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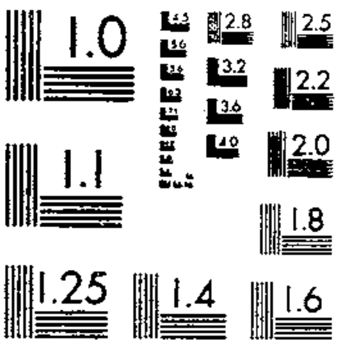
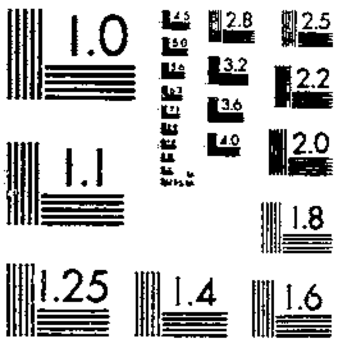


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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SUMMARY AND CONCLUSIONS

The results of this investigation suggest hypothetical land retirement programs which might aid in controlling agricultural production and in maintaining adequate incomes for farmers of the wheat-feed grain-oilmeal-cotton economy. Relative costs are estimated in several simulated land retirement programs. The several alternatives considered are directed toward indicating regional production patterns for wheat, feed grains, soybeans, and cotton. The study is designed to provide insights into the resource adjustments needed to meet the production requirements of these commodities in 1965, and to estimate costs of land retirement programs, with different restrictions on regional adjustments. which would maintain farm output and prices at specified levels.

Three linear programming models were designed to indicate the optimum spatial allocation of agricultural production, subject to assumed prices and costs and restraining conditions of demands for agricultural products, cropland availability, and Government programs. The supply of land was fixed, but all other factors were variable. Uniform costs within each production region were assumed. Each model minimized the total national cost of production and distribution.

A total of 144 producing regions, each having 4 potential producing activities (wheat, feed grains, soybeans, and cotton), reflect the variations in technology, soil productivity, and climate across the United States. These regions account for 95 percent of the Nation's production capacity for the specified crops.

The products were distributed among 31 demand regions which encompass the 48 coterminous States. Quantities of wheat, feed grains, and oilmeals were specified to meet the demands of each consuming region. A single national demand was assumed for cotton lint.

Farm programs considered ranged from unrestricted allocation of production among regions to rather restrictive programs for wheat and feed grain production. Other programs tested the effects of (*a*) different pricing schemes for wheat and (*b*) retirement of submarginal rather than average land within producing areas.

Several solutions, each individually designed to explore separate facets of the overall problem of supply control in agriculture, were obtained from the programming models. Models I and II consider land within producing regions to be homogeneous. The two models differ in the pricing scheme employed for wheat. Model I applies a multiple price plan, with demand for food wheat satisfied at a price above the equilibrium value of wheat, while feed wheat is utilized at its value as livestock feed. Model II employs a single price for both food wheat and feed wheat. Model III assumes three classes of cropland within each producing region.

The models are similar in all respects except those outlined above. All solutions have the same farm policy constraints. Thus, by comparing the results from Models II and III with those from Model I, the effects of alternative wheat price plans on the regional distribution of crop production are isolated.

In the models, 223.9 million acres of cropland are available for the production of the four major feed grains (corn, oats, barley, and grain sorghum), wheat, cotton, and soybeans. Some excess production capacity is indicated in all solutions. Excess cropland varies from 36.1 million acres, for a program requiring the retirement of some feed grain land in all areas, to 52.3 million acres, for a program in which optimal interregional allocation of production is allowed.

Although each model and solution results in different amounts of land diversion and different patterns of land use, some States have large acreages of land diversion indicated under all programs considered. These States are South Carolina, Georgia, Alabama, Mississippi, and Arkansas. Under one solution, more than 75 percent of cropland in these States is indicated for diversion; more than 50 percent of cropland is suggested for diversion under most solutions. Portions of Great Plains States such as Kansas, North Dakota, and South Dakota also are indicated for diversion from crops under most solutions. Yields in these States are limited by moisture, and technical input-output coefficients are generally higher for them than for other wheat and feed grain areas. However, the competitive position of these States is improved under Model III when intraregional land quality differences are recognized.

Very little land diversion is indicated in the major feed and livestock regions east of the Missouri River, the central winter wheat regions of the Great Plains, and the field crop areas of the Pacific States.

The South Atlantic States become more competitive and self-sufficient when regional wheat acreage quotas are eliminated and local feed wheat substitutes for previously imported feed grains. When feed grain acreage quotas are applied in all regions, only a small amount of cropland is indicated for diversion in North Dakota and South Dakota. Production of wheat and feed grains in the Dakotas is required to offset reduced feed grain production in the Corn Belt.

Feed grain acreages required to meet regional and national demands vary widely as different amounts of wheat are used for feed under the alternative land retirement programs. Only 78 million acres of feed grains are required when wheat production is not limited by acreage quotas. When wheat is supported at a price above its equilibrium or feed value, even a mildly restrictive acreage program for wheat increases feed grain acreage to 110.2 million acres.

The location and amount of wheat production are quite sensitive to changes in prices or acreage quota programs for either wheat or feed grains. The lowest wheat acreage, 39.1 million acres, is indicated under solutions which assume all crops to be restricted to their historical base acreage and all wheat to be priced artificially high. Wheat acreage increases to 73.7 million acres when quotas are removed and wheat can be used freely for livestock feed.

Government programs affecting the geographic location and quantity of production of either wheat or feed grains also affect the competition for land use and substitution in consumption, of wheat and feed grains. Therefore, compliance with Government programs affecting both commodities is necessary to obtain optimum efficiency from the program.

The geographic distribution of grain and cotton production appreciably affects the amount and kind of transportation needed for these products. On the other hand, transportation charges have little effect on the location of production.

The equilibrium prices differ considerably under the different solutions and the land diversion programs they represent. Programs which are not restricted by intraregional adjustment of cropland use result in the lowest equilibrium prices; those which limit acreage adjustments both within and between regions result in the (*a*) highest cost of production control and (*b*) highest programmed equilibrium prices.

Under the stated assumptions, the types of control or land diversion programs have great influence on the efficiency of agricultural production and the costs of supply control. However, the type of program does not appreciably affect the total national cost of transportation. Land retirement is assumed to be induced through incentive payments to farmers and farmers are assumed to respond fully to economic incentives. The most expensive land retirement program results when feed-grain quotas are applied uniformly in all regions. But, if land diversion is concentrated in submarginal production areas, program costs for production control to attain specified price and income levels are lower than under programs which require some land to be withdrawn from crop production in all producing regions.

Aggregate Economic Effects of Alternative Land Retirement Programs: A Linear Programming Analysis

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INTRODUCTION

An analysis of the cost, effectiveness, and locational impacts of selected alternative production control programs for agriculture is presented in this report. The major emphasis is on land retirement programs. Interregional linear programming models based on spatially separated producing and consuming regions are the methodological basis of the analysis. Crops included are wheat, feed grains (corn, oats, barley, and grain sorghum), cotton and soybeans. The study refers to technology and population data for 1965.

Some form of production control program has been in effect for the study crops over the last dozen years. However, these programs have not resulted in a long-run solution to the Nation's basic problem of surplus capacity. This study was designed to measure the extent of this surplus capacity and to estimate the acreage adjustment necessary to solve problems of excess supply. The programs included in the analysis emphasize a long-run approach to these supply problems by allowing a more complete interregional shift of production to conform with changes which have occurred over the last two decades in technology, demand, and relative prices. Other items of information presented in this study include equilibrium product prices for various commodities, land rental values, the values of production quotas, and commodity transportation patterns under each alternative land retirement program examined.

The interregional competition models employed in this study are extensions of earlier models constructed by Heady and Egbert (*3*).[1] The models of this study feature an expanded number of producing regions and of spatially separated consuming regions. One model is designed to recog-

[1] Italic numbers in parentheses refer to items in the Literature Cited, p. 53.

nize the differences in land qualities that exist within producing regions. The models, specifically outlined in a later section, also include single and multiple price plans for wheat, and transportation facilities for optimum production allocation.

Objectives of the Study

The major purposes of this study are to define efficient interregional allocations of food production for the entire United States and to explore the effectiveness of alternative farm policies in attaining these patterns. Many changes have taken place in population location, technology, factor prices, and other variables which alter the comparative advantage of producing regions. However, institutional factors have impeded shifts in land use which might have accompanied these changes, and the pattern of land use in a theoretically efficient production pattern is not well known. Interregional shifts in food production also have been restrained by Government policies tied to historic acreages and aimed at curtailing production. Therefore, the specific objectives of this study are:

1. To indicate the amount and location of land that would need to be withdrawn from wheat, feed grains, and cotton if surplus production is to be eliminated, given specified price and demand levels.
2. To estimate an efficient allocation of crop production and land use under a minimum-cost objective function for alternative supply control programs.
3. To specify the impact of alternative wheat or feed grain programs upon the allocation of production of nonprogram crops.
4. To formulate optimal land-use patterns when marginal land within, as well as between, regions is removed from production.
5. To estimate the national costs of alternative supply control programs which allow different degrees of land diversion within regions.
6. To estimate the regional and national equilibrium product prices under each of the program alternatives.
7. To determine the net interregional flows of final products under the production patterns of each program alternative.

PROGRAMMING MODELS

Basic Model

Three similar programming models were used in the analysis of land-use patterns under various farm program possibilities. A mathematical summary of a "basic model" follows, with features common to all of the programming models.

The objective of the basic model is to minimize national costs of production and interregional transportation costs. The objective function is

$$Min\ f(X) = CX \qquad (1)$$

where C is an $nk+t$ row vector including production and transfer and transportation costs conforming to k crops, n producing regions, and t transfer and transportation activities; X is an $nk+t$ vector representing levels of crop production, transfer, and transport activities. The conventional restraints

$$AX' \geqq b' \tag{2}$$
$$X \geqq 0 \tag{3}$$

are included, where A is a coefficient matrix of $(nk+t)(nk+mp)$ order (conforming with the n regions and k land restraints per region, the m demand regions, and p demand restraints per demand region) and b is an $nk+mp$ column vector of maximum acreage restraints within each producing region and minimum demand requirements in each consuming region.

More specifically, this model can be summarized as follows, where equation (4) is the cost function to be minimized:

$$f(c)=\sum_{j=1}^{144}\sum_{k=1}^{4} c_{jk}X_{jk}+\sum_{m=1}^{31}\sum_{r=1}^{31}\sum_{p=1}^{3} c_{mrp}T_{mrp} + \sum_{s=1}^{31} c_s R_s = \text{Minimum} \qquad (r \neq m). \tag{4}$$

Total production in the ith region is restrained by the total cropland equation (5):

$$b_{io} \geq \sum_{k=1}^{4} a_{ijk}X_{jk} \qquad (i=j=1,\ 2,\ \ldots,\ 144), \tag{5}$$

and by the intraregional upper bounds on acreage for each crop in equation (6):

$$b_{ik} \geq a_{ijk}X_{jk} \qquad (i=j=1,\ 2,\ \ldots,\ 144;\ k=1,\ 2,\ 3,\ 4). \tag{6}$$

Minimum requirements for wheat, feed grains, and oilmeals in each consuming region are reflected in equations (7), (8), and (9), respectively:

$$d_{m1} \leq \sum_{j=1}^{n} X_{j1}P_{j1} + \sum_{r=1}^{31} T_{mr1} - R_s \qquad (m,\ r=1,\ 2,\ \ldots,\ 31;\ r\neq m); \tag{7}$$

$$d_{m2} \leq \sum_{j=1}^{n} X_{j2}P_{j2} + \sum_{r=1}^{31} T_{mr2} + R_s \qquad (m,\ r=1,\ 2,\ \ldots,\ 31;\ r\neq m); \tag{8}$$

$$d_{m3} \leq \sum_{j=1}^{n} X_{j3}P_{j3} + \sum_{j=1}^{n} X_{j4}P_{j4'} + \sum_{r=1}^{31} T_{mr3} \qquad (m,\ r=1,2,\ \ldots,31;\ r\neq m). \tag{9}$$

The single national demand for cotton lint is specified as:

$$d_c \leq \sum_{j=1}^{144} X_{j4}P_{j4'}. \tag{10}$$

The symbols used in equations (4) through (10) are defined as follows:

a_{ijk}=The amount of land used by one unit of the kth producing activity of the $i=j$th producing region; k equals 1 for wheat, 2 for feed grains, 3 for soybeans, and 4 for cotton.

b_{ik}=The amount of land available for use by the kth crop in the ith producing region.

b_{iL}=The total cropland available for production in the ith producing region.

c_{jk}=The cost of producing one unit of the kth crop in the jth producing region.

c_{mrp}=The cost of transporting one unit of the pth crop to (from) the mth demand region from (to) the rth demand region; r=30 is the maximum number of such activities that may occur for any crop since there are 31 demand regions.

c_s=The cost of using one unit of wheat as a feed grain in the sth demand region ($s=m$). This cost is an artificial price differential in addition to the normal production costs.

d_c=The national demand for cotton lint expressed in pounds.

d_{mp}=The demand for the pth commodity, expressed in feed units, in the mth demand region; p equals 1 for wheat, 2 for feed grains, and 3 for oilmeals.

P_{jk}=The per unit output of the kth activity in the jth producing region, expressed in feed units for all except cotton lint, which is expressed in pounds; k is defined as above.

P_{jc}=The oilmeal output, in feed units, of the cotton activity in the jth producing region.

R_s=The level of the activity transferring wheat into a feed grain in the sth demand region ($m=s$).

T_{mrp}=The level of transportation of the pth commodity to (from) the mth consuming region from (to) the rth consuming region; p is defined as above.

X_{jk}=The level of the kth producing activity in the jth producing region; k is defined as above.

Assumptions of the Study

To reduce the problems of data collection and machine computation to a manageable size, it was necessary to make several simplifying assumptions in this study. These assumptions, in the opinion of the authors, did not detract greatly from the realism of the investigation, and allowed the construction of sufficiently detailed models for achieving the study objectives.

The basic assumptions used in the models are:

1. The special characteristics can be represented by n spatially separated and independent producing regions, each of which is internally homogeneous.

2. Land within a region is a homogeneous factor and all crops may compete

equally for it, except in Model III, in which three distinct classes of land exist within each region.

3. Cropland area is the limiting factor of production for each region. Other resources are in adequate supply within a region or are sufficiently mobile between regions to have no restricting effect upon production.

4. Potential cropping activities for a producing region are determined by the region's cropping history. Resources required by crops not considered in the study were set aside and were not included in the analysis.

5. Different processes may exist for the same product in each agricultural region, but constant returns are assumed for each; thus single-valued coefficients are used regardless of the output level.

6. The four major feed grains are always produced in the same proportions within a region.

7. There are no differences among regions with respect to crop quality.

8. Farmers maximize profits in choosing among the crops under consideration.

9. There are *m* spatially separated demand regions, each having a demand for food wheat, feed grains, and oilmeals.

10. Costs of transportation for products between points of consumption can be adequately reflected by flat rail rates.

11. Regional demand relations for wheat, feed grains, and oilmeals, including demand for domestic uses and foreign export, are exogenously determined and known.

12. National cost minimization is an appropriate objective function for the analysis of this study.

13. Production equals consumption at specified prices.

In addition to those above, the usual assumptions of linear programming apply.

Cropland availability is considered to be the limiting resource for all production processes of the models. Other acreage restraints are applied to specific crops to simulate certain agricultural programs. It is assumed that the program acreage restraints for any grain crop or cotton in a producing region will be proportional to the historical production of that crop.

Specific Models

Small variations in the basic model allowed the exploration of specific facets of the farm problems of overproduction and resource allocation. To add flexibility to the models and realism to the results, it was necessary to consider different combinations of restraints and input-output data. The specific differences are small in most cases, but they do allow a better view of the intraregional and interregional effects of programs directed toward individual crops. Each model employed 144 producing regions and 31 consuming regions (figs. 1 and 2).

The distinguishing characteristics of each model are described below. For purposes of this study, changes in resource availability or program

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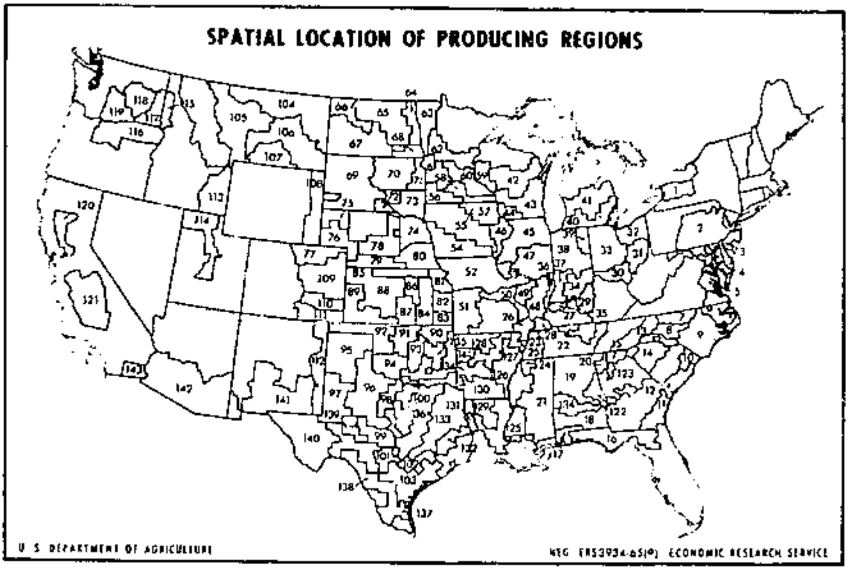

FIGURE 1

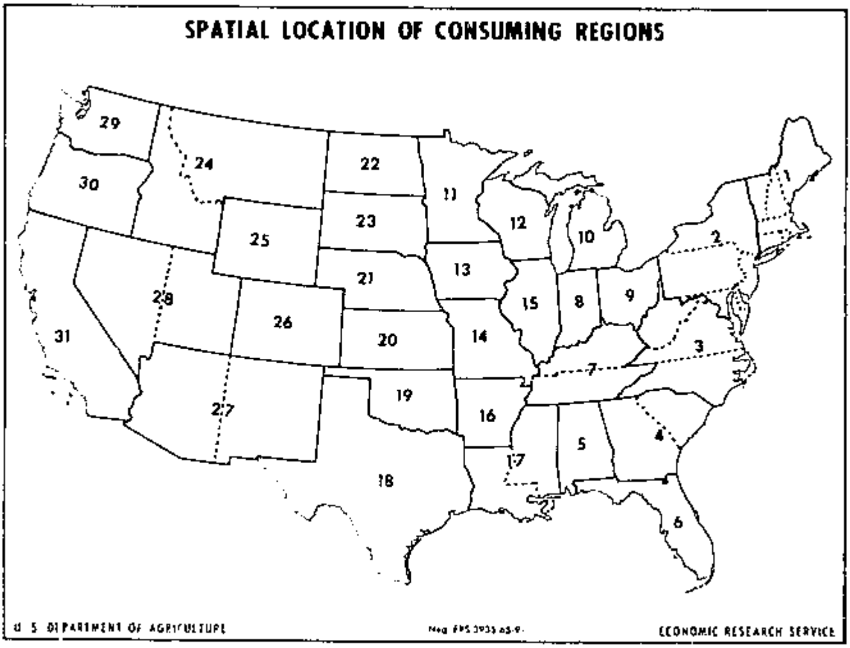

FIGURE 2

constraints are considered variations of the same model. Changes in input-output data or resource structures result in different models. These distinctions are emphasized at this point because of their wide use throughout the remainder of this publication.

Model I

Model I is basically the model outlined previously in mathematical form. Wheat can be used for livestock feed, through a transfer activity, at a price equal to its equilibrium value for this purpose. This transfer activity implies a two-price plan for wheat. Simultaneously, wheat used for food and export can be supported at a price above its equilibrium value, which has been the case for the past several years. This model results in a matrix with 674 constraints and 1,814 real variables.

Model II

Model II is similar in every respect to Model I, with two exceptions: Costs equal to the differential between the supported price of wheat at $1.95 per bushel and the price of corn at $1.10 per bushel are applied to the wheat-feed-grain transfer activities, and wheat production is restricted to the quantity that can be sold or utilized at the higher price. The cost differential varies, however, depending upon the actual historical ratio of wheat and corn prices in each consuming region. This cost is assumed to represent the difference between the equilibrium value and the supported price of wheat. Thus, production control programs for wheat and feed grains are analyzed under the assumption of a one-price plan for wheat. Table 1 summarizes the construction of Model I and Model II.

Model III

Model III differs from Models I and II in that it recognizes intraregional cropland variability. Three cropland categories are used and cropland is no longer assumed to be completely homogeneous within any production region. Crops may be produced on the more productive land in a region while less productive land may be retired partially or entirely.

To allow these possibilities, cropland in each producing region is divided into three production categories on the basis of the estimated variation in crop productivity and permissible cropping intensity. The addition of this feature to the programming model causes a threefold increase in the total cropland constraints and the producing activities. The result is a programming matrix with 962 constraints and 2,682 real activities.

Model Constraints for Program Alternatives

Regional acreage constraints for individual crops are employed to simulate alternative programs. Producing regions have a maximum acreage restraint for each relevant producing activity (i.e., wheat, feed grains, soybeans, and cotton) and an overall constraint which represents total land

Table 1.—*Summary of Models I and II without the identity matrix*

Constraints (row names)	Type of restraint	Activities [a] Wheat production	Feed grain production	Soybean production	Cotton production	Wheat-feed grain transfer	Wheat transportation	Feed grain transportation	Oilmeal transportation	Number of rows
Land in each producing region:										
Total	$\leq$	1	1	1	1	...	...	...	...	144
Wheat	$\leq$	1	...	...	...	...	...	...	...	134
Feed grain	$\leq$	...	1	...	...	...	...	...	...	144
Soybean	$\leq$	...	...	1	...	...	...	...	...	99
Cotton	$\leq$	...	...	...	1	...	...	...	...	58
Regional demand: [b]										
$Wheat_1$	$\geq$	[c] p	...	...	...	[d] $-a$	$-a$	...	...	31
$Feed\ grain_1$	$\geq$	...	p	...	...	a	...	$-a$	...	31
$Oilmeal_1$	$\geq$	...	...	p	p	...	...	...	$-a$	31
$Wheat_2$	$\geq$	...	...	...	...	...	a	...	...	...
$Feed\ grain_2$	$\geq$	...	...	...	...	...	...	a	...	...
$Oilmeal_2$	$\geq$	...	...	...	...	...	...	...	a	...
National demand:										
Cotton lint	$\geq$	...	...	...	p	...	...	...	...	1
Cost	=	[e] C	C	C	C	C	C	C	C	1
Number of activities	...	134	144	99	58	31	459	459	430	...

[a] The number 1 and the letters in the table represent technical coefficients. Multiplied by the level of the activity, the resulting sum of products must bear the indicated relationship to the restraint.

[b] Two sets of demand restraints are shown in order to demonstrate the effect of the transportation activities.

[c] p=the output of each activity. It is expressed in feed units for all except cotton lint which is expressed in pounds.

[d] a=the amount of each commodity transferred within a region or between regions by one unit of the transportation activities.

[e] C=the per unit cost of each activity.

available in the region. The acreage restraint for the individual crop activities, termed the *base acreage*, represents the maximum amount of land which can be devoted to a particular crop. A 10-year (1951–60) average was employed in estimating base acreages for individual crops in each region. The average percentage of cropland devoted to each relevant crop in this period was multiplied by the available regional cropland acreage to estimate the base acreage of each crop in each region.

Alternative supply control programs are simulated by changing the level of the constraints for individual crop activities. For example, if the regional acreage restraints for feed grains and cotton are held at 100 percent of their base acreage and wheat acreage restraints are reduced by 10 percent, a program is simulated in which reduction of wheat acreage is mandatory in all areas (while cotton and feed grains are free to adjust production within the confines of their base acreages).

The programming constraints for each model solution are summarized in table 2. A code is indicated for each as an aid to the reader. For example, the solution of Model I in which wheat acreage quotas are removed while acreage for other crops is at the base acreage level is labeled IWU (I for Model I, W for wheat, and U for unlimited acreage of wheat). Program IBN is a benchmark solution since regional crop acreage constraints for

TABLE 2.—*Percentages of total cropland and of base acreages for specific crops used as limits in simulated land retirement programs* [a]

Model and program code [b]	Total land	Cotton	Wheat	Feed grains
	Percent	*Percent*	*Percent*	*Percent*
Model I:				
IBN	100	100	100	100
IWU	100	100	[c] Unlimited	100
IWL	100	100	90	100
IFU	100	100	100	Unlimited
IFL	100	100	100	92.5
IUU	100	200	Unlimited	Unlimited
Model II:				
IIWU	100	100	Unlimited	100
IIBN	100	100	100	100
Model III:				
IIIWU	100	100	Unlimited	100
IIIBN	100	100	100	100
IIIWL	100	100	90	100
IIIFU	100	100	100	Unlimited
IIIFL	100	100	100	92.5

[a] Soybean production is limited to 40 percent of total cropland except in regions where the historical production of soybeans exceeded this percentage.

[b] The letters in the code have these meanings: I=Model I, II=Model II, III=Model III, W=wheat, U=acreage unlimited except for the total acreage, L=acreage limited below the base acreage, F=feed grains, BN=benchmark solution with acreage restraints set at the base acreage level for each crop. In program IUU, cotton is limited to 200 percent of its base acreage while other crops are limited only to the total acreage in the region.

[c] Unlimited implies that no restrictions, other than total cropland, are used to limit production of that crop.

wheat, feed grains, and cotton are held at 100 percent of their respective base acreages. The benchmark solution does not focus upon any particular crop.

The regional soybean acreage restraint was set at a maximum of 40 percent of available cropland (because of possible diminishing soil productivity or potential erosion hazards), or at the historical acreage in regions where this exceeded 40 percent of available cropland. The regional soybean acreage constraints were the same for all solutions of each model. The regional acreage restraints for wheat, feed grains, and cotton are based on historical production of each crop from 1951 to 1960. The base acreage of each regional crop activity is shown in table 3.

TABLE 3.—*Base acreage of wheat, feed grains, cotton, and soybeans, and total available acreage, 144 producing regions*

Region	Base acreage (1951–60 average)				Total
	Wheat	Feed grains [a]	Cotton	Soybeans [b]	
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
1	271.2	327.8	....	3.6	602.6
2	649.1	1,739.0	....	33.9	2,422.0
3	89.7	344.4	....	163.9	598.0
4	90.8	197.3	....	43.4	331.5
5	42.2	137.1	....	133.0	312.3
6	34.2	563.4	84.2	195.7	877.5
7	70.7	253.0	4.7	6.7	335.1
8	96.1	291.6	35.3	7.8	430.8
9	62.5	1,280.7	396.3	212.8	1,952.3
10	12.2	307.0	106.8	44.7	470.7
11	2.0	270.1	32.7	32.0	336.8
12	116.8	2,948.9	1,289.9	317.8	4,673.4
13	54.1	190.7	84.7	2.7	332.2
14	62.5	379.9	122.0	13.9	578.3
15	17.3	102.2	20.0	1.0	140.5
16	....	530.9	59.9	27.2	618.0
17	....	78.7	17.1	94.6	190.4
18	....	754.3	328.7	5.4	1,088.4
19	....	1,106.4	800.8	27.1	1,934.3
20	5.2	77.8	56.9	1.0	140.9
21	4.8	1,369.1	923.8	83.3	2,381.0
22	80.8	971.5	127.3	44.0	1,223.6
23	16.9	305.2	651.4	232.8	1,206.3
24	6.9	165.0	116.3	23.7	311.9
25	28.8	145.2	398.8	388.2	961.0
26	91.3	305.4	395.5	475.3	1,267.5
27	134.7	831.7	....	102.6	1,069.0
28	20.2	238.3	7.2	22.5	288.2
29	32.6	291.9	....	4.9	329.4
30	138.8	428.4	....	26.1	593.3

See footnotes at end of table.

TABLE 3.—*Base acreage of wheat, feed grains, cotton, and soybeans, and total available acreage, 144 producing regions*—Continued

Region	Base acreage (1951–60 average)				Total
	Wheat	Feed grains [a]	Cotton	Soybeans [b]	
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
31	112.4	298.3	...	4.1	414.8
32	289.2	694.7	...	177.7	1,161.6
33	1,258.7	3,524.3	...	1,071.3	5,854.3
34	147.7	593.0	...	88.8	829.5
35	24.3	241.8	...	71.2	337.3
36	131.4	403.1	...	212.0	746.5
37	271.9	854.8	...	327.1	1,453.8
38	777.4	3,792.5	...	1,319.2	5,889.1
39	202.1	789.0	...	219.0	1,210.1
40	450.1	1,198.0	...	83.1	1,731.2
41	755.2	1,508.2	...	53.3	2,316.7
42	9.9	979.9	...	4.0	993.8
43	43.6	2,239.7	...	13.8	2,297.1
44	1.8	590.7	...	2.4	594.9
45	191.6	5,071.1	...	724.4	5,987.1
46	1.9	1,802.1	...	87.0	1,891.0
47	363.9	4,315.5	...	1,704.5	6,383.9
48	357.3	869.3	...	491.3	1,717.9
49	331.0	635.5	...	504.6	1,471.1
50	202.2	464.1	.8	87.5	754.6
51	384.0	1,233.0	...	185.7	1,802.7
52	641.0	2,964.2	...	941.1	4,546.3
53	283.9	850.2	...	556.0	1,690.1
54	75.7	3,922.0	...	454.1	4,451.8
55	9.4	7,949.2	...	1,393.5	9,352.1
56	28.3	2,407.2	...	389.9	2,825.4
57	2.7	2,567.1	...	169.9	2,739.7
58	32.8	1,458.3	...	440.4	1,931.5
59	9.9	717.7	...	31.1	758.7
60	29.8	1,796.9	...	304.8	2,131.5
61	1,007.5	1,718.4	...	299.5	3,025.4
62	98.1	1,178.8	...	31.4	1,308.3
63	594.1	1,650.4	...	67.0	2,311.5
64	961.6	1,007.9	...	42.2	2,011.7
65	3,195.2	2,760.2	...	84.6	6,040.0
66	1,303.4	563.9	...	...	1,867.3
67	2,525.6	1,496.0	...	...	4,021.6
68	37.1	57.3	...	6.0	100.4
69	1,064.6	686.4	...	...	1,751.0
70	1,594.4	2,319.2	...	3.9	3,917.5
71	305.5	1,028.5	...	48.4	1,382.4
72	351.7	613.4	...	1.0	966.1
73	128.1	3,444.1	...	87.8	3,660.0
74	62.4	3,791.7	...	46.8	3,900.9
75	145.1	201.1	...	...	346.2

See footnotes at end of table.

TABLE 3.—*Base acreage of wheat, feed grains, cotton, and soybeans, and total available acreage, 144 producing regions*—Continued

Region	Base acreage (1951–60 average)				Total
	Wheat	Feed grains [a]	Cotton	Soybeans [b]	
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
76	1,228.4	607.8	...	...	1,836.2
77	396.4	337.7	...	...	734.1
78	314.6	1,497.8	...	16.5	1,828.9
79	876.7	1,061.1	...	1.9	1,939.7
80	1,123.7	3,407.9	...	73.7	4,605.3
81	357.2	858.5	...	16.0	1,231.7
82	293.6	576.2	...	135.8	1,005.6
83	329.4	453.1	...	100.7	883.2
84	365.9	592.6	...	136.9	1,095.4
85	987.4	590.8	...	1.6	1,579.8
86	840.5	468.1	...	2.6	1,311.2
87	1,665.7	544.1	...	11.1	2,220.9
88	4,015.1	1,420.0	...	5.4	5,440.5
89	2,052.8	1,258.1	...	...	3,310.9
90	136.6	299.6	...	11.6	447.8
91	2,164.8	452.8	...	...	2,617.6
92	1,737.8	780.7	...	...	2,518.5
93	315.7	181.4	...	...	497.1
94	1,285.5	415.6	880.3	...	2,581.4
95	1,288.1	1,426.6	425.2	9.4	3,149.3
96	792.0	1,035.0	1,693.2	...	3,520.2
97	52.9	1,271.9	1,452.8	5.6	2,783.2
98	181.1	172.7	47.4	.4	401.6
99	22.5	118.3	79.9	...	220.7
100	191.2	1,061.7	1,262.9	...	2,515.8
101	5.2	92.4	2.4	...	100.0
102	...	293.1	249.6	...	542.7
103	2.8	914.5	496.1	...	1,413.4
104	2,880.1	929.6	...	...	3,809.7
105	1,559.6	553.7	...	...	2,113.3
106	273.2	145.8	...	...	419.0
107	287.2	127.8	...	...	415.0
108	345.2	185.8	...	...	531.0
109	1,786.3	722.5	...	...	2,508.8
110	202.2	205.5	...	...	407.7
111	134.1	87.9	...	...	222.0
112	87.5	231.4	47.2	...	366.1
113	544.2	1,205.5	...	...	1,749.7
114	184.7	99.0	...	...	283.7
115	302.9	143.8	...	...	446.7
116	750.9	218.0	...	...	968.9
117	1,153.1	274.0	...	...	1,427.1
118	1,233.0	234.8	...	...	1,467.8
119	241.5	75.4	...	...	316.9
120	77.0	298.7	...	...	375.7

See footnotes at end of table.

Table 3.—*Base acreage of wheat, feed grains, cotton, and soybeans, and total available acreage, 144 producing regions*—Continued

Region	Base acreage (1951–60 average)				Total
	Wheat	Feed grains [a]	Cotton	Soybeans [b]	
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
121	168.5	805.0	799.8	....	1,773.3
122	1.0	147.1	60.8	.2	209.1
123	41.7	733.1	262.4	4.2	1,041.4
124	0.4	262.7	139.4	.4	402.9
125	43.7	549.1	670.8	102.5	1,366.1
126	33.5	284.4	790.8	412.1	1,520.8
127	41.4	432.8	607.7	799.6	1,881.5
128	8.3	109.8	156.1	56.5	330.7
129	2.2	66.7	51.2	1.3	121.4
130	.3	137.7	152.7	10.5	301.2
131	....	13.6	14.6	....	28.2
132	....	53.2	11.4	....	64.6
133	....	495.5	405.4	.9	901.8
134	12.7	87.9	72.3	.5	173.4
135	20.7	143.2	58.1	8.5	230.5
136	13.7	163.6	40.0	....	217.3
137	....	140.6	599.4	....	740.0
138	.3	68.8	46.2	....	115.3
139	.8	9.9	9.2	....	19.9
140	....	13.8	209.2	....	223.0
141	4.9	25.7	192.6	....	223.2
142	23.9	271.7	527.7	....	823.3
143	11.8	86.0	63.3	....	161.1
144	2.8	22.2	2.0	24.0	51.0
Total	58,526.8	129,235.0	18,641.2	17,553.4	223,956.4

[a] The feed grain base is a composite of the acreage of corn, oats, barley, and grain sorghums.
[b] The acreage restraint used for soybeans was 40 percent of total available acreage and not the soybean base acreage shown here.

Demand restraints are computed as the quantities allowing attainment of the following average U.S. prices: $33.87 per hundredweight for cotton, $1.10 per bushel for corn, 96 cents per bushel for grain sorghum, 67 cents per bushel for oats, 96 cents for barley, and $1.16 per bushel for wheat priced at "feed value."

Requirements were estimated for wheat, feed grains, and oilmeals for each consuming region, on the basis of national demand functions for each commodity. A single national demand was specified for cotton lint. These commodity requirements reflected the composite demands for food, fibers, livestock feed, and export. The same price levels and the resulting demand quantities for agricultural products were applied to all simulated supply control programs. All land retirement programs have the same total national production and the same product distribution among demand regions; only the patterns of production differ among the various plans.

The 1965 per capita consumption of wheat was estimated to be 2.53 bushels. Assuming the population to be 193.6 million, total domestic consumption of wheat is 489.1 million bushels. Wheat used for feed, military procurements, and industrial uses brings total domestic demand up to 598.3 million bushels. Export demand for wheat is estimated at 449.6 million bushels. The regional allocation of wheat demands is shown in table 4.

TABLE 4.—*Wheat: Estimated demand. 31 consuming regions, 1965*

Region	Domestic consumption	Exports	Total demand	Production in nonprogrammed regions [a]	Net demand [b]
	Mil. bu.	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*
1	....	8.86	8.86	0.04	8.82
2	77.98	69.75	147.73	9.29	138.44
3	11.45	15.83	27.28	7.92	19.36
4	1.84	....	1.84	.15	1.69
5	....	6.03	6.03	....	6.03
6	....	....	....	....	....
7	17.67	....	17.67	3.27	14.40
8	8.54	....	8.54	....	8.54
9	26.45	5.62	32.07	....	32.07
10	19.93	1.48	21.41	2.73	18.68
11	68.55	3.51	72.06	.29	71.77
12	4.98	15.15	20.13	.06	20.07
13	10.67	....	10.67	....	10.67
14	50.59	....	50.59	1.04	49.55
15	36.77	.13	36.90	....	36.90
16	....	....	....	.12	—.12
17	.30	52.21	52.51	.01	52.50
18	36.23	142.19	178.42	1.03	177.39
19	24.55	....	24.55	.86	23.69
20	84.80	....	84.80	....	84.80
21	16.37	....	16.37	.10	16.27
22	7.65	....	7.65	....	7.65
23	1.19	....	1.19	.05	1.14
24	11.86	....	11.86	16.98	—5.12
25	.59	....	.59	1.00	—.41
26	10.56	....	10.56	3.93	6.63
27	.59	....	.59	.90	—.31
28	12.93	....	12.93	2.29	10.64
29	24.37	77.07	101.44	1.09	100.35
30	16.25	46.27	62.52	5.41	57.11
31	14.58	5.49	20.07	6.39	13.68
Total	598.24	449.59	1,047.83	64.95	982.88

[a] Some parts of consuming regions were not included in the programming analysis. These regions are termed nonprogrammed regions. The production indicated for them is assumed to be fixed because of crop rotation and other requirements.

[b] Total demand less production in nonprogrammed areas.

Total feed grain demand is a composite of uses for feed, industry, and exports. Table 5 shows a breakdown of feed grain demands by consuming region. Oilmeal demand is based on estimated livestock consumption of cottonseed and soybean oilmeals, plus exports of soybeans and soybean meal. Total oilmeal demand, shown in table 6, was estimated to be equivalent to 671.5 million bushels of soybeans.

TABLE 5.—*Feed grains: Estimated demand, 31 consuming regions, 1965* [a]

Region	Livestock feed	Food	Exports	Total demand	Production in nonprogrammed regions [b]	Net demand [c]
	Mil. bu.	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*
1	113.35	0.92	16.73	131.00	2.80	128.20
2	361.36	14.28	46.48	422.12	43.00	379.12
3	254.22	3.64	29.24	287.10	64.82	222.28
4	243.83	1.77	....	245.60	2.89	242.71
5	119.83	.64	9.57	130.04	....	130.04
6	42.78	.14	....	42.92	.85	42.07
7	173.14	7.21	....	180.35	47.34	133.01
8	283.90	20.80	....	304.70	....	304.70
9	187.71	8.20	10.38	206.29	....	206.29
10	83.22	15.55	1.23	100.00	9.95	90.05
11	323.41	12.25	16.27	351.93	3.01	348.92
12	232.06	42.07	23.97	298.10	3.51	294.59
13	786.30	26.70	....	813.00	....	813.00
14	247.11	21.68	....	268.79	7.56	261.23
15	454.26	63.55	21.22	539.03	....	539.03
16	86.08	.73	....	86.81	3.38	83.43
17	108.11	1.75	65.35	175.21	5.18	170.03
18	134.82	8.79	78.42	222.03	6.31	215.72
19	26.69	.83	....	27.52	3.69	23.83
20	79.44	1.29	....	80.73	....	80.73
21	232.39	.88	....	233.27	2.94	230.33
22	44.61	.45	....	45.06	....	45.06
23	128.80	.45	....	129.25	.06	129.19
24	39.07	....	....	39.07	8.46	30.61
25	7.01	....	....	7.01	3.21	3.80
26	36.85	.29	....	37.14	5.78	31.36
27	21.39	....	....	21.39	1.77	19.62
28	18.95	....	....	18.95	2.63	16.32
29	36.09	3.01	20.17	59.27	2.13	57.14
30	31.88	1.37	9.97	43.22	12.27	30.95
31	213.27	7.10	8.88	229.25	30.24	199.01
Total	5,151.93	266.34	357.88	5,776.15	273.78	5,502.37

[a] This is a composite of the demand for corn, oats, barley, and grain sorghums. This demand was expressed in feed units in the programming models and is shown in corn equivalent units in this table for clarity.

[b] Some parts of consuming regions were not included in the programming analysis. These regions are termed nonprogrammed regions. The production indicated for them is assumed to be fixed because of crop rotation and other requirements.

[c] Total demand less production in nonprogrammed areas.

Export demands, estimated to be equal to average total exports for the years 1957 to 1961, are included in the total demand for the respective consuming regions in which the ports are located. The distribution of export demands by consuming regions is shown in tables 4, 5, and 6.

The 1965 demand for cotton fibers used is 20.4 pounds per person. With

TABLE 6.—*Cottonseed and soybeans: Estimated demand, 31 consuming regions, 1965*

Region	Cottonseed	Soybeans	Soybean exports	Total oilmeal demand [a]	Production in nonprogrammed regions [b]	Net demand [c]
	Thous. tons	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*	*Mil. bu.*
1	58.51	24.94	....	25.86	.12	25.74
2	257.46	78.31	12.24	94.60	1.76	92.84
3	209.29	22.97	8.80	35.06	.16	34.90
4	370.54	14.59	....	20.40	....	20.40
5	258.12	4.51	15.58	24.13	....	24.13
6	150.13	4.29	....	6.64	.05	6.59
7	187.08	17.63	....	20.56	.20	20.36
8	30.51	29.52	....	30.00	....	30.00
9	47.92	21.83	9.65	34.24	....	34.24
10	16.13	10.86	.90	11.92	.01	11.91
11	22.99	16.22	2.25	18.84	.02	18.82
12	10.47	14.91	5.15	20.25	.03	20.22
13	128.71	35.70	....	37.73	....	37.73
14	250.69	23.95	....	27.89	.13	27.76
15	92.08	29.79	13.25	44.49	....	44.49
16	203.77	7.81	....	11.00	.15	10.85
17	453.95	9.13	69.13	85.37	.66	84.71
18	1,375.60	11.39	.11	33.06	.35	32.71
19	353.08	5.22	....	10.75	.37	10.38
20	274.91	8.31	....	12.62	....	12.62
21	101.70	11.78	....	13.38	....	13.38
22	2.54	.68	....	.72	....	.72
23	15.29	2.63	....	2.87	....	2.87
24	45.71	2.53	....	3.25	....	3.25
25	43.19	.58	....	1.26	....	1.26
26	149.96	3.11	....	5.46	....	5.46
27	430.04	1.56	....	8.30	.01	8.29
28	160.13	1.75	....	4.26	....	4.26
29	53.39	6.53	....	7.36	....	7.36
30	48.30	4.19	....	4.95	....	4.95
31	264.66	12.11	....	16.26	.32	15.94
Total	6,060.85	439.33	137.06	673.48	4.34	669.14

[a] Expressed in bushels of soybeans.

[b] Some parts of consuming regions were not included in the programming analysis. These regions are termed nonprogrammed regions. The production indicated for them is assumed to be fixed because of crop rotation and other requirements.

[c] Total demand less production in nonprogrammed areas.

a 1965 population of 193.6 million persons, cotton demand for domestic consumption is estimated at 3,953.3 million pounds. Net exports of cotton lint are estimated at 2,512.7 million pounds for 1965. Hence, the estimated total demand for cotton lint is 6,466 million pounds.

Demand requirements of each consuming region are reduced by the amount of production from minor "blank areas" or nonprogrammed regions within the demand regions as indicated in tables 4, 5, and 6. These nonprogrammed areas were too insignificant to be included as separate producing areas but they do produce small amounts that help to meet total demands of each consuming region.

Composition of Model Activities

Four potential producing activities were considered. They are wheat, feed grains, cotton, and soybeans. According to the crop production history there are 144, 134, 99, and 58 regions having previously produced feed grains, wheat, soybeans, and cotton, respectively. Crops not previously produced in a region were considered unadaptable to that area. The feed grain activity is a composite of corn, oats, barley, and grain sorghums.

The output of each crop activity can provide directly for the demand of the consuming region within which it is produced. Transportation is not required for commodities produced and consumed within the same demand region. All cotton activities produce lint for the single national cotton lint demand. However, the oilmeal output from cottonseed contributes to the individual regional oilmeal demands in the manner of the grain crops.

RESULTS OF THE BENCHMARK PROGRAM

To illustrate the type of results obtained, the benchmark program from Model I (IBN) is discussed in detail below.[2] This program is later used as a basis for comparison with the results of several other programs. Discussion is summarized by presenting results relative to States representing the consuming regions, although the models applied cost-minimization procedures and determined optimal production allocation for the 144 producing regions of figure 1.

Characteristically, program IBN was mildly restrictive for each of the surplus crops: wheat, feed grains, and cotton. Regional production of each crop was limited to 100 percent of its base acreage (table 2). The optimal distribution of land use resulted from the selection of those production and transportation alternatives which satisfy regional product demands at the least possible cost. Land retirement, though affected by the regional crop acreage quotas, was largely confined to areas having high costs and a low

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[2] For a more detailed treatment of all model solutions see Earl O. Heady and Norman K. Whittlesey (*4*).

profit margin. Land retirement could occur as a voluntary response of farmers for diverting submarginal cropland, or in the long run, as normal attrition in production due to losses at equilibrium prices.

Allocation of Production

Production of at least one crop occurs in nearly every producing region under the benchmark program (fig. 3). Even with regional production limited, national production capacity is sufficient to allow adjustment of crop production within and among producing regions. Approximately 80 percent of the total base acreages for wheat and feed grains is used in fulfilling their respective regional demands. About 76 percent of the total cotton base is employed in meeting national demand. Soybeans, a crop with a rapidly increasing demand, requires more than the historical base acreage to meet regional demands. Thus, approximately 82 percent of the 223.9 million acres of cropland was needed to fill regional and national demands for all crops studied. A total of 40.5 million acres of cropland that is not needed in meeting demands for the specified crops could remain idle or be shifted to other crops such as grass and trees.

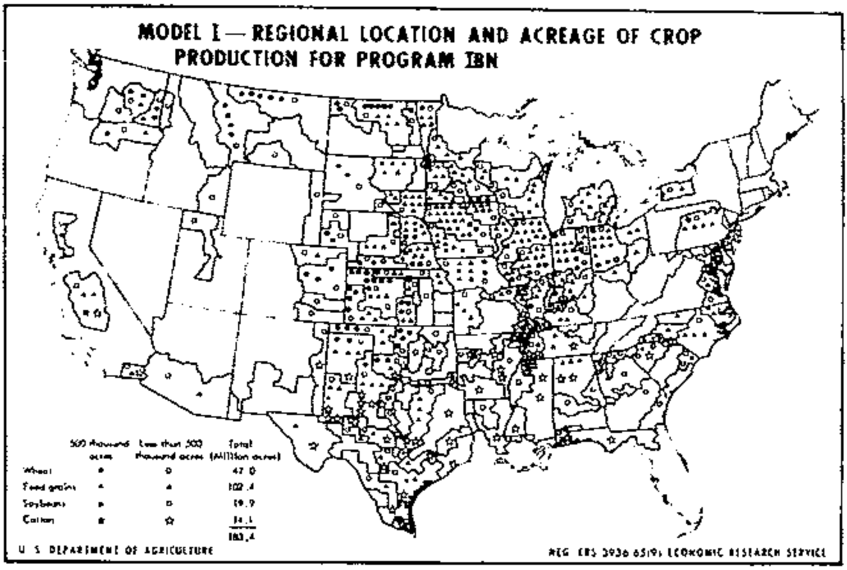

FIGURE 3

Crop production in 1962, a year in which regional production patterns were restrained by production control programs, is compared in table 7 with that suggested by the solutions for the benchmark program. However, given the conditions imposed under the model, the derived production patterns appear to be consistent with expected comparative advantage of various regions. Where differences between programmed production patterns and actual 1962 production patterns occur, the recent acreage trend generally is toward the locations suggested by the model. Given time and removal of the institutional restraints to adjustment, acreage patterns could be expected to become more closely oriented to the allocations derived under the solutions of program IBN.

The largest discrepancies between the model solution and the 1962 production patterns occur for soybeans. The projected demand for soybeans is relatively low. Also, soybean acreages are responsive to yield differences within an area, a condition perhaps not sufficiently recognized by the fixed coefficients of production used in the programming model. In a later section, where results with soil quality differences under Model III are presented, the acreage used by soybeans is greater than for solutions of Model I.

Under the benchmark program, IBN, there was a general shift toward larger feed grain acreages in the Corn Belt and smaller acreages elsewhere. The wheat production patterns under solution IBN, with shifts in conformance to the model restraints, were quite consistent with 1962 acreages. This solution suggested no drastic changes for areas which have a high comparative advantage in wheat production. The Great Plains and the West, the major winter wheat areas, maintained or strengthened their relative positions in wheat production. However, fewer acres in crops were indicated for the South.

In addition to the 50 million bushels of wheat normally used for feed and included in the initial total demands for wheat (table 4), about 310 million additional bushels are used as feed under this model, which includes two prices for wheat and allows it to be used in unlimited amounts for feed at the lower price. Most of the wheat produced for feed is in regions of Wisconsin, Kansas, Colorado, Idaho, Oregon, and Washington (fig. 4). Wheat-for-feed production in Wisconsin may be the result of the absence of a distinction between corn for grain (with which feed wheat competes) and corn for silage.

The location of cotton production in the benchmark program generally agrees with the 1962 actual allocation of production (table 7). There is a slight shift in acreage from the Southeast into Texas and Oklahoma. South Carolina and Georgia show the greatest losses in acreages. Little cotton acreage is allocated to New Mexico and Arizona under the benchmark program because the programming model did not consider quality advantages for western-grown cotton. Also, the technical coefficients for cotton in Model I did not reflect recent rapid yield increases in that area. Hence, cotton yields for selected regions in Texas, Arizona, and New Mexico were raised slightly in Models II and III, resulting in somewhat larger cotton acreages in these States.

Table 7.—*Acreage of wheat, feed grains, cotton, and soybeans as specified in benchmark program IBN, compared with actual acreages in 31 consuming regions, 1962* [a]

Region	Wheat		Feed grains		Soybeans		Cotton		Unused land IBN
	IBN	1962	IBN	1962	IBN	1962	IBN	1962	
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
1	([b])	...	([b])	68	([b])	...	([b])	...	...
2	936.3	832	2,608.5	3,161	371.8	555	...	...	37.5
3	193.0	401	2,716.5	2,479	...	...	84.7	417.0	1,246.0
4	257.7	103	752.3	2,567	223.2	947	178.9	1,267.0	5,969.9
5	1.4	35	1,185.1	1,322	94.6	720	767.4	900.0	1,776.6
6	...	...	...	289	...	39	59.9	20.6	558.1
7	196.1	238	2,880.4	2,323	304.0	682	785.9	546.7	287.4
8	997.0	1,096	6,029.3	4,951	2,356.2	2,761	...	...	...
9	907.7	1,209	4,945.7	3,541	1,422.3	1,808	...	...	748.3
10	510.3	922	2,706.2	2,224	...	351	...	...	831.4
11	1,760.8	731	10,210.0	8,624	775.0	2,294	...	...	787.8
12	55.3	48	4,528.0	3,792	31.1	101	...	...	30.1
13	87.8	88	16,240.4	12,818	2,106.4	3,405	...	...	...
14	1,051.2	976	4,966.7	3,632	1,771.2	2,784	396.3	383.0	185.7
15	1,045.6	1,522	12,144.7	9,852	4,724.5	5,575	...	2.0	81.8
16	49.7	112	...	353	388.2	2,707	1,315.3	1,355.0	1,721.2
17	45.4	70	165.0	1,166	23.7	1,347	1,712.9	2,150.0	3,833.4
18	2,550.6	2,731	6,446.6	7,174	169.9	60	7,021.9	6,473.0	738.9
19	5,673.8	3,787	1,284.2	1,647	161.6	171	880.3	625.0	1,066.4
20	9,561.5	8,986	4,677.9	5,298	909.5	914	...	...	2,930.3

21	2,250.2	2,760	7,191.4	7,808	3,919.7	310	...	...	1,095.9
22	5,460.2	5,519	1,850.9	4,894	...	56	...	...	6,729.9
23	1,416.3	1,721	6,376.7	5,773	137.3	121	...	...	3,746.7
24	5,422.8	4,422	(c)	2,881	...	...	...	...	3,530.6
25	125.1	213	(c)	214	...	...	...	...	405.9
26	2,519.0	1,899	337.7	1,040	...	...	...	...	1,015.9
27	111.4	234	271.7	486	...	...	47.2	661.6	982.3
28	184.7	206	(c)	200	...	...	...	3.5	99.0
29	2,627.6	1,697	508.8	752	...	...	...	...	75.4
30	750.9	680	217.8	581	...	...	...	...	...
31	257.3	307	1,189.7	1,924	...	...	863.1	809.6	...
Total	47,006.7	43,545	102,432.2	103,834	19,890.2	27,708	14,113.8	15,614.0	40,512.4

[a] Harvested acres for 1962 are shown. Taken from Crop Production, 1962 annual summary (*8*).

[b] A small amount of production occurs in the nonprogrammed regions (those without numbers in fig. 1) and is not shown here.

[c] Wheat is used extensively for a feed grain in these areas.

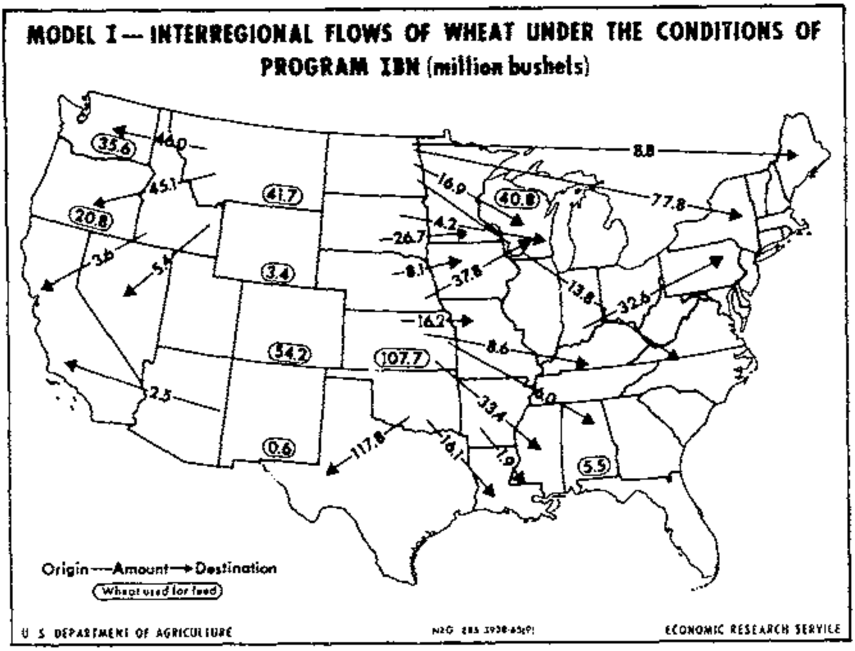

FIGURE 4

Transportation Requirements

Interregional trade or product flows are indicated in figures 4, 5, and 6. The general movement of feed grains is from the Corn Belt into the Southern and Eastern States, with Illinois and Indiana being the largest exporters. Kansas and Montana export large amounts of wheat for livestock feed. Wheat is generally in surplus in the Great Plains States and Montana and in deficit supply elsewhere. North and South Dakota, Nebraska, Kansas, and Oklahoma supply most of the export demand of the eastern half of the United States while the chief export State for Pacific coast regions is Montana.

Because of combined advantages in production and location, Nebraska is the main exporter of oilmeals to the Pacific States (fig. 6). Nebraska regions also export some oilmeals to the Southeast. The central Corn Belt is the main source of oilmeal for other deficit-producing regions. Illinois is the largest producer and shipper of soybeans. Cottonseed meal, when available, also is used to satisfy oilmeal demands. However, none of the cotton-producing States had an exportable surplus of oilmeals and only soybean meal moves among consuming regions.

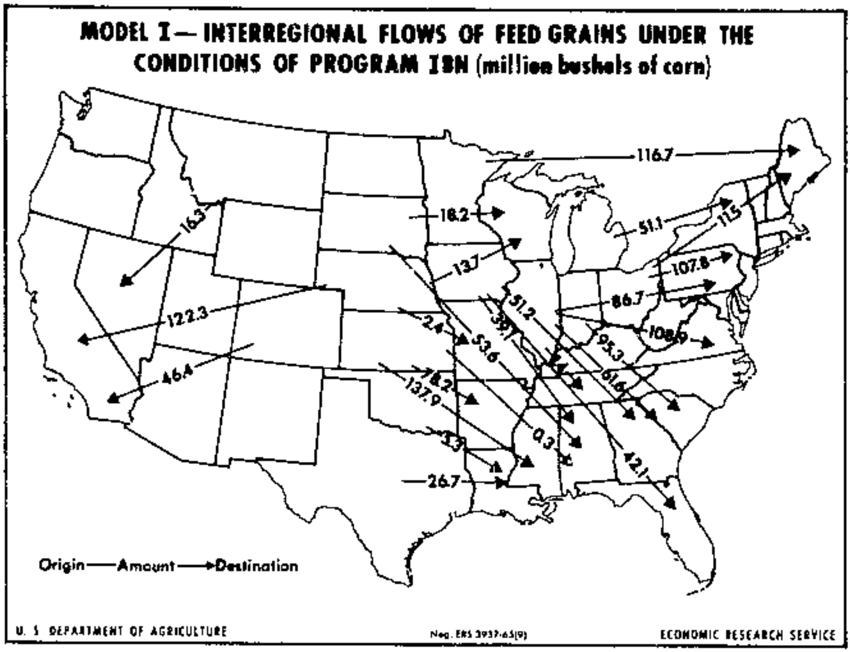

Figure 5

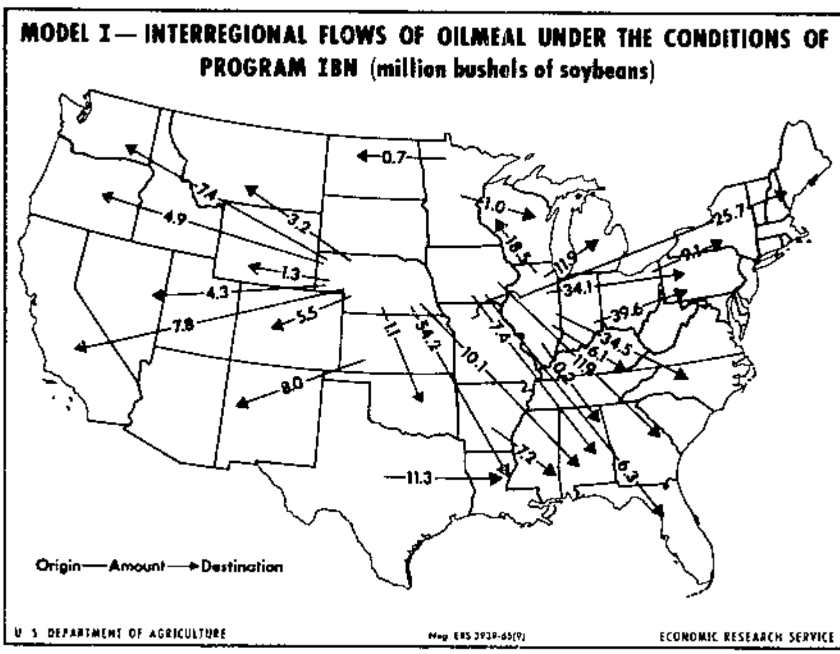

Figure 6

Product Prices

Derived regional prices from the dual solution of the programming model are shown in table 8. They can be considered as programming equilibrium prices for the consuming regions within the context of the model and its discrete supply and demand restraints. These prices reflect regional differentials due to production and transportation costs of the respective commodities.

TABLE 8.—*Programmed equilibrium prices per bushel of wheat, feed grains and soybeans for program IBN, 31 consuming regions*[a]

Region	Wheat	Feed grains[b]	Soybeans
	Dollars	*Dollars*	*Dollars*
1	1.44	1.27	1.21
2	1.39	1.22	1.26
3	1.41	1.24	1.27
4	1.47	1.30	1.15
5	1.48	1.28	1.12
6	1.47	1.30	1.16
7	1.34	1.14	1.04
8	1.06	.92	1.00
9	1.10	.95	1.03
10	1.09	.90	1.12
11	1.08	.73	.87
12	1.10	.98	1.02
13	1.08	.78	.86
14	1.09	.94	.91
15	1.07	.80	.91
16	1.17	.80	.96
17	1.38	1.08	1.08
18	1.24	.63	.85
19	.81	.65	1.01
20	.73	.65	.91
21	.72	.62	.83
22	.64	.51	1.10
23	.66	.58	.81
24	.51	.45	1.35
25	.57	.50	1.05
26	.67	.60	.97
27	.97	.86	1.33
28	1.03	.85	1.35
29	.87	.77	1.35
30	.96	.85	1.35
31	1.31	1.10	1.35

[a] Prices exclude fixed costs and land charges. Regions are shown in figure 2.
[b] Feed grain prices are expressed in corn-equivalent prices.

Programmed wheat prices are highest in eastern consuming regions due to the large excess of demand over production and the need for imports from distant regions. The price of wheat generally diminishes westward and is lowest in the concentrated wheat-producing areas of the Great Plains. Transportation charges account mainly for the differences in wheat price between western producing areas and highly populated eastern consuming regions.[3]

Feed grain prices also diminish from east to west across the United States. The lowest feed grain prices of the West are geared to production costs for competing feed wheat. The programmed equilibrium price of feed grains, expressed as corn equivalent, is about 80 cents per bushel in the large producing States of Iowa and Illinois.

Oilmeal prices are expressed as soybean equivalent prices in table 8. These prices are lowest in the Corn Belt producing area, and prices away from this area increase in proportion to transportation costs (fig. 6).

The national programmed equilibrium price of cotton lint in the benchmark solution is $31.99 per hundredweight. Cottonseed prices, when computed on a feed unit equivalent basis, are about $28 per ton.

AGGREGATE RESULTS AND PROGRAM IMPLICATIONS

We now summarize the results for other solutions or programs represented under the models. The summary is given mainly at the national level, rather than in the detail of the 144 producing regions. The results of each model solution are optimal land use patterns as influenced by the restraining conditions of product demand, cropland availability, and institutional factors of Government programs. Each model solution yields several important items of information relevant to the choice of land retirement programs. These items, including production efficiency, allocation of land use, crop yields, and needed product transportation associated with alternative programs, are emphasized in the following pages.

Programming Models

All the model solutions of this analysis emphasize control of land use as the major instrument of supply control. Special attention is given to derived patterns of land use under each program alternative.

As described previously, the solutions derived from Model I are basic and provide a comparison for similar solutions of Models II and III. The benchmark solution, IBN, which is described in some detail in the preceding section, emphasizes no single crop. Wheat, feed grains, and cotton are each restricted to the historic and regional base acreages shown in table 2. Solutions IWU and IWL also employ Model I, but focus upon specific wheat programs. Solution IWU has no wheat acreage restraints within regions. Conceivably, a region with a marked comparative advantage could devote all of its available cropland to wheat production. However, in total, fixed commodity

[3] The production costs of the models excluded those for marketing, housing, management, and other overhead items. Hence, the cost coefficients used were perhaps 10 percent or more below total costs, had these fixed costs been included. The programmed equilibrium prices also deviate by a like proportion from long-run equilibrium prices based on coefficients which include these overhead costs.

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demand cannot be exceeded. Solution IWL is an acreage allotment program in which all regional base acreage maximums for wheat have been mandatorily reduced by 10 percent. Comparable analyses of feed grain production are made through solutions IFU and IFL.

Solution IUU simulates a program allowing an unrestricted shift in production of all crops to areas of greatest comparative advantage. (Only total land area serves as a restraint to each crop except cotton; for cotton, the restraint is doubled over other solutions.) Solution IUU allows minimum production and transport costs for the given national bill of goods while retaining a given commodity price level. This solution could be interpreted as a program that compensated farmers for land voluntarily diverted from production, with diversion obtained at the lowest cost to the National Treasury. Such an allocation of production could also result from the application of negotiable marketing quotas. In this case farmers with the greatest comparative advantage would bid marketing quotas away from less efficient producers.

In all solutions of Model I, the assumption that wheat can be used as a feed grain, as long as production costs are competitive, has important effects on the production and acreage of wheat and other crops. This fact is illustrated by comparing the results of similar programs under Model II and Model I (tables 9 and 10).

The distinguishing characteristic of Model II is a single price for wheat—a price that is above its equilibrium value in feed uses.[4] Otherwise, the structure of Model II is identical to that of Model I.

Model III is unique in the sense that land quality differentials are recognized to exist within producing regions. Aggregate land use estimates for each simulated program are shown in table 9.

To emphasize the character of each model the results of several alternative wheat programs are summarized in table 10. Model I results in larger acreages of wheat and smaller acreages of feed grains than the other two models. Also, Model I continually results in larger acreages of cotton than the other models.

Model II, which emphasized a one-price plan for wheat with little use of wheat for feed, sharply reduces the production of wheat. Program IIWU, despite a complete lack of acreage quotas on wheat, results in only 41.2 million acres of wheat. Feed grains are in a more highly competitive position under this program. This situation most nearly typifies the wheat programs prior to 1964 when all wheat was supported above its equilibrium value. The change in cotton acreage effected by Model II, as compared to Model I, results from a change in yield estimates (see earlier discussion) in selected areas of the West (and not from the change in assumption regarding wheat prices).

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[4] Programs IWU and IIWU are similar and programs IBN and IIBN are also similar, as shown in table 6, allowing isolation of the effect of price on consumption of feed wheat.

TABLE 9.—*Acreages programmed for wheat, feed grains, soybeans, and cotton under Models I, II, and III* [a]

Model and program [b]	Wheat	Feed grain	Soybeans	Cotton	Total	Cropland unused [c]
	Mil. acres	*Mil. acres*	*Mil. acres*	*Mil. acres*	*Mil. acres*	*Mil. acres*
Model I:						
IWU	73.7	78.0	19.9	14.1	185.7	38.2
IBN	47.0	102.4	19.9	14.1	183.4	40.5
IWL	44.3	105.1	20.0	14.1	183.5	40.6
IFU	41.6	99.9	20.4	14.1	176.0	47.9
IFL	53.6	100.6	19.6	14.1	187.9	36.1
IUU	55.0	89.4	20.2	12.3	176.9	47.2
Model II:						
IIWU	41.2	107.3	19.7	12.6	180.8	43.1
IIBN	39.1	110.2	19.8	12.6	181.7	42.3
Model III:						
IIIWU	63.9	80.7	20.9	11.4	176.9	47.0
IIIBN	45.8	96.7	21.3	11.5	175.3	48.6
IIIWL	44.0	98.0	21.5	11.5	175.0	48.9
IIIFU	41.5	97.3	21.3	11.4	171.5	52.3
IIIFL	49.5	96.2	21.2	11.5	178.4	45.5

[a] The restraining conditions of each program are illustrated in table 2.
[b] See footnote to table 2 for meaning of letters in code.
[c] This is the amount of land which can be diverted from the specified crops, if an optimal distribution is attained under the restraints of control programs and acreage limits specified earlier. It allows domestic and export demands to be met while holding crop prices to specified levels.

TABLE 10.—*Acreages of specified crops under alternative wheat supply control methods in simulated land retirement programs* [a]

Wheat control method and program [b]	Wheat	Feed grain	Soybeans	Cotton	Total	Cropland unused [c]
	Mil. acres	*Mil. acres*	*Mil. acres*	*Mil. acres*	*Mil. acres*	*Mil. acres*
Unlimited quotas:						
IWU	73.7	78.0	19.9	14.1	185.7	38.2
IIWU	41.2	107.3	19.7	12.6	180.8	43.1
IIIWU	63.9	80.7	20.9	11.4	176.9	47.0
Benchmark:						
IBN	47.0	102.4	19.9	14.1	183.4	40.5
IIBN	39.1	110.2	19.8	12.6	181.7	42.3
IIIBN	45.8	96.7	21.3	11.5	175.3	48.6
Mandatory diversion:						
IWL	44.3	105.1	20.0	14.1	183.5	40.6
IIIWL	44.0	98.0	21.5	11.5	175.0	48.9

[a] The restraining conditions of each program are given in table 6. The programs IWU, IIWU, and IIIWU differed only in that they came from Models I, II, and III, respectively, and the same relationship was true for the remaining solutions.
[b] See footnote to table 2 for meaning of letters in code.
[c] This is the amount of land which can be diverted from the specified crops, if an optimal distribution is attained under the restraints of control programs and specified acreage limits. It allows domestic and export demands to be met while holding crop prices to specified levels.

The incorporation of intraregional differences in land quality in Model III reduces the number of acres needed for crop production. Hence, by inference, more land retirement is required for a given supply reduction and for attainment of the given crop prices. Under Model III feed grains shift, at the expense of soybeans and wheat, onto the higher quality cropland in many producing regions. Feed grains replace wheat for feed to some extent and reduce the wheat acreage. Soybeans, not having a substitute, expand in acreage to compensate for production on lower yielding land. Since cotton shifts to higher quality cropland in most regions, its acreage is reduced in Model III. However, a portion of the decrease in cotton acreage results from the production coefficients used in Model III. Cotton yields of selected producing regions in Texas and Arizona were adjusted upward for use in Models II and III, partially accounting for the lower cotton acreages of these two models compared with Model I.

Crop Production

Feed grain production is concentrated in the Corn Belt under all models. Producing regions of the Corn Belt have a strong comparative advantage over the rest of the Nation in feed grain production. Likewise, wheat production is concentrated in the winter wheat areas of the central Great Plains and the Pacific Coast States.

The South Atlantic States and the northern Great Plains were generally submarginal producing areas for the demand restraints employed. All models indicate that large acreages in these States could be shifted from field crops while still allowing national demand requirements to be filled. Land in these regions is needed to meet national demands only where program controls make it impossible for other regions with lower costs to meet demand restraints.

The amount of land needed to fill demands, and hence the amount which could be shifted to other uses, differs considerably under the various program solutions. Potentially, 223.9 million acres of cropland were available under all models for the production of wheat, feed grains, soybeans, and cotton. The smallest acreage specified for meeting national demands is 171.6 million acres under a program completely lacking regional feed grain acreage quotas and allowing differential allocation of crops among lands of various qualities within regions (solution IIIFU, table 9).[5] The largest acreage specified is 187.9 million acres under a simulated program where regional acreage quotas require a 7.5 percent reduction, below the base acreage, of feed grain in all regions and soil is considered to be homogeneous within producing regions (solution IFL). For all solutions, the remainder of the 223.9 million acres is assumed to be shifted to less intensive agricultural uses, shifted to nonagricultural uses, or left idle.

Cotton acreage and production location were highly stable among the

[5] The constraint conditions of all simulated programs are listed in table 2.

solutions with constant acreage quotas under each model. Specified cotton acreage ranged from 12.3 million acres under program IUU to 14.1 million acres under other programs of Model I. It ranged as low as 12.6 million acres under Model II where the more favorable cotton yields in certain western regions caused some production to be shifted from the Southeast. Cotton acreage was rather constant at about 11.5 million acres under Model III which employed the same cotton cost coefficients as Model II.

Cotton had little interaction with other crops under any of the solutions or program simulations. The acreage of cotton was modified within a given model only when the cotton acreage quotas were altered (e.g., program IUU).

While soybean acreage deviated only slightly from 20 million acres in all solutions, considerable competition between soybeans and feed grains was expressed among the different models. Generally, feed grains had prior claim on the more productive land wherever the two crops were in direct competition. Soybeans tended to be concentrated on land of somewhat lower yielding ability. This point is emphasized in Model III with soybean acreages averaging about a million acres higher than in Model I. Model II programs, with less use of feed wheat and greater use of feed grain to meet demand restraints, caused a sharp reduction in Nebraska soybean acreage. Comparing program IIWU with IWU, soybean production in Nebraska is reduced by 2.3 million acres; it is less in IIWU since more land is required for feed grain production.

The amount of land needed for feed grains depends, in the several models and solutions, on the amount of wheat used for feed. Only 78 million acres of feed grains are needed when wheat is not restricted by acreage quotas or high support prices (program IWU). Under Model II, with wheat prices held artificially high, a mildly restrictive wheat acreage program results in reduced feed wheat consumption and a feed grain acreage of 110.2 million acres (program IIBN). Correspondingly, wheat acreage is reduced to 39.1 million. As is shown by comparing programs IFL and IBN in table 9, feed grain acreage is affected relatively little by changing feed grain acreage quotas. However, the output of feed grains is affected by changing acreage quotas. The benchmark program (IBN) was compared with a program (IFL) that reduced feed grain acreage quotas proportionately over all regions; this reduction was 9.7 million acres, only 1.8 million acres less than under program IBN. However, to offset lower feed grain production, wheat acreage is simultaneously increased by nearly 6.6 million acres.

Wheat acreage varies more than that of any crop among models and programming solutions. The allocation of wheat production is quite sensitive to changes in programs directed toward either wheat or feed grains. With total feed grain demand held constant, feed wheat is utilized to offset the changes in feed grain production. The lowest wheat acreage, 39.1 million acres, occurs when wheat prices are artificially high and all crops are limited to their historical base acreages (IIBN). Wheat acreage is largest, 73.7 million acres, when regional wheat acreage quotas and artificial price barriers are removed (IWU).

Wheat Used for Feed

Feed wheat utilization is largest in Model I when wheat acreage quotas are removed (IWU, table 11). Wheat provided 21 percent of the feed grain demand under this solution; over 1 billion bushels of feed wheat are used. The conditions of this program do not restrict wheat acreage or use of wheat for feed, but feed grain acreage quotas are set at the historic base level. Under program IFU, where feed grain acreage quotas are removed and wheat acreage quotas are applied, feed use of wheat falls to one-seventh (141.1 million bushels) of that under program IWU.

TABLE 11.—*Wheat used for feed and percentage of total feed grain demand filled by wheat in simulated land retirement programs*

Model and program [a]	Quantity of wheat	Percentage of feed grain demand
Model I:	*Mil. bu.*	*Percent*
IWU	1,024.0	21.0
IBN	310.3	6.3
IWL	225.4	4.6
IFU	141.1	2.9
IFL	470.8	9.6
IUU	486.6	9.9
Model II:		
IIWU	146.8	3.0
IIBN	76.4	1.6
Model III:		
IIIWU	735.8	15.0
IIIBN	279.5	5.7
IIIWL	239.0	4.9
IIIFU	175.4	3.6
IIIFL	387.4	7.9

[a] See table 2 for meaning of letters in program codes.

Under Model II, a higher price on wheat and the simultaneously imposed wheat and feed grain acreage quotas greatly reduce the use of feed wheat (program IIBN, table 11). The higher price on feed wheat and the wheat acreage quotas imposed under Model II reduce the adjustment opportunities in crop production and result in patterns of production closely related to the actual situation in agriculture at the time of this study.

Recognition of land quality differentials under Model III has a moderating effect on the use of feed wheat. Parallel programs resulting in a very large use of feed wheat in Model I have lower feed wheat consumption figures in Model III. The opposite is true of programs using small quantities of feed wheat in Model I. This moderating effect may be a result of the more realistic structure of Model III.

Average Yields

Efficiency of land use in this study is measured by the total costs of production and product allocation under each alternative program. A consequence, however, of the optional land use patterns derived by the models is the average crop yields. Crop yields are often employed by agricultural scientists as measures of technological progress and production efficiency. The weighted average national crop yields under each program are summarized in table 12. The yield of feed grains (corn, oats, barley, and grain sorghum) is expressed in corn-equivalent terms.

TABLE 12.—*Weighted average national yield per acre of wheat, feed grains, soybeans, and cotton, under simulated land retirement programs* [a]

Model and program [b]	Wheat	Feed grains [c]	Soybeans	Cotton
Model I:	*Bushels*	*Bushels*	*Bushels*	*Pounds*
IWU	27.2	56.3	29.3	458.1
IBN	27.5	50.5	29.3	458.1
IWL	27.3	50.1	29.4	458.1
IFU	27.0	53.7	28.6	458.1
IFL	27.1	49.6	29.8	458.1
IUU	26.7	55.7	28.9	526.8
Model II:				
IIWU	27.4	50.0	29.6	514.6
IIBN	27.1	49.4	29.5	512.9
Model III:				
IIIWU	26.9	58.3	27.9	566.1
IIIBN	27.5	53.9	27.4	564.1
IIIWL	27.8	53.6	27.2	564.1
IIIFU	27.9	54.7	27.4	564.7
IIIFL	27.7	52.9	27.5	564.1

[a] Weighted by acreage of each producing region.
[b] See table 2 for meaning of letters in program codes.
[c] Expressed in terms of corn-equivalent yields.

The average yield of wheat is about 27.5 bushels per acre under all programs despite a fluctuation of wheat from 73.7 million acres to 39.1 million acres (table 9), and considerable difference in production patterns. This result implies that the yield of wheat would, in fact, be unaffected by land retirement programs directed toward wheat. If average yields are likely to remain stable regardless of where and how much land is retired, it follows that land retirement should be concentrated in the high-cost producing areas for maximum program efficiency.

Feed grain yields are more sensitive than wheat yields to the type of supply control program being employed. The average yields of feed grains vary from 49.4 to 58.3 bushels of corn equivalent per acre, with 110.2 million acres and 80.7 million acres, respectively.

Soybean yields are quite stable in all the solutions of Models I and II (table 12), despite variations in the location of soybean production affected by feed grain programs. The conditions of Model III slightly reduced the average yield of soybeans by shifting soybeans to less productive soil.

Cotton yields, because of stable cotton production patterns within each model, were altered but slightly by the land retirement programs represented by the various solutions within each model. However, a change in cotton acreage quotas (program ICU) allowing greater regional specialization raised the average yield of cotton.

Transportation Requirements

The programming objective of each model was to minimize total costs of production and product allocation within the constraints specified for the models. The total effect of transportation charges upon the allocation of production is apparently quite small. Nevertheless, the simulated programs affecting the spatial allocation of production do result in varying demands on the transportation sector.

Transportation requirements of the alternative programs are summarized in table 13. The figures given in this table are not weighted by distances but they show the total interregional product movement. These figures indicate the extent to which transportation charges influence the spatial allocation of production. The percentage of wheat production requiring transportation is least, 24.7 percent, under program IIIWU, when the location of wheat production is given the greatest opportunity to shift. In this program, intraregional land quality differentials are recognized and there are no acreage quotas or price barriers serving as obstacles to adjustment. The smallest percentage of feed grains transported among consuming regions is 22.0 percent, when feed grain acreage restrictions are most stringent (program IIIFL).

The percentage of wheat requiring transportation is largest, 51.9 percent, when feed grain acreage quotas are removed and only a small amount of wheat is produced (program IFU). Wheat production, because of natural and economic considerations, is spatially removed from the areas of its greatest consumption. Thus, when smaller amounts are produced because of program restrictions or more flexibility in production location, the percentage of wheat requiring transportation diminishes. Feed grains, on the other hand, have been produced nearer to areas of high consumption, causing their transportation requirements to increase slightly as historically derived acreage quotas are applied.

When product demands in one solution of Model I were reduced, an increase in the transportation requirements of all products occurred.[6] In this solution, the regions with comparative cost advantages in production continue to produce at full capacity. These regions, with lower demand requirements, are now able to export a greater quantity of their products. Less competitive regions find it cheaper to reduce production and increase imports.

[6] Programs considering variations in demand are not covered in this publication. They are mentioned at this point to emphasize the effect of transportation costs on resulting production patterns.

TABLE 13.—*Wheat, feed grains, and oilmeals transported among consuming regions: Quantity and percentage of total production in simulated land retirement programs*

Model and program [a]	Wheat	Feed grains [b]	Oil meals [c]	Wheat	Feed grains	Oil-meals
	Mil. bu.	*Mil. bu.*	*Mil. bu.*	*Percent*	*Percent*	*Percent*
Model I:						
IWU.....	505.2	1,120.7	337.5	25.2	25.6	50.6
IBN.....	529.2	1,294.7	334.2	40.9	25.0	50.1
IWL.....	529.3	1,326.6	333.8	43.8	25.2	50.0
IFU.....	582.8	1,377.3	339.9	51.9	25.7	51.5
IFL.....	657.2	1,185.3	339.2	45.2	23.7	50.9
ICU.....	471.5	1,394.8	357.1	32.1	28.0	53.5
Model II:						
IIWU.....	477.9	1,293.5	333.4	42.3	24.1	50.0
IIBN.....	577.9	1,307.5	335.7	54.6	24.0	50.3
Model III:						
IIIWU.....	424.9	1,257.5	334.5	24.7	26.8	50.2
IIIBN.....	563.4	1,319.6	321.4	41.6	25.3	48.2
IIIWL.....	562.7	1,311.6	315.1	46.0	24.9	47.2
IIIFU.....	594.7	1,332.9	347.6	51.3	25.0	52.1
IIIFL.....	629.8	1,118.5	320.5	46.0	22.0	48.1

[a] See table 2 for meaning of letters in program codes.
[b] Expressed in bushels of corn.
[c] Expressed in bushels of soybeans.

Solutions under Model III, which distinguished among three land groups in each region, had the most freedom to adjust production location. However, there is little difference in transportation requirements for comparable programs of Model I and Model III. An analysis of all solutions indicates that transportation charges have little influence on the land use patterns. The relative yields and costs among regions are the dominant variables affecting spatial allocation of crop production.

Equilibrium Prices

Programmed equilibrium product prices are also a measure of production and allocation efficiency. These values are "finally determined" by the marginal producing areas which supply the "last units" of the regional demand requirements for each product.[7] Ceteris paribus, farm production increases in cost efficiency as programmed equilibrium product or shadow prices are lowered. However, Government program costs may offset the social savings in production costs, depending on farm program characteristics and the attitude of society toward maintaining net farm income.

The derived equilibrium prices under each program alternative are not necessarily those which should prevail or be administered by the Government. Nor are they even the prices that would have to be in effect under the program assumptions. A specific assumption of Model II was that

[7] See Whittlesey and Skold, (*10*) for a more complete explanation of the linear programming dual.

wheat would be supported above its equilibrium value. Demand and supply quantities, as reflected in a market equilibrium, would not necessarily be equal in this or other solutions (e.g., the demand levels used in setting demand restraints generally suppose prices above their market equilibrium level).

The average equilibrium prices of products derived for each program are presented in table 14. Average farm prices and average consumer prices for each product, as reflected in the programming solutions, are listed separately. The difference between these two sets of prices is represented by transportation costs. Prices received are estimated by weighting the regional equilibrium price of each product by its corresponding regional production. Prices paid were similarly weighted by regional product demands.

Transportation charges added an average of about 30 cents per bushel to wheat prices, 10 cents per bushel to feed grain prices, and 14 cents per bushel to soybean prices (table 14). The spread between prices paid and prices received for wheat is reduced when wheat acreage quotas are lifted, allowing more freedom to adjust production (programs IWU and IIIWU). However, the effect of transportation charges on equilibrium prices of feed grains and oilmeals is relatively constant over all solutions. This fact is further evidence of the small influence which transportation requirements have on production allocation.

There are considerable differences in equilibrium product prices among solutions. Programs allowing freedom to adjust production patterns (IWU, IFU, ICU, IIIWU, and IIIFU) result in much lower equilibrium prices of wheat and feed grains than programs which partially dictate the spatial allocation of production (IWL, IFL, IIIWL, and IIIBN).

The variation in programmed oilmeal prices is less than for wheat or feed grains. However, the competition of soybeans and feed grains for cropland is emphasized by table 14. Programs which allow full adjustment of feed grain production result in lower feed grain prices but higher oilmeal prices (program IFU). Conversely, a program which restricts the location adjustments of feed grain production results in higher feed grain prices but lower oilmeal prices (program IFL).

Cotton prices are very responsive to adjustments in production location. Program ICU, allowing regional cotton acreage quotas to be increased by 100 percent over that of other solutions, reduces cotton prices by 40 percent. Solutions from Model II result in slightly lower cotton prices than corresponding solutions of Model I because of an adjustment of cotton yields in Texas, New Mexico, and Arizona. Recognition of intraregional differentials in land quality through Model III further reduced cotton prices by about 25 percent below those of Model I.

Government programs, therefore, can influence the efficiency of agricultural production. Programs which prescribe the location of crop production and resource use in agriculture may result in higher costs of production than programs which allow more freedom of action. However, the type

TABLE 14.—*Average equilibrium prices per bushel of wheat, feed grains, and oilmeals, and per hundredweight of cotton, in simulated land retirement programs*

Model and program [a]	Prices paid [b]			Prices received [b]			
	Wheat	Feed grains [c]	Oil-meals [d]	Wheat	Feed grains [c]	Oil-meals [d]	Cotton [e]
Model I:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
IWU	0.97	0.83	1.03	0.78	0.75	0.88	32.06
IBN	1.12	.92	1.07	.83	.83	.93	31.99
IWL	1.15	.93	1.08	.85	.83	.94	31.98
IFU	1.11	.76	1.14	.78	.66	1.01	31.93
IFL	1.16	.98	1.03	.88	.88	.88	32.06
IUU	.97	.75	1.13	.68	.66	.97	19.32
Model II:							
IIWU	.92	1.02	1.03	.64	.92	.90	28.17
IIBN	.98	.97	1.03	.67	.87	.90	28.17
Model III:							
IIIWU	.99	.83	1.11	.78	.75	.98	24.64
IIIBN	1.12	.89	1.17	.80	.80	1.04	24.43
IIIWL	1.17	.90	1.19	.85	.80	1.07	24.43
IIIFU	1.11	.78	1.19	.78	.69	1.03	24.66
IIIFL	1.14	.91	1.11	.82	.87	1.00	24.44

[a] See table 2 for meaning of letters in program codes.
[b] The difference between prices paid and prices received are accounted for by transportation charges and do not include processing and retail costs and margins.
[c] Expressed in corn-price equivalents.
[d] Expressed in soybean-price equivalents.
[e] Since no transportation costs were incurred for cotton the prices paid and prices received would be the same.

of program employed probably will not affect the total costs of transportation or marketing.

Net farm income can be maintained at a given level, above that specified by market price equilibrium, either (*a*) through restrictions on output which cause an income transfer from consumers through the market or (*b*) through unrestricted production with direct payments made from the taxpayer, through the Treasury, to the farmer. It is sometimes contended that the two methods have about the same net social costs. However, this argument overlooks the rather large differences in production efficiency that may exist under alternative supply control programs. These differences in efficiency, as indicated by the relative equilibrium product prices shown in table 14, could be quite significant if the program alternatives were unconstrained production adjustment (IUU) and a restrictive feed grain program (IFL).

CROPLAND DIVERSION AND GOVERNMENT PROGRAM COSTS

The previous analysis clearly indicates excess capacity in agriculture for the projected levels of commodity demand, production coefficients, and cropland acreages. We now turn our attention to the costs of land diversion programs represented by the several model solutions. Each of these solutions supposes that production is restrained to the demand levels mentioned earlier, with resulting prices which are above market equilibrium levels. All solutions and programs analyzed assume the same demand and price levels. Hence we estimate, for each solution or land diversion program it represents, the cost to the Government for shifting the specified amount of unused land from crops. In estimating these costs, we assume:

1. The Government supports crop prices at the same level for all programs, a level commensurate with the demand levels used in the models.

2. Soybeans are not in excess supply and Government expenditures are not necessary to establish appropriate output levels for this crop.

3. Wheat, feed grains, and cotton can be limited to their individual regional base acreages without Government expenditures for land diversion.

4. Government expenditures are necessary for reducing the production of any crop below its regional base acreage or retiring land not under a specific acreage quota.

5. The Government cost of withdrawing land from production of any crop is equal to or greater than the potential net revenue from producing that crop at the supported price level.

6. The production patterns resulting from the model solutions are those desired by the Government for each programming alternative or the land diversion program represented by it.

In calculating Government program costs, a distinction was made between a proportional reduction of production in all areas and diversion occurring by disproportionate amounts in submarginal areas. Proportional reduction of area production is termed "mandatory diversion." (It is true that a program that was, strictly speaking, voluntary might achieve an evenly distributed pattern of diversion over all regions.. However, this pattern would most likely occur if the program allowed only one proportionate rate of participation and provided such high payments that all farmers and all areas had "no economic choice" other than to participate.) Nonproportionate diversion of land, where regions need not shift the same percentage of land from crops, is termed "voluntary diversion." All models had some solutions representing voluntary diversion.

Government outlays for either the mandatory or voluntary diversion are assumed to compensate farmers for net income that could have been realized at the specified price levels.[5] Total outlays differ between the two programs since the mandatory program requires the same percentage reduction of crops in all producing regions (fig. 1). Income per acre is higher for land in high-yield regions, and Government payments are consequently larger

[5] The U.S. average prices for the relevant products, given the demand levels used, are $33.87 per hundredweight for cotton, $1.10 per bushel for corn, and $1.16 per bushel for wheat. The prices for the remaining feed grains are 67 cents, 96 cents, and 96 cents per bushel for oats, barley, and grain sorghums. This price for wheat assumes its value for feeding purposes.

under the mandatory program even though fewer acres must be diverted than under voluntary programs where the lower yielding land can be shifted in concentrated regions. In the voluntary programs, more land is retired from crops, and although the number of acres diverted is generally large, the diversion cost per acre is small. (Because of fixed costs, and lower per acre yields, the net income which must be offset by payments results in a lower diversion cost per bushel.)

An additional factor which increases costs under the mandatory programs is the requirement, in this study, that payments must include, in addition to the expected return to land, the returns to labor foregone from the diverted land. Labor costs were added to Government outlay because a mandatory program that diverts a small proportion of the land from each farm and region provides little opportunity for reemployment of labor in nonagricultural pursuits.[9] Under the voluntary diversion program, we assume that entire farms and regions could be shifted from crops and that the labor so released could find employment in other pursuits. Hence, labor returns foregone (i.e. the value of labor used in crop production) are not included in required Government costs for land diversion.

Certain administrative and other Government costs for agriculture are assumed to be fixed and unrelated to land diversion. These fixed costs are listed in table 15 and are assumed to be the same regardless of the type of land diversion program which might be put into effect. Under all programs, we assume the continuation of agricultural exports for "food for peace" and foreign development programs. Hence, costs are included to cover the storage and public deficits related to these exports. The Government costs related to land diversion costs and detailed later are in addition to the fixed costs for agriculture shown in table 15. Total costs, including fixed costs, will differ only by the amounts shown later for the various diversion programs.

TABLE 15.—*Estimated fixed costs of farm program administration for land retirement programs* [a]

	Million dollars
Export program	567
Stock carrying charge for exports	462
Other Government costs [b]	4,471
Total	5,500

[a] Based on Tweeten, Heady, and Mayer (*6*).
[b] Includes cost of wool, rice, tobacco, dairy, research,ed ucation, and other programs for agriculture. Also includes $30 million for administrative costs of diversion programs.

[9] The national weighted average labor costs are $5.59 per acre for feed grains and $2.17 for wheat. These costs are based upon those used to compute the total variable costs of each producing activity.

The costs estimated later assume that farmers do not use diverted land for other purposes or income sources. To permit other uses of diverted land could change the amount and location of diverted land. Also Government costs of diversion would be influenced by the costs and income of farmers using the diverted land.

Pattern of Land Diversion

In general, the study results show that programs requiring proportionate reductions in acreage and production among all regions generally result in a large acreage devoted to crops (see, for example, programs IFL or IWL). Since equal national demands are to be met in all cases, proportionate reduction of acreage requires the use of a larger acreage of low-yielding land to offset a smaller diverted acreage of high-yielding land in more productive regions. However, programs allowing greatest flexibility in crop allocation among regions do not necessarily result in the most intensive use of cropland in productive soil regions and the greatest land withdrawal in marginal productivity regions. The program with no regional restrictions on wheat or feed grain acreages and very liberal restraints on cotton and soybeans (IUU), indicated use of more acres of cropland in meeting national demands than more restrictive programs. Program IUU achieves the programming objective of minimum national costs for crop production and commodity transportation. Hence, amount and location of acreage are oriented to locations of both population concentrations and high soil productivity.

Figures 7 to 14 indicate that South Carolina, Georgia, and parts of Alabama, Mississippi, and Arkansas have land to be diverted from crops under all of the simulated programs. These States have lower yields, less efficient technologies, and small farms. Eastern Kansas, North Dakota, eastern South Dakota, and Idaho also have land denoted for diversion from crops under all solutions. Other regions where land is not needed to meet national demands under some simulated programs are in Michigan, Wisconsin, Montana, Kentucky, and Minnesota. Few acres are indicated for withdrawal, except under proportionate land withdrawal, in major feed and livestock regions east of the Missouri River, in the major wheat regions, or in the field crop areas of the Pacific States.

The program (IWU, fig. 9) which removes wheat acreage quotas and price barriers in use of wheat for feed indicates nearly all land diverted from field crops to be located in the southeastern United States. However, when a highly restrictive program requiring a 7.5 percent feed grain acreage reduction in all regions is imposed, a large amount of feed grain production is indicated for North Dakota and South Dakota (program IFL, fig. 10). Regions of these States are required to produce wheat and feed grains to offset a smaller feed grain production in the Corn Belt under the proportionate reduction in all regions.

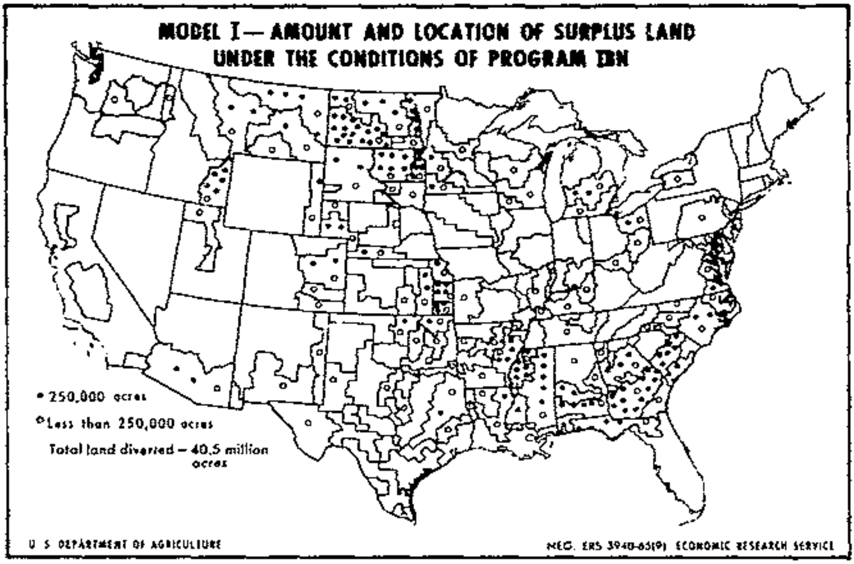
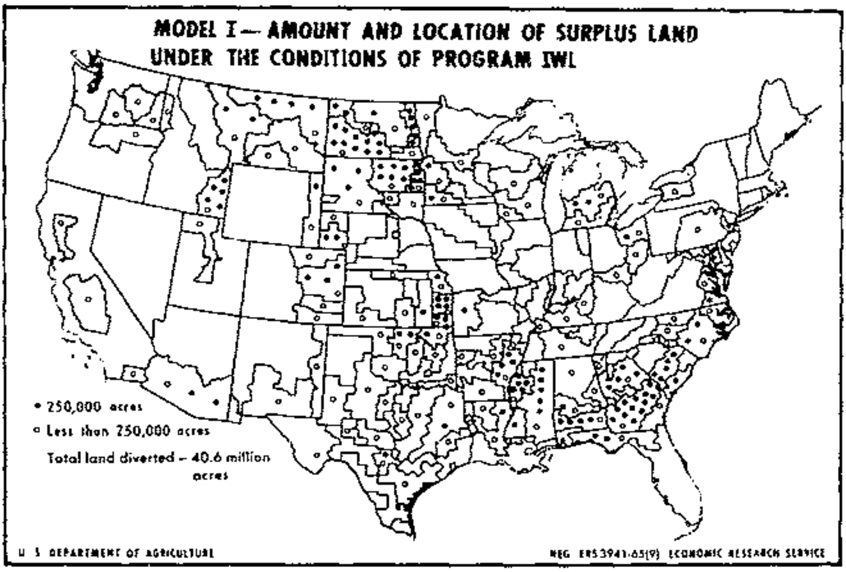


FIGURE 7



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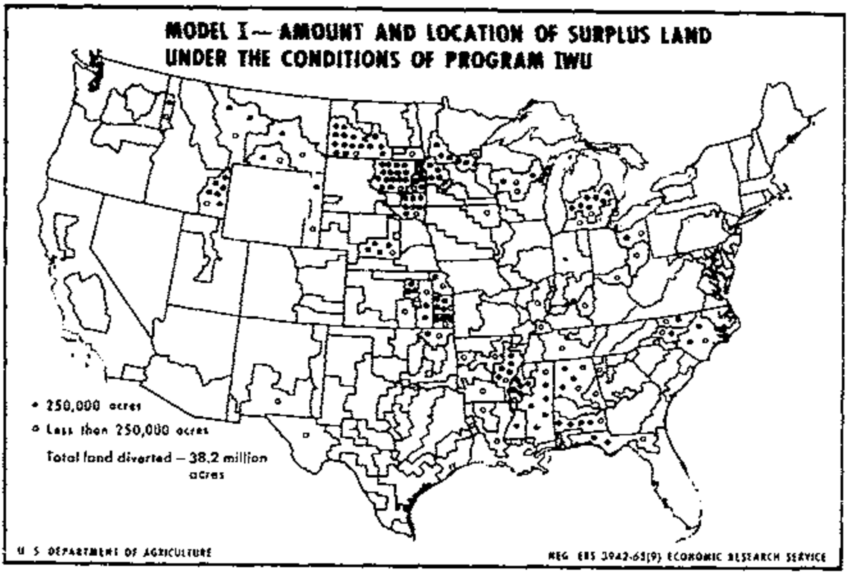

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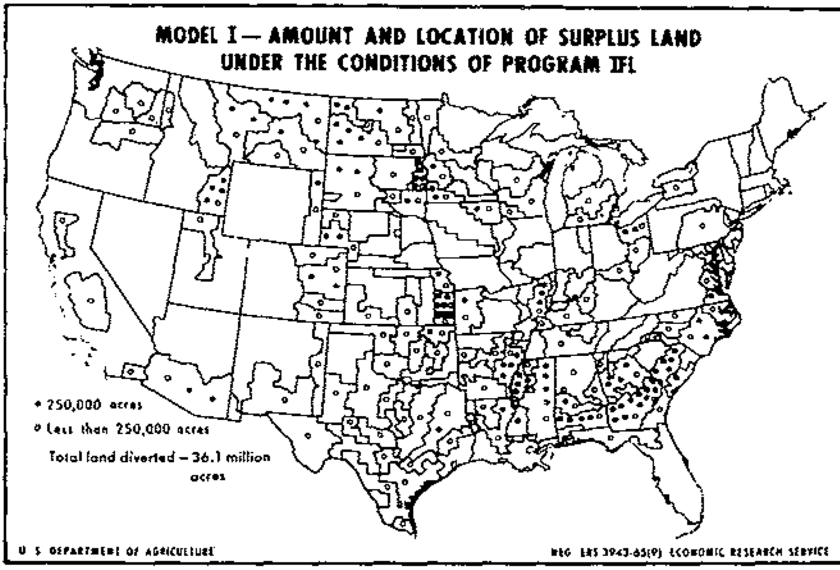

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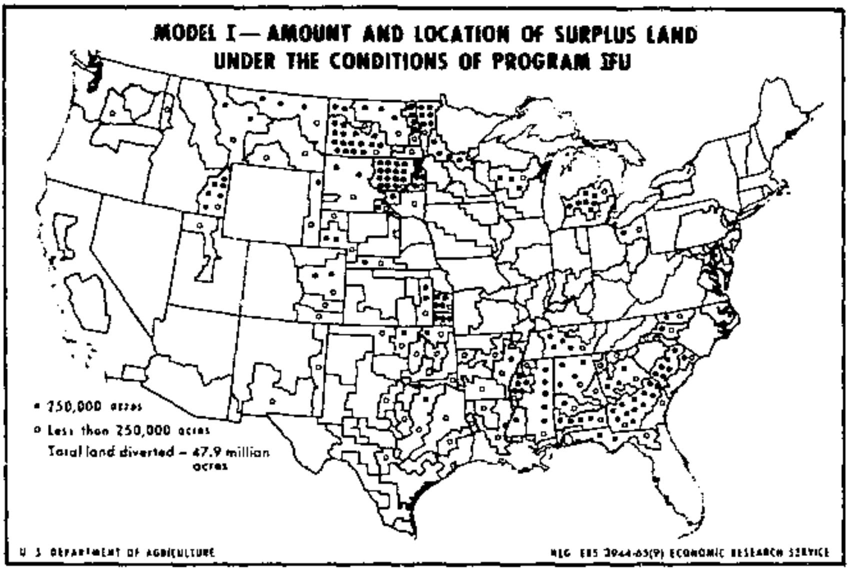

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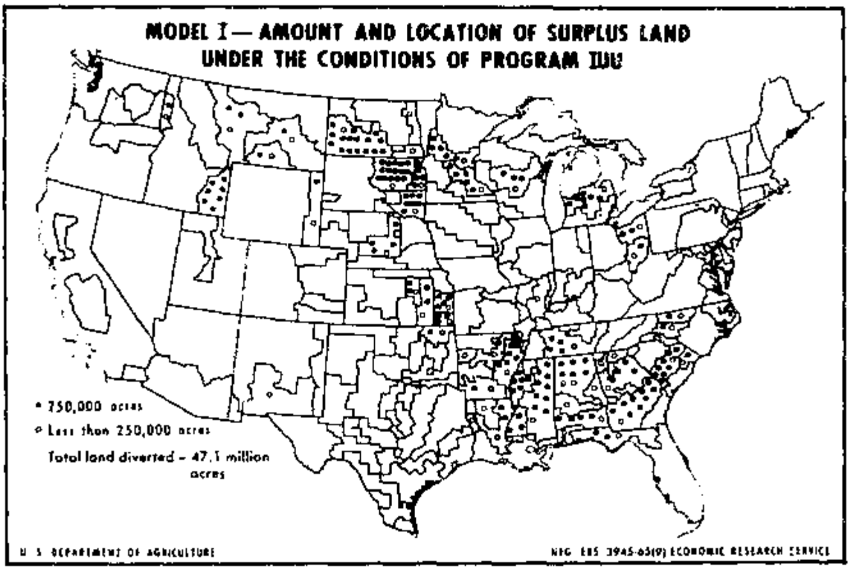

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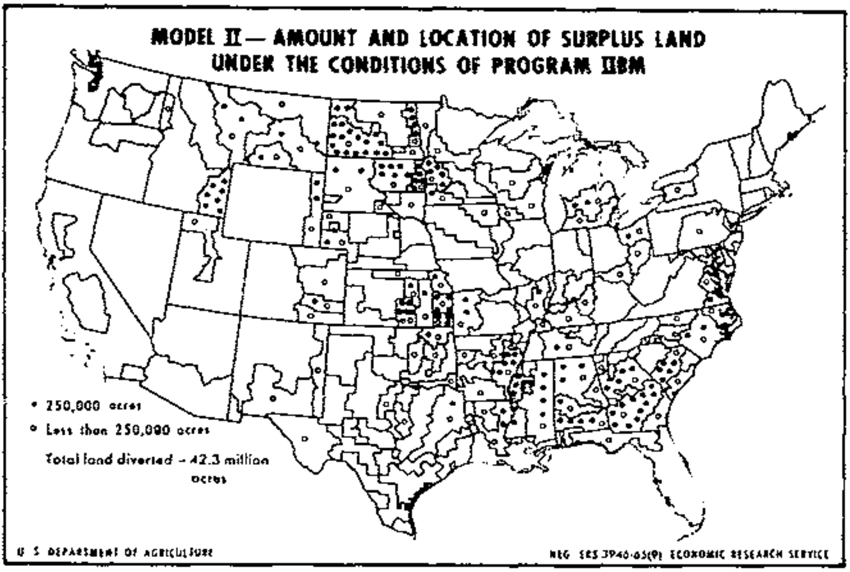

FIGURE 13

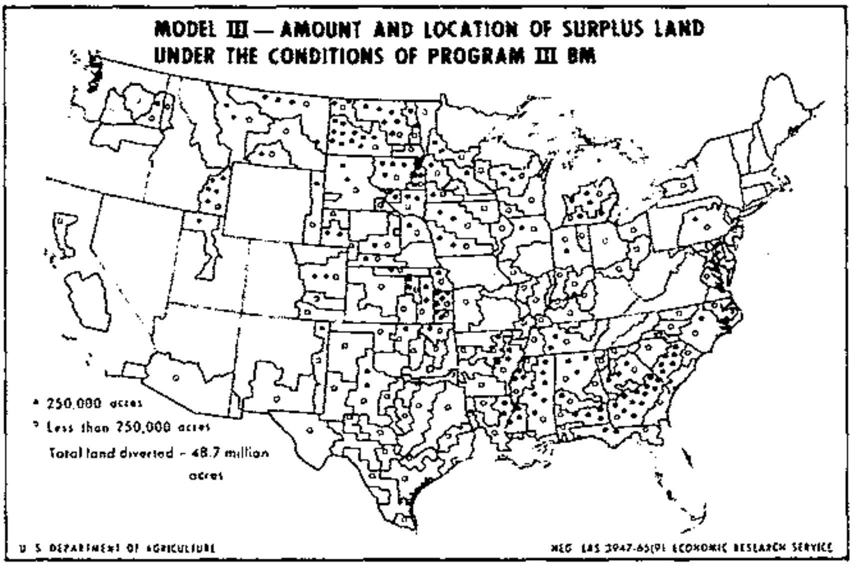

FIGURE 14

Estimated Program Costs

Under the assumptions of this study, total potential production capacity and national product demands are the same for all model solutions or simulated programs. Thus, differences in estimated Government outlays under the alternative programs are one indication of the relative efficiency of these programs.

Estimated Government costs for land diversion, to meet specified national demands and maintain farm prices at the specified levels, are lowest for programs allowing all land diversion to be voluntary. Programs requiring a proportionate output reduction in all areas (mandatory diversion) resulted in the highest estimated Government costs for supply control under the conditions of this study.

Model I: Cropland Diversion and Program Costs

Detailed analysis of costs of land diversion are provided in this section. Only the solutions of Model I are used to estimate Government costs of land diversion. The relative differences in diversion costs among solutions for Model I parallel those expected for Model II and Model III, although the absolute level of costs may differ considerably among models.

Benchmark Program

The results of benchmark solution IBN have been described in considerable detail. This program is not directed toward controlling the supply of any particular crop. Instead, the regional acreage quotas of wheat, feed grains, and cotton are limited to the base acreage of each crop. Soybeans, as in all programs, are physically limited to the use of 40 percent of available cropland. All land diverted from agricultural production under this program is a voluntary reduction below regional acreage quotas. Land diversion can be concentrated in entire areas, depending on the relative costs of obtaining a shift of land from crops. Entire farms can be diverted so that labor can move into other employment. This voluntary land diversion may, in the short run, result from an incentive such as direct Government payments to farmers. The same pattern of land diversion would be expected in the long run under the free play of market variables. Equilibrium market price would force out land with highest production costs (i.e. the land which has lowest comparative advantage under the programming models).

The pattern of land diversion, 40.5 million acres, under the benchmark program is shown in figure 7. Unused acreage quotas for wheat, feed grains, and cotton amount to 42.8 million acres for the benchmark solution (table 16). However, 2.3 million acres of feed grain land in the Corn Belt are used for soybeans, leaving 40.5 million acres of cropland to be diverted from production. Feed grains are voluntarily diverted from 24.5 million acres of cropland in submarginal producing areas. Concentrations of retired land appear in producing regions in North Dakota. South Dakota, Kansas, Arkansas, Mississippi, South Carolina, and Georgia. These regions account for about 62 percent of the total land diversion. The remaining 38 percent is rather uniformly distributed throughout the other States. Only Corn Belt regions have land which remains fully devoted to the study crops.

TABLE 16.—*Estimated costs of diverting land under the conditions of benchmark program IBN*

Item	Wheat	Feed grains	Cotton	Total
Base acreage..........million acres..	58.5	129.2	18.6	206.3
Unused quota..........do..	11.5	26.8	4.5	42.8
Acres used for soybeans..........do..........		2.3	....	2.3
Voluntary diversion..........do....	11.5	24.5	4.5	40.5
Government costs [a]..........million dollars.	80.5	188.4	117.9	386.8
Average cost per acre..........dollars..	7.00	7.69	26.20	9.55

[a] These cost estimates include no charge for labor and are in addition to the other Government costs shown in table 15. Estimated labor costs per acre average $5.59 for feed grains and $2.17 for wheat.

The diversion cost for feed grains is $188.4 million, or an average of only $7.69 per acre. This is the estimated amount necessary to compensate farmers for income losses, at the previously specified price levels, in diverting their land from feed grain. This average payment rate is low, in comparison with that under the present Feed Grain Program. However, only the low-productivity regions are indicated for diversion under program IBN, while land of average (or slightly below average) productivity is diverted in all regions under the Feed Grain Program.

Diverted wheat land amounts to 11.5 million acres under program IBN and would require total payments of $80.5 million or $7 per acre. Cotton, a more intensive crop, has a higher per acre diversion cost. Under program IBN, 4.5 million acres of cotton land is indicated for diversion. The average cost per acre is $26.20.

Land diversion in the pattern allowed by the benchmark program (IBN), allowing land diversion to be concentrated entirely in areas of lowest comparative advantage except for historic base acreages, would require a total Government cost of $386.6 million. (The costs of other Government programs for agriculture indicated in table 15 would be in addition to the $386.6 million.) The 40.5 million acres diverted from wheat, feed grains, and cotton represent 18.1 percent of the Nation's total cropland considered in this study. The average diversion cost per acre for the 40.5 million acres is $9.55 per acre.

Within the confines of the assumptions employed in this study, this program is less costly than any other program alternative analyzed. To shift land from production voluntarily through incentive payments to farmers in submarginal areas appears, therefore, to be a relatively efficient method of land diversion under a criterion of Treasury costs.

Mandatory Diversion of Wheatland

Program IWL simulates a mandatory wheat program. It requires a proportionate 10 percent diversion of wheatland in each producing region. In addition, 8.4 million acres of wheatland are retired voluntarily (table 17). Aside from this "proportionate restriction" on wheat, reduction of acreage for other crops is the same as that allowed for the benchmark program (i.e., diversion in entire regions where comparative advantage is lowest and diversion payments are minimized). Total land indicated for mandatory diversion under this program is 40.6 million acres, about the same as for the benchmark program. However, program IWL results in a somewhat less efficient agriculture and higher indicated Government costs for diversion to attain the same demand quantities and farm price levels. Land diversion (fig. 8) is less concentrated than under the benchmark program since all regions producing wheat are required to reduce acreage diversion of this crop. Consequently, the amount of unused land in the northern Great Plains is much smaller than under the benchmark program. These States are required to increase wheat and feed grain production to compensate for reduced production in other regions of the Nation.

TABLE 17.—*Estimated costs of diverting land under the conditions of program IWL with mandatory diversion of 5.9 million acres of wheat*

Item	Wheat	Feed grains	Cotton	Total
Unused quota ....mil. acres..	8.4	23.8	4.5	36.7
Quota used by soybeans........do....	....	2.0	....	2.0
Voluntary diversion........do....	8.4	21.8	4.5	34.7
Mandatory diversion........do....	5.9	....	....	5.9
Total diversion........do....	14.3	21.8	4.5	40.6
Government payments (voluntary)..mil. dol..	54.1	146.3	117.9	318.3
Government payments (mandatory)[a]..do...	90.5	....	....	90.5
Labor costs on mandatory diversion[b]...do....	12.8	....	....	12.8
Total costs[c]........do....	157.4	146.3	117.9	421.6
Average cost per acre........dollars..	11.01	6.71	26.20	10.38

[a] These cost estimates do not cover a charge for labor.
[b] For the purpose of illustration the labor charges have been broken out and shown here for the mandatory land diversion. The rate of $2.17 per acre also could be applied to voluntarily diverted wheatland if a standard basis for payments were required.
[c] The costs of other programs in table 15 would need to be added to these costs, to compute total Government costs for agriculture.

Approximately 21.8 million acres of land are voluntarily diverted from feed grains and 4.5 million acres from cotton under this program, which requires a 10 percent reduction of wheat acreage in all producing regions but allows other land to be diverted voluntarily. The voluntary diversion allows, aside from the 5.9 million acres of wheatland, concentration of land withdrawal in regions of (*a*) lowest comparative advantage in production and (*b*) lowest Government costs.

Costs of mandatory diversion of wheatland under program IWL are higher than for voluntary diversion under the benchmark program (and also for the voluntary portion of wheatland diversion allowed under IWL). Costs, including a charge for labor, for the land being forcibly retired average $17.51 per acre. The per acre cost for the remaining wheat acreage diverted on a voluntary basis is only $6.44. It is much less costly to attain a given output reduction if diversion is in submarginal areas.

Costs of diverting 1.5 million acres of cotton land under program IWL are the same as for the benchmark situation, $26.20 per acre. Fewer acres are diverted from feed grains under program IWL than under program IBN. Hence, per acre costs for diverting feed grains decline by about 12 percent to $6.71 per acre.

The total estimated Government cost for program IWL is $421.6 million, to divert 40.6 million acres at an average cost of $10.38 per acre. This program has a total cost amounting to $31.8 million more than for the benchmark program. IWL would probably result in payments to a greater number of farmers than the benchmark program since it forces some diversion into all producing regions. Thus, the higher costs of supply control under this program might be justified to benefit a greater number of persons through direct payments.

Unrestricted Wheat Production

An unrestricted wheat program is represented by IWU. Wheat is limited only by total cropland in each region while feed grains and cotton are restricted to their regional historic base acreages. Land diversion under program IWU utilizes a large part of the cropland in regions of several States (fig. 9). Nearly 44 percent of available cropland in North Dakota and South Dakota is indicated for diversion and 67 percent is indicated for Alabama, Mississippi, and Louisiana. Other regions of concentrated land diversion are in Kansas, Michigan, Arkansas, Minnesota, and Idaho. Only small amounts of land are indicated for diversion in other States. Under this program, some feed wheat production is shifted into North Carolina and South Carolina.

Land diverted from crop production is 38.2 million acres under program IWU. Approximately 22.5 million acres are diverted from feed grains, 4.5 million acres from cotton, and 11.2 million acres from wheat (table 18). The net shift from wheat is less than 11.2 million acres, however, since some wheat is indicated for land previously in other crops. Estimated costs for diverting the 11.2 million acres from wheat production are $84.6 million, an average of $7.55 per acre.[10]

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[10] Wheat was assumed to be supported at $1.16 per bushel, its feed value, for the purpose of estimating diversion costs on land other than cotton and feed grain.

The average cost of diverting land from feed grains under this program is $9.30 per acre, a total cost of $209.3 million for feed grains (table 18). Wheat utilizes some land which is marginal for feed grains. Hence, higher program costs are indicated for the retirement of higher yielding feed grain land.

Cotton land diversion costs are the same, $117.9 million, as under previously discussed programs. The pattern of cotton production remains the same as under the benchmark program.

TABLE 18.—*Estimated Government cost of diverting land under the conditions of program IWU with unrestricted wheat production*

Item	Feed grains [a]	Cotton	Other [b]	Total
Unused quota ... mil. acres..	51.2	4.5	11.2	66.9
Used for wheat ... do....	26.5	....	....	26.5
Used for soybeans ... do....	2.2	....	....	2.2
Voluntary diversion ... do....	22.5	4.5	11.2	38.2
Government cost [c] ... mil. dol..	209.3	117.9	84.6	411.8
Average cost per acre ... dollars..	9.30	26.20	7.55	10.78

[a] Payments are not included for land diverted from feed grains to other crops.
[b] Refers to land normally planted in wheat if wheat quotas were in effect. Program costs for diverting land were computed as if it shifted from wheat production.
[c] The costs for other programs in table 15 are in addition to those indicated here.

Total land retirement costs under program IWU, a program without any regional restraints for wheat, are $411.8 million, slightly less than for program IWL where wheat acreage quotas are applied proportionately over all regions. Thus, it is possible for two widely different programs to be equally effective and have similar costs.

Mandatory Diversion of Feed Grain Land

Program IFL requires that feed grain acreage be reduced by 7.5 percent in all regions. However, additional feed grain diversion can occur on a voluntary basis in terms of comparative advantage and lowest Government costs of diversion. Wheat and cotton are restrained only to their regional base acreages. Soybeans are allowed to compete for land diverted from any other crops. The mandatory diversion of feed grains is 9.7 million acres. Voluntary diversion of feed grain, wheat, and cotton land bring total diverted land up to 36.1 million acres, an amount less than for any other programs considered.

Program IFL results in 67 percent of available cropland diverted in regions of South Carolina, Georgia, Alabama, Mississippi, and Louisiana (fig. 10). Otherwise, this program produces a more dispersed pattern of land diversion than the programs previously discussed. Nearly all regions, except those producing soybeans in the central Corn Belt, have some excess cropland. North Dakota and South Dakota have a somewhat smaller diversion, however, because of the mandatory reduction in feed grain production in other States.

The estimated Government costs of program IFL are included in table 19. If payment is required for the feed grain land forced from production, the total estimated cost is $477.3 million when returns to labor are not included. If labor costs are included in payments for the mandatory portion, since labor is not expected to move out of agriculture, the program costs total $531.5 million.

TABLE 19.—*Estimated cost of diverting land under the conditions of program IFL with mandatory diversion of some feed grain land*

Item	Wheat	Feed grains	Cotton	Total
Unused quota . . . mil. acres	5.0	28.6	4.5	38.1
Used for soybeans . . . do		2.0		2.0
Mandatory diversion . . . do		9.7		9.7
Voluntary diversion . . . do	5.0	16.9	4.5	26.4
Total diversion . . . do	5.0	26.6	4.5	36.1
Government payments (voluntary) . . mil. dol.	40.1	89.8	117.9	247.8
Government payments (mandatory) . . . do		229.5		229.5
Labor costs on mandatory diversion . . . do		54.2		54.2
Total cost [a] . . . do	40.1	373.5	117.9	531.5
Average cost per acre . . . dol.	8.02	13.99	26.20	14.72

[a] The costs for other programs in table 15 are in addition to the land retirement costs shown here.

The cost of a required diversion of 9.7 million acres of cropland from feed grain production, proportionately over all regions, is great, amounting to $23.66 per acre without labor charges and $29.25 with labor charges. This figure is nearly four times the average cost of $7.69 per acre for feed grain land voluntarily diverted under the benchmark program. A program retiring average cropland in the Corn Belt is more expensive than one which reduces production by a similar amount through land diversion in less productive regions.

However, programs which reduce crop production in the major grain areas of the Corn Belt and the Great Plains winter wheat regions permit more land to be cropped in the less productive regions of the South Atlantic States and the northern Great Plains.

Unlimited Feed Grain Acreage

Under program IFU, regional acreage quotas are removed entirely for feed grains. These crops are restrained only by the total cropland acreage in each region and national demand requirements for these products. Wheat and cotton acreages are restricted only to the regional base acreage of each crop. All land diversion is assumed to be voluntary, with compensation for this diversion computed as before. No payments are made for land diverted from wheat or cotton to the production of feed grains.

Land diversion under this program totals 47.9 million acres (table 20). Approximately 7.3 million acres are diverted from wheat, 4.5 million acres from cotton, and 36.1 million acres from feed grains. Although feed grain acreage quotas are not applied under this program, these 36.1 million acres otherwise would be in feed grains. Of the 16.9 million acres shifted from wheat, feed grains use 9.6 million acres.

TABLE 20.—*Estimated cost of diverting land under the conditions of program IFU, without restrictions on feed grains*

Item	Wheat [a]	Cotton	Other [b]	Total
Unused quota....................mil. acres..	16.9	4.5	36.1	57.5
Used for feed grains..................do....	9.6	....	....	9.6
Voluntary diversion..................do....	7.3	4.5	36.1	47.9
Government cost [c]..................mil. dol..	66.0	117.9	252.6	436.5
Average cost per acre..................dol....	9.04	26.20	7.00	9.11

[a] Program costs are not included for land diverted from wheat to other field crops.
[b] Refers to land normally planted to feed grains. Costs for this land were computed as if it had been diverted from feed grains.
[c] The costs for other programs shown in table 15 are in addition to the land diversion costs shown here.

Land diversion is highly concentrated under program IFU (fig. 11). In South Carolina, Georgia, Alabama, Florida, Mississippi, and Louisiana, 78 percent of available cropland is diverted. Likewise, in North Dakota and South Dakota, 52 percent of the cropland is diverted. Other pockets of concentrated land diversion occur in Idaho, Michigan, Kansas, and Minnesota. The local impact of such a program thus would be great, because a less intensive agriculture and a thinning of the rural population likely would follow.

All land diversion is assumed to be voluntary and the estimated cost is $436.5 million. The 47.9 million acres are diverted at an average cost of $9.11 per acre. This cost is computed, as mentioned previously, under the assumption of feed grain prices at a level of $1.10 per bushel for corn with comparable prices for other crops.

Diversion costs for 7.3 million acres of wheatland are estimated at $66.0 million, an average of $9.04 per acre. Diversion costs for wheatland are greater only under a partially mandatory program (program IWL, table 17). Costs for diverting the 36.1 million acres from feed grains, $7 per acre, were relatively low as compared to other programs.

The indicated land use pattern also could result from a program of negotiable marketing quotas on feed grains equal to the feed grain demand requirements. If quotas were exchanged among regions in terms of comparative advantage, concentration of production would result from the eventual optimal allocation of these quotas among regions.

Acreage Quotas Removed

Program IUU is designed to simulate a condition which minimizes (*a*) costs of production and transportation and (*b*) Government costs of land diversion to attain the given demand levels and farm product prices. Separate regional acreage restraints for wheat and feed grains are completely removed. Only total available cropland is assumed to limit these crops in each producing region. Cotton acreage is limited to 200 percent of the historical base acreage in each region and soybeans are limited to 40 percent of available cropland in each region. National production of each crop is restrained by its respective demand requirements.

The pattern represented by this solution also could result from negotiable marketing quotas, as described previously. In this case, areas of greatest comparative advantage in production would attract the quotas. Less efficient areas eventually would shift out of crop production. Also, the same pattern (table 14) of production might be expected to result under long-run equilibrium of a free market.

Under long-run equilibrium market prices it is possible that demand quantities would be greater than those used in the programming models of this study. (In another simulated program with larger product demands assumed to result under lower prices, only 21.6 million acres of unused land were indicated for diversion.)[11]

Figure 12 illustrates the areas of concentrated land diversion suggested by the linear programming solution under the conditions posed by IUU. The crop agriculture of the southeastern United States could virtually cease to exist under program IUU. Of the available cropland in South Carolina, Alabama, Georgia, Mississippi, Louisiana, Arkansas, and Florida, 84 percent is indicated to be diverted from the specified crops. In Montana, Idaho, North Dakota, and South Dakota, 14 percent is so indicated. (The results of Model III, however, indicate that some land scattered throughout these areas would remain in production under such a program. Also, solutions of Model III indicate the presence of some land to be diverted in the most productive areas of the Corn Belt.)

Model II: Retired Cropland

The constraint conditions of program IIBN are the same as those of the benchmark program IBN, except for a higher wheat price under the former

[11] This program, with larger demand requirements, was not included in the results shown in this publication. It is mentioned here because the assumed price levels were close to those acquired as equilibrium prices in program IUU. The resulting cropland requirements are, perhaps, more indicative of what would result under conditions of unrestricted production than those shown for program IUU.

(see earlier description of models). Approximately 42.3 million acres of cropland are diverted under program IIBN, a slight increase over the benchmark program. Approximately 69 percent of the cropland in South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Arkansas is diverted (fig. 13). North Dakota benefits from this program, since nearly 1 million more acres are devoted to crops than under program IBN. Still, 37 percent of the cropland in Montana, Idaho, North Dakota, and South Dakota is diverted, and pockets of diverted land also occur in Minnesota, Wyoming, Kansas, and Utah.

An unusual feature of program IWU under Model I is the high employment of land in North Dakota, South Dakota, South Carolina, and Georgia (fig. 9). When the additional cost was imposed on feed wheat through program IIWU, these States again have many acres of excess land.

Model II, with its one-price plan for wheat, results in higher Government costs of land diversion than Model I with a multiple-price plan. If land diverted from wheat production is rewarded in Government payments at a rate consistent with the price of wheat assumed for Model II, the cost per acre of diverted land is much higher than Model I. In program IBN, 11.5 million acres of wheatland are diverted at a total cost of $80.5 million (table 16) when wheat is priced at $1.16 per bushel to represent its feed value. If costs are estimated for program IBN with the assumption of wheat priced at $1.95 per bushel, the total cost of diverting the 11.5 million acres is $312.8 million. Thus, commodity price levels used to compute diversion payments highly influence program costs.

Model III: Retired Cropland

The unique feature of Model III is its recognition of intraregional land quality differences. Model III solutions result in a more diversified crop production pattern and a more intensive land use than solutions under Model I. The result is a large acreage retired under Model III (table 9). It is the diverted land upon which this section is focused.

The pattern of land diversion for solution IIIBN is presented in figure 14. Many areas of the Corn Belt and Great Plains which employed all cropland under simulated programs from Models I and II now have some idle land. However, concentrated regions of diverted land still exist in South Carolina, Georgia, and other Southeastern States. The northern Great Plains States also continue to experience a rather low rate of land employment. The resulting land disposal patterns of other solutions from Model III are similar in their comparisons with the solutions of Model I.

The implications of Model III are quite important in the formulation of agricultural policy. A program removing only submarginal land within regions will require more land diversion to accomplish the same supply control measures than a program removing land of average quality within regions. The comparative costs of such programs are probably similar if all diversion payments are governed by the productivity of land removed from production. However, if below-average land is diverted, and if the diversion payments are based on the productivity of average land, the program efficiency may be greatly reduced.

LAND USE ALTERNATIVES

One of the major problems in land retirement programs is determination of the proper utilization of the excess cropland. It is generally agreed that the diverted land should be devoted to grass, hay, trees, or other uses which avoid excessive erosion and growth of weeds. Establishing these cover crops involves expenses and requires incentive payments to defray establishment costs. Alternatively, farmers may be induced to establish cover crops by the expectation of future benefits. Undoubtedly the greatest short-run benefits from diverted land are derived when it is used for grazing, when considering all diverted lands collectively.

In recent farm programs, farmers have not been allowed to graze or otherwise utilize crops from diverted land during the growing season. They have been permitted to partially employ the diverted acres by grazing very late in the fall or early spring, with very little of the diverted land being fully employed. Many farmers would be willing to accept lower diversion payments if they were permitted to fully utilize the diverted acres. Bottum has estimated the difference in diversion payments between grass-used programs and grass-not-used programs (*1*). When only 14.1 million acres are diverted, he estimated the costs per acre to be $1.20 and $3, respectively. All of the retired land was considered to be marginal in production and value. However, when 80 million acres are retired the estimated costs per acre are $11.30 and $12.75, respectively. When average cropland was assumed to be retired, the costs were much higher and with less divergence between alternatives. In every instance the grass-not-used program was considered to be a more expensive land-retirement alternative to obtain a given acreage of idle land.

Estimates of land diversion costs have not been made for a grass-used program in this study. However, the potential productivity of the diverted acres was assumed to be of interest to future researchers. Under a grass-used program beef production seems the most likely activity to utilize the diverted acres. Other potential uses are probably of minor importance compared to beef. Therefore, using U.S. Department of Agriculture data, the beef that might be produced on the diverted land under several alternative programs has been estimated (*5, 9*). The impact this production might have on the supply and on the market price of beef also has been estimated.

Potential beef production appears to be nearly proportional to the amount and productivity of unused land (table 21). Programs retiring land on the extensive margins (IWU and IUU) result in a slightly lower average production of beef per acre retired than programs retiring land on a more uniform basis (IFL).

TABLE 21.—*Estimated acreages of cropland diverted, annual supply of beef from diverted land, percentage change in supply, and resulting change in beef prices, in simulated land retirement programs*

Program	Diverted cropland	Quantity of beef produced on diverted land	Percentage of total beef production in 1960	Percentage change in beef price
	Mil. acres	*Mil. lb.*	*Percent*	*Percent*
IWU	38.2	3,329.3	11.6	−17.0
IBN	40.5	3,605.5	12.5	−18.3
IWL	40.6	3,634.9	12.6	−18.4
IFU	47.9	4,352.7	15.1	−22.1
IFL	36.1	3,370.6	11.7	−17.1
IUU	47.2	4,155.8	14.5	−21.2
IIBN	42.3	3,855.6	13.4	−19.6
IIIBN	48.6	4,547.6	15.8	−23.1

The percentage change in total beef production, from an estimated 28.7 billion pounds of beef produced in 1960 (*7*), is computed for each program. Brandow's estimated demand elasticity of beef, 0.68, is used to estimate the impact of greater quantities on beef prices (*2*).

Full utilization of the diverted land for beef production is estimated to produce grass-fed beef equaling 11.6 to 15.8 percent of present beef supply inducing a reduction of 17 to 23.1 percent in the price of beef. These estimates are based upon the assumption that all diverted cropland is used for beef production. Undoubtedly, not all diverted land could or would be fully employed for beef production under a grass-used program, thus causing the beef supply and price changes to be smaller than indicated above. Also, changing structures for beef and high cross elasticities of demand with other meats would tend to cushion the price effect of any increased beef production.

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