CANE SUGAR SUPPLY RESPONSE IN THE UNITED STATES

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ABSTRACT

The major supply response in the domestic cane sugar industry would occur at raw sugar prices between $9.00 and $16.00 per hundredweight. At prices below $9.00, not very much cane sugar production is profitable in the long run. At prices above $16.00, most of the sugarcane production that is technically feasible is profitable. Present production of about 3 million tons of raw sugar could be maintained in the long run at a raw sugar price of approximately $14.00 per hundredweight. Regional production patterns, however, would change at this price. Florida and Texas production would increase, while Hawaiian production would probably decrease. Louisiana production would remain about the same.

KEYWORDS: Supply response, cane sugar, Florida, Louisiana, Texas, Hawaii, United States.

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CONTENTS

SUMMARY

What effect will different raw sugar prices have on returns to the domestic cane sugar industry? What effects will different raw sugar prices have on the quantity of sugar which the domestic cane sugar industry supplies over time--i.e., what will be the long-term domestic supply response?

Results indicate the major supply response in the domestic cane sugar industry would occur at raw sugar prices between $9.00 and $16.00 per cwt. At prices below $9.00, not very much sugarcane production is profitable in the long run. At prices above $16.00, most of the sugarcane production that is technically feasible is profitable and would be expected to occur.

The present production of about 3 million tons of raw sugar could be maintained in the long run at a raw sugar price of approximately $14.00 per cwt. Regional production patterns, however, would be expected to change. Expansion would probably occur in the Florida and Texas sugar industries, and decreases would probably occur in the Hawaiian industry. Louisiana's production probably would not change very much.

Prices for competing enterprises would have the greatest effect on the production of cane sugar when raw sugar prices are between $13.00 and $16.00 per cwt. The effect would be less pronounced at prices above $16.00 and below $13.00. At lower prices, most of the substitution possible from sugar to other crops would have occurred, while at higher prices (those above $16.00 per cwt.), most of the substitution from other crops to sugar would have occurred.

The cost of producing raw sugar differs from region to region in the United States and among raw sugar factories within regions because of differences in labor costs, input requirements, and sugar yields. Most of the domestic cane sugar is produced at a cost of between $11.00 and $15.00 per cwt. of raw sugar.

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by G. A. Zepp
Commodity Economics Division, Economic Research Service

INTRODUCTION

Per capita consumption of sugar in the United States is about 100 pounds annually [10].1/ Two-thirds of this is consumed in the form of manufactured foods such as beverages, baked goods, candies, and ice cream. The remainder is used on the table or in kitchen preparation of foods. Twenty-two percent of total U.S. sugar consumption was from domestically produced sugarcane in 1975 (table 1).

Table 1--Sugar deliveries for the continental United States, by source of supply, 1975

Source of supply	Raw value of sugar 1/
	Million hundredweight
Domestic beet sugar	65.1
Domestic cane sugar	56.2
Imported sugar	77.5
Total	198.7

1/ Raw value is a computed quantity of sugar meaning its equivalent in terms of ordinary commercial raw sugar testing 96 percent pure.
Source: Estimated from [10].

Federal sugar legislation has had an important effect on domestic sugar production in the past. In return for so-called "conditional payments," producers were obligated, among other things, to conform to any limitations on production imposed by the U.S. Secretary of Agriculture. The imposition of production limitations was needed to ensure the proper functioning of a marketing quota system provided for by the Sugar Act of 1948, as amended [5]. The system of production controls tended to make sugar supply response an administrative and/or political decision as well as an economic decision. Some growers who may have wanted to expand sugar production could be restrained by their proportionate share quota. Other producers could continue sugar production

1/ Sugar may be any one of a chemical family of carbohydrates used in the kitchen and in food processing. One member of this family, sucrose ($C_6H_{12}O_6$), is the product popularly called sugar. It is manufactured primarily from sugarcane and sugar beets.

longer than they otherwise might have in order to maintain their proportionate share of the domestic marketing quota and to receive the conditional payment.

U.S. sugar legislation expired on December 31, 1974. Some economic questions which have been raised in sugar policy discussions since the termination of the sugar program are: (1) How much sugar will be produced by the domestic industry under alternative free-market raw sugar prices? and (2) what effects will alternative free-market raw sugar prices have on net returns to the domestic sugar industry?

Past production and price relationships may not be an adequate guide to answering these questions because of the effects which production controls and conditional payments had on production and net returns. The purpose of this study is to estimate the domestic cane sugar supply response and net returns to the domestic cane sugar industry at alternative raw sugar prices under a "no-program" or "free-market" situation.

BACKGROUND

Sugarcane is a perennial grass which grows in warm climates. After one crop has been harvested, a new crop grows from the old roots (ratoons). From two to four ratoon crops, on the average, may be harvested from each original planting. Most operations in U.S. production and harvesting of sugarcane have been mechanized. The major exceptions are planting, and the harvesting operation in Florida, where about 70 percent of the cane crop is cut by hand. But even there the industry is in rapid transition from hand cutting to mechanical harvesting. The proportion of the Florida crop harvested mechanically increased from 2 percent in 1970 to 30 percent in 1975.

Most sugar from cane goes through two stages of processing in its manufacture into refined sugar. In the first stage, performed at a raw sugar factory located in the cane growing area, the juice from the sugarcane stalk is extracted and clarified, boiled, and crystallized to obtain raw sugar.2/ Raw sugar, usually 96 to 98 percent pure, may be refined into pure sugar nearby or shipped in its raw form for final processing at a distant refinery. Blackstrap molasses and bagasse are byproducts of sugarcane milling. Molasses is used mainly for cattle feed, while bagasse, the fibrous residue from grinding, is used principally as fuel in the raw sugar factory. Some bagasse also is used as raw material in the manufacture of building materials and certain chemicals.

Sugarcane growing is often a monoculture type farming with only that one crop being produced. Also, much of the U.S. cane sugar industry is vertically integrated from the growing of sugarcane through processing into raw sugar. Often, raw sugar processors produce their own sugarcane. In other cases, sugarcane growers have formed cooperatives for processing their sugarcane.

2/ The terms raw sugar factory and sugarcane mill are used interchangeably in this report and refer to a unit containing both. The sugarcane mill extracts juice from the sugarcane. The raw sugar factory is involved with producing raw sugar from the cane juice. The two operate in tandem and are usually considered as a whole.

LOCATION OF U.S. SUGARCANE PRODUCTION

Five U.S. areas grow sugarcane (table 2). Hawaii was the leading producer during the 1974-75 season. Texas, the newest area, was the smallest. The Hawaiian sugar industry has been in existence since 1835. Hawaii's first million-ton sugar crop was produced during the 1930-31 season, and production has remained at near the 1-million-ton level during most years since 1930. All the sugarcane in Hawaii is processed by 18 raw sugar factories owned by 5 parent companies. Most of the sugarcane is grown on plantations operated by the same management that operates the raw sugar factories. A small amount of sugarcane (about 5 percent of the total) is grown by independent producers. Hawaii's sugar production is unique among U.S. cane growing areas in that it is the only area where the average age of sugarcane is 2 years or more at the time of harvest. The year-round growing season and favorable climate in Hawaii results in very high yields--an average of 94.8 tons of sugarcane and 10.9 tons of sugar per acre during the 1974-75 season. About half of Hawaii's sugarcane acreage is irrigated. Most of the raw sugar production is shipped to the U.S. mainland for refining. A small amount, used primarily for local consumption, is refined in Hawaii.

Florida's sugar industry was established during the 1920's. Until 1960, there were only 3 raw sugar factories operating in the State, which were

Table 2--Selected characteristics of U.S. sugarcane producing areas, 1974-75 season

Area	Farms	Raw sugar mills	Sugarcane harvested for sugar	Production	
				Sugarcane	Raw value sugar
	--Number--		1,000 acres	------1,000 tons------	
Hawaii	339	18	95.8	9,083	1,041
Florida	134	8	258.3	7,482	793
Louisiana	1,180	37	307.7	6,558	594
Puerto Rico	2,551	11	121.6	3,585	287
Texas	115	1	28.5	898	76
Total		73	811.9	27,606	2,791

Source: [8].

producing less than 150,000 tons of raw sugar. Sugarcane acreage ranged from 12,000 to 45,000 acres during this period. Beginning in 1960, the United States stopped importing Cuban produced sugar, and the Florida industry expanded rapidly to help fill the resulting supply void. Florida's record production was 961,000 tons of raw sugar from the 1972 crop. Most of Florida's sugar production is vertically integrated from production of the sugarcane through processing into raw sugar. In addition to vertically integrated firms which grow and process cane, grower-owned cooperatives produce and process much of Florida's sugar. Only about 9 percent of Florida's crop is produced by independent growers.

Most of the Florida sugarcane production is located on organic soils along the southern shore of Lake Okeechobee in south Florida. In addition to having highly fertile soil, the area has a long growing season and generally mild winters which favor sugarcane production. Expansion in the Florida industry is to sandy soils and organic soils located further from the lake. Yields tend to be lower on these lands, and sugarcane is more likely to suffer loss because of occasional winter freezes.

A problem with which the Florida industry will eventually have to contend is subsidence of the soil. Organic soils oxidize when exposed to the atmosphere. Soil subsidence due to oxidization has been estimated at 1 foot every 10 years in Florida's cane growing region [11]. As the organic soils subside, water control becomes more difficult. Eventually, much of the present sugarcane land may have to revert to pasture or other water-tolerant uses. Increases in sugarcane acreage can occur on remaining organic soils at the present time. However, because of soil subsidence, the sugar industry eventually may have to move much of its cane onto sand soils further from the lake to maintain its present acreage. Most of the raw sugar produced in Florida is refined in Georgia and Louisiana.

Sugar production in Louisiana began in 1794. Since the end of World War II, Louisiana sugarcane production has been characterized by a rapid decline in the number of farms producing cane and an increase in the output of the remaining farms on which the crop is grown. Many of the Louisiana sugarcane growers still operate small-scale farms and are not able to realize the economies of size that cane growers in some areas achieve.

Most sugarcane produced in Louisiana is confined to the Delta area in the southern part of the State, where the soils are quite fertile and the climate is mild. Despite the warm climate, freezing weather occurs every year, giving the area a shorter growing season than other domestic cane producing areas. As a consequence, cane yields per acre and sugar yields per ton of cane are lower.

Both production and harvesting of sugarcane in Louisiana are highly mechanized. However, the sugarcane mills tend to be old, small, and relatively inefficient. Further, because of the short harvest season (75 to 90 days), the raw sugar mills stand idle during a longer period of time than do mills in other areas.

While production in most domestic cane sugar producing areas has increased or remained stable, the Puerto Rican industry has been contracting. It reached a peak in 1952, when 1,372,000 tons of sugar were produced. By 1973, production had declined to 255,000 tons. Recently, there has been some evidence that the Puerto Rican industry may stabilize at near 250,000 to 300,000 tons. The 1974 crop yielded 287,000 tons, and the 1975 crop yielded about 302,000 tons.

The Government of Puerto Rico controls about 80,000 of the 130,000 acres that are harvested annually and operates all 11 active raw sugar mills. The industry is characterized by many small-scale producers. During the 1973-74 season, there were 1,600 farms, or 63 percent of the total, with 10 acres or less of cane [8]. Increasing wage rates, together with increasing industrialization and urbanization, have been credited for the decline from the peak production in 1952.

Most raw sugar produced in Puerto Rico is shipped to the U.S. mainland. Small amounts are used to obtain refined sugar for consumption on the island.

The Texas sugar industry is relatively new, harvesting its first crop in 1973. Currently, the Texas industry consists of one grower-owned raw sugar mill which is supplied with cane grown in the lower Rio Grande Valley. As of this writing, the Texas industry has completed two crops. It is difficult to determine, from this limited experience, the long-term profitability of sugarcane production in Texas. The first 2 years were not representative of longer run expectations. During both years, severe killing freezes were encountered early in the harvesting season, resulting in very low sugar yields and abandonment of some cane. Long-term weather records indicate such occurrences to be unusual in this area. Extremely high sugar prices received for the 1974 crop helped offset the adverse weather effect during that season. Sugarcane researchers, Extension workers, and sugar industry personnel are optimistic that sugarcane will be a profitable crop in the Rio Grande Valley.

METHODOLOGY

Types of Models

Industry supply of raw sugar was estimated by determining the relationship between quantity of production and marginal production costs at the firm level and then summing firm supplies.3/ Two approaches were used in studying supply

3/ Classical economic theory defines the shortrun supply curve of a firm in perfect competition as its marginal cost curve for all rates of output equal to or greater than the rate of output associated with minimum average variable cost. If product price is below the minimum variable cost, the equilibrium quantity supplied is zero [3, p.236]. The industry shortrun supply is defined as "the sum of the quantities supplied by all firms which is determined from the marginal cost curve corresponding to the prevailing set of factor prices" [3, p.238]. If factor prices do not change with changes in industry supply, the industry supply curve can be estimated by summing all individual firm supplies at all prices. Shortrun in the economic sense does not indicate a specific length time period, but rather a planning period short enough such that the amount of at least one production input cannot be varied. The shortrun may encompass several production periods if one of the production inputs, for example, a sugarcane factory, is not completely worn out in a single period and if it has little or no salvage value for alternative uses.

at the firm level. A linear programming analysis was used for the Florida, Louisiana, and Texas regions, while an analysis of costs and returns for individual plantations was used for estimating supply response for Hawaii.

With the linear programming approach, the marginal cost function was estimated using parametric programming as a technique to determine the amount of raw sugar production that would be most profitable at alternative sugar prices.4/ The result was a "step-type" function indicating the most profitable level of sugar production at different raw sugar prices. 5/ Substituting marginal cost for product price in the above function gives a step-type marginal cost curve.6/ All production associated with average variable costs above product prices is excluded from the solution. Hence, the step-type function is in fact the marginal cost curve above average variable cost, and therefore the firm supply curve as defined in classical theory.

Profit-maximizing linear programming models were developed for each of the three mainland cane producing areas. In order to aggregate intraregional production, each region was treated as a single firm in the analysis. All firms (including processing firms) in each region were presumed to combine sugarcane and competing crops so as to maximize individual profits; and that by maximizing individual profits, these firms also maximized regional profits. Each linear programming model contained the resource base and crop enterprise alternatives of all farms in the region rather than those for an individual farm.

In the Hawaiian area, sugarcane is grown under a wide range of conditions--from very flat land to very steep land, from loamy soils to clay and rocky soils, and with and without irrigation. Further, the sugarcane plantations in Hawaii tend to be isolated from one another. In most cases, if a plantation were to cease operation, all of its land is likely to be taken out of production, rather than to continue in sugarcane as part of a remaining plantation. It was decided to use the sugarcane plantation as the marginal unit of adjustment in the Hawaiian area rather than the "marginal acre," as was done for the three mainland areas.

An analysis of costs for individual plantations was used to determine the amount of profitable sugar production at different sugar prices. It involved estimating the long-term variable costs, such as labor, materials, and machinery ownership and operation costs, for each plantation.7/ Long-term variable costs were estimated as total costs less long-term fixed costs. Long-term fixed costs were mainly depreciation on the raw sugar mill, on the irrigation system and on the plantation's own road system, and long-term land rental obligations. It was assumed that a parent company owning a sugarcane plantation would evaluate the profitability of continuing operations on any planta-

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4/ The term marginal refers to additional in economic jargon. Marginal cost refers to the added cost associated with a unit of added production.

5/ An illustration of such a relationship is given in [2, p.139].

6/ This substitution is possible since profit maximization under perfect competition requires that cost of the marginal product be equal to product prices.

7/ Long-term variable costs were those which the parent company could phase out after 5-10 years. Long-term fixed costs were those which the parent company would continue to incur, even after 5-10 years.

tion by comparing its long-term variable costs with the prices it expected to receive for sugar. If the long-term variable costs were above the sugar price, it would be more profitable for the parent company to discontinue operation of the plantation than to continue operating at a loss. On the other hand, if the price of sugar at least covered all of the long-term variable costs, it would be profitable for the parent company to continue operating the plantation at its present (1974-75 season) level. Such a supply response implies a vertical section in the plantation's marginal cost curve (fig. 1).

Marginal costs of producing raw sugar are below average variable costs at levels of output between 0 and q_1. When the plantation's production reaches q_1 there is a jump in marginal costs from 0A to 0C because the locally available land and water suitable for sugarcane production is exhausted. To expand output further, cane would have to be transported from other islands or from distant areas of the same island, which would result in substantially higher production costs. Parent companies faced with such a cost relationship would minimize losses by closing down the plantation if the raw sugar price were lower than 0B. If the raw sugar price were between 0B and 0C, the company would maximize profits by producing output $0q_1$. At prices beyond 0C, the parent company would maximize profits by expanding output beyond q_1. It was assumed that the price 0C was beyond the range of raw sugar prices considered in this study.

Hawaii's supply curve was derived by summing the vertical segments of each plantation's marginal cost curve above average variable cost (BC in fig. 1). This resulted in a step-type supply function with horizontal segments repre-

MARGINAL COST AND AVERAGE VARIABLE COST FOR A HAWAIIAN SUGARCANE PLANTATION

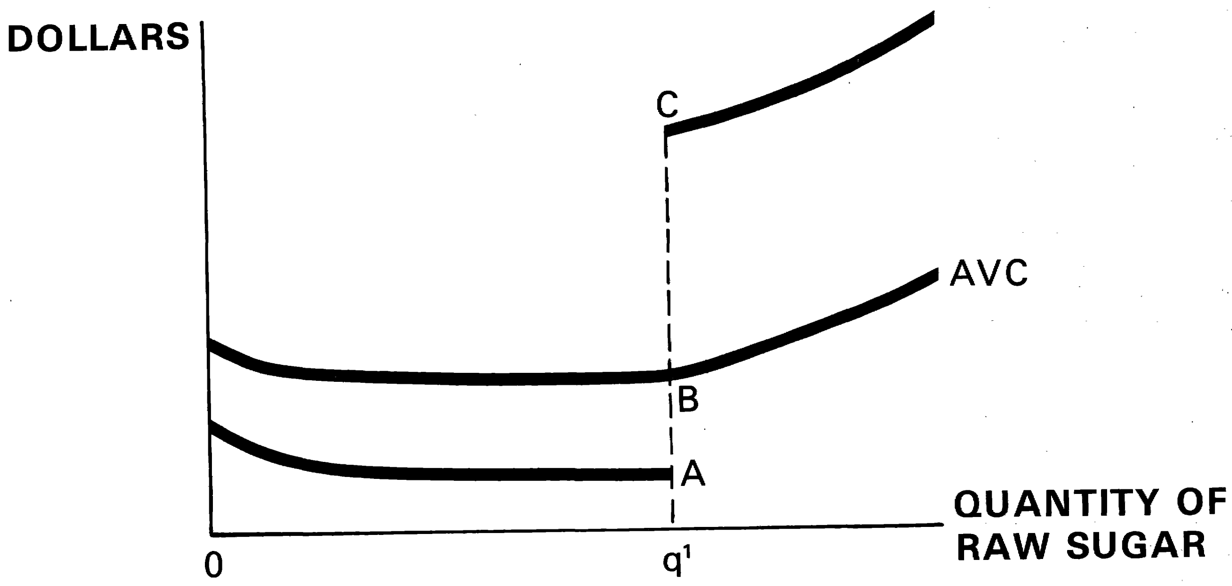


Figure 1

senting full capacity output, Oq_1, for plantations with successively higher average variable costs, OB.

Puerto Rico's supply was treated as a constant 300,000 tons of raw sugar annually in this study. Because of the apparent effort on the part of the Puerto Rican Government to maintain a substantial sugar industry in the country and because of the Government's direct involvement in the present industry, it was assumed that future production would not fall much below present levels. Further, it was assumed that given the industrialization and urbanization in Puerto Rico, no major expansion of the present industry was likely.

Types of Costs

To estimate the effect of different raw sugar prices on returns to the domestic cane sugar industry, total production costs are compared with the net price received for raw sugar in each area. To estimate the effect of different raw sugar prices on the quantity of raw sugar produced domestically after 5-10 years, prices for raw sugar are compared with the marginal cost of producing that sugar.

Total costs in an accounting sense are needed to evaluate the effects of raw sugar prices on returns to the industry. Marginal costs in an economic sense are used to answer the supply response question. The principal difference between the two types of cost estimates is the way in which charges are made against the sugarcane enterprise for the use of fixed resources. In the economic sense, costs for fixed resources are charged at their opportunity cost (that is, the net return they could earn in their next best use other than sugarcane). In the accounting sense, costs for the use of fixed resources are charged at actual value. The annual land useage cost, for example, in the economic sense would be charged at what it earns in its next best use, whereas in the accounting sense it may be charged at actual rental value. Ownership costs on a raw sugar mill may be relatively low in the economic sense if the mill does not have any viable alternative use. The ownership costs in the accounting sense, however, may be quite large because of depreciation and actual interest on a large initial investment.

In this study, economic costs are appropriate for evaluating the firm level decision about the profitable amount of sugar production at different raw sugar prices. Accounting costs are appropriate for purposes of estimating returns to the sugar industry.

DATA

The linear programming models and the data requirements for the three mainland areas are presented in the appendix section to this report. Data were assembled from secondary sources and from discussions with sugarcane growers, processors, and Extension and research personnel familiar with sugarcane production and processing.

The cost analysis for the Hawaiian area was based on costs supplied by the Hawaiian Sugar Planters Association for individual raw sugar mills in that area.

Raw sugar price at the factory was used in the firm level supply analysis. Some common price was needed to sum supply over the several regions. A "New York duty-paid" price per hundredweight (cwt.) of raw sugar was used for this purpose. This New York duty-paid price differed from "at-factory" prices because of differences in transportation costs to the refinery. Adjustments to the New York price needed to arrive at the factory level price are summarized in table 3. Adjustments were needed for costs of transportation from the mill to the refinery, for a price differential between New York prices and prices at points south of Cape Hatteras, and for a discount against mainland sugar for stevedoring allowance.8/

Table 3--Estimated price differential between New York duty-paid raw sugar price and at-factory price

Area	Price difference
	Dollars per cwt.
Florida	1/ 0.65
Louisiana	2/ 0.49
Texas	3/ 0.58
Hawaii	4/ 1.01

1/ Based on an average $0.04 South-Hatteras differential, 15 cents stevedoring discount, and an average transportation cost of 46 cents (75 percent of 35 cents to Savannah and 25 percent of $0.80 to New Orleans).
2/ Based on $0.04 South-Hatteras differential, 30 cents average freight from raw sugar factory to the refinery, and 15 cents stevedoring allowance.
3/ Based on $0.04 South-Hatteras differential, $0.12 stevedoring allowance, plus $0.42 freight from factory to refinery.
4/ Estimated as added transportation cost if raw sugar were shipped to east-coast refineries instead of the C.H. Refinery at Crockett, Calif.

8/ When purchasing offshore sugar, importers are granted a stevedoring allowance by the seller to cover the costs of handling sugar at the port. Usually this allowance is larger than actual unloading costs and the importer realizes a savings in the handling transaction. The stevedoring discount charged against mainland sugar is to compensate the buyer for this savings which he forgoes when he purchases mainland sugar.

RAW SUGAR SUPPLY RESPONSE

The following production estimates are normative in that they indicate the amount of sugar which producers should produce in order to maximize profits, given the assumed costs and prices for competing products. Uncertainty about future prices and costs may cause some growers to produce a different amount of sugar than the quantities which appear most profitable. These estimates are presented to indicate the direction from present production levels which output is likely to move and to provide estimates of the change in sugar production that might occur over 5-10 years at different sugar prices. Profitable amounts of raw sugar production at selected New York duty-paid raw sugar prices from $8.00 to $20.00 per cwt. are presented in table 4 and figure 2.9/

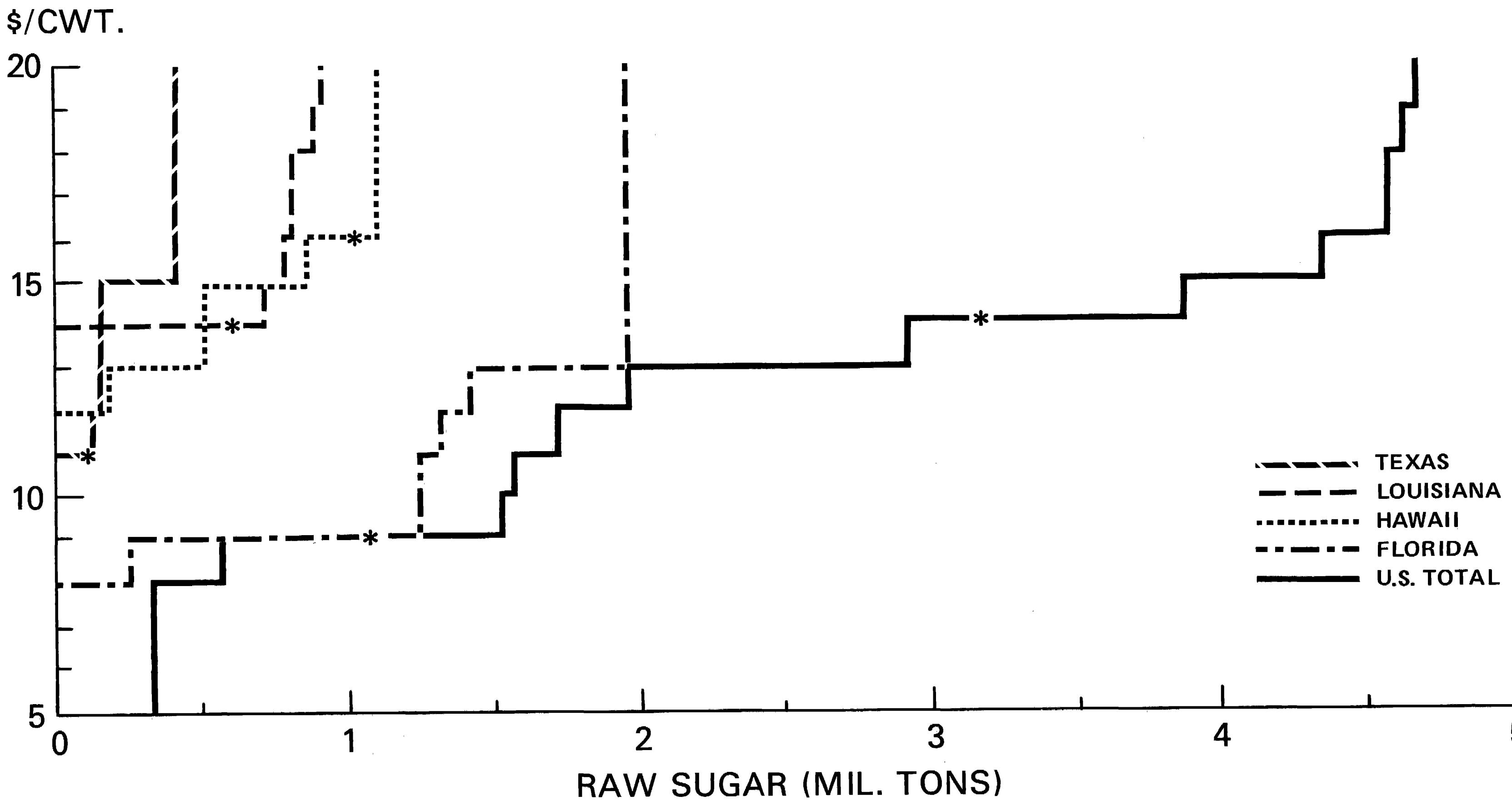
Domestic producers would continue production of 560,000 tons of raw sugar with an $8.00 per cwt. sugar price. However, 300,000 of this total would be Government-supported production in Puerto Rico.10/ The remaining 260,000 tons would be Florida sugar. With the sugar price at $9.00 per cwt., producers in Florida and Puerto Rico would find that their most profitable action would be to continue producing about 1,528,000 tons of raw sugar. Discontinuing sugar production, and, where feasible, switching to alternative crops, would be the most profitable thing for producers in the Louisiana, Texas, and Hawaii areas at all long-term (5- to 10-year period) raw sugar prices below $10.00 per cwt. At sugar prices of $11.00 per cwt., Texas producers would be better off to continue sugar production at its present level of about 120,000 tons than to discontinue production. The lowest price at which all operating costs would be covered in the Hawaiian area over the long run is between $12.00 and $13.00 per cwt. Sugar prices would need to be more than $13.00 per cwt. for production to be profitable in Louisiana in the long run.

9/ The economic model used in this study was specified to estimate supply response in the present production areas. When the price of raw sugar reached $20.00 per cwt., most of the supply response capability in the model was exhausted. If the raw sugar price rose above $20.00 for a long period of time, undoubtedly resources in addition to those in the present production areas would be used in sugarcane production, resulting in supply response beyond that estimated in this study. Therefore, the raw sugar price range considered relevant in this report is limited to those prices of $20.00 per cwt. and lower.

10/ Puerto Rican production was assumed constant at 300,000 tons regardless of the raw sugar price. Currently, the Puerto Rican Government operates all of the active raw sugar mills on the island, and it was hypothesized that the Government would continue to operate these mills to promote the social goals of providing job opportunities for its citizens, even at very low sugar prices.

ESTIMATED LONGRUN DOMESTIC CANE SUGAR PRODUCTION (SUPPLY) AT SELECTED FREE-MARKET RAW SUGAR PRICES°

By Areas and U.S. Total



DATA BASED ON 1975 PRICES. ** INDICATES 1975 PRODUCTION.* *° NEW YORK DUTY PAID.*

Figure 2

Table 4--Estimated longrun raw sugar production, by U.S. producing areas and Puerto Rico at alternative raw sugar prices with typical prices for competing crops (based on 1975 prices and cost levels)1/

Raw sugar price, N.Y. duty-paid basis	Florida	Louisiana	Texas	Hawaii	Puerto Rico	Total domestic
$/cwt.	1,000 tons					
7	0	0	0	0	300	300
8	260	0	0	0	300	560
9	1,228	0	0	0	300	1,528
10	1,237	0	0	0	300	1,537
11	1,294	0	120	0	300	1,714
12	1,388	0	120	145	300	1,953
13	1,969	0	151	486	300	2,906
14	1,969	718	151	707	300	3,845
15	1,969	777	399	862	300	4,307
16	1,969	777	399	1,080	300	4,525
17	1,969	801	399	1,080	300	4,549
18	1,969	801	399	1,080	300	4,549
19	1,969	873	399	1,080	300	4,621
20	1,969	895	399	1,080	300	4,643

1/ Estimates are of the amount of sugar which would be produced after 5 to 10 years if the sugar price and all other prices were constant over that period.

All of the supply response capability for the Florida area in the economic model was exhausted at raw sugar prices above $13.00 per cwt.11/ For the Texas area, supply response was limited to prices below $15.00 per cwt., while for Hawaii it was limited to prices below $16.00.

Evaluating Price Floors

These production estimates can be used to determine the long-term price floors necessary to cause domestic producers to produce a specified amount of sugar. Suppose it were considered a desirable national goal to maintain domestic sugar production at or near present levels. What long-term price floor would be needed to maintain this production level?

Production levels for each region and the United States as a whole in 1975 are indicated by asterisks on the respective supply curves in figure 2.12/ For example, total U.S. production during 1975 was an estimated 3,140,000 tons of raw sugar. The long-term price floor needed to maintain domestic production at or near this level into the future would be between $14.00 and $15.00 per cwt. for raw sugar.13/

Although the $14.00-$15.00 price would most likely stabilize domestic production at current levels, regional production would be expected to change. Expansion would probably occur in the Florida industry. Florida's sugar industry would maximize profits by expanding production to almost 1,970,000 tons of raw sugar at a long-term price of $14.00 per cwt. Processing this amount of sugar would require expansion of present milling capacity, and a substantial amount of sugarcane would be grown on sand soils.

Texas' production also would increase if a raw sugar price floor were between $14.00 and $15.00 per cwt. Expansion in the Texas industry would probably be limited to small acreage increases, and expansion of milling capacity would be limited to modifications of the present mill to handle small additional amounts of cane. The Hawaiian industry probably would experience some contraction in production at a long-run price floor of $14.00 per cwt. as some higher cost plantations would be operating at a long-term loss. With a sugar

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11/ Any linear programming supply response model has some "absolute" restraints which eventually place an upper limit on production. The absolute restraints in this model were land suitable for sugarcane production. Land restraints were estimated to reflect the amount of land which seemed likely to go into sugarcane production at high raw sugar prices in each area. In some cases, this was a physical upper limit on the amount of land suitable for growing sugarcane. In other cases, it was a subjective upper limit reflecting the upper bound on sugarcane acreage given the existing political and institutional environment.

12/ Asterisks on figure 2 indicate 1975 production levels, but not the prices received during 1975.

13/ Determined by locating the 1975 U.S. production level on the long-run supply curve (fig. 2) and determining the price from the vertical axis which would generate that amount of output.

price floor of $14.00 per cwt., total Louisiana production may not change very much. However, there may be some shifting in production from the Northern and Western fringes of the present region to the "main area."

Raw Sugar Production Response to Change in Price of Competing Enterprises

For Florida, Louisiana, and Texas, the analysis examined the relationship between price changes in commodities which compete directly with sugarcane for use of available cropland and the most profitable amount of raw sugar production. Production in the Puerto Rican and Hawaiian areas was assumed not to be affected very much by changes in price of competing crops--in Puerto Rico because of the apparent Government effort to support a substantial sugar industry, and in Hawaii because most of the sugarcane acreage does not have a very viable competing crop enterprise. The net returns which an alternative crop enterprise earns is the opportunity cost to sugarcane producers for the use of land, and was the cost charged against sugarcane for the use of cropland. However, net returns from competing crops change as the prices received for those crops change. In turn, the charge against sugarcane for the use of land changes, and the profitability of sugar production changes. Hence, the amount of sugar production which is profitable is directly related to the price levels for competing crops.

Linear programming was used to determine profitable adjustments for cane sugar producers when assuming two different sets of prices for crop enterprises competing with sugarcane. One set represented prices higher than those assumed to be representative of long-term prices in the above supply analysis. The second set represented lower prices.

In the Florida sugarcane area, the principal competing use for cropland is pasture for grazing beef cattle. Some cropland is substituted between sugarcane and fresh winter vegetable production, but the amount of this substitution is small. Only the beef cattle prices were changed for the Florida area. Typical long-term prices were assumed at $30.00 per cwt. for 400- to 450-pound calves. Feeder cattle prices were reduced to $20.00 per cwt. for the low price assumption and raised to $40.00 per cwt. for the high price assumption.

Cotton and soybeans are the major alternatives to sugarcane in the Louisiana area. The typical price assumptions were $5.50 per bushel for soybeans, 50 cents per pound for cotton lint, and 6 cents per pound for cottonseed. For the "low price" analysis, soybeans were set at $4.50 per bushel, cotton lint at 40 cents per pound, and cottonseed at 5 cents per pound. The high price assumptions in the Louisiana area were $7.00 per bushel for soybeans, 70 cents per pound for cotton lint, and 8 cents per pound for cottonseed.

Cotton and sorghum are the major crop enterprises competing with sugarcane for cropland in the Texas area. Typical prices assumed for the Texas area analysis were $5.50 per cwt. for sorghum, 50 cents per pound for cotton lint, and 6 cents per pound for cottonseed. The "high price" assumptions were $7.70 per cwt. for sorghum, 70 cents per pound for cotton lint, and 8 cents per pound for cottonseed, while the "low price" assumptions were $4.40 per cwt. for sorghum, 40 cents per pound for cotton lint, and 5 cents per pound for cottonseed.

Estimated longrun production of cane sugar with the "typical," "high," and "low" prices are presented in table 5 and figure 3. Prices for competing crop enterprises have a major effect on the production of cane sugar when raw sugar prices are between $13.00 and $16.00 per cwt. The effect is less pronounced at lower sugar prices as well as at higher sugar prices. At lower prices, most of the substitution from sugar to other crops which can occur has already taken place, while at the higher prices (above $16.00 per cwt.) most of the substitution from other crops to sugar which can occur has already been made.

When the sugar price was $13.00 per cwt., longrun raw sugar production with the typical prices would be an estimated 2,906,000 tons. With the "high price" assumptions, the estimated production would be only 2,322,000 tons, while with the "low price" assumptions, the estimated longrun production would be 3,624,000 tons.

EFFECTS OF RAW SUGAR PRICE ON RETURNS TO THE INDUSTRY

The cost of producing raw sugar differs from region to region in the United States and among raw sugar factories within regions because of differences in labor costs, input requirements, sugarcane production per acre, sugar yields per ton of cane, and other factors. Raw sugar costs are summarized for the different regions in table 6.14/

The estimated State average cost for producing raw sugar in Florida during 1975 was $10.51 per cwt. at the factory, or $11.16 delivered to the refinery. Costs were estimated separately for three different soil classes in Florida: Muck soils, peat soils, and sandy soils. Average cost for raw sugar produced from muck land cane was $10.06 per cwt. at the raw sugar factory--$10.71 delivered to the refinery. Muck soils consisted mainly of the custard apple series located adjacent to Lake Okeechobee. The muck soils have some mineral content and are usually located in "warm areas" around the lake. Cane production usually is higher on muck soil than on the other two classes.

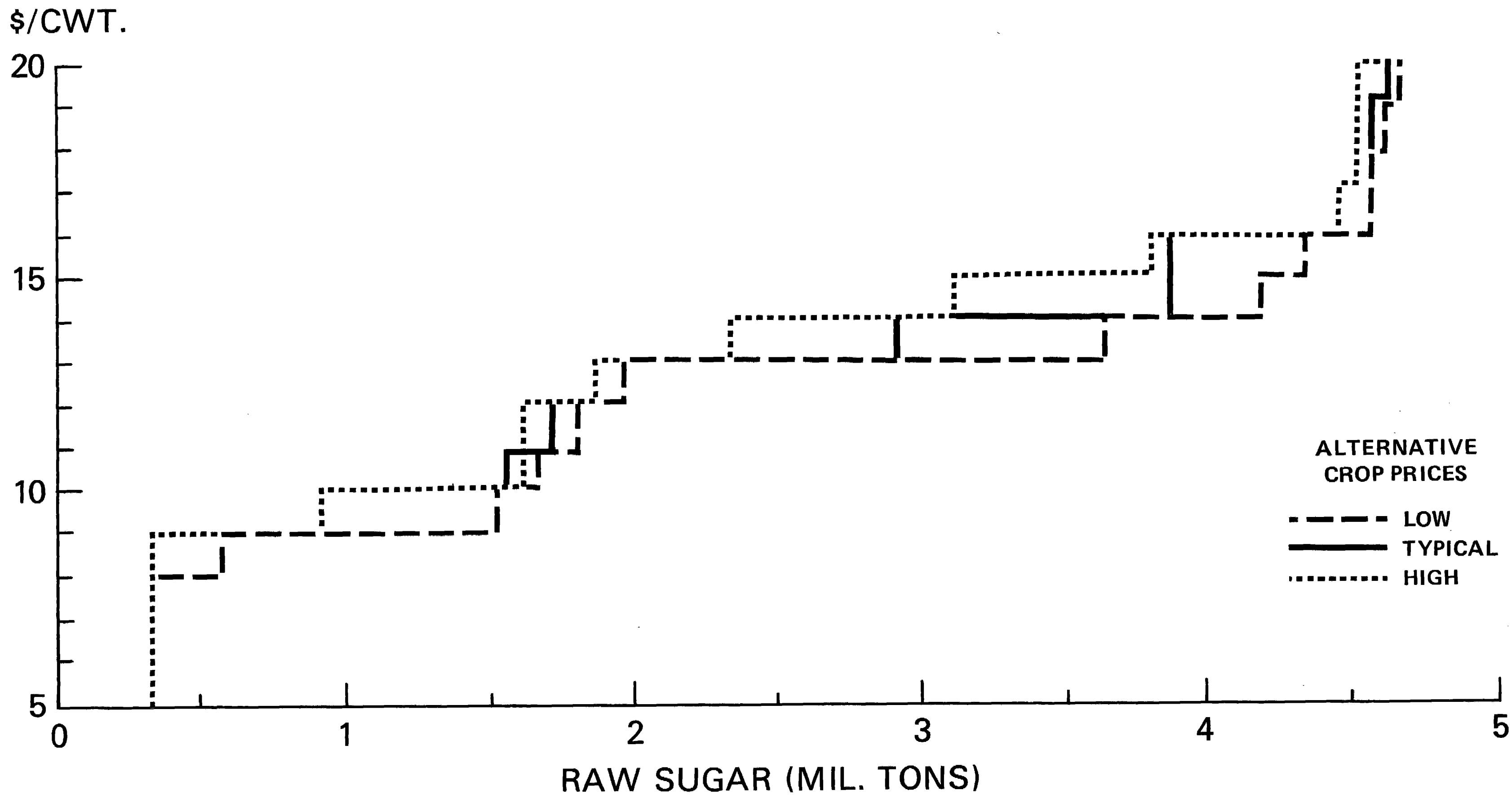
Estimated cost was $10.67 per cwt. of raw sugar from peat soils. Peat soils also are organic and tend to have a lower mineral content than the muck soil. Decomposed sawgrass is the predominate plant material in the peat soils. The peat soils tend to be further from the lake and to be in colder areas than muck soil. Peat soils account for the largest proportion of the Florida sugar production.

Estimated costs for raw sugar produced from cane grown on sandy soils was $10.51 per cwt. Sand soils account for a small proportion of the total Florida raw sugar production. One of the major differences in costs between the sandy soils and the organic soils is in fertilizer cost. Continuing decomposition of organic matter in the organic soils releases adequate nitrogen for sugarcane production, hence no nitrogen fertilizer is needed. However, large amounts of nitrogen fertilizer must be supplied for growing sugarcane on sandy soils, thereby increasing application costs as well as fertilizer material costs.

14/ Includes all costs from growing through processing.

ESTIMATED LONGRUN U.S. CANE SUGAR PRODUCTION (SUPPLY) AT SELECTED FREE-MARKET RAW SUGAR PRICES°

With Three Levels of Prices for Alternative Crops



DATA BASED ON 1975 PRICES. *° NEW YORK DUTY PAID.*

Figure 3

Table 5--Estimated longrun U.S. cane sugar production, by selected free-market raw sugar prices at three price levels for competing crops 1/

Raw sugar price, N.Y. duty-paid basis	Florida			Louisiana			Texas			Puerto Rico & Hawaii	United States		
	Low	Typical	High	Low	Typical	High	Low	Typical	High		Low	Typical	High
($/cwt)	1,000 tons raw sugar												
7	0	0	0	0	0	0	0	0	0	300	300	300	300
8	260	260	0	0	0	0	0	0	0	300	560	560	300
9	1,228	1,228	559	0	0	0	0	0	0	300	1,528	1,528	899
10	1,230	1,237	1,293	0	0	0	120	0	0	300	1,650	1,537	1,593
11	1,368	1,294	1,293	0	0	0	120	120	0	300	1,788	1,714	1,593
12	1,368	1,388	1,416	0	0	0	151	120	0	445	1,964	1,953	1,861
13	1,969	1,969	1,416	718	0	0	151	151	120	786	3,624	2,906	2,322
14	1,969	1,969	1,969	801	718	0	399	151	120	1,007	4,176	3,845	3,096
15	1,969	1,969	1,969	801	777	511	399	399	151	1,162	4,331	4,307	3,793
16	1,969	1,969	1,969	801	777	718	399	399	399	1,380	4,549	4,525	4,466
17	1,969	1,969	1,969	801	801	718	399	399	399	1,380	4,549	4,549	4,466
18	1,969	1,969	1,969	861	801	733	399	399	399	1,380	4,609	4,549	4,481
19	1,969	1,969	1,969	900	873	733	399	399	399	1,380	4,648	4,621	4,481
20	1,969	1,969	1,969	902	895	849	399	399	399	1,380	4,650	4,643	4,597

1/ Based on 1975 costs.

Table 6--Estimated average cost for producing and processing raw sugar in four U.S. production areas, 1975

Area and resource situation	Estimated production of raw sugar	Total costs	
		At the raw sugar factory	Delievered to refinery 1/
	1,000 tons	Dollars per hundredweight	
Florida:			
Muck soil	274.0	10.06	10.71
Peat soil	702.0	10.67	11.32
Sand soil	77.0	10.77	11.42
State total	1,053.0	10.51	11.16
Louisiana:			
Main area			
Sandy soil	358.8	13.71	14.20
Clay soil	191.0	14.31	14.80
Northern Mississippi Delta			
Sandy soil	32.6	13.90	14.39
Clay soil	11.4	14.55	15.04
Red River Delta			
Sandy soil	13.9	14.25	14.74
Clay soil	3.6	14.83	15.32
Western Fringe			
Sandy soil	26.6	14.82	15.31
Clay soil	1.4	15.43	15.92
State total	639.3	14.01	14.50
Texas:			
State total	119.7	10.34	10.92
Hawaii:			
Top third	367.9	11.06	12.07
Middle third	304.4	12.09	13.10
Lower third	355.9	14.20	15.21
State total	1,028.2	12.45	13.46

1/ Equals the "at-factory" cost plus the estimated price differential between the N.Y. duty-paid price and prices of raw sugar at the mill/factory.

Sugar yield per acre tends to be about the same on the sandy soils as on the peat soils, but lower than on the muck soil. Although sandy soil production accounts for a small proportion of Florida's present raw sugar production, it could become more important as there is a large amount of sandland in south Florida which eventually could be developed for sugarcane production.

The State average cost of producing raw sugar in Louisiana during 1975 was $14.01 per cwt. at the raw sugar factory. Costs were estimated separately for four regions within the State and for two soil types (sandy and clay) within each region. The major producing region (called the "main area"), accounting for nearly 85 percent of the Louisiana sugar production, had estimated "at-factory" costs of $13.71 and $14.31 per cwt. on sandy and clay soils, respectively. Highest costs were in the "Western fringe," where at-factory costs per cwt. of raw sugar were $14.82 and $15.43 on sandy and clay soils, respectively.

The estimated average 1975 production cost for the Texas area was $10.34 per cwt. of raw sugar at the mill--$10.92 delivered to the refinery. Texas production is relatively small and is processed by one mill, hence no further breakdown of costs was made beyond the area average.

For Hawaii, the estimated average 1975 production costs were $12.45 per cwt. of raw sugar delivered to the C. & H. Refinery in California. However, costs varied among plantations. Estimated production costs for sugar from plantations with the lowest costs were $11.06 per cwt. For sugar from high-cost plantations, the estimated costs were $14.20 per cwt.

To illustrate the effects different raw sugar prices would have had on the sugar industry during the 1975 season, selected prices were compared with 1975 costs for each area and soil type (from table 6) to determine whether there was a net profit or loss on sugar produced in an area. Net profits or losses per ton of raw sugar were multiplied by the estimated 1975 tonnage produced in the area to determine net profits and losses to the industry (table 7). Sugar produced at a profit was kept separate from that which would be produced at a loss. Generally, different producers would be producing the sugar having a net profit than those producing at a net loss.

If the 1975 season raw sugar price had been $11.00 per cwt., production costs would have been greater than price for an estimated 2,446,500 tons of sugar. Net losses to the industry on this sugar would have been about $100,156,000. An estimated 393,700 tons of raw sugar would have had all production costs covered at an $11.00 price. Total net returns to the lowest cost producers on this production would have been an estimated $1,780,700. Industry losses would have been $98,375,600.

If the 1975 price was $13.00 per cwt., 1,540,600 tons of sugar would have been produced at a net profit of $50,392,000, and 1,299,600 tons would have been produced at a net loss of $35,159,600. Net industry profits would have been $15,232,500.

Table 7--Estimated effects of selected raw sugar prices on the domestic cane sugar industry

Raw sugar price, N.Y. duty-paid	Estimated production with total costs less 1/ than N.Y. price		Estimated production with total costs greater 1/ than N.Y. price		Net industry profits or losses
	Production	Net profits	Production	Net losses	
($/cwt.)	1,000 tons	1,000 dollars	1,000 tons	1,000 dollars	1,000 dollars
11	393.7	1,780.7	2,446.5	100,156.3	- 98,375.6
12	1,172.7	20,095.1	1,667.5	61,666.7	- 41,571.6
13	1,540.6	50,392.1	1,299.6	35,159.6	15,232.5
14	1,845.0	86,683.3	995.2	14,646.8	72,036.5
15	2,441.3	130,558.1	398.9	1,717.6	128,840.5

1/ Production costs taken from table 6. Based on costs per cwt. delivered to the refinery. Puerto Rican production and net returns and losses to its production are not included in this table.

APPENDIX

Three separate linear programming models were developed--one for each of the mainland areas. The following is a description of these linear programming models.

Louisiana

The Louisiana linear programming model consisted of three types of resource constraints. They were land constraints, sugarcane grinding capacity constraints, and constraints on the amount of additional grinding capacity that could be added to present mills. Production activities were included for sugarcane, cotton, and soybeans. The constraints (or rows) for the Louisiana linear programming model are listed in appendix table 1 and the activities in appendix table 2.

Appendix table 1--Constraints included in the Louisiana linear programming model

Constraint or row	Unit	Level
Main area sandy soil	acre	329,134
Main area clay soil	acre	195,866
Northern Mississippi Delta sandy soil	acre	35,870
Northern Mississippi Delta clay soil	acre	14,130
Red River Delta sandy soil	acre	57,353
Red River Delta clay soil	acre	17,647
Western fringe sandy soil	acre	28,125
Western fringe clay soil	acre	1,875
Main area woodland	acre	13,900
Northern Mississippi Delta woodland	acre	6,600
Red River Delta woodland	acre	5,800
Western fringe woodland	acre	6,300
Main area grinding capacity	ton	8,206,320
Northern Mississippi delta grinding capacity	ton	591,120
Red River Delta grinding capacity	ton	202,080
Western fringe grinding capacity	ton	172,800
Add Main area grinding capacity	ton	820,632
Add Northern Mississippi Delta grinding capacity	ton	59,112
Add Red River Delta grinding capacity	ton	20,208
Add Western fringe grinding capacity	ton	17,280
Raw sugar production summation	cwt.	---
Molasses production summation	gal.	---
Soybean production summation	bu.	---
Cotton lint production summation	lb.	---
Cottonseed production summation	lb.	---

Appendix table 2--Activities contained in the Louisiana linear programming model

Activity or column
Sugarcane on main area sandy soil
Sugarcane on main area clay soil
Soybeans on main area sandy soil
Soybeans on main area clay soil
Sugarcane on northern Mississippi Delta sandy soil
Sugarcane on northern Mississippi Delta clay soil
Soybeans on northern Mississippi Delta sandy soil
Soybeans on northern Mississippi Delta clay soil
Cotton on northern Mississippi Delta sandy soil
Cotton on northern Mississippi Delta clay soil
Sugarcane on Red River Delta sandy soil
Sugarcane on Red River Delta clay soil
Soybeans on Red River Delta sandy soil
Soybeans on Red River Delta clay soil
Cotton on Red River Delta sandy soil
Cotton on Red River Delta clay soil
Sugarcane on western fringe sandy soil
Sugarcane on western fringe clay soil
Soybeans on western fringe sandy soil
Soybeans on western fringe clay soil
Cotton on western fringe sandy soil
Clear main area woodland
Clear northern Mississippi Delta woodland
Clear Red River Delta woodland
Clear western fringe woodland
Add to existing main area grinding capacity
Add to existing Red River Delta grinding capacity
Add to existing northern Mississippi Delta grinding capacity
Add to existing western fringe grinding capacity
Build new main area grinding capacity
Build new northern Mississippi Delta grinding capacity
Build new Red River Delta grinding capacity
Build new western fringe grinding capacity
Sell raw sugar production
Sell molasses production
Sell soybean production
Sell cotton lint production
Sell cottonseed production

Constraints

The Louisiana area was divided into four geographic regions with three soil classes in each region. The four regions were: (1) "Main area," consisting of the lower Mississippi Delta, Bayou Lafourche, and Bayou Teche areas; (2) "Northern Mississippi Delta," consisting of Point Coupe and West Baton Rouge Parrishes; (3) "Red River Delta," containing Avoylles, Rapides, and Saint Landry Parrishes; and (4) "Western fringe," containing parts of Lafayette and Vermilion Parrishes. The three soil classes were: (1) "Sandy cropland," (2) "clay cropland," and (3) "clay woodlands." The third could be cleared and planted to sugarcane. The sandy soil class included both sand and loam soils. Clay soils were those with poor internal drainage. Sandy soils are superior to clay soils for sugarcane production. Land constraints represented the amounts of acreage suitable and potentially available for sugarcane production. Acreage estimates were based on reported acres of cropland in each area and on subjective estimates of various persons, who work with the Louisiana sugar industry, about the amount of the potentially available land suitable for sugarcane production.

"Existing grinding capacity" was the second type of constraint. It was based on the amounts of sugarcane ground by each mill in each of the four regions during the 1969 crop harvest. The 1969 crop was chosen because the daily grind during that season was high and represented a practical upper limit on daily grinding capacity. Seasonal grinding capacity was estimated by multiplying estimated daily capacity for each area times 80 days.

Another constraint was an upper limit on the amount of "additional grinding capacity" that could be obtained by expanding the present sugarcane mills. This was estimated at 10 percent of the present grinding capacity. Expansion by more than 10 percent would need to be in the form of a new sugarcane mill.

Other constraints in the linear programming model were transfer rows used for moving production from the various production activities to the product sale activities.

Activities

Five types of activities were included in the linear programming model: Cropland activities, land clearing activities, addition-to-present grinding capacity activities, construction of new grinding capacity activities, and product sale activities. Each acre of sugarcane harvested for sugar required 1.41 acres of cropland. Fallow land and land planted to seed cane accounted for the additional .41 acre. Sugarcane grinding capacity had to be available within an area for all cane grown in that area. Raw sugar yield was estimated at 165 pounds per ton of sugarcane in the Red River Delta area and 175 pounds per ton of sugarcane in the other three areas. Sugarcane yields were based on a 26-ton-per-acre statewide average. Regional differences were based on historical differences among counties in the four regions. Yields for soybeans and cotton in the several regions were based on [1] (app. table 3).

Appendix table 3--Estimated yields and production costs per acre of selected crops in the Louisiana sugarcane area 1/

Area	Sandy soil		Clay soil	
	Cost per acre	Yield per acre	Cost per acre	Yield per acre
	Dollars		Dollars	
Main Area				
Soybeans	53.41	23 bu.	58.95	23 bu.
Sugarcane	2/	25 gross tons 162 gal. molasses		22 gross tons 144 gal. molasses
Northern Mississippi Delta				
Soybeans	53.41	22 bu.	58.95	23 bu.
Cotton	260.62	730#lint; 1146#seed	255.86	550#lint; 864#seed
Sugarcane	2/	24 gross tons 156 gal. molasses		21 gross tons 138 gal. molasses
Red River Delta				
Soybeans	53.41	22 bu.	58.95	23 bu.
Cotton	260.62	730#lint; 1146#seed	255.86	550#lint; 864#seed
Sugarcane	2/	26 gross tons 168 gal. molasses		23 gross tons 150 gal. molasses
Western Fringe				
Soybeans	65.11	24 bu.	75.36	29.4 bu.
Cotton	299.27	550#lint; 864#seed	-----	-------
Sugarcane	2/	20 gross tons 126 gal. molasses		18 gross tons 114 gal. molasses

1/ Cotton and soybean estimates based on [1]. Sugarcane yield estimates based on a 26-ton State average. Regional differences were based on historical differences among counties in the four regions.

2/ See appendix table 5.

Costs for producing cotton and soybeans also were taken from [1]. Land clearing costs were based on information collected by the area agricultural Extension director for the region in which the largest amount of land clearing was presently occurring. Total land clearing costs were amortized over 10 years at 8.5 percent interest to arrive at annual costs. Construction costs for building a new raw sugar factory and for adding additional capacity to present factories were based on discussions with a management consultant firm specializing in sugar management problems. Costs for adding grinding capacity to present mills were estimated at $3,500 per ton of daily capacity. The total construction costs were amortized at 8.5 percent interest over 7 years, giving an annual cost of $8.55 per ton of seasonal grinding capacity. Costs for building a new factory were estimated at $6,000 per ton of daily grinding capacity. This cost, too, was amortized at 8.5 percent interest over 7 years for an annual cost of $14.65 per ton of seasonal grinding capacity. Both of these estimates were exclusive of the costs for harvesting and hauling equipment.15/

One budget was developed to represent sugarcane growing costs for all four areas (app. table 4). Input prices were based on those prevailing during 1975

Appendix table 4--Estimated costs for growing, harvesting, and hauling sugarcane in Louisiana, 1975 1/

Item	Cost per acre	Cost per ton 2/
	Dollars	
Preharvest:		
Variable costs		
Fertilizer	28.17	1.18
Pesticides	26.30	1.11
Labor	48.98	2.06
Custom services	8.58	.36
Equipment operation	27.21	1.14
Interest on operating capital	5.70	.24
Other	.30	.01
Equipment ownership costs	22.77	.96
Total preharvest	168.01	7.06
Harvesting and hauling:		
Variable costs		
Labor	32.98	1.39
Equipment operation	40.18	1.69
Interest on operating costs	.70	.03
Equipment ownership costs	38.65	1.62
Total harvesting and hauling	112.51	4.73
Total all costs	280.52	11.79

1/ Based on Firm Enterprise Data System Budget number 754, [9].
2/ Based on average production of 23.8 tons per acre.

15/ In Florida and Texas, harvesting and hauling were treated as being performed by the sugarcane mill and were budgeted at the mill level. Harvesting and hauling in Louisiana, however, were treated as being performed by the grower and were budgeted at the grower level. Since harvesting and hauling equipment were treated as grower-owned equipment in Louisiana, its ownership costs were not included in the costs for expanding grinding capacity. In Florida and Texas, these costs were assumed to be part of the investment package associated with expanding grinding capacity.

in Louisiana. Production practices were selected to be typical of sugarcane production in Louisiana and may include some practices not followed by some cane farmers as well as omitting some practices followed by others. Where appropriate, harvesting costs were adjusted to reflect differences due to effects of sugarcane yields on harvesting and hauling (app. table 5).

Appendix table 5--Summary of estimated costs for growing, harvesting, hauling, and processing sugarcane in Louisiana, 1975

Region and soil type	Tons cane per acre	Type of cost			
		Growing 1/	Harvesting & hauling 2/	Processing 3/	Total
		Dollars per acre			
Main area:					
Sandy soil	25	168.01	118.25	204.25	490.51
Clay soil	22	168.01	104.06	179.74	451.81
Northern Mississippi Delta:					
Sandy soil	24	168.01	113.52	196.08	477.61
Clay soil	21	168.01	99.33	171.57	438.91
Red River Valley:					
Sandy soil	26	168.01	122.98	212.42	503.41
Clay soil	23	168.01	108.79	187.91	464.71
Western Fringe:					
Sandy soil	20	168.01	94.60	163.40	426.01
Clay soil	18	168.01	85.14	147.06	400.21

1/ From app. table 4.
2/ Harvesting and hauling cost per ton from text table 4 times tons cane per acre.
3/ $8.17 per ton of cane based on unpublished USDA estimates projected from data in [7]. This processing cost includes only the long-term variable costs. It does not include depreciation on the sugarcane mill.

Milling costs were based on data obtained from the Sugar Division of the U.S. Agricultural Stabilization and Conservation Service. Estimated 1975 costs were based on 1974 cost projections made by the sugar division and were increased 10 percent to reflect projected 1975 price levels. Milling and processing costs included cash expenses for mill operation, marketing of raw sugar, and administrative overhead. The raw sugar factory was assumed to have no profitable alternative use and no salvage value; hence, fixed costs, such as interest on mill investment and mill depreciation, were not charged against the raw sugar enterprise.

Florida

Florida's linear programming model consisted of eight land equations, a constraint to limit the amount of sugarcane land that could be switched to vegetables, a grinding capacity constraint, a constraint on the amount of expansion to existing mills, and two production summation rows (app. table 6). Separate constraints were included for land presently in cane and land in pasture. In general, it was assumed that producers would need to further develop the pasture land before planting sugarcane. Some undeveloped peat land and sand land were considered suitable for sugarcane if the land were cleared and drained. Two constraints limiting the amount of such land were included in the Florida model.

Appendix table 6--Constraints included in the Florida linear programming model

Constraint or row	Unit	Level
Muck land presently in cane	acre	90,000
Peat land presently in cane	acre	292,000
Sand land presently in cane	acre	32,000
Muck land in pasture	acre	0
Peat land in pasture	acre	101,000
Sand land in pasture	acre	100,000
Undeveloped peat land	acre	69,000
Undeveloped sand land	acre	100,000
Maximum transfer of muckland from sugarcane to vegetable	acre	5,000
Sugarcane grinding capacity	ton	12,600,000
Maximum expansion of present grinding capacity	ton	1,260,000
Raw sugar production summation	cwt.	--
Molasses production summation	gal.	--

A constraint on the maximum amount of land that could be switched from sugarcane to vegetables was included to prevent large changes in land use from sugarcane to vegetable production at low sugar prices. It was assumed that large changes in land use from sugarcane to vegetables would have a price depressing effect on vegetables, reducing their net returns below the level estimated for this analysis. This constraint permitted some transfer of land to vegetables on the basis of net returns from use for vegetables, but after a point the opportunity cost of land to the sugarcane enterprise would be the net returns from using land for beef production on pasture.

Existing sugarcane grinding capacity for the Florida model was estimated at 12,600,000 tons. Adding grinding capacity by expanding present mills was permitted up to 10 percent beyond present capacity. Expansion beyond this 10 percent required construction of new mills at a higher cost per ton of grinding capacity. Other constraints in the model were product summation rows for tieing production activities to product sale activities.

Nineteen activities were included in the Florida linear programming model (app. table 7). One sugarcane production activity was included for each of the three soil types. Yields and costs for sugarcane production in Florida are summarized in appendix tables 8 and 9. Molasses production was based on 6 gallons per ton of sugarcane. Each acre harvested for sugar required 1.4 acres of cropland. The extra 0.4 acre was land in fallow land planted to seed cane, and land used for roads and irrigation ditches.

Vegetables required 1.1 gross acres of land per harvested acre and yielded an estimated $102 net return per acre. This represented an average net return for vegetables over a period of years in the muck land area.

Beef production on pasture was the third enterprise activity in the Florida model. Net return to beef was an estimated $19.66 on the muck and peat soils, while on sand it was only 7 cents per acre. Three transfer activities permitted changing land use from pasture to cropland suitable for sugarcane production. The costs for the additional drainage needed for sugarcane, on an amortized basis, were $1.90 per acre for muck and peat land and $2.62 per acre for sand.16/ An activity for transferring cane land to pasture for each of the three soil types also was included in the model. No costs were involved in this latter transfer.

Two land clearing activities were included in the model. One was the clearing of peat land at an annual amortized cost of $21.66 per acre. The second was clearing of sand land that had an annual amortized charge of $20.85 per acre.

The cost of adding grinding capacity to existing mills was based on a total cost of $4,500 per ton of daily capacity or $30.00 per ton of annual grinding capacity (based on a 150-day grinding season).17/ Amortizing the annual cost at 8.5 percent interest for 10 years gave a cost of $4.56 per ton of sugarcane. The amortized cost for constructing new raw sugar factory was estimated at $7.81 per ton.18/ Sales of raw sugar and molasses were the only other activities in the Florida model.

16/ Amortized over 7 years at 8.5 percent annual interest.

17/ Includes the additional investment in harvesting and hauling equipment for the ton of cane.

18/ Based on a total cost of $7,500 per ton of daily grinding capacity, including investment in harvesting and hauling equipment.

Appendix table 7--Activities contained in the Florida linear programming model

Activity or column
Sugarcane on muck land
Sugarcane on peat land
Sugarcane on sand land
Vegetable production on muck land
Pasture on muck land
Pasture on peat land
Pasture on sand land
Pasture to cane transfer on muck land
Pasture to cane transfer on peat land
Pasture to cane transfer on sand land
Cane to pasture transfer on muck land
Cane to pasture transfer on peat land
Cane to pasture transfer on sand land
Clear peat land
Clear sand land
Add to existing grinding capacity
Build new grinding capacity
Sell raw sugar production
Sell molasses production

Appendix table 8--Summary of estimated costs for growing, harvesting, hauling, and processing per acre of sugarcane in Florida, 1975

Soil type	Tons cane per acre	Type of cost			
		Growing 1/	Harvesting & Hauling 1/	Processing 2/	Total
	Tons	Dollars per acre			
Custard apple muck	42	186.22	213.56	217.98	617.76
Sawgrass peat	35	199.80	188.30	181.65	569.75
Sand	31	267.08	174.12	160.89	602.09

1/ From text table 4.
2/ $5.19 per ton of cane based on unpublished USDA estimates projected from data in [6]. The processing costs include only long-term variable costs. It does not include depreciation on the raw sugar factory.

Appendix table 9--Estimated costs for growing, harvesting, and hauling sugarcane in south Florida, 1975 1/

Item	Cost per acre			Cost per ton 2/		
	Muck	Peat	Sand	Muck	Peat	Sand
	Dollars					
Preharvest:						
Variable costs--						
Fertilizer	29.19	34.82	90.97	.69	.99	2.93
Pesticides	32.00	28.31	28.82	.76	.81	.93
Labor	56.48	63.83	66.52	1.34	1.82	2.14
Custom services	2.25	2.25	2.25	.05	.06	.07
Equipment operation	28.44	28.44	31.76	.68	.81	1.02
Interest on operating capital	6.85	10.30	14.20	.16	.29	.46
Other	11.47	11.32	11.32	.27	.32	.36
Equipment ownership costs	19.54	19.53	21.24	.46	.56	.68
Total preharvest	186.22	198.80	267.08	4.41	5.66	8.59
Harvesting and hauling:						
Variable costs--						
Labor	90.16	75.94	68.38	2.15	2.17	2.20
Equipment operation	22.48	22.48	22.48	.53	.64	.72
Interest on operating capital	9.05	7.81	7.30	.21	.22	.23
Other	14.37	14.37	14.37	.34	.41	.46
Equipment ownership costs	18.70	18.70	18.70	.44	.53	.60
Hauling costs	58.80	49.00	43.39	1.40	1.40	1.40
Total harvesting and hauling	213.56	188.30	174.62	5.07	5.37	5.61
Total all costs	399.78	387.10	441.70	9.48	11.03	14.20

1/ Based on FEDS budget numbers 775, 776, and 777, [9].
2/ Based on average production per acre of 42, 35, and 31 tons, respectively, for muck, peat, and sand soils.

Texas

The Texas linear programming model contained 11 constraints or rows and 18 activities or columns (app. tables 10-11). There were two land constraints. "Prime cropland" was defined as well-drained soil with a low salts content. Most of the present sugarcane is on prime cropland. "Poorly drained cropland" was acreage which, with additional investment in drainage facilities, would be suitable for sugarcane production. "Minimum vegetable acreage" was an upper limit on the amount of land presently in fruit and vegetables which could be switched to sugarcane. It was included in the programming model to pick up the effects of changing vegetable production or vegetable prices. Shifting more acreage from vegetables than that represented by this constraint would result in higher vegetable prices and net returns, thereby raising the opportunity cost of the vegetable land for use in sugarcane.

Appendix table 10--Constraints included in the Texas linear programming model

Constraint or row	Unit	Level
Prime cropland	acre	80,000
Poorly drained cropland	acre	40,000
Minimum vegetable acreage	acre	10,000
Sugarcane grinding capacity	ton	1,368,000
Maximum expansion of present grinding capacity	ton	360,000
Irrigation water	acre feet	540,000
Raw sugar production summation	cwt.	---
Molasses production summation	gal.	---
Cotton lint production summation	lb.	---
Cottonseed production summation	lb.	---
Sorghum grain production summation	cwt.	---

"Sugarcane grinding capacity" was based on the expected capacity of the present mill in the Texas area operated over a 180-day season. Maximum expansion of the present mill was limited to 25 percent beyond present capacity. "Irrigation water" represented the amount of water available for supplemental irrigation. The 540,000 acre feet available was based on the estimate by several industry representatives that sufficient water would normally be available to grow 120,000 acres of sugarcane. Each acre of cane required an average of 4.5 acre feet of water per year. The remaining constraints in the Texas model were accounting rows for transferring quantities from production activities to sale activities.

Sugarcane production on prime cropland was the only sugar activity included in the Texas linear programming model. Cane could be planted on some land classed as "poorly drained," but only after an expenditure for further drainage. Estimated costs for sugarcane production and processing are summarized in appendix tables 12-13. Estimated yield per acre was 38 tons of gross cane yielding 66.5 cwt. of raw sugar and 228 gallons of molasses.

Appendix table 11--Activities included in the Texas linear programming model

Activity or column
Sugarcane production
Irrigated cotton on prime land
Dryland cotton on prime land
Irrigated sorghum on prime land
Dryland sorghum on prime land
Vegetable production on prime land
Irrigated cotton on poorly drained land
Dryland cotton on poorly drained land
Irrigated sorghum on poorly drained land
Dryland sorghum on poorly drained land
Drain wet land
Add grinding capacity to the present mill
Build new grinding capacity
Sell raw sugar
Sell molasses
Sell cotton lint
Sell cotton seed
Sell sorghum grain

Crops competing with sugarcane for land use were vegetables, cotton, and grain sorghum (app. table 14). Yields and costs were based on budgets of costs for growing cotton and sorghum in the lower Rio Grande Valley for the 1975 season prepared by the Texas A&M Agricultural Extension Service. Costs and yield estimates were based on typical management. Net returns from vegetable production, estimated at $103.00 per acre, was an average from the production of selected major vegetable crops in the lower Rio Grande Valley.

The "draining wet land" activity represented converting poorly drained land to the prime land class. This could be accomplished at a total cost of $350.00 per acre for draining and leveling. Total costs for draining and leveling were amortized over 10 years at 8.5 percent interest for an annual cost of $53.34.

The cost for adding grinding capacity to the existing mill was an estimated $3,500 per ton of daily grinding capacity of $19.44 per ton of seasonal capacity.19/ Amortized at 8.5 percent for 7 years, the cost per ton of season capacity was $3.80. Cost for building new grinding capacity was estimated at $6,000 per ton daily capacity--$33.00 per ton of seasonal capacity. The amortized cost per ton of seasonal capacity, amortized at 8.5 percent for 7 years was $33.33.

The remaining columns in the linear programming model were product selling activities.

19/ Exclusive of investment in harvesting and hauling equipment.

Appendix table 12--Summary of estimated costs for growing, harvesting, hauling, and processing per acre of sugarcane in the lower Rio Grande Valley, Texas, 1975

Type of cost	Amount
	Dollars per acre
Growing 1/	226.81
Harvesting and hauling 1/	142.98
Processing 2/	190.42
Total	560.21

1/ From text table 6. 2/ Based on estimates for the 1975-76 season from the W.R. Cowley mill. Processing costs include only long-term processing costs; it does not include depreciation on the raw sugar factory.

Appendix table 13--Estimated costs for growing, harvesting, and hauling sugarcane in the lower Rio Grande Valley, Texas, 1975

Item	Cost per acre	Cost per ton 1/
	Dollars	
Preharvest:		
Variable costs--		
Fertilizer	50.65	1.33
Pesticides	55.00	1.45
Labor	39.04	1.03
Custom services	13.00	.34
Equipment operation	16.28	.43
Irrigation	31.48	.83
Interest on operating capital	9.96	.26
Equipment ownership costs	11.40	.30
Total preharvest	226.81	5.97
Harvesting and hauling:		
Variable costs--		
Labor	30.54	.80
Equipment operation	60.98	1.60
Interest on operation capital	2.95	.08
Equipment ownership costs	48.51	1.28
Total harvest and hauling	142.98	3.76
Total all costs	369.78	9.73

1/ Based on production of 38 tons sugarcane per acre.

Appendix table 14--Expected yield and costs per acre from growing selected field crops in the lower Rio Grande Valley of Texas, 1975 1/

Crop	Expected yield	Estimated cost
	Lbs. per acre	Dollars
Irrigated cotton on prime land (lint)	650	233
(seed)	1,040	
Dryland cotton on prime land (lint)	425	134
(seed)	680	
Irrigated cotton on poorly drained land (lint)	550	236
(seed)	880	
Dryland cotton on poorly drained land (lint)	350	130
(seed)	560	
Irrigated sorghum on prime land	4,750	131
Dryland sorghum on prime land	3,250	60
Irrigated sorghum on poorly drained land	4,000	105
Dryland sorghum on poorly drained land	2,500	35

1/ Estimates based on unpublished enterprise budgets prepared by the Texas A&M Agricultural Extension Service at Weslaco, Tex., for the 1975 season.

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