U. S. Agricultural Export Capabilities Under Various Price Alternatives, Regional Production Variations, and Fertilizer-Use Restrictions

CARD Report 63

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U.S. AGRICULTURAL EXPORT CAPABILITIES UNDER VARIOUS PRICE ALTERNATIVES, REGIONAL PRODUCTION VARIATIONS, AND FERTILIZER-USE RESTRICTIONS

by

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PREFACE

Two major issues are causing concern about the future of the American agricultural sector, its interaction with the rest of the American economy, and the impacts on the consumer of the food and fiber products produced in agriculture. One of these concerns is the quality of the environment and restraints imposed on agriculture to improve it. Agriculture, the major user of land and water resources, contributes to environmental conditions through sedimentation, fertilizers, pesticides, and animal residues. The second issue is world hunger and demand for food and the potential for large increases in United States grain exports to assist in alleviating this hunger. Both of these developments, the imposition of environmental restraints on agriculture and larger exports of grains, can cause farm commodity prices to rise at the farm level and subsequently food costs to rise for domestic consumers. The World Food Conference held in Rome in 1974 emphasized the growing world concern for greater food output and trade in food commodities.

With emergence of these two important concerns, a question arises as to how they interact. Is it likely that imposition of selected environmental controls in agriculture would reduce United States food production and its exports to other countries? Or, does the nation have enough agricultural producing capacity so that "it can have its cake and eat it too" in the sense that cropping systems, soil loss, and fertilizer use can be restricted

but the nation can maintain or increase its exports? Is it possible, under normal weather conditions and economically efficient interregional allocations of water, crop production and land use, that limits on soil loss and fertilizer use could be implemented while maintaining the nation's food output? Before 1972, United States agriculture operated under supply controls wherein farmers were paid to withhold land from production. Since then controls have been lifted, but unfavorable weather has limited production in parts of the Great Plains and Corn Belt.

This study estimates output potential under alternative environmental restrictions by utilizing a large-scale interregional linear programming model. It provides results that give hopes for greater food output and an improved environment.

Numerous people and organizations contributed to this study. Howard Madsen and James Wade participated in initial steps of planning and model construction. Nancy Turner had major computer programming responsibility, and Vince Sposito assisted with the solution phase of the model. Kenneth J. Nicol made a very large contribution in the development of the model, interpreting the results, and offering suggestions in writing the manuscript. Other persons on the staff of the Center for Agricultural and Rural Development helped in the collection and the verification of data and results. The organizations that provided services, data, and other help include the RANN program of the National Science Foundation, which financed the study, and the Soil Conservation Service of the USDA, which supplied detailed data on soil loss for the many land resources groups, crops, and field technologies.

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I. SUMMARY AND CONCLUSIONS

This study is an analysis of United States agricultural producing and exporting capacity in 1985 under limited environmental controls on soil loss, fertilizer application, and variations in the flexibility of regional production distribution. The potential of production also is explored under two price regimes: one approaching the target prices under the Agricultural Act of 1973 [21] and the other at levels that may encourage all-out production by 1985.

These analyses of production potentials are made in response to the increased concerns about the world food situation. This growing concern has been expressed recently by the 1974 World Food Conference. The conference, meeting in Rome, pointed out that in order to prevent mass starvation, long-term increases in food production are needed in the developing countries as well as short-term increases in food production in the developed countries. The United States is the most important producer and exporter of farm products, accounting for more than half of the international trade in feed grains and 44 percent of the world wheat exports in 1974 [23].

Therefore, it is important to determine the role that the United States could play in the coming years in helping to alleviate world food problems without compromising its own goals of environmental quality and low food costs. The analysis does not incorporate all dimensions of U.S. food-producing and exporting capacity; e.g., shifts in consumer diets (except for lower meat demands resulting from higher meat prices), greater feed substitutions in livestock rations, and alternative utilizations of agricultural residues. These features are included in other studies upcoming in the Center for Agricultural and Rural Development (CARD) under its RANN project on U.S. food producing and export capacity. This study provides an initial view on the production and export capacity with special emphasis on the environmental impacts of these expanded outputs. The study addresses the issue of the mix, the level, and the production patterns which are compatible with agricultural production under variations in the relative prices for farm products, the absolute price level of these products, fertilizer use restrictions, and regional location of production restrictions.

The tool used for the study is a linear programming model which minimizes the total national cost of food production while maximizing the export of agricultural products after meeting prespecified domestic demands. A competitive equilibrium within the agricultural sector is estimated with the return to each resource (land and water) equal to its marginal value in production of farm commodities.[1] Within the model the production allocation is subject to a system of linear constraints representing land and water availability, regional market clearing restraints, and the regional location of production. Activities in the model simulate crop rotations, livestock production, water transfer and distribution, commodity transportation, and net export options.

In the following pages we summarize the three issues investigated in

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[1]Marginal value product of a resource is defined to be equal to the return for an additional unit of the resource employed in production.

this study. Although the issues seem somewhat unrelated, they do have important effects on the production and export potential of agricultural products. The first issue covered by the study is the determination of a desirable export mix as a function of the relative export prices. Second, the capacity of the U.S. farming sector to produce and export the desirable mix of farm products is studied under much higher absolute price levels. Both issues are related to the environmental restraints expressed in terms of limited soil erosion and fertilizer use in agricultural production. The final issue investigated involves the impact of restrictions on fertilizer use.

The model results show that under environmental programs in the form of soil loss and fertilizer-use restrictions applied nationwide, exports could be very large in 1985. Production could be increased by improved farming practices to achieve soil and moisture conservation, a location of production more directly influenced by the regional comparative advantage, and a better and more efficient utilization of land and water resources. Figure 1 summarizes the export potential of U.S. agriculture under high export prices and optimum crop specialization for the seven crops; corn, sorghum, barley, oats, soybeans, wheat, and cotton. Despite the very large export of agricultural commodities during 1972-73, the results indicate a much larger potential for U.S. export if the adjustments of the model are realized. Compared with 1972-73 averages, exports of feed grains by 1985 could increase almost 400 percent, wheat almost 180 percent, and cotton by about 230 percent.

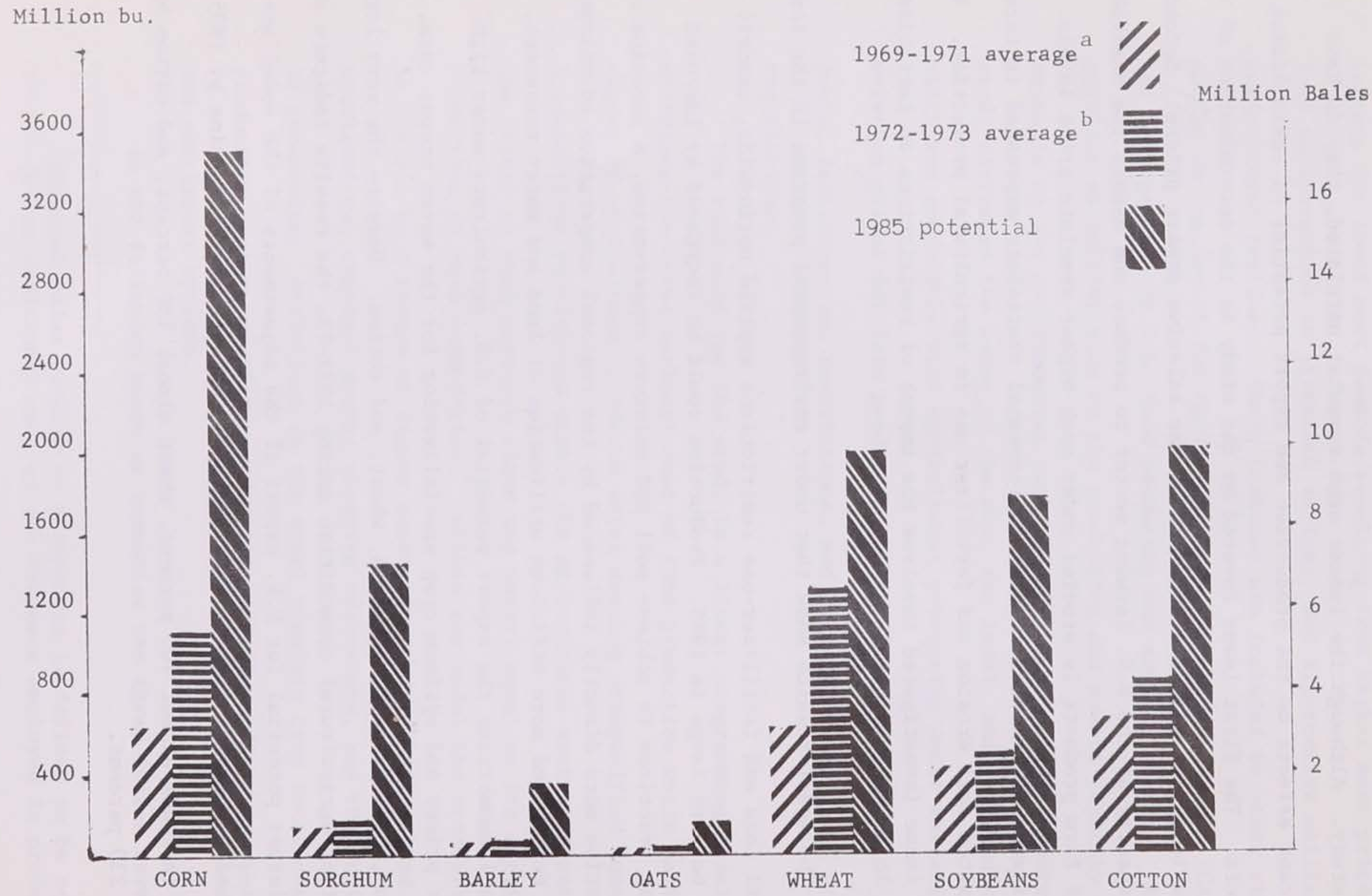

Figure 1. U.S. exports, average 1969-1971, average 1972-1973, and potential in 1985.

[a]Source (23).

[b]Source (6).

The results summarized here show great U.S. agricultural capacity. In fact, if world demand and weather are stabilized, U.S. agriculture may be more concerned with large supplies and low farm prices rather than the inability to fulfill export markets. U.S. agriculture, in years of normal weather or over time with grain reserves to offset variable weather, can produce large quantities of food to aid in solving the world food problem. However, the markets or institutional means must exist to insure prices that reward U.S. farmers for this larger output.

Through the period 1970-73, U.S. farm policy was oriented toward production control and price support programs aimed at stabilizing farm output and prices. Most of these programs incorporated the concept of support prices (target prices) based on parity. The Agricultural Act of 1973 is the most recent attempt of the United States Congress to depart from the parity price concept [21]. In the first part of this study, we show the possibility of achieving an alternative mix of export commodities through the judicious selection of the appropriate target prices.

Two alternatives are used in the first part of the study; they are identical in all assumptions except for export prices. Under the first alternative (Model 1.1), 1974-75 target prices as specified in the Agricultural Act of 1973 are assigned as export prices for corn, wheat, and cotton. For the other export crops, export prices are equal to 60 percent of May 1973 parity prices [18]. The second alternative (Model 1.2) adjusts the magnitudes of these prices to provide a mix of exports more in line with the current export trends. The relative prices of the exported commodities are changed such that corn, barley, and sorghum export prices increase and, at the same time, cotton and wheat export prices decrease. The export prices of soybeans and oats remain unchanged.

The results of the first two alternatives show clearly that the export mix of U.S. agricultural products in 1985 can be readily influenced by the relative export prices. The 1974-75 target prices tend to encourage the export of wheat and cotton. On the other hand, the adjusted target prices tend to encourage feed grain exports and to suppress wheat and cotton exports to levels near their 1972-73 averages. For the calendar years 1972-73, the average feed grains exports were 1.3 billion bushels [6]. This is close to the 1.4 billion bushels of feed grains available for export in 1985 under the adjusted target prices (Model 1.2) and is well above the 0.6 billion bushels of feed grains that could be available in 1985 under the 1974-75 target prices (Model 1.1).

The different price support policies can have further implications on the long-run regional distribution of production and farm income. If the relative support prices in 1985 are set according to the prices specified in the Agricultural Act of 1973, both cotton and wheat producers should have a much higher level of production and total farm income. Feed grain producers, however, can be expected to decrease production and receive less income by 1985.

Overall land-use patterns under both alternatives reflect the higher rate of domestic demand brought about by a 242 million U.S. population in 1985 and the estimated per capita consumption levels as influenced by the commodity prices and per capita incomes. Under the 1974-75 target prices (Model 1.1), 324.7 million acres are utilized for production of endogenous crops,[2] while under the adjusted target prices (Model 1.2), 331.5 million acres are cultivated for the same endogenous crops in 1985. In 1973 the same crops used 303 million acres [19]. Some of the important findings of land-use analysis are concerned with the increase in silage production to reflect a more efficient ration for livestock and a larger proportion of legume hay acreages, encouraged by increased carry-over nitrogen associated with legumes.

Domestic farm level commodity prices (measured in 1972 dollars) are closely related to the export prices used in each model (Table 1). Most prices obtained in both alternatives are lower than 1972 levels. The rise in prices since 1972 is a result of the increase in agricultural exports impacting on a short-run inelastic supply. The prices determined by the model reflect a long-run adjustment to the determined export levels.

The price support system was abandoned in 1972. However, good weather and expanding production could once more lead to surpluses requiring government support programs. Under this situation, the relative support prices would have an influence on the subsequent mix of the agricultural products as exhibited in the analysis of the 1974-75 target prices (Model 1.1) and adjusted target prices (Model 1.2). Policy makers aware of the way in which the relative support prices can effect the production and export mix

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[2]The endogenous crops include barley, corn, corn silage, cotton, legume and nonlegume hay, sorghum, soybeans, sorghum silage, sugar beets, and wheat.

should gear their policies to obtain the most desirable production level and mix.

Table 1. U.S. average commodity prices 1972, under 1974-75 target prices (Model 1.1), and adjusted target prices (Model 1.2) in 1985.

Commodity	Unit	1972[a]	Model 1.1	Model 1.2
			(dollars per unit)	
Corn	(Bu.)	1.57	1.32	1.40
Sorghum	(Bu.)	2.45	1.63	1.78
Barley	(Bu.)	1.21	1.32	1.28
Oats	(bu.)	.73	.65	.68
Wheat	(Bu.)	1.76	1.83	1.82
Soybeans	(Bu.)	4.37	2.73	2.66
Cotton	(Lb.)	.27	.38	.32
Pork	(Cwt.)	55.22	40.61	42.05
Milk	(Cwt.)	6.07	5.11	5.22
Beef	(Cwt.)	58.77	74.20	74.00

[a]Source: Statistical Reporting Service [17].

Three alternatives are analyzed in the second part of the study. All alternatives specify export prices that are double the adjusted target prices to encourage all-out production. The alternatives assume a limited environmental restriction which calls for a five-ton per acre maximum soil loss and differ only with respect to the restrictions placed on the regional location of production. Under the alternative with the most restricted location of production (Model 2.1), production of the specified crops in each region is required to be at least 80 percent, and not more than 200 percent, of the 1969 crop acres or livestock number for corn, sorghum, cotton, soybeans, wheat, legume hay, beef cows, fed beef, hogs, and dairy cows [24]. The upper limit is modified to 300 percent of the 1969 level for livestock numbers and legume hay acreage. Under the less restricted location of production alternative (Model 2.2), the 80 percent restrictions are reduced to 50 percent of 1969 while maintaining the above upper limits. Finally, the third alternative (Model 2.3) assumes no restrictions on production location. The above restrictions, although somewhat arbitrary, represent an increase in regional efficiency because of interregional shifts of resources and increased specialization.

The goal of the three models (2.1, 2.2, and 2.3), presented in the second part of the study, is to evaluate the impact of less than optimal regional location of production.[3] This phenomena is due to economic factors such as risk aversion, uncertainty as to future farm prices and governmental policies, and noneconomic factors such as the desire to live in the country. If the regional location of production is an important factor, effecting export levels and prices, then governmental farm policy should be directed toward guaranteed minimum prices, crop insurance, and financial means which encourage farmers to adopt crops and livestock enterprises more consistent with the optimal regional location of production.

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[3]An optimal or an efficient regional location of production is defined to be that regional production pattern in which any shift of production from one region to another will lead to lower production and/or higher costs.

The results summarized here and presented in the text indicate that under high exports, a more efficient location of production is responsible for somewhat higher exports and lower output prices. The higher exports obtained, however, are mostly because of doubling the export prices, rather than achieving a more efficient regional location of production. Hence, given these high exports, a more efficient regional location of production can be expected to have relatively small impact when compared with the high export price impact.

The great 1985 export potential of U.S. agriculture (Figure 1) has important implications for U.S. agriculture. Under high export prices and optimum regional location of production, it would be possible to increase feed grain exports from their 1973 level of 1.7 billion bushels [6] to as high as 5.5 billion bushels by 1985. At the same time, wheat exports would be increased from 1.4 billion bushels in 1973 to almost 2.0 billion bushels in 1985. Soybean exports could be increased to almost 1.8 billion bushels and cotton exports to 10.0 million bales by 1985. These increases may seem large and are only realizable if the changes assumed by the study would occur.

The above export levels, if attained, could turn the agricultural industry into one of the most important U.S. exporting industries by 1985. During the 1969-71 period, only one of every 10 acres of feed grains harvested produced grain for export [22]. By 1985, almost one of every two acres could produce grain for export. The proportion of wheat acreage produced for export could reach 74 percent by 1985, while soybean and cotton acreages for export could reach 63 and 55 percent, respectively.

The above results, especially those concerned with export potential, can only be obtained under a very specific set of conditions. These conditions include the amount of resources available to agriculture (land and water) by 1985; higher-than-current yields obtained from improved utilization of rotations, fertilizers, and farming technologies under average weather conditions; improved regional location of crop and livestock production; increased utilization of hay and silage by livestock; and a lower-than-present per capita consumption of meat in 1985. These conditions of further technological and economic improvement for U.S. agriculture appear feasible by 1985.

The effect of the historic allocation of production is analyzed in terms of Model 2.1. Under the regional location of production mentioned earlier, exports will be somewhat lower than the levels obtained with the removal of all regional location or production restrictions. The change in the 1985 export levels, caused by the less efficient regional production pattern, includes only a slight alteration of feed grains. Wheat and soybean exports are lower by nearly 200 and 300 million bushels, respectively. Other changes, such as lower domestic commodity prices and a nationally less efficient use of resources, also result from the restrained production pattern.

The substantial increase in agricultural exports implies long-run changes in the availability and use of resources in agriculture. The supply of the less mobile resources in agriculture, such as land and water, is very inelastic. Even though given enough time, land can be reclaimed and additional irrigation can be developed. The supply of other resources, such as fertilizer, other chemicals, and capital inputs, is more elastic, both in the short-run and the long-run. A total of 373.6 million acres of dry and irrigated cropland are available for the endogenous crops in 1985.[4] Under the high export price alternative with no restrictions on regional location of production (Model 2.3), 363.6 million acres are cultivated, more than 97 percent of the available land.[5] With high export prices at the level assumed for this analysis, U.S. agriculture will almost completely use all of the cropland available. Ninety percent of the idle land (about nine million acres) is on land classes characterized by lower productivity and susceptibility to soil erosion rates which, in most cases, exceeds the five-ton per acre soil erosion level allowed. In order to completely utilize the land resources in the United States, the highly erosive lands will need to be developed to control erosion or be transferred into less-intensive uses than specified in the analysis. In some cases, soil conservation measures not only reduce soil loss but also contribute to higher yields.

The high degree of land utilization mentioned above is reflected in land rents. The national average land rent triples in value (from $31.59 per acre to $108.35 per acre) as export prices double from the adjusted target prices (Model 1.2) to the high export prices (Model 2.3) in 1985. This phenomenon, as the change in land prices during 1972-73 showed, is

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[4]The available land reflects the needs for the production of the other crops not included in the model's allocation.

[5]In 1973 the same crops accounted for only 303.0 million acres [19].

due mainly to the higher commodity prices reflected in higher return to resources employed in agriculture.

The quantity of water used responds less to the high export prices than does land use because most of the water that would be used for raising crops is already utilized in producing the lower exports. The higher commodity prices contribute to a 55 percent increase in the marginal value product of water (from $12.59 per acre-foot to $19.53 per acre-foot), as more demand is put on the inelastic water supply in those regions where it is the limiting resource.

The second part of the study indicates a great potential of agricultural production and exports by 1985, even with no further water development after 1980. The major problem facing agriculture in 1985 will be to find markets for its expanded outputs. Any additional resource development, such as water for irrigation, will contribute to even higher production, excess capacity, and declining prices for agricultural commodities--unless the markets can be obtained to handle the additional quantities indicated at the higher prices considered. Under the higher regional return to water, further water supply development may be economically feasible in some regions. However, regional water development should be evaluated from the national agricultural viewpoint and also by considering its impact on farm income stability, regional and rural development, and the environment.

The potentially high export levels of U.S. agricultural products by 1985 raise many other issues which are not covered by this study. However, a high level of agricultural exports could have a noticeable effect on the U.S. balance of payments. The recent deficit in the balance of payments has been amplified by the formation of the OPEC (Organization of Petroleum Exporting Countries) cartel and the sharp increase in oil prices during 1973-74. This deficit could be offset by a higher value of agricultural exports by 1985. The total net value of the seven exported crops in this study could reach $33.8 billion by 1985 if sold at the prices assumed in the study. This compares with the total value of food and fiber exports in the 1973 record year of $17.7 billion [6]. If, however, exports of agricultural commodities fail to expand much beyond 1972-73 levels, domestic agricultural commodity prices will fall below their 1973-74 levels.[6] Under this situation, the government may be pressed to either support prices while subsequently disposing of the surplus production accumulated, or to control production in order to keep prices from declining.

The last section of the study deals with the possible economic effects of restrictions on the use of chemical fertilizers in the United States. This situation may develop either because of environmental concern for nitrogen leaching and runoff or because of a shortage of fertilizer compounds.

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[6]Despite the bad year for agriculture in 1974, the average domestic prices of the commodities continued to fall throughout the last quarter of 1974. By January 15, 1975, the price of wheat was down to $4.11 per bushel from $4.87 per bushel on November 15, 1974; the price of corn was down to $3.07 per bushel from $3.45 per bushel on October 15, 1974; the price of oats was down to $1.62 per bushel from $1.70 per bushel on November 15, 1974; the price of soybeans was down to $6.30 per bushel from $8.17 per bushel on October 15, 1974; and the price of cotton was down to $.42 per pound from $.52 per pound on October 15, 1974. Agricultural Prices, Dec. 15, 1974, and Jan. 15, 1975.

The concern for fertilizer availability is further amplified by the potential for a larger planted acreage in response to the recent high exports bringing an increase in commodity prices.

A close relationship exists between nitrogen fertilizer and energy. Approximately, 40,000 cubic feet of natural gas are required to produce one ton of anhydrous ammonia [3], the major nitrogen fertilizer used in the United States and also a major ingredient component of other nitrogen fertilizers. Prices of all fertilizers have more than doubled since 1972, with nitrogen fertilizers displaying the largest increase.

The effect of a fertilizer-use restriction is quite different when applied at different levels of output in the agricultural sector. Hence, the study deals with the economic impacts of fertilizer application restrictions under the moderate export levels associated with the adjusted target price alternative and under high exports derived in the restrained high export price model. The procedure used involves first solving the unrestricted fertilizer use alternatives for the two 1985 export levels, and subsequently requiring each of the restricted fertilizer use alternatives to export the identical quantities obtained under the unrestricted fertilizer situation.

Reduced nitrogen use, resulting from the fertilizer restrictions, is much larger under high exports than under moderate exports, as the higher return to nitrogen fertilizer under the higher export prices encourages its use. Land is substituted for fertilizer in each of the analyses developed in this part of the study. At the moderate export level, nitrogen use is reduced more than 7 percent (1.2 billion pounds of N), and land use is up by 0.63 percent (2.1 million acres) as the restriction is implemented. However, under the high export alternative, nitrogen use declines more than 11 percent (2.7 billion pounds of N), and land use increases 0.9 percent (3.2 million acres). This leads to a marginal rate of land-for-nitrogen substitution of one acre for every 560 and 830 pounds of nitrogen under moderate and high exports, respectively.[7]

The land-for-nitrogen substitution results in a substantial increase in land rents and water values as the resulting higher commodity prices increase the return to these resources. The average land rent increases by less than 5 percent under moderate exports as the fertilizer use restrictions are imposed, while under the high exports the land rent increases 43 percent for some regional land classes. The average increase in water prices is quite small (less than 2 percent) under the moderate exports and almost 14 percent under the high exports.

The increase in commodity prices leads to an increase in food costs and agricultural resource returns. Under moderate exports, the per capita cost of food and fiber (includes only the raw endogenous commodities) increases by only 1 percent ($2.03 per capita per year in 1972 dollars) as a result of the restriction on fertilizer use. However, when maintaining high exports, the cost of food increases by more than 16 percent ($31.34

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[7]Marginal rate of land-for-nitrogen substitution is defined to be the amount of nitrogen reduction that can be obtained by using an additional acre of cultivated land given no change in the overall production level.

per capita per year in 1972 dollars) as a result of the fertilizer use restriction. These figures more than any other represent the great differences in the effects of the fertilizer use restriction.

Farmers could be better off in 1985 under a restricted fertilizer use policy at both export levels since food demand is inelastic. Under moderate exports, farm income, defined as the total return to land, water, and labor, increases by less than 4 percent ($0.6 billion 1972 dollars), while under the high export levels, farm income increases almost 40 percent ($14.9 billion) as a result of the restriction on fertilizer use. The additional income is mostly distributed between land and water owners, and if these are synonymous with the farmers, then total income is increased by the fertilizer restrictions.

Currently, the feasibility of fertilizer-use restrictions seems a remote possibility. However, a short nitrogen supply in the future may have the same effect. Restrictions on fertilizer use and their effects under different export levels can be easily imputed from the analysis provided in the study. In short, unless exports reach the high levels obtained in the study under high export prices, fertilizer restrictions, or nitrogen shortages in general, may have only minor effects on the capacity of the nation's agricultural sector and the cost of food produced by it.

II. INTRODUCTION

Foreign demand for U.S. agricultural products has changed drastically over the last four years. Although domestic demand in future years can be estimated with relatively minor error, foreign demand is highly uncertain at this time. It is subject not only to weather conditions in other countries, but also is greatly affected by political decisions, the world monetary situation, population, and development programs of other countries.

The World Food Conference

The World Food Conference, sponsored by the United Nations and held in Rome in November 1974, was an expression of growing international concern about the critical nature of the world's food situation. Nineteen substantive resolutions, plus a concluding resolution calling for followup action, were adopted at the conference. The conference agreed that a substantial increase in food production is needed in the developing countries and that short-term increases are needed in the developed countries to lessen the world's current vulnerability to crop shortfalls. One proposal for greater production calls for a survey of land resources to determine food production potential. Another resolution, named the World Soil Character and Land Capability Assessment, recommends that governments apply soil protection and conservation measures in all attempts to increase agricultural production [7]. A resolution concerning fertilizer was passed. Among other things, it says, "All countries are requested to introduce fertilizer quality standards; promote the most efficient use of fertilizers, including utilization of nonmineral sources of plant nutrients; and to voluntarily reduce noncritical uses" [7]. The achievement of the World Food Conference cannot be fully assessed at this time because its impact will depend on how governments, international organizations, and others respond to the conference recommendations.

Recent Developments in U.S. Food Production and Exports

Recently, several studies have been completed on the world food situation. Three important ones are: Food and Agriculture Organization's (FAO) recent "Assessment of the World Food Situation, Present and Future" [8], prepared for the World Food Conference; Iowa State University's Center for Agricultural and Rural Development (CARD) study, "World Food Production, Demand and Trade" [1], published in 1973; and finally, the Economic Research Service of the USDA has completed, "The World Food Situation and Prospects to 1985" [7], a summary of some of the previous studies mentioned.

Before 1972, the world experienced two decades of expanding food production, even surpluses, of grains and other foods. Per capita food production was on the increase nearly every year in that period. Then in 1972 the index of world per capita food production fell from 108 in 1971 (1961-65 = 100) to 104 in 1972 [7], with the decline in production concentrated in the developing countries.

The subsequent demand for U.S. agricultural commodities led to the suspension of the policies that restrained U.S. productive capacity.

Annual exports of U.S. feed grains more than doubled from 1970 to 1974, and the United States has become the world's most important exporter of feed grains (Figure 2), accounting for more than half of the international trade. The United States is the world's leading wheat exporter, accounting for 44 percent of the world exports in 1974 while producing only 13 percent of the world's supply [23]. Similar increases have occurred in other commodities, such as soybeans and cotton.

The higher prices of the agricultural commodities accompanied by the higher quantities exported resulted in more than a 300 percent increase in the value of U.S. agricultural exports between 1970 and 1974 (Figure 3). This, in turn, increased agriculture's net contribution to the balance of payments from less than one billion dollars in 1970 to more than eight billion dollars in 1973 [23]. Hence, U.S. agriculture has become not only the world's most important food supplier, but also food has become a major economic force in the nation's international economic position.

Objective of the Study

This study is made as one appraisal of the United States food-producing capacity over the next decade. Many world leaders and agricultural experts continue to believe that the growth in world food demand of the magnitude reflected thus far into the 1970s will put a continued and heavy pressure on world food supplies. The expected result, worldwide, is high prices to consumers and producers in all countries. Therefore, it is very important to determine the capacity of the farming sector to supplement the growing

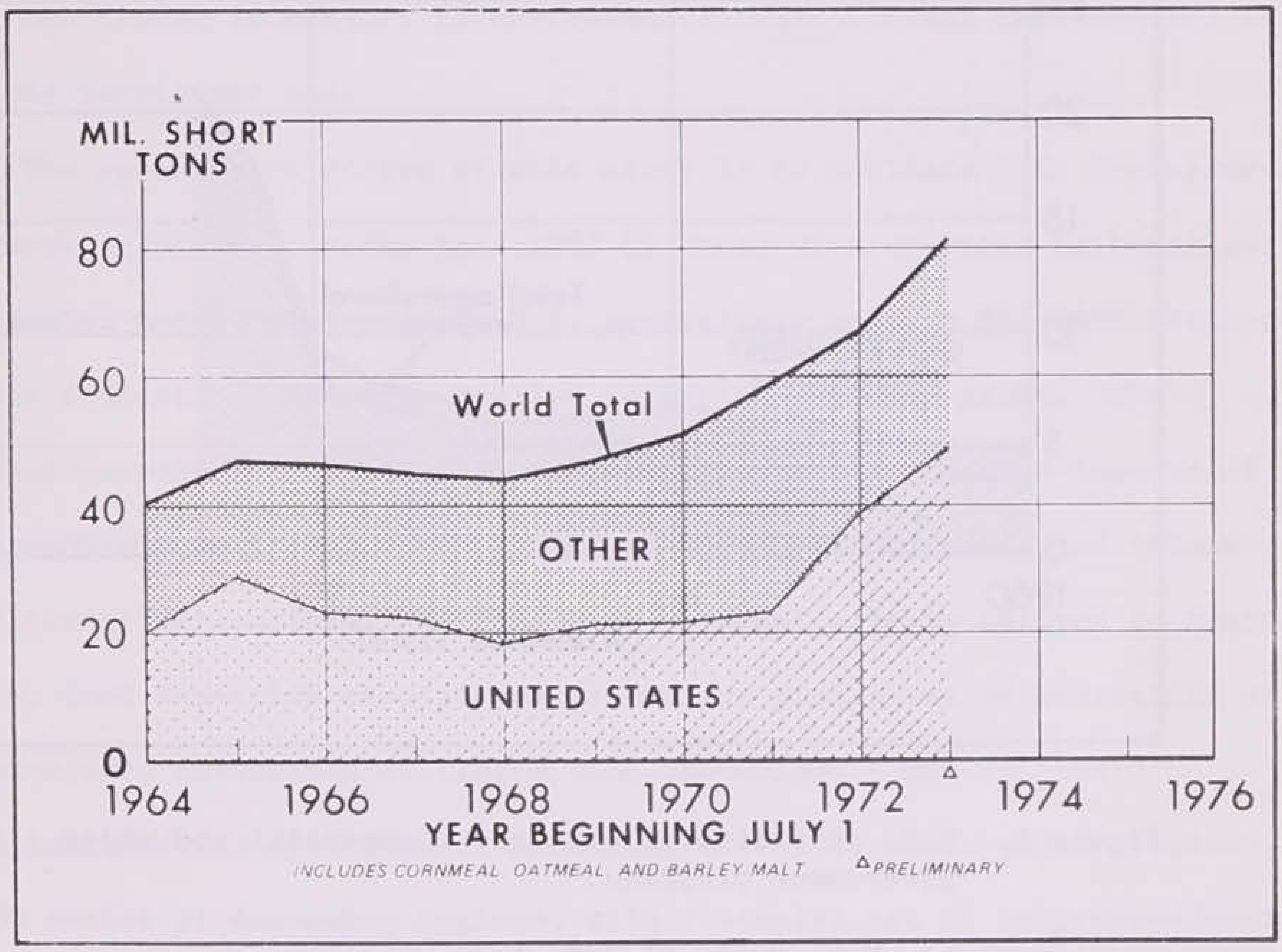

Figure 2. World exports of coarse grains.[a]

[a]Source: U.S. Dept. of Agr. [23].

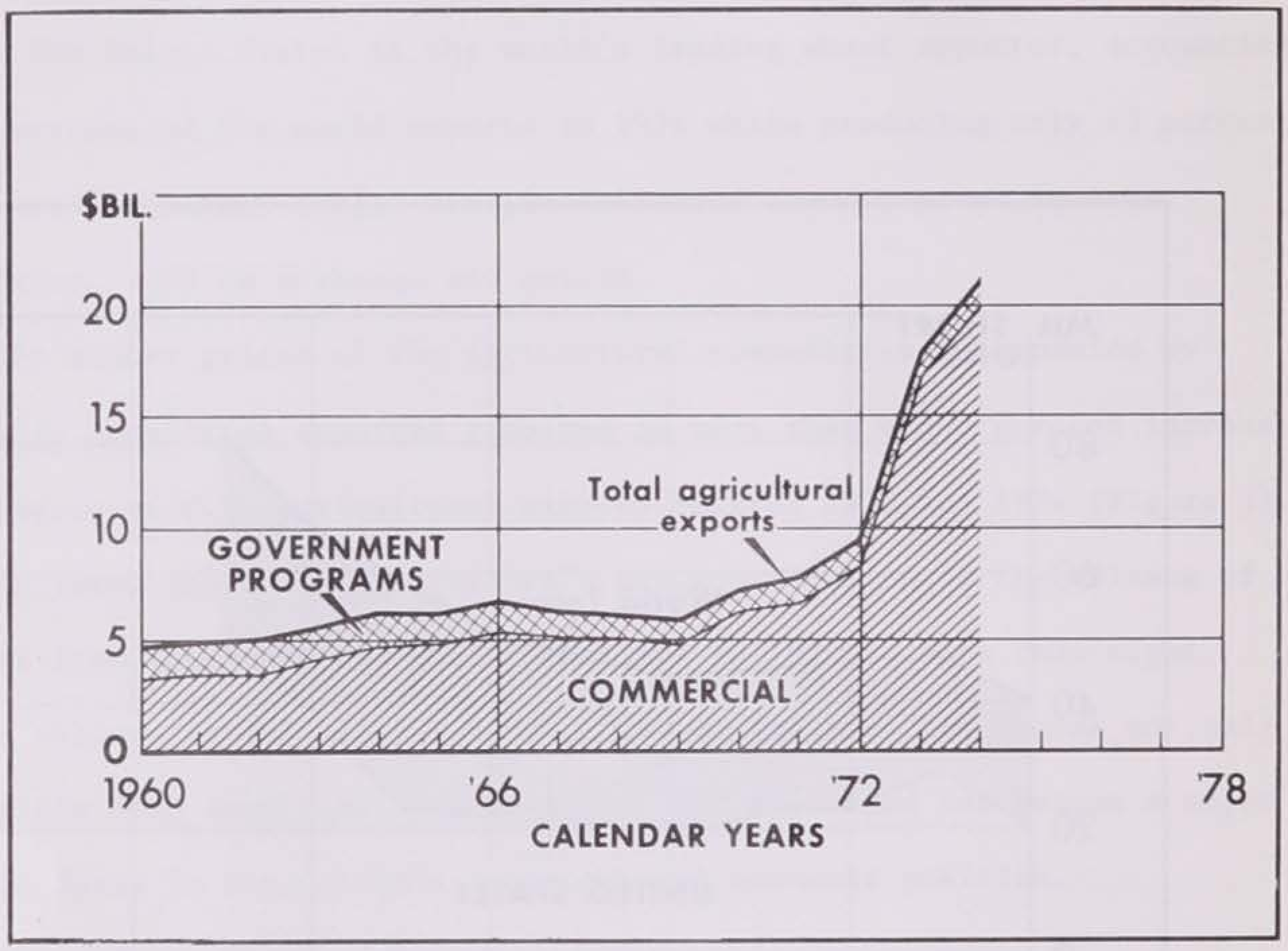

Figure 3. U.S. agricultural exports: Commercial and under government programs.[a]

[a]Source: U.S. Dept. of Agr. [23].

world demand for agricultural products. The potential capacity of U.S. agriculture is greatly influenced by the mix of the crops grown and the growing concern in the United States for environmental improvements. This study provides an estimate of the export capacity of U.S. agriculture and also analyzes alternative desirable export crop mixes. The analysis of these two issues is subject to environmental restrictions that control soil loss and fertilizer use.

The specific objective of this study is to estimate U.S. food-producing and export capacity for the year 1985 by means of a specific mathematical programming model developed for U.S. agriculture under a NSF-RANN (National Science Foundation--Research Applied to National Needs) grant. The original purpose of the ISU-RANN model was to examine certain impacts of environmental and technological limitations on the producing and income abilities of agriculture, but this type of model also is adapted to evaluation of U.S. food exporting capacity under various conditions of restraints on resource use, environmental limits, and technology. The initial model included 223 agricultural producing areas, 51 water supply regions, and 30 market or consuming regions, with a complex set of interdependencies among resources, commodities, and regions reflected through an interregional transportation network and both national and regional markets. Although this larger model is still being used, an alternative model that has large-scale and detailed analytical capability but lower solution costs has also been developed. The model used in this study is such a "reduced model." Because U.S. and world food problems have become so intense, the current model is used to estimate the nation's food-producing and export capacity in 1985 when limited environmental restrictions in terms of soil loss and commercial fertilizer use are applied to production.

This model's application in measuring producing and exporting capacity is one step in an ongoing process of developing models related to U.S. agricultural resource use and producing capacity. Other studies underway test U.S. production capacity under different environmental restraints, substitutions in the rations of livestock and diets of humans, and technological assumptions.

The current model determines the supply capacity, productivity, income potential, food prices, regional distribution of production, and other economic impacts that might prevail under a selected set of environmental conditions for U.S. agriculture. The main objective is to estimate agriculture's capacity to export food and natural fibers, subject to a set of minimum and maximum regional production requirements, a limited set of environmental restraints expressed in terms of practices that restrain sediment losses and limit commercial nitrogen fertilizer application, and predetermined levels of domestic demand for the commodities. The study encompasses all land, water, and other resources representing U.S. agriculture and the majority of the commodities it produces. The basic tool used in the analysis is a detailed interregional, multicommodity, and multiresource model that measures interrelationships among all commodities, resources, and regions of farming.

Answers to the following specific questions are the main thrust of the model: 1. Given a set of environmental restraints and the historic pattern of production, how do changes in the relative prices paid to farmers affect the level and the mix of the U.S. farm basket available for export? 2. What are the impacts of changes in relative farm commodity prices on farm income and food costs? 3. Assuming great demand for U.S. farm products abroad, what could be the level of future farm exports? 4. What are the effects of "less-than-optimal location" of production patterns on the export capacity of U.S. agriculture? 5. What are the impacts of high export levels, accompanied by a high price level, on farm income and the consumer food bill? 6. If soil loss and fertilizer use are restricted, what are the consequences on consumer food costs at different export levels.

The study is made in relation to the year 1985, a date far enough in the future to allow adjustments in agriculture so as to approach the new world market situation that might exist by that time. A domestic population of 242 million people is assumed and combined with projected levels of domestic per capita consumption of agricultural goods.

The study does not attempt to evaluate the future export demand for U.S. agricultural products. Export demand estimation for the few years ahead is complicated by several very large climatic, institutional, economic, and political uncertainties. Our analysis is an attempt to assess U.S. agricultural producing capacity and its ability to aid in meeting the international demand regardless of the means through which it may be distributed. In this study we only touch on the effect which higher exports might have on the U.S. environment, resource conditions, and income distribution between farmers and consumer groups.

Agriculture and the Environment

Part of this study deals with productivity under conditions of certain environmental controls in agriculture. Environmental quality has become a concern of increasing intensity to many Americans in relation to national growth, population distribution, developing technology, and other features of advanced and developed societies. In many ways, agriculture is well prepared to deal with these concerns of society, relative to other sectors of the economy. Agricultural history is engrained with a variety of environmental and resource conservation programs applied in past decades. However, concern of environmental and resource use problems for agriculture have intensified as exports have increased abruptly and the nation is putting more and more land under cultivation. Too, the high prices of grain under this export regime encourage increased levels of chemical application (wherever the chemicals are available and have not increased so greatly in price).

Pollution from agriculture

Through runoff and sedimentation, soil loss is a major source of nonpoint pollution through agriculture.[8] Not only does silt find its way into major streams and water bodies, but also it serves as the major transportation

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[8]Nonpoint pollution is pollution than cannot be traced to a specific geographical location. Feedlots, on the other hand, are examples of point pollution.

mechanism for some of the nitrogen compounds, phosphorus, and some pesticides. The levels of soil loss limits per acre, five and ten tons, are examined in this study as applied to all land resource groups. Some land resource groups now have annual per acre soil losses exceeding 150 tons per acre.

In the case of nitrogen, possible sources include fertilizer, nitrogen fixed by legumes, mineralization, barnyard manure, plant residues (roots and trash), and rainfall. Nitrogen is removed from the land through harvested crops, erosion, leaching of soil and fertilizer nitrogen, and denitrification. Since nitrogen pollution can be derived from any of these sources, it is difficult if not impossible to determine the relative importance of each [16]. The problem is further complicated when nitrogen in streams, wells, and lakes may also come from such additional sources as feedlots and municipal waste treatment plants [14]. In other words, it is difficult to determine the relative importance of each source of nitrogen in the water.

Fertilizer use

The use of all fertilizer has increased by nearly 400 percent over the past two decades (Table 2). More importantly, the amount of nitrogen fertilizer has increased nearly sixfold [4]. Regionally, the Corn Belt, with large acreages of row crops, has shown a dramatic increase in the amount of nitrogen fertilizer applied consistent with the high return to nitrogen in the production of corn.

Table 2. Summary of nitrogen fertilizer use in the 10 farm production regions and for the United States, 1949-1973.

Period	North-east	Lake States	Corn Belt	Northern Plains	Appa-lachian	South-east	Delta States	Southern Plains	Mountain	Pacific	United States	
											Nitrogen	All plant nutrients
					(000 tons)							
1949-54 Average	111	49	222	50	205	267	182	57	47	184	1,430	3,635
1955-59 Average	147	113	398	135	244	341	227	124	94	314	2,197	4,848
1960-64 Average	183	183	815	344	304	434	265	302	161	434	3,484	6,712
1965-69 Average	249	381	1,759	738	417	576	317	588	283	587	5,948	10,652
1970	271	538	2,125	1,093	478	674	369	839	375	646	7,459	12,805
1971	296	698	2,307	1,078	507	685	404	840	383	672	7,925	13,480
1972	273	657	2,124	1,179	491	723	477	896	406	738	7,995	17,170
1973[a]	317	680	2,085	1,319	529	750	443	922	465	779	8,319	17,780

Source: Economic Research Service [4;5].

[a]Preliminary.

Not only has more land been fertilized over the last two decades, but also the quantity of fertilizer applied per acre has been increasing. The average acre of corn for grain fertilized in 1947 received 10 pounds of nitrogen, 23 pounds of phosphorus, and 12 pounds of potassium. However, by 1969 each fertilized acre of corn for grain received 109 pounds of nitrogen, 52 pounds of phosphorus, and 62 pounds of potassium. Other crops also have been receiving increasing amounts of fertilizer, but rates of application have been considerably less than for corn [4].

This study deals with restrictions on the use of fertilizers in agriculture. Major emphasis is directed toward the impact on commodity prices if fixed levels of exports are to be maintained.

Models Evaluated and Their Assumptions

The producing and export capacity of U.S. agriculture in relation to pricing policy, response flexibilities, and the environment is evaluated under seven different model alternatives (Table 3). The seven models are divided into three sets. The details of the models will be explained in later sections of the report, and initial complexities that the reader may encounter in interpreting Table 3 will then disappear.

Set one contains two alternatives (Models 1.1 and 1.2). The analysis of these alternatives is aimed toward evaluating the impacts of a change in the relative prices of the agricultural commodities exported. Model 1.1 assumes that farmers receive the government's 1974-75 target prices specified in the 1973 Agricultural Act [21] for their grains. Model 1.2

Table 3. Summary of model alternatives included in the study and their main assumptions.[a]

		Export prices	Crop location restrictions[b] max (percent)	Crop location restrictions[b] min (percent)	Livestock location restrictions[b] max (percent)	Livestock location restrictions[b] min (percent)	Soil loss limit ton/acre	Export	Fertilizer use restrictions
Set One	Model 1.1	1974-75 target prices	200	80	300	80	10	none	none
	Model 1.2	adjusted target prices	200	80	300	80	10	none	none
Set Two	Model 2.1	high export prices	200	80	300	80	5	corn[c] cotton	none
	Model 2.2	high export prices	200	50	300	50	5	corn[c] cotton	none
	Model 2.3	high export prices	none	none	none	none	5	corn[c] cotton	none
Set Three	Model 3.1	adjusted target prices	200	80	300	80	10	Model 1.2 level	110 lb[d] 55 lb
	Model 3.2	high export prices	200	80	300	80	5	Model 2.1 level	110 lb[d] 55 lb

[a] All alternatives use a 1985 time horizon and 242 million as the expected population.

[b] Crop location restriction is in terms of percent of 1969 crop acreage or livestock unit produced.

[c] Corn is restricted to a maximum export of 3.5 billion bushels per year. Cotton is restricted to a maximum of 10 million bales per year.

[d] Nitrogen application is restricted to 110 lb. N per acre for corn and sorghum and 55 lb. N per acre for barley, oats, wheat; cotton is restricted to 80 lb. N per acre.

is a variation on the price assumption of Model 1.1. In this model the government's 1974-75 target prices are adjusted in such a way that the overall export level is not affected. However, the mix of products being exported is changed to be more in line with historic patterns. The combination of the results of these two alternatives is used to evaluate the impacts of changes in the relative prices and also to indicate how relative prices can be used as a tool by the policy maker wishing to control the output mix.

Set two contains three alternatives (Models 2.1, 2.2, and 2.3). The analysis of this set is aimed toward evaluating U.S. agricultural export capacity under varying rates of production location adjustment. In all three models the prices assigned to the export activities are double the adjusted target price level used in Model 1.2. The alternatives of set two simulate the aggregate farm response to a much higher commodity price level than Model 1.2. The varying degree of location adjustment is defined in terms of the minimum and maximum number of acres or number of livestock units produced in each of the market regions. The first alternative in set two (Model 2.1) assumes a similar interregional adjustment as the alternatives in set one. The second alternative (Model 2.2) allows a greater rate of interregional adjustment, and the third alternative (Model 2.3) allows for complete adjustment of the regional production pattern consistent with the higher commodity price. In the alternatives of set two, an environmental restraint is expressed in terms of a soil loss restriction at a maximum of five tons per acre per year.

The third analysis contains two alternatives (Models 3.1 and 3.2). Set three is aimed toward analyzing the effect of fertilizer use restriction, either in response to an energy shortage or environmental concern. Instead of trying to measure the export capacity under a restricted fertilizer situation, the alternatives assume exports are maintained at the levels obtained in the analysis of the respective base alternatives in sets one and two.

Model 3.1 assumes exports fixed at the level obtained in the analysis of the adjusted target prices (Model 1.2) and provides a benchmark for comparison of the effects of fertilizer limitations on land and water use, farm income, and food prices under moderate export levels.

Similarly, Model 3.2 assumes exports fixed at the level obtained under the higher export price alternative (Model 2.1) and provides an indication of the effect of fertilizer restrictions under a situation of "full capacity." The comparison of the two models in set three allows for some discussion as to the different effect of the fertilizer restriction under different levels of production and export.

Other assumptions could also be examined. However, the seven alternatives described in this study provide important insights into questions of U.S. agricultural export capacity in relation to environmental impacts.

III. BASIC MODEL DESCRIPTION

Many of the model's parameters used in the study are derived from previous ISU-RANN and CARD studies [9, 13]. Explanation of these parameters is in A Model for Regional Agricultural Analysis [12].

The linear programming model used in the study minimizes the cost of food production and transportation. At the same time it maximizes the export of agricultural products after meeting prespecified domestic demands. The model assumes a long-run competitive equilibrium wherein returns to resources are equal to their marginal value in production. The constraints of the model correspond to the land and water supplies by region, production requirements by location, the nature of production, and a market sector constraint which equate supply and demand for the endogenous commodities. There are 1,564 restraints (rows) in the model and 9,795 activities (columns) that simulate crop rotations, livestock production, water transfer and distribution, commodity transportation, and net export activities.

Endogenous crop variables are corn grain, sorghum grain, corn silage, sorghum silage, wheat, soybeans, cotton, sugar beets, oats, barley, legume hay, and nonlegume hay. The production of the other crops (fruits, vegetables, tobacco, potatoes, rice, peanuts, buckwheat, etc.) are determined exogenously. Endogenous livestock activities include beef cows, beef feeding, dairy cows, and hogs. Turkeys, broilers, eggs, sheep and lambs, and other livestock are exogenously determined.

Regional Delineation

The three sets of regions used in the basic mdoel are producing, consuming (market), and water supply regions. The consuming and water supply regions are defined from a compatible subset of the producing areas and reflect the interregional nature of the analysis. For reporting purposes only, another set of regions is defined by aggregating adjacent consuming regions into the seven major zones: North Atlantic, South Atlantic, North Central, South Central, Great Plains, Southwest, and Northwest.

The producing areas (Figure 4) are based on county approximations of the Water Resource Council's 206 subareas [26]. Each of the 90 producing areas in the study consists of a set of contiguous counties and forms a watershed with a common tributary and in which the agricultural crop activities are defined.

The 29 market regions are an aggregation of contiguous producing areas (Figure 5). In addition, the livestock, nitrogen buying, and export activities are defined in these regions. The consuming regions, besides representing market centers, provide the basic network for commodity transportation.

Thirty-five water supply regions are defined in the western half of the United States (Figure 6). These regions consist of contiguous counties in which a dependable water supply can be said to exist. They were obtained by aggregation of water supply regions defined by the Water Resources Council [26].

Figure 4. The 90 producing areas.

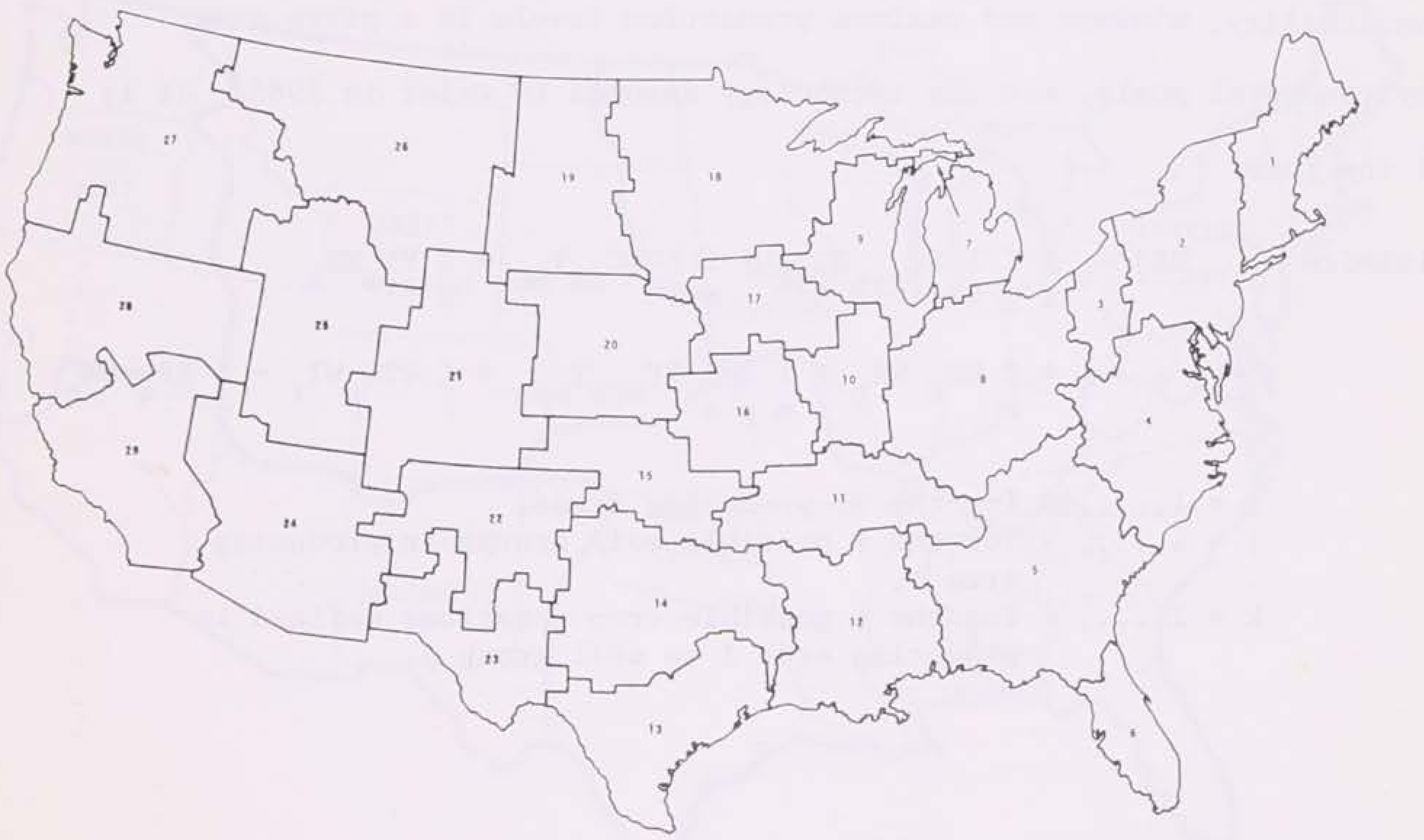

Figure 5. The 29 market regions.

Seven major zones are utilized to facilitate reporting of the results (Figure 7). These zones consist of aggregations of adjacent market regions. All results reported in the above regions are weighted averages of the market regions' results.

The Objective Function

The objective function minimizes the cost of production (labor, machinery, pesticides, fertilizer, water, and feed) and the cost of transporting agricultural raw products from location of production to the market region. In addition, for export maximization, a given negative price is assigned to each export activity. The model will increase the export activity until the cost of producing and transporting another unit of commodity for export becomes greater than the price (cost) of the export activity for that commodity.

The objective function is subject to given domestic demand, resource availability, minimum and maximum production levels in a given area, environmental goals, and the technology assumed to exist in 1985. It is of the form:

$$\text{minimize} \quad OBJ = \sum_i \sum_j \sum_k RC_{ijk} X_{ijk} + \sum_m \sum_n LC_{mn} Y_{mn} + \sum_m PN_m NB_m + \sum_r WC_r WB_r + \sum_m \sum_p \sum_s TC_{mps} T_{mps} + \sum_r WTC_r WT_r - \sum_q EP_q EX_q \tag{1}$$

i = 1,...,90 for the 90 producing areas,
j = 1,..., 9 for the 9 possible soil groups in producing area i,
k = 1,..., t for the t possible crop rotations defined in producing area i on soil group j,

Figure 6. The 35 water supply regions.

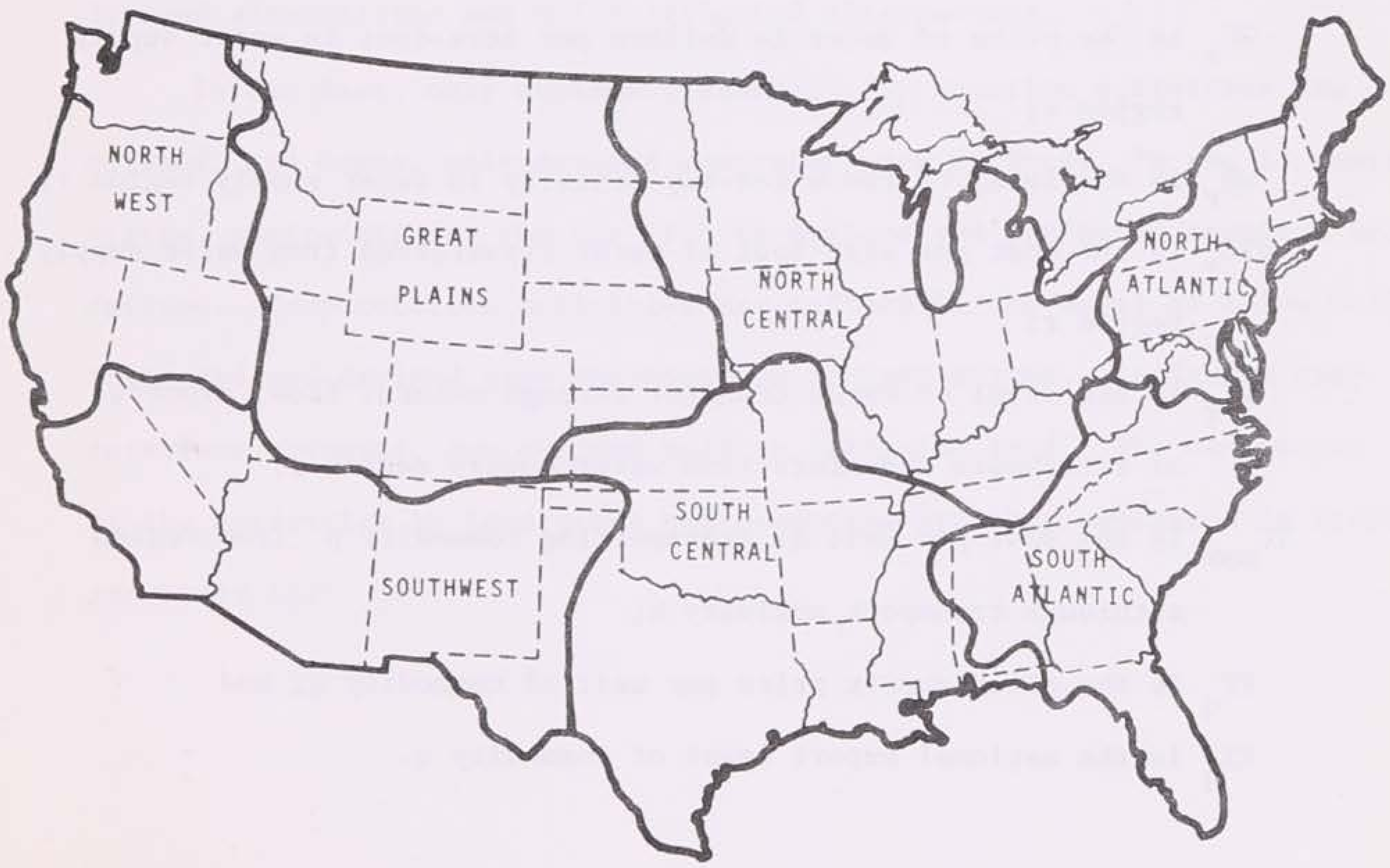

Figure 7. The seven major zones.

$m = 1,\ldots,29$ for the 29 market regions,
$n = 1,\ldots, 4$ for the 4 possible livestock activities in market region m,
$p = 1,\ldots,11$ for the 11 commodities transported,
$q = 1,\ldots, 7$ for the 7 export commodities,
$r = 1,\ldots,35$ for the 35 water supply regions,
$s = 1,\ldots, t$ for the t possible transportation activities defined for commodity p in market region m.

where:

RC_{ijk} is the cost in dollars per acre for crop activity k on soil group j in producing area i;

X_{ijk} is the level of crop activity k on land group j in producing area i;

LC_{mn} is the cost per unit of livestock activity n in market region m;

Y_{mn} is the level of livestock activity n in market region m;

PN_m is the price of nitrogen fertilizer in dollars per pound in market region m;

NB_m is the level of the nitrogen-buy activity in market region m;

WC_r is the price of water in dollars per acre-foot in water supply region r;

WB_r is the level of the water-buy activity in water supply region r;

WTC_r is the cost per acre-foot of water transferred from water supply region r;

WT_r is the level of water transfer through natural flow, exports, or interbasin transfers from water supply region r;

TC_{mps} is the cost per unit of transporting commodity p from region m through transport activity s;

EP_q is the given export price per unit of commodity q; and

EX_q is the national export level of commodity q.

Restraints

Restraints in the model are defined at either the producing area, consuming area, water supply region, or national level. The restraints control the availability of the resources land, water, fertilizer, and livestock feed; commodity production and utilization for domestic and export; regional location of production in terms of 1969 crop acreage and livestock units; and the attainment of environmental goals represented by restrictions on soil loss or fertilizer application.

Restraints at the producing area level

The only restraint defined at the producing level is the availability of dryland and irrigated cropland. For each producing area, the availability of cropland is defined by land group for dry and irrigated alternatives. There is a maximum of 18 land groups for a given producing area--9 for dryland alternatives and 9 for irrigated alternatives.

In the East, only dryland (rainfed) crop rotation activities are defined, and hence, only dryland restraints are defined. In the 17 western states, restraints for the use of both dryland and irrigated cropland are defined. Crop rotation activities are defined in the model to allow both irrigated and dryland crop rotations on irrigated land. Irrigated crop rotations, however, are defined only on irrigated land. The derivation of the activities by land group and producing area are explained in Nicol and Heady [12].

Restraints at the market region level

Restraints are defined at the market region level to regulate commodity market transactions, regional location of production, and the balance in the nitrogen fertilizer sector.

Commodity transfer restraints. The commodity transfer restraints simulate a market place for the commodities [12]. These commodities include corn grain, sorghum grain, barley, oats, wheat, oilmeals, non-legume hay, silage, feeders, fed and nonfed beef, pork, and dairy products. The producing areas within the market regions interact directly with the commodity transfer restraints to satisfy the commodity domestic demands and commodity export demands. The commodity transfer restraints in each market region are linked to the adjacent market regions by the commodity transportation activities of the model.

Regional restraints on the location of production. A set of constraints is defined at the market region level to provide for minimum and maximum levels of crop and livestock production within the region. These restraints are incorporated to approximate the immobility of production resulting from farmer preferences, inflexibility of nonendogenous resources, and the time horizon. In addition, these production restraints could be used to simulate farmers' risk aversion as the model assumed complete certainty on both demands and supplies. These minimum and maximum levels are calculated as a multiple of the 1969 level of the crop acreage or livestock production reported in the 1969 Census of Agriculture [24]. These restraints are defined for: corn (grain and silage combined), sorghum (grain and silage combined), cotton, soybeans, wheat, legume hay, beef cows, fed beef, hogs, and dairy. For a given crop or livestock commodity, m, these restraints have the general form:

$$L_{im} \leqq \sum_{k \epsilon i} \sum_{j} X_{ijk} W_{jkm} \leqq U_{im} \qquad (2)$$

i = 1,...,29 for the market regions,
j = 1,...,10 for the crop or livestock activity,
k = 1,..., t for the t producing areas in market region i, and
m = 1,..., t for the t restrained commodities in activity j.

where:

L_{im} is the minimum number of acres or livestock units of commodity m required in market region i;

X_{ijk} is the level of activity j producing commodity m in producing area k;

W_{jkm} is the acreage proportion of commodity m in activity j in producing area k (for livestock $W_j = 1$);

U_{im} is the maximum number of acres or livestock units of commodity m which can be produced in market region i.

For crops, both irrigated and dryland activities can be used to satisfy the production restraints.

Nitrogen fertilizer transfer restraints. Another restraint is defined at the market region level to act as a market place for the supply and demand of nitrogen fertilizer. Nitrogen is obtained as a by-product of livestock activities, from commercially produced fertilizer, and from the fixation process of the legume crops. Nitrogen is used by the endogenous crop rotation activities, in addition to the given amount allocated for exogenous crops [12].

Restraints at the water supply region level

One restraint is defined in each water supply region. This restraint balances the dependable water supply in the region, including interbasin transfers, natural flows and runoff, and the many water uses. Water consumed onsite, water used by exogenous crops and livestock, municipal and industrial uses of water, and water exports are predetermined exogenously to the model. By forcing supply to be greater than or equal to the sum of all endogenous and the above exogenous demands, an adequate water balance is obtained [12].

Restraints at the national levels

Restraints are defined at the national level for cotton and sugar beets. The activities in each producing area are capable of supplying these commodities directly into national market restraints. In other words, no transportation network is defined for these commodities [12].

Environmental restraints

Environmental goals are defined as a maximum allowance of soil loss per acre and in the nitrogen restriction models for maximum allowable nitrogen to be applied per acre. The soil loss limit is applied uniformly across all producing areas at either five or ten tons maximum soil loss per acre depending on the alternative considered. The nitrogen application limits also are applied uniformly across all producing areas, but they vary from crop to crop. The environmental restraints are incorporated by defining a set of crop rotations such that each activity meets the specified limit.

Thus, for example, while soil erosion varies between 0 and 40 tons per acre per year, only the crop rotations with an erosion level below the maximum of five tons per acre will be included in the five-ton soil loss alternatives.

Activities

Activities serve as a mechanism whereby production alternatives and commodity utilization and transfer systems are incorporated into the model. Basically, there are four classes of activities in the model: 1) production activities, including crops and livestock; 2) transfer activities, including transportation of commodities between regions and transfer of commodities from one use to another; 3) resource supply activities, including water supplies and nitrogen buying; and 4) demand activities, including commodity exports.

Crop production activities

The crop production variables or activities simulate the production of barley, corn grain, corn silage, cotton, legume and nonlegume hay, oats, sorghum grain, sorghum silage, soybeans, sugar beets, and wheat in rotation; they vary from the model in [12] as aggregated to the smaller number of regions and the yields and costs to 1985. The differentiation of wheat production is assumed to be compensated for by the regional production restraints, and thus only one class of wheat is defined. Yields are calculated based on the price of the agricultural commodities and inputs during the 1972-73 crop year and the higher commodity and fertilizer prices, with the price of fertilizer rising relatively more than commodity prices, resulting in a lower optimum fertilizer level and lower yields than using prices at the levels in [12].

Livestock production activities

The livestock variables or activities simulate the production of meat and dairy products. The activities transform the grains and roughages to satisfy the exogenously determined demands for the livestock products. As in the case of crop activities, the market region livestock activities in this model are aggregations of the livestock activities in [12].

Transfer activities

Commodity transportation activities are defined for all major crops. These activities move the commodities between adjacent consuming regions and over some long-haul routes [12]. Meat transfer activities allow fed beef to be used as part of the supply requirements to meet the nonfed beef demand, thus allowing for a high quality product (fed beef) to satisfy lower quality uses.

Resource supply activities

Water activities have three components: downstream flows, interbasin flows, and water-buy activities. The downstream flows are bounded to a maximum of 75 percent of the available water upstream. The interbasin flows are bounded to a maximum of the water transfer system's capacity. Water-buying activities are bounded by the maximum available water supply in each water supply region as defined for the model in [12]. Nitrogen-buying activities are not restrained and are defined in each of the market regions with the purchase price reflecting historic regional differences in fertilizer prices.

Commodity export activities

Export activities are defined to control exports of corn grain, sorghum grain, barley, oats, wheat, oilmeals, and cotton. While being defined as national activities, the total amount exported of each of the above commodities (except for cotton) is distributed among the market regions in proportion to the 1969-71 average exports of the commodities by regions. The activities are unbounded except for upper bounds on the export of corn grain (3.5 billion bushels) and cotton (10 million bales) for some of the alternatives analyzed.

Resources and Exogenous Demands Vector

The acreage available by land class in each of the 90 producing regions was determined from the Soil Conservation Service [2]. An adjustment was made for projected changes in exogenous land uses and irrigation developments in 1984 (Table 4).

Table 4. U.S. total land base acreage in 1985.

Item	(1,000 acres)
Dry cropland	344,172
Irrigated cropland	29,437
Total cropland in the model	373,609
Nonrotation hay and pasture dryland	635,491
Nonrotation hay and pasture irrigated	9,504
Total nonrotation hay and pasture	644,995
Exogenous crops	9,369
Total cultivated land	1,027,972

Final commodity regional demands have the population level, per capita demand, and net import level as their major components. They are based on a total 1985 population of 242 million in the conterminous United States. The population is distributed according to the projected 1985 OBERS level D regional distribution [25]. Two levels of per capita demand are being used in the model (Table 5), using similar derivation methods as the models in [12].

Table 5. Projected national per capita commodity demands in 1985.

Commodity	Unit	Consumption at low prices	Consumption at high prices
Corn	bushels	1.2010	1.2010
Sorghum	bushels	.0486	.0486
Barley	bushels	.5796	.5796
Oats	bushels	.2187	.2187
Wheat	bushels	2.5838	2.5838
Oilmeal	cwt.	-.0873[a]	-.0873[a]
Cotton fibers	pounds	16.0	16.0
Sugar beets	tons	.1089	.1089
Fed beef	lbs. of carcass weight	99.0	74.7
Nonfed beef	lbs. of carcass weight	44.6	33.7
Pork	lbs. of carcass weight	66.7	65.43
Dairy products	cwt. of milk equivalent	4.83	4.83
Broilers[b]	lbs. of ready-to-cook meat	41.1	40.56
Turkeys[b]	lbs. of ready-to-cook meat	8.6	7.019
Lamb & mutton[b]	lbs. of carcass weight	3.1	1.19
Eggs[b]	eggs	250.0	250.0

[a]Negative oilmeal consumption reflects an adjustment for the high protein grain by-products provided from the milling of the per capita equivalent of the other grains.

[b]Exogenous commodities.

Determination of the soil loss levels

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, as some of the 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" as described by Wischmeier and Smith [27] and a release from the Soil Conservation Service [15] are used to develop the gross soil loss coefficients.[9]

For those agricultural lands in the mountain valleys and on the West Coast, the data required for the soil loss equation have not been completely developed, and estimates of soil loss for given rotations were determined in conjunction with the SCS questionnaire circulated [12].

Development of the crop yield coefficients

A unique yield is determined for each of the irrigated and dryland crops as a function of the producing area, soil class, crop rotation, conservation practice, and tillage method. The development of the yields began with a series of state production functions capable of projecting yields to the future. The state projection functions are modifications of the Spillman functions developed by Stoecker [20]. For each crop the function is of the form:

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[9]The data for this equation are developed from tables given by Wischmeier and Smith [27] and from the regional data given for the soil classes by the Soil Conservation Service of the USDA [12].

$$Y(t) = Y_o(t) + A\,(1 - .8^{X(t)})*PF(t) \qquad (3)$$

where:

$Y(t)$ is the estimated average per acre yield of the crop in year t;

$Y_o(t)$ is the estimated average per acre yield on unfertilized land in year t, developed from a linear trend function;

A is the maximum yield response obtainable from fertilization;

$X(t)$ is the number of units of fertilizer applied to each acre of the crop in year t;

$PF(t)$ is the proportion of the acreage of the crop receiving fertilizer in year t, developed from a linear trend of the proportion of the crop acres receiving fertilizer; and

t is years after 1949.

The X(t) defined above represents:

$$X(t) = PO(t) * (\ln (Px/Pc) - \ln A - (\ln (-\ln .8)))/\ln .8 \qquad (4)$$

where:

ln is the natural log of base e;

Px is the weighted price of a unit of fertilizer;

Pc is the price of a unit of crop c;

$PO(t)$ is the proportion of the optimum rate of fertilizer applied in year (t), developed from a linear trend of the proportion of the optimum rates applied.

The above equation represents an estimate of the optimum application of fertilizer obtained by solving the marginal conditions of a profit maximization system adjusted for the proportion of optimality which farmers are projected to be using.

The producing area yield is calculated for each crop based on the above functions, relationships between the states and the producing areas, and the projected levels of fertilizer use. If the rotation in which any crop is defined includes a legume crop, the carry-over nitrogen from these sources is accounted for in predicting the yields. In many instances the legumes, especially alfalfa hay, produced more fertilizer-equivalent nitrogen than would have been applied commercially. When this occurred, the fertilizer-equivalent nitrogen from the legume is used in the yield equation, giving a larger yield than under optimum fertilizer applications.

Fertilizer-use coefficients for the crops

The fertilizer-use coefficients developed from the functions (3) and (4) are independent of the land class, conservation practice, or tillage method. They provide the basis for determining the level of nitrogen supplementation required. The level of commercial fertilization required to meet the projected yields is determined by taking the optimum level of fertilizer use as determined above and subtracting the amount provided by the legume hay and soybeans, if any, in the rotation [12].

The sources of nitrogen are determined endogenously in the nitrogen sector of the model. The nitrogen can be obtained from purchase of commercial nitrogen fertilizer, legume crops, or through the use of livestock wastes. Nonnitrogen fertilizer required to satisfy the calculated optimum application rate is purchased and the costs are included with the production costs to give the exogenous variable costs of production for the crop management system.

A schematic description of the procedures used to develop the yield coefficients and of the adjustment for the nitrogen restrictions is presented in Figure 8. The yield adjustment when nitrogen restrictions are considered is based on a comparison between the amount of nitrogen to be applied to the given crop in a given producing area and the given national limit on the per acre application of nitrogen for the given crop. If the amount of nitrogen to be applied is less than or equal to the specified limit, then no adjustment is made. However, if the amount to be applied (on a per acre basis) is greater than the given limit for the crop, a fertilizer-application ratio reflecting the proportion of the nitrogen to be applied is calculated, and the fertilizer level adjusted by this ratio and a new yield are determined. In addition to the yield adjustment, the new level of nitrogen application is set equal to the nitrogen limit, and the cost of the nonnitrogen fertilizer is adjusted down by multiplying the nonnitrogen fertilizer cost by the fertilizer-application ratio (this assumes phosphorus and potassium are reduced proportionately to nitrogen, Figure 8).

The following sections outline three different applications of the model. The first set, including two alternatives, outlines how different relative commodity prices influence the level of export of each of the commodities. The next set, including three alternatives, analyzes the export capacity of American agriculture under a set of higher commodity prices and three alternative levels of adjustment in regional location of production. The final set, including two alternatives, evaluates the possible impacts of an

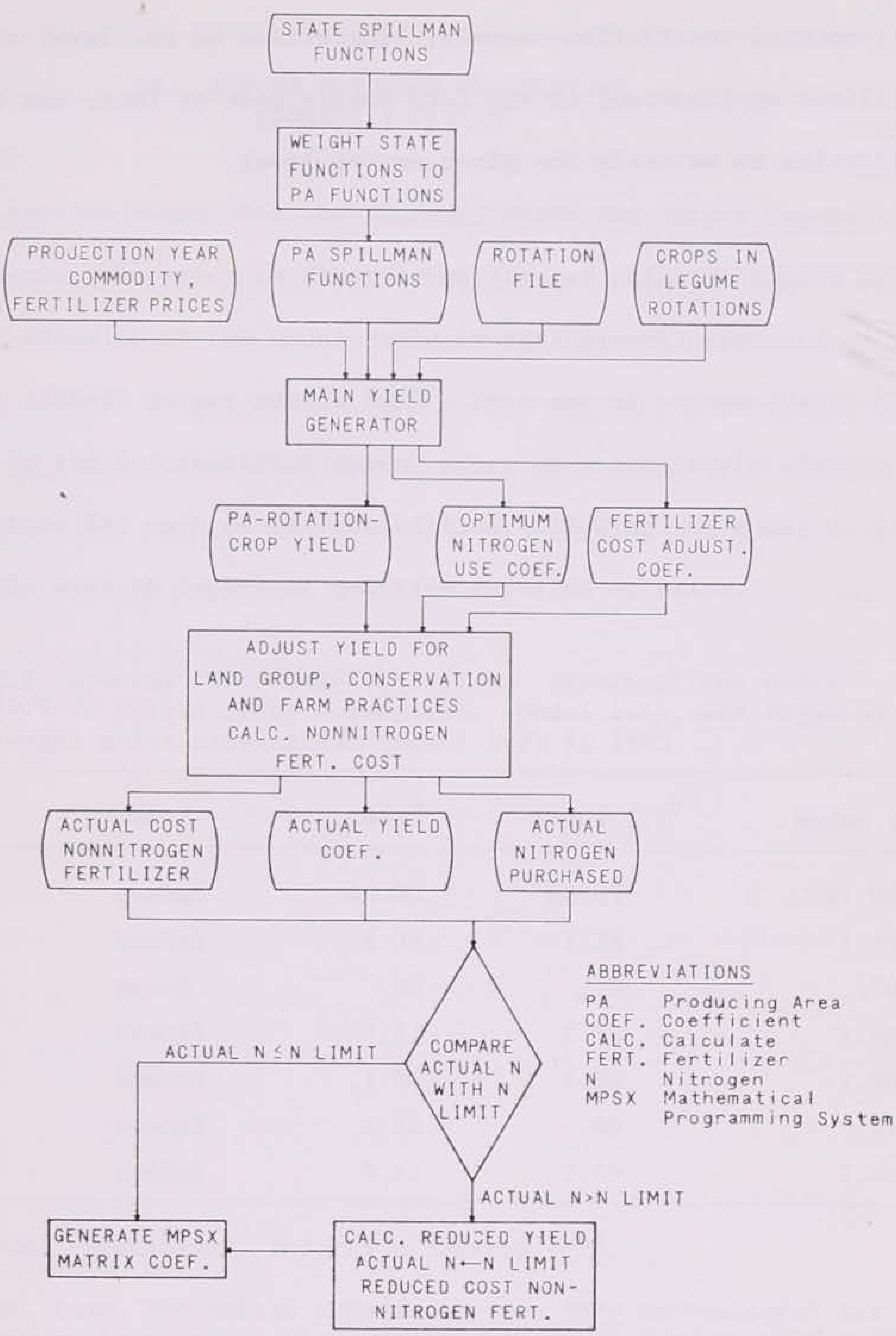

Figure 8. Flow chart for yield developments and yield adjustments.

environmental restriction--namely, limitations on the level of nitrogen fertilizer application, on the farm supply cost of food, and the resource utilization to maintain the given export level.

IV. EXPORT RESPONSE TO RELATIVE COMMODITY PRICES

This section summarizes the responsiveness and output capabilities of the agricultural sector to alternative sets of relative export prices. The initial solution of the model reflects agricultural production patterns under 1974-75 target prices [21]. This set of prices (Table 6) is assumed to be the international demand price on a completely elastic demand function for each of the commodities, allowing the model to estimate export levels with no impact of quantity exported on price.

Table 6. U.S. average 1973 commodity prices, export prices under 1974-75 target price alternative (Model 1.1), and adjusted target price alternative (Model 1.2) in 1985.

Commodity	Unit	1973[a]	Model 1.1[b]	Model 1.2
Wheat	bushel	$4.00	$2.05	$2.00
Corn	bushel	2.38	1.38	1.50
Cotton	pound	.45	.38	.28
Barley	bushel	2.13	1.13	1.40
Sorghum	bushel	3.80	1.36	1.70
Oats	bushel	1.16	.65	.65
Soybeans	bushel	5.57	2.79	2.79

[a]Source: Statistical Reporting Service [17].

[b]Wheat, corn, and cotton prices are from 1973 Agricultural Act [21]; barley, sorghum, oats, and soybean prices set to 60 percent of May 1973 parity prices [18].

The second alternative in this set adjusts the above prices to encourage a mix of exports near the levels of present exports. Corn, barley, and sorghum prices are increased, cotton and wheat prices are reduced slightly, while oats and soybean prices remain unchanged (Table 6). For both solutions a uniform 10-ton maximum per acre soil loss is allowed. Regional production restrictions are set at a lower limit of 80 percent of 1969 and an upper limit of 200 percent of the 1969 acres for all crops except legume hay. Livestock numbers and legume hay acreage restrictions are set at a lower limit of 80 percent and an upper limit of 300 percent of their 1969 levels. The larger upper limit on livestock allows for more production flexibility reflecting increased per capita demand and population level by 1985.

Agricultural Production Under 1974-75 Government Target Prices (Model 1.1)

This section outlines the crop production patterns, export levels, land-use patterns, water use, regional production, and the farming practices utilized in maintaining the soil productivity under a set of prices based on the 1974-75 government target prices (Table 6).

Commodity production and utilization

The data in Table 7 indicate the production, domestic consumption, and net export levels for each of the commodities whose production is allocated by the model. During the calendar year 1973, the export of feed grains (corn, sorghum, barley, and oats) amounted to 1.7 billion bushels [6], much higher than the 0.6 billion bushels of feed grains exported under the 1974-75 target prices. Wheat exports under the 1974-75 target prices (Model 1.1) are 1.3 billion bushels, near the 1973 wheat export level of 1.4 billion bushels [6]. Cotton exports under the 1974-75 target prices (Model 1.1) are 10.1 million bales compared to the 1973 cotton export of 5.5 million bales [6]. Soybean exports are 0.8 billion bushels compared to the 1973 soybean exports of 0.5 billion bushels [6]. The use of 1974-75 target prices as the equilibrium farm prices encourages the production of wheat, cotton, and soybeans relatively more than feed grains. The results indicate the long-run equilibrium levels of production to which the agricultural sector will tend, given the assumed regional location of production.

Table 7. Commodity production and utilization under 1974-75 target prices in 1985 (Model 1.1).

Commodity	Unit	Production	Domestic Consumption	Exports
Corn	million bu.	4,948.1	4,676.4	271.7
Sorghum	"	353.7	353.7	0.0
Barley	"	262.0	262.0	0.0
Oats	"	897.4	586.9	310.5
Wheat	"	1,954.6	681.0	1,273.6
Soybeans	"	2,182.3	1,356.5	825.8
Legume hay	million tons	180.0	180.0	0.0
Nonlegume hay	"	186.8	186.8	0.0
Silage	"	547.8	547.8	0.0
Cotton	million bales	18.1	8.1	10.0
Sugar beets	million tons	26.4	26.4	0.0
Pork[a]	million cwt.	159.3	161.7	-2.4[b]
Milk products[c]	"	1,167.3	1,170.6	-3.3[b]
Beef[a]	"	332.0	348.1	-16.1[b]

[a] Carcass weight.
[b] Imports.
[c] Milk equivalents.

Land use

Of the 373.6 million acres available for cultivation, 331.3 million acres are used for crop production and 42.3 million acres are idled (Tables 8, 9, and 10). Of the 42.3 million acres of idle land, 11.9 million acres are on land class V-VIII and are idled due to their susceptibility to high soil erosion rates. In the analysis, 75.4 million acres are used for feed grain production compared with 102.3 million acres during the 1972-73 crop year [19]. This is consistent with the reduced competitive position of the feed grains resulting from lower relative prices. The higher livestock production and changes in the ration increase the demand for roughages as reflected in the higher acreage of hays and silages (Tables 8 and 9). Nitrogen carryover from the legume hays also provides an incentive to increase hay acreage.

Four regions account for 36.8 million acres or 87 percent of the total unused land under 1974-75 target price analysis (Model 1.1). The South Atlantic region has 17 percent; the North Central region, 28 percent; the South Central region, 18 percent; and the Great Plains region, 24 percent of the total unused land.

Water use

Of the 240 million acre-feet of water available, 43 percent (103 million acre-feet) is utilized under the target price alternative (Table 11). This indicates that the total water available in the western United States is in excess supply; however, in specific regions water availability is critical. Agricultural uses account for 78 percent of all water diversion in the analysis.

Table 8. Dryland acreages by major zones under 1974-75 target prices in 1985 (Model 1.1).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	178,236	83,525	54,504	635,491	9,044	960,800
I, II	121,075	36,266	27,345	0	1,654	186,340
IIIE, IVE	23,478	32,582	21,228	0	3,375	80,663
Other III, IV	33,439	14,299	4,706	0	3,781	56,225
V-VIII	244	378	1,225	0	234	2,081
North Atlantic	5,006	1,209	2,431	11,365	227	20,238
I, II	3,298	651	1,372	0	104	5,425
IIIE, IVE	677	397	743	0	61	1,878
Other III, IV	1,018	158	316	0	35	1,527
V-VIII	13	3	0	0	27	43
South Atlantic	16,260	1,065	795	36,533	1,555	56,208
I, II	12,551	772	662	0	260	14,245
IIIE, IVE	1,151	269	5	0	91	1,516
Other III, IV	2,465	20	128	0	1,070	3,683
V-VIII	93	4	0	0	134	231
North Central	91,297	26,029	19,592	53,235	328	190,481
I, II	70,753	17,582	11,319	0	94	99,748
IIIE, IVE	10,498	4,526	7,564	0	133	22,721
Other III, IV	10,014	3,896	709	0	78	14,697
V-VIII	32	25	0	0	23	80
South Central	47,090	22,419	11,302	172,234	733	253,778
I, II	25,393	8,298	2,768	0	392	36,851
IIIE, IVE	6,425	10,849	5,625	0	75	22,974
Other III, IV	15,253	3,135	2,658	0	238	21,284
V-VIII	19	137	251	0	28	435
Great Plains	9,063	22,399	18,112	190,184	5,177	244,935
I, II	5,830	7,579	10,404	0	670	24,483
IIIE, IVE	1,789	10,508	6,375	0	2,849	21,521
Other III, IV	1,417	4,117	359	0	1,658	7,551
V-VIII	27	195	974	0	0	1,196
Northwest	303	6,398	1,440	48,243	803	57,187
I, II	64	1,004	738	0	38	1,844
IIIE, IVE	112	4,104	336	0	97	4,649
Other III, IV	82	1,279	366	0	655	2,382
V-VIII	45	11	0	0	13	69
Southwest	9,217	4,006	832	123,697	221	137,973
I, II	3,186	380	82	0	96	3,744
IIIE, IVE	2,826	1,929	580	0	69	5,404
Other III, IV	3,190	1,694	170	0	47	5,101
V-VIII	15	3	0	0	9	27

[a]Including other hay and cropland pasture.

[b]Summer fallow lands and orchards and vineyards.

Table 9. Irrigated acreages by major zones under 1974-75 target prices in 1985 (Model 1.1).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	12,559	4,057	7,851	9,503	1,600	35,570
I, II	8,759	1,780	4,382	0	934	15,855
IIIE, IVE	1,646	543	964	0	210	3,363
Other III, IV	2,131	1,679	2,405	0	431	6,646
V-VIII	23	55	100	0	25	203
North Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
South Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
North Central	11	0	467	0	0	478
I, II	11	0	347	0	0	358
IIIE, IVE	0	0	4	0	0	4
Other III, IV	0	0	116	0	0	116
V-VIII	0	0	0	0	0	0
South Central	2,398	625	88	198	87	3,396
I, II	1,346	246	86	0	86	1,764
IIIE, IVE	333	10	0	0	1	344
Other III, IV	719	368	2	0	0	1,089
V-VIII	0	1	0	0	0	1
Great Plains	4,641	1,154	2,760	5,394	17	13,966
I, III	3,458	768	2,076	0	5	6,307
IIIE, IVE	769	179	267	0	8	1,223
Other III, IV	406	204	410	0	3	1,023
V-VIII	8	3	7	0	1	19
Northwest	1,856	1,709	3,129	2,366	679	9,739
I, II	1,138	636	1,399	0	394	3,567
IIIE, IVE	369	264	514	0	108	1,255
Other III, IV	337	758	1,123	0	164	2,382
V-VIII	12	51	93	0	13	169
Southwest	3,653	569	1,407	1,545	817	7,991
I, II	2,806	130	474	0	449	3,859
IIIE, IVE	175	90	179	0	93	537
Other III, IV	669	349	754	0	264	2,036
V-VIII	3	0	0	0	11	14

[a]Including other hay and cropland pasture.

[b]Summer fallow lands and orchards and vineyards.

Table 10. Cropland utilization by major zones under 1974-75 target prices in 1985 (Model 1.1).

Zone and soil class	Available land[a] Dry	Irrig.	Unused cropland Dry	Irrig.	Total
			(000 acres)		
United States	344,172	29,437	40,527	1,820	42,347
I, II	175,594	18,107	958	758	1,716
IIIE, IVE	93,982	4,768	17,361	321	17,682
Other III, IV	61,392	6,256	10,481	594	11,075
V-VIII	13,204	306	11,727	147	11,874
North Atlantic	10,268	0	2,396	0	2,396
I, II	4,838	0	0	0	0
IIIE, IVE	2,743	0	1,039	0	1,039
Other III, IV	2,140	0	810	0	810
V-VIII	547	0	547	0	547
South Atlantic	22,477	0	7,313	0	7,313
I, II	12,724	0	370	0	370
IIIE, IVE	4,196	0	3,071	0	3,071
Other III, IV	4,534	0	2,849	0	2,849
V-VIII	1,023	0	1,023	0	1,023
North Central	144,470	481	11,631	3	11,634
I, II	97,001	358	304	0	304
IIIE, IVE	26,150	4	3,869	0	3,869
Other III, IV	17,522	119	3,661	3	3,664
V-VIII	3,797	0	3,797	0	3,797
South Central	85,427	3,734	7,154	563	7,717
I, II	35,147	2,458	32	463	495
IIIE, IVE	24,932	388	2,466	4	2,470
Other III, IV	22,366	879	2,046	91	2,137
V-VIII	2,982	9	2,610	5	2,615
Great Plains	61,651	9,795	9,253	840	10,093
I, II	23,876	6,028	0	0	0
IIIE, IVE	26,145	1,989	5,784	280	6,064
Other III, IV	7,717	1,688	661	483	1,144
V-VIII	3,913	90	2,808	77	2,885
Northwest	9,428	5,884	1,602	10	1,612
I, II	1,538	2,781	0	0	0
IIIE, IVE	5,188	1,066	950	8	958
Other III, IV	2,328	1,893	278	0	278
V-VIII	374	144	374	2	376
Southwest	10,451	9,543	1,178	404	1,582
I, II	470	6,482	252	295	547
IIIE, IVE	4,628	1,321	182	29	211
Other III, IV	4,785	1,677	176	17	193
V-VIII	568	63	568	63	631

[a]Includes only cropland available for endogenous crops.

Table 11. Withdrawals and consumptive use of water in the western river basins under 1974-75 target prices in 1985 (Model 1.1).

River basin	Total 1970[a]	Projected 1985 Agriculture	Municipal and Industrial[b]	Other[c]	Total
		(000 acre-feet per year)			
		Withdrawals			
Western Basins	182,896	94,307	41,962	6,248	142,517
Missouri	26,880	15,896	5,174	1,734	22,804
Ark.-White-Red	13,440	4,792	8,486	0	13,278
Texas-Gulf	23,520	5,536	13,164	0	18,700
Rio Grande	7,056	4,850	1,084	0	5,934
U. Colorado	9,072	2,952	690	189	3,831
L. Colorado	8,064	6,039	1,013	1,937	8,989
Great Basin	7,504	2,950	742	1,177	4,869
Col.-N. Pacific	33,600	18,201	5,109	0	23,310
Cal.-S. Pacific	53,760	33,091	6,500	1,211	40,802
		Consumptive use			
Western Basins	82,432	80,336	17,382	5,550	103,268
Missouri	13,440	14,029	990	1,734	16,753
Ark.-White-Red	7,616	4,543	1,691	0	6,234
Texas-Gulf	6,944	4,536	6,845	0	11,381
Rio Grande	3,696	3,612	452	0	4,064
U. Colorado	4,592	2,356	286	141	2,783
L. Colorado	5,600	5,382	413	1,746	7,541
Great Basin	3,584	2,385	285	849	3,519
Col.-N. Pacific	12,320	15,845	907	0	16,752
Cal.-S. Pacific	24,640	27,648	5,513	1,080	34,241

[a]Source: Marry and Reevers [10, Table 17].

[b]Includes rural domestic, municipal, self-supplied industrial, recreation, mining, and thermal electric power.

[c]Includes onsite uses and water exports out of the western basins.

The value of water as determined from the return to the water restraint varies greatly across the western United States. The average marginal value product of water is \$12.60 per acre-foot, with a range from \$1.50 per acre-foot to \$88.33 per acre-foot.

Regional location of production

Initially the model's crop location patterns are compared with the crop location using the Census of Agriculture as the base [24]. Then, discussion of the commodity prices is given relating the cost (supply price) and the value imputed to the regional location of production restraints. The value of the regional flexibility restraints can be viewed as a measure of the inefficiency of production resulting from the required regional location of production. The regional production restraint prices are greater than zero for those regions where the model, in order to minimize total cost, would indicate a desire to shift production to another region, or to increase production above the maximum allowed.

Figures 9 and 10 indicate the regional distribution of row crops under Model 1.1 and in 1969, respectively. Under Model 1.1 assumptions, 180.5 million acres are devoted to row crops (Figure 9), compared to 127.1 million acres in 1969 (Figure 10) [24]. The increase in row crop acres is a result of the higher domestic consumption and higher exports in 1985 and concentrates in or adjacent to the Corn Belt.

Figures 11 and 12 indicate the distribution of close-grown crops under Model 1.1 and in 1969, respectively. An additional 11.3 million acres are utilized for production of the close-grown crops above the 1969 level

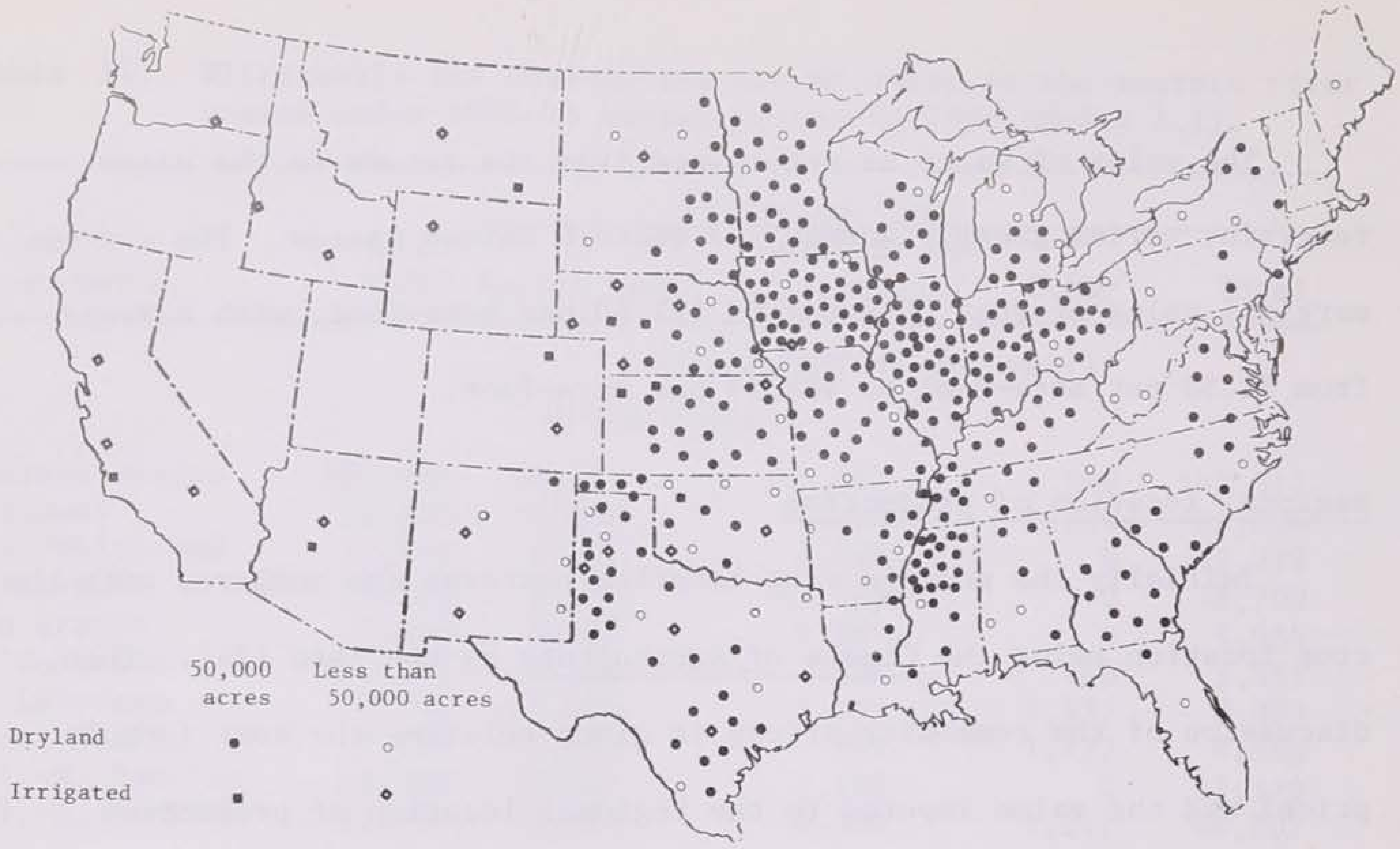

Figure 9. Location of dryland and irrigated row crops under 1974-75 target prices in 1985 (Model 1.1).

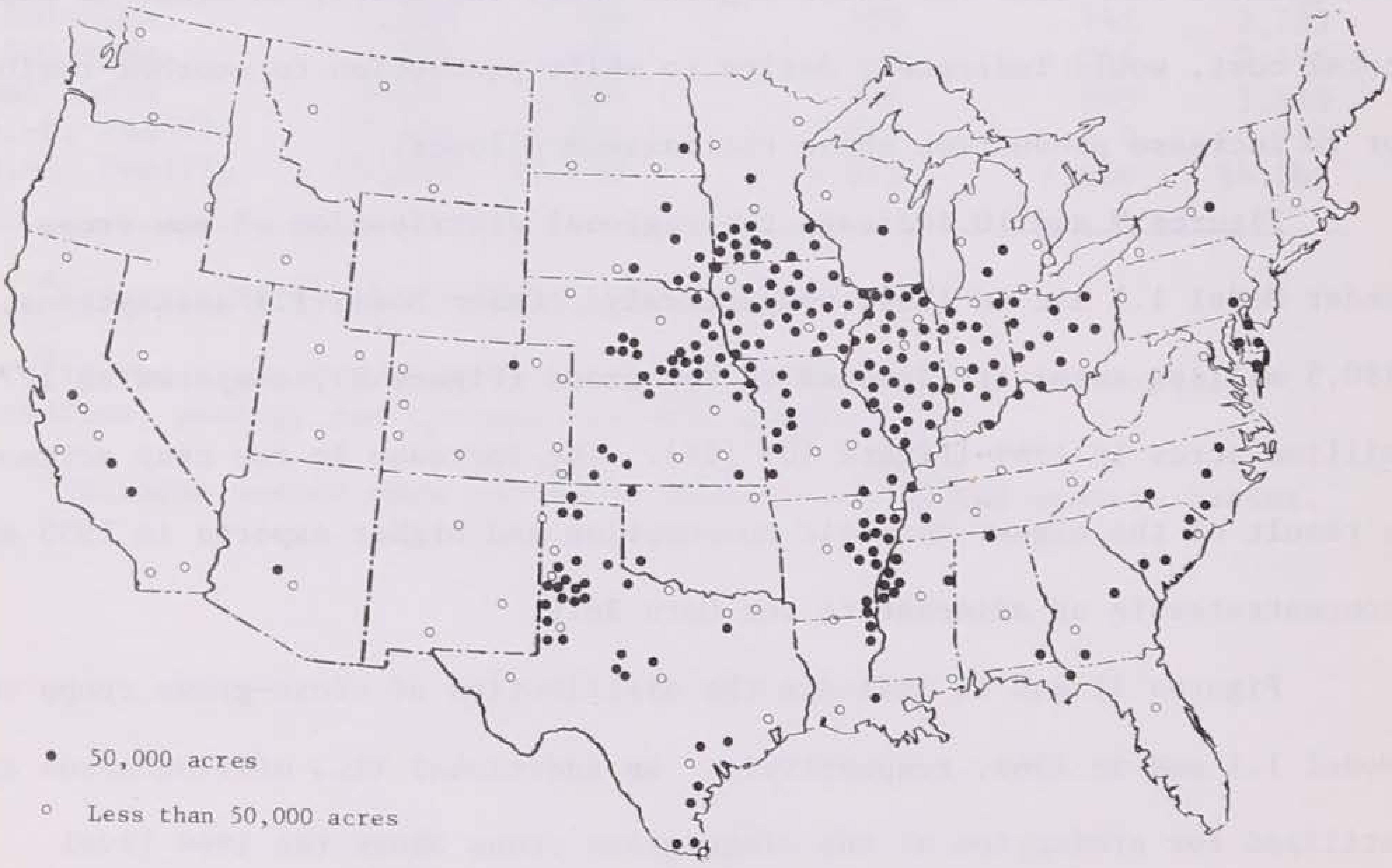

Figure 10. Location of endogenous row crops in 1969.

[i]Source: Census of Agriculture 1969 [24].

Figure 11. Location of endogenous dryland and irrigated close-grown crops under 1974-75 target prices in 1985 (Model 1.1).

Figure 12. Location of endogenous close-grown crops in 1969.

Source: Census of Agriculture 1969 [24].

of 70.6 million acres. Wheat acreage increases by 16.8 million acres from 45.4 million in 1969, with most of the increase in the Central Plains area of the nation.

Figures 13 and 14 indicate the location of hay crops under Model 1.1 and in 1969, respectively. No major shift in location of hay occurs under Model 1.1. The total acres of hay increase by 16.2 million acres from 46.2 million in 1969, due to the higher than 1969 demand for the livestock products. The composition of the hay acreage shifts in response to the nitrogen carryover to include 83 percent legume hay compared with only 48 percent legume hay in 1969.

Regional impacts on commodity prices

The prices of the commodities are determined by both demand or market influences and by the regional location of production influences (Table 12). The regional location of production influences are expressed in terms of location prices. Location prices represent the values of the commodities attributed to a maximum incorporation of the commodities resulting from limitations on the availability of nonendogenous resources and the lower level of production, representing inefficiencies of production as farmers diversify and try to spread risk at the expense of reduced income.[10] Factors affecting the location of production include: farmers' desires to diversify, seasonal labor allocation, diversification for risk purposes, rotations which are not solely of one crop but which contribute to land management, incomplete

[10] The prices are weighted prices on the regional location of production restraints defined for each of the market regions.

Figure 13. Location of endogenous dryland and irrigated hay under 1974-75 target prices in 1985 (Model 1.1).

Figure 14. Location of endogenous hay in 1969.

Source: Census of Agriculture 1969 [24].

information as to the expected prices of the commodities, and other miscellaneous reasons.

Table 12. U.S. average commodity supply, location, and total prices under 1974-75 target prices in 1985 (Model 1.1).

Commodity	Unit	Supply price	Location price	Total price
			(Dollars per unit)	
Corn	(Bu.)	1.32	0.09	1.40
Sorghum	(Bu.)	1.50	0.39	1.89
Barley	(Bu.)	1.32	0.00	1.32
Oats	(Bu.)	0.65	0.00	0.65
Wheat	(Bu.)	1.63	0.27	1.90
Soybeans	(Bu.)	2.72	0.12	2.84
Legume hay	(Ton)	27.73	2.96	30.69
Nonlegume hay	(Ton)	32.56	0.00	32.56
Silage	(Ton)	10.27	0.92	11.19
Cotton	(Lb.)	0.33	0.06	0.39
Pork[a]	(CWT)	39.95	0.16	40.11
Milk[b]	(CWT)	4.86	0.41	5.27
Beef[a]	(CWT)	68.45	0.63	69.08

[a]Carcass weight equivalent.

[b]Milk equivalent.

The national average prices are not the same as the export prices (Table 6) due to transportation costs between the location of production and the exporting market regions where the export prices are obtained. In some regions, because of the small number of acres of a given crop, no production limit has been set and no location price is determined. In the North Atlantic region, 33 percent of the wheat price is attributed to location price. In the South Atlantic region, 40 percent of sorghum price is attributed to location price. The largest location price for corn appears in the South Central region, where 33 percent of the corn price is attributed to location price. In livestock production, pork appears to have the greatest dislocation in the South Central region. On the other hand, beef production seems to be best located in the Northwest, where only one half of one percent of the total price is attributed to location price.

Soil loss and farming practices

Soil erosion in this analysis refers to the gross field loss of soil on the cultivated lands allocated endogenously by the model and reflects a 10-ton per acre maximum soil loss restriction. The average U.S. soil loss per acre is 5.04 tons per year (Table 13). Regionally, the soil loss varies from 2.2 tons per acre in the Northwest to more than 6 tons per acre in the South Atlantic and South Central regions of the country. Under Model 1.1, the total national soil loss from the production of the endogenous crops amounts to more than 1.6 billion tons per year. Of the total soil erosion, 40 percent (.67 billion tons) is produced in the North Central region and 34 percent (.55 billion tons) is produced in the South Central region. The South Atlantic region, which has one of the highest per acre soil loss levels, contributes only 6 percent to the total soil loss because of its relatively small share of the total agricultural product and the farming practices incorporated.

Nationally, 65 percent of the cultivated lands are farmed using conventional tillage-straight row practices (Table 14). All conventional tillage practices taken together account for 85 percent of the cultivated

Table 13. Per acre erosion under conservation practices by major zones under 1974-75 target prices in 1985 (Model 1.1).[a]

Zone and soil class	Conventional tillage Str. row	Contour only	S. crop terrace	Reduced tillage Str. row	Contour only	S. crop terrace	Aver-age
			(ton/acre)				
United States	4.43	7.35	5.14	5.68	8.36	7.49	5.04
I, II	4.62	7.60	5.41	5.34	6.43	0.00	5.14
IIIE, IVE	4.20	6.44	4.79	6.78	9.25	7.51	5.13
Other III, IV	4.12	6.44	5.29	6.41	7.02	6.53	4.65
V-VIII	2.55	7.53	0.00	0.00	0 00	0 00	3.50
North Atlantic	3.66	0.00	0.00	5.20	0.00	4.97	4.83
I, II	2.98	0.00	0.00	5.09	0.00	0.00	4.50
IIIE, IVE	6.75	0.00	0.00	7.52	0.00	4.97	6.61
Other III, IV	0.95	0.00	0.00	3.97	0.00	0.00	3.75
V-VIII	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Atlantic	6.27	7.87	5.53	6.52	7.08	6.03	6.56
I, II	6.22	7.87	5.53	5.71	7.08	0.00	6.51
IIIE, IVE	7.04	7.86	0.00	0.00	0.00	6.03	6.58
Other III, IV	7.27	0.00	0.00	6.82	0.00	0.00	6.87
V-VIII	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Central	4.63	7.68	4.64	5.54	6.96	8.21	5.16
I, II	4.55	7.77	6.45	5.34	5.46	0.00	5.09
IIIE, IVE	4.95	6.96	3.01	6.51	7.94	8.30	5.63
Other III, IV	4.78	7.91	0.00	4.56	0.00	5.54	4.96
V-VIII	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Central	6.97	7.15	5.27	6.56	9.26	7.98	6.69
I, II	7.63	7.55	4.86	5.50	6.19	0.00	7.16
IIIE, IVE	6.34	6.12	5.46	9.35	9.61	7.99	6.85
Other III, IV	5.78	5.16	5.29	9.05	7.02	7.78	5.68
V-VIII	2.51	7.53	0.00	0.00	0.00	0.00	6.68
Great Plains	2.80	3.07	4.88	0.00	0.00	0.00	3.01
I, II	2.95	3.07	2.82	0.00	0.00	0.00	2.95
IIIE, IVE	2.59	0.00	5.06	0.00	0.00	0.00	3.22
Other III, IV	2.68	0.00	0.00	0.00	0.00	0.00	2.68
V-VIII	2.88	0.00	0.00	0.00	0.00	0.00	2.88
Northwest	2.16	0.00	0.00	0.00	0.00	0.00	2.16
I, II	1.59	0.00	0.00	0.00	0.00	0.00	1.59
IIIE, IVE	3.24	0.00	0.00	0.00	0.00	0.00	3.24
Other III, IV	1.41	0.00	0.00	0.00	0.00	0.00	1.41
V-VIII	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Southwest	4.62	5.45	0.00	0.00	0.00	0.00	4.65
I, II	4.58	0.00	0.00	0.00	0.00	0.00	4.58
IIIE, IVE	4.56	5.45	0.00	0.00	0.00	0.00	4.65
Other III, IV	4.72	0.00	0.00	0.00	0.00	0.00	4.72
V-VIII	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a]For all endogenous crops including rotation hay.

Table 14. Acreages under conservation practices by major zones under 1974-75 target prices in 1985 (Model 1.1).[a]

Zone and soil class	Conventional tillage			Reduced tillage		
	Str. row	Contour only	S. crop terrace	Str. row	Contour only	S. crop terrace
	(000 acre)					
United States	215,547	29,123	36,017	37,697	7,779	5,095
I, II	129,259	22,745	10,042	27,683	2,254	0
IIIE, IVE	47,389	4,342	13,582	5,525	5,265	4,965
Other III, IV	37,576	1,725	12,394	4,490	261	130
V-VIII	1,323	312	0	0	0	0
North Atlantic	1,848	0	0	5,533	0	491
I, II	1,365	0	0	3,473	0	0
IIIE, IVE	385	0	0	828	0	491
Other III, IV	97	0	0	1,233	0	0
V-VIII	0	0	0	0	0	0
South Atlantic	3,553	3,681	3,843	2,077	1,222	787
I, II	3,376	3,349	3,843	563	1,222	0
IIIE, IVE	6	332	0	0	0	787
Other III, IV	171	0	0	1,514	0	0
V-VIII	0	0	0	0	0	0
North Central	86,917	11,889	5,312	25,060	1,902	2,236
I, II	64,040	9,659	2,508	20,098	749	0
IIIE, IVE	10,268	1,426	2,804	4,470	1,153	2,164
Other III, IV	12,609	804	0	491	0	73
V-VIII	0	0	0	0	0	0
South Central	36,989	12,490	20,703	5,027	4,655	1,580
I, II	20,838	9,250	3,192	3,549	283	0
IIIE, IVE	9,863	2,007	5,118	227	4,112	1,523
Other III, IV	6,225	920	12,394	1,252	261	57
V-VIII	63	312	0	0	0	0
Great Plains	54,706	486	6,159	0	0	0
I, II	28,918	486	499	0	0	0
IIIE, IVE	16,409	0	5,660	0	0	0
Other III, IV	8,262	0	0	0	0	0
V-VIII	1,118	0	0	0	0	0
Northwest	13,700	0	0	0	0	0
I, II	4,318	0	0	0	0	0
IIIE, IVE	5,297	0	0	0	0	0
Other III, IV	3,943	0	0	0	0	0
V-VIII	142	0	0	0	0	0
Southwest	17,835	577	0	0	0	0
I, II	6,405	0	0	0	0	0
IIIE, IVE	5,161	577	0	0	0	0
Other III, IV	6,269	0	0	0	0	0
V-VIII	0	0	0	0	0	0

[a]For all endogenous crops including rotation hay.

land farmed. Nationwide, 15 percent of the cultivated land is under some form of reduced tillage, concentrating in those areas where a high rate of soil loss takes place. For example, 27 percent of the cultivated acres in the South Atlantic region incorporate reduced tillage in the farming practices as do 22 percent of the cultivated acres in the North Central region.

Agricultural Production Under Adjusted Target Prices (Model 1.2)

This model indicates the production and export response obtainable as the relative commodity prices are altered. In determining the set of altered relative prices, it was desired to obtain an export mix approximating current experiences. Thus, lower prices for cotton and wheat were selected, in conjunction with higher prices for feed grains (Table 6). All other model assumptions remain consistent with the previous analysis (Model 1.1).

Commodity production and utilization

Table 15 indicates the production, domestic consumption, and export levels determined in Model 1.2. The total export of the feed grains reaches 1.4 billion bushels, of which 1.0 billion bushels are corn grain. This compares with the 1973 feed grain exports totaling 1.7 billion bushels, of which 1.3 billion bushels were corn grain [6]. Wheat exports under Model 1.2 assumptions total 1.1 billion bushels compared to 1.4 billion bushels in 1973 [6]. Under Model 1.2 price assumptions, for each bushel of wheat

Table 15. Commodity production and utilization under adjusted target prices in 1985 (Model 1.2).

Commodity	Unit	Production	Domestic consumption	Exports
Corn	million bu.	5,541.4	4,501.7	1,039.7
Sorghum	"	454.9	307.4	147.5
Barley	"	429.7	429.7	0.0
Oats	"	769.6	531.4	238.2
Wheat	"	1,817.9	711.7	1,106.2
Soybeans	"	2,299.2	1,394.3	904.9
Legume hay	million tons	176.8	176.8	0.0
Nonlegume hay	"	187.6	187.6	0.0
Silage	"	564.0	564.0	0.0
Cotton	million bales	12.1	8.0	4.1
Sugar beets	million tons	26.4	26.4	0.0
Pork[a]	million cwt.	159.3	161.7	-2.4[b]
Milk products[c]	million cwt.	1,167.3	1,170.6	-3.3[b]
Beef[a]	million cwt.	332.0	348.1	-16.1[b]

[a]Carcass weight.

[b]Imports.

[c]Milk equivalent.

exported, 1.29 bushels of feed grains are exported. This is close to the 1972-73 ratio of feed grains to wheat exports of 1.23. Sorghum, which is not exported under the 1974-75 target prices (Model 1.1), is exported at the level of 147.5 million bushels under Model 1.2 assumptions. Wheat exports are reduced by 14 percent and cotton exports, which are more than 10 million bales under Model 1.1, reach only 4.1 million bales.

Land use

The data in Tables 16, 17, and 18 indicate the dryland, irrigated, and overall land-use patterns under Model 1.2 assumptions. Total land use increases 6 million acres over the level of Model 1.1. The increase in dryland use accounted for 5.9 million acres of this total. The acreage shifts within the crop-use categories are consistent with the production patterns (Table 15), i.e., corn acreage increases and cotton decreases. Regionally, the increase in land utilization takes place mostly in the North Central (up 2.4 million acres) and the South Central (up 2.9 million acres) regions. Comparing Model 1.2 land use to the 1973 crop year indicates a closer balance in the pattern of production than the distribution obtained under Model 1.1 (Table 19).

Model 1.2 serves as a base model for the remainder of the alternatives in the study. Its results, especially in terms of exports and land use, tend to be more closely related to the current U.S. patterns. Some of the differences can be explained in terms of long-run changes which will take place if U.S. agriculture is exposed to higher prices. For example, the increased production of silage (corn and sorghum) from 15.0 million acres in 1973 [19] to 45.3 million acres in Model 1.2 (Table 19), reflects the fact that one acre of silage can produce up to 50 percent more beef than an acre of grain. Estimates indicate that an acre of corn fed as grain can produce about 800 pounds of beef, while the same acre of corn fed as silage can produce 1,200 pounds of beef.[11]

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[11] Interview given to The Des Moines Register and Tribune by Dr. S.A. Ewing, Head, Department of Animal Science, Iowa State University, Ames, Iowa, July 20, 1974.

Table 16. Dryland acreages by major zones under adjusted target prices in 1985 (Model 1.2).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	186,409	81,534	54,836	635,491	8,462	966,732
I, II	126,064	33,059	26,260	0	1,670	187,053
IIIE, IVE	26,549	32,193	21,890	0	3,511	84,143
Other III, IV	33,552	15,904	5,461	0	3,047	57,964
V-VIII	244	378	1,225	0	234	2,081
North Atlantic	5,288	1,185	2,430	11,365	227	20,495
I, II	3,384	612	1,325	0	104	5,425
IIIE, IVE	674	394	734	0	61	1,863
Other III, IV	1,217	176	371	0	35	1,799
V-VIII	13	3	0	0	27	43
South Atlantic	16,452	1,065	972	36,533	1,555	56,577
I, II	12,694	772	752	0	260	14,478
IIIE, IVE	1,200	269	92	0	91	1,652
Other III, IV	2,465	20	128	0	1,070	3,683
V-VIII	93	4	0	0	134	231
North Central	96,953	23,447	18,890	53,235	328	192,853
I, II	75,463	14,638	9,675	0	94	99,870
IIIE, IVE	11,042	4,526	8,262	0	133	23,963
Other III, IV	10,416	4,258	953	0	78	15,705
V-VIII	32	25	0	0	23	80
South Central	49,362	21,758	11,558	172,234	733	255,645
I, II	25,643	8,328	2,827	0	392	37,190
IIIE, IVE	8,736	9,795	5,463	0	75	24,069
Other III, IV	14,964	3,498	3,017	0	238	21,717
V-VIII	19	137	251	0	28	435
Great Plains	9,257	23,306	18,662	190,184	4,535	245,944
I, II	5,953	7,065	10,801	0	667	24,486
IIIE, IVE	1,932	11,126	6,501	0	2,986	22,545
Other III, IV	1,345	4,920	386	0	882	7,533
V-VIII	27	195	974	0	0	1,196
Northwest	303	6,416	1,510	48,243	803	57,275
I, II	64	945	798	0	38	1,845
IIIE, IVE	112	4,164	276	0	97	4,649
Other III, IV	82	1,296	436	0	655	2,469
V-VIII	45	11	0	0	13	69
Southwest	8,794	4,357	814	123,697	281	137,943
I, II	2,863	699	82	0	115	3,759
IIIE, IVE	2,853	1,919	562	0	68	5,402
Other III, IV	3,063	1,736	170	0	89	5,058
V-VIII	15	3	0	0	9	27

[a] Including other hay and cropland pasture.

[b] Summer fallow lands and orchards and vineyards.

Table 17. Irrigated acreages by major zones under adjusted target prices in 1985 (Model 1.2).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	12,010	4,920	7,626	9,503	1,600	35,659
I, II	8,438	1,710	4,738	0	934	15,820
IIIE, IVE	1,624	598	1,091	0	210	3,523
Other III, IV	1,925	2,557	1,697	0	431	6,610
V-VIII	23	55	100	0	25	203
North Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
South Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
North Central	0	0	478	0	0	478
I, II	0	0	358	0	0	358
IIIE, IVE	0	0	4	0	0	4
Other III, IV	0	0	116	0	0	116
V-VIII	0	0	0	0	0	0
South Central	2,214	605	188	198	87	3,292
I, II	1,288	255	134	0	86	1,763
IIIE, IVE	255	36	52	0	1	344
Other III, IV	671	313	2	0	0	986
V-VIII	0	1	0	0	0	1
Great Plains	5,142	1,135	2,501	5,394	17	14,189
I, II	3,902	702	1,696	0	5	6,305
IIIE, IVE	826	204	342	0	8	1,380
Other III, IV	406	226	456	0	3	1,091
V-VIII	8	3	7	0	1	19
Northwest	1,854	1,713	3,129	2,366	679	9,741
I, II	1,139	636	1,399	0	394	3,568
IIIE, IVE	366	268	514	0	108	1,256
Other III, IV	337	758	1,123	0	164	2,382
V-VIII	12	51	93	0	13	169
Southwest	2,800	1,467	1,330	1,545	817	7,959
I, II	2,109	117	1,151	0	449	3,826
IIIE, IVE	177	90	179	0	93	539
Other III, IV	511	1,260	0	0	264	2,035
V-VIII	3	0	0	0	11	14

[a] Including other hay and cropland pasture.

[b] Summer fallow lands and orchards and vineyards.

Table 18. Cropland utilization by major zones under adjusted target prices in 1985 (Model 1.2).

Zone and land class	Available land[a]		Unused cropland		
	Dry	Irrig.	Dry	Irrig.	Total
	(000 acres)				
United States	344,172	29,437	34,981	1,355	36,336
I, II	175,594	18,107	605	437	1,042
IIIE, IVE	93,982	4,768	13,879	166	14,045
Other III, IV	61,392	6,256	8,770	605	9,375
V-VIII	13,204	306	11,727	147	11,874
North Atlantic	10,268	0	2,141	0	2,141
I, II	4,838	0	0	0	0
IIIE, IVE	2,743	0	1,054	0	1,054
Other III, IV	2,140	0	540	0	540
V-VIII	547	0	547	0	547
South Atlantic	22,477	0	6,944	0	6,944
I, II	12,724	0	137	0	137
IIIE, IVE	4,196	0	2,935	0	2,935
Other III, IV	4,534	0	2,849	0	2,849
V-VIII	1,023	0	1,023	0	1,023
North Central	144,470	481	9,259	3	9,262
I, II	97,001	358	182	0	182
IIIE, IVE	26,150	4	2,628	0	2,628
Other III, IV	17,522	119	2,652	3	2,655
V-VIII	3,797	0	3,797	0	3,797
South Central	85,427	3,734	5,726	228	5,954
I, II	35,147	2,458	32	124	156
IIIE, IVE	24,932	388	1,371	4	1,375
Other III, IV	22,366	879	1,713	95	1,808
V-VIII	2,982	9	2,610	5	2,615
Great Plains	61,651	9,795	8,179	685	8,864
I, II	23,876	6,028	0	0	0
IIIE, IVE	26,145	1,989	4,759	125	4,884
Other III, IV	7,717	1,688	612	483	1,095
V-VIII	3,913	90	2,808	77	2,885
Northwest	9,428	5,884	1,516	10	1,526
I, II	1,538	2,781	0	0	0
IIIE, IVE	5,188	1,066	950	8	958
Other III, IV	2,328	1,893	192	0	192
V-VIII	374	144	374	2	376
Southwest	10,451	9,543	1,216	429	1,645
I, II	470	6,482	254	313	567
IIIE, IVE	4,628	1,321	182	29	211
Other III, IV	4,785	1,677	212	24	236
V-VIII	568	63	568	63	631

[a]Includes only cropland available for endogenous crops.

Table 19. Acres of major crops under 1974-75 target prices (Model 1.1), adjusted target prices (Model 1.2) in 1985, compared with 1973.

Crop	Model 1.1	Model 1.2	1973[a]
		(million acres)	
Corn grain	48.3	53.3	61.8
Soybeans	63.8	67.1	56.4
Wheat	62.2	59.5	53.9
Hay crops	62.3	62.5	62.2
Sorghum grain	7.5	9.9	15.9
Cotton	15.1	11.4	12.0
Barley	5.4	9.1	10.5
Oats	14.3	12.2	14.1
Silage	44.6	45.3	15.0

[a]Source: Statistical Reporting Service [19].

Under Model 1.2, 68 percent of the row crops are grown on land classes I and II. This compares with 63 percent in 1967 [2]. About 80 percent of the close-grown crops are divided between land classes I through IV compared with 96 percent in 1967 [2]. Land classes I-IV also account for 88 percent of all the hay crops under Model 2.1 and 84 percent in 1967 [2]. Total unused cropland under Model 1.2 is 36.3 million acres (Table 18), with a lower concentration of idled cropland in the central regions as compared to Model 1.1.

Regional location of production

The location of production of the row crops, close-grown crops, and hay crops under the adjusted target prices (Model 1.2) shows only minor changes from the 1974-75 target prices (Model 1.1). Because of the large increase in corn acres, the Corn Belt states indicate a larger acreage of row crops. The reduction in cotton acreage is offset by local shifts to soybeans in the South Central and Southeast regions of the country. The close-grown crops concentrate in the Central Plains area.

Regional impacts on commodity prices

At a national level, Model 1.2 indicates slightly higher prices than Model 1.1 (Tables 20 and 12, respectively). Corn price increases five cents per bushel, and sorghum price increases four cents per bushel. However, cotton and soybean prices both decrease. The location price for all grain crops, except wheat, are reduced. This indicates that under the adjusted target prices (Model 1.2), the production restraints are more consistent with the optimal location of production than under the 1974-75 target prices (Model 1.1). The cotton and wheat location prices increased as their relative land use in marginal areas is challenged by the now relatively higher priced feed grains.

One measure of the location efficiency of production[12] is to compare the location price of a commodity to the total price of the commodity. Under Model 1.2, location price increases the national price of the commodities as follows: corn, 4 percent; sorghum, 17 percent; wheat, 15 percent; soybeans, 2 percent; legume hay, 11 percent; and beef, 1 percent (Table 20). It will be shown later that, in general, as the level of production increases to satisfy higher exports, the proportion of location price to the total price of the commodity tends to decrease.

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[12]Inefficiency in regional location of production can be attributed to farmers risk aversion, incomplete information, and slow adoption of new crop varieties and production methods.

Table 20. U.S. average commodity supply, location, and total prices under adjusted target prices in 1985 (Model 1.2).

Commodity	Unit	Supply price	Location price	Total price
		(Dollars per unit)		
Corn	(Bu.)	1.39	0.06	1.45
Sorghum	(Bu.)	1.61	0.32	1.93
Barley	(Bu.)	1.28	0.00	1.28
Oats	(Bu.)	0.68	0.00	0.68
Wheat	(Bu.)	1.64	0.28	1.92
Soybeans	(Bu.)	2.65	0.05	2.70
Legume hay	(Ton)	28.69	3.49	32.18
Nonlegume hay	(Ton)	34.43	0.00	34.43
Silage	(Ton)	10.47	0.83	11.30
Cotton	(Lb.)	0.28	0.07	0.35
Pork[a]	(CWT)	41.41	0.17	41.59
Milk[b]	(CWT)	5.01	0.44	5.46
Beef[a]	(CWT)	70.52	0.72	71.23

[a]Carcass weight equivalent.

[b]Milk equivalent.

Feed consumed by livestock

The data in Tables 21 and 22 indicate the quantity of feed consumed by livestock class and the proportion of the total value represented by each feed, respectively. In general, only minor differences exist between the rations fed under the 1974-75 target prices (Model 1.1) and the adjusted target prices (Model 1.2). Thus, despite changes in the relative prices of the feed grains and roughages, the changes are not large enough to greatly shift the ration composition for the livestock classes.

Table 21. Feed consumption by class of livestock in the United States under adjusted target prices in 1985 (Model 1.2).

Class	Feed grains[a]	High protein supplements[b]	Wheat	Forages[c]
	(000 bu.)	(000 cwt.)	(000 bu.)	(000 tons)
Beef cows	143,887	124,477	0	319,938
Beef feeding	335,723	112,097	0	105,925
Dairy	1,415,820	58,806	32,501	37,337
Hogs	1,905,059	157,631	9,579	2,087
All other[d]	1,281,574	260,601	43,398	101,576
Total	5,082,063	713,612	85,478	566,863

[a]Corn equivalent.

[b]Includes soybean and cottonseed oilmeals and high protein grain supplements. Does not include animal protein supplements.

[c]Includes legume hay, nonlegume hay, and pasture, and corn and sorghum silages in hay-equivalent tons.

[d]Includes sheep and lambs, broilers, turkeys, eggs, and other livestock.

Policy Implications

Since the early 1930s agricultural policy in the United States has been based on production control in terms of set-aside acres and other programs to regulate production. In most of these years, in addition to production control, different programs were established to guarantee a reasonable return to the farmer. Most of the price control programs were based on the concept of a parity price system. The Agricultural Act of 1973 is the most recent attempt by the U.S. Congress to depart from the

Table 22. Feed consumption by class of livestock in the United States under adjusted target prices in 1985 (Model 1.2).

Class	Feed grains[a]	High protein supplements[b]	Wheat	Forages[c]	Total
		(Percent distribution)			
Beef cows	0.68	2.32	0.00	34.71	37.71
Beef feeding	1.59	2.09	0.00	11.80	15.48
Dairy	6.69	1.10	0.20	4.03	12.02
Hogs	9.00	2.94	0.06	0.22	12.22
All others[d]	6.06	4.85	0.27	11.39	22.57
Total	24.02	13.29	0.53	62.15	100.00

[a]Corn equivalent.

[b]Includes soybean and cottonseed oilmeals and high protein grain supplements. Does not include animal protein supplements.

[c]Includes legume hay, nonlegume hay, and pasture, and corn and sorghum silages in hay-equivalent tons.

[d]Includes sheep and lambs, broilers, turkeys, eggs, and other livestock.

parity price concept [21]. Specifically, the act reads, "To extend and amend the Agricultural Act of 1970 for the purpose of assuring consumers of plentiful supplies of food and fiber at reasonable prices" [21, p. 1].

With the aid of Models 1.1 and 1.2, we show that if the agricultural industry is to operate under the price structure suggested by the act, other goals (targets) not specified in the act might not be obtained. One such goal is the maintenance of "balanced exports" as reflected in the farmers' response to the prices.

Figure 15 shows agricultural exports under Model 1.1, Model 1.2, and 1972-73 averages. Under Model 1.1 assumptions, farmers received the 1974-75 target prices for their exported commodities. However, under Model 1.2 assumptions, these prices have been adjusted (Table 6) such that a "balanced export basket" is being produced. The export of feed grains (corn, sorghum, and barley) are clearly being suppressed by the 1974-75 target prices (Model 1.1), which at the same time encourages the export of wheat and cotton. The adjusted target prices (Model 1.2) tend to encourage feed grain production and suppress wheat and cotton production relative to Model 1.2 (Figure 15). The relative product mix of exports under the adjusted target prices (Model 1.2) is more in line with the 1972-73 farm exports' mix.

The way in which the government can obtain the most desirable export mix is shown by the study. If it is desirable to encourage the export of directly consumed commodities, wheat and cotton, then the relative ratio of prices as specified in the Agricultural Act of 1973 [21] and used in Model 1.1 seems to be appropriate. However, if it is desired to increase the relative proportion of feed grains in the export basket, the relative prices used in the adjusted target price alternative (Model 1.2) seem to be appropriate.

The different price support policies can have further implications on the regional distribution of production and farm income. The relative distribution of the cultivated land tends to be in favor of wheat and cotton under 1974-75 target prices (Model 1.1) and tends to reduce the number of acres devoted to feed grains (Figures 16, 17, and Table 19).

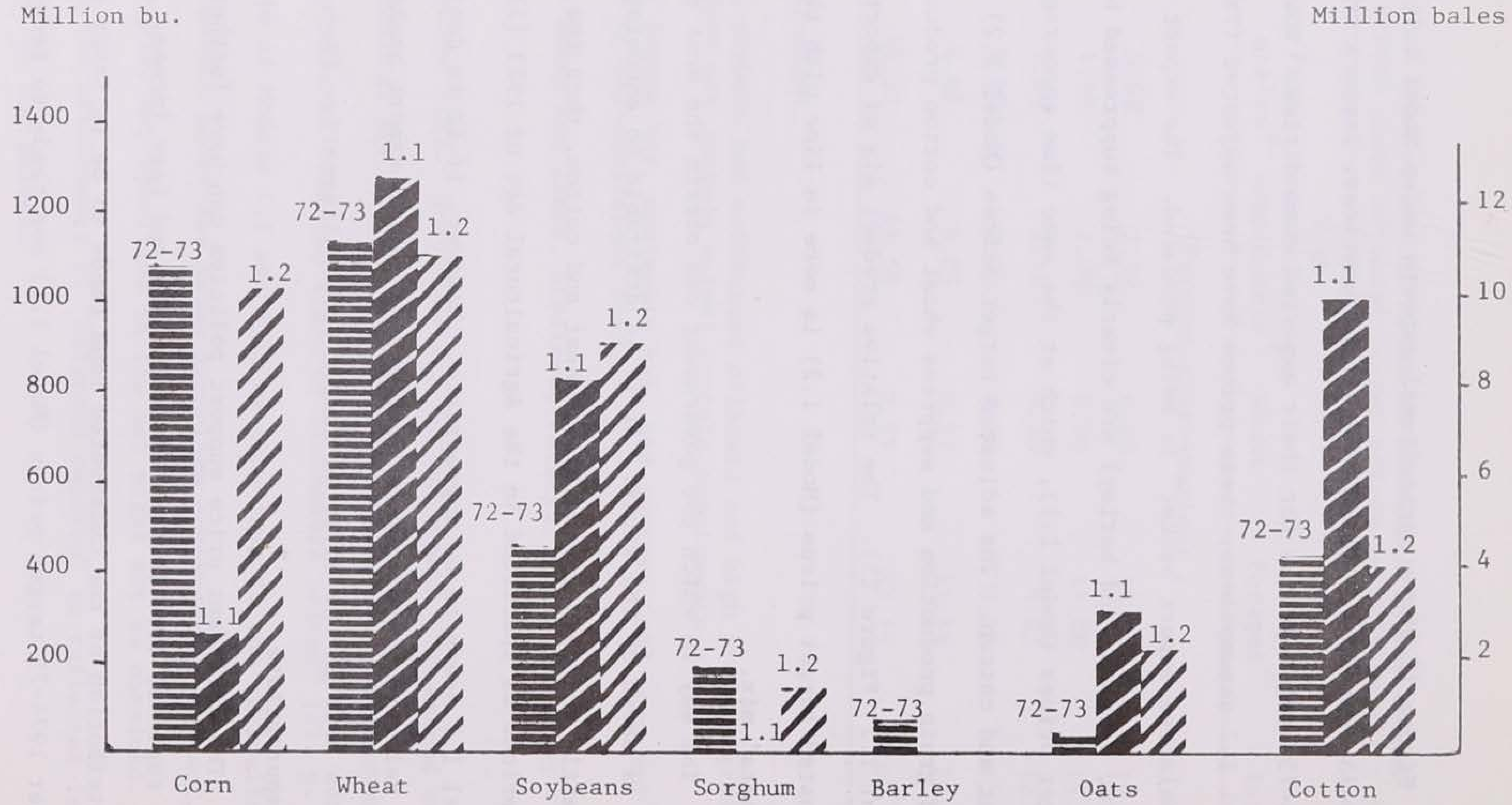

Figure 15. U.S. exports 1972-73 averages,[a] 1974-75 target prices (Model 1.1), and adjusted target prices (Model 1.2) in 1985.

[a]Source: Economic Research Service [6].

target prices (Model 1.2) in 1985.
[a]Source: Economic Research Service [6].

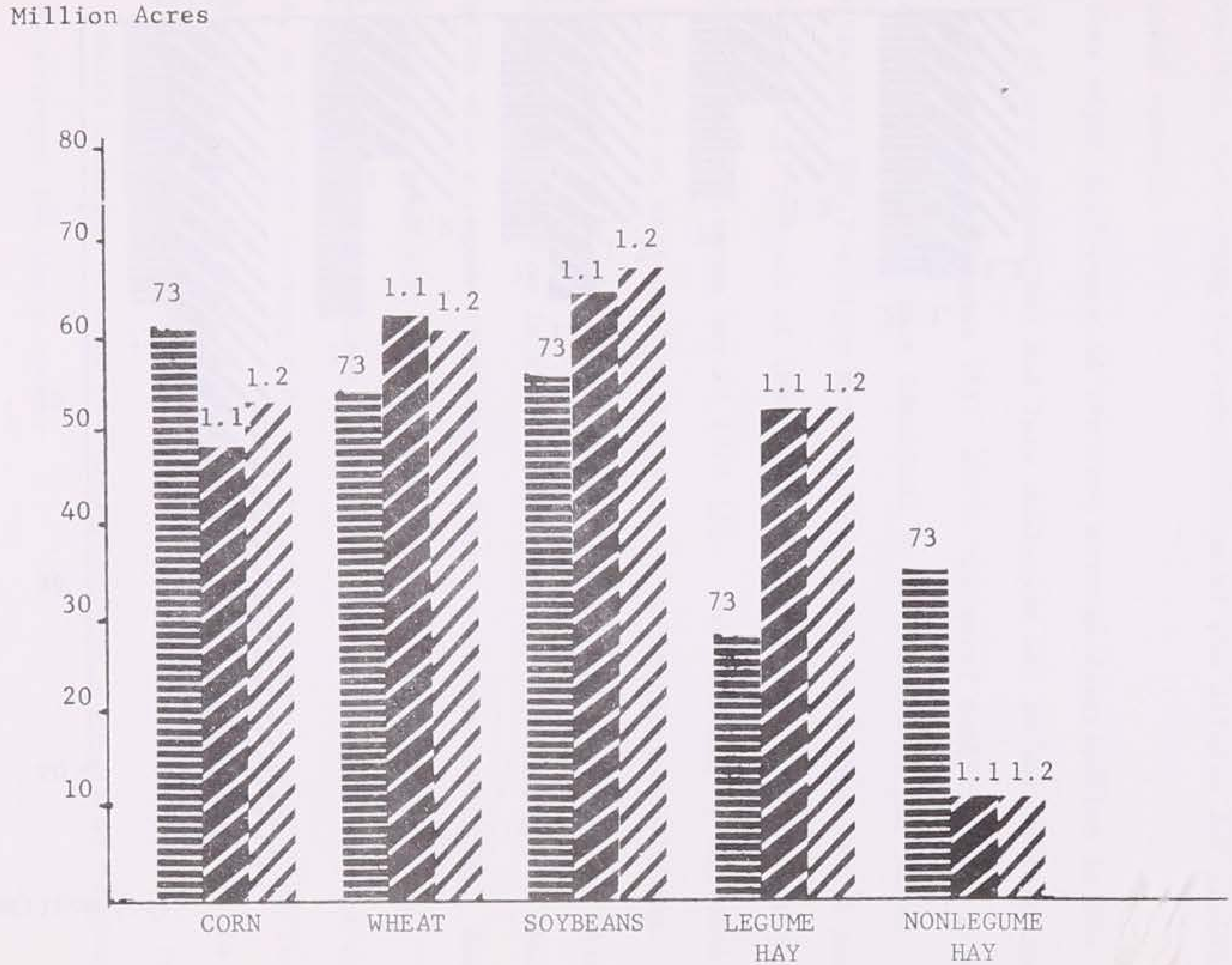

Figure 16. Crop acreages for 1973,[a] 1974-75 target prices (Model 1.1), and adjusted target prices (Model 1.2) in 1985.

[a]Source: Economic Research Service [6].

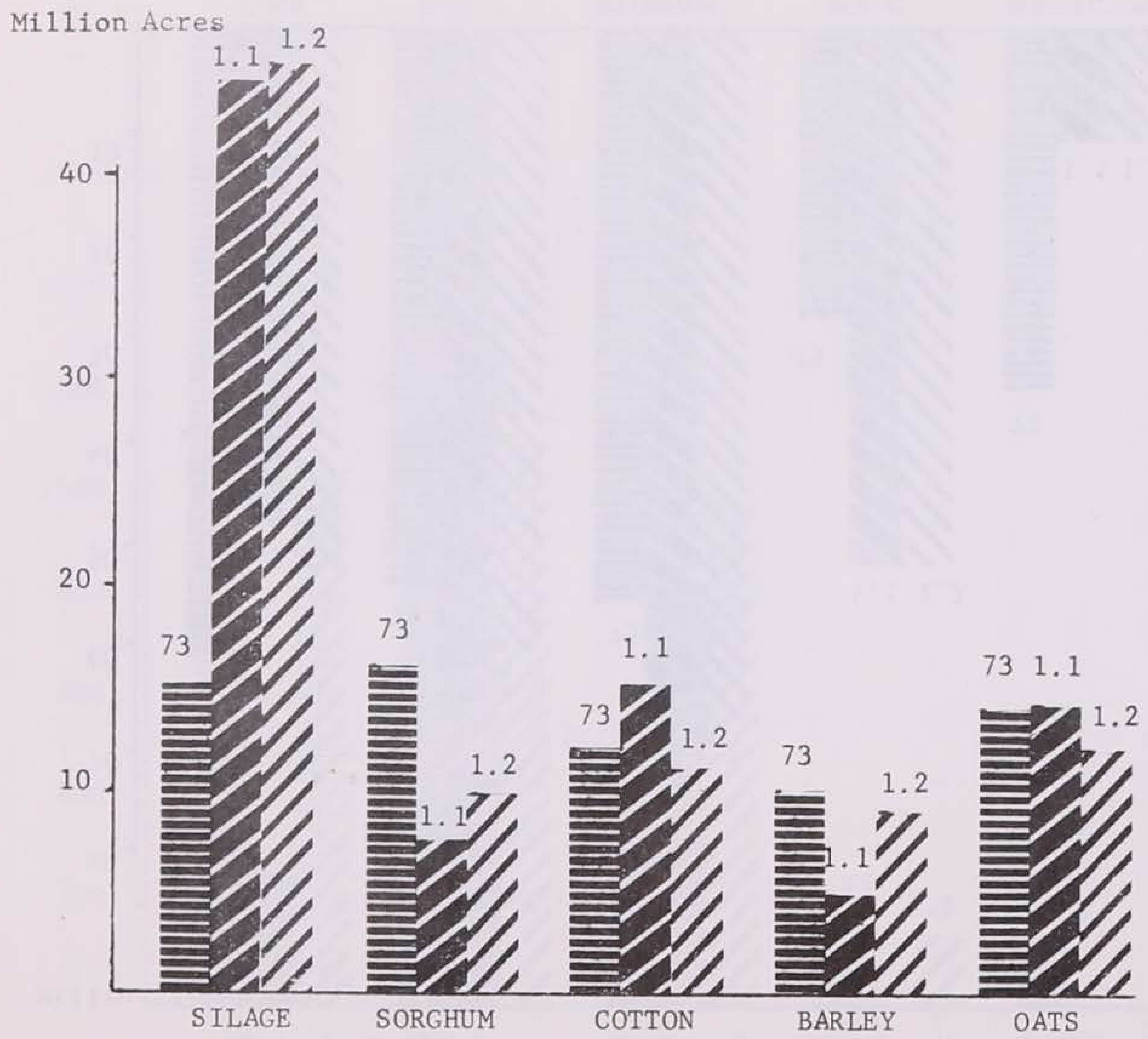

Figure 17. Crop acreages for 1973,[a] 1974,75 target prices (Model 1.1), and adjusted target prices (Model 1.2) in 1985.

[a]Source: Economic Research Service [6].

Overall crop acreages increase by about 20 million acres under the 1974-75 target prices (Model 1.1) and by 28 million acres under the adjusted target prices (Model 1.2) from 1973 [6]. Silage crops (corn and sorghum) present the sharpest increase in acres, up about 30 million acres from 1973, reflecting the substitution of the silages for grains in the livestock rations.

Another major difference in the crop acreage distribution is the appearance of more legume hay and less nonlegume hay in both models compared to 1973 acreages (Figure 16). While the total number of hay acres in Models 1.1 and 1.2 is almost identical to the number of hay acres harvested in 1973 (62.2 million acres), legume hay under Models 1.1 and 1.2 accounts for 83 percent of the total hay acreages. This is compared with only 44 percent legume hay in 1973 [6]. This change, as was explained earlier, reflects an increased utilization of nonfertilizer nitrogen. If the nitrogen produced by the legume crops is credited to the crops which will follow it, as was done in this study, a sizeable advantage is shown by a rotation with a legume crop compared to a nonlegume rotation. Here the model does not take into account noncost technical difficulties associated with the production of legume hay. Despite the technical difficulties, as nitrogen becomes more scarce and expensive because of the energy shortage, and the cost of high protein supplements increases in response to the increase in foreign demand, especially for soybeans, farmers may move toward a larger acreage of legume crops as a source of roughage as well as nitrogen for their crops.

The overall land use increases by about six million acres under the adjusted target prices (Model 1.2) compared with the 1974-75 target prices (Model 1.1). However, the national average land rent (marginal value products) does not show any significant change (Table 23). The regional land rents however, reflect the relative changes in the crops grown. For example, the land rent under the adjusted target prices (Model 1.2) in the North Central region increases because of the larger corn acreage. At the same time, the land rent in the North Atlantic region declines because of the smaller wheat acreage under the adjusted target prices (Model 1.2)

Table 23. Land rents (marginal value products) under 1974-75 target prices (Model 1.1) and adjusted target prices (Model 1.2) in 1985.

Major Zone	Model 1.1	Model 1.2
	(dollars per acre)	
United States	31.63	31.59
North Atlantic	14.61	10.84
South Atlantic	14.04	14.65
North Central	33.03	37.74
South Central	42.05	33.21
Great Plains	21.28	23.39
Northwest	38.12	40.00
Southwest	26.81	23.97

The effect of the different pricing policies on the overall domestic cost of food can be measured in terms of per capita cost of food. Under the adjusted target prices (Model 1.2), the per capita cost of food is up by less than three percent from the 1974-75 target prices (Model 1.1).

Farm income, defined here as the total return to land, water, and labor, is \$85 million higher under the adjusted target prices (Model 1.2) than under the 1974-75 target prices (Model 1.1).

V. EXPORT CAPACITY OF U.S. AGRICULTURE AND REGIONAL PRODUCTION FLEXIBILITY

This part of the study is constructed such that U.S. agriculture capacity can be measured under different assumed rates of adjustment in the regional location of production and crop specialization. Model 2.1 assumes only minor adjustments in the regional production pattern when compared with the regional production in 1969 [24]. It requires crop production to meet at least 80 percent of 1969 acres and livestock units. Under Model 2.2 assumptions, the regional location of production is required to meet 50 percent of 1969 acres and livestock units. For the first two models, crop acreages are not allowed to exceed 200 percent of 1969 acreages, and livestock production is not allowed to exceed 300 percent of 1969 livestock units. The last model in set two, Model 2.3, puts no upper or lower limits on the regional production patterns other than those consistent with the rotations, soil loss restraints, and the land base.

The prices used for these models (Table 24) are twice the level of the commodity export prices determined under adjusted target prices (Model 1.2). The three models in set two used the high export prices to encourage full use of the nation's agricultural resources.

A maximum annual soil loss limit of five tons per acre restricts the crop rotations selected in this part of the study. This restriction encourages the use of farming practices such that, even with increased production and exports of agricultural products, environmental standards can be maintained.

Table 24. Commodity export prices under the high export prices in 1985 (Models 2.1, 2.2, and 2.3) and actual 1973 prices.

Commodity	Unit	1973[a]	High export prices
Wheat	bushel	$4.00	$4.00
Corn	"	2.38	3.00
Cotton	pound	.45	.56
Barley	bushel	2.13	2.80
Sorghum	"	3.80	3.40
Oats	"	1.16	1.30
Soybeans	"	5.57	5.57

[a]Source: Statistical Reporting Service [17].

If no restriction is imposed on the export of corn and cotton, the model will export these commodities in quantities that exceed a reasonable market mix. To overcome this problem, a maximum export of 3.5 billion bushels of corn and 10 million bales of cotton are imposed on the model. These levels still allow for a substantial increase in exports over the 1973 levels of 1.2 billion bushels and 6.1 million bales for corn and cotton, respectively [23].

Production Location Patterns Restricted to 80 Percent of the 1969 Acres (Model 2.1)

Model 2.1 is the most locationally restrictive model in set two. The 1985 production location restrictions include: a minimum of 80 percent of the acres planted in 1969 for corn, wheat, soybeans, cotton, sorghum, and legume hay. These crops, except legume hay, also have a maximum limit of twice the acres planted in 1969 [24]. Legume hay acreage in 1985 is allowed to increase to three times the 1969 acres. A minimum of 80 percent and a maximum of 300 percent of the 1969 livestock production level in each region is set for beef cow, beef feeding, hogs, and dairy production.

Commodity production and utilization

The levels of production, domestic consumption, and exports of the specified agricultural commodities are given in Table 25. Exports of the feed grains increase from 1.4 billion bushels under Model 1.2 (Table 15) to 5.5 billion bushels, almost four times, in response to the higher export prices of Model 2.1. The export of feed grains under the higher export prices is about three times greater than the 1973 feed grain export level [23]. Wheat exports increase from about 1.1 billion bushels to 1.8 billion bushels in response to the price increase between Models 1.2 and 2.1. Soybean exports increase from 0.9 billion bushels in Model 1.2 to 1.4 billion bushels in Model 2.1 (Tables 15 and 25, respectively). Cotton exports under Model 2.1 are at the upper limit allowed of 10 million bales. This compares to the 6.1 million bales exported in 1973 [23], the recent high export level for cotton. As a result of the high meat prices in Model 2.1, the domestic consumption of beef and pork is lower than under Model 1.2. This reduction in demand for livestock products frees feed grains for export as well as freeing land from roughage production. Model 2.1 shows that with moderate flexibility, U.S. farmers can increase their output and exports substantially in response to the higher export prices by 1985.

Table 25. Commodity production and utilization under high export prices in 1985 (Model 2.1).

Commodity	Unit	Production	Domestic Consumption	Exports
Corn	million bu.	8,117.3	4,617.3	3,500.0
Sorghum	"	1,350.4	271.1	1,079.3
Barley	"	821.7	219.8	601.9
Oats	"	570.3	249.6	320.7
Wheat	"	2,436.4	668.1	1,768.3
Soybeans	"	2,540.1	1,127.1	1,413.0
Legume hay	million tons	143.7	143.7	0.0
Nonlegume hay	"	195.1	195.1	0.0
Silage	"	292.2	292.2	0.0
Cotton	million bales	18.1	8.1	10.0
Sugar beets	million tons	26.4	26.4	0.0
Pork[a]	million cwt.	156.2	158.6	-2.4[b]
Milk products[c]	"	1,167.3	1,170.6	-3.3[b]
Beef[a]	"	246.6	262.7	-16.1[b]

[a]Carcass weight equivalent

[b]Imports

[c]Milk equivalent

Land use

The higher commodity prices in Model 2.1 bring an additional 22 million acres of dryland into cultivation (Table 26). The acreage shifts include increases of 18 million acres in row crops and 17 million acres in close-grown crops and a reduction of over 15 million acres of hay crops. The higher return for the export commodities encourages maximum production

Table 26. Dryland acreages by major zones under high export prices in 1985 (Model 2.1).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	204,706	98,455	39,626	635,491	10,631	988,909
I, II	129,706	38,809	17,205	0	2,069	187,789
IIIE, IVE	36,662	41,094	12,906	0	5,646	96,308
Other III, IV	37,841	17,524	7,284	0	2,682	65,331
V-VIII	497	1,028	2,231	0	234	3,990
North Atlantic	5,496	1,237	2,555	11,365	227	20,880
I, II	3,364	612	1,345	0	104	5,425
IIIE, IVE	778	436	815	0	61	2,090
Other III, IV	1,341	186	395	0	35	1,957
V-VIII	13	3	0	0	27	43
South Atlantic	20,306	1,638	1,063	36,533	1,555	61,095
I, II	13,067	896	392	0	260	14,615
IIIE, IVE	2,925	476	504	0	91	3,996
Other III, IV	4,221	262	167	0	1,070	5,720
V-VIII	93	4	0	0	134	231
North Central	108,962	24,261	12,068	53,235	328	198,854
I, II	79,753	16,164	4,041	0	94	100,052
IIIE, IVE	16,886	4,150	5,353	0	133	26,522
Other III, IV	12,269	3,769	2,083	0	78	18,199
V-VIII	54	178	591	0	23	846
South Central	49,763	25,531	9,693	172,234	548	257,769
I, II	24,171	10,168	2,511	0	337	37,187
IIIE, IVE	9,729	11,290	3,928	0	153	25,100
Other III, IV	15,835	3,954	3,212	0	30	23,031
V-VIII	28	119	42	0	28	217
Great Plains	9,363	33,944	11,470	190,184	7,553	252,514
I, II	6,331	8,935	8,063	0	1,144	24,473
IIIE, IVE	2,102	18,456	1,662	0	5,043	27,263
Other III, IV	903	6,062	170	0	1,366	8,501
V-VIII	27	491	1,575	0	0	2,093
Northwest	303	8,286	2,013	48,243	204	59,049
I, II	64	1,222	771	0	38	2,095
IIIE, IVE	112	5,565	183	0	97	5,957
Other III, IV	82	1,488	1,036	0	56	2,662
V-VIII	45	11	23	0	13	92
Southwest	10,513	3,558	764	123,697	216	138,748
I, II	2,956	812	82	0	92	3,942
IIIE, IVE	4,130	721	461	0	68	5,380
Other III, IV	3,190	1,803	221	0	47	5,261
V-VIII	237	222	0	0	9	468

[a] Including other hay and cropland pasture.

[b] Summer fallow lands and orchards and vineyards.

per acre utilizing higher cost per unit output processes. Regionally, the changes in dryland use include an increase of 4.5 million acres in the South Atlantic region, 6.0 million acres in the North Central region, 2.1 million acres in the South Central region, 6.6 million acres in the Great Plains region, and only minor changes elsewhere (Tables 16 and 26).

Irrigated land use totals over 35 million acres for both the adjusted target price and the high export price alternatives (Tables 17 and 27, respectively). The high export price alternative (Model 2.1) has a larger row crop acreage but smaller acreage of the close-grown and hay crops. The Southwest and South Central regions are the only areas where total irrigation increases in response to the high export prices.

Almost 10 million of the 14.6 million idle acres (Table 28) are on land groups V to VIII, which are characterized by high soil loss. For Model 2.1, incorporating a 5-ton soil loss limit, 68 percent of the idle acres are in land groups V to VIII (Table 28), while under Model 1.2, incorporating the 10-ton limit, only 33 percent of the idle acres are on land groups V to VIII (Table 18). The land that remains idle is land which either has a high erosion level, and thus presents an ecological problem, or is of low productivity making it unprofitable to cultivate.

Land rent increases by approximately 300 percent as export prices double from the adjusted target price level (Model 1.2). Regionally, the land rents increase proportionally more in the high-yielding central and southern sections of the United States (Table 29). The much larger increases in the land rents arise because the supply of land is relatively inelastic and any increase in the return per acre is directly capitalized into the value of land.

Table 27. Irrigated acreages by major zones under high export prices in 1985 (Model 2.1).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	12,336	4,369	7,378	9,503	1,600	35,186
I, II	8,716	1,905	4,177	0	934	15,732
IIIE, IVE	1,391	544	783	0	210	2,928
Other III, IV	2,209	1,868	2,325	0	431	6,833
V-VIII	20	52	93	0	25	190
North Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
South Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
North Central	0	0	478	0	0	478
I, II	0	0	358	0	0	358
IIIE, IVE	0	0	4	0	0	4
Other III, IV	0	0	116	0	0	116
V-VIII	0	0	0	0	0	0
South Central	2,170	656	285	198	87	3,396
I, II	1,144	304	231	0	86	1,765
IIIE, IVE	254	36	52	0	1	343
Other III, IV	772	315	2	0	0	1,089
V-VIII	0	1	0	0	0	1
Great Plains	4,897	1,273	2,470	5,394	17	14,051
I, II	3,745	848	1,718	0	5	6,316
IIIE, IVE	708	156	252	0	8	1,124
Other III, IV	439	269	500	0	3	1,211
V-VIII	5	0	0	0	1	6
Northwest	1,738	1,643	2,710	2,366	679	9,136
I, II	1,140	574	1,208	0	394	3,316
IIIE, IVE	249	250	296	0	108	903
Other III, IV	337	768	1,113	0	164	2,382
V-VIII	12	51	93	0	13	169
Southwest	3,531	797	1,435	1,545	817	8,125
I, II	2,687	179	662	0	449	3,977
IIIE, IVE	180	102	179	0	93	554
Other III, IV	661	516	594	0	264	2,035
V-VIII	3	0	0	0	11	14

[a]Including other hay and cropland pasture.

[b]Summer fallow lands and orchards and vineyards.

Table 28. Cropland utilization by major zones under high export prices in 1985 (Model 2.1).

Zone and soil class	Available land[a]		Unused cropland		
	Dry	Irrig.	Dry	Irrig.	Total
	(000 acres)				
United States	344,172	29,437	13,967	652	14,619
I, II	175,594	18,107	32	358	390
IIIE, IVE	93,982	4,768	2,353	117	2,470
Other III, IV	61,392	6,256	1,677	105	1,782
V-VIII	13,204	306	9,905	72	9,977
North Atlantic	10,268	0	1,755	0	1,755
I, II	4,838	0	0	0	0
IIIE, IVE	2,743	0	827	0	827
Other III, IV	2,140	0	381	0	381
V-VIII	547	0	547	0	547
South Atlantic	22,477	0	2,426	0	2,426
I, II	12,724	0	0	0	0
IIIE, IVE	4,196	0	591	0	591
Other III, IV	4,534	0	812	0	812
V-VIII	1,023	0	1,023	0	1,023
North Central	144,470	481	3,259	0	3,259
I, II	97,001	358	0	0	0
IIIE, IVE	26,150	4	68	0	68
Other III, IV	17,522	119	161	0	161
V-VIII	3,797	0	3,030	0	3,030
South Central	85,427	3,734	3,499	226	3,725
I, II	35,147	2,458	32	126	158
IIIE, IVE	24,932	388	344	0	344
Other III, IV	22,366	879	299	91	390
V-VIII	2,982	9	2,824	9	2,833
Great Plains	61,651	9,795	2,299	129	2,428
I, II	23,876	6,028	0	0	0
IIIE, IVE	26,145	1,989	339	83	422
Other III, IV	7,717	1,688	5	0	5
V-VIII	3,913	90	1,955	46	2,001
Northwest	9,428	5,884	353	0	353
I, II	1,538	2,781	0	0	0
IIIE, IVE	5,188	1,066	0	0	0
Other III, IV	2,328	1,893	0	0	0
V-VIII	374	144	353	0	353
Southwest	10,451	9,543	376	297	673
I, II	470	6,482	0	232	232
IIIE, IVE	4,628	1,321	184	34	218
Other III, IV	4,785	1,677	19	14	33
V-VIII	568	63	173	17	190

[a] Includes only cropland available for endogenous crops.

Table 29. Land rents (marginal value products) under the adjusted target prices (Model 1.2) and the high export prices (Model 2.1) in 1985.

Zone	Model 1.2	Model 2.1
	(Dollars per acre)	
United States	31.59	92.62
North Atlantic	10.84	22.99
South Atlantic	14.65	56.89
North Central	37.74	112.08
South Central	33.21	99.79
Great Plains	23.39	70.92
Northwest	40.00	89.92
Southwest	23.97	65.57

Regional location of production and commodity prices

Comparing regional location of production under Model 2.1 to location under adjusted target prices (Model 1.2) reveals only minor changes. The change in production under the high export price assumptions (Model 2.1) resulted from increasing intensity of production in almost all regions. The decrease in hay acreage is most pronounced in the Corn Belt and in the wheat growing regions where the hay crops are replaced by the exported crops: corn, wheat, sorghum, and soybeans. The additional acres of the row crops spread west and north of the traditional Corn Belt states.

In general, commodity prices increase in the same proportion as export prices increased from Model 1.2 with moderate exports to Model 2.1 with high exports. For example, the export price of corn increases from \$1.50 to \$3.00 per bushel, and at the same time, the national average selling price of corn increases from \$1.45 to \$2.86 per bushel (Tables 20 and 30).

National selling prices are not the same as export prices because of transportation costs between the location of production and the exporting market regions. But, the weighted average commodity prices for all the exporting market regions (coastline regions) are exactly equal to the export prices. The average cost of transportation for export, is equal to the difference between the export price and the national selling price. For example, the average cost of transporting one bushel of corn for export is 14 cents ($3.00 minus $2.86). The commodity location price accounts for up to 16 percent of the total commodity price in the case of sorghum and as little as two percent of the total commodity price in the case of corn (Table 30). The relatively large increases in the price of feed grains and roughages are reflected in proportionate increases in the feed costs portion of the livestock activities. The price of pork increases by 37 percent and beef by 27 percent (Tables 20 and 30), reflecting the higher nonfeed costs per unit of output of the beef sector. The reduction in the per capita consumption of beef and pork in response to the higher prices (Table 5) also has an impact on the final equilibrium of livestock and commodity prices. The lower total demand allows the livestock to concentrate relatively more heavily in those areas where its production is efficient and tends to reduce the feed price impact.

Feed consumed by livestock

Many of the changes in feed consumption are the result of the relative change in the level of the per capita consumption of livestock products mentioned above. The decline in the consumption of livestock affects the

Table 30. U.S. average commodity supply, location, and total prices under high export prices in 1985 (Model 2.1).

Commodity	Unit	Supply price	Location price	Total price
			(Dollars per unit)	
Corn	(Bu.)	2.79	0.07	2.86
Sorghum	(Bu.)	2.73	0.55	3.28
Barley	(Bu.)	2.53	0.00	2.53
Oats	(Bu.)	1.26	0.00	1.26
Wheat	(Bu.)	3.25	0.55	3.80
Soybeans	(Bu.)	5.42	0.17	5.58
Legume hay	(Ton)	42.11	4.07	46.18
Nonlegume hay	(Ton)	45.46	0.00	45.46
Silage	(Ton)	13.04	1.61	14.66
Cotton	(Lb.)	0.54	0.66	0.60
Pork[a]	(Cwt.)	56.51	0.43	56.94
Milk[b]	(Cwt.)	6.13	0.59	6.73
Beef[c]	(Cwt.)	88.76	0.84	89.60

[a]Carcass weight equivalent.

[b]Milk equivalent.

relative use of the feed components. Consumption of feed grains, high protein supplements, and wheat is reduced by 300 million bushels, 12.2 billion pounds, and 44 million bushels, respectively. These quantities can move directly into the export market. The 121 million ton reduction in roughage allows for a reallocation of their acres to the export crops (Tables 21 and 31).

Table 31. Feed consumption by class of livestock in the United States under high export prices in 1985 (Model 2.1).

Class	Feed grains[a]	High protein supplements[b]	Wheat	Forages[c]
	(000 bu.)	(000 cwt.)	(000 bu.)	(000 tons)
Beef cows	65,501	42,323	0	232,370
Beef feeding	228,388	85,077	0	77,553
Dairy	1,410,733	60,878	0	38,124
Hogs	1,865,231	154,351	159	1,961
All other[d]	1,211,236	249,064	41,794	96,113
Total	4,781,088	591,693	41,953	446,121

[a]Corn equivalent.

[b]Includes soybean and cottonseed oilmeals and high-protein grain supplements. Does not include animal protein supplements.

[c]Includes legume hay, nonlegume hay, and pasture, corn, and sorghum silages in hay-equivalent tons.

[d]Includes sheep and lambs, broilers, turkeys, eggs, and other livestock.

Production Location Patterns Restricted to 50 Percent of the 1969 Acres (Model 2.2)

Model 2.2 is the intermediate step between the higher restrictive production location alternatives and the removal of these restrictions altogether. Under Model 2.2 assumptions, a minimum of 50 percent in each region of the number of acres planted in 1969 is required in 1985 for the following crops: corn, wheat, sorghum, soybeans, cotton, and legume hay. A maximum of only 200 percent of the acres planted in 1969 [24] is allowed in 1985 for all the above crops except for legume hay, in which case an upper limit of 300 percent is allowed. For the four livestock activities--beef cows, beef feeding, dairy cows, and hogs--a minimum of 50 percent of the number of units raised in 1969 is required in 1985 and a maximum of 300 percent of the 1969 level is allowed. All other assumptions employed in Model 2.2 are identical with those used in Model 2.1. Any change in the model results thus can be attributed to the changes in the production location restraints. Differences between these results and those obtained under 80 percent minimum production restraints in Model 2.1 are very small. The only significant difference is an increase in the export of oats--about 60 million bushels more than in Model 2.1.

As in production, only minor changes in land use are observed between Model 2.1 (80 percent restriction) and Model 2.2 (50 percent restriction). The total cultivated dryland increases by only 200,000 acres under Model 2.2. The decline in row crop and close-grown crop acreages (about one million acres) is offset by the increase in cultivated hay crops. A slight increase in the acreage of irrigated cropland occurs. The average land rent decreases by about \$3 per acre under Model 2.2. Regionally, the land rents vary from an increase of \$6.78 per acre in the North Atlantic region to a reduction of \$9.31 per acre in the South Central region.

Regional location of production and commodity prices

Only minor changes in production location occur between Model 2.1 (80 percent minimum production) and Model 2.2 (50 percent minimum production). There are some substitutions within the row crop category, but only minor substitutions between the row crops and close-grown crops.

The change in regional production location price is sometimes substantial; however, the effect of the increase in regional flexibility on the average price of commodities is quite small (Tables 30 and 32). This implies that the total gain to the economy, if measured in terms of opportunity costs of production, obtained from an increase in flexibility of location of production, is quite small.

Table 32. U.S. average commodity supply, location, and total prices under high export prices in 1985 (Model 2.2).

Commodity	Unit	Supply price	Location price	Total price
		(Dollars per unit)		
Corn	(Bu.)	2.75	0.08	2.83
Sorghum	(Bu.)	2.62	0.57	3.18
Barley	(Bu.)	2.53	0.00	2.53
Oats	(Bu.)	1.23	0.00	1.23
Wheat	(Bu.)	3.27	0.45	3.72
Soybeans	(Bu.)	5.35	0.13	5.49
Legume hay	(Ton)	41.87	4.29	46.16
Nonlegume hay	(Ton)	44.76	0.00	44.76
Silage	(Ton)	12.88	1.50	14.38
Cotton	(Lb.)	0.52	0.04	0.56
Pork[a]	(Cwt.)	56.87	0.44	57.31
Milk[b]	(Cwt.)	6.09	0.14	6.23
Beef[a]	(Cwt.)	91.64	0.70	92.34

[a]Carcass weight equivalent.

[b]Milk equivalent.

Production Location Patterns With No Regional Production Restraints (Model 2.3)

Model 2.3 analyzes the U.S. agriculture industry's capacity to export agricultural products if a complete adjustment in regional location of production is possible. This model represents a measurement of the maximum long-run export capacity of U.S. agriculture if it is assumed that all resources are flexible and producers respond fully to economic forces. In analyzing and comparing the production patterns indicated by Model 2.3 (no location restrictions), Model 2.1 (80 percent of 1969 restrictions) serves as the base. Under Model 2.3 assumptions, corn grain exports are restricted to a maximum of 3.5 billion bushels and cotton exports to 10 million bales to maintain a "balanced export" pattern, as was done in Models 2.1 and 2.2.

Commodity production and utilization

Model 2.3 results show a substantial increase in the production and exports of sorghum grain, barley, oats, wheat, and soybeans (Table 33). Sorghum exports under Model 2.3 are 1.5 billion bushels. This compares with only 0.2 billion bushels of sorghum exports in 1973 [23]. Compared with Model 2.1, exports of barley decline by 244 million bushels and oats decline by 157 million bushels (Tables 33 and 25). Wheat exports increase to 2.0 billion bushels compared with only 1.2 billion bushels in 1973 [23]. Soybean exports also increase substantially from 1.4 billion bushels in Model 2.1 to 1.8 billion bushels in Model 2.3. Soybean exports were at an all-time high in 1974, when the United States exported 0.5 billion bushels of soybeans and soybean products [6].

Table 33. Commodity production and utilization under high export prices in 1985 (Model 2.3).

Commodities	Unit	Production	Domestic Consumption	Exports
Corn	million bu.	7,922.9	4,422.9	3,500.0
Sorghum	"	1,736.0	192.2	1,453.8
Barley	"	579.9	222.0	357.9
Oats	"	261.4	97.6	163.8
Wheat	"	2,662.6	667.8	1,994.5
Soybeans	"	2,808.4	1,051.2	1,757.2
Legume hay	million tons	167.0	167.0	0.0
Nonlegume hay	"	186.4	186.4	0.0
Silage	"	272.3	272.3	0.0
Cotton	million bales	18.1	8.1	10.0
Sugar beets	million tons	26.4	26.4	0.0
Pork[a]	million cwt.	156.2	158.6	-2.4[b]
Milk products[c]	"	1,167.3	1,170.6	-2.3[b]
Beef[a]	"	246.6	262.7	-16.1[b]

[a]Carcass weight equivalent.

[b]Imports.

[c]Milk equivalents.

The increase in export levels, which results from removing the upper limits on the regional location of production restraints, are great. In Model 2.2, the reduction in the location of production restraints did not, in many cases, increase the potential acreage of the region's most advantageous crop, as the acreage of this crop was already at its upper limit. In order to reach full production capacity of agricultural commodities, however, many regions have to more than double their cultivated acreage of specific crops. If an increased regional concentration of crops and a change to production methods consistent with increased output is attained, then export levels significantly above present levels could be forthcoming.

Land use

Removal of the regional restrictions on production has resulted in the increased use of more than four million acres of dryland (Table 34) and 440,000 acres of irrigated land (Table 35). Row crop acreage increases by almost seven million acres and hay crops increase by about five million acres, while close-grown crops decrease by about four million acres when compared with Model 2.1 (Tables 26 and 27). Changes in the acreage of some crops include: soybeans and legume hay increase more than eight million acres each; wheat and sorghum grain increase more than six million acres each; corn silage increases more than 2.5 million acres; barley, oats, and corn grain reduce by about five million acres each; nonlegume hay and summer fallow decrease three million acres each; and cotton decreases about two million acres.

The more efficient location of crop production, in general, results in higher yields. However, in cases where a large increase in the crop acreage takes place, some of the increase in yield is offset by the additional acres of lower yielding land. In some cases, the resulting yield is lower than the yield obtained under Model 2.1. As a result of specialization, a noticeable yield change is indicated for cotton, up by .3 bales per acre. This higher yield allows the same number of bales to be

Table 34. Dryland acreages by major zones under high export prices in 1985 (Model 2.3).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	211,443	93,702	45,033	635,491	7,431	993,100
I, II	130,125	37,028	19,000	0	1,868	188,021
IIIE, IVE	41,378	36,122	17,262	0	2,920	97,682
Other III, IV	39,322	19,071	6,114	0	2,409	66,916
V-VIII	618	1,481	2,657	0	234	4,990
North Atlantic	6,720	1,011	2,832	11,365	227	22,155
I, II	4,132	370	819	0	104	5,425
IIIE, IVE	631	509	1,663	0	61	2,864
Other III, IV	1,940	105	258	0	35	2,338
V-VIII	17	27	92	0	27	163
South Atlantic	20,088	2,021	2,300	36,533	1,555	62,497
I, II	13,225	865	265	0	260	14,615
IIIE, IVE	2,858	772	865	0	91	4,586
Other III, IV	3,912	380	1,170	0	1,070	6,532
V-VIII	93	4	0	0	134	231
North Central	112,045	25,755	7,979	53,235	262	199,276
I, II	81,215	15,766	2,978	0	94	100,053
IIIE, IVE	17,452	5,404	3,625	0	67	26,548
Other III, IV	13,151	4,200	811	0	78	18,240
V-VIII	227	385	565	0	23	1,200
South Central	48,930	22,357	15,256	172,234	238	259,015
I, II	21,187	9,479	6,569	0	112	37,347
IIIE, IVE	11,683	7,468	6,220	0	75	25,446
Other III, IV	15,997	5,209	2,173	0	23	23,402
V-VIII	63	201	294	0	28	586
Great Plains	14,226	31,398	11,563	190,184	4,719	252,090
I, II	7,374	8,654	7,307	0	1,150	24,485
IIIE, IVE	5,775	16,295	2,323	0	2,453	26,846
Other III, IV	1,050	5,958	358	0	1,116	8,482
V-VIII	27	491	1,575	0	0	2,093
Northwest	303	7,004	3,319	48,243	171	59,040
I, II	64	1,230	771	0	38	2,103
IIIE, IVE	112	4,330	1,402	0	97	5,941
Other III, IV	82	1,433	1,123	0	23	2,661
V-VIII	45	11	23	0	13	92
Southwest	9,131	4,156	1,784	123,697	259	139,027
I, II	2,928	664	291	0	110	3,993
IIIE, IVE	2,867	1,344	1,164	0	76	5,451
Other III, IV	3,190	1,786	221	0	64	5,261
V-VIII	146	362	108	0	9	625

[a] Including other hay and cropland pasture.

[b] Summer fallow lands and orchards and vineyards.

Table 35. Irrigated acreages by major zones under high export prices in 1985 (Model 2.3).

Zone and soil class	Row	Close grown	All hay[a]	Pasture	Other[b]	Total
			(000 acres)			
United States	12,239	5,468	6,816	9,503	1,600	35,626
I, II	8,685	1,985	4,053	0	934	15,657
IIIE, IVE	1,425	728	1,069	0	210	3,432
Other III, IV	2,109	2,703	1,597	0	431	6,840
V-VIII	20	52	97	0	25	194
North Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
South Atlantic	0	0	0	0	0	0
I, II	0	0	0	0	0	0
IIIE, IVE	0	0	0	0	0	0
Other III, IV	0	0	0	0	0	0
V-VIII	0	0	0	0	0	0
North Central	0	0	467	0	0	467
I, II	0	0	358	0	0	358
IIIE, IVE	0	0	4	0	0	4
Other III, IV	0	0	105	0	0	105
V-VIII	0	0	0	0	0	0
South Central	2,245	628	235	198	87	3,393
I, II	1,218	279	181	0	86	1,764
IIIE, IVE	253	35	52	0	1	341
Other III, IV	774	313	2	0	0	1,089
V-VIII	0	1	0	0	0	1
Great Plaines	4,822	1,584	2,743	5,394	17	14,560
I, II	3,704	961	1,636	0	5	6,306
IIIE, IVE	748	341	524	0	8	1,621
Other III, IV	365	282	579	0	3	1,229
V-VIII	5	0	4	0	1	10
Northwest	1,738	1,843	2,518	2,366	679	9,144
I, II	1,138	572	1,204	0	394	3,308
IIIE, IVE	251	250	310	0	108	919
Other III, IV	337	970	911	0	164	2,382
V-VIII	12	51	93	0	13	169
Southwest	3,434	1,413	853	1,545	817	8,062
I, II	2,625	173	674	0	449	3,921
IIIE, IVE	173	102	179	0	93	547
Other III, IV	633	1,138	0	0	264	2,035
V-VIII	3	0	0	0	11	14

[a] Including other hay and cropland pasture.

[b] Summer fallow lands and orchards and vineyards.

produced on almost two million acres less land. Under the given cotton export limit of 10 million bales, the removal of the production restraints shifts cotton acres from the irrigated lands of the Southwest (Arizona, New Mexico, and part of Texas) to the dryland acres in the Southeast.

Under Model 2.3 only ten million acres remained unused (Table 36). Of this total, nine million acres are on land groups V to VIII which are subject to high erosion rates normally above the limit of five tons per acre per year used in this model.

The removal of the restrictions on the location of production increases the average land rent to $108.35 per acre (Table 37), an increase of 17 percent compared to Model 2.1 (Table 29). The increase in land rent, as a result of the removal of the regional restriction on production, is due to a shift in the returns above costs totally to the land. The increase in land rents can be used as a partial measure of the degree of inefficiency in the regional location of production exhibited in the previous models (Models 2.1 and 2.2).

Water use

The total water consumed under Model 2.3 declines to 98.8 million acre-feet (Table 39). This decline in water use occurs concurrently with an increase of 440,000 acres of irrigated cropland. Thus, the removal of the restrictions on location of production allows a more efficient use of water as high water-using crops are moved to rainfed areas and the lower water-using crops are substituted allowing for greater acreage in areas where previously water availability limited production. Regionally,

Table 36. Cropland utilization by major zones under high export prices in 1985 (Model 2.3).

Zone and soil class	Available land[a] Dry	Irrig.	Unused cropland Dry	Irrig.	Total
	(ooo acres)				
United States	344,172	29,437	9,606	384	9,990
I, II	175,594	18,107	0	238	238
IIIE, IVE	93,982	4,768	517	75	592
Other III, IV	61,392	6,256	175	14	189
V-VIII	13,204	306	8,914	57	8,971
North Atlantic	10,268	0	479	0	479
I, II	4,838	0	0	0	0
IIIE, IVE	2,743	0	53	0	53
Other III, IV	2,140	0	0	0	0
V-VIII	547	0	426	0	426
South Atlantic	22,477	0	1,023	0	1,023
I, II	12,724	0	0	0	0
IIIE, IVE	4,196	0	0	0	0
Other III, IV	4,534	0	0	0	0
V-VIII	1,023	0	1,023	0	1,023
North Central	144,470	481	2,850	0	2,850
I, II	97,001	358	0	0	0
IIIE, IVE	26,150	4	43	0	43
Other III, IV	17,522	119	131	0	131
V-VIII	3,797	0	2,676	0	2,676
South Central	85,427	3,734	2,476	8	2,484
I, II	35,147	2,458	0	0	0
IIIE, IVE	24,932	388	0	0	0
Other III, IV	22,366	879	20	0	20
V-VIII	2,982	9	2,456	8	2,464
Great Plains	61,651	9,795	2,260	83	2,343
I, II	23,876	6,028	0	0	0
IIIE, IVE	26,145	1,989	300	41	341
Other III, IV	7,717	1,688	5	0	5
V-VIII	3,913	90	1,955	42	1,997
Northwest	9,428	5,884	353	0	353
I, II	1,538	2,781	0	0	0
IIIE, IVE	5,188	1,066	0	0	0
Other III, IV	2,328	1,893	0	0	0
V-VIII	374	144	353	0	353
Southwest	10,451	9,543	165	293	458
I, II	470	6,482	0	238	238
IIIE, IVE	4,628	1,321	121	34	155
Other III, IV	4,785	1,677	19	14	33
V-VIII	568	63	25	7	32

[a] Includes only cropland available for endogenous crops.

Table 37. Land rents (marginal value products) of alternative land classes by major zones under high export prices in 1985 (Model 2.3).

Zone	Land classes: I, II	IIIE, IVE	III-IV	V-VIII	Total[a]
	(Dollars per acre)				
United States	130.66	82.65	87.60	21.63	108.35
North Atlantic	116.35	56.95	82.52	22.94	91.48
South Atlantic	108.97	68.80	62.80	0.00	91.34
North Central	137.68	105.66	85.71	17.70	124.45
South Central	141.38	93.85	113.13	27.50	119.24
Great Plains	107.99	56.67	59.39	17.65	78.12
Northwest	166.18	92.51	77.28	96.85	109.53
Southwest	98.40	66.00	67.77	16.10	76.19

[a]Excluding other hay and pasture lands.

a great decline in water consumption appears in the California-South Pacific region where the total water consumption declines by 2.6 million acre-feet (Table 38). At the same time, the consumption of water increases in the upper Colorado and the Columbia-North Pacific regions. The national average price of water (marginal value products) increases only slightly to $19.53 per acre-foot.

Commodity prices and location of production

The removal of location restrictions on production creates a significant change in the value of the commodities produced. Nationally, the weighted average price of the commodities is reduced by only one

Table 38. Withdrawals and consumptive use of water in the western river basins under high export prices in 1985 (Model 2.3).

River basin	Total 1970[a]	Projected 1985 Agriculture	Municipal and industrial[b]	Other[c]	Total
		(000 acre-feet per year)			
		Withdrawals			
Western basins	182,896	89,302	41,962	6,248	137,512
Missouri	26,880	15,146	5,174	1,734	22,054
Ark.-White-Red	13,440	4,911	8,486	0	13,397
Texas-Gulf	23,520	5,313	13,164	0	18,477
Rio Grande	7,056	4,850	1,084	0	5,934
U. Colorado	9,072	3,424	690	189	4,303
L. Colorado	8,064	5,569	1,013	1,937	8,519
Great Basin	7,504	2,950	742	1,177	4,869
Col.-N. Pacific	33,600	17,355	5,109	0	22,464
Cal.-S. Pacific	53,760	29,784	6,500	1,211	37,495
		Consumptive use			
Western basins	82,432	75,778	17,382	5,550	98,710
Missouri	13,440	13,282	990	1,734	16,006
Ark.-White-Red	7,616	4,662	1,691	0	6,353
Texas-Gulf	6,944	4,202	6,845	0	11,047
Rio Grande	3,696	3,612	452	0	4,064
U. Colorado	4,592	2,828	286	141	3,255
L. Colorado	5,600	5,244	413	1,746	7,403
Great Basin	3,584	2,385	285	849	3,519
Col.-N. Pacific	12,320	15,000	907	0	15,907
Cal.-S. Pacific	24,640	24,563	5,513	1,080	31,156

[a] Source: Marry and Reevers [10, Table 17].

[b] Includes rural domestic, municipal, self-supplied industrial, recreation, mining, and thermal electric power.

[c] Includes onsite uses and water exports out of the western basins.

percent (Table 39), but this is accompanied by a significant increase in exports. Using the prices obtained under Model 2.3 as weights (Table 39), the value of the exported commodities increases by 3.2 billion dollars or by 10.6 percent over the Model 2.1 level.

The removal of the locational restrictions of production reduces all location prices to zero, and price variations between different regions under Model 2.3 (no location restrictions) reflect only transportation costs.

Table 39. U.S. average commodity supply, location, and total prices under high export prices in 1985 (Model 2.3).

Commodity	Unit	Supply price	Location price	Total price
		(Dollars per unit)		
Corn	(Bu.)	2.82	0.00	2.82
Sorghum	(Bu.)	3.11	0.00	3.11
Barley	(Bu.)	2.58	0.00	2.58
Oats	(Bu.)	1.12	0.00	1.12
Wheat	(Bu.)	3.70	0.00	3.70
Soybeans	(Bu.)	5.41	0.00	5.41
Legume hay	(Ton)	48.30	0.00	48.30
Nonlegume hay	(Ton)	45.91	0.00	45.91
Silage	(Ton)	15.45	0.00	15.45
Cotton	(Lb.)	0.56	0.00	0.56
Pork[a]	(Cwt.)	56.79	0.00	56.79
Milk[b]	(Cwt.)	6.22	0.00	6.22
Beef[a]	(Cwt.)	90.94	0.00	90.94

[a]Carcass weight equivalent.

[b]Milk equivalent.

Feed consumed by livestock

Livestock production under Model 2.3 is the same as in Model 2.1, but some changes occur in the rations of Model 2.3 (Table 40) as compared to Model 2.1 (Table 31). The beef cow ration is based entirely on forages--hays and silages. The beef feeding ration also indicates a substitution of forages for feed grains. Those two changes result in a decreased use of about three million bushels of feed grains for the livestock of Model 2.3, offset by an increase of about eight million tons of forage.

Table 40. Feed consumption by class of livestock in the United States under high export prices in 1985 (Model 2.3).

Class	Feed grains[a]	High protein supplements[b]	Wheat	Forages[c]
	(000 bu.)	(000 cwt.)	(000 bu.)	(000 tons)
Beef cows	0	-977	0	236,333
Beef feeding	99,353	84,769	0	82,107
Dairy	1,385,937	55,521	0	37,760
Hogs	1,833,042	151,557	0	1,928
All other[d]	1,203,187	249,064	41,794	96,113
Total	4,521,519	539,934	41,794	454,241

[a]Corn equivalent.

[b]Includes soybean and cottonseed oilmeals and high protein grain supplements. Does not include animal protein supplements. Negative number indicates that the supply of high protein supplements by-products from animal slaughter is greater than the amount consumed as feed.

[c]Includes legume hay, nonlegume hay and pasture, corn, and sorghum silages in hay-equivalent tons.

[d]Includes sheep and lambs, broilers, turkeys, eggs, and other livestock.

The removal of the upper limit on the acreage of legume hay increase it by more than eight million acres. The alfalfa which substitutes for the TDN of the feed grains also reduces the demand for oilmeals because of the higher protein content of the legumes. The legumes are also encouraged by their nitrogen carryover, which reduces the demand for commercial nitrogen. The more efficient production pattern also results in an increase in the acres available for producing export commodities.

Policy Implications and Export Capacity

The results presented in this section have far-reaching implications for any agricultural policy which encourages all-out production. Under high prices, agricultural exports can be expected to increase substantially over the export level which U.S. agriculture experienced in the last few years. Even when the regional allocation of production is not optimal, the possible expansion of production and exports is extensive.

Three models have been presented in this section. All three models assume the same export prices (Table 24). The three models are different only with respect to the regional location of production specifications. The most restricted situation is presented in Model 2.1 and most unrestricted in Model 2.3.

Results under high export prices with a 50 percent production restraint (Model 2.2) show only minor differences from those under high export prices with 80 percent production restraints (Model 2.1). Therefore, only two models of this section (Models 2.1 and 2.3) will be compared to the adjusted target prices model (Model 1.2).

The long-run increase in agricultural exports due to changes in export prices (Figure 18) is presented in terms of the adjusted target prices model (Model 1.2) and the high export prices models (Models 2.1 and 2.3). Further increases in exports can be generated if, in addition to high export prices, the optimum regional allocation of production, subject to regional availability of resources, can be obtained (Model 2.3). Due to the increase in export prices alone, by 1985 export of feed grains could increase from 1.4 billion bushels, if the adjusted target prices (Model 1.2) are realized, to 5.5 billion bushels if the high export prices (Model 2.1) are realized--up almost four times. Other substantial increases in exports due to high export prices are also obtained for wheat, soybeans, and cotton in 1985 (Figure 18).

Such a massive export level requires great reorganizations of farm production, transportation systems, and marketing channels. The possibility of export levels as high as presented in this study is highly dependent on the availability of a worldwide market for U.S. food and fiber. If the quantities produced are to be sold at the prices used in this study, a whole set of questions might be asked concerning possible buyers who can afford to buy U.S. farm products at the supply prices indicated.

Under adjusted target prices (Model 1.2), total net value of the seven export commodities is $5.9 billion (1972 dollars). This total export value increases to $31.5 billion under high export prices (Model 2.1) and to $33.8 billion under high export prices with no regional restriction on production in 1985 (Model 2.3). The latter is almost a sixfold increase.[13]

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[13] For the year ending December 31, 1973, the exported value of the above seven crops is $12.6 billion, which is only 71 percent of the total value of food and fibers exported in that record year amounting to $17.7 billion [6].

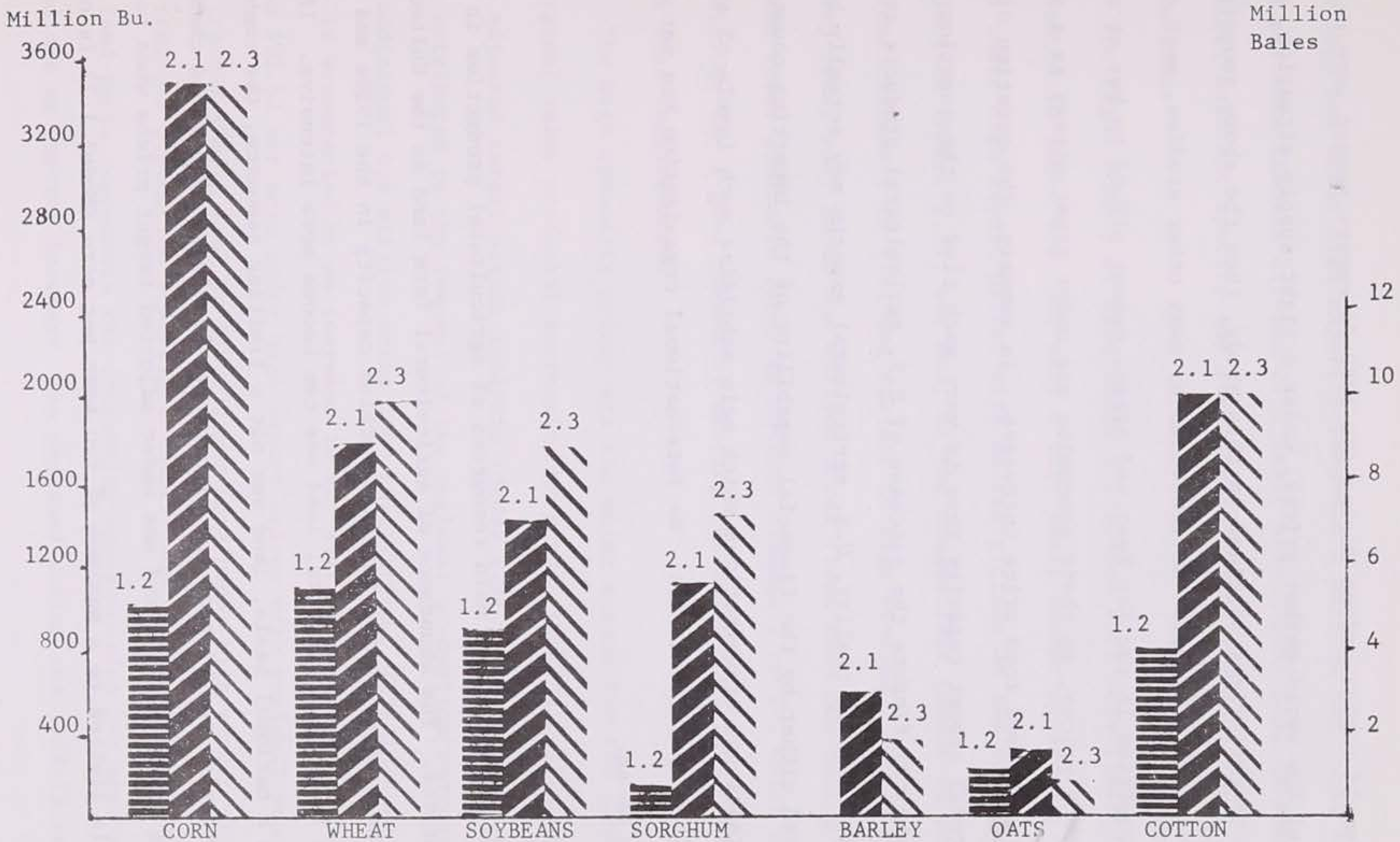

Figure 18. Crop export levels under adjusted target prices (Model 1.2) and high export prices (Models 2.1 and 2.3) in 1985.

If the world market prices during the 1972-74 export season were an indication of how world market prices, under a tight supply situation, are related to the prices obtained in this study, then the above amounts could be substantially higher. As mentioned by many other studies, most of the needy countries in the Far East and Africa cannot afford to buy at such high export prices, as their economies are under great stress as a result of the energy and food price increases. In summary, the question of U.S. agricultural export capacity thus is very much tied to the question of buyers who can finance the purchase of U.S. agricultural products at these supply prices. In reality, U.S. agricultural exports may actually be determined either by the financial capability of the importing countries or international organizations which help subsidize such levels of exports on behalf of poor countries. No international organization has yet come forth to do so.

Land use

Land is one of the main resources of agricultural production in the United States. The abundance of agricultural farm land in the United States was a major reason for farm surplus capacity in the 1950s and 1960s. With the increase in exports, land use can become more intensive. If, at least on a national basis, land was not a limiting resource, the combination of soil erosion restriction and high export levels by 1985 could change this situation drastically. Land use under adjusted target prices when soil erosion is limited to a maximum of ten tons per acre (Model 1.2) is compared with land use under high export prices and a maximum soil loss of five tons per acre (Models 2.1 and 2.3, Table 41). Model 2.3, as mentioned earlier, does not specify any restriction on the regional location of production.

The tight supply of land under a five-ton soil loss limit is clearly presented in Table 41. Not only a very small number of acres remains unused under high export prices with no restriction on the location of production (Model 2.3), but most of the unused land (about 90 percent) is on land classes V to VIII and subject to high erosion. Of the total unused land, only about one million acres (less than one-half of one percent of the total available land) is on land classes I to IV, which under normal conditions has a good chance of meeting the maximum of five tons per acre soil loss requirements.

The high commodity prices are the major reason for the land rents (marginal value products) increasing more than threefold (Figure 19) from the adjusted target prices analysis (Model 1.2). The increase in land use attributed to the removal of the regional production restraints brings an additional 4.6 million acres into cultivation. This increase in land use is accompanied by an increase in the average land rent of 17 percent from \$92.62 per acre under high export prices with regional production restraints (Model 2.1) to \$108.35 per acre under high export prices with no regional production restraints (Model 2.3). This substantial increase in land rents represents the increasing opportunities for agricultural land use as exports increase. As happened during the 1972-73 year, such

Table 41. Land use under adjusted target prices (Model 1.2) and high export prices (Models 2.1 and 2.3) in 1985.[a]

	Model 1.2	Model 2.1	Model 2.3
		(1000 acres)	
Available land dry	344,172	344,172	344,172
Available land irrigated	29,437	29,437	29,437
Available land total	373,609	373,609	373,609
Dry cropland used	309,191	330,205	334,566
Irrigated cropland used	28,082	28,785	29,053
Total land used	337,273	358,990	363,619
Unused dry cropland	34,981	13,967	9,606
Unused irrigated cropland	1,355	652	384
Unused land total	36,336	14,619	9,990
Percent of unused land[b]	9.73%	3.91%	2.67%
Unused land group V-VIII	11,874	9,977	8,971
Percent of the unused land[c]	32.68%	68.25%	89.80%

[a]For endogenous crop uses only.

[b]Total unused land as a percent of the total available land.

[c]Unused land in land group V-VIII as a total of the unused land.

high land rents represent very high gains for farmers who are landowners. However, high land rents tend to discourage new farmers from entering agriculture. Not only does the purchase price of land become very high as a result of the increase in land rents, but also the possible fluctuations in land prices could be much greater if the export levels change from year to year. Relatively, a small change in exports could trigger a much wider fluctuation in land rents and land prices.

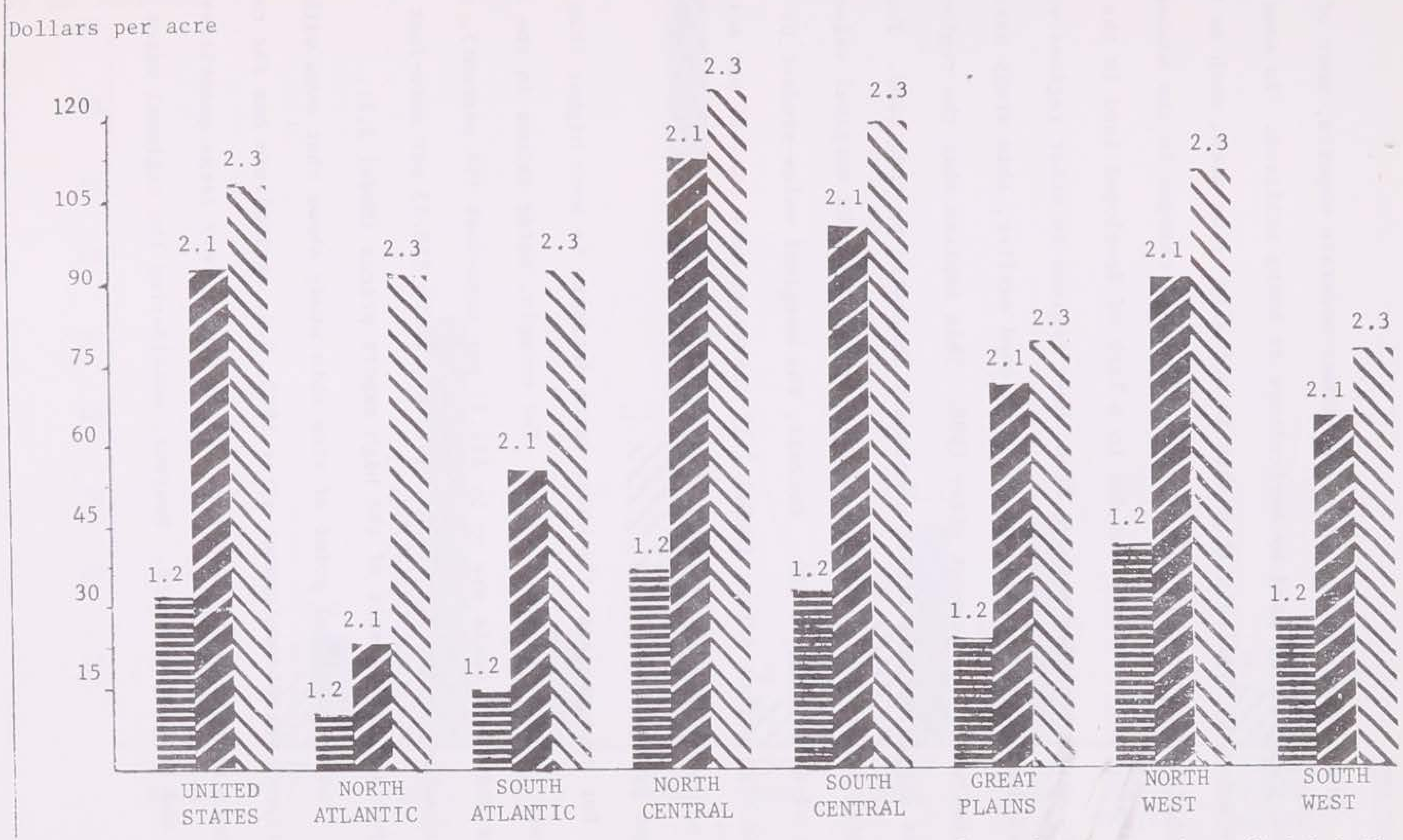

Figure 19. Land rent prices (marginal value products) under adjusted target prices (Model 1.2) and high export prices (Models 2.1 and 2.3) in 1985.

Water use

In contrast to land use, even under moderate exports, most of the water which can be used by agriculture is being utilized. In some regions, more water is available than what is actually being used, such as the Columbia-North Pacific region, but only small changes in the number of irrigated acres are noticed due to a lack of developed land in the region or no water transfer methods from these regions to other regions where developed land is available. As mentioned earlier, this study assumes no further water development after 1980. This implies that the regional water supply becomes almost completely inelastic by that time. The effect of high export prices (Model 2.1) is to increase the marginal value product of water (Figure 20). Overall, the marginal value product of water under high export prices (Model 2.1) increases more than $6 per acre-foot (54 percent) from the average water price obtained under the adjusted target prices (Model 1.2).

For some regions, the water value increase is much higher than the average increase in water value. For example, water values in the Arkansas-White-Red River basin are up by $21.37 per acre-foot (66 percent), and water values in the Rio Grande basin are up by $58.43 per acre-foot or 251 percent as a result of the high export prices (Model 2.1).

From the national point of view this study shows that even without additional water development after 1980, U.S. agriculture has the capacity for both meeting domestic demand and producing very large quantities of food and fiber for export. However, considering the regional water needs,

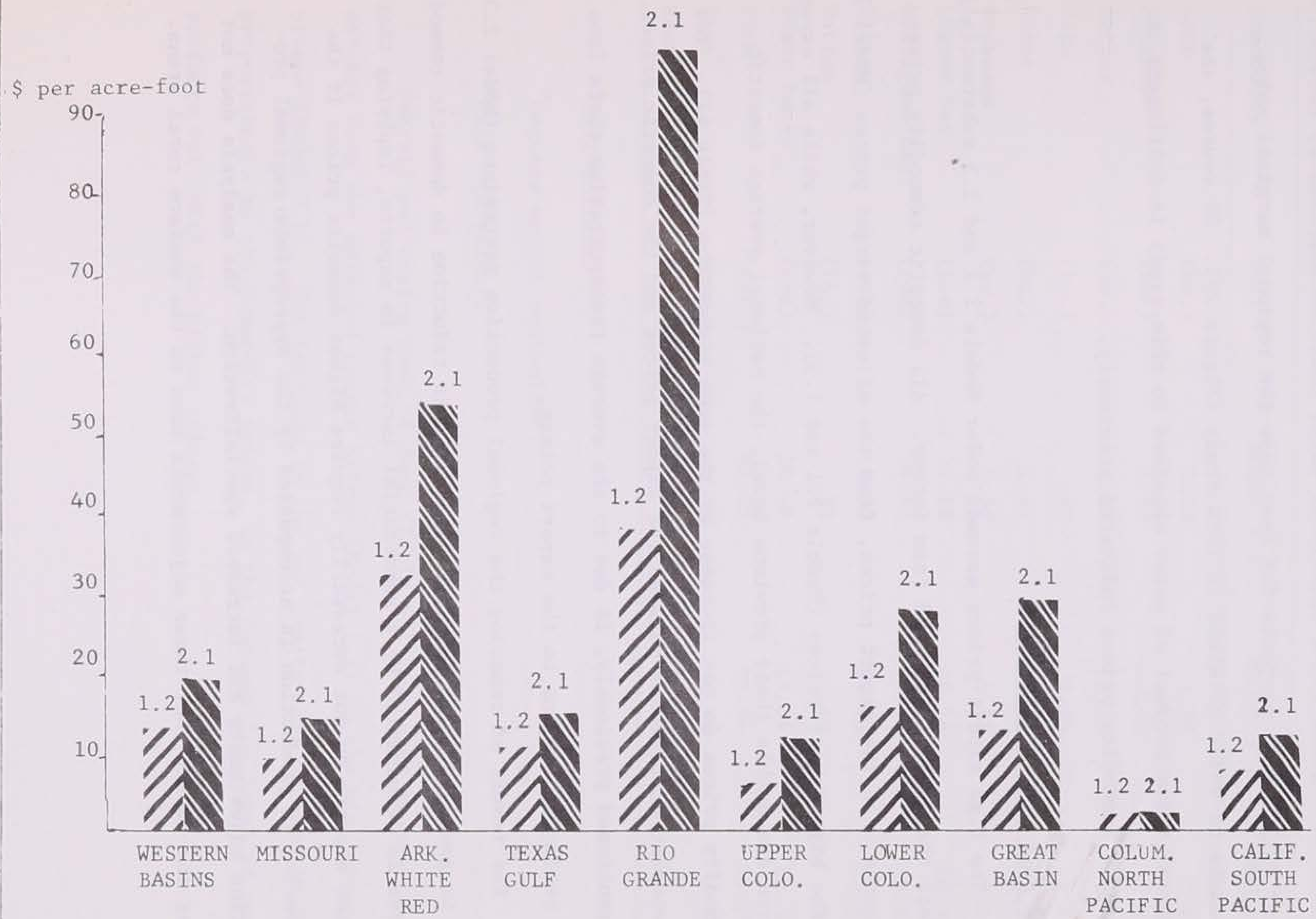

Figure 20. Water shadow prices (marginal value products) under adjusted target prices (Model 1.2) and high export prices (Model 2.1) in 1985.

use, and prices, some expansion of water development can be economical by 1985 in regions where additional water could be supplied by conventional water development projects for less than the regional marginal value products of water obtained in this study (Figure 20). Of course, the marginal value product of water obtained in this study is contingent on the high commodity prices indicated previously.

Food cost and farm income

The high export prices assumed under Models 2.1 and 2.3 substantially affect the cost of food and farm income. All domestic commodity prices increase with the export prices, from the adjusted target prices (Model 1.2) to the high export prices (Models 2.1 and 2.3). However, while all export prices are double their previous level, the national average domestic commodity prices do not increase by the same proportion (Table 42). The consistent differences between the export prices and the domestic prices, as mentioned previously, is due to the average transportation costs from the producing regions to the export points.

The result of removing the regional production restraints (Model 2.3) is, in general, lower domestic prices. This reduction in domestic commodity prices is accompanied by a substantial increase in exports, implying that higher exports do not necessarily require higher domestic prices if the expansion in production is accompanied by the appropriate regional production adjustments and increased specialization. The analysis does not cover the impact that these adjustments have on the nonfarm rural areas.

Table 42. Commodity national average prices under adjusted target prices (Model 1.2) and high export prices (Models 2.1 and 2.3) in 1985.[a]

Commodity	Unit	Model 1.2	Model 2.1	Model 2.3
Corn	(bu.)	1.45	2.86	2.82
Sorghum	(bu.)	1.93	3.28	3.11
Barley	(bu.)	1.28	2.53	2.58
Oats	(bu.)	.68	1.26	1.12
Wheat	(bu.)	1.92	3.80	3.70
Soybeans	(bu.)	2.70	5.58	5.41
Legume hay	(ton)	32.18	46.18	48.30
Nonlegume hay	(ton)	34.43	45.46	45.91
Silage	(ton)	11.30	14.66	15.45
Cotton	(lb.)	.35	.60	.56
Sugar beets	(ton)	10.49	13.24	10.32
Pork[b]	(cwt.)	41.59	56.94	56.79
Milk[c]	(cwt.)	5.46	6.73	6.22
Beef[b]	(cwt.)	71.23	89.60	90.94

[a]1972 dollars.

[b]Carcass weight equivalent.

[c]Milk equivalent.

Overall per capita cost of food (Table 43) increases by only 11 percent from the adjusted target prices (Model 1.2) to the high export prices (Model 2.1). The increase in the per capita cost of food is not proportionate to the commodity prices, as the consumption level of many products fall with the higher prices.

Table 43. Other results summarizing adjusted target prices (Model 1.2) and high export prices (Models 2.1 and 2.3) in 1985.

Item	Unit	Model 1.2	Model 2.1	Model 2.3
Per capita cost[a]	dollars	170.36	192.06	189.70
Net value of export	million dollars	5,940	31,530	33,779
Total soil loss	million ton	1,722.8	997.1	1,010.4
Average soil loss	ton/acre	5.1	2.78	2.78
Average water value	$/acre foot	12.59	18.93	19.53
Average land rent	dollars/acre	31.60	92.62	108.36
Total nitrogen purchased	million lb.	16,445.7	23,905.2	23,375.2
N purchased per acre	lb.	48.76	66.59	64.29
N applied per acre	lb.	69.86	82.55	79.88
Total farm income[b]	million dollars	14,305	37,684	43,715

[a]For raw endogenous commodities only.

[b]Farm income includes total return to land, water, and labor.

Farm income, defined as the total return to land, water, and labor, increases by about 163 percent (Table 43) from the adjusted target prices and moderate exports (Model 2.1), to the high prices and high exports (Model 2.3). Under complete regional adjustments (Model 2.3), farm income can be even higher. Under high exports, however, farmers may possibly be subject to higher costs of all inputs resulting from the higher demand for these inputs.

Environmental impact

In the framework of this study, no serious economic problems seem to be presented if soil loss is restricted to a maximum of five tons per acre. It is interesting to note that the total soil loss, under high exports with the 5-ton per acre maximum soil loss (Model 2.1), is only 60 percent of the soil loss under moderate exports and the 10-ton maximum per acre soil loss (Model 1.2, Table 43). Not only do soil loss restrictions not seem to pose a problem for increasing exports, but by appropriate reallocation of production, exports can be increased and soil loss can be reduced at the same time, as the comparison between Models 1.2 and 2.3 (Table 43) indicates.

Nitrogen purchased is defined as the amount of nitrogen applied less the total nitrogen obtained from livestock manure and legume production. Under high export alternatives (Models 2.1 and 2.3), the quantity of nitrogen purchased is up by almost 50 percent over the level in the moderate export alternative (Model 1.2, Table 43). This is mainly due to an increase in cultivated acreages but also to a larger application per acre which becomes profitable under the high export and domestic prices. It is interesting to note (Table 43) that both the total nitrogen purchased and the nitrogen applied per acre can be reduced when a complete regional production adjustment is made (Model 2.3). This is due to a better allocation of crops and livestock, and hence, to a better utilization of all available input resources.

VI. ANALYSIS OF FERTILIZER RESTRICTIONS UNDER VARYING EXPORT LEVELS

The fertilizer restriction alternatives detailed in the following section are constructed to evaluate the effect of these restrictions on U.S. agriculture production capacity and export potential. The effect of the fertilizer restrictions may vary in conjunction with different export levels. Thus, the analysis is carried out for two levels of exports. Model 3.1 is a follow-up of Model 1.2, the adjusted target price export evaluation. The level of exports under the adjusted target prices (Model 1.2) is fixed, forcing Model 3.1 to export the identical quantities of agricultural commodities but under restricted fertilizer use. The same principle is applied to the analysis and the construction of Model 3.2--restricted fertilizer use at high export levels, using Model 2.1 as the base.

The principle mechanism in which the fertilizer restriction works in the study is via changes in the crop yields. It should be mentioned here that while the restrictions are based on nitrogen applications, they actually imply restrictions on the use of all fertilizers. This results as the use of nitrogen, phosphorous, and potassium (N, P, and K), in deriving yields, is based on a fixed relationship in the study's production functions; any change in the use of nitrogen is accompanied by a proportionate change in the use of phosphorus and potassium. The maximum allowed per acre application of nitrogen for the crops in the study (Table 44) is applied uniformly to all the crop acreages over all producing areas.

Table 44. Nitrogen restriction levels assumed for each crop in 1985 under restricted nitrogen models (Models 3.1 and 3.2).

Crop	Maximum N per acre (lb.)
Barley	55.0
Corn grain	110.0
Corn silage	110.0
Cotton	80.0
Legume hay	none
Nonlegume hay	none
Oats	55.0
Sorghum grain	110.0
Sorghum silage	110.0
Soybeans	none
Sugar beets	none
Wheat	55.0

Fertilizer Restrictions Under Moderate Agricultural Exports in 1985 (Model 3.1)

Model 3.1 is the first of the two fertilizer restriction alternatives. The model evaluates the economic implications for the agricultural industry as a result of imposed nitrogen-use limits (Table 44). The export levels obtained under the adjusted target prices (Model 1.2) are set as fixed levels to be maintained. All other assumptions of Models 1.2 and 3.1 are identical. Even though the absolute value of the results is presented, the interpretation of the results is done by observing the relative changes between the two models.

Commodity production and utilization

Only minor changes in production and domestic consumption occur under restricted fertilizer use at moderate export levels (Table 45). The small changes taking place reflect the same export levels and per capita consumption of the commodities and a slight variability in the livestock rations encouraged by the production possibility changes resulting from the fertilizer restriction.

Table 45. Commodity production and utilization under restricted nitrogen use at moderate exports in 1985 (Model 3.1).

Commodities	Unit	Production	Domestic Consumption	Exports
Corn	million bu.	5,560.7	4,521.0	1,039.7
Sorghum	"	454.0	306.5	147.5
Barley	"	422.9	422.9	0.0
Oats	"	761.4	523.2	238.2
Wheat	"	1,815.7	709.5	1,106.2
Soybean	"	2,300.9	1,396.0	904.9
Legume hay	million tons	178.3	178.3	0.0
Nonlegume hay	"	186.2	186.2	0.0
Silage	"	562.3	562.3	0.0
Cotton	million bales	12.1	8.0	4.1
Sugar beets	million tons	26.4	26.4	0.0
Pork[a]	million cwt.	159.3	161.7	-2.4[b]
Milk products[c]	"	1,167.3	1,170.6	-3.3[b]
Beef[a]	"	332.0	348.1	-16.1[b]

[a]Carcass weight equivalent.

[b]Imports.

[c]Milk equivalent.

Nitrogen use

The imposition of the per acre nitrogen restrictions results in a reduction of 1,193 million pounds of nitrogen use per year (Table 46) as compared to unrestricted nitrogen use at moderate exports. The nitrogen use level is reflected in a reduction of nitrogen purchased. The wastes from livestock provide a relatively constant amount of fertilizer, and the livestock enterprises cover the cost of application. Using 14 cents per pound as the average price for nitrogen, this reduction in nitrogen use amounts to an annual reduction in farm expenditures of $167 million.

Table 46. Nitrogen use by major zones at moderate exports under unrestricted nitrogen use (Model 1.2) and restricted nitrogen use (Model 3.1) in 1985.

Zone	Model 1.2	Model 3.1	Percent change
	(million lbs.)		
United States	16,446	15,254	-7.25
North Atlantic	256	224	-12.50
South Atlantic	1,199	1,122	-6.42
North Central	3,427	3,151	-8.05
South Central	5,266	5,152	-2.16
Great Plains	4,487	4,054	-9.65
Northwest	1,113	1,041	-6.47
Southwest	698	509	-27.08

Yield reduction

Comparing the average national yields per acre under restricted nitrogen use at moderate exports (Model 3.1) with the unrestricted nitrogen use yields (Model 1.2) shows: barley, down 0.5 bushel per acre or 1.2 percent; corn grain, down 2.5 bushels per acre or 2 percent; corn silage, down 0.1 ton per acre or one percent; oats, down 0.2 bushel per acre or less than one-half of one percent; and wheat, down 0.2 bushel per acre, about one-half of one percent. One reason behind the small national yield reduction from nitrogen restrictions is the incorporation of rotations which include legume crops in the study; when the per acre nitrogen application is restricted, these legume rotations become more attractive and replace the continuous rotations used previously. This is one of the main reasons for the high proportion of legume crop acreages in the restricted nitrogen models.

Land use

The restriction on the application of nitrogen results in an important land and nitrogen substitution. While total nitrogen used declines by 1,193 million pounds from the unrestricted nitrogen use (Model 1.2), total acres under cultivation increase by 2.1 million acres (Table 47). Under restricted nitrogen at moderate exports (Model 3.1), this substitution rate is one acre of land for every 560 pounds of commercial fertilizer applied but does not necessarily hold for total nitrogen use, as a large proportion of the nitrogen is supplied from legume crops and livestock wastes.

Table 47. Land use by major zones at moderate exports under unrestricted nitrogen use (Model 1.2) and restricted nitrogen use (Model 3.1) in 1985.

Zone	Model 1.2	Model 3.1	Percent Change
United States	337,273	339,402	+.63
North Atlantic	8,127	8,309	+2.24
South Atlantic	15,533	15,640	+.69
North Central	135,689	136,193	+.37
South Central	83,207	83,311	+.12
Great Plains	62,582	63,353	+1.23
Northwest	13,786	14,008	+1.61
Southwest	18,349	18,588	+1.30

The increase in total land utilization is not distributed equally over all crops. Because of the reduction in yields and the maintenance of the same export levels as in the unrestricted nitrogen situation, an increase in acreage occurs, especially for the crops being exported. Compared with the unrestricted nitrogen use at moderate exports (Model 1.2), corn grain acreage increases 1.5 million acres; cotton acreage increases 240,000 acres; legume hay increases 173,000 acres; and wheat acreage increases 360,000 acres. Acres of the other crops change only slightly.

Overall, land rent as represented by the marginal value product increases by $1.46 per acre as a result of the restriction on fertilizer use at moderate exports. A much larger increase in land rent occurs, for example, in the North Central region where land rent is increased by $4.83 per acre or 45 percent as a result of the restricted fertilizer use.

Commodity prices and farm income

The restriction on fertilizer application at moderate exports resulted in a small increase in commodity prices (Table 48). Such a small change in commodity prices is also reflected in the small change in the average

Table 48. U.S. average commodity supply, location, and total prices under restricted nitrogen use at moderate exports in 1985 (Model 3.1).

Commodity	Unit	Supply price	Location price	Total price
			(Dollars per unit)	
Corn	(Bu.)	1.41	0.05	1.46
Sorghum	(Bu.)	1.63	0.35	1.97
Barley	(Bu.)	1.31	0.00	1.31
Oats	(Bu.)	0.70	0.00	0.70
Wheat	(Bu.)	1.63	0.31	1.95
Soybeans	(Bu.)	2.68	0.05	2.73
Legume hay	(Ton)	28.96	3.68	32.64
Nonlegume hay	(Ton)	35.03	0.00	35.03
Silage	(Ton)	10.73	0.92	11.65
Cotton	(Lb.)	0.29	0.07	0.36
Pork[a]	(Cwt.)	41.84	0.18	42.02
Milk[b]	(Cwt.)	5.05	0.45	5.50
Beef[a]	(Cwt.)	71.39	0.74	72.12

[a]Carcass weight equivalent.

[b]Milk equivalent.

per capita cost of food and fiber. Per capita food and fiber cost (row endogenous commodities only) under restricted nitrogen use at moderate exports (Model 3.1) increased only $2.03 (1.1 percent) per year over the unrestricted fertilizer-use level (Model 1.2). This increase in the per capita cost of food and fibers indicates the small impact of a nitrogen restriction on farm prices when livestock wastes and legumes can be substituted in the rotation and only moderate export levels are experienced.

Fertilizer Restrictions Under High Agricultural Exports in 1985 (Model 3.2)

Model 3.2 addresses itself to the problem of restrictions on the application of fertilizer while facing an expanded demand for the export of U.S. agricultural products. If high exports such as those obtained in this study should occur in the future, the question is: Can the U.S. agricultural sector maintain the high level of exports and still reduce nitrogen use? The analysis covers the impacts on the agricultural industry and on the U.S. consumer's food and fiber budget while maintaining exports at their high levels.

The comparison is based on forcing the export level of agricultural commodities to the level obtained under the unrestricted fertilizer use at high export analysis (Model 2.1, Table 25). Model 2.1 simulates a high export situation when only limited shifts in the location of production take place as compared with the 1969 location of production [24]. In addition, Model 2.1 calls for a five-ton maximum soil loss per acre, with no restriction on nitrogen use. Except for adding the restrictions on fertilizer application (Table 44), Models 2.1 and 3.2 have the same set of assumptions.

Nitrogen use

The total reduction in nitrogen application under restricted fertilizer use at high exports (Model 3.2) is 2,668 million pounds or 1.3 million tons of nitrogen per year (Table 49). This is equal to a reduction in fertilizer purchases of $373.5 million per year with a nitrogen price equal

Table 49. Nitrogen use by major zones at high exports under unrestricted nitrogen use (Model 2.1) and restricted nitrogen use (Model 3.2) in 1985.

Zone	Model 2.1	Model 3.2	Percent Change
	(million lbs.)		
United States	23,905	21,223	-11.22
North Atlantic	272	203	-25.37
South Atlantic	1,919	1,648	-14.12
North Central	7,427	6,248	-15.87
South Central	6,622	6,275	-5.24
Great Plains	5,636	5,159	-8.46
Northwest	1,260	1,119	-11.19
Southwest	769	570	-25.88

to 14 cents per pound. The 11 percent reduction in nitrogen application under high exports is larger than the reduction in nitrogen applied under restricted nitrogen use at moderate exports (Model 3.1). The larger reduction is consistent with farmers harvesting more acres and utilizing more fertilizer per acre under the higher exports and higher price alternatives (Model 3.2). The higher commodity prices yield a higher return for nitrogen than the return for nitrogen obtained under the lower price alternatives. This indicates larger reduction in use on the highly fertilized lands and some reduction on other lands as more acres approach the limits (Table 44) and some acres exceed the limits.

Land use

The yield reductions, when accompanied by the same high export level and thus the same production level, result in a large substitution of land for fertilizer. Total land use under restricted fertilizer use and at high exports increases by 3.3 million acres (Table 50) above the unrestricted fertilizer use alternative at high exports (Model 2.1). The average rate of substitution of land for nitrogen, at the level of production obtained under Model 2.3, is one acre for every 830 pounds of commercial nitrogen applied. Not only is more land substituted for more nitrogen, when nitrogen is restricted at high exports, but also the average rate of substitution is greater than one acre for every 560 pounds of nitrogen determined under restricted nitrogen use at moderate exports.

This fact can be explained by noticing that under high exports (Model 2.1 and 3.2), the marginal productivities of both land and nitrogen are smaller than under moderate exports (Models 1.2 and 3.1). However, the marginal productivity of nitrogen under high exports is declining relatively more than the marginal productivity of land. Therefore, the rate of land for nitrogen substitution under high exports (830 pounds of N) is greater than under moderate exports (560 pounds of N).

Table 50. Land use by major zones at high exports under unrestricted nitrogen use (Model 2.1) and restricted nitrogen use (Model 3.2) in 1985.

Zone	Model 2.1	Model 3.2	Percent Change
	1,000 acres		
United States	358,990	362,220	+.90
North Atlantic	8,513	8,757	+2.87
South Atlantic	20,051	21,447	+6.96
North Central	141,692	142,156	+.33
South Central	85,436	86,023	+.69
Great Plains	69,018	69,060	+.06
Northwest	14,959	15,189	+1.54
Southwest	19,321	19,588	+1.36

The sharp increase in land use also is reflected in the land rents (marginal value products). The average land rent increases from $92.62 per acre under unrestricted fertilizer use at high exports (Model 2.1, Table 29) to $132.25 per acre after the fertilizer restrictions are imposed at high exports (Model 3.2, Table 51). This is an increase of almost 43 percent in land rent. Land rent in the North Central region increases from $112.08 per acre to $160.71 due to fertilizer-use restrictions at high exports. The largest relative change in land rent occurs in the South Atlantic region, where land rent increases by 73 percent as a result of the fertilizer use restrictions at high exports.

Table 51. Shadow prices (marginal value products) of alternative land classes by major zones under restricted nitrogen use at high exports in 1985 (Model 3.2).

Zone	Land classes I, II	IIIE, IVE	III-IV	V-VIII	Total[a]
	(Dollars per acre)				
United States	160.55	103.00	99.86	34.10	132.35
North Atlantic	47.15	27.29	21.98	0.00	37.19
South Atlantic	122.15	64.03	65.20	6.93	98.70
North Central	176.07	143.58	108.79	39.12	160.71
South Central	169.89	105.96	120.03	83.97	137.62
Great Plains	133.80	77.32	80.33	28.68	100.78
Northwest	202.90	105.43	92.84	48.66	128.16
Southwest	129.70	83.86	82.45	19.78	97.38

[a]Excluding other hay and pasture lands.

Water use

Total water consumption increases by 616,000 acre-feet from the unrestricted fertilizer use at high exports (Model 2.1) to 101.7 million acre-feet under the restricted fertilizer use at high exports alternative (Model 3.2). Overall, the value of water increases from $18.93 per acre-foot under unrestricted fertilizer use at high exports (Model 2.1) to $21.50 per acre-foot under restricted fertilizer use at high exports (Model 3.2), an increase of 13 percent in water prices.

Commodity prices

In contrast to the results obtained under restricted fertilizer use at moderate exports (Model 3.1), restricted fertilizer use at high exports (Model 3.2) indicates a sharp increase in all commodity prices (Table 52). Nationally, the increases range from a rise of 16 percent for pork (from \$56.94 per cwt. in Model 2.1) to \$66.23 per hundredweight under restricted fertilizer use at high exports in Model 3.2, to a high of 33 percent for oats (from \$1.26 per bushel in Model 3.2). Other price increases include: sorghum grain, 25 percent; wheat, 28 percent; soybeans, 21 percent; and beef, 20 percent. Corn and cotton are the only crops which display a reduction in price. However, this is due to a simultaneous effect of export restrictions imposed on Models 2.1 and 2.3, and regional location production restrictions on the price of these crops and not to the effect of restrictions on fertilizer use. When export restrictions are not imposed, such in the case of Models 2.1 and 3.1, all prices are higher under the restricted nitrogen alternative.

The average per capita cost of food and fibers (includes raw endogenous commodities only), based on population of 242 million by 1985, increases from \$192.06 per year under unrestricted fertilizer use at high exports (Model 2.1) to \$233.40 per year under restricted fertilizer use at high exports (Model 3.2), an increase of 16 percent.

Table 52. U.S. average commodity supply, location, and total prices under restricted nitrogen use at high exports in 1985 (Model 3.2).

Commodity	Unit	Supply price	Location price	Total price
			(Dollars per unit)	
Corn	(Bu.)	2.74	0.10	2.83
Sorghum	(Bu.)	3.33	0.77	4.10
Barley	(Bu.)	3.26	0.00	3.26
Oats	(Bu.)	1.68	0.00	1.68
Wheat	(Bu.)	4.18	0.67	4.85
Soybeans	(Bu.)	6.60	0.18	6.78
Legume hay	(Ton)	52.26	5.28	57.54
Nonlegume hay	(Ton)	55.31	0.00	55.31
Silage	(Ton)	17.05	2.30	19.35
Cotton	(Lb.)	0.49	0.07	0.56
Pork[a]	(Cwt.)	65.71	0.52	66.23
Milk[b]	(Cwt.)	6.81	0.67	7.48
Beef[a]	(Cwt.)	106.02	1.01	107.03

[a]Carcass weight equivalent.

[b]Milk equivalent.

Policy Implications

The main purpose of the reduced fertilizer models is to evaluate the economic effects on U.S. agriculture of a reduction in the amount of commercial nitrogen used per acre as an environmental measure. This change would serve both energy conservation and environmental concerns. The reduction in nitrogen use is entirely a reduction in nitrogen purchased, as farmers essentially utilize all of the nitrogen available from legume crops and livestock residue before purchasing commercial fertilizer. The analysis and the comparisons are made by observing the different effects which nitrogen, and therefore, all fertilizers could have on commodity prices, nitrogen, land, and water use at moderate exports (Models 1.2 and 3.1) and high exports (Models 2.1 and 3.2).

Land for nitrogen substitution

The percent reduction in nitrogen use, as can be expected, is much larger under high exports (Figure 21). This is mainly due to higher rates of nitrogen application per acre under the unrestricted nitrogen use at high exports, resulting from the higher commodity prices. The regional nitrogen-use reduction ranges from a low of 2.16 percent in the South Central region to 27.08 percent in the Southwest under moderate export levels. The regional reduction in nitrogen use under the high export situation, while higher on the average, has a smaller range between the lowest reduction and the highest reduction than is experienced with the moderate exports (Figure 21).

The increased land use, due to the fertilizer restriction, is expected to increase land rents. However, the magnitude of the increase in land rents is greatly dependent upon the export levels. Under restricted fertilizer use at moderate exports, the national land rent increases only $1.46 per acre. At the same time, under the restricted fertilizer use at high exports, national land rent is up almost 40 dollars per acre (Figure 22). The increase in land rents resulting from restricted fertilizer use varies greatly between regions; the more productive regions display greater changes

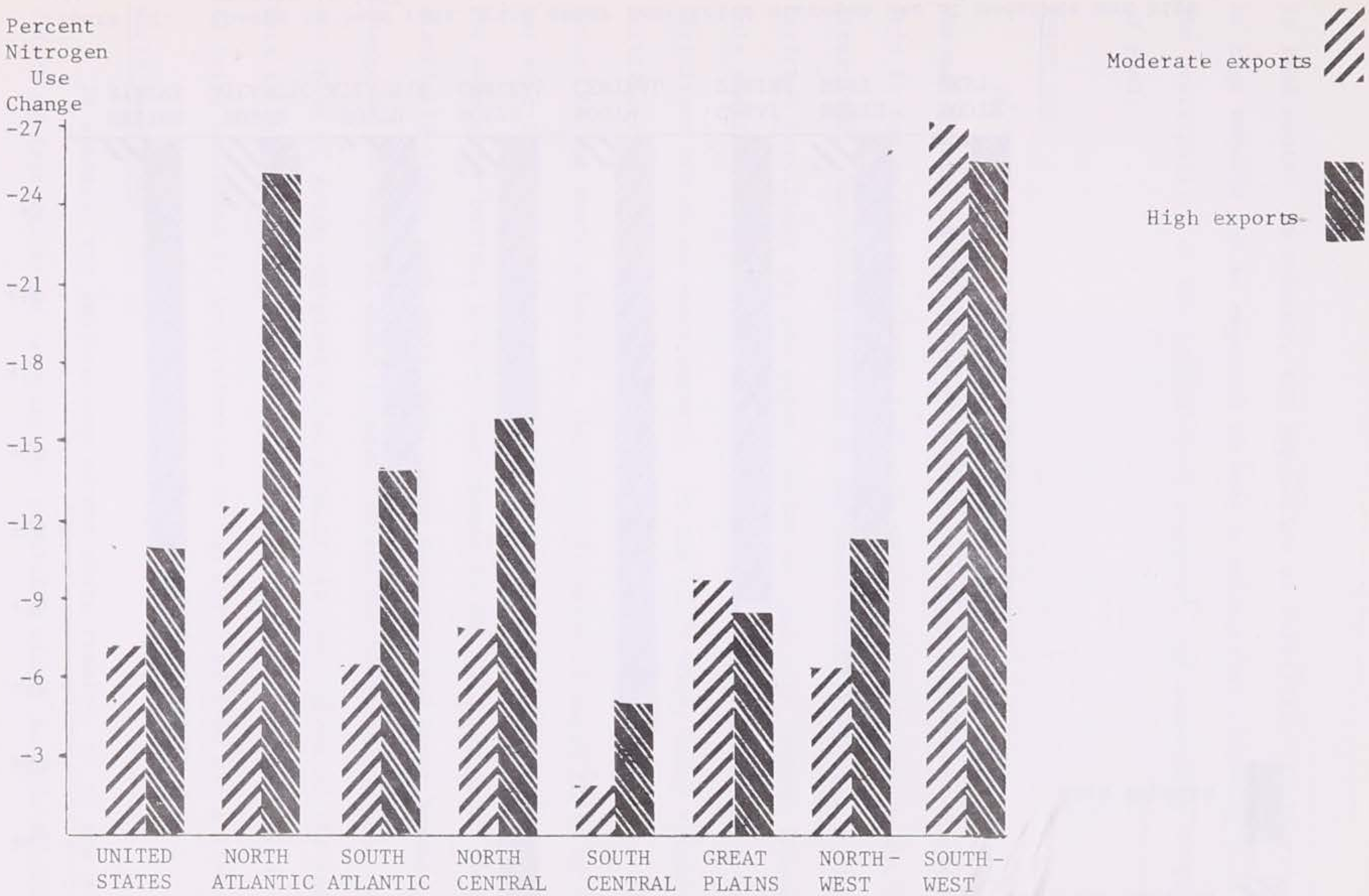

Figure 21. Percent change in nitrogen use under moderate and high exports in 1985.

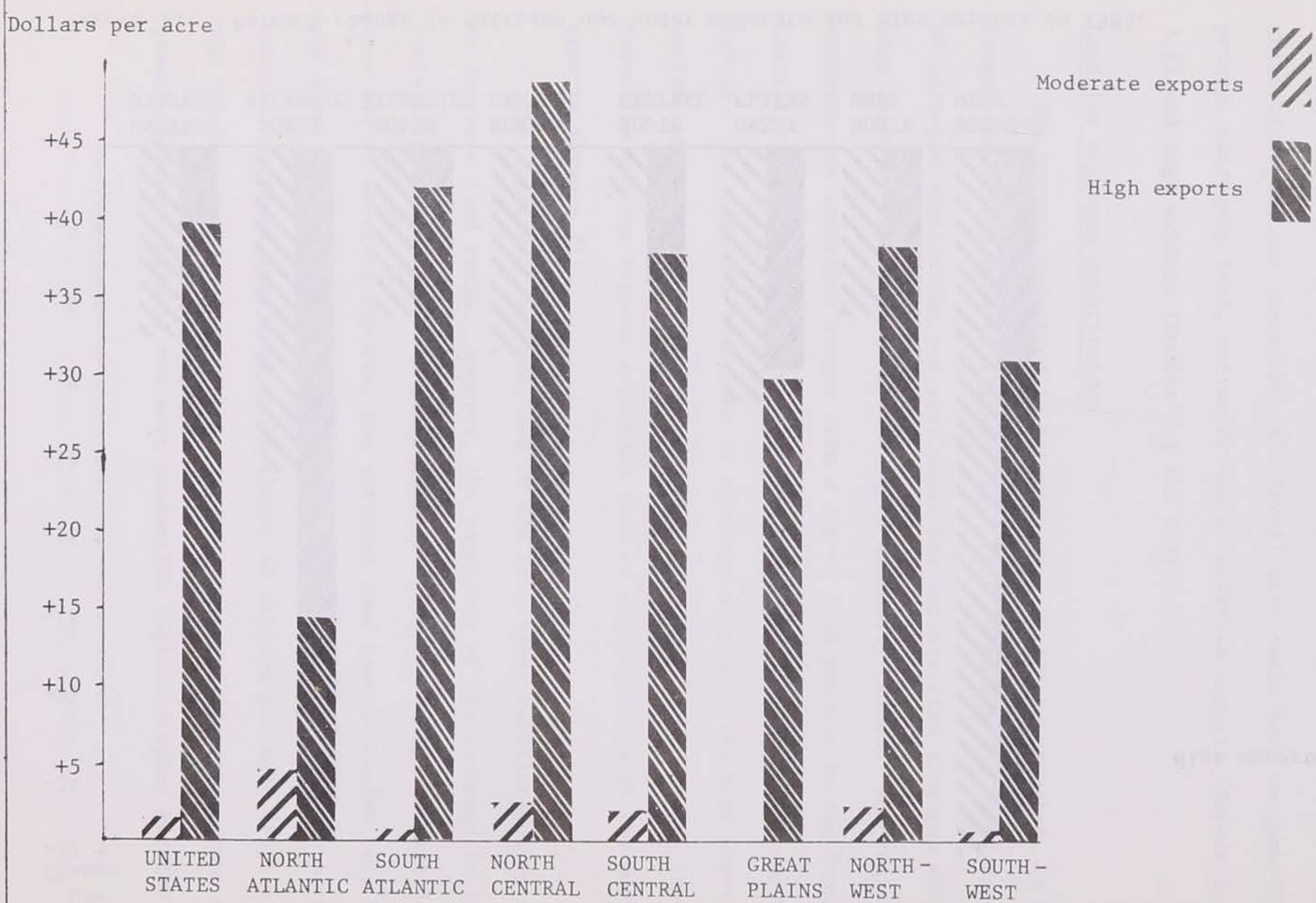

Figure 22. Change in land rent price under restricted nitrogen use at moderate and high exports in 1985.

in land rents. In summary, the imposition of fertilizer-use restrictions at high exports can be expected to have a substantial effect on land rents, the profitability of the agricultural industry, and eventually on the cost of food.

Water use

The effect of a nitrogen restriction on water use is reflected through changes in the value of water rather than the amount of water used. This is due to the relatively inelastic water supply assumed in the model after 1980. The characteristics of the value of water changes under restricted fertilizer use are quite similar to land rent changes (Figure 23). Only small increases in the value of water take place under restricted fertilizer use at moderate exports. On the other hand, under restricted fertilizer use at high exports, significant increases in the value of water occur in the western basins. The over all value of water rises by $2.57 per acre-foot under restricted fertilizer application at high exports. For some river basins, however, the change in the value of water is substantially higher (Ark.-White-Red, Lower Colorado, and Great Basin). No change in the value of water is seen for the Rio Grande River basin where the value of water (marginal value product) is the highest of all cases. This is due to the fact that the shortage of water in the Rio Grande basin is being satisfied by desalinization of sea water at $100 per acre-foot.

World food costs

In summary, the implications of the above results, as to the possible effect of fertilizer-use restrictions resulting either because of environmental

Figure 23. Change in water prices under restricted nitrogen use at moderate and high exports in 1985.

concern or because of an energy shortage, are highly dependent on the level of demand maintained when nitrogen use is restricted. The moderate export level presented is near the 1972-73 export levels of the agricultural commodities. The results indicate that no great adverse effects can be expected on agricultural production in the long run if exports remain at that level. Of course, if the supply of nitrogen is short for a given year, some reduction in yields and production can be expected for that year. However, given sufficient time, farmers could substitute other resources for nitrogen and alter their farming methods in such a way that more nitrogen will be supplied from legume crops and most of the nitrogen in livestock residue will be returned to the soil. Under such circumstances, production, exports, and the cost of food can be back near their long-run trends.

A completely different picture exists if nitrogen use is restricted at high export levels. We could expect a sharp rise in the food bill if exports remain at the same high level. The higher price of farm products increases the farm level price of food and also increases farm income by a greater proportion than the increase in the magnitude of the consumers' food bill.

The high cost of food also affects the balance of payments. Foreign buyers of U.S. produced food and fiber would need to pay $4.5 billion more than for the identical quantities purchased under the unrestricted nitrogen situation. This is a 14 percent increase in the cost of American food and fiber for importing countries.

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