Poultry Litter for Corn Exchange Program for Virginia

Beth Ann Pelletier
David Kenyon

Agricultural Competitiveness

The authors are Research Associate and Professor, respectively, Department of Agricultural and Applied Economics, Virginia Tech.

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EXECUTIVE SUMMARY

House Bill 1207 requires nutrient management plans for poultry farms written after October 1, 2001, to be based on phosphorus utilization. The economic feasibility of a poultry litter for corn exchange program is one potential way of solving the excess litter problem for farmers in the Shenandoah Valley.

Litter is used on corn acres to reduce fertilizer costs, and corn is backhauled to the Shenandoah Valley to improve corn producer prices. The exchange involves regular shipments of litter to receiving stations in corn production regions. The litter is stored and then custom applied on corn acres. Corn is dried and stored on the farm. After each 25-ton load of litter is received, 893 bushels of corn are shipped back to the Shenandoah Valley. The corn producer is paid the current futures price plus a predetermined basis. A broker coordinates the exchange by arranging litter and corn supplies, determining shipping schedules, and facilitating the receiving and disbursing of payments. Analysis indicates that an exchange could involve approximately 55,000 tons of litter and two million bushels of corn. Corn producer returns would increase $2.25 million. A litter cost-share program designed to help move litter from the Shenandoah Valley would cost about $400,000. Overall, the exchange program would improve corn producer returns and help utilize surplus litter.

Some of the major findings that lead to the above overall conclusions are

* Virginia imports more than 40 million bushels of corn per year.
* The Shenandoah Valley produces over 450,000 tons of poultry litter per year.
* A ton of poultry litter contains 62.7 pounds of nitrogen, 62.9 pounds of phosphate, and 26.6 pounds of potash.
* Poultry litter is $12.20 per acre cheaper than commercial fertilizer applied on corn acres.
* Without a backhaul, poultry litter used as fertilizer is cheaper per acre up to 129 miles from the Shenandoah Valley. With a backhaul, litter is cheaper up to 203 miles.
* The 1993-1997 difference between Shenandoah Valley integrator corn prices and major Eastern Virginia corn market prices was 24 cents per bushel. For this price difference, corn can be shipped 125 miles with a backhaul but only 75 miles without a backhaul.
* With a litter/corn exchange, each corn producer would lower corn marketing costs by 15 cents per bushel by selling directly to users in the Shenandoah Valley.
* The proposed cost-share program for hauling litter pays $0.09 per ton per mile beyond 25 miles from the litter source with a cap at $9.00 per ton.
* With litter/corn exchange, litter cost share, and reduced marketing costs, net returns per acre for corn producers increase $27.28 at 100 miles and $9.94 at 200 miles from Harrisonburg, Virginia.
* Approximately 23 million bushels of corn are produced within 203 miles of Harrisonburg, Virginia and are *potentially* available for an exchange program.

* Poultry litter can move up to 100 miles without an exchange program, cost-share program, or reduced marketing costs. With an exchange program and either a cost-share program or reduced marketing costs, litter can move 150 miles. To move litter more than 150 miles, both programs and reduced marketing costs are necessary. The *maximum potential* for a litter/corn exchange is 200,000 tons of litter and 7.2 million bushels of corn.

* Corn farm size, grain drying, and storage facilities limit potential participation in the exchange program.

* Corn producers want poultry litter custom applied like commercial fertilizer.

* Given corn farm size and facility restrictions, variability in year-to-year supply, and the need for corn production to be concentrated in contiguous counties to lower litter application costs, seven locations across Virginia appear to be economically feasible to receive, store, and apply litter in exchange for corn. These seven locations could receive approximately 56,000 tons of litter in exchange for two million bushels of corn.

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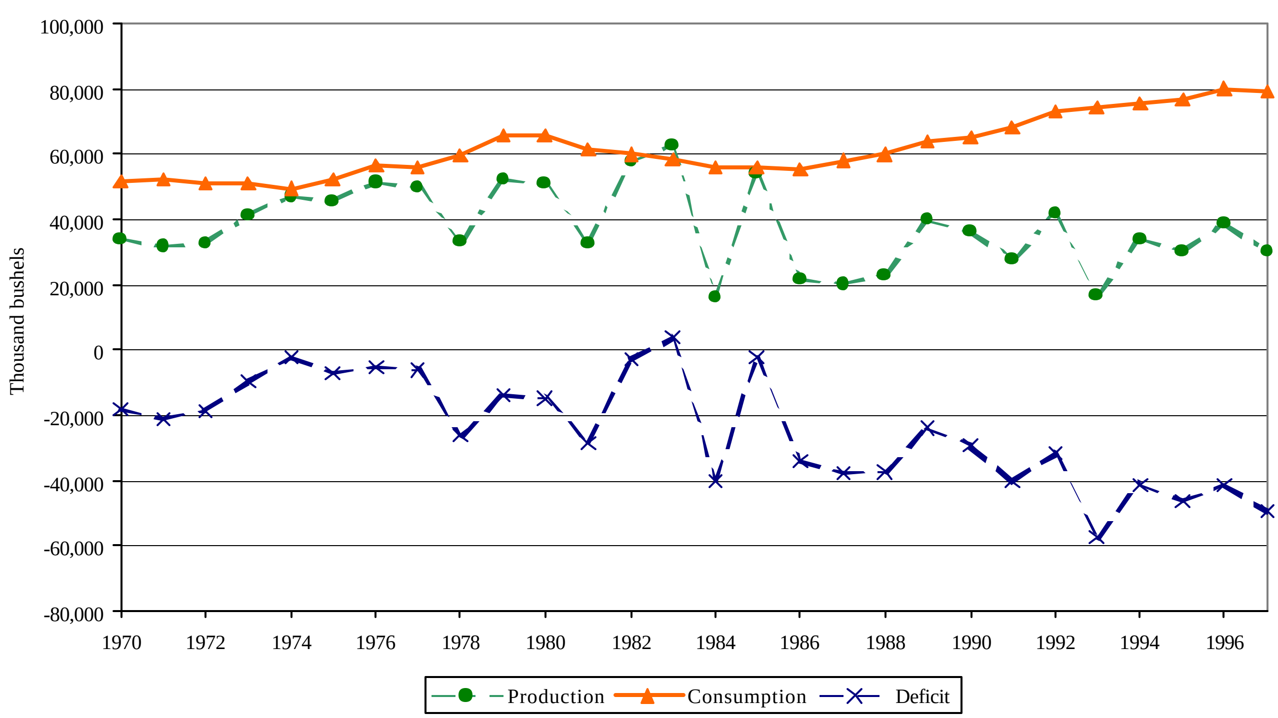
INTRODUCTION

In previous years, much research has been done into the potential for competitive corn production in Virginia. For Virginia to remain competitive in a national market, producers must be able to grow corn at a cost less than the cost of midwestern corn plus transportation costs to Virginia (Thornsbury and Kenyon, p. 11). However, much of the corn land in Virginia cannot consistently produce yields at per bushel costs which are competitive with Midwestern costs plus transportation (Thornsbury, Brann, Kenyon, and Baker). Virginia grain producers are left with two options to improve their competitive position. The first option is to reduce production costs. The second is to realize better prices.

During the past two decades, farms in Virginia have decreased in number and increased in size. In the past 20 years corn to be harvested for grain acreage has decreased and production has declined. During this same time period, poultry feeding in the Shenandoah Valley has expanded dramatically. As a result, the state is importing over 35 million bushels of corn a year and the deficit is getting larger—approaching 60 million bushels in recent years.

The rapid growth of poultry production in the Shenandoah Valley has generated large amounts of poultry litter. In 1999, the Virginia General Assembly passed House Bill 1207. This bill requires that after October 1, 2001, nutrient management plans (NMP) on poultry farms be based on phosphorous utilization. Basing NMPs on phosphorous instead of nitrogen, as is the current practice, will make more poultry litter available for use as fertilizer, feed, or other alternative uses.

Figure 1. Virginia Corn Production, Consumption, and Deficit, 1970-1997



In this study, the use of poultry litter as fertilizer on corn acreage and backhauling corn to the Shenandoah Valley is examined to reduce corn production costs and to improve corn producer prices. Most of the consumption and production of corn in Virginia occurs in two regions separated by the Blue Ridge Mountains. Consumption occurs mostly in the Shenandoah Valley, and production occurs primarily east of Interstate 95 from Fredericksburg to Emporia. These two regions are very different. Corn use in the consuming region is growing and is characterized by a few, large, integrated poultry firms. In the corn production region, production is relatively constant in recent years and consists of many independent producers. Although these two regions are only 100 to 150 miles apart, very little corn moves between them. The Valley region generally finds it more economical to import corn by rail from the Midwest than to buy grain shipped by truck from Virginia producers.

Some of the characteristics of these two regions help identify the current situation and suggest some possible opportunities for the future that might benefit both sectors. The consumption sector in the Valley is dominated by the highly integrated poultry sector, which mixes its own feed. The large integrated poultry firms have less than one-week storage capacity for grain. Therefore, the integrators must have a regular, consistent supply of grain, which they import by rail from the Midwest. These large quantities of grain arriving in the Shenandoah Valley mean that a large volume of nutrients, specifically nitrogen and phosphorous, are being imported into the region. Sufficient cropland acreage does not exist in close proximity to poultry production to permit the land application of all these nutrients under phosphorous-based nutrient management plans. Hence, these nutrients must either be shipped out of the poultry production region to be used as feed and fertilizer or in manufacturing fertilizer, generating energy, or other alternative uses. If the poultry sector is to continue to grow in the Valley, an increasingly larger portion of the poultry litter will need to be converted to other products or shipped elsewhere.

Corn acreage and total bushels produced in Virginia have declined over the last 20 years. The decline in production provides little incentive for grain handlers to expand or upgrade existing grain handling facilities. In addition, the decline in hog production in the Eastern region has resulted in excess feed manufacturing capacity. Unless these two trends change direction in the Eastern region, grain handlers and feed manufacturers in the Eastern region have little incentive to improve the grain assembly, storage, and distribution system.

The large feed demand and surplus nutrients in the Shenandoah Valley and the surplus of grain in Eastern Virginia would seem to indicate that these two sectors should be able to cooperate to improve the economic well being of both sectors. Such an arrangement would have to address several key issues. The poultry sector needs to have a regular supply of high quality grain. To be interested in truck shipments from Eastern Virginia, the poultry sector would need a commitment of a consistent, weekly supply over a number of years. The poultry sector would need to design a system for accumulating litter to be shipped to Eastern Virginia. Grain producers would need to know the nutrient content of the litter so that appropriate application rates can be calculated. Some storage for litter would be needed since crop producers apply fertilizer at specific times while litter is produced almost continuously. Sanitation considerations could arise from hauling grain and litter in the same trucks. These issues would need to be handled to meet integrator requirements.

LITTER FOR CORN EXCHANGE CONCEPT

The many operational issues of the exchange would have to be agreed upon by the participants. The program could basically work as follows. Corn producers would agree to purchase tested, known nutrient content, litter for use as fertilizer. A local dealer/distributor would store and apply the litter as requested by the producer. Each producer accepting poultry litter would be required to have a nutrient management plan. Corn producers would be eligible to commit only up to half their anticipated corn production to poultry integrators since Virginia corn production is highly variable from year to year. Corn producers would be paid the closing futures price on the day the corn is shipped, plus a specified, predetermined basis. The corn would have to meet the poultry industry standards including moisture content of 15 percent or less and appropriate tolerances for aflatoxin. The corn would be backhauled on the same truck used to deliver the poultry litter. The trucks would undergo a sanitizing process, such as rinsing with a high-pressure washer, to eliminate biosecurity problems. Operating standards would be determined and stated prior to participation in the exchange program.

The exchange program would run throughout the year, thus making storage of both poultry litter and corn necessary. Litter storage could occur in either the Valley or the receiving region. Corn storage would take place on the farm, eliminating the need for the grain elevator operator to act as a middleman. Corn shipping dates for individual producers would be selected using a process deemed to be fair to all parties.

The exchange would have to be coordinated by someone, for example a litter/corn brokerage service. Its responsibility would be to determine the amount of litter and corn available for exchange and to commit corn and litter producers to the program. The broker would schedule and coordinate litter pickup, corn shipment, and litter application. The broker could also facilitate the collection and distribution of payments.

This program would benefit corn producers by potentially reducing the cost of fertilizer, eliminating the cost of taking grain to the elevator, and increasing prices received for corn. The exchange program would also benefit poultry producers by allowing them to remove excess poultry litter at little or no cost. Thus, both sectors stand to gain from such a program.

Several important aspects of this corn for litter exchange need to be analyzed to determine the feasibility of the exchange system.

1) How much litter is available for fertilizer use?
2) What is the nutrient value of poultry litter as fertilizer compared to commercial fertilizer?
3) How far can poultry litter be economically hauled for use as fertilizer?
4) What are poultry integrators currently paying for corn?
5) Could Virginia corn producers provide corn to poultry producers at or below Midwest delivered prices?

The rest of this paper addresses each of the questions above to determine the feasibility of an exchange program.

POULTRY INDUSTRY AND LITTER AVAILABILITY

One determination of the potential viability of an exchange program is the amount of poultry litter available and its nutrient content. Over the past 20 to 30 years, the broiler and turkey industries in Virginia have expanded rapidly following the national trend of increased poultry consumption. In 1978, the poultry industry produced 18.7 percent of agricultural cash receipts in Virginia. By 1998, poultry receipts had risen to 32.8 percent, according to Virginia Agricultural Statistics.

One of the direct results of increased poultry production is large quantities of poultry litter which can be used as a substitute for or supplement to commercial fertilizer. In early 1999, amidst concerns for water quality in poultry production regions, the Virginia General Assembly passed HB 1207, a regulatory program for the management of poultry litter. This bill requires that all nutrient management plans developed after October 1, 2001 provide for phosphorous application rates that do not exceed the greater of crop nutrient needs or crop nutrient removal. The requirement that poultry litter be applied on a phosphorous basis will make more poultry litter available to be used for fertilizer or feed.

In the past, poultry litter has been applied primarily on land close to poultry production. The costs of transporting litter much further than 75 miles from the point of origin have been prohibitive. HB 1207 section 1.G.4 requires that a poultry waste transportation study be conducted and provides for the establishment of a "transportation use and alternative use program between the Commonwealth and commercial poultry processors…" The transportation study by Pelletier, Pease, and Kenyon examines the possibility of transporting poultry litter throughout the entire state of Virginia, the economic feasibility of such transportation, and the possibility of a cost-share program to assist in moving more litter.

The Department of Conservation and Recreation (DCR) requested funding for a poultry litter transport cost-share program from the 2000 General Assembly. The cost-share program would pay $0.09 per mile per ton for litter transport beginning at distances beyond 25 miles from the point of litter production. The program would pay for a maximum of 100 miles or $9.00 per ton. The cost-share payment would go to the corn producer utilizing the litter. The Commonwealth of Virginia and poultry integrators would share the cost of the litter transport program equally. If such a program is funded, it could make it possible for litter to be used economically by producers over a much larger area in Virginia.

Poultry Production in Virginia

Although the poultry industry is spread throughout the state, it is highly concentrated in the Shenandoah Valley. Nearly 1,000 of the state's 1,300 poultry farms are located in the Valley counties of Augusta, Page, Rockingham, and Shenandoah (1997 Virginia Census of Agriculture). Other poultry-producing regions of the state include South Central (Amelia, Buckingham, Cumberland, Nottoway, and Prince Edward), Southeast (Isle of Wight, Southampton, and Suffolk), and the Eastern Shore (Accomack).

Given the high concentration of poultry production and presence of heavy corn users in the Shenandoah Valley, the litter for corn exchange analysis will focus on this region. Poultry litter production is estimated using the 1997 Census of Agriculture broiler and turkey numbers and the Virginia DCR estimates of litter production per 1,000 birds. Broilers are assumed to produce 1.25 tons and turkeys 9.0 tons of litter per thousand birds. The estimated litter production in the Shenandoah Valley for 1997 is 234,984 tons of broiler litter and 218,223 tons of turkey litter, for a total production of 453,207 tons of litter (Table 1).

Poultry Litter Nutrient Content

Poultry litter contains nitrogen, phosphorus, and potassium compounds which are valuable for cropland and pasture growth. The form of these fertilizing nutrients is typically referred to as nitrogen (N), phosphate (P_2O_5), and potash (K_2O). The amount of each of these nutrients per ton of poultry litter is found in Table 2. Phosphate levels in Table 2 are based on poultry not receiving the feed supplement phytase.

Table 1. Shenandoah Valley Poultry and Litter Production, 1997

	Broilers		Turkeys	
County	Sold (thousands)[a]	Litter Produced (tons)[b]	Sold (thousands)	Litter Produced (tons)
Augusta	7,934	9,918	6,406	57,654
Page	44,499	55,624	2,228	20,052
Rockingham	117,987	147,484	13,757	123,813
Shenandoah	17,566	21,958	1,856	16,704
Total	**187,986**	**234,984**	**24,247**	**218,223**

[a] 1997 Virginia Census of Agriculture.

[b] Virginia Nutrient Management Standards and Criteria, Virginia Department of Conservation and Recreation.

The values found in Table 2 were compiled from manure tests completed by the Virginia Tech Manure Testing Laboratory. Interviews with Virginia poultry growers indicated these numbers were consistent with nutrient levels found in poultry litter from their operations. The nutrient levels indicated are used by the DCR in the development of nutrient management plans. However, the nitrogen level appears to be a conservative estimate. New data from North Carolina and Pennsylvania indicate the nitrogen content of broiler litter is closer to 70 pounds per ton. However, since nutrient management plans are based on the *Virginia Nutrient Management Standards and Criteria*, the estimates of nitrogen, phosphate, and potash per ton of litter in Table 2 are used in this study. To reduce calculations, a typical ton of poultry litter was estimated by weighting nutrient concentrations by numbers of broilers and turkeys. The weighted average concentrations of a typical ton of poultry litter used in all subsequent calculations are found in Table 2.

Table 2. Nutrient Content of Virginia Poultry Litter

Nutrient	Broiler Litter	Turkey Litter	Poultry Litter[a]
	(lbs/ton)		
Nitrogen (N)	62.58	61.75	62.73
Phosphate (P_2O_5)	62.12	63.68	62.86
Potash (K_2O)	28.57	24.36	26.57

[a] Typical ton weighted by turkey and broiler numbers.

Source: Virginia Tech Manure Testing Laboratory, 1987.

CROP NUTRIENT REQUIREMENTS

Poultry litter can be used as fertilizer on many crops and pasture, but this study will focus on corn acres as part of an exchange program. The following procedure was used to determine potential use of litter and fertilizer for all crops. Nitrogen application rates by county were estimated by 1) computing historical average corn for grain yield from 1994-1998, 2) determining the soil productivity group associated with the average corn yield, and 3) selecting the recommended nitrogen application rate for the soil productivity group.

Potash and phosphorous application rates were estimated by 1) collecting the average county soil test results from the Virginia Tech Soil Testing laboratory data and 2) associating the average soil test result with the recommended agronomic application rate.

Phosphate applications were calculated on both crop nutrient uptake and average yield. The estimated litter application rates presented in Table 3 are based on the greater of recommended phosphate applications or phosphate uptake by crops. The details of crop nutrient requirements, nutrient availability over time, and nutrient loss from storage and volatilization can be found in Pelletier, Pease, and Kenyon.

Table 3. 1997 Shenandoah Valley Poultry Litter Production and Potential Use by Crops

	Tons
Production of broiler and turkey litter	453,206
Use by crops assuming 100% adoption [a]	132,024
Use by crops assuming partial adoption [b]	52,345
Surplus	
100% adoption	321,182
Partial adoption	400,861

[a] Use within Shenandoah region based on phosphorous.

[b] Assumes adoption rates of 50% for corn, wheat, and barley; 20% for hay; and 10% for pasture.

Corn nutrient needs were determined on a county basis using the same procedures discussed above. All future references to corn is for grain production and does not include silage. The weighted average Virginia corn nutrient needs per acre are 120 pounds of nitrogen, 55 pounds of phosphate, and 60 pounds of potash. These averages are weighted by acres in each soil productivity group. The phosphate needs are the greater of agronomic recommendations or crop removal. The 55 pounds of phosphate per acre are based on crop removal rates. Based on these needs, an acre of corn can use 0.86 tons of poultry litter (55 lb per acre/62.58 lb phosphate per ton of litter).

In the Shenandoah Valley region, assuming all crops use poultry litter, the estimated surplus poultry litter is over 321,000 tons. Using a more realistic estimate of usage by producers indicates a surplus of over 400,000 tons. Some of this surplus is already being hauled out of the region for use as feed and fertilizer, but the remaining surplus must be utilized within the region or shipped out to other regions for use as feed and fertilizer. This excess litter could be shipped to Eastern Virginia corn producers with a backhaul of corn.

POULTRY LITTER AND CORN COSTS

Three key assumptions are made about litter. The first assumption is that plant available nitrogen per ton of poultry litter is 40 pounds in the first year. After applying litter as fertilizer for four years, an average of 49 pounds is available to the plant each year due to carryover effects. However, in this study, the year one value of 40 pounds will be used as a conservative estimate of nitrogen value in poultry litter. Sources indicate that plants can absorb an estimated 80 percent of the applied nitrogen in commercial fertilizer (Bosch and Napit, p.62). The second assumption is that poultry litter is applied on a phosphorous basis. In October 2001, poultry growers will be required to apply litter on their farms on a phosphorous basis, and the expectation is that cost-shared litter will also be applied on that basis. The third assumption is that the phosphorous content of litter is based on poultry rations not receiving the feed supplement phytase, which reduces the concentration of phosphorous in poultry litter.

The yearly costs for commercial fertilizer for corn based on weighted average Virginia crop nutrient needs is presented in Table 4. These commercial fertilizer costs are based on 1998 average prices. The phosphate use of 30 pounds per acre is based on agronomic recommendations. Based on 1998 prices, the cost of applying commercial fertilizer is estimated to be $53.80 per acre of corn.

Table 4. Cost of Commercial Fertilizer for Corn, 1998

		$/acre
Nitrogen:	120 lbs/acre at $.26/lb (80% taken up by plant)	31.20
Phosphate:	30 lbs/acre at $0.29/lb	8.70
Potash:	60 lbs/acre at $0.14/lb	8.40
Commercial Application		5.50
Total Nutrient Cost		**53.80**

To estimate comparative costs of litter requires estimating the costs of removal, assembly, storage, and application of poultry litter. The cost estimates assume that the poultry house is cleaned with a skid loader, the litter is hauled 10 miles in 14-ton loads to a storage facility, and it is stored up to six months. The assumptions, equipment, and costs associated with these operations are given in Appendix A. If the poultry producer cleans the house and stores the litter, the market price of litter is $5 to $7 per ton. In this study, the litter buyer cleans the house and hence does not pay the grower for the litter.

The costs of applying poultry litter using a 14-ton spreader truck are estimated to be $3.70 per ton. The assumptions, equipment, and prices used to obtain these estimates are contained in Appendix B. Based on these cost estimates, the total cost of removal, assembly, storage, and application of poultry litter is $12.63 a ton (Table 5).

Table 5. Removal, Assembly, Storage, and Application Costs of Poultry Litter [a]

	$ per Ton
Removal	3.56
Assembly	1.10
Storage	1.82
Testing	0.75
Loading	0.70
Application	3.70
Brokerage	1.00
Total	**12.63**

[a] Costs based on July 1998 and May 1999 prices.

Source: Equipment types and prices came from *Agricultural Price Summary*, USDA, various litter brokers in the Shenandoah Valley, and Bosch and Napit.

If litter application is based on annual phosphorous nutrient removal, an acre of corn would require 0.86 tons of litter. Additional amounts of N and K_2O_5 are satisfied by the application of commercial fertilizer. Based on the costs of commercial fertilizer (Table 4) and the removal, assembly, storage, and application costs of litter (Table 5), the cost of using litter is $41.60 per acre – a savings of $12.70 per acre compared to commercial fertilizer (Table 6).

Table 6. Cost of Poultry Litter as Fertilizer for Corn, 1998[a]	
	$/acre[b]
Poultry Litter (0.86 tons of poultry litter per acre * $12.60 per ton)	10.84
Commercial Fertilizer	
Nitrogen: 120 lbs necessary	
Sources:	
96.0 lbs needed by plant	
34.4 lbs from litter	
61.6 lbs from commercial	
77.0 lbs commercial * $0.26 per lb[c]	20.02
Phosphate: no additional necessary	0
Potash: 37.2 lbs additional at $0.14/lb	5.21
Commercial Application	5.50
Total Nutrient Cost	**41.60**
Savings Compared to Commercial Fertilizer ($53.80-41.60)	**12.20**

[a] Based on P_2O_5 as limiting nutrient with commercial fertilizer supplemented as necessary.
[b] Nutrient prices are from *Agricultural Price Summary*, USDA, July 1998. Commercial fertilizer application costs are from *Doane's Agricultural Report*, Vol. 2, No. 21-5, May 12, 1999.
[c] Only 80% of commercial N is available to plants.

Poultry Litter Transportation Costs

Estimated costs presented in Table 6 clearly indicate **poultry litter can be a viable economic alternative to commercial fertilizer if nutrient availability is accurately estimated, if corn producers are willing to use litter, and if transportation costs from litter source to the farm of application are not considered**. However, transportation costs are significant as the distance litter is shipped increases. To determine the radius within which the use of poultry litter is economically viable requires an estimate of the cost of transporting litter.

Several sources within the poultry and trucking industries have indicated poultry litter could be transported on an 18-wheeler walking trailer with 25-ton capacity at a cost of $0.11 per mile per ton without a backhaul and at $0.07 per mile per ton with a backhaul. These transportation costs include the cost of loading litter at a centralized litter storage location.

The breakeven transportation distance (BTD) indicates the mileage at which litter nutrient costs per acre equal commercial fertilizer nutrient costs per acre.

$$\text{BTD} = \frac{\text{savings/acre}}{\text{\$/ton * tons of litter/acre}}$$

The assembly and loading costs for litter transportation from the poultry farm to a centralized storage location and application are included in the calculations in Tables 5 and 6. The breakeven distance calculations assume a 25-ton load. Under these assumptions, poultry litter could be hauled up to 129 miles (($12.20/($0.11 * 0.86)) at a cost equal to or less than commercial fertilizer. With a backhaul, transportation cost is $0.07 per mile, and the breakeven transportation distance is 203 miles (($12.20/($0.07 * 0.86)). Using these mileage estimates, the amount of poultry litter that could be transported at a cost equal to or less than commercial fertilizer is possible to determine.

The Shenandoah Valley region alone produces around 82 percent of Virginia poultry litter. The distance between Harrisonburg and local county seat of the corn producing county was determined using the mapping computer program *Mapquest*, 1998. A sample version of this program can be found at *http://maps.yahoo.com/py/maps.py*. These distances are based on shortest actual driving mileage from one location to another.

If all corn acres in counties within 129 miles of Harrisonburg were available for application of poultry litter nutrients, over 85,000 tons could be applied at a cost equal to or less than commercial fertilizer. If the litter for corn exchange program were feasible, transportation costs could be reduced to \$0.07 per mile due to the backhaul, and litter could be hauled 203 miles. In 1997, the counties within 203 miles of Harrisonburg, Virginia could potentially have used 203,000 tons of litter on corn acres.

In 1997, Virginia producers harvested 325,000 acres of corn. At an application rate of 0.86 tons of litter per acre, the corn sector could potentially accept 85,000 tons of litter without backhauls and 203,000 tons of litter with backhauls. At 25 tons per load, it would take 3,435 loads without backhauls and 8,150 loads with backhauls. At 56 pounds of corn per bushel, each 25-ton load is equivalent to 893 bushels of corn. Given the number of loads of litter, up to 7,277,950 bushels of corn could be hauled back to the Shenandoah Valley. However, corn will only be hauled back to the Shenandoah Valley if the delivered price to poultry integrators is equal to or less than delivered prices paid for Midwest corn. Eastern Virginia corn producers will only ship to the Shenandoah Valley if their net farm price is higher compared to their current market prices in Eastern Virginia.

Corn Pricing and Transportation Costs

Poultry integrators currently import corn mainly from Ohio by rail car. The Shenandoah Valley is along the Norfolk Southern railway; thus, they draw corn from along the path of the railway in Ohio. The corn is delivered in 50-car units and is sometimes split between poultry integrators. On average, nearly four of these units are delivered per week. Estimates of cash prices poultry integrators are paying for corn were developed using futures market prices and basis information provided by Harris-Crane Inc., North Carolina.

Shenandoah Valley prices paid by integrators were estimated using the Ohio train corn basis plus rail transportation from Columbus, Ohio to Harrisonburg, Virginia. The basis and transportation costs were added to the nearby futures contract closing price. Futures prices on each Tuesday from 1993 to 1997 were used to determine the average futures price paid by week (Table 7).

The average corn price paid by integrators from 1993 to 1997 was \$3.26 per bushel. Prices were lowest during the months of October and November (\$2.90 - \$3.00) and peaked in June at \$3.50 to \$3.60 per bushel. The integrator basis relative to nearby futures was lowest during October and November at \$0.25 over December futures and peaked in September at \$0.50 over December futures.

Corn Price Differences

The important question is how prices paid producers in Eastern Virginia compare to these Shenandoah Valley integrator prices. The average (1993 to 1997) Tuesday cash price received in each of four major markets is subtracted from the average integrator price (Table 8). This difference is the maximum amount producers could pay for transportation costs from various Virginia locations to Harrisonburg without lowering their net farm price.

Table 7. Estimated Poultry Integrator Cash Corn Price in Cents per Bushel (1993-1997 Average)

Cash Month	Week	Corn Futures Contract Month	Corn Futures Tues. Closing Price	Ohio Train Corn Basis[a]	Computed Integrator Cash Price without Delivery	Shenandoah Valley Integrator Total Basis[b]	Integrator Cash Price with Rail Delivery Charge of 40 cents
			----------	----------	¢/bushel	----------	----------
Sept.	1	Dec	269	10	279	50	319
	2		271	10	281	50	321
	3		269	10	279	50	319
	4		265	10	275	50	315
Oct.	1	Dec	265	-15	250	25	290
	2		273	-15	258	25	298
	3		272	-15	257	25	297
	4		273	-15	258	25	298
Nov.	1	Dec	272	-15	257	25	297
	2		270	-15	255	25	295
	3		273	-15	258	25	298
	4		273	-15	258	25	298
	5		273	-15	258	25	298
Dec.	1	Mar	283	-5	278	35	318
	2		283	-5	278	35	318
	3		284	-5	279	35	319
	4		287	-5	282	35	322
Jan.	1	Mar.	283	-2	281	38	321
	2		286	-2	284	38	324
	3		288	-2	286	38	326
	4		290	-2	288	38	328
Feb.	1	Mar.	287	0	287	40	327
	2		287	0	287	40	327
	3		290	0	290	40	330
	4		292	0	292	40	332
Mar.	1	May	299	0	299	40	339
	2		301	0	301	40	341
	3		299	0	299	40	339
	4		298	0	298	40	338
	5		306	0	306	40	346

Table 7. Estimated Poultry Integrator Cash Corn Price in Cents per Bushel (1993-1997 Average) (continued)

Cash Month	Week	Corn Futures Contract Month	Corn Futures Tues. Closing Price	Ohio Train Corn Basis[a]	Computed Integrator Cash Price without Delivery	Shenandoah Valley Integrator Total Basis[b]	Integrator Cash Price with Rail Delivery Charge of 40 cents
			¢/bushel				
Apr.	1	May	302	2	304	42	344
	2		305	2	307	42	347
	3		305	2	307	42	347
	4		304	2	306	42	346
May.	1	July	305	2	307	42	347
	2		307	2	309	42	349
	3		311	2	313	42	353
	4		310	2	312	42	352
	5		305	2	307	42	347
June	1	July	302	5	307	45	347
	2		306	5	311	45	351
	3		305	5	310	45	350
	4		310	5	315	45	355
July	1	Sept.	278	5	283	45	323
	2		284	5	289	45	329
	3		270	5	275	45	315
	4		269	5	274	45	314
Aug.	1	Sept.	269	4	273	44	313
	2		273	4	277	44	317
	3		274	4	278	44	318
	4		278	4	282	44	322
	5		276	4	280	44	320
Average			**287**	**-1**	**286**	**39**	**326**

[a] Basis = Cash Price – Futures Price
[b] Integrator Total Basis = Ohio Train Corn Basis + Rail Delivery Charge

Table 8. Comparison of Shenandoah Valley Integrator to Virginia Corn Prices Paid to Producers, 1993-1997 Average

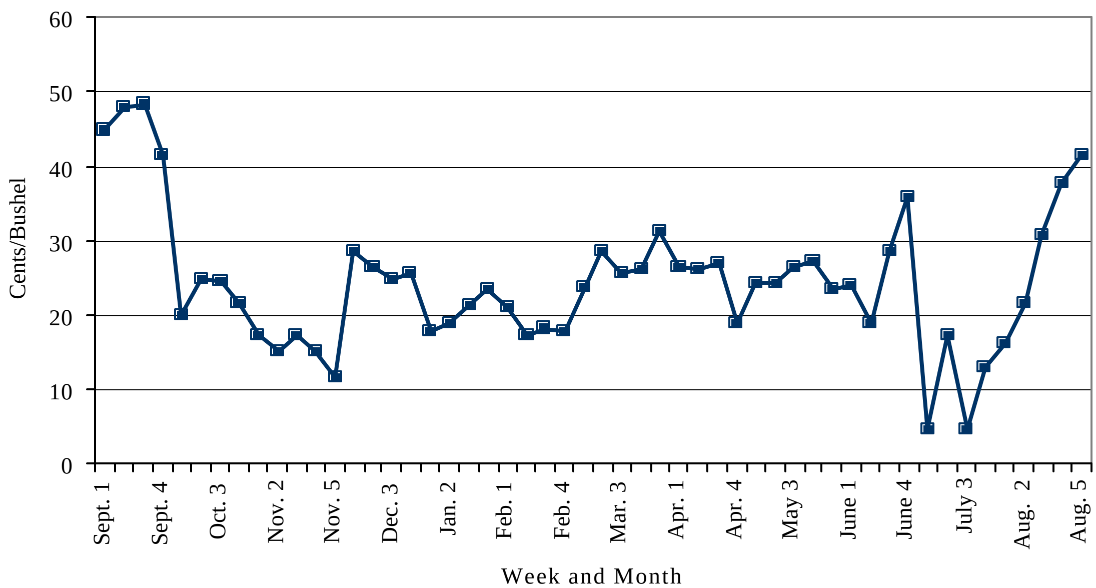
Cash Month	Week	Integrator Price	North Central	Northern Neck	Petersburg	Southeast Virginia	North Central	Northern Neck	Petersburg	Southeast Virginia	Average Difference
		--------------------------Tuesday Cash Prices-----------------------					-----Shenandoah Valley Integrator Price – Local Price------				
		--------------------------------¢/bushel------------------------------					-------------------------------¢/bushel----------------------------				
Sept.	1	319	289	269	272	267	30	50	47	52	45
	2	321	290	265	270	267	31	56	51	54	48
	3	319	279	263	269	272	40	56	50	47	48
	4	315	284	266	274	270	31	49	41	45	42
Oct.	1	290	279	262	269	270	11	28	21	20	20
	2	298	279	266	274	274	19	32	24	24	25
	3	297	275	265	275	275	22	32	22	22	25
	4	298	276	268	282	279	22	30	16	19	22
Nov.	1	297	279	268	286	286	18	29	11	11	17
	2	295	279	269	287	284	16	26	8	11	15
	3	298	277	270	291	284	21	28	7	14	18
	4	298	274	273	295	289	24	25	3	9	15
	5	298	286	275	295	289	12	23	3	9	12
Dec.	1	318	286	281	298	293	32	37	20	25	29
	2	318	289	283	300	294	29	35	18	24	27
	3	319	290	287	303	297	29	32	16	22	25
	4	322	289	292	305	300	33	30	17	22	26
Jan.	1	321	296	298	312	307	25	23	9	14	18
	2	324	296	301	313	311	28	23	11	13	19
	3	326	298	301	309	311	28	25	17	15	21
	4	328	301	302	308	307	27	26	20	21	24
Feb.	1	327	303	302	308	311	24	25	19	16	21
	2	327	308	305	316	309	19	22	11	18	18
	3	330	308	310	320	309	22	20	10	21	18
	4	332	310	311	320	316	22	21	12	16	18
Mar.	1	339	314	312	319	316	25	27	20	23	24
	2	341	313	308	316	312	28	33	25	29	29
	3	339	313	309	318	314	26	30	21	25	26
	4	338	314	306	315	312	24	32	23	26	26
	5	346	311	310	320	318	35	36	26	28	31

Table 8. Comparison of Shenandoah Valley Integrator to Virginia Corn Prices Paid to Producers, 1993-1997 Average (continued)

Cash Month	Week	Integrator Price	North Central	Northern Neck	Petersburg	Southeast Virginia	North Central	Northern Neck	Petersburg	Southeast Virginia	Average Difference
		----Tuesday Cash Prices----					----Shenandoah Valley Integrator Price – Local Price----				
		----¢/bushel----					----¢/bushel----				
Apr. 1	1	344	315	313	321	321	29	31	23	23	27
	2	347	319	315	324	325	28	32	23	22	26
	3	347	324	313	322	321	23	34	25	26	27
	4	346	330	320	331	328	16	26	15	18	19
May 1	1	347	327	315	327	322	20	32	20	25	24
	2	349	328	316	328	327	21	33	21	22	24
	3	353	328	319	331	328	25	34	22	25	27
	4	352	325	320	328	326	27	32	24	26	27
	5	347	326	317	328	323	21	30	19	24	24
June 1	1	347	330	317	326	319	17	30	21	28	24
	2	351	368	317	326	318	-17	34	25	33	19
	3	350	328	315	322	320	22	35	28	30	29
	4	355	325	309	328	315	30	46	27	40	36
July 1	1	323	326	306	326	315	-3	17	-3	8	5
	2	329	320	299	316	312	9	30	13	17	17
	3	315	321	303	312	305	-6	12	3	10	5
	4	314	310	297	299	298	4	17	15	16	13
Aug. 1	1	313	308	304	287	288	5	9	26	25	16
	2	317	301	305	292	284	16	12	25	33	22
	3	318	301	289	277	282	17	29	41	36	31
	4	322	301	289	276	271	21	33	46	51	38
	5	320	294	275	275	270	26	45	45	50	42
Average		326	305	296	305	301	21	30	21	25	24

From 1993 to 1997, Eastern and Northern Virginia corn producers have been receiving an average of $2.96 to $3.05 per bushel, depending upon the market. If these four markets are averaged, the average difference compared to the Shenandoah Valley is $0.24 per bushel. The average weekly difference between the poultry integrator price and four-market average price is shown in Figure 2. During September, the primary corn harvest month in Virginia, the average price difference is $0.43 per bushel. Several sources within the poultry industry indicate harvest time is the only time they generally buy Virginia corn. From October to April, the difference ranges from $0.12 to $0.32 per bushel, with an average difference of $0.21. During the June and July time period, little Virginia corn is available, and the reported cash prices are based on relatively small volume, resulting in large swings in price from week to week.

Figure 2. Difference between Estimated Shenandoah Valley Integrator Price and Average Virginia Price (cents/bu), 1993-1997 Average



The number of weeks during the year that the price difference was between specified $0.05 price ranges is shown in Table 9. The most typical difference is $0.21 to $0.25 per bushel, which occurred during 13 weeks or 25 percent of the year. Price differences of $0.16 to $0.20 occurred during 12 weeks of the year. Thus, the average price difference ranged between $0.16 to $0.30 per bushel about 70 percent of the time. The price difference was only greater than $0.40 five weeks a year.

The average distances corn could be hauled to the Shenandoah Valley based on various price differences are shown in Table 10. These calculations assume 893 bushels per load and transportation rates of $0.11 per mile without a backhaul and $0.07 per mile with a backhaul. The current price differences of $0.16 to $0.30 per bushel suggest that corn could be shipped a maximum of approximately 150 miles based on corn price difference alone. The 150 miles assumes a backhaul is available. Without a backhaul, the price difference only allows hauling 50 to 100 miles.

Table 9. Weekly Distribution of Price Differences Between Poultry Integrator and Virginia Average Cash Prices,[a] 1993-1997

Price Difference (¢/bushel)	Number of Weeks	Percent of Weeks
<16	6	11
16-20	12	23
21-25	13	25
26-30	12	23
31-35	2	4
36-40	2	4
41-45	3	6
46-50	2	4
Total	**52**	**100**

[a] Average of Culpeper, Tappahannock, Wakefield, and Petersburg.

Table 10. Potential Hauling Distances from Shenandoah Valley Based on Corn Price Difference

Price Difference	No backhaul ($0.11/mile/ton)	With Backhaul ($.07/ mile/ton)
$/bushel	--------------miles--------------	
0.13	42.2	66.3
0.18	58.5	91.9
0.23	74.7	117.4
0.28	90.9	142.9
0.33	107.2	168.4
0.38	123.4	193.9
0.43	139.6	219.4
0.48	155.9	244.9

Reduced Producer Corn Marketing Costs

The exchange program would reduce producer costs of taking grain to a local market since the grain would be stored on the farm and hauled directly to the user. The average distance producers currently haul grain to local markets was determined using the survey information found in Pelletier. Pelletier surveyed producers to identify how much and where they market corn. Using the survey responses, the average distance from the county seat where the operation was located to the market location was determined. The average distance to market was 35 miles one way or 70 miles round-trip. Some large-scale grain buyers provide trucks in the field at prices shown in Table 8. In this case, the grain producer would not have a decrease in marketing costs. However, due to the scope of this project, all grain producers were assumed to take their grain to the market. Under the exchange program, producers would store their corn on-farm and ship directly to the Valley, thus avoiding local delivery costs.

Based on survey results and 1997 yield, a typical farm has 143 acres of corn and produces 14,229 bushels per year. Hauling 398 tons of corn requires 16 loads in an 18-wheel truck which would travel a total of 1,120 miles. The annual costs of operating an 18-wheeler are calculated to be $0.078 per mile per ton (Pelletier). At these costs, local hauling costs could be reduced by $0.15 per bushel $\left(\frac{\text{70 miles * \$0.78/mile/ton * 25 tons}}{\text{893 bu/ton}}\right)$ if the producer hauled directly to the user in the Shenandoah Valley.

Truck Washing Costs

The primary increase in marketing costs is washing trucks after removing poultry litter and before hauling grain. Cleaning the trucks is recommended for biosecurity reasons. While the costs of cleaning the trucks are included here, at the present time, poultry integrators may not require cleaning the trucks before loading the grain. Representatives from two major poultry integrators in Virginia indicated they would consider accepting grain in trucks which were not cleaned after hauling litter. Although they are somewhat concerned about biosecurity issues, the integrators are aware that some biosecurity concerns from poultry litter can be controlled by deepstacking the litter for several days. Two litter brokers in the Shenandoah Valley indicated that they occasionally deliver corn to poultry integrators in trucks that have not been cleaned after hauling poultry litter. However, disease concerns are a much greater issue for the turkey industry. In Arkansas, poultry integrator Tysons allows backhauling of bedding materials in trucks which haul poultry litter for fertilizer as long as trucks are cleaned using a bleach and water solution according to Harsch..

Another poultry integrator expressed concerns about cleaning trucks before hauling corn and indicated cleaning might be accomplished by rinsing the trucks with hot water using a high-pressure washer. Poultry litter brokers indicate that cleaning a truck takes ½ to 1 hour. The brokers indicated they use a 2,500-PSI high-pressure washer. A large seller of industrial cleaning equipment indicated the average price for a new electric or gas heated pressure washer is $3,250 with an expected 10-year life. The cleaning would only be a rinsing process that would not include the use of commercial disinfectants, thus eliminating potential environmental problems. Assuming a 3-year life and 250 loads per year, the average cost of washing trucks is approximately $0.01 per bushel (Pelletier). This cost estimate assumes the truck will be washed at a poultry litter receiving station in the corn producing region.

The estimated average corn price paid by poultry integrators in the Shenandoah Valley from 1993 to 1997 is $3.26 per bushel. The average price received by Northern, Eastern, and Southeast Virginia corn producers during the same time period is $3.02 per bushel: a difference of $0.24 per bushel. If producers are currently spending $0.15 per bushel to market corn to grain buyers, these marketing costs could be eliminated if they sold directly to the Shenandoah Valley. If corn was exchanged for litter, marketing costs would increase $0.01 per bushel to wash trucks after hauling litter. Based on these estimates, producers could increase price by $0.24 per bushel and lower marketing costs by $0.14 per bushel by selling directly to the Shenandoah Valley: a difference of $0.38 per bushel.

NET RETURNS PER ACRE

The questions remain: Is the litter/corn exchange feasible and over how large an area? The fertilizer cost savings and corn price increases for corn producers located at various distances from the Shenandoah Valley are shown in Figure 3. The combined net savings and increased price are calculated per acre and assume the availability of a cost-share program for hauling poultry litter and a marketing saving of $0.15 per bushel. Net savings are also calculated without these last two components.

Figure 3 is constructed in the following manner. Poultry litter is produced in the Shenandoah Valley, removed from houses, and stored in a local facility. The litter is shipped 50 to 250 miles to a corn-producing region. Without transportation cost, the litter costs corn producers $12.63 per ton applied to the field.

Figure 3. Net Returns per Acre for Corn Producers at Selected Distances from Harrisonburg

Shenandoah Valley Poultry Litter ($/ton)	
Removal	3.56
Assembly, Storage	4.37
Application	3.70
Brokerage	1.00
Total	**$12.63**

50 miles →
$87.50/load →
$3.50/ton

Corn Producer Fertilizer Value ($/acre)	
Savings	12.20
Transportation	-3.01
Cost share	1.94
Net Savings	**$11.13**

100 miles →
$175.00/ load →
$7.00/ton

Corn Producer Fertilizer Value ($/acre)	
Savings	12.20
Transportation	-6.02
Cost share	5.80
Net Savings	**$11.98**

Corn ($/bu)	
Average Price	3.26

$87.50/load ←
$0.098/bu

Corn ($/bu)	
Net Valley Price	3.16
Local Price	3.05
Price Difference	0.11
LDS[1]	0.15
WC[2]	-0.01
Net Price Gain	**$0.25**

$175.00/load ←
$0.196/bu

Corn ($/bu)	
Net Valley Price	3.06
Local Price	3.05
Price Difference	0.01
LDS[1]	0.15
WC[2]	-0.01
Net Price Gain	**$0.15**

$ Savings/Acre (50 miles)	
Fertilizer Savings	11.13
Price Gain[3]	25.50
Total	**$36.63**
W/o cost share	34.69
W/o LDS	21.33
W/o cost share & LDS	19.39

$ Savings/Acre (100 miles)	
Fertilizer Savings	11.98
Price Gain[3]	15.30
Total	**$27.28**
W/o cost share	21.48
W/o LDS	11.98
W/o cost share & LDS	6.18

[1] Local Delivery Savings
[2] Washing Cost
[3] Assumes 102 bushels per acre average yield

Figure 3. Net Returns per Acre for Corn Producers at Selected Distances from Harrisonburg (continued)

150 miles

→ $262.50/load, $10.50/ton

Corn Producer Fertilizer Value ($/acre)	
Savings	12.20
Transportation	-9.03
Cost share	7.74
Net Savings	**$10.91**

← $262.50/load, $0.294/bu

Corn ($/bu)	
Net Valley Price	2.97
Local Price	3.05
Price Difference	-0.08
LDS[1]	0.15
WC[2]	-0.01
Net Price Gain	**$0.06**

$ Savings/Acre	
Fertilizer Savings	10.91
Price Gain[3]	6.12
Total	**$17.03**
W/o cost share	9.29
W/o LDS	1.73
W/o cost share & LDS	-6.01

200 miles

→ $350.00/load, $14.00/ton

Corn Producer Fertilizer Value ($/acre)	
Savings	12.20
Transportation	-12.04
Cost share	7.74
Net Savings	**$7.90**

← $350.00/load, $0.392/bu

Corn ($/bu)	
Net Valley Price	2.87
Local Price	2.99
Price Difference	-0.12
LDS[1]	0.15
WC[2]	-0.01
Net Price Gain	**$0.02**

$ Savings/Acre	
Fertilizer Savings	7.90
Price Gain[3]	2.04
Total	**$9.94**
W/o cost share	2.20
W/o LDS	-5.36
W/o cost share & LDS	-13.10

250 miles

→ $437.50/load, $17.50/ton

Corn Producer Fertilizer Value ($/acre)	
Savings	12.20
Transportation	-15.05
Cost share	7.74
Net Savings	**$4.89**

← $437.50/load, $0.49/bu

Corn ($/bu)	
Net Valley Price	2.77
Local Price	2.96
Price Difference	-0.19
LDS[1]	0.15
WC[2]	-0.01
Net Price Gain	**-$0.05**

$ Savings/Acre	
Fertilizer Savings	4.89
Price Gain[3]	-5.10
Total	**-$0.21**
W/o cost share	-7.95
W/o LDS	-15.51
W/o cost share & LDS	-23.25

[1] Local Delivery Savings
[2] Washing Cost
[3] Assumes 102 bushels per acre average yield

With a litter/corn exchange program, transportation costs are $0.07 per loaded mile. For a producer located 50 miles from Harrisonburg, a 25-ton load of litter would cost $87.50 per load ($0.07 mile * 50 miles * 25 tons) or $3.50 per ton. The corn producer would save $12.20 per acre by using poultry litter rather than commercial fertilizer (Table 6). Since only 0.86 tons of litter is applied per acre, the transportation cost per acre would be $3.01 ($3.50 ton * 0.86 ton/acre).

The proposed cost-share program for hauling litter pays $0.09 per mile beyond 25 miles from Harrisonburg, Virginia with a cap at $9.00 per ton. For a producer located 50 miles from Harrisonburg, the cost share would be $1.94 per acre (25 miles * $0.09 per mile * 0.86 tons per acre). The net fertilizer savings for a producer located 50 miles from Harrisonburg would be $11.13 per acre.

If the producer shipped corn back to Harrisonburg, he would receive $3.26 per bushel in Harrisonburg. Subtracting the $0.098 per bushel hauling cost to Harrisonburg, the net Valley price to the producer would be $3.16 per bushel. Based on Northern Virginia historical cash prices, the producer would receive a net price increase of $0.11 per bushel ($3.16 – 3.05). If the producer saved $0.15 per bushel in local delivery costs and incurred a $0.01 per bushel cost for washing (WC) the truck after hauling litter, the net price gain is $0.25 per bushel ($0.11 + 0.15 – 0.01).

Combining the fertilizer savings and price improvement, the corn producer could increase returns $36.63 per acre. These calculations assume an average yield of 102 bushels per acre, the average Virginia yield from 1994 to 1998. Without cost share, the increased return would be $34.69 per acre. Without local delivery savings, the improvement would be $21.33 per acre. Without both the cost share and local delivery savings, the return improvement for producers located 50 miles from Harrisonburg would be $19.39 per acre.

The same calculation procedure is used for corn acres located 100, 150, 200, and 250 miles from Harrisonburg. For areas located 100 and 150 miles from Harrisonburg, the Northern Virginia price is used as the current price received by producers. At 200 miles, the average price received on the Northern Neck and Southeast Virginia is used. At 250 miles, the Northern Neck price is used. These different prices are used to reflect that corn prices generally decline as the distance from Harrisonburg increases.

The cost-share maximum of $9.00 per ton is reached at 125 miles from Harrisonburg (125-25 miles = 100 miles * $0.09 per mile = $9.00). Since a producer applies 0.86 tons per acre, the maximum cost share is $7.74 per acre ($9.00 * 0.86 tons per acre). Beyond 125 miles from Harrisonburg, the cost share payment for hauling litter is constant at $9.00 per ton or $7.74 per acre.

Net returns per acre (NRA) at selected distances from Harrisonburg under various assumptions are shown in Figure 3. The net returns per acre are summarized in Table 11 using 25-mile increments under various scenarios. The components in net returns per acre are fertilizer savings and price increase, both with and without cost share and local delivery savings.

With cost share for hauling litter and with local delivery savings, net returns per acre increase up to 225 miles from Harrisonburg (Table 11). When the cost share is removed but local delivery savings remains, the breakeven mileage declines to 200 miles. Without the local delivery savings but with the cost share for hauling litter, the breakeven distance declines to 175 miles. With neither the cost share nor local delivery savings, the breakeven mileage declines to 125 miles. **Hence, the cost-share subsidy and local delivery savings almost double the mileage litter can be hauled and exchanged for corn**. Without a backhaul of corn, the litter transportation cost per ton would increase, and the distances litter could be economically hauled would decline.

Table 11. Net Returns per Acre for Corn Producers at Various Distances from Harrisonburg, Virginia

	Net Returns Per Acre With Cost Share and Local Delivery Savings				Net Returns Per Acre Without Cost Share and/or Local Delivery Savings		
Miles	Reduction Fertilizer Costs	Net Price Gain	Price Gain	Net Returns	Without Litter Cost Share	Without LDS	Neither Cost Share nor LDS
	($/ac)	($/bu)	----------($/ac)-------		-------------------($/ac)----------------------		
25	10.69	0.30	30.60	41.29	41.29	25.99	25.99
50	11.13	0.25	25.50	36.63	34.69	21.33	19.39
75	11.55	0.20	20.40	31.95	28.08	16.65	12.78
100	11.98	0.15	15.30	27.28	21.48	11.98	6.18
125	12.41	0.11	11.22	23.63	15.89	8.33	0.59
150	10.91	0.06	6.12	17.03	9.29	1.73	-6.01
175	9.40	0.07	7.14	16.54	8.80	1.24	-6.50
200	7.90	0.02	2.04	9.94	2.20	-5.36	-13.10
225	6.39	0.00	0.00	6.39	-1.35	-8.9	-16.65
250	4.89	-0.05	-5.10	-0.21	-7.95	-15.51	-23.25

REGIONAL ANALYSIS

Now the question becomes how many bushels of corn are located within various distances of Harrisonburg. The state was divided into four regions based on the distance from Harrisonburg to the county seat of each county within a corn producing region. The four regions are Region 1: 0 to 50 miles, Region 2: 51 to 100 miles, Region 3: 101 to 150 miles, and Region 4: 151 to 203 miles. The counties in each region, their distance from Harrisonburg, tons of poultry litter that could be applied on a P_20_5 basis, and production of corn in 1997 are contained in Table 12.

A litter/corn exchange program, with cost share for litter transport and local delivery savings for corn, could potentially involve a maximum of 203,744 tons of litter (Table 12). The area involved includes 62 counties that produced 22,868,000 bushels of corn in 1997. Under an exchange program, the litter would be exchanged for 7,510,630 bushels of corn, assuming each load of litter was 25 tons and each load of corn was 893 bushels. Hence, at the potential maximum, the litter/corn exchange would utilize 33 percent of the corn production located within 203 miles of Harrisonburg.

A number of considerations, however, indicate that the actual volume of litter and corn involved would be substantially less than the maximum. The cost-share program for hauling litter does not yet exist. Many large corn producers in Eastern Virginia would not experience the $0.15 per bushel local delivery savings. And some regions may not have sufficient corn production to provide a load-for-load exchange of litter for corn.

To obtain a more reasonable estimate of the volume of litter and corn to be exchanged under various circumstances, a regional analysis was performed. The six counties in Region 1 within 50 miles of Harrisonburg could utilize 32,076 tons of poultry litter if every corn acre received 0.86 tons. These six counties produced 4.406 million bushels of corn in 1997. If each 25-ton load of litter is equivalent to 893 bushels of corn, the 5,689 loads of litter could involve 4.15 million bushels of corn. Many of the corn acres in Region 1 are probably already receiving poultry litter as fertilizer, since corn producers' fertilizer costs are lower with litter compared to commercial fertilizer. In Region 1, using litter is feasible without the exchange, litter transport cost share, or local delivery savings.

Table 12. Regional Potential Poultry Litter Application and Corn Production

Region	County	Mileage[a]	Without Exchange	With Exchange	Corn Production
			------------(Tons)	----------	(1,000 bu)
1	Augusta	25	8,347	8,347	1,124
1	Rockingham	25	13,007	13,007	1,943
1	Greene	30	523	523	47
1	Page	34	1,772	1,772	252
1	Shenandoah	40	3,852	3,852	470
1	Madison	46	4,575	4,575	570
Total			32,076	32,076	4,406
2	Orange	59	3,500	300	437
2	Nelson	61	432	432	48
2	Rockbridge	62	1,592	1,592	160
2	Culpeper	64	6,163	6,163	641
2	Rappahannock	66	486	486	52
2	Frederick	70	2,381	2,381	166
2	Clarke	80	1,331	1,331	139
2	Louisa	88	1,399	1,399	135
2	Botetourt	95	845	845	106
2	Fauquier	95	8,448	8,448	995
2	Spotsylvania	100	776	776	99
Total			27,353	27,353	2,978
3	Loudoun	104	11,220	11,220	1,006
3	Goochland	105	2,673	2,673	308
3	Campbell	106	1,608	1,608	94
3	Appomattox	110	813	813	54
3	Craig	117	430	430	46
3	Cumberland	118	692	692	68
3	King George	120	3,487	3,487	476
3	Powhatan	120	1,319	1,319	145
3	Buckingham	125	1,018	1,018	84
3	Bedford	126	793	793	57
3	Henrico	128	2,386	2,386	113
3	Montgomery	135		1,702	216
3	Franklin	136		3,050	366
3	Prince Edward	136		1,222	98
3	Hanover	142		6,972	880
3	Prince William	143		1,983	153
3	Charlotte	146		522	50
3	Pittsylvania	146		1,984	213
3	Westmoreland	146		6,786	1,009
Total			**26,439**	**50,660**	**5,436**

Table 12. Regional Potential Poultry Litter Application and Corn Production (continued)

Region	County	Mileage[a]	Without Exchange	With Exchange	Corn Production
			------------(Tons)----------		(1,000 bu)
4	New Kent	153		2,777	370
4	Floyd	154		525	75
4	Halifax	154		1,890	137
4	King William	154		7,248	935
4	Pulaski	158		687	94
4	Stafford	158		828	103
4	Charles City	161		4,009	307
4	Caroline	162		5,439	759
4	Prince George	162		4,799	451
4	Amelia	165		1,130	145
4	Essex	169		13,769	1,393
4	Dinwiddie	172		2,110	235
4	King and Queen	173		7,463	865
4	Wythe	177		1,241	117
4	Richmond	179		5,084	741
4	James City	180		1,360	143
4	Sussex	181		3,906	284
4	Middlesex	182		3,637	396
4	Nottoway	186		338	40
4	Patrick	186		2,127	111
4	Bland	192		489	42
4	Surry	197		7,708	447
4	Greensville	199		925	109
4	Northumberland	200		7,985	963
4	Smyth	203		729	77
4	Southampton	203		5,452	709
Total		NA		93,655	10,048
Total 1,2,3,4		**NA**	**85,868**	**203,744**	**22,868**

[a] From Harrisonburg to county seat location of corn producing county.

In Region 2, the counties located between 50 and 100 miles from Harrisonburg could utilize 27,353 tons of poultry litter. With exchange, the region could potentially ship about one million bushels of corn to Harrisonburg. At the outer edges of Region 2 (100 miles), the cost savings for litter without both a backhaul and litter transport cost-share program are near the breakeven mileage for hauling poultry litter. The litter transportation cost would be $11 per ton ($0.11 mile * 100 miles) compared to a per acre savings of $12.20. Hence, poultry litter may move up to 100 miles without a cost share, an exchange program, or local delivery savings.

At 100 miles, the net price received by corn producers for corn shipped to Harrisonburg only increases price $0.01 per bushel compared to current local prices (Figure 3). Hence, without cost share, exchange program, and local delivery savings, the maximum distance poultry litter is likely to be shipped is approximately 100 miles. In 1997, 59,429 tons of poultry litter could have been applied on a phosphorous basis within 100 miles of Harrisonburg--if every corn acre received poultry litter instead of commercial fertilizer. Of course, not every corn acre will receive litter. If producers used litter on other crops and pasture, substantially more acreage could receive litter without any cost-share program for hauling . Hence, 100 miles from Harrisonburg is the approximate limit for hauling litter without cost share or a litter/corn exchange program which lowers transportation costs by providing a backhaul or local delivery savings or a combination of all of these.

If a cost-share program were in place and corn producers saved $0.15 per bushel in local delivery costs, producers located 100 miles from Harrisonburg could increase net returns $27.28 per acre (Figure 3 and Table 11). Increased returns of this magnitude should encourage many producers within Region 2 to participate in a litter/corn exchange program.

In Region 3 (100-150 miles), an exchange program does not seem feasible unless corn producers receive either a cost-share payment for litter or experience a local delivery cost savings by shipping corn directly to Harrisonburg. At 150 miles, the fertilizer savings from using litter are $3.17 per acre ($12.20-9.03). But the net Valley price is lower than the current local price resulting in a loss of $6.01 per acre. At the outer edge of Region 3 (150 miles), corn returns per acre are positive with either a cost-share program or a local delivery savings. With both savings, corn producer returns in Region 3 increase from $17.03 to $27.28 per acre, depending upon the distance from Harrisonburg.

Region 3 could have utilized 50,660 tons of poultry litter and produced over 5 million bushels of corn in 1997. These amounts are almost as much as Regions 1 and 2 combined. A litter/corn exchange program that reduced local delivery costs could substantially increase the amount of litter and corn shipped between Harrisonburg and Region 3.

In Region 4 (150-200 miles), corn producers need both the cost-share program and local delivery savings to make the exchange program feasible. Without the cost share, fertilizer costs per acre at 200 miles are about equivalent to commercial fertilizer costs (Figure 3). At 200 miles, producers receive $0.12 per bushel less shipping to Harrisonburg compared to local prices. Even with the $0.15 savings for local delivery, producers have little incentive to participate in a litter/corn exchange without cost share. With cost share and local delivery savings, producers located 150 to 200 miles from Harrisonburg can increase returns $9.94 to $17.03 per acre.

Region 4 contains almost twice as much corn production as Region 3. With a cost-share program and local delivery savings, many producers in Region 4 would have adequate financial incentive to participate in a litter/corn exchange program. Up to 93,655 tons of litter and over 3,345,000 bushels of corn could be exchanged. In 1997, Region 4 produced over 10 million bushels of corn, so the exchange program could potentially utilize up to one-third of the corn production in the region.

In summary, on a regional basis about 59,000 tons of litter and 2.1 million bushels of corn could potentially be involved in an exchange program in Regions 1 and 2 ($\leq$100 miles) without a cost-share program or local delivery savings. In Region 3, it takes either a cost-share program or local delivery savings to make the litter/corn exchange feasible. Potentially, an additional 50,000 tons of litter and 1.8 million bushels of corn could be involved in an exchange program. In Region 4 (150-200 miles), it takes **both** the cost share program and local delivery savings to make the exchange program feasible. Region 4 has the potential for over 90,000 tons of litter and 3.3 million bushels of corn to be exchanged. In total, over 200,000 tons of litter and 7.2 million bushels of litter for corn could be traded. But about half these amounts require both a cost-share program for litter transportation and local delivery costs savings, and the feasibility for another one-fourth of these potential volumes requires one of these two savings. Only about 59,000 tons of litter and 2.1 million bushels can be traded without litter transport cost share or local delivery savings or both.

ADDITIONAL LITTER/CORN EXCHANGE CONSIDERATIONS

The tons of litter and bushels of corn that could potentially be traded under an exchange program discussed to this point are upper limits. A number of practical limitations would suggest that substantially fewer tons and bushels would be traded. Most of these limitations are related to the desires of corn producers and characteristics of their farms. For the exchange program to work, the corn would need to be picked up at the farm to avoid local delivery costs and grain elevator handling margins. Hence, corn farmers need facilities to handle trailer loads (893 bushels) of corn. Many farms do not have the drying and storage facilities to handle large volumes of corn. Pelletier's study, based on a 1998 survey, indicates that only 50 percent of Virginia corn farms had grain-drying facilities. In general, farms with dryers were the larger farms located beyond 150 miles from Harrisonburg. Hence, many of the farms in all the regions would not be able to participate because they do not have drying equipment. In addition, many smaller farms would not be able to use a complete load of litter or provide a full load of corn.

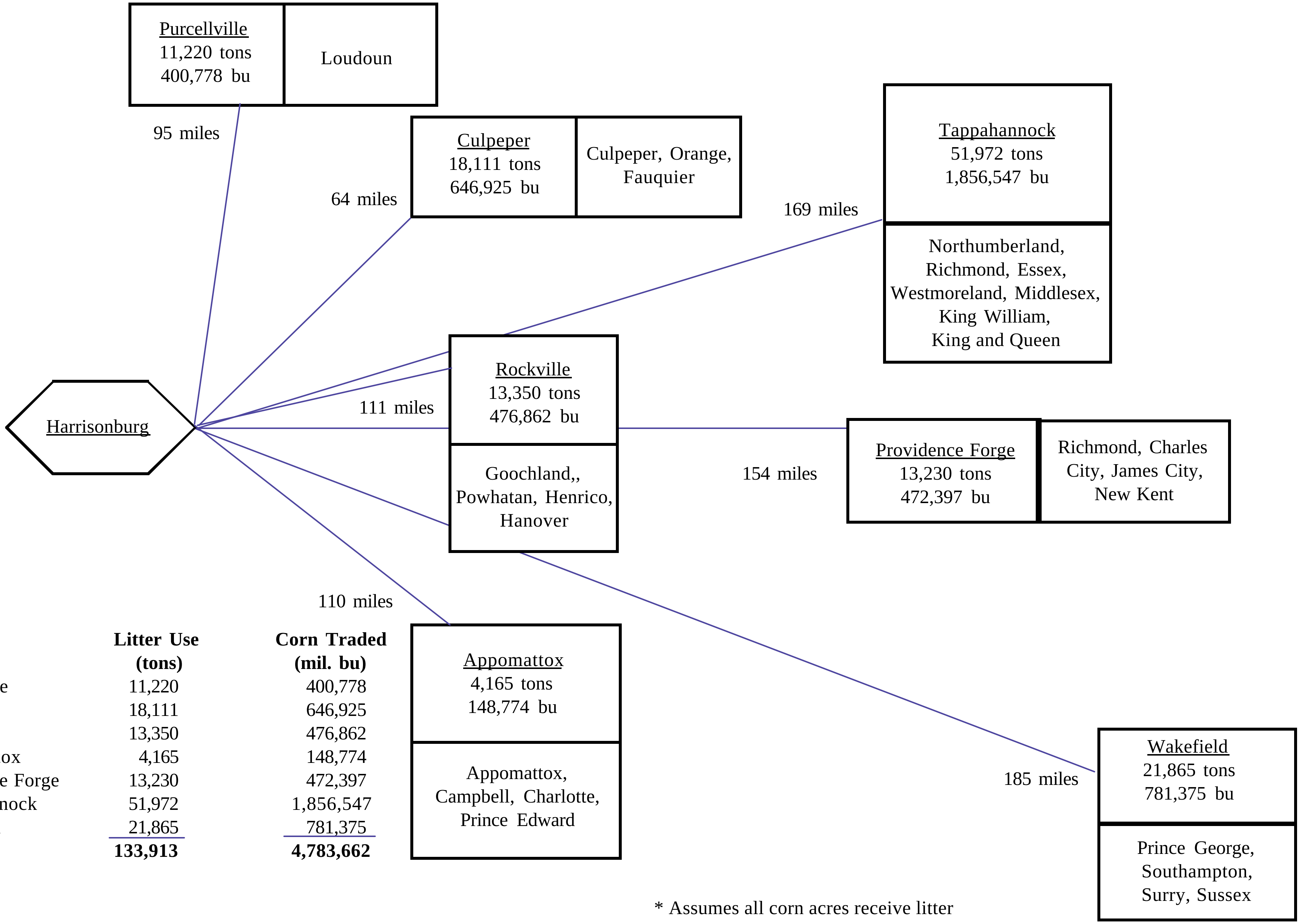
Many producers have never used poultry litter as fertilizer. To help understand producer attitudes toward the use of poultry litter, four focus group discussions about the advantages and disadvantages of poultry litter use were held across Virginia. Over 40 producers participated in these 1½ to 2-hour discussions. In these groups, many producers indicated they would only use litter if it could be ordered and custom-applied similarly to commercial fertilizer. In other words, they did not want to handle and store the litter and apply it themselves.

Given these considerations, the litter/corn exchange program would likely only work in areas where sufficient corn acres exist for a business to receive, store, and custom apply the litter for corn producers. In addition, sufficient corn production is necessary to assure a backhaul of corn to the Shenandoah Valley. Given these considerations, it seems reasonable to look for areas within each region where four or five contiguous counties within 25 miles of a specific location could receive at least one load of litter a day in exchange for corn. At one load a day, the annual litter volume would need to be at least 6,250 tons (25 tons/load * 250 days). Seven locations meet these criteria. These locations seem to be feasible for establishing a storage and distribution center for litter where adequate corn production would be available for backhaul. These locations, the miles from Harrisonburg, the counties included, the tons of litter and bushels of corn exchanged are shown in Figure 4.

The two locations closest to Harrisonburg are in Culpeper and Purcellville, Virginia, and are 64 and 94 miles from Harrisonburg, respectively. These two sites could receive over 29,000 tons of litter and ship one million bushels of corn. According to the previous regional analysis, these two locations would not need to receive either cost share or local delivery savings on corn to make them economically feasible.

The next two locations are Rockville and Appomattox, located approximately 110 miles from Harrisonburg. The Appomattox site would not receive the equivalent of a load a day but is reasonably close. These two sites in Region 3 are relatively close to the border with Region 2 (100 miles). Theoretically, these two locations could operate without cost share or local delivery savings, but producers located 25 miles further from these sites would need either cost share or local delivery savings to interest them in participating in the exchange. These two locations could use 17,500 tons of litter and ship approximately 600,000 bushels of corn. It may be difficult to find a sufficient number of large-scale producers near these two locations to provide the necessary amount of corn.

Figure 4. Potential Locations for Litter Storage and Distribution Sites and Maximum Litter and Corn Exchange*



Location	Litter Use (tons)	Corn Traded (mil. bu)
Purcellville	11,220	400,778
Culpeper	18,111	646,925
Rockville	13,350	476,862
Appomattox	4,165	148,774
Providence Forge	13,230	472,397
Tappahannock	51,972	1,856,547
Wakefield	21,865	781,375
Total	**133,913**	**4,783,662**

* Assumes all corn acres receive litter

Region 4 has three potential locations: Tappahannock, Providence Forge, and Wakefield. These locations need both a cost-share program and local delivery savings to be feasible. But these sites are located in the main grain producing region of Virginia, could use 85,000 tons of litter, and ship over 3 million bushels of corn--substantially more than the other five sites combined. The large grain farms around these sites would make the costs of operating a litter/corn exchange program less than in the other four locations.

The increased returns at the Providence Forge (154 miles) and Tappahannock (169 miles) locations could be attractive to producers. The increased returns at the Wakefield location are less attractive, being close to the 203-mile breakeven distance. Participation at the Wakefield location would probably be low, especially given the presence of Carroll Foods, Inc. and several large grain dealers in the area. Participation by producers in the other two locations in Region 4 might be reduced by the availability of bio-solids and the potential of litter from the Eastern Shore of Virginia and Maryland.

Under current conditions, not much litter is hauled more than 100 miles to be used as fertilizer. If a cost-share program for hauling litter was available and producers experienced reduction in marketing costs by selling directly to the Shenandoah Valley, more litter could be used by producers in the five locations in Regions 3 and 4. If 50 percent of the tonnage and bushels in Appomattox, Rockville, and Providence Forge and 25 percent in Tappahannock and Wakefield locations could be committed to a litter/corn exchange, an additional 49,000 tons of litter could be shipped from the Shenandoah Valley and 1.75 million bushels of corn could be shipped to the Valley.

Based on these seven locations, a litter transport cost-share program paying $0.09 per mile beyond 25 miles from Harrisonburg up to a maximum of 100 miles ($9.00 per ton), would cost $393,198 (Table 13). Under HB 1207, the poultry integrators would be expected to pay one-half the cost of this program.

Table 13. Estimated Litter Transport Cost-Share Expenditures for Seven Potential Locations

				Cost-Share			
Location	Miles[a]	Potential Litter Usage (Tons)	Adoption Rate (%)[b]	Estimated Litter	Miles[c]	$/ton	Total ($)
Culpeper	64	18,111	75	13,583	39	3.51	47,677
Purcellville	94	11,220	75	8,415	69	6.21	52,257
Appomattox	110	4,165	50	2,083	85	7.65	15,931
Rockville	111	13,350	50	6,675	86	7.74	51,665
Providence Forge	154	13,230	50	6,615	100	9.00	59,535
Tappahannock	169	51,972	25	12,993	100	9.00	116,937
Wakefield	185	21,865	25	5,466	100	9.00	49,196
Total	NA	**133,913**	NA	**55,830**[d]	NA	NA	**393,198**

[a] Miles from Harrisonburg
[b] Assumed percent corn acres receiving litter.
[c] Maximum 100 miles.
[d] Weighted by adoption rate in each location.

Producers within 25 miles of these seven locations would increase their returns by about $1.5 million (Table 14). These increases are computed using the net returns per acre for the mileage closest to the actual miles from the seven locations (Table 11). Corn acres are based on applying 0.86 tons of litter per acre at the adoption rate assumed for each location (Table 13).

Table 14. Improved Returns to Corn Producers from Litter/Corn Exchange Program by Location

	Miles		Net Returns[b]		
Location	Actual	Table 11[a]	($/Acre)	Acres[c]	Total ($)
Culpeper	64	75	31.95	15,794	504,618
Purcellville	94	100	27.28	9,785	266,935
Appomattox	110	100	27.28	2,422	66,072
Rockville	111	100	27.28	7,762	211,747
Providence Forge	154	150	17.03	7,692	130,995
Tappahannock	169	175	16.54	15,108	249,889
Wakefield	185	175	16.54	6,356	105,130
Total	NA	NA	NA	**64,919**	**1,535,386**

[a] Closest to actual mileage (Table 11).
[b] Net returns with cost share and local delivery savings.
[c] Assume 0.86 tons/acre and adoption rate in Table 13

In addition to the $1.5 million increase in total returns (Table 15), all corn producers at the four locations near Rockville, Providence Forge, Tappahannock, and Wakefield would likely see an increase in their local corn price. If 1.75 million bushels were shipped to the Shenandoah Valley rather than used in these local markets, the local price could be expected to increase by $0.05 to $0.10 per bushel. When Purdue built a new facility in Tappahannock and started purchasing corn and soybeans, the local basis improved $0.05 to $0.10 per bushel. When Carroll Foods, Inc. built a feed mill in Waverly, the local corn basis improved $0.05 to $0.10 per bushel. Both these facilities purchase more than a million bushels of corn a year. Hence, if 1.75 million bushels of corn were taken out of these markets, the local basis to all producers in these regions might increase by $0.05 per bushel, which means the average cash price would increase by $0.05 per bushel. Since Region 3 and 4 produce about 15 million bushels of corn, (Table 12) the price increase could increase producer returns by an additional $750,000. Thus, an efficiently operated litter/corn exchange program could raise Virginia corn producer returns over $2.25 million dollars (Table 15).

Table 15. Summary Impacts for Litter/Corn Exchange Program at Seven Locations in Virginia, 1997.

	Amount
Tons litter applied	55,830
Bushels corn traded	1,994,248
Litter cost-share expenditure ($)	393,198
Increase producer returns[a] ($)	1,535,386
Increase producer corn price[b] ($)	750,000

[a] Increase from reduced fertilizer costs and reduced marketing costs.
[b] Increase from higher corn prices in Regions 3 and 4.

RESULTS

A litter/corn exchange appears to be feasible for a significant number of producers located within 200 miles of Harrisonburg, Virginia. The exchange would involve approximately 56,000 tons of litter and two million bushels of corn. Corn producer net returns are estimated to increase by $2.25 million. Within 50 miles of Harrisonburg, returns would increase over $35.00 per acre. Up to 100 miles, producers can reduce fertilizer cost by using litter without an exchange program providing a backhaul which lowers transportation costs is used. Beyond 100 miles the exchange program needs either the litter cost-share program or the local delivery savings to be economically feasible. Beyond 150 miles, the exchange program is only feasible if both the litter cost share and local delivery savings are available to producers. The litter cost-share program would cost about $400,000.

The difference between the price of corn sold directly to the Valley compared to local market prices reaches zero at about 100 miles. Beyond that point if producers do not experience a savings in local delivery costs of $0.15 per bushel by participating in the exchange, their local price is higher than the Valley price. Hence, a critical component of the success of this exchange is the development of an exchange program that permits corn to go directly from the farm to the Valley.

Since the Shenandoah Valley does not currently buy much Virginia corn except during September, developing this component of the exchange is crucial. One possible way to make the corn side of the exchange work could involve the following arrangement. Valley users would pay corn producers the closing futures price plus the historical basis on the day of delivery. This pricing formula assures users that they are paying prices comparable to delivered Midwest corn. Both the users and the producers would agree upon a quantity of corn to be delivered each business day that was equivalent to the amount of litter hauled to producers (25 tons of litter for 893 bushels of corn). Both users and producers would have to make arrangements to assure that the predetermined quantity is available each day.

The guaranteed litter quantity could be easily arranged in the Shenandoah Valley. The litter is produced in a very concentrated area and large quantities are available. Corn production, however, is more geographically dispersed with relatively small amounts produced on each farm. Many producers would be needed to supply the agreed upon quantity on the scheduled basis.

To make the exchange work, a broker would need to find enough corn producers near each litter drop-off location who would be willing to commit to this exchange program. Once the producers were committed, a shipping schedule would have to be developed that would be fair to all producers. The producers who agreed to sell corn through the exchange would not necessarily have to be the same producers who use the litter. But whoever is operating this exchange would also need to have buyers for the litter.

The people most likely to be interested in coordinating this exchange are current litter brokers or grain and fertilizer dealers. If the exchange program is successful, existing fertilizer dealers would lose commercial fertilizer sales. Since these dealers already have contact with producers and since they understand the fertilizer business, they could make the necessary adjustments to sell and apply litter with a minimal investment in new facilities and equipment. Some fertilizer dealers also buy grain and might be interested in coordinating the grain portion of the exchange as well. Current litter brokers might also be interested in working with other businesses to arrange storage and custom litter application and in extending their brokerage business into organizing the grain component of the exchange. The improved returns corn producers experience should provide sufficient potential profit for businessmen to be interested in developing this exchange program.

The litter/corn exchange program appears to be economically feasible for a significant volume of litter and corn if a litter transport cost share is available and corn producers can reduce marketing costs by selling directly to the Shenandoah Valley. The exchange program could improve corn producers' returns and help utilize the surplus of litter in the Shenandoah Valley in an environmentally sound manner.

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APPENDIX A

Removal, Hauling, and Storage Costs of 8,000[a] tons of Poultry Litter[b]

Item	Unit	Quantity	Cost/unit	Total Cost
Operating Cost[c]			------------($)-----------	
Elevator	Hr	300	1.20	360
Skid Steer Loader	Hr	1,860	4.11	7,645
Pickup	Mi	5,000	0.17	850
Labor	Hr	2,232	6.00	13,392
Transport[d]	Ton	8,000	1.10	8,800
Operating Interest	$	14,008	0.12	1,681
Total Operating Costs				**32,728**
Ownership Cost				
Storage Structure[e]				14,560
Elevator[f]				769
Skid Steer Loader[g]				1,902
Pickup[h]				1,859
Total Ownership Costs				**19,090**
Total Costs				**51,818**

Assumptions:

[a] Litter may undergo a reduction in weight during storage.

[b] Method adapted from Bosch and Napit, 1991.

[c] Machinery operating costs include fuel, lubrication, and repairs. Labor time equals machine time plus 20 percent overhead. Operating interest is based on six months storage.

[d] Transport costs are based on $0.11 per ton per mile for an average haul of 10 miles.

[e] Storage structure costs are based on $28 per ton investment cost and six months storage. Depreciation, interest, repairs, insurance, and taxes are 13 percent of investment cost. Storage cost per ton = $28 *0.05 *0.13 = $1.82 per ton.

[f] Elevator has 2,000 hour life and $3,660 new cost. Annual depreciation is $549; interest, taxes, insurance, and housing are $220.

[g] Skid loader ownership cost is based on $10,570 new cost and 2,500 hours life. Annual depreciation is $1,268 and annual interest, taxes, insurance, and housing costs are $634 (6 percent of new cost).

[h] Pickup ownership cost is based on $16,900 new cost and 100,000 mile life. Annual depreciation is $845 and interest, taxes, insurance, and housing costs are $1,014 (6 percent of new cost).

APPENDIX B

Ownership and Operating Costs for Applying Poultry Litter[a]

Item	Unit	Quantity	Cost/unit	Total Cost 8,000 tons
Operating Cost			--------------($)----------	
Truck[b]	Hr	250	31.16	7,790
Spreader	Hr	250	2.52	630
Front End Loader	Hr	175	12.06	2,111
Pickup[c]	Mi	4,000	0.017	680
Labor	Hr	500	6.00	3,000
Total Operating Costs				14,211
Ownership Cost				
Truck[d]				7,400
Spreader[e]				1,680
Front End Loader[f]				1,756
Pickup[g]				879
Total Ownership Costs				11,715
Total Costs				**25,926**
Cost/Ton				**3.70**

Assumptions:

[a] Method adapted from Bosch and Napit, 1991.

[b] Operating costs assume 20 minutes to load and 30 minutes to spread a 14-ton load at a rate of 1.5 tons per acre.

[c] Mileage is based on 100 miles per day for 40 days of application.

[d] Truck ownership cost is based on $40,000 new cost and 2,000 hours lifetime. Annual depreciation is $5,000 and annual interest, taxes, housing, and insurance costs are $2,400 (6 percent of new cost).

[e] Spreader ownership is based on $10,500 new cost and 2,500 hours lifetime. Annual depreciation is $979 and annual interest, taxes, housing, and insurance costs are $630 (6 percent of new cost).

[f] Front end loader ownership cost is based on $70,000 new cost, 12,000 hours lifetime, and 1,000 hours annual use. Annual depreciation is $5,833 of which 17.5% ($1,021) is charged to litter application. Annual interest, insurance, tax, and housing costs are $4,200 of which 17.5 percent ($735) are charged to the application activity.

[g] Pickup ownership cost is based on $16,900 new cost, 100,000 miles life, and 20,000 miles annual use. Annual depreciation is $2,600 of which 20 percent ($676) is charged to litter application. Annual interest, insurance, tax, and housing costs are $780 of which 20 percent ($203) is charged to litter application.