Possibilities for Expanding the Market for SUGARCANE BAGASSE

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PREFACE

Acknowledgment is made to the following: Phillip E. Jones, Secretary-Treasurer of the U. S. Beet Sugar Association, formerly with the U. S. Department of Agriculture; M. V. Yarbrough, General Manager of the Youngsville Industries, Youngsville, La; and Marshall E. Miller, Commodity Stabilization Service, for their assistance in early planning of the study.

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POSSIBILITIES FOR EXPANDING THE MARKET FOR SUGARCANE BAGASSE

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SUMMARY AND CONCLUSIONS

Bagasse, the fibrous portion of sugarcane, is a byproduct of sugar processing; and it has physical characteristics making it suitable for use for commercial products. As a result, considerable technical research has been devoted to the development of processes for using bagasse commercially. However, presently only about 10 percent is being used commercially; the rest is burned as fuel in sugar mill furnaces.

In the United States the largest commercial uses for bagasse are in the production of insulation board and poultry litter. Also thermoplastic and thermosetting resins and mulch are produced, and in mid-1954 construction was completed on a small pulp and paper plant. A furfural plant using bagasse is under construction in the Dominican Republic. To be economically feasible in the long run, a commercial use for bagasse must return to the sugar mill an amount equal to or above the cost of alternative fuel. This study undertook to evaluate the possibilities of expanding the present market and developing a market for future bagasse products. The principal criteria used in this evaluation were relative quality and cost of bagasse products compared to those of competing products, and probable market growth for products which are being and can be made from bagasse. Under these criteria, the following observations are made regarding the possibilities of expanding the market for bagasse:

1. The possibilities for using bagasse as a raw material for pulp, paper, and paperboard products appear the most promising in the production of corrugating material and pulp for blending with wood pulp in the manufacture of fine, wrapping, bag, newsprint, and magazine papers, and linerboard. Other possibilities are glassine and greaseproof papers.

Depithed bagasse makes excellent corrugating medium with superior strength, and relatively good greaseproof and glassine papers. For manufacturing fine papers, bagasse pulp is a desirable supplement to wood pulp and is substitutable for varying percentages of woodpulp in making wrapping, bag, newsprint, and magazine papers and linerboard. No data are available on the relative cost of the entire manufacturing process for paper and paperboard using bagasse and competing raw materials. However, the cost of producing bleached and unbleached pulp from depithed bagasse compares favorably with pulp costs using other raw materials in small commercial operations.

Since 1930 output of paper and paperboard has tripled, and there seems to have been no abatement in the general growth trend. Of the container boards, the consumption of fourdrinier kraft liner and semichemical corrugating medium has expanded most rapidly since 1942. The consumption of fine, newsprint, and printing papers has remained about the same as a percent of the total since 1942. The production of glassine and greaseproof papers has not changed in terms of total output in recent years, while the production of bag papers has increased. The published financial statements of pulp, paper, and paperboard manufacturers indicate that the reporting firms, generally the industry's largest, had very favorable cost-price relationships from 1947 to 1951. In 1952 and 1953, the net profit-net worth ratio of the reporting firms, though reasonably favorable, was at the lowest level since 1947, indicating stronger competition.

2. The possibilities for expanding the use of bagasse in insulation board do not seem particularly promising at this time, though bagasse is equally as suitable for insulation board manufacture as competing raw materials. The published financial statements of insulation board producers using bagasse and competing materials indicate that users of bagasse do not appear to have any noticeable cost-price advantage. Capacity increases in bagasse board plants since 1938 have not matched those in plants using other raw materials.

From 1948 to 1953, the production of insulation board remained unchanged. From 1950 to 1953 the industry operated at about three-quarters of capacity and net profit-net worth ratios were at modest levels compared to the immediate postwar period.

3. Since technicians in the field indicate that hardboard of competitive quality may be made from bagasse and the hardboard consumption trend is quite favorable, the use of bagasse by present or possible hardboard producers deserves consideration. The production of hardboard in 1953 was more than double that in 1945 and almost triple that of 1941. It is reasonable to assume that bagasse hardboard could compete pricewise with wood as does bagasse insulation board since the principal methods of manufacture of the two types of board are essentially the same.

Hardboard plant capacity has almost doubled since 1950. The expanding capacity plus the comparatively modest net profit-net worth ratios in recent years assure continued active competition in the industry.

4. The possibility of using domestic bagasse as a furfural raw material does not appear promising at this time. Furfural production from bagasse is economically feasible at only a few locations in this hemisphere, where conditons for low-cost operations are especially favorable. Bagasse has no advantage as a raw material with respect to the quality of furfural produced. The furfural market expanded rapidly from 1942 to 1953, but the expansion rate slowed somewhat in 1954.

5. The poultry litter market is expected to continue its present expansion rate for some years, and bagasse litter should share in this expansion. From 1935 to 1952 litter usage increased from about 8 million to about 13.3 million tons. Most bagasse litter plant managers interviewed believed that they could use a larger producing unit if they had more adequate facilities for storing litter between sugar harvest seasons to service the poultry industry's year-round needs. Bagasse is a good quality litter, high in cleanness, absorbency, and freedom from dust, though with some tendency to mat. In 1952 bagasse litter cost about $17 a ton to produce and was successfully competing in price with other commercial litters.

6. The commercial mulch market, while apparently growing rather rapidly, does not present an outlet in which bagasse is likely to find significant increases in sales. Peat, a material superior to bagasse for mulching, is in plentiful supply commercially at competitive prices.

INTRODUCTION

For more than 100 years the possible utilization of bagasse as a raw material for commercial products has been the subject of research. Bagasse is the fibrous portion of sugarcane left after the extraction of the sucrose-containing juice, and this fibrous portion has physical characteristics making it suitable for certain commercial products. At present most of it is burned as fuel in sugar-mill furnaces.

The search for commercial uses for bagasse has probably been more intense than that for any other agricultural residue. In addition to the general interest in agricultural residues to expand the Nation's fiber supply, the interest in bagasse has been encouraged by the following facts: (1) Large quantities are assembled at the sugar mill as an integral part of the sucrose extraction, causing sugar and molasses to bear the cost of this assembly; (2) most sugarcane is produced in one-crop areas, necessitating the development of new industries for diversification and additional income; and (3) bagasse has a relatively low economic value for competing uses.

Need for Study

The experimental work has resulted in the development of a few commercial enterprises in the United States utilizing bagasse as a raw material and in the development of two consumer uses for dehydrated fiber. However, these markets consume only a small portion of the 3.5 million tons, bone-dry basis, of domestic bagasse produced annually. In the long run, to have economic feasibility, a commercial use for bagasse must return to the sugar mill an amount equal to or greater than the cost of alternative fuels. With this large supply of fiber available there was a need for evaluating the possibility of achieving further commercial use of the material through expansion of the market for bagasse products presently being produced and products in the pilot plant and early commercial stage of development. This study undertook this task using as principal criteria the relative quality and relative cost of bagasse products compared with competing products made from other raw materials and the probable market growth of products which are being and can be made from bagasse.

Scope and Objectives

The research on this project was designed to cover the major economic factors and marketing considerations associated with producing and marketing present and likely bagasse products. The specific objectives were: (1) To determine the average quantity of bagasse available for processing, the stability of output from year to year, and areas in which production is most concentrated; (2) to determine present methods of utilizing bagasse; (3) to determine the cost of bagasse as a raw material; (4) to determine the difference in sugar-mill costs and efficiency attributable to the type of fuel used; (5) to develop the economics of producing and marketing present and likely bagasse products and similar products made from competing raw materials; (6) to determine methods of marketing finished products now being made from bagasse; (7) to evaluate the possibilities of further exploiting the market for products now being made from bagasse; and (8) to determine the market potential for likely bagasse products.

Procedure

In developing this study, a considerable amount of primary and secondary data was brought together for analysis. For many of the lines of inquiry, secondary data proved to be more useful because of the rather disconnected and fragmentary nature of the information available at primary sources. In addition, some of the primary data was considered too confidential by the respondents to be usable for a public report.

Primary data assembled include information from sugar mills about the efficiencies of gas and oil as fuel in mill operations; the availability of alternate fuels if a commercial outlet for bagasse were developed; and the price millowners will have to have for them to justify converting mill equipment from the use of bagasse to oil or gas as fuel.

Manufacturers presently using bagasse as a raw material, consulting engineers, and sugar producers were asked to supply data on the following: Cost of baling and storing bagasse at the sugar-mill site (some manufacturers build, maintain, and operate baling and storing facilities); cost of transporting bagasse from the sugar mill to the manufacturing plant; cost of manufacturing and marketing finished bagasse products; production trends of various end products; methods of marketing; and relative quality and consumer acceptance of bagasse products compared to products made from competing raw materials.

Information gathered from users and distributors of present bagasse products and competing products included trends in use of bagasse products with reasons therefor; relative quality and price of bagasse products and their future market potential; and changes manufacturers might make in merchandising methods to promote sales.

Information on likely bagasse products, their quality characteristics, and their production and marketing costs was obtained from owners of proprietary processes, persons engaged in bagasse research and development in public and private fiber laboratories and pilot plants, and consulting engineers and economists in the fiber and related fields. The persons who supplied information on likely bagasse products were also helpful in supplementing the information gathered from sugar mills and from the manufacturers, users, and distributors of present bagasse products.

Secondary data used include production, consumption, marketing, and price information assembled from various trade associations and publications, and from the records and publications of various agencies of the U. S. Department of Agriculture and the U. S. Department of Commerce, the U. S. Tariff Commission, and the U. S. Bureau of Mines. These data also include technological research data from the Northern Utilization Research Branch, the Forest Products Laboratory, Louisiana State University, Herty Foundation, Vanderbilt University, the National Bureau of Standards, and other research establishments, and the large quantity of literature on the subject of industrial utilization of bagasse.

PRODUCTION AND AVAILABILITY OF BAGASSE

Quantity Produced and Stability of Output

Table 1 shows the annual production of bagasse (bone-dry basis) in the various domestic areas during the crop years 1942-43 to 1952-53.

TABLE 1.—Production of bagasse, bone-dry basis, in domestic areas, 1942-52

Season beginning	Louisiana	Florida	Puerto Rico	Hawaii	Virgin Islands	Total
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1942......	662,331	73,745	1,185,600	931,989	7,385	2,861,050
1943......	746,811	76,001	798,625	961,785	4,608	2,587,830
1944......	702,337	78,360	1,136,570	942,212	7,650	2,867,129
1945......	729,651	101,820	1,063,695	886,013	8,677	2,789,856
1946......	672,572	104,551	1,307,506	731,659	6,221	2,822,509
1947......	612,963	98,672	1,325,277	974,510	8,379	3,019,801
1948......	816,215	93,960	1,528,727	920,199	8,324	3,367,425
1949......	759,646	122,479	1,498,528	981,605	18,304	3,380,562
1950......	822,676	136,090	1,432,942	1,005,503	13,705	3,410,916
1951......	699,988	143,912	1,689,393	1,042,696	23,094	3,599,083
1952......	834,442	175,821	1,417,808	1,069,352	25,089	3,522,512

Basic data from Sugar Division, Commodity Stabilization Service, U. S. Department of Agriculture.

Generally, bagasse production has been very stable over the 11-year period in each of the areas. Even during World War II and the Korean emergency, when prices of many farm commodities rose more than sugarcane, cane growers made no significant shift to the production of other crops. There are three principal reasons for this stability. First, apparently there are no alternate crops as well suited to the land and climate as sugarcane. Second, several crops are harvested from one planting, making short-term adjustments difficult. Third, the operation of the sugar quota system, controlling imports, and domestic production, has been accompanied by prices which have provided protection for the domestic sugar industry and by production generally at the limits permitted.

Under the Sugar Act of 1948 as amended, each domestic producing area has a fixed marketing quota. On a raw-value basis, Hawaii may market 1,052,000 tons annually, Puerto Rico 1,080,000 tons, mainland cane (Louisiana and Florida) 500,000 tons, and the Virgin Islands 12,000 tons. Domestic beet sugar growers may market 1,800,000 tons, raw value, annually.

There is every indication that the production stability which characterized the 1942-43 to 1952-53 period will continue indefinitely. The United States has protected its sugar industry since 1789, and there is little likelihood that such protection will be discontinued. From 1789 to 1934 the principal protective device was the sugar tariff. Since 1934 a quota system has been used.

Current Use and Availability of Bagasse

Most of the bagasse produced in the domestic areas is used as fuel in the sugar mills and is available for commercial purposes. Of the 3,522,512 tons (bone-dry basis) produced in 1952-53 about 350,000 were utilized in commercial products. Of that utilized for commercial products, most was produced in Louisiana. There, about 210,000 tons yearly are used in the manufacture of insulation board, and approximately 65,000 tons are dehydrated annually and sold as poultry litter and agricultural mulch.

In addition, one sugar mill, producing about 20,000 tons a year, is presently utilizing some of its output to manufacture thermosetting and thermoplastic resins. And in 1954 this mill planned to use the balance and perhaps some purchased bagasse for pulp and paper manufacture. In Hawaii, from 25,000 to 50,000 tons of fiber are used annually to produce insulation board, and in Florida it is estimated that 10,000 to 20,000 tons are dehydrated for sale principally as poultry litter. And development of the use of bagasse for hardboard manufacture is contemplated in Puerto Rico.

In processing bagasse for sale as chicken litter or mulch, the bagasse is first dried and then screened and baled. Screening removes the dirt and loose pith. Some of the pith has found a market as a filler for certain types of explosives and as a carrying agent for blackstrap molasses in animal feeds.

Location and Output of Sugar Mills

Figures 1 to 4 show the location and bagasse output (bone-dry basis) of sugar mills in each domestic area. Also, mills presently under long-term contract for the sale of their bagasse or utilizing their own bagasse in a commercial product are noted.

In Hawaii (fig. 1) probably the largest concentration of bagasse production is on the island of Maui. There, 3 factories within about a 12-mile circle produce 164,000 tons of bagasse annually. The island of Oahu also has a heavy concentration of bagasse output. There, 3 factories, about 15 miles apart, produce 197,000 tons a year. On the island of Hawaii, four sugar factories sell a portion of their bagasse under a long term contract to an insulation board plant at Hilo.

The location of the Louisiana sugar mills and bagasse production by parishes are shown in figure 2. Most Louisiana mills produce less bagasse than do mills in the other domestic areas. But in certain sections of the cane area several mills are clustered together, and aggregate bagasse output is relatively large.

All mills are served by railroads and improved highways. Some are also served by navigable bayous or canals. However, none of the mills on the Mississippi River--13 on the west bank and 4 on the east bank--are able to use the river for transportation of their products because of the wide variations in river level and the high cost of dock facilities.

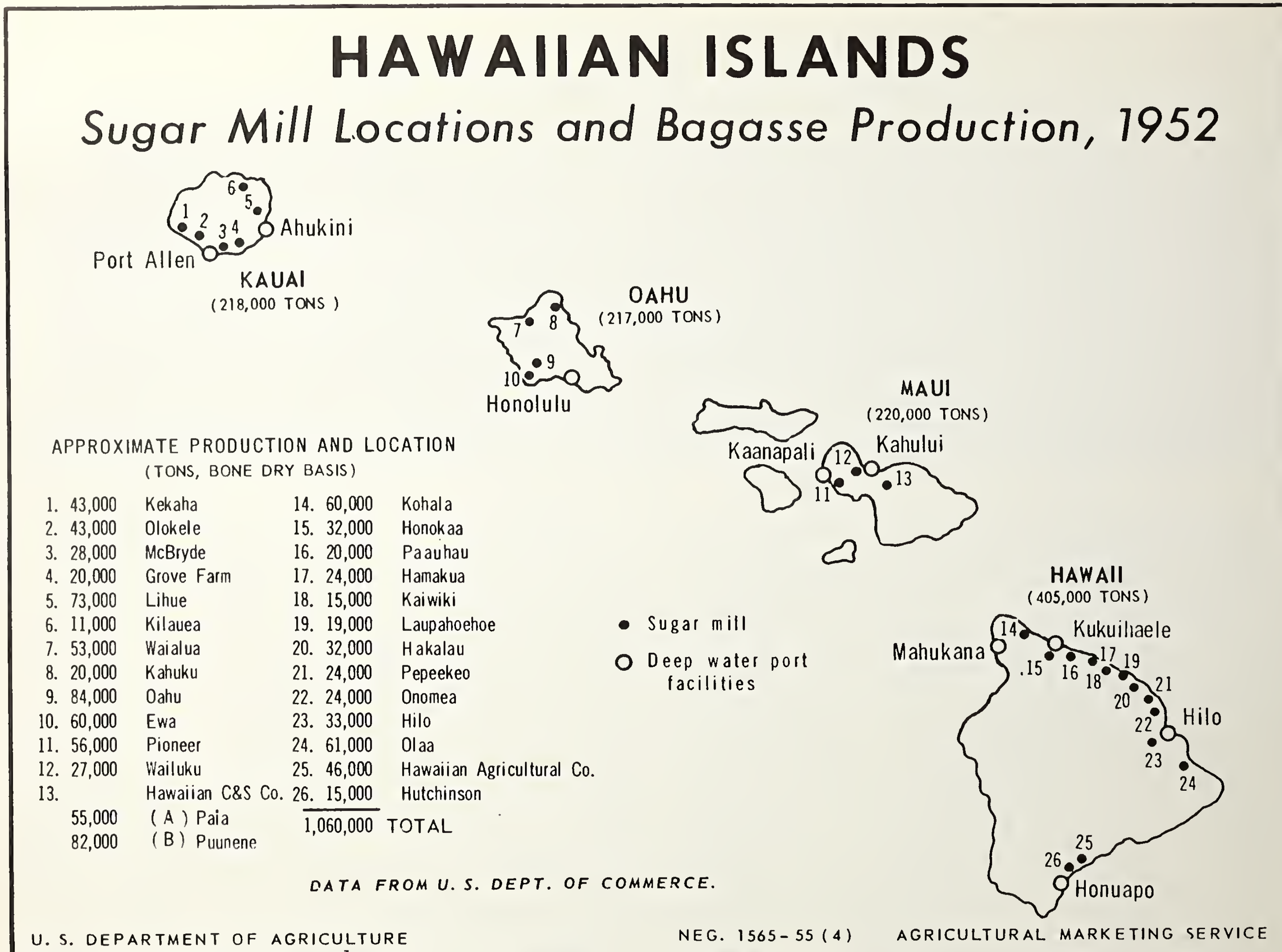
Eleven mills, most of which are among Louisiana's largest, are under a long-term contract with a large insulation board plant for the sale of their bagasse. These factories are generally near the insulation board plant. Three other mills also sell bagasse for use in insulation board, but their contracts contain no specifications about term length. Two mills utilize their bagasse in the manufacture of poultry litter and agricultural mulch. Another uses about half of its bagasse for the production of litter and mulch, and a fourth sells its entire output to a dehydrating firm. In addition, one mill is presently using a portion of its bagasse in the manufacture of plastics. And it recently completed a plant to produce pulp and paper from the balance which may be possibly supplemented by some purchased bagasse.

The largest concentration of fiber presently available for industrial use is in the western portion of the sugarcane belt. This includes St. Mary, St. Martin, Iberia, Lafayette, and Vermilion Parishes. In this area there are 18 mills producing about 210,000 tons of bagasse not presently being used for commercial purposes. Many of these mills lie along Bayou Teche, which is navigable by commercial barges to a point just south of St. Martinville.

The second largest concentration of available bagasse is along the west bank of the Mississippi River in Iberville and West Baton Rouge Parishes. The bagasse in this area could be concentrated by rail or truck with an average haul of 15 miles. Probably the logical point of concentration would be along Bayou Plaquemine, which is navigable and open to the Mississippi River through locks.

As indicated earlier, almost all the bagasse in Puerto Rico is available for commercial use. At present, one commercial venture, hardboard manufacture, is being considered. There are several areas where rather large quantities of bagasse are produced and in which adequate port facilities are located.

The groups of mills which would logically fall into each of these areas from the points

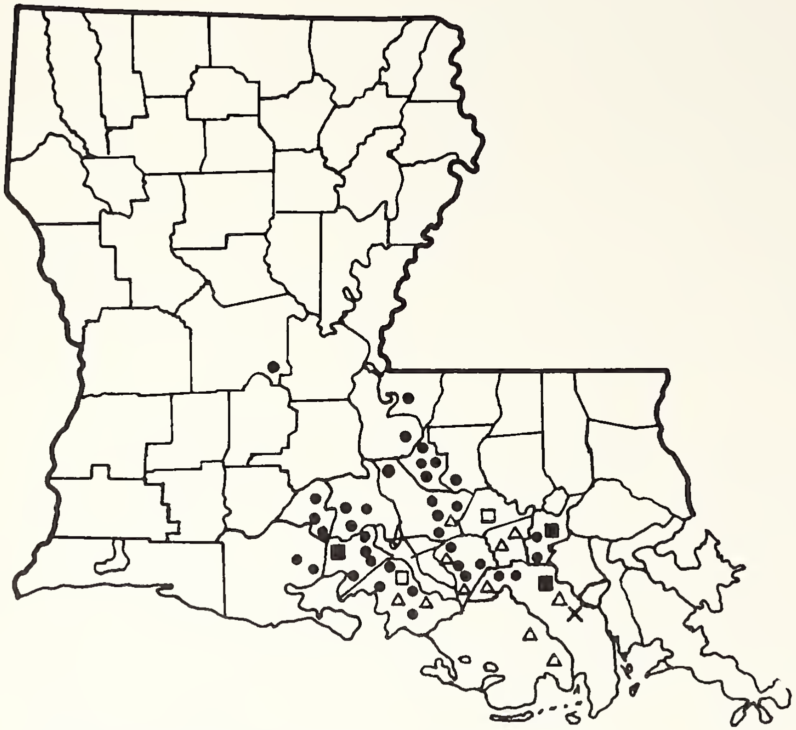


1.	43,000	Kekaha	14.	60,000	Kohala
2.	43,000	Olokele	15.	32,000	Honokaa
3.	28,000	McBryde	16.	20,000	Paauhau
4.	20,000	Grove Farm	17.	24,000	Hamakua
5.	73,000	Lihue	18.	15,000	Kaiwiki
6.	11,000	Kilauea	19.	19,000	Laupahoehoe
7.	53,000	Waialua	20.	32,000	Hakalau
8.	20,000	Kahuku	21.	24,000	Pepeekeo
9.	84,000	Oahu	22.	24,000	Onomea
10.	60,000	Ewa	23.	33,000	Hilo
11.	56,000	Pioneer	24.	61,000	Olaa
12.	27,000	Wailuku	25.	46,000	Hawaiian Agricultural Co.
13.		Hawaiian C&S Co.	26.	15,000	Hutchinson
	55,000	(A) Paia		1,060,000	TOTAL
	82,000	(B) Puunene			

Figure 1

LOUISIANA

Sugar Mill Locations and Bagasse Production



APPROXIMATE PRODUCTION AND PARISH
(TONS, BONE DRY, 1950-52 AV.)

31,213	Rapides, W. Feliciana, Pointe Coupee
44,556	Lafayette, Vermilion
38,795	St. Martin
70,420	Iberia
113,707	St. Mary
83,820	Assumption
174,258	Lafourche, Terrebonne
43,570	St. John the Baptist
48,471	St. James, Ascension
89,709	Iberville
45,177	East Baton Rouge, West Baton Rouge
783,696	TOTAL

MILLS, IN 1952
- ● No contracts for sale of bagasse and no company use.
- △ Under long-term contract with an insulation board corporation for sale of bagasse.
- □ Under short-term contract with an insulation board corporation for sale of bagasse.
- ■ Bagasse mostly dehydrated and sold as poultry litter and agricultural mulch.
- × Portion of bagasse used for plastics manufacture; rest planned for pulp and paper.

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Figure 2

of well-developed interlocking rail and road transportation systems and proximity to port facilities are shown within the dotted circles in figure 3. Bagasse output is largest in the San Juan area, totaling about 252,000 tons yearly. Annual production in the Arecibo area approximates 229,000 tons, and the mills near the port at Aguirre produce an aggregate of about 215,000 tons. The port facilities at Arecibo were still under construction at the time of this writing, but early completion was expected. Three other factories in Puerto Rico produce about 171,000 tons annually.

The bulk of the output of bagasse in Florida is concentrated in a small area just south of Lake Okeechobee (fig. 4) where about 135,000 tons of fiber are produced annually. An estimated 10,000 to 20,000 tons of this bagasse is presently used there in the production of poultry litter and agricultural mulch.

Cost of Bagasse as a Raw Material

Sugarcane bagasse is composed of 70 percent fiber and 30 percent pith. At present it is used for commercial purposes in the United States essentially in "whole" form. Even dehydrated bagasse, which is roughly screened to remove dirt and loose pith prior to sale as poultry litter, retains a substantial percentage of the pith.

Persons developing processes for manufacturing pulp, paper, and paperboard from bagasse are somewhat divided regarding the need for removal of pith from the fiber prior to pulping to gain certain manufacturing efficiencies and desired quality characteristics of end products. However, the weight of opinion today favors pith removal.

Those who hold that the fiber and pith fractions should be separated maintain that: (1) The pith reduces the quality of pulp and paper products that can be made; (2) its presence reduces operating speed and efficiency and causes more frequent stoppages; (3) most of the pith is eventually lost in any pulping process by chemical action and is therefore lost for possible commercial use; and (4) the cost of prepulping pith separation will be more than compensated for by improved returns for better paper and returns from the sale of pith for use in feed as a carrier of blackstrap molasses or other liquid ingredients.

Those believing the bagasse should be used whole or after only partial depithing by rough screening state that depithing processes capable of complete separation result in high pulping costs through reduced yields. It is also believed by these persons that paper of competitive quality can be made from whole or rough screened bagasse.

Since some bagasse products do not require pith removal and future development may call for the use of both whole and depithed bagasse, the cost in both forms will be developed below.

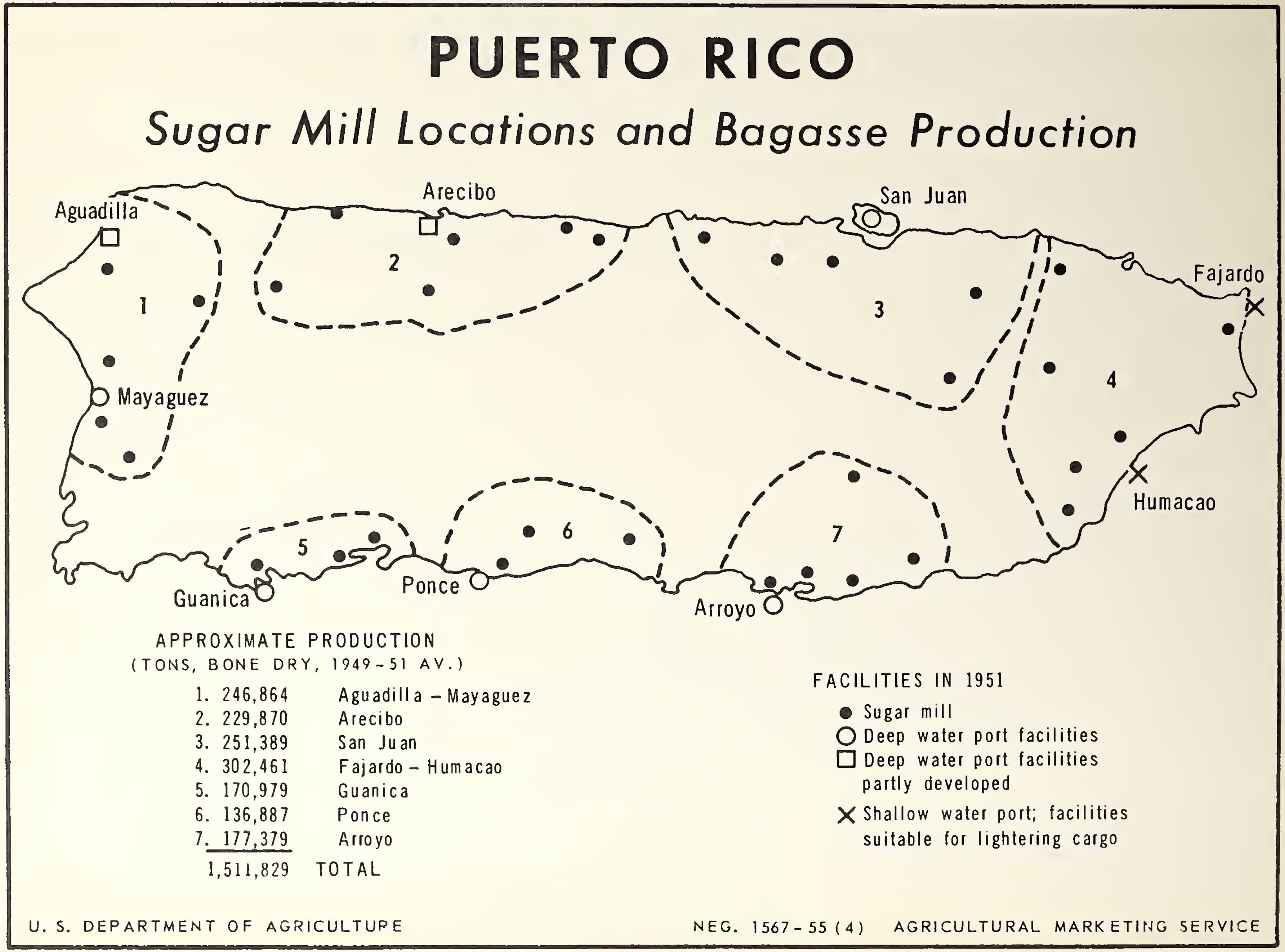
Whole Bagasse

The costs associated with utilizing agricultural residues for commercial purposes generally fall into two categories. These are economic value, or price (on the farm or at the first factory level) and expense of assembling the material at the point of utilization. Economic value for many residues, especially those produced at the farm level, is usually associated with their use as animal or poultry bedding, organic matter for soil building, animal feed roughage, or animal feed ingredient.

Sometimes the value of a residue for one of these purposes is so great that the possibility of its use as a commercial raw material is precluded. For instance, at one time a large manufacturing company used oat hulls, the residue from cereal-making operations, as the raw material for furfural. But in recent years oat hulls have become so valuable as an ingredient in cattle feed that this company has turned to other residues for its raw material supplies.

Bagasse presently has no economic value to the sugar farmer as feed or for other purposes. However, it is a good low-grade fuel to operate the sugar mill and therefore has a value for this purpose about equal to the cost of alternate fuels on a British thermal unit equivalent basis. The bagasse production of a modern sugar factory is adequate to supply the entire fuel requirements of the plant. Where production exceeds fuel requirements, the mill may operate the boilers at lower efficiency or the excess may be discharged onto outdoor piles and burned.

In the domestic areas the sugar mills selling bagasse or using it for commercial purposes have found oil or natural gas the most practical alternative fuels. In view of the fact that returns from the sale of sugar and molasses bear the cost of assembling bagasse at the mill site, sugar mills count only the fuel replacement cost in pricing bagasse. As bagasse first emerges from



PUERTO RICO
Sugar Mill Locations and Bagasse Production
Aguadilla
Arecibo
San Juan
Fajardo
Mayaguez
Humacao
Guanica
Ponce
Arroyo
1
2
3
4
5
6
7
APPROXIMATE PRODUCTION
(TONS, BONE DRY, 1949-51 AV.)
1. 246,864 Aguadilla - Mayaguez
2. 229,870 Arecibo
3. 251,389 San Juan
4. 302,461 Fajardo - Humacao
5. 170,979 Guanica
6. 136,887 Ponce
7. 177,379 Arroyo
1,511,829 TOTAL
FACILITIES IN 1951
Sugar mill
Deep water port facilities
Deep water port facilities partly developed
Shallow water port; facilities suitable for lightering cargo
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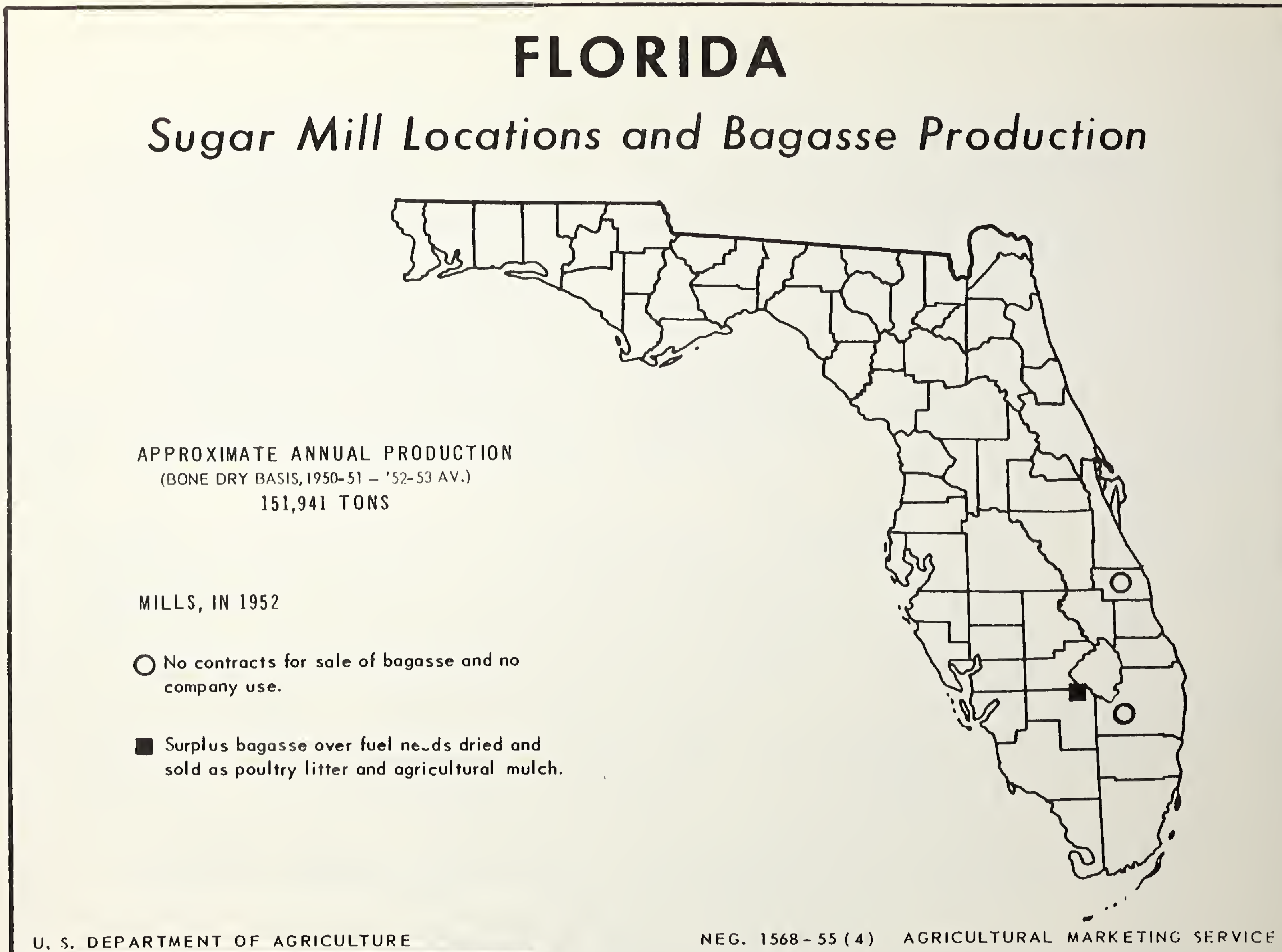
Figure 3


FLORIDA
Sugar Mill Locations and Bagasse Production
APPROXIMATE ANNUAL PRODUCTION
(BONE DRY BASIS, 1950-51 – '52-53 AV.)
151,941 TONS
MILLS, IN 1952
No contracts for sale of bagasse and no company use.
Surplus bagasse over fuel needs dried and sold as poultry litter and agricultural mulch.
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NEG. 1568-55 (4)
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Figure 4

the grinders it contains about 50 percent moisture, and when it is used as fuel it goes directly to the furnaces. Wet bagasse, when burned, has a fuel value of about 6 million B. t. u. a ton.

However, to obtain a uniform basis of pricing bagasse the fuel value is determined on a bone-dry basis. Under actual operating conditions, differences in boiler efficiency or moisture content of the fiber may vary the B. t. u.'s released by the bagasse. Bone dry, the burnable material per ton yields a calculated fuel value of 12 million B. t. u. Natural gas has a heating value of 1,000 B. t. u. per cubic foot and fuel oil a value of about 6 million B. t. u. a barrel. On this basis 12,000 cubic feet of gas or 2 barrels of oil are required to replace a ton of bagasse, bone dry.

In Louisiana the principal replacement fuel is natural gas, whereas oil is used in other areas. Because natural gas is produced in the sugar producing area, the replacement fuel is comparatively inexpensive--about $2 per ton of bagasse, bone-dry basis, at 1952 gas prices (16 2/3 cents per 1,000 cubic feet). In the other areas the replacement fuel must be imported and in 1952 cost about $5 a ton of bagasse at the going prices. While this appears at first to be a rather nominal price for the bagasse, mills realize additional receipts through savings in mill operations with the use of gas or oil rather than bagasse for fuel. According to sugar mill consulting engineers, the overall annual savings in boiler and furnace repair and maintenance and labor to operate the boilers during the season for a mill producing 15,000 tons of bagasse a year, bone-dry basis, would range between $12,000 to $15,000. In addition, in Louisiana, it is customary for the insulation board producer there to pay supplying mills a bonus of about $0.50 a ton, bone-dry basis, over fuel replacement value. Mills which process their own bagasse for commercial purposes calculate raw material price or economic value on the basis of fuel value only.

The other costs associated with bagasse for commercial purposes vary considerably in accordance with a number of factors. For instance, where the user needs only the output of one mill, it is possible to eliminate transportation costs from the sugar mill to the bagasse plant by integrating mill and plant operations. In such cases an endless conveyor would serve as the transport medium, except between sugar processing seasons when bagasse supplies would come out of storage.

However, where users require the output of more than one sugar mill, the cost of assembly at the bagasse plant becomes a fairly large item. It includes not only transportation costs but a portion of the cost of baling as well. (The balance of the baling cost is borne by the storage function as discussed below). The low density of bagasse makes it necessary that it be baled to facilitate handling and transfer to the user's plant. To transport the bagasse in bulk form would be too costly except where the mill and the plant are within close proximity of each other. In Hawaii, for instance, it is estimated that truck transportation costs would approximate 35 cents per dry ton mile for loose bagasse and 10 cents for baled bagasse. Rail rates in Louisiana were about $1.25 per ton per 100 miles in 1952 for wet or cured bagasse (wet baled bagasse partially dried in storage from natural fermentation).

Bagasse must be baled not only to facilitate its transportation, but also to facilitate its storage. Since cane grinding is a seasonal operation, any plan for the commercial use of bagasse must also include provisions for storage of sufficient bagasse during the season to supply the using plant until the next season begins. Baling greatly reduces the space required for storing and permits the bagasse to be placed in stacks through which air can circulate freely removing the heat of fermentation and speeding up the drying.

Bagasse is customarily stored several hundred yards from the mill because of its combustibility. Storage requirements vary considerably between the various areas. In Hawaii such requirements would be nominal, because the sugar production season extends over a 9- to 10-month period. In Louisiana, however, the production period is only 75 to 80 days long. The season in Puerto Rico and Florida extends about 6 months.

The baling of bagasse requires a rather substantial investment in plant and equipment. Based on 1952 experience in Louisiana, baling stations equipped to handle 15,000 tons of fiber, bone-dry basis, per season (75 to 80 days) cost from $200,000 to $250,000 including all equipment plus living quarters for the workers. The typical baler is a heavily reinforced and enlarged version of the hay baler. The bales as made (wet bagasse) weigh around 250 pounds and measure 17 by 21 by 30 inches.

A single baling press has a capacity of about 200 tons of wet bagasse per 24 hours.

The handling and storing of the bales are highly mechanized operations. In Louisiana the bales are moved from the baler to the storage site by open cars on a standard gage railroad. At the storage site a large traveling crane equipped with special tongs lifts the bales from the cars in groups and stacks them in a manner that permits adequate ventilation. The stacks are usually about 66 feet wide, 100 feet long, and 25 feet high. Powdered boric acid is scattered throughout the stack as it is being formed to reduce mold growth and aid in preservation. The finished stacks are covered with corrugated iron sheeting to protect against rain.

During the first few months of storage, fermentation of the residual sugars creates enough heat to reduce the moisture content of the bagasse from 50 to 25 percent. This fermentation-heating also renders the bagasse relatively sterile, and it may be kept in such out-of-door stacks for several years without appreciable loss of the original product--seldom more than 10 percent. When needed by the user, the bagasse is moved out of storage to the truck, railroad car, or barge by the large crane used for stacking.

There is one other cost item associated with the use of bagasse as a raw material--that of converting the furnaces and boilers of the supplying mill to the use of oil or gas as fuel. For a Louisiana mill producing 15,000 tons of bagasse a year, bone-dry basis, the in-plant investment required for the conversion, including new burners, would approximate $5,000 to $7,500 under 1951 conditions, according to consulting sugar engineers. This cost does not include $4 per linear foot for pipe to the gas transmission line. Mills converting to fuel oil would require about the same in-plant investment plus fuel storage tanks.

To summarize, the cost of bagasse as a raw material depends on 4 major variables--its economic value (cost of replacement fuel), the requirements for baling to store or transport bagasse, the requirements for storage as influenced by length of sugar production season, and the requirements for transportation where a user needs the output of more than one mill or is not physically integrated with the supplying mill. Table 2 shows the approximate total cost of these major items for the domestic areas as estimated from various sources for 1952. The economic value of bagasse is much lower in Louisiana than in the other areas. However, in view of the short production season and the lower output per mill, additional cost factors such as baling, storing, loading, and transportation are involved with a larger proportion of Louisiana bagasse than bagasse produced in Florida, Hawaii, and Puerto Rico.

TABLE 2.--Estimated cost per ton of bagasse as a raw material, bone-dry basis, domestic sugarcane areas, 1952

Item	Louisiana	Florida	Puerto Rico	Hawaii
Cost at source of supply	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Fuel replacement cost[1]..	2.00	4.60	4.80	4.80
Other cost items, where involved:[2]				
Baling................	3.00	3.00	3.00	3.00
Storing, stacking and covering bagasse in the field..........	3.25	3.25	3.25	3.25
Loading costs, storage to truck, railroad car or barge........	.55	.55	.55	.55
Total..........	8.80	11.40	11.60	11.60
Transportation costs:[2]				
Truck, per mile:				
Baled.................	0.10	0.10	0.10	0.10
Loose.................	.35	.35	.35	.35
Average per 100 mile haul:				
Rail..................	1.25	1.25	---	---
Barge.................	1.00	---	---	---

[1] Louisiana price based on natural gas rate of 16 2/3 cents per 1,000 cubic feet; Hawaii and Puerto Rico prices based on average delivered price of fuel oil of $2.40 per barrel; Florida price based on average delivered price of $2.30 for fuel oil.

[2] Developed from estimates by Dr. Arthur G. Keller, Professor, Chemical Engineering, Louisiana State University and the Hawaiian Sugar Planters Association.

Depithed Bagasse

The Agricultural Residues Division, Northern Utilization Research Branch, U. S. Department of Agriculture, has done considerable experimental work on bagasse, especially with processes for pulp, paper, and paperboard manufacture. In recent years, research results have indicated to the technologists concerned that it is not possible to make paper of competitive quality from bagasse without removing the pith from the fiber prior to pulping. Researchers at Louisiana State University and certain other research institutions, both private and public, have reached a similar conclusion.

Consequently, in the last few years considerable attention has been devoted to the development of methods for accomplishing complete separation of the fiber and pith fractions. As pointed out earlier, bagasse averages about 70 percent fiber and 30 percent pith, on a bone-dry basis. Screening methods, both dry and wet, have proven to be difficult and do not accomplish a sufficiently complete separation. Chemical separation also seems to have little promise, because the chemical similarity of the two fractions causes a like reaction to the chemicals used. The most promising methods to date are those involving mechanical agitation of the bagasse, loosening the soft pith from the tougher fiber.

Mechanical separation of the pith and fiber can be accomplished either dry or in the presence of cold water. Most of the dry methods subject the bagasse to cutting or crushing action between two metal surfaces in various types of rod mills, hammer mills, and cage mills. This rather violent action shortens the fibers excessively. Such shortening reduces their value for pulping purposes and results in a pith containing an appreciable quantity of fine fibers and reduced yields of separated fiber.

Wet mechanical separation methods generally employ less violent means of separation than dry methods. Wet separation, using the hydrapulper, has been tried successfully on a pilot plant scale at the Northern Utilization Research Branch and in Hawaii by private industry. In this method bagasse at high consistency is agitated with a rotor at the bottom of the hydrapulper tub, producing a high-quality fiber and essentially a fiber-free pith. The hydrapulper has been used for years by the pulp and paper industries to pulp wastepaper and dried pulp. Another wet separation process involving the use of a modified hammer mill and water is being operated on a pilot scale at Louisiana State University.

The results of wet separation tests indicate that it is technically possible to obtain practically complete separation of the fiber and pith fractions of bagasse. However, the economic feasibility of the wet process is still in doubt. To date only the relatively inexpensive dry separation methods are used commercially. Table 4 shows data on the cost of bagasse depithed by dry methods as presented in "Raw Materials for More Paper" (9, p. 66)[1] Based on 1952 information, a metric ton (2,204.6 pounds) of depithed bagasse would cost an average of $10 in the Caribbean area delivered to pulp mills. This includes the economic value of sufficient bagasse to obtain a ton of dried and baled pith-free fiber and the cost of the necessary plant and equipment. Converted to a short-ton basis, this cost would equal about $9 a ton.

At the time data were assembled for this report, the Northern Utilization Research Branch was the only source of fairly well determined cost estimates for a wet separation process. Based on 1954 data, the NURB reported that a ton of pith-free fiber using the hydrapulper would cost about $18 under Louisiana conditions. This does not include provisions for possible storage and transportation costs. It is assumed by the writers that the per-ton cost of these operations would be about equal to their cost for whole bagasse. As with whole bagasse, the elimination of baling, storing, and transportation costs by integrating sugar mill bagasse plant operations would yield savings in raw material cost. It was estimated by NURB that a wet separation plant capable of handling the output of a sugar mill producing 600 tons of bagasse in 24 hours would have cost about $100,000 to $110,000 in 1953.

At present work is being conducted at NURB on the use of the wet separated pith as a high quality carrier for blackstrap molasses in cattle feeds to improve the economic feasibility of the more costly wet process. The use of dry screened pith for this purpose has been only moderately successful to date. But it is believed by the researchers at NURB that pith separated by the wet method has the necessary quality characteristics to greatly expand the pith-molasses feed market.

Research on the possible market potential for this feed is presently going forward at the Agricultural Marketing Service, U. S. Department of Agriculture, and other institutions, both private and public. Unlike dry screened pith, the wet separated material contains almost no residual fibers. Residual fibers in any significant quantity are highly undesirable, since they substantially reduce the absorptive capacity per pound of pith.

MARKET POTENTIALS FOR PRESENT AND POSSIBLE BAGASSE PRODUCTS

The following portions of this report present economic and marketing information and analyses for bagasse products presently being produced which appear to have possibilities for future growth. Analyses are also presented for bagasse products which, from experimental and

[1] Underscored numbers in parentheses refer to Literature Cited, p. 81.

pilot plant tests, appear to have possibilities for commercial development. The material has been assembled and analyzed in the following manner: (1) To shed additional light on the commercial possibilities of bagasse; (2) to give persons considering the commercial use of bagasse more information on which to base their decisions, and (3) to give persons presently producing bagasse products data on the feasibility of expanding production and marketing of such products. Products covered are paper, paperboard, pulp, including market pulp, insulation board, hardboard, furfural, poultry litter, and agricultural mulch.

Paper and Paperboard[2]

For more than 100 years, fiber technologists working in the field of agriculture residue utilization have devoted considerable time and effort to the development of processes to produce paper and paperboard from bagasse. One process dates as far back as 1838. Hundreds of patents have been granted for this purpose, and considerable literature on the subject has been published the world over. There were no successful attempts to produce paper and paperboard commercially from bagasse, however, until about 1938. This was preceded by rather extensive experimental work in various parts of continental United States, and in Hawaii, Argentina, England, Peru, Japan, and the Philippines.

According to information in late 1952, nine mills were in operation; all of these were outside the United States. However, one producer began operation in Louisiana in mid-1954. Practically all the mills outside this country are in areas without large quantities of available low-priced competing wood fiber and a well established paper industry. They are in Formosa, the Philippines, Peru, Argentina, Colombia, India, and Brazil, and are producing paper and paperboard of various kinds from bagasse pulp or mixtures of bagasse and wood pulps. In these areas it has not been necessary to build plants as large as would have been required for economic operations in this country. Most have capacities of 25 tons of pulp per 24-hour day or less, whereas 100 tons per day or perhaps more is believed by many persons to be the minimum capacity for commercial ventures using wood fiber in the United States.

The plant recently constructed in Louisiana, a subsidiary of a sugar company, is reported to have a capacity of about 50 tons of pulp per day to be made from whole bagasse. The sugar mill and the bagasse plant are not physically integrated but are close to each other. The bagasse plant will be able to obtain the bulk of its raw material from the affiliated sugar enterprise, though supplementary supplies purchased from nearby mills will probably be required. When the plant was in the planning stage, manufacturing plans called for the production of dissolving pulp (a raw material for rayon and cellophane manufacture) and newsprint. It is understood that more recently production plans have been changed, and these products may not be among the items produced in important quantities.

Possibilities for Bagasse as a Commercial Raw Material

Likely Bagasse Products as Apparent From Quality Characteristics

At the time field data were being assembled for this study there were no bagasse pulp, paper, and paperboard products being marketed in the United States. Thus it was not possible to obtain information from distributors and users of pulp and paper on the comparative quality of products made from bagasse and competing raw materials. However, many of the persons interviewed who were conducting research on the manufacture of pulp and paper from bagasse at public and private institutions or promoting a developed proprietary process for its manufacture believed that paper of competitive quality can be made from bagasse pulp or from mixtures of bagasse and wood pulps. And most were armed with samples of products and results of quality tests made in laboratories or pilot plants with which to back up their belief.

As indicated earlier, in general, the persons interviewed stated that it is essential to separate the majority of the pith from the bagasse fiber mechanically before pulping if a good quality product is to be made on modern high-speed machines. A few persons stated that depithing was not

[2] The "paper and allied products" field includes paper and paperboard, pulp, and building fiberboards (insulation board and hardboard). Certain statistics on pulp and building fiberboards are included with paper and paperboard data where they are complementary and help develop more meaningful analysis or where it was not possible to separate out the data. These exceptions are noted.

necessary for the process they were sponsoring. However, it is believed in other quarters that such processes accomplish relatively complete pith removal through digestion by the pulping chemicals used and excessive washing and bleaching of the pulp. Pulps made in this manner are reported to be slow running on the paper machines and to produce brittle, hard papers, not likely to be of competitive quality in this country.

Bagasse, principally that depithed by dry mechanical processes, is presently being used for the manufacture of a wide variety of paper and paperboard in other countries. Unbleached 100-percent bagasse pulps have been found to be well adapted for corrugated board. However, bagasse pulp must be mixed with long fiber wood pulps to produce strong wrapping and bag papers. Bagasse fibers are short, and their hemicellulose content is comparatively high, causing pulp made from this material to form dense papers with low tear resistance and opacity. Relatively good grease-proof and glassine papers may, however, be made from bagasse without admixture of long-fibered pulps.

Most newsprint is manufactured in the United States from a mixture of 80-percent groundwood (produced by mechanical grinding) and 20-percent coniferous sulfite and sulfate wood pulps. The chemical pulps are needed to bind the pulp together and improve printability. A number of the persons interviewed stated that bagasse pulps, all of which are chemically produced, would perform the same functions as the chemical wood pulps and would therefore be competitive with them as a raw material for newsprint production. In addition, bagasse pulp may be used to replace the coniferous chemical wood pulps in magazine papers or combined with de-inked waste news.

For the manufacture of fine papers such as bond, tablet, ledger, and book, bagasse pulp was described as being a very desirable supplement to wood pulp. When blended in suitable proportion bagasse pulp improves sheet formation, surface characteristics, and printability of such papers. For these uses, bagasse pulp is not a replacement or substitute but one with special use characteristics.

The Food and Agriculture Organization publication referred to earlier entitled "Raw Materials for More Paper" (9, pp. 49 - 63) contains a discussion of the most likely uses for bagasse pulps made by each of five processes. That publication was prepared by pulp and paper experts from all over the world. Many of the United States specialists who participated in its preparation were among the persons interviewed in this study, and their comments indicated that they generally concurred in its conclusions. The kinds of paper and paperboard for which the publication indicates that pulp from depithed bagasse is suitable both with and without mixture with wood pulps are summarized in table 3. Table 3 shows further the major uses for each type of paper and the proportions in which the publication suggests bagasse and wood pulps should be blended to produce paper of acceptable quality.

The symbols shown in the table indicate which type of pulp should be blended with the bagasse pulp. Where several pulps are indicated for mixture with the bagasse it means that one of them or mixtures may be used. The symbol (F) is shown in certain instances where bagasse pulp in proportions of 60 to 90 percent of the total is suggested. This indicates that the balance may either be bagasse pulp or another type of pulp.

Except for corrugating medium and possibly second-quality fine paper, third-strength wrapping paper, and grease-proof and glassine papers, the publication concludes that bagasse pulp should be mixed with one or more wood pulps, usually long-fibered coniferous, to produce papers of acceptable quality. Some researchers and proprietary process owners interviewed disagreed somewhat with the opinions of the consultants and technicians who prepared the FAO report about the necessity of mixing such large quantities of wood pulps with bagasse pulps to produce acceptable quality paper or with the suggested proportions of bagasse and wood pulp. And their positions may be well founded.

It should be pointed out here that the data summarized in table 3 are very general and simplify a complicated problem. New techniques are continually being developed altering viewpoints and opinions. In addition, market demands differ in various consuming areas. For instance, in certain undeveloped areas, it is reported that 100 percent bagasse pulp is used for practically all grades of paper and paperboard due to lack of competition from products made from other raw materials. However, in the United States market competition is quite keen and consumers much more quality conscious.

The most recent United States publication containing results of bagasse pilot plant pulping tests was issued July 1953 by

TABLE 3.—Paper and paperboard products possible from bagasse, by processes and type of pulp

Bleached pulp

Type of paper	Soda and sulfate		Neutral sulfite		Caustic soda chlorine		Mechano-chemical		Hot lime	
	Percentage bagasse	Pulp blended with bagasse[1]	Percentage bagasse	Pulp blended with bagasse[1]	Percentage bagasse	Pulp blended with bagasse[1]	Percentage bagasse	Pulp blended with bagasse[1]	Percentage bagasse	Pulp blended with bagasse[1]
	Percent		*Percent*		*Percent*		*Percent*		*Percent*	
Newsprint[2]	0-20	A	0-20	A	0-20	A	0-20	A	—	—
Magazine and second quality book paper[3]	20-60	ABE	20-60	ABE	20-60	ABE	20-60	ABE	—	—
Bookpaper first quality[4]	20-60	ABDE	20-60	ABDE	60-90	ABDE	20-60	ABDE	—	—
Fine paper first quality[5]	60-90	DE	60-90	DE	60-90	DE	60-90	DE	—	—
second quality[6]	60-90	F	60-90	F	60-90	F	60-90	F	—	—
Greaseproof[7]	20-60	B	60-90	F	60-90	F	60-90	F	—	—
Unbleached pulp										
Wrapping										
First strength[8]	—	—	0-20	C	0-20	C	0-20	C	—	—
Second strength[9]	0-20	BC	20-60	BC	20-60	BC	20-60	BC	—	—
Third strength[10]	60-90	F	60-90	F	60-90	F	60-90	F	—	—
Kraft liner[11]	0-20	C	20-60	C	20-60	C	20-60	C	—	—
Corrugating medium[12]	100.0	—	100.0	—	100.0	—	100.0	—	100.0	—

[1] The block letters (A, B, C, D, E, F) indicate the kind of pulp with which bagasse should be blended. When several are indicated it means that one of them or mixtures of them may be used. The key for the types of pulp which should be used is as follows:

- A - Ground wood
- B - Unbleached coniferous sulfite
- C - Unbleached coniferous kraft
- D - Bleached coniferous chemical pulp, sulfite or sulfate
- E - Bleached broadleafed chemical pulp
- F - Balance may be bagasse or another type of pulp.

[2] Used for newspapers. [3] Magazines, catalogs, telephone directories, pamphlets, folders, and books. Base paper for machine coating. [4] Books, offset, lithograph. [5] High quality printing paper, bond, ledger and writing, bristol. [6] Bond and writing papers with low brightness and lower strength than those above, also tablet. [7] Greaseproof, glassine, and tracing. [8] Kraft paper, multiwall bags. [9] Most kinds of wrapping and bag paper, combination board liner. [10] Wrapping paper, requiring only low strength and building paper. [11] Liner for corrugating board and combination board. [12] Corrugating medium and center ply in combination board.

the Agricultural Residues Division, Northern Regional Research Laboratory[3], U. S. Department of Agriculture. The paper was entitled "Blends of Mechano--Chemical Sugarcane Bagasse Pulp With Wood Pulps in Various Grades of Machine-Made Papers" (20). This publication presents a number of paper samples of various grades produced by the mechano-chemical process from several types of pulps and pulp blends. The bagasse pulps used were depithed prior to pulping by the wet process using the hydrapulper.

No comments are made as to estimated production costs or relative quality compared to such products made from wood pulp. However, samples of paper made from conventional type pulps are included, and the bagasse papers seem to compare favorably from the standpoint of appearance and strength. The papers made and pulps used are listed below to illustrate some of the experimental and pilot plant work presently being done on bagasse pulp and paper in the United States:

Type of Paper	Pulp or Pulp Blend
Bond	100 pct. bleached bagasse
Bond	100 pct. bleached bagasse; added clay equal to 25 pct. of weight of pulp
Bond	50 pct. bleached balsam sulfite; 50 pct. bleached bagasse; added clay equal to 10 pct. of weight of pulp
Magazine Book	15 pct. bleached balsam sulfite; 60 pct. unbleached groundwood; 25 pct. bleached bagasse; added clay equal to 7 pct. of weight of pulp
Newsprint	70 pct. unbleached spruce-aspen groundwood; 30 pct. bleached bagasse; added clay equal to 7.5 pct. of weight of pulp
Newsprint	40 pct. unbleached tupelo groundwood; 30 pct. unbleached spruce-aspen groundwood; 30 pct. bleached bagasse; added clay equal to 7.5 pct. of weight of pulp

[3] Now known as the Northern Utilization Research Branch.

Type of Paper	Pulp or Pulp Blend
Newsprint	75 pct. unbleached southern pine groundwood; 25 pct. semibleached southern pine sulfate
Newsprint	70 pct. unbleached southern pine groundwood; 15 pct. semibleached southern pine sulfate; 15 pct. semibleached whole bagasse
Newsprint	60 pct. unbleached southern pine groundwood; 20 pct. semibleached southern pine sulfate; 20 pct. semibleached whole bagasse
Newsprint	60 pct. unbleached southern pine groundwood; 15 pct. semibleached southern pine sulfate; 25 pct. semibleached whole bagasse
Newsprint	65 pct. unbleached southern pine groundwood; 20 pct. semibleached southern pine sulfate; 15 pct. semibleached whole bagasse
Newsprint	65 pct. unbleached southern pine groundwood; 20 pct. semibleached southern pine sulfate; 15 pct. semibleached bagasse
Newsprint	60 pct. unbleached southern pine groundwood; 15 pct. semibleached southern pine sulfate;, 25 pct. semibleached bagasse
Newsprint	60 pct. unbleached southern pine groundwood; 15 pct. semibleached southern pine sulfate; 25 pct. semibleached bagasse; added clay equal to 5 pct. of weight of pulp
Bag Kraft	75 pct. unbleached jack pine sulfate; 25 pct. unbleached bagasse
Wrapping Kraft	100 pct. unbleached jack pine sulfate
Wrapping Kraft	50 pct. unbleached jack pine sulfate; 50 pct. unbleached bagasse

This publication contained no samples of paperboard. However, the Agricultural Residues Division and other research and development organizations have made excellent corrugated board with unusual strength characteristics and good quality liner board for containers using only bagasse pulp and mixtures of bagasse and wood pulp.

Bagasse Pulping Costs Compared to Pulping Costs of Competing Raw Materials

It was not possible in this study to assemble firsthand information on commercial costs of producing paper and paperboard from bagasse in the United States, since there were no commercial plants in operation. Cost estimates based on laboratory or pilot plant tests were also unavailable except on a very fragmentary basis due to the fact that process developers naturally regard such data as highly confidential. As a result, the literature was searched for information of this nature which would be significant and of value to persons considering a bagasse paper or paperboard enterprise.

TABLE 4.--Unit prices used in estimating cost of producing pulp

Item	Unit	Price [1]
		Dollars
Coniferous pulpwoods	Cord	25.00
Broadleafed wood		
Temperate	....do	19.00
Tropical	....do	10.00
Straw, 90 percent dry	Metric ton[2]	15.00
Bagasse, depithed and 90 percent dry	....do	10.00
Bamboo, as in India and 90 percent dry	....do	24.00
Chemicals[3]		
Caustic soda	Kilogram[4]	.077
Chlorine	....do	.084
Quicklime (CaO)	....do	.015
Hydrated lime	....do	.015
Limestone	....do	.004
Salt	....do	.010
Saltcake	....do	.030
Soda ash	....do	.030
Sodium silicate	....do	.030
Sulfur	....do	.030
Services[5]		
Electricity	Kilowatt hour	.008
Steam	Metric ton[2]	1.65
Water	1,000 U.S. gallons	.05
Labor[6]		
Operating, including direct plant supervision	Man-hour	1.70
Repair and maintenance	....do	2.50

[1] Prices for coniferous pulpwoods, temperate broadleafed woods, and tropical broadleafed woods are based on wood delivered at mill and barked and chipped for digesters or delivered to grinders; prices for straw, bagasse, and bamboo are based on material cut, delivered, cleaned, and dusted ready for digesters. Prices of coniferous and temperate broadleafed woods are representative for the United States, tropical broadleafed woods for areas in which produced, bagasse for the Caribbean area, bamboo for India.
[2] Metric ton equals 2,204.6 lbs.
[3] Approximate 1952 U. S. prices, f.o.b. U. S. ports.
[4] Kilogram equals 2.2046 lbs.
[5] Approximate 1952 prices for integrated mills (producing both pulp and paper) in industrially advanced countries such as the United States.
[6] Reduced to common denominator for the various underdeveloped countries in which FAO is conducting programs and developed countries such as the United Statea.

Data from "Raw Materials for More Paper" (9).

Table 5.--Estimated cost per metric ton of producing various types of pulp from various types of raw materials, 1952

Type of pulp and raw material	Cost: Fiber raw material[1]	Cost: Miscel-laneous materials	Cost: Chem-icals	Operating expenses: Power	Operating expenses: Steam	Operating expenses: Water	Labor: Operat-ing	Labor: Repair	Repair and maintenance materials	Super-vision and overhead	Deprecia-tion, plant equipment	Total	Plant investment excluding steam and power	Working capital required	Daily capacity on which costs are based	Pulp yield
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Million dollars*	*Million dollars*	*Tons*	*Percent*
Groundwood pulp, coniferous wood																
Newsprint grade	29.40	.50	--	8.80	--	0.52	3.74	0.75	3.00	1.50	5.50	53.71	1.2-1.5	0.6-1.0	50	95.0
Steamed paperboard	34.30	.50	--	4.80	--	1.95	8.50	.75	3.50	2.50	6.60	63.40	1.2-1.5	0.6-1.0	50	85.0
Sulfate																
Unbleached pulp																
Coniferous wood	44.10	--	4.32	3.20	0.33	1.30	8.50	2.50	3.00	4.00	11.50	82.75	4.5-6.0	1.5-3.0	100	48.0
Tropical broadleafed wood	12.00	--	4.01	2.60	--	1.30	8.50	2.50	3.00	4.00	11.50	49.41	4.5-6.0	1.0-3.0	100	52.0
Straw, paperboard grade	25.50	--	3.90	3.20	2.48	1.30	8.50	2.50	3.00	4.00	12.00	66.38	2.5-3.5	1.0-1.5	50	60.0
Bagasse																
Paperboard grade	15.00	--	3.90	3.20	2.48	1.30	8.50	2.50	3.00	4.00	12.00	55.88	2.5-3.5	1.0-1.5	50	68.0
Wrapping paper grade	18.50	--	6.80	3.20	.83	1.30	8.50	2.50	3.00	4.00	12.00	60.63	2.5-3.5	1.0-1.5	50	55.0
Bamboo	48.00	--	7.70	3.20	.83	1.30	8.50	2.50	3.00	4.00	11.50	90.53	2.5-3.5	1.0-1.5	50	50.0
Bleached pulp																
Bamboo	60.00	--	17.27	4.00	2.80	3.25	10.20	3.75	4.00	5.00	14.00	124.27	2.5-3.5	1.0-1.5	50	40.0
Coniferous wood	51.45	--	14.61	4.00	2.80	3.25	10.20	3.75	4.00	5.00	13.00	112.06	4.5-6.0	1.5-3.0	100	43.0
Tropical broadleafed wood	13.20	--	12.47	3.40	2.47	3.25	10.20	3.75	4.00	5.00	13.00	70.74	4.5-6.0	1.0-3.0	100	48.0
Straw	33.00	--	15.33	4.00	2.80	3.25	10.20	3.75	4.00	5.00	14.00	95.33	2.5-3.5	1.0-1.5	50	45.0
Bagasse																
All chemicals purchased	21.00	--	16.17	4.00	2.80	3.25	10.20	3.75	4.00	5.00	14.00	84.17	2.5-3.5	1.0-1.5	50	48.0
Electrolytic plant to recovar chemicals	21.00	--	7.50	6.00	2.80	3.25	11.90	5.00	5.00	5.00	16.00	83.45	2.9-3.9	1.0-1.5	50	48.0
Sulfite																
Bleached pulp, Coniferous wood	52.92	--	12.97	2.96	5.78	5.20	9.78	3.75	4.00	5.00	13.00	115.36	5.0-6.0	2.0-3.0	100	42.0
Unbleached pulp, coniferous wood	49.00	--	5.70	2.40	4.95	2.60	8.50	2.50	3.00	4.00	11.50	94.15	5.0-6.0	2.0-3.0	100	46.0
Neutral sulfite																
Semichemical pulp, temparate broadleafed woods																
Corrugating board grade	20.47	--	5.92	2.80	3.30	1.04	5.10	1.25	2.00	2.50	7.00	51.38	1.0-1.5	0.5-0.8	50	75.0
Bleached for printing paper	25.87	--	23.41	3.44	5.78	2.21	6.80	2.50	3.00	3.00	9.00	85.01	1.5-2.0	0.5-0.8	50	58.0
Unbleached pulp, straw	24.00	--	5.80	1.60	2.48	.98	11.90	1.25	2.00	5.00	9.00	64.01	0.7-1.3	0.3-0.5	20	62.0
Bleached pulp, straw	33.00	--	17.70	3.04	4.95	1.95	13.60	2.50	3.00	5.00	12.00	96.74	0.7-1.3	0.3-0.5	20	45.0
Lime pulp, straw paperboard grade	20.25	--	2.73	.96	1.50	.33	10.20	1.25	1.50	4.00	7.00	49.72	0.5-0.8	0.2-0.3	20	75.0
Cold caustic groundwood, semibleached pulp, temperate broadleafed woods	17.25	--	18.86	4.80	0.00	1.04	6.80	2.50	2.00	2.00	7.00	62.25	1.2-1.5	0.5-0.8	50	88.0

[1] Raw material pricas adjusted from thosa shown in tabla 4 to reflect pulp yield.

Summarized from data included in "Raw Materials for More Paper" (9).

It is believed that the best published data on bagasse product manufacturing costs are shown in the FAO publication (9, pp. 67-83) discussed in the preceding section entitled "Likely Bagasse Products as Apparent From Quality Characteristics." In preparing the publication, the specialists were asked to develop manufacturing costs for products made from available unused or little-used raw materials where the pulping of such products appeared technically feasible and to make general comparisons with manufacturing costs for such products using conventional raw materials.

Table 5 summarizes the process cost estimates based on 1952 conditions as presented in the FAO publication. The unit prices used as a basis for estimation are shown in table 4. The cost factors used are for modern operations in the main pulp-producing countries. Readers are cautioned that the estimates are not from specific experiences and are to be used for general comparisons only. Careful investigation and analysis must be made of each individual proposal for new pulp, paper, or paperboard facilities to provide the answer to economic feasibility. The process costs shown cover only the first stage of processing, the production of slush pulp. Additions of $8 to $15 per short ton are suggested as reasonable allowances for sheeting and drying the pulp to 10- to 15-percent moisture content.

It is noted that the costs of producing depithed bagasse pulps compare favorably with pulp costs using other raw materials. The costs of producing unbleached and bleached bagasse sulfate pulps are lower than all the other unbleached and bleached sulfate pulps except those produced from tropical broadleafed wood. Three other pulps, made by processes other than sulfate, are slightly less costly to produce than unbleached sulfate bagasse pulp. These are groundwood pulp (newsprint grade), neutral sulfite semichemical pulp for corrugated board using temperate broadleafed woods, and straw pulp for paperboard using the lime process.

Market Potential for Paper and Paperboard

Industry Growth

Since 1930, the United States paper and paperboard industry has almost tripled, in terms of tons of output (table 6). The trend in production has been strongly upward each year except during the depression of the early 1930's and in the World War II period, when materials restrictions precluded the development of any substantial additional capacity. Prior to World War II increases in rated capacity were well in advance of production increases (see table 6). But since 1940 production growth has almost kept up with capacity growth, and the production-capacity ratio has ranged between 85 and 95 percent most years.

In 1951 production exceeded rated capacity slightly. Tonnagewise, capacity is increasing at the highest rate in the industry's history. During the past 10 years the increase in capacity has averaged 864,400 tons per year as compared to 325,000 during the 1930's, 510,000 in the 1920's, 295,000 from 1909 to 1920, and 251,000 from 1899 to 1909. It was estimated by Dobrow (6) that capacity in 1954 would exceed that existing in 1953 by 885,000 tons.

TABLE 6.--Paper and paperboard: Production, rated capacity, and production as a percentage of capacity, 1930-54 [1]

Year	Production	Capacity [2]	Production as a percentage of rated capacity
	1,000 tons	*1,000 tons*	*Percent*
1930	10,169	13,643	74.5
1931	9,382	13,972	67.1
1932	7,998	13,728	58.3
1933	9,190	13,728	66.9
1934	9,187	13,888	66.2
1935	10,479	13,986	74.9
1936	11,976	14,458	82.8
1937	12,837	15,573	82.4
1938	11,380	16,191	70.3
1939	13,510	16,557	81.6
1940	14,484	16,891	85.7
1941	17,762	18,522	95.9
1942	17,084	18,772	91.0
1943	17,036	18,830	90.5
1944	17,183	19,260	89.2
1945	17,371	20,282	85.6
1946	19,278	20,420	94.4
1947	21,114	22,025	95.9
1948	21,897	23,389	93.1
1949	20,315	23,954	84.8
1950	24,375	24,480	99.6
1951	26,048	25,346	102.8
1952	24,423	27,578	88.6
1953	[3] 26,566	27,904	95.2
1954	--	[4] 29,475	--

[1] Includes building fiberboards and building paper.
[2] Based on 310-day year.
[3] Preliminary.
[4] Estimated by Morris C. Dobrow (6)

Data for 1930-51 from "The Statistics of Paper, 1952" (2); 1952 and 1953 from "Pulp, Paper and Board" (37), and "Lockwood's Directory of the Paper and Allied Trades" (15)

Except for newsprint, the production of paper and paperboard essentially represents consumption. This country is a small net exporter of all other types of paper and of paperboard (table 7). In the case of newsprint, we are dependent on imports for over 80 percent of our requirements. Most newsprint comes from Canada where large supplies of timber considered ideal for this type of paper are available at relatively low prices. Canadian newsprint enters duty free.

TABLE 7.--Foreign trade in paper and paperboard, 1946-53

Year	Newsprint paper		Printing paper		Wrapping, bag, and converting paper[1]		Fine paper		Tissue paper		Absorbent, sheathing, building and industrial paper		Other paper		Paperboard[5]		All paper and paperboard	
	Imports	Exports	Imports	Exports[1]	Imports	Exports	Imports	Exports	Imports[2]	Exports[3]	Imports[4]	Exports	Imports	Exports	Imports	Exports	Imports	Exports
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1946.......	3,492	28	80	44	7	44	1	81	(6)	7	1	13	0	0	13	61	3,594	278
1947.......	3,958	28	74	54	23	41	2	68	(6)	8	1	14	0	1	26	97	4,084	311
1948.......	4,395	28	83	44	18	29	2	45	(6)	5	(6)	10	2	0	45	98	4,545	259
1949.......	4,639	39	28	28	6	28	1	44	1	10	1	12	0	20	48	89	4,724	270
1950.......	4,863	44	35	20	11	40	1	39	(6)	7	2	11	1	14	55	98	4,968	273
1951.......	4,953	71	47	34	11	77	1	48	(6)	7	2	13	11	27	81	226	5,106	503
1952.......	5,033	105	43	48	10	88	1	40	(6)	5	2	10	0	29	57	149	5,146	474
1953.......	5,004	47	41	16	35	54	2	34	2	6	4	12	1	21	100	173	5,189	363

1 Book paper, uncoated.
2 Tissue and crepe paper.
3 Sanitary and tissue paper.
4 Absorbent and building only.
5 Excludes building board.
6 Less than 500 tons.
Data for 1946, "The Statistics of Paper, 1952" (2); 1947-53 from "Pulp, Paper and Board" (37).

Figure 5 shows total consumption or new supply (production plus imports less exports) of paper and paperboard from 1930 to 1953 and projections of consumption to 1960. The indicated potential consumption in 1960 for paper and for paperboard, not including building paper and board, is 18-1/2 million tons and 14 million tons, respectively.

Consumption of paper and paperboard has not only increased in total quantity but on a per capita basis as well. Currently the average American is consuming about 392 pounds a year as compared to 254 pounds in 1940, 201 pounds in 1930, 91 pounds in 1909, and 58 pounds in 1899 (table 8).

TABLE 8.—Per capita consumption of paper and paperboard, specified years[1]

Year	Quantity	Year	Quantity	Year	Quantity	Year	Quantit
	Pounds		Pounds		Pounds		Pounds
1899...	58.0	1935...	200.4	1944...	281.6	1949...	331.0
1909...	90.6	1940...	254.0	1945...	281.8	1950...	382.5
1920...	144.6	1941...	306.6	1946...	318.8	1951...	396.1
1925...	179.8	1942...	293.7	1947...	343.7	1952...	369.7
1930...	200.6	1943...	284.8	1948...	355.9	1953...	[2] 392.4

1 Includes building paper and building fiberboards.
2 Preliminary.

Data from 1899 to 1951 from "The Statistics of Paper, 1952" (2). Data for 1952 and 1953 from "Pulp, Paper and Board" (37).

Growth of Various Segments of the Paper and Paperboard Industry

Paper.--Since 1940 each segment of the paper industry has shown growth, but some minor shifts have taken place in their relative importance to total output (table 9). Percentagewise, tissue paper consumption has expanded more rapidly than that of other papers, while the consumption of coarse papers has expanded less rapidly than the average. The consumption of newsprint, printing papers, and fine paper has remained approximately the same, as a percentage of the total, over the period covered.

Two-thirds of all "coarse papers" are kraft papers for packaging purposes. They include wrapping, bag, and converting papers. Wrapping papers include butchers, kraft, glassine, greaseproof, vegetable parchment, and bogus wrappers. Bag papers include kraft grocery and variety bags, glassine, greaseproof, vegetable parchment, and waxed bags and shipping sacks. And converting papers include asphalting stock, envelope and gumming stock, twisting and spinning, waxing stock over 18 pounds weight, and paper cup stock. Since 1942 the production of glassine, greaseproof, and vegetable parchment wrapping and bag papers, and other wrapping papers has not changed in terms of total output. However, the production of other types of bag paper and of converting papers has increased. The growth of shipping sack production has been especially significant since 1942.

Tissue paper includes all types of sanitary and wrapping tissues. In order of importance from a volume standpoint are toilet tissue, towels, facial tissues, napkins, and wrapping tissues.

The fine paper group is comprised of writing papers, cover and text, bristols, and thin paper. More than 80 percent of the fine papers are writing papers followed in order by bristols, thin (such as cigarette), cover, and text. Since 1942, practically all the growth of the production of

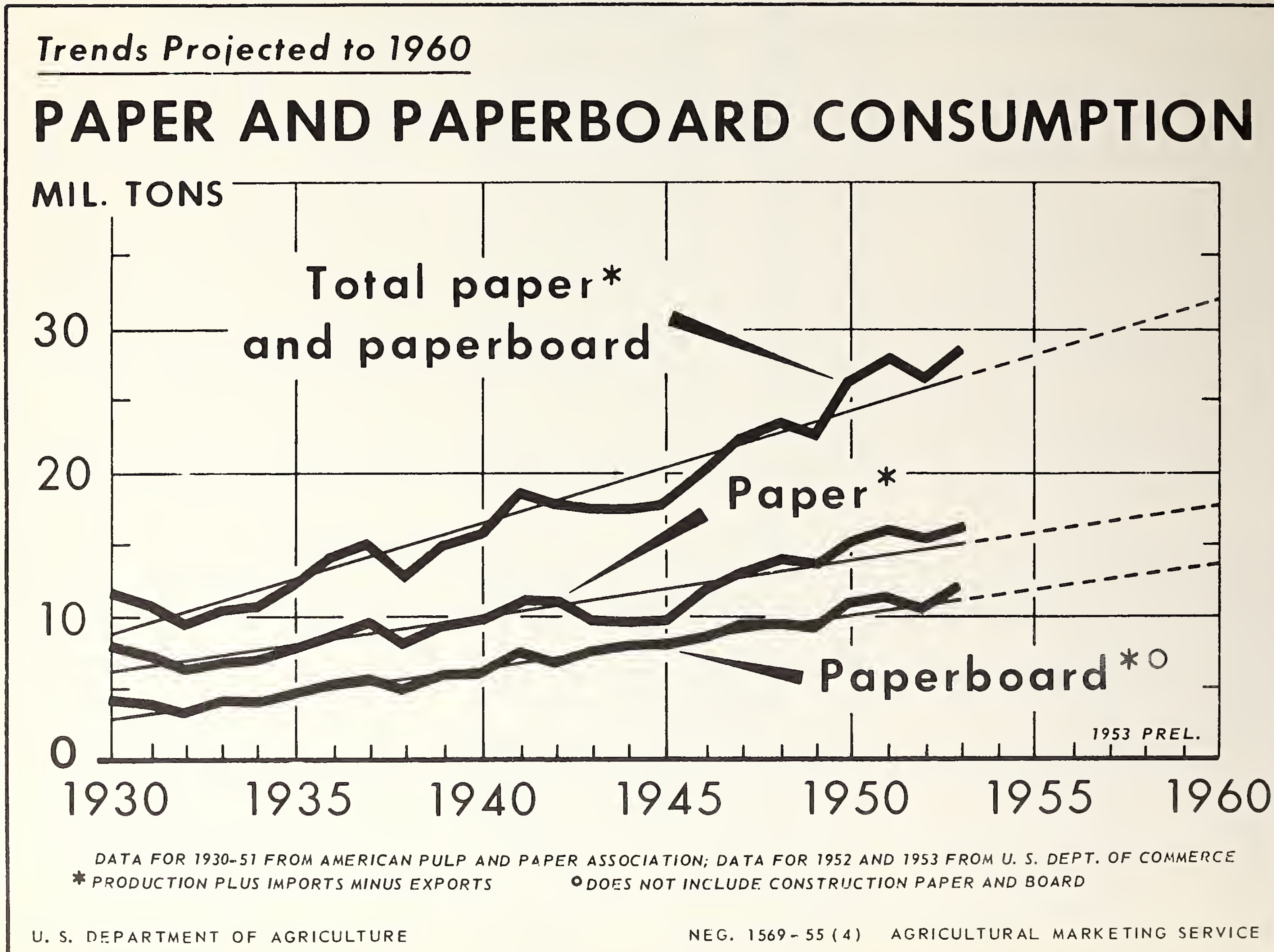

Trends Projected to 1960
PAPER AND PAPERBOARD CONSUMPTION
MIL. TONS
30
20
10
0
Total paper*
and paperboard
Paper*
Paperboard*°
1953 PREL.
1930
1935
1940
1945
1950
1955
1960
DATA FOR 1930-51 FROM AMERICAN PULP AND PAPER ASSOCIATION; DATA FOR 1952 AND 1953 FROM U. S. DEPT. OF COMMERCE
* PRODUCTION PLUS IMPORTS MINUS EXPORTS
° DOES NOT INCLUDE CONSTRUCTION PAPER AND BOARD
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1569-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 5

TABLE 9.—Consumption of major types of paper, 1940-53[1]

Year	Quantity						Percentage					
	Newsprint	Printing papers, except newsprint	Fine paper	Coarse paper	Tissue paper	Total	Newsprint	Printing papers, except newsprint	Fine paper	Coarse paper	Tissue paper	Total
	Million tons	Million tons	Million tons	Million tons	Million tons	Million tons	Percent	Percent	Percent	Percent	Percent	Percent
1940	3.8	2.2	.7	2.4	.7	9.8	38.9	22.4	7.1	24.5	7.1	100.0
1941	4.0	2.6	.9	2.5	.9	10.9	36.6	23.9	8.3	22.9	8.3	100.0
1942	3.8	2.3	1.0	2.5	1.0	10.6	35.9	21.7	9.4	23.6	9.4	100.0
1943	3.4	2.2	.9	2.3	.9	9.7	35.0	22.7	9.3	23.7	9.3	100.0
1944	3.2	2.2	.9	2.3	.9	9.5	33.6	23.2	9.5	24.2	9.5	100.0
1945	3.3	2.1	.9	2.4	1.0	9.7	34.1	21.6	9.3	24.7	10.3	100.0
1946	4.2	2.7	1.1	2.7	1.0	11.7	35.9	23.1	9.4	23.1	8.5	100.0
1947	4.8	3.0	1.1	2.9	1.1	12.9	37.2	23.3	8.5	22.5	8.5	100.0
1948	5.2	3.2	1.1	3.0	1.2	13.7	38.0	23.4	8.0	21.8	8.8	100.0
1949	5.5	3.0	1.0	2.8	1.2	13.5	40.8	22.2	7.4	20.7	8.9	100.0
1950	5.8	3.3	1.2	3.3	1.4	15.0	38.7	22.0	8.0	22.0	9.3	100.0
1951	6.0	3.5	1.3	3.6	1.5	15.9	37.8	22.0	8.2	22.6	9.4	100.0
1952	6.0	3.4	1.3	3.2	1.4	15.3	39.2	22.2	8.5	20.9	9.2	100.0
1953	6.0	3.6	1.2	3.4	1.5	15.7	38.2	22.9	7.6	21.7	9.6	100.0

[1] Does not include building paper.

Data for 1940-51 from "The Statistics of Paper, 1952" (2), 1952 and 1953 from "Pulp, Paper, and Board" (37).

fine papers has been in writing paper made from wood pulp (rags are also used in making writing paper).

Printing papers include machine coated papers, groundwood printing, and book papers. Book paper production presently comprises about 45 percent of the total for this group, machine-coated paper about one-third and groundwood the rest. Since 1942, the production of machine-coated papers has almost quadrupled, while that of the other two types has increased moderately.

Paperboard.--"Paperboard" is a general term indicating greater weight and thickness than paper. It includes packaging and industrial boards, such as electrical pressboard, binders' board, automobile panel, shoeboard, and other wet machine board. Building board is also usually included in the paperboard category in industry production and price statistics. However, for purposes of this report, building boards are dealt with in a separate section.

Packaging boards, principally container board, folding boxboard, and set-up boxboard, comprise the bulk of the paperboard group (table 10). In 1953 container board production alone constituted 54 percent of total paperboard production. The increase in paperboard production since 1942 has been mostly in container board and "other board." "Other board" includes tube, can and drum stock, match board, egg case filler and solid wood pulp board.

TABLE 10.—Production of various kinds of paperboard, 1942-53[1]

Year	Quantity							Percentage						
	Container board	Folding boxboard	Setup boxboard	Cardboard	Wet machine board	Other board[2]	Total	Container	Folding boxboard	Setup boxboard	Cardboard	Wet machine board	Other board[2]	Total
	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Thousand tons	Percent	Percent	Percent	Percent	Percent	Percent	Percent
1942	3,755	1,712	997	54	86	313	6,917	54.3	24.8	14.4	.8	1.2	4.5	100.0
1943	4,088	2,047	829	64	121	408	7,557	54.1	27.1	11.0	.8	1.6	5.4	100.0
1944	4,228	2,116	750	70	130	581	7,875	53.6	26.9	9.5	.9	1.7	7.4	100.0
1945	4,131	2,092	721	71	112	891	8,018	51.5	26.1	9.0	.9	1.4	11.1	100.0
1946	4,315	2,317	521	89	138	1,154	8,534	50.6	27.2	6.1	1.0	1.6	13.5	100.0
1947	4,944	2,257	595	92	150	1,300	9,338	52.9	24.2	6.4	1.0	1.6	13.9	100.0
1948	5,079	2,024	596	87	142	1,580	9,508	53.4	21.3	6.3	.9	1.5	16.6	100.0
1949	4,680	1,943	617	83	131	1,674	9,128	51.3	21.3	6.8	.9	1.4	18.3	100.0
1950	5,830	2,352	712	87	166	1,944	11,091	52.6	21.2	6.4	.8	1.5	17.5	100.0
1951	6,323	2,362	733	85	148	2,116	11,767	53.7	20.1	6.2	.7	1.3	18.0	100.0
1952	5,766	2,193	687	69	139	2,056	10,910	52.9	20.1	6.3	.6	1.3	18.8	100.0
1953	6,740	2,427	755	88	155	2,295	12,460	54.1	19.5	6.1	.7	1.2	18.4	100.0

[1] Does not include building board.
[2] Includes tube, can and drumstock, match board, egg case filler board, solid wood pulp board.

Basic data from "Pulp, Paper and Board" (36 and 37).

In the preceding section entitled "Likely Bagasse Products as Apparent From Quality Characteristics," corrugated board and liner board, the two main types of container board, were included among the possible bagasse products. Table 11 shows growth in production from 1942 to 1952 of various kinds of liner and corrugated board. The production of fourdrinier kraft liner and semichemical 0.009 corrugated board has increased very rapidly since 1942. Almost all other types have declined in production somewhat.

TABLE 11.--Production of container board, by types, 1942-52

Year	Jute liner	Cylinder kraft liner	Four-drinier kraft liner	Corrugat-ing liner chip	Solid fiber chip	.009 kraft corrugated board	.009 semi-chemical corrugated board	.009 straw corrugated board	Other .009 corrugated board	Total[1]
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
1942	821	277	1,174	72	331	269	151	361	151	3,607
1943	1,052	189	1,254	84	333	158	248	388	233	3,939
1944	1,128	130	1,340	97	338	120	331	389	249	4,123
1945	1,145	138	1,308	83	314	155	301	377	279	4,100
1946	1,220	190	1,312	114	215	174	399	385	305	4,314
1947	1,309	232	1,596	82	249	138	506	407	369	4,888
1948	1,123	220	1,909	87	234	134	486	402	365	4,960
1949	771	196	2,038	71	199	226	536	313	276	4,624
1950	922	210	2,587	76	238	228	721	351	374	5,705
1951	1,087	204	2,760	80	277	206	841	343	426	6,224
1952	771	183	2,741	74	254	213	846	279	288	5,649

[1] Totals may not equal the sum of the quantities representing the production of each type of board due to rounding.

Compiled from "Fibre Containers" (5).

Economics of Producing Paper and Paperboard in the United States

As indicated earlier, there are no data available on the economics of producing bagasse paper and paperboard commercially in the United States. However, doubtless a number of laboratories, firms, or other groups engaged in developing or perfecting bagasse-using processes have confidential cost estimates. The available profit, price, and other economic data on the production of paper and paperboard from wood are presented in this section of the report. This information will help the persons or firms having such cost data to determine the price competition to be faced, investment required, and essential location and other requirements of a modern pulp and paper mill. Readers are cautioned not to regard the presentation of profit data as necessarily indicative of the returns that might be expected from new enterprises, especially small ones, using new raw materials. The financial data available to this study represents primarily large, well established firms, many of which are integrated.

Wood pulp manufacturing factors.--Dr. G. H. Chidester, Chief, Division of Pulp and Paper, Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wis., developed wood pulp manufacturing factors for this report based on mid-1953 conditions. Dr. Chidester covered minimum economic size, investment costs, water, power, steam, labor and raw material requirements, and stream pollution factors. His estimates are summarized as follows:

Wood Pulp Manufacturing Factors

Minimum economic size for pulp mills:

Groundwood and semichemical pulp	50 tons per 24 hours
Chemical pulp	100 tons per 24 hours for certain specialty products to 250 tons per 24 hours for products such as kraft wrapping or paperboard pulp.

Pulp mill investment costs, including buildings:

Groundwood and semichemical (without recovery of chemicals)	$20,000 to $30,000 per ton of daily capacity
Chemical pulp	$50,000 to $75,000 or more per ton of daily capacity

Pulp mill operating data:

Average water requirements:	
Groundwood	10,000 gallons per ton of pulp
Kraft, unbleached	35,000 gallons per ton of pulp
Kraft, bleached	92,000 gallons per ton of pulp
Sulfite, unbleached	50,000 gallons per ton of pulp
Sulfite, bleached	95,000 gallons per ton of pulp
Semichemical (neutral sulfite)	10,000 to 30,000 gallons per ton of pulp
Steam for pulping:	
Kraft	2,500-5,000 pounds per ton of pulp
Sulfite	3,500-7,500 pounds per ton of pulp
Semichemical	2,000-4,000 pounds per ton of pulp
Electric power	
Groundwood pulping	900-1,800 kilowatt hours per ton of pulp
Chemical pulping	250 kilowatt hours per ton of pulp
Semichemical	400-600 kilowatt hours per ton of pulp
Labor (direct):	
Groundwood and semichemical pulping	3 man-hours per ton of pulp
Chemical pulping	5 man-hours per ton of pulp
Wood requirements:	
Groundwood pulping	0.9-1.3 cords per ton of pulp
Chemical pulping	1.7-2.4 cords per ton of pulp
Semichemical	1.0-1.5 cords per ton of pulp

Pollution of streams by pulp mills:

Kraft pulping	About 55 pounds of oxygen (5-day BOD[1]) per ton of pulp.
Sulfite pulping	About 415 pounds of oxygen (5-day BOD) per ton of pulp.[2]
Semichemical pulping	About 200 pounds of oxygen (5-day BOD) per ton of pulp.[2]
Groundwood pulping	About 3 pounds of oxygen (5-day BOD) per ton of pulp.
Municipal sewage	About 167 pounds of oxygen (5-day BOD) 1,000 persons.

Minimum stream flows required to maintain necessary dissolved oxygen:[3]

For 100-ton sulfite mill without liquor recovery:

1,200 cubic feet per second at 15° C.
1,800 cubic feet per second at 20° C.
2,600 cubic feet per second at 25° C.

For kraft mill: About 1/7 that of a sulfite mill without liquor recovery.

In most instances stream flows well above these minimum values should be available.

[1]Biochemical oxygen demand for 5 days (BOD) or the consumption of oxygen in the stream by the waste affluent over a 5-day period.

[2]Without liquor recovery.

[3]The minimum amount of dissolved oxygen in a stream required for the support of fish life is about 3 parts per million for streams in the Middle and Eastern States and about 5 parts per million for cold water fish in the streams of the Western States.

Costs of Producing Paper and Paperboard from Wood.--The various public research institutions did not have first-hand information on wood pulp, paper, or paperboard production costs at the time of the field work on this project. A search of the literature on the subject revealed two sources of cost estimates of relatively recent date for pulp, paper and paperboard products. Based on early and mid-1940 data, Guthrie (11) estimates production costs for several items. These include kraft corrugating and kraft liner board, Canadian and U. S. newsprint, kraft wrapping paper, groundwood, unbleached sulfite and unbleached sulfate pulps, jute liner, and sulfite bond. Siecke (24) develops estimates for kraft pulp and paper and paper mills based on 1949 conditions.

Profit Trends by Industry Segments.--Many large paper and paperboard firms report their financial condition annually, either to the Securities and Exchange Commission or in published reports to stockholders. Each year these financial reports--consolidated balance sheets and income statements--are summarized and published by Moody's Investors Service in a publication entitled "Moody's Manual of Investments-Industrials" (18). Using these reports, it is possible to compute economic ratios for individual firms or for entire industries or industry segments. Thus, an insight is gained into cost-price relationships of firms using raw materials other than bagasse and the price competition companies using a new raw material might face.

It is recognized that many small companies do not make their financial condition public and that ratios computed from Moody's do not cover a large portion of an industry from the point of number of companies. However, the firms that do report are generally the largest industry units and their production is a major portion of the total. Normally, trends that affect the industry would show up in the operations of the firms covered by Moody's.

The paper and paperboard manufacturers for which Moody's reports financial statements are classified according to the major type of product being manufactured. Using these classifications, with adjustments in the light of additional knowledge, the ratio of net profits after income taxes to net worth was calculated for nine industry segments from 1946 to 1953 (table 12). Canadian as well as United States firms are included. The representation of Canadian firms in each category is shown in table 12. For each segment, except newsprint, the Canadian representation is small. Canadian companies were included, because their methods and size of operation are similar to those of United States firms, and because they supply most of the newsprint consumed in the United States.

TABLE 12.--Net profit after income taxes as a percentage of net worth of various segments of the North American paper and paperboard industry 1946-53.

Industry segment	Unit	Fiscal year ending							
		1946	1947	1948	1949	1950	1951	1952	1953
Writing paper	Percent...	7.05	10.97	9.03	7.03	14.43	12.68	8.04	9.05
Companies..	Number....	3	3	4	11	12	12	11	11
Toilet paper.	Percent...	10.29	12.20	14.09	21.86	24.15	23.32	15.61	17.36
Companies..	Number....	3	4	4	7	7	7	6	6
Containers...	Percent...	28.54	41.77	25.58	13.11	17.90	19.56	13.47	12.42
Companies..	Number....	16	16	17	24	30	30	30	24
Kraft paper and board..	Percent...	14.72	23.57	23.05	14.71	17.65	16.85	13.29	13.35
Companies..	Number....	8	8	8	11	13	13	13	10
Newsprint....	Percent...	--	--	--	15.11	21.57	18.59	12.66	11.73
Companies..	Number....	--	--	--	12	20	18	18	15
Magazine.....	Percent...	10.25	16.94	13.39	12.60	13.95	13.69	11.40	10.09
Companies..	Number....	6	6	6	9	10	10	10	10
Paper bags...	Percent...	--	--	--	9.83	9.54	10.85	9.37	7.34
Companies..	Number....	--	--	--	3	3	3	3	3
Converters...	Percent...	19.17	24.55	12.91	7.72	13.53	11.89	6.04	7.86
Companies..	Number....	3	3	3	8	8	8	8	8
Miscellaneous	Percent...	16.65	19.61	19.86	11.05	18.36	14.53	10.24	10.32
Companies..	Number....	12	12	12	16	24	23	23	19
Average......	Percent...	15.93	24.61	20.10	13.46	17.82	16.84	12.33	11.87
Companies..	Number....	51	52	54	101	127	124	122	106

Computed from financial reports published in "Moody's Manual of Investments-Industrials" (18). These data are based on consolidated balance sheets and income statements of the paper and paperboard manufacturers for which data are reported. Profits and net worth cover all operations of the reported companies whether domestic or foreign, paper and paperboard or non-paper and paperboard. Foreign companies, other than Canadian, were excluded as were paper and paperboard manufacturers whose major business was non-paper and paperboard.

The companies were grouped according to their major line of paper and paperboard manufacture. Where the major line of a multiple line producer could not be determined, the company was included in the group entitled "miscellaneous." The Canadian United States representation in each group is typified by the companies included in 1952. In 1952 the representation was: Writing paper--2 Canadian, 9 United States; toilet paper--no Canadian; containers 3 Canadian, 27 United States; kraft paper and paperboard--1 Canadian, 12 United States; newsprint--12 Canadian, 6 United States; magazine--1 Canadian, 9 United States; paper bags--1 Canadian, 2 United States; converters--1 Canadian, 7 United States; miscellaneous--1 Canadian, 22 United States.

The net profit-net worth ratio measures returns on investment. In general, returns rose sharply from 1946 to 1947, declined in 1948 and 1949, and recovered slightly in 1950 and 1951. However, in 1952 and 1953, profits were at postwar lows. The segments of the industry which have had the highest net profits as a percent of net worth in the most recent years are toilet paper, containers, kraft paper and board, and newsprint. Those which have generally had lower than average profits for this period are writing paper, magazine paper, paper bags, miscellaneous, and converters.[4]

[4] Converters are firms which buy primary paper or paperboard from manufacturers and process the paper for further sales. Many of the items produced are specialty items such as laminated paper. But converters also produce toilet paper, paper boxes and other products from purchased primary paper or paperboard.

General Price Trends of Pulp, Paper, and Paperboard.--In total, prices of pulp, paper, and paperboard products remained relatively stable during the immediate postwar period, 1947 to 1950 (table 13). But with the outbreak of hostilities in Korea prices rose sharply in 1951 to post-World War II peaks. As emergency pressures eased in 1952, prices declined to close to 3 percent in the aggregate, leveling off in 1953.

TABLE 13.--Index numbers of wholesale prices of selected subgroups and classes of wood pulp, paper, and paperboard, 1947-53

[1947 to 1949 = 100]

Item	1947	1948	1949	1950	1951	1952	1953
Pulp, paper and products	98.6	102.9	98.5	100.9	119.6	116.6	116.1
Wood pulp............	95.6	107.3	97.0	95.6	114.4	111.5	109.0
Wastepaper...........	148.3	90.4	61.3	119.5	188.2	70.1	90.7
Paper................	93.4	102.8	103.8	106.5	119.1	124.0	125.6
Newsprint..........	92.6	101.9	105.5	106.2	115.4	125.7	131.1
Other..............	93.7	103.1	103.3	106.5	120.4	123.5	123.6
Paperboard...........	99.2	102.0	98.8	105.0	131.8	127.4	124.3
Converted products....	100.5	102.4	97.1	97.7	116.9	113.8	112.2

Data are from "Pulp, Paper and Board" (37).

While the prices of these products from an overall standpoint have declined somewhat from 1951 levels, there have been rather pronounced opposing price trends among the major subgroups and classes. The groups which have declined more than the average since 1951 are the wood pulp, wastepaper, paperboard, and converted products subgroups. The prices of wastepaper, normally quite sensitive to changes in demand, have declined far more than any other group. Prices of this subgroup in 1953 were less than half those in 1951. In contrast, prices for the paper subgroup continued firm and rising in 1952 and 1953. Within the paper subgroup, price trends have been stronger in the newsprint class than in the ''other'' class.

Prices of Likely Bagasse Products.--An earlier section of this study entitled ''Likely Bagasse Products as Apparent From Quality Characteristics,'' presents a discussion of the bagasse products and bagasse-wood pulp blend products which may be competitive qualitywise with similar products made from other raw materials. For persons developing bagasse processing cost data, it is important to review the price trends of the most likely bagasse products as well as general paper and paperboard price data.

It may be useful to review such trends in the light of net earnings ratios as developed in the section entitled ''Profit trends by industry segments.'' This review will help to determine the existing cost-price relationships and the probable price competition from products made from other raw materials. Fortunately, except for toilet paper, the list of likely bagasse products duplicates the list of principal products made by the industry segments for which earnings ratios were calculated. Profit trends were developed for toilet paper, but this product was not included among the list of likely bagasse products.

Table 14 shows the prices of the duplicate list of paper and paperboard products described above and the prices of toilet paper during the years 1947 to 1953. Each product is higher in price than in 1947, and the price trend of most has continued strong after the sharp increase in all types in 1951. Writing paper, wrapping paper (standard kraft), bookpaper, newsprint, kraft liner, and toilet tissue have been firm to higher in price since 1951. Paper bags and corrugating medium declined slightly in price in 1952 and 1953.

TABLE 14.--Prices of likely bagasse products and products of the paper and paperboard industry segments for which net profit to net worth ratios have been calculated (see table 12), 1947-53

Item	1947	1948	1949	1950	1951	1952	1953
Items which are both likely bagasse products and related to profit ratios:	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Writing paper, 100 pounds, zone 1[1]........	18.21	19.32	19.15	20.87	23.63	24.00	24.00
Wrapping paper standard kraft, 100 pounds[1]........	5.92	6.73	6.63	6.86	7.86	8.00	8.19
Bookpaper, A Grade, 100 pounds, carlot quantities, zone 1[1]........	10.11	10.82	11.31	11.66	12.88	13.52	13.69
Newsprint, standard, rolls, contract, per ton, principal ports[2]........	88.66	97.56	101.01	101.68	110.48	120.35	125.52
Paper bags, grocery, kraft, 1,000 bags, in carlot quantities[2]........	3.01	3.26	3.04	3.15	3.69	3.69	3.63
Container board class, 100-pound test liner, fourdrinier kraft, central and eastern territories, 1,000 sq. ft. in carlot quantities[2]........	2.13	2.11	2.14	2.18	2.47	2.47	2.50
0.009 corrugating medium, central and eastern territories, 1,000 sq. ft.[2]........	1.37	1.43	1.40	1.46	1.71	1.59	1.61
Additional item related to profit ratios only:							
Toilet tissue, case of 100-650 sheet rolls[1]........	5.06	5.86	6.05	6.14	6.82	6.91	6.93

[1] F.O.B. mill, carload freight allowed.
[2] Delivered.

Data are computed from "Prices and Price Relatives" (25).

These firm and rising price tendencies in 1952 and 1953 were not reflected in increased profits those years (see table 12). In fact, profits have been at postwar lows, indicating a less favorable cost-price relationship. It does not appear likely that the net profit-net worth ratio of the paper and paperboard industry will increase in 1954 without abnormal demand. Plans for increased capacity (see table 6) indicate continued active competition.

Market Competition in Major United States Consuming Areas

Persons thinking about producing bagasse paper and paperboard products in the various domestic cane producing regions should learn about the likely market competition they may expect in the major consuming areas and the areas of greatest market growth (fig. 6). The logical markets for Puerto Rican and Hawaiian products would be the areas in the vicinity of port cities. Louisiana and Florida producers would probably be most concerned with nearby interior points of consumption. To help establish the degree of competition in various markets available State and regional data on location and production of existing paper and paperboard mills are presented in this section.

Location of Pulp, Paper, and Paperboard Mills and Mill Capacity by States.--Figure 7 shows the approximate location of pulp mills and nonintegrated and integrated paper and paperboard mills in the United States in 1953 and daily State paper, paperboard and pulp capacities. In 1953 the leading States in total paper and paperboard capacity were New York, Michigan, Wisconsin, Ohio, Pennsylvania, Louisiana, Maine, New Jersey, Florida, Georgia, and Washington, in that order. For pulp, the leading States were Washington, Florida, Louisiana, Maine, Georgia, Wisconsin, South Carolina, New York, Virginia, and North Carolina, in the order named.

Production Trends of Pulp, Paper, and Paperboard by Regions.--The South and West have enjoyed the most rapid growth in total paper and paperboard production since 1929 (fig. 8). Growth has been especially spectacular in the South. The paper industry moved to these areas for cheaper and more abundant raw materials. Most of the plants in these regions have modern high speed machines and are generally larger than those in the Northeast and North Central regions.

Likewise, production of wood pulp has expanded much more rapidly in the South and West in the last 20 to 25 years than in the other major geographic regions. The South now produces almost half the Nation's wood pulp.

To compete with the newer regions many of the mills in the Northeast and North Central areas have modernized and reduced production costs. Others have concentrated on manufacturing papers requiring special skills--such as fine, special industrial, sanitary, folding boxboard, setup boxboard, and groundwood printing paper. In 1947, the latest year for which data are available, the New England and Middle Atlantic regions produced the largest volume of special industrial, absorbent, newsprint, and groundwood printing papers. And the New England, Middle Atlantic, and East North Central regions produced most of the book and fine papers (table 15).

TABLE 15.--Percentage distribution of shipments of principal paper and paperboard products from various regions, 1947

Region	Coarse paper	Special industrial and absorbent	Sanitary and tissue	Container board	Bending board	Non-bending board	Miscellaneous paper board	Newsprint and groundwood paper	Book and fine paper
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
New England	13.4	30.3	15.2	--	10.9	9.7	12.1	40.2	24.5
Middle Atlantic	13.2	31.0	48.0	[1]12.6	24.3	55.5	26.4	21.9	22.1
East North Central	[2]24.9	15.5	25.6	27.7	[2]41.4	[2]19.9	[2]40.1	8.8	[2]38.4
West North Central	--	--	--	2.5	--	--	--	11.0	--
South Atlantic	16.3	[3]23.2	[3]11.2	[4]51.1	[4]17.7	[4]11.3	[4]15.0	[3]18.1	[3]15.0
East South Central	9.5	--	--	--	--	--	--	--	--
West South Central	12.5	--	--	--	--	--	--	--	--
Mountain	--	--	--	--	--	--	--	--	--
Pacific	10.2	--	--	[5]6.1	[5]5.7	[5]3.6	[5]6.4	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Includes New England.
[2] Includes West North Central.
[3] Includes East South Central, West South Central, Mountain and Pacific.
[4] Includes East South Central and West South Central.
[5] Includes Mountain region.

Computed from data on value of shipments by regions and States, "The Statistics of Paper-1952" (2).

New England includes Connecticut, Massachusetts, New Hampshire, Rhode Island, Vermont; Middle Atlantic--New Jersey, New York, Pennsylvania; East North Central--Illinois, Indiana, Michigan, Ohio, Wisconsin; West North Central--Iowa, Kansas, Minnesota, Missouri; South Atlantic--Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia; East South Central--Alabama, Mississippi, Tennessee; West South Central--Arkansas, Louisiana, Oklahoma, Texas; Mountain--Colorado, Idaho, New Mexico; Pacific--California, Oregon, Washington.

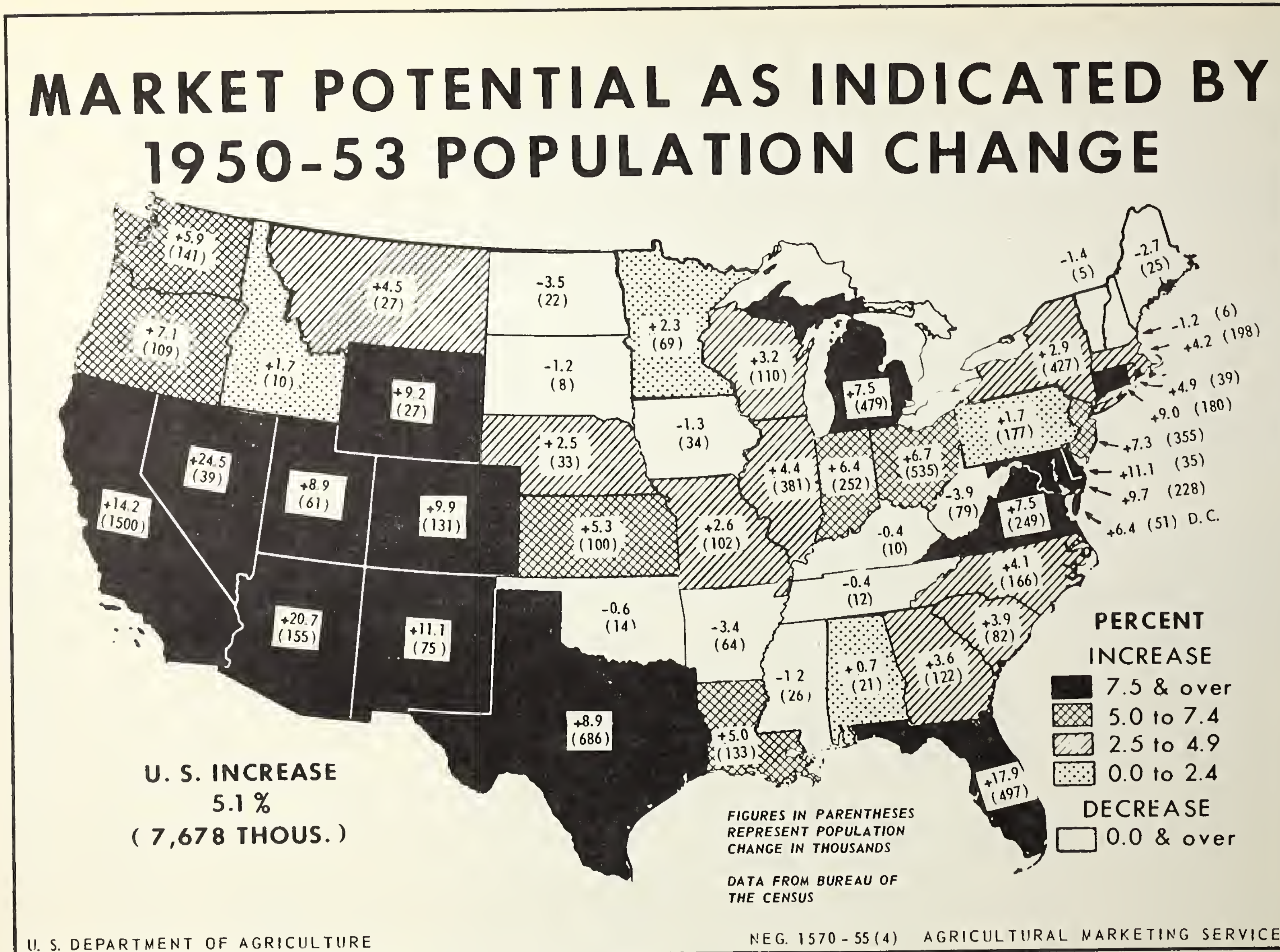
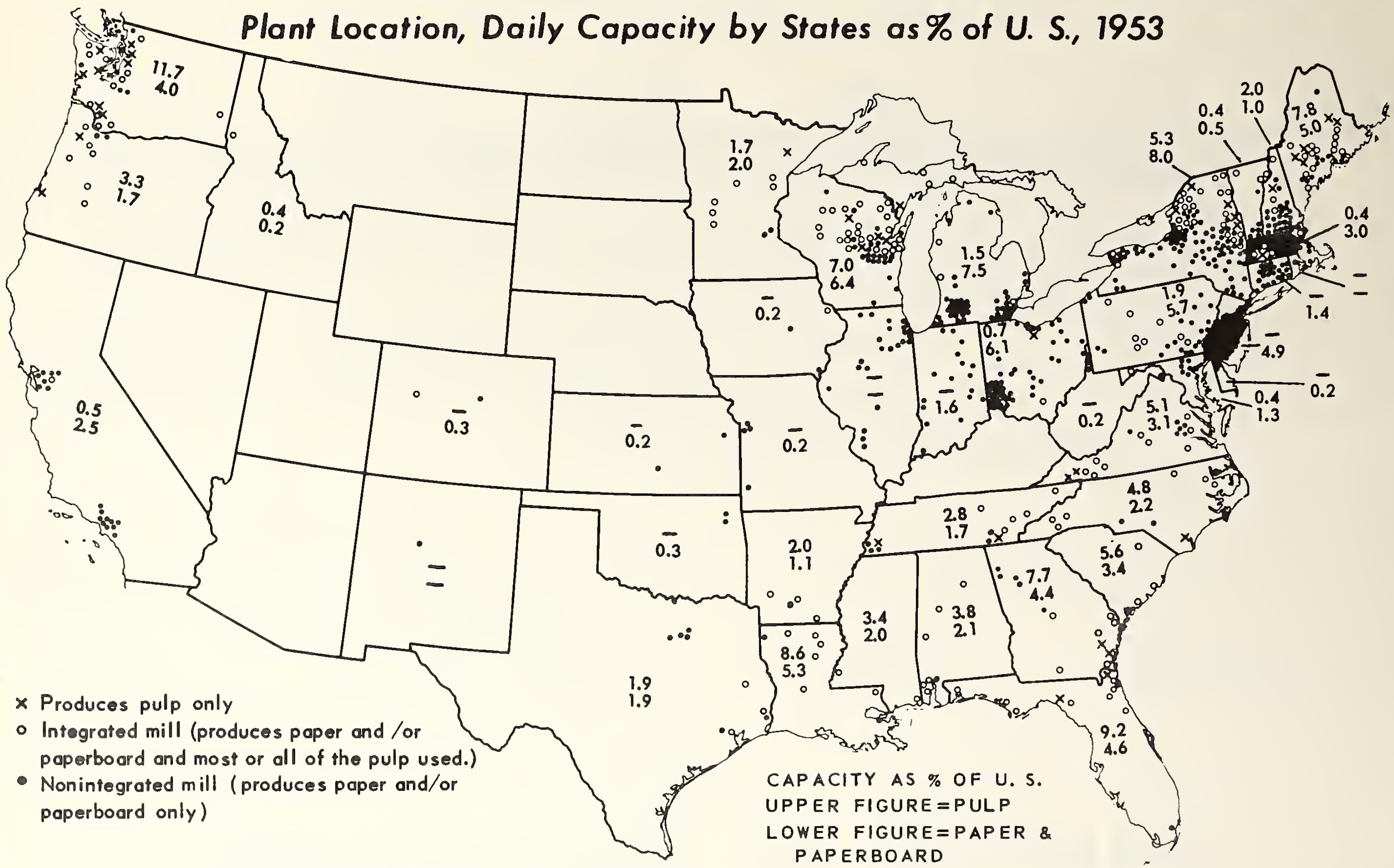

MARKET POTENTIAL AS INDICATED BY
1950-53 POPULATION CHANGE
+5.9 (141)
+7.1 (109)
+1.7 (10)
+4.5 (27)
-3.5 (22)
-1.2 (8)
+9.2 (27)
+14.2 (1500)
+24.5 (39)
+8.9 (61)
+9.9 (131)
+2.5 (33)
+5.3 (100)
+20.7 (155)
+11.1 (75)
-0.6 (14)
+8.9 (686)
+2.3 (69)
-1.3 (34)
+2.6 (102)
-3.4 (64)
+5.0 (133)
+3.2 (110)
+4.4 (381)
+7.5 (479)
+6.4 (252)
+6.7 (535)
-0.4 (10)
-0.4 (12)
-1.2 (26)
+0.7 (21)
+3.6 (122)
+17.9 (497)
+3.9 (82)
+4.1 (166)
-3.9 (79)
+7.5 (249)
+1.7 (177)
+2.9 (427)
-1.4 (5)
-2.7 (25)
-1.2 (6)
+4.2 (198)
+4.9 (39)
+9.0 (180)
+7.3 (355)
+11.1 (35)
+9.7 (228)
+6.4 (51) D.C.
PERCENT
INCREASE
7.5 & over
5.0 to 7.4
2.5 to 4.9
0.0 to 2.4
DECREASE
0.0 & over
U. S. INCREASE
5.1 %
(7,678 THOUS.)
FIGURES IN PARENTHESES REPRESENT POPULATION CHANGE IN THOUSANDS
DATA FROM BUREAU OF THE CENSUS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1570 - 55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 6

PULP, PAPER, AND PAPERBOARD PLANTS

Plant Location, Daily Capacity by States as % of U. S., 1953



DATA FROM "THE PAPER INDUSTRY", DEC. 1953.
INCLUDES PLANTS UNDER CONSTRUCTION AND IN PLANNING STAGE; EXCLUDES BUILDING BOARD.

U. S. DEPARTMENT OF AGRICULTURE — NEG. 1571-55 (4) — AGRICULTURAL MARKETING SERVICE

Figure 7

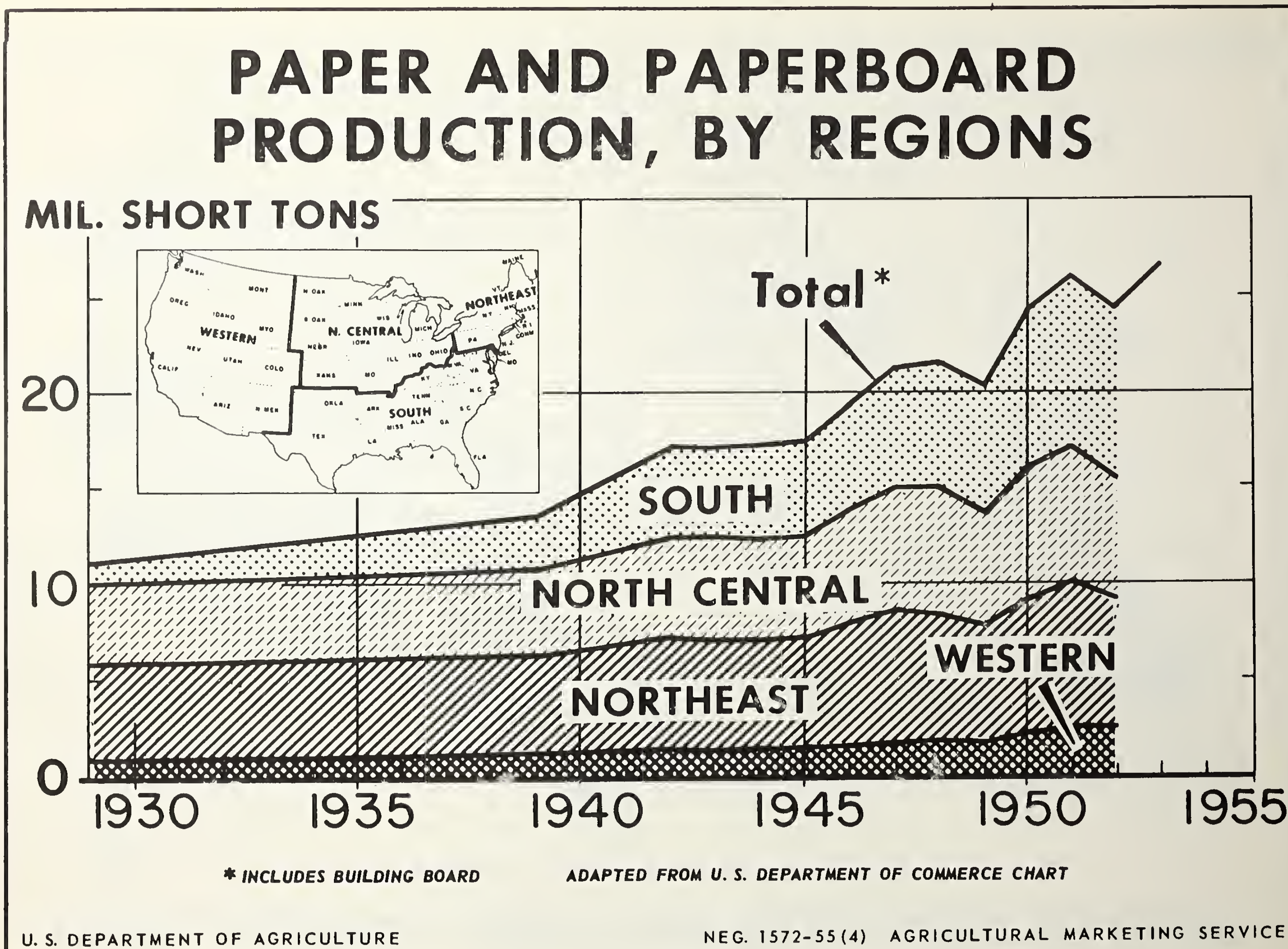

PAPER AND PAPERBOARD PRODUCTION, BY REGIONS
MIL. SHORT TONS
20
10
0
1930
1935
1940
1945
1950
1955
Total*
SOUTH
NORTH CENTRAL
NORTHEAST
WESTERN
N. CENTRAL
* INCLUDES BUILDING BOARD
ADAPTED FROM U. S. DEPARTMENT OF COMMERCE CHART
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1572-55(4) AGRICULTURAL MARKETING SERVICE

Figure 8

Sanitary and tissue papers were produced primarily in the Middle Atlantic and East North Central regions. These two regions also produced large quantities of paperboard. Coarse paper production was rather well scattered with the highest production in the East North Central and South Atlantic regions. Container board was manufactured principally in the South Atlantic region, though large quantities were also made in the East North Central region.

Foreign producers provide little competition to the paper and paperboard industry except for newsprint (table 7). Canada supplies about 80 percent of the newsprint consumed in this country.

Raw Materials Used in Paper and Paperboard Manufacture

Since 1940 wood pulp has comprised about 60 percent of the raw materials consumed in paper and paperboard manufacture. Wastepaper, sometimes called the "secondary forest," has comprised almost a third of the raw materials used (table 16). Rags and straw each constituted from about 1-1/2 to 3 percent of the raw materials used during the period covered and "all other" about 2 percent.

TABLE 16.--Raw materials used in paper and board manufacture, 1940-51[1]

Year	Quantity						Percentage					
	Wood-pulp	Waste-paper	Rags	Straw	All other	Total	Wood-pulp	Waste-paper	Rags	Straw	All other	Total
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1940......	9,782	4,668	403	492	149	15,494	63.1	30.1	2.6	3.2	1.0	100.0
1941......	11,364	6,075	530	666	221	18,856	60.3	32.2	2.8	3.5	1.2	100.0
1942......	11,038	5,495	481	516	328	17,858	61.8	30.8	2.7	2.9	1.8	100.0
1943......	10,635	6,368	426	488	282	18,199	58.4	35.0	2.3	2.7	1.6	100.0
1944......	10,502	6,859	428	557	401	18,747	56.0	36.6	2.3	3.0	2.1	100.0
1945......	10,825	6,800	414	520	409	18,968	57.1	35.8	2.2	2.7	2.2	100.0
1946......	12,092	7,278	403	535	445	20,753	58.3	35.1	1.9	2.6	2.1	100.0
1947......	13,285	8,009	462	521	510	22,787	58.3	35.2	2.0	2.3	2.2	100.0
1948......	14,375	7,585	416	524	512	23,412	61.4	32.4	1.8	2.2	2.2	100.0
1949......	13,636	6,600	382	386	447	21,451	63.5	30.8	1.8	1.8	2.1	100.0
1950......	16,509	7,956	442	406	592	25,905	63.7	30.7	1.7	1.6	2.3	100.0
1951......	17,731	9,079	389	429	626	28,254	62.8	32.1	1.4	1.5	2.2	100.0

[1] Includes building paper and board.

Data are from "The Statistics of Paper, 1952" (2).

Until the late 1800's straw and rags were among the principal raw materials used for paper and paperboard manufacture. But with the development of processes to make pulp from wood, an abundant and relatively inexpensive product, wood pulp soon became the dominant raw material. In 1951 straw and rags combined comprised only 2.9 percent of all the raw materials.

Table 17 shows, on a percentage basis, the types of raw material used by the principal segments of the paper and paperboard industry during 1947, the most recent year for which such data are available. Raw materials used in making building board are also shown for comparison.

Straw was used principally to produce container board (.009 corrugating medium), and rags were used to make book, fine, absorbent, and building papers. Wastepaper was an ingredient in the manufacture of all major grades of paper and board, but it was used primarily in paperboard and building paper. Woodpulp was also used in all grades of paper and board and was the predominant raw material for coarse and special industrial paper, newsprint, groundwood paper, book, fine, and absorbent paper, and building board.

TABLE 17.—Percentage distribution of types of raw materials used in the manufacture of various types of paper and board, 1947

Type	Wood-pulp	Waste-paper	Rags	Straw	Other	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Book, fine and absorbent.	74.7	18.9	3.6	0	2.8	100.0
Coarse and special industrial............	93.8	5.2	.2	0	.8	100.0
Newsprint and groundwood.	98.6	1.4	0	0	0	100.0
Flexible insulation and building paper.........	23.1	42.8	22.4	0.1	11.6	100.0
Tissue paper and sanitary stock.................	86.7	13.3	0	0	0	100.0
Container board..........	49.4	41.8	0	8.8	0	100.0
Bending board............	21.8	77.8	0	.3	.1	100.0
Nonbending board.........	1.5	98.3	0	.2	0	100.0
Other paperboard.........	15.8	79.1	.8	1.8	2.5	100.0
Building board[1]..........	71.0	11.0	0	0	18.0	100.0
Total.................	58.3	35.2	2.0	2.3	2.2	100.0

[1] Building board included for purposes of comparison.

Basic data from which calculations made from "Census of Manufactures, 1947" (28).

Outlook for Future Raw Material Supplies

In considering the establishment of new bagasse product enterprises, it is well to review the probable future supplies of competing raw materials.

Pulpwood.--In 1945, the United States Forest Service appraised the volume of standing timber and the annual growth and drain of timber on commercial forest lands (table 18). At that time there was a favorable balance of timber growth in all areas in hardwoods, though an unfavorable balance for softwoods on the Pacific Coast and in the South. Softwoods or conifers have traditionally been the principal type of pulpwood. And the unfavorable balance of their growth may appear serious until one considers the magnitude of the total volume of standing softwood timber and the recent development of satisfactory processes for pulping hardwoods.

TABLE 18.—Volume, growth, and drain cf timber on commercial forest lands, by regions, 1945

Item	North-east	Lake	Central and Plains	South	Rocky Mountain	Pacific Coast	United States
	Million cubic feet	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*
Volume:							
Softwoods......	16,694	7,000	1,748	58,332	47,501	188,722	319,997
Hardwoods......	35,291	16,200	22,967	72,542	1,291	1,757	150,048
Total........	51,985	23,200	24,715	130,874	48,792	190,479	470,045
Growth:							
Softwoods......	692	178	106	3,520	714	1,546	6,756
Hardwoods......	1,602	634	1,454	2,871	21	32	6,614
Total........	2,294	812	1,560	6,391	735	1,578	13,370
Drain:							
Softwoods......	555	323	56	3,703	412	3,102	8,151
Hardwoode......	1,052	424	1,263	2,758	8	5	5,510
Total........	1,607	747	1,319	6,461	420	3,107	13,661
Difference between growth and drain:							
Softwoode......	137	-145	50	-183	302	-1,556	-1,395
Hardwoode......	550	210	191	113	13	27	1,104
Total........	687	65	241	-70	315	-1,529	-291

Data are from "The Newsprint Problem" (39).

The Forest Service is presently conducting a new appraisal of the Nation's commercial timber supplies. Preliminary observations indicate at least as good an overall timber supply situation as that which existed in 1945, due to better fire and insect control and improved methods of forest management. It is believed that only the larger specimens of desirable lumber type trees are likely to be in shorter supply in the near future. Further, in recent years, pulp mills have found wood waste from lumbering suitable for pulping, especially in the Pacific Coast area.

Less and less reliance has been placed on imports for United States supplies of pulpwood in recent years. In 1953, only 5.6 percent of total pulpwood came from foreign sources. Receipts of imported pulpwood as a percentage of total receipts from 1942 to 1953 are shown in table 19.

TABLE 19.—Pulpwood: Imports as percentage of total receipts, 1942-53

Year	Percentage	Year	Percentage	Year	Percentage
	Percent		*Percent*		*Percent*
1942........	13.0	1946	10.5	1950	8.1
1943........	11.2	1947	10.1	1951	9.5
1944........	9.7	1948	10.3	1952	8.4
1945........	10.2	1949	8.5	1953	5.6

Computed from data reported in "Pulp, Paper and Board" (37).

Woodpulp.--Most of the woodpulp used in the United States is produced domestically. During 1952 and 1953 about 11 percent of the total was imported, principally from Canada. Future domestic production depends on available supplies of pulpwood, discussed above, and on the pulp industry's capacity to produce. Table 20 shows production, rated capacity, and production-capacity ratios for the pulp industry during the 1949-53 period and estimated rated capacity for 1954. Over the last 5 years the industry's capacity to produce has expanded at an average annual rate of about 1.1 million tons a year. It is estimated that this capacity will increase another 1.1 million tons in 1954. In 1953 production was 89 percent of rated capacity.

TABLE 20.—Woodpulp: Capacity and production and production as a percentage of capacity, 1949-54

Year	Capacity	Production	Production as a percentage of capacity
	1,000 tons	*1,000 tons*	*Percent*
1949............................	15,018	12,207	81
1950............................	16,167	14,849	92
1951............................	17,668	16,524	94
1952............................	18,771	16,464	88
1953............................	19,800	17,525	89
1954............................	[1] 20,900	--	--

[1] Estimated.

From "1953 Production at a New High" (6).

The data on likely pulpwood supplies and the woodpulp industry's capacity to produce indicates that supplies of woodpulp are likely to be reasonably plentiful in the foreseeable future, barring new military emergencies or other conditions bringing about abnormal demand.

Wastepaper.--The volume of wastepaper available for use is dependent primarily on the consumption of paper and board and the diligence of wastepaper dealers in collecting and distributing it. The diligence of collection and distribution is further dependent on the demand for wastepaper. For instance, the sharply rising demand for paperboard in late 1950 and the first half of 1951 in turn strengthened the demand and price (see table 13) for wastepaper, resulting in greatly increased supplies. The reverse occurred in 1952 with reduced demand and sharply lower prices.

Attempts are presently being made by the wastepaper industry to achieve greater stability in its operations. The Waste Paper Utilization Council was recently organized to help solve some of the technical problems in using wastepaper and to stabilize price and supply conditions.

Other Raw Materials.--Other raw materials that might compete with bagasse are various agricultural residues such as wheat, rye, and rice straws, and woody stalks of flax, cotton and soybeans, and possibly bamboo. Straws are the only residues presently being used in the United States in the paper and paperboard field and these mostly to make .009 corrugated board. According to estimates made by the Agricultural Residues Division, Northern Utilization Research Branch, there are 30 million tons of straw available for off-farm uses. This is above the needs for animal and poultry bedding, soil improvement, and erosion control.

In recent years the use of straw for paperboard manufacture has declined somewhat (see table 16). Probably one of the major reasons for the decline in the use of straw is the expense and difficulty of collection. Prices that can be paid the farmer for straw at prevailing paper and board prices are apparently not sufficiently high to encourage its baling and delivery to collection points.

Market Pulp

"Market" pulp consists of domestic or imported pulp purchased from a pulp mill not under the same ownership or control as the purchaser or an integrated pulp and paper mill producing pulp in excess of requirements. (Some imported pulp is produced by mills owned or controlled by United States paper and paperboard manufacturers.) Pulp obtained from a mill owned by the user is called "own" pulp.

Pulp was discussed in an overall way in the preceding section, principally where raw material costs and supplies for paper and board manufacture were analyzed. But the various economic aspects of producing pulp for sale as an adjunct to or in lieu of a paper and board enterprise were not covered except for those factors which were common to both "own" and "market" pulp. These factors will be noted and reference made to the foregoing pages on which they are analyzed.

Likely Bagasse Products for Market Pulp

As shown in table 3, page 16, bagasse pulps produced by 1 or more processes are suitable for the manufacture of a rather wide variety of paper and paperboard products. For some products 100-percent bagasse pulp may be used. For others bagasse pulps are suggested for mixture with other pulps or as replacement for varying proportions of presently produced pulps, such as newsprint and fine paper pulps.

It was believed by some of the persons interviewed that dissolving pulps made from bagasse may be competitive with such pulps presently made from wood and cotton linters. Dissolving pulp is used in paper and board manufacture, but its principal uses are in the manufacture of nonpaper and board products such as rayon and acetate fibers, cellophane, plastics, explosives, photographic film, and lacquers. It is one of the principal types of market pulp and is almost pure alpha-cellulose. The name "dissolving pulp" is derived from the fact that the fibers are dissolved in its manufacture.

Yields of dissolving pulp from depithed bagasse are about equal to yields from wood, the principal raw material used. The alpha-cellulose content of depithed bagasse is estimated by Lathrop (14) to range from 40-43 percent, compared to 40-45 percent for coniferous woods and 38-49 percent for deciduous woods. Cotton linters have a much higher alpha-cellulose content than either wood or bagasse but their cost limits their use for dissolving pulp. Myers (19) estimates that cotton linters are about 75 percent alpha-cellulose.

Market Potential for Market Pulp

Industry Growth

Although there is a substantial tonnage of market pulp consumed in this country, the growth in its use is relatively moderate compared to own pulp (table 21). The consumption of market pulp for all purposes increased from 2,324,000 tons to 3,034,000 tons from 1940 to 1952, while consumption of own pulp increased from 7,379,000 tons to 15,156,000 tons over the same period. As a result the percentage of market pulp to total pulp declined from 24.0 percent in 1940 to 16.7 percent in 1952. This trend in the relationship of own and market pulp consumption reflects the fact that capacity increases in pulp-using plants have been principally in plants integrated with their own pulp mills. Imports supply about 55 percent of the market pulp consumed in paper and board manufacture and a third of that consumed in the manufacture of nonpaper and board products.

TABLE 21.—New supply of wood pulp, by types, 1940-52[1]

Year	Quantity			Percentage		
	Own	Market	Total	Own	Market	Total
	1,000 tons	1,000 tons	1,000 tons	Percent	Percent	Percent
1940.........	7,379	2,324	9,703	76.0	24.0	100.0
1941.........	8,695	2,509	11,204	77.6	22.4	100.0
1942.........	8,971	2,670	11,641	77.1	22.9	100.0
1943.........	8,441	2,244	10,685	79.0	21.0	100.0
1944.........	8,753	2,209	10,962	79.8	20.2	100.0
1945.........	8,937	2,849	11,786	75.8	24.2	100.0
1946.........	9,667	2,706	12,373	78.1	21.9	100.0
1947.........	10,888	3,250	14,138	77.0	23.0	100.0
1948.........	11,808	3,147	14,955	79.0	21.0	100.0
1949.........	11,349	2,500	13,849	81.9	18.1	100.0
1950.........	13,676	3,462	17,138	79.8	20.2	100.0
1951.........	15,147	3,537	18,684	81.1	18.9	100.0
1952.........	15,156	3,034	18,190	83.3	16.7	100.0

[1] For own pulp, "new supply" is United States production for own use (total minus market pulp production) plus imports of own pulp. For market pulp, "new supply" is market pulp production plus imports and minus exports of market pulp.

Data from annual issues of "Wood Pulp Statistics" (40).

About 80 percent of the market pulp is consumed in paper and board manufacture and 20 percent in nonpaper products (table 22). Usage in nonpaper products has increased somewhat percentagewise since 1950.

TABLE 22.—Consumption of market woodpulp, 1947-52

Year	Quantity in-			Percentage in-		
	Paper and board[1]	Nonpaper and board	Total	Paper and board[1]	Nonpaper and board	Total
	1,000 tons	1,000 tons	1,000 tons	Percent	Percent	Percent
1947.........	2,511	583	3,094	81.2	18.8	100
1948.........	2,586	627	3,213	80.5	19.5	100
1949.........	2,325	547	2,872	81.0	19.0	100
1950.........	2,902	662	3,564	81.4	18.6	100
1951.........	2,742	731	3,473	79.0	21.0	100
1952.........	2,252	695	2,947	76.4	23.6	100

[1] Includes building board.

Data on consumption in paper and board from "Pulp, Paper and Board" (36). Data on nonpaper and board from "Wood Pulp Statistics, 1953" (40).

Growth of the Market Pulp Industry, by Segments

The principal grades of market pulp consumed in paper and board manufacture in 1952 were bleached sulfite, bleached sulfate, and unbleached sulfite (table 23). The market pulp showing the strongest growth trend since 1946 is bleached sulfate. Semibleached sulfate has also shown a rather strong growth trend, but the production of this type of market pulp is still quite small. The use of unbleached sulfite and unbleached sulfate market pulps has declined substantially since 1946, while consumption of groundwood, soda, and bleached sulfite has remained stable.

Most market pulps for nonpaper and board users are the dissolving grades. Fully bleached sulfite and sulfate pulps comprise practically all the balance. Growth trends of dissolving and fully bleached pulps in the manufacture of nonpaper products are shown in table 24.

TABLE 23.—Consumption of various types of market pulp in paper and board manufacture, 1946-52[1]

Type of pulp	1946	1947	1948	1949	1950	1951	1952
	Quantity						
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Dissolving pulp..	(2)	(2)	(2)	25	38	50	48
Sulfite:							
Bleached.......	707	694	711	739	834	766	675
Unbleached.....	777	739	744	549	614	546	388
Sulfate:							
Bleached.......	119	186	247	295	400	405	452
Semibleached...	18	15	18	15	30	33	31
Unbleached.....	530	528	456	357	543	481	287
Soda............	101	89	81	96	115	104	106
Groundwood.......	213	201	266	209	272	294	213
Other............	59	61	64	41	57	63	52
Total..........	2,524	2,513	2,587	2,326	2,903	2,742	2,252
	Percentage						
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Dissolving pulp..	(2)	(2)	(2)	1.1	1.3	1.8	2.1
Sulfite:							
Bleached.......	28.1	27.7	27.5	31.8	28.6	28.0	30.0
Unbleached.....	30.8	29.4	28.8	23.6	21.2	19.9	17.2
Sulfate:							
Bleached.......	4.7	7.4	9.5	12.7	13.8	14.8	20.1
Semibleached...	.7	.6	.7	.6	1.0	1.2	1.4
Unbleached.....	21.0	21.0	17.6	15.3	18.7	17.5	12.7
Soda............	4.0	3.5	3.1	4.1	4.0	3.8	4.7
Groundwood.......	8.4	8.0	10.3	9.0	9.4	10.7	9.5
Other............	2.3	2.4	2.5	1.8	2.0	2.3	2.3
Total..........	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Includes building board.
[2] Included with bleached sulfite.

Basic data from "Wood Pulp Statistics, 1953" (40).

TABLE 24.—Consumption of principal grades of market pulp for nonpaper and board uses, 1949-52

Type of pulp	1949	1950	1951	1952
	Quantity			
	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Dissolving pulp..........................	535	645	713	673
Fully bleached sulfate and sulfite.......	10	13	13	16
Total..............................	545	658	726	689
	Percentage			
Dissolving pulp..........................	98.2	98.0	98.2	97.7
Fully bleached sulfate and sulfite.......	1.8	2.0	1.8	2.3
Total..............................	100.0	100.0	100.0	100.0

Compiled from "Wood Pulp Statistics, 1953" (40).

Economics of Market Pulp Production

Except for price and profit trends, the available information on the economics of the production of pulp for paper and board are included in the following portions of the "Paper and Paperboard" section: "Bagasse Pulping Costs Compared to Pulping Costs of Competing Raw Materials," "Economics of Producing Paper and Paperboard in the United States," and "Outlook for Future Raw Material Supplies." Most of the economic factors affecting the manufacture of chemical woodpulp for paper and paperboard are important to the production of dissolving woodpulp. Dissolving woodpulp comprises the especially refined pulp grades in which isolation of the cellulose and the purification of the pulp have been accomplished to a greater degree than is the case with other grades of pulp.

Trends in net profit after income taxes as a percent of net worth may be calculated for producers of market sulfite and dissolving woodpulp as was done for paper and paperboard producers (see table 12). This will provide some insight into existing cost-price relationships for firms using wood and the price competition that companies using other raw materials would likely encounter. The net profit-net worth ratios covering the years 1946 to 1953 are shown in table 25. Though there are only two producers in the dissolving pulp group, they produce close to half of the pulp of this type consumed in the United States. Canadian companies are included because a substantial portion of the United States supply of sulfite and dissolving pulps originates in Canada.

TABLE 25.--Net profit after income taxes as a percentage of net worth of North American producers of two types of market pulp, 1946-53

Industry segment	Unit	1946	1947	1948	1949	1950	1951	1952[1]	1953
Sulfite pulp.....	Percent	17.36	31.22	27.34	12.32	16.01	17.72	13.42	11.6
Companies......	Number	3	3	3	6	7	6	7	6
Dissolving woodpulp.........	Percent	--	--	--	--	20.00	24.28	12.33	11.0
Companies......	Number	--	--	--	--	2	2	2	2

[1] In 1952, "sulfite pulp" included 5 United States and 2 Canadian producers; dissolving pulp, 1 United States and 1 Canadian producer.

Computed from data presented in "Moody's Manual of Investments-Industrials" (18).

Both sulfite and dissolving pulp producers have had relatively high returns on investment in the post-World War II years. However, returns declined somewhat during 1952 and 1953.

Prices of most of the principal grades of market pulp are shown in table 26 for 1947-53. Prices of sulfate and sulfite pulp include varying freight allowances; prices of groundwood and dissolving pulp are prices delivered to the user. Pulp prices are generally considerably higher than in 1947, though trends in the last 3 years, 1951 to 1953, have been mixed. Since 1951 southern unbleached sulfate has weakened noticeably in price, and groundwood and bleached sulfate pulps are down somewhat. However, bleached sulfite and soda pulps have remained firm in price since 1951. For the years during which comparable prices are available, dissolving pulps were substantially higher in price than the other types of pulps.

TABLE 26.--Prices per air-dry ton of major types of market pulp, 1947-53

Type of pulp	1947	1948	1949	1950	1951	1952	1953
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Sulfate, southern, unbleached[1]............	102.20	117.19	92.83	92.10	125.62	114.38	101.26
Sulfate, bleached[1]......	106.87	160.11	136.45	126.23	156.21	145.05	145.05
Sulfite, bleached, No. 1 book quality[1].........	121.38	130.25	123.38	122.63	140.00	140.00	140.00
Soda, bleached[1].........	118.97	131.49	121.33	119.59	139.91	142.89	139.91
Groundwood[2]............	127.25	133.38	114.38	112.00	152.62	149.25	137.50
Dissolving pulps:							
For regular tenacity viscose filament yarn[2]	140.50	159.17	158.83	158.25	(3)	(3)	(3)
For high tenacity viscose filament yarn[2]	148.87	169.00	168.75	169.33	(3)	(3)	(3)
For acetate cupra filament and staple and specialty products[2]	160.83	184.33	181.25	184.33	(3)	(3)	(3)

[1] F.O.B. shipping point, varying freight allowances.
[2] Delivered.
[3] Not available.

Data for dissolving pulps from "Wood Pulp Statistics, 1953" (40). Data for other pulps computed from "Prices and Price Relatives" (25).

Markets for Market Pulp

The location of the Nation's paper and paperboard mills is shown in figure 7. The nonintegrated mills purchased slightly more than 60 percent of all market pulp consumed in 1952 (table 27). About 32 percent of the pulp consumed by partially integrated mills was market pulp, while integrated mills purchased about 1 percent of the pulp they consume. Because of the total pulp consumption by integrated mills, the 1 percent consumed in the form of market pulp amounts to a rather substantial quantity--112,000 tons in 1952.

The types of pulps purchased in largest quantity by integrated paper and paperboard mills in 1952 were bleached sulfate, bleached sulfite, and groundwood, in the order named. Partially integrated mills used more bleached and unbleached sulfite and bleached sulfate than any other types of pulp. Nonintegrated mills used more bleached sulfite than any other type of pulp, but bleached sulfate and unbleached sulfate and sulfite were also purchased in large quantities. Nonintegrated mills, more than any other group, concentrate on the

TABLE 27.—Consumption of own and market pulp by integrated, partially integrated, and nonintegrated paper and board mills, 1952[1]

Type of pulp	Quantity											
	Integrated mills			Partially integrated mills			Nonintegrated mills			All mills		
	Own	Market	Total	Own	Market	Total	Own	Market	Total	Own	Market	Total
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
Dissolving and special alpha	19	1	20	3	1	4	--	47	47	22	49	71
Sulfite, paper grades	1,357	28	1,385	551	392	943	--	643	643	1,908	1,063	2,971
Bleached	886	22	908	383	193	576	--	460	460	1,269	675	1,944
Unbleached	471	6	477	168	199	367	--	183	183	639	388	1,027
Sulfate, paper grades	7,923	48	7,971	443	259	702	--	461	461	8,366	768	9,134
Bleached	1,756	41	1,797	292	158	450	--	253	253	2,048	452	2,500
Semibleached	255	1	256	21	4	25	--	26	26	276	31	307
Unbleached	5,912	6	5,918	130	97	227	--	182	182	6,042	285	6,327
Soda	109	5	114	247	20	267	--	81	81	356	106	462
Groundwood	2,051	16	2,067	346	105	451	--	91	91	2,397	212	2,609
All other	1,931	14	1,945	55	5	60	--	32	32	1,986	51	2,037
Total	13,390	112	13,502	1,645	782	2,427	--	1,355	1,355	15,035	2,249	17,284
	Percentage											
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Dissolving and special alpha	95.0	5.0	100.0	75.0	25.0	100.0	0	100.0	100.0	31.0	69.0	100.0
Sulfite, paper grades	98.0	2.0	100.0	58.4	41.6	100.0	0	100.0	100.0	64.2	35.8	100.0
Bleached	97.6	2.4	100.0	66.5	33.5	100.0	0	100.0	100.0	65.3	34.7	100.0
Unbleached	98.7	1.3	100.0	45.8	54.2	100.0	0	100.0	100.0	62.2	37.8	100.0
Sulfate, paper grades	99.4	.6	100.0	63.1	36.9	100.0	0	100.0	100.0	91.6	8.4	100.0
Bleached	97.7	2.3	100.0	64.9	35.1	100.0	0	100.0	100.0	81.9	18.1	100.0
Semibleached	99.6	.4	100.0	84.0	16.0	100.0	0	100.0	100.0	89.9	10.1	100.0
Unbleached	99.9	.1	100.0	57.3	42.7	100.0	0	100.0	100.0	95.5	4.5	100.0
Soda	95.6	4.4	100.0	92.5	7.5	100.0	0	100.0	100.0	77.1	22.9	100.0
Groundwood	99.2	.8	100.0	76.7	23.3	100.0	0	100.0	100.0	91.9	8.1	100.0
All other	99.3	.7	100.0	91.7	8.3	100.0	0	100.0	100.0	97.5	2.5	100.0
Total	99.2	.8	100.0	67.8	32.2	100.0	0	100.0	100.0	87.0	13.0	100.0

[1] Includes building board.

Data from "Wood Pulp Statistics, 1953" (40). A mill is considered "integrated" if 90 percent or more of its wood pulp consumption is of "own" manufacture. Some but less than 90 percent of the consumption of wood pulp of a "partially integrated" mill is of "own" manufacture. A "nonintegrated" mill consumes no pulp of "own" manufacture.

production of fine and other specialty papers.

As indicated earlier, woodpulps sold outside the paper and board industry are mainly dissolving grades. The largest uses for dissolving pulps are in rayon and acetate fiber and cellophane manufacture in which an estimated 80 percent is consumed. The location of the rayon and acetate manufacturers and cellophane producers is shown in figure 9. Trends in sales of cellophane for packaging and in pulp consumption for rayon manufacture are shown in figures 10 and 11, respectively. Dissolving pulps are also used for the manufacture of plastics, explosives, photographic film, lacquers and saturating paper.

The export market for market pulp for all uses changed little between 1943 and 1952--ranging between about 100,000 and 200,000 tons in total most years (table 28). The principal export pulps are bleached sulfite, unbleached sulfite, and unbleached sulfate.

Market Competition

As indicated earlier, imports supply about 55 percent of the market pulp consumed in paper and board manufacture and a third of that consumed in the manufacture of non-paper and board products. Canada and Newfoundland supply the largest proportion of imports, and the rest comes from Norway, Sweden, and Finland. The principal grades of market pulp imported are shown in table 28 with trends in quantity imported from 1943 to 1952.

Although the South produces the largest proportion of total pulp (own and market), the Pacific region produces over half the market pulp produced domestically and shipped to domestic users (table 29). The South produces slightly more than a fourth of the market pulp and New England 13 percent. Dissolving pulps are produced in the Pacific and South regions in about equal quantities, while most bleached sulfite for the market is produced in the Pacific and New England regions. Sulfate grades are produced mostly in the South and Pacific regions. The location of pulp mills and pulp-producing paper and paperboard mills is shown in figure 7.

Raw Materials Used and Outlook for Future Supplies

Usage of raw materials for the manufacture of paper and paperboard was covered in the "Paper and Paperboard" section of this report.

The raw materials used to make dissolving pulps are wood and cotton linters. Except for rayon, no data are available on tonnage of each of these materials used for making the various end products. In rayon manufacture dissolving woodpulp is the dominant raw material, and its proportionate use for this purpose is increasing (fig. 11). In 1952 about 81 percent of the dissolving pulps used in rayon manufacture were made from wood.

As a source of alpha-cellulose, cotton linters are superior to wood and the resultant pulps slightly higher in alpha-cellulose content. Neither woodpulp nor linters pulp is 100 percent alpha-cellulose, but linters pulp more nearly approximates complete purity. The prices of pulpwood have generally been much steadier than linters and enough lower to offset the disadvantage with respect to alpha-cellulose yields. Linters prices are affected by the size of the cotton crop and prices of related products such as cottonseed oil and staple cotton. These influences have contributed to relatively unstable and often higher prices for linters, compared to pulpwood.

As indicated in the section entitled "Paper and Paperboard," the supply outlook for wood for pulping appears reasonably favorable for some years to come.

The supply of cotton linters, of course, depends on the size of the cotton crop. In recent years, production has totaled approximately 300,000 to 400,000 tons annually. Linters procurement is somewhat restricted by the need for extensive storage facilities to maintain sources of supply between production seasons. It is not likely that linters pulp will present nearly the raw material competition to bagasse dissolving pulp producers as dissolving woodpulp does chiefly because of raw material cost.

Building Fiberboards

Building fiberboards are sheet materials manufactured from refined or partly refined vegetable fiber. They are normally included in the "paper and allied products" field and, as with paper and paperboard, wood is the principal raw material used.

Most fiber building boards are manufactured by adaptations of the papermaking process; that is, the raw material is reduced to a pulp and formed into a mat on the screen of a paper machine. The wet mat is then dried in a continuous drier and simultaneously compressed to the desired density. Some high-density building boards

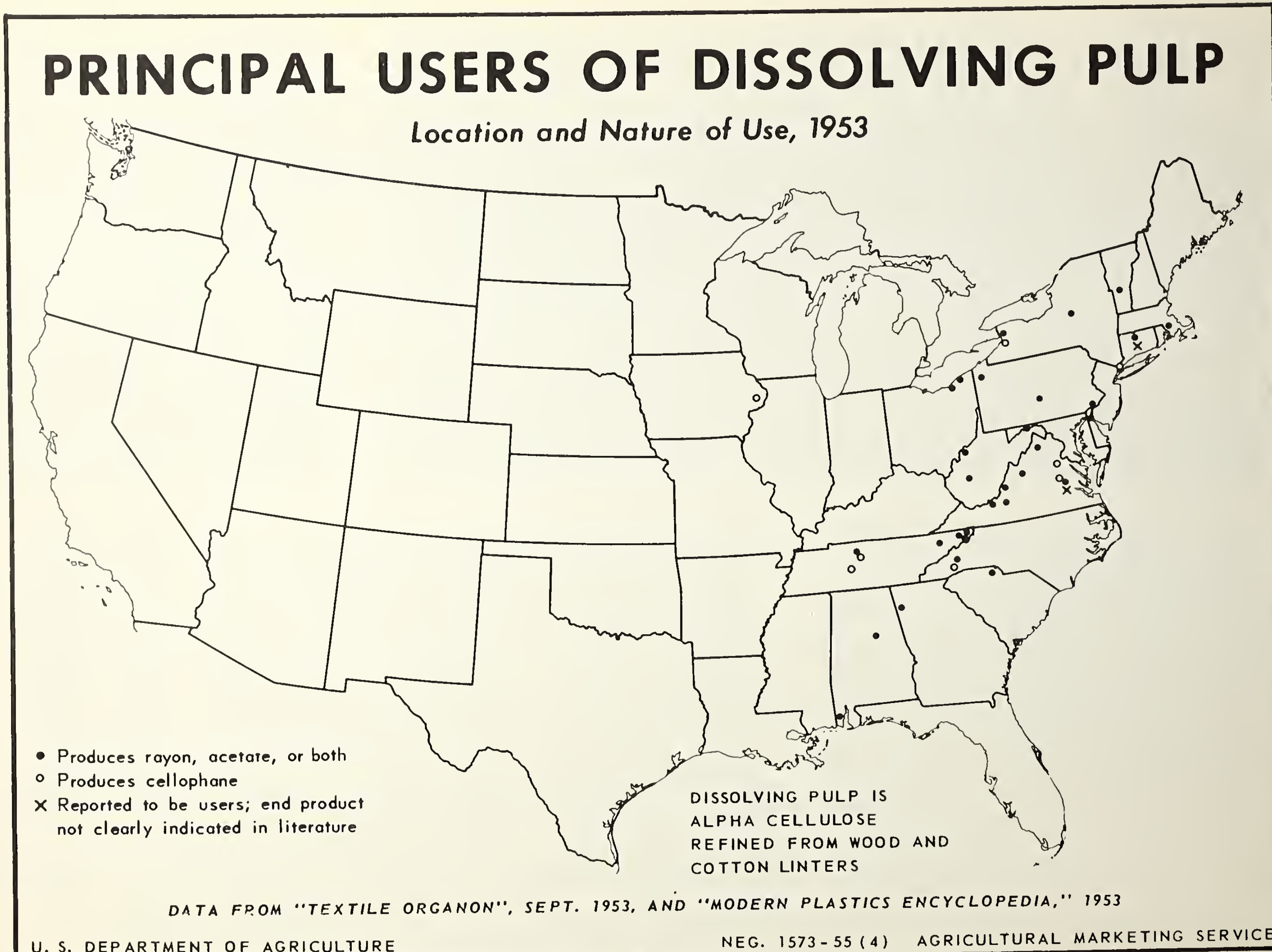

PRINCIPAL USERS OF DISSOLVING PULP
Location and Nature of Use, 1953
• Produces rayon, acetate, or both
o Produces cellophane
X Reported to be users; end product not clearly indicated in literature
DISSOLVING PULP IS ALPHA CELLULOSE REFINED FROM WOOD AND COTTON LINTERS
DATA FROM "TEXTILE ORGANON", SEPT. 1953, AND "MODERN PLASTICS ENCYCLOPEDIA," 1953
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1573-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 9

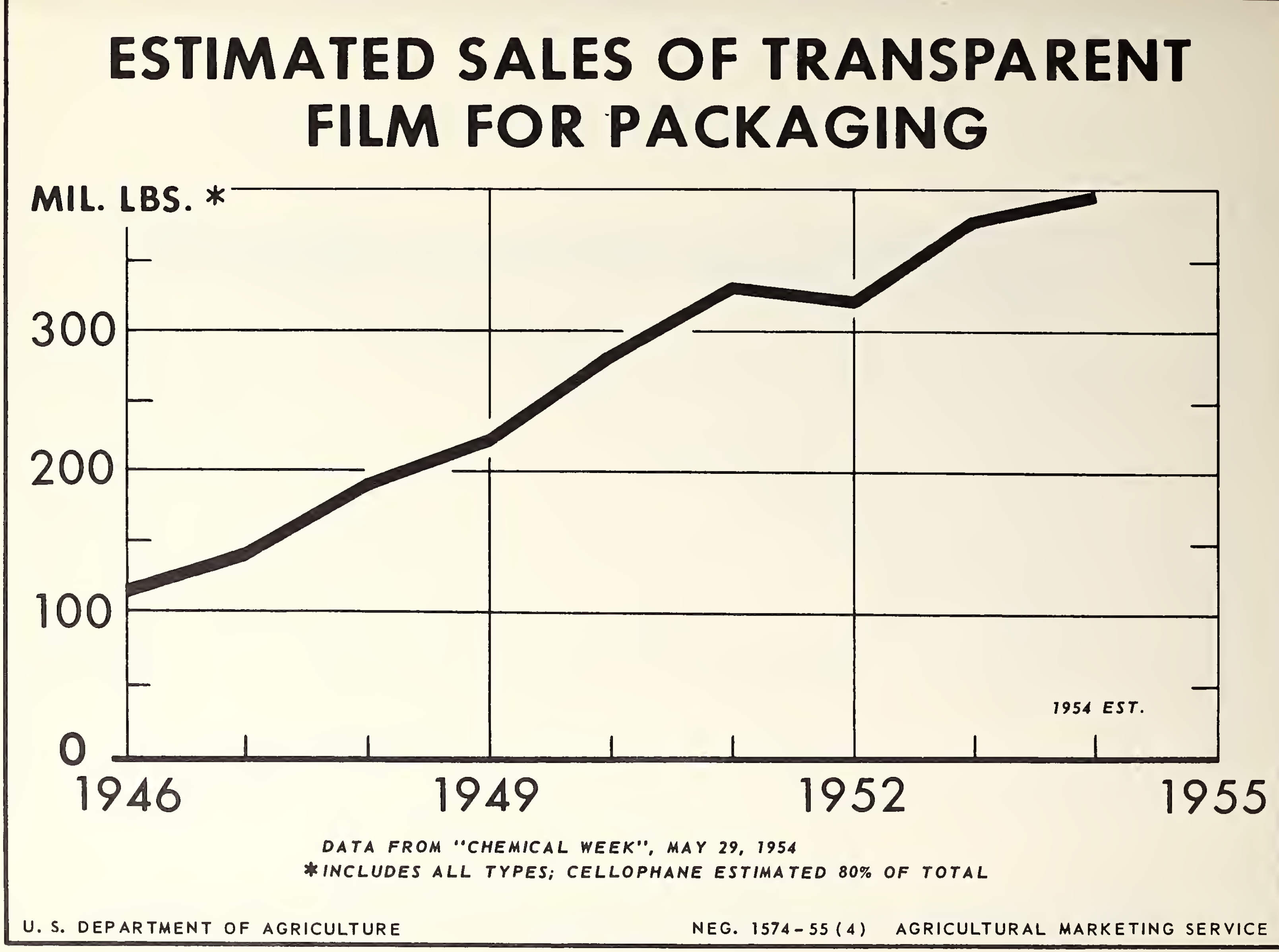

ESTIMATED SALES OF TRANSPARENT FILM FOR PACKAGING
MIL. LBS. *
300
200
100
0
1946
1949
1952
1955
1954 EST.
DATA FROM "CHEMICAL WEEK", MAY 29, 1954
*INCLUDES ALL TYPES; CELLOPHANE ESTIMATED 80% OF TOTAL
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1574-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 10

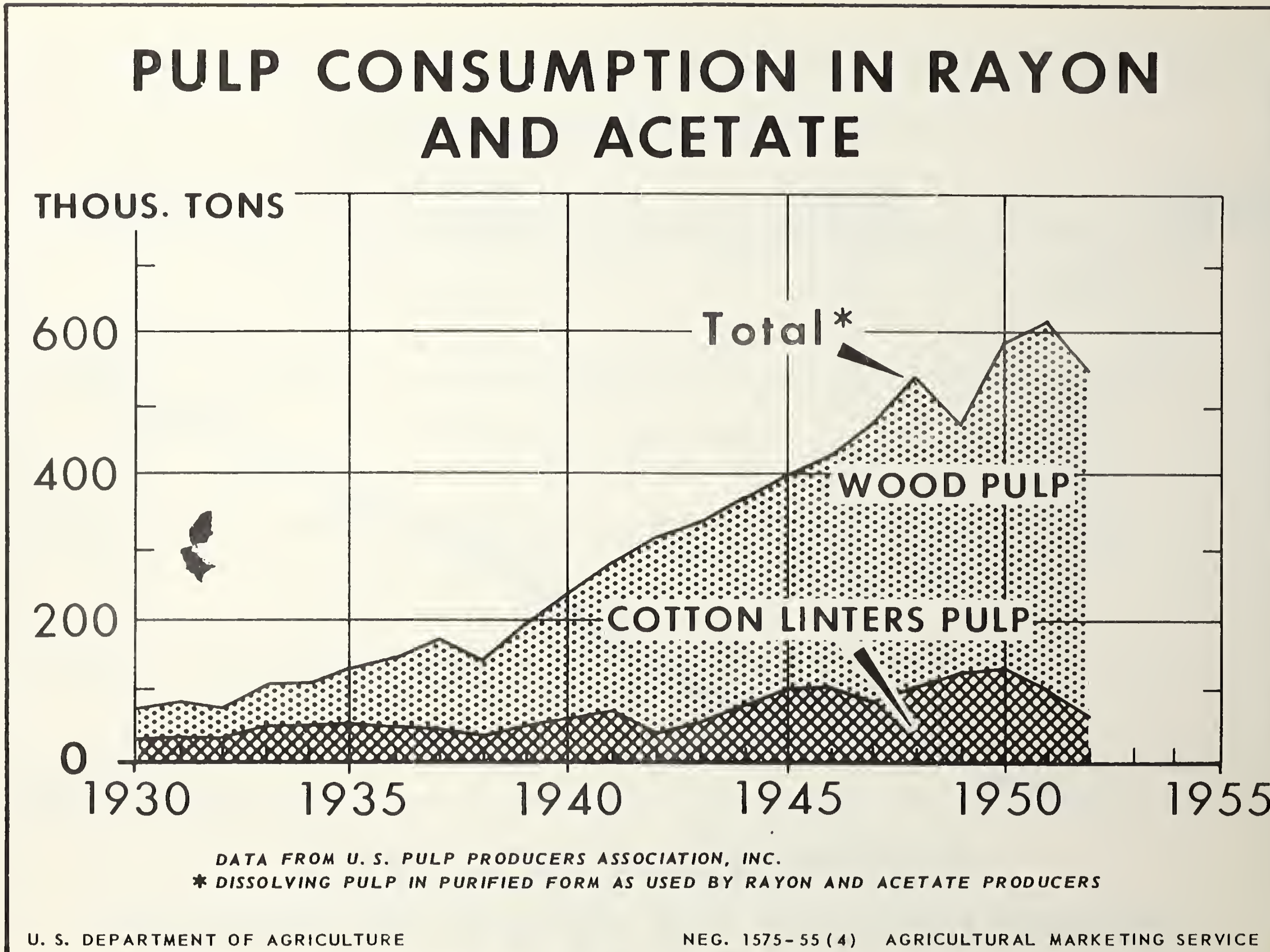

PULP CONSUMPTION IN RAYON AND ACETATE
THOUS. TONS
600
400
200
0
1930
1935
1940
1945
1950
1955
Total*
WOOD PULP
COTTON LINTERS PULP
DATA FROM U. S. PULP PRODUCERS ASSOCIATION, INC.
* DISSOLVING PULP IN PURIFIED FORM AS USED BY RAYON AND ACETATE PRODUCERS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1575-55 (4) AGRICULTURAL MARKETING SERVICE

Figure 11

TABLE 28.--Imports and exports of principal grades of market pulp, 1943-52

Year	Sulfite, Bleached, Rayon and special chemical grades: Imports	Sulfite, Bleached, Rayon and special chemical grades: Exports	Sulfite, Bleached, Other: Imports	Sulfite, Bleached, Other: Exports	Sulfite, Unbleached: Imports	Sulfite, Unbleached: Exports	Sulfate, Bleached: Imports	Sulfate, Bleached: Exports	Sulfate, Unbleached: Imports	Sulfate, Unbleached: Exports	Soda: Imports	Soda: Exports	Groundwood: Imports	Groundwood: Exports	Total: Imports	Total: Exports
	1,000 tons	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*	*1,000 tons*
1943..........	129	23	153	45	401	90	34	16	53	121	20	5	164	1	954	301
1944..........	133	11	111	38	292	46	32	7	44	106	16	11	103	(1)	731	219
1945..........	146	13	159	17	537	27	54	6	331	60	21	10	135	2	1,383	135
1946..........	202	8	140	7	518	17	60	1	300	5	20	(1)	150	1	1,390	39
1947..........	249	11	193	44	648	54	167	2	390	17	21	1	190	2	1,858	131
1948..........	235	18	233	13	586	54	187	1	265	6	25	1	189	1	1,720	94
1949..........	154	25	266	20	323	39	182	9	210	27	27	(1)	129	1	1,291	121
1950..........	237	28	340	18	468	33	209	5	405	10	34	(1)	195	3	1,888	97
1951..........	217	31	272	44	491	43	246	9	300	71	33	1	242	2	1,801	201
1952..........	180	65	204	24	375	35	254	12	173	76	28	[2]1	162	1	1,376	214

[1] Less than 500 tons.
[2] Includes "screenings" and other wood pulp.

From "Wood Pulp Statistics, 1953" (40). Includes data for pulp for paper and paperboard and non-paper and paperboard uses.

TABLE 29.--Percentage distribution of shipments of domestic market pulp by regional origin, 1952

Region[1]	Shipped to domestic users: Dissolving and special alpha	Shipped to domestic users: Sulfite, Bleached, paper grades	Shipped to domestic users: Sulfite, Unbleached	Shipped to domestic users: Sulfate, Bleached and semibleached, paper grades	Shipped to domestic users: Sulfate, Unbleached	Shipped to domestic users: Soda	Shipped to domestic users: Groundwood	Shipped to domestic users: Other	Shipped to domestic users: All pulp	Shipped for export: All pulp	Total shipments
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Pacific..........	53.0	83.0	56.0	41.0	4.0	--	--	43.0	53.0	42.0	52.0
South..........	--	--	--	51.0	80.0	--	--	--	27.0	41.0	29.0
New England..........	--	12.0	--	--	7.0	--	--	--	13.0	2.0	11.0
Lake..........	--	--	--	--	9.0	--	--	--	4.0	15.0	4.0
Middle Atlantic..........	--	--	30.0	--	--	--	--	--	3.0	--	4.0
New England and South..........	47.0	--	--	--	--	--	--	--	--	--	--
New England, Lake and Middle Atlantic..........	--	--	--	8.0	--	--	--	--	--	--	--
New England and Middle Atlantic..........	--	--	--	--	--	62.0	57.0	22.0	--	--	--
New England and Lake..........	--	--	14.0	--	--	--	--	--	--	--	--
Lake and Middle Atlantic..........	--	5.0	--	--	--	--	--	--	--	--	--
Lake and South..........	--	--	--	--	--	38.0	--	35.0	--	--	--
Lake and Pacific..........	--	--	--	--	--	--	43.0	--	--	--	--
Total..........	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] New England includes Conn., Maine, Mass., N. H., R. I., and Vt.; Middle Atlantic-N. Y., Pa., N. J.; Lake-Ill., Ind., Iowa, Mich., Minn., Ohio and Wis.; Pacific-Alaska, Calif., Idaho, Oreg., and Wash.; South-Ala., Ark., Fla., Ga., La., Md., Miss., N. C., S. C., Tenn., Tex., and Va.

Data from "Wood Pulp Statistics-1953" (40).

are also made by semidry processes in which the fibers are carried in an air suspension, air-felted into a mat, and compressed. Others are made by blending together fiber particles or chips with various resins and consolidating the mixture under heat and pressure. These boards are manufactured in densities ranging from 2 to 90 pounds per cubic foot, and the density differentials chiefly determine end use. The lower-density materials are used primarily as insulation and accoustical board, and the higher density boards are used as structural materials or bearing surfaces.

Approximately 60 percent of all building fiberboards produced in the United States are classed as "insulation" boards with densities of 24 pounds or less per cubic foot (classification changed to 26 pounds or less per cubic foot in 1953). The balance of the fiberboards are generally referred to as "hardboards." Bagasse is presently used only in the production of insulation board. However, the major bagasse insulation board producer did manufacture hardboard from bagasse for a short while in the middle 1930's. It is reported that patent difficulties with an existing hardboard producer made continued operations impossible at that time. Researchers at the Forest Products Laboratory and the Northern Utilization Research Branch pointed out that bagasse is suitable qualitywise for hardboard manufacture. The market potential for both types of board is covered in the following sections.

Insulation Board

Bagasse served as the first raw material for the manufacture of insulation board. A private corporation pioneered the development of this product and began production in 1920 at Marrero, Louisiana--just across the Mississippi River from New Orleans. Since that time other manufacturers have entered the field, utilizing mostly wood as raw material. Waste paper, licorice root, and straw are also serving as raw materials; and a second bagasse plant is in operation at Hilo on the Island of Hawaii.

Industry Growth

The production of insulation board increased from 1,670 million square feet in 1941 to 2,428 million square feet in 1953, though 3 rather distinct production periods are apparent during this span of years (table 30). During World War II the industry operated at more than 90 percent of rated capacity, but increases in production were precluded primarily by lack of materials for capacity expansion. Immediately after the war capacity expanded rapidly, and production rose sharply to a new and much higher plateau in response to demand for construction materials. Since 1948 insulation board production has been quite stable, except for a sharp interruption in 1949 when production fell below that of any year during the period covered, due principally to reduced building activity. (The data on production of insulation board in 1953 are slightly inflated compared to previous years, because the Bureau of the Census changed the classification from boards with densities of 24 pounds or less per cubic foot to boards with densities of 26 pounds or less per cubic foot (table 30)). In addition, industry capacity has changed little in recent years. From 1950 to 1953 the insulation board industry operated at about three-quarters of capacity.

Estimates by the U. S. Department of Commerce and the U. S. Department of Labor at the time of publication indicated that on a dollar basis 1954 would be a record breaking year in construction activity. For 1955, new construction activity is expected to reach an all-time high of $39-1/2 billion, 7 percent above the $37 billion volume indicated for 1954, possibly indicating increased demand for insulation board. New residential building (nonfarm) is expected to increase by 13 percent to $15 billion and to account for 55 percent of all private construction next year.

TABLE 30.—Insulation board: Production and capacity, surface measure, and production as percentage of capacity, 1941-53

Year	Production[1] [2]	Capacity[3]	Production as a percentage of capacity
	Million square feet	*Million square feet*	*Percent*
1941	1,670	1,848	90.4
1942	1,849	1,898	97.4
1943	1,776	1,898	93.6
1944	1,789	1,944	92.0
1945	1,826	1,942	94.0
1946	1,952	1,901	102.7
1947	2,100	2,387	88.0
1948	2,387	2,669	89.4
1949	1,602	2,887	55.5
1950	2,321	3,076	75.5
1951	2,383	3,060	77.9
1952	2,242	3,105	72.2
1953	[4]2,428	3,105	78.2

[1] Data for 1941-46 from files of Dr. Arthur G. Keller, Professor, Chemical Engineering, Louisiana State University; 1947-53 from "Facts for Industry" (31).
[2] Before 1953 the Bureau of the Census classified insulation board as those boards with densities of 24 pounds or less per cubic foot. In 1953 the classification was changed to 26 pounds or less per cubic foot.
[3] Computed for a 310-day year from data on daily rated capacity as reported for the various insulation board firms by "Lockwood's Directory of the Paper and Allied Trades" (15) and "Posts' Paper Mill Directory" (21).
[4] Thickness not specified in source data except 1953 production, which is on a 1/2" thick basis.

Market Growth by Types of Insulation Board

Most insulation board is manufactured in the higher density ranges for this type of board and has "structural" strength as well as insulating and sound-absorbing qualities. These boards have many uses in housing and allied applications. Insulation boards manufactured in the lower density ranges have about the same heat flow characteristics as blanket or batt insulation and are used in truck bodies and other places where vibrations are so severe that batt insulation may shift or pack.

The principal types of insulation board presently being produced are the following: (1) Sheathing board (asphalt waterproofed on the sides and edges), (2) insulating siding base (backing for building siding, such as asphalt shingles), (3) building board, natural finish (used for the exterior of buildings), (4) roof insulation, (5) lath for plaster base, (6) boards factory finished and decorated for interior use (tile, planks, panels, and wall boards), and (7) thinboard. Insulation boards vary in thickness from about 3/8 inch to 1-1/2 inches, but most types are about 1/2-inch thick. Some interior tile is especially processed for acoustical purposes. This type of tile has a high-density surface through which numerous small holes have been drilled to break the sound pattern.

Since 1947, the Bureau of the Census has reported annual production of the various types of insulation board (table 31). The production of building board, natural finish, lath for plaster base, and boards finished or decorated for interior use declined in relative importance and in actual quantity manufactured between 1947 and 1952. The types of board which were produced in larger quantities in 1952 than in 1947 were roof insulation, panel (including tile), plank, sheathing, insulating siding base, and thinboard.

TABLE 31.--Insulation board: Production by types, 1947-52

Type	Quantity[1]						Percentage					
	1947	1948	1949	1950	1951	1952	1947	1948	1949	1950	1951	1952
	1,000 square feet	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Building board, natural finish..........	306,526	481,706	321,144	549,306	450,018	268,246	14.4	20.2	20.0	23.7	18.9	12.0
Lath for plaster base..................	88,848	129,238	68,040	140,531	103,812	64,165	4.2	5.4	4.2	6.0	4.4	2.9
Roof insulation board..................	107,253	149,448	134,453	185,251	180,010	187,167	5.0	6.2	8.4	8.0	7.5	8.3
Interior board, factory finished												
Wallboard............................	641,018	678,149	321,824	376,624	417,844	391,413	30.1	28.4	20.1	16.2	17.5	17.5
Panel, including tile................	193,004	331,422	241,517	314,781	357,761	379,244	9.1	13.9	15.1	13.6	15.0	16.9
Plank................................	31,803	44,746	39,310	42,458	51,993	55,031	1.5	1.9	2.5	1.8	2.2	2.4
Sheathing board........................	196,737	525,120	173,349	398,539	393,390	457,558	9.2	22.0	10.8	17.2	16.5	20.4
Insulating siding base.................	(2)	(2)	246,882	234,244	309,507	324,041	(2)	(2)	15.4	10.1	13.0	14.4
Thinboard (3/8" thick or less).........	(2)	(2)	44,397	55,314	92,172	84,622	(2)	(2)	2.8	2.4	3.9	3.8
Other insulating board (not laminated) including other interior.............	565,712	47,126	10,641	23,897	26,373	30,721	26.5	2.0	.7	1.0	1.1	1.4
Total............................	2,130,901	2,386,955	1,601,557	2,320,945	2,382,880	2,242,208	100.0	100.0	100.0	100.0	100.0	100.0

[1] Square footage of board of varying thickness as it comes off production line.
[2] Not reported separately.

Basic data from "Facts for Industry" (31).

Economics of Producing Insulation Board

Cost of Production.--No data are available on current costs of manufacturing structural insulation board. However, an unpublished analysis by Dr. Arthur G. Keller, Professor, Chemical Engineering, Louisiana State University, develops such costs under 1947 conditions. This study assumes a plant capacity of 550,000 square feet of 1/2-inch thick board per 24-hour day and a location in the Louisiana sugarcane area. On this basis Dr. Keller shows production costs broken down per 1,000 square feet of 1/2-inch board as follows:

Sales price, f.o.b. factory		$29.31
Direct costs:		
Raw materials (bagasse, wastepaper, chemicals)	$5.58	
Labor............................	4.50	
Other direct costs	3.91	
Total direct costs..........	$13.99	
General and administrative costs............................	7.66	
Total costs........................		21.65
Net..................................		$ 7.66

A plant producing 550,000 square feet of insulation board a day will produce about 170 million square feet a year. To maintain this production rate, the plant would require approximately 57,000 tons of bagasse, bone-dry basis, annually, assuming a finished board made from pulp comprised of 75 percent bagasse and 25 percent wastepaper. One ton of bone-dry bagasse will produce about 3,000 square feet of board mixed with wastepaper in these proportions.

In 1947, according to Dr. Keller, a bagasse insulation board plant of the size assumed above would have cost approximately $5,200,000, including $1,000,000 working capital. This estimate excludes the costs of land, railroad sidings, manufacturing supplies, and any baling stations that the manufacturer might be required to maintain at sugar mills to obtain bagasse. At least 35 acres of land for all facilities and equipment would have been required for such a plant.

The capacity selected by Dr. Keller as being of minimum capacity in 1947 for reasonably profitable and stable operations was about equal to the present average for the industry. In 1953 insulation board plant capacity averaged about 500,000 square feet per 24-hour day. In addition, the largest number of plants had capacities ranging near 500,000 square feet per day, though some were much smaller.

Profit Trends.--Most insulation board firms manufacture other types of building materials, including other kinds of structural board, such as gypsum board. Published source material on these companies counted insulation board production as being the major activity of only 3 of the 20 companies producing insulation board in 1953. One of these firms uses bagasse, the others use competing raw materials. For these 3 companies, net profit after income taxes as a percent of net worth was calculated for 1947 to 1953.

Since their joint capacity was equal to about a third of industry capacity in recent years, trends in their financial position should be indicative of overall trends for insulation board manufacture. The sources of the financial data used for computation were reports published by the Securities and Exchange Commission (42) and reports published in "Moody's Manual of Investments-Industrials" (18). The net profit-net worth ratios for the years covered are shown below:

	1947	1948	1949	1950	1951	1952	1953
Percent	33.2	28.6	6.8	10.1	10.9	4.9	9.0
No.Co's	3	3	3	3	3	3	3

During 1947 and 1948, profits on investments were comparatively high. However, since that time the percentage of net profit on net worth has declined to a more modest level. The bagasse producer appeared to have no cost-price advantage during the period covered.

Price Trends.--The insulation board manufacturer divides the country into freight differential zones and charges all dealers and jobbers within each zone the same price per carlot delivered.

As noted in a later section entitled "Evaluation of relative quality by users and distributors of insulation board," the building materials dealers and users interviewed indicated that the competing insulation board firms seldom engage in extensive price cutting. Prices of all brands offered in an area are ordinarily uniform for the various types of board. A firm devotes its attention to other markets if it cannot compete at the going price. Most manufacturers endeavor to expand sales through merchandising and dealer service activities rather than by discounting prices, according to the dealers interviewed.

Insulation board prices increased steadily from 1947 to mid-1953, showing a tendency to level off the last half of 1953 (table 32). This rather strong price trend has continued in spite of materially reduced earnings on investment in recent years, indicating an even stronger upward trend in costs.

TABLE 32.--Insulation board: Price per 1,000 square feet, annual average, 1947-52, by months, 1953[1]

Year and month	Price	Year and month	Price
	Dollars		Dollars
1947	37.8	1950	43.6
1948	41.6	1951	46.9
1949	42.2	1952	47.9
1953		1953	
January	49.0	July	51.0
February	49.0	August	51.0
March	49.0	September	51.0
April	49.0	October	51.0
May	51.0		
June	51.0		

[1] Price per 1,000 square feet, interior board, 1/2 inch by 4 feet by 8 feet, manufacturer to dealer or jobber in carlots, full freight included.

Computed from data in "Prices and Price Relatives" (25).

Markets for Insulation Board

The insulation board industry must look principally to the construction industry and individual home users for outlets, and therefore its markets are widely dispersed throughout the country. Areas in which population growth is greatest (fig. 6) or where commercial development is going forward are, of course, the markets in which the opportunities for expanded sales are most promising.

Low-density insulation boards are also used for heat insulation in truck and bus bodies, automobiles, refrigerators, railway cars, on the outside of duct work, and in other places where vibrations are so severe that loose-fill or batt insulation may pack or shift. And they are used as sound insulation, for the walls of telephone booths, public address systems, and phonographs, and as cushioning in utility quality furniture and packaged material.

The export market apparently offers little opportunity for increased sales of insulation board. Since 1946 only 2 to 3 percent of total production has been exported, and there is no growth trend evident (table 33).

TABLE 33.--Insulation board: Imports and exports, annual, 1946-53[1]

Item	1946	1947	1948	1949	1950	1951	1952	Jan.-Nov. 1953
	1,000 square feet	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*
Exports..	40,263	63,882	41,500	46,096	41,247	53,102	43,514	41,079
Imports..	2,003	3,749	236	25	6,415	7,966	9,978	11,018

[1] Where data were shown on a poundage basis, they were converted to square feet by using the factor 1 pound = 1.31366 square feet. Thickness not specified in data source.

Data from Census Reports No. FT110, "U. S. Imports of Merchandise for Consumption" (34) and No. FT410, "U. S. Exports of Domestic and Foreign Merchandise" (33).

Market Competition Among Insulation Board Producers

Location and Capacity of Competing Mills. Most of the competition for expanded production of bagasse insulation board would come from other insulation board producers. The location of the Nation's insulation board plants operating in 1953 and total capacity by States are shown in figure 12. The greatest concentration of plants in 1953 was in the South where 6 are located in or near the lower reaches of the Mississippi River. Louisiana has the largest total daily capacity of any State, followed in order by Minnesota, Mississippi, Massachusetts, New Jersey, Virginia, Alabama, Georgia, Oregon, the Territory of Hawaii, and Washington. In contrast, there were no insulation board plants in the States contiguous to the lower Great Lakes nor in the Plains area.

Trends in Importance of Bagasse as Insulation Board Raw Material.--Data are not available on actual insulation board production by type of principal raw material used. But it is possible to compute plant capacity by type of raw material from data in "Lockwood's Directory of the Paper and Allied Trades" and "Post's Paper Mill Directory."

Judging from trends in plant capacity in the insulation board industry, bagasse board has not shared equally in the vast increase in the market that has taken place in recent years. From 1938 to 1953 total rated capacity increased slightly more than 100 percent, while capacity of plants using bagasse increased only about 48 percent (table 34). As a result, bagasse board plant capacity declined from 35.6 percent to 26.2 percent of total industry capacity. Practically all this capacity loss, percentagewise, was matched by a net gain in capacity of plants using wood as raw material. The aggregate capacity of plants using raw materials other than wood or bagasse increased from 6.2 to 7.2 percent of total capacity during the period covered.

TABLE 34.--Insulation board industry: Daily production capacity, 1938-41 and 1948-53

Principal raw material used	1938	1939	1940	1941	1948	1949	1950	1951	1952	1953
	Quantity[1]									
	1,000 sq.ft.	*1,000 sq. ft.*	*1,000 sq. ft.*	*1,000 sq. ft.*	*1,000 sq. ft.*	*1,000 sq. ft.*	*1,000 sq. ft.*	*1,000 sq.ft.*	*1,000 sq.ft.*	*1,000 sq.ft.*
Wood........	2,906	3,308	3,308	3,825	5,500	6,203	6,604	6,577	6,670	6,670
Bagasse.....	1,778	1,778	1,778	1,778	2,624	2,624	2,649	2,624	2,624	2,624
Other[2]......	313	318	318	358	486	486	670	670	723	723
Total..	4,997	5,404	5,404	5,961	8,610	9,313	9,923	9,871	10,017	10,017
	Percentage									
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Wood........	58.2	61.2	61.2	64.2	63.9	66.6	66.6	66.6	66.6	66.6
Bagasse.....	35.6	32.9	32.9	29.8	30.5	28.2	26.6	26.6	26.2	26.2
Other[2]......	6.2	5.9	5.9	6.0	5.6	5.2	6.8	6.8	7.2	7.2
Total..	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Thickness not specified in data source.
[2] Mostly licorice root, straw, hemp, wastepaper.

Computed from data in "Lockwood's Directory of the Paper and Allied Trades" (15) and "Post's Paper Mill Directory" (21). Capacity for 310-day year--24 hours per day.

Relative Quality of Insulation Board as Governed by Raw Material.--Knowledge of the relative quality of bagasse insulation boards and competing insulation boards, as influenced by the raw material used, is important to persons considering the feasibility of building new board plants using bagasse or expanding present facilities for production of bagasse board. Information on quality factor was obtained from various

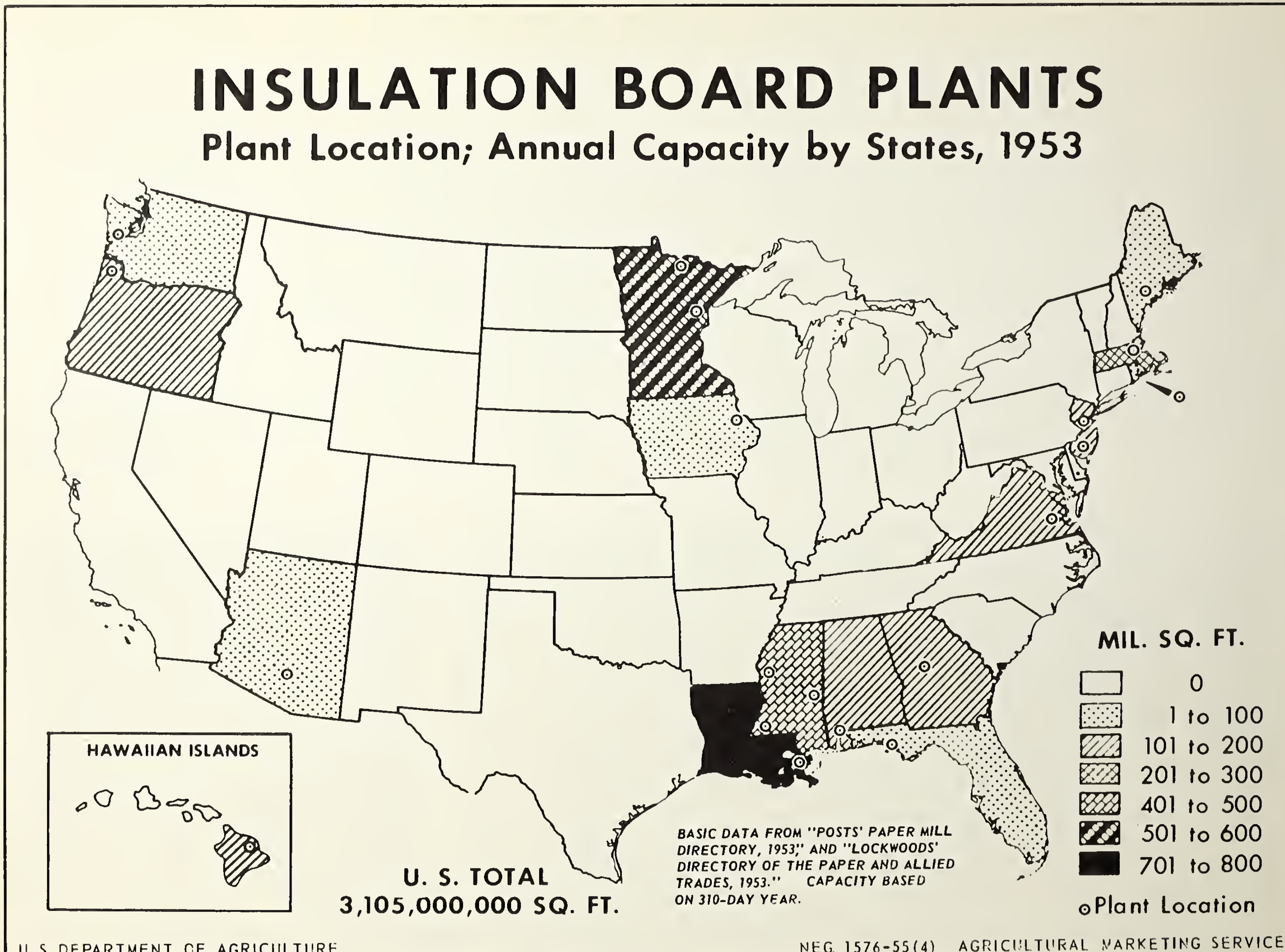

INSULATION BOARD PLANTS
Plant Location; Annual Capacity by States, 1953
HAWAIIAN ISLANDS
U. S. TOTAL
3,105,000,000 SQ. FT.
BASIC DATA FROM "POSTS' PAPER MILL DIRECTORY, 1953," AND "LOCKWOODS' DIRECTORY OF THE PAPER AND ALLIED TRADES, 1953." CAPACITY BASED ON 310-DAY YEAR.
MIL. SQ. FT.
0
1 to 100
101 to 200
201 to 300
401 to 500
501 to 600
701 to 800
Plant Location
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1576-55(4)
AGRICULTURAL MARKETING SERVICE

Figure 12

fiber research and testing institutions, trade associations, distributors and users of insulation board, and from literature on the subject.

The Forest Products Laboratory, the National Bureau of Standards, Louisiana State University, and the Northern Utilization Research Branch were visited to get information and opinions on board quality characteristics.

Most researchers interviewed believed that raw material used has little influence on the quality of the finished insulation board. The opinions of the persons interviewed at the National Bureau of Standards are typified by published results of extensive tests on the properties of fiber boards made from wood, bagasse, cornstalks, licorice root, and wastepaper. A report (44) on these tests includes a summary of findings quoted in part as follows:

> That the source of the vegetable fiber used had a relatively unimportant effect on the essential properties of the boards may be observed from the rather uniformly good correlation between the density and other properties, especially thermal conductivity, for all boards.

Insulation board specialists at the Forest Products Laboratory supported these conclusions, indicating that the quality of insulating board depends mostly on the skill or care of manufacture. In their opinion, the bagasse boards presently on the market represent about average quality. It was pointed out that 2 or 3 competing boards have greater strength and resistance to sag than bagasse board, while others are not as well made as bagasse board.

Persons interviewed at the Northern Utilization Research Branch took a somewhat different view than those at the other institutions visited. They indicated that the quality of building boards was influenced significantly by the raw material used. According to tests at NURB, the structural and nail holding strength and the resistance to impact of bagasse board was greater than that of board of equal density made from other raw materials. Other important quality factors such as insulating value, permeability to air and water, and appearance, were not believed to be dependent on raw material but on methods of manufacture.

The Federal Specifications for insulating fiberboard deal very briefly with types of material from which fiberboard should be made. The raw materials specifications are as follows:

> Boards shall be manufactured from wood or other vegetable fiber, by a felting or molding process, suitable sizing material being incorporated in the product to render it water resistant. The materials shall be subjected to such drying temperature as to effect complete destruction of rot-producing fungi.

Users, builders, and retail distributors of building materials were interviewed to ascertain their opinions of comparative quality characteristics of board made from bagasse and other raw materials. The users interviewed were selected with advice of the National Association of Home Builders and the distributors with the help of State associations of retail lumber dealers. No attempt was made to sample dealers and builders by size, geographical location, or other criteria often used for opinion surveys. The only criterion used was that the firms or persons at the cities visited have had extensive experience with all types of insulating material and, therefore, would be likely to have an interest in the subject of insulation board.

Most of the builders and distributors interviewed had no strong feelings regarding relative quality of the various brands of insulation board. If a builder needs insulation board, he usually orders it without caring from which raw material it is made.

Table 35 summarizes the opinions and comments of the persons interviewed. Some of the quality differentials referred to by these persons are related to the influence of the raw materials, others to methods of manufacture. As will be noted, there were a few differences of opinion among some of the persons interviewed regarding relative quality of boards produced from bagasse and competing raw materials. For instance, 5 persons thought that bagasse board had superior structural strength, and 2 thought that the manufacturers of bagasse board did a better job of asphalt impregnation of the sheathing type board. Wood boards were judged by 2 persons as having greater nail-holding strength, and 4 persons viewed the wood board as being superior in appearance.

TABLE 35.--Insulation board: Opinions of builders and distributors as to the relative quality of the boards made from various raw materials, April 1953

Opinion	Chicago, Ill.		Little Rock Ark.		Atlanta, Ga.		Jacksonville, Fla.		Jackson, Miss.		Mobile, Ala.		Chattanooga, Tenn.		Washington, D. C.	New Orleans, La.	Total
	Bldr.	Dist.	Bldr.	Dist.	Bldr.	Dist.	Bldr.	Dist.	Bldr.	Dist.	Bldr.	Dist.	Bldr.	Dist.	Distributor	Distributor	
Wood board better because—																	
More effective asphalt impregnation of sheathing.	*Number* 1	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* —	*Number* 1
Leaves cleaner cut when sawed..................	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
More sag resistant........	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
Greater nail holding strength................	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	2
Smoother appearance of interior board..........	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Acoustical board has neater appearance because holes bored more neatly..................	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Harder surface............	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Unpainted board has more attractive appearance...	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Bagasse board better because—																	
Greater structural strength................	—	—	1	1	—	—	—	—	—	—	—	1	—	1	1	—	5
More effective asphalt impregnation of sheathing.	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	2
Less expansion and contraction................	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Sheathing has better appearance................	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
No quality difference.......	—	1	—	1	—	1	—	1	—	1	1	1	1	1	—	—	9
Don't know................	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1

The point made most often was that there is no significant quality difference between various boards presently on the market. Distributors and users pointed out that, consequently, their decision regarding which brand of board to handle at a particular time is based on factors other than quality. Principal among these factors were personal friendship between salesmen and buyers and the dealer service and other merchandising assistance provided by the board producer. Seldom was price differential mentioned as an important influence. The persons interviewed indicated that in general there is no price differential between the various brands of boards.

Relative Effectiveness of Merchandising Activities of Insulation Board Manufacturers.--Users and distributors of building board were asked to evaluate the relative effectiveness of the sales programs of the various manufacturers. Most of the insulation board manufacturers sell a variety of building materials. To many of these firms insulation board is not as important from the point of sales volume as other items, and merchandising emphasis is placed on other products. Bagasse board producers, on the other hand, are largely in the insulation board business.

Judging from the comments of the users and distributors of building material, the bagasse board producers have a more complete promotion program for insulation board than other manufacturers in the field. All producers have competent salesmen calling on distributors and large builders; but bagasse producers conduct, in addition, a rather aggressive promotion program aimed at individual home users. Some dealers indicated that the consumer demand created by these activities helped them merchandise bagasse insulation board.

Market Competition From Products With Similar End Uses.

The principal products which present important competition to insulation board are gypsum wallboard and other types of insulating material. Sales of the principal types of gypsum board from 1946 through the first 9 months of 1953, are shown in table 36. Prices of the same types of gypsum board are in table 37. As with insulation board, production seems to have leveled off in recent years after rapid immediate postwar growth, and prices are continuing strong.

TABLE 36.—Gypsum board: Sales or use by type, 1946-53

Type	1946	1947	1948	1949	1950	1951	1952	1953[1]
	1,000 square feet	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*	*1,000 square feet*
Lath, 3/8-inch basis	1,147,353	1,703,818	2,504,733	2,015,638	2,793,620	2,756,278	2,318,960	1,883,272
Wallboard, 3/8 to 1/2-inch basis[2]	1,922,096	2,047,957	2,531,865	2,439,121	2,901,947	3,243,676	3,456,587	2,677,435
Sheathing, 1/2 to 5/8-inch basis	76,914	106,482	129,632	97,037	113,785	116,204	116,665	99,643
Tile, 4-inch basis[3] [4]	10,821	26,769	27,181	28,518	45,032	37,862	27,394	19,212
Total	3,157,184	3,885,026	5,193,411	4,580,314	5,854,384	6,154,020	5,919,606	4,679,562

[1] First 9 months.
[2] Includes laminated board.
[3] Includes partition, roof, floor, soffit, shoe, and all other gypsum tiles and planks.
[4] Minor quantities of a thickness other than 4 inches.

Data for 1946 to 1951 from Minerals Yearbook (27); for 1952 and first 9 months of 1953 from "Mineral Industrial Surveys" (26).

TABLE 37.—Gypsum board: Price per 1,000 square feet, by types, 1946-52

Type	1946	1947	1948	1949	1950	1951	1952
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Lath, 3/8-inch basis[1]	16.17	18.92	21.40	21.36	21.70	23.42	[2] 23.48
Wallboard, 3/8 to 1/2-inch basis[1] [3]	22.99	25.96	28.40	28.03	29.16	32.39	32.88
Sheathing, 1/2 to 5/8-inch basis[1]	26.29	33.20	34.19	33.68	33.84	36.49	36.57
Tile, 4-inch basis[1] [4] [5]	47.92	67.37	72.40	73.17	75.26	77.49	78.54

[1] F.o.b. producing plant.
[2] Estimated.
[3] Includes laminated board, but price represents wallboard only.
[4] Minor quantities of a thickness other than 4 inches.
[5] Includes partition, roof, floor, soffit, shoe, and all other gypsum tiles and planks. Price represents partition tile only.

Data for 1946 to 1951 from Minerals Yearbooks (27); for 1952 from "Mineral Industrial Surveys" (26).

Various types of insulating material compete with insulation board, the most important of which is probably mineral wool. The latest information available on the production of mineral wool insulation by uses is included in the "Census of Manufacturers, 1947" (28). In 1947, about 773,000 tons of mineral wool, loose and in batts, were shipped for building insulation, and about 75,000 tons were shipped for insulation of installed industrial equipment such as boilers and ducts. In addition, 108,000 tons were transported for installation as an integral part of equipment such as refrigerators and hot water heaters. In total, the tonnage shipped was valued at $79,094,000 compared to $150,664,000 in 1950, $134,128,000 in 1951, and $138,305,000 in 1952. Prices on mineral wool are not quoted in Government or trade publications.

Plywood and hardboard also compete with insulation board for certain uses such as interior wallboard. Production and price trends for these products are covered in the section following entitled "Hardboard."

Hardboard

Hardboard, unlike insulation board, is presently made exclusively from wood. Pulpwood, low-quality saw logs, and forest waste, such as sawdust, shavings, and slabs, supply the bulk of the wood fiber used, though some good quality saw logs are also used.

Hardboards range in thickness from 1/8 to 1/2 inch and in density from 25 to 90 pounds per cubic foot, though most are 1/8 inch thick and in the higher density ranges. (In 1953 minimum density was placed by the Bureau of the Census at "more than 26" pounds per cubic foot.) Their uses are governed by degree of density--"low density," "high density" and "very dense." "Low density" hardboards, ranging in density from "more than 26" to 50 pounds per cubic foot, are used principally for interior wall covering where a more abrasive resistant surface is needed than that provided by rigid insulation board. These boards also have limited use in furniture manufacture as drawer bottoms, dividers, and cabinet backs.

"High density" hardboards have densities ranging from 50 to 70 pounds per cubic foot. Most hardboards fall within this group. High density hardboards are further classified into 2 sub-groups--"untreated" and "treated." Untreated boards range from 50 to 65 pounds per cubic foot in density and treated boards from 60 to 70 pounds. A treated board is an untreated board which has been further processed by impregnation with drying oils to increase strength and water resistance. High density hardboards have many of the same uses as thin plywood.

A new group of "very dense" hardboards has been developed recently for specialized purposes. These boards are available in densities of from 85 to 90 pounds a cubic foot. They are used to make dies, manufacturing jigs, and bases and panels for electrical apparatus.

The existing official specification for hardboard is Federal Specification LLL-F-311 used for Government procurement purposes. It deals with "high density" boards only and specifies with respect to material that "the fibrous-felted hardboard shall be comprised of interfelted lignocellulosic fibers consolidated under heat into a board characterized by a predominantly natural bond."

Industry Growth

The production of hardboard has demonstrated a strong growth trend since the end of World War II (table 38). In 1953 production was 1,225,808,000 square feet, more than double the 1945 output and almost triple the 1941 production. These data do not show the complete picture for market growth in recent years, because they do not include the production of chip and particle board. (In 1953 hardboard production on a tonnage basis was slightly deflated as compared to previous years, because the Bureau of the Census changed the classification from boards with densities of more than 24 pounds per cubic foot to boards with densities of more than 26 pounds per cubic foot. In square footage, the 1953 production was slightly inflated compared to previous years, because the reporting of these data was changed from a surface measure to a 1/8 inch thickness basis.)

TABLE 38.—Hardboard: Production, 1941-53[1]

Year	Production by—		Year	Production by—	
	Surface measure	Weight		Surface measure	Weight
	1,000 square feet	*Short tons*		*1,000 square feet*	*Short tons*
1941	415,000	—	1948	957,080	364,562
1942	551,000	—	1949	532,668	216,530
1943	576,000	—	1950	916,202	382,827
1944	573,000	—	1951	801,422	343,552
1945	550,000	—	1952	1,002,654	435,154
1946	600,000	—	1953[2]	1,225,808	423,418
1947	745,479	301,551			

[1] Production does not include chip and particle board. Prior to 1953, the Bureau of the Census classified hardboard as those boards with densities of over 24 pounds per cubic foot. In 1953, the classification was changed to over 26 pounds per cubic foot.
[2] Thickness not specified in source data except 1953 production, which is on a 1/8-inch thick basis.

Compiled as follows: Data from 1941 to 1946 from files of Dr. Arthur G. Keller, Professor, Chemical Engineering, Louisiana State University; data from 1947 to 1953 from annual issues of "Facts for Industry" (31).

The recent capacity growth of the industry indicates the production is likely to continue upward for the next few years (see table 39). The rated capacity of the industry in 1954, including that for chip and particle board (estimated on the basis of the plants in operation in 1953 and those scheduled for completion in 1954) is expected to be almost double capacity in 1950. This capacity growth indicates optimism regarding the future hardboard market on the part of businessmen. And the existence of this expanded capacity will encourage intensified sales effort to assure profitable use of plants and facilities.

TABLE 39.—Hardboard: Production capacity of the industry, 1948-54[1]

Year	1/8-inch basis	Year	1/8-inch basis
	Million square feet		*Million square feet*
1948	985	1952	1,578
1949	1,050	1953	1,628
1950	1,075	1954	[2] 1,903
1951	1,337		

[1] Includes capacity for producing chip and particle hardboard.
[2] Estimated on basis of 1953 plant capacity and capacity of plants scheduled to come into production in 1954.

Data from files of Business Defense Services Administration, U. S. Department of Commerce.

Economics of Producing Hardboard

Cost of Production.--In September 1952 Baird and Schwartz (4) issued data on 1951 manufacturing costs for making hardboard. Table 40 summarizes these cost data for the various commercial processes.

TABLE 40.—Hardboard: Cost of producing 1,000 square feet, by principal commercial processes, 1951

Type of process	Board thickness	Cost
	Inches	*Dollars*
Wet, continuous felting:		
Explosion (Masonite)	1/8	23.62
Asplund	1/8	21.70
Small Fourdrinier-Asplund	1/8	25.00 - 30.00
Wet, continuous felting—dry pressing:		
Softboard-hardboard combination	1/8	29.00
Wet, batch:		
Deckle-box	1/8	25.00 - 30.00
Deckle-box	1/4	36.80
Dry, batch:		
Granular-wood hardboard	1/4	44.40

Baird and Schwartz also develop details of cost for the more important processes as shown in table 41.

Newly developed processes, called "semidry," with lower investment costs are also discussed briefly by Baird and Schwartz. In 1951, plants being established to use this process cost from \$3,700 to \$7,400 per 1,000 square feet per day of

TABLE 41.--Hardboard: Cost of producing 1,000 square feet of 1/8 inch, by process, 1951

Item	Method of processing	
	Explosion (Masonite)	Mechanized wet batch
	Dollars	*Dollars*
Wood	[1] 4.50	[2] 1.50
Conversion-process[3]	11.11	23.09
Other charges[4]	[5] 8.01	[6] 3.99
Total	23.62	28.58

[1] 1 cord of pulpwood, 2,400 pounds oven dry, costs $10 and yields 2,200 square feet of board.
[2] 1 cord of slabs, 1,800 pounds oven dry, costs $3 and yields 2,000 square feet of board.
[3] Power, steam, water, rosin size, and labor.
[4] Maintenance, property tax, depreciation, administrative expenses, and interest on investment.
[5] Assumes investment of $10,000 per 1,000 square feet of capacity per day.
[6] Assumes investment of $5,000 per 1,000 square feet of capacity per day

capacity, compared to $7,400 to $14,800 per 1,000 square feet of capacity for the conventional wet-process hardboard plant. The semidry processes also seem to lend themselves to somewhat smaller plant sizes than have been generally considered economical for the wet processes. Production capacity of 40,000 to 80,000 square feet per day of semidry formed boards appears to be practicable for economic operations as compared to 135,000 to 270,000 square feet capacity daily for plants producing wet formed boards.

While the costs summarized above were developed for wood hardboard, it is reasonable to assume that bagasse hardboard can compete pricewise with wood as does bagasse insulation board since the principal methods of manufacture of the two types of board are essentially the same.

Prices of Hardboard.--There are no published or official price quotations for hardboard. During the last 18 months, however, the field offices of the Business Defense Services Administration, U. S. Department of Commerce, has assembled prices on hardboard at 6-month intervals. These prices were taken from price sheets of hardboard manufacturers. The Business Defense Services Administration has not yet published the data but made them available for publication in this report.

Hardboard is priced to dealers in carlots or in pool cars, wholesale, delivered in major cities in four geographic regions (table 42). Prices quoted for standard (untreated) board and tempered (treated) boards are quite uniform throughout the country. The Far West, 1 of the 2 principal centers of production (the South is the other), enjoys no significant price advantage. Comparable prices were not obtained by BDSA for southern cities.

TABLE 42.--Hardboard: Wholesale price per 1,000 square feet of 1/8 inch standard and tempered, delivered to dealers in carlots or pool cars, specified dates

Region and city	Standard (untreated)				Tempered (treated)			
	July 1952	Jan. 1953	July 1953	Jan. 1954	July 1952	Jan. 1953	July 1953	Jan. 1954
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
East								
Boston	(1)	(1)	57.00	57.00	(1)	(1)	73.50	73.50
New York	54.00	54.00 to 55.00	57.00	57.00	70.50	71.50	73.50	73.50
Philadelphia	52.00	52.00	52.00	52.00	(1)	(1)	(1)	(1)
Midwest								
Cleveland	56.00	56.00	57.00	57.00	(1)	71.50	73.50	73.50
Detroit	(1)	(1)	(1)	57.00	68.50	70.00	70.00	73.50
Chicago	59.00	59.00	61.00	61.00	(1)	(1)	(1)	(1)
St. Louis	(1)	(1)	(1)	(1)	(1)	(1)	73.50	73.50
Kansas City	55.00	55.00	57.00	57.00	71.50	71.50	73.50	73.50
South								
New Orleans	(1)	(1)	(1)	[2] 68.20	(1)	(1)	(1)	[2] 88.00
Far West								
San Francisco	(1)	(1)	(1)	(1)	(1)	(1)	(1)	71.50 to 75.50
Los Angeles	55.00	55.00	55.00	55.00	71.50	71.50	71.50	71.50
Seattle	(1)	(1)	55.00	55.00	(1)	(1)	71.50	71.50

[1] Not available
[2] Believed to be less than carlot price.

Unpublished data supplied by Business Defense Services Administration, U. S. Department of Commerce.

Profit Trends in the Hardboard Industry.--To aid in the determination of cost-price relationships among wood users and the price competition companies using a new raw material might encounter, an analysis was made of earnings trends on the hardboard industry. A review of the published financial statements of the firms manufacturing hardboard revealed that only one firm could be classified as being principally a hardboard manufacturer. The other firms producing hardboard for which financial data were available were engaged principally in other activities. The available financial data on manufacturing concerns are consolidated balance sheets and income statements covering all operations. Therefore, an analysis of the producers engaged principally in activities other than hardboard would not be useful in appraising hardboard industry economic trends.

However, it is believed that a financial analysis of the operations of the one corporation yields meaningful information on economic trends in the hardboard industry, since this firm has always manufactured the bulk of the Nation's hardboard. From 1940 to 1951 this corporation operated over 85 percent of the hardboard capacity in the United States. The establishment of new firms in 1952 and 1953 reduced the magnitude of its dominance somewhat, but even as late as 1953 it had about 62 percent of total hardboard capacity in operation. Net profits after income taxes as a percent of net worth from 1936 to 1953 for the corporation discussed above, as taken from reports filed with the Securities and Exchange Commission (42) and calculated from reports published in "Moody's Manual of Investments--Industrials" (18) are shown in table 43.

TABLE 43.—Hardboard industry: Net profit after income taxes as a percentage of net worth, 1936-53

Fiscal year ending	Percentage	Fiscal year ending	Percentage	Fiscal year ending	Percentage
	Percent		*Percent*		*Percent*
1936.......	43.9	1942.......	17.9	1948.......	47.6
1937.......	43.9	1943.......	12.8	1949.......	13.5
1938.......	23.6	1944.......	11.5	1950.......	27.5
1939.......	22.9	1945.......	11.4	1951.......	12.5
1940.......	29.5	1946.......	17.2	1952.......	10.5
1941.......	31.5	1947.......	38.6	1953.......	10.8

The hardboard industry enjoyed high returns on net worth during much of the period covered. Returns on net worth were lowest during World War II, probably reflecting the influence of price ceilings under the regulations of the Office of Price Administration. They were also comparatively low during 1951, 1952, and 1953, indicating increased competition.

Hardboard Markets

About half the hardboard made in the United States is used in home, office, and industrial construction and half in manufacturing various items, principally furniture and appliances. In construction hardboards are used mostly for interior paneling, prefinished enameled wall panels for kitchens and bathrooms, floor surfacing and exterior siding. Areas where population growth (fig. 6) and industrial development are the greatest offer the most promise for increased sales for hardboard used for construction purposes. The largest number of furniture and appliance makers is in the Northeast and North Central regions.

The manufacturing uses for hardboard are as follows: Mirror backs, drawer bottoms, desk tops, insert panels and backs for chests of drawers and wardrobes, backs for radios and television sets, liners and backs for refrigerators and freezers, templets, jigs, and dies, electrical control panels, facings for flush doors, backs, doors and tops for kitchen cabinet and storage units, panels, liners, and partitions in trucks, bus, trailer and pullman car bodies, advertising displays, signs, toys, facing for plywood, base for plastic overlays, and crossband material for veneered furniture.

Possible future uses, as viewed by specialists in the field, are in molded shapes and as core stock for veneered furniture.

The export market seems to offer little opportunity for expanded sales, judging from the trend in exports since the end of World War II (table 44). Exports totaled only 9,008,000 square feet the first 11 months of 1953 compared to 54,100,000 in 1948, the year in which postwar exports were highest.

TABLE 44.—Hardboard: Imports and exports, United States, 1946-53

Item	1946	1947	1948	1949	1950	1951	1952	1953[1]
	1,000 square feet[2]	*1,000 square feet*[2]	*1,000 square feet*[2]	*1,000 square feet*[2]	*1,000 square feet*[2]	*1,000 square feet*[2]	*1,000 square feet*[2]	*1,000 square feet*[2]
Imports...	184	1,201	1,019	801	3,399	11,769	1,886	3,85[illegible]
Exports...	27,057	40,945	54,100	13,300	18,184	11,127	19,255	9,008

[1] January-November.
[2] Thickness not specified in data source.

Data from Bureau of the Census reports No. FT410, "U. S. Exports of Domestic and Foreign Merchandise" (33) and No. FT110, "U. S. Imports of Merchandise for Consumption" (34).

Market Competition for Hardboard

As with insulation board, most market competition will come from existing plants. Figure 13 shows the location of the various board plants in operation and under construction and their daily rated capacity by States.

The production of hardboard is concentrated principally in Mississippi and in the Pacific Coast States. Most of the growth in capacity since the end of the war has come in the Pacific region, and all of the plants under construction in 1953 were in that region. However, the Pacific region has not yet caught up with Mississippi in rated capacity. Other States have either no plants

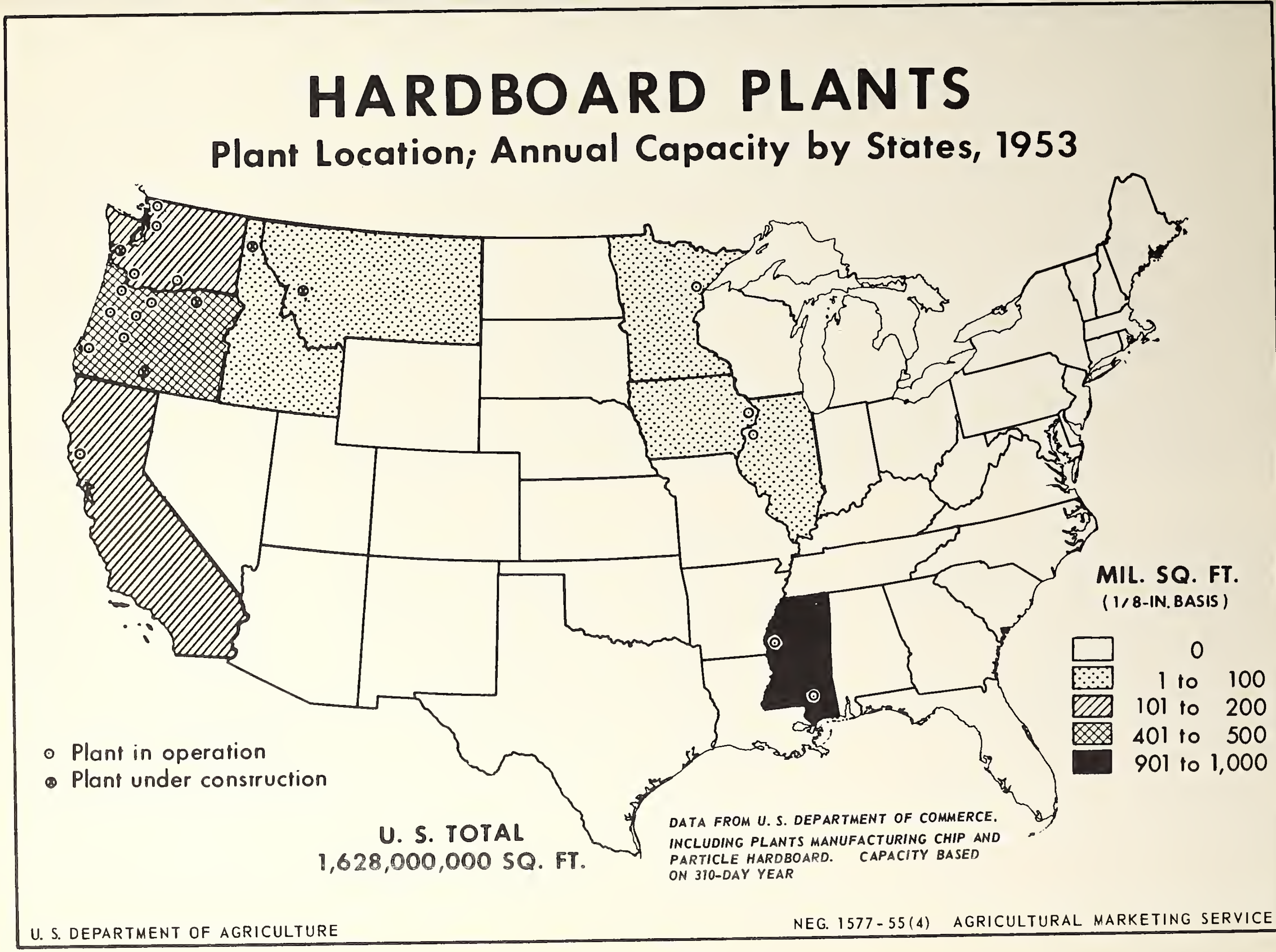

HARDBOARD PLANTS
Plant Location; Annual Capacity by States, 1953
MIL. SQ. FT.
(1/8-IN. BASIS)
0
1 to 100
101 to 200
401 to 500
901 to 1,000
Plant in operation
Plant under construction
U. S. TOTAL
1,628,000,000 SQ. FT.
DATA FROM U. S. DEPARTMENT OF COMMERCE.
INCLUDING PLANTS MANUFACTURING CHIP AND PARTICLE HARDBOARD. CAPACITY BASED ON 310-DAY YEAR
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1577-55(4) AGRICULTURAL MARKETING SERVICE

Figure 13

or plants with a very small total rated capacity.

Plywood, especially thin plywood, is hardboard's major competitor, and in 1952 the production of plywood was about four times as large as that of hardboard (table 45). In addition, production has shown a strong growth trend since the end of World War II, though less marked than hardboard.

TABLE 45.--Plywood: Production, by type, 1946-53

Year	Softwood 3/8 inch	Hardwood, surface measure	Total
	1,000 square feet	*1,000 square feet*	*1,000 square feet*
1946	1,436,065	(1)	1,436,065
1947	1,700,446	(1)	1,700,446
1948	1,953,883	(1)	1,953,883
1949	1,976,649	(1)	1,976,649
1950	2,675,580	(1)	2,675,580
1951	2,994,773	1,467,248	4,462,021
1952	3,178,344	1,423,521	4,601,865
1953[2]	(1)	875,786	875,786

[1] Not available.
[2] Six months.

Data from "Facts for Industry" (29).

The prices of all grades of plywood are substantially higher than those of untreated hardboard and moderately higher than treated hardboard. Plywood prices (table 46) are quoted f.o.b. plant, and hardboard prices are quoted as delivered to dealers (see table 42).

TABLE 46.--Plywood: Price per 1,000 square feet f.o.b. plant, by type, 1947-53

Year	Softwood			Hardwood veneer, water resistant	
	1/4 inch smooth side	3/8 inch, 1 good side, interior grade sheathing	5/16 inch both sides rough	Gum	Birch
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1947	68.08	90.05	50.95	127.25	184.84
1948	86.53	118.50	64.23	133.04	192.79
1949	74.10	104.12	55.80	109.27	190.14
1950	85.39	117.35	69.13	119.62	205.85
1951	89.43	127.57	72.78	131.93	221.93
1952	81.73	117.77	63.78	114.93	217.76
1953	81.96	116.10	67.48	124.30	229.87

Computed from "Price and Price Relatives" (25).

At present, competition from foreign sources is somewhat greater than in the early postwar years, though still relatively insignificant. (See table 44). Imports in 1951 were highest since the end of World War II, and imports in 1953 next highest.

Furfural

Furfural is a colorless to reddish brown liquid. It is a chemical which is soluble in alcohol or ether and partially soluble in water; and it darkens on exposure to air. Furfural may be produced from agricultural residues and forest products with a high pentosan content, such as oat hulls, corncobs, cottonseed hull bran, rice hulls, peanut hulls, cornstalks, tanbark oak, yellow pine, and bagasse.

Various estimates indicate that about 50 percent of all furfural is now being used in the production of adiponitrile--a chemical used in the manufacture of a portion of the nylon molecule. Furfural's other principal uses in approximate order of importance are the following: (1) As a processing agent for refining lubricating oils, rosins and similar compositions; (2) as a component of phenolic resins; (3) in the production of furfuryl alcohol; and (4) in the extraction of butadiene. It is also used in weedkillers, as a solvent for nitrocellulose, cellulose acetate, shoe dyes, and wetting agents, in the refining of wood rosin, in the manufacture of abrasive wheels and brake linings, and in the production of pharmaceuticals.

Furfural was discovered in the laboratory in 1832. However, work on the development of its use for commercial purposes did not begin until 1920. After World War I a large company, searching for a use for oat hulls, the residue from its breakfast cereal operations, saw in furfural a possibility for turning this waste material into a usable commercial product. Accordingly, an intense research program was initiated, aimed at the development of a practicable commercial process for furfural manufacture. As a result, the first commercial plant was built at Cedar Rapids, Iowa, and it commenced operations in February 1922. Then a market development program was initiated in which prices were repeatedly reduced below existing costs to increase volume and lower production costs to the point where reasonable returns on investment might be realized.

For many years the plant at Cedar Rapids was able to supply the Nation's entire demand for furfural. Then came World War II. In 1942 the Reconstruction Finance Corporation entered into an agreement with this producer of furfural under which the producer's experience and process were made available for the design, construction, and operation of a new plant at Memphis, Tenn. The plant was built in 1943 by the Defense Plant Corporation to produce furfural for the extraction of butadiene, a raw material for the manufacture of synthetic rubber. Cottonseed hull bran was chosen as the raw material. In 1946 the furfural manufacturer purchased the Memphis plant and again became, and still remains, according to available information, the sole United States producer of furfural.

During World War II, oat hulls and cottonseed hull bran became so valuable as cattle feed ingredients that their prices increased to prohibitive levels for furfural manufacture. At this time and after the war corncobs became the principal furfural raw material. In 1951 the furfural manufacturer built a third plant at Omaha, Nebraska, which uses corncobs as raw material.

In recent years, with the increased demand for furfural, the company referred to above has evaluated the possibility of using other raw materials, including bagasse. On November 25, 1953, it was announced that a new furfural plant designed to use bagasse was to be constructed by a sugar company in the Dominican Republic and that it would operate for some years under the technical and business supervision of personnel provided by the furfural producer mentioned. According to the furfural producer, this mill is one of the few in this hemisphere at which furfural production appeared economically feasible. This sugar mill is one of the largest in the world and will furnish all the bagasse required by the furfural plant.

Because of the interest in bagasse as a furfural raw material, this section presents the available pertinent economic and marketing data on its possible use for this purpose.

Industry Growth

There are no published data on the actual production of furfural. But apparently enough is known about plant capacity and the approximate percentage of this capacity utilized to yield a basis for estimating production (see fig. 14). From 1928 to 1940, production increased from about 1 million to 3 million pounds a year. During the war maximum use was made of the Cedar Rapids plant with its 15 million-pound rated capacity and the Memphis plant with a rated capacity of 24 million pounds a year. During the latter part of the war the Memphis plant actually produced at a rate of 35 million pounds a year or almost 146 percent of rated capacity.

Most wartime uses for furfural have continued as part of normal industrial demand. Some new uses, postponed by the war, have entered commercial operation, and the furfural market and rated plant capacity are presently more than double that of the maximum war year. Estimates made in the spring of 1953 place the furfural market and rated plant capacity at from 90 million to 100 million pounds a year. Trade information indicates that the rate of increase of the furfural market slowed somewhat in 1954.

Apparently holders of investment capital believe that the furfural market continues to have growth potential, as indicated by the announcement during 1953 of the construction of a fourth furfural plant in this hemisphere. The company in the Dominican Republic will depend principally on the United States market for its outlets. It is reported that the major United States producer of nylon has agreed to purchase a substantial quantity of the output of the new plant for the next few years.

Economics of Producing Furfural

Furfural prices have been exceedingly stable over the years and, in 1953, were only 20 percent above pre-World War II levels (table 47). The price per pound in tank cars was 9.0 cents from 1930 to 1942 and 9.5 cents from 1943 to 1950. Since 1950 furfural prices have increased slightly more than 1/2 cent per pound per year, reaching 11.4 cents per pound in 1953.

Production costs of furfural for the spring of 1953 were estimated to be 7 to 9 cents a pound by R. S. Aries and Associates in "Chemonomics" (3) compared to the average tank car price of 11.2 cents a pound, f.o.b. producer, for about the same period of 1953. (See table 47.)

TABLE 47.—Furfural: Price per pound f.o.b. tank cars, selected periods, 1930-53; and production cost, spring 1953

Period	Tank car price per pound[1]	Approximate production costs per pound[2]
Average:	*Cents*	*Cents*
1930-42	9.0	—
1943-50	9.5	—
1951	10.2	—
1952	10.8	—
1953		
Spring	11.2	7.0-9.0
Annual	11.4	

[1] Data from 1930 to 1946 from "Industrial Chemicals" (8); prices from 1947 to 1953 computed from weekly prices published in Oil, Paint and Drug Reporter (22).
[2] Data from "Chemonomics" (3).

Growth of Specific Furfural Uses

Nylon

From 1947 to 1952 the production of 100-percent nylon fabrics increased more

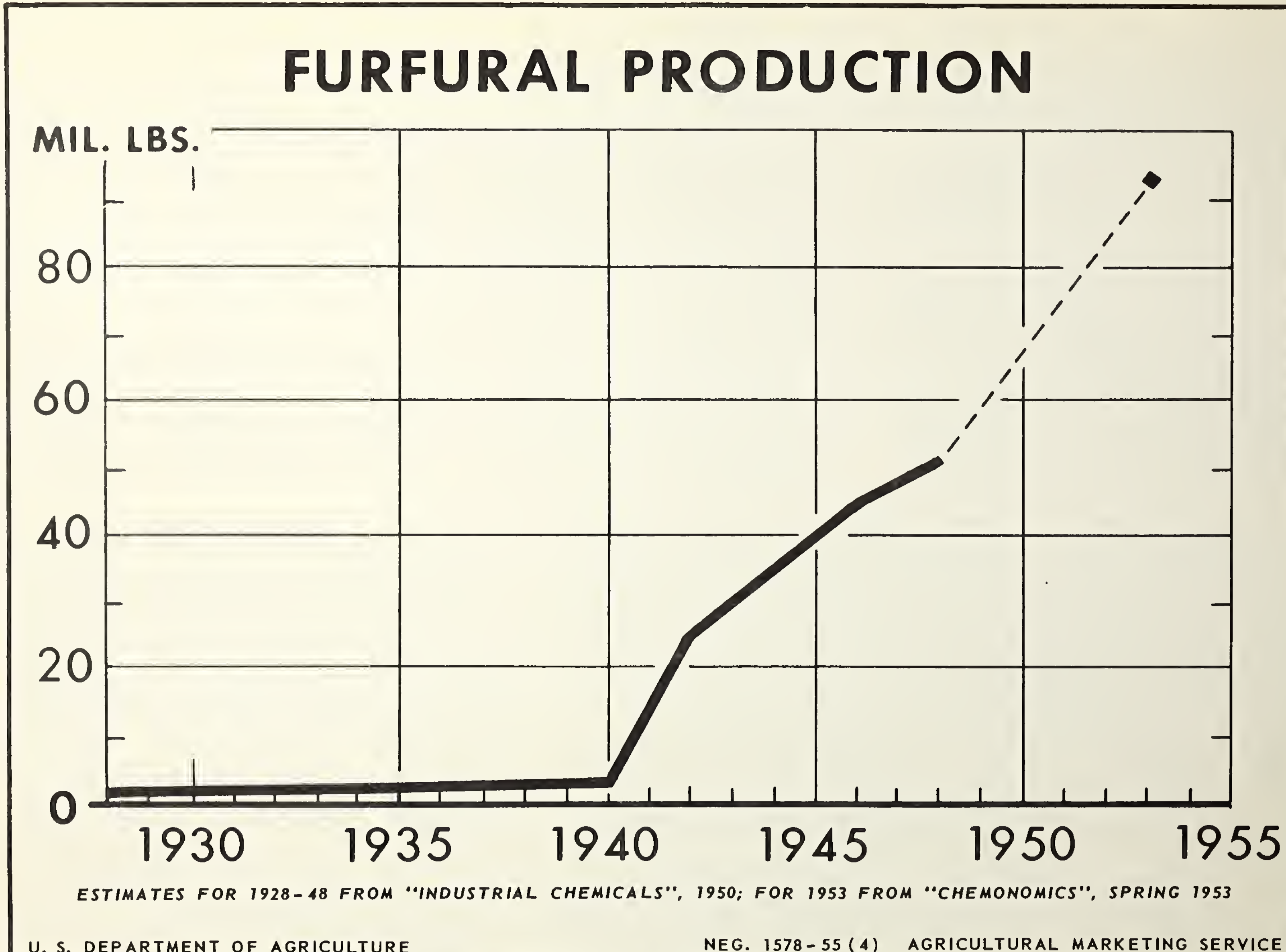

FURFURAL PRODUCTION
MIL. LBS.
80
60
40
20
0
1930
1935
1940
1945
1950
1955
ESTIMATES FOR 1928-48 FROM "INDUSTRIAL CHEMICALS", 1950; FOR 1953 FROM "CHEMONOMICS", SPRING 1953
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1578-55 (4) AGRICULTURAL MARKETING SERVICE

Figure 14

than 1,000 percent (table 48). The production of nylon molding powder is estimated to have increased from about 1 million pounds in 1950 to about 12 million pounds in 1953.

TABLE 48.—Nylon: Production, by products, 1947-53

Year	Nylon, broadwoven fabrics (100 percent nylon)[1]	Rayon and nylon tire cord and fabric[1]	Nylon molding powder[2]
	1,000 linear yards	1,000 pounds	1,000 pounds
1947	21,881	(3)	(4)
1948	32,658	251,181	(4)
1949	92,887	279,478	(4)
1950	110,233	296,983	1,000
1951	167,561	314,753	(4)
1952	279,168	391,979	(4)
1953	(4)	(4)	12,000

[1] Data for 1947 from "Census of Manufactures, 1947" (28); data for the years 1948-52 from "Facts for Industry" reports (30).
[2] Estimates as presented in "Modern Plastics" (17). Production was estimated at about 12 million pounds in 1953 as compared with 1 million pounds "only a few years ago." Discussions with experts in the field established "only a few years ago" as about 1950.
[3] Not reported.
[4] Not available.

Nylon prices increased about 6 percent from 1947 to 1949 but remained unchanged from 1949 to 1953--a period during which furfural showed a moderate price increase (table 49).

TABLE 49.--Nylon yarn: Index numbers of prices, by type, 1947-53

(1947-49=100)

Type of yarn	1947	1948	1949	1950	1951	1952	1953
15 denier	97.4	98.3	104.3	104.3	104.3	104.3	104.3
40 denier	98.4	99.2	102.4	102.4	102.4	102.4	102.4
70 denier	96.4	99.0	104.7	104.7	104.7	104.7	104.7

Data from "Prices and Price Relatives," (25).

Until 1953, one company was the sole producer of nylon, with plants at Seaford, Del., Chattanooga, Tenn., and Martinsville, Va. In late 1953, trade sources reported new plants under construction, at Hopewell, Va., Enka, N. C., and Pensacola, Fla. However, these new plants are planning to use competing materials rather than furfural in nylon manufacture. These materials are referred to in greater detail later.

Lubricating Oils

Judging from production data, lubricating oils present a market for furfural producers in which moderate and continuing growth seems assured (fig. 15), although some irregularities in production have occurred since 1949.

Phenolic Resins

There was little change in the production and a moderate increase in the price of phenolic resins, the third most important furfural market, from 1948 to 1953. The 1953 production of phenolic resins was about equal to the 1950 and 1951 production and 20 to 25 percent above the 1948 and 1952 levels (see table 50).

TABLE 50.--Production and price of phenolic and mixed phenolic resins, 1948-53

Item	1948	1949	1950	1951	1952	1953
	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds
Production, dry basis	376,643	290,926	451,130	473,587	393,351	484,942
	Cents	Cents	Cents	Cents	Cents	Cents
Price per pound[1]	23.0	23.0	23.0	27.0	27.0	27.0

[1] F.o.b. producing plant.

Data are from "Synthetic Organic Chemicals, U. S. Production and Sales," (43).

Butadiene

Without the pressure of wartime needs for synthetic rubber the demand for butadiene declined, and production was more than cut in half from 1946 to 1949 (see table 51). Demand for butadiene was again stimulated during the Korean emergency, and prices and production rose sharply in 1951 and 1952. However, percentagewise, butadiene did not regain its World War II dominance as a furfural market. This was due to the postwar growth of other markets and the fact that processing improvements substantially reduced furfural consumption per unit of butadiene manufactured. Slightly more than a third of the butadiene plant capacity existing in 1953 was equipped to use furfural as a raw material.

Furfuryl Alcohol

Since furfuryl alcohol is made exclusively by one company, the data on its production are confidential. A search of the literature revealed no estimates of furfuryl alcohol production.

Market Competition for Furfural

Furfural producers meet considerable competition in the marketplace from manufacturers of other raw materials, which can be used interchangeably with furfural in producing end products.

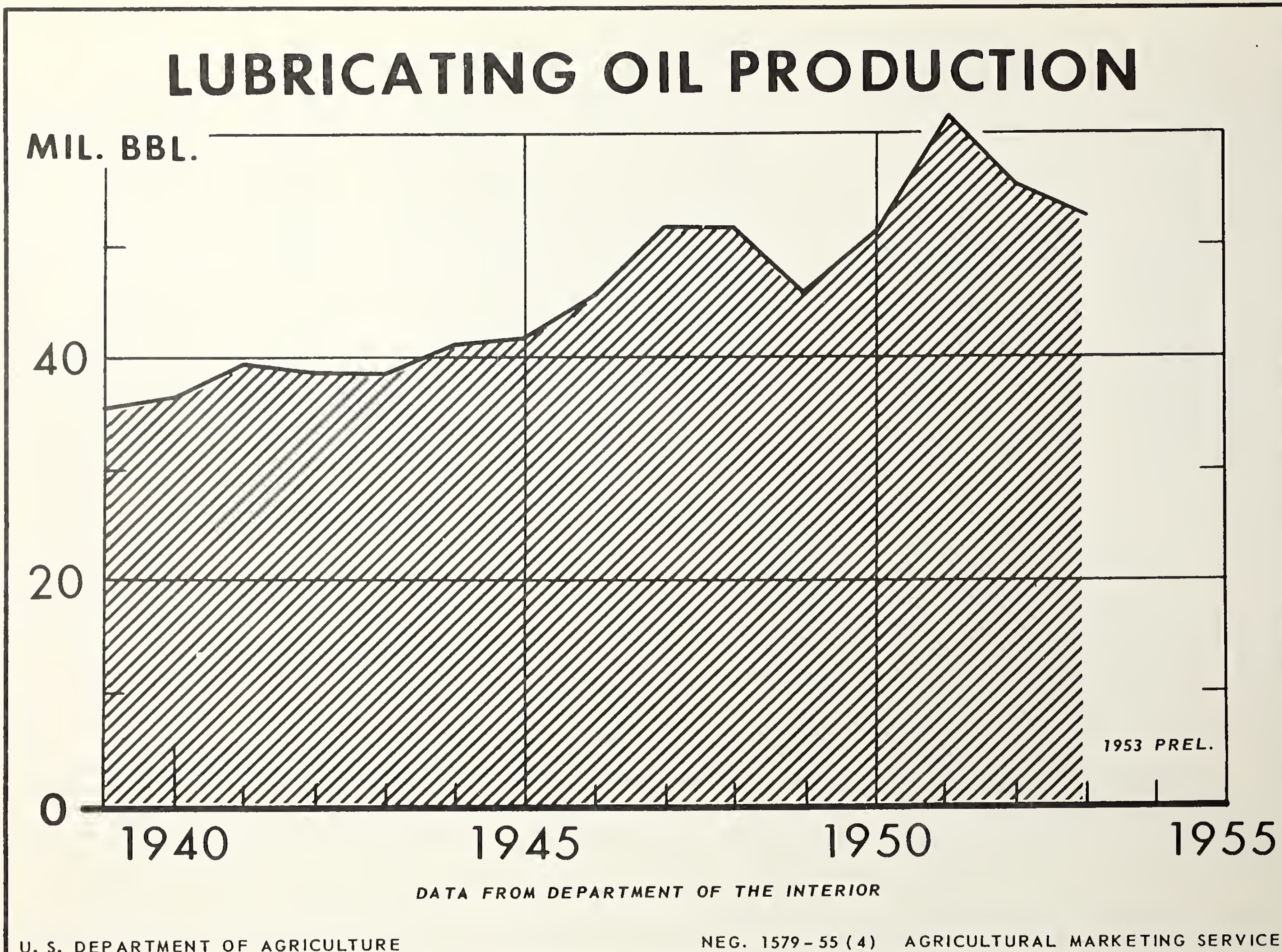

LUBRICATING OIL PRODUCTION
MIL. BBL.
40
20
0
1940
1945
1950
1955
1953 PREL.
DATA FROM DEPARTMENT OF THE INTERIOR
U. S. DEPARTMENT OF AGRICULTURE
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Figure 15

Competitors for the Nylon Market

Tables 51 and 52 show the production, sales, and prices of the major furfural competitors for the nylon market--butadiene, benzene, and cyclohexane--from 1946 to 1952. The difference between production and sales of these products represents the quantity used by the producing plant in manufacturing other items plus inventory changes.

TABLE 51.--Butadiene: Production and price, 1946-53, and plant capacity, 1953

Year	Production[1]	Price per pound[2]	Capacity of plants[3]	
			Total	Equipped to use furfural as raw material
	1,000 pounds	*Cents*	*1,000 pounds*	*1,000 pounds*
1946...........	1,074,040	10.0		
1947...........	696,388	8.0		
1948...........	660,915	8.0		
1949...........	493,844	8.8		
1950...........	610,056	8.3		
1951...........	1,222,411	14.8		
1952...........	1,106,445	14.1		
1953...........	(4)	14.2	1,804,000	692,000

[1] 1946-52 from "Synthetic Organic Chemicals, U. S. Production and Sales," (43); 1953 prices calculated from price quotations reported in the "Oil, Paint and Drug Reporter" (22).
[2] F.o.b. producing plant.
[3] Data from "Program for Disposal to Private Industry of Government-owned Rubber Producing Facilities" (41).
[4] Not available.

Butadiene production, plant capacity, and price trends are discussed in the previous section entitled "Growth of Specific Furfural Uses."

In 1952, the production of benzene was nearly double the 1946 output. Over the same period prices rose steadily until in 1952 benzene prices were three times the 1946 level.

Data on cyclohexane production are not available for the years prior to 1951. However, judging from the tremendous increase in sales between 1946 and 1952, production probably increased substantially. It is, of course, possible that a larger percentage of production was consumed in the producing plants in 1946 than during 1951 and 1952. If so, the increase in sales does not necessarily reflect an increase in production. In 1951 and 1952 cyclohexane prices were somewhat less than in 1946.

Competitors for the Lubricating Oil Market

Phenol is the principal competitor with furfural as a refining agent in the production of lubricating oils. Production of phenol increased somewhat between 1946 and 1952, but sales remained approximately the same (table 52). Phenol prices increased from 9 to 12 cents a pound from 1946 to 1948, remained at 12 cents through 1950, and then rose sharply to 18 cents a pound in 1951 and 1952.

TABLE 52.--Production, sales, and price of benzene, cyclohexane, phenol, and formaldehyde, 1946-52

Year	Benzene[1]			Cyclohexane			Phenol			Formaldehyde		
	Production	Sales[2]	Price per gallon[3]	Production	Sales[2]	Price per pound[3]	Production	Sales[2]	Price per pound[3]	Production	Sales[2]	Price per pound[3]
	1,000 gallons	*1,000 gallons*	*Cents*	*1,000 pounds*	*1,000 pounds*	*Cents*	*1,000 pounds*	*1,000 pounds*	*Cents*	*1,000 pounds*	*1,000 pounds*	*Cents*
1946..................	136,353	126,799	13.1	(4)	3,969	7.0	203,829	177,553	9.0	458,877	341,507	3.0
1947..................	167,652	150,605	16.5	(4)	(4)	(4)	265,269	235,226	10.0	520,642	388,389	3.0
1948..................	173,860	156,652	19.4	(4)	(4)	(4)	297,338	198,535	12.0	617,187	418,253	4.0
1949..................	133,258	128,119	20.0	(4)	(4)	(4)	224,544	146,833	12.0	549,744	331,439	3.0
1950..................	186,152	172,522	21.5	(4)	(4)	(4)	312,107	199,819	12.0	835,142	509,419	3.0
1951..................	265,731	234,035	35.0	256,695	106,909	4.0	388,429	244,011	18.0	987,456	601,161	4.0
1952..................	251,667	216,998	38.4	252,384	98,418	5.0	337,761	187,645	18.0	1,022,366	554,722	3.0

[1] Does not include motor-grade benzene.
[2] Represents production not consumed by producing plants plus reflection of inventory changes.
[3] F.o.b. producing plant.
[4] Not reported.

Data are from "Synthetic Organic Chemicals, U. S. Production and Sales," (43).

Competitors for the Phenolic Resin Market

Formaldehyde is furfural's major competitor in the production of phenolic resins. The production of formaldehyde in 1952 was more than double production in 1946, while sales were up moderately (table 52). However, formaldehyde prices did not change over the period covered.

Competing Raw Materials for Furfural Manufacture

The competition between various raw materials for the furfural market is based solely on relative cost. Apparently the quality of furfural is unaffected by the raw material used. Costs of a material for furfural manufacture are determined principally by the following: (1) Yields of furfural per ton of material (see table 53 for some comparative yield data), (2) the delivered cost of the material at the furfural plant, and (3) storage requirements for a 12-month supply of raw material as influenced by length of the raw material production season.

TABLE 53.--Furfural: Typical analysis of possible raw materials for manufacture

Raw material	Moisture content	Theoretical furfural
	Percent	*Percent*
Cleaned oat hulls	6.0	20.0
Corncobs	20.0	19.0
Cottonseed hull bran	9.5	17.5
Cornstalks[1]	15.0	16.5
Bagasse[2]	10.0	15.0
Buckwheat hulls	11.0	15.0
Tanbark oak	3.0	13.0
Rice hulls	10.0	12.0
Flax shives	10.0	12.0
Peanut hulls	7.5	11.0
Yellow pine	6.0	5.0

[1] Harvested after freezing weather.
[2] After air drying.

Data from "Commercial Production of Furfural in Its Twenty-Fifth Year," (12).

The United States furfural producer must watch constantly for new raw materials because from time to time expansion of furfural production has been precluded or the continuation of operations at the going level threatened by raw material costs. As raw material requirements have grown in recent years and the collection area expanded, the cost of corncobs has become a problem in furfural production, and the feasibility of using bagasse has been studied. Officials of the experienced company, at an interview late in 1953, related their conclusions regarding the possible use of bagasse as follows:

1. To achieve minimum output for economic operations, plants using bagasse must be larger than plants using corncobs. The reason is that the furfural yield per ton of bagasse is lower, and its low density will not permit an equivalent amount of raw material to be placed in the digesters.

2. Minimum capacity should probably not be less than 15,000,000 pounds of furfural per year. To achieve this capacity furfural plants using bagasse would cost between $4,000,000 to $8,000,000 exclusive of operating capital.

3. It is not likely that a furfural operation can support a bagasse price much in excess of its value as fuel.

4. As a corollary to No. 3 above, it appears doubtful that bagasse would be an economically competitive raw material where a furfural plant required the output of a number of sugar mills and collection costs are involved.

5. A furfural plant using bagasse would have the most chance of success where the following conditions exist: (a) A single sugar mill can supply the bagasse required by a furfural plant of minimum economic capacity; (b) the sugar-furfural operations are integrated physically and are under the same ownership; and (c) the sugar production season extends over a long period.

Where a single sugar mill can furnish the required bagasse and its operations are physically integrated with the furfural plant, joint use can be made of heat and steam facilities. Also, costs of transferring bagasse to the furfural plant are minimized. Joint ownership would assure a reliable source of raw material at a reasonable price. And a long sugar production season would hold bagasse baling and storing costs to a minimum. The furfural producer stated further that all of these conditions would be found at only a few locations in this hemisphere.

Dehydrated Fresh Bagasse

At present, the second most important commercial use of bagasse is its dehydration, screening, and baling for sale as poultry litter, animal bedding, and agricultural mulch. An estimated 85,000 tons, 10-percent moisture basis, are marketed annually in this form with much the largest proportion going to poultry producers.

There are four sugar companies presently producing dehydrated bagasse. One company, with sugar mills at Reserve and Raceland, La., pioneered the development of the process in the early 1930's. In 1941, a third Louisiana mill was licensed to dehydrate bagasse using such process, and in 1947 a Florida mill was similarly licensed. In 1948, a fourth dehydrating company, which purchases its supplies from a nearby mill, was constructed in Louisiana.

Poultry Litter

In poultry production, the maintenance of dry, sanitary, and dust-free conditions in poultry houses is extremely important in holding down disease losses. Among the important factors contributing to the required degree of sanitation and dryness is the use of suitable litter or bedding materials on the poultry house floors and in nests. Many locally produced agricultural and forest residues and a number of commercial litters are currently in use as bedding by poultry producers.

For purposes of this report "locally produced" litters are those which are produced with little or no processing or handling and are consumed in the locality in which produced. "Commercial" litters are materials which require some processing or handling and which generally move long distances for sale in competition with locally produced litters. The list of locally produced litters includes sawdust, wood shavings, wheat and other small grain straws, and beach or field sand. Commercial litters are peat, bagasse, ground or crushed corncobs, peanut shells, cottonseed hulls, oat hulls, buckwheat hulls, and two types of porous mineral material.

Sometimes materials here classed as locally produced litters qualify as commercial litters where processing and handling are involved. Cereal straws and wood shavings, for instance, are baled and sold commercially in certain areas. Likewise, some litters usually classed as commercial, such as crushed corncobs and peanut shells, would qualify as locally produced when they are consumed in the area of production without baling or otherwise processing for sale or shipment. Bagasse litter is one of the commercial litters which can never be classed as locally produced using the standards set forth in this report. Bagasse must be dehydrated to be suitable for litter, and practically all bagasse litter is sold outside the cane-producing areas.

Market Growth

There are no published data on trends in the use of poultry litter. However, a rough approximation of trends in total poultry litter usage may be obtained by multiplying the number of birds produced per year by estimated average annual litter usage per bird. Litter usage, per bird per year, as estimated by poultry production specialists, averages approximately as follows: Chickens, excluding broilers, 25 pounds; broilers, 15 pounds, and turkeys, 5 pounds. The application of litter usage of each type of bird to the number produced, as given in Agricultural Statistics (35), yields the litter usage trends shown in figure 16. The total consumption of litters, as calculated in the manner described above, increased from about 8 million tons in 1935 to about 13.3 million tons in 1952. A straight line projection of these consumption data indicates that litter consumption in 1960 is likely to total about 15.5 million tons.

Economics of Producing Poultry Litter

Production Costs and Prices.--No details of production costs are available for bagasse chicken litter. Based on estimates of plant managers and a consulting engineer, the total cost of producing bagasse litter in 1952, f.o.b. producing plant, averaged about $17 per ton. A litter plant of economic size (10,000 to 15,000 tons, 10-percent moisture basis, annually) would have cost about $350,000 in 1952.

Published price quotations are not available for the various types of litter on a comparable basis. For this reason delivered prices to users were obtained from litter distributors and users during the course of field visits to a number of important poultry-producing areas in April 1953 (table 54). Prices were obtained for all litters then in use in the areas visited.

The locally produced and commercial litters can quickly be identified from the data in table 54. Locally produced materials, such as sawdust and shavings, are often available free to a poultryman because they present a disposal problem to the producing sawmill or planing mill. The only costs involved are hauling charges, normally $4 to $5 a ton. Occasionally a nominal price is added if demand is brisk.

Commercial litters are much more expensive than locally produced litters. Therefore, they cannot compete where local litters are abundant except for specialized uses, such as under young chicks or where users are small and require only a few hundred pounds of litter at a time for their houses. At the time of field work, bagasse litter was usually priced competitively with other types of commercial litters. In addition, bagasse litter was available in practically all areas visited, whereas competing commercial litters were not.

The differential in price between locally produced litters and bagasse litter is not, in actual practice, as wide as it seems. A number of users, for instance, pointed out that a bale of bagasse will cover substantially more area than an equal quantity of shavings or sawdust. Estimates of additional area covered ranged from plus 50 to plus 90 percent. However, even with this adjustment bagasse litters cost substantially more than most locally produced litters.

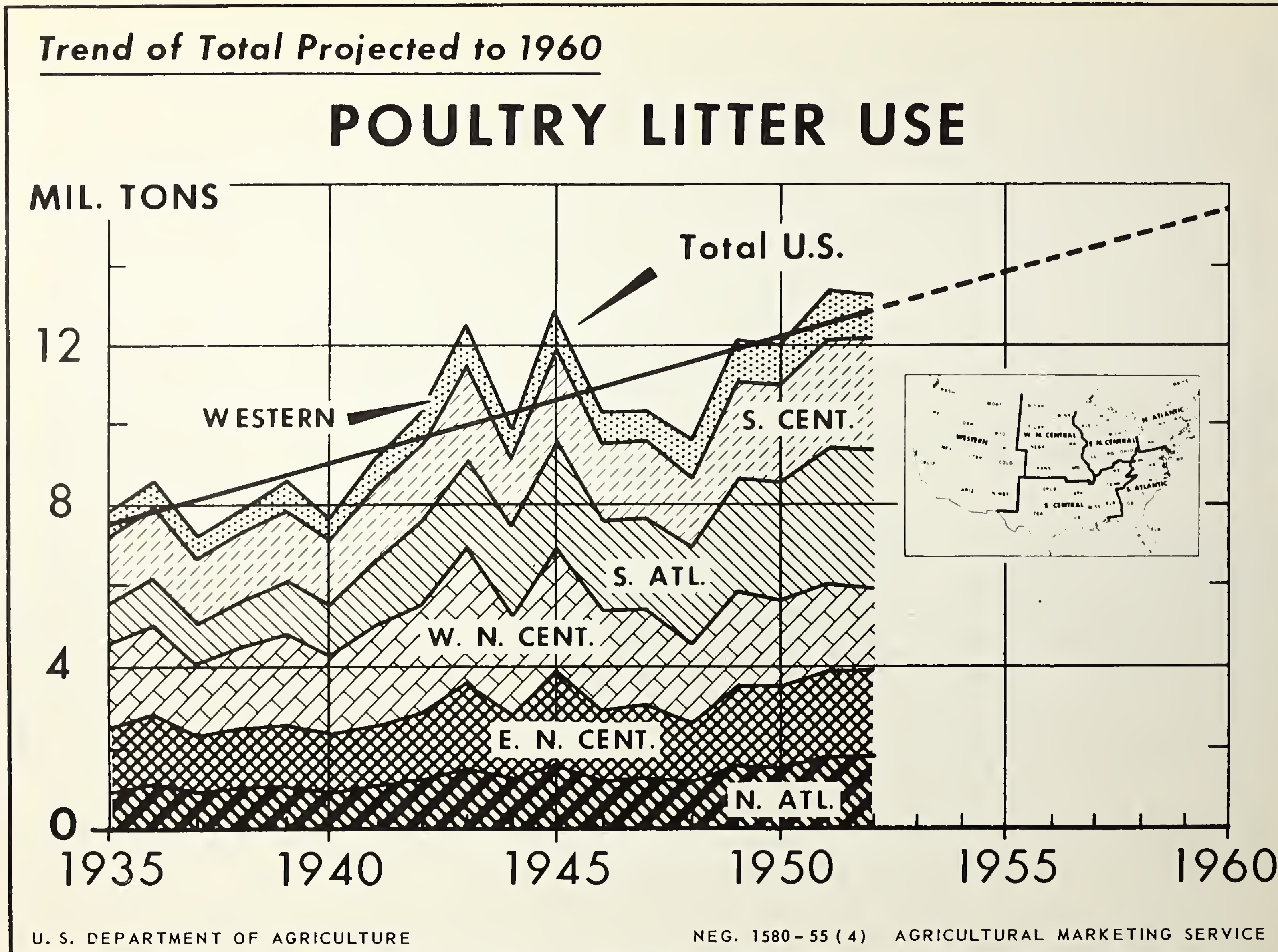
Trend of Total Projected to 1960
POULTRY LITTER USE
MIL. TONS
12
8
4
0
Total U.S.
WESTERN
S. CENT.
S. ATL.
W. N. CENT.
E. N. CENT.
N. ATL.
1935
1940
1945
1950
1955
1960
U. S. DEPARTMENT OF AGRICULTURE
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Figure 16

TABLE 54.--Approximate delivered prices to users for bagasse litter and competing litters, selected chicken producing areas, April 1953

User or distributor location	Type of litter										
	Bagasse litter		Sawdust	Wood shavings	Peanut hulls	Oat hulls	Rice hulls	Ground corn-cobs	Straw	Peat	
	Carload lots	Small lots								Small lots	Carload lots
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Del., Md., and Va., broiler area............	36.00	45.00	5.00	--	36.00	--	--	10.00	--	--	--
Del., Md., and Va., broiler area............	36.00	45.00	8.00	--	--	--	--	--	--	--	--
North Georgia broiler area..................	--	--	--	4.00	--	--	--	--	--	--	--
North Georgia broiler area..................	30.00	45.00	--	4.00	--	--	--	--	--	--	--
North Georgia broiler area..................	32.50	43.00	--	7.00	--	--	--	--	--	--	--
Atlanta, Georgia, area......................	--	45.00	--	--	--	--	--	--	--	--	--
Northeast Florida area......................	--	41.00	--	--	--	62.00	--	--	--	--	--
Arkansas broiler area.......................	--	39.00	--	4.00	--	--	5.00	--	--	--	--
Arkansas broiler area.......................	--	--	--	4.00	--	--	--	--	--	--	--
Arkansas broiler area.......................	--	40.00	--	4.00	--	--	--	--	36.00	--	--
Mississippi broiler area....................	--	35.00	--	4.50	--	--	--	--	--	--	--
Mississippi broiler area....................	--	32.00	--	4.00	--	--	--	--	--	--	--
Mississippi broiler area....................	--	35.00	--	4.50	--	--	--	--	--	--	--
Mobile, Alabama, area.......................	--	35.00	--	--	--	--	--	--	--	50.40	--
New Orleans area............................	--	33.00	--	4.00	--	--	--	--	--	39.20	--
New Orleans area............................	--	36.00	--	--	--	--	--	--	--	--	--
Chicago area................................	--	--	--	--	--	--	--	--	--	39.20	36.40
North East and Middle Atlantic poultry area..	--	40.00	--	36.00 (baled)	42.00	--	--	--	35.00	--	--

Data are from field survey conducted in April 1953.

Production as Percentage of Capacity.--No data are available permitting a mathematical computation of production as a percentage of capacity. However, it was apparent during field interviews with plant managers that the industry is not suffering from excess capacity. Most managers seemed to believe that they could use even a larger producing unit if there were more adequate facilities for storing litter between sugar harvest seasons to fully service the poultry industry's needs.

Market Location

The areas in which chickens and turkeys are produced are, of course, the natural markets for poultry litter. The most recent year for which poultry numbers have been ranked by sections of the country is 1949. These data were presented as "Turkeys Raised" and "Chickens Sold" in a special report entitled, "Ranking Agricultural Counties" (32), issued by the Bureau of the Census in 1952. For purposes of this report, "Chickens Sold" and "Turkeys Raised" have been converted to production and then to litter usage with the conversion factors referred to earlier in the section entitled "Market Growth." United States total poultry output as presented in "Agricultural Statistics" was distributed by counties in accordance with Census data on "Chickens Sold" and "Turkeys Raised."

Figures 17 and 18 show by counties the litter usage by chickens and turkeys, respectively, during 1949. The counties showing heavy usage of litter are not the only markets for commercial litters, though they may offer the best possibility for establishing mass distribution. Many commercial litter distributors in the areas visited indicated that their best customers were small poultry producers not equipped to use large enough lots of litter to justify arranging for trucks to haul locally produced materials. Small producers may be found servicing local demand in the vicinity of practically every town and city.

It is important not only to know the areas in which litter usage is presently concentrated but also the areas offering the most promise for expanded markets in the future. The use of litter is shown in figure 16 by regions from 1935 to 1952. The litter market was expanded most rapidly in the South Central, South Atlantic, and North Atlantic regions and least in the West North Central and East North Central regions during the period covered.

Market Competition

Producing Centers of Competing Litters.--Locally produced rather than commercial litters offer the principal competition to bagasse litter. Inexpensive and suitable agricultural and forest residues are


CHICKEN LITTER USE, 1949
U. S. TOTAL
11,986,000 TONS
ESTIMATED ANNUAL PER BIRD USE: CHICKENS EXCLUDING BROILERS, 25 LBS.; BROILERS, 15 LBS.
EACH DOT REPRESENTS 2,000 TONS
ADAPTED FROM BUREAU OF THE CENSUS MAP
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1581-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 17

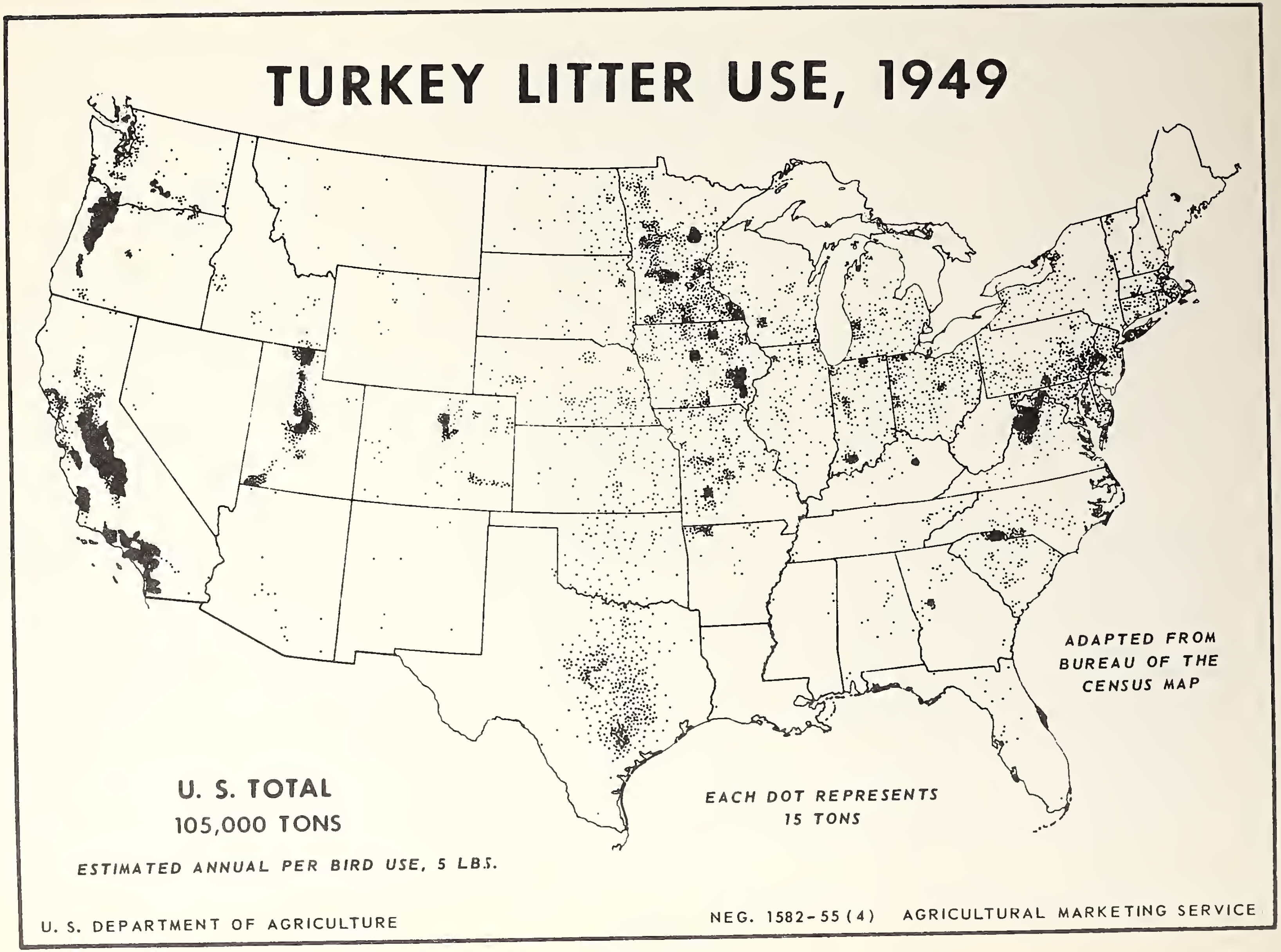
TURKEY LITTER USE, 1949
U. S. TOTAL
105,000 TONS
ESTIMATED ANNUAL PER BIRD USE, 5 LBS.
EACH DOT REPRESENTS
15 TONS
ADAPTED FROM
BUREAU OF THE
CENSUS MAP
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1582-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 18

available in many sections of the country except in the proximity of metropolitan centers where commercial litters are most competitive.

Figures 19, 20, 21, and 22 show the production centers for wheat, corn for grain, peanuts and domestic peat, respectively, and the production of straw, corncobs, and peanut hulls by States during 1949. Straw, cob, and peanut hull production was obtained by applying conversion factors to yields of wheat, corn for grain, and peanuts. Competition from agricultural residues and domestic peat would be strongest in the principal areas of production. Since about half the peat consumed in this country is imported, competition from this product would also be keen near points of entry. The most recent information on the importance of various areas in the production of sawdust and shavings is shown in table 55, which presents annual drain of saw timber by regions and sub-regions.

TABLE 55.--Annual drain of saw timber, by regions[1]

Section and region	Total	Softwoods	Hardwoods
	Billion bd. ft.	*Billion bd. ft.*	*Billion bd. ft.*
North:			
New England	2.20	1.44	0.76
Middle Atlantic	2.30	.58	1.72
Lake	2.01	.84	1.17
Central	2.34	.12	2.22
Plains	.18	.01	.17
Total	9.03	2.99	6.04
South:			
South Atlantic	6.14	4.30	1.84
Southeast	11.93	7.54	4.39
West Gulf	6.83	3.80	3.03
Total	24.90	15.64	9.26
West:			
Pacific Northwest:			
Douglas-fir sub-region	12.00	11.98	.02
Pine sub-region	2.53	2.53	—
Total	14.53	14.51	.02
California	3.16	3.16	—
North Rocky Mountain	1.79	1.76	.03
South Rocky Mountain	.48	.47	.01
Total	19.96	19.90	.06
United States	53.89	38.53	15.36

[1] Drain for commodities is based on 1944 data; estimates for loss by destructive agents are based on 1934–43 averages.

Data are from "Forests and National Prosperity, A Reappraisal of the Forest Situation in the United States." (38).

Competion as Viewed by Litter Distributors and Users in Selected Areas.--In the course of field work on this study during 1953 in selected poultry production areas litter distributors and users were asked the extent to which bagasse litter was being used and which competing litters were being used in important quantities. Their comments are summarized in table 56. In the areas visited the largest quantities of bagasse were used in the northwest Arkansas broiler area, the area in the vicinity of Mobile, and in the Northeast, especially New Jersey, southeastern New York, Massachusetts, Connecticut, and Rhode Island. Locally produced shavings and sawdust offered the strongest competition in most areas visited due to their abundance and low prices (see table 54). The commercial litters competing with bagasse litter in those areas were peat, peanut hulls, baled shavings, and baled straw.

TABLE 56.--Comments of litter distributors and users regarding the approximate usage of bagasse litter and competing litters, selected areas, 1953

Location of distributor or user	Usage of bagasse litter	Usage of competing products
Del., Md., and Va., broiler area	Limited	Sawdust mostly ground corncobs limited
Del., Md., and Va., broiler area	Limited	Sawdust mostly ground corncobs limited
North Georgia broiler area	Limited	Shavings mostly
North Georgia broiler area	Limited	Shavings mostly
North Georgia broiler area	Limited	Shavings mostly
North Georgia broiler area	Limited	—
Northeast Florida area	Limited	Oat hulls mostly
Arkansas broiler area	Limited	Shavings mostly
Arkansas broiler area	60% of total	Shavings--40% of total
Arkansas broiler area	75% of total	Shavings and baled straw--25% of total
Mississippi broiler area	Very limited	Shavings mostly
Mississippi broiler area	Limited	Shavings mostly
Mississippi broiler area	None	Shavings exclusively
Mobile area	80% of total	Peat--20% of total
New Orleans area	60% of total	Shavings--25% of total Peat--15% of total
New Orleans area	Exclusively	None
Chicago area	10% of total	Peat--80% of total Shavings and straw--10% of total
New Jersey, Southeastern New York, Massachusetts, Connecticut and Rhode Island	Mostly	Peanut hulls, limited; baled shavings very limited; baled straw, very limited

Data are from field survey, April 1953.

Relative Quality of Bagasse and Competing Litters.--Litter quality characteristics of primary importance are high absorptive ability, low matting tendency, freedom from dust, and cleanness. Also important, but to a lesser extent, is the manure value of used litter. Two State agricultural experiment stations have tested the quality of bagasse and competing litters by their performance under actual operating conditions. The results of these tests are included in this report to indicate the approximate relative quality of bagasse litter with its competitors.

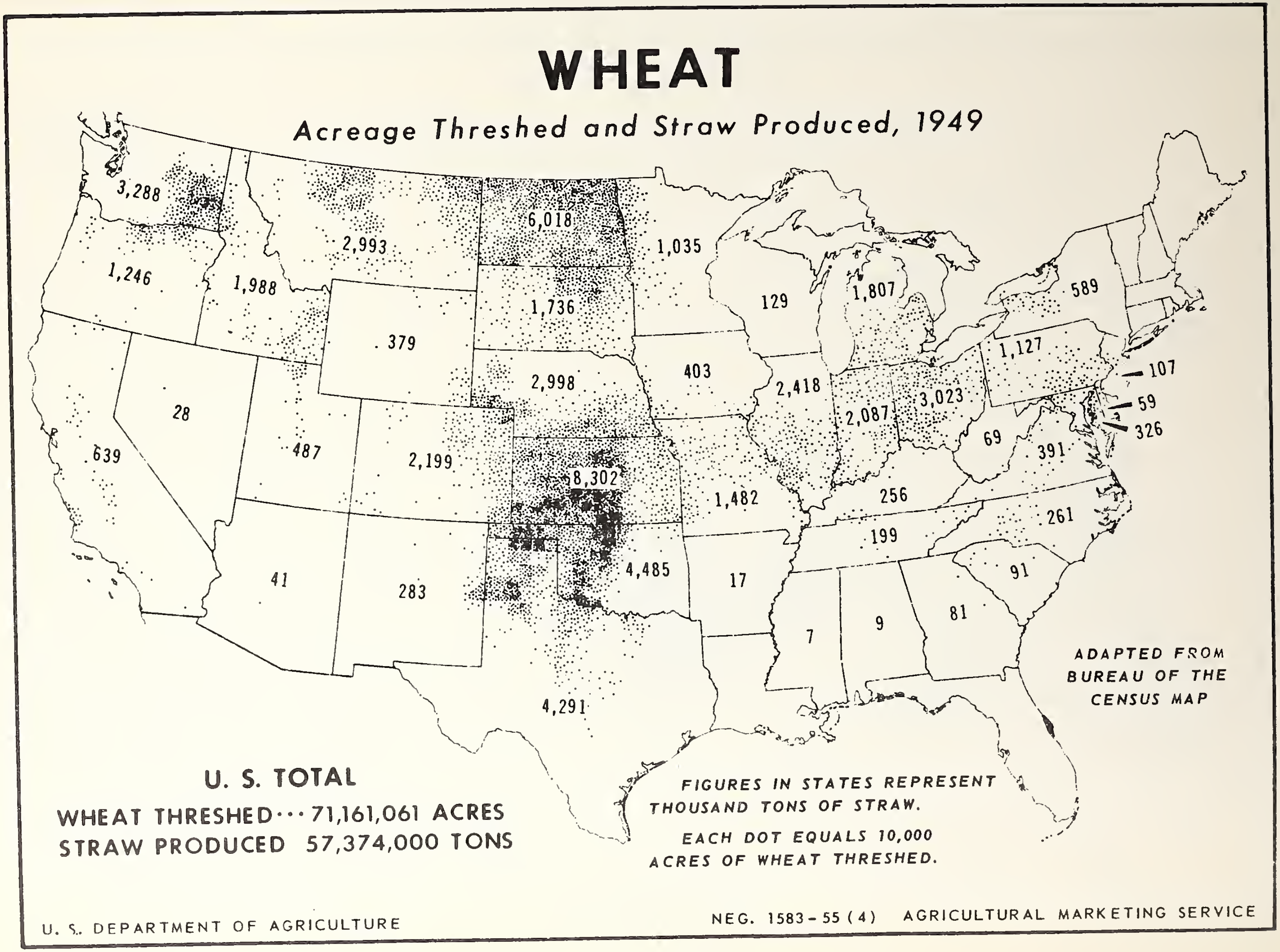
WHEAT
Acreage Threshed and Straw Produced, 1949
3,288
1,246
1,988
2,993
6,018
1,035
1,736
379
28
639
487
2,199
2,998
403
8,302
41
283
4,485
4,291
1,482
17
129
1,807
2,418
2,087
3,023
589
1,127
107
59
326
69
391
256
199
261
91
81
9
7
ADAPTED FROM
BUREAU OF THE
CENSUS MAP
U. S. TOTAL
WHEAT THRESHED··· 71,161,061 ACRES
STRAW PRODUCED 57,374,000 TONS
FIGURES IN STATES REPRESENT
THOUSAND TONS OF STRAW.
EACH DOT EQUALS 10,000
ACRES OF WHEAT THRESHED.
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1583-55 (4) AGRICULTURAL MARKETING SERVICE

Figure 19

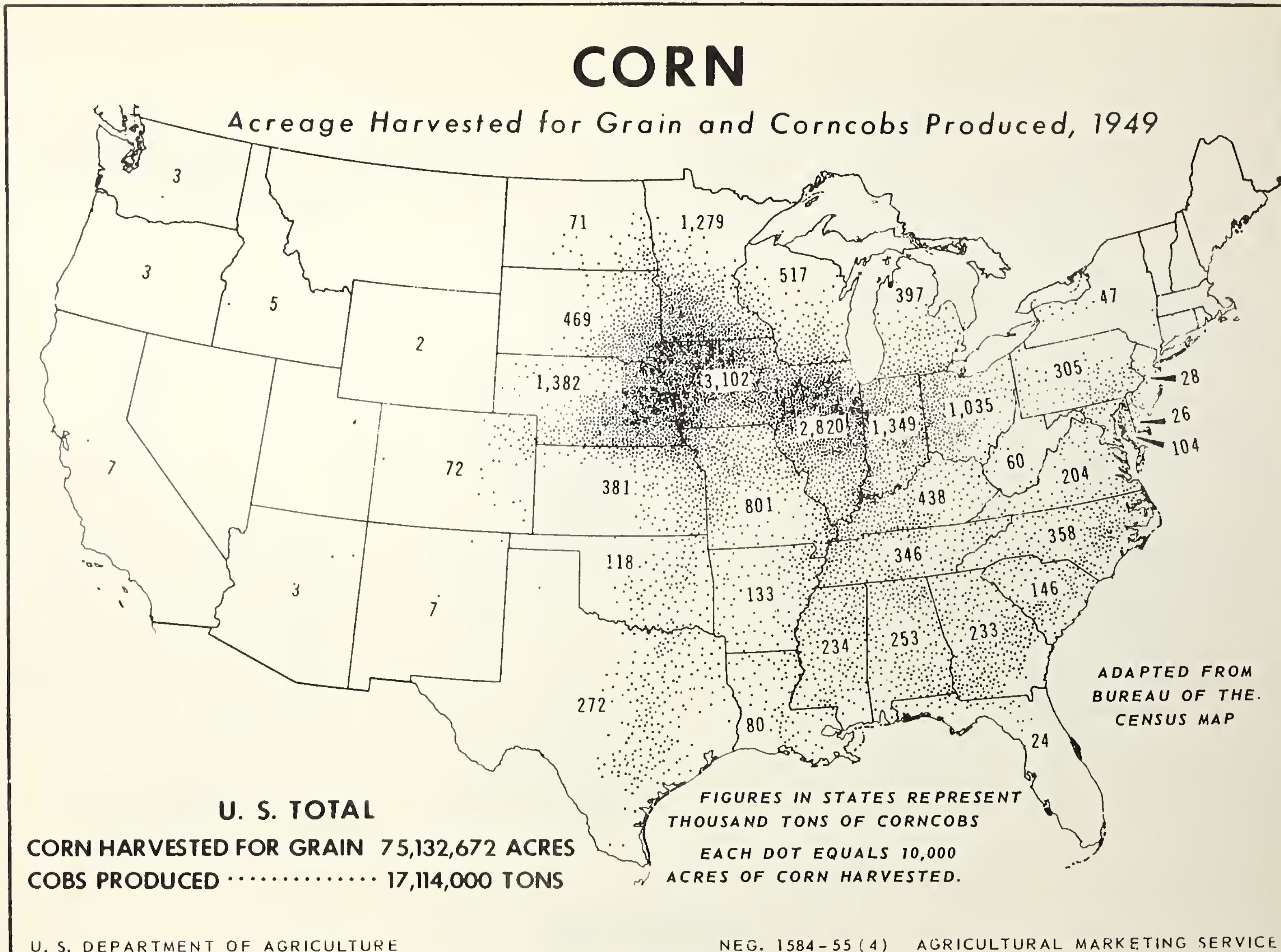
CORN
Acreage Harvested for Grain and Corncobs Produced, 1949
3
3
5
2
7
3
7
72
71
1,279
469
1,382
3,102
381
118
272
517
397
2,820
1,349
1,035
801
133
80
438
346
234
253
233
146
358
204
60
305
47
28
26
104
24
ADAPTED FROM
BUREAU OF THE
CENSUS MAP
FIGURES IN STATES REPRESENT
THOUSAND TONS OF CORNCOBS
EACH DOT EQUALS 10,000
ACRES OF CORN HARVESTED.
U. S. TOTAL
CORN HARVESTED FOR GRAIN 75,132,672 ACRES
COBS PRODUCED .... 17,114,000 TONS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1584-55 (4) AGRICULTURAL MARKETING SERVICE

Figure 20

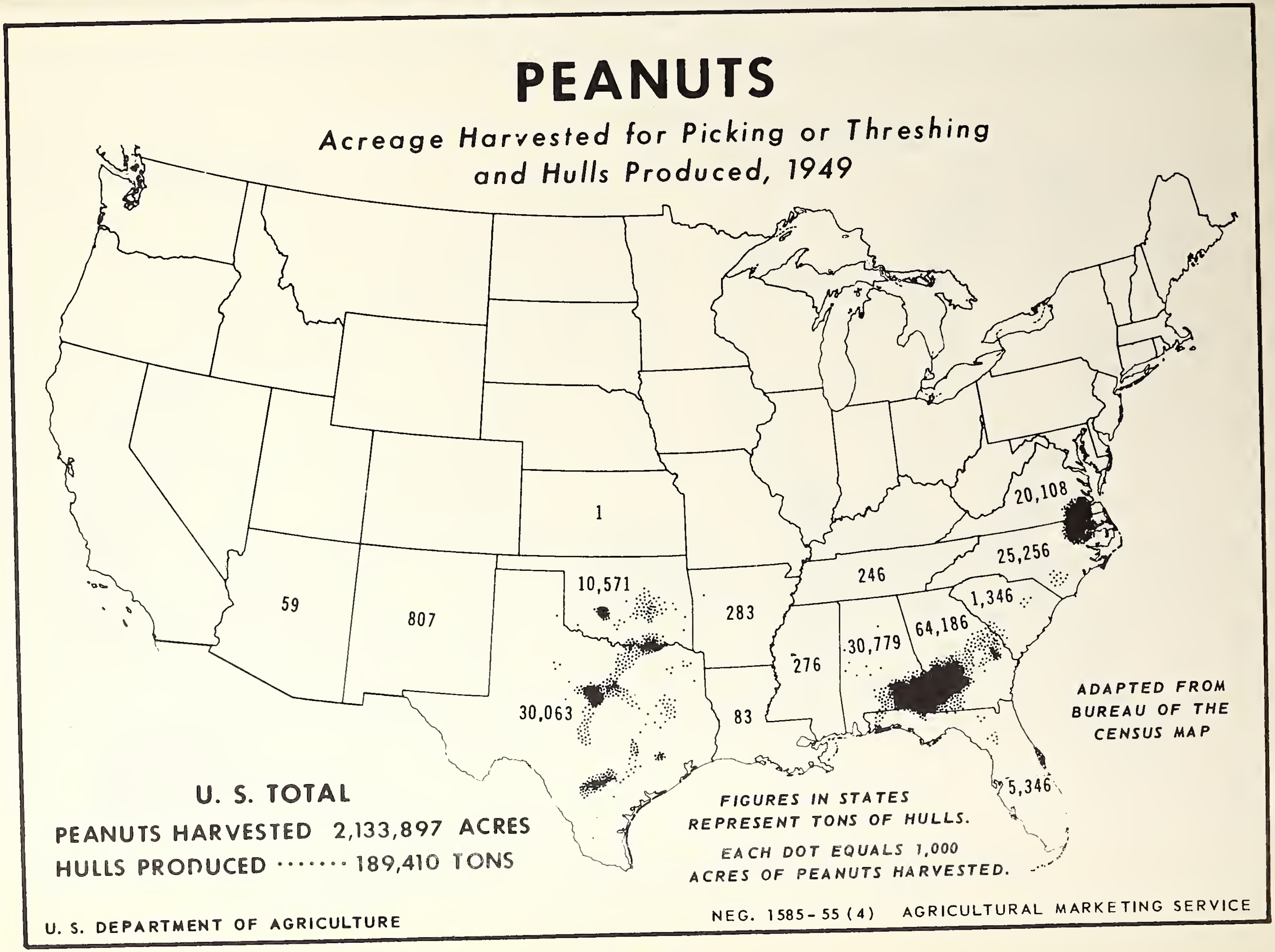
PEANUTS
Acreage Harvested for Picking or Threshing
and Hulls Produced, 1949
1
10,571
30,063
59
807
283
83
276
246
30,779
64,186
1,346
25,256
20,108
5,346
ADAPTED FROM
BUREAU OF THE
CENSUS MAP
U. S. TOTAL
PEANUTS HARVESTED 2,133,897 ACRES
HULLS PRODUCED .... 189,410 TONS
FIGURES IN STATES
REPRESENT TONS OF HULLS.
EACH DOT EQUALS 1,000
ACRES OF PEANUTS HARVESTED.
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1585-55 (4)
AGRICULTURAL MARKETING SERVICE

Figure 21

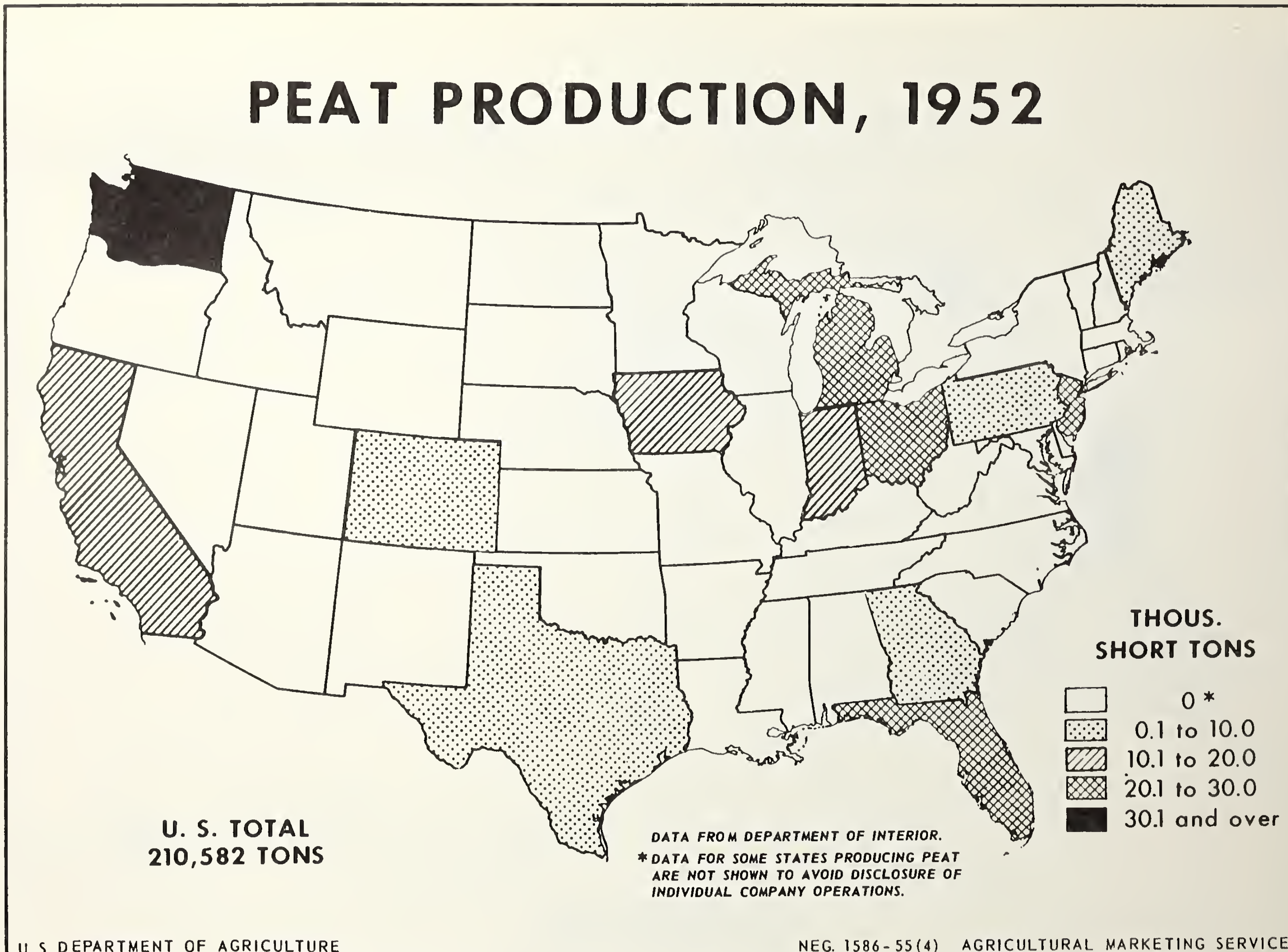
PEAT PRODUCTION, 1952
THOUS.
SHORT TONS
0 *
0.1 to 10.0
10.1 to 20.0
20.1 to 30.0
30.1 and over
U. S. TOTAL
210,582 TONS
DATA FROM DEPARTMENT OF INTERIOR.
* DATA FOR SOME STATES PRODUCING PEAT ARE NOT SHOWN TO AVOID DISCLOSURE OF INDIVIDUAL COMPANY OPERATIONS.
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1586-55(4) AGRICULTURAL MARKETING SERVICE

Figure 22

Seeger, Tomhave, and Lucas (23) tested 12 litters used for broiler production. These included sawdust, shavings, corncobs, sand, bagasse, cottonseed hulls, peanut shells, cornstalks, peat, and 3 types of mineral litter at the University of Delaware Agricultural Experiment Station. Seven experiments were made over a period of about 5 years comparing 2 or more of the 12 litters in each experiment. Sawdust was used as a comparative standard litter in each experiment. No attempt was made to compare the effectiveness of a litter in one experiment with its effectiveness in another or with the effectiveness of a competing litter in a different experiment because the tests were conducted at different times and performance of flocks is affected by variations in the incidence and severity of disease.

Performance of the litters was checked with respect to four major factors--mortality, pounds of broiler produced per chick started, pounds of feed required per pound of broiler produced and litter cost per 1,000 chicks started. Mortality expressed as percentage loss from bronchitis is shown in table 57 for all experiments.

TABLE 57.--Percentages of broiler flocks lost from bronchitis, by type of litter used, selected periods, August 1942 to December 1947

Experiment and type of litter	Percentage loss	Experiment and type of litter	Percentage loss
Experiment 1 (Aug. 1942 to July 1943):	*Percent*	Experiment 5 (Dec. 1944 to March 1945):	*Percent*
Sawdust............	5.54	Sawdust............	0.11
Shavings............	6.30	Peanut shells......	.11
Cobs................	2.94	Cornstalks.........	.44
Sand................	17.94	Air-dry sawdust....	.35
Experiment 2 (Aug. 1942 to Dec. 1947):		Experiment 6 (Dec. 1946 to March 1947):	
Sawdust............	5.96	Sawdust............	6.17
Cobs................	4.27	Cobs................	5.06
		Peat................	4.83
Experiment 3 (Dec. 1944 to May 1946):		Mineral (Georgia)..	10.28
		Mineral (Chick bed)	13.56
Sawdust............	2.16		
Peanut hulls........	2.06	Experiment 7 (April 1947 to Dec. 1947):	
Experiment 4 (Aug. 1943 to Dec. 1943):		Sawdust............	0
		Cobs................	0
Sawdust............	0	Peat................	0
Cottonseed hulls....	.20	Dryzone (mineral)..	0
Bagasse.............	0		

Data from "A Comparison of Litters Used for Broiler Production" (23).

Losses attributable to bronchitis were markedly greater on mineral litters than on organic litters. The investigators concluded that the type of litter used had no influence on the severity of coccidiosis. Table 58 shows production results using the various litters and litter cost per 1,000 chicks started.

In summarizing their observations, Seeger, Tomhave, and Lucas (23) rank the litters tested in order of relative quality as follows:

1. Peanut shells
2. Cobs
3. Peat
4. Bagasse
5. Sawdust
6. Shavings
7. Cottonseed hulls
8. Cornstalks
9. Dryzone (mineral)
10. Sand
11. Chick bed (mineral)
12. Georgia (mineral)

The authors further conclude that generally the best litter for broiler production is one that is of organic origin, dry, fine in texture, light in weight, relatively free of dust, low fire hazard, and relatively low-priced.

The Poultry Department of the Louisiana State University Agricultural Experiment Station recently compared the effectiveness of straw, bagasse, shavings, and peanut hull litters in the production of broilers. The results of the tests have not yet been published, but they have been made available for publication in this report by Dr. Charles W. Upp, Head, Poultry Industry Department. The summary and conclusions of the Graduate Thesis reporting the results are quoted as follows:

"Data are presented concerning the effects of litter materials on broiler growth, feed efficiency, mortality, dressing percentages, carcass grade, and breast angle. Moisture content of litters and information concerning management of litters are also presented. This experiment covers a nine week period with two thousand thirty-eight meat strain broilers on four types of litter. The following conclusions may be drawn from these data.

"1. Broiler growth was different on the various litters used in this experiment. Chicks on peanut hulls litter did not make as rapid growth as chicks on the other litter materials, straw, bagasse, and shavings.

"2. Growth rate between chicks grown on straw, bagasse, and shavings litter did not differ in this experiment.

"3. No difference was secured in feed efficiency of the broilers produced on the various litters. Feed efficiency was quite uniform for all pens.

"4. No difference was secured in mortality for the different litters, but considerable variation occurred from pen to pen.

"5. Moisture content of litter samples that were taken at weekly intervals ranked

TABLE 58.--Production results with various types of poultry litter in seven experimental tests, selected periods, August 1942 to December 1947

Experiment and litter	Chicks started	Mortality	Broilers sold per chick started	Feed required per lb. of broiler sold	Litter cost per 1,000 chicks started
No. 1. Flocks, 1, 2, and 3					
Aug. 1942-July 1943	*Number*	*Percent*	*Pounds*	*Pounds*	*Dollars*
Sawdust	2,738	7.60	2.92	4.52	6.26
Shavings	2,738	9.13	2.96	4.54	7.35
Cobs	2,738	6.32	2.98	4.59	16.73
Sand	2,738	15.30	2.73	4.66	9.53
No. 2. Flocks 1, 2, 3, 12, 14, and 16A					
Aug. 1942-Dec. 1947					
Sawdust	7,283	8.06	3.03	4.46	7.95
Cobs	7,283	6.37	3.22	4.36	26.51
No. 3. Flocks 7, 8, 9, and 10					
Dec. 1944-May 1946					
Sawdust	6,354	11.47	3.03	4.54	10.31
Peanut shells	6,354	8.96	3.27	4.45	20.49
No. 4. Flock 4					
Aug. 1943-Dec. 1943					
Sawdust	988	33.60	2.47	5.35	4.87
Cottonseed hulls	988	13.40	3.40	4.65	17.40
Bagasse	988	14.70	3.45	4.53	13.74
No. 5. Flock 7					
Dec. 1944-Mar. 1945					
Sawdust	918	3.38	3.43	4.02	8.72
Peanut shells	918	1.53	3.58	3.92	18.74
Cornstalks	918	4.68	3.35	4.10	--
No. 6. Flock 12					
Dec. 1946-Mar. 1947					
Sawdust	1,800	11.33	3.00	4.75	11.11
Cobs	1,800	10.44	3.37	4.53	35.72
Peat	1,800	8.94	3.33	4.62	20.83
Mineral (Georgia)	1,800	23.28	2.55	5.16	24.03
Mineral (chick bed)	1,800	22.39	2.72	4.93	8.47
No. 7. Flocks 14 and 16A					
April 1947-Dec. 1947					
Sawdust	3,654	6.51	3.22	4.09	8.42
Cobs	3,654	7.25	3.23	4.19	32.24
Peat	2,736	10.75	3.15	4.22	27.96
Mineral (dryzone)	3,654	8.98	3.11	4.28	54.19

Data from "A Comparison of Litters Used for Broiler Production," (23).

in this order: Straw litter had the highest moisture content followed by bagasse litter, peanut hulls litter and shavings litter.

"6. Laboratory tests were conducted on the moisture-holding capacity of the four litter materials. These tests were made entirely with fresh air dried samples. Bagasse absorbed the most moisture but lost moisture more slowly than did straw litter. Straw had the next highest absorptive ability but lost moisture faster than the other three materials. Peanut hulls litter and shavings litter ranked third and last in absorptive ability.

"7. Dressing percentages, carcass grade, and breast angle of the birds were apparently not affected by the litters tested.

"8. In the management of litters straw litter required the most stirring. The other litters ranked in this order for time required to stir the litter: bagasse, shavings and peanut hulls. In view of the fact that peanut hulls and shavings litter did not cake or mat easily, it required less work to keep these litter materials in good condition.

"9. All four of the litter materials used gave satisfactory results.

"10. The experiment should be repeated at other seasons of the year and under varying conditions to test the litter materials under different environmental conditions."

As mentioned at the beginning of this section, absorbency is one of the major quality requisites of poultry litter. Reference has been made to this requirement in the studies cited above, but there was no measure of their actual absorbing capacity. A list of litter materials arranged in approximate order of their ability to absorb follows as reported in the Massachusetts Dairy Digest (7, p. 2).

	Moisture absorbing capacity (times by wt.)
Peat (German)	10
Peat	5 - 7
Bagasse	4
Straw (fine cut)	2 - 6
Peanut shells	2 - 5
Sawdust (pine)	1.6- 4.3
Straw	1.8- 3.6

Moisture absorbing capacity (times by wt.)--con.	
Shavings	1.2- 2.6
Leaves	1.8- 2.0
Oat hulls	1.9
Corncobs (ground)	1.35
White pine needles	1.0
Sand	.25

During the course of field work on this study, litter users and distributors were invited to express opinions on bagasse litter quality. Most persons interviewed ranked bagasse high in absorptive ability, high in manure value, and low in dustiness--all desirable quality characteristics. But bagasse was generally considered to have a comparatively high matting tendency because of its long fiber bundles. This is an undesirable characteristic, because chickens cannot keep the litter stirred up and loose, thus somewhat impairing its usefulness where deep litters are desired or required. Two users suggested that bagasse fiber bundles be shortened through grinding to reduce the tendency of bagasse litter to mat.

Prospective Future Supplies of Competing Litters

Locally Produced Litters.--Most locally produced litters of agricultural origin will continue to increase in production as the Nation's food and feed requirements increase with expansion in population. In addition, there seems to be little doubt as to the availability of these materials for litter except possibly locally produced cereal straws. More and more small grain is being harvested by combine; and, while the use of combines has no effect on straw production, it leaves the residue in the field in contrast to the thresher which centralizes straw supplies on the farm. To collect straw scattered about the field requires rakes, pickup balers and trucks, or wagons. By the time raking, baling, and hauling is accomplished, considerable expense has been added and the straw approaches the cost of commercial litters.

Sawdust and shavings supplies are not likely to increase without excessive drain on resources. Even in areas with a favorable growth-drain balance, the margin of growth over drain is not large (see table 18). However, at present, much of this residue is wasted and greater effort will be made to collect it for litter purposes if prices become more attractive.

Commercial Litters.--The commercial materials which are likely to be available in larger supplies are peat, crushed corncobs, and peanut shells. Since the end of World War II, consumption of peat has approximately doubled, and the trend is strongly upward (see fig. 23). However, to date, practically all of these increased supplies have been used for soil improvement and fertilizer filler. Relatively small quantities have been used for poultry litter and stable bedding, and there appears to be no significant growth in peat use for this purpose.

From the comments of users and distributors on the availability of various litters, some expansion is going forward in the baling and sale of peanut shells for poultry litter. However, actual production of peanut shells has shown little change since 1941, judging from the quantity of peanuts threshed. Between 1941 and 1952 the quantity of peanuts threshed ranged from about 14 billion to 21 billion pounds. The poundage threshed in 1951 and 1952 was somewhat below the average for the period covered.

Ground or crushed corncobs are being produced in increased quantities for poultry litter, according to the Agricultural Residues Division, Northern Utilization Research Branch. In recent years plants have been established specifically for the commercial production of cob litter.

There was no evidence either from the literature or information collected in the field that mineral litters are offering important competition to bagasse litter or that their use is likely to expand. Likewise, the use of oat and cottonseed hulls for chicken litter will probably show no expansion in view of their high value as feed ingredients. The likely availability of baled straw was commented on in the portion of the "Paper and Paperboard" section of this report entitled "Other raw materials."

Suggestions by Users and Distributors for Increasing Bagasse Litter Sales.

In general, users and distributors believed that manufacturers were doing a creditable job of processing and merchandising bagasse litter. Their suggestions to manufacturers about measures which might increase sales centered around two major points. These were as follows: (1) The achievement of lower prices through the development of economies in processing and transportation, and (2) the development of processing methods that will reduce the tendency of the material to mat.

Suggested as a possible economy was the production of larger, more tightly packed bales. It was believed that it might be less expensive to process larger bales and that more tightly packed bales would cost less per pound to ship. A shortening of the long fiber bundles was suggested as a possible means of reducing matting tendencies.

Possibility of Bagasse Litter Enterprises in Offshore Domestic Cane Areas

It is noted that no bagasse litter is presently being produced in Hawaii or Puerto Rico either for the local or United States market. The reason for the lack of litter enterprises in these areas is not known to the authors. A review of comparative transportation rates to principal port cities indicates Puerto Rican and Hawaiian litters might be able to compete pricewise with bagasse litter produced on the mainland and other commercial litters in poultry areas close to port cities. This assumes that production costs would not exceed those on the continent and that no further processing is necessary to achieve the degree of sterilization required under quarantine regulations for offshore bagasse.

Table 59 compares bagasse rail rates from New Orleans, La., and Clewiston, Fla., with bagasse ocean rates from Honolulu, Hawaii, and San Juan, Puerto Rico, to selected port cities on the Atlantic and Pacific coasts. Ocean rates are also shown from New Orleans to the selected port cities for comparison, even though most bagasse from mainland cane areas moves by rail. Some truck shipments are made to points near the litter processing plants. No ocean rates are available for Florida bagasse.

TABLE 59.--Comparison of bagasse rail and ocean rates, per ton, between selected points, spring, 1954

Transportation and point of origin	Destination					
	Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Los Angeles, Calif.	San Francisco, Calif.	Seattle, Wash.
Rail:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
New Orleans, La.	18.63	16.79	16.10	62.33	62.33	65.09
Clewiston, Fla.	17.94	16.10	15.41	74.75	74.75	74.75
Ocean:						
Honolulu, Hawaii	34.15	34.15	34.15	17.50	17.50	17.50
San Juan, Puerto Rico.	10.58	10.58	10.58	35.20	35.20	35.20
New Orleans, La.	12.65	12.19	12.42	27.14	27.14	27.14

Transportation and Warehousing Division, CSS, U. S. Dept. Agr.

The Louisiana bagasse litter manufacturers indicated that rail transportation is less expensive to distant port cities than ocean transportation, even though quoted ocean rates from New Orleans to these cities are less than rail rates. More handling operations are required for water transport, and bagasse landed at dock warehouses must be redistributed to users and distributor warehouses, most of which are at country points.

It is possible that the costs of handling bagasse litter from Puerto Rican or Hawaiian sugar mills to island ports and of redistributing it from docks at United States ports precludes the possibility of pricing the litter at competitive levels just as these costs apparently eliminate the use of water transportation for bagasse produced on the mainland. Calculations of actual net difference in cost of moving bagasse to selected points by water and by rail cannot presently be made, because there are no data available on the various handling and redistribution costs. However, the differential between Puerto Rican bagasse ocean rates and mainland bagasse rail rates to the selected Atlantic coast port cities shown in table 59 is wider than the differential between rail and ocean rates for Louisiana bagasse. This additional leeway for Puerto Rican bagasse may make competitive pricing possible. At Pacific coast ports the differential between Hawaiian bagasse ocean rates and mainland bagasse rail rates is even wider than that between mainland rail and Puerto Rican ocean freight rates to Atlantic coast ports.

Agricultural Mulch

The largest tonnage of mulch used is in the form of agricultural residues or cover crops tilled into the soil by farmers as a normal part of farm operations. Farmers also use substantial quantities of agricultural residues and local forest residues as a top mulch in crop operations. Such mulches are vitally important to agriculture in reducing wind and water erosion, controlling weeds, minimizing evaporation, increasing the ability of the soil to store moisture, and improving soil tilth.

The agricultural mulches discussed in this report perform all of the functions outlined above. However, they principally serve markets in which the plants produced are especially valuable individually and in which mulching and the selection of the type of mulch are important. The mulching operation and type of mulch used must be important enough to require the purchase of at least some processed or baled material falling within the definition of commercial as set forth in the section entitled "Poultry Litter." Commercial mulch may also serve markets in which the characteristics of the mulch are not of particular importance but in which a shortage of inexpensive forest or agricultural residues exists.

The mulches covered in this report are used principally in the nursery industry and for ornamental shrubs and flowers in landscaping homes and other buildings. In addition they are used for lawn improvement, tobacco seedbeds, market gardens, orchards, small fruit and berry production, and other special uses. The materials generally used in important quantities for such specialized purposes are peat, sawdust, wood chips, wood shavings, and pine needles (or pine straw, as they are sometimes called). Reed and sedge peats are the principal United States peats. Most imported peats are of sphagnum moss origin.

Also used, but in lesser quantities, are vermiculite, a mineral, and agricultural residues available in abundant quantities in the area of use. Among the agricultural residues being used by the nurseries visited in connection with this project were tung nut hulls, cotton ginning and cottonseed cleaning operation screenings, ground corncobs, wheat straw, and dehydrated and wet baled bagasse.

Dehydrated fresh bagasse is used principally as poultry litter, finding only a limited market among mulch users. It is very tentatively estimated that about 5,000 tons of bagasse mulch are used annually, mostly in the vicinity of domestic cane areas. Since its use there has been successful, and the mulch market appears to be expanding rapidly, the possibility of increasing its use is considered in this report. Information and statistics on mulch are not as plentiful as they are on many of the other products for which bagasse is suitable. However, the available pertinent data are presented in succeeding pages.

Market Growth

Accurate information on current and historical use of the various materials suitable for mulching purposes is available for peat only. Usage of other materials is presented in descriptive terms such as "large quantities" or "moderate amounts." If the trend in the use of peat for mulch is any indicator of the growth of the mulch market in total, mulch producers have enjoyed a rapidly expanding market since the end of World War II (fig. 23). The consumption of peat for mulch almost doubled from 1945 to 1952 after a period of almost static consumption from 1938 to 1945. Part of the lack of growth from 1938 to 1945 was doubtless due to lack of adequate shipping space for foreign peat during the war years. About half the peat consumed in this country is supplied by foreign countries.

Although close to 60 percent of the peat marketed in this country is used for mulching, substantial quantities are also used as fertilizer filler, poultry litter, and animal bedding (see fig. 23). The use of peat for litter has been relatively stable since the end of World War II, while its use as a fertilizer filler has expanded rapidly. Dry peat is used in the manufacture of fertilizers in which some of the ingredients are hygroscopic--able to absorb moisture from the air in damp weather and dry out again in dry weather. As a result such fertilizers are sticky at times and harden or cake at others. The ability of peat to absorb solution from the surface of fertilizer particles reduces stickiness and caking. Peat is mixed with the other fertilizer ingredients in proportions of 5 to 10 percent of the finished product.

The net change over the years in the quantity of bagasse mulch used is impossible to determine from the available data. However, judging from the comments of nurserymen visited who are familiar with its use, the consumption of bagasse mulch has changed little since the end of World War II. For instance, some nurserymen who used dehydrated bagasse in place of peat during the war, when peat imports declined, indicated that they were again using peat since supplies have once more become plentiful. Other nurserymen stated that they had always used bagasse for mulching and saw no reason to change. And a few new users were interviewed in the Alabama azalea nursery area.

Economics of Producing Agricultural Mulch

The cost of producing dehydrated bagasse is covered in the section entitled "Poultry Litter." Dehydrated bagasse used for mulch is identical with that used for chicken litter including type and size of bale. Bagasse baled wet and allowed to cure in storage

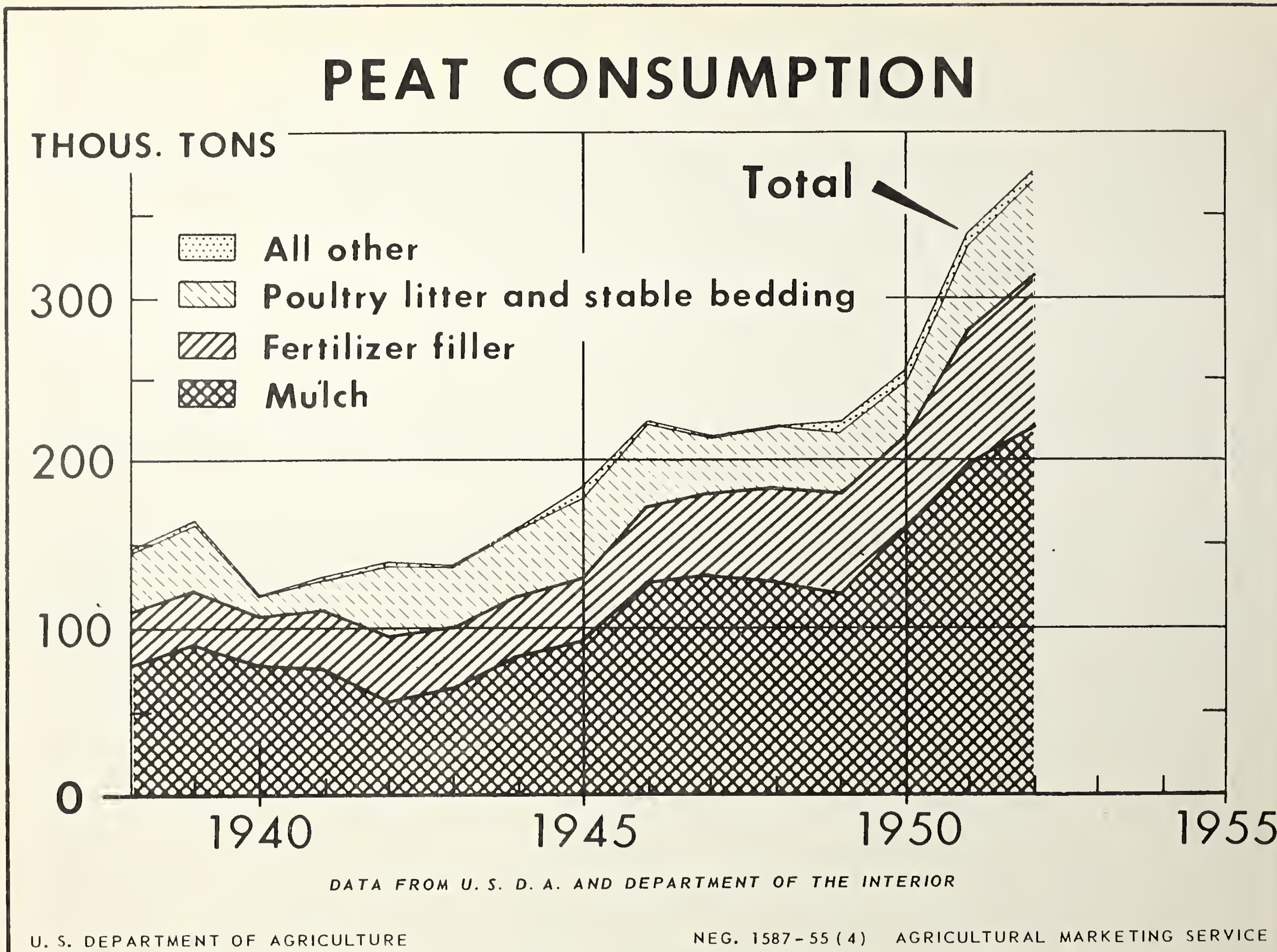
PEAT CONSUMPTION
THOUS. TONS
Total
All other
Poultry litter and stable bedding
Fertilizer filler
Mulch
300
200
100
0
1940
1945
1950
1955
DATA FROM U. S. D. A. AND DEPARTMENT OF THE INTERIOR
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1587-55 (4) AGRICULTURAL MARKETING SERVICE

Figure 23

is also used to some extent by nurserymen in the Louisiana cane area. Wet baled bagasse is usually less expensive to produce per ton than dehydrated bagasse, due principally to elimination of the drying process.

Wood chips cost about $5 a ton to produce, according to McIntyre in "Wood Chips for the Land" (16, p. 3). There are no data on production costs of other mulches.

As with chicken litter materials, no comparable prices have been published for the various types of mulches. Peat was the only material for which sources of regularly quoted prices were discovered. Prices for imported peat unloaded on the dock at major ports of entry are published weekly in "Feedstuffs."

In view of the lack of comparable published price data, information on prices of various mulches delivered to users was obtained during April and early May 1953 while interviewing mulch users (table 60). Most forest and agricultural residues were available free at the point of production, and users estimated the prices of these materials as equivalent to hauling costs to the point of use. Many users were uncertain as to the charge they should make to hauling, but most estimates and "guesstimates" centered around $4 a ton.

The price of $12.50 per ton shown for ground corncobs represents the delivered price to the user of $7.50 for unground cobs plus a cost of $5 for subsequent grinding. (According to recent information received from the Agricultural Residues Division, Northern Utilization Research Branch, commercial grinding plants were charging from $10 to $20 a ton, f.o.b. plant, for cobs crushed for mulch or litter during 1954.) Tung nut hulls were in some demand in the area of production, and a nominal price was added to hauling charges.

Peat supplied at least a portion of the mulch requirements for all nurseries visited except the two in Lafayette, La. However, because of its relatively high price, nurserymen use peat sparingly except for those purposes for which they believe there is no adequate substitute. Near or at ports of entry peat cost to users visited was about $35 to $38 a ton. At interior points prices ranged from $55 to $60 a ton (see table 60).

Bagasse was not used for mulch by any of the nurseries visited except those located in or near the Louisiana cane area. Dehydrated bagasse cost nurserymen from $20 to $35 a ton; baled wet bagasse about $10 a ton; and unbaled wet bagasse cost $4 a ton.

TABLE 60.--Price per ton for bagasse mulch and competing mulches, delivered, by location of users interviewed, spring 1953[1]

Location of user	Bagasse	Peat	Sawdust	Wood shavings	Pine needles	Ground corncobs	Leaf mold	Tung hulls	Cottonseed screenings
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Chattanooga, Tenn.	--	56.68	[2] 4.00	--	--	--	--	--	--
Jacksonville, Fla.	--	38.89	--	--	--	--	--	--	--
Semmes, Ala.	--	36.08	--	[2] 4.00	--	--	--	--	--
Semmes, Ala.	30.00	36.08	--	--	--	--	--	--	--
Semmes, Ala.	35.00	36.08	--	--	[2] 4.00	--	--	--	--
Jackson, Miss.	--	55.50	--	--	[2] 4.00	--	--	--	--
Jackson, Miss.	--	55.50	--	--	--	--	[2] 4.00	--	[2] 4.00
New Orleans, La.	33.00	38.85	--	--	[2] 4.00	--	--	--	--
New Orleans, La.	--	40.00	--	--	--	--	--	--	--
Folsom, La.	[3] 10.00	32.00	--	--	--	--	--	10.00	--
Lafayette, La.	20.00	60.00	--	--	--	--	--	--	--
Lafayette, La.	[4] 4.00	60.00	--	--	--	--	--	--	--
Chicago, Ill.	--	36.40	--	--	--	12.50	--	--	--

[1] Data from nurserymen interviewed in the vicinity of the cities shown.
[2] Represents approximate hauling cost from point of production of nursery.
[3] Represents price of baled wet bagasse.
[4] Represents approximate hauling cost from sugar mill to nursery of wet unbaled bagasse.

Markets

The most concentrated areas of commercial mulch usage are near the larger centers of population. Many commercial nurserymen locate near large towns and cities to serve the local demand for flowers, shrubs, and trees. In addition, individual home users of mulch are, of course, most numerous at these points.

Considerable commercial mulch is also used by nurseries in rural areas. Nurserymen producing stock for fruit and berry production are located principally in or near the producing areas they serve. Nurseries that grow certain types of ornamentals for large scale shipment may also be found away from population centers. Notable among this latter group are the azalea producers located in the Southeast and South.

Market Competition

Areas in Which Competing Mulches are Produced--Bagasse mulch will encounter the strongest competition in the areas in which competing materials are produced. Figures 19, 20, and 21 in the section entitled "Poultry Litter" show the areas in which important competing agricultural residues are produced in abundance. Table 55 shows the region where sawdust and shavings are likely to be available in the largest quantities, and figure 22 shows the States in which domestic peat is produced. Vermiculite is produced in Westchester County, Pa; Macon and Buncombe counties, N. C; Lincoln county, Mont; and in Colorado, Wyoming, Nevada, California, and South Carolina. Pine needles are found in large quantities in the longleaf pine forests of the Southeast and Southern Coastal Plain areas.

Competition from peat is present from foreign as well as domestic sources. Normally, about 45 percent of the United States supply of peat is imported from Canada and northern Europe, and competition from these sources would, naturally, be keenest near interior and coastal entry points. Judging from the rapid increase in peat supplies since the end of the war (see fig. 23) the competition from this material is not likely to lessen in any area in the near future.

Relative Quality of Bagasse and Competing Mulches.--The important quality characteristics of mulches generally are ability to absorb and retain moisture, effectiveness in weed control, fertilizer value, effectiveness in controlling wind or water erosion, and ability to build up the humus content of the soil. A quality characteristic important for certain specialized use is the influence of the mulch in achieving the desired degree of soil acidity or alkalinity. For example, the types of mulches which produce acid soil conditions are regarded as almost indispensable to the culture of azaleas and other acid-loving plants by many nurserymen.

The horticultural staff of the Southwestern Louisiana Institute, Lafayette, La., has used fresh and decomposed or composted bagasse for mulching for the past several years. The Institute, which commenced using bagasse because of its low price and abundance at Lafayette, has found the material completely satisfactory for all mulching needs. Fresh bagasse, both dehydrated and wet, is used as a top mulch; while decomposed or composted bagasse is used for mixing with the soil. However, untreated bagasse mulch is considered somewhat inferior to treated bagasse because the untreated bagasse is more likely to contain weed seeds and sugarcane nematodes. Technologists at the Institute indicate that decomposed or composted bagasse is equally as satisfactory as peat for soil conditioning. Fresh bagasse, while controlling weeds effectively, is not as efficient as peat for moisture conservation. However, unlike peat, it will not blow or float away upon drying.

Other data also indicate that peat is superior to competing mulches in moisture holding capacity. Peat can absorb a quantity of water equal to from 5 to 10 times its weight compared to 4 times for bagasse, 1.6 to 4.3 times for sawdust (pine), 1.2 to 2.6 for shavings, 1.4 for ground corncobs, and 1.0 for pine needles.

The Houma, La., laboratory of the Agricultural Research Service, U. S. Department of Agriculture, uses fresh bagasse successfully to mulch sugarcane seedlings in greenhouses. Technicians at the laboratory indicated that fresh bagasse may also be used for ornamentals. However, additional nitrogen fertilizer is needed to prevent temporary nitrogen deficiency symptoms of growing plants which occur during the early stages of bagasse decomposition. Decay organisms utilize nitrogen in accomplishing decomposition of vegetable materials. The temporary nitrogen depleting action of fresh bagasse makes it less desirable for mulching than partially decomposed bagasse according to the technicians at Houma.

The desirability of permitting bagasse to decompose somewhat prior to use was also mentioned by Franklin (10). He compares the effectiveness of a number of mulches in establishing vegetation on eroded areas and ranks them for this purpose as follows: (1) Pine branches; (2) grain straw; (3) lespedeza stems; (4) bagasse (weathered a year before use); (5) pine litter; (6) hardwood tops; (7) hardwood litter. He further points out that fresh bagasse is not satisfactory for this purpose.

A paper entitled "Effect of Different Mulches upon the Nutritive Value of Tomatoes," by Holmes and others (13) reports the results of an experiment comparing the performance of three mulches--horse manure, straw, and bagasse. All of the mulches tended to improve retention of moisture and prevent weed growth, but they were not rated in these respects. A summary of the data indicated that mulching was desirable from a nutritional standpoint, and that, based on the nutritional value of the crop, straw and bagasse were superior to horse manure.

According to the literature mulches generally have little overall variation in fertilizer value. However, it was indicated that the relative nitrogen content of mulches does vary sufficiently to be an important consideration in ranking their effectiveness. Peat is superior in nitrogen content to other mulches currently being marketed commercially. Peat, which is partially decomposed vegetable matter, has a nitrogen content of 1 to 3 percent, while other mulches currently in widespread use have virtually none. For peat, which decomposes slowly due to long submergence in water, 1- to 3-percent nitrogen is adequate to supply the needs of decay organisms. And it is not necessary to add supplemental fertilizer to avoid temporary nitrogen deficiency of plants. As indicated earlier, decomposed bagasse, not now sold commercially, causes fewer nitrogen deficiency problems than fresh bagasse.

Mulches with sufficient nitrogen to preclude the necessity of adding supplemental fertilizer can naturally command a somewhat higher price than competing mulches, other things being equal. As a rough indication of the premium such mulches would likely bring, Allison and Anderson (1, p. 17) reported that the quantity of various nitrogen sources required to counteract the nitrogen-depleting effect of a ton of fresh dry sawdust would range in cost from $4.25 for ammonium sulfate to $12.50 for 5-10-5 fertilizer, using 1951 prices (table 61).

TABLE 61.--Approximate quantity and retail cost of various nitrogen sources required to counteract the nitrogen-depleting effect of a ton of average fresh, dry sawdust

Nitrogen source	Nitrogen content	Quantity required[1]	Retail cost[1 2]
	Percent	*Pounds*	*Dollars*
Ammonium sulfate	21.0	115	4.25
Ammonium nitrate	33.5	72	4.55
Sodium nitrate	16.0	150	6.00
10-6-4 fertilizer	10.0	240	8.15
5-10-5 fertilizer	5.0	480	12.50

[1] Quantities needed for a bushel of sawdust and the cost may be obtained by dividing these values by 150.
[2] Washington, D. C., 1951.

"The Use of Sawdust for Mulches and Soil Improvement," (1).

As indicated earlier, only those users in or near the Louisiana sugarcane area had experience with bagasse mulch. Generally, these users commented favorably on the effectiveness of dehydrated fresh bagasse as a top mulch for weed control and moisture retention. However, fresh bagasse was not considered as suitable as partially decayed bagasse or peat for incorporation in the soil as a conditioner. According to the users, fresh bagasse may not be mixed with soil in proportions in excess of 1/3 bagasse and 2/3 soil without danger of raising soil temperatures past the safe point for the roots of growing plants. Apparently, the rate of decomposition of fresh vegetable material mixed with the soil is so rapid during the early stages that considerable heat is generated.

Users' Comments Regarding Means of Obtaining Wider Use of Bagasse Mulch.

In April and early May 1953, nurserymen were interviewed in Tennessee, Georgia, Alabama, Florida, Louisiana, Mississippi, Arkansas, and Illinois regarding the relative importance of the various mulches being used (table 62). In the aggregate, the nurserymen visited used more peat than any other mulch for mixing with soil as a conditioner. Vermiculite, leaf mold, cottonseed screenings, tung nut hulls, and bagasse (principally decomposed) were also used for this purpose. Pine needles were the principal top mulch used though peat, sawdust, wood shavings, tung nut hulls, bagasse (both fresh and decomposed), and ground corncobs were also used.

Bagasse mulch was used only by the Alabama and Louisiana nurserymen interviewed. Nurserymen elsewhere generally had knowledge of its existence but felt they did not know enough about its suitability for various mulching purposes to risk its use. They commented that the use of bagasse as a mulch was not being promoted as was the case with certain other commercial materials, especially peat.

Most nurserymen were quite interested in having new mulches introduced, particularly materials which can perform the functions of the higher priced commercial materials. They suggested that domestic bagasse producers might be able to dispose of larger quantities of mulch with adequate merchandising of the product and dissemination of information regarding its use.

It was also suggested that ground bagasse or bagasse pith might be competitive with peat as a fertilizer filler. Bagasse is highly

TABLE 62.--Approximate importance of the use of various mulches by nurserymen interviewed in April and May, 1953

Location of nurseryman	Use of bagasse mulch	Use of competing mulches			
		Peat	Pine straw	Wood shavings and sawdust	Other
Chattanooga, Tenn.	None	Moderate	None	Moderate	--
Atlanta, Ga.	--	Mostly	None	None	Vermiculite (limited)
Jacksonville, Fla.	None	Moderate	Moderate	None	--
Mobile, Ala.	Limited	Moderate	None	Moderate	--
Mobile, Ala.	Limited	Moderate	Moderate	None	--
Mobile, Ala.	Very limited	Moderate	Moderate	None	--
Jackson, Miss.	None	Moderate	Moderate	None	--
Jackson, Miss.	None	Limited	None	None	Leaf mold (limited) Cottonseed screenings (limited)
New Orleans, La.	None	Moderate	Moderate	None	--
New Orleans, La.	Limited	Mostly	None	None	--
Folsom, La.	Very limited	Limited	None	None	Tung nut hulls (mostly)
Lafayette, La.	Mostly	Limited	None	None	--
Lafayette, La.	Mostly	None	None	Limited	--
Chicago, Ill.	None	Moderate	None	None	Ground corncobs (moderate)

absorptive, and absorptiveness is the property required of a filler. In addition, the rapidly increasing use of peat for this purpose (see fig. 23) indicates that the fertilizer filler market offers some promise of expansion.

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