Cooperative Extension Service

Assessment of the Potential for Livestock and Poultry Manure to Provide the Nutrients Removed by Crops and Forages in Kentucky

A project by the Animal Waste Focus Group[1] of the Environmental and Natural Resources Issues Task Force

Introduction

Livestock and poultry manure has been used for many years to provide basic fertilizer nutrients to improve crop and forage production. In addition, it has long been known that the chemical and physical properties of soils can be improved by applications of animal manure. Because of these benefits, much of the manure produced by livestock and poultry has been and continues to be applied to cropland and pastureland. Not only does this practice benefit crop production, it also has the environmental benefit of recycling nutrients to the soil from which they originated.

Over the past few decades, significant structural changes in animal production have occurred. Farms have become more specialized, with livestock and poultry operations becoming fewer in number but larger in size. In some cases, livestock or poultry operations are more concentrated in certain geographical regions. As these changes have occurred, concerns have been raised regarding the potential environmental effects of continued manure application to the land. One particular question is whether the current land base in crop and pasture production is adequate to utilize all nutrients (especially nitrogen and phosphorus) from manure produced by Kentucky's livestock and poultry operations. Stated another way, there is concern about the potential application of manure nutrients at rates that will exceed current crop and pasture production requirements.

The primary purpose of this publication is to provide a conservative assessment of the degree to which nutrients removed annually from the land by harvested crops and grazed forages potentially could be supplied from nutrients present in livestock and poultry manure in each Kentucky county. The intent of the assessment is to provide a snapshot comparison of estimated manure nutrient production relative to potential nutrient removal capacity on a fairly large scale and does not include many farm level variables that will determine environmental impact. Due to the broad nature of the assessment, the information presented here should only be used as a starting point for discussions pertaining to animal production and manure nutrient use.

Methods

The basic approach in the assessment was to estimate, for each county in Kentucky, the amount of recoverable (potentially land-applied) nitrogen, phosphorus, and potassium from all livestock and poultry manure and the quantity of these nutrients that would normally be removed from the land through harvested crops and grazed forages. Once the manure nutrient supply and the crop and forage nutrient removal estimates were made, the following ratio was computed on a county-by-county basis:

$$\frac{\text{Total recoverable manure nutrients from livestock and poultry\}}{\text{Total nutrients removed by harvested crops and grazed forages}}$$

Crop acreage, crop yields, and livestock inventories were obtained primarily from the 1997-1998 Kentucky Agricultural Statistics report. Some missing information was obtained from the 1997 U. S. Census of Agriculture and from industry surveys. Manure nutrient production was estimated for beef cattle, dairy cattle, swine, layers, and broilers. Crops and forages included in the assessment were corn harvested for grain, corn harvested for silage or green chop, soybean harvested for beans, winter wheat harvested for grain, sorghum harvested for grain, barley harvested for grain, alfalfa hay, all other types of hay (excluding alfalfa), burley tobacco, dark fire-cured tobacco, dark air-cured tobacco, and forages from pastureland.

The methods used to estimate manure and nutrient production from livestock and poultry operations and nutrient removal potential of crops and forages grown in Kentucky were based on the procedure developed by Lander et al. (1998). Where appropriate, modifications were made to more accurately reflect conditions unique to Kentucky. However, the major difference between this assessment and that of Lander et al., which used 1992 U.S. Census of Agriculture data, is the use of more recent animal inventory data (which includes significant recent expansion in Kentucky's poultry industry) and crop production data. The following discussion outlines the methods and assumptions used.

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Livestock and Poultry Inventory Estimates

Inventories for beef, dairy, swine, and poultry within each Kentucky county were included in the assessment. It is recognized that significant inventories of horses and mules are found in some counties (particularly many counties located in Central Kentucky), but reliable inventory estimates for these animals are not available. Therefore, horses and mules were not included in the assessment.

The county inventory estimates for beef, dairy, and swine were taken from Kentucky Agricultural Statistics. For counties with only a limited inventory of beef, dairy, or swine, no inventory estimate was available. For example, counties with an inventory estimate of less than 500 head of cattle and calves were included in an "Other Counties" category within a district in the Kentucky Agricultural Statistics report. This was also true for counties that had inventories of less than 500 head of hogs and pigs and less than 300 head of milk cows. A two-step approach was used to determine an inventory estimate for each county that was included in the "Other Counties" category. The first step in the process involved determining which counties included in the "Other Counties" category had an actual inventory of zero (0). Because this information was not available in the Kentucky Agricultural Statistics report, the 1997 U.S. Census of Agriculture was consulted. The U.S. Census of Agriculture makes a distinction between counties with an inventory of zero (0) and those with an inventory that is not reported for reasons of confidentiality. Counties with a reported inventory of zero (0) in the 1997 U.S. Census of Agriculture were assigned an inventory of zero (0) in this assessment. The second step of the process involved equally dispersing the inventory estimate given for "Other Counties" among those counties within the district whose inventory was greater than zero (0) but whose actual inventory estimate was not given in the Kentucky Agricultural Statistics report.

To more accurately estimate manure and nutrient production from swine, it was necessary to partition the reported inventory for hogs and pigs into two groups: (1) breeding stock and (2) nursery and finishing pigs. This grouping allowed for separate evaluations of swine that are limit fed versus those that are fed *ad libitum* (full fed). It was assumed that 12% of the reported hogs and pigs inventory was breeding stock and the remaining 88% was nursery and finishing pigs (Coffey 1999). The breeding stock inventory was further segregated into lactating sows with litters (18% of breeding stock inventory) and gestating sows, boars, and replacement gilts (82% of breeding stock inventory). Gestating sows, boars, and replacement gilts were assumed to be limit fed, and lactating sows with litters and nursery and finishing pigs were assumed to be fed *ad libitum.*

The inventory estimates for milk cows in the Kentucky Agricultural Statistics report does not include dairy heifers. On most dairy operations, the inventory of heifers is approximately 80% of the inventoried mature cows; therefore, dairy heifer inventory was estimated as 80% of the reported inventory for milk cows (Crist 1999).

The inventory estimates for all cattle and calves in the Kentucky Agricultural Statistics report includes both dairy and beef cattle. To estimate the inventory for all beef cattle and calves, the inventory estimates for dairy cows and dairy heifers were subtracted from the reported inventory for all cattle and calves.

Due to limited availability of data, county inventory estimates for layers, breeder layers, pullets, breeder pullets, and broilers were determined by a survey of private companies that operate in Kentucky (Pescatore 1999). These inventory estimates are not reported in Kentucky Agricultural Statistics for reasons of confidentiality. Poultry inventories for many counties are also not given in the U.S. Census of Agriculture, which does not report a poultry inventory estimate for a county if doing so would disclose information about an individual farm or owner.

For purposes of this assessment, the production year was set at 365 days for all animal classes. No adjustments were made to livestock and poultry inventories to account for periods of time when facilities would be empty between production cycles. For some operations, particularly swine and poultry operations that have multiple growth cycles per year, this lack of adjustment could result in either overestimation or underestimation of manure and nutrient production on an annual basis. The inventory estimates in the Kentucky Agricultural Statistics report represent inventories as of December 1, 1997, rather than total animal capacity at an operation. The number of operations that were between production cycles and had facilities empty at the time the inventories were taken would influence the annual manure and nutrient production. However, the direction of this influence on the assessment is not known.

Animal inventory estimates by county that were used in the assessment are shown in **Table 1**. For reasons of confidentiality, poultry inventory estimates are not included.

Table 1. Livestock inventories and crop production estimates.

County	All beef cattle and calves[1] (head)	Dairy cows[1] (head)	Dairy heifers[2] (head)	Lactating sows with litters[3] (head)	Gestating sows, boars, and gilts (head)	Nursery and finishing pigs[4] (head)	Corn for grain[1] (bu)	Corn for silage or green chop[5] (tons)	Soybean for beans[1] (bu)	Winter wheat for grain[1] (bu)	Sorghum for grain[1] (bu)	Barley for grain[1] (bu)	Alfalfa hay[1] (tons)	All other hay[1] (tons)	Burley tobacco[1] (lbs)	Dark fire-cured tobacco[1] (lbs)	Dark air-cured tobacco[1] (lbs)	Pasture-land forage[5] (tons)
District 1:																		
Ballard	8,920	600	480	264	1,200	10,736	2,666,00	6,877	1,414,400	986,000	110,500	0	4,550	15,000	3,172,000	28,000	0	36,108
Calloway	10,280	1,400	1,120	102	462	4,136	3,932,60	4,138	1,389,600	1,632,000	0	0	4,070	23,400	630,000	4,798,000	149,000	39,865
Carlisle	4,780	900	720	194	886	7,920	2,388,00	4,976	1,141,000	416,000	0	0	3,040	15,120	570,000	408,000	49,000	18,105
Fulton	2,800	0	0	17	79	704	2,982,40	0	2,286,000	864,000	0	0	1,750	4,080	5,500	0	0	7,301
Graves	14,160	1,300	1,040	356	1,624	14,520	5,965,50	14,135	2,498,400	1,855,000	93,500	0	4,800	27,140	893,000	4,830,000	738,000	54,865
Hickman	5,880	400	320	71	325	2,904	3,687,50	4,144	1,636,800	1,134,000	0	0	1,100	8,640	73,000	159,000	47,000	16,774
Livingston	16,460	300	240	84	384	3,432	735,000	5,340	310,300	246,000	56,000	0	3,200	47,250	5,500	0	0	63,877
Lyon	7,030	150	120	76	344	3,080	445,500	224	189,000	54,000	0	0	3,300	11,210	490,000	461,000	28,000	20,956
Marshall	11,230	150	120	91	413	3,696	1,081,00	224	608,400	235,000	0	0	1,600	23,600	441,000	326,000	53,000	38,676
McCracken	4,830	150	120	19	89	792	1,188,00	3,322	868,000	275,000	120,000	0	1,100	12,760	1,319,000	143,000	0	18,588
Trigg	18,730	150	120	324	1,476	13,200	1,864,80	2,240	554,400	649,000	0	0	5,950	36,000	1,685,000	1,708,000	20,000	51,915
District 2:																		
Caldwell	15,740	700	560	225	1,023	9,152	1,872,50	12,235	568,800	464,000	0	0	9,360	38,410	1,272,000	603,000	77,000	62,739
Christian	36,400	2,000	1,600	313	1,427	12,760	7,112,00	16,639	2,148,800	3,060,000	50,400	49,200	7,440	79,580	7,247,000	3,042,000	64,000	114,848
Crittenden	18,280	400	320	65	295	2,640	1,242,00	2,600	304,500	82,500	0	0	5,950	50,600	39,000	0	0	84,727
Daviess	20,380	900	720	499	2,273	20,328	7,693,00	11,777	3,189,400	1,210,000	66,500	0	6,600	32,550	7,547,000	0	888,000	49,889
Hancock	7,888	63	50	216	984	8,800	686,000	0	409,600	228,000	0	0	1,600	12,980	2,608,000	0	12,000	27,965
Henderson	13,388	63	50	151	689	6,160	6,722,10	7,761	3,090,500	987,000	48,300	0	5,760	25,600	836,000	0	409,000	31,488
Hopkins	11,888	63	50	529	2,411	21,560	2,366,00	1,175	1,134,600	208,000	0	0	2,240	28,800	393,000	0	182,000	43,185
Logan	37,160	3,800	3,040	486	2,214	19,800	5,551,00	32,468	2,032,000	3,072,000	0	451,000	12,040	77,000	3,946,000	1,039,000	2,059,000	112,588
McLean	6,388	63	50	508	2,312	20,680	4,462,00	3,059	1,841,000	500,000	42,000	0	1,800	12,600	1,559,000	0	525,000	21,714
Muhlenberg	13,888	63	50	346	1,574	14,080	932,200	2,096	426,600	96,000	0	0	2,400	28,600	966,000	758,000	108,000	51,105
Ohio	18,888	63	50	76	344	3,080	2,014,50	3,846	783,000	100,000	0	0	3,000	37,200	2,595,000	0	118,000	66,827
Simpson	12,520	1,100	880	171	777	6,952	2,969,40	9,833	1,369,500	1,682,000	0	277,400	9,240	22,540	2,010,000	109,000	568,000	44,259
Todd	15,280	2,900	2,320	272	1,240	11,088	4,824,00	45,674	1,456,000	1,920,000	0	120,000	7,560	29,500	3,110,000	1,878,000	567,000	55,192
Union	20,888	63	50	626	2,854	25,520	9,420,00	8,390	2,721,900	840,000	82,800	0	9,620	24,500	13,000	0	0	45,379
Webster	11,888	63	50	76	344	3,080	4,741,50	224	1,456,000	378,000	39,000	0	3,600	23,760	294,000	0	401,000	38,729
District 3:																		
Adair	29,960	7,800	6,240	41	187	1,672	455,000	56,794	37,400	54,600	0	0	10,560	88,750	5,677,000	0	0	133,050
Allen	35,200	1,000	800	907	4,133	36,960	287,000	3,336	57,800	77,000	0	0	8,500	58,000	3,722,000	0	48,000	119,108
Barren	64,460	10,300	8,240	71	325	2,904	814,000	74,726	151,800	234,000	0	0	35,400	134,400	13,318,00	0	0	235,694
Breckinridge	39,230	150	120	490	2,234	19,976	1,360,10	8,922	350,900	253,500	0	0	8,840	114,140	9,252,000	0	0	176,903
Bullitt	8,420	600	480	39	177	1,584	170,000	9,708	115,200	32,900	0	0	6,800	19,800	1,283,000	0	0	32,373
Butler	15,780	400	320	477	2,175	19,448	1,245,00	5,973	474,000	54,000	0	0	1,350	41,600	919,000	0	41,000	88,000
Casey	33,420	3,100	2,480	248	1,132	10,120	378,400	34,026	73,500	13,000	0	0	17,280	78,000	7,349,000	0	0	121,594
Clinton	16,880	900	720	24	108	968	60,000	9,772	18,500	13,000	0	0	9,600	31,970	2,588,000	0	0	60,497
Cumberland	10,060	800	640	10	44	396	48,000	4,890	44,200	13,000	0	0	4,400	39,480	2,747,000	0	0	79,082
Edmonson	16,480	1,400	1,120	106	482	4,312	248,200	5,489	108,900	24,500	0	0	5,890	42,460	1,785,000	0	0	59,183
Grayson	33,420	3,100	2,480	404	1,840	16,456	1,116,00	37,973	254,200	143,500	0	0	9,300	71,600	4,440,000	0	0	132,083
Green	28,520	3,600	2,880	10	44	396	418,700	20,824	66,600	40,000	0	0	12,800	77,500	6,689,000	0	0	107,851
Hardin	42,820	2,600	2,080	346	1,574	14,080	2,407,00	40,528	910,800	391,000	0	0	33,600	81,600	5,190,000	0	0	147,696
Hart	35,000	5,000	4,000	24	108	968	273,000	31,988	44,400	36,000	0	0	36,890	72,000	9,880,000	0	0	150,270

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Table 1. Livestock inventories and crop production estimates–*Continued.*

County	All beef cattle and calves[1] (head)	Dairy cows[1] (head)	Dairy heifers[2] (head)	Lactating sows with litters[3] (head)	Gestating sows, boars, and gilts (head)	Nursery and finishing pigs[4] (head)	Corn for grain[1] (bu)	Corn for silage or green chop[5] (tons)	Soybean for beans[1] (bu)	Winter wheat for grain[1] (bu)	Sorghum for grain[1] (bu)	Barley for grain[1] (bu)	Alfalfa hay[1] (tons)	All other hay[1] (tons)	Burley tobacco[1] (lbs)	Dark fire-cured tobacco[1] (lbs)	Dark air-cured tobacco[1] (lbs)	Pasture-land forage[5] (tons)
Jefferson	5,730	150	120	19	89	792	159,600	751	68,200	33,600	0	0	3,900	14,760	522,000	0	0	16,735
Larue	23,880	3,400	2,720	99	453	4,048	974,400	27,291	473,600	161,000	0	0	21,830	45,310	3,826,000	0	0	74,171
Marion	38,260	4,300	3,440	261	1,191	10,648	679,000	48,761	315,400	180,000	0	0	20,800	73,830	7,208,000	0	0	130,490
Meade	22,460	300	240	205	935	8,360	853,200	6,297	332,800	342,000	0	0	14,960	59,800	2,224,000	0	0	79,393
Metcalfe	20,180	4,900	3,920	11	49	440	196,000	19,460	50,400	39,000	0	0	13,950	70,000	6,234,000	0	0	105,620
Monroe	37,900	4,500	3,600	15	69	616	135,000	42,477	17,000	36,400	0	0	14,060	93,600	4,114,000	0	0	168,050
Nelson	30,960	5,300	4,240	918	4,182	37,400	616,200	50,717	343,000	126,000	0	0	33,480	83,950	5,330,000	0	0	122,183
Russell	24,240	3,200	2,560	32	148	1,320	715,000	28,825	105,600	31,500	0	0	6,290	61,500	4,437,000	0	0	101,018
Taylor	26,560	3,300	2,640	52	236	2,112	960,300	29,366	230,400	184,500	0	0	9,200	84,160	6,116,000	0	0	105,793
Warren	62,620	4,100	3,280	438	1,998	17,864	2,713,20	36,515	839,800	1,188,000	0	0	20,440	106,700	6,294,000	0	65,000	176,260
District 4:																		
Boone	12,100	500	400	19	89	792	322,000	6,330	59,500	9,000	0	0	6,500	19,520	3,438,000	0	0	36,449
Bracken	12,520	1,100	880	17	79	704	135,000	5,506	8,220	9,000	0	0	11,880	28,600	8,093,000	0	0	74,623
Campbell	8,540	200	160	5	22	194	37,600	3,714	8,220	9,000	0	0	4,550	14,820	845,000	0	0	31,709
Carroll	8,140	200	160	28	128	1,144	45,500	4,574	57,600	0	0	0	2,560	22,250	4,237,000	0	0	51,267
Gallatin	4,480	400	320	5	22	194	37,600	4,136	68,000	9,000	0	0	3,600	11,880	2,536,000	0	0	32,818
Grant	17,960	300	240	5	22	194	55,300	4,873	8,220	9,000	0	0	8,410	36,550	6,860,000	0	0	82,706
Henry	26,860	2,300	1,840	17	79	704	390,000	21,931	80,600	54,000	0	0	27,200	49,500	10,177,00	0	0	90,698
Kenton	6,460	300	240	5	22	194	72,800	1,752	8,220	9,000	0	0	5,760	16,280	1,552,000	0	0	29,314
Oldham	12,060	800	640	41	187	1,672	493,500	7,988	115,500	89,300	0	0	9,000	16,910	1,429,000	0	0	42,953
Owen	20,060	800	640	5	22	194	56,800	2,735	8,220	9,000	0	0	12,160	63,250	9,501,000	0	0	134,586
Pendleton	18,060	800	640	11	49	440	70,400	1,643	51,000	9,000	0	0	11,880	47,150	5,981,000	0	0	105,240
Trimble	8,360	300	240	13	59	528	153,000	1,309	107,300	38,000	0	0	7,770	17,280	4,433,000	0	0	45,832
District 5:																		
Anderson	15,020	1,100	880	17	79	704	33,000	2,890	12,338	0	0	0	5,270	40,800	3,309,000	0	0	62,950
Bath	24,060	800	640	13	59	528	329,800	12,639	57,600	10,180	0	0	7,920	50,750	7,404,000	0	0	129,163
Bourbon	47,708	163	130	153	699	6,248	783,200	16,910	211,700	122,400	0	0	20,000	93,840	11,598,00	0	0	218,810
Boyle	31,880	900	720	26	118	1,056	324,000	22,474	28,800	83,300	0	0	10,200	46,200	5,209,000	0	0	86,519
Clark	41,708	163	130	19	89	792	269,500	8,460	42,000	36,000	0	0	7,480	57,750	7,940,000	0	0	151,027
Fayette	25,708	163	130	43	197	1,760	344,000	8,851	101,400	95,000	0	0	13,260	43,340	11,164,00	0	0	152,502
Fleming	34,480	6,400	5,120	43	197	1,760	604,500	39,625	55,100	64,000	0	0	38,080	72,000	9,205,000	0	0	180,686
Franklin	15,708	163	130	5	24	214	153,000	895	18,000	40,500	0	0	4,500	26,720	5,316,000	0	0	49,212
Garrard	37,340	1,200	960	26	118	1,056	200,200	16,989	12,338	10,180	0	0	13,940	49,200	8,215,000	0	0	146,155
Harrison	33,780	400	320	30	138	1,232	464,100	11,020	80,000	98,400	0	0	20,250	84,000	11,005,00	0	0	176,461
Jessamine	24,708	163	130	5	24	214	142,500	4,471	23,200	21,000	0	0	8,250	42,000	7,112,000	0	0	73,239
Lincoln	44,540	4,700	3,760	22	98	880	1,118,60	46,430	136,500	80,000	0	0	26,270	79,250	8,262,000	0	0	166,754
Madison	62,100	500	400	26	118	1,056	269,800	14,502	12,338	10,180	0	0	7,130	94,300	11,093,00	0	0	237,003
Mason	20,620	4,100	3,280	22	98	880	282,000	42,556	29,000	50,400	0	0	21,080	60,500	9,991,000	0	0	106,466
Mercer	31,280	2,900	2,320	5	24	214	360,000	20,399	66,000	45,000	0	0	19,140	50,000	7,036,000	0	0	114,386
Montgomery	28,100	500	400	5	24	214	150,000	9,188	37,700	21,000	0	0	8,500	56,280	7,396,000	0	0	107,059
Nicholas	20,208	163	130	5	24	214	104,000	4,715	12,338	10,180	0	0	6,480	34,200	5,727,000	0	0	84,716
Robertson	5,960	300	240	5	24	214	47,400	868	0	10,180	0	0	2,160	16,920	2,796,000	0	0	31,807
Scott	33,708	163	130	13	59	528	273,000	11,736	32,000	28,000	0	0	8,000	63,000	11,465,00	0	0	131,769

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Table 1. Livestock inventories and crop production estimates–*Continued.*

County	All beef cattle and calves[1] (head)	Dairy cows[1] (head)	Dairy heifers[2] (head)	Lactating sows with litters[3] (head)	Gestating sows, boars, and gilts (head)	Nursery and finishing pigs[4] (head)	Corn for grain[1] (bu)	Corn for silage or green chop[5] (tons)	Soybean for beans[1] (bu)	Winter wheat for grain[1] (bu)	Sorghum for grain[1] (bu)	Barley for grain[1] (bu)	Alfalfa hay[1] (tons)	All other hay[1] (tons)	Burley tobacco[1] (lbs)	Dark fire-cured tobacco[1] (lbs)	Dark air-cured tobacco[1] (lbs)	Pasture-land forage[5] (tons)
Shelby	34,720	4,600	3,680	253	1,151	10,296	924,000	55,736	422,500	225,500	0	0	27,250	100,800	12,126,00	0	0	147,913
Spencer	13,260	1,800	1,440	11	49	440	264,000	12,846	158,100	76,500	0	0	13,200	23,400	4,286,000	0	0	44,369
Washington	36,740	3,200	2,560	52	236	2,112	258,400	22,758	71,300	87,400	0	0	10,500	85,100	7,580,000	0	0	146,706
Woodford	25,208	163	130	5	24	214	230,400	7,042	80,500	52,800	0	0	10,540	35,070	10,380,00	0	0	129,973
District 6:																		
Bell	1,300	0	0	4	16	146	14,792	0	0	0	0	0	372	1,440	0	0	0	1,416
Boyd	3,803	54	43	4	16	146	14,792	605	10,144	0	0	0	2,100	5,760	47,000	0	0	24,577
Breathitt	1,003	54	43	4	16	146	14,792	224	0	0	0	0	372	2,300	1,135,000	0	0	22,667
Carter	10,403	54	43	4	16	146	57,400	1,920	10,144	3,445	0	0	4,800	26,250	3,719,000	0	0	70,771
Clay	3,403	54	43	13	59	528	78,400	994	0	0	0	0	372	4,320	2,903,000	0	0	15,893
Elliott	3,803	54	43	4	16	146	37,500	860	0	0	0	0	2,380	9,200	2,565,000	0	0	34,445
Estill	7,903	54	43	15	69	616	159,600	670	21,000	3,445	0	0	4,290	14,700	1,562,000	0	0	33,737
Floyd	703	54	43	4	16	146	14,792	224	0	0	0	0	372	1,470	6,000	0	0	2,318
Greenup	9,703	54	43	4	16	146	190,800	6,234	21,700	3,445	0	0	2,970	20,400	2,168,000	0	0	51,609
Harlan	153	54	43	0	0	0	0	0	0	0	0	0	372	537	6,000	0	0	633
Jackson	12,060	800	640	4	16	146	70,000	17,322	10,144	3,445	0	0	2,970	26,750	3,355,000	0	0	47,651
Johnson	1,303	54	43	4	16	146	14,792	224	10,144	0	0	0	372	3,220	677,000	0	0	8,513
Knott	153	54	43	0	0	0	14,792	0	0	0	0	0	372	537	0	0	0	2,733
Knox	4,303	54	43	4	16	146	102,300	3,270	10,144	3,445	0	0	372	11,340	1,047,000	0	0	20,352
Laurel	19,420	600	480	19	89	792	203,700	8,529	0	3,445	0	0	5,780	49,220	4,698,000	0	0	70,714
Lawrence	2,903	54	43	4	16	146	51,000	224	0	3,445	0	0	2,040	8,410	695,000	0	0	30,196
Lee	1,303	54	43	4	16	146	48,600	0	0	3,445	0	0	372	4,000	583,000	0	0	9,805
Leslie	153	54	43	0	0	0	0	0	0	0	0	0	372	537	74,000	0	0	1,751
Letcher	153	54	43	4	16	146	0	0	0	0	0	0	372	537	6,000	0	0	953
Lewis	10,440	1,700	1,360	4	16	146	336,700	4,621	59,500	38,400	0	0	10,080	46,480	5,838,000	0	0	61,394
Magoffin	1,703	54	43	4	16	146	88,200	623	0	0	0	0	372	3,220	1,609,000	0	0	12,386
Martin	500	0	0	4	16	146	14,792	0	0	0	0	0	372	1,560	0	0	0	2,404
McCreary	2,103	54	43	4	16	146	14,792	224	10,144	0	0	0	372	5,250	95,000	0	0	6,148
Menifee	4,203	54	43	4	16	146	14,792	1,453	0	0	0	0	372	11,760	1,714,000	0	0	21,864
Morgan	8,103	54	43	4	16	146	67,500	5,760	0	3,445	0	0	3,700	22,250	4,454,000	0	0	70,754
Owsley	1,803	54	43	4	16	146	14,792	224	0	0	0	0	372	2,850	1,860,000	0	0	6,590
Perry	703	54	43	4	16	146	14,792	224	0	0	0	0	372	537	59,000	0	0	3,823
Pike	700	0	0	4	16	146	14,792	0	0	0	0	0	372	537	0	0	0	1,903
Powell	3,303	54	43	4	16	146	36,000	580	20,300	0	0	0	372	8,580	902,000	0	0	13,772
Pulaski	53,800	4,000	3,200	24	108	968	987,900	55,699	152,100	70,500	0	0	13,340	140,000	7,870,000	0	0	185,046
Rockcastle	14,700	1,000	800	11	49	440	198,900	10,287	10,144	3,445	0	0	9,900	37,250	3,665,000	0	0	68,750
Rowan	5,503	54	43	4	16	146	171,700	3,975	10,144	0	0	0	3,850	27,720	1,785,000	0	0	35,810
Wayne	25,060	800	640	188	856	7,656	730,800	10,042	210,000	66,300	0	0	10,530	36,000	3,586,000	0	0	81,012
Whitley	7,503	54	43	4	16	146	46,000	2,773	0	3,445	0	0	372	15,120	635,000	0	0	26,748
Wolfe	2,403	54	43	4	16	146	43,800	1,406	0	0	0	0	372	7,220	1,922,000	0	0	18,970
TOTALS	2,139,000	145,000	116,000	12,744	58,056	519,200	120,510,	1,438,492	44,160,00	28,620,00	709,000	897,600	990,000	4,600,000	470,800,0	20,290,00	7,216,000	8,642,705

[1]Estimates adapted from Kentucky Agricultural Statistics, 1997-1998.
[2]Dairy heifer inventory estimated as 80% of dairy cow inventory reported in Kentucky Agricultural Statistics.
[3]12% of hogs and pigs inventory reported in Kentucky Agricultural Statistics partitioned into breeding stock. Breeding stock inventory partitioned into lactating sows with litters (18%) and gestating sows, boars, and replacement gilts (82%).
[4]Nursery and finishing pig inventory estimated as 88% of hogs and pigs inventory reported in Kentucky Agricultural Statistics.
[5]Estimates adapted from U.S. Census of Agriculture, 1997.

Estimates of Manure Production and Nutrient Availability from Manure

The manure parameters estimated in the assessment were dry matter manure production, nitrogen (expressed as total nitrogen), phosphorus (expressed as P_2O_5), and potassium (expressed as K_2O). Manure production and nutrient composition values published by the 1993 American Society of Agricultural Engineers (ASAE) Standards were the primary source for calculating these parameters. The ASAE Standards do not report manure production and manure nutrient content data for pullets and breeder pullets; therefore, these values were taken from the *Natural Resources Conservation Service (NRCS) Agricultural Waste Management Field Handbook* (1992). For certain classes of livestock, the reported values were adjusted to more accurately estimate manure and nutrient production. For example, the values given in the ASAE Standards for swine overestimate the manure production and manure nutrient content of swine that are limit fed (gestating sows, boars, and replacement gilts). For these classes of swine, the values reported in the 1993 ASAE Standards were lowered by 50% to more accurately reflect the reduced manure output and nutrient content resulting from limit feeding. **Table 2** shows the manure production and nutrient content values and the average animal liveweights used in the assessment.

It was necessary to estimate the amount of excreted manure (and, consequently, manure nutrients) that is recoverable and available for land application. In the process of collecting and storing manure from livestock and poultry production facilities, a portion of the manure and nutrients is lost. The degree to which these losses occur is dependent on the type of manure collection and storage system used by the livestock enterprise (the reader is referred to the *NRCS Agricultural Waste Management Field Handbook,* Chapter 11, Table 11-15, for estimates of losses from various types of manure systems). Unfortunately, there are no available estimates of the number of each type of manure system used in Kentucky. Therefore, values used in the assessment to estimate recoverable manure, nitrogen, phosphorus, and potassium were adapted from Lander et al. and are shown in **Table 3**. The recovery factors reported by Lander et al. were derived from consultation with numerous individuals from the U.S. Department of Agriculture (USDA), universities, and industry groups, and were based on the following general assumptions:

- Nitrogen losses will greatly exceed those of phosphorus and potassium, primarily due to volatilization of nitrogen compounds.
- As the quality (from an automation standpoint) and numbers of manure management systems improve, the loss of nutrients, particularly nitrogen, will likely increase. For example, as the manure management system becomes more automated, nitrogen losses through volatilization will increase.
- Phosphorus will primarily be found within the bottom sludge of lagoons and holding ponds. Even though the sludge may not be removed on a regular basis, it will need to be removed at some point, and the phosphorus content of the sludge should be considered in a long-term land application strategy.

Calculated estimates of the amounts of recoverable manure (on a dry-matter basis), nitrogen, phosphorus, and potassium produced annually in manure from livestock and poultry by county are shown in **Table 4**. In addition to the recovery factors shown in Table 3, these calculated estimates are also based on nutrient availability factors that were established for each manure nutrient considered in the assessment. For phosphorus and potassium, an availability factor of 100% was used. This factor was based on the assumption that over time, all of the phosphorus and potassium in manure applied to land would be available for plant removal. For manure nitrogen, an availability factor of 70% was used. Under ideal conditions in Kentucky, approximately 30% of the nitrogen in land-applied manure will not be available for plant removal due to nitrogen losses associated with denitrification, volatilization, etc. To account for these losses, 1.43 pounds of manure nitrogen would be needed for each pound of nitrogen that would be removed by plants.

The manure and nutrient recovery factors and the nutrient availability factors used in the assessment do not account for nutrient losses that might occur as a result of the method used to apply manure to land. It should be recognized that additional nitrogen losses would occur when manure is not injected or incorporated into the soil immediately after surface application. However, reliable estimates of the proportion of manure that is applied using the different land application methods are not available.

Table 2. Average liveweights, manure production, and manure nutrient content from livestock and poultry.

		Lbs per day per 1,000 lbs liveweight			
Animal type	**Average live-weight (lbs)**	**Dry matter manure**	**Total nitrogen**	**P_2O_5**	**K_2O**
Beef (all cattle and calves)[1]	800	8.5	0.34	0.21	0.25
Dairy cows[1]	1,300	12.0	0.45	0.21	0.35
Dairy heifers[1]	650	12.0	0.45	0.21	0.35
Lactating sows with litters[1]	350	11.0	0.52	0.41	0.35
Gestating sows, boars, and replacement gilts[1]	325	5.5	0.26	0.20	0.17
Nursery and finishing pigs[1]	135	11.0	0.52	0.41	0.35
Layer[1]	3.30	16.0	0.84	0.69	0.36
Breeder layer[1]	5.75	16.0	0.84	0.69	0.36
Pullet[2]	1.40	11.4	0.62	0.55	0.31
Breeder pullet[2]	2.25	11.4	0.62	0.55	0.31
Broiler[1]	2.65	22.0	1.10	0.69	0.48

[1]Adapted from 1993 ASAE Standards.
[2]Adapted from 1992 *NRCS Agricultural Waste Management Field Handbook.*

Table 3. Annual recovery of dry matter, nitrogen, phosphorus, and potassium from animal manures[1].

	Annual recovery[2] (% of total)			
Component of manure	**Beef[3]**	**Dairy**	**Swine**	**Poultry**
Total dry matter	10	70	80	95
Total nitrogen	30	40	25	65
Phosphorus (expressed as P_2O_5)	85	85	85	85
Potassium (expressed as K_2O)	90	90	90	90

[1]Adapted from Lander et al. (1998).
[2]These recovery factors only account for losses that occur during collection and storage of manure.
[3]Potential manure recovery from beef cattle is very low because a vast majority of the beef cattle in Kentucky are pastured.

Crop and Forage Production Estimates

Harvested crops included in the assessment were corn harvested for grain, corn harvested as silage or green chop, soybean harvested for beans, winter wheat harvested for grain, sorghum harvested for grain, barley harvested for grain, alfalfa hay, all other types of hay (excluding alfalfa), burley tobacco, dark fire-cured tobacco, and dark air-cured tobacco. With the exception of corn harvested as silage or green chop, county estimates for the production of these harvested crops were taken from Kentucky Agricultural Statistics. Production estimates were not available for some counties within a district that had limited production of certain crops, in particular for many counties located in the eastern half of Kentucky. For example, counties with less than 500 acres of harvested corn for grain were included in an "Other Counties" category within a district. Crop production estimates for these counties were determined using the process described under "Livestock and Poultry Inventory Estimates." For crops that are grown almost exclusively in certain geographical regions (sorghum, barley, dark fire-cured tobacco, and dark air-cured tobacco), only counties with a reported production estimate in Kentucky Agricultural Statistics were included in the assessment.

Production estimates for corn harvested as silage or green chop are not reported in Kentucky Agricultural Statistics, and were taken from the 1997 U.S. Census of Agriculture. Production estimates for corn harvested as silage or green chop were not given for 10 counties in the census to avoid disclosing data for individual farms. For these counties, production estimates were assigned by (1) determining the difference between the total production of corn harvested as silage or green chop reported for the state and the total production that was reported for the other counties and (2) equally dividing this difference among the 10 counties whose production estimate was not reported.

Forage production from land that is used strictly for pastureland was also included in the assessment. Pastureland acreage for each county was taken from two categories of pastureland reported in the 1997 U.S. Census of Agriculture: (1) "Cropland Used Only for

Table 4. Recoverable manure, nitrogen, phosphorus, and potassium produced annually by livestock and poultry and nutrients removed annually by crops and forages.

	Recoverable manure and manure nutrients from livestock and poultry[1] (lbs per year)				Nutrients removed by crops and forages[2] (lbs per year)		
County	**Dry matter manure**	**Total nitrogen**	**P_2O_5**	**K_2O**	**Total nitrogen**	**P_2O_5**	**K_2O**
District 1:							
Ballard	24,185,975	413,116	646,522	576,537	8,804,781	3,028,289	4,731,845
Calloway	34,206,357	642,714	865,274	784,876	10,742,530	3,894,564	5,869,652
Carlisle	21,751,051	375,581	596,362	521,486	6,574,309	2,278,002	3,582,102
Fulton	12,980,621	296,838	382,571	276,763	10,289,823	3,324,963	4,246,625
Graves	119,012,948	2,588,479	3,322,893	2,589,831	16,310,141	5,785,426	8,509,625
Hickman	57,333,139	1,300,051	1,605,532	1,220,172	9,436,588	3,384,184	4,267,420
Livingston	10,511,471	138,557	257,716	266,047	4,318,693	1,518,212	4,428,206
Lyon	4,182,163	36,684	99,737	114,425	1,791,250	602,793	1,556,738
Marshall	17,818,919	342,706	481,613	407,074	4,235,085	1,428,548	3,129,455
McCracken	7,193,990	138,017	200,902	165,677	4,703,627	1,532,262	2,655,508
Trigg	12,344,227	104,576	326,674	342,535	6,105,675	2,197,660	4,765,890
District 2:							
Caldwell	12,567,925	113,168	291,112	342,952	6,273,461	2,259,098	5,202,414
Christian	34,301,499	430,933	812,152	880,703	20,401,664	7,550,621	13,116,776
Crittenden	15,186,442	241,628	369,634	364,775	4,862,263	1,756,506	5,174,333
Daviess	41,238,652	677,502	1,105,428	998,727	19,140,336	6,735,387	10,178,744
Hancock	9,520,952	121,206	264,898	246,824	2,993,929	982,713	2,175,958
Henderson	7,933,534	85,121	218,744	213,959	16,867,237	5,906,279	8,386,462
Hopkins	77,524,872	1,636,386	2,238,530	1,719,788	6,932,103	2,386,690	4,524,593
Logan	46,291,636	525,395	1,054,247	1,215,752	19,289,760	7,040,464	12,509,867
McLean	107,803,619	2,391,060	3,110,770	2,328,789	10,214,124	3,626,603	5,034,356
Muhlenberg	52,110,659	1,108,353	1,746,927	1,183,108	3,849,100	1,303,645	3,425,874

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Table 4. Recoverable manure, nitrogen, phosphorus, and potassium produced annually by livestock and poultry and nutrients removed annually by crops and forages–*Continued.*

County	Recoverable manure and manure nutrients from livestock and poultry[1] (lbs per year)				Nutrients removed by crops and forages[2] (lbs per year)		
	Dry matter manure	Total nitrogen	P_2O_5	K_2O	Total nitrogen	P_2O_5	K_2O
Ohio	52,472,082	1,155,529	1,454,143	1,128,852	6,251,591	2,175,977	5,028,000
Simpson	19,175,831	281,030	524,277	490,253	10,432,601	3,721,888	5,810,138
Todd	53,500,885	948,607	1,583,173	1,287,560	12,878,221	4,829,838	7,504,195
Union	20,554,143	199,086	582,163	563,541	17,725,175	6,749,669	9,185,151
Webster	107,760,841	2,508,895	3,038,251	2,263,923	9,646,290	3,602,183	5,507,205
District 3:							
Adair	51,829,742	526,662	841,588	1,364,606	6,350,835	2,194,204	8,496,934
Allen	36,060,288	354,950	973,452	984,767	4,461,258	1,490,790	5,931,172
Barren	75,722,332	768,134	1,272,756	1,993,306	11,747,496	3,921,271	14,936,479
Breckinridge	22,560,170	214,971	589,341	612,666	9,317,912	3,180,604	11,051,736
Bullitt	6,260,927	59,518	120,378	167,249	2,039,612	663,493	2,308,103
Butler	26,012,666	373,597	709,047	653,978	4,917,793	1,723,556	4,770,763
Casey	30,851,340	294,809	601,424	825,830	6,141,343	2,028,301	8,058,319
Clinton	10,148,806	103,047	196,251	267,417	2,601,722	842,928	3,501,844
Cumberland	16,076,135	282,955	376,947	374,042	2,842,927	924,516	3,906,310
Edmonson	16,355,881	190,888	361,747	427,288	3,097,975	1,032,193	3,907,131
Grayson	46,002,927	610,847	1,078,722	1,169,271	6,669,471	2,346,532	7,756,477
Green	27,372,849	272,091	458,502	721,930	5,650,236	1,880,109	7,426,403
Hardin	32,451,887	302,132	673,028	874,038	11,640,568	3,980,156	11,196,270
Hart	37,090,551	370,088	619,744	978,229	7,241,342	2,303,548	9,386,333
Jefferson	2,670,709	24,139	55,411	71,797	1,286,130	428,791	1,448,984
Larue	27,002,674	266,397	477,517	716,076	6,224,731	2,058,470	6,196,982
Marion	39,023,109	377,478	736,544	1,041,326	7,501,958	2,484,130	8,701,052
Meade	21,235,047	331,182	549,740	516,780	5,883,575	2,005,228	6,239,026
Metcalfe	32,579,878	331,061	525,717	857,223	5,174,040	1,687,342	6,915,578
Monroe	43,708,632	557,735	835,923	1,102,473	6,539,267	2,207,293	9,131,337
Nelson	56,691,107	535,839	1,222,494	1,536,366	8,260,188	2,706,770	9,669,714
Russell	24,558,594	243,703	417,690	648,705	4,909,571	1,717,973	6,150,878
Taylor	26,103,936	257,804	451,183	690,517	6,749,598	2,330,217	7,987,106
Warren	54,603,180	619,286	1,213,106	1,429,717	13,170,463	4,669,314	12,579,705
District 4:							
Boone	6,204,785	57,927	118,024	165,332	2,093,752	692,013	2,460,944
Bracken	9,611,379	93,579	169,423	254,553	3,116,303	951,260	4,065,716
Campbell	3,336,242	30,355	64,388	88,905	1,227,935	403,654	1,657,880
Carroll	3,730,769	33,606	77,922	100,361	1,980,593	608,993	2,568,839
Gallatin	3,444,574	33,609	60,206	91,154	1,390,049	421,030	1,663,394
Grant	6,232,298	55,854	121,718	166,162	3,159,081	979,458	4,299,307
Henry	19,866,711	193,786	345,172	525,373	5,501,302	1,731,632	6,741,682
Kenton	3,377,998	31,878	62,037	89,697	1,373,798	444,284	1,813,373
Oldham	8,326,122	79,203	157,602	222,004	2,451,902	850,925	2,571,819
Owen	9,543,578	89,528	174,837	253,238	4,995,704	1,561,080	6,927,042
Pendleton	9,175,202	86,417	168,505	243,600	3,993,340	1,251,049	5,370,821
Trimble	4,023,325	37,276	77,390	107,297	2,269,263	689,920	2,597,845
District 5:							
Anderson	10,231,879	98,791	182,397	271,176	2,665,897	858,641	3,749,578
Bath	10,710,125	99,305	201,088	284,802	4,557,405	1,489,139	6,017,290
Bourbon	15,994,091	135,841	363,928	433,779	8,850,806	2,904,918	11,101,432
Boyle	13,483,398	123,737	258,787	359,264	3,981,794	1,338,284	5,125,788
Clark	11,670,076	99,880	243,177	312,845	4,958,133	1,614,413	6,687,984
Fayette	8,201,827	70,683	176,042	220,837	5,288,031	1,665,474	6,619,647
Fleming	45,185,160	454,436	748,272	1,191,251	7,927,995	2,603,866	10,082,074
Franklin	4,916,412	43,188	98,748	131,378	2,265,453	716,549	2,937,483
Garrard	16,512,606	152,698	312,455	439,436	4,845,461	1,557,049	6,536,892
Harrison	11,256,363	99,159	229,318	301,398	7,341,295	2,378,328	9,564,977
Jessamine	7,150,212	61,952	145,455	191,220	3,377,430	1,061,227	4,495,110

Continued on next page

Table 4. Recoverable manure, nitrogen, phosphorus, and potassium produced annually by livestock and poultry and nutrients removed annually by crops and forages–*Continued.*

County	Recoverable manure and manure nutrients from livestock and poultry[1] (lbs per year)				Nutrients removed by crops and forages[2] (lbs per year)		
	Dry matter manure	Total nitrogen	P_2O_5	K_2O	Total nitrogen	P_2O_5	K_2O
Ohio	52,472,082	1,155,529	1,454,143	1,128,852	6,251,591	2,175,977	5,028,000
Simpson	19,175,831	281,030	524,277	490,253	10,432,601	3,721,888	5,810,138
Todd	53,500,885	948,607	1,583,173	1,287,560	12,878,221	4,829,838	7,504,195
Union	20,554,143	199,086	582,163	563,541	17,725,175	6,749,669	9,185,151
Webster	107,760,841	2,508,895	3,038,251	2,263,923	9,646,290	3,602,183	5,507,205
District 3:							
Adair	51,829,742	526,662	841,588	1,364,606	6,350,835	2,194,204	8,496,934
Allen	36,060,288	354,950	973,452	984,767	4,461,258	1,490,790	5,931,172
Barren	75,722,332	768,134	1,272,756	1,993,306	11,747,496	3,921,271	14,936,479
Breckinridge	22,560,170	214,971	589,341	612,666	9,317,912	3,180,604	11,051,736
Bullitt	6,260,927	59,518	120,378	167,249	2,039,612	663,493	2,308,103
Butler	26,012,666	373,597	709,047	653,978	4,917,793	1,723,556	4,770,763
Casey	30,851,340	294,809	601,424	825,830	6,141,343	2,028,301	8,058,319
Clinton	10,148,806	103,047	196,251	267,417	2,601,722	842,928	3,501,844
Cumberland	16,076,135	282,955	376,947	374,042	2,842,927	924,516	3,906,310
Edmonson	16,355,881	190,888	361,747	427,288	3,097,975	1,032,193	3,907,131
Grayson	46,002,927	610,847	1,078,722	1,169,271	6,669,471	2,346,532	7,756,477
Green	27,372,849	272,091	458,502	721,930	5,650,236	1,880,109	7,426,403
Hardin	32,451,887	302,132	673,028	874,038	11,640,568	3,980,156	11,196,270
Hart	37,090,551	370,088	619,744	978,229	7,241,342	2,303,548	9,386,333
Jefferson	2,670,709	24,139	55,411	71,797	1,286,130	428,791	1,448,984
Larue	27,002,674	266,397	477,517	716,076	6,224,731	2,058,470	6,196,982
Marion	39,023,109	377,478	736,544	1,041,326	7,501,958	2,484,130	8,701,052
Meade	21,235,047	331,182	549,740	516,780	5,883,575	2,005,228	6,239,026
Metcalfe	32,579,878	331,061	525,717	857,223	5,174,040	1,687,342	6,915,578
Monroe	43,708,632	557,735	835,923	1,102,473	6,539,267	2,207,293	9,131,337
Nelson	56,691,107	535,839	1,222,494	1,536,366	8,260,188	2,706,770	9,669,714
Russell	24,558,594	243,703	417,690	648,705	4,909,571	1,717,973	6,150,878
Taylor	26,103,936	257,804	451,183	690,517	6,749,598	2,330,217	7,987,106
Warren	54,603,180	619,286	1,213,106	1,429,717	13,170,463	4,669,314	12,579,705
District 4:							
Boone	6,204,785	57,927	118,024	165,332	2,093,752	692,013	2,460,944
Bracken	9,611,379	93,579	169,423	254,553	3,116,303	951,260	4,065,716
Campbell	3,336,242	30,355	64,388	88,905	1,227,935	403,654	1,657,880
Carroll	3,730,769	33,606	77,922	100,361	1,980,593	608,993	2,568,839
Gallatin	3,444,574	33,609	60,206	91,154	1,390,049	421,030	1,663,394
Grant	6,232,298	55,854	121,718	166,162	3,159,081	979,458	4,299,307
Henry	19,866,711	193,786	345,172	525,373	5,501,302	1,731,632	6,741,682
Kenton	3,377,998	31,878	62,037	89,697	1,373,798	444,284	1,813,373
Oldham	8,326,122	79,203	157,602	222,004	2,451,902	850,925	2,571,819
Owen	9,543,578	89,528	174,837	253,238	4,995,704	1,561,080	6,927,042
Pendleton	9,175,202	86,417	168,505	243,600	3,993,340	1,251,049	5,370,821
Trimble	4,023,325	37,276	77,390	107,297	2,269,263	689,920	2,597,845
District 5:							
Anderson	10,231,879	98,791	182,397	271,176	2,665,897	858,641	3,749,578
Bath	10,710,125	99,305	201,088	284,802	4,557,405	1,489,139	6,017,290
Bourbon	15,994,091	135,841	363,928	433,779	8,850,806	2,904,918	11,101,432
Boyle	13,483,398	123,737	258,787	359,264	3,981,794	1,338,284	5,125,788
Clark	11,670,076	99,880	243,177	312,845	4,958,133	1,614,413	6,687,984
Fayette	8,201,827	70,683	176,042	220,837	5,288,031	1,665,474	6,619,647
Fleming	45,185,160	454,436	748,272	1,191,251	7,927,995	2,603,866	10,082,074
Franklin	4,916,412	43,188	98,748	131,378	2,265,453	716,549	2,937,483
Garrard	16,512,606	152,698	312,455	439,436	4,845,461	1,557,049	6,536,892
Harrison	11,256,363	99,159	229,318	301,398	7,341,295	2,378,328	9,564,977
Jessamine	7,150,212	61,952	145,455	191,220	3,377,430	1,061,227	4,495,110

Pasture or Grazing" and (2) "Pastureland and Rangeland Other than Cropland and Woodland Pastured." The acreage of "Cropland Used Only for Pasture or Grazing" in two counties and the acreage of "Pastureland and Rangeland Other than Cropland and Woodland Pastured" in three counties were not reported in the 1997 U.S. Census of Agriculture to avoid disclosing data for individual farms. Acreage estimates for these categories of pastureland within those counties whose estimate was not reported were determined by finding the difference between the total acreage reported for each category in the entire state and the acreage total that was reported for each category in the other counties. This difference was then equally divided among those counties whose pastureland acreage was not reported. The amount of forage produced on each acre of "Cropland Used Only for Pasture or Grazing" within each county was assumed to be the same as the harvested per acre yield of hay (the "all other hay" category, which excludes alfalfa hay) as reported in Kentucky Agricultural Statistics. Land that is included in the category of "Pastureland and Rangeland Other Than Cropland and Woodland Pastured" tends to be of lower quality than land from the category of cropland used only for pasture or grazing. Therefore, it was assumed that forage production from this category of pastureland would only be 60% of the reported hay production value for the "all other hay" category (excluding alfalfa hay) in Kentucky Agricultural Statistics (Thom 1999).

Crop and forage production estimates (annual yields) by county used in the assessment are shown in Table 1.

Crop and Forage Nutrient Removal Estimates

The removal of nitrogen (expressed as total nitrogen), phosphorus (expressed as P_2O_5), and potassium (expressed as K_2O) was estimated for each of the crop and forage categories. For purposes of the assessment, nutrient removal refers to the amount of a nutrient that will be removed from the land when the crop is harvested or the forage is grazed by livestock. *Nutrient removal should not be confused with the nutrient requirements of the crops and forages or the total nutrient uptake by crops and forages. The nutrient removal capacity of crops and forages will be lower than the total amount of a nutrient that is taken up and utilized by the plant for growth.*

For harvested crops, nutrient removal was estimated based on the total yield and the nutrient content of the harvested biomass. A basic assumption was made that plant residues from harvested crops were not removed from the field unless they routinely were considered a part of the harvested material. For example, the crop residue from corn harvested as grain was assumed to remain in the field. For corn harvested as silage or green chop, both the ears and stalks were considered to be removed from the field. Similar logic was used for all other harvested crops included in the assessment.

For grazed forages, it was recognized that a large percentage of the nutrients consumed by livestock grazing pastureland would be recycled back onto the land through excreted manure. To account for these recycled manure nutrients, nutrient removal from forages on pastureland was estimated as 30% of the nutrient removal values used for the "all other hay" category (Thom 1999).

The values used to estimate nutrient removal by harvested crops and grazed forages were based on data from Wells and Thom (1994) and Lander et al. and are shown in **Table 5**. Based on these nutrient removal values and the annual production yields for each crop and forage category, annual nutrient removal was calculated. The annual removal of nitrogen, phosphorus, and potassium by crops and forages for each county is shown in Table 4.

Results

Estimated Nitrogen Balance

The results for the estimated balance between nitrogen in livestock and poultry manure and nitrogen removed by crops and forages are shown in Figure 1. The potential for nitrogen removal by harvested crops and grazed forages substantially exceeds the amount of recoverable manure nitrogen produced annually by livestock and poultry in all 120 counties. On a statewide basis, crops and forages have the capacity to remove almost 600 million pounds of nitrogen annually. At the present level of animal production, nitrogen from livestock and poultry manure could potentially supply only approximately 6% of the nitrogen that is removed by crops and forages grown in Kentucky.

Less than 10% of the nitrogen removed annually by crops and forages could be supplied by manure nitrogen in 112 counties. At the highest level for any county, manure from livestock and poul-

Table 5. Nutrient removal by crops grown in Kentucky[1].

			Nutrients removed (lbs per yield unit)		
Crop	**Yield unit**	**Lbs per yield unit**	**Total nitrogen**	**P_2O_5**	**K_2O**
Alfalfa hay	ton	2,000	50	14	55
All other hay (except alfalfa)	ton	2,000	35	12	53
Barley for grain	bushel	48	0.900	0.410	0.300
Corn for grain	bushel	56	0.700	0.400	0.350
Corn for silage or green chop	ton	2,000	7.5	3.6	8.0
Forage from pastureland[2]	ton	2,000	10.5	3.6	15.9
Sorghum for grain	bushel	56	0.950	0.410	0.300
Soybean for beans	bushel	60	3.000	0.700	1.100
Tobacco, burley	pound	1	0.070	0.011	0.075
Tobacco, dark air-cured	pound	1	0.070	0.006	0.060
Tobacco, dark fire-cured	pound	1	0.070	0.006	0.060
Winter wheat for grain	bushel	60	1.200	0.500	0.300

[1]Adapted from Wells and Thom (1994) and Lander et al. (1998).
[2]Nutrient removal for forage from pastureland estimated as 30% of the values given for all other hay (except alfalfa).

try operations in Muhlenberg County could potentially provide approximately 29% of the nitrogen its crops and forages have the capacity to remove (i.e., approximately 1.1 million pounds of the approximately 3.8 million pounds of nitrogen removed annually by crops and forages could be supplied by livestock and poultry manure).

After accounting for nitrogen that could be supplied from livestock and poultry manure, the crops and forages in each of 97 counties have the ability to remove greater than 1 million additional pounds of nitrogen. Five of these counties (Christian, Logan, Daviess, Union, and Henderson) each have the capacity to remove more than 16 million additional pounds of nitrogen. A majority of the 23 counties that could each remove less than 1 million additional pounds of nitrogen are located in the eastern half of the state and have limited animal and crop production.

Estimated Phosphorus Balance

The results for the estimated balance between phosphorus in livestock and poultry manure and phosphorus removed by crops and forages are given in Figure 2. Crops and forages grown in Kentucky have the potential to remove about 204 million pounds of phosphorus on an annual basis. Manure phosphorus from livestock and poultry presently produced within the state could potentially supply only about 26% of the phosphorus that is removed annually by crops and forages.

Based on these estimates, seven counties have manure phosphorus production levels that could supply between 50% and 94% of the phosphorus removed annually by the crops and forages grown in those counties (Letcher, 51%; Graves, 57%; Allen, 65%; Ohio, 67%; Webster, 84%; McLean, 86%; and Hopkins, 94%). Results for Muhlenberg County indicate that its livestock and poultry generate more manure phosphorus than its crops and forages have the capability to remove (134%). However, when drawing conclusions from these results, it must be recognized that all factors influencing the true balance of phosphorus for a county were not included in the assessment due to limitations in available data. A detailed discussion of factors that likely contributed to these high values, which should be considered when interpreting these results, follows later in the "Limitations of the Assessment" section of this publication.

Crops and forages in each of 57 counties have the capacity to remove more than 1 million additional pounds of phosphorus annually above the phosphorus that is currently recovered from livestock and poultry manure in those counties. Fifteen of these counties could each remove between 2 and 3 million additional pounds of phosphorus, and five counties (Christian, Union, Logan, Henderson, and Daviess) each have the potential to remove more than 5 million additional pounds of phosphorus on a yearly basis. A majority of the 63 counties whose crops and forages could each remove less than 1 million additional pounds of phosphorus (in excess of the phosphorus from livestock and poultry manure) are located in the eastern half of the state, although a few are located in the western half.

Estimated Potassium Balance

The results for the estimated balance between potassium in livestock and poultry manure and potassium removed by crops and forages are shown in Figure 3. The potassium removal capacity of crops and forages substantially exceeds the amount of potassium recovered from livestock and poultry manure in all 120 Kentucky counties. Of the almost 584 million pounds of potassium removed annually by crops and forages in Kentucky, only approximately 10% could be supplied by the potassium in animal manure.

The estimates indicate that the potassium recovered from livestock and poultry manure would supply less than 25% of the potassium removed annually by crops and forages in each of 114 counties. After accounting for potassium that is supplied by animal manure, the crops and forages in 101 counties have the capacity to remove more than 1 million additional pounds of potassium each. The 19 counties whose crops and forages could each remove less than 1 million additional pounds of potassium are located solely in the eastern one-third of Kentucky, where forests and terrain limit crop and forage production. A total of 88 counties could each remove in excess of 2 million additional pounds of potassium, and 59 counties could each remove more than 4 million additional pounds of potassium.

At the highest levels for any counties, manure potassium from livestock and poultry operations in McLean County and Webster County could supply 46% and 41%, respectively, of the potassium removed annually by crops and forages. However, after accounting for the potassium from animal manure, the crops and forages in these counties have the capacity to remove substantial amounts of additional potassium (McLean, 2.7 million additional pounds; Webster, 3.2 million additional pounds).

Discussion

Potential Uses of the Assessment

As stated previously, the purpose of this assessment is to provide an estimate (for each Kentucky county) of the degree to which nutrients removed annually by harvested crops and grazed forages could potentially be supplied by nutrients from livestock and poultry manure. The results of the assessment are only a snapshot of potential manure production and nutrient removal on a relatively large scale (a county or statewide basis) and do not allow for evaluations at the individual farm level, so prudence must be used when drawing conclusions from the results.

The assessment may be most beneficial when used as a benchmark of potential manure utilization for a county or region of the state, based on current animal inventories and crop and forage production levels. When used in this manner, these estimates may help identify large areas within the state where additional manure (either from the expansion of existing operations or the construction of new operations) could be utilized. This information may also help in identifying areas where alternative uses for manure should be explored. For example, if a county's crop and forage production is limited, manure utilization options other than for plant growth may need to be considered. The assessment may also be used to provide some insight into the concentration of livestock and poultry within Kentucky relative to crop and forage production.

The assessment is not intended to define the potential for any county's future livestock or poultry production, nor should it be used to place any restrictions on future production. While this information may be used as a starting point for discussion, when evaluating the potential for expansion of existing animal enterprises or the opportunity for new animal operations, farms must be evaluated individually, based on their own merits. It also would be erroneous to conclude from this assessment that livestock or poultry production either does or does not cause environmental problems in any county or region. No assessment of environmental impact can be made from the nutrient production and removal estimates that are presented here. The environmental impact of livestock and poultry operations within a county or area is dependent on manure management practices at the individual farm level.

Limitations of the Assessment

It is important when using this information to understand that it does not provide a complete balance of nutrients for a county, since it does not account for the distribution of crops within a county or for farm-level variables. Data for these factors, as well as others known to influence nutrient balance, are simply not available at the present time.

For purposes of this assessment, it was necessary to make several general assumptions concerning livestock and poultry inventories, crop and forage production levels, manure management strategies, and crop nutrient removal potential. It should be recognized that actual animal inventories, crop and forage acreage, soil fertility, production efficiencies, and management practices at the farm level affect the balance of nutrients within a county.

A specific county may have a high or excessive level of manure nutrients compared to crop nutrient removal capacities because of either a relatively large animal inventory or a relatively small acreage of cropland and pastureland. Since either of the two is a possibility, a county which may appear to have or to be approaching an excess of manure nutrients must be studied more closely. A number of factors not included in the assessment (due to unavailable or insufficient data) could significantly alter the estimated nutrient balance within a county. Following is a discussion of some of those factors and how they may affect the use or interpretation of this assessment. These factors represent areas where additional research and (or) data collection are needed to gain a better understanding of the true nutrient balance within Kentucky counties:

- **Potential for transporting animal manure from surplus to deficit areas**—The estimates reported here are based on the assumption that the manure produced within a county would also be utilized within that county. While this assumption likely would hold true for a majority of dairy and swine operations, where manure is handled primarily as a liquid, the assumption could be flawed for many poultry operations. Broiler and layer litter is handled as a solid and is easily transported by truck. Although it may not be economically practical to transport the manure long distances, the opportunity certainly exists to transport poultry litter across county lines to areas where the nutrients are needed by crops, and this is currently being done. No data exist, however, to provide a reliable estimate of the amount of manure that is currently being moved from one county to another.
- **Alternative or additional uses for animal manure**—It was assumed in the assessment that all livestock and poultry manure would be applied on crop or forage land. However, there are other ways to manage manure that would reduce the amount available for land application. For example, manure from livestock and poultry operations can be composted and marketed as a product for gardening and greenhouses. Applying manure to strip-mined land can help with reclamation projects by increasing the organic matter content and water-holding capacity of the soil. Other options include utilizing manure in constructed wetlands to provide a habitat for wildlife and using methane digesters to convert manure to an energy source that can be used by the livestock or poultry operation.
- **Other crops and forages and crop nutrient removal variability**—While the crops and forages included in the assessment represent the major ones that are grown in Kentucky, there are others that constitute significant production in some counties (such as wheat silage) which were not included due to insufficient production estimates. Also, nutrient removal potential from land in woodlands provides another opportunity for utilization of manure nutrients, but data were not available for its inclusion in the assessment. Furthermore, nutrient removal potential for crops and forages was estimated using average yields reported for each county. This does not allow for any intensive production efforts that might increase yields with an accompanying increase in nutrient removal on a farm-specific basis.
- **Periods of time when facilities are empty due to production cycles**—As previously discussed, it was assumed for all animal classes that animals would occupy facilities 365 days out of the year. However, many swine and poultry operations have multiple growth cycles throughout the year, with facilities sitting empty between groups of animals. Depending on the number of these operations that were between production cycles and had facilities empty when inventories were taken, annual manure and nutrient production may have been either overestimated or underestimated.
- **Variations in the nutrient composition of manure**—The manure nutrient composition values used in the assessment represent average values that typically would be found in various animal manures. However, analyzed manure values from a particular operation could vary substantially from the values reported here. The nutrient composition of manure is dependent on several factors, including the ingredients that make up the diet, the genetic composition of the animals, the health status of the animals, and the environmental conditions under which the animals are reared. Including certain enzyme additives to the diet can also alter the nutrient content of manure. For example, including the enzyme phytase in diets for swine and poultry will reduce the amount of phosphorus excreted in the manure by about 30%.
- **Nutrient losses associated with the method of land application**—The primary purpose of the assessment was to compare the amount of recoverable manure nutrients and potential nutrient removal capacity by harvested crops and grazed forages. Because of this focus, neither the manure and nutrient recovery factors nor the nutrient availability factors that were used in the assessment accounted for losses associated with the method of manure application to the land. The reader

should realize that the method used to land-apply manure can dramatically influence the nutrients (primarily nitrogen) that are available for plant utilization. Greater amounts of nitrogen will be lost when manure is surface applied as compared to manure incorporated shortly after being surface applied or injected into the soil. However, no estimates are available of the amounts of manure that are applied by surface application, surface application followed by incorporation into the soil, or injection into the soil.

- **Land available or suitable for manure applications**—It was assumed in the assessment that all land currently in crop or forage production could receive manure applications. However, there are conditions that exist that make some land unavailable or unsuitable for manure applications. For example, some land may be located in an area that is inaccessible to manure application equipment or is located too far from the manure source to make transport feasible. Also, the geographic properties of some land make it unsuitable for manure applications. The amount of land that is unavailable or unsuitable for receiving manure is not known.

Interpretation of the Results

What can be assumed if crop nutrient removal capacity is greater than manure nutrient production? The results of the assessment indicate that nearly all Kentucky counties currently have crop nutrient removal capacities that exceed the amount of manure nutrients produced annually by livestock and poultry. For these counties, nutrients supplied solely from manure would be insufficient to meet the nutrient removal capacity of the total acreage of crop and pastureland.

Has a county reached or exceeded the level of animal production it can support if manure nutrient production is equal to or greater than crop and forage nutrient removal capacity? This assessment should provide some overall perspective and serve as a starting point for discussion about expanding livestock or poultry production in a county or an area of the state. An apparent surplus of manure nutrients does not automatically mean that those nutrients cannot, or are not, being used appropriately. Where the quantity of manure nutrients is relatively high in comparison to crop and forage nutrient removal, close attention should be given to several other factors, such as:

- Potential alternative uses for the manure (composting, land reclamation, etc.).
- Potential for transporting manure to nutrient-deficit crop production areas.
- Potential for reducing the nutrient content of manure.
- General soil fertility and nutrient needs in the area.
- Capability for implementing sound, farm-specific manure management plans.

As an example of how other factors can be important, consider the estimates for Muhlenberg County, which indicate that the production of manure phosphorus exceeds crop and forage phosphorus removal by 443,282 pounds. It is well known that much of the manure in that county is handled as a solid and is routinely transported to various off-site destinations, including some sites out of the county. Much manure has been used locally in strip mine reclamation projects, a large land area that is not included in the crop and forage land base of this assessment. Also, the assessment shows that in nearby counties, crop and forage phosphorus removal exceeds manure phosphorus production by over 20 million pounds. Thus, there is substantial potential to effectively use the apparent surplus of manure phosphorus, and it cannot be stated unequivocally that the limits of animal production have been reached in Muhlenberg County.

Proper manure management is ultimately site specific and is more correctly evaluated on a farm-by-farm basis rather than county by county. The operative question becomes one of distribution and appropriate land application rather than a simple computation of quantities. Thus, this assessment alone is inadequate to define future livestock and poultry production potential.

Does a high percentage of manure nutrients meeting crop nutrient removal capacity indicate an environmental problem exists or is likely to occur within the county? Although the assessment may indicate a county requires a high percentage of its crops and forages to remove the manure nutrients produced by livestock and poultry, it does not imply that environmental problems presently exist, nor does it imply they are likely to occur. The potential for the occurrence of nutrient imbalances and environmental problems is dependent on the manure management practices at the farm level. Therefore, when addressing environmental concerns, each animal operation should be evaluated on an individual basis.

It is important to understand that animal operations are presently subject to several regulations to help ensure that manure is utilized in an environmentally sound manner. Animal operations that collect and store manure as a liquid are required to obtain an operating permit (the No Discharge Operational Permit) from the Kentucky Division of Water. A part of the permitting process requires operators to provide assurances that they have an adequate land base to utilize the manure that will be produced. Additionally, all farm animal enterprises within Kentucky are required to evaluate their system of manure management and develop an Agricultural Water Quality Plan to ensure that manure nutrients are being utilized in a manner that protects the environment.

Summary

This assessment provides a comparison of total recoverable manure nutrients from livestock and poultry and total nutrients removed by harvested crops and grazed forages for each county in Kentucky. The estimates derived from the assessment provide a snapshot (or point-in-time) picture, which is based primarily on animal and crop production data collected by established agricultural statistics services.

The following conclusions are drawn from the results of the assessment:

- A relatively high ratio of manure nutrients to crop nutrient removal can be the result of either a low crop and forage land base or a large animal production base. Thus, including a comparison of the actual quantities (pounds) of manure nutrients to crop nutrient removal capacity provides a better assessment than using the ratio alone.
- Recoverable manure nitrogen from livestock and poultry is less than 30% of the total nitrogen removed annually by crops and forages in each of the 120 counties. In each of 60 counties, crop and forage nitrogen removal capacity exceeds recoverable manure nitrogen by more than 4 million pounds.

- Recoverable manure phosphorus from livestock and poultry is less than 50% of the phosphorus removed by crops and forages in 112 of 120 counties. In four counties, recoverable manure phosphorus from livestock and poultry is greater than 75% of the phosphorus removed by crops and forages. In each of 57 counties, crop and forage phosphorus removal capacity exceeds recoverable manure phosphorus by more than 1 million pounds.
- Recoverable manure potassium from livestock and poultry is less than 50% of the potassium removed by crops and forages in each of the 120 counties. In each of 88 counties, crop and forage potassium removal capacity exceeds recoverable manure potassium by more than 2 million pounds.

Through discussions and reviews of the assessment, several areas were noted where data were either incomplete or not available. Listed below are some suggestions for future research and (or) data collection to improve the existing information base:

- Better estimates of animal inventories, manure production rates, and manure recovery factors.
- Estimates of the quantity of land that is either available or unavailable for crop and forage production.
- More precise estimates of nutrient availability factors for individual crops and forages and the fate of manure nutrients after land application.
- Effects of existing soil fertility conditions on manure applications.
- Estimates of the quantities of manure that are used for purposes other than for crop and forage production.
- Estimates of the quantities of manure that are transported across county lines.
- Effects of dietary modifications on manure nutrient content.

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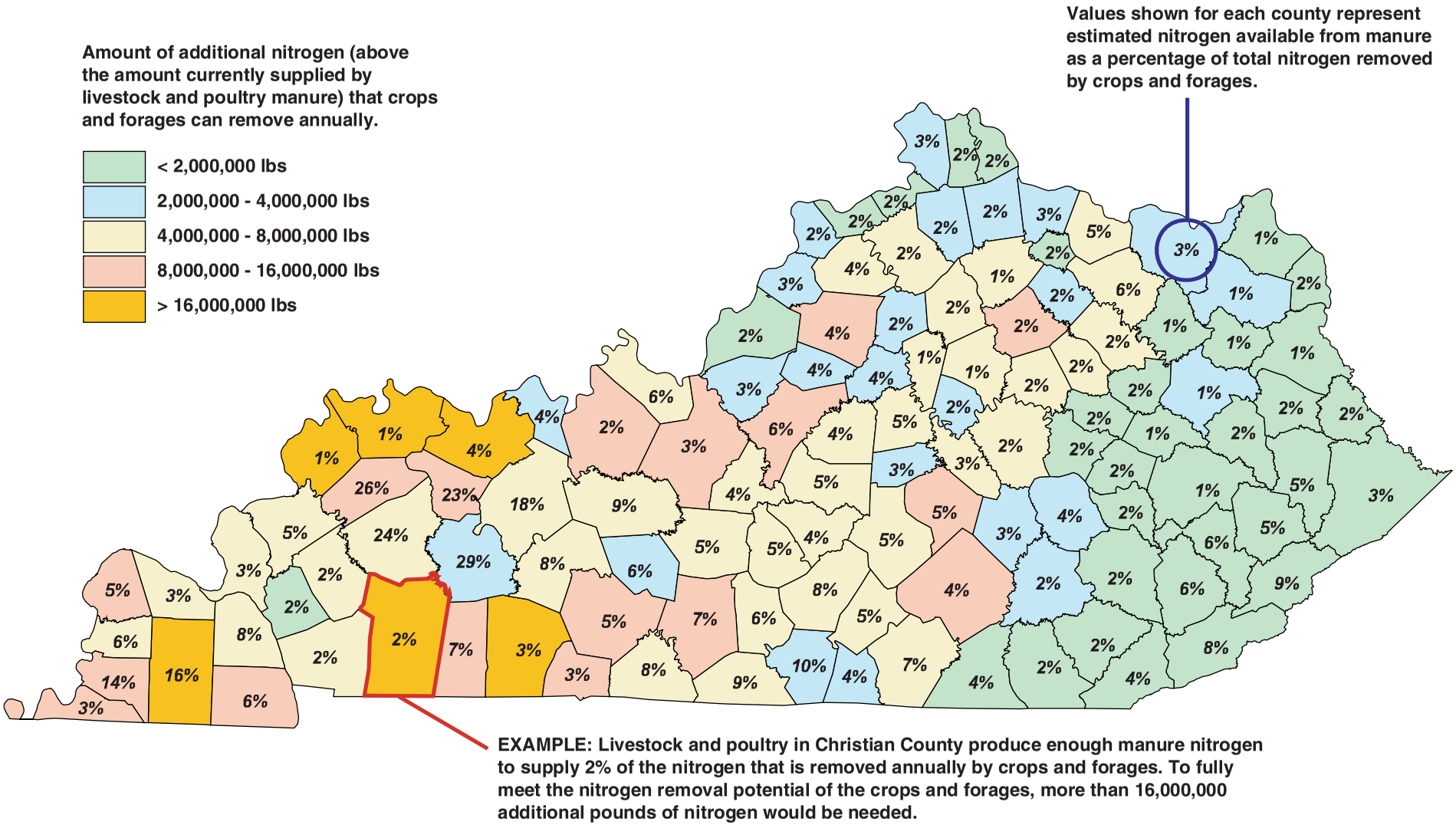
Lexington, KY 40506 Revised 02-2025

Figure 1. Nitrogen Supplied by Manure Relative to the Amount Removed by Crops and Forages



NOTES:
(1) Nutrient removal refers to the amount of a nutrient removed from the land when crops are harvested and forages are grazed.
(2) Countywide estimates of nutrient removal potential should not be used alone to evaluate the potential environmental impact of animal production.

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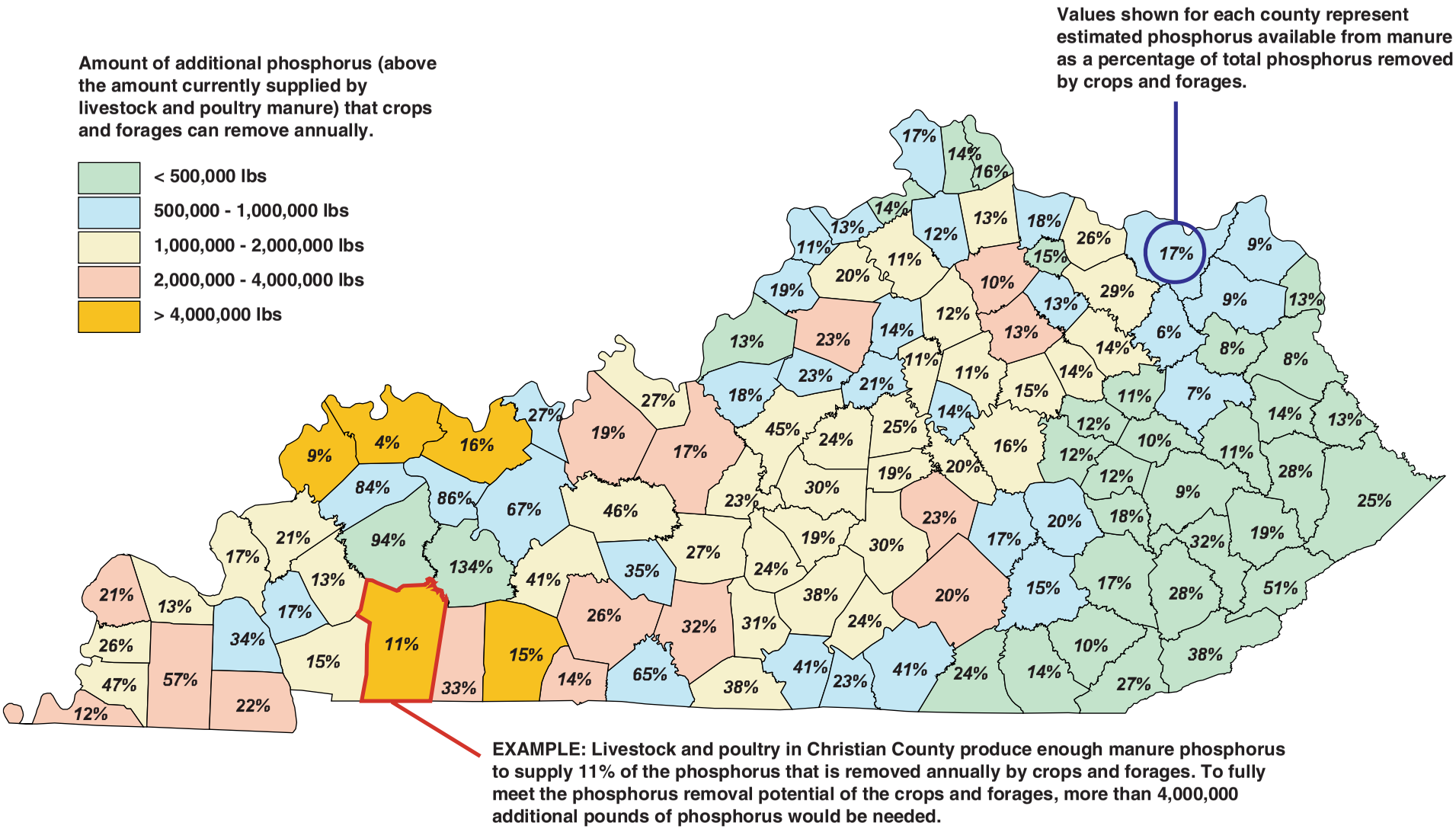
Figure 2. Phosphorus Supplied by Manure Relative to the Amount Removed by Crops and Forages



NOTES:
(1) Nutrient removal refers to the amount of a nutrient removed from the land when crops are harvested and forages are grazed.
(2) Countywide estimates of nutrient removal potential should not be used alone to evaluate the potential environmental impact of animal production.

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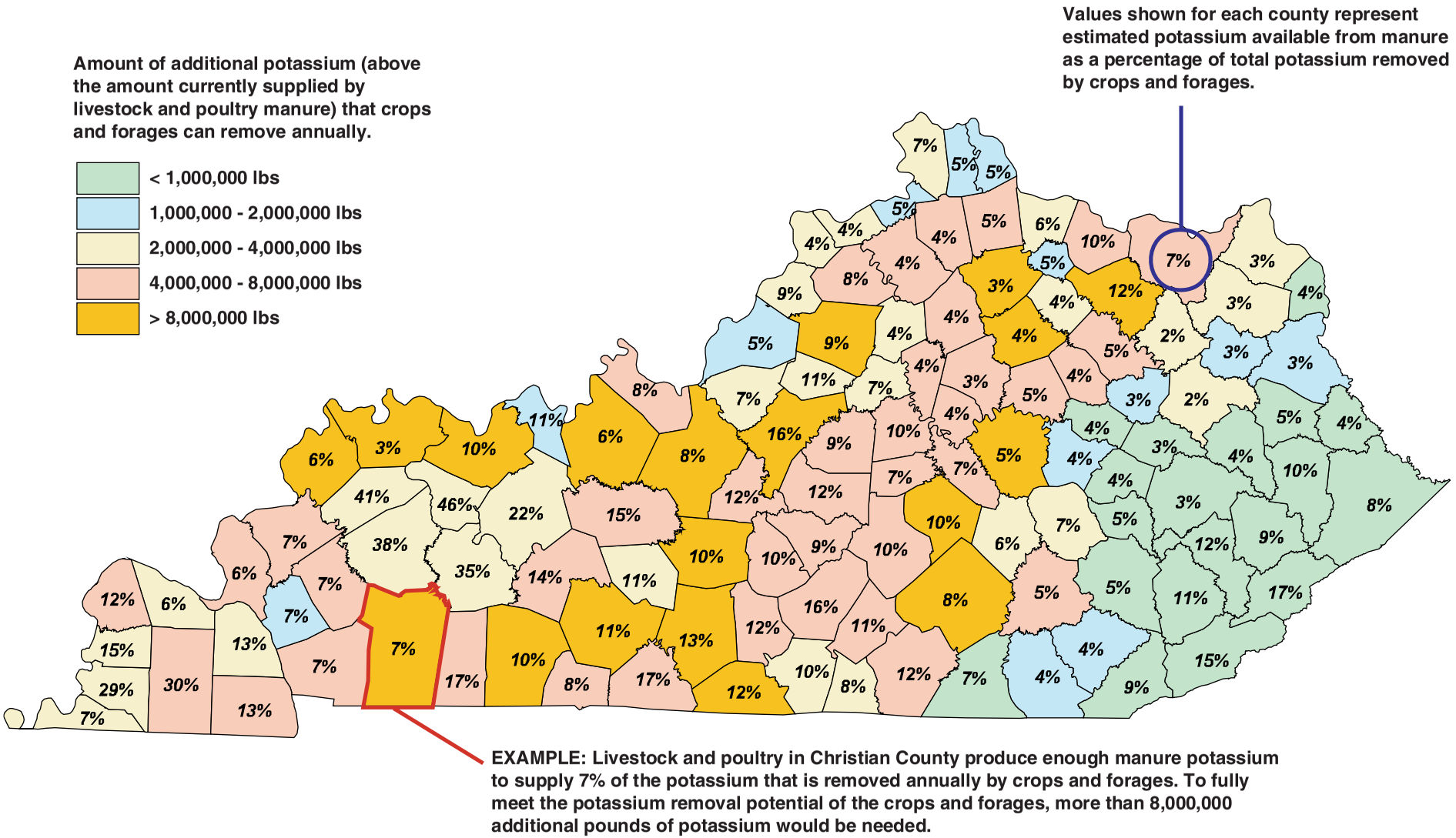
Figure 3. Potassium Supplied by Manure Relative to the Amount Removed by Crops and Forages



NOTES:
(1) Nutrient removal refers to the amount of a nutrient removed from the land when crops are harvested and forages are grazed.
(2) Countywide estimates of nutrient removal potential should not be used alone to evaluate the potential environmental impact of animal production.

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