B-1382
January 1982

Economic Implications of Pelleting Cotton Gin Trash as an Alternative Energy Source

The Texas Agricultural Experiment Station, Neville P. Clarke, Director, The Texas A&M University System, College Station, Texas

CONTENTS

The research upon which this report is based was funded in part by the Center for Energy and Mineral Resources and the Texas Agricultural Experiment Station, Texas A&M University.

Economic Implications of Pelleting Cotton Gin Trash *as an Alternative Energy Source*

AUTHORS

Donald S. Moore, associate professor (retired) Texas Agricultural Experiment Station (Department of Agricultural Economics)

Ronald D. Lacewell, professor, Texas Agricultural Experiment Station (Department of Agricultural Economics)

Calvin Parnell, associate professor, Texas Agricultural Experiment Station and Texas Agricultural Extension Service (Department of Agricultural Engineering)

SUMMARY

Conversion of crop residues to energy is one possible alternative for supplementing increasingly scarce and costly traditional sources of energy. This report estimates the costs of converting cotton gin trash to energy pellets. Estimated costs per unit of energy available from gin trash are compared with costs of other sources of energy. The analysis is directed specifically to the area around Lubbock, Texas, because of its concentrated cotton production.

Costs estimated are for (1) moduling trash soon after ginning, (2) storing modules, (3) trucking the modules to a pelleting plant at Lubbock, and (4) pelletizing gin trash at the plant. The estimates do not include the costs of market development and distribution of the product from the pelleting plant to the point of use. An analysis of the energy balance involved shows that about 200,000 Btu's of energy would be required to produce 1,000,000 Btu's of energy from pelletized gin trash.

The results indicate it would cost between \$2.20 and \$3.89 per million Btu's, or around \$3 per MBtu as an overall subjective estimate, to produce pelletized gin trash at Lubbock. The wide range in costs results from alternative levels of payment to gins and different heat losses resulting from storage. Thus, pelletized gin trash is not currently competitive with natural gas or coal. But it is potentially an attractive alternative as a stationary engine fuel source to replace diesel or fuel oil.

INTRODUCTION

Agricultural biomass may be an alternative to scarce and costly traditional energy sources for several reasons.

First, the potential volume of agricultural biomass is substantial. One estimate placed the amount of crop residues that might be collected in the U.S. with current harvesting equipment at 3 quads/year[1]; about 2.3 quads per yr. of the total are needed to prevent soil erosion, so the quantity of crop residues available as an energy source would be about 0.7 quads/yr. Crop residues contain energy equivalent to about 13 million Btu/ton (Office of Technology Assessment 1980).

Second, agricultural biomass is a renewable source of energy. While variations in production do occur from year to year because of weather and other factors, there is no problem of exhaustion or depletion over time. With proper husbandry and continued technological advance, the production of crops and crop residues may be expected to increase over time.

Third, since agriculturally-based energy is domestically produced, it could help reduce dependence for energy on foreign sources.

And fourth, much of the residue from agriculture, beyond that needed for erosion control and soil enhancement, now goes unused. If residue conversion to energy were an economically viable alternative, it could eliminate waste while providing an additional source of income to the agricultural and energy industries.

Although the production of substantial quantities of energy from agricultural biomass is technically feasible, considerable uncertainty exists over its economic feasibility. Among the many agricultural residues or wastes that offer possible economic potential for energy production, cotton gin trash may be one of the most attractive.

The over-all purpose of this study was to estimate the costs and assess some of the economic implications that would be associated with producing a pelletized solid fuel from cotton gin trash. The analysis was directed primarily to the southern High Plains of Texas and specifically at the area around Lubbock.

OBJECTIVES

The specific objectives of this study were as follows:

1. To estimate the amount of gin trash produced in the High Plains, the amount produced close enough to be economically accessible to a pelleting plant in Lubbock, the year to year variability in the amount of gin trash production, and the total heat content that might be converted from gin trash for commercial use.
2. To describe the production processes involved in converting gin trash to pellets for use as a source of fuel and to estimate the total costs of each of the production processes, the costs in terms of units of energy (MBtus), and the sensitivity of costs to changes in some of the variables.
3. To review and evaluate the major problems and uncertainties involved in converting gin trash to energy at a pelleting plant in Lubbock, the likely competitiveness of pellets with alternate sources of energy in the area, and the energy balance (energy produced compared with energy consumed in the conversion plant).

DESCRIPTION OF THE STUDY AREA

The Southern High Plains of Texas is the major cotton-producing area in the State, yielding approximately two-fifths of the annual State production of 3 to 4 million bales. Figure 1 shows locations of principal cotton-producing counties in the area; Lubbock County usually leads other counties in volume of production. Cotton production diminishes sharply in counties farther north because of a shorter growing season and dangers of early frost. Acres of cotton harvested and number of bales produced are shown in Appendix Table 1 for the decade of the 1970s for each of the major cotton-producing counties in the area.

During the 1970s, cotton acreage accounted for approximately half the crop acres harvested in the Southern High Plains (see Appendix Table 1). However, there was some variability from year to year because of weather and changes in prospective income relationships with other crops. Grain sorghum ranked second to cotton in number of acres harvested, accounting for approximately one-third of the total. Other crops each usually accounted for less than 5 percent of harvested acres and included wheat, corn, sunflower, soybeans, and hay.

Although cotton has consistently been the major crop produced in the area, there have been wide year to year variations in production. Over the past 10 years, for example, production has fluctuated from slightly over 1 to nearly 3 million bales per year (see Appendix Table 1). Although changing income relationships with other crops, primarily grain sorghum, is probably the most important reason for the variability, weather is also a very important factor. Since rainfall averages only about 18 inches a year, drought is a major hazard. During severe dry spells, production can be reduced to almost nothing on non-irrigated fields. Hail also is a major hazard and can reduce production substantially. Occasionally early frost strikes before cotton reaches full maturity, particularly in the northern part of the area.

On the favorable side, insect and disease problems usually are much less severe in the High Plains than in the more humid cotton-producing areas. Less use of pesticides and natural dessication or defoliation reduce the environmental problems associated with using gin trash as an energy feedstock in the High Plains compared with other areas. In gin trash which contains large amounts of pesticide, chemicals such as arsenic acid are released in the combustion process and can create environmental or control problems.

Annual variability in the amount of gin trash available as an energy feedstock is a factor that needs to be considered in evaluating the economic feasibility of pelleting cotton gin trash.

[1]A quad is one quadrillion Btu's, or about 8 billion gallons of gasoline.

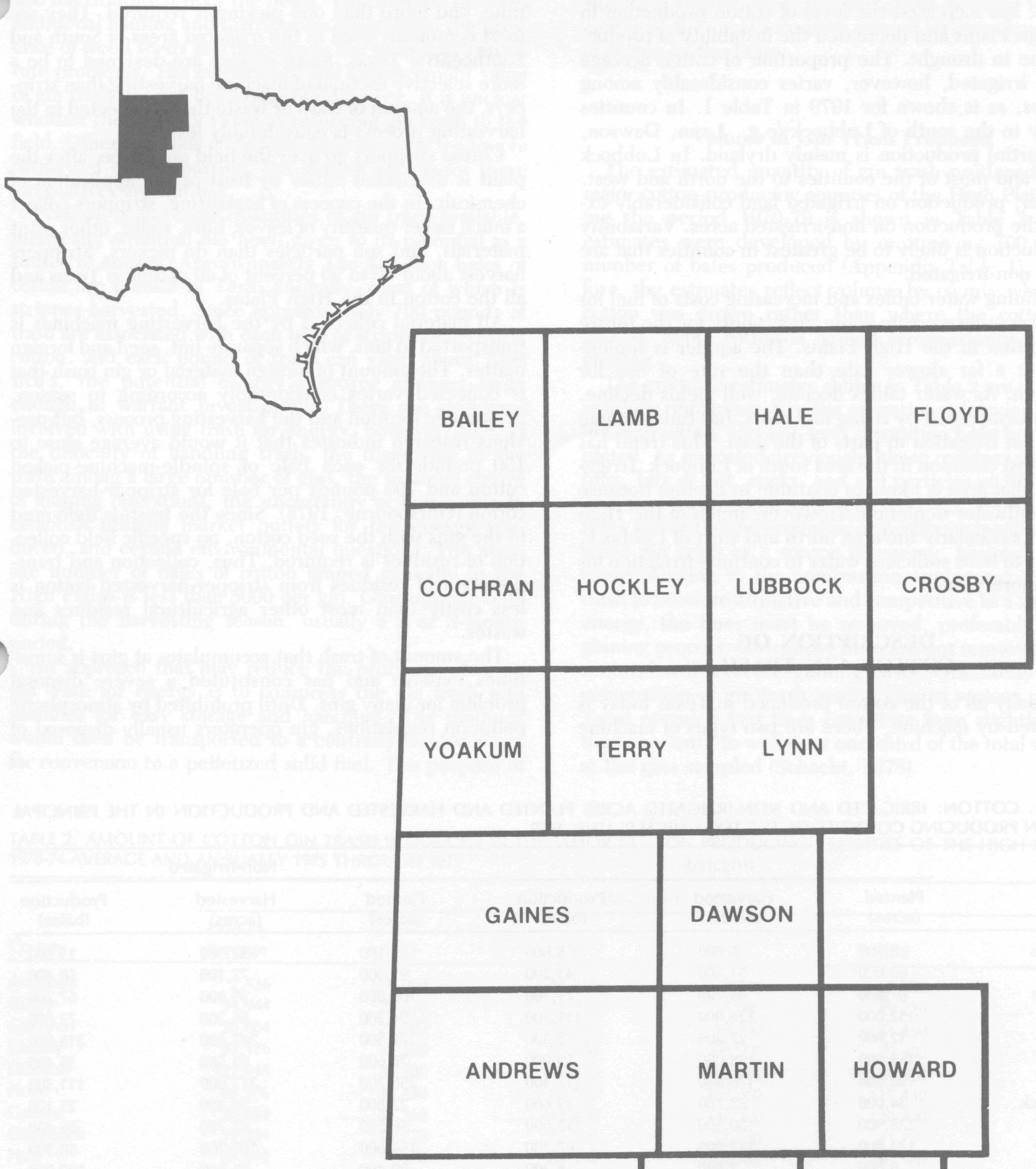

Figure 1. Principal cotton-producing counties in the Southern High Plains of Texas.

An important factor of cotton production in the Southern High Plains is irrigation. The development of irrigation from groundwater, primarily since the end of World War II, has increased the level of cotton production in the High Plains and decreased the instability of production due to drought. The proportion of cotton acreage that is irrigated, however, varies considerably among counties, as is shown for 1979 in Table 1. In counties directly to the south of Lubbock (e.g., Lynn, Dawson, and Martin) production is mainly dryland. In Lubbock county and most of the counties to the north and west, however, production on irrigated land considerably exceeds the production on non-irrigated acres. Variability of production is likely to be greatest in counties that are mostly non-irrigated.

Declining water tables and increasing costs of fuel for irrigation pumps create some uncertainty for the future of irrigation in the High Plains. The aquifer is replenished at a far slower rate than the rate of use for irrigation. As water tables decline, well yields decline. This, accompanied by rising fuel costs, has caused some decline in irrigation in parts of the area. This trend has been most common in the area south of Lubbock. Irrigation in that area is likely to continue to decline because of groundwater depletion. However, much of the High Plains, particularly the area north and west of Lubbock, appears to have sufficient water to continue irrigation for many more years.

DESCRIPTION OF COTTON GIN TRASH

Virtually all of the cotton produced in Texas today is harvested by machine. There are two types of machine harvestors, (1) spindle pickers and (2) strippers. Pickers are used primarily in areas where the growing season is long, the cotton matures over an extended period of time, and more than one picking is required. They are most commonly used in the irrigated areas of South and Southcentral Texas. Since pickers are designed to be a more selective method of machine harvesting than strippers, the amount of trash or waste that is collected in the harvesting process is considerably less.

Cotton strippers go over the field only once, after the plant is dessicated either by frost or the application of chemicals. In the process of harvesting, strippers collect a much larger quantity of leaves, burs, stalks, other plant materials, and soil particles than do pickers. Strippers harvest about 85 to 90 percent of all cotton in Texas and all the cotton in the High Plains.

All material collected by the harvesting machines is transported to gins, which separate lint, seed and foreign matter. The amount of foreign material or gin trash that is collected varies considerably according to season, geographic location and the harvesting process, but previous research indicates that it would average close to 150 pounds for each bale of spindle-machine-picked cotton and 700 pounds per bale for stripper-harvested cotton (Oursbourne, 1978). Since the trash is delivered to the gins with the seed cotton, no specific field collection of residues is required. Thus, collection and transportation of residues from stripper-harvested cotton is less costly than most other agricultural residues and wastes.

The amount of trash that accumulates at gins is sometimes massive and has constituted a severe disposal problem for many gins. Until prohibited by atmospheric pollution regulations, gin operators usually disposed of

TABLE 1. COTTON: IRRIGATED AND NON-IRRIGATED ACRES PLANTED AND HARVESTED AND PRODUCTION IN THE PRINCIPAL COTTON PRODUCING COUNTIES OF THE TEXAS HIGH PLAINS, 1979

	Irrigated			Non-Irrigated		
County	Planted (acres)	Harvested (acres)	Production (bales)	Planted (acres)	Harvested (acres)	Production (bales)
Andrews	8,500	6,800	5,600	53,100	32,500	11,500
Bailey	60,000	51,600	41,200	95,000	77,100	50,400
Cochran	87,500	85,700	71,100	100,800	99,900	67,200
Crosby	132,000	126,000	111,700	94,300	86,200	72,000
Dawson	32,000	27,200	25,800	276,800	247,800	218,000
Floyd	163,900	115,000	59,000	78,600	61,500	35,400
Gaines	193,000	176,000	117,400	258,700	217,000	111,300
Glasscock	34,000	32,700	39,600	22,800	20,300	25,100
Hale	228,900	180,300	112,000	56,500	47,700	26,400
Hockley	173,000	112,000	67,200	154,600	100,200	58,300
Howard	8,000	7,800	8,300	99,400	95,800	105,000
Lamb	180,000	122,000	73,200	100,300	71,500	48,200
Lubbock	222,000	198,000	154,000	126,200	106,500	86,800
Lynn	62,000	57,000	43,100	242,100	236,000	178,900
Martin	13,000	12,300	14,800	152,600	126,200	144,600
Midland	10,000	8,000	8,800	33,400	25,900	27,200
Terry	145,000	115,000	93,200	214,300	169,000	104,200
Yoakum	70,000	58,900	41,000	114,100	93,100	40,300
Total	1,822,800	1,492,300	1,087,000	2,273,600	1,914,200	1,410,800

Source: Texas Crop and Livestock Reporting Service.

the trash by incineration. The most prevalent disposal method used currently is hauling the trash back to farms and distributing it over the fields. This method involves additional hauling and distribution costs. Also, the presence of weed seeds and diseases in the trash may constitute problems. The erosion and soil enhancement value of gin trash has not been quantified; hence, it is unclear whether there is any value in returning gin trash to the field. Other methods of disposal have been by feeding to cattle and by composting, but market outlets for these alternatives are limited.

Because of the large quantities of gin trash available, increasing attention has been given to its potential as a source of energy. Approximately 3 to 4 million bales of cotton are ginned in Texas annually, most of which is stripper-harvested. Since approximately 700 pounds of trash are associated with each bale of stripper-harvested cotton, and each pound of trash can yield about 7000 Btu's, the potential energy resource appears large enough to warrant investigation. There are problems involved with using trash for energy, however, such as the difficulty of handling trash, the dispersion of the trash among a large number of gins, the seasonal nature of ginning operations, the uncertainty of being able to establish reliable market outlets for the energy produced, and certain environmental questions. The average number of bales of cotton ginned annually in the High Plains is less than 5000 per gin. Gins operate only during the harvesting season, usually a 2 or 3-month period.

An approach that may reduce the problems of using gin trash for energy is to compress the gin trash into modules for easy storage and handling. The modules would then be transported to a centrally-located plant for conversion to a pelletized solid fuel. The purpose of this study is to estimate the economic potential of this alternative in some detail. Lubbock was chosen as the site for a hypothetical pelleting plant because it is the center of the most intensive area of stripper-harvesting of cotton in the State.

Volume of Gin Trash Produced

The estimated quantity of gin trash produced in the major cotton-producing counties of the High Plains during the period 1970-79 is shown in Table 2. These estimates were developed by multiplying 700 by the number of bales produced (Appendix Table 1). Therefore, the estimates reflect volume by county where the cotton was grown rather than where the cotton was ginned. Some cotton is hauled across county lines for ginning.

The gin trash estimates shown in Table 2 are the gross residues remaining after the operations of drying, cleaning, extracting, and lint-seed separation have been completed. As indicated previously, these residues consist of burs, bits of lint, sticks, and soil particles or fine trash. This fine trash, commonly referred to as "fines" constitutes one of the uncertainties or problems involved with using gin trash as a source of energy, because it may cause clogging in the combustion equipment. For gin trash to be more attractive and competitive as a source of energy, the fines must be removed, preferably in the ginning process. Currently, fines are not removed; thus, removal will increase ginning costs. One study of the composition of gin trash among gins in various parts of Texas revealed that fines constitute from slightly more than one-tenth to well over one-third of the total volume at the gins sampled (Schacht, 1978).

TABLE 2. AMOUNT OF COTTON GIN TRASH PRODUCED IN THE MAJOR COTTON PRODUCING COUNTIES OF THE HIGH PLAINS, 1970-74 AVERAGE AND ANNUALLY 1975 THROUGH 1979

County	Gin Trash Produced (1,000 lbs.) 1970-74 Average	1975	1976	1977	1978	1979
Andrews	2,436	4,060	11,760	8,820	4,690	11,970
Bailey	34,944	22,050	16,240	64,890	49,210	64,120
Cochran	36,064	21,700	22,400	79,800	54,460	96,810
Crosby	85,176	67,200	95,900	108,500	99,400	128,590
Dawson	122,444	86,380	170,940	161,000	64,400	170,660
Floyd	68,376	38,430	63,980	126,000	115,430	66,080
Gaines	98,924	83,160	141,470	204,400	120,400	160,090
Glasscock	12,334	14,770	16,380	34,720	21,700	45,290
Hale	89,810	56,070	84,350	154,700	115,360	96,880
Hockley	91,882	61,390	70,000	182,700	99,400	87,850
Howard	35,882	52,500	53,900	64,890	23,800	79,310
Lamb	77,840	58,310	58,940	146,300	114,800	84,980
Lubbock	152,208	95,690	136,710	242,200	159,600	168,560
Lynn	105,210	101,360	140,420	143,500	86,800	155,400
Martin	54,166	74,410	91,700	82,600	35,350	111,580
Midland	11,886	11,970	18,060	20,160	12,740	25,200
Terry	85,778	45,920	77,280	166,600	92,400	138,180
Yoakum	28,616	12,530	22,400	54,320	28,350	56,910
Total	1,193,976	907,900	1,292,830	2,046,100	1,298,290	1,748,460

Potential Energy Value from Gin Trash

The heat value of cotton gin trash is dependent upon the chemical composition and moisture content. Schacht (1978) analyzed gin trash from cotton harvested with stripper machines. The results of his study are shown in Table 3.

Measurements of the heat values of gin trash indicate an average of about 7000 Btu's per pound of material, although there is some variability due to differences in constituent parts of the material and in moisture content. The estimate of 7000 Btu's per lb. is associated with about 11 percent moisture (Oursbourn et al., 1978).

The estimated maximum potential quantity of energy available from cotton gin trash is shown in Table 4 for the major cotton-producing counties of the High Plains. These estimates were derived by multiplying 7000 by the quantity of gin trash produced as shown in Table 2. The year-to-year variability in energy values reflects the year to year variability of cotton and gin trash production.

Since these estimates of energy values were developed from the gross quantity of gin trash produced as shown in Table 2, with no allowance made for the removal of fines, they probably overstate the actual quantity of energy that could be produced by the pelleting plant. Another factor that would likely reduce the quantity of energy that would be produced from gin trash in an operation that runs throughout the year is loss associated with storage and transportation. For a 12-month pelleting operation, some of the trash would need to be stored for a maximum period of nearly a year, since cotton gins usually operate only during the 2- to 3-month cotton-harvesting season. During the period of storage, some losses could be expected to occur due to natural deterioration and wind loss.

TABLE 3. TYPICAL CHARACTERISTICS OF COTTON GIN TRASH ON THE TEXAS HIGH PLAINS

Item	Percent (Dry Basis)
Physical Properties	
Lint	7.7
Burs	56.6
Sticks	10.7
Fine	24.9
Chemical Properties	
Carbon	42.0
Hydrogen	5.4
Nitrogen	1.4
Sulfur	<0.5
Oxygen and Error	35.0

Source: Schacht

METHODOLOGY

Costs associated with producing and delivering feedstock to a pelleting plant in Lubbock and of pelleting the feedstock are estimated by budgeting analysis. The number of gins, the number of bales ginned, and the associated quantity of gin trash that would be available for pelleting in an average or typical year are shown in Table 5 for specified distances from Lubbock up to a maximum of 50 miles. As of 1980, there are 231 active gins located within a 50-mile radius of Lubbock; they gin approximately 1 million bales in a typical year. The basis for these data are ginning records in the Cotton Ginners Redbook. The number of bales ginned per year average 4,329 per gin, with the volume for only two of the 231 gins exceeding 10,000 bales per year. The amount of trash available for pelleting in a typical year would average 276,876 tons for the 231 gins, or an average of almost 1200 tons per gin. The estimate of 276,876 tons of

TABLE 4. ESTIMATED ENERGY VALUE FROM COTTON GIN TRASH, 1970-74 AVERAGE AND ANNUALLY 1975 THROUGH 1979

	Energy Value (Mil. Btu)[a]					
County	1970-74	1975	1976	1977	1978	1979
Andrews	17,052	28,420	82,320	61,740	32,830	83,790
Bailey	244,608	154,350	113,680	454,230	344,470	448,840
Cochran	252,448	151,900	156,800	558,600	381,220	677,670
Crosby	596,232	470,400	671,300	759,500	695,800	900,130
Dawson	857,108	604,660	1,196,580	1,127,000	450,800	1,194,620
Floyd	478,632	269,010	447,860	882,000	808,010	462,560
Gaines	692,468	582,120	990,290	1,430,800	842,800	1,120,630
Glasscock	86,338	103,390	114,660	243,040	151,900	317,020
Hale	628,670	392,490	590,450	1,082,900	807,520	678,160
Hockley	643,174	429,730	490,000	1,278,900	695,800	614,950
Howard	251,174	367,500	377,300	454,290	166,600	555,170
Lamb	544,880	408,170	412,580	1,024,100	803,600	594,860
Lubbock	1,065,455	669,830	956,970	1,695,400	1,117,200	1,179,920
Lynn	736,470	709,520	982,940	1,004,500	607,600	1,087,800
Martin	379,162	520,870	641,900	578,200	247,450	781,060
Midland	83,202	83,790	126,420	141,120	89,180	176,400
Terry	600,446	321,440	540,960	1,166,200	646,800	967,260
Yoakum	200,312	87,710	156,800	380,240	198,450	398,370
Total	8,357,832	6,355,300	9,049,810	14,322,760	9,088,030	12,239,220

[a]Based on an energy conversion value of 7000 Btu's per lb. of gin trash.

TABLE 5. ESTIMATED TYPICAL AMOUNT OF COTTON GIN TRASH THAT WOULD BE AVAILABLE ANNUALLY FOR PELLETING WITHIN SPECIFIED DISTANCES OF LUBBOCK

Distance from Lubbock (miles)	No. of gins	Bales Ginned: Total	Bales Ginned: Average per gin	Tons Trash Available for Pelleting[a]: Total	Tons Trash Available for Pelleting[a]: Average per gin
0 - 30	71	311,806	4,392	83,315	1,173
31 - 40	79	346,762	4,389	98,935	1,252
41 - 50	81	341,448	4,215	94,626	1,168
Total	231	1,000,016	4,329	276,876	1,199

[a]Excluding fines.

gin trash available for pelleting excludes fines. Since special separating equipment, hence additional investment, is required at the gin for removal of the fines, there is some uncertainty whether all gins would be willing to make this investment and also whether all gins would be willing to make their entire supply of trash available for pelleting.

Two major types of cost items were included in the budgeting analysis. These two types were (1) costs associated with acquisition and delivery of the feedstock to a pelleting plant in Lubbock, and (2) costs of pelleting at the plant. Because of the uncertainty over the size of payments to gins that would be required, alternative levels of payment for the trash were incorporated in the budgeting analysis to determine their effect on total costs.

Costs of Feedstock

A computer model developed at the Department of Agricultural Engineering at Texas A&M was used to assist in estimating the quantity of gin trash that would be available for pelleting and the costs of processing and delivering the feedstock to the plant in Lubbock. It was assumed the trash would be compressed into 20,000 pound modules shortly after ginning, that the modules would be stored at or near the gin, and that the modules would be hauled to the plant in Lubbock as required to maintain steady operations around the year. Four major costs would be involved for the feedstock. These four costs are (1) payments to gins for the trash and the removal of fines, (2) moduling, (3) storage, and (4) transportation of the modules from the storage area to the pelleting plant in Lubbock.

Payments to gins

As indicated previously, the payment that would be required for gins to remove the fines and make the trash available for pelleting constitutes one of the major uncertainties involved in evaluating the economic feasibility of pelleting gin trash. Currently, many of the gins in the area pay about $5 per ton for disposal of the trash. It seems likely that some payment to gins would be required for removing the fines and contracting access to the trash, but the actual amount is speculative. In this analysis, it was assumed that payment of $5 per ton would be the amount required, but alternative payments of zero and $10 per ton also were included to analyze sensitivity of total cost of pellets to the amount of payment for gin trash. Long-term contracts between the gins and the pelleting plants would help alleviate the uncertainty of supply.

Moduling

Loose gin trash is bulky, unwieldy to handle, and subject to much greater wind and decomposition (energy) losses during storage. In this analysis, it was assumed that trash would be formed into modules soon after ginning, using the same type of equipment that is currently used for moduling seed cotton at many gins to ease the problems of storage and handling during periods of peak harvest. During peak harvest periods, harvest rates usually greatly exceed ginning rates. Without the use of modules, seed cotton waiting for access to the gin would have to be stored in trailers, which greatly increases costs and which may, if harvesting is delayed because trailers are tied up at the gin, cause losses due to adverse weather. For this analysis, it was assumed a module builder would be used exclusively for moduling gin trash.

The module builder assumed in this analysis consists of a unit 32 feet long and 8 feet wide, with an initial cost of $20,000. Both the fixed and the variable costs of moduling were developed on the basis of cost per ton, using procedures similar to those used by Lalor (1977). The cost estimates were based on the assumption that one 20,000 pound (10 ton) module could be built in about half an hour. A 10-year life and 10 percent interest with no salvage were assumed in estimating investment costs for the module builder. Other assumptions included a labor rate of $4.50 per hour and an average ginning volume of 5000 bales annually, yielding a total of about 3.5 million pounds of gin trash per year. Actually, this is slightly larger than the average volume of gins in the study area, as is indicated in Table 4. For gins with an annual volume of less than 5000 bales per year, the per-ton costs of moduling would be somewhat higher than the cost estimates in this analysis, while for larger gins the costs would be lower because fixed investment costs would be spread over a larger volume. The detail for the moduling costs per ton which were used in this analysis is as follows:

	Cost Per Ton
Investment (depr. & int.)	$1.86
Labor	.22
Repairs	.38
Power	.40
Total	$2.86

The costs shown above do not include the costs of pallets and tarpaulin. Use of these items probably would reduce significantly the problem of deterioration during storage. However, they are expensive to use. In this analysis, cost estimates were developed both with and without the use of pallets and tarp, accompanied by alternative estimates of energy losses due to deterioration. Where pallets and tarp were included, the costs involved the following assumptions: an initial investment cost of $430 for a pallet and tarp, a 5-year life, and an average annual use rate of 1.5 times per year. Costs per ton of gin trash for pallets and tarp are in addition to moduling costs and were estimated as follows:

	Cost Per Ton
Investment	$7.54
Repairs	.64
Total	$8.18

Storage

After the modules had been built, it was assumed they would be transferred to a storage area near the gin where they would remain until needed by the pelleting plant. It was also assumed that storage space could be leased, with space requirements averaging about 1 acre per 50 modules. The storage costs were estimated on the basis of a flat annual charge of $2000 per gin plus a charge of $2 per 20,000 pound module. The total storage costs for each gin were calculated by the computer model available in the Department of Agricultural Engineering, Texas A&M University.

Transportation

Estimated costs for transportation were based on current rates for hauling by truck published by the Texas Railroad Commission. Little if any transportation would be by rail. The distance from each of the 231 gins within the study area to Lubbock was determined. Total transportation costs for each gin were then estimated by multiplying the volume of trash for each gin by the published truck transportation rate for the determined distance. These data are internal to the computer model.

Costs of Pelleting

The estimated costs of pelleting cotton gin trash were based on the pelleting costs of the Tennessee Woodex pelleting plant at Knoxville, Tennessee. For the past several years, their plant has been producing a densified solid fuel from sawmill residues. It is believed the same system of pelleting wood residues could be used to pelletize cotton gin trash. The costs to the Woodex plant were obtained by H. G. Corneil of Exxon Enterprises, Inc. and made available to Texas A&M University (Corneil, 1980). These costs were adapted, or adjusted where deemed appropriate, to reflect pelleting costs likely at a plant in Lubbock. The major cost items are detailed as follows:

Electricity

The number of kwh required per ton of product for the Lubbock plant was based on kwh input requirements of the Tennessee Woodex plant. Cost per kwh was estimated at $.06, which is the approximate current rate charged for electricity in the Lubbock area.

Diesel fuel and lubes

The cost was estimated at $.85 per ton of feedstock, which is the same as the cost to the Woodex plant.

Repairs

Again the same cost rate to the Woodex plant was used. This amounted to $5.00 per ton of feedstock.

Salaries, labor, employment benefits

The costs supplied by Woodex for this item reflected slight economies of size. Reduced costs per unit of product from economies of size were adapted by interpolation to reflect unit costs deemed appropriate for the scale of operations at the Lubbock plant.

Insurance, property taxes, rent, etc.

Costs per unit of product for this item were based on unit costs to Tennessee Woodex.

Depreciation

Capacity of the Woodex plant was 100,000 tons per year and could be duplicated at an estimated investment cost of 3.5 million dollars. The same size plant and investment cost were assumed for Lubbock. Where the volume of product exceeded the 100,000 ton capacity, an additional plant or plants were assumed with the same investment and operating costs. Depreciation was calculated on a 10-year, straight-line basis.

RESULTS

Considerable uncertainty exists with respect to what amount to estimate for several of the cost items. One of the uncertainties is the level of payment needed to obtain the trash from the gins. In this analysis, it was assumed that payments of $5 per ton would be near the level of payment required. To determine the effect on total costs of alternative levels of payments, however, the analysis also shows results with the assumption of no payments and of payments of $10 per ton.

A second uncertainty concerns the extent of loss in heat value that might be anticipated from the storage of gin trash over the period of up to one year. This has not been thoroughly documented. One study revealed a 10 percent loss of gross heat content of a module after 9 months storage, even though the top of the module was covered with canvas (Schacht, 1978). Use of pallets and tarpaulin could be expected to reduce deterioration significantly, but it seems likely that some loss would still occur due to some deterioration on the sides and losses from wind and handling. Because of the high cost of pallets and tarp, there is some question whether the savings in deterioration losses would be sufficient to justify their additional expense. If pallets and tarp were not used, the maximum loss in heat content after a full year of storage is estimated to be 20 percent. This would be equivalent to an average loss over the year of 10 percent since, if the gin trash were pelleted at a steady rate during the year, the modules would be stored for an average period of 6 months. Due to the uncertainty regarding gin trash deterioration on the High Plains, cost estimates were developed both with and without the use of pallets and tarp, and with average annual deterioration losses of zero, 6 percent and 10 percent. While it seems unrealistic to expect that use of pallets and tarp would eliminate deterioration losses entirely, the most optimistic assumption was still included to obtain some additional insight in the potential savings from using pallets and tarp.

Benchmark Cost Estimates

Costs are shown in detail for only one base set of assumptions. The base set of assumptions selected was (1) payment to gins of $5 per ton for use of their gin trash, (2) no pallets and tarp, and (3) an average loss in heat value of 10 percent, equivalent to a maximum loss of 20 percent over a full 12-month period. This means that each pound of gin trash, rather than yielding 7000 Btu's, would yield 6300 Btu's. Costs are not shown in detail for other than the one set of base assumptions because most of the cost items do not change and to show them in full detail would be repetitive. Rather, only the total costs of the feedstock and of pelleting are shown per MBtu for each of the alternative assumptions. Total costs of the feedstock per ton also are shown for each of the alternate assumptions. It was felt this would be sufficient to show the sensitivity of costs to a rather wide range of conditions.

A detailed summary of the major production cost items is shown in Table 6. This shows the estimated cost of acquiring, handling, and pelleting the product up to marketing. In order to show the effect on volume and on costs of acquiring feedstock from varying distances from Lubbock, the results are shown for three sets of assumptions regarding range of acquisition distances. One column in Table 6 shows the results if the acquisition of gin trash is restricted to within a 30-mile radius of Lubbock. A second column shows results if acquisition is expanded to a radius of 40 miles, and a third column shows the results if expanded to a radius of 50 miles. If the processing capacity of each pelleting plant is restricted to 100,000 tons a year, one plant would be sufficient if acquisition of trash came from only a radius of 30 miles, but two plants would be required if acquisition was expanded to a 40-mile radius, and 3 plants for a 50-mile radius. This however, is based only on production for a typical year and does not take into consideration the high year-to-year variability in cotton production characteristic of the area (see Table 2).

Costs of feedstock

Of the four components of feedstock costs considered (payments to gins, moduling, storage, and transportation) payments to gins was the largest, amounting to $0.40 per MBtu or slightly over one-third of total feedstock costs. This indicates that the level of payment to gins is indeed a significant factor in evaluating the economic feasibility of pelleting gin trash.

The costs of transportation were the second largest of the four components of feedstock costs. Although rates per ton for distances of about 50 miles from Lubbock were over one-third higher than the rates per ton for distances of 15 miles or less, the marginal rate differences had only a nominal effect in raising average costs. Transportation costs hauled from a 50-mile radius averaged $0.39 per MBtu, only 4 cents higher than the $0.35 per MBtu average if hauls were restricted to a 30-mile radius. However, the profitability of hauls from longer distances should be evaluated in terms of marginal rather than average comparisons. Transportation costs per MBtu are the only one of the four feedstock cost components that would be affected significantly by hauling from longer distances. Slight differences are evident for storage costs when these costs are estimated on the basis of dollars per ton. These differences are caused by the way the storage costs are calculated, which gives slightly lower average unit costs to larger gins. The differences were not large enough, however, to be reflected in costs per MBtu. If gin trash hauls are restricted to within a 30-mile radius of Lubbock, total costs of feedstock to the pelleting plant would average $1.13 per MBtu or $14.24 per ton. This compares with averages of $1.17 per MBtu or $14.58 per ton if the hauls are expanded to within a radius of 50 miles.

Costs of pelleting

Total costs of pelleting average $1.78 per MBtu or $22.36 per ton of product if the gin trash pelleted is drawn from within a 30-mile radius of Lubbock, compared with costs of $1.69 per MBtu or $21.32 per ton if the trash is drawn from within a radius of 50 miles. The slightly lower unit costs when hauls are expanded to a 50-mile radius reflect slight size economies in the salaries, insurance, taxes, and depreciation components. Actually, these size economies were sufficient to offset the effects of higher transportation on the feedstock costs. Total production costs (feedstock and pelleting costs combined) average $2.91 per MBtu or $36.30 per ton for hauls within a radius of 30 miles compared with an average of $2.86 per MBtu or $35.90 per ton for hauls within a radius of 50 miles.

Sensitivity of costs to alternative assumptions

Costs per MBtu with alternative assumptions in several of the variables are shown in Table 7. These alternative assumptions include the choice of pallets and tarp, payments per ton to gins of 0, $5, and $10, and average annual rates of heat loss of 0, 6 percent, and 10 percent. Only data for a 50-mile radius are shown in Table 7, since the data in Table 6 indicated differences in distances made little differences in average unit costs.

Pallets and tarp are by far the most important of the cost variables considered. Their use would not appear justified within the range of assumptions considered. Even if the use of pallets and tarp eliminated heat losses

TABLE 6. PRODUCTION COST SUMMARY ASSUMING A $5 PER TON PAYMENT TO GINS, NO USE OF PALLETS AND TARP, AND A 10 PERCENT LOSS OF HEAT VALUE IN FEEDSTOCK

	Miles from Lubbock		
	30-Mile Radius	40-Mile Radius	50-Mile Radius
Production			
Trash Available (tons/year)	83,315	182,250	276,876
Energy Production (KMBtu/year)[a]	1,050	2,297	3,488
Cost of Production ($1,000)			
Cost of Feedstock to Pelleting Plant:			
Payment to gins @ $5/ton	417	912	1,385
Moduling	238	521	792
Storage	159	337	518
Transportation	372	847	1,343
Total feedstock cost	1,185	2,617	4,038
Cost of Pelleting:			
Electricity (.06/Kwh)	405	886	1,346
Diesel fuel & lubes @ 0.85/tons product	71	155	235
Repairs @ $5/ton product	417	912	1,385
Salaries, labor, employment benefits	508	1,032	1,553
Insurance, property taxes, rent, etc.	112	224	336
Depreciation	350	700	1,050
Total pelleting cost	1,863	3,909	5,905
Total Production Cost	3,048	6,526	9,943
Cost of Production ($/MBtu)			
Cost of Feedstock to Pelleting Plant:			
Payment to gins	.40	.40	.40
Moduling	.23	.23	.23
Storage	.15	.15	.15
Transportation	.35	.37	.39
Total feedstock cost	1.13	1.15	1.17
Cost of Pelleting:			
Electricity	.39	.39	.39
Diesel fuel, lubes	.07	.07	.07
Repairs	.40	.40	.40
Salaries, labor, employment benefits	.48	.45	.44
Insurance, property taxes, rent, etc.	.11	.10	.09
Depreciation	.33	.30	.30
Total pelleting cost	1.78	1.71	1.69
Total production cost	2.91	2.86	2.86
Cost of Production ($/ton)			
Cost of Feedstock to Pelleting Plant:			
Payment to gins	5.01	5.01	5.00
Moduling	2.86	2.86	2.86
Storage	1.91	1.85	1.87
Transportation	4.46	4.46	4.85
Total feedstock costs	14.24	14.37	14.58
Cost of Pelleting:			
Electricity	4.86	4.86	4.86
Diesel fuel, lubes	.85	.85	.85
Repairs	5.01	5.00	5.00
Salaries, labor, employment benefits	6.10	5.66	5.61
Insurance, property taxes, rent, etc.	1.34	1.23	1.21
Depreciation	4.20	3.84	3.79
Total pelleting costs	22.36	21.44	21.32
Total Production Cost	36.60	35.81	35.90

[a]Assuming an average of 6300 Btu's per lb. of gin trash residue, which reflects heat loss of 10 percent from the original 7000 Btu per lb.

TABLE 7. ESTIMATED COST PER MBTU UNDER ALTERNATIVE ASSUMPTIONS REGARDING USE OF PALLETS AND TARP, PAYMENTS TO GINS, AND ENERGY LOSS DUE TO DETERIORATION OF FEEDSTOCK[a]

Use of Pallets and Tarp	Payment Per ton to gins	Average % Heat Loss 0	6	10
		Cost of Feedstock to Pelleting Plant		
Yes	0	$1.27	$1.35	$1.41
Yes	$ 5	1.63	1.73	1.81
Yes	$10	1.98	2.11	2.20
No	0	.68	.73	.76
No	$ 5	1.04	1.11	1.17
No	$10	1.40	1.49	1.55
		Cost of Pelleting		
Yes	0	$1.52	$1.62	$1.69
Yes	$ 5	1.52	1.62	1.69
Yes	$10	1.52	1.62	1.69
No	0	1.52	1.62	1.69
No	$ 5	1.52	1.62	1.69
No	$10	1.52	1.62	1.69
		Total Production Cost		
Yes	0	$2.79	$2.97	$3.10
Yes	$ 5	3.15	3.35	3.50
Yes	$10	3.50	3.73	3.89
No	0	2.20	2.35	2.45
No	$ 5	2.56	2.73	2.86
No	$10	2.92	3.11	3.24

[a]Assuming the feedstock is hauled from within a radius of 50 miles.

entirely, which is a highly optimistic assumption, the savings would not be sufficient to offset the additional costs if the maximum loss over a 12-month period totaled no more than 20 percent. For pallets and tarp to be justified, savings in heat loss would have to be greater than the range considered here, or use would have to be justified on the basis of other factors, such as ease in handling and transportation. The significance of the level of payments to gins is reflected in Table 7. For each increase of $5 per ton in payments, costs of feedstock increase from $0.35 to $0.40 per MBtu. This is also shown in Table 8 on a per ton basis with and without the use of pallets and tarps. It is expected the cost of feedstock delivered to a pelleting plant in Lubbock would range between $10 and $30 per ton.

CONCLUSIONS

This study indicates that it would cost between $2.20 and $3.89 per million Btu to produce pelletized cotton gin trash at Lubbock. A best subjective judgment would be approximately $3.00 per MBtu. This does not include costs of distribution from Lubbock to the point of use. It would be necessary to develop markets for the gin trash pellets and assure the users of a stable long-term supply.

To assess the competitive position of cotton gin trash pellets as an energy source, approximate costs of current fuels are useful. Of course, prices of energy are rapidly changing. However, a natural gas price in the range of $3.00 per MBtu is reasonable. Diesel fuel at $1.00 per gallon is equivalent to about $7.57 per MBtu; i.e., there are 7.57 gallons of diesel per MBtu. Cost for Northwest coal delivered to Texas is about $30 per ton or $1.66 MBtu while Texas lignite is $12 per ton at the mine or $0.92 MBtu. Cotton gin trash pellets do not appear to be currently competitive with natural gas or coal, but they are potentially an attractive alternative as a stationary engine fuel source to replace diesel or fuel oil.

Use of trash pellets as an alternative fuel to oil raises questions of energy balance. A rather crude estimate of energy use to produce gin trash pellets includes .209 gallons of diesel per MBtu or 2.55 gallons per ton of trash and 175 cubic feet of natural gas per MBtu to produce electricity for pelletizing (or 212 thousand cubic feet). With one gallon of diesel equivalent to 120,000 Btu and one thousand cubic feet of natural gas equivalent to one million Btu, a rough estimate is 200,000 Btu's of energy required to produce one million Btu's of energy in the form of pelletized gin trash.

Thus, this study indicates potential for the use of cotton gin trash as an alternative energy source. However, there are several limitations to many aspects of the study. These include development of a market for cotton gin trash pellets, cost to transport the pellets from Lubbock to users, and assured long-term supply of cotton gin trash.

BIBLIOGRAPHY

College of Agriculture, Purdue University, *The Potential of Producing Energy from Agriculture,* contractor report prepared by the staff of the College of Agriculture, Purdue University, for the Office of Technology Assessment, Congress of the United States, 1979.

Condra, G. D. and Ronald D. Lacewell, *The Impact of Natural Gas Pricing on Irrigated Agriculture in the Trans-Pecos Region of Texas,* Texas Agricultural Experiment Station, TA-12683, 1976.

Corneil, H. G., "Economics Data for Woodex Pelletizing System", personal communication to R. D. Lacewell, Exxon Enterprises, Inc., Florsham, New Jersey, October 1980.

Continued

Dugas, Doris J., "Fuel From Organic Matter", Paper P-5100, The Rand Corporation, Santa Monica, California, 1973.

Dugas, Doris J., "Fuel From Organic Matter: Possibilities for the State of California", Paper P-5107, The Rand Corporation, Santa Monica, California, 1973.

Lacewell, R. D., C. Robert Taylor and Edward A. Hiler, "Energy Generated From Cotton Gin Trash", report prepared for the Texas Energy and Natural Resources Advisory Council and Office of Technology Assessment, Texas Agricultural Experiment Station, Center for Energy and Mineral Resources, College Station, Texas, 1980.

Lalor, W. F., J. K. Jones, G. A. Slater, Gary Underbrink and L. H. Wilkes, "Dump Trailers for Central Moduling Facilities", Agro-Industrial Report Vol. 4i No. 2, Cotton Incorporated, Raleigh, North Carolina 1977.

Lalor, W. F., J. K. Jones and G. A. Slater, "Cotton Gin Trsh as a Ruminant Feed", Agro-Industrial Report Vol. 2, No. 1, Cotton Incorporated, Raleigh, North Carolina, 1975.

Lalor, W. F. and M. L. Smith, "Use of Cotton Ginning Wastes as an Energy Source", proceedings of the 1977 Cornell Agricultural Waste Management Conference, College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.

Office of Technology Assessment, *Energy from Biological Processes*, Volume I and Volume II, Congress of the United States, Washington, D. C., 1980.

Oursbourne, C. D., W. A. LePori, R. D. Lacewell, K. Y. Lam and O. B. Schacht, *Energy Potential of Texas Crop and Agriculture Residues*, MP-1361, Texas Agricultural Experiment Station, Center for Energy and Mineral Resources, College Station, Texas, 1978.

Railroad Commission of Texas Motor Freight Commodity Tariff No. 8-f, Containor's Rates, Rules, Regulations, and Changes Governing the Transportation of Livestock, Livestock Feedstuffs, Farm Machines, Cottonseed and Grain by Specialized Motor Carriers Between Points in Texas, 1979.

Schacht, Otto Byron, *Energy Analysis of Cotton Gin Waste*, unpublished Ph.D. dissertation, Department of Agricultural Engineering, Texas A&M University, College Station, Texas 1978.

Texas Department of Agriculture and USDA Statistical Reporting Service, "Cotton Statistics", reports for 1970 through 1979, Austin, Texas.

Texas Cotton Ginners Association, "Cotton Ginners Redbook", reports for 1970 through 1979.

ACKNOWLEDGEMENTS

Special appreciation is expressed to Mr. H. G. Corneil for assistance in developing the costs of the pelleting operation. Also, the cooperation and assistance of Mr. Jeff Galyon of Tennessee Woodex is gratefully acknowledged. Tennessee Woodex was most helpful in developing estimates of pelleting costs and by volunteering to pelletize cotton gin trash for study by Texas A&M.

Mr. Lambert Wilkes provided consultation and articles relative to moduling operations. We certainly appreciate his wisdom and help.

The manuscript was significantly improved through suggestions by Ron Griffin, John Sweeten and Glenn Collins. For their time and patience in reviewing the manuscript we are most appreciative.

Lastly, we express our gratitude to Ms. Dianne Miller for her excellence in typing the several drafts of the report.

APPENDIX TABLE 1. COTTON ACRES HARVESTED AND BALES PRODUCED IN THE PRINCIPAL COTTON PRODUCING COUNTIES OF THE TEXAS SOUTHERN HIGH PLAINS, 1970-74 AVERAGE AND 1975 THROUGH 1979

	Acres Harvested						Production (bales)[a]					
County	1970-74 Average	1975	1976	1977	1978	1979	1970-74 Average	1975	1976	1977	1978	1979
Andrews	7,100	10,500	24,300	30,000	23,000	39,300	3,480	5,800	16,800	12,600	6,700	17,100
Bailey	69,100	75,000	34,900	106,000	122,000	128,700	49,920	31,500	23,200	92,700	70,300	91,600
Cochran	73,920	73,200	54,600	142,000	143,000	185,600	51,520	31,000	32,000	114,000	77,800	138,300
Crosby	136,560	146,600	161,900	175,000	197,000	212,200	121,680	96,000	137,000	155,000	142,000	183,700
Dawson	198,780	237,600	271,400	290,000	271,000	275,000	174,920	123,400	244,200	230,000	92,000	243,800
Floyd	107,360	101,400	122,500	174,500	199,000	176,500	97,680	54,900	91,400	180,000	164,900	94,400
Gaines	188,460	204,600	261,100	374,000	383,000	393,000	141,320	118,800	202,100	292,000	172,000	228,700
Glasscock	17,200	22,900	26,300	39,800	40,700	53,000	17,620	21,100	23,400	49,600	31,000	64,700
Hale	150,380	139,000	151,100	213,500	204,000	228,000	128,300	80,100	120,500	221,000	164,800	138,400
Hockley	186,180	194,400	163,900	284,000	264,000	212,200	131,260	87,700	100,000	261,000	142,000	125,500
Howard	68,340	83,900	87,500	96,200	89,000	103,600	51,260	75,000	77,000	92,700	34,000	113,300
Lamb	153,880	152,300	116,600	209,000	226,000	193,500	111,200	83,300	84,200	209,000	164,000	121,400
Lubbock	236,440	245,800	244,600	315,000	305,000	304,500	217,440	136,700	195,300	346,000	228,000	240,800
Lynn	182,740	215,300	260,000	269,000	269,000	283,000	150,300	144,800	200,600	205,000	124,000	222,000
Martin	101,700	124,100	138,700	150,000	118,000	138,500	77,380	106,300	131,000	118,000	50,500	159,400
Midland	22,700	22,100	33,300	38,400	34,800	33,900	16,980	17,100	25,800	28,800	18,200	36,000
Terry	164,940	136,600	172,300	276,000	257,000	284,000	122,540	65,600	110,400	238,000	132,000	197,400
Yoakum	55,180	31,100	48,600	95,600	82,500	152,000	40,880	17,900	32,000	77,600	40,500	81,300
Total	2,120,960	2,218,400	2,323,600	3,278,000	3,228,000	3,396,500	1,705,680	1,297,000	1,846,900	2,923,000	1,854,700	2,497,800

Source: Texas Crop and Livestock Reporting Service.

[a] 500 lbs. gross, 480 lbs. lint.

B-1382
2M—1-82