Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture—2012 Results

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Noel R. Gollehon
USDA/NRCS, Beltsville, MD

Robert L. Kellogg
USDA/NRCS, Beltsville, MD, retired

David C. Moffitt
Texas A&M's AgriLife Research, Temple, TX

Summary of Findings

This study provides a 2012 update to a report "Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture" that presented estimates of recoverable and non-recoverable manure nutrients for the Agriculture Census years 1982, 1987, 1992, 1997, 2002, and 2007. The report examining the period from 1982 – 2007 found increasing concentration in the confined livestock industry with fewer and larger operations, concentrating livestock in local areas. This 2012 study records the same trend, at a somewhat slower rate than previous periods. As a consequence, the utilization and disposal of animal manure from animal feeding operations continues to be an important farm management challenge if producers are to be successful in reducing water quality degradation related to land application of manure. When nutrients are recycled on the land at rates that exceed the capacity of the land to utilize the nutrients, continued manure applications can lead to a buildup of nutrients in the soil. This increases the potential for nutrients to move from the field through leaching and runoff to pollute groundwater and surface water.

This study used data from the Census of Agriculture for 2012 and combined it with previous estimates based on data from the 2007 Census of Agriculture to estimate the quantity of recoverable (generally concentrated in a small area) and non-recoverable (generally dispersed over the landscape as with grazing animals) manure nutrients produced by the animal agriculture sector. Using a methodology consistent with the report "Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture," this study adds 2012 to the series.

Using Census inventory and sales data, we estimate manure nutrients based on estimates of the number of animal units (AUs), by animal type, for each Census farm. Based on animal numbers and type, farms were classified into groups of no livestock, livestock farms with non-recoverable manure, and two size classifications of livestock farms with recoverable manure; the smaller generally referred to as animal feeding operations (AFOs) and the larger generally referred to as concentrated animal feeding operations (AFO-CAFOs). (CAFOs are defined by the Environmental Protection Agency using animal numbers and farm conditions. We can only estimate the number of AFOs that are potential CAFOs, hence AFO-CAFO.) Estimates of the quantity of manure were based on literature coefficients and the average animal unit numbers per operation.

The total number of farms in 2012 decreased slightly (about 4 percent) from 2007. This decrease in farms applied to both non-AFO and AFO farms. The number of AFO farms decreased by 10 percent, with the greatest decline in small AFOs, continuing a long-term trend of a declining number of AFOs. The number of large AFO-CAFOS, which has been steadily increasing over time through 2007, fell by 5 percent in 2012 compared to 2007.

Pastured (non-confined) livestock AUs fell 11 percent from 2007 to 2012, while confined AU fell only 3 percent. On large AFO-CAFOs, however, confined AU increased 3 percent compared to 2007, in spite of the 5-percent decline in the number of large AFO-CAFOs, continuing the trend of concentration. Confined AU on medium AFO-CAFOS decreased 14 percent and confined AU on small AFOs decreased by 11 percent compared to levels in 2007—mirroring about the same percentage decreases in the number of these AFOs. The composition of AU by livestock type in 2012 was about the same as in 2007.

Over half of the livestock manure is not recoverable. Relative to the total manure and manure nutrients produced on all farms by both pastured livestock and confined livestock, the recoverable manure portion represents 43 percent of the quantity of manure *as excreted* (wet weight), containing 20 percent of manure nitrogen *as excreted*, and 32 percent of manure phosphorus *as excreted*.

Over three-fourths of the manure produced by confined livestock is recoverable and may be managed. The recoverable manure in 2012 was 78 percent of the total amount of manure *as excreted* produced by confined livestock on AFOs. About 60 percent of the recoverable manure was produced on the large potential AFO-CAFOs, while only 2 percent of recoverable manure was produced on the very small AFOs. Small AFOs and medium AFO-CAFOs each accounted for about 20 percent of the recoverable manure. The recoverable manure nitrogen was 34 percent of *as excreted* level and recoverable manure phosphorus was 76 percent. The remaining manure and associated manure nutrients from confined AU on AFOs were categorized as non-recoverable.

The amount of recoverable manure, manure nitrogen, and manure phosphorus was higher in 2012 than in 2007, continuing the upward trend since 1982. The amount of recoverable manure nitrogen and phosphorus in 2012 was about 2 percent higher than in 2007, but on the large AFO-CAFOs manure nitrogen in 2012 was 7 percent higher than in 2007 and manure phosphorus was 8 percent higher.

The amount of farm-level excess manure nitrogen and phosphorus increased about 3 percent in 2012 compared to levels estimated for 2007. On the large AFO-CAFOs, however, the farm-level excess manure nitrogen and phosphorus increased 5 percent compared to levels estimated for 2007.

Overall, only a few areas of the country have county-level excess manure, but these areas have been increasing over time. There were 205 counties (of the approximately 3,070 counties included in the Census of Agriculture database) with county-level excess manure in 2012. The number of counties with county-level excess manure increased by 15 percent compared to 2007.

This study informs policy initiatives and policy choices by describing the recoverable manure nutrients, the excess nutrients, and areas with excess nutrients. By describing these changes in indicator variables, we establish an "upper" bound on the reach of polices to manage manure nutrients. In addition, we provide a consistent comprehensive data set for further analysis by NRCS and other natural resource agencies.

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Introduction

A separate report—"Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture,"[1] presented estimates of recoverable and non-recoverable manure nutrients for Agriculture Census years 1982, 1987, 1992, 1997, 2002, and 2007. The purpose of this report is to present similar results for the Agriculture Census year 2012. Methods and assumptions for deriving the 2012 estimates are the same as those for 2007 as reported in the previous report unless specified in later sections of this report.

Livestock populations reported in the Census of Agriculture are used in this report to estimate total manure and manure nutrients *as excreted*, which are then disaggregated into two parts—

- recoverable manure from Animal Feeding Operations (AFOs), where manure from confined animals is assumed to be collectable and available for land application after recovery, and
- non-recoverable manure from all farms with livestock.

Non-recoverable manure includes manure deposited by pastured animals and manure that was assumed to not be recoverable from AFOs. Manure from confined livestock types on farms too small to qualify as AFOs (based on the size of the on-farm livestock population of confined livestock types) was included with pastured livestock, representing nutrient loadings on farmland in the vicinity of small farms.

Specifically, data from the Census of Agriculture databases are used to estimate the average annual on-farm livestock population, which in turn was used to estimate[2]—

1. quantity of manure and manure nutrients *as excreted* for all farms with livestock,
2. quantity of recoverable manure and manure nutrients for AFOs,
3. quantity of non-recoverable manure nutrients for all farms with livestock, and
4. potential application rates of recoverable manure on crops and pastureland.

This information was then used to identify areas where the amount of recoverable manure nutrients exceeds the assumed availability of farmland for land application. Results from this estimation process identify areas potentially needing more land for manure application or alternative manure utilization options.

Presented along with this report is a database supplement that includes estimates by 6-digit Hydrologic Unit Codes (HUCs) of manure, manure nutrients, and other related variables derived from the 2012 Census of Agriculture Database.

[1] USDA-NRCS. 2016. Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture.

[2] The Census of Agriculture is conducted by the National Agricultural Statistics Service (NASS), Department of Agriculture. Electronic databases of farm-level responses maintained by NASS were used to make the calculations at the farm level. Farm-level estimates were then aggregated for reporting. Access to the farm-level data base is restricted to protect the confidentiality of respondents. All estimates published in this report meet the disclosure criteria used by NASS to assure confidentiality.

Animal Units by Type of Livestock Farm

The basic building block of the estimation process is an animal unit (AU), which represents 1,000 pounds of live animal weight. AU is a convenient measure for aggregating over different types of livestock. The number of AUs on a farm varies throughout the year as livestock grow and are bought or sold. The average annual number of AUs on each farm was estimated from reported data on number of livestock sold or on hand at the end of the year.

To convert head-count data reported in the Census of Agriculture to average annual AUs, assumptions are needed on how long the animals are kept on the farm and the average weight of the animal while on the farm. Animal unit conversions (number of animals per AU) were based on determinations of the *average* live weight associated with each livestock category**.** For some livestock categories (such as poultry), the animal unit conversion represents the average weight from birth to market. For others, such as beef and dairy calves, it represents the average weight for the time period that the animal was assumed to be in the specified category.

Estimates of average annual AUs may be overstated or understated for individual farms because of the numerous assumptions required to make the calculations. The estimates are not intended to accurately represent each individual farm. The estimates are reasonable, however, for aggregations over large numbers of farms and are appropriate for quantifying trends in the magnitude of livestock populations and manure production and changes in the size and distribution of livestock operations over time.

Farms vary by size and type of operation. Some farms are primarily crop producing farms with no or few livestock. Other farms are livestock operations that primarily raise confined livestock types or primarily raise pastured livestock. Animal Feeding Operations (AFOs) are farms with significant populations of confined livestock, and they are considered to be the farms that generate recoverable manure—that is, manure that would be available for land application.[3] The number and sizes of the largest AFOs, called Concentrated Animal Feeding Operations (CAFOs), are an important focus for this report.

Criteria for an AFO were developed based on the number of confined livestock type AUs and the estimated amount of manure generated on the farm during a year of operation. Farms were considered AFOs if the population of livestock on the farm was large enough to require manure handling equipment and storage facilities on the farm, and where manure collection and removal from the animal holding facilities would be expected to occur routinely throughout the year. For this analysis, a farm was identified as an AFO if both of the following criteria were met—

1. 12 or more average annual AUs of confined livestock types, (fattened cattle or veal calves, milk cows, swine, or poultry) including the portion of pastured livestock that were assumed to be confined, and
2. 40 or more tons of manure at hauling weight produced by confined livestock types on the farm in a year.

Farms that did not meet these criteria would not be expected to have sufficient manure production to require on-going removal and disposal. In most cases, the volume of manure would be too small to require manure handling equipment other than a small tractor with a loader or scraper, and any manure disposal would take place on the farm. It is possible that these farms with small livestock populations could be maintained on only a few acres (10 to 15). It is also likely that livestock on these farms would be mostly or at least partially pastured or free-roaming, regardless of the livestock type. Based on the type and extent of livestock reported on the farm in the Census and the above definitions for AFOs, farms were categorized into one of nine farm types.

1. ***Farms without livestock***—no livestock sales or livestock AUs on farm.
2. ***Farms with a few livestock but not a livestock operation***—no livestock sales, less than 2 average annual AUs of confined livestock, less than 6 average annual AUs of confined and pastured livestock, less than 5 average annual AUs of specialty livestock, and less than 20 tons per year of manure production at hauling weight for all livestock.
3. ***Farms with very small livestock operations***—less than 30 average annual AUs of all livestock, less than 12 average annual AUs of confined livestock, less than 60 tons per year of manure production at hauling weight for all livestock, and less than 40 tons per year of manure production at hauling weight for confined livestock.
4. ***Farms with specialty livestock operations with few confined livestock***—specialty livestock AUs more than 50 percent of total AUs, less than 12 average annual AUs of confined livestock, and less than 40 tons per year of manure production at hauling weight for confined livestock.
5. ***Farms with pastured livestock operations with few confined livestock***—specialty livestock AUs less than 50 percent of total AUs, less than 12 average annual AU of confined livestock, and less than 40 tons per year of manure production at hauling weight for confined livestock.
6. ***Very small AFOs***—less than 35 average annual AUs of confined livestock.

[3] EPA defines an AFO as a "lot or facility where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and where crops, vegetation forage growth, or post-harvest residues are not sustained over any portion of the lot or facility in the normal growing season." The Census of Agriculture has information about the number and types of livestock on each farm, but provides no information on how the animals are raised or to what extent or how long animals are held in confinement. Consequently, it is not possible to identify whether or not a farm in the census database is an AFO using the EPA definition.

7. ***Small AFOs***—35 or more average annual AUs of confined livestock but livestock populations below criteria for medium or large AFO-CAFOs.[4]
8. ***Medium AFO-CAFOs***—livestock population meets EPA head-count criteria for "medium CAFOs."
9. ***Large AFO-CAFOs***—livestock population meets EPA head-count criteria for "large CAFOs."

The farm-type criteria presented above were designed to segregate farms into four major groups—

1. farms without any livestock (farm type 1),
2. farms with too few livestock to have recoverable manure (farm types 2 through 4),[5]
3. farms with significant numbers of pastured livestock but too few confined livestock types to have recoverable manure (farm type 5), and
4. farms with recoverable manure—AFOs (farm types 6 through 9).

About 36 percent of farms in 2012 had no livestock inventory or sales (table 1) and another 35 percent of farms had only small numbers of confined or pastured livestock types (farm types 2 through 4). Less than 5 percent of AU of all types, including 1 percent of confined livestock types, were on these 1.48 million farms in 2012 (table 1).

About 22 percent of farms had significant numbers of pastured livestock but few confined livestock types (farm type 5) in 2012. About 81 percent of the AU for pastured livestock types and 40 percent of the AU for all livestock types were on these 454,377 farms in 2012.

AFOs represented 8.1 percent of all farms in 2012 (table 1), totaling 170,144 farms. Nearly all—98.7 percent—of the confined livestock types were on these farms. Including other livestock types, AU on AFOs constituted 55 percent of all AU. About 32 percent of all AU and 62 percent of confined AU were on large AFO-CAFOS, which represented only 12,632 farms—0.6 percent of the farms in 2012.
Generally the number and type of farms in 2012 decreased slightly from 2007 to 2012, as did the number of AU on those farms. (Appendix A, table A1). Overall, the total number of farms decreased 4 percent compared to 2007.

The number of AFOs, however, decreased 10 percent, led by a 15-percent decrease in small AFOs, continuing the long-term downward trend in the number of AFOs (fig. 1). The number of large AFO-CAFOS, which has been steadily increasing over time through 2007, fell by 5 percent in 2012 compared to 2007.

Pastured livestock AUs fell 11 percent from 2007 to 2012, while confined AU fell only 3 percent (fig. 2 and appendix A, table A1). On large AFO-CAFOs, however, confined AU increased 3 percent compared to 2007, in spite of the 5-percent decline in the number of large AFO-CAFOs. Confined AU on medium AFO-CAFOS decreased 14 percent and confined AU on small AFOs decreased by 11 percent compared to levels in 2007—mirroring about the same percentage decreases in the number of these AFOs.

The composition of AU by livestock type in 2012 was about the same as in 2007 (fig. 3). Milk cow AU did not change between 2007 and 2012, while AU for fattened cattle, poultry, and swine decreased somewhat (appendix A, table A1). AU for confined pastured livestock types (consisting mostly of cattle associated with dairies) increased about 8 percent in 2012 compared to 2007.

[4] EPA provides livestock population criteria for "large CAFOs," and for "medium CAFOs" that might also be designated by EPA as a CAFO if they also meet certain "method of discharge" criteria. However, these criteria are based on livestock thresholds *at any point in time* throughout the year. The end-of-year inventory and sales data provided in the Census of Agriculture are thus not adequate to identify a farm as a CAFO. Nevertheless, the EPA livestock population criteria are useful for identifying the largest two groups of AFOs, even though those criteria are applied to the *average annual number of AU* on the farm, as estimated in this study. Thus, estimates for CAFOs in this study should be interpreted as estimates for *potential CAFOs*, rather than CAFOs that meet EPA criteria.

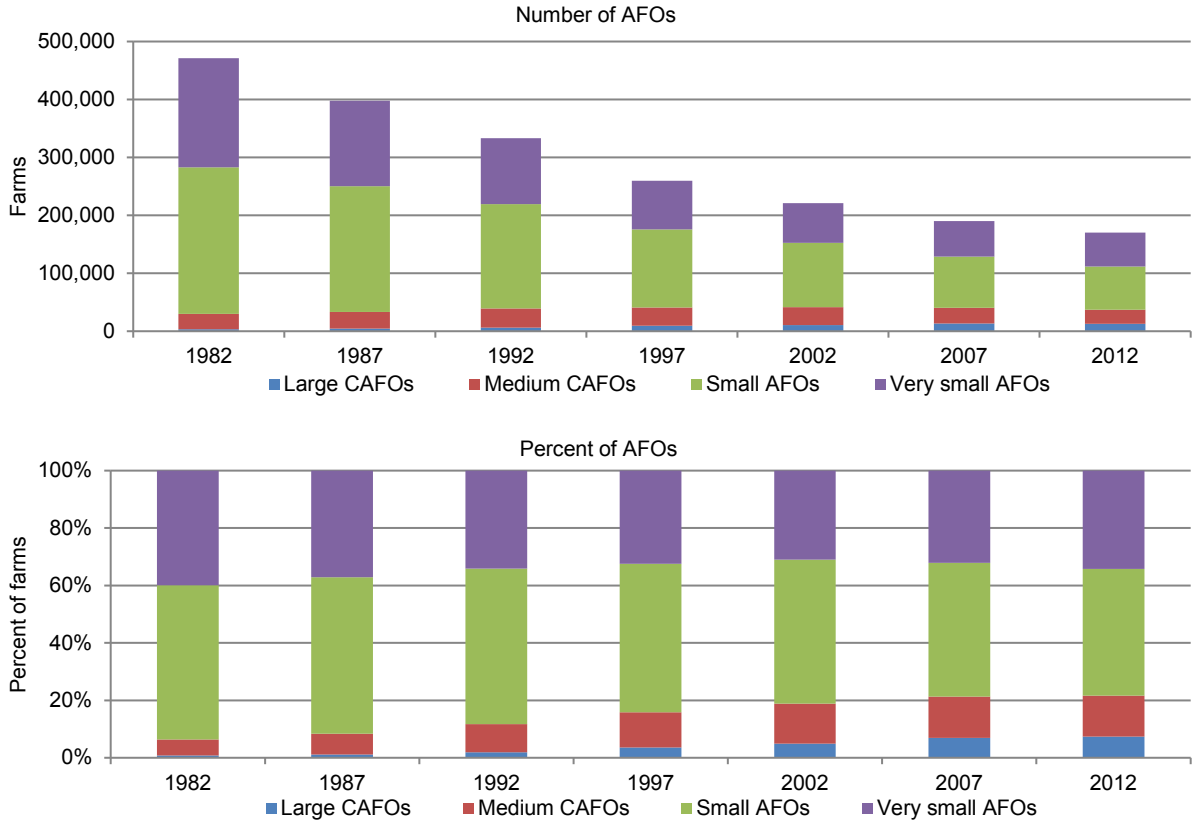
[5] Farms with "specialty livestock operations with few confined livestock" would be expected to have recoverable amounts of manure. However, sufficient information on manure characteristics was not available to estimate the quantity of manure for specialty livestock types. As these farms have too few confined livestock types to qualify as AFOs on the basis of those livestock types, no recoverable manure was estimated for these farms.

Table 1. Farm counts and average annual AUs by farm type, all U.S., 2012

	Farms		All livestock types		Pastured livestock types*		Confined livestock types**		Specialty livestock types	
	Number	Percent of total	1,000 AU	Percent of total	1,000 AU	Percent of total	1,000 AU	Percent of total	1,000 AU	Percent of total
Non-AFOs										
Farms without livestock	748,801	35.5%	0	0	0	0	0	0	0	0
Farms with some livestock but not a livestock operation	114,978	5.5%	259	0.3%	238	0.5%	14	<0.1%	6	2.1%
Very small livestock operations	617,567	29.3%	4,006	4.2%	3,437	7.3%	519	1.1%	50	16.2%
Specialty livestock operations with few confined livestock	3,436	0.2%	319	0.3%	103	0.2%	1	<0.1%	215	69.8%
Pastured livestock operations with few confined livestock	454,377	21.5%	38,485	40.5%	38,377	81.3%	86	0.2%	22	7.2%
AFOs										
Very small AFOs	58,227	2.8%	1,874	2.0%	730	1.5%	1,141	2.4%	2	0.7%
Small AFOs	75,044	3.6%	10,697	11.3%	2,301	4.9%	8,392	17.7%	4	1.1%
Medium AFO-CAFOs	24,241	1.1%	8,940	9.4%	1,099	2.3%	7,840	16.5%	1	0.4%
Large AFO-CAFOs	12,632	0.6%	30,428	32.0%	943	2.0%	29,478	62.1%	7	2.4%
All non-AFOs	1,939,159	91.9%	43,067	45.3%	42,154	89.3%	620	1.3%	293	95.3%
All AFOs	170,144	8.1%	51,939	54.7%	5,073	10.7%	46,851	98.7%	14	4.5%
Total	2,109,303	100%	95,006	100%	47,227	100%	47,471	100%	307	100%

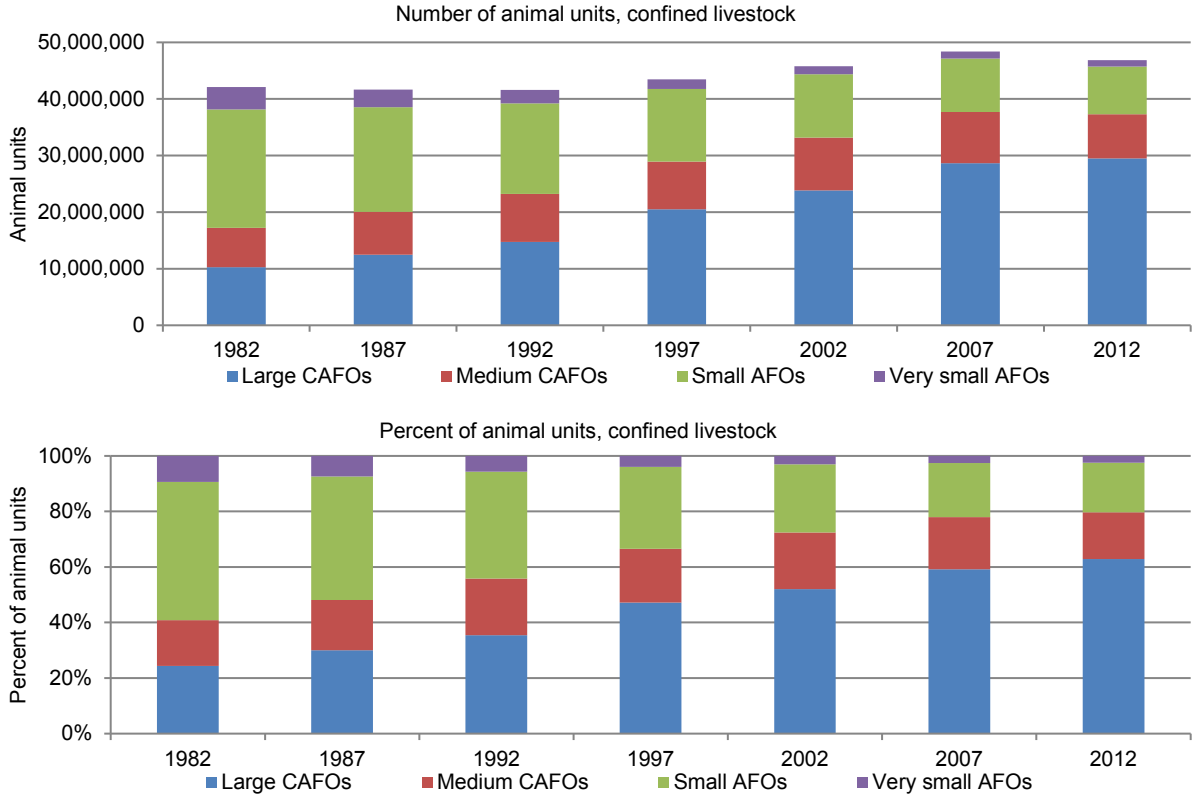
* Excludes partially or wholly confined pastured livestock types.
** Includes partially or wholly confined pastured livestock types.

Figure 1. Number and percent of AFOs by farm type



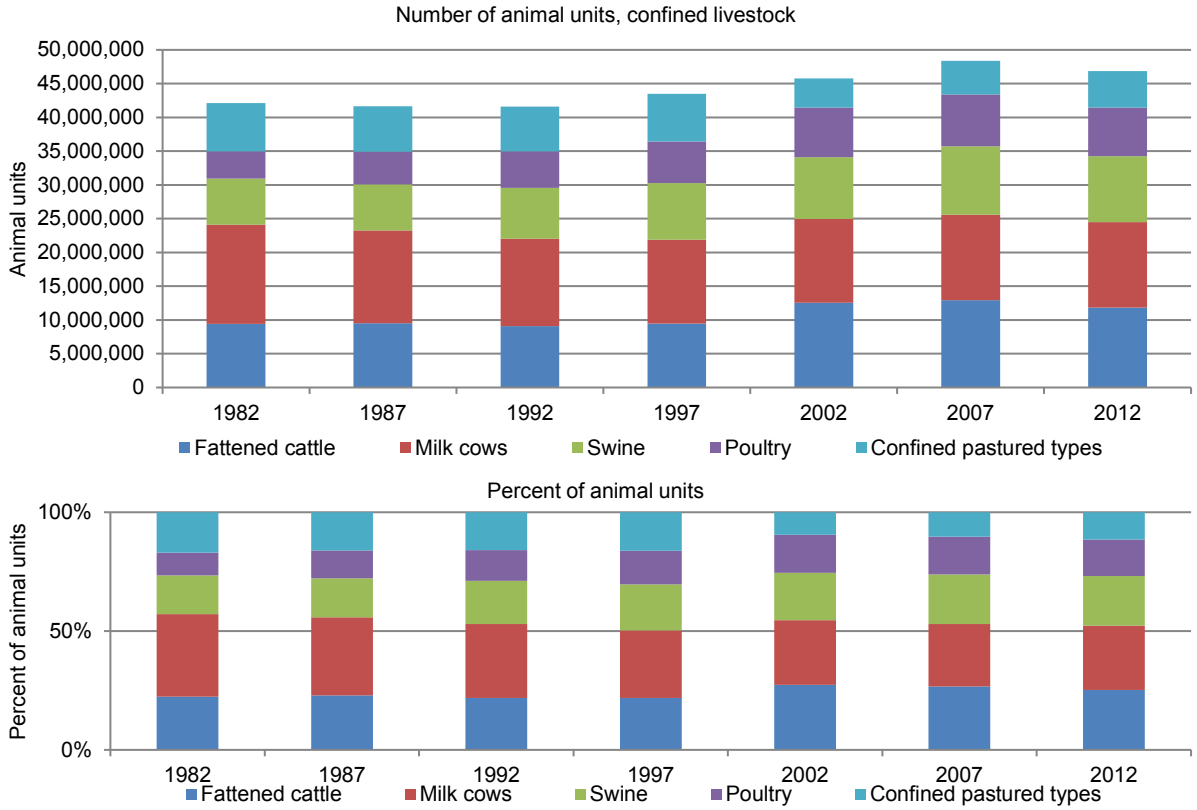
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 2. Number of animal units for confined livestock on AFOs, by AFO farm type



Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 3. Number of confined livestock on AFOs, by livestock group



Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Map 1 provides a two panel visual representation of the number and county locations[6] of potential medium and large AFO-CAFOs in 2012 and changes from 2007. The location of medium and larger AFO-CAFOs did not change significantly over the 2007-2012 period. But because there was a decline in the total number of operations, there are more losses than gains shown in panel b. Losses of medium and large AFO-CAFOs were spread throughout the areas of concentration shown in panel a, with a few exceptions. There are concentrations of farm declines in the eastern half of North Carolina and in central California. On the increase side, most of the increase in farm numbers occurred in northern Georgia and Alabama.

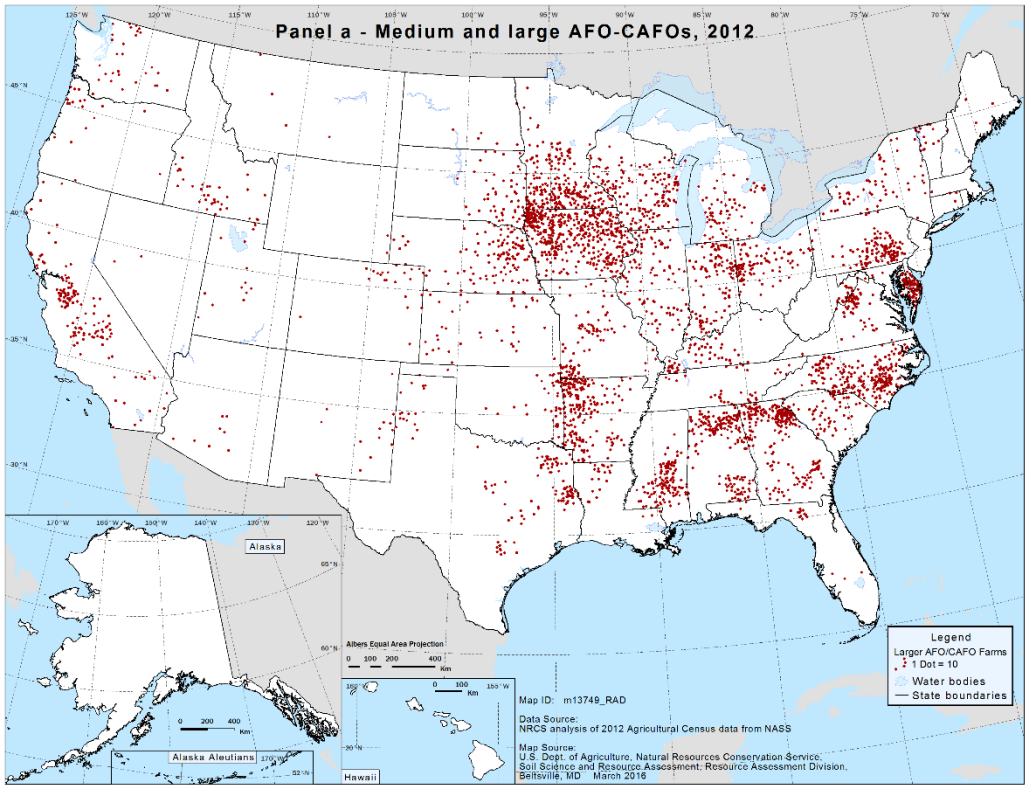
Map 2 presents the 2012 distribution and 2007-2012 change in the location of confined animal units. The number and location of confined AUs did not change significantly over the 2007-2012 period. However, the location of confined AU is not static. There was a small increase in confined AUs in areas with existing high concentrations, especially in Nebraska, western Kansas and southward into the Texas panhandle.

Other areas of increase include central California, southern Idaho and Washington and the upper Midwest (from Iowa into Wisconsin and Michigan). There are areas of gain adjacent to areas of decline in many states. For example, western Kansas shows an increase while central Kansas has a decline. Similar observation could be made about Nebraska, Iowa and North Carolina.

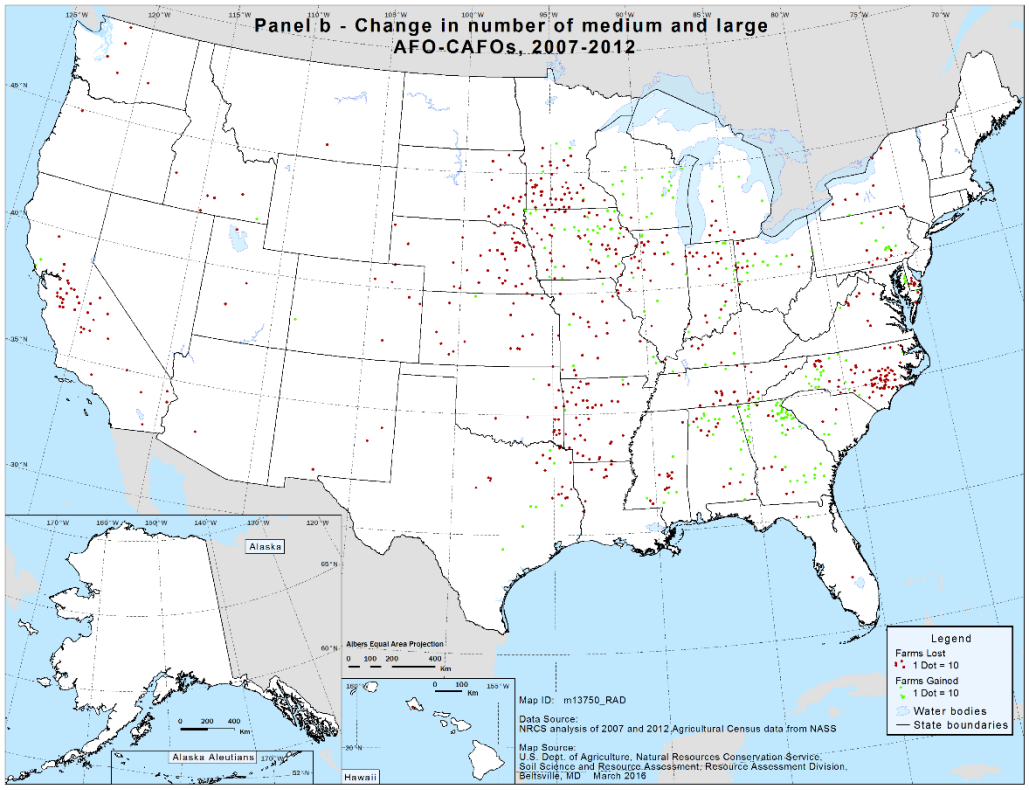
The combination of information in maps 1 and 2 indicates that there has been a decline in both AFO farms numbers and confined AUs in Eastern North Carolina. Other areas with changing farm numbers (example increase in northern Alabama) did not reflect an associated change in confined AUs and *visa-versa*. This highlights the difficulty in making broad statements about the changing nature of an industry considering only a relatively short 5-year period as compared to a longer time line.

[6] Maps indicating county locations are prepared using a randomized dot placement within the county and are rounded to the nearest unit, which is map specific.

Map 1. County location of potential medium and large AFO-CAFOs for 2012 and change in the county location of potential medium and large AFO-CAFOs for 2007-2012

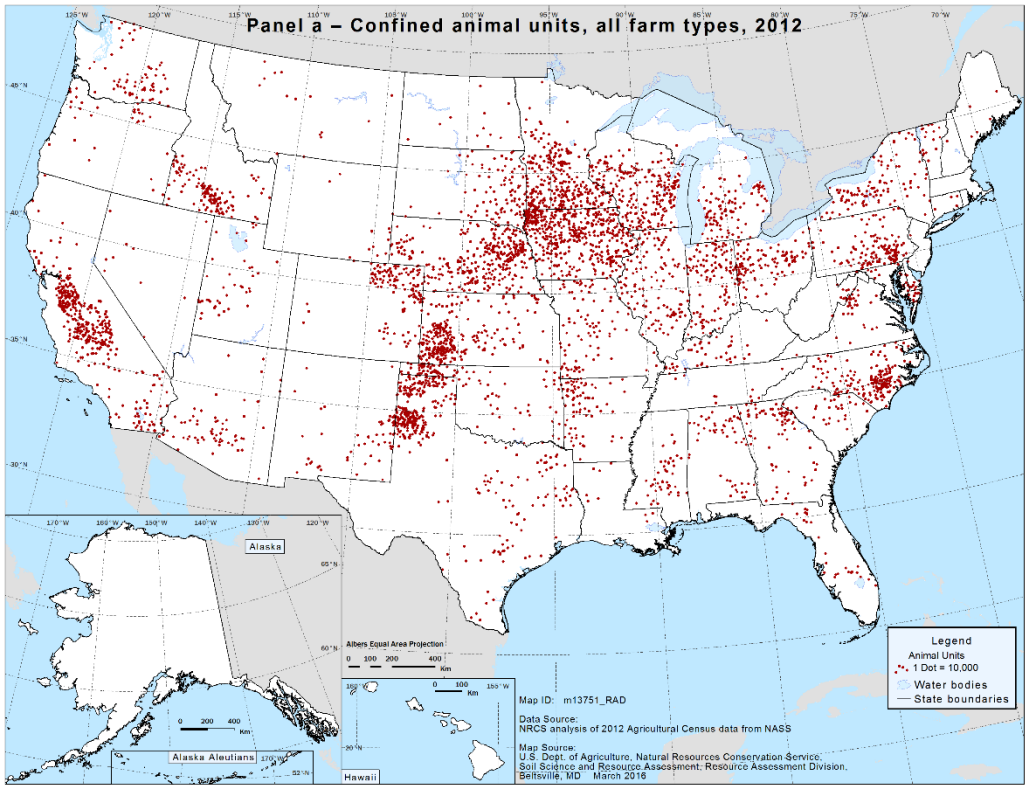


Legend: Dot = 10 farms
Source: NRCS analysis of the 2012 Agricultural Census data from NASS

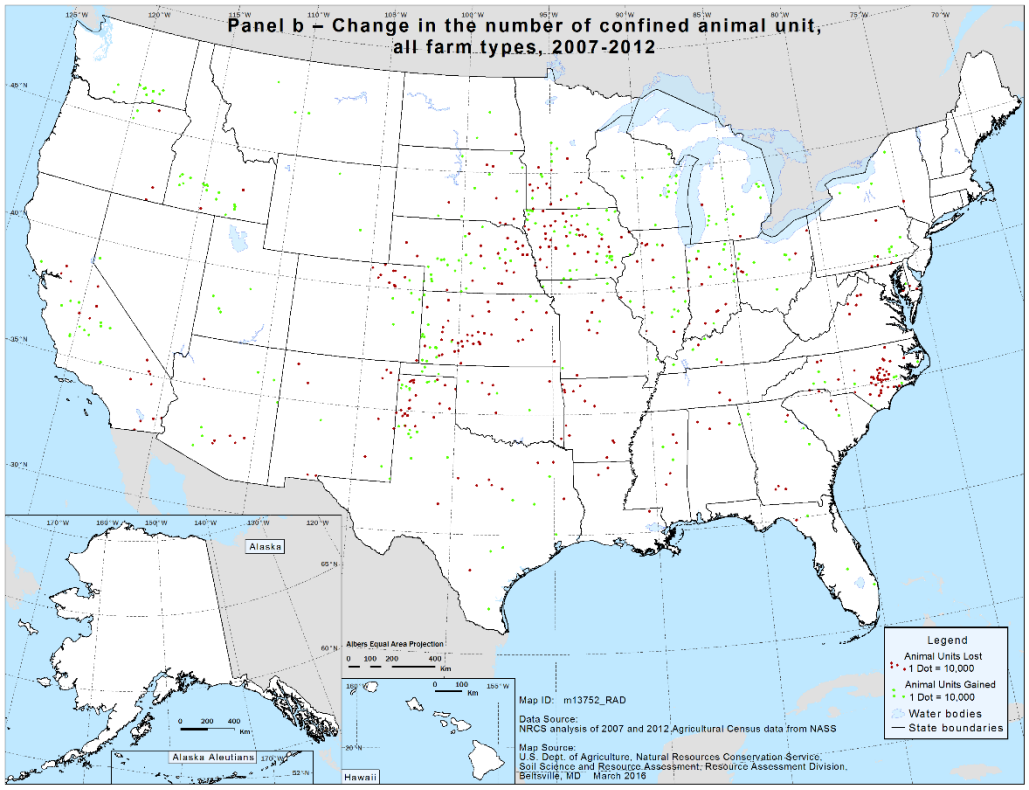


Legend: Green dot = 10 farm gain and red dot = 10 farm loss.
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Map 2. County location of confined animal units (AU) on all farm types for 2012 and change in the county location of confined animal units for 2007-2012



Legend: Dot = 10,000 AU
Source: NRCS analysis of the 2012 Agricultural Census data from NASS



Legend: Green dot = 10,000 AU gain and red dot = 10,000 AU loss.
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Manure and Manure Nutrients Produced by Livestock

The amount of manure *as excreted* that is produced on a farm annually is calculated as the number of average annual AU times the amount of manure produced by an animal unit. Values include both urine and feces. Manure nitrogen and manure phosphorus *as excreted* were calculated by multiplying the tons of manure (wet weight) by standard values for the pounds of elemental nutrients per ton of manure (wet weight) *as excreted*. The quantity of manure and manure nutrients were estimated for confined livestock types and pastured livestock types. Estimates of manure and manure nutrients were not made for specialty livestock types, which make up less than 1 percent of total AUs.

In 2012, livestock on farms in the US produced about 1.23 billion tons of manure, wet-weight *as excreted* (table 2). The AFO farm types produced the majority of the manure—60 percent of the total manure produced. Farms with pastured livestock operations with few confined livestock produced 36 percent. Only about 4 percent of the manure was produced on the three other types of non-AFO farms with livestock.

This manure production represents about 16.17 billion pounds of manure nitrogen and 4.53 billion pounds of manure phosphorus, *as excreted* (tables 3 and 4). The AFO farm types produced the majority of the manure nitrogen—64 percent (table 3), whereas non-AFOs produced the majority of the manure phosphorus—52 percent (table 4). The higher share of phosphorus for non-AFOs reflects, in part, the higher manure phosphorus content of pastured livestock manure relative to the phosphorus content of manure of most confined livestock types.

Changes in the quantity of manure and manure nutrients over time closely correspond to changes in AU (appendix A, table A-2). Total manure production on all farms in 2012 was 6 percent less than in 2007—10 percent less for non-AFOs and 3 percent less for AFOs. The change in manure nutrients was about the same.

On large AFO-CAFOs, however, the quantity of manure nutrients produced increased slightly from 2007 to 2012—3 percent for phosphorus and 4 percent for nitrogen. These increases correspond to a 3-percent increase in confined AU on these farms.

Milk cows accounted for about one-third of manure nitrogen for confined livestock on AFOs; poultry accounted for one-fourth; swine and fattened cattle each accounted for 16-18 percent; and confined pastured livestock accounted for 7 percent (appendix A, table A-2).

Poultry accounted for the largest share of manure phosphorus in 2012—37 percent (appendix A, table A-2). Milk cows accounted for 31 percent; swine accounted for 16 percent; fattened cattle accounted for 10 percent; and confined pastured livestock accounted for 7 percent.

Table 2. Quantity of manure produced *as excreted* (wet weight) by livestock, all U.S., 2012

	Pastured livestock types*		Confined livestock types**		All livestock types***	
	1,000 Tons	Percent of total	1,000 Tons	Percent of total	1,000 Tons	Percent of total
Non-AFOs						
Farms without livestock	0	0.0%	0	0.0%	0	0.0%
Farms with some livestock but not a livestock operation	2,421	0.4%	169	<0.1%	2,590	0.2%
Very small livestock operations	36,304	6.7%	6,295	0.9%	42,599	3.5%
Specialty livestock operations with few confined livestock	1,056	0.2%	8	<0.1%	1,064	0.1%
Pastured livestock operations with few confined livestock	440,592	81.7%	1,086	0.2%	441,678	35.9%
AFOs						
Very small AFOs	8,332	1.5%	17,688	2.6%	26,021	2.1%
Small AFOs	26,630	4.9%	145,328	21.0%	171,958	14.0%
Medium AFO-CAFOs	12,766	2.4%	116,207	16.8%	128,974	10.5%
Large AFO-CAFOs	10,940	2.0%	404,241	58.5%	415,181	33.8%
All non-AFOSs	480,373	89.1%	7,558	1.1%	487,931	39.7%
All AFOs	58,668	10.9%	683,465	98.9%	742,133	60.3%
Total	539,041	100.0%	691,023	100.0%	1,230,064	100.0%

* Excludes partially or wholly confined pastured livestock types.
** Includes partially or wholly confined pastured livestock types.
*** Excludes specialty livestock types.

Table 3. Quantity of manure nitrogen produced *as excreted* by livestock, all U.S., 2012

	Pastured livestock types*		Confined livestock types**		All livestock types***	
	1,000 Pounds	Percent of total	1,000 Pounds	Percent of total	1,000 Pounds	Percent of total
Non-AFOs						
Farms without livestock	0	0.0%	0	0.0%	0	0.0%
Farms with some livestock but not a livestock operation	31,065	0.5%	2,082	<0.1%	33,147	0.2%
Very small livestock operations	452,869	6.9%	65,202	0.7%	518,070	3.2%
Specialty livestock operations with few confined livestock	12,791	0.2%	102	<0.1%	12,893	0.1%
Pastured livestock operations with few confined livestock	5,327,210	81.6%	13,626	0.1%	5,340,835	33.0%
AFOs						
Very small AFOs	100,912	1.5%	169,654	1.8%	270,566	1.7%
Small AFOs	320,811	4.9%	1,594,504	16.5%	1,915,315	11.8%
Medium AFO-CAFOs	153,985	2.4%	1,893,702	19.7%	2,047,687	12.7%
Large AFO-CAFOs	132,341	2.0%	5,896,880	61.2%	6,029,220	37.3%
All non-AFOSs	5,823,935	89.2%	81,011	0.8%	5,904,946	36.5%
All AFOs	708,049	10.8%	9,554,740	99.2%	10,262,789	63.5%
Total	6,531,984	100.0%	9,635,750	100.0%	16,167,734	100.0%

* Excludes partially or wholly confined pastured livestock types.
** Includes partially or wholly confined pastured livestock types.
*** Excludes specialty livestock types.

Table 4. Quantity of manure phosphorus produced *as excreted* by livestock, all U.S., 2012

	Pastured livestock types*		Confined livestock types**		All livestock types***	
	1,000 Pounds	Percent of total	1,000 Pounds	Percent of total	1,000 Pounds	Percent of total
Non-AFOs						
Farms without livestock	0	0.0%	0	0.0%	0	0.0%
Farms with some livestock but not a livestock operation	9,963	0.4%	434	<0.1%	10,397	0.2%
Very small livestock operations	156,968	6.0%	13,425	0.7%	170,393	3.8%
Specialty livestock operations with few confined livestock	4,195	0.2%	21	<0.1%	4,216	0.1%
Pastured livestock operations with few confined livestock	2,150,995	82.4%	2,478	0.1%	2,153,473	47.6%
AFOs						
Very small AFOs	40,318	1.5%	33,963	1.8%	74,281	1.6%
Small AFOs	131,315	5.0%	306,885	16.0%	438,200	9.7%
Medium AFO-CAFOs	63,373	2.4%	428,793	22.4%	492,166	10.9%
Large AFO-CAFOs	54,332	2.1%	1,129,937	59.0%	1,184,269	26.2%
All non-AFOSs	2,322,120	88.9%	16,359	0.9%	2,338,479	51.7%
All AFOs	289,338	11.1%	1,899,577	99.1%	2,188,916	48.3%
Total	2,611,459	100.0%	1,915,936	100.0%	4,527,395	100.0%

* Excludes partially or wholly confined pastured livestock types.
** Includes partially or wholly confined pastured livestock types.
*** Excludes specialty livestock types.

Recoverable Manure

Livestock operations with animals held in confinement have "recoverable manure." Recoverable manure is the portion of manure that is routinely collected and removed from buildings and lots where livestock are held, and which would thus be available for land application or other use. As indicated earlier, AFOs have been defined for the purposes of this study to be livestock operations where management and disposal of manure would be expected based on the kind and number of livestock on the farm as reported in the Census of Agriculture.

It was assumed that all manure from confined livestock types on AFOs was potentially recoverable, as well as manure from pastured livestock types assumed to be confined because of limited or no grazing land available on the farm. The quantity of manure *as excreted* was multiplied by "recoverability coefficients." Recoverability coefficients vary over time, region of the country, and by farm size so as to represent varying levels of manure handling and management. Larger farms would be expected to have more efficient manure management technologies in use. It is also expected that manure handling and management technologies have improved over time as older, less efficient operations are replaced by newer and better designed operations or upgraded with newer technologies.[7] Consequently, recoverability coefficients for 2012 are the same as or larger in 2012 than in 2007 and prior years. Recoverability coefficients for 2012 are reported in USDA/NRCS (2016).[8]

Recoverable manure nutrients are the nitrogen and phosphorus content of recoverable manure, adjusted for losses during collection, transfer, storage, and treatment. Recoverable manure nutrients are *not* adjusted for losses of nutrients during the land application process.

In 2012, the total amount of recoverable manure totaled 532 million tons, wet weight (equivalent to 73 million tons dry[9] weight) (table 5). Sixty percent by wet weight (58 percent by dry weight) was produced on the 12,632 large potential AFO-CAFOs. Only 2 percent of recoverable manure was produced on the very small AFOs. Small AFOs and medium AFO-CAFOs each accounted for about 20 percent (table 5).

Overall, the amount of recoverable manure in 2012 was 78 percent of the total amount of manure *as excreted* produced by confined livestock on AFOs (table 5). The amount of recoverable manure nitrogen was 34 percent and recoverable manure phosphorus was 76 percent. The remaining manure and manure nutrients from confined AU on AFOs were categorized as non-recoverable.

Relative to the total manure and manure nutrients produced on all farms by both pastured livestock and confined livestock, the recoverable portion represents 43 percent of the quantity of manure *as excreted* (wet weight), 20 percent of manure nitrogen *as excreted*, and 32 percent of manure phosphorus *as excreted* (table 5).

The amount of recoverable manure, manure nitrogen, and manure phosphorus was higher in 2012 than in 2007, continuing the upward trend since 1982 (figs. 4, 5, and 6). The amount of recoverable manure nitrogen and phosphorus in 2012 was about 2 percent higher than in 2007 (appendix A, table A-3). On the large AFO-CAFOs, however, manure nitrogen in 2012 was 7 percent higher than in 2007 and manure phosphorus was 8 percent higher.

Poultry had the largest share of recoverable manure nitrogen in 2012—40 percent (fig. 7 and appendix A, table A-3), which was about the same as poultry's share in 2007. Milk cows had the next highest share at 28 percent, followed by fattened cattle at 14 percent and swine at 12 percent.

Poultry and milk cows also had the largest shares of recoverable manure phosphorus in 2012—41 percent for poultry and 27 percent for milk cows (fig. 8 and appendix A, table A-3), followed by swine at 17 percent and fattened cattle at 9 percent.

Map 3 presents the distribution and change in the estimated location of recoverable manure (dry weight equivalent) from confined animal units. The location of recoverable manure closely follows the location of confined animals shown in map 2. Recoverable manure is most concentrated in regions of confined livestock production. Across most of the U.S. a strong trend is not evident and areas of increased recoverable manure availability are often located adjacent to areas of decreased recoverable manure. Decreases in recoverable manure reflect decreases in confined livestock populations from 2007 to 2012. Increases in recoverable manure reflect increases in confined livestock population as well as more efficient manure management practices (i.e., larger recoverability coefficients).

There are some clear areas of increased recoverable manure in the west (Idaho, Washington, and California) and a broad region where the increases exceed the decreases (from the Texas panhandle northward through western Kansas, across Nebraska, Iowa, southern Minnesota, and Wisconsin to eastern Pennsylvania). The slight decrease in confined animals and the change in location (map 2) is reflected in the decreases observed in recoverable manure in areas of Arkansas, Louisiana, and North Carolina.

[7] For example, since 1997, most large operations have CAFO permits and over 35,000 Comprehensive Nutrient Management Plans (CNMPs) have been prepared.

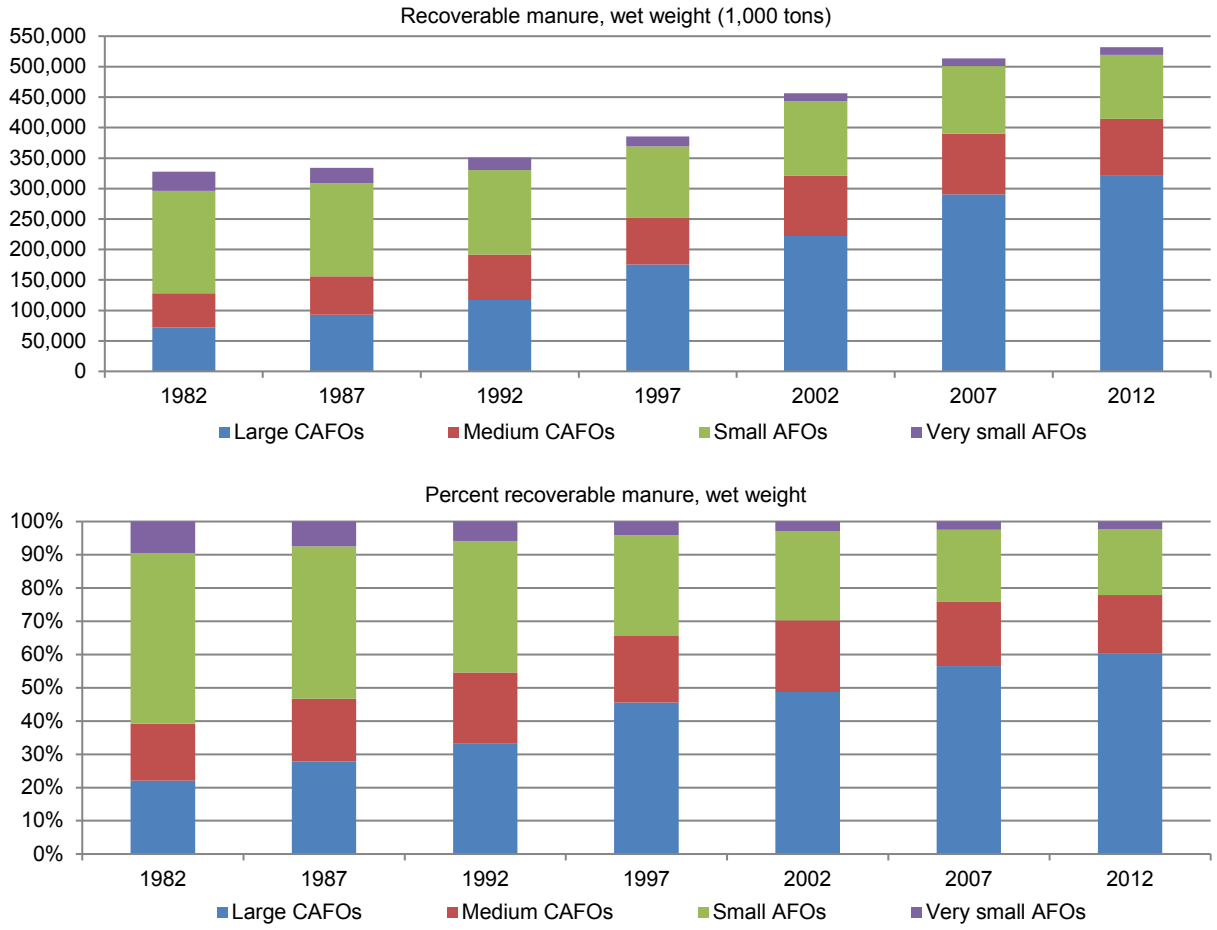
[8] Manure recoverability coefficients for 2012 are presented in table 9 of USDA/NRCS (2016). See footnote 1.

[9] Dry weight is equal to the total solids content of the *as excreted* manure.

Table 5. Quantity of recoverable manure and manure nutrients after adjusting for losses, all U.S., 2012

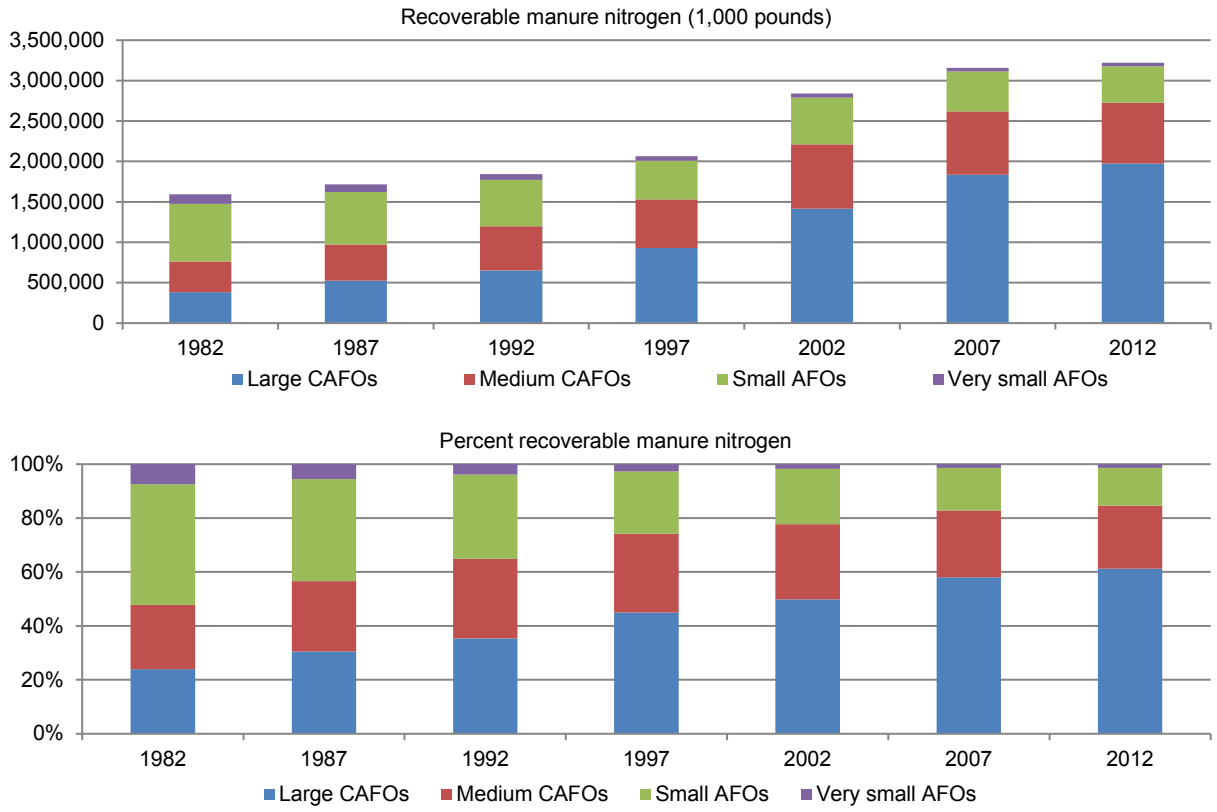
	Quantity of recoverable manure (wet weight)		Quantity of recoverable manure (dry weight)		Recoverable manure nitrogen		Recoverable manure phosphorus	
	1,000 tons	Percent of total	1,000 tons	Percent of total	1,000 pounds	Percent of total	1,000 pounds	Percent of total
AFOs								
Very small AFOs	12,711	2.4%	1,594	2.2%	42,637	1.3%	22,125	1.5%
Small AFOs	105,109	19.8%	13,334	18.2%	451,438	14.0%	208,697	14.5%
Medium AFO-CAFOs	93,206	17.5%	15,964	21.8%	754,304	23.4%	345,263	23.9%
Large AFO-CAFOs	321,063	60.3%	42,345	57.8%	1,971,818	61.2%	867,799	60.1%
Total	532,089	100.0%	73,237	100.0%	3,220,198	100.0%	1,443,883	100.0%
Recoverable manure as a percentage of manure *as excreted* for confined livestock produced on all AFOs	78%	--	80%	--	34%	--	76%	--
Recoverable manure as a percentage of total manure *as excreted* produced on all farms	43%	--	41%	--	20%	--	32%	--

Figure 4. Amount and percent of recoverable manure (wet weight), by AFO farm type



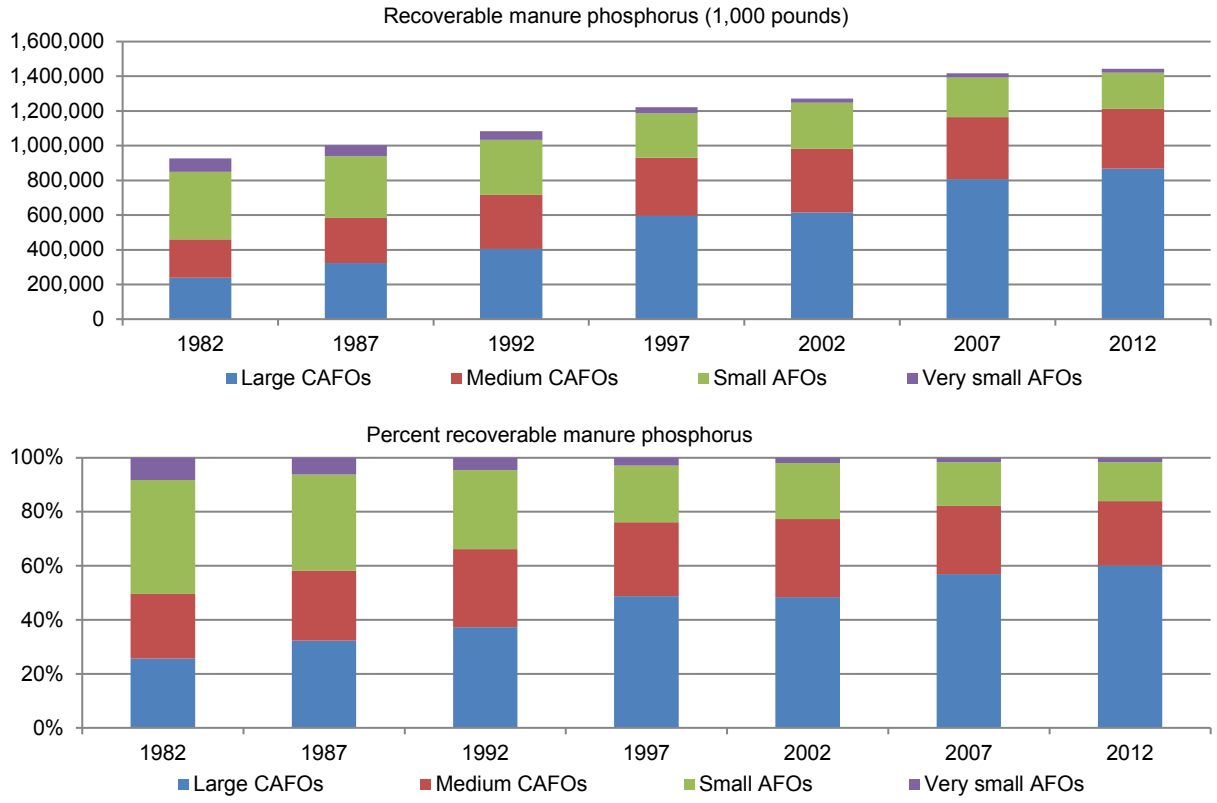
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 5. Amount and percent of recoverable manure nitrogen, by AFO farm type



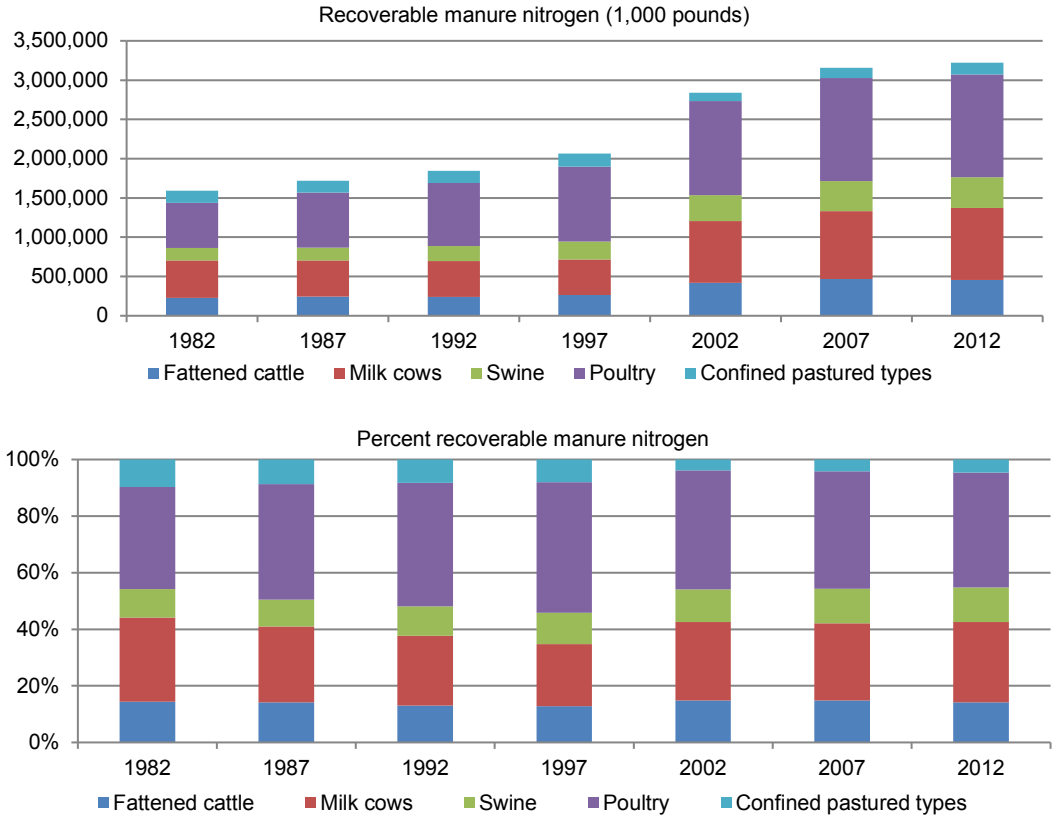
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 6. Amount and percent of recoverable manure phosphorus, by AFO farm type



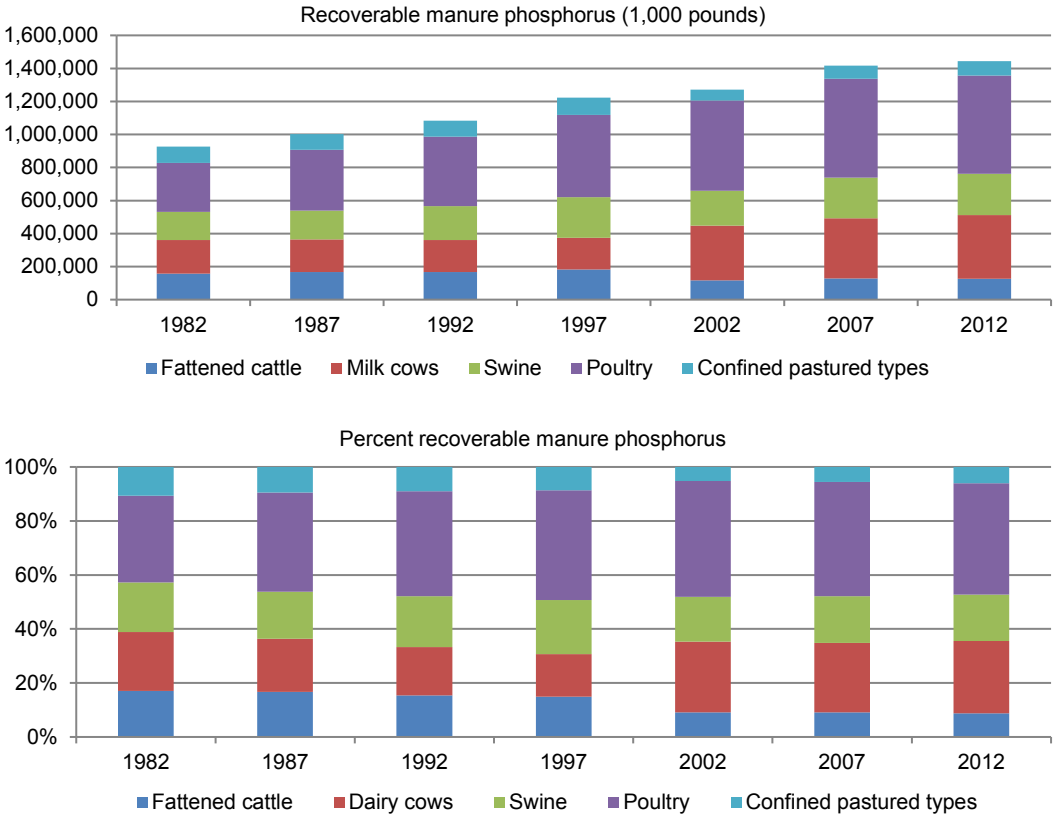
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 7. Amount and percent of recoverable manure nitrogen, by livestock group



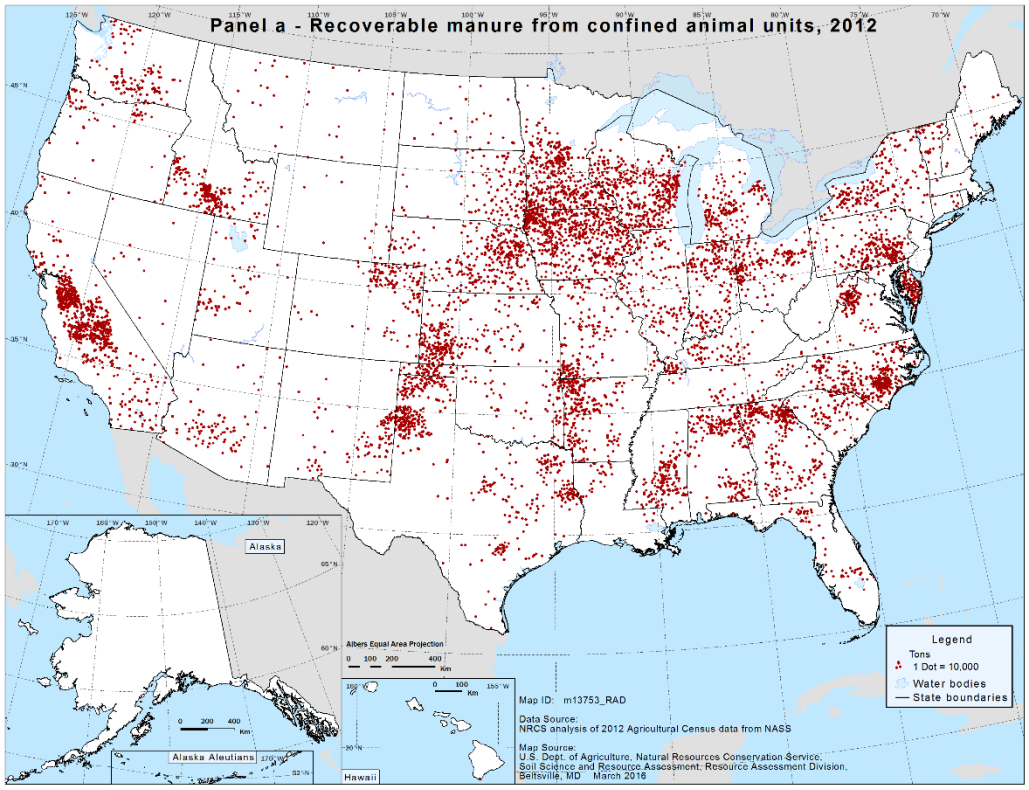
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 8. Amount and percent of recoverable manure phosphorus, by livestock group

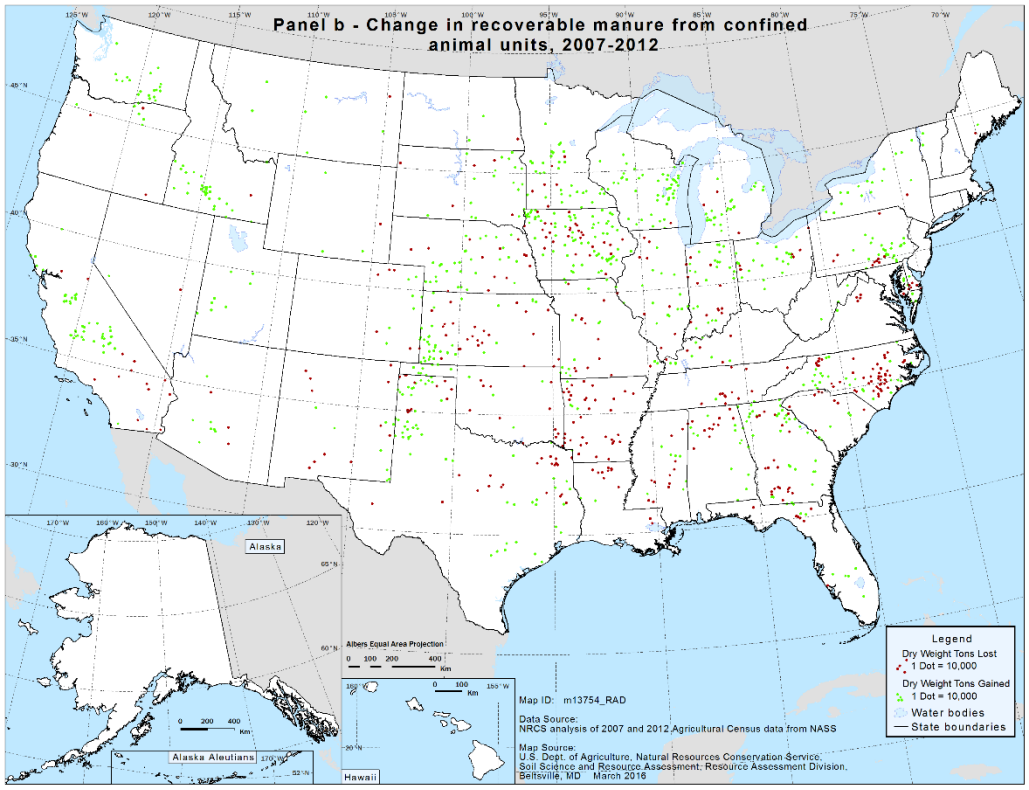


Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Map 3. County location of recoverable manure from confined animals for 2012 and change in the county location of recoverable manure from confined animals 2007-2012



Legend: Dot = 10,000 tons (dry weight)
Source: NRCS analysis of the 2012 Agricultural Census data from NASS



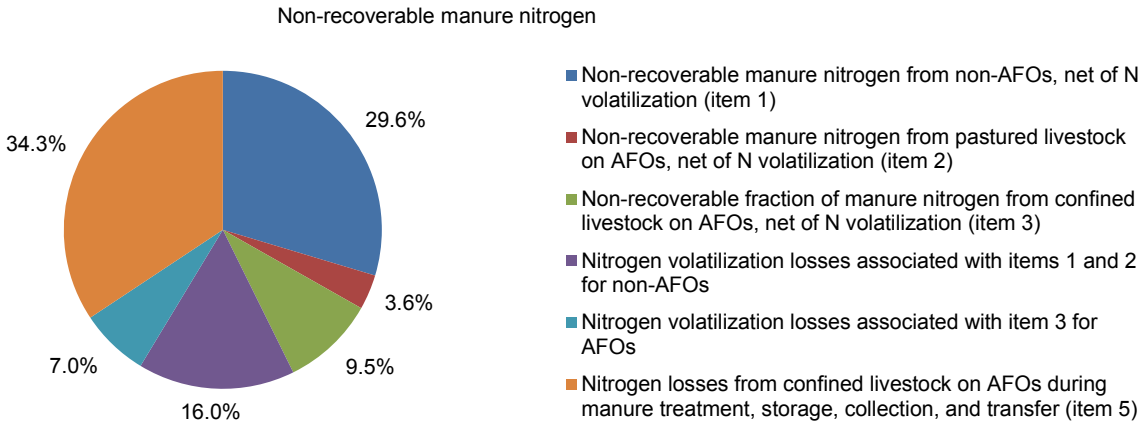
Legend: Green dot = 10,000 ton gain and red dot = 10,000 ton loss (dry weight).
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

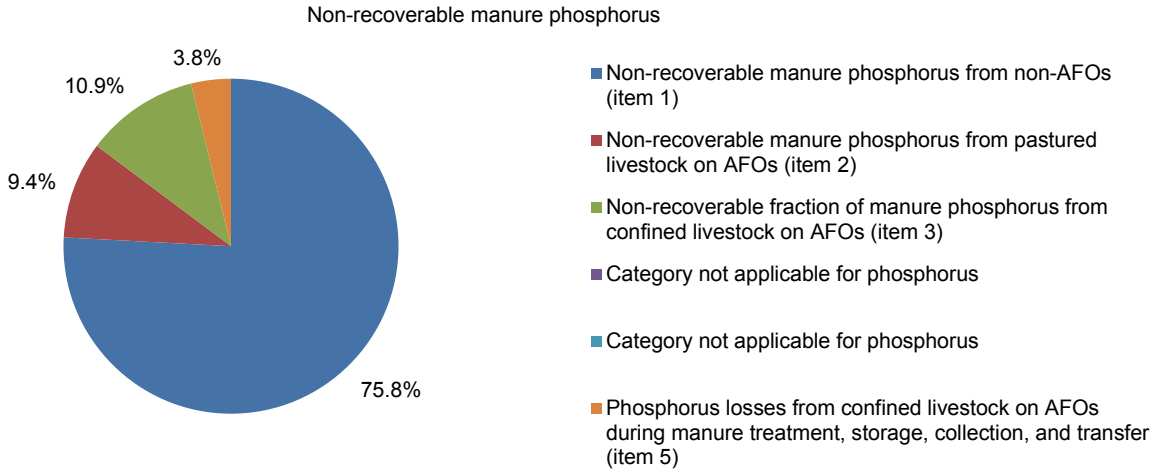
Non-Recoverable Manure

The difference between *as excreted* manure nutrients and recoverable manure nutrients can be broken down into the following components of non-recoverable manure nutrients.

1. Nutrients in manure *as excreted* for all livestock types on **farms *not* identified in this study as AFOs**, excluding nitrogen volatilization. Non-recoverable manure nutrients originate from all pastured and confined livestock types on these farms. It was assumed that 35 percent of the non-recoverable manure nitrogen *as excreted* would volatilize.
2. Nutrients in manure *as excreted* for **all pastured livestock on AFOs**, excluding nitrogen volatilization. It was assumed that 35 percent of the non-recoverable manure nitrogen *as excreted* would volatilize.
3. Manure nutrients in the **non-recoverable fraction of manure from confined livestock** on AFOs, excluding nitrogen volatilization. Nutrients in the non-recoverable fraction of manure from confined livestock on AFOs were estimated using the same nutrient content coefficients as used to estimate manure nutrients in the recoverable fraction.
4. **Nitrogen volatilization losses** associated with items 1, 2, and 3.
5. Nitrogen volatilization losses and other nutrient losses during manure treatment, storage, collection, and transfer of **recoverable manure from confined livestock** on AFOs. This also includes uncollected manure deposited on outside lots and walkways often associated with confined livestock operations.

Figure 9. Six components of non-recoverable manure nutrients for 2012





Source: NRCS analysis of 2012 Census of Agriculture database.

In 2007, the amount of non-recoverable manure totaled 698 million tons, wet weight (equivalent to 107.5 million tons dry weight) (table 6). Non-recoverable manure represented 57 percent of the total wet weight of manure *as excreted*. The majority of this amount (63 percent) was produced on farms with pastured livestock operations and few confined livestock. About 30 percent was produced on AFOs, and the remaining 7 percent was produced on the remaining non-AFO farms with livestock.

The amount of non-recoverable manure nitrogen totaled 12.9 billion pounds in 2012 (table 6), representing a decrease of 8 percent relative to 2007 (appendix A, table A-4). Non-recoverable manure nitrogen represented about 80 percent of the total manure nitrogen *as excreted*. The majority of this amount, about 54 percent of the non-recoverable manure nitrogen, was produced on AFOs in 2012; 46 percent was produced on non-AFOs.

The amount of non-recoverable manure phosphorus totaled 3.1 billion pounds in 2012 (table 6). Non-recoverable manure phosphorus represented 68 percent of the total manure phosphorus *as excreted*. About 76 percent was produced on non-AFOs, with 70 percent from pastured livestock operations with few confined livestock. Non-recoverable manure phosphorus decreased 12 percent from 2007 to 2012 (appendix A, table A-4)—a 16-percent decrease on AFOs and a 10-percent decrease on non-AFOs.

Table 6. Quantity of non-recoverable manure and manure nutrients *as excreted*, all U.S., 2012

	Quantity of non-recoverable manure (wet weight)		Quantity of non-recoverable manure (dry weight)		Non-recoverable manure nitrogen*		Non-recoverable manure phosphorus**	
	1,000 Tons	Percent of total	1,000 Tons	Percent of total	1,000 Pounds	Percent of total	1,000 Pounds	Percent of total
Non-AFOs								
Farms without livestock	0	0	0	0	0	0	0	0
Farms with some livestock but not a livestock operation	2,590	0.4%	526	0.5%	33,147	0.3%	10,397	0.3%
Very small livestock operations	42,599	6.1%	7,915	7.4%	518,070	4.0%	170,393	5.5%
Specialty livestock operations with few confined livestock	1,064	0.2%	227	0.2%	12,893	0.1%	4,216	0.1%
Pastured livestock operations with few confined livestock	441,678	63.3%	70,989	66.1%	5,340,835	41.2%	2,153,473	69.8%
AFOs								
Very small AFOs	13,310	1.9%	1,976	1.8%	227,929	1.8%	52,156	1.7%
Small AFOs	66,849	9.6%	9,184	8.5%	1,463,877	11.3%	229,503	7.4%
Medium AFO-CAFOs	35,767	5.1%	5,092	4.7%	1,293,383	10.0%	146,903	4.8%
Large AFO-CAFOs	94,118	13.5%	11,549	10.7%	4,057,402	31.3%	316,471	10.3%
All non-AFOSs	487,931	69.9%	79,658	74.1%	5,904,946	45.6%	2,338,479	75.8%
All AFOs	210,044	30.1%	27,801	25.9%	7,042,591	54.4%	745,032	24.2%
Total	697,975	100.0%	107,459	100.0%	12,947,537	100.0%	3,083,511	100.0%

* Includes all components of non-recoverable nitrogen shown in figure 9, including nitrogen volatilization.
** Includes all component of non-recoverable phosphorus shown in figure 9.

Excess Manure and Manure Nutrients

"Excess" manure nutrients occur when the quantity of recoverable manure nutrients exceeds the assimilative capacity of cropland and pastureland to receive manure nutrients under the assumption that the goal is to recycle all recoverable manure nutrients using land application. Farm-level excess manure nutrients are the amount of recoverable manure nutrients that exceed the assimilative capacity on farms with livestock. County-level excess manure nutrients are the amount of farm-level excess nutrients in excess of the remaining assimilative capacity on all farms within a county.

Excess manure nutrients are estimated in this study by simulating the land application of manure. In the simulation, manure is first applied on the land available on AFOs on a crop-by-crop basis. The simulation is conducted individually for each AFO using data on recoverable manure and crops grown specific to each individual farm. When available land on AFOs is insufficient for land application of the full amount of recoverable manure produced on the farm, the "*farm-level excess recoverable manure*" was made available for off-farm land application. Off-farm applications are simulated for available land on non-AFO farms within the county using data on crops grown on non-AFO farms.[10] If there was insufficient land within a county—where a "county" is the proxy for a manure distribution area—for off-farm land application of the farm-level excess manure, the remaining manure was designated as "*county-level excess manure*."

The land application simulation was used to estimate the number of on-farm and off-farm acres that would receive manure such that the amount of recoverable manure nutrients produced in each year would be recycled as much as possible using land application. The simulation requires the following assumptions:

1. The amount of manure nitrogen applied relative to the uptake and removal of nitrogen with the crop yield, with separate assumptions for on-farm and off-farm applications and for different years to represent gradual adoption of nutrient management plans.
2. The land available for manure application, with separate assumptions for on-farm land application of manure on AFOs and for off-farm application on non-AFOs.
3. The priority order in which crops would receive manure applications on AFOs (for calculation of farm-level excess) and non-AFOs (for calculation of county-level excess).

The land simulation model and specific assumptions has previously been described in "Estimates of Recoverable and Non-Recoverable Manure Nutrients Based on the Census of Agriculture" published by USDA/NRCS. Assumptions used for the 2007 model simulation described in that report were also used for the 2012 simulation.

Farm-Level Excess

Under the assumptions of the simulation model, there were 60,584 of the 170,144 AFOs in 2012 that could not land-apply all of the manure produced on the farm, resulting in farm-level excess manure (table 7)—36 percent of AFOs. This included 64 percent of all large potential AFO-CAFOs and 58 percent of all medium potential AFO-CAFOs. Only 22 percent of the small AFOs and 38 percent of the very small AFOs had farm-level excess manure. The total number of AFOs with farm-level excess manure in 2012 was about the same as in 2007 (fig. 10).

AFOs in 2012 had about 1,913 million pounds of farm-level excess manure nitrogen and 855 million pounds of excess manure phosphorus, equal to 59 percent of the total recoverable manure nutrients produced on the farms (table 7). The bulk of the farm level excess manure nutrients were on the large potential AFO-CAFOs—71 percent of the farm-level excess manure nitrogen and 70 percent of the farm-level excess manure phosphorus. The medium potential AFO-CAFOS had 24 percent of the farm-level excess manure nitrogen and phosphorus. Less than 7 percent of the excess manure nutrients were from the small and very small AFOs.

The amount of farm-level excess manure nitrogen and phosphorus increased about 3 percent in 2012 compared to levels estimated for 2007 (figs 11 and 12). On the large AFO-CAFOs, however, the farm-level excess manure nitrogen and phosphorus increased 5 percent compared to levels estimated for 2007 (appendix A, table A-4).

Overall for 2012, about 8.5 million acres on AFOs received manure applications in the simulation (table 7). About 38 percent of these acres (3.2 million acres) were on the 12, 632 large AFO-CAFOs, and 26 percent (2.2 million acres) were on the 24,241 medium AFO-CAFOs. The remaining 36 percent of AFO acres receiving manure were on the 75,044 small AFOs and the 58,227 very small AFOs.

Map 4 presents the distribution of AFO acres receiving manure in 2012 as estimated by the simulation model. (A comparison of estimates of acres receiving manure based on the model simulation to acres reported in the Census on which animal manure was applied is presented in Appendix B.) The distribution of AFO acres receiving manure closely follows the pattern of recoverable manure described in Map 3. There are some differences, for example in southwest Kansas where map 3 shows a high concentration in recoverable manure and map 4 indicates that much of the manure is not applied on the AFOs of production. Compared to 2007, panel b indicates an increase in AFOs receiving manure across the Corn Belt, from eastern Nebraska through Ohio.

All the available land on 36 percent of the AFO's was used for land application, as those farms had farm-level excess manure

[10] AFOs without farm-level excess manure have acres that could be available for off-farm applications from other AFOs. However, the land application simulation model did not allow manure applications on any of these remaining AFO acres that did not receive manure from on-farm sources. Off-farm applications to available acres on other AFOs is not a universally accepted practice because of the potential for the spread of disease between farms, although it occurs to some extent in some regions of the country.

that required exporting off-farm for land application or other uses. The remaining 64 percent of AFO's had additional on-farm unused capacity for land application of manure that totaled about 37 million acres. Most of these acres are on the smaller AFOs (table 7).Use of this land for manure application would have meant that manure from one AFO would have been applied to a portion of the acres on a neighboring or nearby AFO. As noted earlier in this section, this was not allowed in the land application simulation model because of bio-security concerns (spread of disease). To the extent that cropland and pastureland on one AFO is used for land application of manure from another AFO, estimates of excess manure reported are overstated. The authors believe that, while this will happen to some extent in some areas, it is generally a practice that the vast majority of livestock operations avoid, especially the larger operations that are the source of the bulk of the farm-level excess manure.

Map 5 presents the distribution and change from 2007 to 2012 in the location of AFOs with farm-level excess manure estimated by the simulation model. Panel a shows the national extent of the farm-level excess and the need to move manure off the farm of production for land application. Increases in the numbers of farms with excess are widely scattered. Declines in the number of farms with excess are also scattered but with some concentration in Iowa, eastern North Carolina, and northwest New Mexico. (The New Mexico case may be a data issue associated with the large number of Native American farms in this region.)

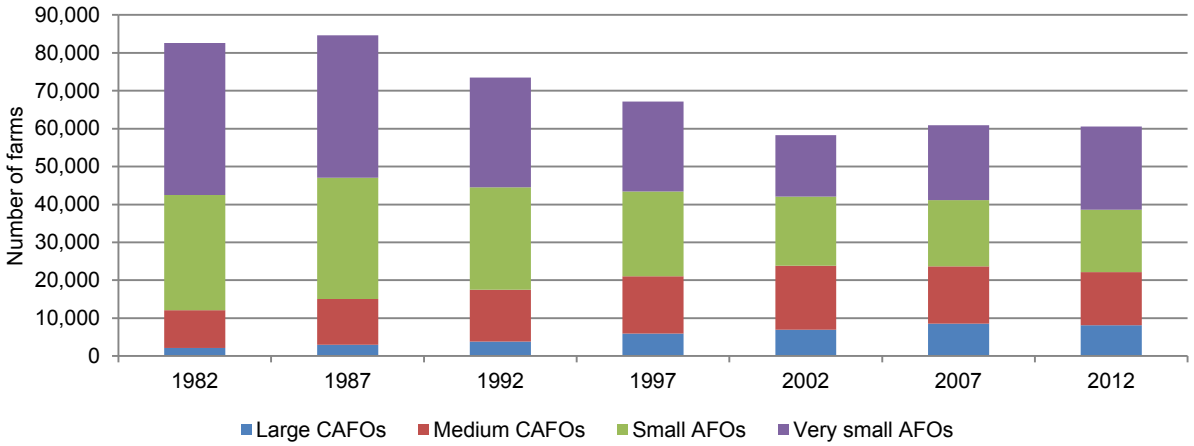
Map 6 presents the *quantity* of farm-level excess manure nitrogen associated with the farm numbers shown in map 5. Farm-level excess indicates that the manure needs to leave the production farm for land application off-farm and does not imply that manure nutrients are being mismanaged. The quantity of farm-level excess nitrogen roughly follows the pattern of medium and large AFO-CAFOs in map1 adjusted by the recoverable manure production in map 3. For example, there are relatively few operations in southwest Kansas in map1, but a high quantity of recoverable manure in map 3, resulting in a large quantity of farm-level excess in map 6. (Phosphorus maps (not shown) look identical the nitrogen maps when scaled to reflect the difference in total production.)

Table 7. Farm-level excess manure nutrients on AFOs and related estimates, all U.S., 2012

		Very small AFOs	Small AFOs	Medium AFO-CAFOs	Large AFO-CAFOs	All AFOs
Number of AFOs with farm-level excess manure*		22,004	16,454	13,988	8,138	60,584
Number of AFOs (from table 4)		58,227	75,044	24,241	12,632	170,144
	Percent	38%	22%	58%	64%	36%
Farm-level excess nitrogen (million pounds)		15	100	433	1,365	1,913
Recoverable manure nitrogen (million pounds) (from table 5)		43	451	754	1,972	3,220
	Percent	34%	22%	57%	69%	59%
Farm-level excess phosphorus (million pounds)		8	50	202	594	855
Recoverable manure phosphorus (million pounds) (from table 5)		22	209	345	868	1,444
	Percent	36%	24%	59%	68%	59%
Manure nitrogen applied under the assumptions of the (million pounds)						
Cropland and pasture		28	352	321	607	1,308
Pasture only (cropland used as pasture and half of permanent pasture)		2	8	12	11	32
Cropland only (acres of the 21 crops included in simulation)		26	344	310	596	1,275
Manure phosphorus applied under the assumptions of the model (million pounds)						
Cropland and pasture		14	159	143	273	589
Pasture only (cropland used as pasture and half of permanent pasture)		1	3	5	5	14
Cropland only (acres of the 21 crops included in simulation)		13	155	138	269	575
Acres available for manure application on AFOs (1,000s) under the assumptions of the model						
Cropland and pasture		6,897	22,564	8,544	7,376	45,381
Pasture only (cropland used as pasture and half of permanent pasture)		487	1,535	730	440	3,192
Cropland only (acres of the 21 crops included in simulation)		6,410	21,029	7,815	6,935	42,189
Acres receiving manure on AFOs under assumptions of the model (1,000s)						
Cropland and pasture		360	2,743	2,226	3,219	8,547
Pasture only (cropland used as pasture and half of permanent pasture)		53	220	310	247	830
Cropland only (acres of the 21 crops included in simulation)		307	2,523	1,915	2,972	7,717
Percent of available cropland and pasture land on AFOs that received manure under the assumptions of the model		5%	12%	26%	44%	19%

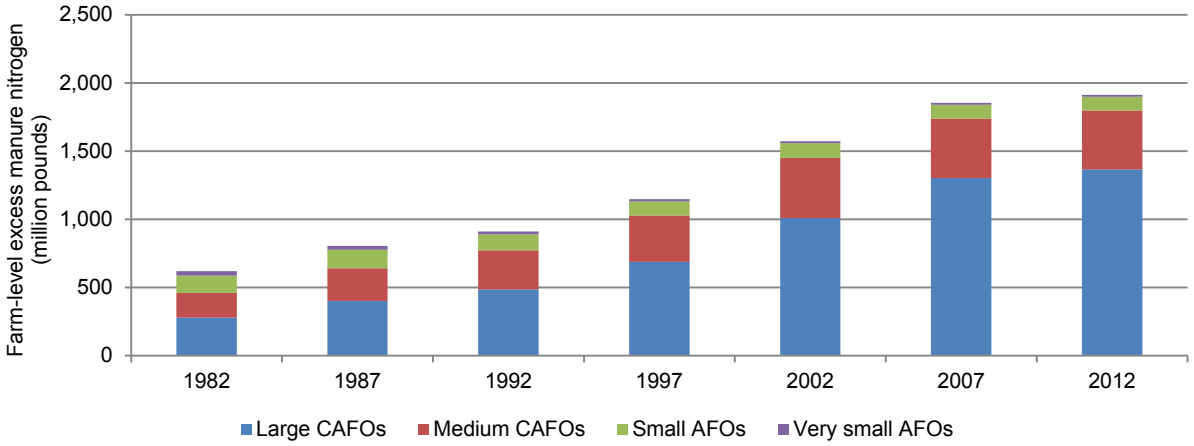
* Excludes farms with less than 100 pounds of farm-level excess manure nitrogen.

Figure 10. Number of AFOs with farm-level excess manure, by AFO farm type



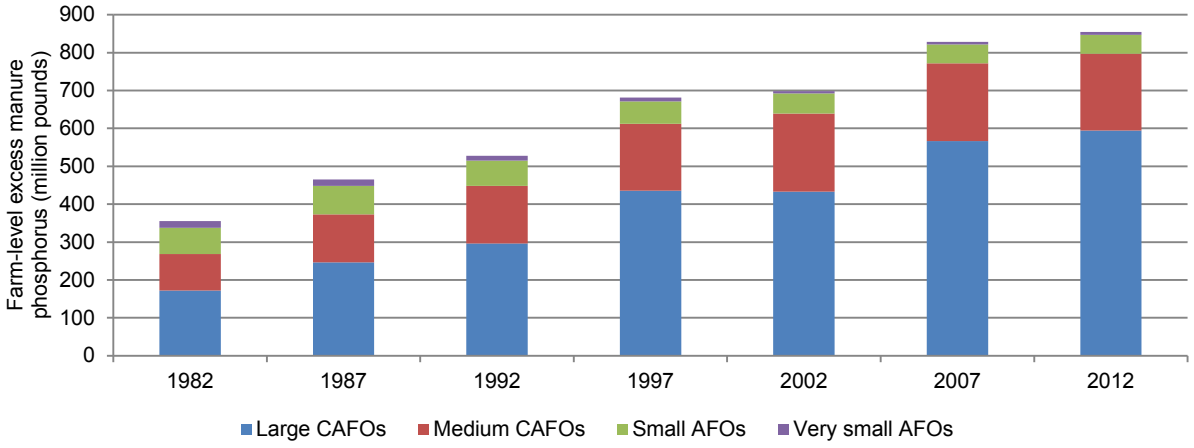
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 11. Farm-level excess manure nitrogen, by AFO farm type



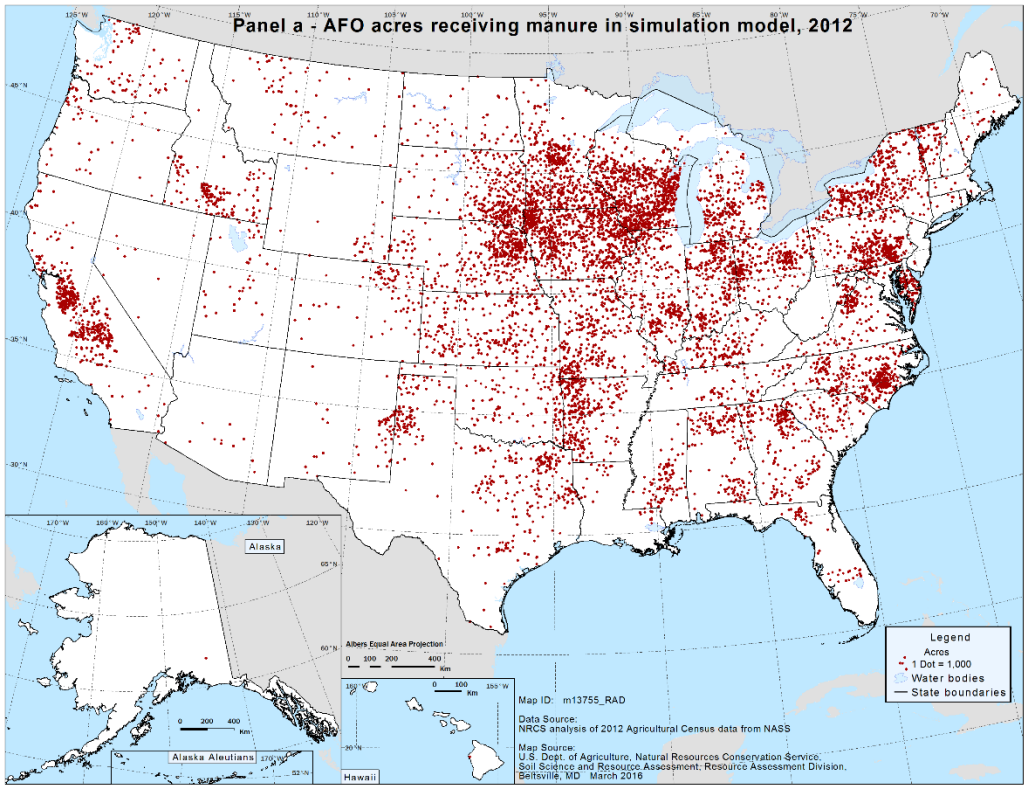
Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Figure 12. Farm-level excess manure phosphorus, by AFO farm type

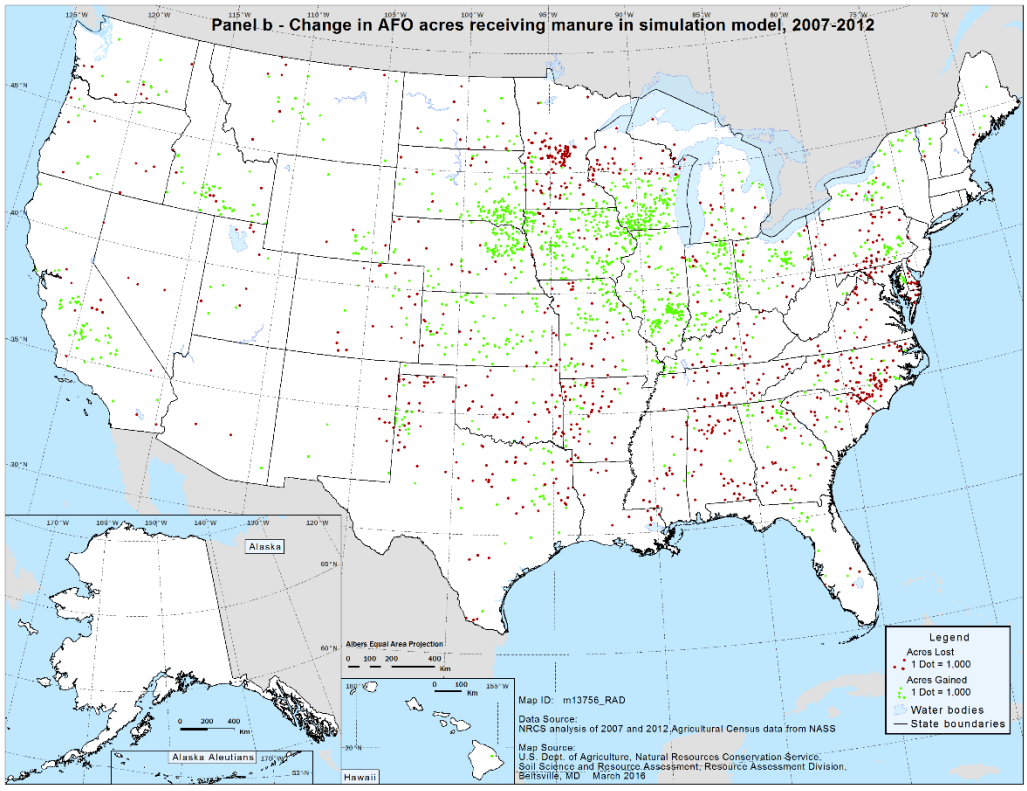


Source: NRCS analysis of 1982-2012 Census of Agriculture databases. Note: See appendix A for data by census year.

Map 4. County location of AFO acres receiving manure in the simulation model for 2012

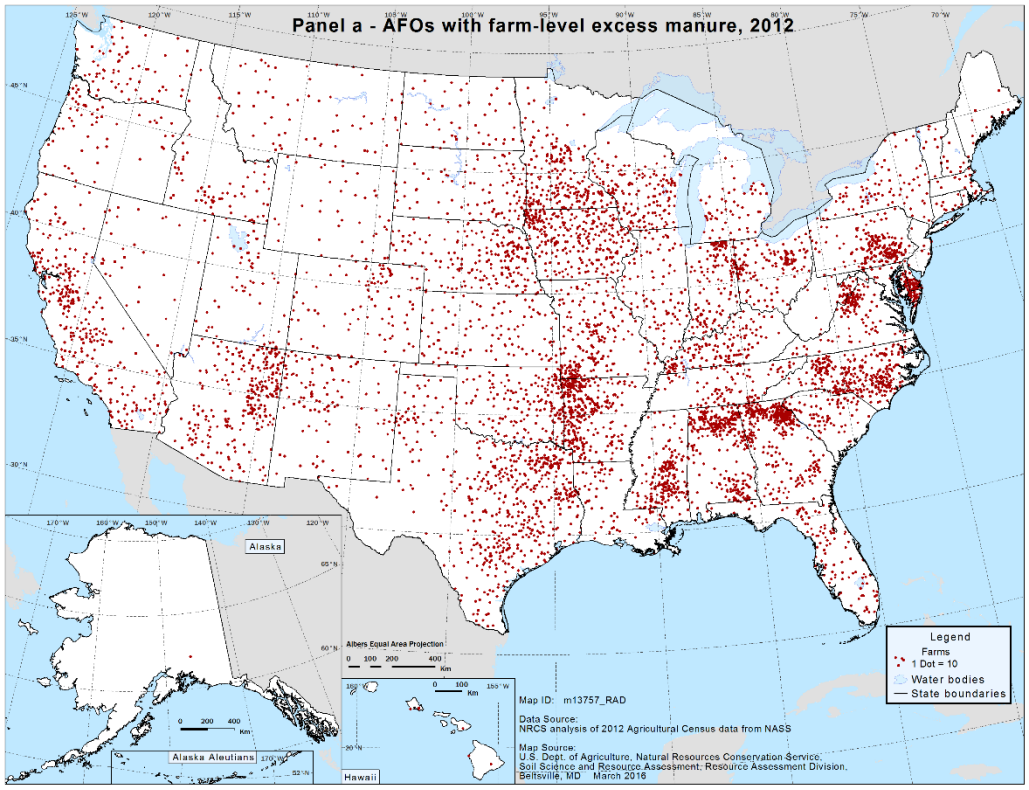


Legend: Dot = 1,000 acres
Source: NRCS analysis of the 2012 Agricultural Census data from NASS

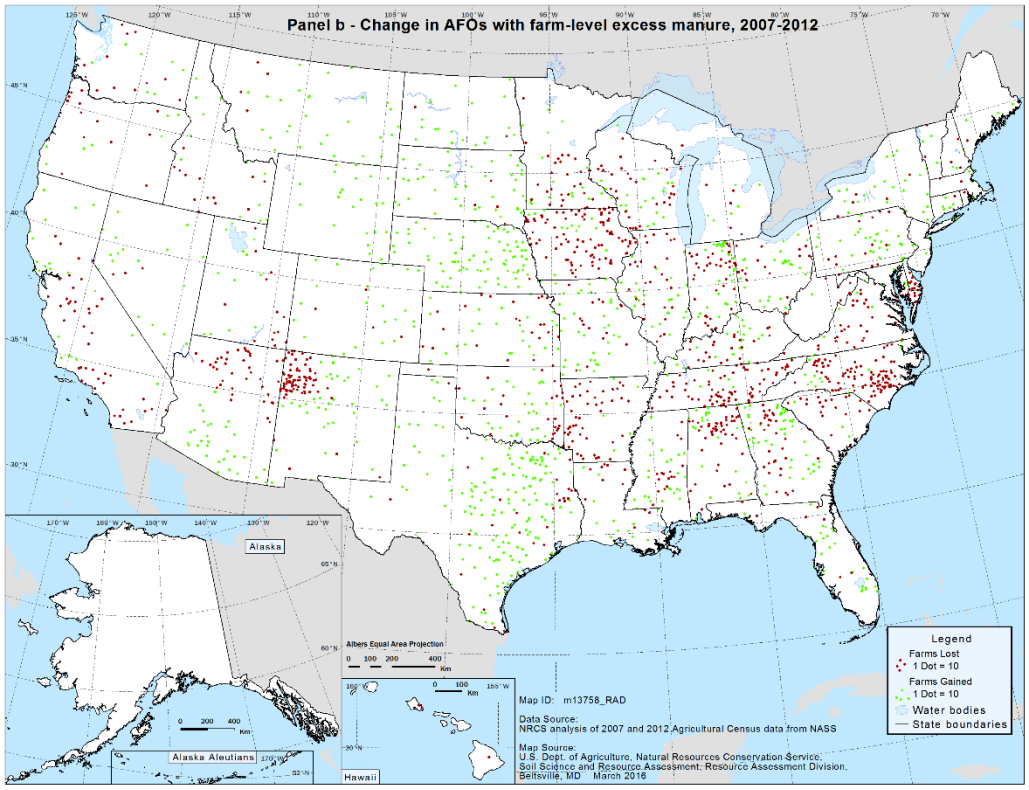


Legend: Green dot = 1,000 acres gain and red dot = 1,000 acres loss.
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Map 5. County location of AFOs with farm-level excess manure* for 2012 and change in the county location of AFOs with farm-level excess manure* for 2007-2012

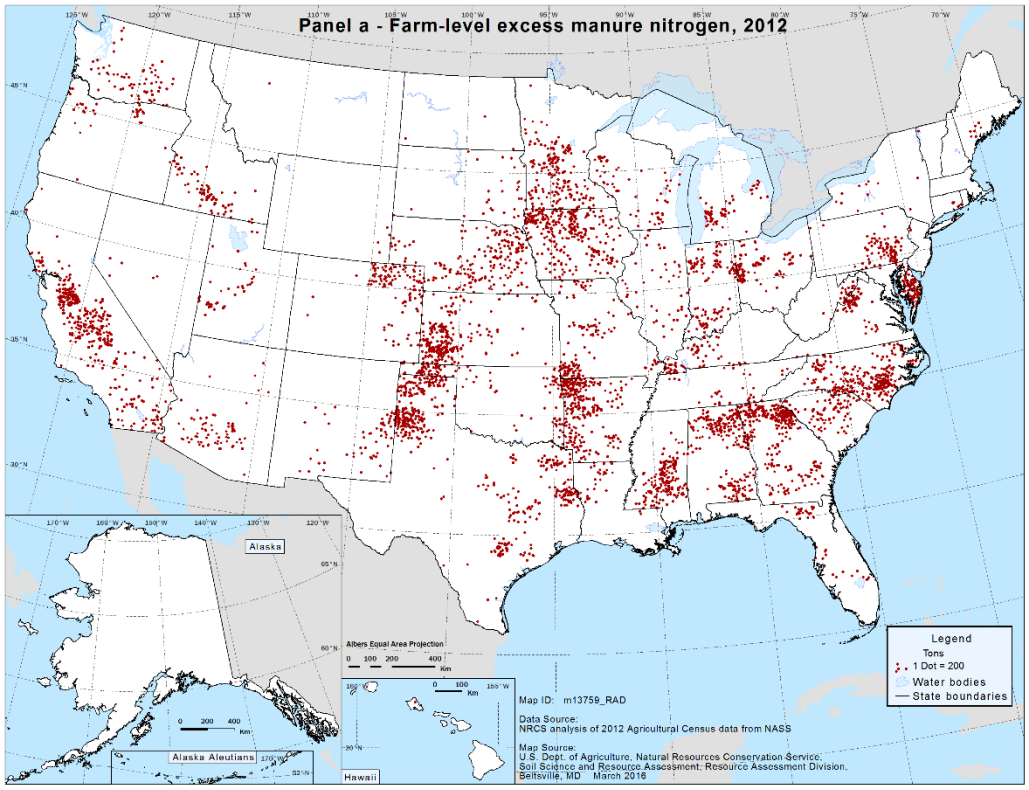


Legend: Dot = 10 farms
**Excludes farms with less than 100 pounds of excess manure.*
Source: NRCS analysis of the 2012 Agricultural Census data from NASS

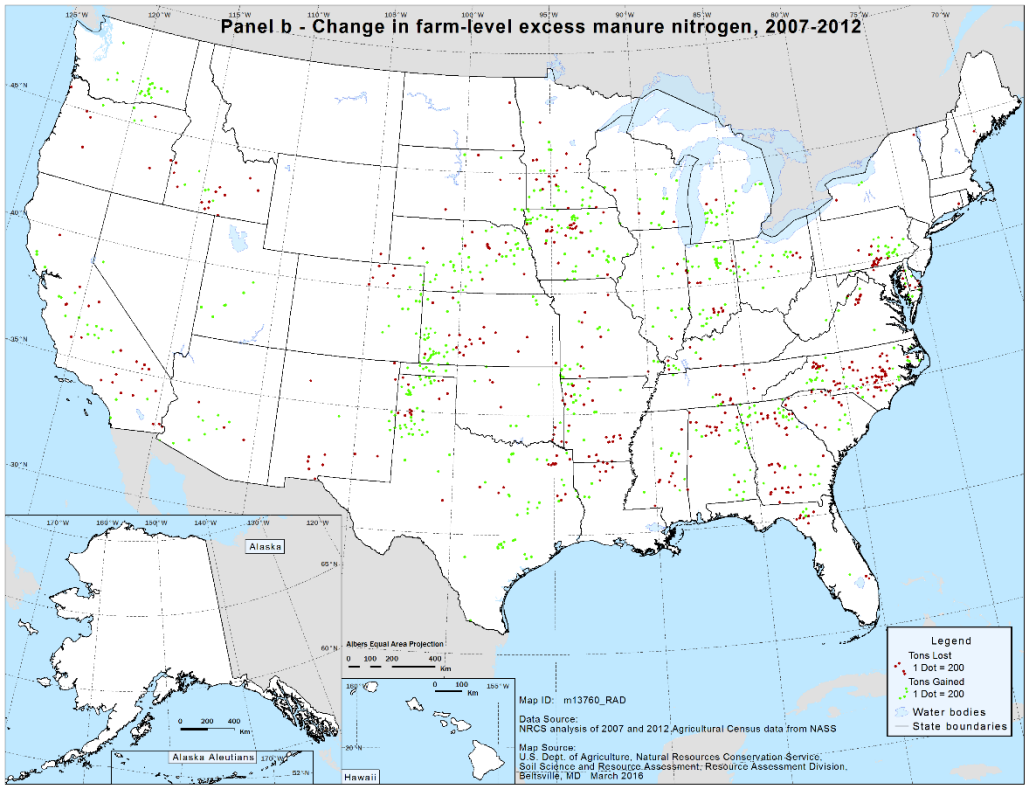


Legend: Green dot = 10 farm gain and red dot = 10 farm loss.
**Excludes farms with less than 100 pounds of excess manure.*
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Map 6. County location of the quantity of farm-level excess manure nitrogen for 2012 and change in the county location of farm-level excess manure nitrogen for 2007-2012



Legend: Dot = 200 tons.
Source: NRCS analysis of the 2012 Agricultural Census data from NASS



Legend: Green dot = 200 ton gain and red dot = 200 ton loss.
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

County-Level Excess

The first step in simulating off-farm land application of manure is to aggregate farm-level excess manure and crop and pastureland acres for non-AFOs to the county level. *Thus, each county is treated as one large farm for the allocation of the remaining manure*.

In most counties, sufficient acreage exists for off-farm land application of manure to exhaust the supply of farm-level excess manure produced in the county (table 8). In some counties, however, manure production exceeds the assimilative capacity of the acres available for manure application under the assumptions of the model simulation. This excess manure is categorized as *county-level excess manure*.

The presumption is that either this manure is presently being transported to areas outside of the county for application, is being used for purposes other than land application, is being applied to lands not considered in this analysis, such as available land on AFOs with no excess manure, or is held in storage temporarily. Lagoons, for example, accumulate manure nutrients as the solids settle to the bottom and the liquid is pumped off for land application. These solids are retained in the lagoon sometimes for many years before being cleaned out and applied to the land. In addition, manure is sometimes allowed to "stack up" for long periods of time in arid regions of the country, and is not removed for land application every year. It is also possible that some of this county-level excess manure, as measured by the simulation model, is actually land applied but at rates higher than simulated.

In 2012, about 1.6 billion of the 1.9 billion pounds of farm-level excess manure nitrogen was applied to non-AFOs, according to the model simulation, leaving 335 million pounds of county-level excess manure nitrogen (table 8). The phosphorus associated with the excess manure totaled 155 million pounds of county-level excess manure phosphorus.

Overall, only a few areas of the country have county-level excess manure, but these areas have been increasing over time. There were 205 counties (of the approximately 3,070 counties included in the Census of Agriculture database) with county-level excess manure in 2012. The number of counties with county-level excess manure increased by 15 percent compared to 2007 (table 8 and fig. 13).

Map 7 presents the distribution and change in the non-AFO acres receiving manure as estimated by the simulation model. This map shows movement of manure off AFO operations with recoverable manure in excess of source-farm assimilative capacity to other (non-AFO) farms in the county. The simulation model considered only the land area of non-AFO farms in the county (shown in this map) as a proxy for farms near the AFO to minimize transportation costs. In actuality, application of recoverable manure is not limited by county boundaries. Another interpretation is that the map describes the acres needed for off-farm export and land application of manure (shown in map 6) near the AFO. The location of non-AFO acres receiving manure in panel a closely follow the location of recoverable manure.

The changes in acres on non-AFOs receiving manure in the simulation model (panel b) reflect changes in the quantity of farm-level recoverable manure as well as differences in crop yields (and thus assimilative capacity) between 2007 and 2012. For example, increases in acres receiving manure will reflect the 3-percent increase in the amount of recoverable nitrogen from 2007 to 2012, including a 4-percent increase for very small AFOs and a 5-percent increase for large AFO-CAFOs (appendix A, table A-4). Increases will also reflect lower per-acre crop yields in 2012 relative to 2007, as more acres are needed to apply manure at acceptable rates of application. Similarly, decreases in acres receiving manure will reflect decreases in some areas in the amount of recoverable nitrogen from 2007 to 2012 and also reflect higher per-acre crop yields in 2012 relative to 2007, as fewer acres are needed to apply manure at acceptable rates of application.

Panel b of map 7 shows significant gains in acres on non-AFOs receiving manure in the center of the country, with additional gains in acres in southern California and eastern Washington. Areas of declining non-AFO acres receiving manure included the southeast and an area centered in Minnesota.

Map 8 shows the distribution in the quantity of county-level excess manure nitrogen as estimated by the simulation model after considering the assimilative capacity of the available land on the farm of production *and* in the county. Overall, only a few areas of the country are shown to have county-level excess manure, but these areas have been increasing over time. The distribution of county-level excess manure nitrogen in 2012 (panel a) shows clusters of excess manure in 27 States, primarily across the southern half of the nation. Of significance is the lack of county-level excess in the Corn Belt and Plains, regions with significant farm-level excess shown in map 6. In these regions, there is sufficient capacity on non-AFO farms to assimilate the recoverable manure produced on AFOs. (As was the case with farm-level excess, the nitrogen and phosphorus maps are indistinguishable when the legend is adjusted for weight. Only nitrogen maps are shown.)

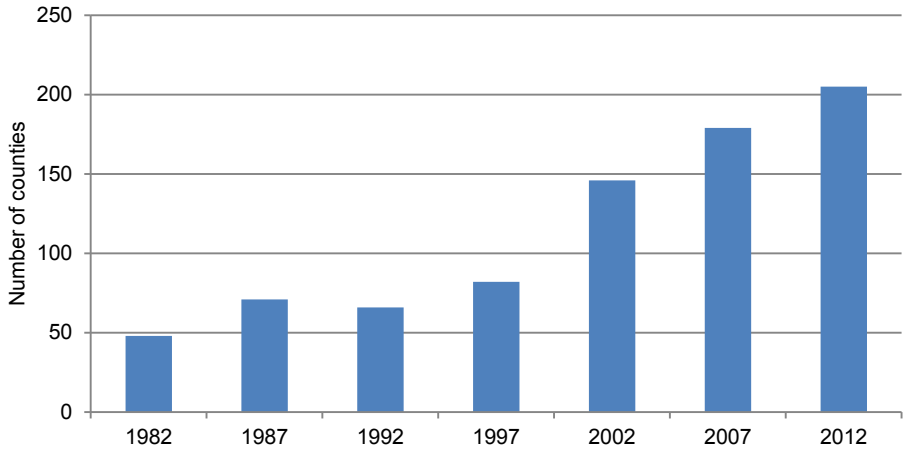
Map 8, panel b shows the change in county-level excess manure nitrogen from 2007 to 2012. Nearby counties often have both increases and decreases (see Mississippi, Alabama, and Georgia). A general area of decline in county-level excess occurs in North Carolina, South Carolina, northern Louisiana, southern Arkansas, and southern California. Areas showing an increase in county-level excess include western Arkansas and small areas in Washington, Texas, New Mexico, Colorado, Kansas, Indiana, and Pennsylvania. Increases in county-level excess occur in areas with a combination of greater recoverable manure in the county and less available land, either on AFOs or on non-AFOs in the county.

Table 8. County-level excess manure nutrients

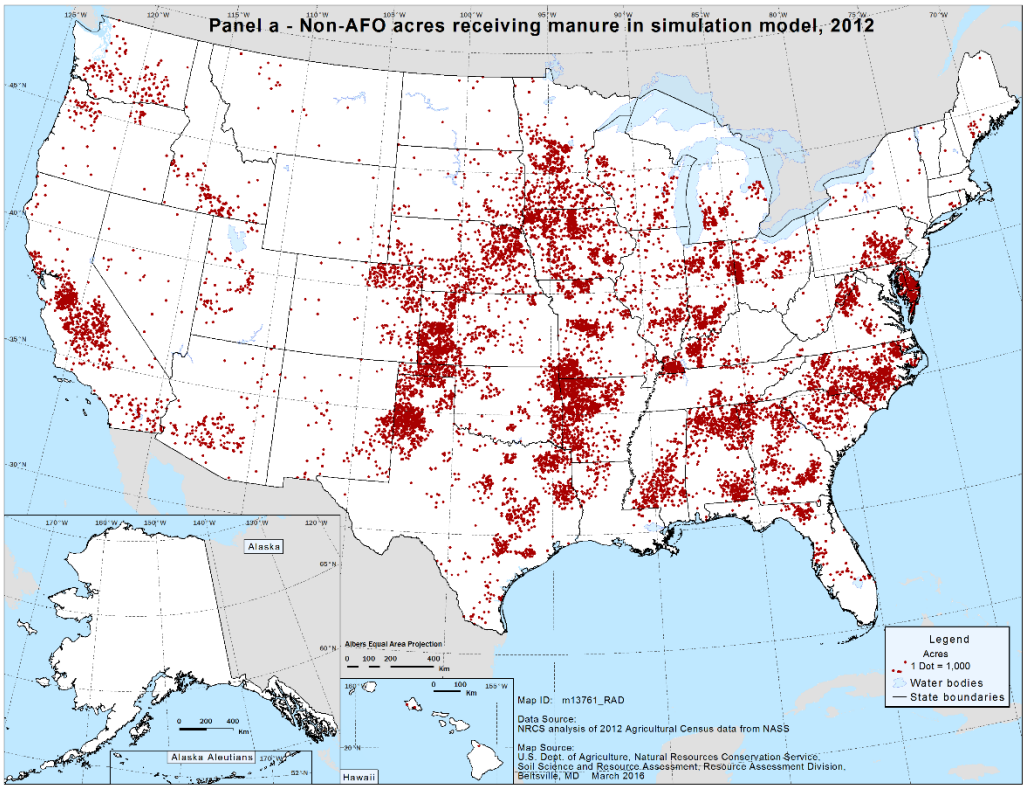
	1982	1987	1992	1997	2002	2007	2012
Number of non-AFOs (manure receiving farms)	1,769,568	1,689,964	1,592,377	1,652,057	1,907,742	2,014,868	1,939,159
Acres available for manure application on non-AFOs under assumptions of the model (1,000s)							
Cropland and pasture	118,585	112,480	145,850	151,487	152,759	152,610	148,870
Pasture only (cropland used as pasture and half of permanent pasture)	35,981	36,969	38,638	39,293	40,063	32,680	24,065
Cropland only (acres of the 21 crops included in simulation)	82,603	75,511	107,212	112,194	112,696	119,930	124,806
Acres receiving manure on non-AFOs under assumptions of the model (1,000s)							
Cropland and pasture	3,899	5,046	5,052	6,327	9,977	10,992	12,943
Pasture only (cropland used as pasture and half of permanent pasture)	664	914	801	910	1,355	1,187	1,100
Cropland only (acres of the 21 crops included in simulation)	3,234	4,131	4,251	5,417	8,622	9,806	11,843
Percent of available cropland and pasture land on non-AFOs that received manure under the assumptions of the model	3%	4%	3%	4%	7%	7%	9%
Farm-level excess manure nitrogen (million pounds) (from table A-4)	620	806	911	1,149	1,572	1,854	1,913
Manure nitrogen applied to non-AFOs under assumptions of the model (million pounds)	577	725	831	1,049	1,332	1,522	1,578
County-level excess manure nitrogen (million pounds)	43	82	81	100	239	332	335
Farm-level excess manure phosphorus (million pounds) (from table A-4)	355	465	528	681	699	829	855
Manure phosphorus applied to non-AFOs under assumptions of the model (million pounds)	335	425	487	630	586	672	699
County-level excess manure phosphorus (million pounds)	20	41	41	51	112	156	155
Number of counties with county-level excess manure*	48	71	66	82	146	179	205

* Excludes counties with less than 2,000 pounds of county-level excess manure nitrogen.

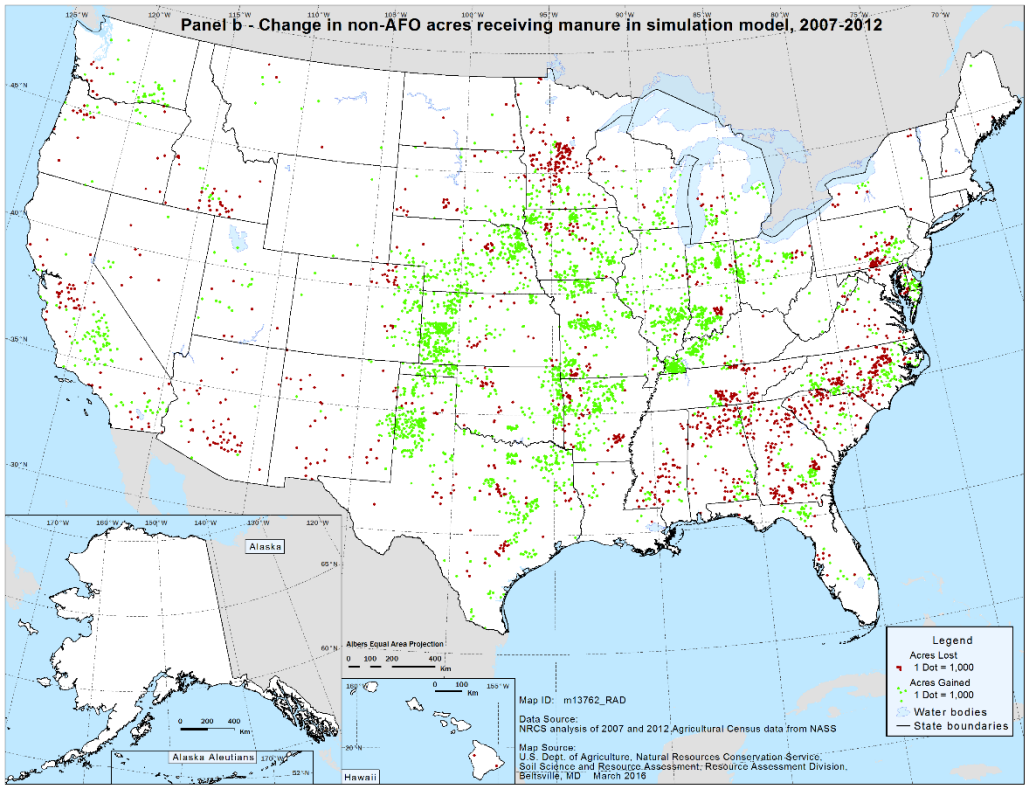
Figure 13. Number of counties with county-level excess manure under the assumptions of the simulation model



Map 7. County location of non-AFO acres receiving manure in the simulation model for 2012 and change in the county location of Non-AFO acres receiving manure in the simulation model for the period 2007-2012

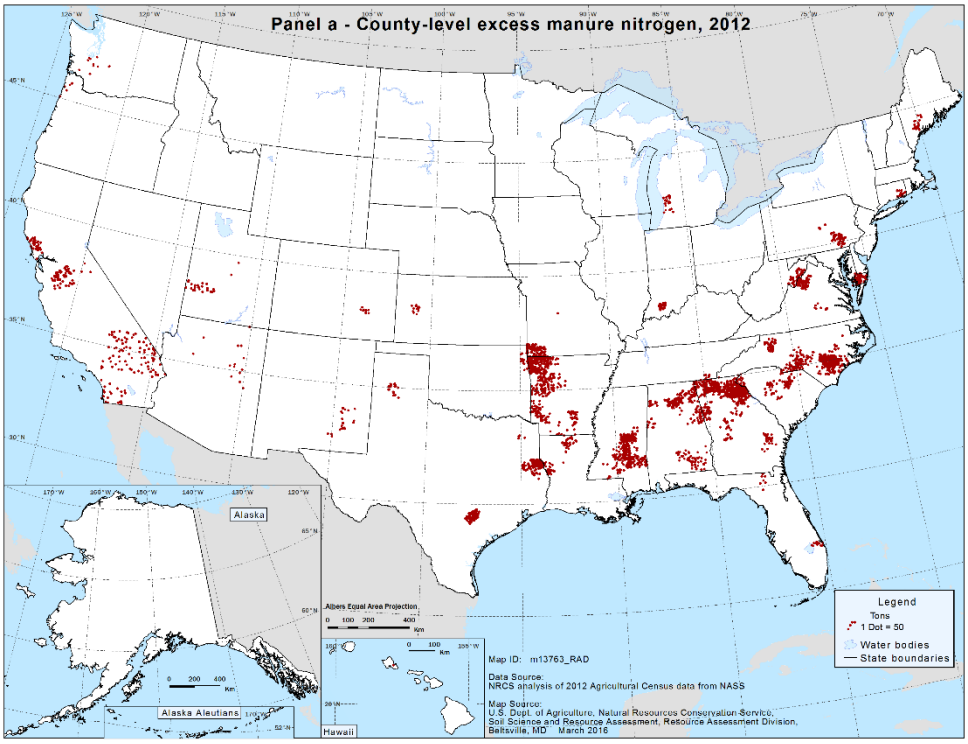


Legend: Dot = 1,000 acres
Source: NRCS analysis of the 2012 Agricultural Census data from NASS

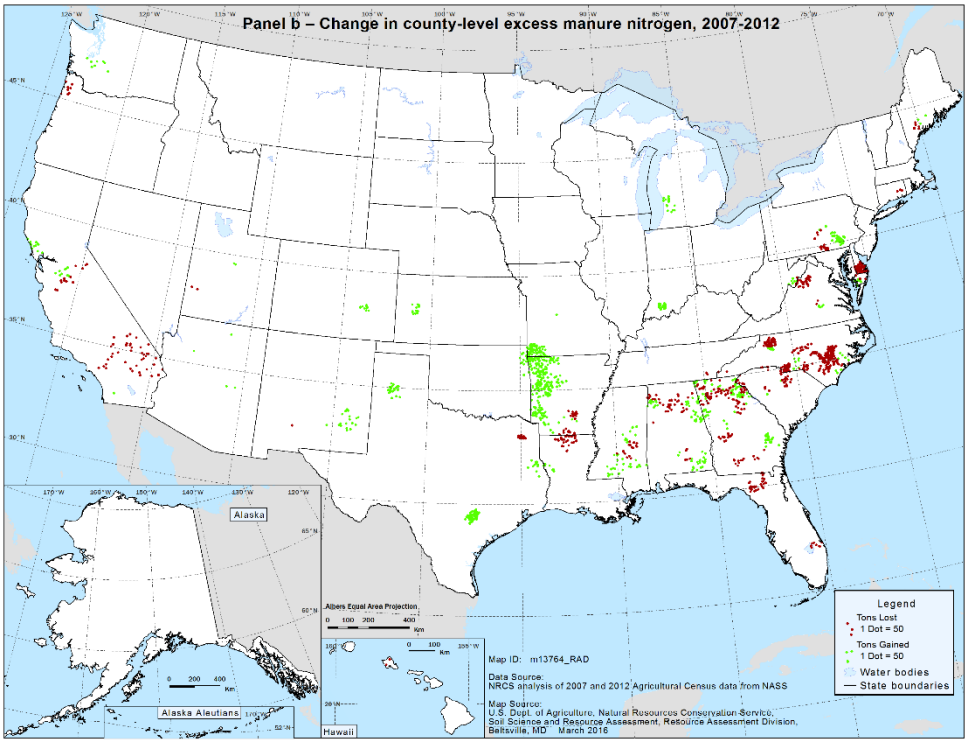


Legend: Green dot = 1,000 acres gain and red dot = 1,000 acres loss.
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Map 8. Location of county-level excess manure nitrogen* for 2012 and change in the location of county-level excess manure nitrogen* for periods 2007-2012,



Legend: Panel a-c dot = 50 tons.
**Excludes counties with less than 2,000 pounds of county-level excess manure nitrogen.*
Source: NRCS analysis of the 2012 Agricultural Census data from NASS



Legend: Green dot = 50 ton gain and red dot = 50 ton loss.
**Excludes counties with less than 2,000 pounds of county-level excess manure nitrogen.*
Source: NRCS analysis of the 2007 and 2012 Agricultural Census data from NASS

Appendix A: Estimates by Census Year of Selected Variables Derived from the 1982–2012 Census of Agriculture Databases

Table A-1. Number of farms and animal units

	1982	1987	1992	1997	2002	2007	2012	Percent change from 2007
Number of farms (1,000 farms)								
Non-AFOs								
Farms without livestock	576.3	566.7	564.8	596.8	684.2	762.6	748.8	-2%
Farms with some livestock but not a livestock operation	80.2	65.5	58.7	60.3	96.6	101.5	115.0	13%
Very small livestock operations	602.5	567.1	474.1	471.3	598.7	642.9	617.6	-4%
Specialty livestock operations with few confined livestock	1.0	1.5	1.7	1.7	3.3	3.2	3.4	6%
Pastured livestock operations with few confined livestock	509.5	489.2	493.0	522.0	525.0	504.7	454.4	-10%
All non-AFOs	1,769.6	1,690.0	1,592.4	1,652.1	1,907.7	2,014.9	1,939.2	-4%
AFOs								
Very small AFOs	188.3	147.6	113.5	84.3	68.7	61.1	58.2	-5%
Small AFOs	253.2	216.8	180.3	134.4	111.0	88.3	75.0	-15%
Medium AFO-CAFOs	26.2	28.8	32.9	31.7	30.8	27.4	24.2	-12%
Large AFO-CAFOs	3.7	4.7	6.3	9.4	10.8	13.2	12.6	-5%
All AFOs	471.4	397.8	332.9	259.8	221.2	189.9	170.1	-10%
All farms	2,241.0	2,087.8	1,925.3	1,911.9	2,129.0	2,204.8	2,109.3	-4%
Animal units for pastured livestock types (1,000 AU)								
Non-AFOs	43,458	41,900	43,477	47,111	46,899	46,957	42,154.3	-10%
AFOs	12,896	10,946	10,061	8,571	6,765	6,085	5,073.1	-17%
All farms	56,354	52,846	53,538	55,682	53,664	53,042	47,227.4	-11%
Animal units for confined livestock types (1,000 AU)								
Non-AFOs	1,541	1,215	905	688	711	665	619.7	-7%
All AFOs	42,122	41,627	41,599	43,483	45,771	48,371	46,851.3	-3%
All farms	43,663	42,841	42,504	44,171	46,482	49,036	47,471.0	-3%
AFOs								
Very small AFOs	3,947	3,102	2,383	1,732	1,383	1,220	1,141.0	-6%
Small AFOs	20,941	18,491	15,991	12,805	11,227	9,437	8,392.3	-11%
Medium AFO-CAFOs	6,983	7,550	8,495	8,423	9,317	9,074	7,840.1	-14%
Large AFO-CAFOs	10,251	12,484	14,730	20,523	23,844	28,640	29,477.9	3%
AFOs								
Fattened cattle	9,412	9,530	9,099	9,473	12,533	12,928	11,828.5	-9%
Milk cows	14,681	13,712	12,928	12,405	12,428	12,665	12,640.8	<1%
Swine	6,825	6,825	7,558	8,400	9,163	10,109	9,793.3	-3%
Poultry	4,027	4,870	5,358	6,134	7,318	7,702	7,211.9	-6%
Confined pastured livestock types	7,177	6,689	6,656	7,071	4,329	4,966	5,376.9	8%
Percent of total confined AU found on large CAFOs	23.5%	29.1%	34.7%	46.5%	51.3%	58.4%	62.1%	--
Percent of total confined AU found on medium CAFOs	16.0%	17.6%	20.0%	19.1%	20.0%	18.5%	16.5%	--
Percent of total confined AU found on small and very small AFOs	57.0%	50.4%	43.2%	32.9%	27.1%	21.7%	20.1%	--

Table A-2. Quantity of manure and manure nutrients *as excreted*

	1982	1987	1992	1997	2002	2007	2012	Percent change from 2007
Quantity of manure *as excreted* (1,000 tons wet weight)								
Non-AFOs	516,453	493,274	508,766	549,258	543,867	542,734	487,931	-10%
AFOs	726,354	690,725	680,235	688,664	740,206	767,985	742,133	-3%
All farms	1,242,807	1,183,999	1,189,001	1,237,922	1,284,073	1,310,719	1,230,064	-6%
Manure nitrogen *as excreted* (million pounds)								
Non-AFOs	6,271	5,995	6,188	6,648	6,586	6,572	5,905	-10%
AFOs	8,375	8,148	8,130	8,322	10,302	10,682	10,263	-4%
All farms	14,646	14,143	14,318	14,970	16,888	17,253	16,168	-6%
AFOs, confined livestock only								
Very small AFOs	578	449	341	246	218	184	170	-8%
Small AFOs	3,253	2,881	2,479	1,981	2,293	1,854	1,595	-14%
Medium AFO-CAFOs	1,277	1,432	1,661	1,732	2,241	2,131	1,894	-11%
Large AFO-CAFOs	1,462	1,853	2,239	3,162	4,606	5,664	5,897	4%
All AFOs	6,569	6,615	6,721	7,122	9,358	9,832	9,555	-3%
Fattened cattle	1,093	1,106	1,056	1,099	1,621	1,671	1,528	-9%
Milk cows	2,392	2,234	2,106	2,021	3,266	3,328	3,322	<1%
Swine	932	928	1,044	1,181	1,602	1,770	1,730	-2%
Poultry	1,275	1,534	1,709	1,977	2,340	2,463	2,329	-5%
Confined pastured livestock types	877	813	806	843	530	600	646	8%
Manure phosphorus *as excreted* (million pounds)								
Non-AFOs	2,485	2,374	2,466	2,668	2,612	2,600	2,338	-10%
AFOs	2,407	2,345	2,344	2,391	2,251	2,307	2,189	-5%
All farms	4,892	4,719	4,809	5,059	4,863	4,907	4,527	-8%
AFOs, confined livestock only								
Very small AFOs	144	113	86	60	42	36	34	-6%
Small AFOs	729	645	554	439	434	355	307	-14%
Medium AFO-CAFOs	358	403	464	480	504	473	429	-9%
Large AFO-CAFOs	436	556	660	918	884	1,095	1,130	3%
All AFOs	1,667	1,717	1,765	1,897	1,864	1,960	1,900	-3%
Fattened cattle	335	339	324	337	198	204	187	-8%
Milk cows	430	401	378	363	581	593	591	<1%
Swine	277	276	310	350	284	313	304	-3%
Poultry	439	527	581	667	695	731	692	-5%
Confined pastured livestock types	186	173	171	180	106	120	125	4%

Table A-3. Recoverable manure and manure nutrients

	1982	1987	1992	1997	2002	2007	2012	Percent change from 2007
Quantity of recoverable manure (1,000 tons wet weight)								
Very small AFOs	31,064	25,120	20,415	15,873	13,212	12,702	12,711	<1%
Small AFOs	168,200	152,944	138,795	116,774	122,339	110,651	105,109	-5%
Medium AFO-CAFOs	56,039	62,928	74,653	77,222	98,369	100,060	93,206	-7%
Large AFO-CAFOs	72,199	93,053	116,956	175,433	222,296	290,302	321,063	11%
All AFOs	327,502	334,046	350,820	385,302	456,216	513,716	532,089	4%
Recoverable manure nitrogen (1,000 pounds)								
Very small AFOs	118,637	94,862	72,268	54,905	49,946	44,634	42,637	-4%
Small AFOs	712,048	649,571	573,730	476,964	581,509	496,402	451,438	-9%
Medium AFO-CAFOs	379,613	450,113	546,313	602,512	793,847	782,747	754,304	-4%
Large AFO-CAFOs	381,976	522,957	651,984	928,768	1,415,731	1,834,458	1,971,818	7%
All AFOs	1,592,273	1,717,503	1,844,296	2,063,148	2,841,032	3,158,242	3,220,198	2%
Fattened cattle	228,393	243,455	241,424	263,954	421,343	468,609	457,993	-2%
Milk cows	474,582	459,566	454,271	452,181	786,106	861,899	913,810	6%
Swine	159,768	163,439	191,893	230,130	329,707	383,920	393,110	2%
Poultry	574,337	702,327	804,397	952,492	1,194,229	1,312,330	1,305,223	-1%
Confined pastured livestock types	155,194	148,716	152,311	164,391	109,648	131,483	150,062	14%
Recoverable manure phosphorus (1,000 pounds)								
Very small AFOs	76,692	62,358	49,049	35,060	24,500	22,815	22,125	-3%
Small AFOs	390,840	356,198	317,007	256,976	264,584	228,828	208,697	-9%
Medium AFO-CAFOs	221,137	260,392	313,139	334,845	367,366	358,885	345,263	-4%
Large AFO-CAFOs	238,042	323,032	403,966	595,792	615,086	806,144	867,799	8%
All AFOs	926,710	1,001,981	1,083,162	1,222,673	1,271,536	1,416,672	1,443,883	2%
Fattened cattle	157,603	167,903	166,485	182,025	115,865	128,930	126,098	-2%
Milk cows	202,441	196,036	193,777	192,886	332,361	364,406	386,353	6%
Swine	170,821	174,887	205,063	245,670	211,031	244,662	249,016	2%
Poultry	296,959	368,110	420,802	496,870	546,344	599,985	595,310	-1%
Confined pastured livestock types	98,887	95,044	97,035	105,223	65,935	78,689	87,106	11%

Table A-4. Non-Recoverable manure, AFOs with excess manure, and excess manure nutrients

	1982	1987	1992	1997	2002	2007	2012	Percent change from 2007
Non-recoverable manure nitrogen (million pounds)								
Non-AFOs	6,271	5,995	6,188	6,648	6,586	6,572	5,905	-10%
AFOs	6,783	6,430	6,286	6,258	7,461	7,523	7,043	-6%
All farms	13,054	12,425	12,474	12,906	14,047	14,095	12,948	-8%
Non-recoverable manure phosphorus (million pounds)								
Non-AFOs	2,485	2,374	2,466	2,668	2,612	2,600	2,338	-10%
AFOs	1,481	1,343	1,260	1,168	980	891	745	-16%
All farms	3,966	3,717	3,726	3,836	3,591	3,490	3,084	-12%
Number of AFOs with farm-level excess manure								
Very small AFOs	40,159	37,525	28,983	23,774	16,203	19,800	22,004	11%
Small AFOs	30,370	32,044	27,043	22,329	18,207	17,470	16,454	-6%
Medium AFO-CAFOs	9,960	12,088	13,649	15,121	16,886	15,116	13,988	-7%
Large AFO-CAFOs	2,132	2,968	3,828	5,947	6,981	8,543	8,138	-5%
All AFOs	82,621	84,625	73,503	67,171	58,277	60,929	60,584	-1%
Farm-level excess manure nitrogen (million pounds)								
Very small AFOs	32	29	21	17	12	14	15	4%
Small AFOs	127	136	117	104	109	101	100	-1%
Medium AFO-CAFOs	182	238	288	338	440	437	433	-1%
Large AFO-CAFOs	279	403	485	689	1,010	1,302	1,365	5%
All AFOs	620	806	911	1,149	1,572	1,854	1,913	3%
Farm-level excess manure phosphorus (million pounds)								
Very small AFOs	18	17	13	10	6	7	8	14%
Small AFOs	69	75	66	59	53	50	50	<1%
Medium AFO-CAFOs	97	127	152	177	206	205	202	-1%
Large AFO-CAFOs	172	246	297	436	433	567	594	5%
All AFOs	355	465	528	681	699	829	855	3%

Appendix B: Comparison of Estimates of Acres Receiving Manure Based on the Model Simulation to Values Reported in the 2007 and 2012 Agricultural Census Surveys

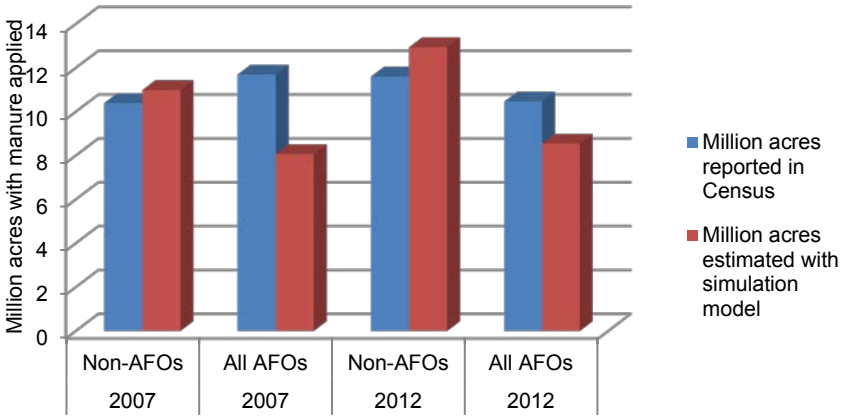
In 2007 and 2012, the Census of Agriculture survey asked all farmers to record the number of acres of "cropland and pastureland on which animal manure was applied" on the operation. Additional information on the manure applications was **not** requested, such as which crops received the manure or whether the manure was generated on the farm or off the farm. The question was included in the long form of the survey in previous years, but only a small percentage of farms were asked to complete the long version in those years. In 2007 and 2012, however, all farms were asked to complete the long version of the survey. It is thus possible to compare estimates of acres receiving manure based on the model simulation to acres reported by respondents of the Agriculture Census Surveys for 2007 and 2012.

The Census found that 22.096 million acres of pastureland and cropland received manure in 2007 and 22.073 million acres received manure in 2012—essentially the same in both years. Using the land application simulation model, this study estimated that—

- 19.063 million acres received manure in 2007, understating actual acres receiving manure by 3.033 million acres (14 percent), and
- 21.490 million acres received manure in 2012, understating actual acres receiving manure by 0.583 million acres (3 percent).

The model simulation overstated acres receiving manure on non-AFOs (off-farm manure applications) by 6 percent for 2007 and 12 percent for 2012 (fig. B1). Conversely, the model understated acres receiving manure on AFOs by 31 percent in 2007 and 18 percent in 2012. These comparisons suggest that the model overestimates the amount of farm-level excess manure to some extent by not allowing more recoverable manure to be applied on AFOs.

Figure B1. Comparison of estimates of acres with manure applied, 2007 and 2012



Both the acres with manure applied on non-AFOs reported in the Census and the acres estimated by the simulation model increased from 2007 to 2012—12 percent for acres reported in the Census and 18 percent for acres estimated by the simulation model. For AFOs, however, the model simulation estimated a 6-percent increase in acres receiving manure whereas the Census values showed an 11-percent decrease from 2007 to 2012.

Further comparisons indicate that the model's under-estimation of acres with manure applied on AFOs occurs primarily on the very small AFOs and the small AFOs (table B1). The model underestimated acres receiving manure on very small AFOs by 0.418 million acres in 2007 and 0.353 million acres in 2012. The underestimation was most striking for small AFOs; where the model underestimated acres receiving manure by 2.520 million acres in 2007 and

1.951 million acres in 2012. In contrast, the model overstated the amount of acres receiving manure on large AFO-CAFOs by 0.246 million acres in 2007 and 0.807 million acres in 2012.

Table B1. Acres with manure applied, 2007 and 2012

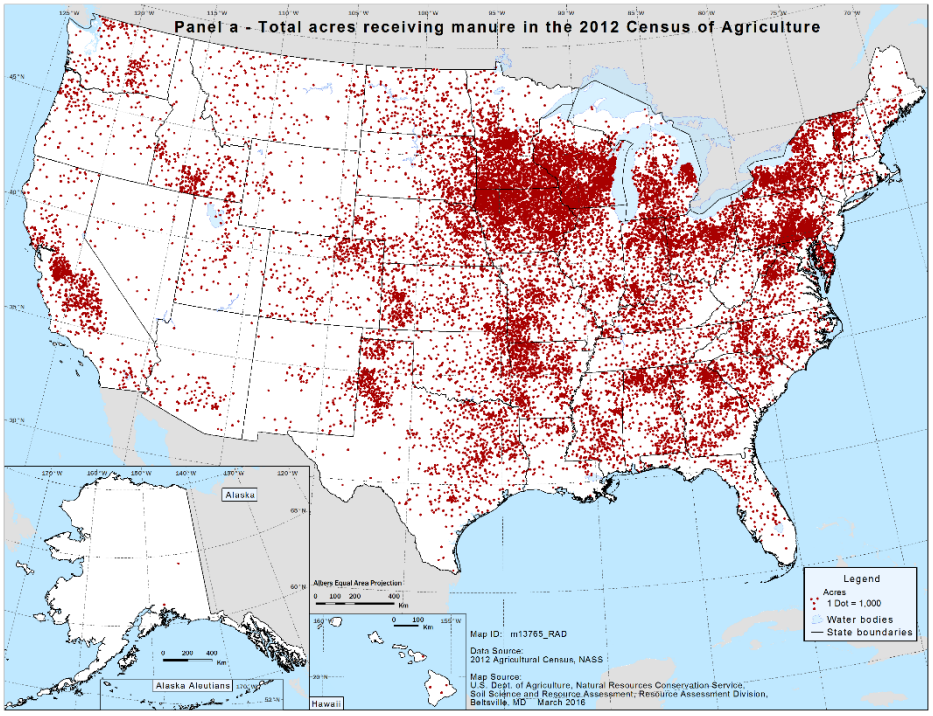
	Million acres reported in Census	Million acres estimated with simulation model	Difference	Percent difference
2007				
Non-AFOs	10.398	10.992	0.594	6%
All AFOs	11.698	8.071	-3.627	-31%
All farms	22.096	19.063	-3.033	-14%
2012				
Non-AFOs	11.606	12.943	1.336	12%
All AFOs	10.467	8.547	-1.919	-18%
All farms	22.073	21.490	-0.583	-3%
2007				
Very small AFOs	0.773	0.355	-0.418	-54%
Small AFOs	5.366	2.846	-2.520	-47%
Medium AFO-CAFOs	3.152	2.217	-0.935	-30%
Large AFO-CAFOs	2.407	2.653	0.246	10%
2012				
Very small AFOs	0.713	0.360	-0.353	-49%
Small AFOs	4.694	2.743	-1.951	-42%
Medium AFO-CAFOs	2.648	2.226	-0.422	-16%
Large AFO-CAFOs	2.412	3.219	0.807	33%

It is not possible to identify the specific reasons for the under-estimates by the land application model for very small and small AFOs. One possibility, however, is that cropland or pastureland on one AFO is used for land application of farm-level excess manure from another AFO. The model simulation does not allow for that because of the likelihood that livestock producers would be concerned about the spread of diseases among farms.

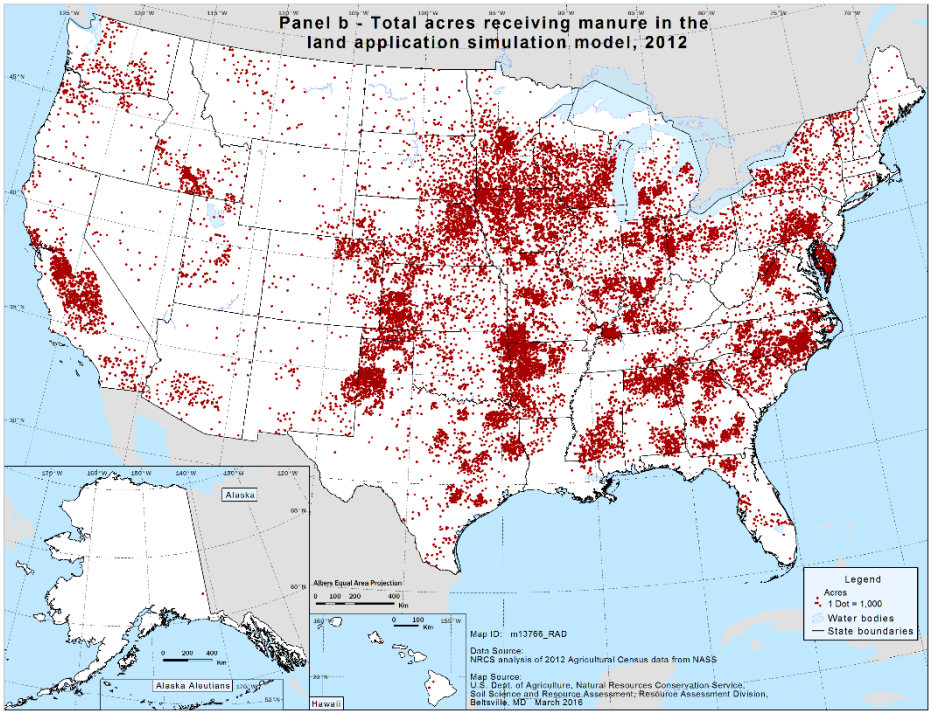
Another possibility for the under-estimates of acres receiving manure on AFOs is that the use of supplemental commercial fertilizer was not considered in the simulation model. To the extent that cropland on AFOs received commercial fertilizer applications, the assimilative capacity for additional manure applications would be reduced, thereby requiring additional acres for on-farm disposal of the manure. If this was the case, the model would apply more manure per acre than farm operators would apply if they were adhering to application rates consistent with a Nutrient Management Plan, and the model would thus require fewer acres to dispose of the recoverable manure nutrients generated on the farm.

Map B1 contrasts the spatial distribution of acres receiving manure as reported in the Census of Agriculture and the estimates from the land application model for 2012. Spatially, the comparison of actual to simulated acres, while not perfect, appears to be acceptable. Areas of concentrated livestock are well represented both in the actual and the simulated acres and the centers of most manure application are the same. A visual comparison indicates that the model under-represents acres receiving manure in areas where confined livestock are less concentrated on the landscape, especially in the Corn Belt. There was a better match in areas with larger livestock operations where demand for land for manure application is highest.

Map B1. County location of acres receiving manure as reported in the 2012 Census of Agriculture and as estimated by the land application simulation model for 2012



Legend: Dot = 1,000 acres
Source: 2012 Agricultural Census data from NASS



Legend: Dot = 1,000 acres
Source: NRCS analysis of the 2012 Agricultural Census data from NASS