Land's Capacity To Use Manure Nutrients

The clustering of confined animals does not necessarily mean that manure nutrients will contribute to water quality problems. It is the balance of manure production and crop nutrient use that often determines movement of nutrients to water bodies. A national overview shows how total manure production and potential excess differ by animal type. County-level data show how policies may need to be tailored to local conditions.

Nationally, Poultry Manure a Growing Source of Excess Nutrients

Confined livestock produced an estimated 1.23 million tons of recoverable nitrogen and 0.66 million tons of recoverable phosphorus in 1997.[11] The 73 million acres of cropland and permanent pasture controlled by operators of confined animal operations were estimated to have the capacity to assimilate only 40 percent of the nitrogen and 30 percent of the phosphorus (table 2). Growth in the number of confined AU from 1982 to 1997 increased the quantities of nutrients produced by about 20 percent. Meanwhile, the amount of land on livestock and poultry farms relative to the nutrients produced diminished, resulting in more than a 20-percent increase in potential excess onfarm manure nutrients. The increase in excess nutrients over the 15-year period is one reason for the increased policy attention directed toward confined livestock operations.

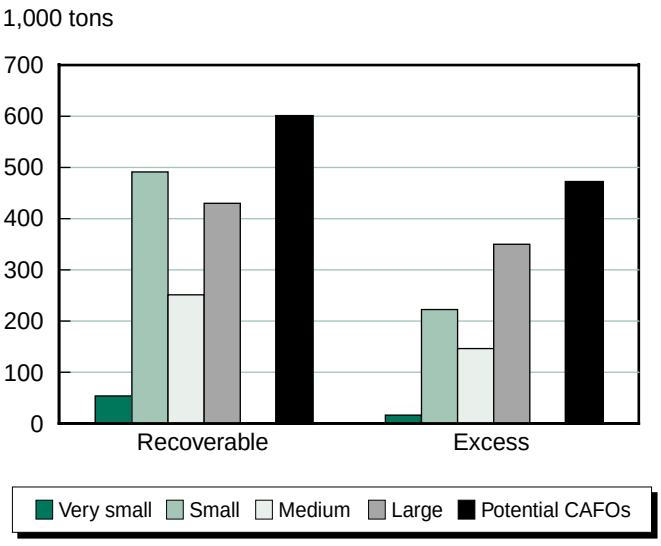
Most farms have the potential to control manure nutrient movement to water sources with proper nutrient management. Across all animal types and size classes, 78 percent of confined animal farms have the assimilative potential to use all the manure nitrogen produced on the farm, 69 percent of farms for phosphorus (table 2). This estimate of the physical feasibility of using manure nutrients at agronomic rates on land does not imply that all producers are doing so, or that it is an economically feasible production option. A farm with the potential assimilative capacity to use all the manure onfarm just means that land application is a viable physical strategy and the producer has control over the entire decision process. The economic viability depends on the costs of adjusting the farm's nutrient plan to include manure, transportation distance and costs, application technology and costs, and savings from fertilizer purchases.

On the 22 percent of farms that produce excess nitrogen and the 31 percent with excess phosphorus, the inability to assimilate all the manure nutrients affects operations of all sizes. In 1997, about 20 percent of the very small farms (<50 AU) did not have the capacity to use all the phosphorus produced on the farm (15 percent for nitrogen). The share of large farms (>1,000 AU) that produce more nutrients than can be used onfarm increases to 72 percent of farms for nitrogen and to over 90 percent of farms for phosphorus.

Small farms (50-299 AU) produce more recoverable nitrogen than any other size class, almost 500,000 tons in 1997 (fig. 8), down from 534,000 tons in 1982. These farms produce about 30 percent of the excess onfarm nitrogen, almost all from poultry farms. Small poultry farms are currently not covered by NPDES permit requirements, except under special circumstances. These farms, along with most others, are eligible for voluntary USDA assistance with manure management through the Environmental Quality Incentives Program and Conservation Technical Assistance Program. Very small farms produce only about 2 percent of the national total of excess onfarm nutrients.

Nutrient production grew significantly from 1982 to 1997 within the medium and large animal operations,

Figure 8
Recoverable and excess manure nitrogen, by size class, 1997



Source: Economic Research Service, USDA.

[11] For comparison, commercial fertilizer use was 12.4 million tons for nitrogen and 4.6 million tons for phosphorus in 1997 (USDA, 2000a).

Table 2—Farms, animal units (AU), land base, and nutrients by confined animal facility size class, 1997

Animal type[1]	Farm size class[2]										
	Very small (<50 AU)		Small (50-299 AU)		Medium (300-999 AU)		Large (>1,000 AU)		Total	Potential CAFOs[4]	
	Number	*%[3]*	*Number*	*%*	*Number*	*%*	*Number*	*%*	*Number*	*Number*	*%*
Feedlot beef:											
Farms	37,975	81	7,082	15	1,226	3	871	2	47,154	1,897	4
Animal units (1,000)	487	5	734	8	635	7	7,463	80	9,318	8,033	86
Land base (1,000 acres)	16,627	66	6,295	25	1,483	6	938	4	25,343	2,200	9
Nitrogen available (tons)	10,180	5	15,356	8	13,286	7	156,120	80	194,941	168,057	86
Nitrogen excess (tons)	4,741	3	2,091	1	2,411	2	131,082	93	140,325	133,371	95
Phosphorus available (tons)	6,632	5	10,004	8	8,655	7	101,709	80	127,000	109,486	86
Phosphorus excess (tons)	4,392	4	2,501	2	3,062	3	96,008	91	105,963	98,890	93
Dairy:											
Farms	17,981	21	62,536	72	4,534	5	1,303	2	86,354	1,296	2
Animal units (1,000)	583	6	5,344	54	1,836	19	2,135	22	9,899	2,130	22
Land base (1,000 acres)	3,188	12	20,693	75	2,808	10	824	3	27,512	821	3
Nitrogen available (tons)	18,721	6	171,615	54	58,950	19	68,563	22	317,849	68,384	22
Nitrogen excess (tons)	1,799	3	11,352	17	15,291	22	40,041	58	68,483	39,904	58
Phosphorus available (tons)	7,184	6	65,852	54	22,620	19	26,309	22	121,965	26,240	22
Phosphorus excess (tons)	1,236	3	9,262	22	9,600	23	21,918	52	42,016	21,862	52
Swine:											
Farms	35,646	56	22,932	36	4,134	6	1,011	2	63,723	4,374	7
Animal units (1,000)	612	7	2,656	32	2,113	26	2,852	35	8,233	4,670	57
Land base (1,000 acres)	11,696	43	12,118	45	2,525	9	566	2	26,905	2,647	10
Nitrogen available (tons)	10,136	7	44,648	33	35,928	26	46,327	34	137,038	78,375	57
Nitrogen excess (tons)	4,627	7	10,054	14	18,216	26	36,537	53	69,434	53,270	77
Phosphorus available (tons)	10,242	7	45,043	33	36,202	26	46,913	34	138,400	79,083	57
Phosphorus excess (tons)	4,258	5	14,648	17	25,390	29	43,893	50	88,189	67,148	76
Poultry:											
Farms	13,158	37	18,783	52	3,312	9	688	2	35,941	3,763	10
Animal units (1,000)	202	3	2,433	40	1,651	27	1,833	30	6,118	3,019	49
Land base (1,000 acres)	1,692	36	2,113	45	660	14	206	4	4,671	730	16
Nitrogen available (tons)	21,402	4	264,540	46	138,414	24	152,080	26	576,436	278,244	48
Nitrogen excess (tons)	14,261	3	211,014	44	115,761	24	142,611	29	483,646	250,044	52
Phosphorus available (tons)	9,463	3	114,927	42	72,026	26	80,515	29	276,932	136,030	49
Phosphorus excess (tons)	7,157	3	98,090	39	67,719	27	79,527	31	252,493	130,343	52
Total over all types:											
Farms	85,575	40	109,856	52	13,560	6	3,970	2	212,961	11,242	5
Animal units (1,000)	1,612	5	11,105	33	6,387	19	14,463	43	33,568	17,981	54
Land base (1,000 acres)	24,031	33	38,905	53	7,644	10	2,651	4	73,231	6,280	9
Nitrogen available (tons)	53,469	4	491,267	40	251,625	21	429,903	35	1,226,264	599,007	49
Farms with excess nitrogen	13,228	28	24,407	52	6,463	14	2,886	6	46,984	7,483	16
Nitrogen excess (tons)	15,838	2	222,776	30	146,244	20	349,547	48	734,405	470,843	64
Phosphorus available (tons)	29,067	4	233,364	35	141,935	21	259,932	39	664,298	354,331	53
Farms with excess phosphorus	17,133	26	35,514	54	9,566	14	3,718	6	65,931	9,813	15
Phosphorus excess (tons)	8,540	2	112,372	24	100,252	22	241,160	52	462,323	313,243	68

[1] Not additive across animal types, since farms may have more than one type. Excess values summed over farms with an excess. Land base is cropland plus pastureland.
[2] Size classes were based on the total numbers of animals on the farm. Data are for confined operations only.
[3] Percent of total farms, not the percent over all animal types.
[4] Potential CAFOs are all the farms in the large and part of the farms in the medium farm size classes.

Source: Economic Research Service, USDA.

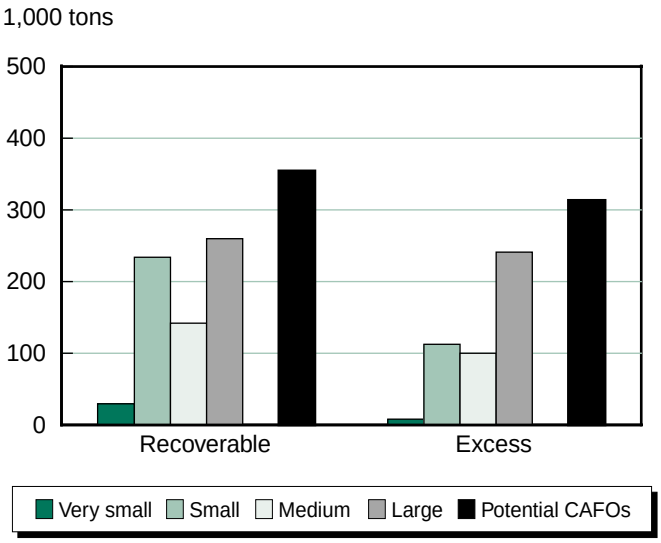
due to the increase in both farms and AU in these size classes. Recoverable nitrogen production on medium-sized operations increased by 68 percent to 250,000 tons in 1997 and on large farms by over 100 percent to 430,000 tons. Excess onfarm nitrogen increased by 83 percent to 146,000 tons on medium-size farms and by 104 percent to 350,000 tons on large farms in 1997. The 6 percent of livestock farms in the medium size class accounted for 20 percent of the excess nitrogen in 1997, and large farms (2 percent of the total number of farms) accounted for almost half of the excess onfarm nitrogen. Estimated increases in recoverable phosphorus were similar to those for nitrogen. In 1997, medium-size farms accounted for 22 percent and large farms for over half of the excess onfarm phosphorus (fig. 9, table 2).

The production of more excess onfarm nutrients in larger size classes resulted from the shift to more concentrated production units, more specialized management, and the separation of land from livestock.

The production of more excess onfarm nutrients in larger size classes resulted from the shift to more concentrated production units, more specialized management, and the separation of land from livestock. Available cropland and pastureland controlled by confined operations on which to spread manure declined from an average of 3.6 acres per animal unit in 1982 to 2.2 acres per AU in 1997. While very small confined operations had an average of about 15 acres of land on which to spread the manure from each animal unit, large operations were limited to 0.2 acre in 1997 (table 3).[12] These ratios changed little by size group from 1982 to 1997, which implies that nutrient management problems on the average farm of any size group were no worse in 1997 than in 1982. The aggregate problem is much greater, however, because there are now many more large farms with excess nutrient production.

[12] Based on average nutrient production across all animal types and average uptake over all confined animal farm acres, it required 0.9 acre per AU to apply the nitrogen produced at agronomic rates and 3.7 acres per AU for phosphorus in 1997. This estimate is based on only confined livestock farms and includes the influence of farms with no land on which to spread manure.

Figure 9
Recoverable and excess manure phosphorus, by size class, 1997



Source: Economic Research Service, USDA.

In 1997, calculated total recoverable manure nitrogen exceeded 1.2 million tons, and 60 percent of that nitrogen exceeded the amount that could be assimilated on the farms that produced it (fig. 10). Crop uptake and pastureland applications on confined livestock farms, with no transfer to other farms, could use only 40 percent of the recoverable manure nitrogen, assuming no commercial fertilizer use. Poultry generated 47 percent of the total recoverable nitrogen and own-farm use could absorb only 8 percent of that amount. The 39 percent of recoverable poultry nitrogen above farm assimilative capacity accounts for 484,000 tons, or 64 percent, of the total excess onfarm nitrogen (fig. 10). Poultry operations produced more excess nitrogen than other animal types because poultry manure contains more nitrogen per AU and poultry operations typically have a much smaller land area over which to spread manure relative to other animal types.

Dairy produced 26 percent of recoverable nitrogen in 1997, and 21 percent could be used on the farm. Thus, dairy operations produced only 5 percent of nitrogen in excess of farm needs, or 9 percent of total excess onfarm nitrogen. Feedlot beef farms produced 18 percent and swine 9 percent of the excess nitrogen (fig. 10).

The share of total recoverable nitrogen in excess of farm needs increased by 17 percentage points from

1982 to 1997. This increase in excess nutrients implies a growing need to move nutrients off the farm where they are produced. In a species-by-species comparison, 11 points of the 17-percentage-point increase in excess onfarm nutrients occurred in poultry production. A slightly larger share of the beef, dairy, and swine nitrogen was in excess in 1997 compared with 1982.

Poultry operations produced more excess nitrogen than other animal types because poultry manure contains more nitrogen per AU and poultry operations typically have a much smaller land area over which to spread manure relative to other animal types.

Confined livestock operations were even less able to fully use phosphorus on the farm than they were nitrogen. In 1997, 70 percent of the 664,000 tons of recoverable manure phosphorus was in excess of onfarm uptake needs (fig. 11). As with nitrogen, dairy farms were able to use a greater share of the phosphorus produced relative to other animal types, and poultry produced the most recoverable phosphorus. However, the relative share of the poultry contribution was less than for nitrogen, with about half of the excess onfarm phosphorus. Feedlot beef farms generated 22 percent and swine 18 percent of the excess onfarm phosphorus. The largest increases in excess onfarm phosphorus from 1982 to 1997 occurred in poultry, with about 10 percent more of the poultry phosphorus in excess in 1997 than in 1982. The share of swine-produced excess onfarm phosphorus increased by about 7 percent, with little change in dairy and beef.

Potential CAFO Nutrient Production

Farms of sufficient size to need an NPDES permit under the Clean Water Act deserve special attention since they may be currently regulated. Our estimation procedure for determining a concentrated animal feeding operation (CAFO) is based on current regulations, considering only the number of animals without exemptions.

In 1997, the 5 percent of farms identified as potential CAFOs were the source of about half of the recoverable nutrients and two-thirds of the excess onfarm nitrogen and phosphorus from all confined livestock operations (table 2, figs. 8 and 9). CAFOs generated 120 percent more recoverable nitrogen and phosphorus in 1997 than in 1982, with similar increases for excess onfarm nitrogen and phosphorus.

Excess Nutrients Greatest and Growing in Southern Seaboard

National figures show significant quantities of excess manure nutrients. However, as with confined livestock operations, manure nutrients are not evenly distributed across the Nation. A regional assessment of county-level data provides more detail and demonstrates geographical shifts in the livestock industry.

The amount of total recoverable manure nitrogen declined from 1982 to 1997 in the Northern Crescent and slightly in the Basin and Range (fig. 12). The amount increased in all other regions, with the greatest increase in the Southern Seaboard in both absolute (95,000 tons) and relative terms (60 percent).

In 1997, the Southern Seaboard produced the most recoverable manure nitrogen (256,000 tons, over 20 percent of the Nation's total) of any region—despite having about half the animal units of the Heartland (fig. 6). (The Southern Seaboard also had fewer AU

Table 3—Average onfarm acres per animal unit,[1] by size class, 1982 and 1997

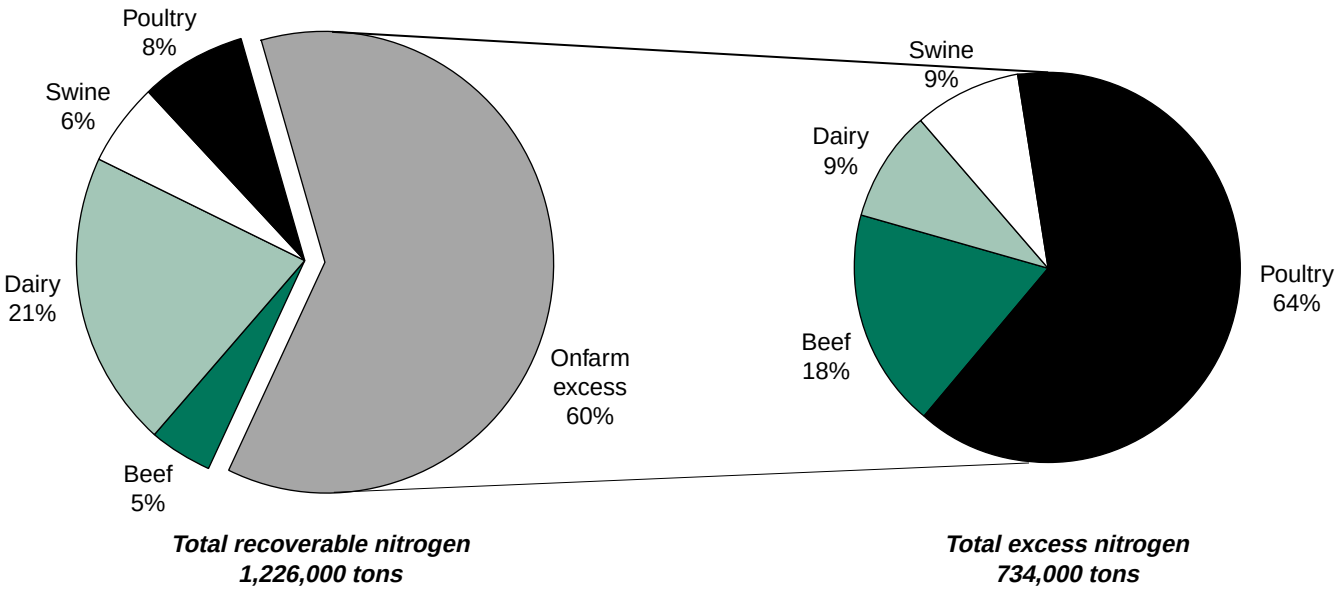
Year	Very small < 50 AU	Small 50-300 AU	Medium 300-1,000 AU	Large > 1,000 AU	Potential CAFO[2]
	Onfarm acres per animal unit				
1982	11.27	3.57	1.31	0.19	0.39
1997	14.91	3.50	1.20	0.18	0.35

[1] Based on 1 AU equaling 1,000 pounds of live animal weight.
[2] Potential CAFOs were based on animal numbers specified in the Clean Water Act.

Source: Economic Research Service, USDA.

Figure 10

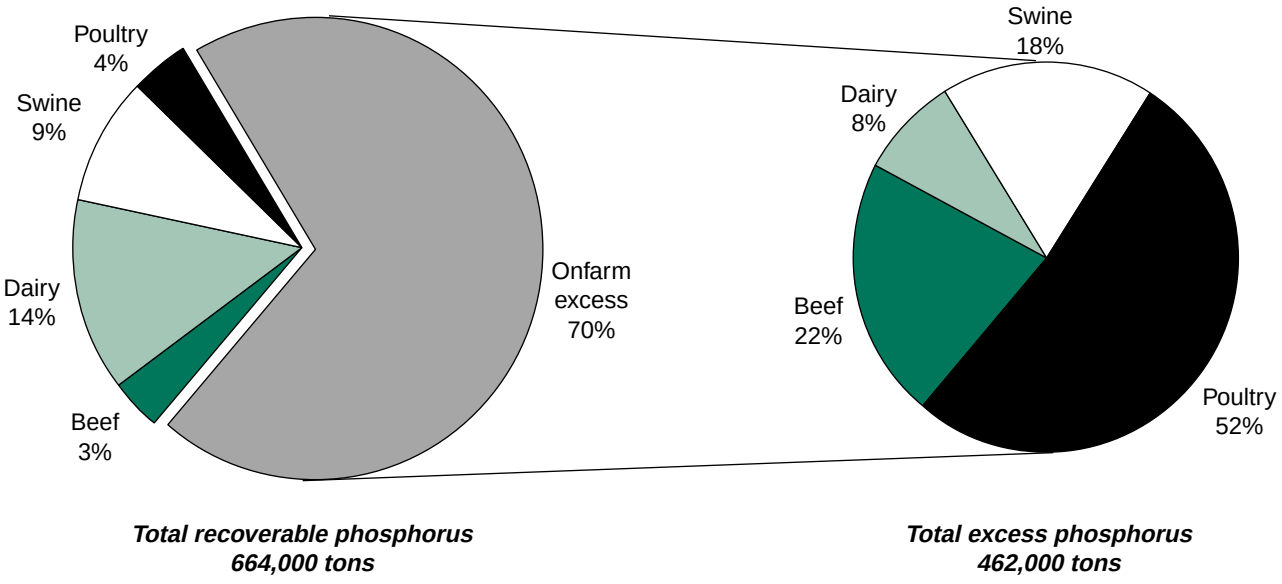
Onfarm manure nitrogen and excess manure nitrogen, by animal type, 1997



Source: Economic Research Service, USDA.

Figure 11

Onfarm manure phosphorus and excess manure phosphorus, by animal type, 1997



Source: Economic Research Service, USDA.

than the Prairie Gateway and Northern Crescent.) Nutrient production per AU differs by animal type, with some types of poultry producing up to five times as much nitrogen and three times as much phosphorus as feedlot beef per AU. While both the Heartland and Southern Seaboard regions specialize in swine, the Southern Seaboard has more poultry and fewer bovines, resulting in greater recoverable nutrients from fewer AU.

Manure nitrogen in excess of the production farm's ability to assimilate it increased in all regions between 1982 and 1997, with the largest tonnage increases in the Southern Seaboard (almost 90,000 tons) followed by the Heartland, Prairie Gateway, and Eastern Uplands, each with almost 50,000 tons (fig. 12). The Heartland experienced the greatest percentage increase in excess nitrogen (130 percent), indicating significant concentration in the livestock sector and an increasing need to move manure nutrients off the production farm. In the Northern Crescent, excess nitrogen quantities increased over the period despite the decline in recoverable nitrogen production, an indication of increased animals relative to assimilative land. Other major regions (Eastern Uplands, Prairie Gateway, and Southern Seaboard) had 70 to 80 percent increases in excess nitrogen over 1982-97. In 1997, the Southern Seaboard produced the most excess nitrogen (200,000 tons, over 27 percent of the Nation's total excess) of any region; its farms have among the smallest area per AU on which to apply manure.

Manure nitrogen in excess of the production farm's ability to assimilate it increased in all regions between 1982 and 1997, with the largest tonnage increases in the Southern Seaboard.

Recoverable manure phosphorus and excess manure phosphorus follow a temporal pattern similar to nitrogen (fig. 13). In the Heartland, the large number of animals but fewer AU per farm results in large amounts of recoverable manure phosphorus with little tonnage increase. However, the Heartland exhibits increasing concentration in its livestock sector, as it had the greatest percentage increase in onfarm excess nutrients. The Southern Seaboard produced 25 percent of the Nation's excess phosphorus, consistent with the region's poultry and swine concentration.

The recoverable manure nitrogen per county closely follows the location of animal units, though not directly because recoverable nitrogen varies by animal type (fig. 14). For example, the greater recoverable nutrients per animal unit for broiler poultry result in relatively high quantities of manure nitrogen in parts of Georgia, Alabama, and Mississippi.[13]

Figure 15 shows the share of recoverable nitrogen in excess of onfarm crop and pastureland needs in 1997. Shaded counties are those in which there is at least 1 ton of excess manure nitrogen produced on confined livestock and poultry farms somewhere in the county. This does not imply that manure nitrogen is necessarily contributing to water quality and other environmental problems. Figure 15 does indicate that manure movement off confined livestock farms is necessary to avoid excess nitrogen accumulation in 75 percent of the Nation's counties.

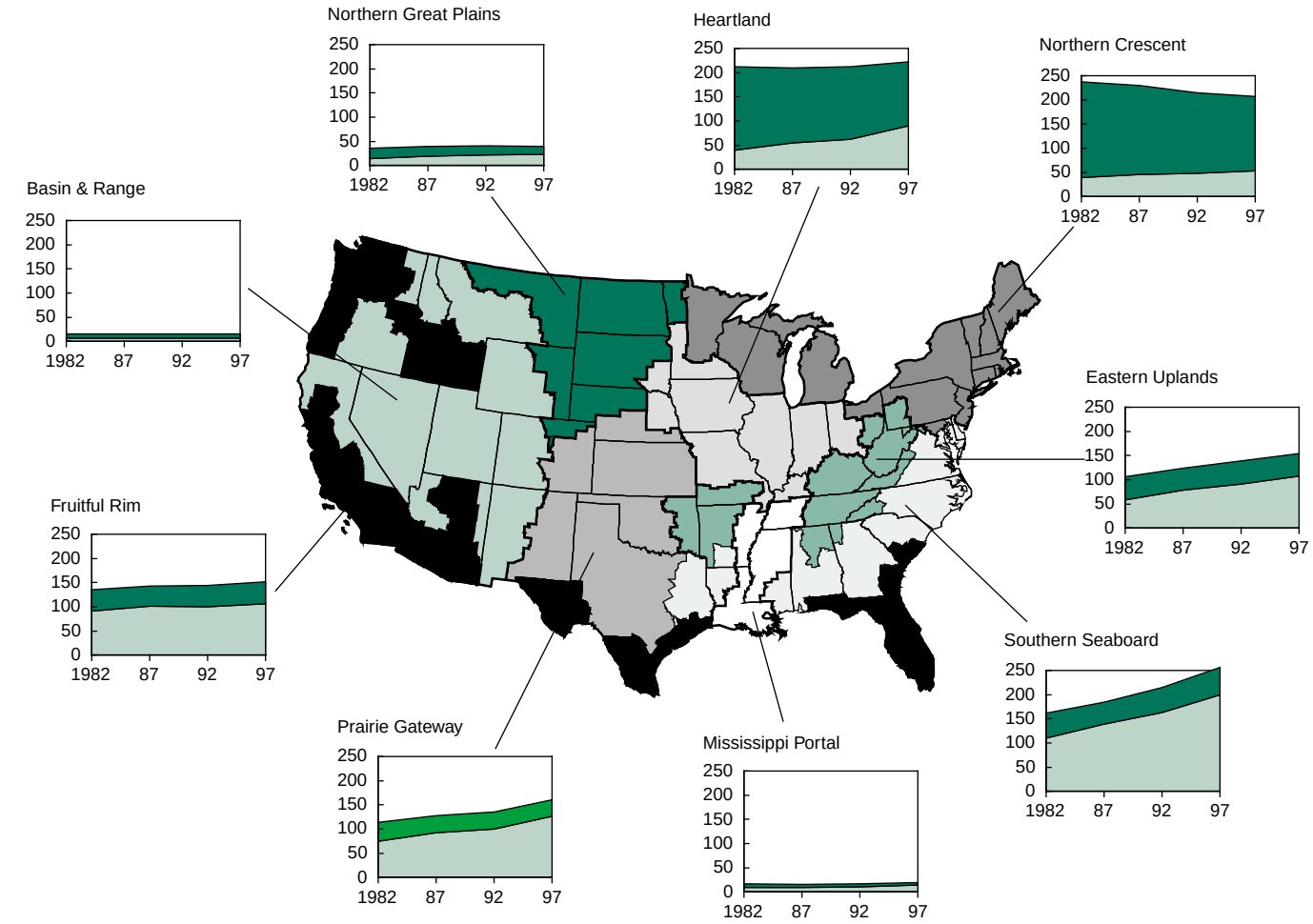
The darker the shading in figure 15, the greater the share of manure nitrogen in excess of onfarm needs, assuming no commercial fertilizer applications. Generally, excess onfarm manure nitrogen is greatest in counties with the most confined animals (fig. 6). As with recoverable nitrogen, northern Alabama and Georgia have levels of excess nitrogen beyond that suggested by AU numbers because poultry manure has a high nitrogen content, poultry is the dominant animal there, and poultry operations do not control as much land for spreading manure. Conversely, northeastern Iowa and southern Wisconsin had among the highest concentration of animals, but have less excess nitrogen than might be expected because of more available land and lower nitrogen production per AU. Again, a large quantity of excess onfarm nitrogen does not indicate an environmental problem; it does indicate where manure must move off-farm to avoid an overapplication of nitrogen.

Manure nitrogen may be used in an agronomic manner if cropland or pastureland on other farms in the "excess" county (or adjacent counties) is available for application. Figure 15 indicates counties where manure would have to move from confined livestock farms to other farms or counties. Not all crop or pastureland in

[13] Ranked the number 1, 3 and 5 States, respectively, in broiler production in the 1997 Census of Agriculture (USDA, 1999b).

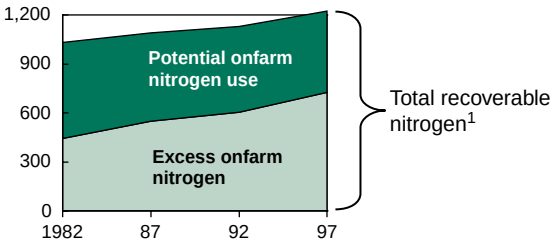
Figure 12

Recoverable and excess onfarm manure nitrogen from confined animal by ERS region, 1997



U.S. total

1,000 tons

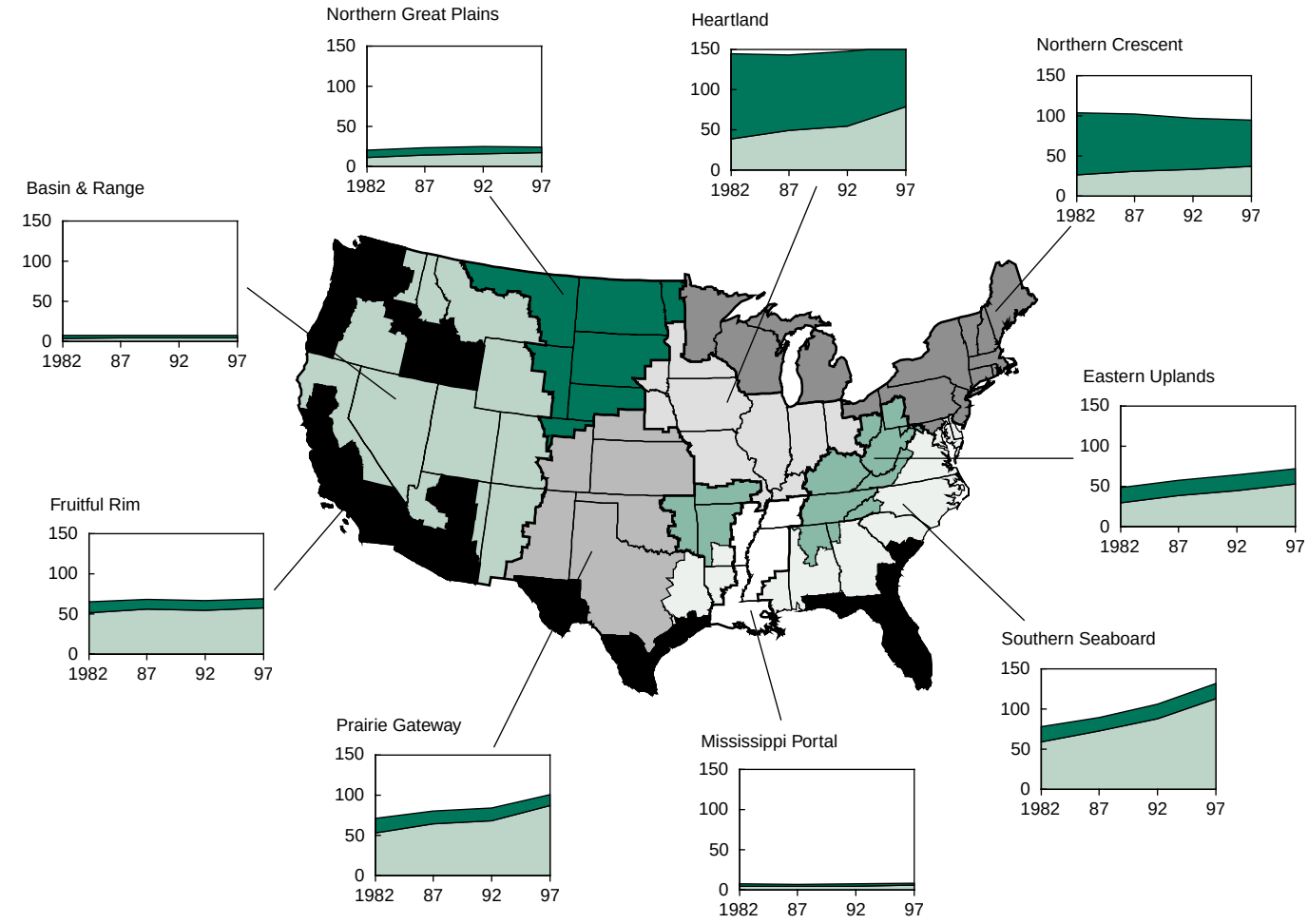


[1] The chart height represents the total recoverable manure nutrient for the 1982, 1987, 1992 and 1997 census years. All regions are drawn on the same scale. The darker area on top represents the onfarm nutrient assimilation potential, and the lighter lower part of each chart presents the nutrient excess of the production farm's assimilation potential.

Source: Economic Research Service, USDA.

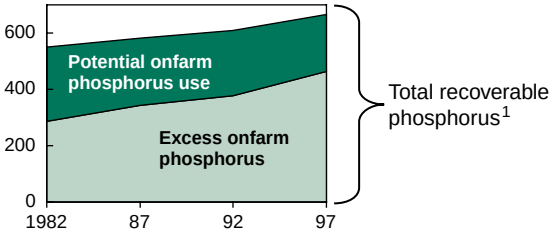
Figure 13

Recoverable and excess onfarm manure phosphorus from confined animal by ERS region, 1997



U.S. total

1,000 tons



[1] The chart height represents the total recoverable manure nutrient for the 1982, 1987, 1992 and 1997 census years. All regions are drawn on the same scale. The darker area on top represents the onfarm nutrient assimilation potential, and the lighter lower part of each chart presents the nutrient excess of the production farm's assimilation potential.

Source: Economic Research Service, USDA.

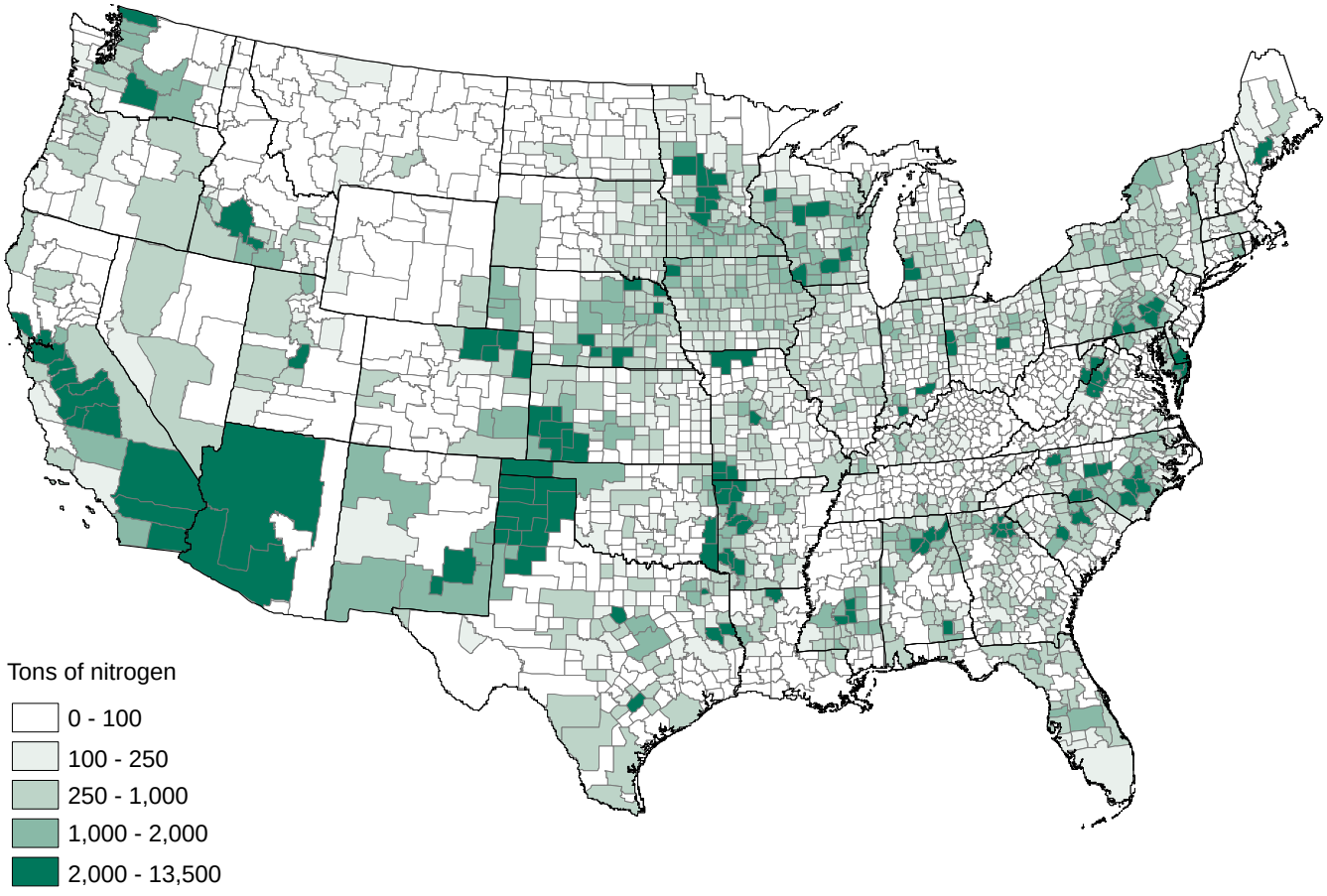
the county will be available for manure application for many reasons, including transportation costs, timing of applications relative to farming operations, concerns about odors, unclear liability rules for environmental discharges, and producer preference. For example, a 1996 survey showed that 92 percent of corn acres in the Southeast did not receive manure as a nutrient source, possibly indicating a preference of crop producers not to use it (Christensen *et al*., 1998).

Manure movement off confined livestock farms is necessary to avoid excess nitrogen accumulation in 75 percent of the Nation's counties.

We estimate that most U.S. counties (78 percent) need to move manure phosphorus from at least some confined animal farms to avoid phosphorus accumulation (fig. 16). As with nitrogen, excess onfarm manure phosphorus exceeds 75 percent of total manure phosphorus in areas with large numbers of animals (fig. 6).

Figure 14

Recoverable manure nitrogen by county, 1997

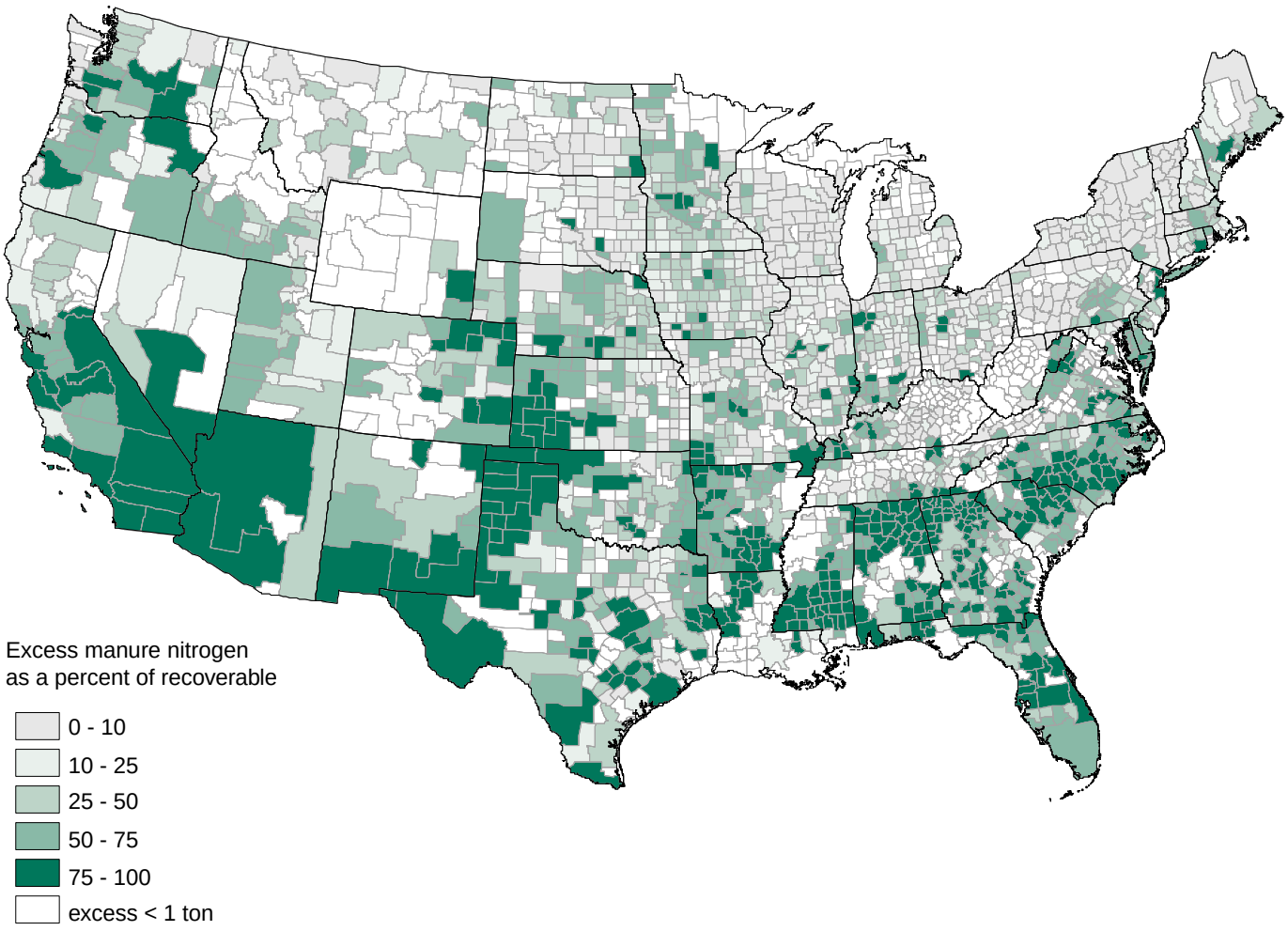


Some counties are combined to meet disclosure criteria.

Source: Economic Research Service, USDA.

Figure 15

Excess onfarm manure nitrogen as a share of recoverable nitrogen, 1997

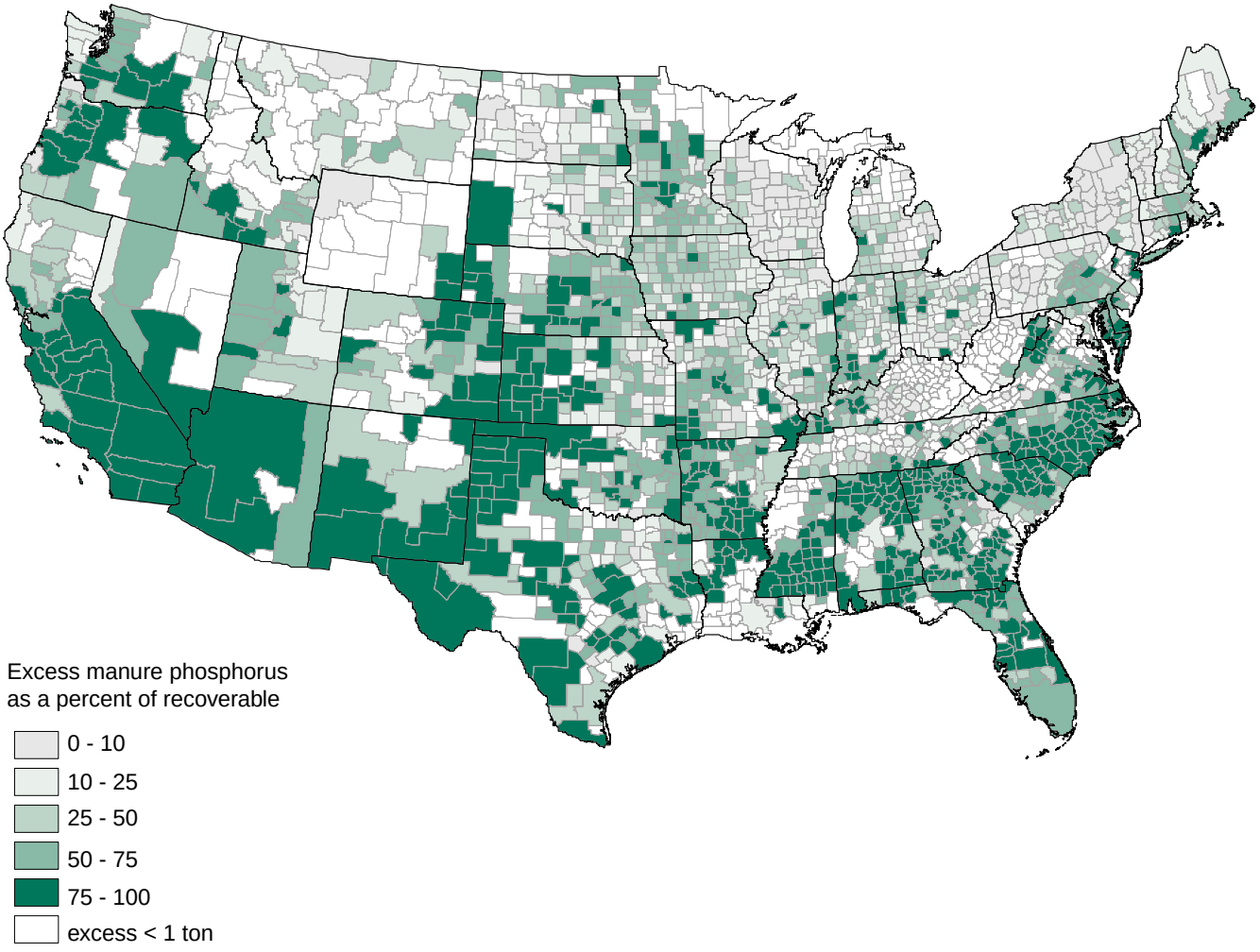


Some counties are combined to meet disclosure criteria.

Source: Economic Research Service, USDA.

Figure 16

Excess onfarm manure phosphorus as a share of recoverable phosphorus, 1997



Some counties are combined to meet disclosure criteria.

Source: Economic Research Service, USDA.