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Economic Analysis of Kenaf Production for Poultry Litter in the United States

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ECONOMIC ANALYSIS OF KENAF PRODUCTION FOR POULTRY LITTER IN THE U.S.*

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Introduction

Kenaf (Hibiscus cannabinus L.) is an annual, non-wood fiber crop native to tropical Africa and the East Indies. It is cultivated in Southern China, Java, West Africa, Central America, and other tropical countries. Kenaf is closely related to okra and in the same plant family as cotton (Sij, 1987). Kenaf stems are an important source of raw material for pulp in the manufacture of newsprint and other paper products. In addition, kenaf can also be made into carpet backing and padding, roofing felt, cattle feed, chicken litter, fire logs, and cardboard. In Africa and parts of Asia, it is made into clothing, nautical rope, twine, cooking oil, and cigarette paper. In Sudan, its leaves are eaten as a vegetable (Agricultural Research, 1988). Kenaf stems contain two distinctly different types of fiber. The bast fiber is in the outer bark portion of the stem, whereas the shorter, woody fibers are in the thick inner core. Average length of the bast fibers is approximately 2.5mm and that of the woody core fibers is 0.5-0.6mm. Both the outer bast fiber and inner woody core may be utilized in pulps (White et al., 1970).

Kenaf woody core represents a potential source of poultry litter and the "spent" litter an excellent material for composting. Currently, there is a growing interest in the U.S. poultry industry to use the thick inner core of kenaf stem as a poultry litter, instead of wood chips which are getting more expensive. Like wood chips, kenaf core may be used as the main bulking agent in sludge composting and bedding material for poultry. The objective of this study is to examine the total market, transportation costs, and expected price of kenaf core for poultry litter in Texas and the U.S.

Kenaf Production

Kenaf is grown in rows using standard farm equipment (Kugler, 1988). Plants may grow 12 - 20 feet tall, and is largely unbranched in thick stands. Kenaf can be grown over most of the U.S., but yields are greater in the southern tier of the United States, from Virginia to California. Kenaf is also currently grown in Delaware. The crop requires 55° F soil temperatures for seed germination and a 150-day growing season for maturation (Kugler, 1988). Studies at the Texas A&M University Agricultural Research and Extension Center at Beaumont have shown that kenaf can be produced under the natural rainfall conditions of Southeast Texas. In this region, plants can attain heights in excess of 12 feet within a 6-month growing period, with most vegetative growth complete when the plants begin to flower in late September (Sij, 1988). The climate and soil conditions of the Lower Rio Grande Valley of Texas are most appropriate for kenaf production. Hoever, it can be produced across the state and U.S. Plant growth and production requirements differ by region.

Kenaf generally appears to be economically competitive for acreage with other field crops such as corn, soybeans and cotton. Kenaf yields are quite variable depending on soil, climate, length of growing season, and other conditions. Test plantings by the Institute of Food and Agricultural Sciences near Gainesville, Florida, in the 1970's produced dry stem yields of 4 to 20 tons per acre (Chuck Woods, 1987). Under favorable conditions, yields of 6 tons or more per acre (dry fiber) are expected in most of the Southeast U.S. (White et al., 1970). Depending on planting date, yields of 5 to 7 tons per acre were obtained at

Beaumont, Texas, in 1986. Yields in California were reported as high as 12.5 tons per acre. (Sij and Turner, 1988).

Per-acre production costs for kenaf grown in the Lower Rio Grande Valley of south Texas were developed by using 1989 data from field tests and farmer interactions (Scott and Taylor, 1990). Total costs of production for irrigated kenaf were estimated to be $204.00 per acre with a mean yield of 7.5 tons per acre as compared to $163.00 per acre with a mean yield of 6 tons per acre for rainfed kenaf. These production cost estimates did not include any harvesting and hauling expenses. In addition, land preparation costs, including chisel, disc only, disc/herbicide and disc, preplant fertilizer application, and bedding ($38.50 per acre), and irrigation costs, including water and labor ($22.00 per acre) appear to be low as compared to cotton and corn in the same location. However, it should be emphasized that input requirements for kenaf production in Texas has not yet been well documented. Little information is available for control of diseases and insects and the amount of costs that will be incurred.

There have been several experiments with harvest of kenaf. After trying various harvesting vehicles, modified sugarcane equipment is currently thought to be most efficient. Agricultural engineers are now testing the prototype of a new kind of harvester that will be used to cut the first commercial crops of kenaf (Photo Feature #322, USDA, 1988)

Kenaf's woody core makes up about 55-65% of the stem and has market potential for use as poultry litter. Cost and availability of suitable poultry litter materials vary widely in different areas. The rapid growth characteristics and low cost of production of kenaf make it a promising alternative (Lacy, 1989). The suitability of kenaf core particles as a potential broiler litter material was evaluated at the University of Delaware and Texas A&M University. Malone et al. (1990) at Delaware evaluated the suitability as broiler litter of kenaf core in two floor-pen experiments. Experiment 1 compared fresh kenaf core particles (KFC) to fresh pine sawdust (FPS). Experiment 2 evaluated FKC, FPS, reused kenaf, and reused sawdust (from experiment 1) and a 2-cm layer of FKC on top of a reused sawdust base. Both fresh litter treatments were placed in pens at a depth of 6.4 cm. Six replicate pens of 55 (Experiment 1) or 60 (Experiment 2) broilers per pen were used per treatment. Within each litter age (fresh and reused), litter type (kenaf and sawdust) had no significant effect on body weight, feed conversion, mortality, or incidence of breast blisters. Although total aerobic bacteria counts of the fresh litters prior to usage were similar, FPS had higher ($P<.05$) initial yeast and mold counts than FKC in both experiments. By 46 days of age in Experiment 1 and 42 days in Experiment 2, FKC had 21 and 16% higher ($P<.05$) litter moisture, respectively, than FPS. The effect of litter type on fecal caking was not consistent between experiments. Overall, fresh and reused kenaf appeared comparable to pine sawdust as a broiler litter material (Malone et al., 1990).

Texas A&M University conducted a study comparing the use of pine shavings to kenaf core material as litter for market turkeys. Preliminary results detected little to no differences in growth rate, feed conversion or total mortality when comparing turkey hens reared on conventional pine shavings versus those reared on kenaf core. Mold count, moisture content and aerobic plate count showed very slight differences between litter types initially and there were virtually no differences detected when litter was evaluated toward the latter part of the growing period (Hyatt, 1990).

The market for wood shavings has been expanding in recent years, particularly as a feedstock for particle board and other composition in wood products. This demand is not only increasing the price of wood shavings but also causing periodic shortages and improving the economic potential of comparable litter materials such as, kenaf. Kenaf as a subtitute for wood shavings for poultry litter is not expected to affect the price of wood shavings appreciably.

Procedures

This study is an evaluation of the market potential, transportation costs and implications of alternative prices of kenaf core for poultry litter. The analysis required establishing number and location of poultry, estimating total poultry litter needs, transportation costs for kenaf core based on current litter and value of core materials given alternative litter prices based on experience with wood chips. The analyses were limited to broilers and turkeys and considered the Texas market potential as well as U.S. totals.

Number and Location of Poultry

Total number of broilers and turkeys produced in Texas by leading counties were collected from the Census of Agriculture for 1982 and 1987 (Appendix Tables 1 and 2). In addition, total broilers and turkeys by major producing states in the U.S., including Texas, were collected from the Agricultural Statistics for 1988 (Appendix Tables 3 and 4). There were about 226.0 million broilers and other meat type chickens sold in Texas in 1987 as compared to 176.4 million in 1982, indicating an increase of about 28% (Census of Agriculture, 1987). Broiler production in Texas increased further to 266.3 million in 1988 (Agricultural Statistics, 1989). Total number of broilers produced in the U.S. was about 5,235.6 million in 1988 (Agricultural Statistics, 1989). Some of the major broiler production areas are: northwestern Arkansas, northern Georgia and Alabama, central Mississippi, eastern Texas, the Delmarva (Delaware, Maryland and

Virginia) Peninsula, Virginia's Shenandoah Valley, North Carolina, and central California. Based on 1988 data, the top ten states established an early lead in the broiler industry and maintained a high percentage of the U.S. production now currently estimated to be about 85% (Hyatt and Gardner, 1990; Table 1).

The number of turkeys sold in Texas was about 10.5 million in 1987 as compared to 5.0 million in 1982, which is an increase of about 110% (Census of Agriculture, 1987). However, in 1988, Texas turkeys declined to about 7.8 million (Table 2). Counties in the South Central region of Texas lead in turkey production. Total number of turkeys raised in the U.S. was about 242.0 million in 1988 (Agricultural Statistics, 1990). North Carolina leads the turkey producing states, followed by Minnesota, California, Missouri, and Arkansas. These five states produced about 57% of the total turkeys produced in the U.S. in 1988 (Table 2).

TABLE 1. LEADING BROILER PRODUCTION STATES : 1988.

State Ranked	Number (million)	Million lbS.	Percent of U.S.
1. Arkansas	896.8	3677.0	(16.4)
2. Georgia	772.8	3400.4	(15.1)
3. Alabama	702.8	2881.4	(12.8)
4. North Carolina	500.1	2300.5	(10.2)
5. Mississippi	361.8	1480.0	(6.6)
6. Texas	266.3	1118.5	(5.0)
7. Delaware	217.4	1087.3	(4.8)
8. Maryland	252.4	1085.3	(4.8)
9. California	212.2	997.3	(4.4)
10. Virginia	175.7	790.9	(3.5)
U.S.A.	5235.6		(100)

Source: Hyatt and Gardner (1990).

TABLE 2. LEADING TURKEY PRODUCTION STATES : 1988.

State Ranked	Number (million)	Million lbs.	Percent of U.S.
1. North Carolina	47.9	938.8	(18.5)
2. Minnesota	38.5	704.6	(13.9)
3. California	26.5	572.4	(11.3)
4. Arkansas	18.0	370.8	(7.3)
5. Missouri	16.5	335.0	(6.6)
6. Virginia	16.3	306.4	(6.0)
7. Indiana	12.9	225.4	(5.0)
8. Iowa	7.8	187.2	(3.7)
9. South Carolina	5.6	164.3	(3.2)
10. Texas	7.8	160.0	(3.2)
U.S.A.	242.0		(100)

Source: Hyatt and Gardner (1990).

Poultry Litter Requirements

Total amount of poultry litter requirements in Texas and the U.S. are based on the number of broilers and turkeys produced in 1988. Amount of litter required per broiler was estimated to be 0.1875 cu. ft. per year (Kruger and Hyatt, 1990). Because the litter is replaced with about every 6th lot of broilers, total litter requirements per broiler were estimated to be 0.03125 cu. ft. per year. The total number of broilers produced in Texas and the U.S. were multiplied by this litter requirement to estimate the amount of litter used in the broiler industry each year. The amount of litter required by a market turkey was estimated to be 0.75 cu. ft. (Kruger and Hyatt, 1990). Unlike broilers, the litter for turkeys is assumed to be replaced for every second brood. So, the estimated amount of litter used in the turkey industry was obtained by multiplying the total number of turkeys in Texas and the U.S. by 0.375 cu. ft. of litter per turkey.

Transportation Costs

Transportation costs for kenaf core are based on wood chips and/or sawdust (Railroad Commission of Texas, 1990), which are currently used as litter material for poultry. Transportation costs for kenaf core were estimated assuming a truck that has a capacity of 40,000 lb. delivered to a distance of 50, 100, 200, 400, and 800 miles in Texas. Although the truck capacity is 40,000 lb., the low density of kenaf results in a load weighing only 15,000 lb. The total charge includes rates for mileage in hundred weight (based on truck capacity), fuel adjustment charge for mileage covered and 4.1% surcharge for insurance. A 40 foot trailer that has a capacity of about 40,000 pounds would carry only about 15,000 pounds (3,000 cu. ft.) of kenaf core (based on 5 lbs. of kenaf per cubic foot). The delivered price of wood chips (kenaf core) range between 22¢ to 45¢ per cubic foot. The value of kenaf core above transportation costs was estimated by subtracting estimated transportation costs and the delivered price of core material under four sets of assumed prices, e.g., 20¢, 25¢, 35¢, and 45¢ per cu. ft.

Value of Kenaf Core

The value of kenaf core per acre depends on the total kenaf yield and percent that is core as well as delivered core price less transportation costs. As indicated earlier, core yields range from 55-65% of the stem yields. To estimate the value of core material, a spread sheet was developed with alternative stem yields of 5, 10, and 15 tons per acre and core yields of 65, 60, and 55% for each yield level. The value or returns per acre of core material was estimated to be:

$$V = Y * (P - C)$$

Where: V = Returns per acre of core material,
Y = Yield of core per acre in cu. ft.,
P = Delivered price of core per cu. ft.,
C = Transportation cost of core per cu. ft.

Delivered prices of core were alternatively assumed at 20¢, 25¢, 35¢, and 45¢ per cu. ft. and transportation distance was assumed to be 50, 100, 200, 400, and 800 miles. This provides some insight into the sensitivity of the economic feasibility of kenaf core for poultry litter as related to base cost of the core material and transportation implications.

Results

Results are presented relative to kenaf core as a potential litter material for the poultry industry in Arkansas, Texas, and the U.S. This was used to establish the potential acreage of kenaf with alternative yield levels assuming it were the sole source material used for poultry litter. Next, transportation costs per cubic foot of kenaf core delivered to varying distances were estimated. This method was used to estimate the value above transportation costs associated with kenaf core. Finally, per acre returns to kenaf core were estimated for varying transportation distances and alternative yield levels.

Litter Requirements in Texas

Broilers: The estimated amount of litter needed by the broiler industry by leading Texas counties for 1982 and 1987 are presented in Appendix Table 5. Counties located in the eastern Texas area are the leading users of poultry litters in both

1982 and 1987. For most of the counties, litter requirements were increased in 1987 in comparison with 1982. Overall, there was about 28 percent increase of litter requirements in Texas in 1987 as compared to 1982.

Turkeys: The estimated amount of litter requirements by the turkey industry by leading Texas counties in 1982 and 1987 are presented in Appendix Table 6. In both years, Blanco, Bosque, Gillespie, Gonzales, and San Saba were leaders in use of poultry litter. Although McLennan was the second leading county in 1982, information for 1987 was withheld to avoid disclosing data for individual farms. All these counties experienced increased litter needs in 1987 as compared to 1982. Overall, there was about 110 percent increase of litter needed by the Texas turkey industry in 1987 as compared to 1982. Estimated total amount of litter requirements by the poultry industry (both broilers and turkeys) in Texas by leading counties in 1987 are shown in Figure 1.

Litter Requirements in U.S.

Total litter requirements by the broiler and turkey industries in Arkansas, Texas, and the U.S. in 1988 are presented in Table 3. About 254.4 cu. ft. of litter use was estimated for the combined broiler and turkey industries in the U.S. in 1988. Of the total, about 13.7 percent was required in Arkansas as compared to 4.4 percent in Texas. It is obvious that Arkansas uses a large amount of poultry litter since it ranked first in broiler production and fourth in turkey production in the U.S. in 1988 (see Appendix Tables 7 and 8 for litter requirements by major states in the U.S.). Estimated total litter requirements by the poultry industry (both broilers and turkeys) in the U.S. by major poultry producing states in 1988 are shown in Figure 2.

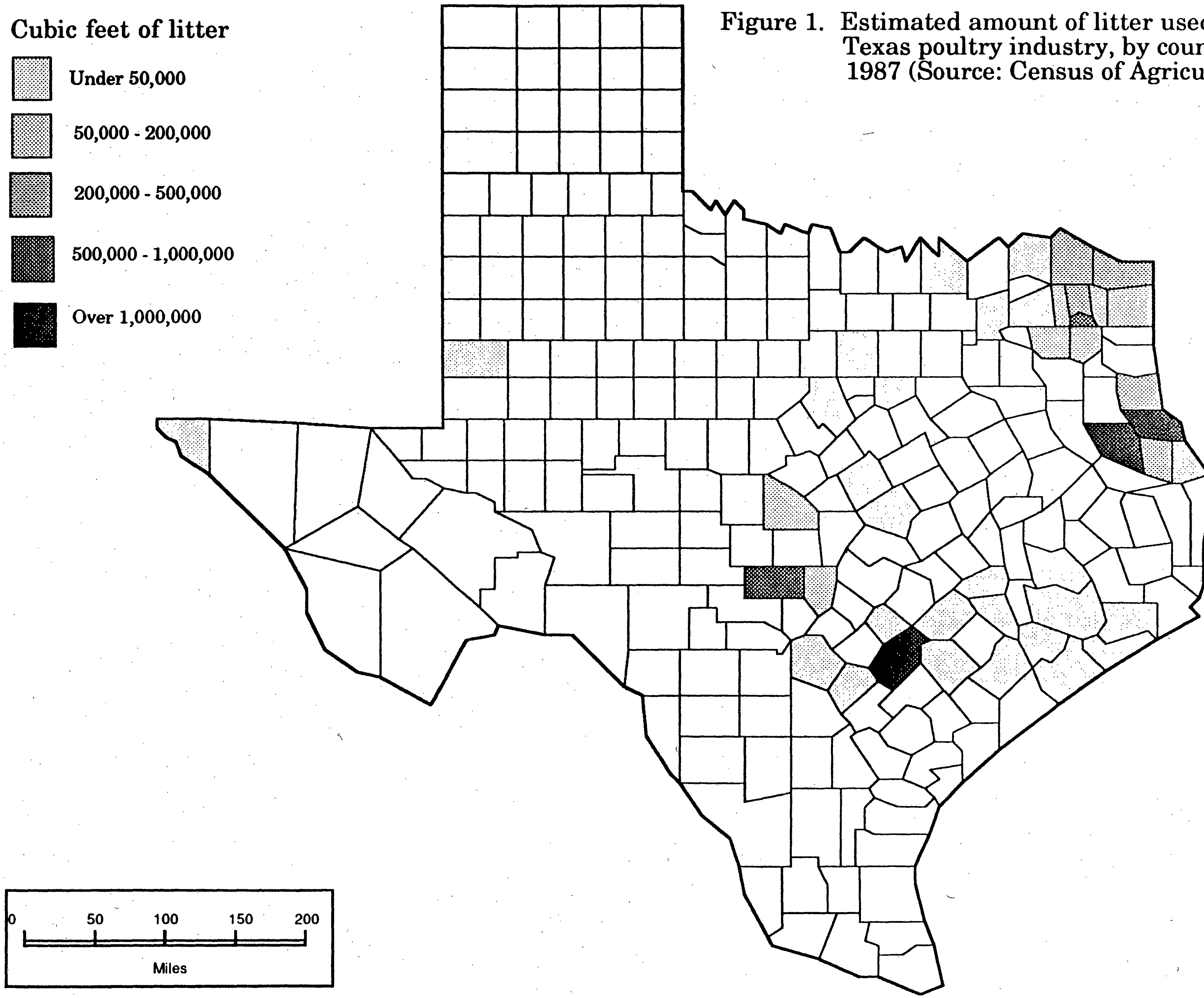


Figure 1. Estimated amount of litter used by the Texas poultry industry, by counties, 1987 (Source: Census of Agriculture).

Figure 2. Estimated amount of litter used by the U.S. poultry industry, by States, 1988 (Source: Agricultural Statistics).

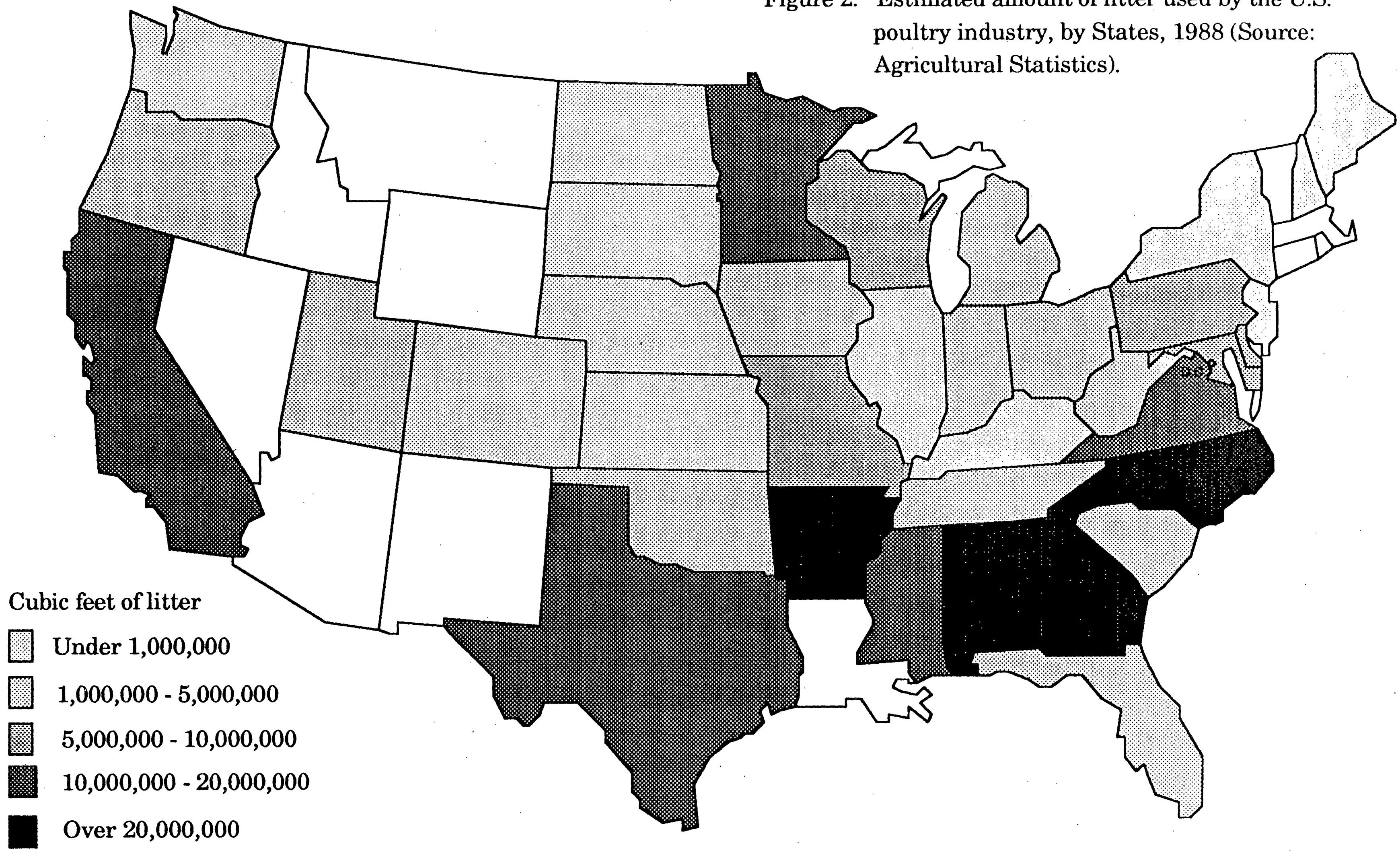


TABLE 3. **ESTIMATED ANNUAL AMOUNT OF TOTAL LITTER REQUIREMENTS BY THE POULTRY INDUSTRY IN ARKANSAS, TEXAS, AND THE U.S., 1988.**

Region	Broiler	Turkey	Total
	------------------------ cubic feet	--------------------	
Arkansas	28,026,000	6,750,000	34,776,000
Texas	8,321,875	2,925,000	11,246,875
U.S.A.	163,612,656	90,758,625	254,371,281

Acreage Requirements

Kenaf acreages were estimated based on poultry litter requirements being satisfied with kenaf core only. Acreages were estimated assuming kenaf (bast and core) yield levels of 5, 10, and 15 tons per acre. To show the effect of core yield on acreages, the results are shown for three sets of core yields as a percent of total yield, e g. 65, 60, and 55% (Table 4). Kenaf acreages that could satisfy poultry litter needs vary inversely with the yield; e.g., as the yield increases, acreages needed to produce core decreases. Also for the same yield level, as the percentage of woody core in the stem yield increases kenaf acreages decline (Table 4). For example, at 5 tons per acre yield level and assuming 65% core, about 195,670 acres of kenaf are needed in the U.S. to satisfy poultry litter needs, compared to 231,247 acres at the same yield level with 55% core (Table 4).

Transportation Costs

The estimated transportation cost of kenaf core (based on wood chips) per cubic foot in Texas is shown in Table 5. To show the effect on costs of transporting litter material to varying distances, the results are shown for five sets of assumptions regarding distances covered. The first row in Table 5 shows, for

TABLE 4. ESTIMATED ACREAGES OF KENAF NEEDED TO SATISFY FOR POULTRY LITTER NEEDS IN ARKANSAS, TEXAS, AND THE U.S.

Scenario	Kenaf yield per acre, tons		
	5	10	15
		acres	
I. 65% woody core			
Arkansas	26,751	13,375	8,917
Texas	8,651	4,326	2,884
U.S.A.	195,670	97,835	65,223
II. 60% woody core			
Arkansas	28,980	14,490	9,660
Texas	9,372	4,686	3,124
U.S.A.	212,976	105,988	70,659
III. 55% woody core			
Arkansas	31,615	15,807	10,538
Texas	10,224	5,112	3,408
U.S.A.	231,242	115,623	77,082

example, the results if the distance is restricted to 50 miles, and the last row shows the results if the distance is 800 miles. Similarly, the second, third, and fourth rows show the results if the distances of core transported are restricted to 100, 200, and 400 miles, respectively. If kenaf core is transported to a distance of 50 miles, total costs would average $0.0804 per cu. ft. This compares with averages of $0.6277 per cu. ft. if the distance transported is 800 miles (Table 5). As mileage increases, transportation costs increase at a decreasing rate. This assumes no load for the backhaul. Interstate and unregulated intrastate transportation costs, however, depend on competition, demand and supply forces

TABLE 5. ESTIMATED TRANSPORTATION COSTS PER CUBIC FOOT OF KENAF CORE (WOOD CHIPS) IN TEXAS.

Distance delivered	Charge, per cwt. [a]	40,000 lb. truck load [b]	Insurance (4.1% of truck load)	Fuel charge	Total charge	Total charge per cu. ft. [c]
miles	dollars					
50	0.55	220.0	9.02	12.30	241.32	0.0804
100	0.85	340.0	13.94	25.97	379.91	0.1266
200	1.13	452.0	18.53	53.31	523.84	0.1746
400	1.96	784.0	32.14	107.99	924.13	0.3080
800	4.00	1600.0	65.60	217.35	1882.95	0.6277

Source: Railroad Commission of Texas, 1990

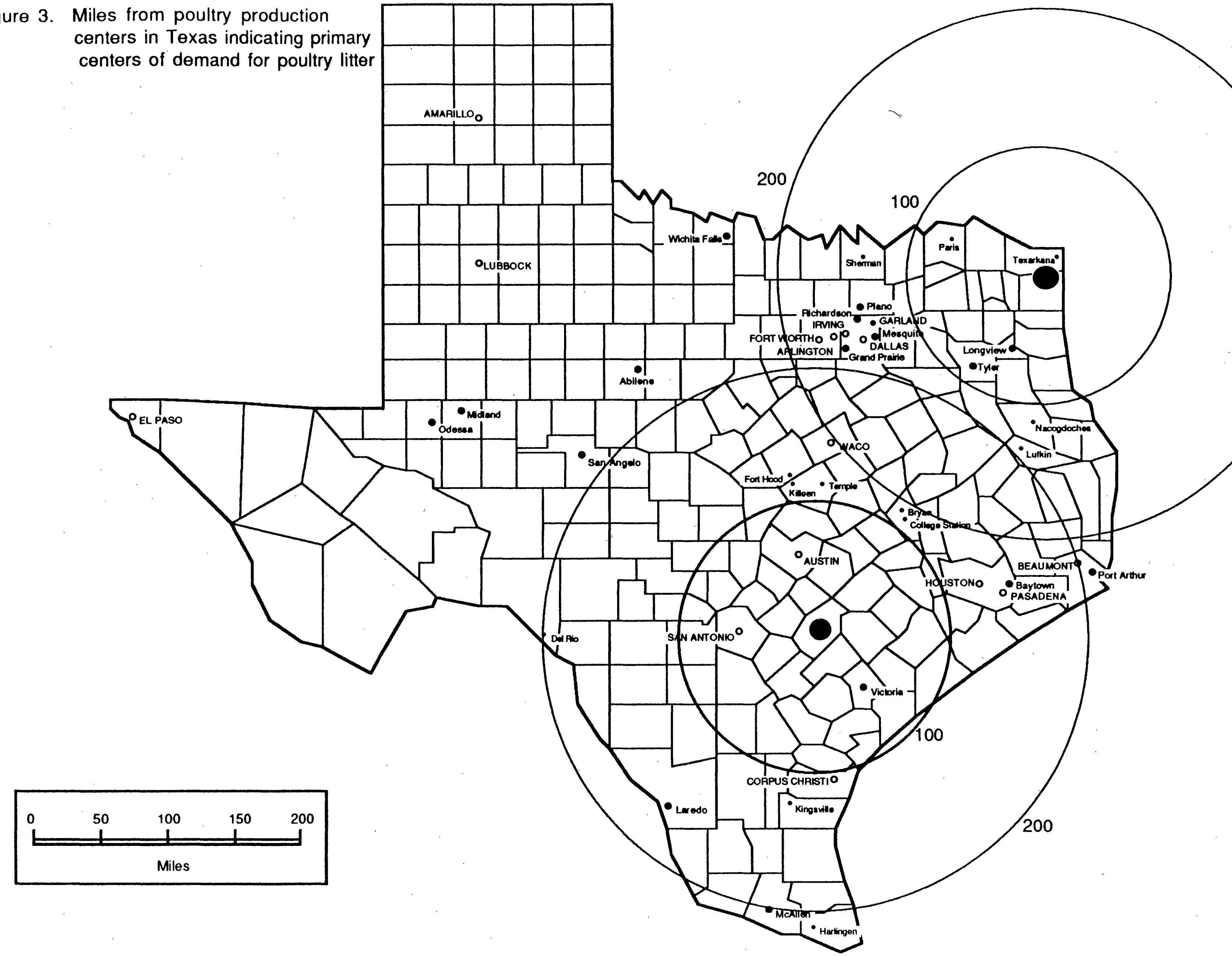
a Based on 40,000 lb. truck capacity. Actual weight of kenaf is much less.

b Assumes use of a truck with 40,000 lb. capacity, actual kenaf weight would be only 15,000 lb.

c Based on 3,000 cu. ft. of kenaf core.

and are expected to be at least 12 to 15% lower than the within - Texas regulated costs (Fuller et al., 1983). Lower hauling costs naturally improve the economic estimate for long hauls such as, 200 miles or more. Figure 3 shows two principal poultry production centers in southcentral and northeast Texas with 100 and 200 mile circles from each. This analysis suggests that kenaf production within 100 miles keeps transportation costs within a feasible range but there may be opportunities to haul as far as 200 miles. The South Texas and Beaumont locations for kenaf production both lie near the 200 mile range. The Winter Garden region near San Antonio and East Texas area would place kenaf production in closer proximity to poultry production.

Figure 3. Miles from poultry production centers in Texas indicating primary centers of demand for poultry litter



Returns to Kenaf Core

For this analysis, the returns to kenaf were calculated on a cubic foot basis and then on a per acre basis.

Cubic Foot: The estimated returns to kenaf core, as a substitute for,wood chips per cu. ft. above the transportation cost is indicated in Table 6. The difference in the price received for kenaf core and the transportation costs provides some insight into a residual to the kenaf supplier to cover grower costs,

TABLE 6. ESTIMATED VALUE OF KENAF CORE PER CUBIC FOOT ABOVE TRANSPORTATION COST. [a]

Distance in Miles	Delivered price of kenaf core per cubic foot			
	20¢	25¢	35¢	45¢
	dollars			
50	0.1196	0.1696	0.2696	0.3696
100	0.0734	0.1234	0.2234	0.3234
200	0.0254	0.0754	0.1754	0.2754
400	-0.1080	-0.0580	0.0420	0.1420
800	-0.4277	-0.3777	-0.2777	-0.1777

a The values represent the difference between the price paid per cubic foot of kenaf core and the transportation costs. This represents revenue that can be used to pay the farmer for production, harvesting and processing. At a cost of $40/ton to the farm operator to produce kenaf, this represents an added 10 cents/cu. ft. cost that would be deleted from each of the values.

processing costs and any storage costs. This does not indicate economic viability of the kenaf industry. To show the effect on delivered prices and distances covered, the results are shown for four alternative delivered prices of kenaf core with each of five sets of distances transported. The values of core above transportation costs were positive in all situations except when transporting to a distance of (1) 800 miles and delivered prices were 20¢ to 45¢ and (2) 400 miles and delivered prices were 20¢ and 25¢. The highest value above the transportation cost was about $0.3696 per cu. ft. when core was transported to 50 miles with a delivered price of 45¢ per cu. ft. The lowest positive value was $0.0254 per cu. ft. and was achieved when transported to 200 miles with a delivered price of 20¢ per cu. ft. (Table 6).

Per Acre: Estimated returns on a per acre basis to kenaf core with alternative assumptions in several of the variables are shown in Table 7. These alternative assumptions include the delivered core prices per cu. ft. of $0.20, $0.25, $0.35, and $0.45, kenaf yields per acre of 5, 10, and 15 tons, core yields of 65, 60, and 55% of stem yields, and miles delivered of 50, 100, 200, 400, and 800. The significance of each is reflected in table 7. Core yields and prices are positively related to per acre core returns. Total returns average $1,441.44 per acre if the core price is $0.45 per cu. ft. and kenaf yield is 15 tons giving a core yield of 9.75 tons per acre when delivered to a distance of 50 miles, compared with returns of $155.48 per acre if the price is $0.20 per cu. ft. and core yield is 3.25 tons (total yield 5 tons) per acre when delivered to the same distance of 50 miles. Returns to core also depend on percentage of core yields. The higher the percentage of core yield, the higher will be the per acre returns for a specific kenaf yield. When the core yield is 65%, for example, returns per acre will be higher in comparison with core yield of 55%, all things remaining constant (Table 7).

Basically the information in Tables 6 and 7 suggest a viable marketing alternative for kenaf core, particularly if the production and processing is near the poultry production. With litter prices above 25¢ per cubic foot and less than 200 miles distance for transportation, the core can represent a significant source

TABLE 7. RETURNS PER ACRE TO KENAF WOODY CORE.[a]

core price/ cu. ft. ($)	Miles delivered	Kenaf yields per acre, tons 5	10	15
		-------------$/acre (65% core yield)-------------		
0.20	50	155.48	310.96	466.44
	100	95.42	190.84	286.26
	200	33.02	66.04	99.06
	400	-140.40	-280.80	-421.20
	800	-556.01	-1,112.02	-1,668.03
0.25	50	220.48	440.96	661.44
	100	160.42	320.84	481.26
	200	98.02	196.04	294.06
	400	-75.40	-150.80	-226.20
	800	-491.01	-982.02	-1,473.03
0.35	50	350.48	700.96	1,051.44
	100	290.42	580.84	871.26
	200	228.02	456.04	684.06
	400	54.60	109.20	163.80
	800	-361.01	-722.02	-1,083.03
0.45	50	480.48	960.96	1,441.44
	100	420.42	840.84	1,261.26
	200	358.02	716.04	1,074.06
	400	184.60	369.20	553.80
	800	-231.01	-462.02	-693.03

[a] Returns are net of transportation cost. Costs of production, harvesting, processing, and storage are not considered. Returns to the bast fiber are not included.

TABLE 7. CONTINUED

core price/ cu. ft. ($)	Miles delivered	Kenaf yields per acre, tons 5	10	15
		------------$/acre (60% core yield)------------		
0.20	50	143.52	287.04	430.56
	100	88.08	176.16	264.24
	200	30.48	60.96	91.44
	400	-129.60	-259.20	-388.80
	800	-513.24	-1,026.48	-1,539.72
0.25	50	203.52	407.04	610.56
	100	148.08	296.16	444.24
	200	90.48	180.96	271.44
	400	-69.60	-139.20	-208.80
	800	-453.24	-906.48	-1,359.72
0.35	50	323.52	647.04	970.56
	100	268.08	536.16	804.24
	200	210.48	420.96	631.44
	400	50.50	100.80	151.20
	800	-333.24	-666.48	-999.72
0.45	50	443.52	887.04	1,330.56
	100	388.08	776.16	1,164.24
	200	330.48	660.96	991.44
	400	170.40	340.80	511.20
	800	-213.24	-426.48	-639.72

[a] Returns are net of transportation cost. Costs of production, harvesting, processing, and storage are not considered. Returns to the bast fiber are not included.

TABLE 7. CONTINUED

core price/ cu. ft. ($)	Miles delivered	Kenaf yields per acre, tons 5	10	15
		------------$/acre (55% core yield)------------		
0.20	50	131.56	263.12	394.68
	100	80.74	161.48	242.22
	200	27.94	55.88	83.82
	400	-118.80	-237.60	-356.40
	800	-470.47	-940.94	-1,411.41
0.25	50	186.56	373.12	559.68
	100	135.74	271.48	407.22
	200	82.94	165.88	248.82
	400	-63.80	-127.60	-191.40
	800	-415.47	-830.94	-1,246.41
0.35	50	296.56	593.12	889.68
	100	245.74	491.48	737.22
	200	192.94	385.88	578.82
	400	46.20	92.40	138.60
	800	-305.47	-610.94	-916.41
0.45	50	406.56	813.12	1,219.68
	100	355.74	711.48	1,067.22
	200	302.94	605.88	908.82
	400	156.20	312.40	468.60
	800	-195.47	-390.94	-586.41

[a]Returns are net of transportation cost. Costs of production, harvesting, processing, and storage are not considered. Returns to the bast fiber are not included.

of returns to complement the bast. The cost of production, harvesting, and processing are not estimated and represent a major cost factor that needs to be identified.

Conclusions

This paper contains an examination of the production, market potential, transportation costs, expected prices, and potential acreage requirements of kenaf core if used for all poultry litter in Texas and the U.S. Kenaf core is basically evaluated as an alternative to wood chips as a source of poultry litter. However, there may be other potential uses of kenaf core such as, bulking agent for composting and bedding material for dairy, that are not considered in this study.

Currently, wood chips are used as a poultry litter. Wood chips vary in price but have trended upward in recent years. As a result, the poultry industry in Texas and other major producing states across the U.S. are looking for alternative litter material. An excellent substitute for wood chips is kenaf core, which is made up of about 55-65% of the kenaf stem. Test plot results indicated that kenaf can be grown very successfully in the southern tier of the U.S., from Virginia to California but also has potential in Northern states. Kenaf has been grown in Southeast and South Texas. For South Texas, total costs of production for irrigated kenaf were estimated to be $204.00 per acre as compared to $163.00 per acre for rainfed kenaf. The farmer price of kenaf was assumed to be $40.00 per ton. If kenaf core is 50% of the yield and there are five pounds per cubic foot, the amount paid to the farmer would be 10 cents per cubic foot. These estimates by Scott and Taylor (1990), although not complete, indicated the farmers will keep more dollars per acre by growing kenaf than they can generally expect to receive from corn, milo, and cotton. In addition, they will usually have much less at risk with the kenaf crop due to its lower input requirements (though not well established), and lesser vulnerability to agriclimate and pest factors (Scott and Taylor, 1990).

The total litter requirement by the U.S. poultry industry were estimated to be about 254 million cubic feet in 1988. Of the requirements, about 13.7% were for Arkansas and 4.4% for Texas. Amount of acreages needed to produce kenaf core to match the demand for poultry litter in the U.S. were found to range from 65,223 to 231,242. For Arkansas and Texas, acreages ranged from 8,917 to 31,615 and 2,884 to 10,224, respectively. Thus, production of kenaf will require an insignificant amount of land and little cropping pattern adjustment. However, it would be necessary to develop markets for kenaf core as a poultry litter and assure the users of a stable long-term supply.

Kenaf core is very light; and as such, a 40,000 ton capacity trailer would carry about 15,000 tons of core material. Total transportation cost per cu. ft. was found to range from $0.0804 for a 50 mile haul to $0.6277 for an 800 mile haul in Texas. The estimated value of kenaf core was found to be negative for a price range of $0.20 to $0.25 when delivered to 400 miles or more. The value of kenaf core considering transportation costs only was also found to be negative for a price range of $0.35 to $0.45 when delivered to a distance of 800 miles.

Results of the study indicate the benefits and economic impact of kenaf core. The return to kenaf core are sensitive to price and transportation distance. Continued pressure for wood chips and periodic shortages suggest a relatively high price for them which enhances the position of kenaf core for poultry litter. Regardless, distance traveled is a critical factor in competitiveness of kenaf core as poultry litter and suggests production in close proximity to poultry.

Since baling or compressing of wood chips is not typically done, we did not consider baling of kenaf in our analysis. However, given the relatively high transportation costs as compared to value and the low density of kenaf, it seems there would be merit in exploring the feasibility of baling or compressing kenaf for long hauls. This would facilitate more efficient transportation. Of course, the cost of baling must be offset by lower transportation costs in order that baling be feasible. In addition, we did not consider hauling of kenaf by trucks where transportation rates are not regulated. Because regulated for-hire truck rates in Texas are relatively high, many firms which would normally purchase for-hire service would elect to integrate into transportation, i.e. purchase their own truck(s). As such, their rates are not regulated and because their costs are below regulated rates they might find it an attractive alternative.

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APPENDIX TABLE 1. BROILERS AND OTHER TYPE CHICKENS SOLD IN TEXAS, 1987.

County	1982 Number	1987 Number
Austin	D	24
Bell	D	405
Bexar	305	D
Bowie	4,103,563	7,710,010
Brazos	1,637	D
Caldwell	1,326,325	1,046,010
Camp	8,936,532	22,952,842
Cass	4,237,030	5,499,805
Franklin	2,063,105	4,271,272
Gaines	-	246
Galveston	153	666
Gonzales	36,540,351	34,477,620
Hopkins	D	1,047,350
Johnson	37	359
Lamar	210,468	135,050
Lavaca	1,238,403	1,140,249
Lubbock	13,585	D
McLennan	D	333
Morris	1,175,800	1,765,800
Nacogdoches	37,861,776	47,182,568
Panola	13,715,666	14,361,967
Red River	1,239,293	2,035,266
Sabine	6,826,250	1,774,444
San Augustine	8,806,804	7,868,409
Shelby	33,337,380	48,949,219
Titus	3,915,180	7,464,679
Upshur	3,183,987	3,457,806
Washington	54	98
Wharton	123	159
Wood	1,905,903	4,913,092
TEXAS	176,390,727	226,038,116

Source: Census of Agriculture

APPENDIX TABLE 2. TURKEYS SOLD IN TEXAS, 1987.

County	1982 Number	1987 Number
Austin	46	43
Bexar	92	120
Blanco	163,825	313,973
Bosque	112,200	D
Brazoria	119	129
Cass	15	-
Chambers	D	17
Colorado	98	D
Comal	50	-
Coryell	D	39
El Paso	D	15
Erath	D	31
Fanin	260	D
Fayette	D	349
Fort Bend	D	88
Gillespie	1,153,811	1,853,230
Gonzales	520,667	3,432,987
Grayson	45	86
Grimes	21	D
Guadalupe	D	34
Harris	67	14
Hopkins	D	48
Hunt	D	44
Johnson	D	32
McLennan	1,112,335	D
Montgomery	279	25
Parker	51	16
San Saba	173,160	299,521
Wharton	D	115
Wilson	94	6,993
TEXAS	4,973,546	10,454,720

Source: Census of Agriculture

APPENDIX TABLE 3. BROILER PRODUCTION IN THE U.S. BY STATES - 1987.

State	1987 [a] Number	1988 [b] Number
Alabama	666,538,000	702,784,000
Arkansas	878,574,000	896,832,000
California	196,120,000	212,199,000
Delaware	209,818,000	217,455,000
Florida	116,980,000	123,198,000
Georgia	733,417,000	772,825,000
Hawaii	2,311,000	2,261,000
Iowa	2,600,000	3,000,000
Kentucky	2,894,000	2,704,000
Maryland	264,196,000	252,400,000
Michigan	675,000	750,000
Minnesota	31,700,000	33,100,000
Mississippi	343,395,000	360,971,000
Missouri	-	54,500,000
Nebraska	1,074,000	1,129,000
New York	2,100,000	2,500,000
North Carolina	477,700,000	500,100,000
Ohio	11,000,000	12,000,000
Oklahoma	90,600,000	120,900,000
Oregon	17,000,000	17,300,000
Pennsylvania	115,635,000	126,900,000
South Carolina	68,051,000	70,832,000
Tennessee	92,500,000	87,000,000
Texas	259,000,000	266,300,000
Virginia	154,036,000	175,748,000
Washington	26,200,000	28,200,000
West Virginia	32,770,000	35,166,000
Wisconsin	13,200,000	13,200,000
Other States	192,850,000	143,451,000
U.S.A.	5,002,934,000	5,235,605,000

[a] Source: Agricultural Statistics, 1988.
[b] Source: Agricultural Statistics, 1989.

APPENDIX TABLE 4. TURKEY PRODUCTION IN THE U.S. - 1987.

State	1987 [a] Number	1988 [b] Number
Arkansas	18,000,000	18,000,000
California	25,500,000	26,500,000
Connecticut	30,000	30,000
Georgia	2,432,000	2,400,000
Illinois	698,000	1,700,000
Indiana	13,000,000	12,900,000
Iowa	8,500,000	7,800,000
Kansas	193,000	227,000
Maryland & Delaware	133,000	135,000
Maine	140,000	150,000
Michigan	3,000	3,000,000
Minnesota	40,500,000	38,500,000
Missouri	15,500,000	16,500,000
Nebraska	1,942,000	1,772,000
New Hampshire	26,000	26,000
New Jersey	115,000	100,000
New York	437,000	343,000
North Carolina	48,350,000	47,900,000
North Dakota	1,200,000	1,200,000
Ohio	3,400,000	3,600,000
Oregon	1,830,000	1,650,000
Pennsylvania	8,000,000	7,900,000
South Carolina	3,950,000	5,570,000
South Dakota	2,367,000	2,370,000
Utah	3,731,000	3,900,000
Virginia	16,200,000	16,300,000
West Virginia	2,400,000	2,300,000
Wisconsin	5,450,000	-
Other States	13,316,000	19,250,000
U.S.A.	240,349,000	242,023,000

[a] Source:Agricultural Statistics, 1988.

[b] Source:Agricultural Statistics, 1989.

APPENDIX TABLE 5. ESTIMATED AMOUNT OF LITTER NEEDED BY THE TEXAS BROILER INDUSTRY.

County	1982 Cu. ft./year	1987 Cu. ft./year
Austin	D	1
Bell	D	13
Bexar	10	D
Bowie	128,236	240,939
Brazos	51	D
Caldwell	41,448	32,688
Camp	279,267	717,276
Cass	132,407	171,869
Franklin	64,472	133,477
Gaines	-	8
Galveston	5	21
Gonzales	1,141,886	1,077,426
Hopkins	D	32,730
Johnson	1	11
Lamar	6,577	4,220
Lavaca	38,700	35,633
Lubbock	425	D
McLennan	D	10
Morris	36,744	55,181
Nacogdoches	1,183,181	1,474,455
Panola	428,615	448,811
Red River	38,728	63,601
Sabine	213,320	55,451
San Augustine	275,213	245,888
Shelby	1,041,793	1,529,663
Titus	122,349	233,271
Upshur	99,500	108,056
Washington	2	3
Wharton	4	5
Wood	59,559	153,534
TEXAS	5,512,210	7,063,691

D = Withheld to avoid disclosing data for individual farms.

APPENDIX TABLE 6. ESTIMATED AMOUNT OF LITTER NEEDED BY THE TEXAS TURKEY INDUSTRY.

County	1982 Cu. ft./year	1987 Cu. ft./year
Austin	17	16
Bexar	35	45
Blanco	61,434	117,740
Bosque	42,075	D
Brazoria	45	48
Cass	6	-
Chambers	D	6
Colorado	37	D
Comal	19	-
Coryell	D	15
El Paso	D	6
Erath	D	12
Fanin	98	D
Fayette	D	131
Fort Bend	D	33
Gillespie	432,679	694,961
Gonzales	195,250	1,287,370
Grayson	17	32
Grimes	8	D
Guadalupe	D	13
Harris	25	5
Hopkins	D	18
Hunt	D	17
Johnson	D	12
McLennan	417,126	D
Montgomery	105	9
Parker	19	6
San Saba	64,935	112,320
Wharton	D	43
Wilson	35	2,622
TEXAS	1,865,080	3,920,520

D = Withheld to avoid disclosing data for individual farms.

APPENDIX TABLE 7. ESTIMATED AMOUNT OF LITTER NEEDED BY THE U.S. BROILER INDUSTRY - 1987.

State	1987 Cu. ft./year	1988 Cu. ft./year
Alabama	20,829,313	21,962,000
Arkansas	27,455,438	28,026,000
California	6,128,750	6,631,219
Delaware	6,556,813	6,795,469
Florida	3,655,625	3,849,938
Georgia	22,919,281	24,150,781
Hawaii	72,219	70,656
Iowa	81,250	93,750
Kentucky	90,438	84,500
Maryland	8,256,125	7,887,500
Michigan	21,094	23,438
Minnesota	990,625	1,034,375
Mississippi	10,731,094	11,280,344
Missouri		1,703,125
Nebraska	33,563	35,281
New York	65,625	78,125
North Carolina	14,928,125	15,628,125
Ohio	343,750	375,000
Oklahoma	2,831,250	3,778,125
Oregon	531,250	540,625
Pennsylvania	3,613,594	3,965,625
South Carolina	2,126,594	2,213,500
Tennessee	2,890,625	2,718,750
Texas	8,093,750	8,321,875
Virginia	4,813,625	5,492,125
Washington	818,750	881,250
West Virginia	1,024,063	1,098,938
Wisconsin	412,500	409,375
Other States	6,026,563	4,482,844
U.S.A.	156,341,688	163,612,656

APPENDIX TABLE 8. ESTIMATED AMOUNT OF LITTER NEEDED BY THE U.S. TURKEY INDUSTRY - 1987.

State	1987 Cu. ft./year	1988 Cu. ft./year
Arkansas	6,750,000	6,750,000
California	9,562,500	9,937,500
Connecticut	11,250	11,250
Georgia	912,000	900,000
Illinois	261,750	637,500
Indiana	4,875,000	4,837,500
Iowa	3,187,500	2,925,000
Kansas	72,375	85,125
Maryland & Delaware	49,875	50,625
Maine	52,500	50,625
Michigan	1,125	1,125,000
Minnesota	15,187,500	14,437,500
Missouri	5,812,500	6,187,500
Nebraska	728,250	664,500
New Hampshire	9,750	9,750
New Jersey	43,125	37,500
New York	163,875	128,625
North Carolina	18,131,250	17,962,500
North Dakota	450,000	450,000
Ohio	1,275,00	1,350,000
Oregon	686,250	618,750
Pennsylvania	3,000,000	2,962,500
South Carolina	1,481,250	2,088,750
South Dakota	887,625	888,750
Utah	1,399,125	1,462,500
Virginia	6,075,000	6,112,500
West Virginia	900,000	862,500
Wisconsin	2,043,750	
Other States	4,993,500	7,218,750
U.S.A.	90,130,875	90,758,625

POTENTIAL PRODUCTS FROM KENAF: ISSUES AND OPPORTUNITIES

In the process of evaluating the economic feasibility of kenaf as source of poultry litter, several other potential uses of kenaf became evident. Because the major focus of the study was related to using kenaf core for poultry litter, some of these other uses are only identified with some of the major issues and potential opportunities discussed. This paper is basically an addendum to the report on kenaf for poultry litter. Credit for most of the concepts and uses as well as some of the characteristics of kenaf belong to Mr. Bob Bledsoe. Regarding use of kenaf in the composting of manure, Dr. John Sweeten provided insight based on research he is doing through Texas A&M.

Forage

Kenaf can serve as a substitute for alfalfa in providing forage for livestock. It is estimated that the total kenaf stalk is about 16% protein, compared to 22% for alfalfa. Also, kenaf stalks provide a filler which the cattle need. Kenaf would likely be cut twice a year when the stalk reached about 5-6 feet. Estimated yield ranges from 6 to 10 tons of wet material per acre per year. The bulk material could be fed directly or pelletized. Some issues to be addressed are as follows:

1. Cost to grind and pelletize if this option were selected;
2. Feeding trials comparing kenaf to alfalfa are needed;
3. Quantification of cost to produce and harvest kenaf (per acre and per ton);
4. Cost of hauling from the field to feedlot or pelletizing plant (bulk kenaf weights about 11 pounds per cubic foot);
5. Bottom line cost comparison of kenaf to alfalfa as a forage.

Composting

Animal waste disposal has become a major issue for feedlots, dairies and other confined livestock and poultry operations. Kenaf core provides an excellent material to serve as filler for composting of manure. There are national initiatives related to composting animal wastes. When animal manure is 60% moisture, it weighs about 60 lb/cu.ft. Kenaf core weighs only 8 lb/cu.ft. The amount of kenaf core required in the composting process depends upon moisture content of the animal manure. For manure that is 60% moisture, it takes .5 to 1 ratio of kenaf to manure on a volume basis. This is compared to a 1 to 1 ratio for manure that is 80% moisture. Fortunately, between 50 and 65% of the kenaf core can be recycled which improves the economic implications significantly. As with using kenaf for forage, there are several issues that relate to using kenaf core for composting animal and poultry manure. Typically, filler material used in a composting operation is of very low value which means the kenaf core is competing with a very low value alternative. Some issues relating to using kenaf core for composting are as follows:

1. Cost of grinding and screening the kenaf core;
2. Transportation costs of kenaf core (it is obvious from the poultry litter study that the kenaf core would have to be grown in close proximity to the composting operation);
3. Alternatives to kenaf core in the region such as peanut hulls, pecan hulls, peanut vines, cotton gin trash, municipal waste sources, etc.;
4. Opportunities to apply the manure to agricultural fields in the region without composting;
5. Current cost of manure disposal;
6. Marketing potential for the composted material.

Other Uses

There is a host of other potential uses of kenaf of which only a few are included here. Of course, a major consideration is the use of kenaf as a feedstock for paper. As we look into the future, some possibilities might include:

1. Blend with coal in electrical generating plants to reduce sulphur emissions (What is btu content of kenaf and what is the effect on emissions as well as cost-low value use?);
2. Serve as sludge collection in city waste water management, sell product for fertilizer (What is effectiveness, market potential for this product, and alternative products to kenaf?);
3. Produce charcoal (What is cost, market potential, and alternative feedstock for charcoal- is kenaf competitive?);

4. Produce a variety of lumber products as boards, particle board, etc. that are fire resistant, water resistant and rot resistant (What is strength of the material, cost to manufacture, and cost of alternative products?);
5. Produce insulation, headliners and other similar materials (What is cost to produce and characteristics relative to alternatives?).

These suggestions serve to illustrate that there are numerous products that could be produced with kenaf. No effort was expended to develop economic implications for any of these uses. However, in all cases there are several viable alternatives and the market for kenaf can be expected to be highly competitive. Economic implications are significantly affected by the cost to produce and harvest kenaf. This cost can be affected by federal farm programs and alternative crops available to producers. Production of kenaf must return a farmer at least as much as the current crop or there is no incentive to adjust cropping patterns. Further, there is much uncertainty regarding production of a "new" crop in an area where producers do not have many years of experience with optimal planting, fertilization, weed control, insect pest control, and disease control. Equally important is cost to process the kenaf into the desired product. Again there are viable alternatives available and kenaf must match or exceed quality as well as be cost competitive.

Based on the analysis, the short run market potential for kenaf is expected to be a feedstock for paper products and, where kenaf production is near, a source of poultry litter. Only in rare cases is kenaf expected to be competitive when used for composting animal manure. These cases are where there is an environmental problem, agricultural land is not in close proximity for land application of the manure, and no inexpensive filler is available locally to use in the composting process. As a substitute for alfalfa, the issue relates to the cost to provide kenaf as compared to the cost to provide alfalfa where feeding value are the same. This will require some feeding trials and basic budgeting analysis.