Projected Cropland Requirements and Land Availability for Major U.S. Production Regions

C. A. M. Santana and R. M. Adams

The decade of the 70's witnessed an expansion in U.S. cropped acreage in response to rising foreign demand. During this same period, substantial acreages of cropland were converted to non-agricultural uses. An issue arising from these land adjustments is whether available cropland will constrain agricultural production in the near future? This paper provides some insight by developing cropland requirements to meet 1985 demand for major U.S. commodities and then compares these projections with recent data in cropland availability. The results indicate that agricultural production should not be constrained by land availability at the national level, even in the event of high demand levels and slowed yield growth. When the analysis is extended to specific farm production regions, some shifts in production are suggested.

The major agricultural adjustment policy of the U.S. during most of the Post-World War II period was one of supply reduction. More recently, however, the situation has changed as agricultural output expanded in response to rising export demands. The increased level of total agricultural output realized during the mid-seventies was achieved primarily by expanding total cropped acreage. For example, between 1970 and 1978, the aggregate harvested acreage of the eight major U.S. commodities increased from approximately 255 million acres to 295 million acres, an increase of over 15 percent [USDA, 1979].

The increasing role of the U.S. in world agricultural trade with attendant increases in cropland use, focused popular attention on future limits to agricultural productivity [Tammeus; Anderson]. Much of this concern stems from what appears to be a dwindling supply of available cropland. Specifically, between 1967 and 1975 30.5 million acres of cropland were converted to nonagricultural uses [SCS]. Such losses serve to exacerbate concerns over the ability of the agricultural sector to meet future domestic and foreign food demands.

Land requirements are primarily a function of commodity demand and per acre yields. Thus, future cropland requirements are hypothesized to be influenced by changes in commodity demands (particularly exports) and the rate of growth in per acre yields. While the 70's have witnessed a rapid increase in U.S. farm exports, there also has been a general reduction in the rate of crop yield increases, a slowdown which may be attributed to a declining technological base [Schuh; Lu, et al]. Any slowdown in the growth of agricultural yields in the face of rising demand places greater emphasis on land in agricultural production and argues for increased cropland requirements in the future.

The combination of such factors suggesting

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increased cropland requirements and a continued loss of cropland to other uses underscore the need for an assessment of future cropland requirements and availability. The central issue arising from the interplay of these variables is thus whether available cropland will constrain agricultural production in the near future. This paper provides some insight into this question by developing cropland requirements to meet future demand for major U.S. commodities and then compares these projections with recent SCS data on cropland availability.

Study Objectives and Procedure

The overall objective of this anlysis is to provide estimates of future cropland requirements associated with alternative commodity demand and yield levels and compare these cropland requirements with current and potential cropland as established by the SCS. The analysis includes both national and regional projections for eight major commodities to examine possible adjustments in cropland use across regions. The specific objectives are to: (1) provide estimates of 1985 foreign and domestic demands for selected agricultural commodities using traditional demand analysis models and trend projections; (2) provide estimates of future yields for these crops, based on trend projections, and finally (3) estimate future land requirements on national and regional levels. The future land requirements estimates can then serve to indicate possible adjustments by region and commodity. The feasibility of such adjustments is tested by comparison with the SCS cropland inventory.

The procedure used in this analysis is similar to that employed by Johnston and Tolley in an earlier effort. The methodology consists of estimating mean and variance of future domestic and foreign demand for selected commodities, as well as for future yields of the included commodities. The quotient of the demand and yield estimates serves to define future cropland requirements. This projection approach is appealing in that it provides a range or interval around an expected value (or point estimate). This interval may help to capture some of the uncertainties inherent in any projection. Another desirable feature is that it can be easily extended to estimation of regional cropland requirements.

Eight commodities (corn, sorghum grain, oats, barley, wheat, cotton, soybeans and hay), which together account for 88 percent of total harvested acreage[1] in the U.S. over the 1965-77 period, were selected as the basis on which to determine future land requirements. This set of crops should provide a good indication of cropland requirements to meet aggregate U.S. agricultural demand in 1985 given their large share of total harvested acreage.

The time span used in the projection analysis is the period 1955 to 1977. The choice of 1985 as the year of projection is based on the belief that the time horizon is sufficiently long to permit changes or adjustments which may be necessary to facilitate regional production changes, and yet is near enough at hand to anticipate future needs with some credibility. In addition, the existence of other demand and yield projection studies utilizing the same projection year (see for example, USDA, 1973 and 1976) provides a check on the demand and yield projections used here. In addition to national land requirements (by crop and in the aggregate), regional projections are also provided for total cropped acreage and by specific commodity. The regional definition is based on the 10 farm production regions established by the USDA.

Projections of U.S. Commodity Demand for 1985

The demand projections developed in this study include both mean values and corresponding high and low estimates for the eight commodities. These estimates are reported

[1]Area in principal crops harvested as reported by the Crop Reporting Board, plus area in vegetables, fruit, tree nuts and farm gardens.

in Table 1. The general procedure used to obtain the projections include (1) estimation of annual rates of change and corresponding variances, which are applied to base period or actual demand, to provide 1985 low, mean and high estimates, and (2) estimation of 1985 export levels, based on trend projection, with some subjective modification to reflect institutional uncertainties. The discussion in the text is intended to be a brief overview of the estimation procedures; for a more complete discussion, the interested reader is referred to Santana and Adams or Johnston and Tolley.

The demand projections are driven by the two traditional demand shifters, population and real disposable personal income. The effects of price changes are discounted, given the generally price inelastic nature of demand for products at the farm level. The period 1955-77 is the base period from which 1985 projections are generated.

The nature of some of the included commodities suggests a derived demand relationship. This would appear to be particularly true for feed grains, soybeans and hay. Thus the demand projections used in the analysis required projected changes in livestock demand as well as 1985 population and disposable personal income.

The estimated mean annual rate of population growth used here is the same as that observed over the period 1970 to 1977 (0.8 percent per year). Assuming this rate of growth from 1977 to 1985 results in an estimated U.S. population of 231.163 million. The high and low estimate of the mean annual rate of change in population of 1.05 and 0.55 percent annual increase yields a high and low population range of 236.4 million and 226.1 million persons, respectively, for 1985.

The other traditional demand shifter, personal disposable income, was estimated for 1985 by trend projection using income data for the period 1960-77. Real disposable income in 1985 is expected to be $3,927, implying a mean annual rate of change equal to 2.1 percent per year from the base year of 1977. The high and low estimates of per capita real disposable income are $4,004 and $3,850, respectively, derived by applying the expression of the variance of an individual forecast to the regression equation used to

TABLE 1. Summary Table of Commodity Domestic Disappearance and Export Estimates for 1985.

Commodity	Disappearance	Units	Observed in 1975-77	Estimated 1985 Low	Estimated 1985 Mean	Estimated 1985 High
Feed grains	Domestic	million tons	146.9	164.1	178.7	194.5
	Export		57.7	58.1	66.5	74.9
	Total		204.6	222.2	245.2	269.4
Wheat	Domestic	million bushels	775.7	792.4	815.4	838.4
	Export		1,074.3	802.0	1,099.0	1,396.0
	Total		1,850.0	1,594.4	1,914.4	2,234.4
Cotton	Domestic	million bales	6.8	5.1	7.2	9.3
	Export		4.5	3.6	4.7	5.8
	Total		11.3	8.7	11.9	15.1
Soybeans	Domestic	million bushels	913.3	1,165.7	1,234.0	1,302.3
	Export		576.4	776.9	826.5	876.1
	Total		1,489.7	1,942.6	2,060.5	2,178.4
Hay	Domestic	million tons	125.9	128.6	143.5	158.4

project the mean value of real disposable income for 1985.

Future Domestic Requirements for Livestock Products

An examination of historical disappearance for the included crops indicates the importance of the livestock complex in the domestic utilization of feed grains, soybeans and hay. In order to determine domestic demand for these commodities the first step is to thus project U.S. requirements for domestic livestock products in 1985.

Following Johnston and Tolley, the mean annual rate of growth in the domestic demand for livestock products is expressed as:

$$(1)\ \hat{Q}_L = \hat{N} + \eta\hat{Y} + \hat{K}$$

where N is population, Y level of income, η the income elasticity for livestock products and K a residual trend which accounts for changes in demand not directly related to population and income.

Assuming that the variables N, K and (ηY) are independent variables whose covariances are zero, the variance for the mean annual rate of growth of the demand for livestock products is given by:

$$(2)\ \text{Var}\ \hat{Q}_L = \text{Var}\ \hat{N} + \text{Var}\ (\eta\hat{Y}) + \text{Var}\ \hat{K}$$

The income elasticity for all livestock products (η) used in expression 1 is derived from the weighted sum of the coefficients of elasticity for each livestock component, as estimated by Brandow and George and King. The weighting factors are based upon the expenditure proportion expressed as a percentage of all expenditures. A midpoint of 0.27 (between the Brandow and George and King estimates) was selected to represent an approximation of the income elasticity for all livestock products, with an associated variance of 0.0025. Finally the mean annual rate of change and the respective variance for the variable K in expression 1 is estimated to be -0.17 percent per year and 0.0216, respectively, indicating a downward movement in the residual component of livestock demand.

Using the estimates derived for the variables N, Y, η and K, equations 1 and 2 provide a mean annual rate of change for domestic requirements for livestock products equal to 1.20 percent, with an associated variance of 0.36.

Domestic demand for feed grains for feeding purposes is also a function of the efficiency of feedstuff conversion into livestock products. That is:

$$(3)\qquad \hat{Q}_{FG} = \hat{Q}_L - \hat{E}$$

where

$\hat{Q}_{FG}$ = mean annual rate of change in feed grain requirements for feeding purposes.

$\hat{Q}_L$ = mean annual rate of change in domestic demand for livestock products.

$\hat{E}$ = mean annual rate of change in feed grain efficiency in livestock production.[2]

The variance expression for the above equation is:

$$(4)\qquad \text{Var}\ \hat{Q}_{FG} = \text{Var}\ \hat{Q}_L - \text{Var}\ \hat{E}$$

The resulting estimates for the low, mean and high annual rate of change for domestic requirements of feed grains for feeding purposes, derived by the use of equations 3 and 4, are 1.09, 2.08 and 3.07 percent, respectively.

Demand Projections for Feed Grains, Soybeans, and Hay

Applying the three estimates of annual rate of change, derived above, to the average quantity of feed grain fed to livestock during 1975-77 results in the low, mean and high

[2]This term is negative because as efficiency increases, less grain is needed to meet livestock requirements. It is also implicitly assumed that the relative price structure to 1985 will parallel that of the estimation period, 1955-77.

quantities of feed grain required to meet 1985 feed usage. These values, of 142.2, 156.8 and 172.6 million tons, respectively, when combined with the 21.9 million tons for non-feed domestic use, yield the disappearance estimates reported in Table 1.

Exports of feed grain have increased steadily in the last 23 years. Assuming that the rate of growth registered during this period will prevail through 1985, the mean estimate of feed grain exports is 66.5 million tons, obtained by trend projection. The high and low estimates are 74.9 and 58.1 million tons, respectively. The total required feed grain supply for 1985 may be found in the summary table.

Conceptually, domestic disappearance of soybeans is a function of the quantity of whole beans used for feed, seed, crushing and any residual. Among these components, utilization of soybeans for crushing (meal and oil) is the major outlet for soybeans and the one which has changed most over time.[3] This amount combined with the relatively stable domestic consumption of nonprocessed soybeans yields total requirements to meet 1985 domestic disappearance.

The low, mean, and high annual rate of change for domestic requirements of soybean meal for feeding purposes are 1.50, 2.39 and 3.28 percent, respectively. Application of these three estimated levels of annual rate of change to base period feed consumption (1975-77) of soybean meal for feeding purposes resulted in the respective 1985 requirements. Adding the industrial soybean meal requirements and soybean meal exports to those for feed purposes and converting to whole bean equivalents results in high, mean and low estimates of 1.234, 1.160 and 1.092 billion bushels, respectively for domestic crushing.[4] To these values are added the average quantity of whole beans used for feed, seed and other uses (73.6 million bushels for the 1970-77 period), which results in total domestic disappearance of soybeans for 1985.

A trend projection of soybean exports resulted in the mean estimate of exports of 826.5 million bushels for 1985, with a range or upper and lower bound for future foreign demand of 876.1 and 776.9 million bushels, respectively. Summing the estimates of future foreign demand for soybeans (whole) and total domestic disappearance, results in the 1985 levels of total demand for soybeans reported in Table 1.

Utilization of hay is directly related to the importance or proportion of roughage-consuming animal units in livestock production. Using the observed relationship between hay demand, roughage consuming animal units and the demand for livestock products, the mean estimate of annual rate of change in the demand for hay is 1.32 percent per year, with a corresponding variance of 1.22 percent per year.

This variance results in a standard deviation of 1.11 percent per year, which provides the alternative rates of 2.43 and 0.21 percent per year. The application of the three rates of change to the base period hay disappearance (1975-77), provides the estimates for hay demand in 1985 (see Table 1).

Demand Projections for Wheat and Cotton

Domestic utilization of wheat for food consumption, the most important component of overall disappearance, was determined as a function of population size and level of per capita utilization. Assuming that per capita consumption of wheat will not decline from 1975-77 to 1985, the mean level of demand for food consumption is 580 million bushels.

[3]The process of soybean crushing yields two important joint products, soybean meal and soybean oil. Since these products are derived jointly, there are two alternative methods which may be employed to estimate future domestic requirements of soybeans for crushing. They are simply projecting the demand for soybean oil, or the demand for soybean meal. The latter approach is used in this paper.

[4]The average soybean meal yield of 47.7 pounds per bushel of beans crushed was used to convert soybean meal to whole bean equivalents.

This estimate assumes an increase in food utilization of wheat equal to the annual rate of change in population growth (0.8 percent per year). The low estimate of 557 million bushels is equal to that observed for the period 1975-77, while the high estimate of 603 million requires an increase of 46 million bushels over the 1975-77 disappearance estimate.

Adding nonfood use of 235.4 million bushels to food use results in the alternative levels of total domestic requirements of wheat for 1985.

Exports of wheat increased significantly since 1971, jumping from 610 million bushels in 1971 to 1,135 million in 1972. Following this quantum jump, exports averaged about 1,100 million bushels over the 1973-77 period. The high level of exports is estimated to be 1,396 million bushels, while the lowest is 802 million bushels. The mean estimate of 1,100 million bushels, represents the average for the 1972-77 period. Aggregating these estimates of foreign demand for wheat with domestic demand results in the 1985 estimates of total demand reported in the summary table.

Domestic disappearance of cotton is a derived demand for domestically produced cotton products, and is expressed in quantities consumed by cotton processing mills. Future domestic demand for cotton was determined by interfacing three assumed levels of domestic per capita consumption of cotton fiber (18, 15 and 10.6 pounds per person),[5] with the mean population estimate by each of the assumed levels of domestic per capita consumption of cotton fibers, and transforming the results to equivalent bales of 480 net pounds. The mean estimate of cotton exports in 1985 is equal to the average of 4.7 million bales observed during the 1973-77 period. The high and low estimates of 5.8 and 3.6 million bales are derived using the standard deviation of 1.14 million bales obtained for the same period.

Crop Yield Projections for 1985

Comparing the growth in yields registered during the last decade with those observed for the period 1935-60 indicates a general slowdown in productivity growth in recent years [Schuh]. This slowdown has become a matter of discussion with possible price impacts on food. Even though researchers are not in full agreement with respect to future yield growth, there is evidence that indicates that it is unlikely that the high rates of growth achieved during the period 1935-60 will continue through 1985.[6]

Schuh has noted that there are productivity cycles characterized by high and low rates of growth, reflecting the period required to generate technical change and the corresponding lag time for full adoption. The slowdown in the rate of productivity growth recorded in the last decade leads to the plausible hypothesis that the U.S. is probably reaching the maximum economic yields that can be attained from current levels of technology.

Besides technology, perhaps an equally important aspect of yields are weather patterns. Weather remains one of the most crucial production inputs in farming, and by far the least controllable. There are widely divergent viewpoints held by meteorologists concerning future weather patterns. Given the short term nature of these projections and uncertainty attendant to weather predictions, it seems preferable to assume that weather patterns will change little through 1985 from those observed in the 1970's.

[5]The highest estimate is slightly below the level registered in 1973, while the mean is about the same as that observed in 1975. The low level was derived assuming that the decrease noted in average consumption between 1965-67 and 1975-77 will persist through 1985.

[6]See for example Bonner; Cotner, Skold and Krause; Cotner, 1976; Culver; Duncan and Harshbarger; Evans; Matthews; National Academy of Science; Renshaw; and Schuh. It should also be noted however, that preliminary data on 1979 crop yields indicate that corn, soybeans, sorghum, barley and hay set new national records (although within the ranges projected in this study).

The estimation of future crop yields was accomplished by first projecting national average crop yield for 1985. These yields were then translated into regional yields based upon the relationship between regional yields and national yield, for the period 1968-77. The average U.S. crop yield for 1985 was derived for each commodity by regressing each average national crop yield on time for two periods, 1958-77 and 1963-77. The mean estimates were selected from the two trend projections for each crop, and modified as deemed necessary, based upon subjective judgements of plant scientists. The alternative yield levels, i.e. the high and low estimates, were derived by applying the formula for the variance of the individual forecast [Johnston, p. 154] to the equation which resulted in the mean estimate of national average crop yield, or to that which most closely approximated it (in cases where modifications were made). The resultant high, mean and low estimates of U.S. crop yield for 1985 and recent yield levels are reported in Table 2.

Regional yield estimates for 1985 are derived from national yields. Specifically, a mean regional yield deviation (from the national yield) was used to adjust the mean national yield estimate for 1985, resulting in a mean regional yield estimate. This was done for each of the commodities in each region.

That is:

$$(5) \qquad \hat{Y}ij = \hat{Y}i + \hat{d}ij$$

where:

$\hat{Y}ij$ = mean yield for 1985 for the i^{th} crop in the j^{th} region

$\hat{Y}i$ = projected national yield of the i^{th} crop for 1985

$\hat{d}ij$ = mean deviation observed during the 1968-77 period for the i^{th} crop in the j^{th} region.

The standard deviation of each regional yield was obtained from the variance estimate of the projected national yield of the i^{th} crop and the variance of past yields of the i^{th} crop in the j^{th} region about the same region's mean yield deviation from average U.S. yields. This procedure defined the limits of expected crop productivity in 1985 for each region. The estimated mean yield by region and commodity, along with standard deviations are reported in Table 3.

Projection of Regional and National Land Requirements

Two general assumptions were used to estimate land requirements. The first asserts that supply and demand will be in equilibrium in 1985. The second assumes that in 1985 each region will maintain the same per-

TABLE 2. High, Mean and Low Estimates of U.S. Crop Yields for 1985 and Recent Yields.

		Estimates of U.S. Crop Yield for 1985			Recent U.S. Yields[a] 1970-78	1976-78
Crop	Unit	High	Mean	Low	Average	Average
Corn	bu/acre	114	104	94	87.4	93.3
Oats	bu/acre	61	55	49	50.5	51.2
Barley	bu/acre	51	47	43	43.5	45.7
Sorghum grains	bu/acre	64	57	50	53.1	53.4
Wheat	bu/acre	35	33	31	31.1	30.8
Cotton	lb/acre	529	485	441	467.1	468.7
Soybeans	bu/acre	32.9	30.8	28.7	27.6	28.6
Hay	ton/acre	2.3	2.2	2.1	2.1	2.1

[a]Source: *Agricultural Statistics* 1972, 1978 and 1979.

TABLE 3. Projected Regional and National Commodity Yields for 1985.

Farm Production Region	Corn (bu/acre)	Oats (bu/acre)	Barley (bu/acre)	Sorghum Grains (bu/acre)	Wheat (bu/acre)	Cotton (lb/acre)	Soybeans (bu/acre)	Hay (ton/acre)
Pacific	121.3 ± 13.7	55.8 ± 7.1	54.4 ± 5.1	75.5 ± 8.6	45.0 ± 5.4	965 ± 118	a	3.53 ± .12
Mountain	111.2 ± 13.3	49.1 ± 7.3	48.7 ± 4.3	53.4 ± 8.3	31.7 ± 3.3	885 ± 111	a	2.35 ± .14
Northern Plains	95.5 ± 10.7	49.2 ± 6.6	41.2 ± 4.8	56.5 ± 8.5	31.3 ± 2.9	a	27.1 ± 4.1	1.59 ± .12
Southern Plains	101.2 ± 23.6	39.1 ± 8.6	37.8 ± 5.8	56.2 ± 8.2	26.2 ± 4.1	352 ± 52	27.2 ± 3.0	2.11 ± .21
Lake States	100.6 ± 14.3	59.7 ± 6.4	47.8 ± 5.8	a	37.0 ± 3.5	a	29.2 ± 3.5	2.63 ± .18
Corn Belt	113.0 ± 10.3	60.5 ± 6.5	46.3 ± 4.2	68.0 ± 8.9	40.5 ± 4.4	474 ± 107	34.6 ± 2.3	2.42 ± .10
Delta States	60.9 ± 12.8	62.5 ± 10.6	a	48.2 ± 8.7	33.0 ± 5.0	535 ± 77	25.8 ± 2.8	1.91 ± .10
Northeast	99.0 ± 14.8	58.8 ± 7.6	53.0 ± 5.3	a	38.0 ± 3.7	a	29.8 ± 3.6	2.21 ± .15
Appalachian	89.8 ± 13.5	52.3 ± 7.5	50.1 ± 5.6	56.3 ± 8.6	37.2 ± 3.7	429 ± 92	27.5 ± 2.7	1.79 ± .10
Southeast	64.9 ± 15.9	49.0 ± 7.5	44.6 ± 6.6	38.6 ± 10.3	30.3 ± 5.2	424 ± 89	25.0 ± 3.6	2.02 ± .16
U.S.	104.0 ± 10.0	55.0 ± 6.0	47.0 ± 4.0	57.0 ± 7.0	33.0 ± 2.0	485 ± 44	30.8 ± 2.1	2.20 ± .10

[a] Limited or no production of this commodity in this region over the base period, 1968-77.

centage contribution to total U.S. production, or the same market share as registered during the three-year period 1975-77.

Using the above demand and yield projections, 90 percent confidence intervals for total harvested acreage requirements at the regional and national level were constructed, based upon a normal approximation to the true distribution of commodity land requirements. Specifically, it can be argued that the quotient of two normally distributed variables, while not normally distributed, is nearly so [Fieller]. Thus, the distributions of land requirements, derived from the quotient of the normally distributed demand and yield variables, is itself approximately normally distributed.

Invoking this assumption, 90 percent confidence intervals[7] for total national and regional land requirements were constructed and reported in Table 4 together with the noted directional adjustments on future land usage.[8] As reported in the table, the 90 percent confidence interval on harvested acreage for total national land requirement to meet total demand for feed grains, wheat, cotton, soybean and hay in 1985 falls between 285.73 and 309.41 million acres.

[7] The term "confidence interval" as used here may constitute an abridgement of this precise statistical concept, given its derivation from an approximation to the true distribution. However, since Fieller has shown the properties of the distribution to be essentially the same, the use of this term seems a reasonable abstraction.

[8] The specific expression used to construct 90 percent confidence intervals for regional land requirements across the eight commodities is:

(a) $$\hat{\bar{R}} \pm 1.645\, \hat{\sigma}_{R_j}$$

where:

$\hat{\bar{R}}$ = summation of the normal approximated mean estimates of land requirement relative to the i crops in the j[th] region.

$\hat{\sigma}_{R_j}$ = square root of the summation of the normal approximated variance estimate of the i crops in the j[th] region, assuming independence of de-

TABLE 4. Total Regional and National Harvested Acreage Requirements for 1985 and Respective Directional Adjustments on Future Land Usage.

Farm Production Region	Confidence Interval for 1985 Total Regional Harvested Acreage Requirements	Directional Adjustments on Future Land Usage[a]
	(million acres)	
Pacific	10.28 to 14.02	
Mountain	18.84 to 25.52	
Northern Plains	52.27 to 67.15	Decrease from 1975-77
Southern Plains	24.46 to 33.94	
Lake States	28.17 to 33.35	
Corn Belt	82.73 to 93.13	Increase from 1968-77, 1975-77, 1978
Delta States	15.28 to 20.52	Increase from 1968-77
Northeast	9.17 to 12.15	
Appalachian	14.75 to 17.93	Increase from 1968-77
Southeast	9.20 to 12.28	
United States	285.73 to 309.41	Increase from 1968-77

[a]Determined by comparing actual 1968-77, 1975-77, and 1978 regional harvested acreages with the projected confidence limits.

The range of confidence intervals presented in Table 4 is compared with the average harvested acreage actually noted in three time periods — 1968-77, 1975-77 and 1978 — to suggest future directional adjustments in harvested acreage. Adjustments are reported in the last column of the table. Four out of ten farm production regions require an adjustment in the aggregate amount of harvested acreage needed to balance the aggregate supply and demand in 1985 for the eight commodities. Of these four regions, the Northern Plains appears to be the only region that will experience a decrease in total regional harvested acreage requirement for 1985.[9] The expected acreage is below the actual average harvested acreage noted for the period 1975-77. The Delta States and Appalachian region will require an expansion in total amount of harvested acreage over their average 1968-77 harvested acreages.[10]

Comparing these three base period harvested acreage levels (1968-77, 1975-77 and 1978) with the confidence interval of total regional land requirement derived for the Corn Belt region indicates that an increase over all three historical observations in harvested acreage will be required for 1985.[11]

mand among crops and independence of yields among regions.

The aggregate measure for national land requirements for the i crops over all j regions, with probability of occurrence equal to 90 percent, was obtained by the following expression:

(b) $$\hat{\bar{N}} \pm 1.645\, \hat{\sigma}_N$$

where:

$\hat{\bar{N}}$ = summation of normal approximated mean estimates of land requirement of the i crops over all j regions.

$\hat{\sigma}_N$ = square root of the summation of normal approximated variance estimates of the i crops over all farm production regions.

In constructing this confidence interval, independence of demand among the i commodities and independence of yield among crops and regions is again assumed.

[9]This decrease is mainly attributed to a reduction in land usage devoted to feed grains.

[10]Wheat and soybeans are the two crops which will require expanded land use in the Delta States. In the case of the Appalachian region, soybeans are responsible for the increase in land requirements.

[11]Increased demands for feed grains, wheat and soybeans contribute to this expansion.

Finally, the results suggest that total national land requirements to produce the eight selected commodities will be greater in 1985 than the 1968-77 harvested acreage level, due primarily to increased demand for soybeans.

Land Requirements vs. Land Availability

To place the above projections and adjustments in perspective, these results are compared with the national and regional cropland availabilities established by the SCS. Such a comparison provides insight into the feasibility of meeting projected 1985 land requirements.

The comparison of projected land requirements with available cropland is based on the 90 percent confidence interval established for regional and national land requirements (see Table 4), and on the inventory of present and potential cropland as reported by the Soil Conservation Service. However, the confidence intervals reported in Table 4 are expressed in terms of harvested acreage, whereas the results of the SCS study refer to total cropland. Thus, these estimates are converted to a standard consistent with the SCS results, [12] i.e. harvested acreage plus pasture and other land.[13] This conversion procedure gives rise to 1985 estimates for total cropland needed by all crops as well as land for pasture. It is implicitly assumed that the remaining crops (which are responsible for 12 percent of total U.S. harvested acreage) will maintain their current pattern and level of land use through 1985.

The 90 percent confidence interval for regional and national land requirements, expressed in terms of total cropland needed in 1985, as well as total regional and national potential cropland, are reported in Table 5.

As is evident, 1985 requirements for food and fiber should not be constrained by the availability of land at the national level. Specifically, it appears that total projected demand can be met by bringing into production a minimum of 34.6 million acres or a maximum of 70.6 million additional acres from that observed in 1975. This additional acreage could be taken from marginal land currently classified as "high potential" by the SCS. Of the 78.1 million acres of land with high potential[14] for conversion to cropland, 34.9 million acres have no problems and conversion can be accomplished simply by beginning tillage. The remaining 43.2 million acres have one or more problems that must be considered before conversion to cropland is feasible.

Regional cropland availability to meet 1985 projected demand is adequate for all regions except the Southern Plains, Corn Belt, Delta States, and Appalachian regions, if the lower bound of the confidence interval is in fact realized. If regional demand levels are moderate (at their projected mean level) and high yields are achieved demands in the Southern Plains, Delta States and Appalachian regions can be met by bringing a portion of available "high potential" land into production. However, this is not true for the Corn Belt which tends to be fully utilized with respect to cropland. The 14.85 million acres of total potential cropland, when added to 1975 actual cropland use in the Corn Belt, are not sufficient to meet even lower bound cropland requirements projected for 1985. In the case of the Southern Plains, Delta States and Appalachian region, the maximum acreage of cropland of 51.92, 30.87 and 31.88 million acres, respectively, are contained within the confidence interval on future requirements.

Examining the upper bound of cropland requirements derived for the Pacific, Moun-

[12]See Santana and Adams for a detailed discussion of the procedure underlying this conversion.

[13]"Other land" includes cropland used only for soil improvement crops, land on which all crops failed, cultivated summer fallow, idle cropland, and land planted with crops to be harvested after the year covered by the Census.

[14]High potential for conversion to cropland under 1974 commodity prices, development costs and production costs.

tain, Northern Plains and Southeast region in Table 5, an expansion of 0.64, 5.82, 9.29 and 3.99 million acres, respectively, is expected for each region above 1975 cropland usage. However, the magnitude of these projected expansions is sufficiently small to be met by use of additional high potential land, assuming adequate irrigation supplies in the Pacific and Mountain region. Thus, with the exception of the Corn Belt, Southern Plains, Delta States, and Appalachian region, land availability does not appear to pose a constraint either regionally or nationally. However, since any additional land brought into production will probably have lower inherent productivity and hence lower yields, the potential plateauing of yields may be aggravated. This in turn could affect the requirements for land in 1985.

Conclusions

The ability of U.S. agriculture to meet rising export demand in the face of slowed productivity growth and continued loss of farmland to non-agricultural uses has been the subject of considerable conjecture. This study indicates that agricultural production in 1985 should not be constrained by land availability at the national level, even in the event of high demand levels and stagnation of crop yield growth. However, when the analysis is extended to specific farm production regions, some regional shifts in production are suggested. For example, the Corn Belt region does not appear to have sufficient cropland to maintain the market share recorded in the 1975-77 period. The rather sharp increase in land requirements for this region stems mainly from the projected increase in soybean demand. The prospect that the Corn Belt will not be able to maintain its market share in 1985 implies that regions with a comparative advantage (with respect to land availability) will expand market shares for soybeans.

In addition to the Corn Belt, the Southern

TABLE 5. Comparison of 1985 National and Regional Cropland Requirements with Total National and Regional Cropland Availabilities.

Farm Production Region	90% Confidence Interval for Cropland Needed in 1985	Cropland Used in 1975[a]	Potential for New Cropland			Total Cropland Available[a]
			High[b]	Medium[c]	Total	
	(million acres)		(million acres)			
Pacific	16.55 to 22.57	21.93	2.73	0.04	2.77	24.70
Mountain	34.29 to 46.45	40.63	8.63	5.29	13.92	54.55
Northern Plains	77.88 to 100.05	90.76	12.27	5.48	17.75	108.51
Southern Plains	42.81 to 59.40	41.06	9.60	1.26	10.86	51.92
Lake States	36.60 to 43.36	44.19	4.22	1.80	6.02	50.21
Corn Belt	109.20 to 122.93	86.73	11.32	3.53	14.85	101.58
Delta States	24.30 to 32.63	20.24	7.36	3.27	10.63	30.87
Northeast	12.75 to 16.89	17.34	2.14	1.38	3.52	20.86
Appalachian	29.50 to 35.86	20.31	9.47	2.10	11.57	31.88
Southeast	15.36 to 20.51	16.52	10.39	8.44	18.83	35.35
U.S.	434.31 to 470.30	399.71	78.13	32.59	110.72	510.43

[a]Source: U.S. Department of Agriculture, *Potential Cropland Study,* Soil Conservation Service, Statistical Bulletin 578, 1977.

[b]High potential for conversion to cropland under 1974 commodity prices, development costs and production costs. Similar land has been recently converted in the locality.

[c]Medium potential for conversion to cropland under 1974 commodity prices, development costs and production costs.

Plains, Delta States and Appalachian region may also face a reduction in their respective market shares as a result of land constraints. However, for these three regions the situation with respect to land availability does not appear as binding as in the Corn Belt, since the lower limit of the 90 percent confidence interval does not exceed total cropland available. Thus, depending on the exact demand level realized for 1985 (i.e., within the confidence interval), these regions could maintain their current market share.

The 90 percent confidence interval for total cropland requirements for the Pacific, Mountain, Northern Plains and Southeast regions suggest that if the upper bound is in fact realized, an expansion in cropland over the 1975-77 level will result. However, the magnitude of these adjustments is small when compared to the amount of potential new cropland in each of these regions. Thus, any loss in market share by the Corn Belt, Southern Plains, Delta States and Appalachian region may be offset by increases in the Pacific, Mountain, Northern Plains, Lake States, Northeast and Southeast production regions.

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