

S441
.S8557

SARE Project AS92-1

Market Structure For Poultry Litter in Arkansas



A Report to Winrock International In Fulfillment of Subagreement No. 238-340-93-01-00

By

Wayne P. Miller
Extension Economist

Carmen Tharp
Extension Associate

University of Arkansas
Cooperative Extension Service

June 1994

MARKET STRUCTURE FOR POULTRY LITTER IN ARKANSAS

This report is a summary of our findings related to the market structure for poultry litter in Arkansas. Information about the supply, movement and use of poultry litter was obtained from poultry growers, cleanout contractors, middlemen, dealers, and users of poultry litter. In this report we present an overview of poultry litter marketing arrangements in Arkansas and identify issues affecting the movement of litter to its highest value end use.

Overview

New markets are developing for poultry litter which provide additional marketing options for poultry producers and cleanout contractors. In the past nearly all poultry litter was used to fertilize forages. Currently poultry litter is used as a soil amendment for row crops on precision graded soils, valuable feedstuff for cattle, soil amendment for mine and landfill reclamation, and as an organic product in nurseries in addition to being used to fertilize forages. Some suggest that has considerable potential as an energy or heat source since the heating value of poultry litter is 3,000 to 4,000 Btu/lb.

The demand for poultry litter for some of these new uses is growing rapidly, although the demand is sometimes far from poultry growing areas. For example, the demand for poultry litter by farmers applying it to precision leveled soils is primarily in eastern Arkansas, whereas, more poultry litter is produced in the western part of the state. There is a growing demand for poultry litter in Arkansas and in the north and west regions of the United States as a soil amendment for mine reclamation which is sometimes far from concentrated poultry growing areas. These new markets, which require large quantities on short notice and transporting long distances, provide

opportunities for middlemen to purchase, transport, and apply litter on a timely basis. Currently there are cleanout contractors and other middlemen performing some or all of these functions.

Poultry litter prices vary widely depending on the type of litter purchased, from whom purchased and who spreads it. The range of litter prices, litter content variability, and different services provided by the seiler make it difficult to identify the best value and evaluate whether the use of poultry litter for a particular purpose is economically feasible. As more middlemen enter the market and as end users obtain more information on price and quality differences, the prices will begin to stabilize.

In evaluating the market structure for poultry litter we used information which was obtained from surveys and interviews with poultry growers, cleanout contractors, middlemen who move poultry litter, dealers, and users of poultry litter. This report summarizes our findings from these studies and presents information on poultry litter supply, uses, and market structure.

POULTRY LITTER SUPPLY

It is estimated that there is approximately one million metric tons of poultry litter produced from broilers in Arkansas.¹ This is a valuable resource that has many uses. The findings of our survey of poultry growers² indicate that about 30 percent of growers clean out their own poultry houses and most of the litter is applied to their pasture and hay land. However, approximately 60 percent of poultry houses are cleaned by cleanout contractors and a significant amount (50%) of litter is taken off the farm and used for a variety of purposes.

In 1992 there were over one billion broilers produced in Arkansas. This was an increase of 335,488 broilers produced per year in Arkansas between 1982 and 1992.³ Broiler production, and therefore poultry litter, is concentrated in the Northwest.

FIGURE 1:

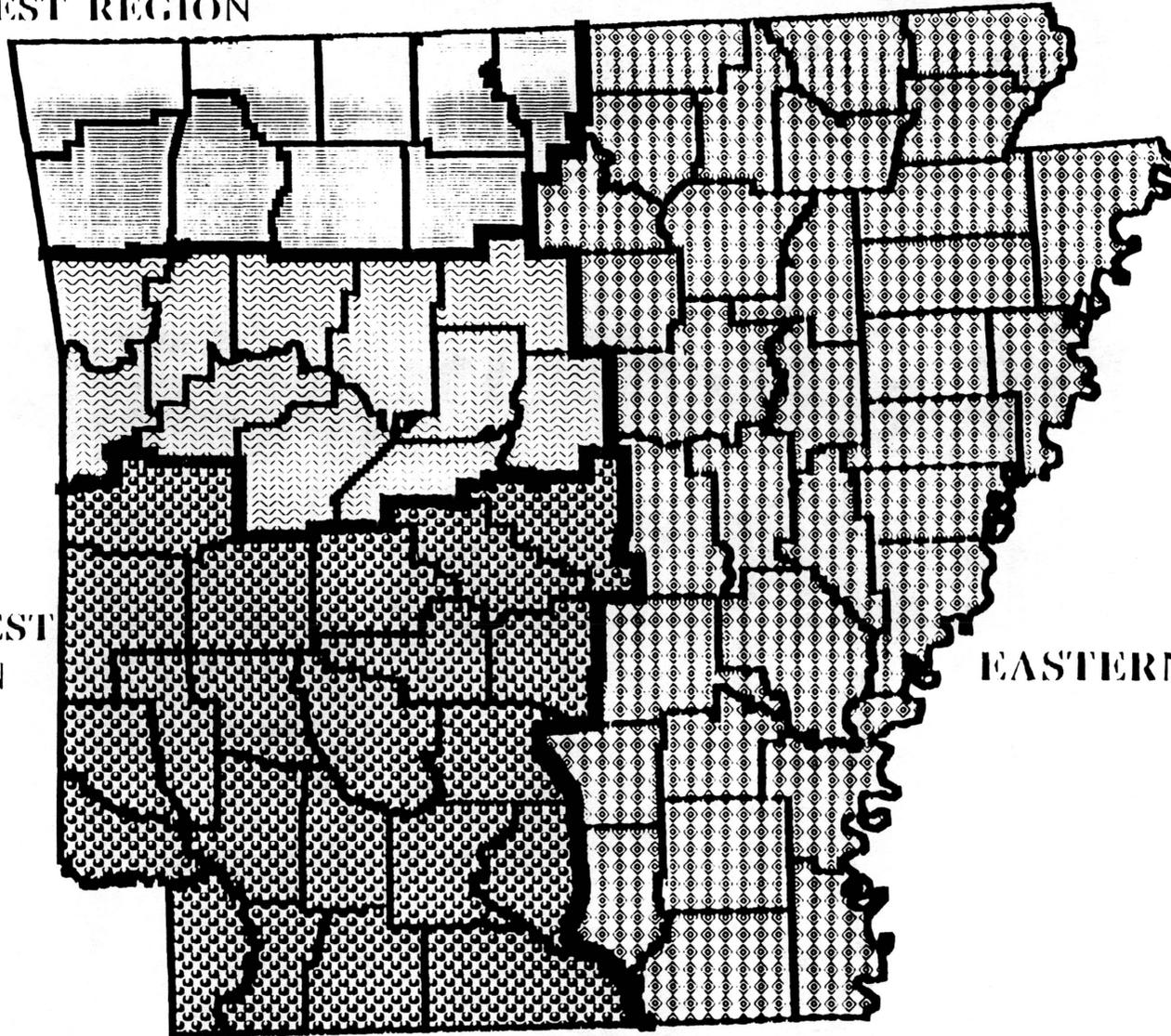
POULTRY REGIONS IN ARKANSAS

NORTHWEST REGION

RIVER
VALLEY
REGION

SOUTHWEST
REGION

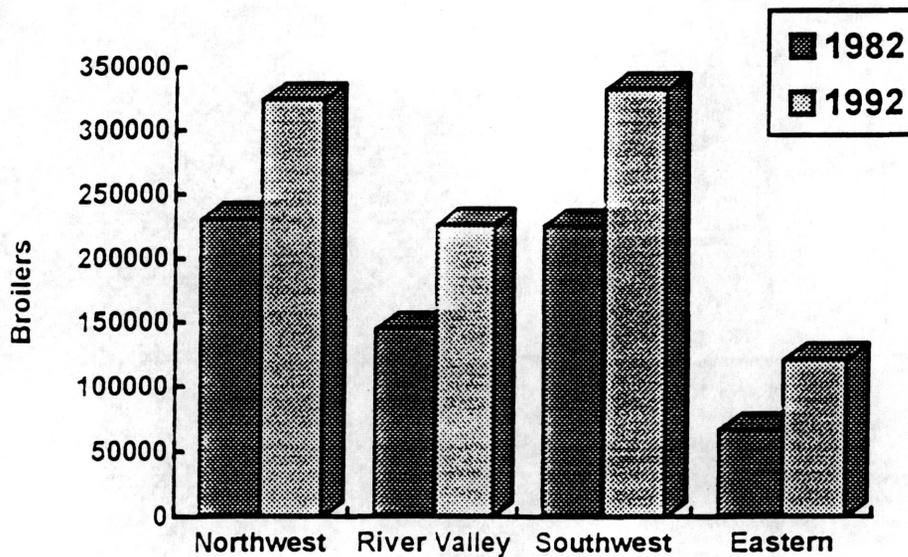
EASTERN REGION



Southwest and Arkansas River Valley regions of Arkansas (figure 1). In 1992, approximately two-thirds of all broilers produced in Arkansas were grown in the Northwest and Southwest regions combined. The River Valley region produced almost one-fourth of the broilers and the Eastern region produced the remaining 12 percent.

While the number of broilers produced has increased in all regions of the state from 1982 to 1992 (figure 2), the greatest percentage increase occurred in the eastern region with an 81 percent increase in the number of broilers produced. Comparatively, during this ten year period broiler production increased only 40 percent in the northwest region and 47 percent in the southwest region. Broiler production increased by 56 percent in the river valley region during this period. The growth in the relative importance of broiler production in the eastern region is depicted by the increase, from 10 percent to 12 percent, of total broiler production in Arkansas.

Figure 2: Growth in Broiler Production in Arkansas By Region, 1982 to 1992



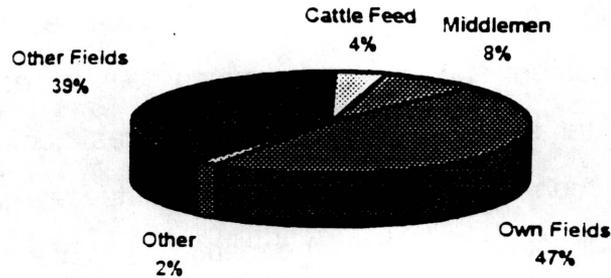
POULTRY LITTER USES

Most of the poultry litter in Arkansas is applied to pasture or forage land near where it is produced. However, there are other uses of poultry litter and some of the markets are growing. Other uses include using poultry litter for cattle feed, applying litter to leveled soils as a soil amendment and applying to mined soils to reclaim these soils. The growing demand for litter as a soil amendment provides additional markets for poultry litter. Because the high concentrations of poultry litter are far from locations where the demand is the highest and because the market structure for buying, selling, transporting and applying litter is not well developed, there are widely varying prices and services offered among regions.

Most growers apply some of their poultry litter to their own fields (86%) and over one-half report that some of their litter is spread on other nearby fields (56%). Some use litter for cattle feed (19%), sell to row crop farmers (2%), sell to middlemen/haulers (12%), and sell for cattle feed (4%). About 25 percent of the growers have experience in using or selling litter for purposes other than application on land planted to forages.

Although most of the poultry litter is still applied to forages, a significant portion of the litter is used for other purposes. Growers indicated that 47 percent of the litter from their poultry houses was spread on their own fields and 39 percent was spread on other area fields (figure 3). Eight percent was sold to middlemen/haulers, 3 percent was used as feed on the grower's farm, 1 percent was sold directly to row crop farmers, 1 percent was sold as a cattle feed, and 1 percent was used for other purposes such as given to friends, neighbors, or used in composters. Therefore, approximately 50 percent of the poultry litter is used off the grower's farm and enters the growing poultry litter market.

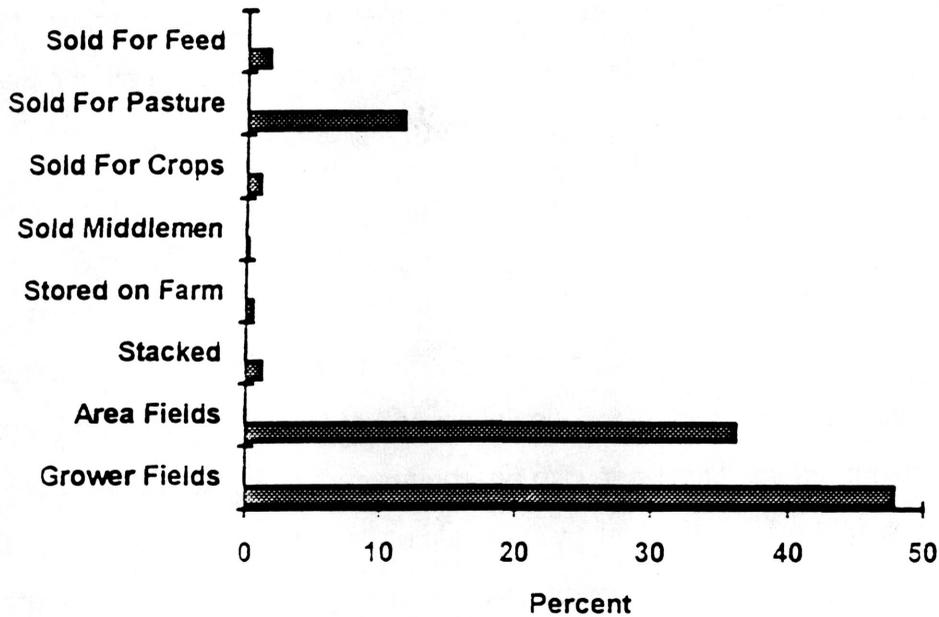
Figure 3: Poultry Litter Use By Growers



Source: **Poultry Litter Practices of Arkansas Poultry Producers**, University of Arkansas Staff Paper SP0494.

Uses of litter by cleanout contractors surveyed⁴ closely matched those found in the study of growers (figure 4). Cleanout contractors in the study applied about half of litter on the grower's own fields and about one-third of litter on other area fields. Over 14 percent of the litter removed by cleanout contractors was sold to farmers and middlemen. Most of the litter sold was used as a fertilizer on pasture, although some was sold for cattle feed, as a soil amendment on leveled soils, and directly to middlemen. Two percent of litter removed by contractors was either piled on grower's land or stored for future use. Although most of the litter removed from poultry houses is spread on the growers' or nearby pasture land, a significant quantity of litter is sold for other uses.

Figure 4: Poultry Litter Use By Cleanout Contractors



In a survey of growers in the Millwood watershed of Southwest Arkansas⁵, poultry growers indicated poultry litter use practices similar to those found in the Southwest region of the poultry growers survey. In the Millwood watershed, almost all (91%) poultry producers responding spread most of their litter on their pasture or hay land. About one-third sell litter as fertilizer. 12 percent give litter away, 10 percent use litter as a cattle feed and one farmer applies litter to cropland. Poultry producers in the Millwood watershed survey reported applying 73 percent of their litter on their own fields. Nineteen percent of their litter was sold as fertilizer and small portions were given away or used to feed their cattle. These findings are also similar to those found in the growers survey for the Southwest region.

Although most poultry growers apply most of their litter to their own or nearby pasture and forage land, there are a significant number of growers who use litter for other purposes. In response to our grower survey we found there to be regional differences on what poultry producers do with their litter, particularly between the eastern and western halves of the state. For example, in the eastern half of the state 70 percent of litter is used off the grower's farm with 9 percent sold directly to row crop farmers and

28 percent sold to middlemen/haulers. Growers in the Northwest and River Valley regions used litter for on and off farm purposes about equally. In the Southwest region, however, 79 percent of the litter stayed on the growers' farms. The greatest differences in litter use exist between the Southwest and Eastern regions.

POULTRY LITTER DEMAND

Historically, there has been a demand for poultry litter as a fertilizer for pasture and hay land on poultry growers' own fields. However, half of the litter moves off the poultry growers' farms. Some of this litter is sold to nearby farmers who use it on forages or as cattle feed. Some of their poultry litter is sold to cleanout contractors and middlemen who move the litter to other markets, one of which is row crop farmers who use litter as a soil amendment.

From a study of row crop farmers, dealers and middlemen in eastern Arkansas it was found that the demand for poultry litter as a soil amendment on leveled soils is growing rapidly. A survey of rice growers ⁶ found that nearly three out of four respondents are future buyers of poultry litter with an additional nine percent being potential buyers. According to follow-up telephone calls, row crop farmers are very pleased with poultry litter as a soil amendment. They are concerned about fluctuating prices and the availability of raw litter when needed. Many have not purchased raw litter because they did not know whom to contact. Many cleanout contractors and middlemen indicate that they could sell more poultry litter to row crop farmers if it was available. Most compost litter dealers surveyed think sales will increase.

STRUCTURE OF POULTRY LITTER INDUSTRY

Buyers & Sellers

There are many cleanout contractors in Arkansas that purchase and market at least some of the litter they remove from poultry houses. In the past most of the litter they take ownership of and market is sold within a 15 to 50 mile radius of the poultry growers farm. However, as new markets develop some of these contractors are playing a crucial role in moving litter to other markets, including mine and landfill reclamation and as a soil amendment for row crop farmers. Often these markets are far from the where the poultry litter is produced and involve cleanout contractors and/or other middlemen in making the arrangements and moving the litter from seller to buyer.

Poultry litter brokers facilitate the movement of litter from a seller to a buyer. Litter is purchased by brokers from poultry growers, poultry house cleanout contractors, or manufacturers, and sold to row crop farmers, cattlemen, nurseries and others. There are presently 19 known brokers/middlemen of raw litter, and 6 known brokers of composted or pelleted litter.

There are a variety of people working as poultry litter brokers/middlemen. Some are cleanout contractors who take ownership of a portion or all of the litter they remove. Others are row crop farmers in the Eastern region who use litter on their own farms and started buying and selling litter for other farmers. Some are truckers who also haul other products such as gravel and bedding.

Litter from Batesville and the surrounding area is often purchased by brokers who come to the grower's farm, load and haul away the litter. From this area, poultry litter typically moves east to southeast where it is almost exclusively sold as an amendment for row crop soils. The demand for litter from this area has drastically increased in the

past few years with the widespread practice of precision grading soils in eastern Arkansas.

Although Batesville and the surrounding area seems to be the center of the raw poultry litter market, other parts of the state are also involved in the movement of litter. Another large concentration of marketed litter is in the River Valley region. Brokers from this area typically clean out, load, transport, and sell to various buyers throughout Arkansas including many row crop and cattle farmers.

Middlemen in the Southwest region sell litter for mine reclamation, in water treatment systems of the mining industry and most often for pasture. Raw litter from this concentrated area may soon begin to move eastward to row crops due to a large amount of litter available for moving from the grower at a low price. Growers from this area hire cleanout contractors to clean out and spread the litter on pasture. Personal interviews with middlemen in the southwest indicate that many growers view litter as a problem and a waste. Raw litter from southern counties is marketed by cleanout contractors to nearby cattlemen with some going to row crop farmers in the delta. The litter is typically "purchased" by contractors for the cleanout service.

Brokers from the northeast move anywhere from 500 to 10,000 tons of raw litter per year per broker from the producer to consumer. Poultry litter brokers moving litter from the River Valley area move approximately 7,000 tons per year per broker. In the Southwest region, litter is often marketed in the local area. For example, one cleanout business in this area moves (locally) approximately 13,200 tons of raw litter off of the producers farms per year out of 33,000 tons cleaned out. One business marketing in a large radius of southwest Arkansas moves approximately 25,000 yards per year. A broker in southern Arkansas moves 500 tons of litter per year.

Respondents to the survey of cleanout contractors removed between 760 to 92,950 tons of litter each in 1992 with an median of 9,617 tons. Although there were few

respondents, findings suggest that there are regional differences in the marketing of litter by cleanout contractors. Respondents from the Northwest region sold 9 percent of the litter they removed for cattle feed and nearly 1/4 for use on pasture. Cleanout contractors from the Eastern region sold over 1/3 of the litter they removed for a variety of uses. This area had the largest number of markets for litter with 14 percent sold to row crop farmers, 14 percent sold for pasture, 4 percent sold to dealers or middlemen, and 4 percent sold for cattle feed.

Functions of Buyers & Sellers

The middlemen have many different ownership and transportation arrangements and provide a variety of services. Those who are cleanout contractors remove litter from poultry houses and may also store, load, transport, and spread litter. Others do not have means of transporting large quantities of litter and only clean out, spread locally and sell litter to others to be transported long distances. Often, brokers buy from cleanout contractors or growers who have already cleaned out the litter. These brokers then will typically load, transport, and spread the litter. Some brokers only transport litter and pile it on the buyer's land for others to spread. The range of operation of brokers varies from "only locally" to "anywhere in Arkansas." Most brokers have a range of operation of about 100 miles. Some brokers selling to row crop farmers in eastern Arkansas must have longer ranges of operation.

POULTRY LITTER PRICES

Poultry litter prices vary greatly among and within regions and by type of litter. This is not unusual in situations where markets are newly developing, where information is scarce, and where the market is thin (few transactions). In a study of row crop farmers in Arkansas, the prices paid for raw poultry litter varied from \$0 to \$80 per ton. They paid from \$85 to \$900 per ton for composted and pelleted poultry litter.

Raw poultry litter has varying prices at different stages in the marketing channel. The first stage in which litter is handled is when the litter is removed from the poultry house by the grower himself, or a hired cleanout contractor. Litter cleaned out by growers in the Eastern region ranges from \$8 to \$12 per ton. Litter removed and purchased by cleanout contractors in the River Valley region is purchased from the grower at a price ranging from \$3 to \$6 per ton. Growers in the Southwest region receive approximately 3 dollars per ton of litter in addition to the cleanout service. However, there are many instances in the southwest region when poultry litter is purchased from growers for the cleanout service itself.

Some cleanout contractors take ownership of a portion of the litter they remove from poultry houses. Since many cleanout contractors cannot haul the litter long distances, it is sold either locally for various uses or to a broker who will transport it to eastern Arkansas. Prices for this stage in the marketing channel range from \$5 to \$12 per ton in different regions of the state.

Composted pelleted litter from northwest Arkansas is transported to eastern Arkansas and sold in farm supply stores to row crop farmers. Truckers do not take ownership of the composted litter when they transport it from source to buyer as is often the case with raw litter. Composted pelleted litter from northwest Arkansas costs approximately \$100 per ton at the manufacturer.

Composted poultry litter is purchased from dealers in eastern Arkansas either in bulk or in bags. Several dealers indicated that bulk prices ranged from \$135 to \$180 per ton. Prices for 50 pound bags ranged from \$150 to \$200 per ton. Dealers reported prices of large bags, sometimes referred to as bulk bags or super bags, to be from \$150 to \$225 per ton. Some of these prices include transportation and application costs while others do not. Some dealers custom spread pelleted litter with airflow truck and charge a spreading fee in addition to the standard price per ton.

Transportation Costs

It is difficult to ascertain the transportation costs of moving litter from the poultry farms to the end user because the transportation costs are often not reported separately, but included in the final price paid by the user. However, we were told that it costs \$20 per ton to transport composted pelleted poultry litter from northwest to eastern Arkansas.

Other businesses reported transportation costs for raw poultry litter ranging from \$1.25 to \$2.00 per loaded mile. Since most businesses reported transportation costs closer to \$2.00 per loaded mile, we use this figure in estimating transportation cost of litter per ton.

Therefore, the cost of transporting poultry litter 200 miles on a truck with a capacity of 20 tons is \$20 per ton. Transportation costs vary depending on the distance traveled, size of load, and whether a backhaul can be arranged.

Transaction Costs

Transaction costs of getting litter from poultry farms to end users are high. These costs are usually hidden and consist of the time and expense of finding buyers, poultry litter, making transportation arrangements, and negotiating services to be provided by everyone involved in getting poultry litter to the end user. There are several reasons why these transaction costs are high. First, there are few established channels to obtain information about litter availability, buyers, product quality, services provided, and prices. Also, there are few standards used to market poultry litter. This makes it difficult and time consuming to compare prices with the type and quality of product being marketed and to compare the services being provided by different middlemen.

MARKETING BARRIERS

There is considerable potential for reducing transaction costs and increasing the marketing efficiency of getting poultry litter from poultry producers to row crop farmers wanting to use litter as a soil amendment. Some of the barriers include, lack of

information, storage facilities, transportation difficulties, no uniform product or standards by which to evaluate litter, different services provided, and different methods of pricing litter and services. We will address each of these issues separately.

Information

One reason Winrock International established this project, and the poultry litter marketing hotline in particular, was to facilitate the flow of information between buyers and sellers of poultry litter. The hotline has been successful in helping buyers and sellers contact each and facilitating the exchange of litter as well as educating extension agents and farmers about the potential of using poultry litter as a soil amendment. However, additional channels for information flow are still needed, not only to facilitate the exchange of litter, but to provide information on the differences in prices among and within regions on the different types of litter.

Product Uniformity

Currently there is no product uniformity or standards by which to evaluate and compare poultry litter from different sources and regions. Litter from different regions and poultry types are different in the time spent in the poultry house which affects the quality of litter. The more often litter is removed the higher the percent of bedding material in the litter. According to middlemen, many growers from the northcentral to northeast poultry growing areas (Eastern region) regularly remove litter from their houses every 6 to 8 weeks, after each batch of broilers. Middlemen indicated that turkey and broiler growers in the River Valley region clean their poultry houses one or two times per year and growers in the Southwest region typically only clean their poultry houses once per year. These different litter removal practices suggest that litter from the Eastern region contains a larger percentage of bedding material than litter from the other regions.

The moisture content of the raw litter also varies considerably resulting in variable litter quality. Litter moved directly from the poultry house to the field will have a higher moisture content than litter stacked for days or weeks before land application.

The nutrient content of litter may vary depending on the type of poultry, time in the poultry house, and even the area of the house in which it was taken. Standardization is needed so that buyers will be able to accurately compare quality and prices.

In addition to the differences in the type and quality of raw litter available, the litter is available in different forms. In addition to raw litter, farmers may purchase litter which has been composted, pelleted, or composted and pelleted. Little information is available to compare the yield response among the various forms of poultry litter.

Storage

To have poultry litter available when needed by row crop farmers, more storage facilities are needed. Row crop farmers need most of their poultry litter in the spring during a short time period before planting. Some also apply litter in the fall after harvesting. Since poultry houses are cleaned between batches as recommended by the integrator or as needed to insure healthy birds, the litter is not always available when needed by row crop farmers.

Many middlemen have expressed an interest in storage sites in eastern Arkansas to make litter available to farmers when they need it and to reduce transportation costs. Storage close to poultry production is also needed so that brokers can buy litter year round and increase their supply for the spring and fall peaks.

Transportation

Transporting litter from the producer to the user is one of the largest barriers in marketing poultry litter to row crop farmers. Row crop farmers usually have a short time period when they want litter applied to their soils. In the absence of storage facilities near to where the litter is to be applied, much litter has to be transported from the source to the destination in a very short time. Middlemen have informed us that it is not easy to obtain trucks to transport large amounts of litter on short notice.

Transportation arrangements are typically made by the broker rather than the supplier or the buyer. Large amounts of litter are typically hauled in 30-40 foot aluminum trailers. Most middlemen own one or more trucks and hire out others during the busiest season. Brokers may also hire workers to load, haul, transport and spread litter.

Much of the poultry litter used by row crop farmers in eastern Arkansas comes from northcentral and northeast Arkansas which is closer to major rice producing areas than other poultry regions of the state.

Pricing Schemes

During our interviews with poultry growers, poultry litter middlemen, dealers and row crop farmers we learned that there are differences in the way users are charged for poultry litter and related services. Some sell poultry litter by volume and some sell by weight. Volume measures include price per cubic yard and price per truck load. A cubic yard is a standard measure which does not vary among suppliers and is not affected by varying moisture content of litter. The volume of litter in a truck load will vary depending on the size of the truck which makes it difficult for a buyer to compare costs among suppliers. The amount of litter received when purchased by weight, usually per ton, will vary considerably depending on the moisture content.

Some middlemen prefer to only sell raw litter by volume per truck load or yardage, rather than sell by weight. However, many middlemen prefer to sell litter by the ton. There needs to be a standard measure by which litter is sold to enable the buyer to compare prices per unit of litter among different suppliers.

Land Application

Typically, row crop farmers do not own litter spreading equipment. Middlemen often apply poultry litter for the row crop farmers which involves transporting a loader and spreader truck long distances. Furthermore, litter spreading equipment was designed for pasture use, not for row crops. Some delta farmers have purchased litter spreaders and adapted them for better use in fields. If more spreading equipment were available in eastern Arkansas it would lower transportation costs for brokers and farmers could have litter applied to their fields when they need it.

POULTRY LITTER HOTLINE

A poultry litter hotline was established by Winrock International as a mechanism to provide more information to buyers and sellers and to provide buyers and sellers with a means of contacting each other.

The hotline which began in January 1993 was operated by Thone Brothers who took telephone calls and obtained essential information from buyers and sellers on the quantity of litter, location, etc. This information was entered onto a computer database which was uploaded onto the Cooperative Extension Service electronic bulletin board which made the information available to farmers in all 75 counties of Arkansas. The information on the database was also faxed to several poultry litter middlemen. Information was updated, faxed and uploaded onto the bulletin board weekly.

Hotline Use

As of December 29, 1993, there were 42 buyer listings and 38 seller listings on the hotline.³ Nearly half of buyers were from eastern Arkansas, while only 2 buyers were from the northwest. Almost half of seller listings were from the River Valley with an additional 28 percent from northwest Arkansas.

Most buyers called the hotline in January and February needing litter for the spring. Most wanted to purchase small quantities of litter, between 5 and 200 tons. Only one-third of buyers could transport litter, and one half could apply the litter to their land themselves. Sellers indicated having litter available year-round, with an average of 430 tons or 4 houses of litter per responding seller available. Half of sellers indicated they could deliver litter, however, half of these would only deliver locally not over 10 miles. Sellers in eastern Arkansas often could not deliver over 50 miles to the buyer. Over one-third of sellers could spread litter, but it is not known how far they would travel to spread. Findings suggest a need for middlemen to be involved in the transportation of litter, and possibly in litter application.

Bulletin Board Use

County Extension Agents were given lists of cleanout contractors to make available to interested farmers and were asked to download the hotline information off the electronic bulletin board and provide these lists of buyers and sellers to interested parties. They were also asked to provide information to help farmers use the hotline.

Thirty-five counties are known to have had some hotline activity, that is they either had requests for lists of buyers and sellers or they retrieved the lists from the electronic bulletin board. More people used information from the hotline than actually called the hotline. A total of 64 lists were requested, mostly in the fall. About half of requests for buyers and sellers lists were from counties in the River Valley region, and another one-

third were made in counties in eastern Arkansas. In addition, 19 counties reported a total of 37 requests for information about the Poultry Litter Marketing Hotline. Over half of these were from counties in eastern Arkansas and almost one-third were from counties in the River Valley. County agents reported over a thousand more people were known to become aware of the potential for buying and selling litter as a result of their activity concerning the Poultry Litter Marketing Hotline. Several people were known to have purchased or sold litter as a result of the hotline.

SUMMARY

As the amount of poultry litter in Arkansas grows and as new markets for poultry litter are developing there is a need for more information by buyers and sellers to move litter to its highest end use. Currently buyers pay widely varying prices for litter, have no way of comparing the different forms and quality of litter available, and receive vastly differing services from the seller. On the other hand, many poultry producers are unaware of the new developing markets for poultry litter. Winrock International is playing a key role by operating a hotline to enable buyers and sellers to more easily contact each other. Additional information is still needed on the response of crops to poultry fertilizer and ways to evaluate and compare the quality of litter in different forms and from different sources to enable the industry to become more efficient in moving litter to its highest end use.

Endnotes

¹ **Arkansas Water Resources Research Center Annual Report 1990-1991**. University of Arkansas, Fayetteville.

² **Poultry Litter Practices of Arkansas Poultry Producers**, Department of Agricultural Economics and Rural Sociology Staff Paper SP094. University of Arkansas, Fayetteville, May 1994.

³ **1982 and 1992 Arkansas Agricultural Statistics**. Arkansas Agricultural Experiment Station, University of Arkansas.

⁴ The findings of the cleanout contractor survey are presented in **Poultry Litter Cleanout Contractor Practices** by Carmen Tharp and Wayne P. Miller, Department of Agricultural Economics and Rural Sociology Staff Paper No. SP0394. May 1994.

⁵ The findings of this study are presented in a report titled **Poultry Growers Perceptions and Knowledge of Animal Waste Practices in the Millwood Watershed** by Wayne P. Miller and Carmen Tharp, Cooperative Extension Service. University of Arkansas. November 1993.

⁶ The results of this study are presented in **Poultry Litter Purchases and Use By Rice Growers**, by Carmen Tharp and Wayne P. Miller, University of Arkansas, Department of Agricultural Economics and Rural Sociology Staff Paper No. SP1493. September 1993.

⁷ **Poultry Litter Purchases and Use By Rice Growers**. University of Arkansas, Department of Agricultural Economics and Rural Sociology Staff Paper SP1493, September 1993.

⁸ **Poultry Litter Marketing Hotline: Use in Arkansas, 1993**. University of Arkansas. Department of Agricultural Economics and Rural Sociology Staff Paper SP0294, May 1994.