B-1125
October 1972

ECONOMIES OF SIZE ON FARMS in the Blackland Area of Texas

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Summary

The potential efficiencies of one- and two-man farms with four-row equipment and one-, two- and three-man farms with six-row equipment for level areas of the Central Texas Blackland are compared. Efficiency is measured in terms of total cost per dollar of gross farm sales. Short-run cost curves are developed for each of the five plant sizes, and an envelope or long-run planning curve is fitted to the short-run curves.

Results of the analysis indicate that average per-unit costs of production decrease rapidly on all plant sizes as output nears full employment of the regular labor force and full utilization of the field equipment. On the smallest of the five plant sizes considered—the one-man unit with four-row equipment—the lowest cost-income ratio that can be achieved is $0.908. This is reached when 479 acres are operated. Total capital investment required for the 479-acre farm is approximately $187,500, with returns to management of about $4,060. Nearly 200 acres are required to recover all costs.

Of the five plant sizes analyzed, the lowest cost-income ratio that can be reached is $0.824 on the two-man farm with six-row equipment. This two-man six-row unit consists of 1,376 acres with $110,000 gross income and $19,325 returns to management and requires a total initial capital investment of approximately $530,000.

For the three-man unit with six-row equipment, the lowest cost-income ratio that can be achieved is $0.864. Per-unit production costs are higher for the three-man farm primarily because of incomplete utilization of some of the harvesting equipment and because of higher costs associated with dispersion and management of the larger size unit. While farm plants larger than the three-man, six-row unit are not included in the analysis, it appears that average per-unit costs would rise slowly for levels of output greater than those included in the study. Net income would continue to increase with increasing size but at a decreasing proportionate rate because of decreasing efficiency.

The least-cost farm organization is essentially the same for each of the five plant sizes. It consists of cotton and grain sorghum on row crop land and a spring calving cow-calf enterprise for grazing improved pasture. If the regular labor force is not fully utilized and additional land is not available, returns to management can be increased by adding hogs. If land is available, however, expansion of land would be the preferable way to expand.

Results of the analysis indicate that with units of less than 500 acres, four-row equipment likely would be most advantageous. With acreages of approximately 500 and above, however, six-row equipment would be most advantageous. Not only are the potential efficiencies greater, but significantly larger acreages can be handled with a given labor force. With the uncertainty and increasing cost of labor, this is a significant factor.

A comparison of the results of this analysis with the size structure of farms in the Blackland area as given in the 1964 census indicates that a substantial proportion of farms in the area is below the size required to attain maximum efficiency. More than 96 percent of the farms in the area were below 1,000 acres in size in 1964, while over 87 percent were below 500 acres. Operators of small farms with high cost-income ratios are likely to find increasing pressure to adjust to larger and more efficient units in the future.

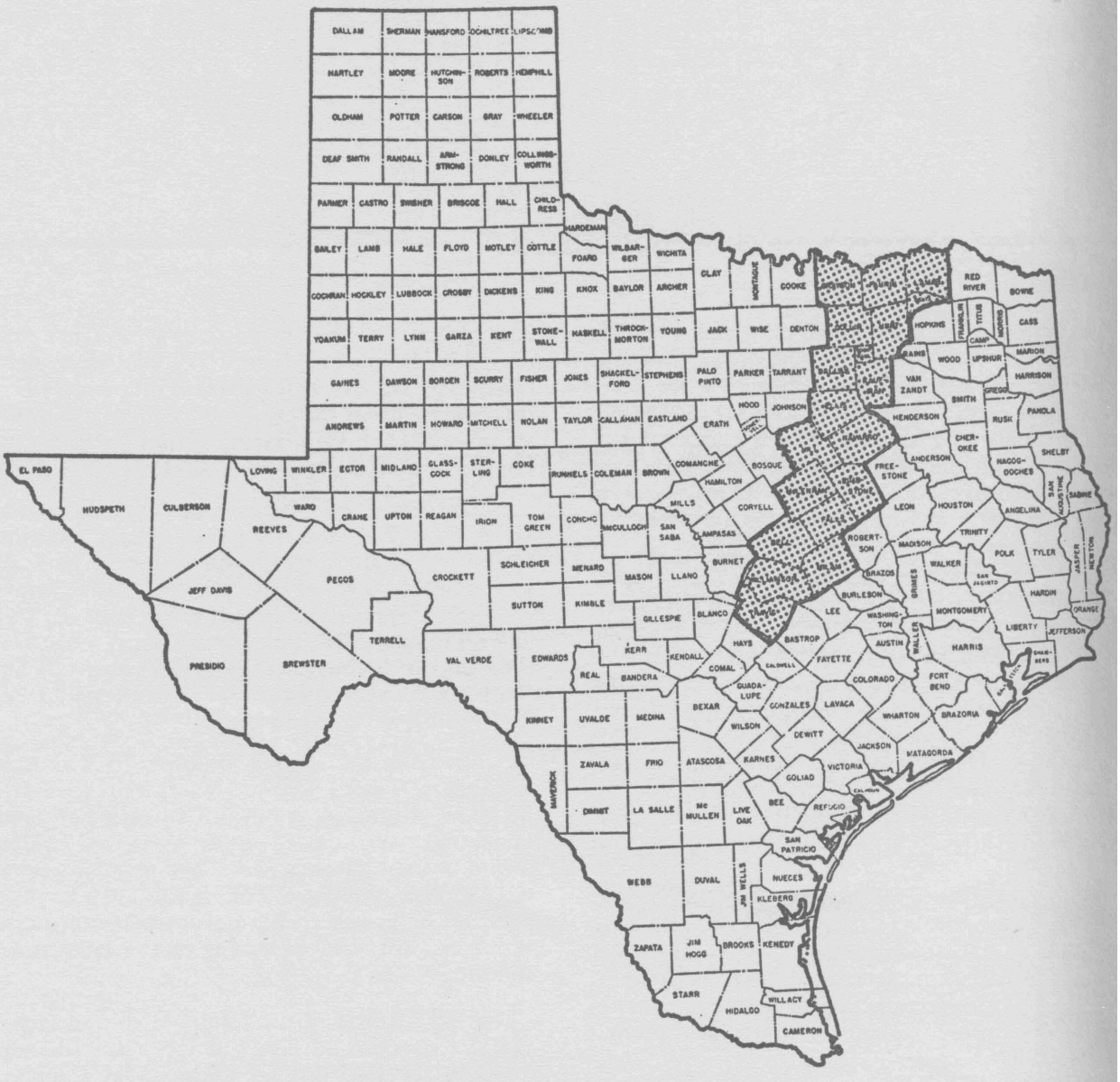

Figure 1. Blackland study area following county lines.

ECONOMIES OF SIZE ON FARMS in the Blackland Area of Texas

Carl G. Anderson and D. S. Moore*

MANY FARMS IN THE BLACKLAND AREA of Texas are undersized from the standpoint of utilizing efficiently the resources of a full-time operator and of machinery and equipment. Per-unit costs of fixed or "lumpy" resources such as regular labor and durable production items are minimized when these resources are most completely utilized. Substitution of capital for labor and the adoption of larger machinery complements suggest that the relationship of farm size to efficiency of production is of increasing importance. Farmers with units too small to realize the economies of size may be at an increasing disadvantage in today's competitive agriculture. More information is needed on the significance of size of unit to efficiency and profitability.

OBJECTIVES

The general objective of this study is to examine the efficiency and profitabilty of various sizes of farms on level soils of the Blackland area of Texas. Specific objectives are (1) to determine the relationship between the degree of utilization of specified plant sizes and per-unit average production costs; (2) to compare the efficiency and profitability of specified plant sizes; (3) to determine the resource requirements and enterprise organization associated with the least-cost utilization of resources; and (4) to determine the implications of size-efficiency relationships to the future structure of commercial farms in the Blackland area. Plant size is defined by size of the regular labor force and the capacity and size of power and field machinery. Regular labor includes both the operator's labor and full-time hired labor.

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AREA OF STUDY

The general geographic area for this study is the Blackland Prairie of Texas, which is a large, wedge-shaped area extending through Central Texas from near the Red River on the north to the vicinity of San Antonio on the south. The area is approximately 300 miles long and up to 75 miles wide. The study area consists of all or parts of 19 counties as shown in Figure 1.

The Blackland area is one of the major agricultural areas of Texas. Major upland soils are dark calcareous clays, moderately well supplied with organic matter. Topography is quite varied. Although much of the area is rolling and characterized by many streams and ravines, there also are substantial acreages of relatively level land which can feasibly utilize large field machinery such as six-row crop equipment. This study is primarily applicable to the relatively level blackland soils of Houston, Houston Black, Bell and Austin clays. However, farms in the more level areas of the Blacklands generally have some rolling land utilized as pasture. Data compiled by the Soil Conservation Service indicate that land capability classes I and II[1] comprise approximately two-thirds of the soils in the more level areas, while the remaining one-third consists mostly of land capability classes III and IV. The more level soils (capability classes I and II) generally are utilized in the production of row crops, while the utilization of the more rolling soils (capability classes III and IV) has been trending toward forage for livestock.

[1]Land capability classes I and II are level to moderately sloping soils (slope of 3 percent or less) with negligible to moderate erosion. Land capability classes III and IV have slopes of 3 to 5 percent with moderately severe to severe erosion.

On the more productive soils, cotton and grain sorghum are the major cash crops. Beef cattle (cow-calf or stocker operations) and hogs are the primary livestock enterprises of the area and are usually produced in conjunction with crops. Commercial poultry, beef feeding and dairy enterprises tend to be specialized operations. Dallas, Fort Worth, Waco, Austin and San Antonio, the major cities located near or in the area, provide favorable markets for farm products.

Farms in the Blackland area numbered more than 66,000 in 1945 and averaged 135 acres in size. By 1964 the number had declined by more than one-half to approximately 30,000, while the average size had almost doubled to 269 acres. The trend toward fewer and larger farms was general throughout the area (Table 1). The number of farms of 500 acres or more increased from about 3 percent of the total in 1945 to nearly 13 percent in 1964. Although composing only about 13 percent of the total number of farms in 1964, farms of 500 acres or more accounted for about 40 percent of the total farm acreage in the Blackland area.

CONCEPTS AND PROCEDURES

Economies associated with farm size may arise from two sources. One source is frequently referred to as market or pecuniary economies. It is the result of reduced acquisition costs of inputs or increased selling prices as the size of farm is increased. This source of economies was not included in the analysis because preliminary investigation indicated it was of minor importance in the Blacklands area. The second source of economies associated with size results from more complete utilization of the productive capacity of the resources and from the ability of larger farms to utilize larger, more efficient machines. This is the type of economies analyzed in this report.

In the process of expansion, it is usually impossible to increase all resources in equal proportion. When major durable items of production such as tractors and associated field machinery and regular labor are committed to production, they become fixed in the short run. The degree of utilization of these durable items depends on the acreage operated and other resources used in production. The average

TABLE 1. CHANGE IN THE NUMBER AND SIZE OF FARMS, BLACKLAND AREA OF TEXAS, 1945-64

Size of group, acres	Number of farms		Percentage of farms	
	1945	1964	1945	1964
Fewer than 10	6,244	917	9.4	3.0
10-69	20,505	6,991	30.9	22.9
70-139	20,570	7,217	31.0	23.6
140-219	10,249	4,970	15.5	16.3
220-259	2,273	1,623	3.4	5.3
260-499	4,401	4,934	6.6	16.1
500-999	1,489	2,765	2.2	9.0
1000 and more	645	1,148	1.0	3.8
All sizes	66,376	30,565	100.0	100.0

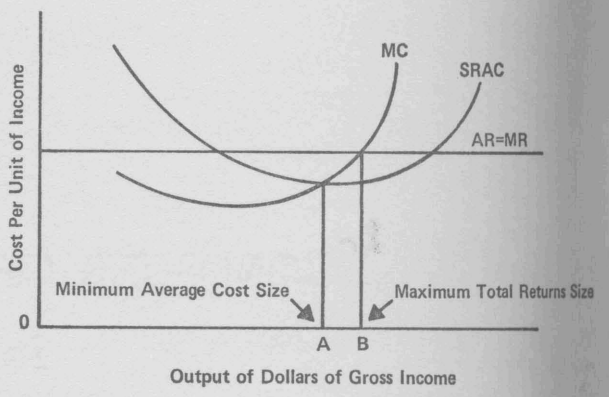

Figure 2. Illustration of minimum average cost and maximum total returns.

total cost of production per unit of output varies according to the degree of utilization of the fixed plant. As fixed resources become more completely utilized, the average cost of production per unit is reduced. If production is increased to the level of maximum net income, however, the average cost per unit of production eventually increases on most farms.

A short-run average cost curve (SRAC), which traces the average total cost per unit of production as output is varied, is shown in Figure 2. If the objective is to minimize average cost of production, output should be OA. If profit maximization from the fixed plant is the goal of the operator, output should be expanded to OB where the marginal revenue (MR) equals the marginal cost (MC). Production cannot be expanded profitably beyond OB without an additional fixed plant. When a farm business expands by adding another fixed plant, it begins operating on a new short-run average cost curve. This curve typically has the same "U" shape as the average cost curve shown in Figure 2. Increases in fixed plants create a series or family of short-run average cost curves as illustrated in Figure 3. An envelope curve formed as a tangency to these short-run curves (long-run average cost curve or LRAC) is defined as the cost planning curve. Theoretically, as the farm operation expands from a relatively small size, economies result at first so that short-run cost curves reach successively lower levels until diseconomies occur at some level of output.

Analytical Techniques

Linear programing models were used to develop short-run cost curves and least-cost farm plans. The primary goals in the models were the least cost per dollar of gross income, given specific sets of resources and a gross income objective.

The procedure involved establishing five separate plant sizes consisting of a specified number of full-time workers equipped with basic field machinery. All other resources were made available without limit, and minimum cost situations were programed for successively higher levels of gross income until the

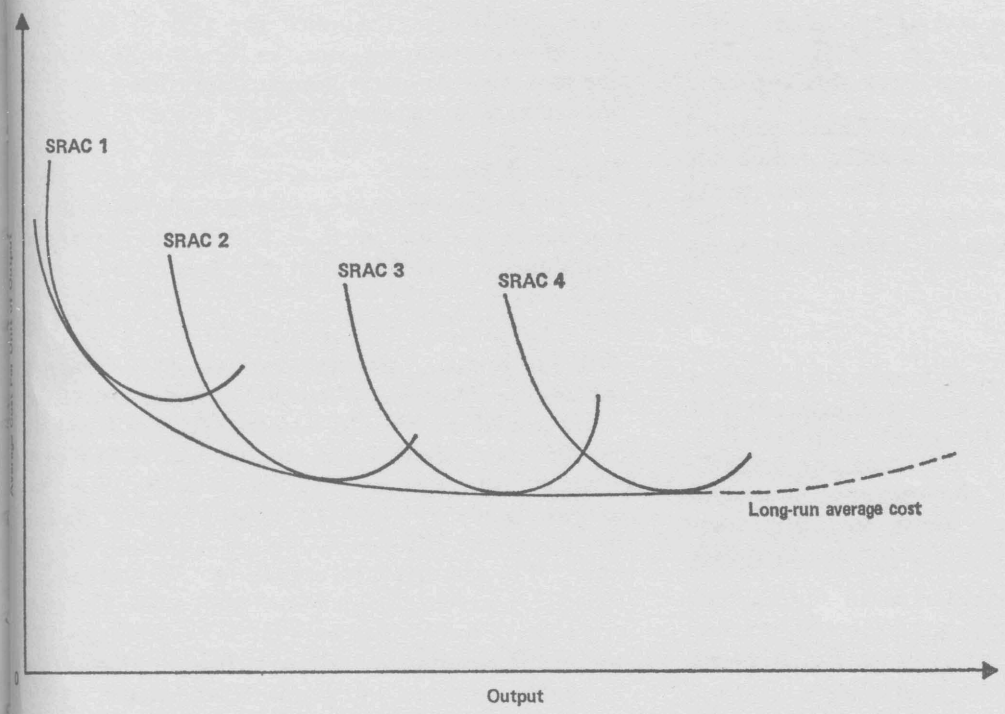

Figure 3. Hypothetical short-run and long-run average cost curves.

oint of maximum net returns was reached. The sults produced an average cost curve for each size farm business considered. An envelope curve fitted the series of five short-run cost curves for succesively larger plant sizes formed an approximization of long-run cost curve.[2]

Plant Sizes

The five plant sizes considered in the analysis re shown in Table 2. The machine sizes consisted four- and six-row tractors and associated complements of field equipment. Maximum size of operaon considered was three six-row units, since preliminary analysis indicated that no additional economies ould be achieved by larger size operations.

Tractor operating time was restricted to 1,000 ours a year per tractor. Minimum depreciation harges were set for 800 hours annually per tractor. dditional depreciation charges within the ranges etween 800 hours and 1,000 hours were incurred only needed.

Sources of Data

Input-output coefficients and prices used in this udy were developed from several sources, including ata from progressive farmers in the area, the Stiles arm Foundation, experiment station research reports, ngineering data and technical specialists. Market ivestock prices were 5-year monthly averages at the ort Worth market for 1963–67.

[2]For a more detailed discussion of this and alternative methods of analyzing economies of size, see J. P. Madden, "Economies of Size in Farming," Agricultural Economic Report No. 107, Economic Research Service, U.S. Department of Agriculture, February 1967.

Assumptions and Definitions

The results of this study should be evaluated in light of the assumptions on which the analyses were based. These assumptions follow.

Level of Technology and Management

Limited capabilities of management place a major restriction on size of business. This study assumes a level of management which is capable of managing

TABLE 2. ESTIMATED COMPLEMENT OF EQUIPMENT FOR SELECTED SIZE CROP-LIVESTOCK FARMS, BLACKLAND AREA

Equipment item[1]	Regular labor force and size of equipment				
	1-man		2-man		3-man
	4-r	6-r	4-r	6-r	6-r
	Number				
Tractor, 4-r, 50-59 hp	1	0	2	0	0
Tractor, 6-r, 60-69 hp	0	1	0	2	3
Cultivator, 4-r, 6-r	1	1	2	2	3
Planter, 4-r, 6-r	1	1	2	2	3
Bedder, 4-r, 6-r	1	1	2	2	2
Moldboard, 3-b-14", 4-b-16"	1	1	2	2	2
Tandem disc harrow, 7', 14'	1	1	2	2	2
Harrow, spike, 16', 24'	1	1	2	2	2
Sprayer, 4-r, 6-r	1	1	2	2	2
Pre-emerge rig, 4-r, 6-r	1	1	2	2	2
Roller, 4-r, 6-r	1	1	2	2	2
Cotton stripper, 2-r tm.	1	0	2	0	0
Cotton stripper, 2-r tm. w/basket	0	1	0	2	3
Trailer, 2 bale, 3 bale	6	4	12	8	8
Rotary shredder, 2-r, 4-r	1	1	2	2	2
Combine, 14' sp.	0	1	1	1	2
Truck, 1½ t.	0	1	1	1	2
Stock trailer	1	1	1	1	1

[1]First size figure is for four-row equipment, and the second is for six-row equipment.

large farms and supervising several employees without loss in management efficiency. Many present farm operators probably do not have this capacity.

Use of the operator's time was shifted progressively from farm work to supervision and coordination as the hired labor force increased. The assumptions on farm practices correspond closely to current recommendations of experiment station reports and extension specialists.

Enterprise Alternatives

Budgets for the crop and livestock enterprises included in the analyses are given in a separate report.[3] These enterprises represent the major crop and livestock uses for level cropland soils in the Central Blackland area. However, since the operation was considered to be primarily land based, specialty enterprises such as dairy and poultry were not included.

Cash crop enterprises considered in the analysis were cotton and grain sorghum. Cropland production for supplying temporary grazing for livestock included small grain and hybrid sudangrass. Permanent pasture was improved and established in Coastal bermudagrass. Hay could be produced for winter feeding or sold.

Land-based livestock alternatives included four different buy-sell steer grazing programs and five cow-calf programs. A confinement system of complete market hog production was also included. Restrictions on the size of hog enterprise included a 50-sow-capacity unit and the amount of grain sorghum produced on the farm. Larger operations tend to be specialized in nature and not associated with land-based operations. Likewise, a specific pathogen free (SPF) hog operation was not included as an alternative because of its relatively specialized nature.

Land Resources

Two-thirds of the land resource was assumed to be in land capability classes I and II and suitable for production of row crops. Approximately one-third of the land resource was assumed to consist of lower capability classes and more suitable for forage production. This composition is typical of the more level portions of the Blackland area.

Cotton production was restricted to an annual maximum of one-third of the cropland. This was an agronomic restriction due to cotton root rot which can be controlled by deep plowing and a rotation system of heavy residue crops such as grain sorghum for 2 consecutive years. In addition, grain sorghum could be planted on all cropland, and improved pasture could be established on cropland. Allotment restrictions were not specifically imposed. Therefore, noncompliance was assumed for feed grains. Since the agronomic restriction for cotton was more restrictive than government allotments, no cotton allotment restriction was required.

[3]See Anderson, C. G. and Moore, D. S., "Production and Production Requirements, Costs and Expected Returns for Crop and Livestock Enterprises—Level Blackland Soils of the Central Blackland Prairie of Texas," Texas Agr. Expt. Sta. MP-1004.

Tenure of Operator

This study is concerned primarily with a long-run planning situation which will enable the operator to produce specified levels of total output at the lowest total cost.

The study in its present stage is not concerned with the problem of how operators obtain control of the use of resources, whether by ownership, renting or custom hiring. Under competitive conditions, rent theoretically approaches ownership costs over a period of years. The resources needed for any specified level of gross income would be approximately the same irrespective of whether operators are owners or tenants. Therefore, for simplicity of calculations, this study assumes full ownership of all resources except grain harvesting equipment. Grain could be harvested by owned equipment, or harvesting could be custom hired depending on which was the cheaper alternative.

Labor

Optimal organizations were developed for farms with up to two full-time employees. Full-time or regular labor was committed to the farm for the entire production season, irrespective of the extent to which it was actually used. The maximum number of man-hours available per man-year of regular hired labor was considered to be 2,400. In addition, the operator had an initial maximum of 2,500 hours available for farm work; this maximum amount was reduced proportionately as size increased to reflect increasing requirements for supervision and managerial duties. Supplemental labor was assumed to be available for $2 per hour. Hours of work time available by seasons are shown in Table 3.

TABLE 3. ESTIMATED HOURS OF OPERATOR'S TIME AVAILABLE FOR FARM WORK, MANAGEMENT AND SUPERVISION BY NUMBER OF EMPLOYEES, AND WORK TIME PER REGULAR EMPLOYEE

Season	Number of regular employees			Work time per regular employee
	0	1	2	
	Hours			
January-February	450	360	288	400
March	250	200	160	200
April	250	200	160	200
May-July	750	600	480	600
August-September	500	400	320	400
October-December	700	560	448	600
Total annual time available	2,500[1]	2,000[1]	1,600[1]	2,400
Time required for management and supervision	500	1,000	1,400	

[1]The sum of the hours available by seasons is greater than the annual total time in order to permit limited flexibility between seasons.

come and Costs

In this study, cost per unit of output is reflected the total cost-total gross income ratio. Gross income the total revenue received from the sale of farm oducts. Total costs constitute the payment for all ources at going market rates. The costs included opportunity charge of $4,200 annually for opera-'s labor. Capital was charged at a rate of 6 per-nt on investment capital and 7 percent on operating pital. Land was valued at $300 per acre and consti-ted a major portion of investment capital.

Costs which could be attributed directly to the dividual crop and livestock enterprises were incorpo-ted in the enterprise budgets. Some costs common the entire farm business could not be incorporated the enterprise budgets. These costs included de-eciation and interest charges on investment for farm achinery and utility sheds, machinery complements d general cash overhead costs such as pickup ex-nses, farm organization dues, telephone, electricity, surance, taxes and bookkeeping and tax services. hey were handled as general farm overhead expenses the programing models.

Prices paid and received for crops sold by farmers the study area were estimates of 1967–68 prices. arket livestock prices were 1963–67 monthly aver-es at the Fort Worth market. The price for cotton sumed a blend of cash market price and direct overnment payment.

EMPIRICAL RESULTS

Results of the analyses are presented in the follow-g order: (1) the effect of the degree of ultilization farm plants on efficiency, income and organization; a comparison of the efficiency and resource re-irements of specified plant sizes; and (3) the impli-tions of the findings with respect to farm expansion d the future structure of commercial farms in the lacklands area.

Short-Run Cost Curves

The effect of the degree of utilization of farm lants on efficiency is indicated by short-run cost rves. The five discrete plant sizes considered are own in Table 2. In interpreting the results, it is portant to remember that all factors were consid-ed variable except full-time labor and specified mplements of machinery and equipment associated ith the labor force. The results indicate the level d allocation of variable resources, including land, hich will utilize the fixed labor and equipment re-urces most efficiently. Efficiency per unit of pro-uction is measured in terms of total cost per dollar gross income. The short-run cost curves thus trace, r each plant size, the relationship between cost per nit and volume of gross income.

our-Row Equipment

Average total costs per dollar of gross income for ne- and two-man farms with four-row equipment

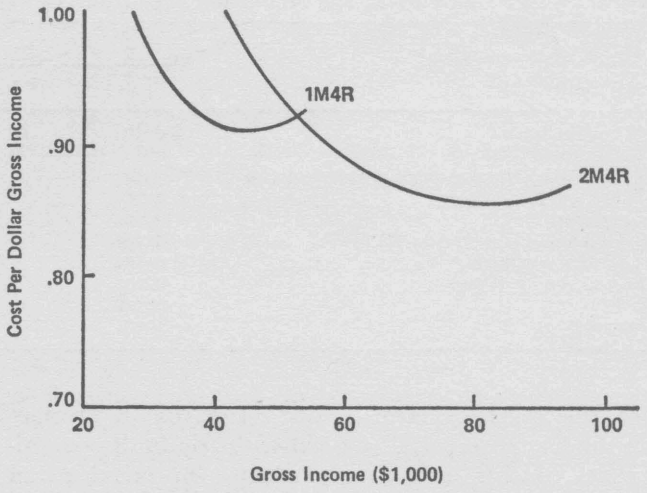

Figure 4. Short-run average total cost curves for one- and two-man least-cost crop-livestock farms with four-row equipment at various levels of gross income.

are shown in Figure 4. These curves have the "U"-shaped pattern typical of short-run cost curves. Initially, as the volume of gross income increases, costs per unit of output decline because of more complete utilization of the fixed machinery and labor force. Minimum cost is reached with complete utilization of one or more of the fixed resources. Additional increases in gross income then are possible only by substituting more costly enterprises or by expanding enterprises that can be produced from resources not completely utilized. This is higher cost income and causes the average cost curve to increase.

For the one-man farm with four-row equipment, nearly 200 acres are required to break even. Total gross sales from the 200 acres are nearly $28,000 (Figure 4).

When more land is added, the machinery and regular labor force can be utilized more completely. This causes the cost-income ratio to decline steeply until available tractor time is completely exhausted. The regular labor force also is utilized completely at near this level of operation. Exhaustion of tractor time occurs when 479 acres are operated. At this point, total cost per dollar of gross income has declined to $0.908, which is the lowest point attainable for one-man farms with four-row equipment. Gross income is approximately $44,000, with returns to management totaling $4,063 (Figure 4 and Table 4). Returns to management can still be increased slightly, however, by expanding the hog enterprise. This is high-cost income because a considerable amount of supplemental hired labor is required. Expansion of the hog enterprise causes the cost-income ratio to rise sharply. Maximum net income is reached with management returns of $4,400, gross income of approximately $56,000 and a cost-income ratio of $0.936.

The major changes in farm organization that occur with movement along the short-run cost curve

TABLE 4. LEAST-COST FARM ORGANIZATION FOR FIVE SPECIFIED FARM PLANT SIZES

Item	Unit	Four-row equipment		Six-row equipment		
		One-man	Two-man	One-man	Two-man	Three-man
Gross income	dollar	44,000	80,000	56,000	110,000	164,000
Total cost	dollar	39,937	67,618	48,688	90,675	141,783
Total cost per dollar of gross income	dollar	.908	.845	.869	.824	.864
Total land	acres	479	958	688	1,376	2,064
Cropland	acres	319	639	459	918	1,376
Cotton	acres	106	213	153	306	459
Grain sorghum	acres	213	426	306	612	917
Permanent pasture	acres	160	319	229	459	688
Cows	head	64	128	92	183	275
Sows	head	16	11	4	3	2

for the one-man farm consist primarily of changes in the hog enterprise. Basically, the optimum organization consists of cotton produced on one-third of the cropland and grain sorghum on the remaining two-thirds. Forage supplied by the permanent pasture land is utilized by a spring calving, cow-calf enterprise. At the break-even level of operation, where only about 200 acres are operated, the optimum farm plan includes nearly 40 sows. With only 200 acres operated, there is a considerable quantity of unutilized regular labor which can be used most profitably in producing hogs. As more acres are operated, labor required for crop production becomes competitive with labor required for hog production, and since crop production offers the more profitable utilization of regular labor, the hog enterprise is reduced to a minimum of 16 sows at the least-cost ratio of $0.908. At income levels beyond this point, the hog enterprise is again expanded, as discussed previously, reaching a total of about 47 sows at the level of maximum net income.

The short-run cost curve for the two-man farm with four-row equipment follows a similar pattern to that of the one-man farm. As would be expected, the curve lies to the right of the curve for the one-man farm. Gross income of approximately $42,000 is required to break even as compared with a break-even income of $28,000 for the one-man farm. The level of greatest efficiency occurs when gross income totals about $80,000 and 958 acres are operated. The cost-income ratio at this level is $0.845, which indicates that the potential efficiencies of two-man farms with four-row equipment are significantly greater than those of one-man farms. Changes in farm organization occurring for the two-man farm with movement along the short-run cost curve are very similar to the changes that occurred for the one-man farm. One distinction occurs in machinery investment. Custom hiring is the cheaper method of harvesting grain sorghum on one-man farms, whereas the ownership of a combine is the cheaper method on two-man farms.

Six-Row Equipment

Average cost curves for one-, two- and three-man farms with six-row equipment are shown in Figure 5. For each full-time man in the labor force, there is a six-row tractor and associated complements of necessary equipment. The one- and two-man farms have one set of grain harvesting equipment (combine and truck), while the three-man farm has two sets. For the three-man farm, the salary of one of the regular employees was increased from $4,200 to $4,800. Due to relatively small tracts in the Blacklands area, there is usually considerable geographic dispersion of farmland for farms with large acreages. The increase in salary was to reflect costs associated with greater dispersion and the higher remuneration and cost required for an experienced and dependable employee who would require a minimum of supervision.

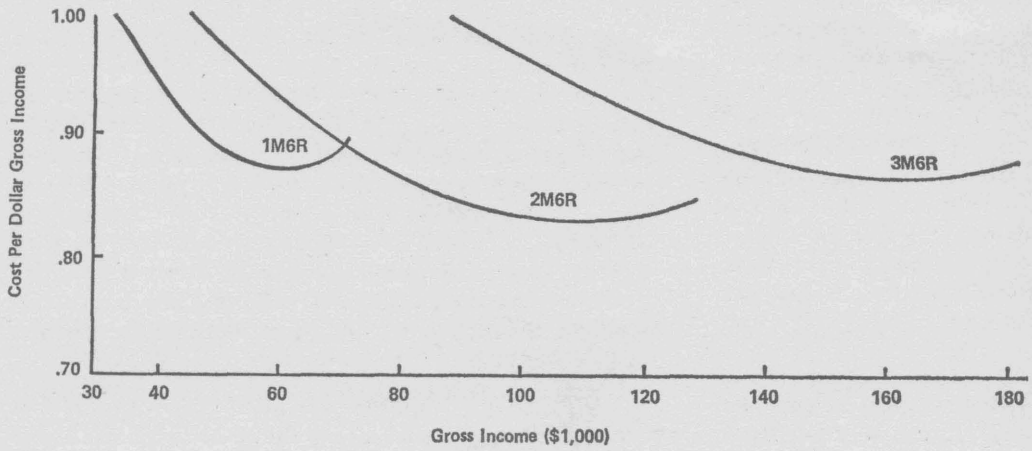

Figure 5. Short-run average total cost curves for one- to three-man least-cost crop - livestock farms with six-row equipment at various levels of gross income.

The short-run cost curves for six-row equipment own in Figure 5 have the same typical "U"-shaped ttern of the cost curves for four-row equipment own in Figure 4. The cost-income ratios decline a minimum of $0.869 for the one-man, six-row farm, .824 for the two-man farm and $0.864 for the three-an farm. This compares with ratios of $0.908 and .845, respectively, for the one- and two-man farms ith four-row equipment. One factor contributing the higher cost-income ratio for the three-man farm the underutilization of the second set of grain harsting equipment. To expand acreage to make more mplete utilization of the grain harvesting equipent, however, would require an additional hired an and an additional tractor.

For each of the six-row units considered, crop reage is restricted by exhaustion of tractor time. dditional net returns can be generated by expanding e hog enterprise, but this is higher cost income and uses the average cost curve to increase.

east-Cost Farm Organizations

The least-cost organizations for the five farm lants are shown in Table 4. Total acreages operated nged from 479 acres for the one-man farm with ur-row equipment to 2,064 acres for the three-man rm with six-row equipment. The only differences farm organization are in the declining importance the hog enterprise for the farms with six-row equipent. For least-cost farms with six-row equipment, e hog enterprise probably would be excluded. On ch of the five farms, the hog enterprise is included higher levels if the acreage operated is less than at required for least-cost production. Otherwise the bor force would be underemployed.

come and Investment Requirements

Gross income, which includes the returns from l sales plus government payments, ranges from 4,000 on least-cost one-man farms with four-row quipment to $164,000 on three-man farms with six-w equipment (Table 5). Net returns to management, a residual after deducting all costs except management, range from $4,063 to $22,217. Management returns per man are substantially higher for the two-man farm with six-row equipment than for the other farm sizes. This is primarily because of the greater efficiency of this size unit. Other measures of income shown in Table 5 are returns to operator's labor and management and returns to operator's labor, capital and management which range from almost $20,000 on the smallest size farm to almost $75,000 on the largest size.

Capital requirements are quite high. On the most efficient of the five farm plants, the two-man farm with six-row equipment, a total initial investment of more than $500,000 is required. On the least efficient, a one-man farm with four-row equipment, an investment of nearly $200,000 is required. The higher capital intensity of least-cost six-row units compared with four-row units is reflected in the substantially higher total investment per man. Investment in land makes up slightly more than three-fourths of total investment for all farm sizes.

Labor Requirements

Operator's time available for farm operations amounted to 2,500 hours annually for one-man farms, about 2,000 hours for two-man farms and 1,600 hours for three-man farms. In addition, each regular hired man provided 2,400 hours annually to the labor force. For each of the least-cost farm organizations, some additional supplementary hired labor is required to meet seasonal requirements (Table 6). The largest amounts of supplementary labor are required on two- and three-man farms with six-row equipment during the August-September harvest season.

The greater labor efficiency of the larger farms is reflected in Table 6. Total labor requirements decline from 5.6 hours per acre on one-man farms with four-row equipment to 3.7 hours per acre on both two- and three-man farms with six-row equipment.

ABLE 5. INVESTMENT REQUIREMENTS AND SELECTED MEASURES OF FARM INCOME FOR LEAST-COST FARM ORGANIZATIONS

Item	Four-row equipment		Six-row equipment		
	One-man	Two-man	One-man	Two-man	Three-man
ross income	$ 44,000	$ 80,000	$ 56,000	$110,000	$164,000
otal cost	39,937	67,618	48,688	90,675	141,783
eturns to management	4,063	12,382	7,312	19,325	22,217
Per man	4,063	6,191	7,312	9,662	7,406
alue of operator's labor	4,200	4,200	4,200	4,200	4,200
eturns to operator's labor and management	8,263	16,582	11,512	23,525	26,417
nterest on:					
Land capital	8,622	17,244	12,384	24,768	37,152
Other capital	2,786	5,685	3,831	7,318	11,113
eturns to operator's labor, management and capital	19,671	39,511	27,727	55,611	74,682
and investment	143,700	287,400	206,400	412,800	619,200
otal investment[1]	187,508	379,693	273,967	530,134	801,762
Per man	187,508	189,846	273,967	265,067	267,254

[1] Total initial investment in land, equipment and livestock.

TABLE 6. ANNUAL LABOR REQUIREMENTS OF LEAST-COST FARM ORGANIZATIONS FOR SPECIFIED PLANT SIZES

Item	Four-row equipment		Six-row equipment		
	One-man	Two-man	One-man	Two-man	Three-man
	Hours				
Operator's labor[1]	2,500	1,883	2,500	2,000	1,600
Regular hired labor	0	2,400	0	2,400	4,800
Supplementary labor	187	466	171	708	1,143
Total	2,687	4,749	2,671	5,108	7,543
Labor requirements per acre	5.6	5.0	3.9	3.7	3.7

[1]Includes time spent in supervising supplementary labor.

Long-Run Average Cost

A comparison of the short-run average total cost curves for the five farm plants analyzed is shown in Figure 6. The long-run average total cost is approximated by a curve fitted tangent to the cost curves for each of the five farm sizes. The lowest portion of this curve indicates over time the size of farm operation that results in the most efficient use of resources.

The least-cost point on this curve occurs on the two-man farm operated with six-row equipment. This represents the size of farm that results in the most efficient use of resources and is the size toward which farming units in the Blackland area should trend given the assumptions and restrictions posed in this analysis.

Costs per unit of production are higher for the three-man farm with six-row equipment than for the two-man farm primarily because of incomplete utilization of the second set of harvesting equipment and higher cost rates for the regular hired labor force. Analysis of a four-man unit was not included in the study because such units are quite rare in the Blacklands area. While some increase in efficiency for four-man units might occur because of more complete utilization of machinery and equipment, this likely would be offset by increased costs resulting from problems of geographic dispersion and supervision. In conclusion, it appears that the long-run average total cost curve would rise slowly for levels of output greater than those included in this study. Net income would still continue to increase with increasing size but at a decreasing proportionate rate because of declining efficiency.

Comparison of Least-Cost Organization with Maximum Net Income

The least-cost points on short-run average cost curves are reached when one or more of the fixed resources are fully utilized. When the fixed machinery and labor resources are fully utilized in the short-run, net returns may still be increased by adding or expanding enterprises which do not require the use of the fixed resources. On the farms considered in this analysis income could be increased by expanding the hog enterprise. As indicated, this is more costly income and causes the short-run cost curves to rise, giving the typical "U"-shaped pattern. Maximum net returns are reached when the marginal returns from the expanded enterprise equal the marginal cost.

Comparison of the maximum net returns with the returns under the minimum cost organization is shown in Table 7 for the five specified plant sizes. Expansion of the hog enterprise requires substantial increases in cost with only nominal increase in returns to management. Substantial increases in cost are involved because a large amount of supplementary hired labor is required. For the one-man farm with four-row equipment, for example, increases of nearly $12,000 in total cost result in additional returns to management of only $77. The cost-income ratio increases from $0.908 for the minimum cost organization to $0.926 for the maximum net income organization. Similar results are indicated for the other plant sizes. The risk and uncertainty associated with the added investment would discourage most farmers

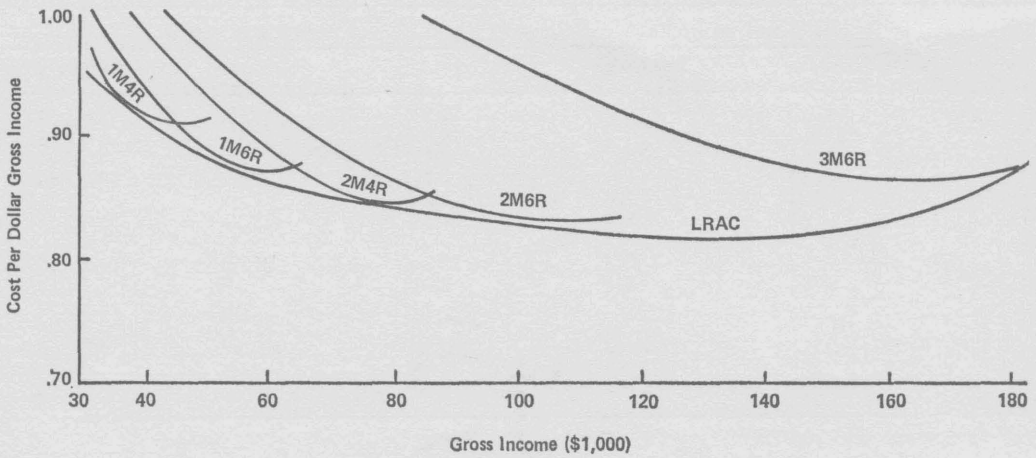

Figure 6. Short-run and long-run average cost curves for one to three regular workers on crop-livestock farms with selected sizes of equipment at various levels of gross income.

ABLE 7. COMPARISON OF LEAST-COST WITH MAXIMUM ET INCOME

Size of plant	Minimum unit cost	Maximum net income
man, 4-row equipment		
Gross income	$ 44,000	$ 56,000
Total cost	39,937	51,860
Returns to management	4,063	4,140
Cost-income ratio	.908	.926
man, 4-row equipment		
Gross income	80,000	94,000
Total cost	67,618	81,274
Returns to management	12,382	12,726
Cost-income ratio	.845	.865
man, 6-row equipment		
Gross income	56,000	72,000
Total cost	48,688	64,585
Returns to management	7,312	7,415
Cost-income ratio	.869	.897
man, 6-row equipment		
Gross income	110,000	128,000
Total cost	90,675	108,559
Returns to management	19,325	19,441
Cost-income ratio	.824	.848
man, 6-row equipment		
Gross income	164,000	182,000
Total cost	141,783	159,667
Returns to management	22,217	22,333
Cost-income ratio	.864	.877

om expanding the hog operation for the returns ealized. Based on the results in this analysis, it ppears that hog enterprises on primarily crop farms n the Blacklands would be most competitive on small arms where labor is underutilized and where oppor- unities do not exist for adding additional cropland. Where additional cropland is available, cropland ould offer economically more attractive alternatives or expansion than hogs.

IMPLICATIONS FOR FARM EXPANSION

Results of this study indicate that a two-man farm with six-row equipment has the greatest potential efficiency of the five plant sizes considered. The number of total acres associated with a least-cost two- man, six-row unit is 1,376 (Table 4). For a least-cost one-man, four-row farm, the total number of acres required is 479, while for a one-man, six-row unit it is 688. A comparison of these acreage requirements with the 1964 size structure of farms in the Blackland area shown in Table 1 indicates that a substantial proportion of farms in the area are below the size required to attain potential efficiencies. More than 86 percent of the farms in the area were below 1,000 acres in size in 1964, while more than 87 percent were below 500 acres. Those farm operators who have units well below least-cost size and do not have non- farm sources of income are likely to find survival increasingly difficult unless they adjust to larger and more efficient units.

This study did not attempt to deal with the *process* of resource adjustment or expansion of farm business sizes. Rather, the objective was to delineate the potentials and goals toward which farm operators need strive if they are to attain the most efficient utilization of resources. Nevertheless, certain impli- cations for growth and growth patterns may be derived from this analysis.

With four-row equipment, a one-man unit re- quires approximately 200 acres to cover all costs and 479 acres to minimize per unit costs. Initial invest- ment requirements in land, equipment and livestock total approximately $102,000 and $188,000, respec- tively, for the 200-acre and 479-acre units. The major portion of the difference in investment requirements between the two size units is in land. No additional investment in equipment is required. While a 200- acre owner-operated unit with 100 percent equity could probably continue to survive under the assump- tions of this analysis, both the pressures and incentives to expand are quite high.

Additional land resources may be acquired by either purchasing or renting. Although this analysis assumed owner-operated units, tenure under optimal share arrangements would have no effect on the size of business unit needed for minimum unit costs. Tenure could, of course, affect the income and invest- ment requirements of the operator, and it could affect the time associated with movement along the long-run planning curve. Since land constitutes the major portion of the total investment requirements, young operators with limited capital usually can obtain the services of the land resources associated with minimum per-unit costs more quickly by renting than by pur- chasing. Studies of farm firm growth have found this to be consistently true.

For farm operations to expand beyond the one- man, four-row farm operation, assuming land is avail- able, there are basically two choices: hire an annual employee and become a two-man, four-row unit or convert to six-row equipment. The major motivation for expanding to a larger size is assumed to be greater management returns and, over time, acquisition of the most efficient plant size. A two-man, four-row farm can increase management returns and lower the cost-income ratio below those of the one-man unit, but the operations with six-row equipment have the greater potential for increasing returns and efficiency.

When capital or other factors restrict operations to less than 500 acres in size, four-row equipment likely would be most advantageous. With acreages of approximately 500 and above, however, this analysis indicates that six-row equipment would be most ad- vantageous. Not only are the potential efficiencies greater, but significantly larger acreages can be han- dled with a given labor force. With the uncertainties and increasing cost of labor, this is a significant factor.

Movement from one size plant to another requires substantial additional investment in equipment and regular labor but need not result in any significant loss in net returns. For example, a least-cost one-man unit with six-row equipment operates a total of 688

acres and has management returns of $7,312 and a cost-income ratio of $0.869. A two-man, six-row unit with approximately the same acreage realizes approximately the same management returns but has a higher cost-income ratio because of underutilized capacity. With no additional investment in regular labor or equipment, considerably greater efficiency and higher management returns can eventually be realized, however, with the two-man unit by adding more land and reducing hog production. Similar relationships are evident for the other plant sizes. In the process of moving from a smaller to a larger size plant, operators might find custom hiring advantageous in some situations; for example, instances in which capital was restricted or limited acreages of additional land were available. Whether custom hiring or the purchase of additional machinery would be the preferable alternative for expansion could be determined by capital budgeting.

LIMITATIONS OF THE ANALYSIS

Numerous assumptions and restrictions were made in analyzing cost economies and resource requirements associated with different plant sizes in this study. Results and implications of the analysis need to be interpreted with these conditions in mind.

Farm expansion may be limited by several factors: (1) Availability of skilled and reliable employees is essential for farms to expand beyond a one-man operation. (2) Land, as well as labor, is necessary to increase farm size. Large farms of contiguous acreages are rare in the Blackland area of Texas. Thus, widely separated tracts of land may have higher production costs than assumed in this analysis. (3) Managers of farm operations may not be equally capable of managing all farm sizes as assumed. Little empirical evidence is available relative to the ability of farm managers to cope with large complex farm business operations. (4) This analysis assumes unlimited capital and does not evaluate alternative methods of acquiring capital. (5) Returns reported in this analysis do not reflect the impact of income and social security taxes. Therefore, they do not reflect proportionate disposable income for various farm sizes. (6) No attempt was made in the analysis to determine the implications of institutional factors for farm expansion.

The implications of risk and uncertainty were not considered specifically in this analysis. Estimated costs, income and production levels were essentially static and did not reflect the effects of variability and uncertainty or of changes in technology over time. However, average production coefficients estimated include some resource and cost adjustments to account for the effects of risk and uncertainty. The farm tenure situation assumed was that of an owner-operator with full equity. All land was valued at a constant price of $300 per acre.

Only internal economies of crop-livestock farms were evaluated. No attempt was made to investigate external economies. Therefore, the results of this study do not include external factors and their implications associated with changes in farm size over an area or region. However, the results can serve as a foundation for further studies on the many economic problems of farm size adjustment.

NEED FOR ADDITIONAL RESEARCH

That agriculture is undergoing rapid, continuous change is widely recognized. A clearer understanding of the processes and implications of the growth and restructuring of farms is urgently needed by policy makers, legislators, farm lenders, businesses serving farms and farm operators themselves. This study provides some useful information on the potential efficiency and profitability of different sizes of farms under the assumptions indicated. However, it leaves many important questions unanswered.

What are the optimal routes of resource accumulation through which a farmer may reasonably expect to shift from a smaller to a larger farm, from a less profitable to a more profitable size of farm business? What resource inputs should be fully owned, purchased with borrowed capital, rented or custom hired, and how might these decisions be affected by changes over time in position on the cost curves? How is the replacement of depreciable capital items best scheduled?

Furthermore, in attempting to better understand the changing structure of agriculture, the factors affecting the growth of individual firms need to be placed in the broader context of the changes going on simultaneously in all farms in the local area and region and in the nation as a whole. The overall quantities of land and farm labor available in a given area are limited, as are the markets for farm products. Changes in the number, size distribution and structural organization of farms occur as farmers compete for these limited resources. The full extent and likely implications of these changes are at present largely unknown.

Finally, the sole criterion for "optimum" in this analysis was efficiency defined in terms of least-cost production. If all farms adjusted to an optimum, the total number of farms in the area would be drastically reduced. Major adjustments would be required, not only in physical resources but also in human resources. A large proportion of the current rural population in the area would need to seek alternative sources of employment and alternative places to live. The implications and social impact of adjustments of the magnitude indicated in this analysis also need to be considered in future research endeavors.

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