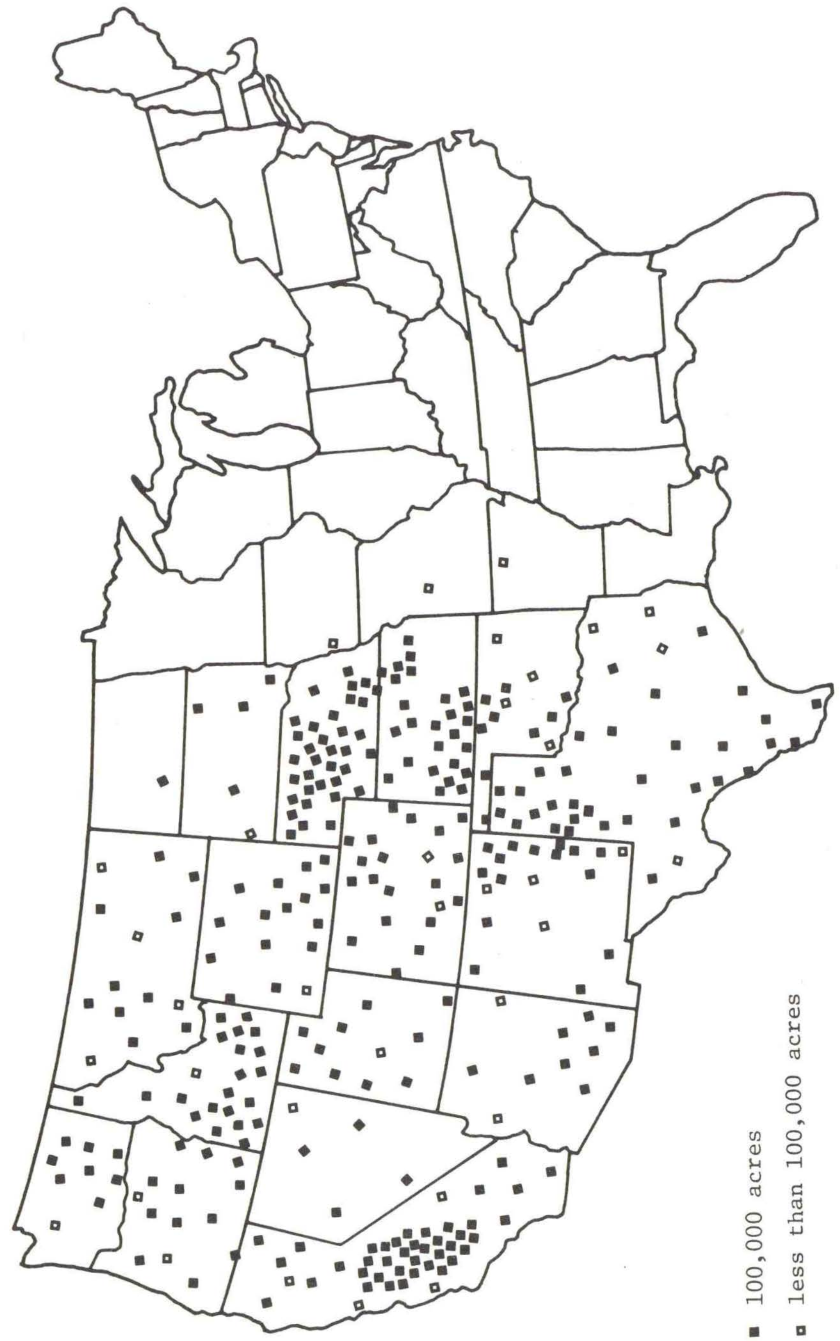
Table 8. Irrigated acres harvested by crops and major river basins for E' 1985 and 2000 alternatives.

Item	Average 1971-73[a]	1985 E'	2000 E'
River basin		(thousand acres)	
Missouri	6,609	7,154	8,312
Ark-White-Red	3,420	4,372	4,679
Texas-Gulf	3,340	3,144	2,124
Rio Grande	1,403	1,429	1,510
Upper Colorado	1,015	919	995
Lower Colorado	1,091	964	982
Great Basin	1,136	1,101	1,168
Col-Nth-Pacific	3,646	3,890	4,324
California	3,945	4,186	4,275
Crop			
Barley	1,677	2,688	1,064
Corn	4,110	2,504	1,483
Cotton	3,305	1,950	1,543
Oats	225	253	104
Sorghum	3,568	5,070	1,688
Roughages	9,290	11,668	19,363
Soybeans	213	388	325
Sugarbeets	961	881	347
Wheat	2,305	1,756	2,452
Crop total[b]	25,685	27,159	28,369

[a]Source: [16].

[b]May not add because of rounding.

Another important result is the amount of land developed. The 3.8 million acres by 1985 and 10.6 million acres by 2000 represents clearing of forest lands and the drainage of wet soils. In the environmental alternatives, land developed would be detrimental to environmental quality because of reductions in fish and wildlife habitats. Therefore, no land



■ 100,000 acres
□ less than 100,000 acres

Figure 10. Location of irrigated land in 2000 for the OBERS-E' solution.

development is allowed in the environmental alternatives even though it is profitable. New land for irrigation also is developed for both 1985 and 2000.

Table 9. Total cropland available and its use by type of use for the OBERS-E' alternatives.

Item	OBERS E' 1985	OBERS E' 2000
	(million acres)	
Available	393.1	388.4
Wetland developed	3.8	10.6
Total available	396.9	399.0
Dryland used	286.8	286.5
Irrigated land used	27.2	28.4
Land used for exogenous crops	23.7	24.0
Total used	337.6	338.9
Idle land	59.3	60.1
Irrigated land development	3.9	6.6
Percentage of idle land in the land groups I-V	48%	46%

At the regional level there are some significant changes in crop acreages. The approximate doubling of the soybean acreage by 2000 is because of high export levels and a greater demand for soybeans for feed. Most variations in the U.S. totals of individual crops, when compared with 1971-73 data, can be explained by observing the changes in: a) the projected levels of per capita food consumption and exports, and b) feed demand by livestock. Table A.2 shows the estimated average solution rations for the different livestock categories. Between 1985 and 2000

there is a distinct shift in rations from feed grains and hay towards more soybean meal and silage. This shift is partly reflected in changes in U.S. soybean and roughage acreages for the two years. For example, cattle on feed in 1971 consumed on the average 1.30 cwt of oilmeal equivalents while in the 2000 solution this increases to 2.19 cwt. Similarly, for dairy cows which consumed, in 1971, 4.47 cwt of oilmeal equivalent, the 2000 solution shows an average of 6.38 cwt [15].

Cotton acreage decreases due to a projected decrease in domestic cotton consumption and little change in exports while projected yields increase. Irrigated crop acreage generally decreases compared to the 1971-73 average. Exceptions are barley, sorghum, and soybeans in 1985. The only crops that show a substantial increase in both 1985 and 2000 are the roughages with silage experiencing the greatest increase.

A comparison of projected 2000 United States production totals, by crops, with actual 1971-73 data is presented in Table A.3. The results in this table show the combined effect of changes in irrigated and dry acreages of each of the crops and the changes in yields. For example the yield increase in soybeans combined with an increase in acreage leads to a large increase in total soybean production. The decrease in cotton acreage combined with an increase in yield maintains total cotton production at the fixed level specified.

Regional Land Use and Crop and Livestock Production Patterns

In the model, exogenous crop acres are predetermined, but endogenous crop acres are determined. Total endogenous cropland use is presented in Tables 10 and 11. Percentagewise, the Missouri River Basin is the only region where total land use drops significantly by 1985 and even more by 2000. Increases are shown in 1985 for the Ohio, Arkansas-White-Red, and Texas-Gulf river basins but all three have land use shares which are reduced again in 2000. The South Atlantic-Gulf and Great Lake river basins increase their total crop acreage between 1985 and 2000.

Even though total land use patterns do not change drastically, there are some significant changes in acreages of individual crops. Comparing 1985 and 2000 with 1971-73, feed grain acres decrease in the Missouri basin and increase in the Great Lakes, Ohio, and (to a lesser extent) in the Arkansas-White-Red and Texas-Gulf basins. In the Ohio basin soybeans replace roughages, especially in the year 2000. The distribution of wheat production is similar to the 1971-73 average except for the Ohio basin in which a significant increase occurs. Also, there is a general decrease in wheat acreage in the Western states. Presenting regional crop production patterns in a different way, row crops[8] are aggregated and presented in Figure 11 on a state map. A similar map is provided for the 2000 land and water conservation alternative and the 2000 environmental enhancement alternative. The decrease in irrigated crop acres, except for roughages, is reflected in the regional

[8]Row crops are corn, sorghum, silages, soybeans, and cotton.

Table 10. Total crop and crop land use acres by major river basins for the E' 1985 base model with actual 1971-73 data for comparison.

River Basin	Feed grains 1971-73 Average	Feed grains 1985	Wheat 1971-73 Average	Wheat 1985	Cotton 1971-73 Average	Cotton 1985	Soybeans 1971-73 Average	Soybeans 1985
				(thousand acres)				
New England	39	32	-	-	-	-	-	-
Mid Atlantic	2,607	4,640	534	691	-	-	842	1,194
S. Atlantic-Gulf	5,034	4,283	636	787	1,563	1,172	4,133	5,434
Great Lakes	6,585	8,425	1,119	1,081	-	-	3,332	4,161
Ohio	9,945	9,971	1,679	3,084	3	-	7,081	9,671
Tennessee	553	278	144	127	267	166	270	577
Upper Mississippi	27,130	27,687	1,572	953	-	-	14,901	22,437
Lower Mississippi	1,021	530	588	369	3,354	2,059	10,757	14,969
Souris-Red-Rainy	4,943	3,246	4,758	8,256	-	-	535	781
Missouri	26,474	23,639	18,158	14,988	-	-	4,959	7,250
Ark.-White-Red	4,963	6,582	12,064	12,888	1,272	841	1,251	2,812
Texas-Gulf	5,675	7,416	1,028	770	3,843	2,794	124	153
Rio Grande	471	603	27	16	712	407	-	-
Upper Colorado	130	149	179	109	-	-	-	-
Lower Colorado	295	352	192	79	307	207	-	-
Great Basin	226	253	312	322	2	1	-	-
Col.-N. Pacific	1,662	1,135	4,398	3,437	-	-	-	-
California	1,649	1,485	554	643	849	461	-	-
United States[b]	99,402	100,712	47,942	48,608	12,172	8,110	48,185	69,445

[a]Includes all endogenous crops.

[b]May not add because of rounding.

Table 10, continued

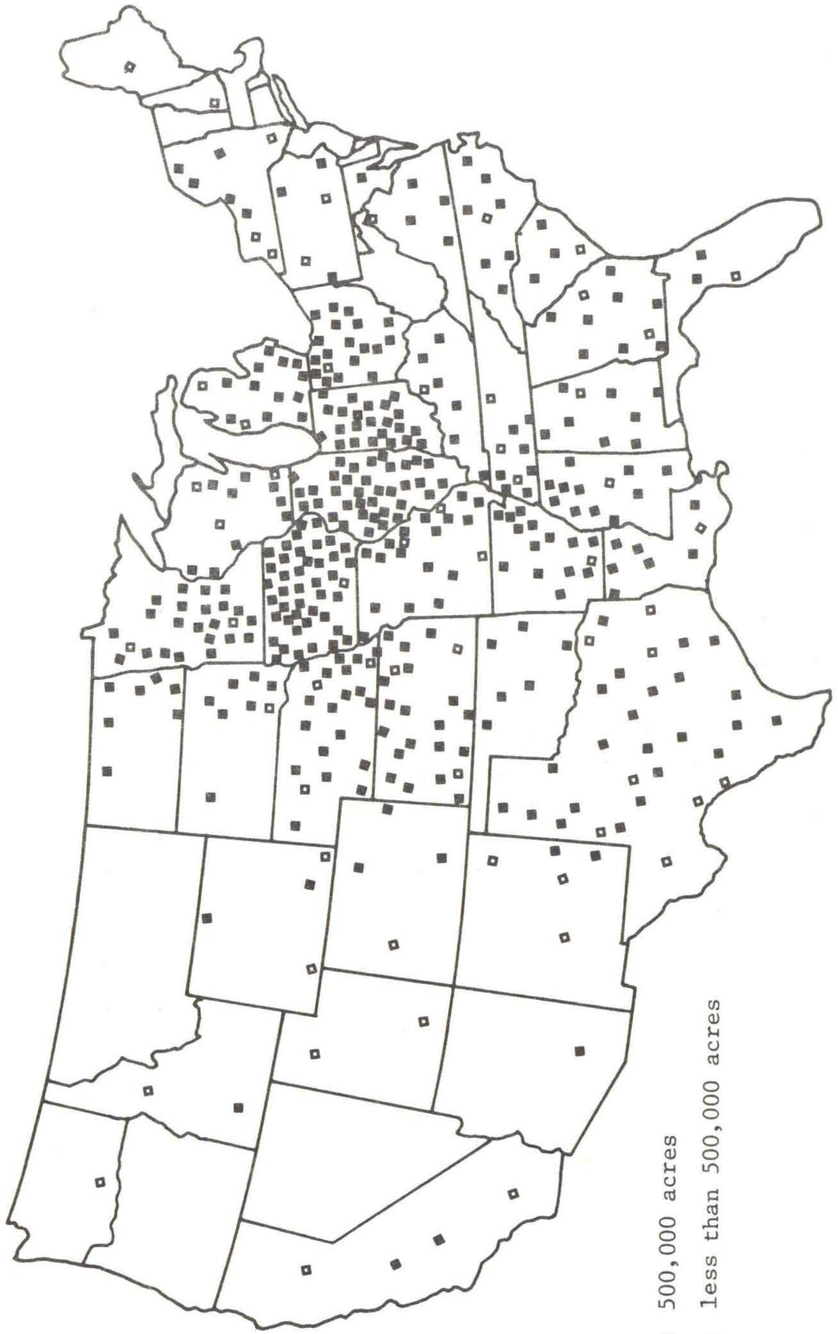
River Basin	Roughages 1971-73 Average	1985	Sugar 1971-73 Average	1985	Total crop land used[a] 1971-73 Average	% of Total	1985	% of Total
			(thousand acres)					
New England	1,306	392	-	-	1,345	.5	424	.1
Mid Atlantic	4,265	1,594	-	-	8,248	2.9	8,119	2.8
S. Atlantic-Gulf	2,619	1,427	-	-	13,985	5.0	13,103	4.4
Great Lakes	5,600	3,878	118	253	16,754	5.9	17,798	6.0
Ohio	5,660	5,435	1	-	24,369	8.6	28,161	9.5
Tennessee	1,164	1,246	-	-	2,398	.9	2,394	.8
Upper Mississippi	10,013	8,459	39	37	53,655	19.0	59,536	20.2
Lower Mississippi	1,138	198	-	-	16,858	6.0	18,125	6.1
Souris-Red-Rainy	2,242	1,185	144	400	12,622	4.5	13,868	4.7
Missouri	21,437	18,910	314	344	71,342	25.3	65,131	22.1
Ark.-White-Red	6,156	9,071	39	48	25,745	9.1	32,194	10.9
Texas-Gulf	2,558	6,783	-	13	13,228	4.7	17,929	6.1
Rio Grande	744	496	1	-	1,955	.7	1,522	.5
Upper Colorado	935	684	6	17	1,250	.4	959	.3
Lower Colorado	302	321	-	18	1,096	.4	977	.3
Great Basin	1,077	846	27	54	1,644	.6	1,476	.5
Col.-N. Pacific	3,617	3,643	265	186	9,942	3.5	8,401	2.8
California	1,909	2,143	312	198	5,353	1.9	4,930	1.7
United States[b]	72,822	66,719	1,261	1,572	281,789		295,407	

Table 11. Total crop, pasture, and cropland use acres by major river basins for the E' 2000 alternative.

River Basins	Feedgrain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
				(thousand acres)			
New England	18	-	-	-	303	351	3,787
Mid Atlantic	2,855	2,104	-	1,325	1,657	7,851	12,377
S. Atlantic-Gulf	2,293	1,475	2,580	11,874	2,256	20,478	40,084
Great Lakes	10,552	1,697	-	4,812	2,422	20,940	9,799
Ohio	10,751	2,236	-	12,731	1,299	27,017	28,496
Tennessee	127	26	94	1,977	126	2,350	6,846
Upper Mississippi	26,107	790	-	23,276	8,533	58,724	21,917
Lower Mississippi	343	2,217	1,176	12,527	2,676	18,669	19,782
Souris-Red-Rainy	6,646	4,692	-	2,207	2,156	15,781	4,418
Missouri	17,496	12,946	-	8,731	23,448	62,782	201,112
Ark.-White-Red	4,560	7,158	480	5,799	15,549	33,564	91,591
Texas-Gulf	5,143	1,859	1,628	1,957	5,022	15,616	78,732
Rio Grande	785	25	258	-	489	1,557	76,397
Upper Colorado	63	74	-	-	877	1,018	46,169
Lower Colorado	154	110	118	-	719	1,111	77,971
Great Basin	107	501	-	-	821	1,440	70,475
Col.-N. Pacific	1,035	3,433	-	-	3,723	8,213	88,058
California	788	701	263	-	2,959	4,821	44,961
United States[b]	89,828	41,962	6,602	87,219	75,044	302,283	922,979

[a]Includes all endogenous crops.

[b]May not add because of rounding.



■ 500,000 acres
▫ less than 500,000 acres

Figure 11. Location of row crop acres in 2000 for the OBERS-E' solution.

acreages, Table 8. Some of the shifts in crop acres are encouraged by relocation of livestock production. In Table 12, the river basins have been aggregated into four zones, and livestock production patterns are reported at these zone levels.

Table 12. Percentage distribution of total livestock production in the four major zones for the OBERS-E' alternatives.

Zone	Beef Cows		Beef Feeding		Dairy		Hogs	
	I[e]	II[f]	I	II	I	II	I	II
				(percent)				
North-East[a]	16.3	9.0	30.1	13.2	53.8	52.0	64.3	83.0
South-East[b]	9.1	5.7	2.5	20.9	17.5	20.5	4.9	2.4
Mid-Continent[c]	57.4	67.5	51.2	49.4	17.3	16.2	30.2	14.3
West[d]	17.2	17.8	16.0	16.6	11.3	11.3	.4	.2

[a] Includes river basins 1, 2, 4, 5, and 7.

[b] Includes river basins 3, 6, and 8.

[c] Includes river basins 9, 10, 11, and 12.

[d] Includes river basins 13, 14, 15, 16, 17, and 18.

[e] OBERS-E' alternative 1985.

[f] OBERS-E' alternative 2000.

Combining the results in Table 12 with the information on average solution rations, Table A.2, the increase in beef cows in the Mid Continent region and the greater importance of soybeans and roughages in the year 2000 rations, explains the decrease in feed grain acreages and increase in soybeans and roughage acres in the Missouri, Arkansas-White-Red and Texas-Gulf basins. Beef feeding tends to move into the South-East from the North-East. Hence, an increase in soybeans and roughage production is encouraged in these basins. Regional dairy production changes little between the two solutions except for some increase in the South-East region. Hog production in 2000 compared to 1985, concentrates more in the North-East. Table A.4 compares 2000 production of livestock products with 1971-73 average production. The figures in this table amplify in more detail the shifts in livestock production shown by means of the four major zones.

Consumptive Water Use

Consumptive water use for the two solutions is presented in Tables 13 and 14. Total consumptive use is projected to increase by 7 percent in 1985 because of the increase in irrigated acres and livestock. Although the total increase in consumptive use by agriculture is not great, only .5 percent per year, some regional changes are of a greater magnitude and in opposite directions. In the Missouri and Columbia-North-Pacific basins, consumptive water use increases by 27 and 39 percent, respectively, but in Texas-Gulf, Lower Colorado, and California basins consumptive use decreases by 12, 11, and 8 percent, respectively.

For the year 2000, water use declines from the 1985 total of 87 million acre-feet to 86 million acre-feet. Irrigated acres increase very little between these two time periods while use efficiency increases.

Table 13. Consumptive water use by crops and livestock by major river basins for the E' 1985 model with actual 1971-73 data for comparison.

River basin	1971-73 Av.			E' 1985					Shadow Price
	Irr.	Lvst.	Total	Irr.[a]	Lvst.[b]	Total[c]	Supply	Surplus	$
	----thousands of acre-feet----								
Miss.	13,136	451	13,587	16,778	504	17,284	23,634	6,350	16.46
Ark-White-Red	7,171	235	7,406	6,894	293	7,189	11,720	4,531	23.57
Texas-Gulf	9,396	196	9,592	8,158	241	8,401	10,020	1,619	21.59
Rio Grande	4,312	42	4,354	4,174	57	4,234	4,399	165	6.84
Upper Colo.	2,418	30	2,448	3,012	27	3,040	3,040	0	6.54
Lower Colo.	6,049	53	6,102	5,373	54	5,429	5,929	500	7.89
Great Basin	3,505	33	3,538	3,494	42	3,538	3,538	0	8.14
Col-N. Pacific	12,249	77	12,326	17,085	105	17,191	76,473	59,282	3.53
California	23,966	103	24,069	22,145	98	22,240	30,619	8,373	10.35
Western basins[c]	82,202	1,220	83,422	87,123	1,431	88,555	169,372		11.82

[a]Includes; exogenous crops, exogenous roughages, endogenous crops.

[b]Includes; exogenous and endogenous livestock.

[c]May not add because of rounding.

Table 14. Consumptive water use by crops and livestock by major river basins for the E' 2000 alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,656	712	17,370	6,266
Ark.-White-Red	11,212	6,165	385	6,553	4,659
Texas-Gulf	7,696	5,865	270	6,137	1,559
Rio Grande	4,368	3,943	84	4,027	341
Upper Colorado	3,040	3,008	30	3,040	-
Lower Colorado	5,497	4,967	66	5,035	462
Great Basin	3,538	3,454	82	3,538	-
Col.-N. Pacific	76,473	17,179	113	17,294	59,179
California	30,619	22,653	105	22,760	7,859
Western basins[c]	166,077	83,890	1,847	85,757	

[a] Includes exogenous crops and roughages and endogenous crops.

[b] Includes exogenous and endogenous livestock.

[c] May not add because of rounding.

Also in 2000 there is some opportunity to relocate irrigated acres to those regions with highest comparative advantage. This relocation and higher water use efficiency lead to the decrease in water use while irrigated acres increase slightly.

In two river basins, the Upper Colorado and Great Basin, all available water is used in both years. As mentioned earlier, in several producing areas the model was not able to satisfy the 1969 irrigated acreage restraint. These regions are 67, 72, 74, 101, and 103 for 1985 and 67, 72, 74, 95, and 104 for 2000. Failure to attain the restraint results because there is not enough a) land in the region (after exogenous crops have taken their share) or b) water to irrigate this minimum required acreage. Producing areas 67, 72, and 74 in the Texas High Plains have a water shortage (ground water supplies decrease). In regions 101 and 103 higher water use efficiency in 2000 effectively increases water supplies and the land use restraints can now be met.

Conservation-Tillage Practices and Soil Loss

Soil loss by river basin is presented in Table 15. Increases in production to satisfy final demand in the year 2000 lead to an increase in acreage cultivated and a higher total soil loss. The only restriction placed on soil loss is that no rotation with a soil loss greater than 10 times the t factor or 40 tons can be utilized. At the river basin level, the South Atlantic Gulf basin more than doubles soil loss between 1985 and 2000, as more of both soybeans and silage are produced in the area.

Table 15. Levels of soil loss by major river basins for the OBERS-E' alternatives.

River Basin	OBERS-E' 1985	2000
	(thousand tons)	
New England	1,026	881
Mid Atlantic	46,747	46,824
S. Atlantic-Gulf	89,861	222,998
Great Lakes	28,391	45,555
Ohio	101,520	112,272
Tennessee	12,117	20,392
Upper Mississippi	303,014	447,466
Lower Mississippi	228,341	282,894
Souris-Red-Rainy	18,273	34,329
Missouri	201,446	315,185
Ark.-White-Red	91,514	117,710
Texas-Gulf	88,135	88,010
Rio Grande	4,814	4,725
Upper Colorado	2,355	1,861
Lower Colorado	697	678
Great Basin	4,600	4,047
Col.-N. Pacific	48,729	47,859
California	4,160	3,924
United States[a]	1,275,748	1,797,618

[a]May not add because of rounding.

Table 16 shows the conservation-tillage practices for the two base runs. Increased production levels in 2000 and loosely restricted soil loss levels lead to a higher percentage of straight row cropping. Minimum tillage decreases as a percentage of total tillage practices. Hence, increased production occurs in the absence of conservation management to reduce soil loss and preserve moisture.

Equilibrium Commodity Prices, Land Rents, and Water Prices

Final commodity prices are presented in Table 17. These can be considered as supply prices for the particular year and commodity. Prices

Table 16. Acreage under conservation and tillage practices for the OBERS-E' alternatives.

Item	OBERS-E' 1985	2000
	(percentages)	
<u>Tillage practices</u>		
Conventional tillage residue removed	15.1	18.0
Conventional tillage residue left	43.8	48.4
Minimum tillage	41.0	33.5
<u>Conservation practices</u>		
Straightrow	31.4	39.8
Contouring	32.8	31.6
Strip cropping	15.4	14.3
Terracing	20.3	14.3

reported in Table 17 are to serve as a reference base for comparison with other alternative futures later. An increase in the price level indicates an increase in cost to society of obtaining final demand commodities. Supply prices tend to be higher in 1985 because production restraints do not allow regional comparative advantages to be as fully reflected as in 2000.

Shadow prices on land, or land rent, show the opportunity cost of an additional acre of land. Tables A.5 and A.6 in the appendix present these rents by river basins. Relatively high rents indicate the regions that have the highest comparative advantage. River basin land rents are weighted aggregates of producing area rents. The same interpretation

Table 17. Farm level commodity prices for the E' 1985 and 2000 alternatives.

Commodity	Unit	Commodity Prices [2] $ 1985	$ 2000	1971-72 Normalized Price[1]
Corn	bu.	.98	.90	1.42
Sorghum	bu.	1.03	.94	1.39
Barley	bu.	1.04	.84	1.19
Oats	bu.	.94	.80	.77
Wheat	bu.	1.47	1.26	1.72
Oilmeals	cwt.	12.81	4.87	
Leg. Hay	tons	26.68	22.48	}34.37
Nonleg. Hay	tons	38.90	27.38	
Silage	tons	8.42	7.75	
Pasture	tons	39.64	26.95	
Cotton	bales	159.62	106.76	145.92
Sugar	tons	12.89	10.14	18.74
Pork	cwt.	39.72	26.61	28.21
Milk	cwt.	5.29	3.91	7.48
Feeders	head	215.66	188.37	
Fed Beef	cwt.	56.18	47.79	37.05

[1] The purpose of the price normalization process is to eliminate short-term abnormalities; and at the same time to adhere to the current general price as reflected in the latest published price information [20].

[2] Values in 1972 dollars.

holds for water prices as presented in Tables A.7 and A.8. The rents for land and water reflect a potential return to these resources as a component of farm income. However, they should be viewed as very dependent on the flexibility of the model and the regions ability to adjust to its highest comparative advantage.

Conclusion for the Base Models

Results of the two base models discussed above serve as a basis against which other alternative futures can be contrasted. Changes to

1985 and 2000 are not drastic or unusual since the model was built to allow only gradual changes (i.e. the effect of production restraints). However, the results indicate the direction agriculture would take in movement toward optimal resource use and allocation. Possible bottlenecks are pinpointed. An example is water availability at the producing region level. From the base models it is apparent that those with environmental restraints will have substantial regional impacts, especially in the alternative futures where available water supplies are reduced and levels of allowable soil loss are lowered. The alternative futures are discussed in the next section.

IV. THE IMPACT OF CHANGING DEMAND AND EXPORT ASSUMPTIONS

Three alternative futures involve changes in the base assumptions on per capita consumption and export levels. These alternatives are: 1) the 1985 OBERS-E' base model with high exports, 2) the 2000 OBERS-E' base model with high exports, and 3) the 2000 OBERS-E' base model with OBERS-E per capita consumption and export demands. The first two will be referred to as the high export alternatives and the third as the low demand alternative. The high export levels represent substantial demand increases for all grains, soybeans, and cotton, Table 6. Livestock product net exports remain the same or decrease as in the case of beef and veal. Except for this change in export levels, all other assumptions of the OBERS-E' base model are retained. The low demand alternative uses the OBERS-E projections rather than the OBERS-E'. (See Tables 5 and 6.)

Aside from these changes in the per capita consumption and export levels, all other assumptions of the 2000 base model are retained.

Total Acreage and Distribution of Dryland and Irrigated Crops

Under the higher export alternatives, total endogenous crop acres increase by 26 and 15 percent for 1985 and 2000, respectively, over the corresponding base runs totals, Table 18. The lower demand alternative results in a 26 percent decrease in endogenous crop acres.

Table 18. Endogenous crop acres for the United States for the high export and low demand alternatives.

Crop	High Export 1985	High Export 2000	Low Demand
		(thousand acres)	
Barley	21,627	6,226	6,716
Corn	63,763	66,533	46,304
Cotton	8,594	6,833	6,804
Oats	16,819	9,402	7,767
Sorghum	18,269	14,844	7,924
Roughages	87,721	81,548	57,361
Soybeans	69,728	94,694	53,081
Sugar	1,627	1,864	1,285
Wheat	67,438	58,936	37,540
Endogenous crop total	355,586	340,880	224,782
Percentage of acres irrigated	7.9	8.5	11.9

Irrigated acres in the high export alternatives increase by less than one million acres, Table 19. The total acreage of irrigated crop varies little and this is reflected in the percentage figures expressing irrigated acres as a percent of total acres cultivated for endogenous crops.[9]

[9]Whenever talking about numbers of acres irrigated it has to be kept in mind that in every alternative future the 1969 irrigated acreage has to be irrigated (approx. 22 million acres).

Table 19. Irrigated harvested crop acres by major river basins for the high export and low demand alternatives.

Item	High Export 1985	High Export 2000	Low Demand 2000
River basin		(thousand acres)	
Missouri	7,362	8,382	8,061
Ark.-White-Red	4,330	4,702	4,558
Texas-Gulf	3,143	2,113	2,085
Rio Grande	1,498	1,480	1,425
Upper Colorado	929	1,002	965
Lower Colorado	971	982	903
Great Basin	1,198	1,282	1,096
Col.-N. Pacific	4,025	4,499	3,591
California	4,491	4,468	3,975
Crop			
Barley	2,187	1,034	1,274
Corn	2,684	1,418	1,392
Cotton	2,065	1,564	1,433
Oats	218	80	200
Sorghum	7,840	2,333	1,729
Roughages	8,456	19,596	17,670
Soybeans	606	325	215
Sugarbeets	935	423	422
Wheat	2,955	2,136	2,324
Crop total[a]	27,947	28,910	26,659

[a]May not add because of rounding.

For the two high export alternatives, this percentage decreases while for the low demand alternative it increases.

Total cropland use for the 1985 and 2000 high export alternatives is 392.9 and 376.7 million acres, respectively, Table 20. The amount of cropland not used for crops reduces from 59 million acres in the base model to 7 million acres in 1985 and from 60 to 27 million acres in 2000. Hence, under the 1985 projections of the high export model, U.S. agriculture

Table 20. Total cropland available and its use by type of use for the high export and OBERS-E (low demand) alternatives.

Item	High exports 1985	High exports 2000	OBERS-E 2000
		(million acres)	
Available	393.1	388.4	388.4
Wet soils developed	7.0	15.8	3.7
Total available	400.1	404.2	392.1
Dryland used	341.3	323.8	210.2
Irrigated land used	27.9	28.9	26.7
Land used for exogenous crop			
Total used	392.9	376.7	257.8
Idle land	7.2	27.5	134.4
Irrigated land development	3.9	6.7	6.5
Percentage of idle land in land groups I-V	33%	21%	64%

would come close to full utilization of all cropland. However, the supply of cropland is not strictly fixed. While the physical supply is fixed, the economic supply varies. The increase in export demand also increases commodity prices and returns to resources. These increases in returns make it profitable to develop more wet soils and clear more forest lands. Table 20 shows that 7.0 million acres of wet soils development would occur in the 1985 high export alternative. This compares to 3.8 in the base run. For 2000 the comparable figures are 15.8 and 10.6 million acres, respectively. Potential land available for development is 7.7 million acres in 1985 and 18.3 million acres in 2000. Hence, under higher prices even more land could be added to the cropland base.

The larger acreage of land not used for crops in the 2000 high export alternative reflects the greater adjustment in resource use and crop relocation allowed between 1985 and 2000 as lower and upper production restraints are widened. Under the lower demand alternative in 2000, adjustments allowed in crop allocation to regions with highest comparative advantages free more than 134 million acres of cropland in meeting required commodity demands. Also, wet soils development decreases to 3.7 million acres under this alternative.

Crop production patterns for the high export and low demand alternatives are similar to those in the base runs. The same general changes occur between years and the reasons are similar to those discussed in the previous section, Table 18. The largest increases for individual crops are in corn, wheat and roughages for the high export alternative. Soybeans show a large increase for 2000 but 1985 soybean acreage is nearly the same as that for the base run. Compared with the base run, lower oilmeal and silage rations are fed in the 1985 high export alternative, Table A.2. The decrease in the two feed components allows the larger exports. Changes in the other major crops also reflect large increases in their respective exports to all-time highs. However, cotton acreage and production declines in both years since exports hardly increase in the OBERS E' projections, average yield increases and more cotton is grown on better land, Table A.1.

Irrigated acres increase for most crops in the 1985 high export alternative. Also, some changes over the base run occur for 2000 but are not major. The lower demand alternative has a decrease in irrigated acres of approximately 1.7 million acres as compared to the 2000 base run.

Regional Land Use and Crop and Livestock Production Patterns

Regional production and land use patterns for the three alternatives being discussed are presented in Tables 21, 22, and 23. Comparing endogenous cropland use by river basin in the high export alternatives with the base run, some large regional shifts are noted for both 1985 and 2000. The basins that would be affected most are the South Atlantic-Gulf, Missouri, Arkansas-White-Red, Texas-Gulf, and the Columbia-North Pacific. Under higher demands, the increased acreage needed comes largely from these three basins. When demand decreases these basins have large decreases in cropped acres. (See the low export demand alternative, Table 23.)

Because of the production restraints incorporated in the model, the 1985 high export alternative would result in little change in the regional production shares of individual crops. Increases in feed grain, wheat, and roughage acreages would occur in regions which have large increases in total cropland use. The increase in the feed grain acreage would occur mainly in the South Atlantic-Gulf, Missouri, and Arkansas-White-Red basins. The major share of feed grain production, however, would come out of the Upper Mississippi basin where, in 1985 and 2000, over 29 million acres are grown. This same river basin also produces the largest U.S. share of soybeans. The amount of cropland not used for crops in this basin is zero in 1985 and is 2.8 million acres in 2000. This uncropped land was identified in land groups unsuitable for feed grain and soybean

Table 21. Total crop and cropland use by major river basins for the 1985 high export alternative.

River Basin	Feedgrain	Wheat	Cotton	Soybeans	Roughage	Total Cropland Used[a]	Pasture
			(thousand acres)				
New England	445	-	-		545	990	3,779
Mid Atlantic	5,122	691	-	1,194	1,806	8,813	12,252
S. Atlantic-Gulf	8,213	787	1,397	5,434	5,971	21,802	42,094
Great Lakes	10,645	1,555	-	4,186	4,646	21,285	10,686
Ohio	10,642	3,374	-	9,671	5,766	29,453	28,805
Tennessee	495	133	166	577	2,397	3,768	7,083
Upper Mississippi	29,110	953	-	22,448	9,316	61,864	22,605
Lower Mississippi	669	369	2,075	14,979	1,422	19,514	22,408
Souris-Red-Rainy	4,065	8,574	-	781	1,547	15,367	4,971
Missouri	26,774	25,161	-	7,486	23,732	83,560	201,596
Ark.-White-Red	10,291	15,051	896	2,812	10,556	39,639	92,885
Texas-Gulf	8,544	1,390	2,815	153	9,963	22,878	78,351
Rio Grande	733	16	407	-	884	2,040	76,408
Upper Colorado	339	202	-	-	580	1,138	46,170
Lower Colorado	310	127	207	-	323	985	77,988
Great Basin	247	523	1	-	1,061	1,877	70,481
Col.-N. Pacific	1,520	7,715	-	-	4,924	14,353	88,070
California	2,309	811	626	-	2,275	6,579	45,057
United States[b]	120,480	67,438	8,594	69,728	87,722	355,905	931,701

[a]Includes all endogenous crops.

[b]May not add because of rounding.

Table 22. Total crop and cropland use by major river basins for the 2000 high export alternative.

River Basin	Feedgrain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
			(thousand acres)				
New England	49	-	-	-	1,670	1,719	1,811
Mid Atlantic	2,963	2,362	-	1,533	1,249	8,107	12,377
S. Atlantic-Gulf	2,725	2,281	2,809	13,698	2,275	23,788	34,782
Great Lakes	12,439	1,235	-	4,274	2,136	21,426	9,799
Ohio	10,973	3,285	-	13,011	1,393	28,662	27,558
Tennessee	171	98	94	2,170	199	2,732	6,846
Upper Mississippi	29,904	795	-	24,780	4,164	59,661	21,200
Lower Mississippi	445	2,241	1,176	11,229	5,139	20,230	19,782
Souris-Red-Rainy	8,801	3,761	-	3,742	858	37,472	4,418
Missouri	15,236	22,558	-	12,718	26,630	77,142	200,416
Ark.-White-Red	4,778	8,865	480	5,578	18,930	38,649	91,318
Texas-Gulf	5,512	4,168	1,628	1,956	6,292	19,563	78,154
Rio Grande	699	25	260	-	639	1,623	76,397
Upper Colorado	57	74	-	-	893	1,028	46,169
Lower Colorado	128	148	118	-	708	1,112	77,971
Great Basin	70	634	-	-	848	1,563	70,475
Col.-N. Pacific	1,207	5,582	-	-	4,254	11,141	88,058
California	840	816	263	-	3,264	5,293	44,961
United States[b]	97,007	58,936	6,833	94,694	81,549	360,911	912,500

[a]Includes all endogenous crops.

[b]May not add because of rounding.

Table 23. Total crop and cropland use by major river basins for the low demand alternative

River Basin	Feedgrain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
			(thousand acres)				
New England	16	-	-	-	226	242	3,787
Mid Atlantic	2,543	1,642	-	421	1,496	6,102	12,531
S. Atlantic-Gulf	2,467	1,437	2,781	5,999	2,053	14,737	42,120
Great Lakes	7,837	1,892	-	2,723	1,825	14,807	11,262
Ohio	9,203	2,390	-	10,016	1,578	23,107	29,724
Tennessee	127	98	94	1,110	57	1,486	7,310
Upper Mississippi	23,229	768	-	20,026	8,134	52,409	24,548
Lower Mississippi	320	1,884	1,176	5,961	4,287	13,628	21,871
Souris-Red-Rainy	4,403	4,532	-	285	1,573	10,873	5,343
Missouri	9,706	9,126	-	2,847	15,783	37,623	201,777
Ark.-White-Red	3,578	8,311	480	1,644	10,818	24,849	93,816
Texas-Gulf	2,587	1,022	1,630	2,045	2,136	9,427	78,695
Rio Grande	596	25	257	-	569	1,447	76,398
Upper Colorado	57	74	-	-	855	990	46,169
Lower Colorado	177	114	118	-	491	910	77,973
Great Basin	97	330	-	-	746	1,184	70,477
Col.-N. Pacific	803	3,105	-	-	2,685	6,691	88,057
California	956	782	263	-	2,041	4,151	44,987
United States[b]	68,712	37,540	6,804	53,081	57,363	224,743	936,854

[a]Includes all endogenous crops.

[b]May not add because of rounding.

production. For all practical purposes, the Upper Mississippi basin would be used to full capacity in both high export alternatives.

The tight production restraint in the 1985 alternatives prevent major regional crop substitutions. However, in the 2000 solutions, under wider adjustment limits, crop substitution would take place in the Missouri river basin where wheat, soybeans, and roughages increase in acreage and feed grain acres decrease under the high export alternative. Increases in soybeans also would occur in the South Atlantic-Gulf, Upper Mississippi, and Souris-Red-Rainy basins.

The low demand alternative would not bring drastic changes in cropping patterns. Acreages decrease with demand. The largest changes would take place in the three central or "buffer zone" river basins. In the Lower Mississippi basin, soybean acreage decreases by 7 million acres while roughage acreage increases.

Livestock production patterns are presented in Table 24. Comparing the 1985 and 2000 base runs with the 1985 high export run shows some movement of beef feeding into the Mid Continent and West zones out of the North-East zone. However, in the 2000 high export alternative, beef feeding moves in the opposite direction. This reallocation of beef feeding is one reason for fluctuating feed grain acreages in the Missouri, Arkansas-White-Red, and Texas-Gulf river basins. Beef cow patterns change little from the base run except for a small increase in the North-East zone and decreases in the other three zones in 2000. Regional shares of hog production change very little while dairy cows increase their share in the South-East and Mid-Continent zones in the 1985 solution.

Table 24. Percentage distribution of total livestock production in the four major zones for the high export and low demand alternatives.

Zone	Beef Cows			Beef Feeding			Dairy			Hogs		
	I[e]	II[f]	III[g]	I	II	III	I	II	III	I	II	III
	(percentage of total production)											
North-East[a]	14.9	7.0	11.2	24.5	14.8	15.4	48.1	52.0	51.9	62.9	80.1	87.1
South-East[b]	10.0	6.8	10.0	2.0	26.0	24.3	22.3	20.5	20.5	6.2	2.4	2.6
Mid-Continent[c]	57.7	68.1	62.0	55.1	42.4	43.9	21.4	16.2	16.2	30.3	17.3	10.0
West[d]	17.4	18.1	16.8	18.4	16.8	16.4	8.1	11.4	11.3	.6	.3	.3

[a]Includes river basins 1, 2, 4, 5, and 7.

[b]Includes river basins 3, 6, and 8.

[c]Includes river basins 9, 10, 11, and 12.

[d]Includes river basins 13, 14, 15, 16, 17, and 18.

[e]High export alternative 1985.

[f]High export alternative 2000.

[g]OBERS-E, or low demand alternative.

Consumptive Water Use

Total consumptive water use would increase for both high export alternatives, Tables 25, 26, and 27. The increase is due solely to greater irrigated acreages. Again, the Upper Colorado and Great Basin use all available water in 1985 and producing areas 67, 72, 74, and 103 cannot comply with the 1969 irrigated acres restraint. In 2000, the higher demand for water is partly concentrated in the Rio Grande basin where irrigated acreage of corn silage increases to absorb all available water.

The lower demand alternative shows a decrease in the irrigated acreage. While total consumptive water use would be lower when compared with the 2000 base run, the relative regional usage parallels that in the base run.

This constancy in consumptive water use is readily explained. Increases in production to satisfy the high export demand level occurs mainly on dry land as water supplies were limiting in 25 producing areas and irrigated land was exhausted in 23 producing areas providing the possibility for increased irrigation in only 10 of the 58 western regions.

Conservation-Tillage Practices and Soil Loss

Under high exports, increased cropped land and cultivation of more erosive lands is expected to increase total soil loss. However, a different crop distribution and crop mix actually led to opposite results under the 1985 high export alternative. The acreage in soybeans

Table 25. Consumptive water use by crops and livestock by major river basins for the 1985 high export alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,95[illegible]	552	17,506	6,128
Ark.-White-Red	11,720	7,587	309	7,898	3,822
Texas-Gulf	10,020	8,175	244	8,421	1,599
Rio Grande	4,399	4,290	49	4,341	58
Upper Colorado	3,040	3,010	29	3,040	0
Lower Colorado	5,929	5,503	57	5,562	367
Great Basin	3,538	3,492	43	3,538	0
Col.-N. Pacific	76,473	16,734	119	16,854	59,619
California	30,619	22,286	99	23,107	7,512
Western basins[c]	169,372	88,760	1,501	90,270	

[a]Includes exogenous crops and roughages and endogenous crops.
[b]Includes exogenous and endogenous livestock.
[c]May not add due to rounding.

Table 26. Consumptive water use by crops and livestock by major river basins for the 2000 high export alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,847	700	17,549	6,084
Ark.-White-Red	11,212	6,440	426	6,869	4,343
Texas-Gulf	7,696	5,937	283	6,222	1,474
Rio Grande	4,368	4,278	90	4,369	0
Upper Colorado	3,040	3,009	28	3,040	0
Lower Colorado	5,497	5,013	66	5,081	416
Great Basin	3,538	3,449	87	3,538	0
Col.-N. Pacific	76,473	17,197	116	17,316	59,157
California	30,619	23,506	109	23,616	7,003
Western basins[c]	166,077	85,688	1,854	87,604	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add due to rounding.

Table 27. Consumptive water use by crops and livestock by major river basins for the low demand alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,629	559	17,109	6,445
Ark.-White-Red	11,212	5,662	341	5,995	5,217
Texas-Gulf	7,969	5,201	222	5,414	2,555
Rio Grande	4,368	4,064	85	4,150	218
Upper Colorado	3,040	3,006	31	3,040	0
Lower Colorado	5,497	4,553	60	4,615	882
Great Basin	3,538	3,466	69	3,538	0
Col.-N. Pacific	76,473	16,035	94	16,131	60,341
California	30,619	19,963	93	20,058	10,561
Western basins[c]	166,077	78,590	1,543	80,135	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add due to rounding.

is constant under this alternative but the acreages of roughages and small grains increase substantially. This change in the overall crop mix would lead to a decrease in soil loss for the 1985 high export solution, Table 28 when compared with the base run, Table 15. The large increase in soybeans, from 87 million acres in the base model to 95 million acres in the 2000 high export alternatives, would cause soil loss levels to increase in the South Atlantic-Gulf and Lower Mississippi river basins. While higher acreages of hay and small grains also occur in the 2000 high export alternative, soil loss would be greater than in the base run because of the greater soybean and corn acreages.

Soil loss would drop significantly in the lower demand alternative compared with the 2000 base run. However, it would increase in the Upper Mississippi basin as more corn and soybeans are grown on erosive lands. Oats, sorghum, and wheat replace some corn and soybeans on the less productive land and force the latter two crops, both with high soil loss levels, to other land groups.

Conservation and tillage practices are shown in Table 29. Percentagewise there would be little change in the practices for the high export alternative compared with the base run, Table 16, except for a higher occurrence of the conservation practices. Straight row cropping decreases for both 1985 and 2000 under the high export alternative. Terracing would increase for both years (4.8 percent over the 1985 base run percentage and 3.7 percent over the 2000 percentage).

The low demand alternative shows quite large changes in 2000 compared with the base run. With acres cultivated reduced and a smaller

Table 28. Levels of soil loss by major river basins for the high export and low demand alternatives.

River basin	High Export 1985	High Export 2000	Low Demand
		(thousand tons)	
New England	3,554	6,311	516
Mid Atlantic	33,253	41,236	27,257
S. Atlantic-Gulf	127,629	233,735	134,078
Great Lakes	30,698	44,120	28,954
Ohio	101,720	133,058	83,024
Tennessee	39,068	23,154	12,969
Upper Mississippi	265,926	434,698	490,807
Lower Mississippi	240,421	300,411	192,065
Souris-Red-Rainy	14,086	36,244	21,638
Missouri	175,794	334,516	118,360
Ark.-White-Red	85,973	140,597	80,691
Texas-Gulf	94,132	105,218	80,662
Rio Grande	6,294	6,928	5,849
Upper Colorado	4,209	2,018	1,851
Lower Colorado	453	678	582
Great Basin	3,654	4,377	1,949
Col.-N. Pacific	32,930	38,454	31,532
California	4,999	4,591	3,074
United States[a]	1,264,793	1,890,335	1,315,858

[a]May not add due to rounding.

proportion of erosive lands used, straight row cropping would increase from 39.8 percent, Table 16, in the base model to 46.2 percent in the low demand alternative. Also other conservation practices decrease. Tillage practices would change very little between the low demand alternative and the base model.

Shadow Prices

Shadow prices for land, water, and final commodities are presented in Appendix II. Final farm level commodity prices, Table A.9, show a

Table 29. Acreage under conservation and tillage practices for the high export and low demand alternatives.

Item	High Export 1985	High Export 2000	OBERS-E Low Demand
	(percentages)		
Tillage Practices			
Conventional tillage residue removed	16.9	18.3	19.0
Conventional tillage residue left	42.2	46.9	46.1
Minimum tillage	40.8	34.8	34.9
Conservation practices			
Straightrow	28.1	33.9	46.2
Contouring	32.9	32.5	30.0
Strip cropping	13.9	15.6	13.6
Terracing	25.1	18.0	10.2

significant increase for the 1985 high export alternative. Feed grain prices would double with the result that beef prices also nearly double. The overall increase in the price level is reflected in the cost of food per capita which increases from $153.61 to $288.04.[10] Prices in the 2000 high export alternative, Table A.10, also increase but by a smaller amount. The built-in ability of the model to increase the relocation of production in a least-cost manner in 2000 allows a large increase in production without doubling the price level. Per capita food costs increase by only 10 percent to $136.58.

[10]Per capita food costs refer only to the commodities endogenous to the model valued at the prices paid to farmers and do not reflect any of the normal marketing margin. Hence, they exclude the costs of fruits, vegetables, and other commodities which are exogenous.

Shadow prices for water are presented in Table A.7 and A.8. The higher commodity price level in the 1985 high export solution would raise the revenue of an acre of crop produced relative to the base and by a larger amount this occurs in 2000. Water prices which are the marginal value product of an additional acre-foot of water are therefore much higher in the 1985 than in the 2000 solutions. In both high export alternatives, water prices would increase over those in the base model. They reach highs of $64.51 in 1985 and $39.71 per acre-foot in 2000. In the low demand alternative, water prices would increase in some river basins and decrease in others as compared to the base run.

Conclusion

U.S. agriculture has the capability and resource flexibility to adjust to alternative levels of domestic and export demand in 1985 and 2000. Results in this section show that the conditions underlying each of the three alternative futures analyzed do not lead to drastic changes in the utilization of land and water resources, compared to the respective base runs. If the projected high exports become a reality and if only a 2 percent rate per annum of adjustment towards least-cost resource allocation and crop production is achieved, then in 1985 the United States will be very close to capacity production. Rents on land, the price of water and commodity prices will more than double and there will be a substantial increase in the per capita food costs to consumers. However, allowing further adjustments and efficiencies over time, the 2000 solutions present a different picture. Production will still be close to capacity but real prices would increase little relative to the base solution.

Few major changes take place at the regional level. Some crop relocation and increased resource scarcity occurs as is reflected in regional shadow prices for land and water.

V. THE LAND AND WATER CONSERVATION AND ENERGY ALTERNATIVES

This section deals primarily with water quality and greater water use efficiency. The soil loss restraint which was 10 times the t value or 40 tons in the previous alternatives is now reduced to the t value. The restraint is lowered to reduce erosion and maintain land productivity and reduce sediment loads in rivers. This value, in tons of soil loss per acre per year, is considered compatible with maintaining long-run productivity. Soil loss tolerance levels, or t values, in the United States range from one to five tons per acre per year, depending upon soil properties, soil depth, topography, and prior erosion (26).

In addition to a soil conservancy program, the conservation alternatives also are designed to evaluate the impacts on the agricultural sector of a water conservancy program. Technologies exist which can improve irrigation water delivery systems requiring less water diverted per unit of agricultural output. A set of high-efficiency water use coefficients are used in these alternatives to reflect improved irrigation technologies.

The other alternative considered in this section is the energy run. Energy resource development will place heavier demand on scarce water supplies. Energy resource development is given first choice of available

water supplies. The OBERS-E' water supplies are therefore reduced by the projected water needed in energy development. These projections were presented in Table 4.

A public water and soil conservation program or decreases in regional water supplies will have impacts on water use, production costs, land use, and income. These results and impacts are analyzed in the following subsections.

Total Acreage and Distribution of Dryland and Irrigated Crops

Total endogenous crop acres for the land and water conservation alternatives (called conservation alternatives hereafter) increase over the base run levels by 11.7 and 23.3 percent, respectively, for the years 1985 and 2000, Table 7 and Table 30. The increase in cropland needed to produce the same level of demand and exports as in the base runs is due to the less intensive cropping practices employed to meet the soil loss restrictions.

Irrigated acres, Table 31, increase by 1 million acres in 1985 and decrease by 1.1 million acres in 2000 when compared with the base run, Table 8. The largest decrease occurs in the Columbia-North Pacific basin where the irrigated acreage decreases from 4.3 to 3.8 million acres. All of this decrease occurs in producing area 94 where both feed grain and roughage acreages decline.

Irrigated acreage also declines in the energy alternative. This reduction is due to a different crop mix and reduced water availabilities.

Table 30. Endogenous crop acres for the United States for the land and water conservation and energy alternatives.

Crop	Land and Water Conservation 1985	Land and Water Conservation 2000	Energy 2000
Barley	22,371	9,565	8,824
Corn	54,946	59,578	57,671
Cotton	9,155	6,629	6,603
Oats	18,628	9,559	9,516
Sorghum	17,196	16,763	14,385
Roughages	86,473	79,012	74,555
Soybeans	61,194	84,236	87,165
Sugar	1,594	1,808	1,888
Wheat	58,231	42,343	41,715
Endogenous crop total	329,788	309,493	302,322
Percentage of acres irrigated	8.6	8.8	9.2

Little change takes place by 1985 in the total crop mix for the conservation alternatives. With the exception of soybeans and roughages, all individual crop acreages increase. Silage acres decrease and hay acres increase to lower soil loss levels. For 2000, the conservation restraints lead to similar results. Except for soybeans and wheat, other crops increase in acreage.

Irrigated crop acreages increase for the 1985 conservation alternative except for corn and roughages (both high water-using or soil loss-causing crops). In 2000, corn, cotton, and roughage acreages decrease when compared to the base model. Irrigated acres for the energy alternative correspond closely to those of the base model except for a large decrease in irrigated corn acreage (mostly in the Columbia-North Pacific basin).

Table 31. Irrigated acres harvested by crops and major river basins for the land and water and energy alternatives.

Item	Land and Water Conservation 1985	Land and Water Conservation 2000	Energy 2000
River basin		(thousand acres)	
Missouri	7,507	8,463	8,290
Ark.-White-Red	4,558	4,115	4,676
Texas-Gulf	3,142	1,860	2,125
Rio Grande	1,463	1,406	1,488
Upper Colorado	905	1,002	996
Lower Colorado	971	982	982
Great Basin	1,251	1,168	1,147
Col.-N. Pacific	3,999	3,894	3,909
California	4,492	4,307	4,275
Crop			
Barley	2,743	1,494	1,063
Corn	2,265	1,723	917
Cotton	2,465	1,219	1,545
Oats	264	113	102
Sorghum	6,754	1,868	1,656
Roughages	9,765	17,350	19,394
Soybeans	605	471	325
Sugar beets	952	594	423
Wheat	2,435	2,362	2,457
Crop total[a]	28,252	27,197	27,888

[a]May not add because of rounding.

Total cropland use figures are presented in Table 32. Comparison of the three alternatives with the appropriate base runs, Table 9, shows that there are few changes in cropland use at the national level. Wet soils development is higher in 1985 but lower in 2000. The increase in total land use leaves fewer uncropped acres. Also, a lower percentage of uncropped acres fall in highly productive land groups.

Table 32. Total cropland available and its use by type of use for the conservation and energy alternatives.

Item	Land and Water Conservation 1985	Land and Water Conservation 2000	Energy 2000
	(million acres)		
Available	393.1	388.4	388.4
Wet soils developed	5.5	9.6	10.6
Total available	398.6	398.0	399.0
Dryland used	316.4	290.0	286.3
Irrigated land used	28.3	27.2	27.9
Land used for exogenous crops	23.7	24.0	24.0
Total used	368.3	341.2	338.2
Idle land	30.3	56.8	60.8
Irrigated land development	3.9	6.7	6.6
Percentage of idle land in the land groups I-V	44%	45%	47%

Regional Land Use and Crop and Livestock Production Patterns

Regional crop and land use comparisons are presented in Tables 33, 34, and 35. Comparison of the 1985 base run with the conservation run shows that the extra 14 million acres needed in the conservation run to produce the same demand and export levels as for the base run come from the South Atlantic-Gulf, Great Lakes, Souris-Red-Rainy, Missouri, and Arkansas-White-Red basins. These basins increase cropped land by approximately 21 million acres. The additional cropped land is necessary to replace land, removed from production for soil loss reasons in the Lower Mississippi (6.6 million acres), Ohio, Upper Mississippi, and Texas-Gulf basins.

Table 33. Total crop and cropland use acres by major river basins for the 1985 land and water conservation alternative

River Basin	Feed Grains	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
				(thousand acres)			
New England	31	--	--	--	294	325	6,393
Mid Atlantic	2,927	2,298	--	726	1,877	7,819	12,377
S. Atlantic-Gulf	2,826	1,684	1,673	9,649	2,308	18,140	41,673
Great Lakes	10,020	1,861	--	5,127	2,710	20,832	9,799
Ohio	10,025	2,989	--	12,183	2,232	27,429	28,123
Tennessee	127	113	110	1,882	216	2,448	6,846
Upper Mississippi	25,480	2,171	--	20,367	10,724	58,760	21,848
Lower Mississippi	340	446	2,023	7,845	1,081	11,735	20,911
Souris-Red-Rainy	9,488	2,352	--	4,987	1,653	18,560	4,418
Missouri	20,816	14,835	--	13,575	24,666	74,071	201,033
Ark.-White-Red	5,239	7,133	480	5,934	15,852	34,806	91,318
Texas-Gulf	5,738	941	1,637	1,957	5,475	15,755	78,732
Rio Grande	699	3	269	--	506	1,477	76,397
Upper Colorado	68	58	--	--	895	1,029	46,169
Lower Colorado	121	58	169	--	753	1,111	77,971
Great Basin	107	496	--	--	826	1,440	70,475
Col.-N. Pacific	628	4,226	--	--	3,904	8,856	88,058
California	780	679	263	--	3,040	4,872	44,961
United States[b]	95,467	42,343	6,629	84,236	79,014	309,497	924,905

[a] Includes all endogenous crops.

[b] May not add because of rounding.

Table 34. Total crop and cropland use acres by major river basins for the 2000 land and water conservation alternative

River Basin	Feed Grains	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
				(thousand acres)			
New England	246	--	--	--	513	759	6,419
Mid Atlantic	4,691	582	--	1,189	1,847	8,309	12,252
S. Atlantic-Gulf	6,406	787	1,401	5,434	4,204	18,232	42,860
Great Lakes	10,111	1,422	--	5,179	4,245	20,161	10,928
Ohio	9,678	3,374	--	9,324	5,841	28,217	29,105
Tennessee	258	133	309	577	2,001	3,278	7,102
Upper Mississippi	28,371	1,678	--	21,450	8,463	59,999	22,605
Lower Mississippi	855	495	2,059	7,803	1,104	12,316	22,886
Souris-Red-Rainy	3,893	8,574	--	781	1,107	14,755	4,971
Missouri	28,111	17,329	--	7,486	27,187	80,551	201,606
Ark.-White-Red	8,669	14,329	896	2,812	9,990	36,755	93,381
Texas-Gulf	7,401	1,032	2,794	153	10,730	22,123	78,872
Rio Grande	686	16	407	--	909	2,018	76,408
Upper Colorado	368	102	--	--	597	1,089	46,170
Lower Colorado	238	72	263	--	396	987	77,988
Great Basin	269	481	1	--	1,031	1,806	70,481
Col.-N. Pacific	1,149	7,005	--	--	4,205	12,542	88,070
California	1,734	811	1,021	--	2,102	5,860	45,057
United States[b]	113,143	58,231	9,155	61,194	86,475	329,792	934,565

[a]Includes all endogenous crops.
[b]May not add because of rounding.

Table 35. Total crop and cropland use acres by major river basins for the energy alternative.

River Basin	Feed Grains	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
				(thousand acres)			
New England	18	--	--	--	304	322	3,787
Mid Atlantic	2,855	2,014	--	1,325	1,657	7,851	12,377
S. Atlantic-Gulf	2,293	1,475	2,579	11,875	2,256	20,478	40,084
Great Lakes	10,600	1,727	--	4,847	2,400	20,939	9,799
Ohio	10,748	2,232	--	12,736	1,297	27,013	28,496
Tennessee	127	26	94	1,977	126	2,350	6,846
Upper Mississippi	25,968	790	--	23,207	8,742	58,725	21,917
Lower Mississippi	343	2,222	1,176	12,771	2,527	19,039	19,782
Souris-Red-Rainy	6,938	4,356	--	2,437	2,137	15,948	4,418
Missouri	18,321	12,596	--	8,585	22,643	62,306	201,112
Ark.-White-Red	4,594	7,006	480	5,443	15,755	33,296	91,591
Texas-Gulf	5,213	1,615	1,627	1,957	5,091	15,510	78,732
Rio Grande	626	25	260	--	623	1,534	76,397
Upper Colorado	63	74	--	--	877	1,018	46,169
Lower Colorado	157	110	118	--	716	1,111	77,971
Great Basin	107	505	--	--	805	1,428	70,475
Col.-N. Pacific	628	4,232	--	--	3,633	8,591	88,058
California	791	701	263	--	2,957	4,822	44,961
United States[b]	90,398	41,715	6,603	87,165	74,556	302,322	922,979

[a]Includes all endogenous crops.
[b]May not add because of rounding.

In 2000, the Missouri, Arkansas-White-Red, and Texas-Gulf basins increase in acreage in the conservation solution to a total of 28 million acres. Also, the Columbia-North Pacific and California basin increase over the base runs by 4.0 and 1.0 million acres, respectively. Decreases take place in several basins, the greatest changes occurring the South Atlantic-Gulf and the Lower Mississippi basins. The South Atlantic-Gulf and Texas-Gulf regions actually would reverse the impact compared to 1985.

Changes in individual crops are complex. As an example, in 1985 feed grains increase in acreage over the base run for the Souris-Red-Rainy (4.5 million acres), Missouri, Arkansas-White-Red, Texas-Gulf, Great Lakes, and Ohio basins. Decreases occur in the Mid-Atlantic, South Atlantic-Gulf and most of the western basins. However, in 2000 under the conservation alternative as compared to the base run, the reverse happens except for the three central basins where further increases take place.

Most affected by the soil loss restraint are the Lower Mississippi and Upper Mississippi basins. A significant drop in soybeans, and some decrease in cotton, wheat, and feed grain acres occurs in these basins. This shift in crop acres is summarized in a state map, Figure 12. Comparison of Figure 12 with Figure 11 shows the shift of row crops out of the regions with erosion-prone soils.

The energy run's regional crop distribution is nearly identical to the year 2000 base run.

Livestock production patterns are presented in Table 36. In the 1985 conservation alternative there is a large shift in beef feeding

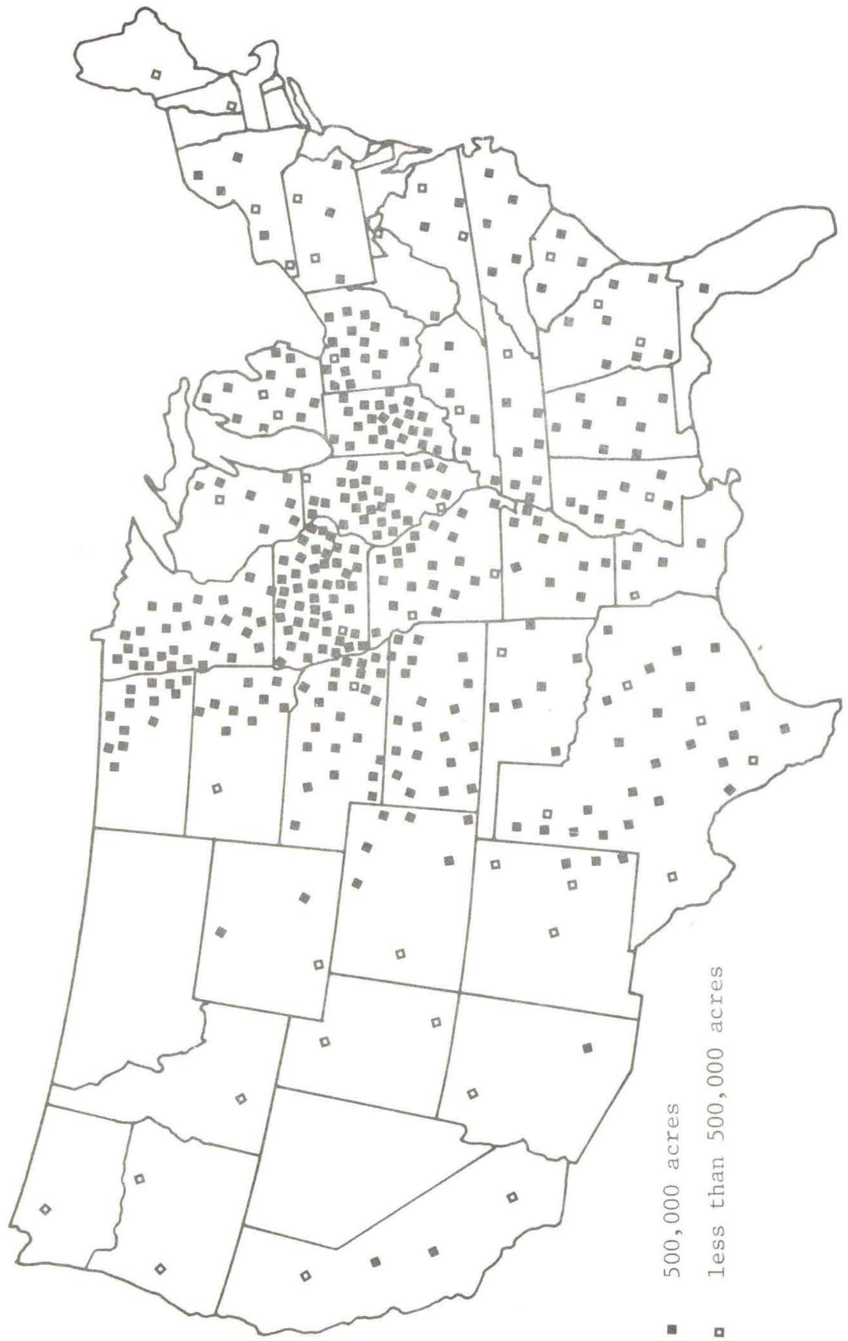


Figure 12. Location of row crop acres in 2000 for the land and water conservation solution.

Table 36. Livestock production patterns by four major zones for the conservation and energy alternatives.

Zone	Beef Cows			Beef Feeding			Dairy			Hogs		
	I[e]	II[f]	III[g]	I	II	III	I	II	III	I	II	III
	(percentage of total production)											
North-East[a]	15.3	11.0	8.9	20.0	15.7	13.3	45.3	51.9	52.0	62.4	83.0	83.0
South-East[b]	7.5	6.6	5.7	1.4	9.7	19.6	22.1	20.4	20.5	6.2	2.4	2.4
Mid-Continent[c]	59.2	64.0	67.6	60.9	59.3	50.2	24.5	16.2	16.1	30.9	14.3	14.3
West[d]	18.0	18.2	17.8	17.8	17.1	16.9	8.0	11.3	11.4	.4	.3	.3

[a] Includes river basins 1, 2,4, 5, and 7.

[b] Includes river basins 3, 6, and 8.

[c] Includes river basins 9, 10, 11, and 12.

[d] Includes river basins 13, 14, 15, 16, 17, and 18.

[e] Land and water conservation alternative 1985.

[f] Land and water conservation alternative 2000.

[g] Energy alternative.

from the North and South-East to the Mid-Continent and West zones. This movement coincides with the large increase in feed grains, soybeans, and roughages in the Mid-Continent region. The dairy and hog production shares in the North-East zone decrease the South-East zone's share of hog production and the South-East and Mid-Continent shares of the dairy all decrease. Dairy also decreases in the West zone.

The rations for the livestock activities, Table A.2, show that there is a general shift in feeding, as compared with the two base runs, away from oilmeals, silage, and corn, to other feed grains and hay. This ties in well with the fact that corn, soybeans, and silages are crops associated with high soil loss levels.

Consumptive Water Use

Consumptive water use for three alternatives is presented in Tables 37, 38, and 39. Comparing the 1985 conservation alternative with the 1985 base runs, (Table 13), the figures in Table 37 show that although irrigated acres increase, total consumptive water use decreases in most basins except for the Upper Colorado and Arkansas-White-Red with the latter increasing water use. Even the Great Basin has a small water surplus.

The decrease in irrigated acres for the 2000 conservation alternative combined with the higher efficiency in water use causes a three million acre-feet decline in total consumptive water use. The decrease in consumptive use is uniform over all basins and the Upper Colorado basin still exhausts all available water.

Table 37. Consumptive water use by crops and livestock by major river basins for the 1985 land and water conservation alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,625	577	17,204	6,430
Ark.-White-Red	11,720	7,324	300	7,625	4,095
Texas-Gulf	10,020	7,526	190	7,716	2,304
Rio Grande	4,399	3,867	45	3,914	485
Upper Colorado	3,040	3,009	30	3,040	0
Lower Colorado	5,929	5,157	73	5,231	698
Great Basin	3,538	3,493	36	3,530	8
Col.-N. Pacific	76,473	16,047	116	16,165	60,308
California	30,619	21,461	93	21,557	2,070
Western basins[c]	169,372	84,517	1,510	86,029	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Table 38. Consumptive water use by crops and livestock by major river basins for the 2000 land and water conservation alternatives.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	23,634	16,599	688	17,289	6,338
Ark.-White-Red	11,212	5,849	361	6,211	5,001
Texas-Gulf	7,696	5,248	267	5,517	2,179
Rio Grande	4,368	3,821	84	3,906	462
Upper Colorado	3,040	3,008	33	3,040	0
Lower Colorado	5,497	4,725	68	4,795	702
Great Basin	3,538	3,449	75	3,526	12
Col.-N. Pacific	76,473	16,290	113	16,405	60,068
California	30,619	21,911	115	22,028	8,591
Western basins[c]	166,077	80,910	1,876	82,787	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Table 39. Consumptive water use by crops and livestock by major river basins for the energy alternative, 2000.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
		(thousand acre-feet)			
Missouri	23,236	16,618	710	17,331	5,905
Ark.-White-Red	11,210	6,161	391	6,554	4,656
Texas-Gulf	7,696	13,561	271	6,137	1,559
Rio Grande	4,361	4,252	89	4,343	18
Upper Colorado	2,750	2,718	29	2,750	0
Lower Colorado	5,381	4,930	66	4,998	383
Great Basin	3,538	3,458	79	3,538	0
Col.-N. Pacific	76,375	17,166	111	17,280	59,095
California	30,504	22,646	105	22,753	7,751
Western basins[c]	165,057	83,826	1,859	85,687	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Water again is scarce in some producing areas and the 1969 irrigated acres restraint cannot be met. In the 1985 run, these PA's are 67, 70, 72, 74, and in the 2000 run they are 70, 72, and 82. Furthermore in three PA's the restraint may not be met because of a shortage of irrigated land. These regions are 69, 71, and 92 in both 1985 and 2000.

Water use in the energy alternative is very similar to the 2000 base run, even though supply is reduced in nearly all basins. The reductions in regional water supplies, by the amount of water diverted for energy resource development, are relatively small and have little effect on total consumptive water use.

Conservation-Tillage Practices and Soil Loss

The soil loss restriction imposed on the model drastically reduces the total soil loss level when the two conservation alternatives are compared to the base run, Table 15. Table 40 indicates that soil loss is reduced by 56 and 65 percent for the 1985 and 2000 alternatives, respectively. At the river basin level, changes are large. For example, in the Lower Mississippi basin soil loss decreases by 189,000 and 245,000 tons, respectively, for 1985 and 2000. The energy alternative's total and regional soil loss is again very similar to the E' 2000 base run. The 2000 conservation run can therefore be compared with the soil loss figures for the energy run to determine the impact of the soil loss restraint.

Table 40. Soil loss by major river basins for the conservation and energy alternatives .

River Basin	Land and Water Conservation 1985	Land and Water Conservation 2000	Energy 2000
	(thousand tons)		
New England	1,051	281	886
Mid Atlantic	12,110	14,648	46,824
S. Atlantic-Gulf	47,827	47,600	223,004
Great Lakes	24,000	32,613	44,431
Ohio	57,350	57,378	112,237
Tennessee	4,910	5,865	20,392
Upper Mississippi	118,547	150,783	447,293
Lower Mississippi	39,906	37,956	284,129
Souris-Red-Rainy	14,571	19,203	32,877
Missouri	112,522	133,748	321,055
Ark.-White-Red	53,081	57,067	115,000
Texas-Gulf	32,329	28,956	88,454
Rio Grande	4,153	3,370	6,208
Upper Colorado	2,018	1,530	1,862
Lower Colorado	498	678	679
Great Basin	2,517	2,425	4,100
Col.-N. Pacific	26,928	20,403	29,080
California	4,783	3,944	3,932
United States[a]	559,102	618,450	1,792,444

[a]May not add because of rounding.

Other regions with large reductions in soil loss are the Upper Mississippi and Missouri basins. Nearly every basin shows a substantial decrease except for those where soil loss was already low and where few of the endogenous crops prone to high soil loss are grown. Some of the western regions fall in this category.

To achieve this reduction in soil loss, crop management practices have to change toward soil conserving technologies. Table 41 shows the distribution of the different management practices. In conservation

Table 41. Acreage under conservation and tillage practices for the conservation and energy alternatives.

Item	Land and Water Conservation 1985	Land and Water Conservation 2000	Energy 2000
	(percentages)		
Tillage practice			
Conventional tillage residue removed	16.8	17.0	17.9
Conventional tillage residue left	40.2	42.6	48.5
Minimum tillage	43.0	40.4	33.6
Conservation practices			
Straight row	25.0	23.8	39.4
Contouring	33.1	36.1	31.7
Strip cropping	11.6	14.5	14.3
Terracing	30.3	25.6	14.6

alternatives for 1985 and 2000, straight row cropping decreases substantially while contouring and terracing increase relative to the base alternatives, Table 16. The energy alternative causes little change in crop management practices.

Among the tillage practices, more emphasis is placed on minimum tillage while conventional tillage with residue remaining decreases in both conservation solutions. Conventional tillage with residue removed increases slightly in the 1985 alternative, but decreases in the 2000 alternative when compared with the base model. Tillage practices under the energy alternative are similar to the 2000 base model.

As a result of changes in crop management system aimed at lowering soil loss levels, average U.S. yields decrease, Table A.1. The largest decrease, 1985 sorghum silage yield, is reduced by more than one-half. This large reduction results as sorghum silage is grown in less productive regions on less productive lands. The general reduction in crop yields is due to a less intensive use of land as conservation practices are employed. Soybeans and oats are exceptions to the general decrease in yields. A major factor increasing soybean yield is a decrease of 6.6 million acres in the Lower Mississippi basin. These acres are removed from land groups IIIs, c, w. In the OBERS-E' 2000 run, average yield achieved on these acres was 26 bushels per acre. Total soybean acreage decreases 8.2 million acres. Hence, this 6.6 million acres removes the least productive land from soybeans and raises average U.S. yield.

Equilibrium Commodity Prices, Land Rents, and Water Prices

Improving water quality, the simulated conservation alternative, by restricting soil loss is associated with higher cost. The added costs of conservation practices is reflected in commodity prices as some crops have to be relocated away from regions with highest comparative advantage (which in some cases, have high soil loss). An example is soybeans in the Lower Mississippi basin and some corn in the Upper Mississippi basin. This relocation puts pressure on the "good" or the less erosive lands and is reflected in higher land rents.

Commodity prices, land rents, and water prices are presented in Tables A.3-A.10. In the 1985 conservation alternative, the solution is

still quite closely restricted by the production restraints. To conform with production and soil loss restraints simultaneously, some regions shifts completely to conservation practices. For instance, in the Lower Mississippi the 3,000 acres remaining in straight row cropping are all under minimum tillage management. In the year 2000, more regional shifts in crops can take place. Table A.10 shows that for the 1985 conservation alternative, prices increase substantially. The total impact of this price increase is reflected in the 69 percent increase in per capita food costs from $153.61 to $259.26. By 2000 the price increase is minor, and only 4 percent per capita as compared to the base solution. Land rents presented in Tables A.3 and A.4 show a similar difference for the two alternatives. In 1985 they reach very high levels.

The efficient water use coefficients of the conservation alternative decrease the per acre amount of water needed. At the same time, returns per acre increase and land and water receive the residual. Hence, water prices increase in the short-run. In 1985, water prices increase in all basins except for the Columbia-North Pacific. In 2000, the regional impact on water prices varies, and the U.S. average price declines. This decrease is due to the large reduction in acres irrigated and in consumptive water use.

In the energy alternative water prices increase in all major river basins. Water use is based on the normal efficiency coefficient and there is less water available than in the conservation alternative.

Conclusion

The conservation alternative deals with questions of water quality and soil conservation. The aim was to determine the national and regional impacts of a soil loss restriction. It simultaneously incorporates greater efficiency in water use, a possible policy alternative for the future. The results from the alternative indicate that agriculture has the productive and technological capacity to attain the environmental improvement specified. The impact on domestic food prices depends, however, on the year considered. In 2000, with fewer restrictions on the production patterns, the increase in prices and cost per capita is minimal. In contrast attaining the environmental improvement by 1985 with little adjustment in historical cropping pattern allowed, causes substantial rise in consumer food costs. Overall, however, the conclusion of the conservation runs are: It is possible to achieve the arbitrary levels set for soil loss if a) the higher efficiency in water use can be attained, and b) if we are willing to pay the cost in terms of price and income changes.

The energy alternative has little impact on either water prices, consumer food costs, or production patterns.

VI. THE IMPACT OF AN ENVIRONMENTAL ENHANCEMENT POLICY

In the environmental enhancement alternative restrictions are placed on water quality, animal waste runoff, and adequacy of water and breeding space for fish and wildlife. To attain the latter, no conversion of

wetlands and forest land is allowed and water flows in rivers is maintained at or above a specified minimum stream flow level. These conditions reduce a) Class I land available by the amount that was allowed to be developed at cost from wetland and forest land in previous alternatives, and b) water by the amounts shown in Table 4.

The soil loss restraint is set at the same level as in the conservation alternative. In regions where surplus nitrogen from animal wastes prevailed in previous alternatives, the animal waste runoff restraint will either force animal production out of market regions (until balance is created between available cropland for waste disposal and waste production) or have no effect where ample land is available. Together, the environmental restraints have a significant impact on regional land use and cropping patterns. Spatial production patterns readjust in favor of those regions which can best cope with the policy restrictions.

For the environmental enhancement alternative solutions are made for 1985 and 2000 under the assumptions of the OBERS E' demand and export projections. The third solution for 2000 uses the OBERS E projections.

Total Acreage and Distribution of Dryland and Irrigated Crops

The environmental restraints cause a sharp rise in the amount of cropland used. The availability, use, and development of cropland for 1985 and 2000 are summarized in Table 42. In the 1985 environmental solution, the restraints cause a 12 percent increase in total cropland

Table 42. Total cropland available and its use by type of use for the environmental enhancement alternatives.

Item	Environmental Enhancement 1985	2000	Low Demand
	(million acres)		
Available	380.8	376.1	376.1
Wet soil developed	0.0	0.0	0.0
Total available	380.8	376.1	376.1
Dryland used	332.3	299.4	220.5
Irrigated land use	22.1	22.3	22.5
Land used for exogenous crops	23.7	24.0	20.9
Total used	378.0	345.6	263.9
Idle land	2.7	30.5	112.2
Irrigated land development	3.9	6.7	8.5
Percentage of idle land in land groups I-V	73%	41%	65%

used when compared to the base alternative, Table 9. In 2000, the increase is two percent. The smaller increase in the 2000 solution is ascribed to the assumed greater resource mobility reflected in the reduced production restraints. The optimal interregional adjustment of agriculture can proceed much further in 2000 than in 1985.

The supply of cropland for cultivation is smaller in the environmental solutions than for the base model. The reason is that some lands, especially in groups VI through IX of the CNI, never meet the soil loss restraint and are sown to pasture. Hence, they are unavailable for cropping. Also the potential amount of cropland is smaller because pasture and forest wet soil development is not allowed (where as 3.8 and 10.6 million acres were developed, respectively, for 1985 and 2000 in the base model).

Some of the required increase in cropland acres results from the minimum soil loss restraint. Crop production must move away from the intensive margin to be able to meet the soil loss restraint. Movement towards the extensive margin brings more land into production. Some of this land is in land groups with greater conservation needs and lower yields.

Cropland not used for crops in the 1985 solution is only 2.7 million acres in addition to those acres converted to pasture. Hence, the simultaneous achievement of the environmental restraints and higher production level brings U.S. agriculture to full capacity production under high demand conditions (OBERS E' projections).

The impact of the environmental restraints on land use under a situation of low demands (OBERS E projection) is to raise total land use from 258 million acres in the low demand alternative with no environmental restraints, Table 20, to 264 million acres, Table 42. The magnitude of the projected demands is an important factor in determining the adequacies of land resources. The environmental enhancement analysis shows that if actual future demand and exports lie anywhere between the OBERS-E and OBERS-E' projections, land resources are adequate to meet this demand. But full capacity is approached with demand at the OBERS-E' level.

Irrigated acres decrease substantially in all three environmental enhancement solutions, Table 43. Compared with the 1985 and 2000 base model solutions, Table 9, and the 2000 low demand alternative, Table 20,

Table 43. Irrigated acres harvested by crops and major river basins for the environmental enhancement alternatives.

	Environmental Enhancement		
River Basins	1985	2000	Low Demand 2000
	(thousand acres)		
Missouri	6,035	6,829	7,342
Ark-White-Red	3,319	3,290	3,292
Texas-Gulf	2,621	1,436	1,452
Rio-Grande	1,226	1,354	1,273
Upper Colorado	502	525	526
Lower Colorado	968	969	893
Great Basin	1,039	1,129	1,055
Col.-Nth-Pacific	3,015	3,015	3,013
California	3,419	3,777	3,647
Crops			
Barley	2,228	2,243	2,242
Corn	1,288	858	1,092
Cotton	2,020	1,337	1,275
Oats	13	9	122
Sorghum	6,153	970	878
Roughages	5,488	12,735	13,165
Soybeans	754	379	367
Sugarbeets	983	418	425
Wheat	3,214	3,375	2,926
Crop total[a]	22,146	22,328	22,498

[a]May not add because of rounding.

the irrigated acreage decreases by 5.1, 6.1, and 4.2 million acres, respectively, for the 1985 and 2000 environmental solution with high demand and the environmental alternative with low demand. This decline in irrigated acres results from the large decreases in regional water supplies as high priority is given to maintaining minimum stream flow levels for fish and wildlife needs. This decrease in irrigated acres is illustrated in Figure 13. Comparison of this figure with Figure 10 indicates the regions most affected by the environmental enhancement alternative.

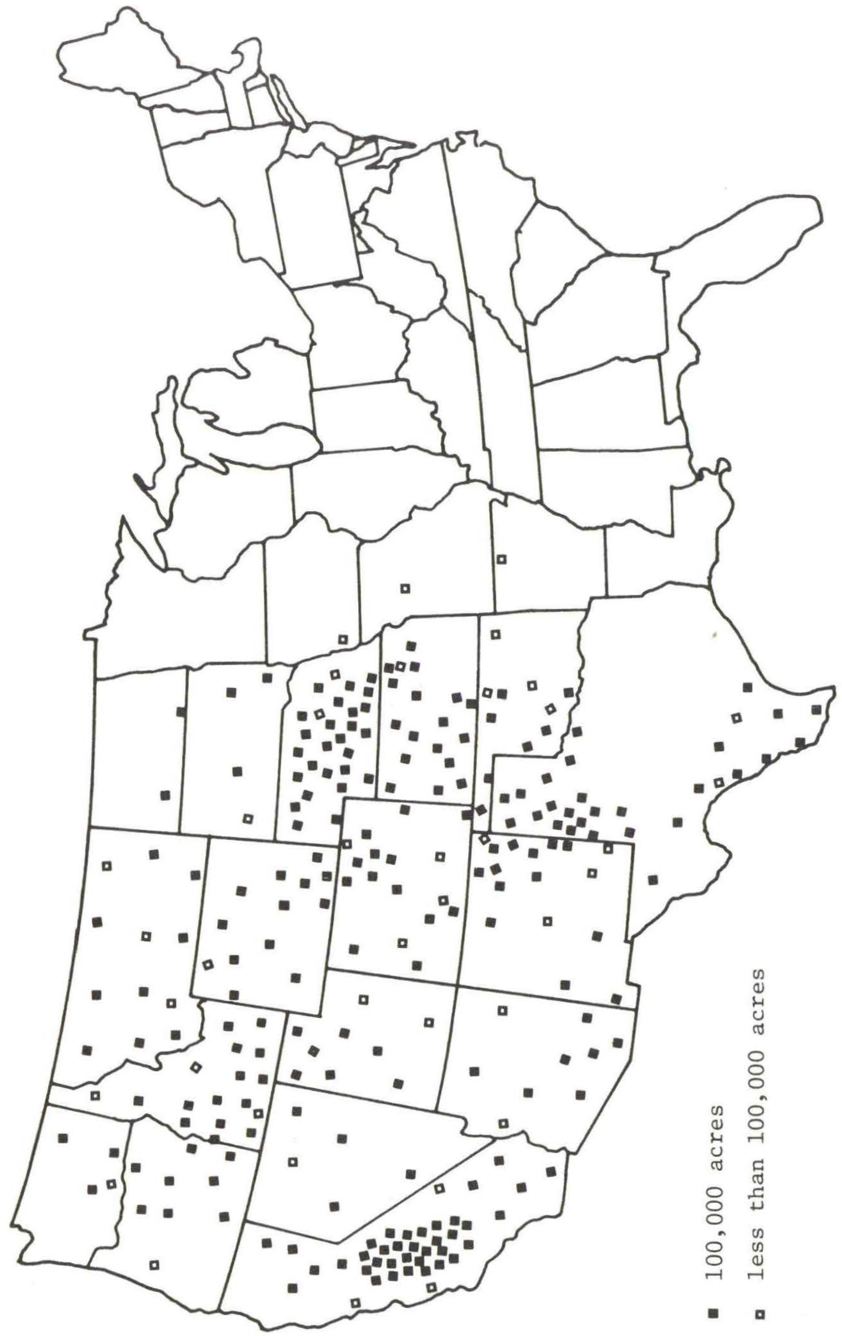


Figure 13. Location of irrigated land in 2000 for the environmental enhancement solution (high demand).

The crop mix for the environmental alternatives is presented in Table 44. Acreage of most crops increase but soybeans decrease in all three alternatives compared to their respective base alternatives. Corn decreases in the 1985 solutions and sugar beet acres decline in 2000 for both high and low demands under the environmental enhancement alternative. These crops decline since the soil loss restriction penalizes row crops. Other crops such as hay, barley, wheat, and other small grains meet the soil loss restraint. In the low demand alternative, wheat acreage declines as a result of a change in the demand and export mix.

Regional Land Use and Crop and Livestock Production Patterns

Changes at the national level do reflect the relatively larger regional changes under the environmental restraints on land and water use. Hence, land use is broken down by river basins in Tables 45, 46, and 47.

The total amount of cropland used in the 1985 base model and environmental alternative with large demand differs by as much as 53 million acres. At the regional level, the four central basins, the Souris-Red-Rainy, Missouri, Arkansas-White-Red, and Texas-Gulf increase the number of acres cultivated by 3.8, 22, 7, and 5 million, respectively, or a total of 37.8 million acres. Also, increases occur in the South Atlantic-Gulf and Columbia-North Pacific basins. The only region experiencing a decrease is the Lower Mississippi basin. The

Table 44. Endogenous crop acres for the United States for the environmental enhancement alternatives.

Crop	Environmental Enhancement		
	High Demand		Low Demand
	1985	2000	2000
	(thousand acres)		
Barley	23,149	9,664	9,596
Corn	57,597	59,402	47,179
Cotton	12,547	6,794	6,811
Oats	19,338	10,028	9,030
Sorghum	17,496	17,062	8,661
Roughages	95,121	81,641	60,995
Soybeans	60,502	85,701	51,543
Sugar	1,607	1,865	1,274
Wheat	61,587	42,662	36,151
Endogenous crop total	348,944	314,819	231,243
Percentage of acres irrigated	6.3	7.1	9.7

soil loss restraint forces land out of row crop production here and some land remains unused. In the 2000 solution, total endogenous crop acres increase by only 12 million acres. Three regions, the South Atlantic-Gulf, Lower Mississippi, and Upper Mississippi, all decrease in cultivated land acreage. Increased crop acreage occurs mainly in the Souris-Red-Rainy, Missouri, Arkansas-White-Red, and Texas-Gulf basins.

Under the low demand environmental enhancement alternative land used for crops increases by 7 million acres as compared with the parallel base run. Decreases again occur in regions with a high proportion of land susceptible to soil erosion. Cropped acreage also decreases in the Columbia-North Pacific basin, while large increases occur in the four central and the New England basins.

Table 45. Total crop and cropland use acres by major river basins for the 1985 environmental enhancement alternative, high demand.

River Basin	Feed grain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used	Pasture
			(000 thousand acres)				
New England	362	-	-	-	731	1,093	3,844
Mid-Atlantic	4,259	691	-	1,190	2,078	8,218	13,232
South Atlantic-Gulf	6,070	787	2,020	5,434	4,875	19,186	46,232
Great Lakes	10,173	1,512	-	4,164	5,402	21,437	12,096
Ohio	10,401	3,374	-	9,262	5,433	28,470	30,933
Tennessee	257	113	474	577	1,732	3,153	7,827
Upper Mississippi	28,719	1,593	-	21,358	7,621	59,328	26,161
Lower Mississippi	1,813	495	2,059	7,086	2,368	13,821	28,057
Souris-Red Rainy	6,172	8,574	-	781	1,727	17,654	5,362
Missouri	29,284	21,541	-	7,486	28,351	87,272	204,813
Arkansas-White-Red	8,676	13,953	2,222	2,812	11,630	39,343	95,165
Texas-Gulf	6,823	932	3,915	345	10,430	22,458	79,039
Rio Grande	611	16	410	-	1,016	2,053	76,423
Upper Colorado	268	179	-	-	699	1,156	46,170
Lower Colorado	289	61	355	-	254	959	77,988
Great Basin	195	504	4	-	1,325	2,051	70,481
Columbia-North Pacific	1,833	6,567	-	-	6,024	14,509	88,711
California	1,346	686	1,084	-	3,648	6,933	45,057
United States[a]	117,580	61,587	12,547	60,502	95,121	348,944	958,045

[a]May not add beeause of rounding.

Table 46. Total crop and cropland use acres by major river basins for the 2000 environmental enhancement alternative, high demand.

River Basin	Feed grain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used	Pasture
			(thousand acres)				
New England	120	-	-	-	637	757	6,393
Mid-Atlantic	2,841	1,717	-	1,517	1,713	7,788	12,531
South Atlantic-Gulf	3,217	1,346	1,885	8,630	2,243	17,321	45,700
Great Lakes	9,513	1,805	-	4,082	2,389	20,036	12,027
Ohio	10,247	2,815	-	11,895	2,324	27,281	29,724
Tennessee	207	47	94	1,820	143	2,311	7,310
Upper Mississippi	25,865	1,919	-	21,706	7,991	57,499	24,548
Lower Mississippi	523	446	1,605	6,866	1,434	10,874	24,299
Souris-Red Rainy	9,283	2,410	-	4,960	1,364	18,097	5,343
Missouri	19,929	15,943	-	15,064	26,095	77,192	202,327
Arkansas-White-Red	5,306	6,090	706	6,305	18,532	36,955	93,816
Texas-Gulf	6,125	1,170	1,620	1,948	9,198	20,068	78,732
Rio Grande	725	3	403	-	579	1,710	76,397
Upper Colorado	152	126	-	-	434	727	46,169
Lower Colorado	211	58	212	-	641	1,132	77,971
Great Basin	54	554	-	-	842	1,461	70,475
Columbia-North Pacific	979	5,283	-	-	2,788	9,110	88,058
California	851	921	263	-	2,289	4,459	44,961
United States[a]	96,157	42,662	6,794	85,701	81,641	314,819	944,184

[a]May not add because of rounding.

Table 47. Total crop and cropland use acres by major river basins for the 2000 low demand environmental enhancement run.

River Basin	Feed grain	Wheat	Cotton	Soybeans	Roughages	Total Cropland Used[a]	Pasture
			(thousand acres)				
New England	181	-	-	-	452	633	3,787
Mid Atlantic	2,650	1,952	-	415	1,301	6,318	12,531
S. Atlantic-Gulf	2,741	904	2,078	4,779	1,519	12,021	45,700
Great Lakes	7,650	1,483	-	3,638	2,136	15,657	12,027
Ohio	8,922	3,094	-	9,842	1,524	23,382	29,724
Tennessee	127	106	94	1,694	62	2,083	7,310
Upper Mississippi	23,154	2,320	-	17,804	9,961	53,257	24,548
Lower Mississippi	353	540	1,722	5,259	850	8,724	24,299
Souris-Red-Rainy	5,297	3,110	-	1,306	1,786	11,579	5,343
Missouri	12,658	9,574	-	3,647	18,296	44,336	202,327
Ark.-White-Red	4,032	6,860	480	1,201	14,099	26,688	93,816
Texas-Gulf	3,632	437	1,622	1,954	3,113	10,765	78,732
Rio Grande	629	3	410	-	576	1,618	76,397
Upper Colorado	121	126	-	-	312	574	46,169
Lower Colorado	293	115	137	-	344	899	77,971
Great Basin	46	390	-	-	734	1,181	70,475
Col.-N. Pacific	1,112	4,620	-	-	1,769	7,567	88,058
California	860	511	263	-	2,155	3,924	44,961
United States[a]	74,467	36,151	6,811	51,543	60,997	231,243	944,184

[a]May not add because of rounding.

Changes in cropping patterns, when comparing the 1985 environmental solutions of high demand with the 1985 base model, occur in nearly all regions. The 17 million acres increase in total feed grain acreage is distributed over many regions. Some of the larger increases in this 1985 alternative, occur in the Souris-Red-Rainy, Missouri, and Arkansas-White-Red basins. Increased cropped acreage, mostly small grains, occurs in basins such as the South Atlantic-Gulf and Lower Mississippi with erosion-prone soils.

Wheat acreage increases most noticeably in the Missouri, Upper Mississippi, Arkansas-White-Red, and Columbia-North Pacific basins, under the 1985 environmental alternative with high demand. Cotton acres decrease in the Arkansas-White-Red and Tennessee basins but increase in other basins where cotton is grown. Total soybean acreage decreases by 9 million acres in the Lower Mississippi (1.1 million) and Upper Mississippi (1.9 million) basins. Roughages, on the other hand, are up by nearly 30 million acres. All regions except the Upper Mississippi and Lower Colorado basins increase roughage acres. The shift to more hay and less crops comes about with the changes in crop management systems to be below the allowed soil loss levels. These changes also affect livestock production patterns and rations. Greater emphasis now is placed on hay and feed grains and less on soybeans and silages.

In the 2000 environmental solution with high demands, total feed grain acreage is smaller than for the 2000 base model. The decrease, distributed over all regions, is greatest in the four central river basins:

the Souris-Red-Rainy, Missouri, Arkansas-White-Red, and Texas-Gulf. The distribution of wheat follows a pattern similar to that in the base model except that less is grown in the Souris-Red-Rainy and Arkansas-White-Red basins and more is grown in the Columbia-North Pacific and Missouri basins. Cotton acreage decreases in the South Atlantic-Gulf basin but increases in other basins. The changes in the distribution of soybean acres, when compared with the base model, are similar to those observed in the 1985 solution for environmental enhancement under high demand. The changes in cropping patterns in the year 2000 are again presented by means of a state map. Comparison of Figure 14 with Figure 11 and 12, illustrates the shifts discussed above.

In the 2000 low demand environmental alternative, cropping pattern changes are all in the same direction as discussed for the previous two alternatives.

Changes in regional irrigated acreages and cropping patterns are summarized in Table 43. The percentage change in regional acreage is similar for the low demand and high demand alternatives for environmental enhancement. All basins, except for the Lower Colorado, have reduced irrigated acreages with the largest decreases occurring in the Arkansas-White-Red, Texas-Gulf, and Columbia-North Pacific basins. The crop mix for the low demand alternative is less consistent with the high demand alternative.

Livestock production patterns are summarized by four major zones in Table 48 for both the high and low demand environmental enhancement alternatives. The restrictions of the 1985 environmental alternative

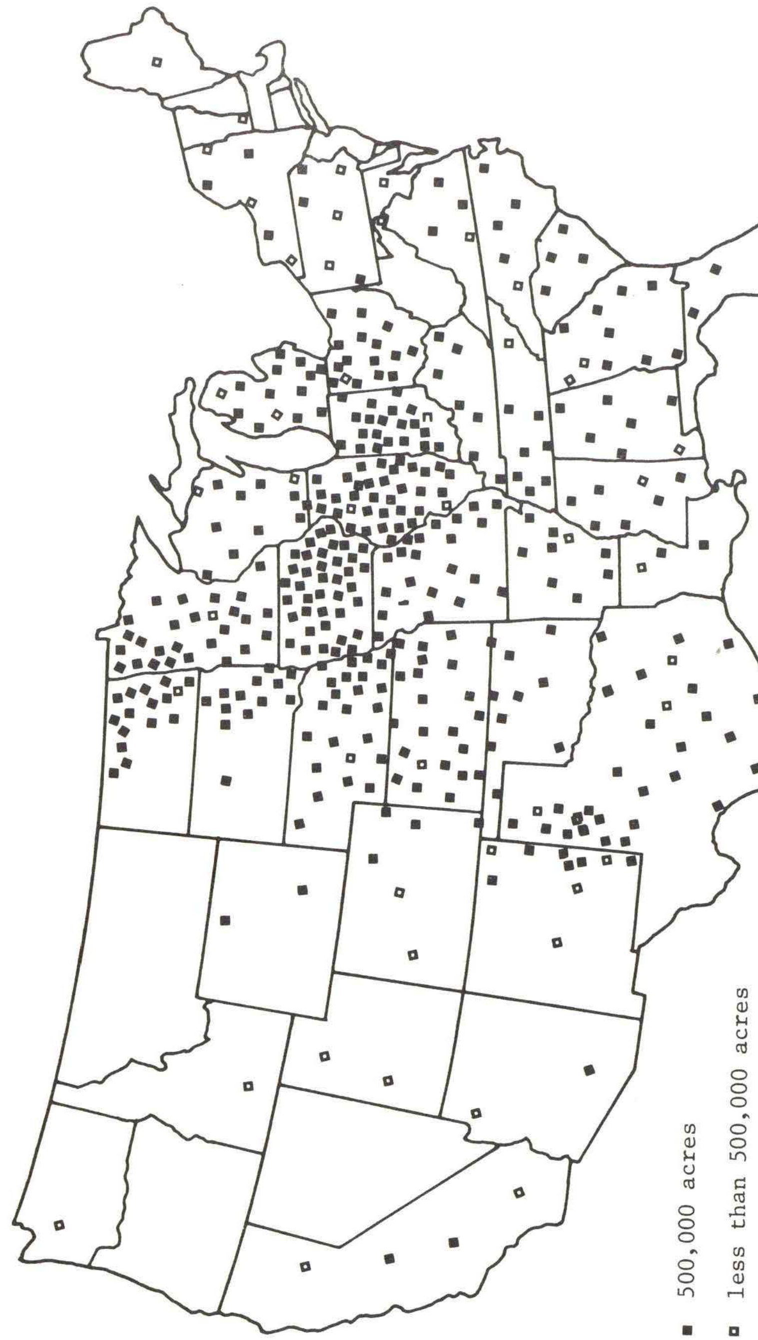


Figure 14. Location of row crop acres in 2000 for the environment enhancement solution.

Table 48. Livestock production patterns by four major zones for the environmental alternatives.

Zone	Beef Cows			Beef Feeding			Dairy			Hogs		
	I[e]	II[f]	III[g]	I	II	III	I	II	III	I	II	III
	(percentage of total production)											
North-East[a]	15.7	11.5	13.9	18.4	14.5	19.1	43.7	52.1	52.0	57.8	77.1	87.6
South-East[b]	8.6	10.6	10.3	1.3	7.6	10.5	19.6	20.5	20.5	8.8	2.4	2.6
Mid-Continent[c]	58.6	65.2	63.4	62.2	64.3	57.9	28.9	16.2	16.3	32.2	20.3	9.5
West[d]	17.1	12.8	12.4	18.1	13.7	11.5	7.7	11.2	11.2	1.2	.3	.3

[a] Includes river basins 1, 2, 4, 5, and 7.

[b] Includes river basins 3, 6, and 8.

[c] Includes river basins 9, 10, 11, and 12.

[d] Includes river basins 13, 14, 15, 16, 17, and 18.

[e] Environmental enhancement alternative 1985.

[f] Environmental enhancement alternative 2000.

[g] Low demand environmental alternative.

have little effect on the distribution of beef cows but cause large changes in location of beef feeding as compared to the base solution. Fed beef decreases in the North-East and South-East zones but increases in the Mid-Continent and West zones. The number of dairy cows and hogs also decreases in the North-East zone. The Mid-Continent zone increases its shares of all four livestock activities. The general decrease in the North-East zone is partly attributable to the animal waste restriction. The shift of livestock to the Mid-Continent zone coincides with the movement of feed grain and oilmeal production away from the South-East zone. The small decreases in the West zone are attributed to the decreased water supplies.

Comparing the 2000 high demand environmental alternative with the base model, beef cows increase in the North-East and South-East zones but decrease in the Mid-Continent and West zone. Fed beef concentrates more in the Mid-Continental zone at the expense of all other zones. Dairy cow numbers remain constant in all zones and hogs decrease in the two eastern zones and increase in the Mid-Continental zone.

In the low demand environmental alternative, very few changes take place in livestock production patterns as compared to the base solution. The changes that do occur are in the same direction as those observed between the 2000 base model and the 2000 environmental alternative.

Consumptive Water Use

The large decrease in regional water supplies causes a substantial decrease in the number of acres irrigated. This smaller irrigated acreage is reflected in the total consumptive water use reported in Tables 49, 50, and 51. Consumptive water use for the 1985 high demand environmental alternative is 27 percent lower than in the 1985 base model. The decrease occurs in all river basins. The more detailed producing area results show that in many regions water supplies are inadequate to attain the 1969 irrigated acreage of endogenous crops and supply water for exogenous crops and livestock. The primary impact of reduced water supplies is on the income of those engaged in agriculture. The secondary impact is on people in those communities dependent upon this agricultural activity. In a later section we discuss these impacts in detail.

The 2000 high demand solution has lower water use coefficients. Because of this higher efficiency and further adjustments in cropping patterns, water use changes slightly from that for the 1985 high demand alternative. Two river basins, however, still exhaust all available water and many producing areas cannot attain the 1969 irrigated acreage level. Similar shortages occur in the low demand environmental alternative.

Consumptive water use is greatly affected by the large minimum stream flow requirements. The magnitude of these requirements is emphasized when the supply figures for the Columbia-North Pacific regions are compared under the base and the environmental models. Water supply is 76 million in the base model but only 21 million in the 1985 high demand environmental alternative. It is not surprising, therefore, that this basin becomes a water deficit area in two of the three environmental solutions.

Table 49. Consumptive water use by crops and livestock by major river basins for the 1985 high demand environmental enhancement alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
		(thousand acre-feet)			
Missouri	13,399	12,757	610	13,369	30
Ark.-White-Red	5,688	5,387	332	5,722	-34
Texas-Gulf	6,083	7,073	218	7,293	-1,210
Rio Grande	3,754	3,665	36	3,703	51
Upper Colorado	926	898	26	926	0
Lower Colorado	5,693	5,405	51	5,458	235
Great Basin	2,712	2,669	41	2,712	0
Col.-N. Pacific	9,099	8,978	120	9,981	-882
California	21,308	20,129	99	20,231	1,077
Western basins[c]	68,669	66,973	1,542	68,518	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Table 50. Consumptive water use by crops and livestock by major river basins for the 2000 high demand environmental enhancement alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	13,334	12,614	714	13,331	3
Ark.-White-Red	5,192	4,196	412	4,610	582
Texas-Gulf	3,895	4,561	384	4,947	-1,052
Rio Grande	3,721	3,638	60	3,699	22
Upper Colorado	920	895	23	920	0
Lower Colorado	5,688	5,136	58	5,197	491
Great Basin	2,690	2,630	58	2,690	0
Col.-N. Pacific	9,052	8,985	81	9,068	-16
California	21,295	20,010	94	20,106	1,189
Western basins[c]	65,841	62,677	1,892	64,571	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Table 51. Consumptive water use by crops and livestock by major river basins for the 2000 low demand environmental alternative.

River Basin	Available	Irrigation[a]	Livestock[b]	Total[c]	Surplus or Deficit
			(thousand acre-feet)		
Missouri	13,334	12,744	592	13,338	-2
Ark.-White-Red	5,192	4,146	358	4,506	686
Texas-Gulf	3,895	3,954	273	4,229	-334
Rio Grande	3,718	3,655	58	3,716	2
Upper Colorado	920	895	23	920	0
Lower Colorado	5,688	4,387	49	4,439	1,249
Great Basin	2,691	2,630	47	2,679	12
Col.-N. Pacific	9,052	8,938	63	9,004	48
California	21,295	19,223	94	19,286	2,009
Western basins[c]	65,841	60,549	1,568	62,119	

[a]Includes exogenous crops and roughages and endogenous crops.

[b]Includes exogenous and endogenous livestock.

[c]May not add because of rounding.

Conservation-Tillage Practices and Soil Loss

The effectiveness of the soil loss restraints in reducing soil loss levels is apparent from the results in Table 52. Reductions in total U.S. soil loss over the corresponding base model levels are 58, 66, and 60 percent, respectively, for the 1985 and 2000 environmental high demand and the environmental low demand alternatives. Although these are large reductions, individual regions have relatively larger reductions. The Missouri and South Atlantic-Gulf are two basins with very large reductions in soil loss over the base run.

Table 52. Soil loss by major river basins for the environmental enhancement alternatives.

River basin	Environmental enhancement		
	1985	2000	Low Demand 2000
	(thousand tons)		
New England	1,778	1,396	1,376
Mid Atlantic	11,494	14,263	12,874
S. Atlantic-Gulf	49,507	44,119	30,090
Great Lakes	23,945	30,446	28,804
Ohio	54,740	57,088	49,771
Tennessee	5,070	5,125	5,184
Upper Mississippi	117,377	144,161	153,200
Lower Mississippi	44,448	33,574	30,057
Souris-Red-Rainy	10,133	18,549	23,427
Missouri	94,104	130,127	92,729
Ark.-White-Red	54,566	62,658	39,157
Texas-Gulf	32,908	37,462	27,122
Rio Grande	4,167	3,949	3,695
Upper Colorado	2,064	1,303	1,044
Lower Colorado	600	464	415
Great Basin	2,342	2,189	1,552
Col.-N. Pacific	24,072	18,704	17,063
California	4,881	3,532	3,096
United States[a]	538,208	609,117	520,665

[a]May not add because of rounding.

The policy restraining soil loss to the t value is effective but reduction is obtained at a cost. Reductions in soil loss levels are achieved in two ways, a) through changes in regional land use patterns and crop mixes, and b) through changes in conservation and tillage practices. The first type of change, already examined, indicated sizeable changes in land use and crop patterns. The second type of change is indicated by the percentages for the different conservation and tillage practices, Table 53. Comparing the environmental alternatives with respective benchmarks, straight row farming decreases and conservation practices increase, in the 1985 high demand environmental solution. The decrease in straight row farming is 11 percent as compared to the base solution which included the higher 10 times t or 40 ton soil loss limit. These acres remain in production but are shifted to contouring or terracing.

In the 2000 high demand environmental alternative, the decrease in straight row farming is even greater, 19 percent, when compared with the 2000 base model. Minimum tillage increases at the expense of conventional tillage practices with residue left. In the low demand environmental alternative for 2000, straight row farming also shows a decrease while the conservation practices used increase.

Equilibrium Commodity Prices, Land Rents and Water Prices

Shadow prices and commodity prices are reported in Table A.5 through A.10. Commodity prices increase substantially in the 1985 high demand environmental alternative as compared to the base run. Farm level cost of

Table 53. Acreage under conservation and tillage practices for the environmental enhancement alternatives.

Item	Environmental Enhancement		
	High Demand		Low Demand
	1985	2000	2000
	(percentages)		
Tillage practices			
Conventional tillage residue removed	18.2	19.0	18.2
Conventional tillage residue left	40.3	41.4	40.2
Minimum tillage	41.5	39.6	41.5
Conservation practices			
Straight row	20.8	20.2	34.7
Contouring	35.2	37.2	32.7
Strip cropping	9.8	13.9	16.7
Terracing	34.3	28.8	15.9

food (for commodities endogenous to the model) per capita increases from $153.61 to $620.88. Hence, the achievement of environmental enhancement is obtained at great implied cost to the consumers. In the year 2000, however, with the larger amount of adjustment possible and the greater efficiency assumed in crop and livestock production and water use, the increase in commodity prices is small for the high demand environmental alternative. Food cost per capita in 2000 increases only from $124.01 under the base solution to $136.49 under the environmental solution.

The changes in shadow prices imply that environmental restrictions imposed by 1985 can be achieved only with high costs to the consumer

and parts of the farm sectors. Owners of land and water rights benefit in higher inputed values. But in those areas where the soil is susceptible to erosion or where water is taken away to be used for other purposes, farmers are expected to experience a decrease in income. Further, communities surrounding these farms and dependent on the agricultural activities for employment and income generation also will pay for the higher environmental quality achieved through reduced incomes. Imposing the same restrictions by 2000 allows for the achievement of environmental quality at a much lower cost as production restraints are relaxed in the long run. Large changes in land use and cropping patterns will still occur, however, in some regions the costs will still be high to select groups of farmers and communities.

Conclusion

The above discussion points out the impact of certain possible environmental enhancement policies on U.S. agriculture. The impact on land use and cropping patterns is similar to those observed in the conservation alternatives. Large interregional changes in farming are required as restraints on soil loss are attained. Most affected are the row crops. In several regions, such as the Lower Mississippi basin, row crops can no longer be grown on several land groups. On other land groups they can be grown only if the conservation and tillage practices are changed. Drastic changes in both land use and cropping patterns are expected to have significant impacts on regional incomes. An important finding for the high demand situation, however, is that the environmental alternatives, as specified in the model, could be achieved only with exceptional shifts in production and price impacts while simultaneously meeting projected domestic and export demands. This difficulty indicates that in the environmental alternative, agriculture approaches its maximum capacity under the E' demand and export levels. Even under the low demand environmental alternative, water still is in short supply.

The large increases in land rents and commodity prices, especially in the high demand 1985 solution, suggests that inequitable distribution of the costs of environmental enhancement might take place in the absence of offsetting policy. Large increases in land rents and water values are favored by ownership of these resources. However, their gains have to be compared to the losses experienced by those resource owners in regions where certain lands cannot be cropped if the environmental restraints are to be attained. Under the highly restrained conditions of the 1985 high demand environmental alternative, consumers also are faced with a large increase in per capita food costs.

The three environmental solutions analyzed in this section represent one set of possible futures. Any change in the conditions underlying the models and alternatives (such as higher yields and more efficient water use) may allow the environmental solutions to become feasible. Still, the results as obtained can serve as a base against which changes in the basic conditions and specifications in the model can be analyzed.

VII. POLICY IMPLICATIONS

This study shows that the land and water resources available to U.S. agriculture will allow the sector to readily meet domestic demands and a high level of exports in the years 1985 and 2000. In fact, without any environmental restraints, demands in these years can be met so readily that there is the possibility of surplus conditions unless exports are kept at very high levels or supply restraints are in effect. It also appears that future domestic and export demands can be met at high levels even with interregional land use, cropping patterns, and management practices conforming to a soil loss restraint.

However, if the pattern of production were to conform with a higher level of environmental enhancement which a) imposes land use and cropping technologies restraints to restrict soil loss, b) prevents pasture or forest wet soils from being transformed into cropland, and c) lessens greatly the supply of water available to agriculture in order that stream levels will maintain fish and wildlife populations, agriculture would produce at full capacity and a lower level of exports would need to prevail. Simultaneous imposition of all of these conditions would launch a complex pattern of income costs and sacrifices among farmers, farming regions, and consumers. In general, incomes would be reduced in farming areas where land is extremely erosive and costly conservation practices or extensive land uses would need to be initiated. They would be reduced in regions where water supplies available for irrigation are lessened. Communities surrounding farms with reduced incomes would also suffer economic depression. And until further adjustments and technological advances in agriculture could be attained, consumers also would bear a sacrifice in the form of considerably higher food costs.

Gains would accrue to farmers and communities with soils which are not erosive and which do not depend on water for irrigation. In these cases, the land could be cropped even more intensively to conform with conditions of high demand and restricted production in other food supply areas. As results of this study show, resource values would increase greatly for these favored groups. Also, livestock production would have increased comparative advantage in those regions where conventional cropping practices can be retained and feed grains can receive increased emphasis as supply capacity is environmentally restrained for the nation as a whole.

The environmental restraints incorporated in the alternatives analyzed in this study are, of course, only possible futures which might be imposed. Others also could be specified. However, legislation is now in effect or being posed at state and national levels that would parallel the alternatives examined in this study in their effect on land use, agricultural productivity and interregional shifts in crop production and farm income generation. Examples are the Iowa Soil Conservancy Act and several of the restraints on pesticide use imposed by the Environmental Protection Agency. Hence, it is realistic and practical to examine the policy implications of income and cost redistributions resulting from restraints on resource use to attain environmental or other national goals.

Gain to society at large from improved quality of the environment could be attained through enactment of the environmental enhancement alternatives examined in this study. This gain to society would be complementary to those farmers and communities favored by higher incomes and resource values. But, as mentioned previously, it would come at a cost in the sense of requiring somewhat lower exports than otherwise would be possible and in reduced income to the particular groups of farmers, rural communities, and regions or river basins mentioned above. Hence, a public decision has to be made. If the world remains short on food and farm commodity prices are high, should we try to produce a maximum for world exports or should we better preserve our own resources and environment while food-short nations develop their own agriculture more rapidly or import from the other nations? Although the United States has large capacity to produce, the question is relevant only if countries and international organizations are able to develop policies and institutions that will provide buffer stocks and a pricing framework to guarantee U.S. farmers prices that will give them a favorable return on their resources. With the nation's large food producing capacity, exports at only modest levels would cause U.S. food supplies to be large relative to demand. Then, because demand is inelastic for major farm commodities, less total production through soil loss, stream flow, reduced irrigation water, and other environmental restraints would cause U.S. farm revenue to be larger than in the absence of these restraints.

Still, as mentioned previously, the distribution of this greater market revenue would not necessarily be equitable. Relatively more of it would go to those regions with nonerosive soils and irrigation water supplies that would not be disturbed. Reduced incomes could even go to regions with much erosive land that must be shifted to less intensive forage and small grain crops from corn, soybeans, and cotton; or to farmers in irrigated areas where stream levels were increased at the expense of water to agriculture. The redistribution of income through large and complex environmental programs would form an intricate pattern among regions. Hence, with costs in the form of lower income falling on some groups, methods of compensation might need sacrifice in income. The rental values for resources generated in this study could serve as one criterion of the interregional distribution of gains and sacrifices. Other supplementary data also would be necessary. An appropriate and publicly acceptable program to guarantee that national environmental or resource conservation gains do not cause great income sacrifices by particular regions and groups would require systematic and detailed planning inputs. However, without such a policy we cannot be sure that large-scale and national environmental enhancement programs bring net welfare over all groups of producers, consumers, and communities.

VIII. SUMMARY

The main objective of this study is to evaluate the nation's resource capabilities relative to future magnitudes of major variables

affecting agriculture and its resources and technologies. Particular emphasis is placed on land and water resources.

To accomplish this objective a model is built that is capable of analyzing interregional interaction. The model incorporates 105 producing areas based on the U.S. Water Resources Council's aggregate subareas, 28 market regions, 57 regions with water demands and supplies defined, a transportation submodel, crops and livestock submodels, and all of the agricultural land and irrigation water of the nation.

The model analyzes changes required in land and water uses of individual regions, agricultural commodity production, interregional production shifts, regional and national soil loss, required conservation practices by regions, commodity prices, resource returns, and other relevant parameters.

To evaluate future resource adequacies, a base model and several alternative futures were determined. In each of these alternative futures, one or two parameters are changed with respect to the basic conditions in the base model. The base model represents a continuation of present trends in yields, per capita food consumption, and exports. Per capita consumption and export levels are obtained from the OBERS projections. For our purposes, two of these projections were used, the OBERS E and the OBERS E'. The E' projections were prepared at a later date and represent, on the whole, higher domestic and export consumption levels. The base model is solved for the years 1985 and 2000.

The alternative futures can be combined into three groups. The first group analyzes changes in projected demand and export levels on interregional production patterns, land and water use, and prices. In two alternative futures, high export levels are introduced while all other basic conditions stay constant. This high export alternative is solved for both 1985 and 2000. The third future analyzes lower demand levels (using OBERS-E instead of OBERS-E' projections) for the year 2000, only.

The second group deals with water quality, increased water use efficiency, and energy water demand. Water quality is assumed directly related to sheet and rill erosion from cultivated lands. To simulate increases in quality (or decreases in erosion) within each of the 105 producing areas, the dryland and irrigated cultivated lands are each allocated to nine land groups based on their erodibility characteristics. Activities are defined within each producing area and land group to simulate rotations producing alternative crop combinations under alternative conservation and tillage practices. Each rotation has a specific level of associated gross field soil loss as determined from the Universal Soil Loss Equation. The results from the solution indicate national and regional impacts of any restrictions on soil erosion. Two alternatives in this group analyze the impacts of a soil loss restriction of "t" tons per acre per year, where "t" stands for an amount of soil loss that will not reduce the productive capacity of the particular region over time. This factor varies among producing regions. Simultaneously in this alternative, a higher water use efficiency is assumed to analyze the impact of a water conservancy policy. These two alternatives, called the land and

water conservation alternatives, are solved for the year 1985 and the year 2000. Also included in this group is an energy alternative in which water is allocated to energy development and agriculture is left with a smaller water supply for irrigation purposes.

The third group deals with the enhancement of environmental quality. The environmental parameters involved are soil erosion, wet soil development, animal waste disposal, and minimum stream flow requirements to preserve fish and wildlife habitats. Restrictions on all of the above are incorporated in the model and three alternatives analyze the impacts of such restrictions. The first alternative analyzes this situation for the year 1985, the second for the year 2000, and the third also analyzes the year 2000, but now under the lower set of demand re-requirements (OBERS-E).

The results of the base models and the alternatives indicate that agriculture has a large capacity to produce higher levels of output while at the same time contributing to reduced gross field loss of soil and increased environmental quality. If this increased output and higher environmental quality were to be required by the year 2000, the results show that the high levels could be attained with only small increases in the farm level prices. If, however, the achievement of greater output and higher water quality is required by 1985, prices will increase sharply, and drastic changes would be needed in land use and cropping patterns.

With respect to land resources, the results of the model alternatives indicate that there is sufficient land, especially cropland, to produce projected increases in food and fiber demand for the years 1985 and 2000. The 1985 high export alternative comes close to exhausting all available cropland, with only 7.2 million acres not cropped, Table 54. The greater adjustment in regional crop distribution allowed by the year 2000 increases the number of unused acres to 27.5 million. The 1985 environmental alternatives, for all practical purposes, exhausts the supply of land that can be cropped under the soil loss conditions of this alternative. Again, greater adjustment by 2000 takes the pressure off land use.

The high export alternative and the environmental enhancement alternative represent two extremes in land use. The first of these two alternatives analyzes the impact of an all-time high level of exports with no environmental restrictions, while the second alternative analyzes a future with many environmental restrictions and a lower level of exports. The results show that although total available land supply is not exhausted, the 1985 alternatives come close to using land up to its full capacity. These results, however, are based on specific assumptions about other forces competing for land. If the demand for land for urban, transportation, park and wildlife increases at a rate higher than incorporated in the models, the results may no longer apply. But in such a case, the alternative futures analyzed can still serve as a benchmark against which changes in the base assumptions or various policies can be evaluated.

The overall results on land use show that cropland available is not a limiting factor in achieving high exports or a higher quality of

Table 54. Estimated level of some of the major parameters at the U.S. level for the base models and all alternatives.[a]

Alternatives	Cropland cultivated	Endogenous crop acres irrigated	Cropland unused	Land developed	Land rents	Water shadow price	Food cost per capita	Soil loss
	(million acres)				($/acre)	($/acre-foot)	($)	(billion ton)
OBERS-E' 1985	337.6	27.2	59.3	3.8	31.66	11.14	153.61	1.3
OBERS-E' 2000	338.9	28.4	60.1	10.6	23.93	10.14	124.01	1.8
High exports 1985	392.9	27.9	7.2	7.0	35.76	25.35	288.04	1.3
High exports 2000	376.7	28.9	27.5	15.8	35.09	12.52	136.58	1.9
Low demand 2000	257.8	26.7	134.4	3.7	11.17	14.31	98.42	1.3
Conservation 1985	368.3	28.3	30.3	5.5	103.33	17.67	239.41	.6
Conservation 2000	341.2	27.2	56.8	9.6	28.65	10.46	129.15	.6
Energy 2000	338.2	27.9	60.8	10.6	24.73	12.59	124.31	1.8
Environmental 1985	378.0	22.1	2.7	0.0	416.20	222.18	620.88	.5
Environmental 2000	345.6	22.3	30.5	0.0	34.58	21.25	136.49	.6
Environmental and Low demand 2000	263.9	22.5	112.2	0.0	NA	NA	NA	.5

[a]All prices are in 1972 dollars.

the environment by the years 1985 and 2000 while simultaneously meeting projected food and fiber demand. This is an encouraging result, but it is a result that has to be viewed in light of the comment made about other competitive sources of demand for land.

To evaluate total water supplies is more difficult. Adequate water supplies can be defined as either an adequate amount available to agriculture as a whole to produce food and fiber demands, or as an adequate supply available in each production region to assure that land presently irrigated can also be irrigated in the future.

The base models and all alternatives show that total water supply at the U.S. level is adequate to produce the projected level of food and fiber demand for 1985 and 2000 under the alternatives considered. The results of the alternatives considered indicate that the simultaneous achievement of a set of policies to enhance the environment and expanded export levels may not be easily attained. This is an important result, but one that has to be viewed in light of the conditions underlying the assumptions. The crucial condition or requirement is that high priority be given to water demands by fish and wildlife. Some of these demands are of magnitudes several times larger than the projected water deficits within specific producing areas. Hence, small reductions in the minimum stream flow requirements will allow simultaneous achievement of a slightly lower level of environmental enhancement yet allow projected demands to be attained.

Comparison of the net water balances of the conservation and environmental alternatives shows that the surpluses reported, at the river

basin level, in the conservation alternative are larger than the deficits reported in the environmental alternative. The difference in assumptions between the two sets of alternatives is that in the conservation alternative water supplies are decreased to maintain minimum stream flow levels for fish and wildlife. The comparison of the net water balances leads to the conclusion that if high water use efficiency can be reached, i.e., higher than presently assumed in the environmental alternatives, the simultaneous achievement of the environmental enhancement restraints and the production of projected demand levels is a possibility. This is a rough comparison and applies more to the year 2000 than to the year 1985. It cannot be ignored, however, that a water conservancy policy to decrease net irrigation requirements through better irrigation technologies and improved management systems may well represent one of the most promising policy directions indicated in the study, if the nation is to pursue simultaneously high exports and enhanced environmental quality.

In the remainder of this section, each set of alternatives, (for 1985 and 2000) where applicable, is briefly summarized in terms of national and regional impacts.

The Base Models

The results of the base models stand very much by themselves. There is no bench mark against which these models can be contrasted to determine possible trade-offs. In the section on the base runs, therefore, the results were compared against actual 1971-73 data when possible.

The results show that the projected demand and productivity increases in the years 1985 and 2000 require an increase in cropland acres used. This increase over 1971-73, for total acres of endogenous crops, was 14 million acres in 1985 and 20 million acres in 2000. Total irrigated acreage changes little compared with 1971-73 data. Land development takes place in both solutions and up to 6 million acres of dryland are converted to irrigated land. Consumptive water use increases by seven percent in 1985 compared with 1971-73 and decreases in 2000. Large water surpluses are available in many river basins except for the Upper Colorado and Great Basin.

The results show, given trend increases in per capita consumption, yields, and exports, the nation's land and water resources are in adequate supply to produce the projected food and fiber and exports demanded by the years 1985 and 2000. This result is encouraging given the study objective of determining resource adequacies. The overall results, however, can overshadow some of the negative regional impacts of changed land use and crop production patterns. Compared with 1971-73, of the major river basins, the Missouri basin decreases significantly in the amount of cropland cultivated. Other basins increase their share of total land use. Further significant changes take place in regional crop patterns.

Water shortages in some of the producing areas also pose potentially serious impacts on communities and farmers in those regions where water for irrigation often means the difference between production or yield failure.

The base results are reassuring in evaluating resource adequacies to meet projected food and fiber demands without imposition of new environmental and land and water use restraints. The water supplies available to agriculture in 1975, plus the outflows in the main irrigation months, are assumed to (with adjustments for decreases in ground water supplies) be available in the years 1985 and 2000. With regard to environmental impacts under the base solutions, 3.9 million acres in 1985 and 10.6 million acres in 2000 come from cleared forest lands and drained wet soils. Also, 1.3 and 1.8 billion tons of soil are eroded every year in the 1985 and 2000 solutions. Further, no restrictions are placed on the disposal of animal wastes. Sectors other than agriculture compete for the total amount of water available, including the amount presently used by agriculture. The priorities of demands may change and agriculture could become a residual user after other demands with higher priorities have been satisfied. This is not a prediction but such changes are evaluated in the alternative futures considered. The alternatives analyzed represent only a small subset out of the total set of possible futures.

The High Export and Low Demand Alternatives

Under the assumptions of the high export alternative without environmental restraints, use of land for crops reaches 393 million acres in 1985 and 377 million acres in 2000. Acres of land unused for crops reaches a low level of 7.2 million acres in 1985 and 27.5 million acres in 2000. Development of wet soils and forest lands takes place in the amount of 7 million acres in 1985 and 15.8 million acres in 2000. In the latter year, the amount so used approaches the maximum 18.1 million acres of total lands that can be developed. Irrigated acres increase slightly over the base run levels.

The land use summary shows that this alternative generally exhausts total cropland capacity for the United States. The acres of idle land are mainly in the land groups of low productivity. Especially in 1985, very little productive capacity is left. The results are, however, dependent on the specifications of the model. For example, the two percent per year adjustment in production restraints allowed may not be appropriate if government policy is for full production and conditions that favor faster adjustment. The result does show, however, that production of the projected export level will put some strain on agricultural capacity.

Changes take place in land use patterns when compared with the base models. The river basins showing the largest changes are the South Atlantic-Gulf, Missouri, Arkansas-White-Red, Texas-Gulf, and Columbia-North Pacific basins. The three large basins in the middle of the United States perform the role of a buffer zone. When demand levels increase, the greater acreage needed comes largely from these three basins. But when demand decreases these basins have large decreases in cultivated acres.

Total consumptive water use increases for both years. This increase is due to increases in irrigated acres and changes in crop patterns to higher water use crops. The pattern of regional net water balances

are similar to those of the base runs. This constancy in consumptive water use is not surprising since most of the increased production for higher export levels occurs on dryland.

The greater demand for cropland brings into production lands previously not cultivated. Many of these have a lower productivity and a high susceptibility to soil erosion. Total soil loss increases by 100 million tons in the 2000 solution. However, it decreases slightly in the 1985 solution. This decrease is the result of a change in crop mix with a greater emphasis on small grains and hay production. There are no significant changes in conservation and tillage practices.

Under the 2000 low demand alternative total land use decreases, irrigated acres decrease slightly, and changes take place in the crop management systems utilized. Compared with the parallel 2000 base run, straight row farming increases.

The overall impact on farm income and regional income derived from agriculture is implied in changed land rents and shadow prices for water. In the 1985 alternative, the U.S. average land rents increases from $32 to $136. However, at the regional levels this increase is not uniform. The highest land rent, $516 per acre, is found in the Lower Mississippi while rent increases in New England by only $21. Land rents are not so volatile in 2000 and the regional changes are much more uniform. Shadow prices on water also increased in both alternatives, showing a pattern of increases similar to land rents. In 1985 the cost of an average basket of food (for commodities endogenous to the study) increases from $153 to $288, while in 2000 the increase is from $124 to $137.

The high export alternative shows that large increases in exports can be met without reaching full capacity. However, if achievement of these high levels is attained in 1985, land resources come close to full utilization. In this alternative, U.S. agriculture is shown to have a large capacity to produce food. Given the assumptions on regional crop adjustments, high export levels are within the productive capacity of the nation. A policy, designed to achieve this expanded export level by 1985, also might have to deal with the impacts of expanded production. From an environmental standpoint, soil loss levels are high, wetland development is increased, and greater quantities of water are withdrawn from the waterways, all reducing environmental quality and for the consumer, food costs increase markedly. From the standpoint of farmers and farm communities, the changes in land use patterns have varying impacts on incomes received in the different regions.

In the year 2000, these same impacts occur but to a much smaller extent. Expanded output can be achieved at a relatively smaller increase in real prices to consumers and smaller changes in regional farm incomes. However, the degradation of the environment, in terms of the parameters mentioned above, will take place at a more rapid rate.

The Land and Water Conservation and Energy Alternatives

The effect of the soil loss restraint in the land and water conservation alternatives is to increase the total quantity of cropland used by approximately 30 million acres in 1985 and 3 million acres in

2000. This extra required cropland reflects the change in crop management practices towards conservation-type systems that use land less intensively. Irrigated land shows little change when compared with the base model, except for a small decrease in the 2000 irrigated acreage. Available cropland is again augmented through land development to the amount of 5.5 million acres in 1985 and 9.6 million acres in 2000. Land use at the U.S. level for the energy alternative is nearly identical to the 2000 base model.

The crop mix in all three solutions also is very similar to the base models except for some decreases in soybean and roughage acreages. Silage acres especially decrease. These decreases are the result of the low level of allowable soil loss and both soybeans and silages are row crops that can increase soil loss on erosion-prone soils.

Changes in regional land use patterns indicate that the soil loss restraint has a distinct and nonuniform impact on agricultural production. In regions with many acres of highly erosive land, land used for crops decreases drastically. The region in which this is most noticeable is the Lower Mississippi basin. In 2000, 8 million acres are taken out of production in this basin. To compensate for production on this land, acreages in the Souris-Red-Rainy, Missouri, Arkansas-White-Red, Texas-Gulf, and Columbia-North Pacific basins all increase. Regional crop production patterns show a movement of the row crops, such as corn, silage, and soybeans, out of erosion-prone regions. Either these crop acreages are replaced by small grain or hay acreages, or the acreage remains unused. The energy alternative shows no significant changes in either land use or crop mix.

Total water use is down when compared with the base model. This, of course, results from the higher water use efficiency incorporated in the alternative. Under this condition only one region (the Upper Colorado) exhausts its water supply. The regional water balances are similar to those in the base models because the irrigated crop mix as well as the regional irrigated acreages do not change much from the results of the base model. The effect of water shortage on the irrigated acreages in producing region 67, 72, and 74 is still present; however, the magnitude of the impact is much smaller. In the energy alternative, the decrease in water supply, because of the higher priority given to water use for energy development, has only a significant impact on the Colorado basin.

The impact of the soil loss restraint in the land and water conservation alternatives is clearly shown in the large reduction in the total amount of eroded soil. Even more noticeable are the large reductions in regions like the South Atlantic-Gulf, Upper and Lower Mississippi, and Missouri basins. Achieving these large reductions in soil loss requires many changes not only in regional land use and crop patterns but also in conservation and tillage practices. Straight row cropping decreases substantially while increases occur in contouring and terracing. Also minimum tillage practices increase. The energy alternative does not impose a maximum allowable soil level. Hence, it shows few changes in conservation and tillage practices.

The cost of improving water quality is reflected in a) increases in land rents , and b) increases in prices to the consumer. Land rents in the 1985 solution show large increases while in 2000 they are small. Commodity prices show a similar pattern of increase--large increases in 1985 and small increases in 2000. Water shadow prices decrease in the 2000 alternative due to the higher efficiency incorporated. Price changes for the energy alternative are small.

The results imply that a policy of land and water conservation can lead to drastic changes in land use and cropping patterns. The farm level-cost of food to the consumer increases greatly in 1985. Other costs also occur in achieving the specified improvement in water quality. For example, sharp reductions in farm incomes occur in regions such as the Lower Mississippi basin. This total cost to society represents an impact which should be weighted against the benefits derived from the soil conservation policy.

However, the water conservation alternative shows that if the higher water use efficiency level assumed can be reached by either 1985 or 2000, doubts about adequacy of the nation's water supplies for agriculture can be dissipated.

The results of the energy alternative are encouraging. If the projected amounts of water needed for energy development come close to future actual needs, then irrigation agriculture is not endangered. However, these results are for conditions of no environmental restraints and no added competition for agricultural water other than those for energy development.

The Environmental Enhancement Alternatives

The imposition of environmental standards results in the use of 378 and 346 million acres for crops in 1985 and 2000, respectively. These acreages are increases of 40 and 7 million acres over the base models, respectively, for the two years. Out of the total cropland base, with no development of wet soils and forest lands allowed, only 2.7 million acres in 1985 and 30.5 million acres in 2000 are not used for crops. Decreased agricultural water availability results in fewer irrigated acres, with many regions irrigating the minimum area allowed by the model's restraints. Several other regions fall short of this minimum level.

The decrease in potentially available land and the decrease in available water supplies combine to cause more intensive cropping of erosive land groups in this environmental alternative. This increase in the use of erosive lands and the imposition of the soil loss restraint causes increases in conservation practices in both 1985 and 2000. Less than 20 percent of all crops are farmed in straight rows. Close to 40 percent of all land harvested is minimum-tilled. The changes in conservation and tillage practices reduce erosion by two-thirds from the base models.

The environmental alternative is characterized by several large changes in land use by region. The large decrease in regional water supplies causes a substantial decrease in the number of acres irrigated. Consumptive water use in the 1985 environmental alternative is 27 percent

lower than total water use in the 1985 base model. The 2000 level of consumptive water use is 64 million acre-feet, less than the 1985 level and reflecting the higher efficiency in water use and further adjustments in cropping patterns. However, the important bottleneck or infeasibility is in simultaneously achieving the specified environmental, demand, and export levels. Small reductions in the minimum stream flow levels can, however, rectify this infeasibility and the two goals can be met.

To achieve the environmental enhancement specified encompasses several costs: a) increased consumer food prices, and b) the inequity in the redistribution of the farm income. Also, if several environmental standards such as low erosion levels, minimum disturbances of fish and wildlife habitats, and the disposal of animal wastes on land are achieved, an increased use of pesticides might be an offsetting force in environmental impact.

With all alternatives evaluated, what are the policy implications? First, the results show that U.S. agriculture has a large producing capacity. Also, environmental improvement can be brought to a high level through several major adjustments in agriculture. But in further environmental attainments, water supplies are exhausted.

Finally, the environmental alternatives imply large reductions in income and resource value in some major river basins. Therefore, simultaneous achievement of high levels of environmental quality and exports would call for a comprehensive policy to redress inequitable income effects.

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APPENDIX

Table A.1. Estimated average crop yields for the United States for the base models and all alternatives with 1972 data for comparison.

Crop	Unit	1972 Actual[a]	Base Model	High Exports	Land and Water Conservation	Environmental Enhancement
			1985			
Barley	bu.	43.60	60.16	51.98	55.91	49.47
Corn	bu.	97.10	107.18	103.48	104.87	102.59
Corn Silage	tons	13.10	13.71	12.08	10.99	11.08
Legume Hay	tons	2.88	4.07	3.76	3.87	3.42
Nonlegume Hay	tons	1.55	2.13	1.88	1.97	1.88
Oats	bu.	51.20	63.47	60.27	64.01	62.11
Sorghum Grain	bu.	60.50	73.05	75.27	72.84	65.78
Sorghum Silage	tons	11.80	16.83	7.45	6.36	6.50
Soybeans	bu.	27.80	35.53	35.78	36.43	36.48
Sugar Beets	tons	21.40	21.35	20.64	21.05	21.00
Wheat	bu.	32.70	35.18	34.20	35.09	34.88
Cotton	bales	1.06	1.34	1.28	1.38	1.14

[a]Source: [18].

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Table A.2 (continued)

Crop	Unit	Base Model	Low Demand	High Exports	Land and Water	Energy	Environmental Enhancement	
					Conservation			Low Demand
		2000						
Barley	bu.	69.74	70.25	63.62	69.63	70.13	71.27	72.45
Corn	bu.	120.44	123.88	118.91	119.39	120.20	116.99	123.21
Corn Silage	tons	16.74	18.12	17.49	16.61	17.18	15.29	17.48
Legume Hay	tons	4.43	4.90	4.45	4.40	4.46	4.06	4.42
Nonlegume Hay	tons	2.80	2.92	2.48	2.89	2.83	2.64	2.97
Oats	bu.	67.87	73.33	67.78	69.11	67.91	68.62	72.60
Sorghum Grain	bu.	58.42	76.67	60.31	57.95	58.35	51.96	63.97
Sorghum Silage	tons	18.10	19.10	17.71	16.29	18.06	14.17	16.23
Soybeans	bu.	40.63	42.08	40.24	41.05	40.60	40.92	42.47
Sugar Beets	tons	20.96	22.32	21.40	22.07	21.13	21.39	22.51
Wheat	bu.	40.35	43.11	37.98	39.97	40.60	39.75	44.86
Cotton	bales	1.63	1.64	1.63	1.62	1.63	1.58	1.63

Table A.2. Average livestock rations for the base models and all alternatives.

Livestock Class and Alternative	Corn (bu.)	Sorghum (bu.)	Barley (bu.)	Oats (bu.)	Wheat (bu.)	Oil-meals (cwt)	Legume hay (tons)	Nonlegume hay (tons)	Silage (tons)
Beef cows 1985									
Base model				6.90		.81	1.63	3.24	.21
High exports				3.31		.24	1.91	3.16	.00
Low demand									
Land and water conservation				7.26		.02	1.96	3.05	.17
Environmental enhancement				7.90		.02	1.84	3.21	.00
Beef cows 2000									
Base model				5.87		1.32	1.56	2.66	2.03
High exports				5.60		1.34	1.66	2.59	1.92
Land and water conservation				6.14		.92	1.73	2.94	.81
Energy				5.86		1.31	1.57	2.67	1.99
Environmental enhancement				6.40		.13	1.47	3.06	1.02
Beef feeding 1985									
Base model	15.66	15.69	7.91			1.29	.40	.19	2.36
High exports	20.95	20.71	6.18			.95	.52	.13	1.38
Low demand									
Land and water conservation	25.80	21.31	10.05			.59	.61	.04	.55
Environmental enhancement	30.45	13.58	12.21			.72	.57	.05	.60

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Table A.2 (continued)

Livestock Class and Alternative	Corn (bu.)	Sorghum (bu.)	Barley (bu.)	Oats (bu.)	Wheat (bu.)	Oil-meals (cwt)	Legume hay (tons)	Nonlegume hay (tons)	Silage (tons)
Beef feeding 2000									
Base model	6.92	1.97	3.81			2.19	.10	.17	5.42
High exports	2.53	2.37	.28			2.36	.03	.07	6.51
Land and water conservation	9.57	5.13	5.50			1.94	.18	.20	4.46
Energy	6.83	1.95	4.45			2.17	.10	.17	5.37
Environmental enhancement	7.40	2.87	5.75			2.08	.13	.23	4.84
Dairy 1985									
Base model	82.41		37.78	37.48	2.36	3.93	1.54	1.34	1.50
High export	62.22		47.21	56.20	3.17	2.42	1.43	1.34	1.29
Low demand									
Land and water conservation	63.81		45.28	54.06	3.14	2.35	1.46	1.30	1.34
Environmental enhancement	66.22		45.48	50.82	3.13	2.09	1.58	1.17	1.45
Dairy 2000									
Base model	112.77	2.83	4.84	6.96	.56	6.38	1.49	1.56	1.66
High exports	115.23		3.74	5.84	.40	6.57	1.44	1.67	1.62
Land and water conservation	115.60		4.46	6.36	.48	6.31	1.53	1.53	1.71
Energy	112.55	2.85	5.17	7.10	.57	6.34	1.50	1.55	1.67
Environmental enhancement	110.50	.17	9.27	7.50	.74	6.51	1.38	1.77	1.51

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Table A.2(continued)

Livestock Class and Alternatives	Corn (bu.)	Sorghum (bu.)	Barley (bu.)	Oats (bu.)	Wheat (bu.)	Oil-meals (cwt)	Legume hay (tons)	Nonlegume hay (tons)	Silage (tons)
Hogs 1985									
Base model	6.48	.08	.005	.03	.79	.56	.012		
High export	5.83	.03	.005	.03	1.51	.52	.02		
Low demand									
Land and water conservation	5.32		.005	.002	2.06	.49	.019		
Environmental enhancement	5.31		.005	.002	2.06	.49	.019		
Hogs 2000									
Base model	5.74	.37	.003	.03	.06	.50	.006		
High exports	5.84	.33	.003	.03	.002	.51	.006		
Land and water conservation	5.78	.36	.003	.03	.06	.51	.007		
Energy	5.74	.38	.003	.03	.06	.50	.007		
Environmental enhancement	5.66	.46	.003	.03	.06	.50	.006		

Table A.3. Projected production of major agricultural crops in the United States for the 2000 OBERS-E' solution and all alternatives for the year 2000, 1971-73 data for comparison.

Crop	Unit	1971-73 Avg.[a]	Base Model	High Exports	Land and Water Conservation	Energy	Environmental Enhancement
			(million)				
Barley	bu.	437.2	581.2	396.2	666.1	618.9	688.8
Corn	bu.	5,610.6	6,939.8	7,911.9	7,113.5	6,932.3	6,949.5
Cotton	bales	12.4	10.8	11.2	10.8	10.8	10.8
Hay	tons	130.8	342.0	345.3	380.0	343.5	357.7
Oats	bu.	745.7	646.0	637.3	660.7	646.3	688.2
Silage	tons	151.5	434.9	498.8	301.6	429.6	335.1
Sorghum	bu.	873.8	839.0	895.4	971.6	837.4	886.6
Soybeans	bu.	1,336.3	3,616.5	3,884.7	3,531.9	3,611.4	3,580.3
Sugar Beets	tons	26.6	39.9	39.9	39.9	39.9	39.9
Wheat	bu.	1,619.9	1,693.2	2,239.0	1,692.8	1,693.9	1,696.0

[a] Source: [16].

Table A.4 Estimated livestock production by major river basin for the 2000 OBERS E' solution with actual 1971-73 data for comparison.

River basin	Cattle and Calves		Hogs		Dairy	
	1971-73 Average[a]	Base Model	1971-73 Average[a]	Base Model	1971-73 Average[a]	Base Model
	(thousand cwt carc. wt.)				(million lbs. milk equiv)	
New England	925	2,188	249	67	4,530	3,984
Mid Atlantic	4,966	6,337	2,731	802	13,665	17,492
S. Atlantic-Gulf	13,628	29,041	14,056	3,259	6,508	13,620
Great Lakes	7,368	5,133	6,982	16,955	19,340	19,080
Ohio	13,989	8,622	23,302	71,950	9,937	8,056
Tennessee	3,227	17,141	1,899	487	1,875	2,754
Upper Miss.	28,757	28,709	62,247	63,087	26,647	18,363
Lower Miss.	6,629	21,941	2,782	604	1,601	715
Souris-Red-Rainy	2,942	3,385	1,153	1,539	1,597	1,125
Missouri	60,870	114,832	39,843	23,027	7,973	6,571
Ark.-White-Red	31,749	27,530	5,196	1,220	4,033	2,324
Texas-Gulf	19,732	39,990	2,992	604	2,779	5,739
Rio Grande	3,672	6,649	251	36	350	803
Upper Colorado	2,757	2,775	181	22	242	184
Lower Colorado	4,153	7,558	253	59	721	1,642
Great Basin	2,330	12,624	120	23	994	701
Col.-N. Pacific	9,183	12,190	910	223	4,911	3,186
California	11,932	19,472	384	104	10,170	12,354
United States	228,809	366,117	165,531	184,068	117,873	118,753

[a]Source: [16].

Table A.5. Shadow prices for land by major river basin for the 1985 base model and all alternatives for the year 1985.

River basin	OBERS E'	High Exports	Land and Water Conservation	Environmental Enhancement
		(dollars per acre)		
New England	2.86	24.61	5.27	91.93
Mid-Atlantic	20.07	100.79	76.15	309.70
South Atlantic-Gulf	10.39	57.04	40.77	292.62
Great Lakes	32.76	108.92	76.17	501.61
Ohio	57.58	257.13	216.61	810.48
Tennessee	8.46	74.60	40.26	250.98
Upper Mississippi	49.25	222.89	193.56	734.49
Lower Mississippi	18.45	515.50	532.25	1473.88
Souris-Red-Rainy	6.84	51.86	28.43	123.52
Missouri	15.62	71.63	45.26	219.24
Arkansas-White-Red	12.98	67.42	39.63	184.05
Texas-Gulf	9.61	67.80	35.73	204.76
Rio Grande	30.36	186.01	122.25	363.89
Upper Colorado	31.20	80.67	40.27	158.45
Lower Colorado	34.55	99.86	96.61	270.99
Great Basin	13.19	51.42	33.15	181.99
Columbia-North Pacific	19.48	70.08	41.60	216.31
California-South Pacific	27.49	97.18	70.80	287.72
U.S.	31.66	135.76	103.33	416.20

Table A.6. Shadow prices for land by major river basin for the 2000 base model and all alternatives for the year 2000.

River Basin	E' with Low Demands	OBERS E'	High Exports	Energy	Land and Water Conservation	Environmental Enhancement
			(dollars per acre)			
1	3.38	4.96	16.71	4.98	7.18	12.88
2	9.01	23.18	38.33	23.24	25.27	35.00
3	9.41	28.29	40.91	27.96	29.31	42.44
4	11.59	28.55	44.90	28.41	35.50	45.19
5	12.53	26.30	52.15	35.33	42.71	53.60
6	4.03	27.20	34.34	26.89	34.41	46.48
7	12.99	35.51	52.02	35.49	41.34	52.63
8	13.39	31.04	42.45	30.70	44.80	51.54
9	1.31	9.49	19.88	9.74	13.81	20.70
10	8.95	13.96	21.04	14.33	16.76	19.80
11	10.95	20.54	28.60	20.68	23.16	29.96
12	9.67	17.41	19.47	15.81	17.30	19.65
13	19.01	37.55	49.03	42.88	43.95	70.23
14	24.37	39.95	50.13	36.87	41.12	8.73
15	26.71	37.14	44.17	35.24	43.62	61.32
16	11.00	13.98	22.87	12.26	16.28	18.62
17	11.84	20.91	25.67	20.98	24.80	22.56
18	24.45	37.34	51.61	39.48	46.54	20.44
U.S.	11.17	23.93	35.09	24.73	28.65	34.58

Table A.7. Shadow prices for water by river basin for the 1985 base model and all alternatives for the year 1985.

River basin	OBERS E'	High Exports	Land and Water Conservation	Environmental Enhancement
		(dollars per acre-foot)		
Missouri	16.48	36.71	18.14	186.83
Arkansas-White-Red	19.64	58.47	36.54	164.57
Texas-Gulf	17.73	64.51	66.98	193.47
Rio Grande	6.84	13.85	7.29	139.19
Upper Colorado	6.54	10.26	8.36	451.15
Lower Colorado	7.89	24.02	7.98	84.34
Great Basin	8.14	17.00	12.36	96.90
Columbia-North-Pacific	3.53	6.25	2.61	673.72
California	10.35	10.21	10.53	108.75
U.S.	11.14	25.35	17.67	222.18

Table A.8. Shadow prices for water by major river basin for the 2000 base model and all alternatives for the year 2000.

River basin	E' With Low Demands	OBERS E'	High Exports	Energy	Land and Water Conservation	Environmental Enhancement
			(dollars per acre-foot)			
Missouri	11.63	16.41	19.62	16.62	12.58	26.27
Arkansas-White-Red	26.15	34.98	39.71	35.88	23.08	44.47
Texas-Gulf	12.64	17.80	22.01	20.85	20.06	29.18
Rio Grande	10.65	8.70	11.06	8.68	6.94	22.82
Upper Colorado	5.54	6.63	7.40	6.61	6.45	17.39
Lower Colorado	7.69	7.73	9.39	7.74	7.71	8.02
Great Basin	6.29	8.48	9.33	8.47	8.98	17.19
Columbia-North Pacific	3.01	2.89	5.06	2.88	2.54	6.92
California	10.98	10.65	10.53	10.65	10.61	21.22
U.S.	10.14	12.52	14.31	12.59	10.46	21.25

Table A.9. Farm level commodity (shadow) prices for the 1985 base model and all alternatives for the year 1985.

Commodity	Unit	OBERS E'	High Exports	Land and Water Conservation	Environmental Enhancement
			(dollars)		
Corn	bu.	.98	1.82	1.01	2.89
Sorghum	bu.	1.03	2.52	1.84	5.85
Barley	bu.	1.04	2.37	1.70	5.08
Oats	bu.	.94	2.04	1.57	4.88
Wheat	bu.	1.47	3.84	2.50	8.82
Oilmeals	cwt	12.81	46.73	49.15	153.28
Legume Hay	tons	26.68	56.96	43.52	126.75
Nonlegume hay	tons	38.90	87.84	65.12	178.34
Silage	tons	8.42	16.34	17.06	38.76
Pasture	tons	39.64	90.27	66.96	179.69
Cotton	bales	159.62	257.49	223.01	430.07
Sugar	tons	12.89	18.52	14.69	49.09
Pork	cwt[2/]	39.72	85.14	74.34	196.29
Milk	cwt[3/]	5.29	7.16	6.37	12.67
Feeders	head	215.66	356.09	283.71	698.00
Fed beef	cwt[2/]	56.18	98.11	75.61	192.49
Nonfed Beef	cwt[2/]	56.09	97.99	75.17	190.43
Cost per capita		153.61	288.04	239.41	620.88

[1/] Prices in 1972 dollars

[2/] Carcass weight.

[3/] Milk equivalents.

Table A.10. Farm level commodity (shadow) prices for the 2000 base model and all alternatives for the year 2000.

Commodity	Unit	E' With Low Demands	OBERS E'	High Exports	Energy	Land and Water Conservation	Environmental Enhancement
				(dollars per unit)			
Corn	bu.	.79	.90	1.04	.90	.90	.97
Sorghum	bu.	.83	.94	1.12	.97	.95	1.06
Barley	bu.	.77	.84	1.15	.85	.87	.94
Oats	bu.	.65	.79	1.00	.79	.80	.92
Wheat	bu.	1.02	1.26	1.55	1.26	1.31	1.42
Oilmeals	cwt.	3.41	4.84	5.60	4.85	5.70	6.47
Legume hay	tons	18.29	22.48	25.67	22.56	24.07	27.07
Nonlegume hay	tons	22.90	27.12	31.97	27.14	29.36	29.75
Silage	tons	6.33	7.55	8.61	7.66	8.23	8.65
Pasture	tons	22.91	25.95	31.02	26.71	29.21	28.37
Cotton	bales	97.35	104.76	112.21	105.11	108.52	107.66
Sugar	tons	10.89	10.14	11.80	10.60	10.75	10.69
Pork	cwt[1]	23.61	26.61	28.90	26.63	27.33	28.79
Milk	cwt[2]	3.74	3.91	4.09	3.91	3.94	4.10
Feeders	head	165.48	188.37	206.37	189.23	195.97	209.03
Fed beef	cwt[1]	41.83	47.79	52.81	47.86	49.89	52.73
Nonfed beef	cwt[1]	41.47	47.56	52.35	47.65	49.86	52.80
Cost per capita		98.42	124.01	136.58	124.31	129.15	136.49

[1] Carcass weight.

[2] Milk equivalents.