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Economic Analysis of Virginia Poultry Litter Transportation

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Abstract

Over the past 20 years, the poultry industry has expanded rapidly in Virginia, resulting in local surpluses of poultry litter. In 1997, over 550,000 tons of poultry litter were produced in Virginia, containing approximately 35 million pounds of phosphate and an equal amount of nitrogen. In order to minimize water quality impacts of litter applications, public and private entities are analyzing how to properly utilize these nutrients. This study examines one of these alternatives: a litter transport program designed to increase use of poultry litter as fertilizer throughout the Commonwealth. Poultry litter production is calculated on a state, regional, and county basis. Appropriate application rates are developed based on soil test summary data on a crop and county basis. Crop, hay, and pasture nutrient application potential for all counties/cities exceed 7 million tons of litter to meet nitrogen requirements, and 3.2 million tons of litter to meet phosphate requirements. Crop nutrient budgets, travel distances, and transport costs are used to compare the economic value of poultry litter to that of commercial fertilizer. Within the breakeven transport distance for litter and without a subsidy, average per-acre cost savings from using litter on non-legume crops range from $6-$7, including all transport, handling, and application costs. Savings would be higher with multiple-year applications to crop rotations. Over 2.1 million tons of poultry litter could be used within the breakeven transportation distance with 100 percent adoption of poultry litter on crop, hay, and pasture acreage. Nearly 80 percent of such application potential is on hay and pasture acres. Focus groups organized with current and potential litter users indicate that concerns about price, logistics of handling, storing, and spreading litter, performance as a nutrient source, weed seeds in litter; supplemental commercial fertilizer applications, and regulatory concerns could limit adoption of poultry litter for fertilizer. If a reduced adoption rate of 50 percent of corn, wheat, and barley acres and 10 percent of hay and pasture acreage and no transport subsidy is assumed, 374,000 tons of poultry litter would be used within the breakeven distance at a savings of nearly $17 million to litter users. Most litter is currently transported only 50 to 100 miles. A transport program subsidized by a public agency or public/private collaboration would likely increase adoption rates and extend the distance that poultry litter is transported. A potential program that assumes low adoption rates and pays transport costs up to a maximum subsidy rate of $11 per ton could transfer 374,000 tons of poultry litter to a distance of 170 miles at a total subsidy cost of approximately $2.8 million annually or an average of $7.90 per ton. A more restricted program designed to transfer approximately 135,000 tons up to 100 miles would cost approximately $559,000 per year. The cost of such a program would vary depending on participation rates and on changes in production of poultry and poultry litter. Expansion of alternative uses for poultry litter would also decrease the cost of a litter transport subsidy program. Public concerns imply that further research concerning the issues of raw litter transport and alternative uses is warranted.

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Introduction

"Great opportunities are often brilliantly disguised as unsolvable problems." -- Anonymous

Over the past 20 to 30 years, the agricultural industry in Virginia has experienced many changes. Perhaps the most striking of these changes is the composition of agriculture within the state. The broiler and turkey industries have expanded rapidly following the national trend of increased poultry consumption. In 1978, the poultry industry produced 18.7 percent of Virginia farm cash receipts. By 1998, poultry receipts had risen to 32.8 percent of all Virginia cash receipts (Virginia Agricultural Statistics).

Virginia provides a sizeable proportion of the additional poultry being consumed in the United States and abroad. In 1998, Virginia ranked fourth nationally in turkey production and eighth in broiler production. According to the Virginia Poultry Federation, the industry has built over 700 new houses in Virginia since 1990. This growth brought the total of farms with poultry to over 1,300 in Virginia in 1996.

One of the direct results of increased poultry production is the production of large quantities of poultry litter, which can be used as a substitute for or supplement to commercial fertilizer. In 1996, nearly 15.2 billion pounds of broiler litter were produced in the United States. This amount of broiler litter is enough litter to cover a two-lane highway 3 feet deep for 1,619 miles or the distance from New Orleans, Louisiana to Chicago, Illinois and on to Fargo, North Dakota (*Poultry Water Quality Handbook*, Section 2-3).

In early 1999, amidst concerns for water quality in poultry production regions, the Virginia General Assembly passed House Bill 1207[1], a regulatory program for the management of poultry waste. This bill requires that confined poultry operations of more than 200 animal units (20,000 broilers or 11,000 turkeys) must obtain a permit which requires a nutrient management plan. All nutrient management plans for poultry producers developed after October 1, 2001 must provide for phosphorous application rates which do not exceed the greater of crop nutrient needs or crop nutrient removal. By requiring that poultry litter be applied on a phosphorous basis, HB 1207 will induce export of litter from producing farms and make more poultry litter available to those who wish to use it for fertilizer or feed.

In the past, poultry litter has primarily been applied on land close to poultry production. The costs of transporting litter much further than 100 miles from the point of origin have been considered

[1] Full text in Appendix A.

prohibitive. HB 1207 requires that a poultry waste transportation study be conducted and authorizes the establishment of a "transportation use and alternative use program between the Commonwealth and commercial poultry processors…". This study examines the possibility of transporting poultry litter throughout Virginia, the economic feasibility of such transportation, and the possibility of a cost-share program to assist in managing this process.

Chapter

1

Poultry Production in Virginia

The quantity of poultry litter produced can be estimated using county poultry production from the *1997 Virginia Census of Agriculture*. 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. 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).

The Shenandoah Valley Region includes four poultry-producing counties. Rockingham is the number one county in Virginia in poultry production and farm cash receipts. Augusta ranks second in overall poultry production and in cash receipts. According to the *1997 Virginia Census of Agriculture*, Rockingham accounts for 45.6 percent of Virginia broiler production. The second-ranking county for broiler production is Page which accounts for 17.2 percent. Rockingham also leads turkey production with 52.8 percent of production. The second-ranking turkey county is Augusta, with 24.6 percent of production.

The top 13 poultry-producing counties and their respective state share are shown in Table 1-1. This table clearly shows the dominance of the Shenandoah Valley in Virginia poultry production. Nevertheless, significant poultry production occurs in the other regions of the state as well.

Table 1-1. Virginia Poultry Production[1], 1997

County	Broilers		Turkeys	
Region	**(thousands)**	**% of state total**	**(thousands)**	**% of state total**
Accomack	22,432	9	(D)	(D)
Eastern Shore	*22,432*	*9*	*(D)*	*(D)*
Augusta	7,934	3	6,406	25
Page	44,499	17	2,228	9
Rockingham	117,987	46	13,757	53
Shenandoah	17,566	7	1,856	8
Shenandoah Valley	*187,986*	*73*	*24,247*	*95*
Isle of Wight	2,949	1	0	0
Southhampton	1,424	1	0	0
Suffolk	1,563	1	0	0
Southeast	*5,936*	*3*	*0*	*0*
Amelia	13,711	5	0	0
Buckingham	4,508	2	0	0
Cumberland	8,965	3	0	0
Nottoway	6,523	3	0	0
Prince Edward	1,647	1	0	0
South Central	*35,354*	*14*	*0*	*0*
Virginia Total	*258,684*	*100*	*26,031*	*100*

Source: 1997 Virginia Census of Agriculture
(D) Denotes not all could be disclosed due to reporting requirements.

[1] Counties with significant proportion of state production.

Poultry Litter Production

There are four major vertically integrated companies operating in Virginia. These companies contract with growers who operate on short-term contracts. The companies typically own the birds and the feed. Growers own the poultry houses and manage bird production. The growers are also responsible for disposing of dead birds and litter, and for purchasing poultry bedding. The growers are typically paid based on how much weight the birds gain relative to how much they are fed. The number of birds grown per house varies widely based on the capacity of the house. In some cases, the grower is allowed to decide when litter cleanout is conducted. In other cases, poultry integrators mandate when the houses are cleaned out. National literature indicates houses are typically cleaned out once per year (Evers, p.1). However, this practice varies widely, and producers in the Shenandoah Valley clean houses at a frequency that varies between once per flock to once every five years. Turkeys produce considerably more litter than broilers per bird, and this increased litter production also affects cleaning rates. Bedding material in Virginia typically consists of pine shavings or peanut hulls. The amount of bedding spread in a house varies depending on grower preference and bedding costs, and the type of bedding chosen is based on price and availability. Growers cite little or no preference between the two bedding types, other than the perceived appeal of peanut hulls in poultry litter used for cattle feed. When the house is cleaned out, the poultry litter consists of poultry excreta, feathers, wasted feed, and bedding materials (Evers, p.1).

Growers may clean out the houses themselves, or permit others to clean their houses. If someone else cleans the house, the common exchange is to receive the poultry litter in return for the cleaning service. The houses are cleaned using equipment such as a skid loader or a tractor outfitted with a scraping device. If the poultry grower cleans out the house, the poultry litter has been typically sold for $12-15 per ton for feed or $3-6 per ton for fertilizer (depending on season). Typically, turkey litter is only suitable for fertilizer while most broiler litter may be also suitable for livestock feed. However, nearly all broiler litter is currently used for fertilizer. Poultry litter used for livestock feed should be very low in moisture and granular in consistency. Litter not used for feed is typically removed from the house in a process called caking. According to various producers, litter should then be deepstacked in storage sheds for at least seven days to kill bacteria in the litter with heat.

Over 95% of poultry litter produced in the United States is applied to agricultural land as fertilizer (Evers, p.1). Poultry litter as a fertilizer has several desirable attributes in addition to nitrogen, phosphate, and potash nutrients. These attributes include slower nitrogen release, which reduces leaching; potassium and calcium content, which reduces soil acidity; and organic matter, which improves the water and nutrient holding capacity of the soil (Evers, p.1). As with commercial fertilizer, poultry litter should be applied at rates appropriate for the soil type and crop. Timing of any fertilizer application is also extremely important in order to avoid nitrogen losses and to assure nutrient availability at the appropriate time. Failure to consider proper application rates and timing can result in leaching and run-off of nitrogen and phosphorous. These nutrients, although valuable to plants at appropriate levels, pose potential environmental hazards if they reach surface or ground water.

Table 1-2 indicates the estimated amount of poultry litter produced in Virginia during 1997 based on the poultry production shown in Table 1-1. For these calculations, broilers were assumed to produce 1.25 tons of manure per thousand birds, and turkeys were assumed to produce 9 tons of manure per thousand birds (Coelho and Kornegay, p.11 and Virginia Department of Conservation and Recreation)[2]. When the poultry litter for the counties included in the Shenandoah Valley region (Augusta, Page, Rockingham, and Shenandoah) are summed, the region alone accounts for over 82 percent of the total poultry litter produced in Virginia.

[2] These estimates understate total poultry manure and litter produced, since neither chicken layers nor broiler and turkey breeder flocks are considered.

Table 1-2. Virginia Poultry Litter Production, 1997

County/*Region*	Broiler Litter Produced (tons)	Turkey Litter Produced (tons)
Accomack	28,041	(D)
Eastern	*28,041*	*(D)*
Augusta	9,918	57,656
Page	55,624	20,049
Rockingham	147,484	123,810
Shenandoah	21,958	16,708
Shenandoah Valley	*234,983*	*218,223*
Isle of Wight	3,686	0
Southhampton	1,781	0
Suffolk	1,954	0
Southeast	*7,421*	*0*
Amelia	17,139	0
Buckingham	5,635	0
Cumberland	11,206	0
Nottoway	8,154	0
Prince Edward	2,058	0
South Central	*44,192*	*0*
Virginia Total	*323,356*	*234,276*

Source: 1997 Census of Agriculture
Broilers 1.25 tons litter/1000 birds (Coehlo and Kornegay, p. 11)
Turkeys 9 tons litter/1000 birds (Coehlo and Kornegay, p.11)
(D) Denotes not all could be disclosed due to reporting requirements. Some numbers may not sum due to rounding.

Poultry Litter Nutrient Content

Poultry litter contains nitrogen, phosphorus, and potassium compounds as well as small amounts of some micronutrients. The form of the major nutrient compounds are nitrogen (N), phosphate (P_2O_5), and potash (K_2O). Typical concentrations of these nutrients in Virginia poultry litter are shown in Table 1-3. The phosphate levels in Table 1-3 are based on poultry not receiving the feed supplement phytase[3].

Table 1-3. Nutrient Content of Poultry Litter

Nutrient	Broiler Litter (lbs/ton)	Turkey Litter (lbs/ton)
Nitrogen (N)	62.58	61.75
Phosphate (P_2O_5)	62.12	63.68
Potash (K_2O)	28.57	24.36

Source: Virginia Tech Manure Testing Laboratory, 1987.

The concentrations shown in Table 1-3 were compiled from manure tests completed by the Virginia Tech Manure Testing Laboratory. The nutrient concentrations indicated are used by the Department of Conservation and Recreation in the development of nutrient management plans. These nitrogen concentrations appear to be lower than other averages. New data from North Carolina and Pennsylvania (Carter and *Poultry Waste Management Handbook*) indicate that the nitrogen concentration of broiler litter is often closer to 70 pounds per ton. Analysis of unpublished Virginia litter tests from 1998-99 indicate average total nitrogen concentrations of 71.6 pounds per ton. However, since nutrient management plans are based on the Nutrient Management Planning Standards, the estimate of 62.58 lbs of nitrogen per ton of broiler litter was used in this study as well as the P_2O_5 and K_2O concentration found in Table 1-3. Using Virginia poultry litter production shown in Table 1-2, and nutrient concentrations found in Table 1-3, it is possible to estimate nutrient production for the top 13 poultry producing counties/cities in Virginia. Nutrients produced by broilers are shown in Table 1-4 and by turkeys are shown in Table 1-5.

[3] The supplement phytase is a feed additive developed to reduce the amount of phosphorous in poultry litter. Phytase use is expected to reduce phosphorous content in litter by 15-35 percent. However, investigations determining the field effectiveness of feeding phytase to Virginia poultry are still in progress.

Table 1-4. Broiler Litter Nutrients, 1997

County/ *Region*	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_20)
	(thousand lbs)	(thousand lbs)	(thousand lbs)
Accomack	1,755	1,742	801
Eastern Shore	*1,755*	*1,742*	*801*
Augusta	621	616	283
Page	3,481	3,455	1,589
Rockingham	9,230	9,162	4,214
Shenandoah	1,374	1,364	627
Shenandoah Valley	*14,706*	*14,597*	*6,713*
Isle of Wight	231	229	105
Southhampton	111	111	51
Suffolk	122	121	56
Southeast	*464*	*461*	*212*
Amelia	1,073	1,065	490
Buckingham	353	350	161
Cumberland	701	696	320
Nottoway	510	507	233
Prince Edward	129	128	59
South Central	*2,766*	*2,746*	*1,263*
Virginia Total	*20,236*	*20,087*	*9,238*

Source: 1997 Census of Agriculture, Virginia Tech Manure Testing Laboratory
Totals may not sum due to rounding.

Table 1-5. Turkey Litter Nutrients, 1997

County/ *Region*	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_20)
	(thousand lbs)	(thousand lbs)	(thousand lbs)
Accomack	(D)	(D)	(D)
Eastern Shore	*(D)*	*(D)*	*(D)*
Augusta	3,560	3,672	1,404
Page	1,238	1,277	488
Rockingham	7,645	7,884	3,016
Shenandoah	1,032	1,064	407
Shenandoah Valley	*13,475*	*13,896*	*5,315*
Isle of Wight	0	0	0
Southhampton	0	0	0
Suffolk	0	0	0
Southeast	*0*	*0*	*0*
Amelia	0	0	0
Buckingham	0	0	0
Cumberland	0	0	0
Nottoway	0	0	0
Prince Edward	0	0	0
South Central	*0*	*0*	*0*
Virginia Total	14,467	14,919	5,707

Source: Estimated from 1997 Census of Agriculture, Virginia Tech Manure Testing Laboratory litter sample results.
(D) Denotes not all could be disclosed due to reporting requirements. Totals may not sum due to rounding.

Summed nutrient production for broilers and turkeys from Tables 1-4 and 1-5 are shown by region in Table 1-6. The Shenandoah Valley is the dominant Virginia region in poultry nutrient production, accounting for 82 percent of total nitrogen in litter production, 84 percent of phosphate, and 82 percent of potash. The next closest region is South Central, which accounts for 7 percent of nitrogen, 8 percent of phosphate, and 8 percent of potash.

Table 1-6. Virginia Poultry Litter Nutrients by Region, 1997[1]

Region	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_20)
		---(thousand lbs)---	
Eastern Shore	1,755	1,742	801
Shenandoah Valley	28,181	28,494	12,029
Southeast	464	461	212
South Central	2,766	2,746	1,263
Total	34,702	35,006	14,945

Source: 1997 Census of Agriculture, Virginia Tech Manure Testing Laboratory
[1]Estimates are conservative due to census reporting disclosure requirements.

Poultry Litter Nutrient Availability to Crops

Nutrient concentrations per ton of broiler and turkey litter were weighted by total tons produced to estimate the nutrient concentration of a 'typical' ton of litter. The weighted average nitrogen concentration is 62.23 pounds, phosphate concentration is 62.86 pounds, and potash concentration is 26.57 pounds per ton of poultry litter.

Not all nitrogen in poultry litter removed from a production facility will be immediately available to the crops or pastures on which it is applied. Some nitrogen is lost through volatization of ammonium (NH_4-N). A portion of the organic nitrogen is not available to plants in the first year after application. In estimating nitrogen availability from poultry litter applications, the following assumptions are used:

1) Organic/inorganic nitrogen per ton
   (Source: *Virginia Nutrient Management Standards and Criteria*)
   Organic N: 77 percent
   Inorganic N: 23 percent
2) Ammonium volatization after application
   (Source: *Virginia Nutrient Management Standards and Criteria*)
   Spring application, no incorporation: 50 percent

3) Organic N availability
   Year 1: 60 percent
   Year 2: 12 percent
   Year 3: 5 percent
   Year 4: 2 percent

Therefore, the 'typical' ton of poultry litter estimates the following nitrogen availability during the first year after application:

1) Organic N:
   62.23 lbs x 77% organic x 60% Year 1 availability = 28.75 lbs/ton
2) Inorganic N:
   62.23 lbs x 23% inorganic x 50% availability after volatilization = 7.16 lbs/ton
3) Total Year 1 availability:
   28.75 lbs/ton Organic N + 7.16 lbs/ton Inorganic N = 35.9 lbs/ton N available

Table 1-7 shows that after four years of annual applications, 45 pounds of nitrogen will be available to plants from each ton of litter applied. According to *Virginia Nutrient Management Standards and Criteria*, all phosphate and potash applied are considered available to the plant in year 1. Accordingly, it is assumed that each ton of poultry litter applied to crops, hay, or pasture provides the following plant-available nutrients during the first year after application: nitrogen 36 lbs/ton, phosphate 62.86 lbs/ton, and potash 26.57 lbs/ton.

Table 1-7. Plant Available Nitrigen From Annual Applications[1]

	Pounds of N Available per Ton of Applied Litter				
	--Year --				
Annual Application	**1**	**2**	**3**	**4**	**5**
1st	36	6	2	1	---
2nd	---	36	6	2	1
3rd	---	---	36	6	2
4th	---	---	---	36	6
5th	---	---	---	---	36
Total	36	42	44	45	45

[1] N pounds rounded to nearest integer.

Other Organic Waste Production

Poultry litter is not the only organic waste currently being used for land application as fertilizer in Virginia. Dairy manure, other livestock and poultry manures, and biosolids from waste treatment plants are applied. This study does not estimate all nutrient production from other poultry and livestock sources, but applications of biosolids and estimates of dairy manure are compiled here for reference purposes.

Municipal biosolids are currently contracted for application as fertilizer in Virginia. These biosolids are generated from Virginia wastewater treatment facilities and from the Blue Plains Wastewater Treatment Plant in Washington, D.C. In 1994, 157,000 tons of dry biosolids were applied in Virginia. The nutrient value of these biosolids varies greatly depending on the treatment method. For 157,000 dry tons, the plant available nitrogen content is approximately 3.1 million pounds or 1,570 tons per year. This value is based on an average of 20 pounds of plant available nitrogen per dry ton of biosolids (Evanylo, 1999a).

On average, potash constitutes 0.4 percent of biosolids, thus approximately 628 tons of potash were applied in biosolids. The concentration of phosphate in biosolids is approximately 2.5 percent. However, phosphate available for plant uptake is uncertain, and a range of 50 percent to 100 percent is commonly cited. Therefore, phosphate availability from biosolids applications in 1994 ranged from 1,963 to 3,925 tons (Evanylo, 1999a).

More recent data is available indicating where municipal biosolids have been applied in Virginia. The Virginia Department of Health maintains records of municipal biosolids land applied by contractors in Virginia. In 1998, municipal biosolids contractors applied biosolids to 27,658 Virginia acres. Of this acreage, records indexed by county indicate where nearly 90 percent of this land is located. Table 1-8 shows the data summarized by Virginia Agricultural Statistics Crop Reporting Districts. A listing of counties in each district is found in Appendix B. Individual county data is not disclosed due to reporting disclosure restrictions.

Table 1-8. Virginia Contractor Land Application of Municipal Biosolids

District	Total Acres
Central	7,830
Eastern	4,285
Northern	9,054
Southern	2,237
Southeastern	370
Western	484
Total	27,658

Source: Virginia Department of Health.

Dairy manure is also being used as fertilizer in various parts of Virginia. Use of dairy manure is especially important in the Shenandoah Valley, where most of the poultry litter is produced. Dairy manure estimates are summarized by Virginia Agricultural Statistics Service regions in Table 1.9. This table only includes counties having over 1,000 milk cows in 1997.

Table 1-9. Virginia Dairy Manure Production, 1997

County and Region	Dairy Cows (#)	Total manure ('000 gals/yr)	Inorganic N (lbs/year)	Organic N (lbs/year)	P2O5 (lbs/year)
Culpeper	3,556	22,159	212,063	288,956	267,461
Fauquier	5,801	36,149	345,945	471,381	436,317
Madison	2,493	15,535	148,671	202,578	187,509
Prince William	1,116	6,954	66,553	90,685	83,939
Rockingham	25,477	158,760	1,519,330	2,070,226	1,916,229
Shenandoah	2,701	16,831	161,075	219,480	203,153
Northern Total	41,144	256,388	2,453,637	3,343,305	3,094,608
Amelia	1,849	11,522	110,266	150,247	139,071
Bedford	3,490	21,748	208,127	283,593	262,497
Campbell	1,212	7,553	72,278	98,485	91,159
Orange	1,360	8,475	81,104	110,512	102,291
Powhatan	1,552	9,671	92,554	126,113	116,732
Prince Edward	1,197	7,459	71,384	97,267	90,031
Central Total	10,660	66,428	635,713	866,217	801,782
Mecklenburg	1,593	9,927	94,999	129,445	119,816
Southeastern Total	1,593	9,927	94,999	129,445	119,816
Floyd	1,379	8,593	82,237	112,056	103,720
Franklin	10,568	65,854	630,226	858,741	794,862
Grayson	2,306	14,370	137,519	187,382	173,444
Montgomery	2,641	16,457	157,497	214,604	198,640
Nottoway	1,180	7,353	70,370	95,885	88,753
Patrick	1,388	8,649	82,774	112,787	104,397
Pittsylvania	2,171	13,529	129,468	176,412	163,290
Pulaski	1,376	8,575	82,058	111,812	103,495
Smyth	2,388	14,881	142,409	194,046	179,611
Tazewell	1,257	7,833	74,962	102,142	94,544
Washington	4,519	28,160	269,492	367,208	339,892
Wythe	4,048	25,225	241,404	328,935	304,467
Southwestern Total	35,221	219,479	2,100,417	2,862,010	2,649,115
Augusta	10,234	63,773	610,308	831,601	769,741
Botetourt	1,803	11,235	107,523	146,509	135,611
Rockbridge	1,625	10,126	96,907	132,045	122,223
Western Total	13,662	85,135	814,738	1,110,155	1,027,575
State Total	102,280	637,357	6,099,505	8,311,133	7,692,897

Sources: *1997 Virginia Census of Agriculture, Virginia Department of Conservation and Recreation*, and Pease, et al.
[1] Counties with over 1,000 Milk Cows

Table 1-9 shows that the Northern and Southwestern regions dominate dairy production. Together these two regions account for 75 percent of Virginia dairy manure production. The Northern region alone accounts for 40% of dairy manure production. Moreover, if Augusta County (which borders the Northern region) were added, the Northern region would account for over 50 percent of production. The Northern region also closely overlaps the poultry production of the Shenandoah Valley. The Northern region also is the largest user of municipal biosolids. Thus, in the Northern region, poultry litter competes as a nutrient source with municipal biosolids and dairy manure in addition to commercial fertilizer. However, the limited availability and higher transportation costs of municipal biosolids and dairy manure give poultry litter a competitive advantage.

The Southwestern region accounts for 34 percent of dairy manure production and does not overlap any of the major poultry production areas. The farm land nutrient needs in this region far exceed the amount of dairy manure produced. This region also has no reported use of biosolids and most counties within this region are over 100 miles from Harrisonburg. In this region, commercial fertilizer has few competitors and the distance from poultry production regions has been a prohibitive factor in the use of poultry litter as fertilizer.

Due to applications of municipal biosolids and dairy manure for fertilizer in Virginia and the lack of detailed county data, the potential cropland nutrient use from poultry litter will be somewhat overestimated in Chapter 3. The data contained in Tables 1-8 and 1-9 indicate any overestimation would be the highest in the Northern, Central, and Southwestern districts.

Chapter

2

Potential Value of Poultry Litter as Fertilizer in Virginia

Because of crop nitrogen/phosphorus nutrient ratio requirements, rotation considerations, and other management requirements, some crops are more suitable than others for nutrient application with litter. An example of a crop relatively well-suited for poultry litter applications is corn. Litter applications in spring before planting can provide nutrients at the time needed by growing plants. An example of a crop whose nutrient needs are less well-served by poultry litter applications is soybeans. Soybeans do not require nitrogen applications, and a valuable nutrient source in the poultry litter would be underutilized.

Another important criterion in determining the suitability of a crop for poultry litter applications is the manner in which fertilizer is applied. Some crops require a very uniform fertilizer application. For crops such as wheat and barley, the application of poultry litter must be closely monitored to ensure that nutrient needs are not exceeded at any given time. Although wheat and barley are not the best-suited crops for poultry litter, success using poultry litter for fertilizer can be achieved with monitored applications at the appropriate times.

With these criteria in mind, the crops which are considered by agronomists to be best-suited for poultry litter applications are listed in Table 2-1[4]. The 1997 harvested acres of each crop are also shown.

[4] Source: Personal communication, Dr. Daniel Brann, Crop and Soil Environmental Sciences, Virginia Tech and Russ Perkinson, VA Department of Conservation and Recreation.

Table 2-1. Virginia Crop, Hay, and Pasture Acres, 1997	
Crop	**'000 Acres**
Corn Grain	325
Corn Silage	165
Alfalfa	130
Other Hay	1,110
Wheat	250
Barley	65
Pasture[1]	1,520
Total	3,565

Source: Virginia Census of Agriculture 1997 and Virginia Agricultural Statistics Bulletin 1997
[1] "Cropland Used for Pasture" includes land used for pasture which could have been used for cropland without further improvements. All such land is assumed to be suitable for litter applications.

Procedures for Estimating Crop Needs

Several factors determine the potential litter nutrient needs of crop enterprises suitable for poultry litter applications. The first factor includes the nutrient needs of each crop. The nutrient needs for the crops listed in Table 2-1 can be found in the *Virginia Nutrient Management Standards and Criteria* published by the Virginia Department of Conservation and Recreation and most recently revised in November 1995. This publication provides standard nutrient recommendations for crops in Virginia based on soil productivity group and soil test levels of phosphorous and potash.

In previous studies, representative soil types and soil test levels have been used to estimate nutrient needs for the entire state. In order to reflect county-specific data, a method was developed to estimate soil productivity and to use such information along with reported soil test results to estimate nutrient needs by crop and by county.

Recommended nitrogen applications for each crop enterprise are based on soil productivity group in the VALUES system (Donohue et al.). County-level soil productivity was estimated by 1) computing the average of 1994-1997 county yields for each crop; 2) associating the average yield thru Table I-2 of the *Virginia Nutrient Management Standards and Criteria*[5] to estimate a soil productivity group for each crop and county; and 3) determining the appropriate nitrogen recommendation for each county's crop according to Table 3 of the *Virginia Nutrient Management Standards and Criteria*. The midpoint of the suggested application rate for each soil productivity group was used to estimate nitrogen needs by crop and county. This method generates a reasonable estimate of crop nitrogen needs tied to actual yields. However, nutrient needs estimates may vary in accuracy. Historical yields are not so strictly associated with

[5] Table I-2 can be found in Appendix C

recommended nutrient applications if yields and soil productivity are asymmetrically distributed within the county, or if managers do not accurately estimate expected yields.

To compare these nitrogen crop needs with previous studies, the county nitrogen recommendations were then weighted by crop acres per county to calculate state average nitrogen agronomic recommendations for each crop. The agronomic average nitrogen need compared very closely to previous nitrogen needs estimates calculated on a statewide basis using a typical soil productivity type for the state (Bosch, p.13). County nitrogen needs were also estimated based on plant nutrient uptake of the calculated average yield[6].

Estimation of phosphate and potash nutrient needs was based on soil tests. These results categorize soil test levels as low, medium, high or very high. The amount of phosphate or potash recommended for a crop is then based on the soil test level (Simpson et al.). County soil test summaries from 1995-1997 published by the Crop Soils and Environmental Sciences Department at Virginia Tech were used to determine soil test levels for each crop by county (http://www.ext.vt.edu/vce/specialty/cropsoil/testsum/, accessed September 27, 2000). The percentage of soil test results falling within each level was then weighted by county harvested acres of each crop to provide an estimate of acres by soil test level for each crop/county, and consequently the agronomic nutrient recommendation.

In addition, phosphate uptake by crop was estimated. Agronomic recommendations indicate the nutrients that the plant needs to achieve optimum growth. Plant uptake, on the other hand, indicates the amount of nutrients that the plant removes from the soil. For "high" and "very high" soil test phosphorus levels, there is expected to be no agronomic response from phosphate applications. In such cases, nutrient management planning does allow for application of phosphate in an amount equal to expected plant uptake. Potential phosphate applications by county and crop were thus calculated based on both agronomic needs and plant uptake, and the greater of the two estimates is used here as reflecting county phosphate need.. The plant uptake needs result in state phosphate applications higher than those estimated for application based on agronomic needs.

Total Nutrient Needs

Based on the methodology described above, county nutrient needs were determined for each crop on a county basis. A weighted average of these results on a state basis is found in Table 2-2.

[6] *Chesapeake Bay Region Nutrient Management Training Manual*, Table 3-4.

Table 2-2. Virginia Weighted Average Crop Nutrient Needs[1]

Crop	Nitrogen (lbs/acre)	Phosphate (P2O5) (lbs/acre)	Potash (K2O) (lbs/acre)
Corn Grain	116 (75-140)[2]	54 (29-100)	61 (43-93)
Corn Silage	113 (75-140)	54 (43-75)	138 (120-176)
Wheat	100	53 (38-77)	68 (56-91)
Barley	100	52 (38-70)	72 (61-84)
Alfalfa	0	51 (42-64)	182 (159-201)
Other Hay	90	57 (39-67)	100 (83-122)
Pasture	50	61 (35-73)	59 (47-80)

[1]Crop nutrient need by county weighted by harvested acreage across state calculated from Virginia agricultural statistics and http://www.ext.vt.edu/vce/specialty/cropsoil/testsum/

[2]Range of nutrient need across counties. Crop nutrients without range indicate constant nutrient need across counties.

Table 2-3 summarizes estimates of total crop nutrient needs for 1997. The amount of poultry litter necessary to meet such nutrient needs on a phosphorous basis (assuming that no additional phosphorous is applied through commercial fertilizer applications, other livestock manure, or biosolids) is also indicated.

Table 2-3. Virginia Crop Nutrient and Litter Needs

				Litter Need Based on:	
Crop	Nitrogen (mill. lbs.)	Phosphate (mill. lbs.)	Potash (mill. lbs.)	Nitrogen Basis ('000 tons)	Phosphate Basis ('000 tons)
Corn Grain	36.7	17.0	19.3	1,020.2	270.0
Corn Silage	15.5	7.4	19.0	431.3	117.7
Wheat	26.4	14.1	17.8	732.8	224.3
Barley	7.3	3.8	5.2	201.8	60.4
Alfalfa	0	6.2	22.2	0	98.5
Other Hay	92.9	58.8	103.4	2,580.8	935.1
Pasture	74.4	91.5	87.2	2,066.3	1,455.3
Total	253.2	193.7	274.7	7,033.2	3,161.3

Litter needs are based on the weighted average poultry litter nutrient concentrations described in Chapter 2. Litter nutrient needs based on phosphorous and nitrogen needs by crop and county are shown in Appendix D. Shifting from a nitrogen to a phosphorus basis for litter applications indicates that the amount of litter which can be applied is reduced by more than 50 percent.

The top ten counties in Virginia based on the potential quantity of poultry litter that could be applied on a phosphorous basis on all corn, wheat, barley, hay, and pasture acres are Augusta, Rockingham, Fauquier, Loudon, Bedford, Pittsylvania, Washington, Wythe, Albemarle, and Franklin. The total quantity of poultry litter that could be applied if poultry litter were used on all corn, wheat, barley, hay and pasture acres on a phosphorous basis in these counties is more than 917,000 tons, far more than state production. However, three-fourths of suitable crop

acreage in these ten counties is hay and pasture. Much of this hay and pasture is not intensively managed and would not typically receive annual commercial fertilizer applications. In addition, most of these counties are located too far from poultry production regions for litter transport to be feasible.

The top ten counties based on potential use of poultry litter on only corn, wheat, and barley acres are: Rockingham, Accomack, Essex, Augusta, Northumberland, Westmoreland, King William, Chesapeake, Hanover, and Fauquier. These ten counties alone could use over 230,000 tons of poultry litter if all acres of corn, wheat, and barley were fertilized at poultry litter application rates calculated on a phosphorous basis. Transport costs become a significant factor because the distance of the counties from Harrisonburg ranges from Rockingham County (in the middle of the poultry production region) to Chesapeake (more than 200 miles from Harrisonburg).

Economic Value of Poultry Litter Versus Commercial Fertilizer

Determining the economic value of poultry litter relative to commercial fertilizer helps to estimate the potential use of poultry litter as fertilizer in Virginia. The 1991 Bosch and Napit study *The Economic Potential for More Effective Poultry Litter Use in Virginia* indicates that poultry litter could be a viable alternative to commercial fertilizer when applied on a nitrogen basis. In order to assess the economic feasibility of poultry litter as fertilizer, it is necessary to estimate the relative costs of fertilization with chemical fertilizer compared to the costs of using poultry litter as fertilizer.

Several key assumptions are used to make this comparison. The first assumption is based on estimated plant available nitrogen as described in Chapter 1. The estimated plant available nitrogen per ton of poultry litter is 36 pounds in the first year. If annual applications in equal quantities are made for 4 years, 45 pounds of nitrogen will be plant-available per ton due to carryover effects. However, in this study, the conservative first-year value of 36 pounds will be used. Another key assumption is that poultry litter will be applied on a phosphorous basis. Beginning in October of 2001, nutrient management plans for poultry growers will require that litter applications on their farms be made on a phosphorous basis. In addition, it is assumed that farmers receiving government support for litter use will be required to apply litter on a phosphorous basis as well. A final key assumption is that the phosphorous content of litter is based on poultry rations typical before introduction of the feed supplement phytase, which reduces the concentration of phosphorous in poultry litter.

Using these assumptions and secondary data sources, nutrient costs with chemical fertilizer and poultry litter as alternative nutrient sources for corn (grain and silage), wheat, barley, alfalfa and other hay, and pasture were estimated. Table 2-4 summarizes the annual costs for commercial fertilizer for each crop enterprise based on weighted average Virginia crop nutrient needs presented in Table 2-2. These commercial fertilizer costs are based on 1998 average prices.

Table 2-4. Virginia Average Chemical Fertilizer Nutrient Application Rates and Costs[1]

Crop	N Applied (lbs/acre)	P2O5 Applied (lbs/acre)	K2O Applied (lbs/acre)	N Cost ($/acre)	P2O5 Cost ($/acre)	K2O Cost ($/acre)	Total Cost ($/acre)
Corn Grain	116	54	61	30.20	15.56	8.53	59.79
Corn Silage	113	54	138	29.25	15.55	19.32	69.63
Wheat	100	53	68	26.00	15.50	9.45	56.45
Barley	100	52	72	26.00	15.16	10.06	56.72
Alfalfa	0	51	182	0.00	14.72	25.43	45.66
Other Hay	90	57	100	23.40	16.51	14.02	59.44
Pasture	50	61	59	13.00	17.83	8.20	44.53

[1] Application rates are acreage-weighted averages of estimated county rates. Commercial nutrient costs for this analysis are $0.26/lb (nitrogen), $0.29/lb (phosphate), and $0.14/lb (potash). Total cost includes $5.50/acre application charge. Source: *Agricultural Price Summary*, USDA, July 1998 (Nutrient Prices); *Doane's Ag. Report*, Vol. 2, No. 21-5, 5/21/99. (Fertilizer Application Costs).

To estimate relative costs of poultry litter versus commercial fertilizer, the costs of buying, storing, assembling, and applying poultry litter must be estimated. The removal, assembly, storage, testing, loading, application, and brokerage cost estimates are based on the method developed by Bosch and Napit (1991). The figures reported in the publication were updated with more recent equipment and labor costs based on July 1998 *Agricultural Prices* and on information from litter brokers in the Shenandoah Valley. It is assumed that litter is hauled 10 miles in a walking trailer to a storage facility. A front-end loader is used to fill a 14-ton fertilizer spreader. Loading and spreading takes 50 minutes per load.

The following assumptions are used to estimate poultry litter application costs:

8,000 tons per year hauling capacity

1 full-time employee

25-ton walking bed trailer to haul litter

4,000-ton storage capacity for assembling litter haul

$0.70 per ton loading cost

14-ton spreader on truck

These assumptions are used to calculate costs per ton of poultry litter (Table 2-5). Cost details are described in Appendix E. Costs assume that litter is cleaned out of houses in exchange for free litter. Depending upon supply and demand conditions, producers could earn $3 or more per ton above costs by selling their litter at the farm.

Table 2-5. Assembly, Storage, and Other Costs of Poultry Litter[1]

	$/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

Source: Equipment Types and Prices came from *Agricultural Price Summary*, USDA, July 1998, various litter brokers in the Shenandoah Valley, and Bosch and Napit, June 1991.
[1] Costs based on July 1998 and May 1999 prices

The poultry litter application rates to satisfy state weighted average nitrogen and phosphorus needs of each crop are found in Table 2-6. Litter applications on a nitrogen basis supply all nutrient needs for the crop (except for alfalfa, which has no nitrogen requirement). Litter applications on a phosphorus basis require subsequent supplementation with commercial nitrogen and potash to satisfy crop needs.

Table 2-6. Litter Application Rate Satisfying Crop Nutrient Requirements

Crop	Nitrogen Basis	Phosphorous Basis[1]
	---tons/acre---	
Corn Grain	3.2	0.9
Corn Silage	3.1	0.9
Wheat	2.8	0.9
Barley	2.8	0.8
Alfalfa	0.0	0.8
Other Hay	2.5	0.9
Pasture	1.4	1.0

[1] Applications rates are acreage-weighted average rates across Virginia counties producing the crop. P2O5 rates based on greater of average agronomic needs or crop nutrient uptake.

It is difficult and costly to apply litter at low application rates and most producers would rather apply a larger application satisfying nutrient requirements of a multi-year crop rotation. Current nutrient management planning standards permit litter applications sufficient to satisfy two years' phosphate requirements as long as the nitrogen application rate does not exceed the requirements of the crop grown in the first year. Table 2-7 indicates the relative nutrient costs of commercial fertilizer versus poultry litter applications for selected rotations. By applying larger litter rates in a single year, producers can reduce litter application charges, and hence save more money using litter as a nutrient source.

Table 2-7. Two-year Rotation Nutrient Application Rates and Costs[1]

Rotation	Total N Required (lbs/acre)	Total P2O5 Required (lbs/acre)	Total K2O Required (lbs/acre)	Litter Application Rate[2] (tons/acre)	Two-year Commercial Fertilizer Cost ($/acre)	Two-year Litter Cost[3] ($/acre)	Two-year Litter savings ($/acre)
Corn silage/ryelage (continuous)	426	228	396	3.6	$243	$170	$73
Corn grain/wheat, DC soy	216	167	189	2.7	$142	$90	$52
Hay (maintenance)	180	114	200	1.8	$119	$82	$37

[1]Nutrient requirements based on state weighted average county requirements. Commercial fertilizer cost assumes applications at the required rate with fertilizer priced at $0.26/lb N, $0.29/lb P2O5, and $0.14/lb K2O.

[2] Litter application rate calculated to satisfy two-year phosphate needs for the rotation.

[3]Litter cost includes cleanout, storage, handling, and spreading costs, but does not include cost of litter transport.

Unfortunately, there is no reliable Virginia data source indicating the acres planted in a particular rotation. As a second-best alternative, this analysis was conducted assuming that annual litter and chemical fertilizer application rates are applied to individual crops, the data for which is available in Virginia.

The annual cost to satisfy crop nutrient needs using poultry litter is shown for each crop enterprise in Table 2-8. Nutrient budgets are estimated assuming that litter is applied only to satisfy annual P_2O_5 removal rates. Nutrient cost savings with litter applications range from $7.53 per acre for alfalfa (which does not require nitrogen applications) to $18.27 per acre for pasture (which requires the least supplemental nitrogen and potash). As noted above, the cost savings would be more in favor of poultry litter if applied on a multi-year rotation basis.

Table 2-8. Virginia Average Poultry Litter Nutrient Application Rates and Costs[1]

Crop	Litter Applied (tons/acre)	Supple-mental N (lbs/acre)	Supple-mental K_2O (lbs/acre)	N Cost ($/acre)	K_2O Cost ($/acre)	Total Cost ($/acre)	Cost Savings ($/acre)
Corn Grain	0.9	85	38	22.21	5.35	43.84	15.95
Corn Silage	0.9	82	115	21.27	16.15	53.69	15.93
Wheat	0.9	69	45	18.04	6.29	40.57	15.88
Barley	0.8	70	50	18.22	6.96	41.18	15.53
Alfalfa	0.8	0	160	0.00	22.43	38.13	7.53
Other Hay	0.9	57	76	14.92	10.65	42.52	16.92
Pasture	1.0	15	33	3.84	4.56	26.26	18.27

[1]Litter application rates are acreage-weighted average rates across all counties to satisfy phosphate requirement. Supplemental N and K_2O applications satisfy crop nutrient needs. Commercial nutrient costs for this analysis are $0.26/lb (nitrogen), $0.29/lb (phosphate), and $0.14/lb (potash). Total cost includes $5.50/acre commercial fertilizer application charge and $12.63/ton poultry litter charge. Total litter cost does not include litter transport, but does include all other litter-related costs. Source: Agricultural Price Summary, USDA, July 1998 (Nutrient Prices); Doane's Ag. Report, Vol. 2, No. 21-5, 5/21/99. (Fertilizer Application Costs).

[2]Cost savings represents savings from annual litter applications relative to cost of commercial fertilizer applications except for cost of litter transport.

Transportation Costs

Litter brokers in the Shenandoah Valley indicate that poultry litter can be transported in an 18-wheeler walking trailer with 25-ton capacity at a cost of $0.11 per ton-mile without a backhaul and at $0.07 per ton-mile with a backhaul, including the cost of loading litter at a centralized litter storage location. The cost without a backhaul is used here, but opportunities exist for economizing on transport costs with backhauls if bio-security issues could be resolved. The distance that poultry litter can be transported to satisfy phosphorus needs at a per-acre nutrient cost less than or equal to that of commercial fertilizer is found by equating the two costs and solving for mileage:

$$FC = (N\_rec * PN) + (P\_rec * PP) + (K\_rec * KP) + FAPP$$

$$LC = PL\_rec * ((TC * BTD) + LAPP) + PN * (N\_rec - (PLN * PL\_rec)) + PK * (K\_rec - (PLK * PL\_rec)) + FAPP$$

where (all costs on per-acre basis) FC is total cost of commercial fertilizer nutrients and application; LC is total cost of litter, application and chemical fertilizer supplements; N_rec, P_rec, and K_rec are nutrient needs; PN, PP, and PK are unit commercial fertilizer prices; PL_rec is tons of poultry litter to satisfy phosphorus needs, PLN, PLP, and PLK are nutrient concentrations in poultry litter; FAPP is commercial fertilizer application cost, LAPP is all costs of litter application except transport, TC is the per-ton/mile litter transport cost; and BTD is the breakeven transport distance. Equating FC = LC and solving for BTD, it can be shown that, for all crops needing nitrogen applications, the distance litter can be transported at a crop enterprise nutrient cost equal to or less than that of commercial fertilizer is approximately 170 miles. Alfalfa is the only crop that does not need nitrogen, and because litter

nitrogen is not credited in the crop enterprise budget, the BTD for alfalfa is only 85 miles. Crops within counties falling within the BTD are candidates for litter transfers, all beyond that radius are not.

Production of poultry litter is largely concentrated in the Shenandoah Valley. The remaining poultry litter production is spread over the Eastern Shore, South Central and Southeastern portions of Virginia. Combined, the latter three regions produce less than 20 percent of Virginia litter. The litter produced in the Eastern Shore, South Central, and Southeastern regions can be utilized on surrounding crop land at relatively low transportation cost, and these regions are not expected to have surplus litter. However, the Shenandoah Valley region produces approximately 82 percent of Virginia litter. Calculated on a phosphorus basis, the Shenandoah Valley has a large litter surplus, and transportation costs considered here will assume that Harrisonburg, the county seat of Rockingham County, is the primary shipping source. Table 2-9 indicates counties and their county seats within 170 miles of Harrisonburg. Mileages are by the shortest road route from Harrisonburg to the county seat of the receiving county.

Table 2-9. Road Mileage From Harrisonburg

County name	County seat	Distance	County name	County seat	Distance
Rockingham	Harrisonburg	0	Craig	New Castle	117
Augusta	Verona	25	Cumberland	Cumberland	118
Greene	Stanardsville	30	King George	King George	120
Page	Luray	34	Powhatan	Powhatan	120
Shenandoah	Woodstock	40	Buckingham	Buckingham	125
Madison	Madison	46	Bedford	Bedford	126
Orange	Orange	59	Arlington	Arlington	127
Nelson	Lovingston	61	Henrico	Richmond	128
Albemarle	Charlottesville	62	Montgomery	Christiansburg	135
Rockbridge	Lexington	62	Prince Edward	Farmville	136
Warren	Front Royal	64	Franklin	Rocky Mount	136
Culpeper	Culpeper	64	Hanover	Hanover	142
Highland	Monterey	64	Chesterfield	Chesterfield	143
Rappahannock	Washington	66	Prince William	Prince William	143
Frederick	Winchester	70	Pittsylvania	Chatham	146
Bath	Warm Springs	72	Charlotte	Charlotte Court House	146
Fluvanna	Palmyra	78	Westmoreland	Montross	146
Clarke	Berryville	80	New Kent	New Kent	153
Amherst	Amherst	87	Floyd	Floyd	154
Louisa	Louisa	88	Halifax	Halifax	154
Botetourt	Fincastle	95	King William	King William	154
Fauquier	Warrenton	95	Henry	Collinsville	158
Spotsylvania	Spotsylvania	100	Stafford	Stafford	158
Alleghany	Covington	100	Pulaski	Pulaski	158
Loudon	Leesburg	104	Charles City	Charles City	161
Goochland	Goochland	105	Prince George	Prince George	162
Campbell	Rustburg	106	Caroline	Bowling Green	162
Roanoke	Roanoke	110	Amelia	Amelia	165
Appomattox	Appomattox	110	Essex	Tappahannock	169
Fairfax	Fairfax	115	Giles	Pearisburg	169

Table 2-10 shows average cost savings of litter fertilization over commercial fertilizer per crop with and without transportation costs. Transportation costs are significant as litter shipment distances increase. Transporting litter 100 miles may cost as much as all other litter cleanout, assembly, handling, and application costs combined.

Table 2-10. Virginia Average Nutrient Cost Savings Using Poultry Litter[1]

Crop	Litter Savings Except Transport Cost ($/acre)	Litter Savings Including Transport Cost ($/acre)
Corn Grain	15.95	6.27
Corn Silage	15.93	6.75
Wheat	15.88	6.07
Barley	15.53	6.04
Alfalfa	7.53	2.64
Other Hay	16.92	6.94
Pasture	18.27	6.43

[1] Acreage-weighted nutrient cost savings across all counties within the Breakeven Transport Distance (BTD). Transport costs are estimated at $0.11 per ton-mile and are calculated for all counties with listed crops within the BTD.

Table 2-11 indicates potential acreage by crop within the BTD. If all corn, wheat, barley, hay, and pasture acres were available for litter application, over 2.1 million tons of litter could be applied on a phosphorous basis at a cost equal to or less than that of commercial fertilizer. However, nearly 80 percent of such acres are other hay and pasture acres. Current low applications of litter on such acreage warrants considerable caution as to the likelihood of higher adoption rates among farmers if more litter were to become available in such receiving counties. Nevertheless, it appears that poultry litter can be a viable economic alternative to commercial fertilizer if nutrient availability is accurately estimated, if farmers are willing to use litter as a nutrient source, and if transport costs from litter source to the farm of application are accurately considered.

Table 2-11. Potential Litter Needs by Crop/County (100% adoption)[1]

County	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	County Total
				(tons)				
Albemarle	1,891	0	923	1,377	33,515	34,282	426	72,414
Alleghany	0	0	833	0	3,346	6,744	651	11,574
Amelia	0	1,831	1,818	2,023	7,754	7,430	1,071	21,928
Amherst	0	0	0	701	11,638	18,777	0	31,116
Appomattox	0	531	1,221	865	15,333	21,160	1,106	40,215
Augusta	10,058	1,495	9,310	10,473	32,645	55,234	2,027	121,242
Bath	664	0	0	0	6,856	10,397	0	17,917
Bedford	0	0	1,333	3,453	36,241	52,227	554	93,809
Botetourt	0	0	864	1,493	13,672	18,834	488	35,351
Buckingham	0	0	700	0	15,393	15,767	526	32,386
Campbell	0	771	1,549	1,683	18,367	23,344	1,264	46,979
Caroline	0	2,829	5,340	531	2,691	2,886	5,138	19,415
Charles City	0	1,432	4,499	0	0	801	6,313	13,045
Charlotte	0	0	1,176	1,039	13,649	19,088	1,981	36,933
Chesterfield	0	0	508	0	1,948	2,441	982	5,879
Clarke	1,699	738	2,519	1,709	13,149	17,934	1,218	38,966
Craig	0	0	0	0	5,843	11,965	0	17,809
Culpeper	1,707	872	6,353	5,375	24,568	25,471	1,801	66,147
Cumberland	0	0	654	820	7,815	13,266	479	23,033
Essex	0	4,140	11,290	0	0	1,638	8,749	25,816
Fairfax	0	0	0	0	0	594	0	594
Fauquier	0	2,104	8,916	5,830	37,386	42,416	2,461	99,114
Floyd	0	0	802	2,074	19,770	33,783	0	56,429
Fluvanna	611	0	824	0	11,582	11,521	492	25,031
Franklin	0	473	2,412	8,856	25,135	32,174	840	69,890
Frederick	2,827	0	2,845	1,317	16,963	23,413	956	48,321
Giles	0	0	0	0	7,389	17,777	0	25,166
Goochland	0	916	2,373	662	7,047	7,909	2,092	20,999
Greene	415	0	1,101	492	6,379	9,337	0	17,724
Halifax	0	0	2,443	1,078	17,224	32,694	6,912	60,351
Hanover	0	4,690	6,604	1,364	9,021	8,212	7,620	37,510
Henrico	0	675	1,524	0	0	811	2,179	5,189
Henry	0	0	0	0	0	4,185	490	4,674
Highland	717	0	0	0	7,094	882	0	8,693
King George	0	1,082	3,594	0	0	1,437	3,305	9,418
King William	0	3,404	9,593	690	0	820	7,034	21,540
Loudon	0	1,140	9,001	1,695	36,975	40,464	6,544	95,819
Louisa	0	629	2,441	1,265	11,810	14,048	1,428	31,621
Madison	1,455	510	4,440	2,830	15,316	19,115	517	44,182
Montgomery	0	0	1,054	2,080	13,193	19,904	0	36,231
Nelson	512	0	690	0	11,029	18,533	0	30,764
New Kent	0	647	2,181	0	0	561	2,306	5,695
Orange	1,169	905	3,468	2,327	19,101	21,967	742	49,679

Table 2-11. Potential Litter Needs by Crop/County (100% adoption)[1]

County	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	County Total
				(tons)				
Page	1,182	685	2,404	1,358	11,504	14,819	409	32,362
Pittsylvania	0	0	2,702	3,043	29,148	43,222	7,194	85,309
Powhatan	0	0	1,173	1,316	6,197	5,649	342	14,677
Prince Edward	0	493	984	967	11,032	13,730	685	27,891
Prince George	0	0	3,166	0	0	950	3,541	7,656
Prince William	0	725	2,498	1,607	0	6,654	1,198	12,682
Pulaski	0	0	862	1,948	14,652	20,046	0	37,508
Rappahannock	2,057	0	687	0	12,873	16,493	0	32,111
Roanoke	0	0	0	0	4,526	6,477	0	11,003
Rockbridge	2,496	0	1,797	1,529	21,506	31,011	275	58,613
Rockingham	6,214	1,437	12,172	16,009	30,637	41,728	1,696	109,893
Shenandoah	2,791	1,291	4,283	2,995	17,890	25,152	754	55,157
Spotsylvania	0	565	1,447	1,228	9,375	7,356	805	20,776
Stafford	0	0	1,152	0	0	3,325	0	4,477
Warren	822	0	0	0	7,637	9,987	0	18,446
Westmoreland	0	3,851	7,878	0	0	1,225	9,092	22,047
Total	39,286	40,861	160,400	96,100	713,815	970,067	106,684	2,127,212

[1] Litter application satisfying crop phosphate need on 100% of county acres for counties within Breakeven Transport Distance.

Although analysis indicates the economic benefit of using poultry litter as a nutrient source in the above counties, actual usage is much lower. Among other reasons, many crop producers are accustomed to the ease and convenience of commercial fertilizer and are hesitant to use a nutrient product of uncertain concentration, plus requiring more management time and supplemental commercial fertilizer applications. Many producers use other organic fertilizer sources such as biosolids. Some producers are unwilling to use poultry litter due to nuisance concerns related to odor and concerns that the use of litter will be prohibited in some municipalities. Still other producers do not have appropriate road access or appropriate storage. In addition, most hay and pasture acres currently receive very little commercial fertilizer. Producers who do not currently use commercial fertilizer would be unlikely to use poultry litter at the expected rates. The infrastructure of the litter brokerage industry is not fully developed. Litter brokers are hesitant to expand their businesses, partly due to uncertain impacts of new poultry waste management regulations, alternative poultry litter uses, and heavily subsidized poultry litter entering the state from Maryland. Such concerns result in litter applications far less than the potential indicated in Table 2-11. Producer attitudes towards litter use are investigated further in the next chapter.

Chapter

3

Producer Attitudes Towards Poultry Litter Use as Fertilizer

The adoption of poultry litter for use as fertilizer depends not only on the value of litter nutrients, but also on user attitudes and opinions concerning litter performance as fertilizer, handling and application issues, regulatory concerns, and other factors. To elicit potential litter user opinions, several discussion groups were organized.

The meetings were conducted with the participation of Virginia Cooperative Extension personnel in the localities of Warrenton, Harrisonburg, Tappahannock, and Amelia. Participants were selected by the local county extension agent. Over thirty people throughout Virginia participated in discussion groups during October of 1999. Sessions lasted from 1 _ to 2 _ hours. Several telephone discussions were conducted as well. During the group sessions, end users discussed advantages, disadvantages, concerns, hesitations, past experiences and other factors regarding poultry litter use as fertilizer. Group discussions were designed to be conducted in an informal manner with a facilitator guiding.

Table 3-1. Poultry Litter Discussion Groups

Location	Total Participants	Litter Users	Litter Nonusers
Amelia County	10	9	1
Essex County	7	0	7
Fauquier County[1]	6	3	3
Rockingham County	9	9	0
TOTAL	32	21	11

[1] Fauquier participants reflect those conducted by telephone and personal interview

The groups were a valuable tool in determining the primary issues for crop and pasture producers regarding the use of poultry litter. Overall, potential end users expressed interest in trying poultry

litter as a fertilizer or a willingness to continue using poultry litter if they already employed the practice. The major concerns expressed regarding poultry litter use were:

- price
- logistics of handling, storing, and spreading litter
- performance as nutrient source
- weed seeds in litter
- supplemental commercial fertilizer applications
- regulatory concerns

The primary concern mentioned in each group was the cost of poultry litter compared to the cost of commercial fertilizer. Producers indicated pricing of poultry litter would be the primary factor in their decision. After two years of drought, crop and pasture producers are searching for new ways to reduce costs. Virginia grain producers are also looking for ways to reduce costs to strengthen their competitiveness relative to Midwestern grain producers.

Producers also indicated that handling, storage, and spreading concerns would be a major factor in their decision to use litter. Currently, commercial fertilizer and biosolids can be applied to crops and pasture with little manager time required. In particular, large-scale producers indicated an unwillingness to spread the litter themselves. However, they did suggest that if litter were provided at little to no cost, they would consider spreading it themselves if rental equipment were available. Many current litter users were concerned about equipment as well. Much older equipment currently in use does not have the capacity to spread litter at rates less than one or even less than two tons per acre. Given low recommended application rates on a phosphorous basis, such equipment would not be usable. Large-scale producers were also very concerned about how litter would be stored. They expressed serious concerns about storing litter on their farms and about the labor, space, and additional training for workers that on-site storage of litter would require. Participants in several groups were interested in the possibility of obtaining cost-share funds for construction of poultry litter storage sheds. Neighbor concerns regarding litter odor and questions regarding the appropriate times for application were also issues discussed by participants.

Nearly every current user indicated a willingness to continue using litter, and nearly all such users expressed a preference for poultry litter compared to commercial fertilizer. Improved soil organic matter and perceived improvements in water holding capacity were universally seen as major benefits from using poultry litter. Many participants stated that they would continue to use some free municipal biosolids for improving soil quality, even if litter were available.

Concerns were expressed about increased weed seed germination after using poultry litter. Weed seed germination was typically a concern among participants who had not previously used poultry litter. Of those who had used poultry litter, only one producer indicated that he had experienced a weed problem. This user characterized the problem as very minor and expressed the common opinion that "…[poultry litter] makes everything grow better, including the weeds." The same user still

preferred poultry litter compared to any other type of fertilizer available because of its past performance on his row crops. Other current poultry litter users praised the carry-over nitrogen effects and credited soil improvement to poultry litter usage. Producers in Amelia expressed the desire to use more poultry litter, but stated that it is not currently available. Some producers in Amelia had already contracted for poultry litter to be delivered in the spring to ensure availability.

In the Tappahannock group, none of the producers had ever used poultry litter for fertilizer. These participants were the group most concerned about weeds, although the topic was discussed in every group. The Tappahannock group suggested more education and demonstration of poultry litter use as fertilizer in their area to help potential users evaluate the practice. Producers also indicated that incentives or subsidies for using poultry litter as fertilizer would serve to increase adoption and alleviate any weed or yield concerns.

The Tappahannock group was also the group most concerned about the need for supplemental commercial applications. In their area of the state, soil compaction is a serious problem, and group members indicated that they would prefer to run equipment over their fields as few times as necessary. Initially, participants stated that this was only a minor concern; however, as the discussion progressed, it became clear that supplemental commercial applications were perceived as a major issue for some producers. However, if poultry litter performed well, the group expressed the opinion that they would not perceive soil compaction concerns to be a major disincentive to adoption.

Regulatory concerns were the final major issue discussed. Some potential end users were concerned about the possibility that local governing bodies might prohibit the use of poultry litter, as some localities currently prohibit the application of municipal biosolids. Producers indicated they would want to be fully informed about all regulations before adopting poultry litter. Producers are seeking profitable sets of practices over the long term. Their willingness to adopt poultry litter is partially contingent on the long-term prospects of using this product as a fertilizer. Several participants expressed their desire for poultry litter to be considered as demand for "fertilizer" rather than for "organic waste."

Several minor concerns were indicated by participants. The potential requirement of a nutrient management plan was one of these minor concerns. Few participants indicated a nutrient management plan requirement would be a disincentive for using poultry litter. Currently, many producers use biosolids and/or already have nutrient management plans, while others perceive the plans as a source of liability protection for their operations. However, some producers were concerned about the long wait necessary to obtain a nutrient management plan.

The uncertainty concerning nutrient concentration of poultry litter was another minor concern. Participants perceived poultry litter as a relatively consistent product due to the precise rations fed. They would initially be interested in assessing litter nutrient content, but over the longer term it would not be necessary to test each load of litter for nutrient content. Periodic testing would be sufficient if nutrient content were fairly consistent. It is important to potential end users that litter be stacked for at least 7 days before being shipped. Anything more than an occasional dead bird in the litter would be unacceptable to users.

Of all the concerns expressed, the cost of poultry litter use compared to commercial fertilizer was the primary concern. An overall willingness and desire to use poultry litter, if it was inexpensive and

easy to handle, was expressed throughout the state. If the amount of required additional manager and labor time was significant, the willingness to use poultry litter declined among the discussion group participants, particularly among large-scale producers.

Based on the group discussions, poultry litter is competitive with chemical fertilizer under the following conditions. In the best case scenario, the producer would call a broker or an existing fertilizer dealer to order poultry litter several months in advance of application. The end user would indicate which crops or pasture to be fertilized. When application time arrives, poultry litter would be spread on the indicated fields within the time period requested. Producers would not have to store or spread the poultry litter themselves or purchase any additional equipment. A minimum nutrient concentration would be certified by the broker or dealer. The bill for litter brokering, litter, transportation, handling and spreading would be paid to one business entity. Ideally, total cost of using poultry litter for fertilizer would be equal to or less than the cost of commercial fertilizer. End users would like to have the option to apply up to two or three years of crop phosphorous requirements in one application to reduce the need for supplemental commercial fertilizer applications.

Most producers indicated that they would be willing to use poultry litter in any form—raw, pelletized, or granular--on all or part of their acreage if the above conditions existed. Participants clearly expressed the opinion that they would be most willing to use poultry litter if the contractual and application process were as similar as possible to that of commercial fertilizer. Absent such similarity, producers are less likely to use poultry litter as fertilizer. Although opinions varied across producers, participants would likely only fertilize with poultry litter on a smaller portion of their acreage initially if they were responsible for litter storage and spreading. However, some producers, and particularly those with marginal soils, would still be likely to use poultry litter if it could be cheaply transported and delivered.

Chapter

4

Potential Costs of Poultry Litter Transportation Program

HB 1207 Section G 4 implies that cost-share incentives will be available to help litter move from production-intensive regions to farms that can use litter. Assuming some reasonable level of adoption, poultry litter will not move far enough in Virginia to use current surpluses without these incentives. Table 4-1 summarizes litter production and crop, hay, and pasture litter needs on a phosphorus basis for counties in Virginia poultry production regions. Among the four poultry production regions, the least complex to consider is the Southeast region. Litter needs for crops within the Southeast region far exceed production.

Given the small amount of litter production relative to other regions (approximately 1.4 percent of state production) and high crop nutrient needs, cost-share incentives less than 100 percent of transportation costs are unlikely to cause much litter to be exported from the region.

Table 4-1. Poultry Litter Production and Potential Use by Region, 1997[1]

Region	Poultry Litter Produced[2] ('000 tons)	Poultry Litter Needed for Crops[3] ('000 tons)
Eastern Shore	28.0	29.1
Shenandoah Valley	453.2	318.7
Southeast	7.4	51.1
South Central	48.5	128.2

[1] Use within poultry production counties of the region. Crop/hay/pasture needs estimated on phosphorus-need basis.
[2] Summed tons of broiler and turkey litter.
[3] Suitable crops include corn, wheat, barley, hay, and pasture, with 100% adoption.

The South Central region also does not provide enough litter nutrients to satisfy county crop nutrient needs. Participants in the South Central region discussion group indicated that they would be ready and willing to use more litter in crop, hay, and pasture production. Given partial adoption of poultry litter, some litter might be exported to surrounding counties. However, litter from this region is not likely to move long distances, since even partial adoption rates in adjoining counties imply crop needs totaling over 44,000 tons of litter.

Accomack County on the Eastern Shore is a one-county production region with a small surplus of litter over nutrient needs. Given nutrient needs of crops in adjoining Northampton

County, and given that transport across the Bay Bridge Tunnel to other suitable Virginia cropland is costly, it is likely that the best alternative to reduce any surplus litter problem is to reduce phosphorus concentration in litter through applying the enzyme phytase to poultry feed. This alternative would increase allowable application rates and reduce or eliminate any regional litter surplus.

The Shenandoah Valley region has by far the largest litter surplus among Virginia production regions, totaling approximately 135,000 tons on a phosphorus-need basis even if adoption rates were 100 percent of potential acres within the Valley counties. The phosphorus-need estimate presented here does not consider applications of phosphorus fertilizer or phosphorus in biosolids produced by municipal waste treatment plants, poultry processing plants, or other industries. In addition, the litter surplus is further underestimated if it can be reasonably assumed that dairy manure produced in the four counties of the Valley must be applied to Valley fields before consideration of poultry litter. Dairy manure is very expensive to transport and is preferably applied to dairy farm fields or those of close neighbors. Dairy cows in the Valley produce approximately 2.9 million pounds of P_20_5 (Table 1-9). If applied on a phosphorus basis, consideration of dairy manure increases the effective litter surplus of the four Shenandoah Valley counties to at least 180 thousand tons, even if every available farmland acre were to receive litter applications.

On non-poultry farms, litter application rates will not necessarily be restricted to a phosphorus-need basis. Calculation of crop, hay, and pasture nutrient needs on a nitrogen-basis indicates a Shenandoah Valley litter need of 800,000 tons, considerably more than current production. State incentive and regulatory programs are likely to encourage litter exports of substantial tonnage out of the Valley, and transportation subsidies are likely to induce profit-seeking crop producers outside the production counties to adopt litter as a nutrient source.

Litter can be transported and applied at costs competitive with commercial fertilizer. Chapter 2 showed that 2.1 million tons could supply crop, hay, and pasture nutrient needs at or below the nutrient cost of commercial fertilizer within the breakeven transportation distance. Such a quantity is far in excess of total annual litter production in all Virginia poultry producing regions. Why the market does not currently function to connect users and producers has been partially explored through the focus group process. A subsidy program for litter transport could increase adoption rates within the breakeven transportation distance as well as extend that distance into new counties. Currently no programs subsidize poultry litter transport in Virginia. However, HB 1207 Section G4 does authorize "development of a poultry waste transportation and alternative use equal matching grant program between the Commonwealth and commercial poultry processors." To examine the potential litter tonnage and cost of subsidized transportation, the following set of assumptions are used.

1) Because only the Shenandoah Valley production region produces far more than regional crop needs, most litter will continue to be shipped from that region rather than from other Virginia regions. Further, since Rockingham County produces approximately 60 percent of Shenandoah Valley litter and serves as the major shipping point for litter brokers, it is assumed that all litter will be transported from Harrisonburg. Road mileages from Harrisonburg to each county seat are calculated.

2) No subsidy would be necessary to ship litter within the four Shenandoah Valley poultry-producing counties. No subsidy would be paid within a 25-mile radius of Harrisonburg.

3) Litter adoption rates in surrounding counties will stabilize after an initial period of experimentation and trial adoption. To estimate the likely use of litter over the longer term and to estimate potential subsidies paid to enhance the competitiveness of poultry litter relative to commercial fertilizer, it is assumed that poultry litter will be applied on a phosphorus basis to 50 percent of suitable corn, wheat, and barley acres and 10 percent of hay and pasture acres in counties within the BTD.

4) Litter transport costs $0.11 per ton-mile to any distance, and the subsidy program will pay 100 percent of the transportation cost beyond the first 25 miles up to a maximum of $11 per ton.

Table 4-2 shows potential litter usage based on the assumed adoption rates by county within the breakeven transportation distance. Economically beneficial litter applications of approximately 374,000 tons could be applied to crop, hay, and pasture acreage under the stated assumptions with no transport subsidy. Counties with a litter need exceeding 10,000 tons (estimated on a phosphorous basis, and assuming partial adoption rates) include Rockingham, Augusta, Fauquier, Loudon, Pittsylvania, Culpeper, Essex, Franklin, Hanover, Bedford, Westmoreland, King William, and Halifax. The top counties in terms of potential litter use on row crops are Rockingham (15,700 tons), Essex (12,100 tons), Augusta (11,700 tons), Westmoreland (10,400 tons), King William (10,400 tons), and Hanover (10,100 tons).

Table 4-3 indicates the cost savings for litter users based on replacing commercial fertilizer with transported litter, taking into account assembly, transportation, application, and other costs associated with litter use as well as supplemental commercial fertilizer costs. The potential cost savings from using poultry litter versus commercial fertilizer for corn grain, corn silage, wheat and barley is estimated to total $2.8 million per year without any subsidy. If recommended nutrient application rates were applied to alfalfa hay, other hay, and pasture acres, the potential cost savings is estimated to total over $14 million per year without a subsidy. Counties with potential cost savings exceeding $0.5 million include Rockingham, Augusta, Albemarle, Fauquier, Shenandoah, Culpeper, Loudon, Rockbridge, Orange, Madison, and Frederick. In terms of cost savings on row crop acreage, the top counties are Rockingham, Augusta, Culpeper, Fauquier, Shenandoah, and Loudon. However, even the litter adoption rates examined here are only likely to occur over a period of several years of experimentation and trial use of poultry litter. If a litter transport subsidy program were instituted, it can be expected that: 1) litter adoption rates within the breakeven transport distance would increase, and 2) some usage outside the BTD would occur as the breakeven radius is increased by transport subsidies.

Table 4-2. Potential Litter Needs by Crop/County (50%/10% Adoption)[1]

County name	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	County Total
				(tons)				
Albemarle	189	0	461	688	3,351	3,428	213	8,332
Alleghany	0	0	416	0	335	674	325	1,751
Amelia	0	915	909	1,012	775	743	536	4,890
Amherst	0	0	0	350	1,164	1,878	0	3,392
Appomattox	0	266	610	432	1,533	2,116	553	5,510
Augusta	1,006	747	4,655	5,236	3,265	5,523	1,014	21,446
Bath	66	0	0	0	686	1,040	0	1,792
Bedford	0	0	667	1,727	3,624	5,223	277	11,517
Botetourt	0	0	432	746	1,367	1,883	244	4,673
Buckingham	0	0	350	0	1,539	1,577	263	3,729
Campbell	0	385	775	841	1,837	2,334	632	6,805
Caroline	0	1,414	2,670	265	269	289	2,569	7,476
Charles City	0	716	2,249	0	0	80	3,156	6,202
Charlotte	0	0	588	519	1,365	1,909	991	5,371
Chesterfield	0	0	254	0	195	244	491	1,184
Clarke	170	369	1,260	854	1,315	1,793	609	6,370
Craig	0	0	0	0	584	1,197	0	1,781
Culpeper	171	436	3,176	2,688	2,457	2,547	900	12,375
Cumberland	0	0	327	410	781	1,327	239	3,084
Essex	0	2,070	5,645	0	0	164	4,374	12,253
Fairfax	0	0	0	0	0	59	0	59
Fauquier	0	1,052	4,458	2,915	3,739	4,242	1,231	17,636
Floyd	0	0	401	1,037	1,977	3,378	0	6,793
Fluvanna	61	0	412	0	1,158	1,152	246	3,029
Franklin	0	237	1,206	4,428	2,513	3,217	420	12,022
Frederick	283	0	1,422	658	1,696	2,341	478	6,879
Giles	0	0	0	0	739	1,778	0	2,517
Goochland	0	458	1,187	331	705	791	1,046	4,517
Greene	41	0	550	246	638	934	0	2,410
Halifax	0	0	1,222	539	1,722	3,269	3,456	10,208
Hanover	0	2,345	3,302	682	902	821	3,810	11,862
Henrico	0	337	762	0	0	81	1,090	2,270
Henry	0	0	0	0	0	418	245	663
Highland	72	0	0	0	709	88	0	869
King George	0	541	1,797	0	0	144	1,652	4,134
King William	0	1,702	4,796	345	0	82	3,517	10,442
Loudon	0	570	4,500	847	3,697	4,046	3,272	16,934
Louisa	0	314	1,221	633	1,181	1,405	714	5,467
Madison	145	255	2,220	1,415	1,532	1,912	258	7,737
Montgomery	0	0	527	1,040	1,319	1,990	0	4,877
Nelson	51	0	345	0	1,103	1,853	0	3,352
New Kent	0	323	1,091	0	0	56	1,153	2,623
Orange	117	452	1,734	1,164	1,910	2,197	371	7,945

Table 4-2. Potential Litter Needs by Crop/County (50%/10% Adoption)[1]

County name	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	County Total
Page	118	343	1,202	679	1,150	1,482	205	5,179
Pittsylvania	0	0	1,351	1,521	2,915	4,322	3,597	13,706
Powhatan	0	0	587	658	620	565	171	2,600
Prince Edward	0	247	492	483	1,103	1,373	343	4,041
Prince George	0	0	1,583	0	0	95	1,770	3,448
Prince William	0	362	1,249	803	0	665	599	3,679
Pulaski	0	0	431	974	1,465	2,005	0	4,875
Rappahannock	206	0	344	0	1,287	1,649	0	3,486
Roanoke	0	0	0	0	453	648	0	1,100
Rockbridge	250	0	898	765	2,151	3,101	137	7,302
Rockingham	621	718	6,086	8,005	3,064	4,173	848	23,515
Shenandoah	279	646	2,142	1,497	1,789	2,515	377	9,245
Spotsylvania	0	282	723	614	938	736	403	3,695
Stafford	0	0	576	0	0	333	0	908
Warren	82	0	0	0	764	999	0	1,845
Westmoreland	0	1,925	3,939	0	0	122	4,546	10,533
Total	3,929	20,430	80,200	48,050	71,382	97,007	53,342	374,339

[1]Litter application satisfying crop phosphate need on 50% of county corn, wheat, and barley acres and 10% of alfalfa, other hay, and pasture acres for counties within Breakeven Transport Distance.[1] Savings reflect cost of litter removed, assembly, transportation, and application costs by county. Values of zero indicate the county is: 1) not within the breakeven distance, or 2) does not grow the crop.

Table 4.3. Potential Litter Cost Savings by Crop/County (50%/10% Adoption)[1]

County	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	Total
Albemarle	$4,725	$0	$10,945	$16,328	$397,458	$406,556	$5,058	$841,071
Alleghany	$0	$0	$6,397	$0	$25,696	$51,790	$4,998	$88,881
Amelia	$0	$969	$962	$1,071	$4,104	$3,932	$567	$11,604
Amherst	$0	$0	$0	$6,384	$106,016	$171,042	$0	$283,441
Appomattox	$0	$3,494	$8,032	$5,688	$100,880	$139,215	$7,274	$264,583
Augusta	$66,070	$23,812	$148,308	$166,826	$520,012	$879,831	$32,289	$1,837,149
Bath	$929	$0	$0	$0	$73,770	$111,861	$0	$186,561
Bedford	$0	$0	$6,425	$16,642	$174,655	$251,692	$2,670	$452,084
Botetourt	$0	$0	$7,113	$12,284	$112,510	$154,990	$4,015	$290,910
Buckingham	$0	$0	$3,448	$0	$75,876	$77,718	$2,594	$159,636
Campbell	$0	$5,409	$10,875	$11,812	$128,923	$163,859	$8,876	$329,753
Caroline	$0	$2,431	$4,588	$456	$2,312	$2,480	$4,414	$16,681
Charles City	$0	$1,388	$4,360	$0	$0	$776	$6,118	$12,643
Charlotte	$0	$0	$3,079	$2,720	$35,749	$49,996	$5,190	$96,734
Chesterfield	$0	$0	$1,498	$0	$5,744	$7,199	$2,897	$17,338
Clarke	$882	$7,292	$24,890	$16,882	$129,906	$177,172	$12,030	$369,054
Craig	$0	$0	$0	$0	$33,945	$69,509	$0	$103,454
Culpeper	$3,890	$10,153	$73,943	$62,562	$285,952	$296,460	$20,959	$753,918
Cumberland	$0	$0	$3,727	$4,673	$44,538	$75,604	$2,729	$131,271
Essex	$0	$369	$1,007	$0	$0	$146	$780	$2,303
Fairfax	$0	$0	$0	$0	$0	$3,582	$0	$3,582
Fauquier	$0	$17,315	$73,375	$47,975	$307,659	$349,048	$20,254	$815,625
Floyd	$0	$0	$1,395	$3,607	$34,384	$58,755	$0	$98,142
Fluvanna	$452	$0	$8,319	$0	$116,970	$116,357	$4,971	$247,069
Franklin	$0	$1,761	$8,972	$32,936	$93,482	$119,660	$3,125	$259,936
Frederick	$4,577	$0	$31,235	$14,459	$186,237	$257,061	$10,496	$504,065
Giles	$0	$0	$0	$0	$659	$1,586	$0	$2,245
Goochland	$0	$6,529	$16,920	$4,717	$50,239	$56,384	$14,916	$149,705
Greene	$2,497	$0	$16,932	$7,565	$98,105	$143,592	$0	$268,692
Halifax	$0	$0	$4,249	$1,876	$29,956	$56,861	$12,021	$104,963
Hanover	$0	$14,347	$20,202	$4,172	$27,596	$25,123	$23,311	$114,752
Henrico	$0	$3,103	$7,009	$0	$0	$3,729	$10,022	$23,863
Henry	$0	$0	$0	$0	$0	$5,437	$637	$6,073
Highland	$1,635	$0	$0	$0	$82,564	$10,267	$0	$94,466
King George	$0	$5,929	$19,692	$0	$0	$7,873	$18,107	$51,602
King William	$0	$5,920	$16,684	$1,201	$0	$1,425	$12,233	$37,463
Loudoun	$0	$8,255	$65,157	$12,269	$267,666	$292,930	$47,373	$693,651
Louisa	$0	$5,660	$21,970	$11,386	$106,280	$126,418	$12,847	$284,561
Madison	$6,195	$6,943	$60,466	$38,546	$208,592	$260,335	$7,037	$588,114
Montgomery	$0	$0	$4,035	$7,966	$50,517	$76,216	$0	$138,734
Nelson	$1,335	$0	$8,255	$0	$132,009	$221,829	$0	$363,428
New Kent	$0	$1,196	$4,034	$0	$0	$1,038	$4,264	$10,532
Orange	$3,308	$11,031	$42,267	$28,366	$232,827	$267,758	$9,048	$594,606
Page	$6,592	$10,240	$35,920	$20,293	$171,858	$221,378	$6,115	$472,397
Pittsylvania	$0	$0	$7,077	$7,969	$76,345	$113,206	$18,842	$223,440
Powhatan	$0	$0	$6,429	$7,210	$33,954	$30,952	$1,873	$80,419

Table 4.3. Potential Litter Cost Savings by Crop/County (50%/10% Adoption)[1]

County	Alfalfa	Barley	Corn Grain	Corn silage	Other hay	Pasture	Wheat	Total
Prince Edward	$0	$1,835	$3,659	$3,596	$41,028	$51,066	$2,549	$103,733
Prince George	$0	$0	$2,720	$0	$0	$816	$3,042	$6,578
Prince William	$0	$2,137	$7,368	$4,739	$0	$19,624	$3,534	$37,401
Pulaski	$0	$0	$1,120	$2,530	$19,036	$26,044	$0	$48,730
Rappahannock	$4,236	$0	$7,846	$0	$146,997	$188,342	$0	$347,421
Roanoke	$0	$0	$0	$0	$29,778	$42,611	$0	$72,389
Rockbridge	$6,238	$0	$21,305	$18,138	$255,039	$367,764	$3,259	$671,742
Rockingham	$57,909	$26,836	$227,361	$299,038	$572,281	$779,438	$31,680	$1,994,544
Shenandoah	$13,730	$18,440	$61,162	$42,760	$255,456	$359,152	$10,768	$761,467
Spotsylvania	$0	$4,335	$11,111	$9,427	$71,993	$56,492	$6,183	$159,541
Stafford	$0	$0	$1,496	$0	$0	$4,320	$0	$5,816
Warren	$1,873	$0	$0	$0	$88,893	$116,242	$0	$207,007
Westmoreland	$0	$10,087	$20,635	$0	$0	$3,208	$23,815	$57,744
Total	$187,075	$217,215	$1,165,975	$957,069	$6,046,446	$7,935,750	$445,779	$16,955,309

[1]Litter application satisfying crop phosphate need on 50% of county corn, wheat, and barley acres and 10% of alfalfa, other hay, and pasture acres for counties within Breakeven Transport Distance. Savings are cost differences between commercial fertilizer and litter nutrient costs, and reflect cost of litter removed, assembly, transportation, and application costs by county. Zero values of zero indicate the county is: 1) not within the breakeven distance, or 2) does not grow the crop.

Table 4-4 displays the results of grouping all Virginia counties into 25-mile distance zones from Harrisonburg and calculating potential litter transported and transport subsidy costs for supplying crop/hay/pasture nutrient needs at assumed adoption rates within each zone. As noted previously, the assumed adoption rates are 50% for corn, wheat and barley and 10% for hay and pasture. A detailed breakdown of each zone by county and mileage is found in Appendix F.

The quantity of litter potentially transported depends upon the adoption rate, the litter requirement on a phosphorus basis within counties of the mileage zone, and the relative distance of such counties from Harrisonburg. If a transport subsidy were paid, all 374,000 tons assumed to be utilized within the BTD total nearly $2.8 million per year at an average transport subsidy of $7.90 per ton. Shipping this quantity from the Shenandoah Valley (somewhat more than 4 of every 5 tons of litter produced) implies the equivalent of 15,000 25-ton truckloads per year traveling state highways.

The phosphorus-basis litter surplus in the Shenandoah Valley counties is approximately 135,000 tons. If the objective of a transport subsidy program were to move that surplus out of the Valley, it can be expected that such surplus litter would have to be transported up to 100 miles in order to access sufficient crop, hay, and pasture land at the assumed adoption rates. A litter transport subsidy program with such a goal could potentially cost $559,000 per year at an average subsidy of slightly less than $4 per ton.

Table 4-4. Potential Litter Transport and Subsidy Cost by Mileage Zone[1]

Mileage Zone	Litter Transported[2] ('000 tons)	Cumulative Litter Transported ('000 tons)	Subsidy Cost ('000 $)	Cumulative Subsidy Cost ('000 $)	Average Subsidy Cost[3] ($/ton)
≤ 25	23.5	23.5	0	NA[4]	NA
26-50	46.0	69.5	39.6	39.6	0.86
51-75	54.2	123.7	230.4	270.0	2.69
76-100	40.6	164.3	289.0	559.0	3.97
101-125	52.0	216.2	474.8	1,033.8	5.36
126-150	84.8	301.0	932.7	1,966.5	7.09
151-170	73.3	374.3	806.3	2,772.8	7.90

[1] Assumes litter transport subsidy program paying 100% of transport cost over 25 miles from Harrisonburg at $0.11/ton-mile (maximum subsidy $11/ton) with assumed adoption rates of 50 percent of suitable corn, wheat and barley acres, and 10% of alfalfa, hay, and pasture acres in each county.
[2] Litter needs are greater of P_2O_5 recommendation or crop removal rates.
[3] Cumulative subsidy cost per ton of subsidized litter transported.
[4] NA = Not Applicable

Even with the assumed adoption rates, farmer education and market development efforts over several years are likely to be necessary to achieve poultry litter transport goals. As adoption increases with experimentation and use, many producers may elect to pay litter transport costs in order to avoid recommendations or restrictions of the subsidy program. If such litter transport

occurs without subsidization, program costs will decrease. However, transport subsidy costs could be higher if poultry and litter production continue to increase at historical rates.

Administrative organization for such a litter transport subsidy program has not been considered here. Although estimated administrative costs are included in brokerage fees for poultry litter; it is likely that a public agency or public/private collaborative managing organization will be needed.

If alternative uses for litter rather than transport for use as fertilizer capture a larger portion of litter production, litter transport subsidy program costs will decrease. A number of alternative uses for litter are currently employed or are being considered, including:

- Incineration or gasification for heat/power generation
- Pelletization/granulation for use as fertilizer
- Feed for cattle
- Composting

However, the litter tonnage for these alternative uses is not likely to be sufficiently large in the next few years to use a large portion of the litter surplus if nutrient needs are estimated on a phosphorus basis. In such a case, environmental concerns imply raw litter transport and associated transport subsidies may be necessary for the foreseeable future.

The use of poultry litter as fertilizer in Virginia recycles what has been considered by some as waste and turns it into a valuable resource. A poultry litter transfer program in Virginia has the opportunity to improve the quality and water-holding capacity of Virginia soils and to lower nutrient costs for Virginia crop, hay, and pasture producers. Poultry producers and integrators would benefit from the public assuming a share of the burden of managing nutrient surpluses under new environmental regulations. Litter applications at environmentally benign and agronomically recommended rates may benefit the citizens of the Commonwealth of Virginia by sustaining the economic benefit of poultry production while water quality damage. Further research should be conducted on the technical and economic feasibility of alternative uses of poultry litter, more detailed litter transport logistics and costs, and how potential litter users learn to adopt poultry litter for use as fertilizer.

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Appendices

VIRGINIA ACTS OF ASSEMBLY -- 1999 SESSION

CHAPTER 1

An Act to amend the Code of Virginia by adding in Article 3 of Chapter 3.1 of Title 62.1 a section numbered 62.1-44.17:1.1, relating to poultry waste management.

[H 120**7]**

Approved January 29, 1999

Be it enacted by the General Assembly of Virginia:

1. That the Code of Virginia is amended by adding in Article 3 of Chapter 3.1 of Title 62.1 a section numbered 62.1-44.17:1.1 as follows:

§ 62.1-44.17:1.1 Poultry waste management program.

A. As used in this section, unless the context requires a different meaning:

"Commercial poultry processor" means any animal food manufacturer, as defined in § 3.1-884.18, that contracts with poultry growers for the raising of poultry.

"Confined poultry feeding operation" means any confined animal feeding operation with 200 or more animal units of poultry.

"Nutrient management plan" means a plan developed or approved by the Department of Conservation and Recreation that requires proper storage, treatment and management of poultry waste, including dry litter, and limits accumulation of excess nutrients in soils and leaching or discharge of nutrients into state waters.

"Poultry grower" means any person who owns or operates a confined poultry feeding operation.

B. The Board shall develop a regulatory program governing the storage, treatment and management of poultry waste, including dry litter, that:

1. Requires the development and implementation of nutrient management plans for any person owning or operating a confined poultry feeding operation;

2. Provides for waste tracking and accounting; and

3. Ensures proper storage of waste consistent with the terms and provisions of a nutrient management plan.

C. The program shall include, at a minimum:

1. Provisions for permitting confined poultry feeding operations under a general permit; however, the Board may require an individual permit upon determining that an operation is in violation of the program developed under this section;

2. Provisions requiring that:

a. Nitrogen application rates contained in nutrient management plans developed pursuant to this section shall not exceed crop nutrient needs as determined by the Department of Conservation and Recreation. The application of poultry waste shall be managed to minimize runoff, leaching, and volatilization losses, and reduce adverse water quality impacts from nitrogen;

b. For all nutrient management plans developed pursuant to this section after October 1, 2001, phosphorus application rates shall not exceed the greater of crop nutrient needs or crop nutrient removal, as determined by the Department of Conservation and Recreation. The application of poultry waste shall be managed to minimize runoff and leaching and reduce adverse water quality impacts from phosphorous;

c. By December 31, 2005, the Department of Conservation and Recreation, in consultation with the Department of Environmental Quality, shall (i) complete an examination of current developments in scientific research and technology which shall include a review of land application of poultry waste, soil nutrient retention capacity, and water quality degradation and (ii) adopt and implement regulatory or other changes, if any, to its nutrient management plan program that it concludes are appropriate as a result of this examination; and

d. For all nutrient management plans developed pursuant to this section after December 31, 2005,

and not prior thereto, phosphorous application rates shall conform to the provisions of subdivision 2 b of this subsection and shall be in accordance with other regulatory criteria and standards, if any, amended or adopted by the Department of Conservation and Recreation pursuant to subdivision 2 c of this subsection to protect water quality or to reduce soil concentrations of phosphorous or.2 *phosphorous loadings. The application of poultry waste shall be managed to minimize runoff and leaching and reduce adverse water quality impacts from phosphorous.*

D. The program shall reflect Board consideration of existing state-approved nutrient management plans and existing general permit programs for other confined animal feeding operations, and may include such other provisions as the Board determines appropriate for the protection of state waters.

E. After October 1, 2001, all persons owning or operating a confined poultry feeding operation shall operate in compliance with the provisions of this section and any regulations promulgated thereunder.

F. Any person violating this section shall be subject only to the provisions of §§ 62.1-44.23 and 62.1-44.32 (a), except that any civil penalty shall not exceed $2,500.

G. On or before January 1, 2000, or prior to commencing operations, each commercial poultry processor operating in the Commonwealth shall file with the Board a plan under which the processor, either directly or under contract with a third party, shall:

1. Provide technical assistance to the poultry growers with whom it contracts on the proper management and storage of poultry waste in accordance with best management practices;

2. Provide education programs on poultry waste nutrient management for the poultry growers with whom it contracts as well as for poultry litter brokers and persons utilizing poultry waste;

3. Provide a toll-free hotline and advertising program to assist poultry growers with excess amounts of poultry waste to make available such waste to persons in other areas who can use such waste as a fertilizer consistent with the provisions of subdivision C 2 or for other alternative purposes;

4. Participate in the development of a poultry waste transportation and alternative use equal matching grant program between the Commonwealth and commercial poultry processors to (i) facilitate the transportation of excess poultry waste in the possession of poultry growers with whom it contracts to persons in other areas who can use such waste as a fertilizer consistent with the provisions of subdivision C 2 or for other alternative purposes and (ii) encourage alternative uses to land application of poultry waste;

5. Conduct research on the reduction of phosphorus in poultry waste, innovative best management practices for poultry waste, water quality issues concerning poultry waste, or alternative uses of poultry waste; and

6. Conduct research on and consider implementation of nutrient reduction strategies in the formulation of feed. Such nutrient reduction strategies may include the addition of phytase or other feed additives or modifications to reduce nutrients in poultry waste.

H. Any amendments to the plan required by subsection G shall be filed with the Board before they are implemented. After January 1, 2000, each commercial poultry processor shall implement its plan and any amendments thereto. Each commercial poultry processor shall report annually to the Board on the activities it has undertaken pursuant to its plan and any amendments thereto. Failure to comply with the provisions of this section or to implement and follow a filed plan or any amendments thereto shall constitute a violation of this section.

2. That the State Water Control Board shall adopt the regulations required by § 62.1-44.17:1.1 no later than October 1, 2000. The Board shall impanel an advisory group to assist in the development of the program in accordance with its public participation guidelines. Membership of the group shall be balanced among organizations and persons expressing an interest in the program and shall include a minimum of three representatives of poultry growers, three representatives of commercial poultry processors, and three representatives of environmental organizations.

3. That the Director of the Department of Conservation and Recreation, with the consultation of

the Director of the Department of Environmental Quality and the Commissioner of Agriculture and Consumer Services, shall, by December 20, 1999, recommend to the Governor, the Senate Committee on Agriculture, Conservation and Natural Resources, the House Committee on Conservation and Natural Resources, and the House Committee on the Chesapeake and Its Tributaries ways that the Commonwealth should assist poultry growers and processors to improve the economic feasibility of transporting and selling poultry waste, and pursue alternative uses for poultry waste, including the establishment of the equal matching grant.3 **program referred to in subdivision G 4 of § 62.1-44.17:1.1.**

4. That on or before December 31, 2003, the Director of the Department of Environmental Quality, in consultation with the Director of the Department of Conservation and Recreation and the Commissioner of Agriculture and Consumer Services, shall report to the Governor and the General Assembly on the effectiveness of the plans implemented by commercial poultry processors pursuant to subsection G of § 62.1-44.17:1.1 in assisting poultry growers with whom they contract with the proper management, storage, disposal, and transportation of poultry waste, including excess poultry waste, for the protection of water quality.

Virginia Agricultural Statistics Service Regions

Northern	Eastern	Central	Southeastern	Southern	Southwestern	Western
Clarke	Accomack	Albemarle	Brunswick	Charlotte	Bland	Alleghany
Culpeper	Charles City	Amelia	Dinwiddie	Franklin	Buchanan	Augusta
Fairfax	Essex	Amherst	Greensville	Halifax	Carroll	Bath
Fauquier	Gloucester	Appomattox	Isle of Wight	Henry	Dickenson	Botetourt
Frederick	James City	Bedford	Mecklenburg	Lunenburg	Floyd	Craig
Loudon	King and Queen	Buckingham	Prince George	Nottoway	Giles	Highland
Madison	King George	Campbell	Southampton	Patrick	Grayson	Roanoke
Page	King William	Caroline	Surry	Pittsylvania	Lee	Rockbridge
Prince William	Lancaster	Chesterfield	Sussex		Montgomery	
Rappahannock	Mathews	Cumberland	Chesapeake		Pulaski	
Rockingham	Middlesex	Fluvanna	Suffolk		Russell	
Shenandoah	New Kent	Goochland	Virginia Beach		Scott	
Warren	Northampton	Greene			Smyth	
	Northumberland	Hanover			Tazewell	
	Richmond	Henrico			Washington	
	Westmoreland	Louisa			Wise	
	York	Nelson			Wythe	
		Orange				
		Powhatan				
		Prince Edward				
		Spotsylvania				

Table I-2
Estimated Yields in Bushels (Bu) or Tons (T) per Acre (A) of Various Non-Irrigated Crops for Identified Soil Productivity Groups

	I		II		III		IV		V
Crop	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	
Corn									
Grain (Bu/A)	160	150	140	130	120	110	100	85	65
Silage (T/A)	21	20	19	18	17	16	15	13	10
Wheat (Bu/A)									
Standard	64		56		48		40		24
Intensive	80		70		60		50		30
Barley (Bu/A)									
Standard	100		70		60		50		30
Intensive	115		88		75		63		38
Tallgrass Hay (T/A)	>4.0		3.5-4.0	3.0-3.5	<3.0		NA		NA
Bermudagrass Hay (T/A)	>6.0		4.0-6.0		<4.0		NA		NA
Alfalfa (T/A)	>6.0		4.0-6.0		<4.0		NA		NA
Pasture (Ac/AU)	1.0		1.1-1.5		1.6-3.0		3.1-6.5		NA

Reproduced from Virginia Department of Conservation and Recreation. *Virginia Nutrient Management Standards and Criteria*. November 1995. p. 23.

Litter Needs on P_2O_5 Basis									Litter Needs on N Basis						
County/city	Alfalfa	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter PBasis	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter NBasis
						(tons)									
Fairfax	0	0	0	0	0	594	0	594	0	0	0	0	924	0	924
Fauquier	3,390	2,104	8,916	5,830	37,386	42,416	2,461	102,503	5,903	31,243	21,847	98,813	62,506	6,875	227,187
Floyd	2,433	0	802	2,074	19,770	33,783	0	58,862	0	2,444	8,500	49,938	42,688	0	103,570
Fluvanna	611	0	824	0	11,582	11,521	492	25,031	0	2,037	0	28,375	15,594	1,111	47,117
Franklin	2,256	473	2,412	8,856	25,135	32,174	840	72,147	1,759	8,115	31,139	66,438	45,321	3,333	156,105
Frederick	2,827	0	2,845	1,317	16,963	23,413	956	48,321	0	7,191	2,903	44,938	31,221	2,222	88,475
Giles	893	0	0	0	7,389	17,777	0	26,059	0	0	0	19,688	24,090	0	43,778
Gloucester	0	916	4,543	0	0	275	1,045	6,779	3,403	18,750	0	0	565	3,472	26,190
Goochland	547	916	2,373	662	7,047	7,909	2,092	21,546	2,361	5,938	1,833	18,500	11,840	5,347	45,819
Grayson	1,399	0	843	1,248	17,817	44,996	0	66,303	0	2,667	5,500	47,125	55,665	0	110,957
Greene	415	0	1,101	492	6,379	9,337	0	17,724	0	3,972	1,528	18,500	13,282	0	37,282
Greensville	0	0	1,143	0	0	2,797	948	4,887	0	5,080	0	0	4,296	3,889	13,265
Halifax	1,144	0	2,443	1,078	17,224	32,694	6,912	61,495	0	6,267	2,375	43,000	44,065	16,319	112,026
Hanover	1,489	4,690	6,604	1,364	9,021	8,212	7,620	39,000	15,000	29,431	4,156	25,875	13,974	22,500	110,936
Henrico	0	675	1,524	0	0	811	2,179	5,189	1,944	5,576	0	0	1,371	6,111	15,002
Henry	0	0	0	0	0	4,185	490	4,674	0	0	0	0	6,786	1,111	7,897
Highland	717	0	0	0	7,094	882	0	8,693	0	0	0	20,125	1,178	0	21,303
Isle of Wight	0	723	7,288	0	0	2,553	6,310	16,874	2,708	29,885	0	0	5,507	23,125	61,225
James City	0	621	1,341	0	0	355	1,179	3,496	1,736	4,333	0	0	501	3,264	9,834
King & Queen	0	3,535	9,253	0	0	952	6,461	20,201	11,667	36,250	0	0	1,414	20,347	69,678
King George	0	1,082	3,594	0	0	1,437	3,305	9,418	2,708	14,083	0	0	2,118	8,194	27,103
King William	0	3,404	9,593	690	0	820	7,034	21,540	11,944	38,729	2,375	0	1,617	23,542	78,207
Lancaster	0	1,240	3,171	0	0	285	2,942	7,636	4,097	13,632	0	0	524	8,681	26,934
Lee	950	0	740	0	16,498	43,457	0	61,644	0	2,139	0	44,000	52,097	0	98,236
Loudon	3,167	1,140	9,001	1,695	36,975	40,464	6,544	98,986	3,403	26,813	5,608	98,875	61,206	17,292	213,197
Louisa	1,556	629	2,441	1,265	11,810	14,048	1,428	33,177	1,736	7,028	4,201	38,500	21,064	3,958	76,487
Lunenburg	0	0	0	0	0	9,816	577	10,393	0	0	0	0	16,346	1,806	18,152
Madison	1,455	510	4,440	2,830	15,316	19,115	517	44,182	1,574	15,660	9,854	44,813	29,681	1,528	103,110
Mathews	0	432	774	0	0	433	414	2,053	1,389	2,750	0	0	792	1,389	6,320
Mecklenburg	763	563	1,257	1,276	20,860	34,300	3,386	62,406	2,222	3,035	3,035	56,500	42,981	8,681	116,454

Litter Needs on P_2O_5 Basis									Litter Needs on N Basis						
County/city	Alfalfa	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter PBasis	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter NBasis
							(tons)								
Middlesex	0	927	3,206	0	0	454	3,670	8,256	2,639	12,458	0	0	647	11,042	26,786
Montgomery	2,145	0	1,054	2,080	13,193	19,904	0	38,376	0	4,167	8,583	35,563	30,506	0	78,819
Nelson	512	0	690	0	11,029	18,533	0	30,764	0	2,111	0	30,833	26,274	0	59,218
New Kent	0	647	2,181	0	0	561	2,306	5,695	2,778	9,701	0	0	960	7,292	20,731
Northampton	0	1,975	1,626	0	0	366	12,061	16,027	8,472	7,674	0	0	913	46,806	63,865
Northumberland	0	2,702	8,651	0	0	347	10,080	21,780	8,056	35,875	0	0	590	29,653	74,174
Nottoway	702	383	628	1,069	7,003	10,424	0	20,207	1,389	2,243	3,563	23,875	23,026	0	54,096
Orange	1,169	905	3,468	2,327	19,101	21,967	742	49,679	2,847	12,167	8,250	50,500	30,764	2,292	106,820
Page	1,182	685	2,404	1,358	11,504	14,819	409	32,362	2,708	10,924	5,271	35,625	22,321	1,574	78,423
Patrick	847	0	2,028	920	11,714	15,619	0	31,129	0	3,896	3,667	29,000	22,439	0	59,002
Pittsylvania	2,013	0	2,702	3,043	29,148	43,222	7,194	87,322	0	7,521	9,701	71,938	58,683	26,250	174,093
Powhatan	508	0	1,173	1,316	6,197	5,649	342	15,185	0	3,896	4,882	17,625	8,608	1,111	36,122
Prince Edward	934	493	984	967	11,032	13,730	685	28,825	1,875	3,167	3,365	30,250	19,794	2,222	60,673
Prince George	0	0	3,166	0	0	950	3,541	7,656	0	13,667	0	0	1,649	11,458	26,774
Prince William	0	725	2,498	1,607	0	6,654	1,198	12,682	1,806	5,872	3,760	0	9,446	2,986	23,870
Pulaski	1,440	0	862	1,948	14,652	20,046	0	38,948	0	3,222	7,917	39,063	27,917	0	78,119
Rappahannock	2,057	0	687	0	12,873	16,493	0	32,111	0	1,833	0	37,375	23,267	0	62,475
Richmond	0	2,840	6,113	0	0	695	6,936	16,583	8,194	29,264	0	0	1,110	19,583	58,151
Roanoke	431	0	0	0	4,526	6,477	0	11,434	0	0	0	11,688	8,221	0	19,909
Rockbridge	2,496	0	1,797	1,529	21,506	31,011	275	58,613	0	5,576	5,917	60,125	45,794	833	118,245
Rockingham	6,214	1,437	12,172	16,009	30,637	41,728	1,696	109,893	5,625	54,076	71,556	101,625	73,307	6,597	312,786
Russell	2,010	0	0	434	14,152	40,018	0	56,615	0	0	1,630	44,313	51,778	0	97,721
Scott	1,684	0	646	560	14,458	31,670	0	49,018	0	1,833	1,042	38,750	42,401	0	84,026
Shenandoah	2,791	1,291	4,283	2,995	17,890	25,152	754	55,157	4,792	16,917	11,167	54,813	39,625	2,639	129,953
Smyth	2,219	0	1,074	2,434	16,652	34,112	0	56,492	0	3,500	11,181	43,875	42,711	0	101,267
Southampton	0	0	8,083	0	989	4,194	4,148	17,413	0	33,646	0	2,500	8,854	16,319	61,319
Spotsylvania	604	565	1,447	1,228	9,375	7,356	805	21,380	1,759	5,167	3,628	24,750	9,878	2,500	47,682
Stafford	0	0	1,152	0	0	3,325	0	4,477	0	4,333	0	0	4,688	0	9,021
Surry	0	0	4,112	0	0	656	7,263	12,031	0	16,882	0	0	1,218	22,361	40,461
Sussex	0	0	3,805	0	873	1,205	4,560	10,443	0	13,788	0	3,000	2,321	17,708	36,817

Litter Needs on P_2O_5 Basis									Litter Needs on N Basis						
County/city	Alfalfa	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter PBasis	Barley	Corn Grain	Corn Silage	Other hay	Pasture	Wheat	Total Litter NBasis
						(tons)									
Tazewell	2,165	0	0	1,348	12,220	33,952	0	49,685	0	0	3,892	34,938	44,682	0	83,512
Warren	822	0	0	0	7,637	9,987	0	18,446	0	0	0	22,688	15,613	0	38,301
Washington	2,942	0	1,346	3,014	25,482	48,036	0	80,820	0	4,736	12,583	73,125	65,558	0	156,002
Westmoreland	0	3,851	7,878	0	0	1,225	9,092	22,047	12,361	33,222	0	0	2,268	27,083	74,934
Wise	0	0	0	0	0	3,433	0	3,433	0	0	0	0	4,871	0	4,871
Wythe	3,837	0	1,484	4,435	22,845	43,576	0	76,177	0	4,889	17,417	57,938	56,858	0	137,102
York	0	0	0	0	0	201	0	201	0	0	0	0	340	0	340
Chesapeake	0	0	10,753	653	0	1,468	9,142	22,016	0	43,250	2,438	0	2,442	34,375	82,505
Suffolk	0	681	7,949	0	0	1,193	7,024	16,847	2,500	32,722	0	0	2,083	24,931	62,236
Virginia Beach	0	0	4,929	0	434	581	6,799	12,742	0	21,396	0	1,750	1,144	26,736	51,026
STATE TOTAL	98,476	60,399	269,962	117,724	935,092	1,455,325	224,315	3,161,294	201,759	1,020,271	431,264	2,580,771	2,066,325	732,824	7,033,214

Application and Associated Costs

Item	Unit	Quantity	Cost/unit ($)	Total Cost ($) for 7000 tons[a]
Operating Cost				
Truck[a]	Hr	250	31.16	7,790
Spreader	Hr	250	2.52	630
Front End Loader	hr	175	12.06	2,111
Pickup[b]	mi	4,000	.017	680
Labor	hr	500	6.00	3,000
Total Operating Costs				14,211
Ownership Cost				
Truck[c]				7,400
Spreader[d]				1,680
Front End Loader[e]				1,756
Pickup[f]				879
Total Ownership Costs				11,715
Total Costs				25,926
Cost/Ton				$3.70

[a]Moisture evaporation is considered. 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.

[b]Mileage is based on 100 miles a day for 40 days of application.

[c]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).

[d]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).

[d]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.

[e]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.

*Method adapted from Bosch and Napit, 1991.

Appendix F – Counties by Mileage Zone Within Breakeven Transport Distance[1]

County_name	Zone
Rockingham	<25
Augusta	25-50
Greene	25-50
Madison	25-50
Page	25-50
Shenandoah	25-50
Albemarle	50-75
Bath	50-75
Culpeper	50-75
Frederick	50-75
Highland	50-75
Nelson	50-75
Orange	50-75
Rappahannock	50-75
Rockbridge	50-75
Warren	50-75

County_name	Zone
Amherst	75-100
Botetourt	75-100
Clarke	75-100
Fauquier	75-100
Fluvanna	75-100
Louisa	75-100
Alleghany	100-125
Appomattox	100-125
Campbell	100-125
Craig	100-125
Cumberland	100-125
Fairfax	100-125
Goochland	100-125
King George	100-125
Loudon	100-125
Powhatan	100-125
Roanoke	100-125
Spotsylvania	100-125

County_name	Zone
Arlington	125-150
Bedford	125-150
Buckingham	125-150
Charlotte	125-150
Chesterfield	125-150
Franklin	125-150
Hanover	125-150
Henrico	125-150
Montgomery	125-150
Pittsylvania	125-150
Prince Edward	125-150
Prince William	125-150
Westmoreland	125-150
Amelia	150-170
Caroline	150-170
Charles City	150-170
Essex	150-170
Floyd	150-170
Giles	150-170
Halifax	150-170
Henry	150-170
King William	150-170
New Kent	150-170
Prince George	150-170
Pulaski	150-170
Stafford	150-170

[1]Distance measured between Harrisonburg and county seat of respective county. Breakeven transport distance is 170 miles for nitrogen-using crops.