turkeys (such as ducks and geese) on 1,490 farms (17 percent), mink and rabbits on 641 farms (7 percent), and other exotic livestock on 1,923 farms (22 percent). Obviously, farms specializing in aquaculture or honey production would not need a CNMP. Furthermore, farms with other exotic livestock types would be expected to be largely pasture-based, and so would not likely need a CNMP. The two remaining groups—farms with poultry other than chickens and turkeys and farms with mink and rabbits—are most likely to be raising animals in confined settings, and so were identified as farms that may need a CNMP.

Including these 2,131 farms with specialty livestock types, the total number of census farms that are expected to need a CNMP is 257,201. These farms are referred to as **CNMP farms** throughout this publication. Figure 1 presents a map showing the geographical distribution of CNMP farms, and table 1 provides a breakdown by livestock type. The CNMP costs presented in this study are based on the assumption that all of these 257,201 farms would implement a CNMP.

Overview of the cost assessment approach

The objective of this assessment is to estimate the costs of implementing CNMPs on all livestock operations in the United States that are expected to need a CNMP, assuming a 10-year implementation period. CNMP-related costs are those costs that would be incurred as a direct result of upgrading the livestock facility or modifying management practices to meet NRCS criteria for a CNMP. Costs associated with facility upgrades that are production-related and not directly related to meeting CNMP criteria are not included. The cost of development of the CNMP is also included, which covers alternatives development and evaluation, design, implementation, and followup. The assessment also does not address who would pay for the CNMP; the full cost is estimated without adjustment for government subsidies or technical assistance provided by USDA or other programs.

Table 1 CNMP farms by dominant livestock type*

Category of CNMP farm	Number of CNMP farms
Farms with more than 35 AU of the dominant livestock type	
Fattened cattle	10,159
Milk cows	79,318
Swine	32,955
Turkeys	3,213
Broilers	16,251
Layers/pullets	5,326
Confined heifers/veal	4,011
Small farms with confined livestock types dominant	42,565
Farms with pastured livestock types dominant**	61,272
Farms with specialty livestock types	2,131
All CNMP farms	**257,201**

* Source: Appendix A, tables A-7 and A-8.
** Includes 24,697 farms with pastured livestock types and few other livestock and 36,575 farms with 4-35 AU of confined livestock types with beef cattle (other than fattened cattle) as the dominant livestock type.

A CNMP is customized to meet the specific needs of each livestock operation within the context of the production goals of the operator. Consequently, the need for modifications to meet CNMP criteria varies widely among operations. Some operations will require only modest changes to meet criteria. Other operations will require extensive modifications. CNMP needs will vary among farms because of siting characteristics, the condition of the facility, previous manure handling and land application practices, runoff and drainage features at the site, the scale of operation relative to the capacity of the facility, and availability of land for application of manure on the farm or on surrounding properties. To precisely calculate the costs of CNMP development and implementation would thus require knowledge of the present condition of each operation, which is clearly beyond the scope of this study.

This assessment represents an **approximation** of the costs that would be expected if CNMPs were fully implemented. To incorporate as much farm-specific information as possible, the assessment is based on a microsimulation model built around the 1997 Census of Agriculture. Using an approach similar to that presented in Kellogg et al. (2000), the amount of recoverable manure nutrients generated by each livestock operation and the acres required for manure application were estimated. Assumptions about likely production technologies and assumptions of expected CNMP needs and per unit costs were integrated with the farm-level census data to provide the information base for making the assessment. The simulation model is therefore a mix of precise information from the Census of Agriculture and generalized information on manure handling practices and CNMP needs. It is recognized that errors will be made in linking information on manure handling practices and CNMP needs to specific farms in the Census of Agriculture. However, the expectation is that underestimates of CNMP costs for specific farms will balance against overestimates for other farms, and that the final result will be a reasonable cost estimate at the national and regional level.

Because the cost assessment is based on the 1997 Census of Agriculture, cost estimates may be overstated somewhat because of changes in the livestock industry since 1997. In the 5 years since 1997, it is likely, given the trends reported in Kellogg et al. (2000), that concentration of the industry has continued to occur. It is expected that there are now more large livestock operations and fewer small livestock operations, and that the new facilities would have fewer CNMP needs than the operations they replaced.

Using the simulation model, unique estimates of CNMP costs were obtained for each of the 257,201 CNMP farms. CNMP-related cost estimates for each CNMP farm were made for six categories:

- Onfarm nutrient management costs
- Off-farm transport costs
- Land treatment costs
- Manure and wastewater handling and storage costs
- Recordkeeping costs
- CNMP development costs

In addition, costs associated with off-farm land application were estimated for each county. One of the outcomes of CNMP implementation is that more manure needs to be exported off the farm as livestock operations reduce application rates to meet nutrient management criteria. The costs of transporting manure to off-farm recipients are included in the estimates of CNMP costs, but costs associated with off-farm land application are not a direct CNMP cost. Nonetheless, they are real costs that, if not incurred, diminish the environmental benefits associated with CNMP implementation. Consequently, costs associated with off-farm land application were calculated, and assumed to be borne by the manure-receiving farms.

Specialty livestock farms (2,131 farms producing mostly ducks, geese, rabbits, and mink) were included in the assessment, but costs were not based on farm-specific information because appropriate conversion factors were not available for estimating the amount of manure nutrients produced. CNMP cost estimates for all cost categories for specialty livestock farms were based on the average CNMP costs for small broiler farms (i.e., farms with 35 to 60 broiler animal units).

Considerations not addressed in the cost assessment

The assessment did not address Federal, State, and local regulatory requirements associated with animal feeding operations. Many States have, or are in the process of, adopting regulations that would require some livestock operations to implement systems that are equivalent to a CNMP or part of a CNMP. Some of these regulations impose stricter requirements than represented by the NRCS CNMP guidelines. Consideration of regulatory trends was given, however, to the determination of CNMP needs, particularly for large operations.

This assessment did not attempt to account for the implementation of CNMPs or elements of CNMPs since 1997. Consequently, part of the costs presented in this assessment may have already been borne by some livestock operations.

Cost estimates may be overstated somewhat because they do not account for innovation and technological advances that are expected to occur as the CNMP initiative is implemented. Implementing CNMPs on nearly 260,000 livestock operations within a 10-year period is an ambitious undertaking. It is expected that efficiencies will arise both in CNMP development and in implementing manure-handling practices during the implementation. Technological advancements in equipment and in the design of structures for handling and treating manure may also arise, reducing costs. It is impossible to foresee where these innovations and efficiencies will occur or how much they may reduce the total costs, but cost savings could occur.

No attempt was made to account for payment by recipients for manure exported off the farm or charges to the livestock operation by recipients for accepting the manure. A variety of payment arrangements presently exist, depending on traditions and markets established in the production region, the type of manure, and existing State and local regulations. In some cases the livestock operator is responsible for applying the manure to the recipient's land. For the purposes of this cost assessment, it is assumed that all manure exported off the farm would be given and accepted without payment, the livestock operation bears the cost of transporting the manure to the manure-receiving farm, and the off-farm land application cost is borne by the recipient.

CNMP development and implementation costs are not estimates of the costs to producers of complying with EPA regulations

The largest livestock operations and operations that may pose a risk to the environment because of location are regulated by the U.S. Environmental Protection Agency. Under the National Pollutant Discharge Elimination System (NPDES), Concentrated Animal Feeding Operations (CAFOs) are required to have permits to ensure that the operation of the facility does not threaten water quality. In December 2002, EPA announced revisions to the CAFO rule. Under the new rule all large CAFOs will be required to apply for a permit, submit an annual report, and develop and follow a plan for handling manure and wastewater. EPA estimates that the CAFO rule will affect about 15,500 operations nationwide.

It was **not** the purpose of this publication to estimate the costs to livestock operations of complying with EPA regulations, but rather to estimate the costs for the development and implementation of Comprehensive Nutrient Management Plans (CNMPs). The costs associated with regulation may be more or less than the costs of developing and implementing a CNMP, depending on the specific location and characteristics of the facility. Cost estimates presented in this publication are for the 257,201 operations with confined livestock that are expected to need a CNMP.

No account was made of the financial benefits that may be realized because of CNMP implementation, including any savings in commercial fertilizer costs on the additional acreage that will receive manure applications. The nutrient value of manure is considered one of the many benefits of implementing CNMPs. Other benefits, which are more difficult to put into economic terms, include the value of manure as a soil amendment, enhanced waterholding capacity of the soil due to increased organic matter in the soil, enhancement of animal health with improved manure handling, water quality enhancement both on the farm

and off the farm, and soil erosion reduction associated with the land treatment practices installed on acres receiving manure. No attempt was made to offset CNMP costs for any of these benefits.

No attempt was made to adjust costs for inflation, even though it is recognized that some cost increases will occur over the 10-year implementation period. To make this adjustment, one would need to know the rate at which CNMPs would be implemented, which will depend on regulatory incentives, financial incentives, and the availability of technical assistance. Cost estimates reported here may therefore be understated to some extent, depending on the rate of inflation and implementation over the next 10 years.

This cost assessment also does not account for cost savings that could be realized by improvements in feed management. Agricultural research has shown that the amount of nitrogen and phosphorus in animal feed can sometimes be reduced without endangering animal health. For some livestock types, feed additives have been developed (such as phytase) that enable livestock to convert more of the phosphorus in animal feed to animal tissue, thereby reducing the quantity of phosphorus needed in the feed and the resulting amount of phosphorus that is excreted. Feed management practices can reduce the number of acres required to meet CNMP land application criteria. No attempt was made in this assessment to adjust the calculations of recoverable manure nutrients for feed management practices. To the extent that feed management practices are already in place, the cost estimate presented here will overstate costs. (An assessment of the potential reductions in CNMP costs associated with feed management practices will be addressed in Part II, which will be published subsequent to this publication.)

The model simulation shows that alternatives to land application of manure are needed in some regions of the country. Under the assumptions of the model simulation, 248 counties do not have adequate land to assimilate the manure produced in those counties when applied at rates that meet CNMP criteria (see appendix B). Most of these counties are co-located, reducing the opportunity to transport the manure to surrounding counties for land application. The amount of county-level excess manure represents about 16 percent of the total recoverable manure nutrients produced by all CNMP farms in the country. Included in the cost assessment are estimates of the cost of transporting this county-level excess manure off the farm, but no other costs are estimated for the disposal or use of this manure. (The costs of alternatives to land application that are associated with CNMP implementation will also be addressed in Part II.)

Approach used to determine CNMP needs

The most challenging aspect of the cost assessment is defining CNMP needs. Different approaches were used for each of the CNMP elements, taking advantage of as much farm-specific information as possible.

CNMP needs for the nutrient management element and off-farm transport

CNMP needs for the nutrient management element were determined by the amount of manure produced on each farm and the additional number of acres required to meet CNMP land application criteria on each farm. Two land application scenarios were constructed:

- A baseline scenario, designed to simulate land application of manure before implementation of CNMPs, and
- An after CNMP scenario, designed to simulate land application at rates that correspond to NRCS nutrient management criteria.

The difference in the number of acres with manure applied between the two scenarios defines the additional acres needed to meet CNMP criteria. Estimates were also made for the amount of manure exported off the farm to surrounding properties, defining CNMP needs for off-farm transport. The number of acres required for off-farm land application of the exported manure were determined and used to estimate off-farm land application costs associated with CNMP implementation.

CNMP needs for the land treatment element

A CNMP includes criteria for erosion control on acres receiving manure to protect water quality. The National Resources Inventory (NRI) provides estimates of sheet and rill erosion at the county level, which were used to assess the need for land treatment practices. NRI data for the year 1997 were used to correspond to the timeframe represented by the census database.

CNMP needs for the manure and wastewater handling and storage element

Manure and wastewater storage and handling includes components and activities associated with the production facility, feedlot, storage structures and areas, and any areas or mechanisms used to facilitate transfer of manure and wastewater. Manure and wastewater storage and handling needs are specific to the production technology on the farm. Data at the national level are not available on CNMP needs for this element, nor can CNMP needs be derived from other databases, as was done for nutrient management, land treatment, and off-farm export. CNMP needs for manure and wastewater handling and storage components were estimated by a team of experts using a consensus approach to approximate what the needs might be. The team of experts consisted of agricultural engineers, environmental engineers, economists, and agronomists with extensive experience working with livestock producers and government technical assistance programs. Team members also consulted with other experts who had knowledge about specific industries or areas of the country.

CNMP needs for the manure and wastewater handling and storage element were defined based on typical, or dominant, production technologies, livestock type, farm size, and production region. Production technologies ranged from simple (no storage, daily spreading, for example) to complex (liquid collection systems with lagoons, for example). These production technologies were then assigned to farms in the census based on the dominant livestock type, farm size, and production region for the census farm. In many cases a single production technology was assigned to a census farm. In other cases, however, there was more than one production technology that would be expected for a given farm size in a given production region. Where more than one production technology was assigned to a census farm, the probability that each production technology would occur was also assigned.

The basic set of production technologies was defined in terms of **representative farms** for each livestock type. Representative farms define broad groups of livestock production facilities that, within a livestock sector, have similar characteristics for managing the livestock and managing the manure; in other words, a hypothetical farm with a typical animal waste handling system for a given livestock type. This set of representative farms was expanded to a larger set of **model farms** by adding the dimensions of size and location. Size categories for the dominant livestock type were selected to reflect differences in production technologies by farm size. Geographic regions generally reflected major production regions with further delineation by climate, where climate would be expected to influence the kind of production system found in the region. Not all representative farms are present in each size class and location. Each model farm is thus a representative farm of a certain size in a specified location.

Representative farms were derived from two sources of information—farmer surveys and expert judgment. Results from farmer surveys were available for dairies, swine, and layers. These surveys were not conducted for the specific purpose of inventorying manure-handling practices on farms, but did include questions about the production technologies in use and a few questions about manure management. A team of USDA experts evaluated the survey results and identified the dominant manure management technologies, basing them on manure handling characteristics as much as possible. Only the most dominant technologies were included; technologies that occurred relatively infrequently in survey results were discarded. Farmer survey results were not available for fattened cattle, veal, confined heifers, broilers, pullets, or turkeys. For these livestock types, representative farms were derived by the team of USDA experts based on their knowledge of industry practices.

In addition to providing a structure for deriving CNMP needs for the manure and wastewater handling and storage element, this analytical framework was used to assign costs related to manure testing and recordkeeping. A slightly expanded version of the framework was used to estimate CNMP development costs and used in appendix B to parameterize the simulation model for estimating recoverable manure nutrients and tons of manure for handling and transport.

Model farms for dairy. Five representative farms were derived for dairy based on a 1996 National Animal Health Monitoring System (NAHMS) survey of 2,542 dairies in 20 states (USDA, APHIS, 1996). The survey included questions about the manure storage facilities on the farm and the frequency of manure spreading. Production technologies for dairies were

therefore defined in terms of manure storage. The five representative farms are:

#1. Essentially no storage, frequent spreading.
#2. Solids storage (typically outside separate from pens, but may include some manure pack and dry lot conditions); no appreciable liquid storage.
#3. Liquid to slurry storage in deep pit or aboveground tank; some solids storage; no earthen basins, ponds, or lagoons; typically less than monthly spreading.
#4. Primarily liquid manure stored in basin, pond, or lagoon; some solids storage for outside areas; typically less than monthly spreading.
#5. Liquid system (any combination of 3 and 4) primarily used in the West and Southeast; often associated with manure pack and solids spreading in the West.

Survey results were obtained for three size classes (35 to 135 milk cow AU, 135 to 270 milk cow AU, and more than 270 milk cow AU) in the North Central and Northeast States and in the West. Survey results for the Southeast could be obtained only for two size classes (35 to 135 AU and more than 135 AU) because of the small sample size in that region. The combinations of representative farms, production regions, and size classes produced 20 model farms for dairies. The percentage of the dairies in each region and size class that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 2 along with an estimate of the number of model farms, extrapolating from census farm counts. The three production regions are shown in figure 2 along with the location of CNMP farms with milk cows as the dominant livestock type.

Figure 2 CNMP farms with milk cows as the dominant livestock type and more than 35 milk cow animal units (79,318 farms)

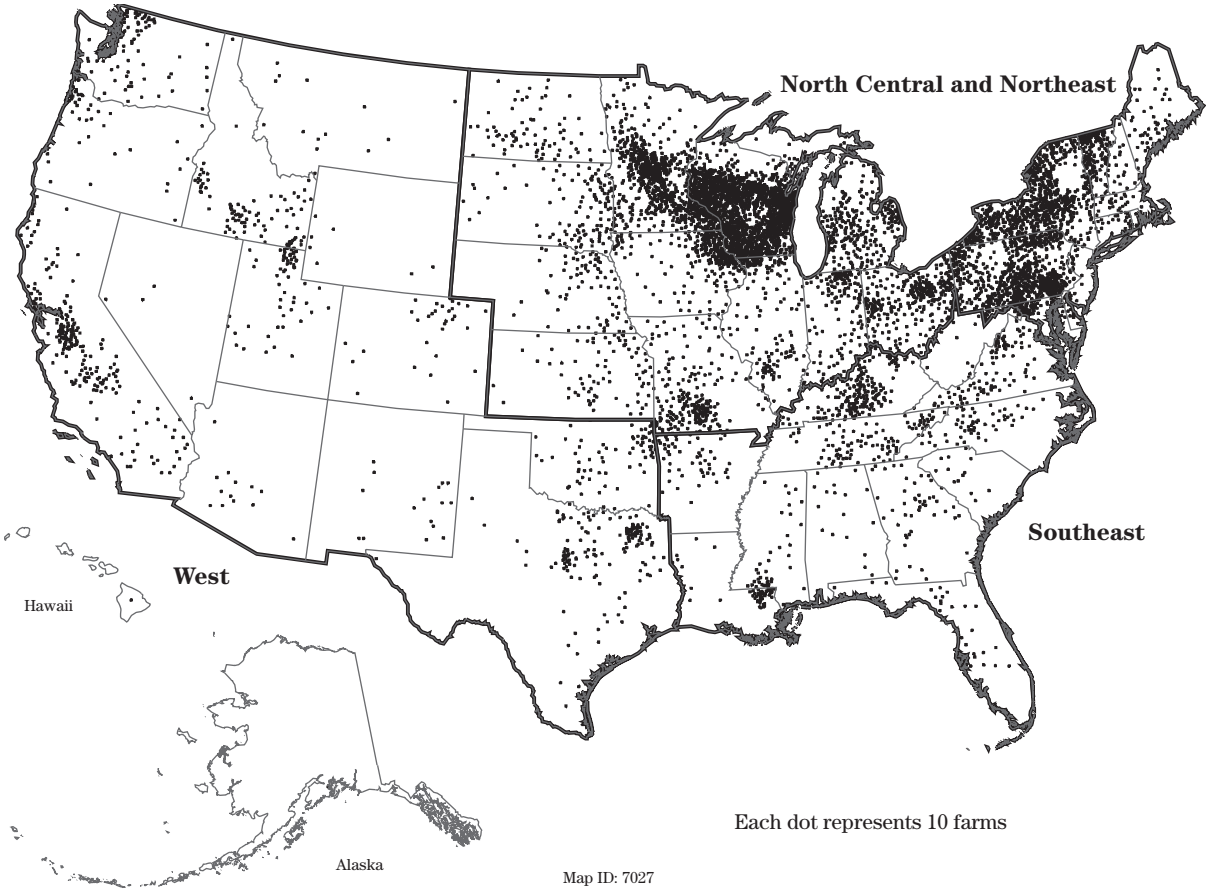


Table 2 Model farms for dairies

Region and size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
North Central and Northeast*				
35-135 AU	#1: no storage	29	—	15,385
	#2: solids storage	47	—	24,935
	#3: liquid storage—deep pit or slurry	7	—	3,714
	#4: liquid storage—basin, pond, lagoon	17	—	9,019
	All	100	53,053	
135-270 AU	#1: no storage	15	—	1,303
	#2: solids storage	28	—	2,433
	#3: liquid storage—deep pit or slurry	14	—	1,216
	#4: liquid storage—basin, pond, lagoon	43	—	3,736
	All	100	8,688	
> 270 AU	#2: solids storage	14	—	366
	#3: liquid storage—deep pit or slurry	18	—	471
	#4: liquid storage—basin, pond, lagoon	68	—	1,779
	All	100	2,616	
Southeast**				
35-135 AU	#2: solids storage	59	—	2,566
	#5: any liquid storage	41	—	1,783
	All	100	4,349	
> 135 AU	#2: solids storage	30	—	845
	#5: any liquid storage	70	—	1,970
	All	100	2,815	
West***				
35-135 AU	#2: solids storage	50	—	1,175
	#5: any liquid storage, manure pack	50	—	1,174
	All	100	2,349	
135-270 AU	#2: solids storage	11	—	200
	#5: any liquid storage, manure pack	89	—	1,625
	All	100	1,825	
> 270 AU	#5: any liquid storage, manure pack	100	3,623	3,623
All farms			79,318	79,318

* NAHMS survey states include MN, IA, MO, WI, IL, MI, IN, OH, PA, NY, IL, and VT. States added to the group include ND, SD, NE, KS, NJ, MD, DE, MA, CT, RI, NH, and ME.
** NAHMS survey states include KY, TN, and FL. States added to the group include VA, WV, NC, SC, GA, AL, MS, AR, and LA.
*** NAHMS survey states include CA, OR, WA, ID, NM, and TX. States added to the group include HI, AK, AZ, UT, NV, MT, WY, CO, and OK.

Model farms for layers. Three representative farms were derived for layers based on a 1999 NAHMS survey of 526 layer farms in 15 states (USDA, APHIS, 1999). The survey included a question about the type of facility used relative to manure collection and handling. Production technologies for layers were therefore defined in these terms. Five types of systems were identified in the survey, but were combined into three groups of representative farms because of similar CNMP needs and cost assumptions. The three representative farms are:

- High rise (pit at ground level with elevated house) or shallow pit (house not elevated)
- Flush system to lagoon
- Manure belt or scraper system

Survey results were obtained for two size classes (35 to 400 layer AU and more than 400 layer AU) for each of four regions: Southeast, West, South Central, and North Central and Northeast. The combinations of representative farms, production regions, and size classes produced 15 model farms for layers. The percentage of the layer farms in each region and size class that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 3 along with an estimate of the number of model farms, extrapolating from census farm counts. The four production regions are shown in figure 3 along with the location of CNMP farms with layers as the dominant livestock type.

Figure 3 CNMP farms with layers as the dominant livestock type and more than 35 layer animal units (4,052 farms)

Table 3 Model farms for layers

Region and size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
North Central and Northeast*				
35-400 AU	#1: high rise or shallow pit	80	—	762
	#3: manure belt or scraper system	20	—	191
	All	100	953	
> 400 AU	#1: high rise or shallow pit	81	—	234
	#3: manure belt or scraper system	19	—	55
	All	100	289	
Southeast**				
35-400 AU	#1: high rise or shallow pit	57	—	916
	#2: flush with lagoon	43	—	691
	All	100	1,607	
> 400 AU	#1: high rise or shallow pit	52	—	42
	#2: flush with lagoon	48	—	38
	All	100	80	
West***				
35-400 AU	#1: high rise or shallow pit	49	—	51
	#3: manure belt or scraper system	51	—	53
	All	100	103	
> 400 AU	#1: high rise or shallow pit	18	—	18
	#3: manure belt or scraper system	82	—	83
	All	100	102	
South Central****				
35-400 AU	#1: high rise or shallow pit	45	—	396
	#3: manure belt or scraper system	55	—	483
	All	100	879	
> 400 AU	#2: flush with lagoon	100	39	39
All farms			4,052	4,052

* NAHMS survey states include MN, MO, NE, IA, PA, OH, and IN. States added to the group include SD, ND, KS, MI, WI, IL, KY, WV, VA, MD, DE, NJ, NY, and New England States.
** NAHMS survey states include AL, FL, GA, and NC. States added to the group include SC, MS, and TN.
*** NAHMS survey states include CA and WA. States added to the group include AK, AZ, HI, ID, NV, NM, OR, UT, MT, CO, and WY.
**** NAHMS survey states include TX and AR. States added to the group include OK and LA.

Model farms for swine. Five representative farms were derived for swine based on two farmer surveys: a 1995 NAHMS survey of 1,477 swine farms in 16 states (USDA, APHIS, 1995), and a 1998 Agricultural Resource Management Study (ARMS) survey on 1,600 swine farms in 21 states (USDA, ERS, 2000). The surveys included questions about the type of facility used to rear swine and the type of manure handling and storage system. Production technologies for swine were therefore defined in these terms. The initial breakdown was made using the NAHMS survey results. The ARMS survey results were used to update the representation of confinement facilities that had storage ponds or lagoons and used to estimate representation in the West. The representative farms are:

- #1 Total confinement with liquid system including lagoon.
- #2 Total confinement with slurry system, no lagoon.
- #3 Open building with outside access and liquid to slurry system (holding pit under slat or open flush gutter).
- #4 Open building with outside access and semi-solid to solid wastes (mechanical scraper/ tractor scrape/hand clean).
- #5 Pasture or lot with or without hut.

Survey results were obtained for two size classes (35 to 500 swine AU and more than 500 swine AU) in the West and the North Central and Northeast. A different size class breakdown (35 to 100 swine AU and more than 100 swine AU) was necessary for the Southeast because production technologies for farms with more than 100 swine AU were not diverse in that region. The survey showed that production technologies also varied according to the type of swine facility. Thus, survey results were also broken down by farms that were primarily farrowing operations, primarily grower-feeder operations, or a combination of both (farrow-to-finish operations). The combinations of type of operation, region, size class, and representative farms produced 36 model farms for swine. The type of operation for census farms was inferred based on the relative numbers of breeding hogs and hogs for slaughter reported for each farm. Farms with more than 75 percent of the swine AU consisting of breeding hogs were identified as farrowing operations. Farms with more than 75 percent of the swine AU consisting of hogs for slaughter were identified as grower-feeder operations. All other swine farms were identified as farrow-to-finish operations.

The percentage of the swine farms in each region, size class, and type of operation that corresponded to a particular representative farm was determined from the survey results. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 4 along with an estimate of the number of model farms, extrapolating from census farm counts. The three production regions are shown in figure 4 along with the location of CNMP farms with swine as the dominant livestock type.

Figure 4 CNMP farms with swine as the dominant livestock type and more than 35 swine animal units (32,955 farms)

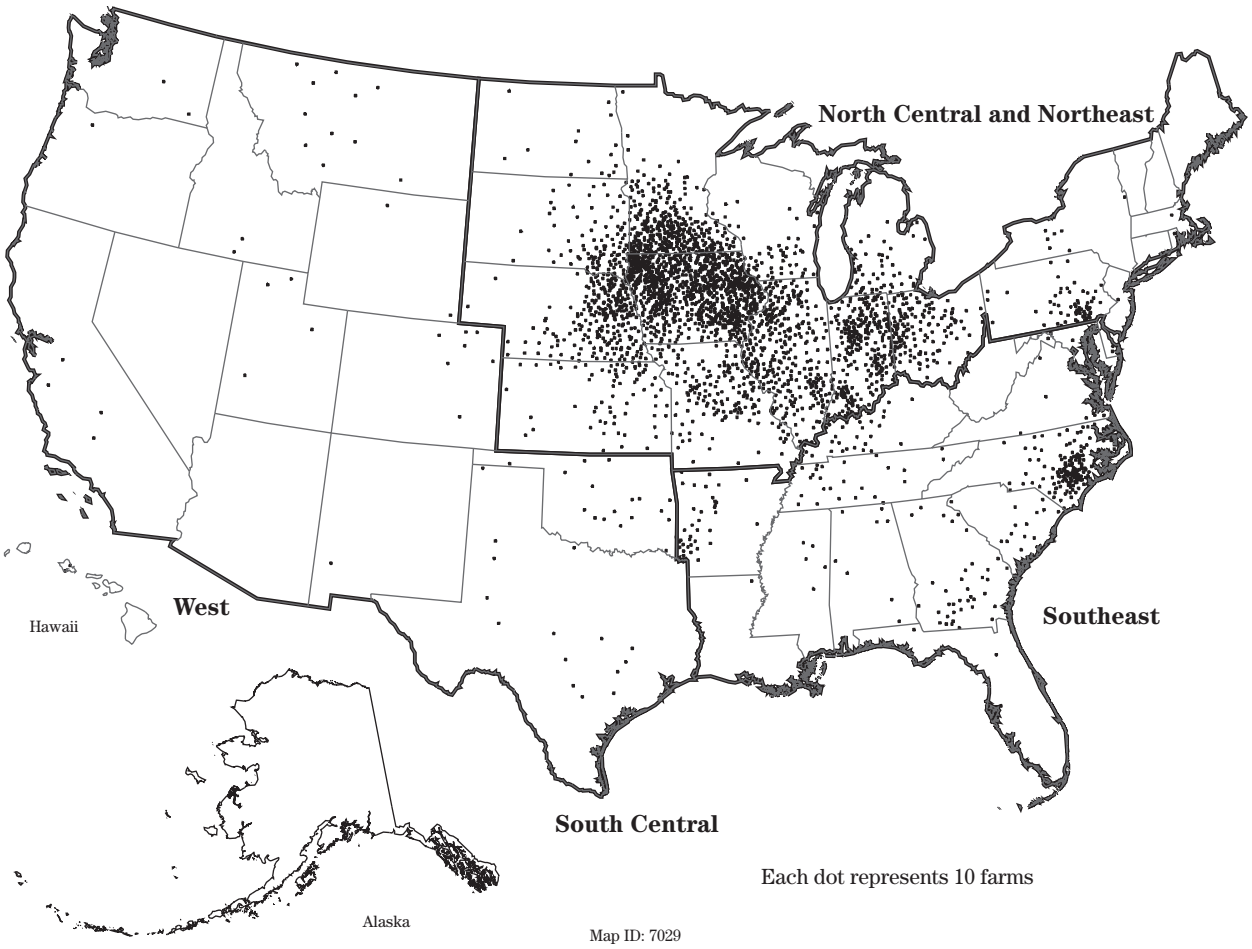


Table 4 Model farms for swine

Region and type of operation	Size class (AU)	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Southeast*					
Farrowing	35–100	#1: total confinement, liquid, lagoon	100	43	43
	> 100	#1: total confinement, liquid, lagoon	100	270	270
Grower-feeder	35-100	#1: total confinement, liquid, lagoon	90	—	254
		#2: total confinement, slurry, no lagoon	10	—	28
		All	100	282	
	> 100	#1: total confinement, liquid, lagoon	100	1,389	1,389
Farrow-to-finish	35–100	#1: total confinement, liquid, lagoon	40	—	233
		#2: total confinement, slurry, no lagoon	10	—	58
		#5: pasture or lot	50	—	292
		All	100	583	
	> 100	#1: total confinement, liquid, lagoon	90	—	782
		#2: total confinement, slurry, no lagoon	10	—	87
		All	100	869	
North Central and Northeast**					
Farrowing	35–500	#1: total confinement, liquid, lagoon	10	—	103
		#2: total confinement, slurry, no lagoon	76	—	782
		#4: building with outside access, solids	14	—	144
		All	100	1,029	
	> 500	#1: total confinement, liquid, lagoon	85	—	101
		#2: total confinement, slurry, no lagoon	15	—	18
		All	100	119	
Grower-feeder	35–500	#1: total confinement, liquid, lagoon	6	—	560
		#2: total confinement, slurry, no lagoon	53	—	4,956
		#3: building with outside access, liquid	14	—	1,309
		#4: building with outside access, solids	27	—	2,525
		All	100	9,350	
	> 500	#1: total confinement, liquid, lagoon	27	—	119
		#2: total confinement, slurry, no lagoon	73	—	323
		All	100	442	

Table 4 Model farms for swine—Continued

Region and type of operation	Size class (AU)	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Farrow-to-finish	35–500	#1: total confinement, liquid, lagoon	15	—	2,526
		#2: total confinement, slurry, no lagoon	75	—	12,627
		#4: building with outside access, solids	10	—	1,684
		All	100	16,837	
	> 500	#1: total confinement, liquid, lagoon	40	—	428
		#2: total confinement, slurry, no lagoon	60	—	641
		All	100	1,069	
West***					
Farrowing	35–500	#1: total confinement, liquid, lagoon	45	—	40
		#2: total confinement, slurry, no lagoon	25	—	22
		#5: pasture or lot	30	—	27
		All	100	89	
	> 500	#1: total confinement, liquid, lagoon	65	—	14
		#2: total confinement, slurry, no lagoon	35	—	8
		All	100	22	
Grower-feeder	35–500	#1: total confinement, liquid, lagoon	100	113	113
	> 500	#1: total confinement, liquid, lagoon	100	39	39
Farrow-to-finish	35–500	#1: total confinement, liquid, lagoon	10	—	35
		#2: total confinement, slurry, no lagoon	90	—	316
		All	100	351	
	> 500	#1: total confinement, liquid, lagoon	10	—	6
		#2: total confinement, slurry, no lagoon	90	—	53
		All	100	59	
All farms				32,955	32,955

* NAHMS survey states include KY, TN, GA, and NC. States added to the group include MD, DE, VA, WV, SC, FL, AL, MS, LA, and AR.
** NAHMS survey states include IA, KS, MN, MO, NE, SD, IL, IN, MI, OH, PA, and WI. States added to the group include New England States, ND, NY, and NJ.
*** ARMS survey states include CO, UT, and OK. States added to the group include WA, OR, CA, NV, ID, MT, WY, NM, AZ, TX, AK, and HI.

Model farms for other confined livestock types. Survey results for the remaining confined livestock types are not available. The predominant production technologies for each livestock type were defined by the team of USDA experts. Representative farms were defined as follows:

Fattened cattle
- #1 Dry lot (small) scraped on a frequent basis, manure stacked until application
- #2 Dry lot with manure pack and occasional complete clean out and removal; at least rudimentary runoff collection/storage

Confined heifers
- #1 Confinement barns with bedded manure; solids handling
- #2 Small open lots with scraped solids and minimal runoff control

Veal
- #1 Confinement house with liquid/slurry components

Turkeys
- #1 Confinement house
- #2 Turkey ranching (building with open sides and lot)

Broilers
- #1 Standard broiler house; complete litter clean out and/or cake out

Pullets
- #1 High rise or shallow pit confinement house

Model farm regions for these livestock types were defined as shown in figures 5 to 9. Regions were defined based on production, the expected occurrence of representative farms, and climate where production technologies included open lots. CNMP needs for one or more components of the manure and wastewater handling and storage element vary among these regions. Size classes were defined only for fattened cattle, where small farms in each region were expected to have different CNMP needs than larger operations.

The percentage of the farms in each region and size class that corresponded to a particular representative farm was also defined by the team of USDA experts. These percentages were used as probabilities in the assignment of model farms to census farms. These probabilities are presented in table 5 along with an estimate of the number of model farms, extrapolating from census farm counts.

Table 5 Model farms for fattened cattle, confined heifers, veal, turkeys, broilers, and pullets

Dominant livestock type and region	Size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Fattened cattle					
Northeast	> 35	#1: scrape and stack	100	277	277
Southeast	> 35	#1: scrape and stack	30	—	111
		#2: manure pack, runoff collection	70	—	260
		All	100	371	
Midwest	35–500	#1: scrape and stack	30	—	748
		#2: manure pack, runoff collection	70	—	1,746
		All	100	2,494	
	> 500	#2: manure pack, runoff collection	100	1,504	1,504
North	35–500	#2: manure pack, runoff collection	100	925	925
	> 500	#2: manure pack, runoff collection	100	52	52
Central Plains	35–1,000	#2: manure pack, runoff collection	100	3,499	3,499
	> 1,000	#2: manure pack, runoff collection	100	666	666
West	35–500	#2: manure pack, runoff collection	100	252	252
	> 500	#2: manure pack, runoff collection	100	119	119
		All		10,159	10,159
Confined heifers					
Northeast	> 35	#1: confinement barn/bedded manure	70	—	117
		#2: open lots with scraped solids	30	—	50
		All	100	167	
Midwest	> 35	#1: confinement barn/bedded manure	40	—	974
		#2: open lots with scraped solids	60	—	1,462
		All	100	2,436	
South and West	> 35	#2: open lots with scraped solids	100	1,240	1,240
Veal	> 35	#1: confinement house	100	168	168
Turkeys					
East	> 35	#1: confinement houses	90	—	1,266
		#2: turkey ranch	10	—	141
		All	100	1,407	
South Central	> 35	#1: confinement houses	100	740	740

Table 5 Model farms for fattened cattle, confined heifers, veal, turkeys, broilers, and pullets—Continued

Dominant livestock type and region	Size class	Representative farms	Percent of farms in group	Number of farms in census	Estimated number of farms in group
Midwest	> 35	#1: confinement houses	90	—	768
		#2: turkey ranch	10	—	85
		All	100	853	
West other than California	> 35	#1: confinement houses	50	—	39
		#2: turkey ranch	50	—	39
		All	100	78	
California	> 35	#1: confinement houses	80	—	108
		#2: turkey ranch	20	—	27
		All	100	135	
Broilers					
East and South	> 35	#1: confinement houses	100	15,531	15,531
West	> 35	#1: confinement houses	100	720	720
Pullets					
North Central and Northeast	> 35	#1: layer-type confinement houses	100	369	369
South and West	> 35	#1: layer-type confinement houses	100	905	905

Figure 5 CNMP farms with fattened cattle as the dominant livestock type and more than 35 fattened cattle animal units (10,159 farms)

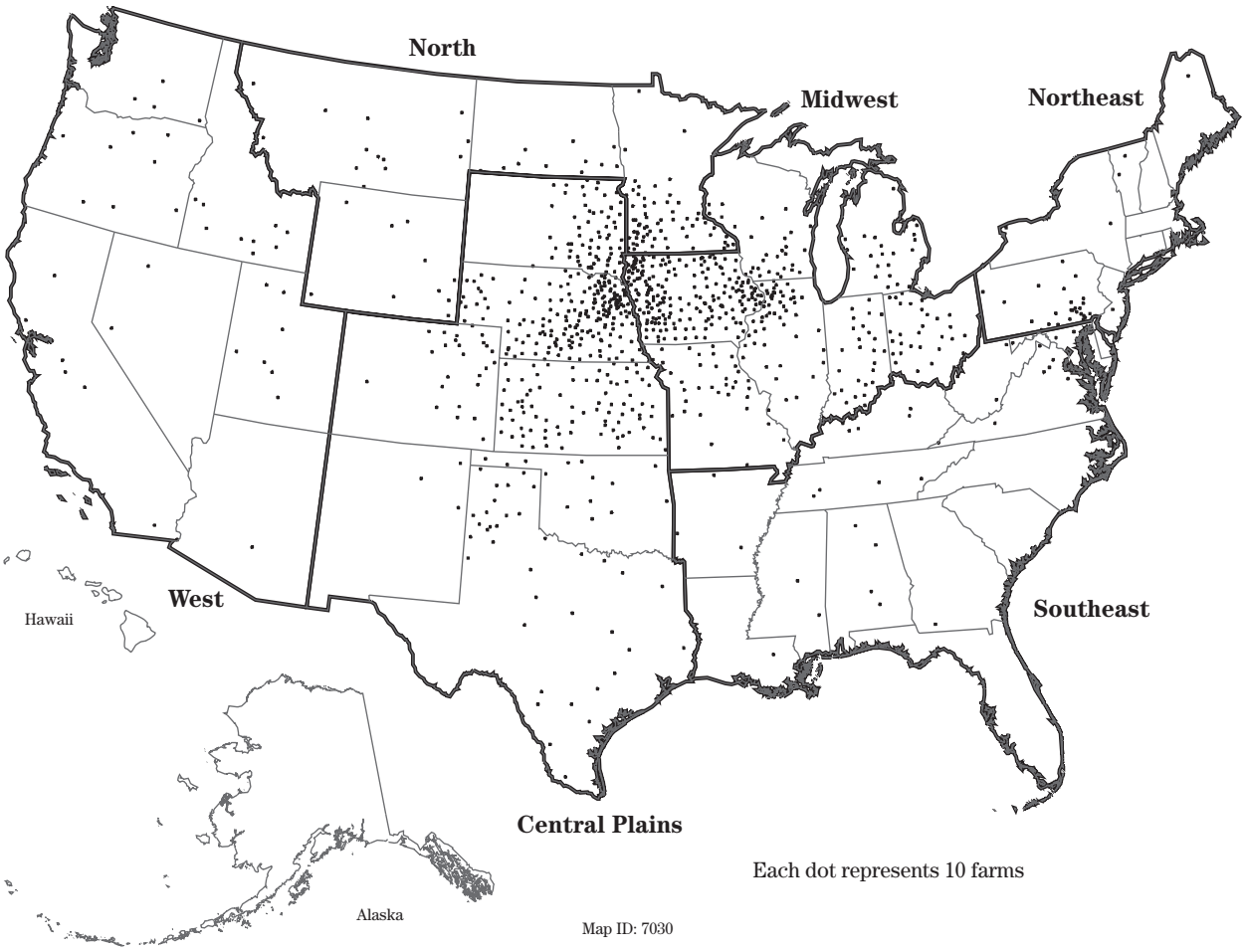


Figure 6 CNMP farms with broilers as the dominant livestock type and more than 35 broiler animal units (16,251 farms)

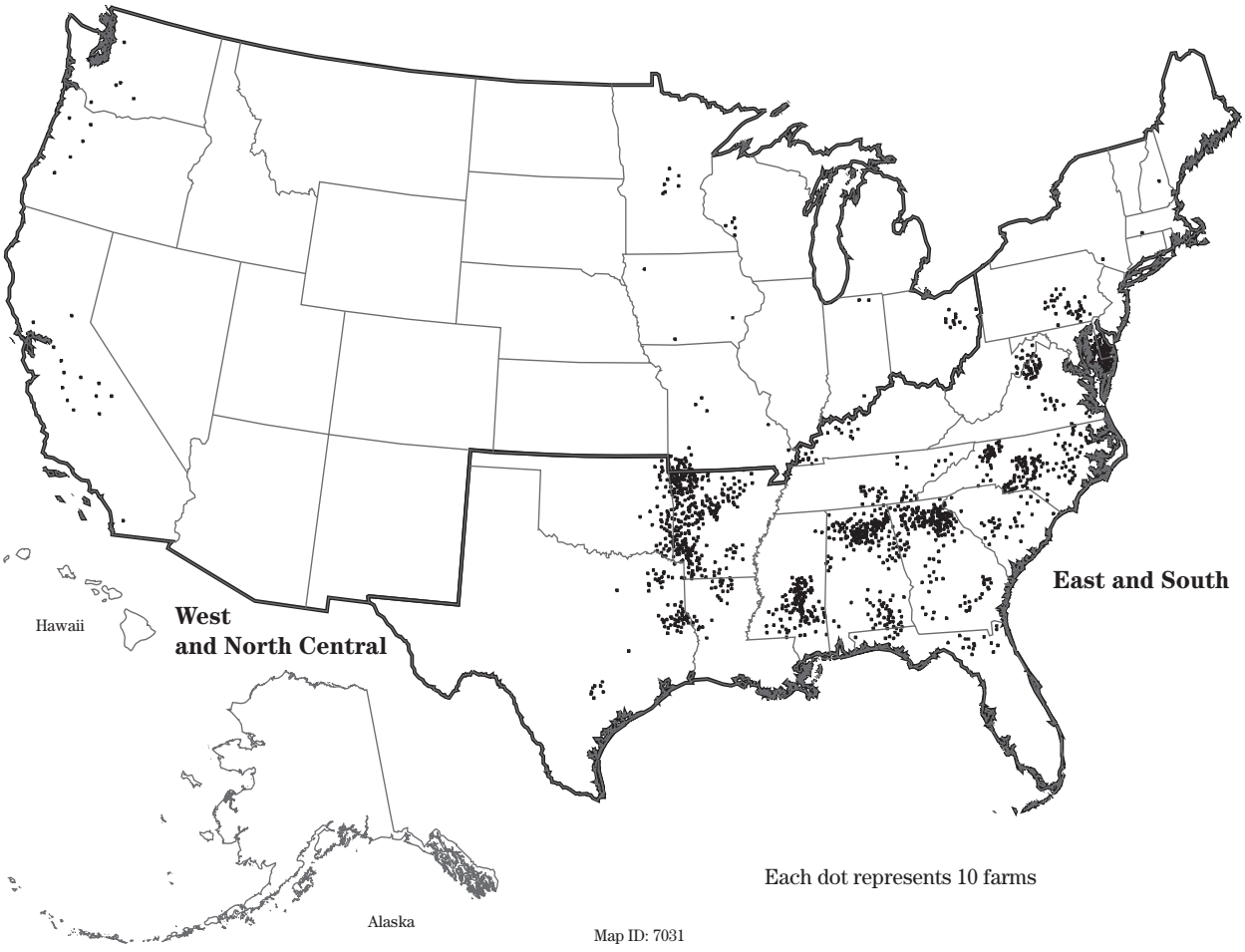


Figure 7 CNMP farms with turkeys as the dominant livestock type and more than 35 turkey animal units (3,213 farms)

Figure 8 CNMP farms with pullets as the dominant livestock type and more than 35 pullet animal units (1,274 farms)

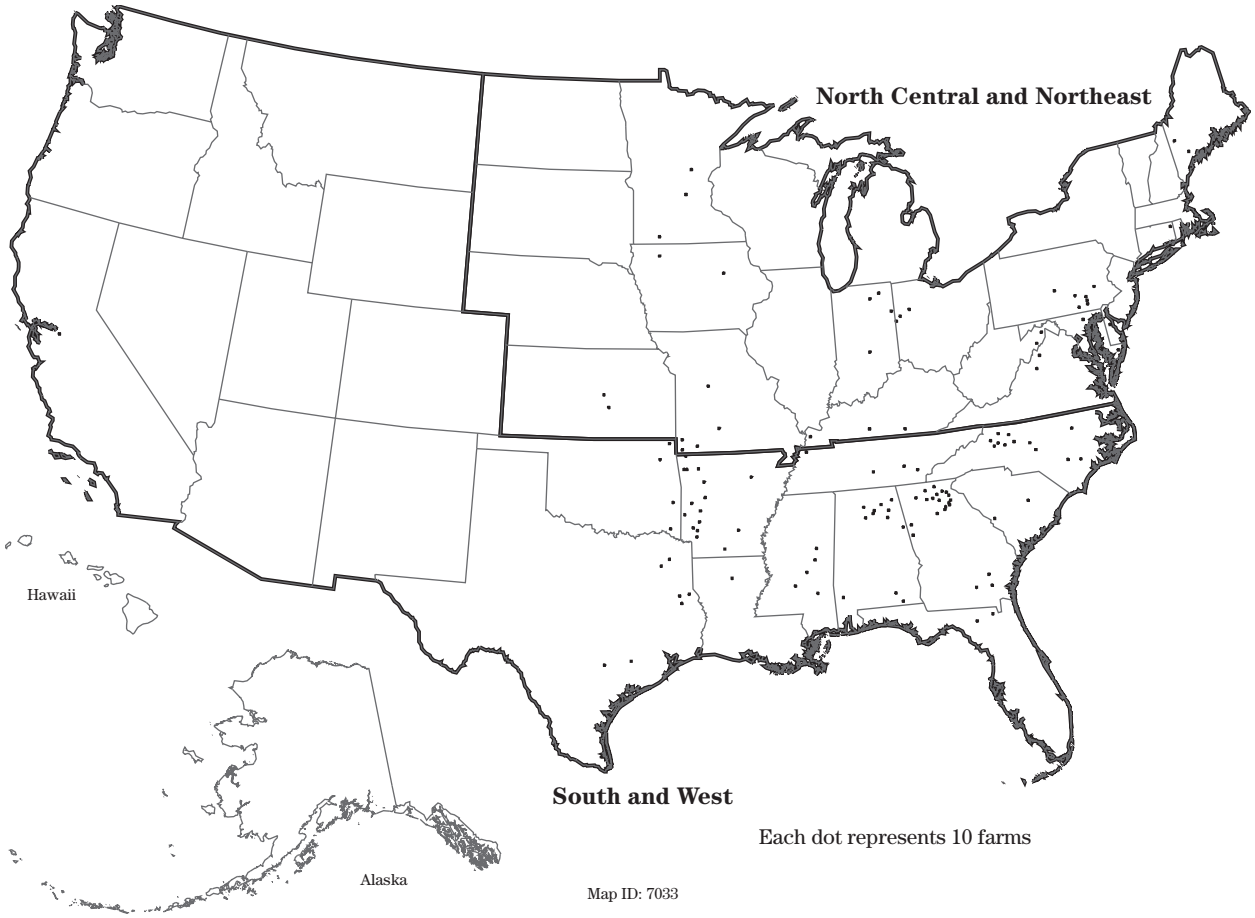
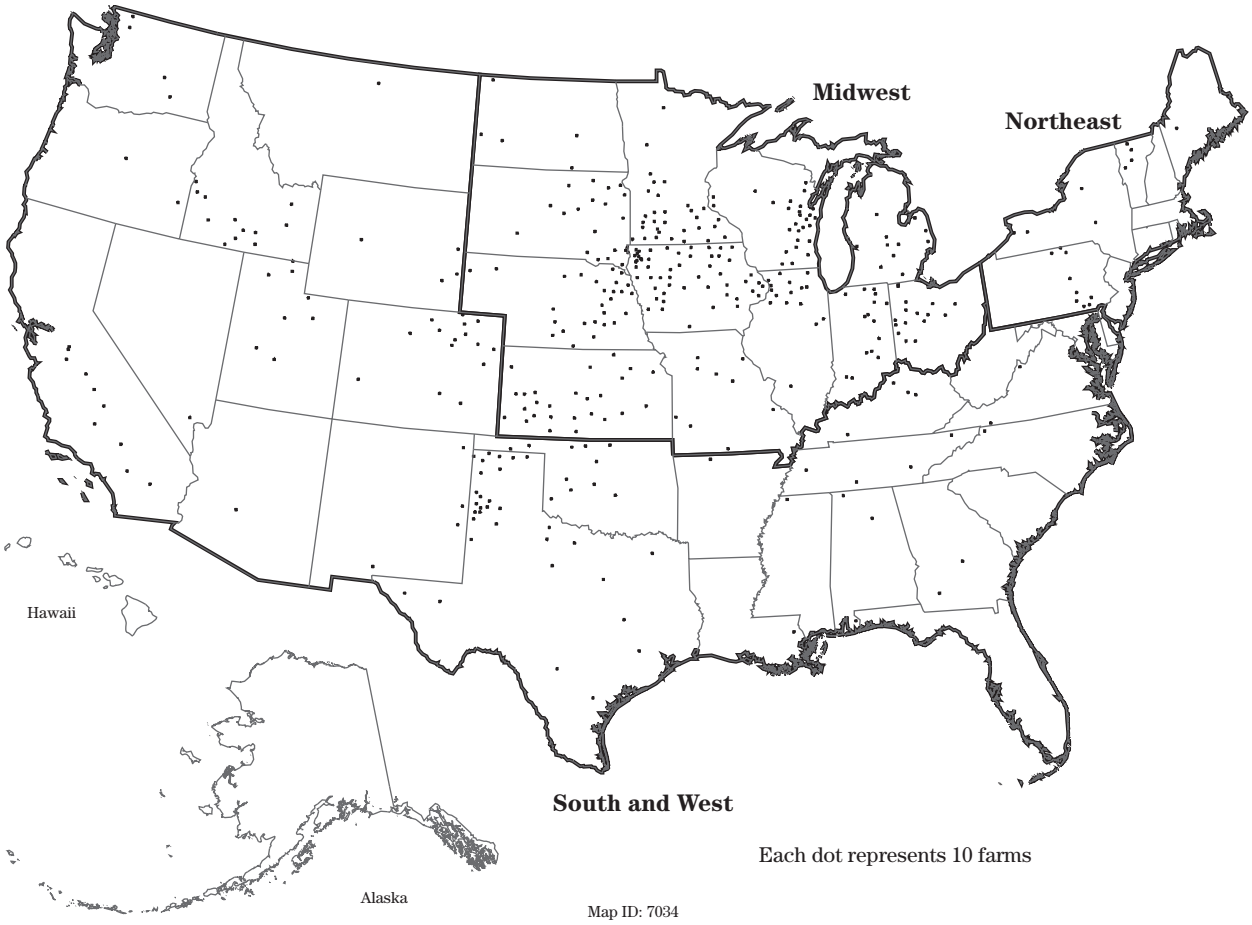


Figure 9 CNMP farms with confined heifers or veal as the dominant livestock type (4,011 farms)



Model farms for pastured livestock types. Costs associated with conservation practices for pastured livestock are grouped under the manure and wastewater storage and handling element, although they include some costs associated with pasture management that would be expected to be included in a CNMP for these farms. As shown in appendix A, 24,697 farms with pastured livestock and few other livestock qualified as farms that may need a CNMP because of the amount of recoverable manure that would potentially be produced on these farms. An additional 36,575 farms had less than 35 AU of confined livestock types, but had beef cattle as the dominant livestock type on the farm. These two groups comprise the set of farms for which CNMP needs are defined for farms with pastured livestock. Four representative farms were identified for this group of farms:

#1 Pasture with heavy use area
#2 Pasture with windbreak and/or shelterbelt
#3 Pasture with lot and scrape-and-stack manure handling
#4 Pasture with barn for shelter

Six production regions were defined, as well as two size classes for the Northeast. The six production regions are shown in figure 10. Representative farms were assigned to each region as follows:

South—#1: pasture with heavy use protection (17,731 farms)

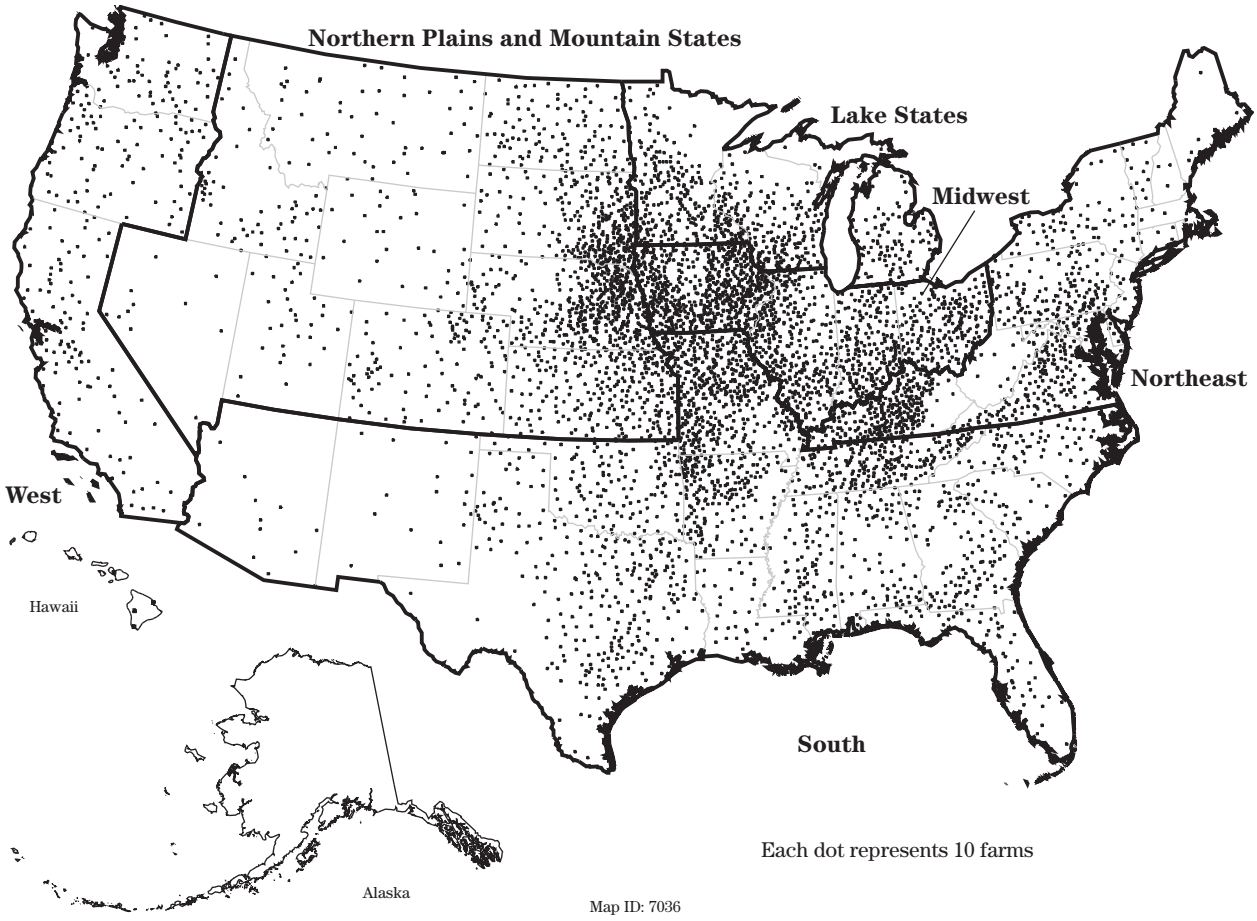
Midwest—#3: pasture with lot (13,950 farms)

Lake States—#4: pasture with barn (5,896 farms)

Northeast, less than 70 AU—#4: pasture with barn (5,299 farms)

Northeast, more than 70 AU—#1: pasture with heavy use protection (2,133 farms)

Figure 10 CNMP farms with pastured livestock types (61,272 farms)



Northern Plains and Mountain States—#2: pasture with windbreak/shelterbelt (13,840 farms)

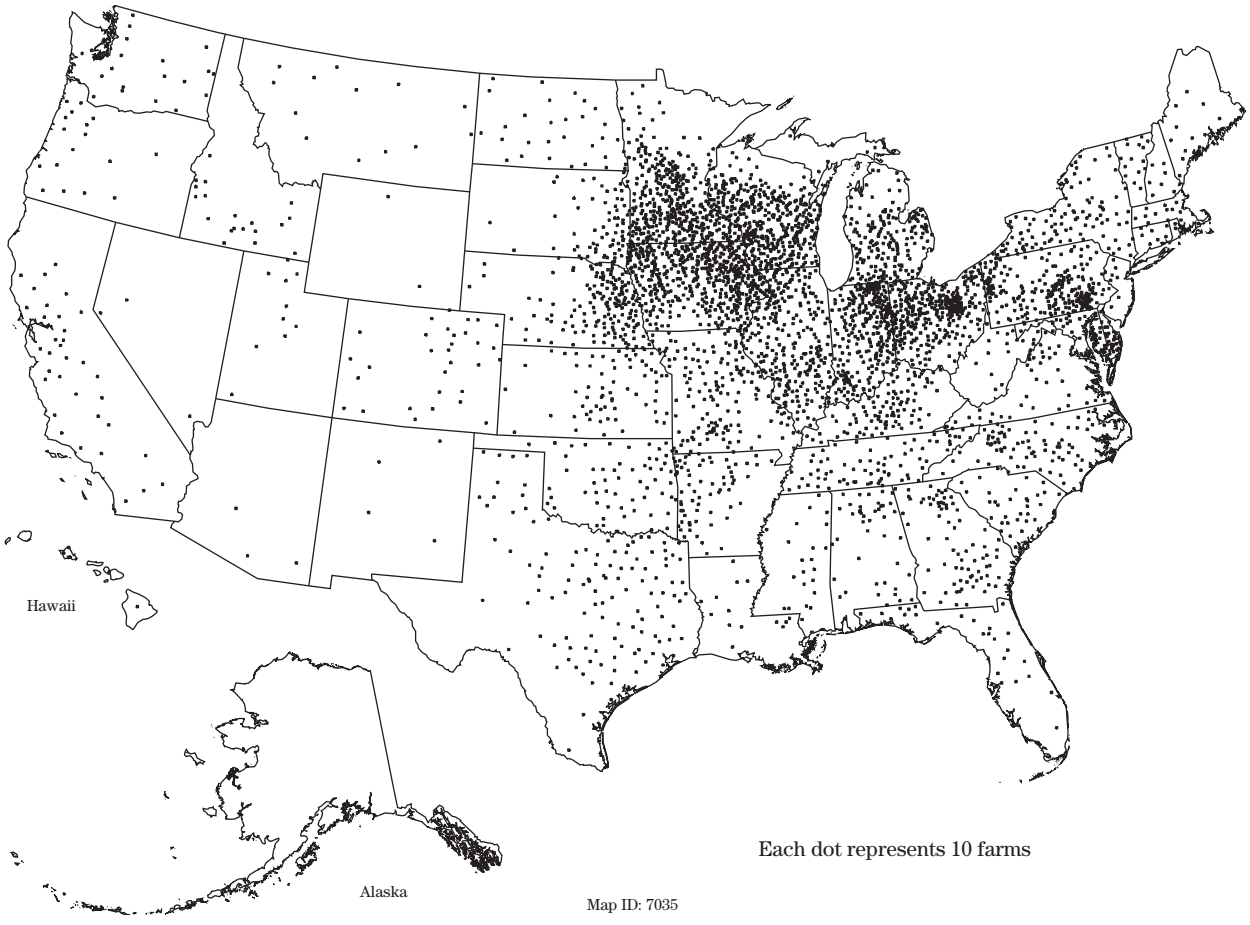
West Coast—#2: pasture with windbreak/shelterbelt (2,423 farms)

Small farms with confined livestock types. Farms with less than 35 AU where confined livestock types were dominant (42,565 farms) were judged to be too diverse with respect to the type of production technologies employed in producing livestock to apply an approach to estimating CNMP needs based on representative farms. They generally also have a more diverse collection of livestock types. These small farms tend to use small lots and pastured environments to a greater extent than larger farms. Furthermore, CNMPs for these smaller farms would likely address only a subset of the components that would be addressed for larger farms, focusing on situations and practices associated with environmental impacts. The spatial distribution of these small farms is shown in figure 11. Manure and wastewater handling and storage costs for this group of farms were based on costs derived for small dairies (see section Manure and Wastewater Handling and Storage Costs).

Approach used to determine per-unit costs

Per-unit costs are the costs for specific equipment, installed structures, or activities that are needed to meet CNMP criteria. Most per-unit cost estimates were based on economic studies reported in the literature or on costs compiled in the NRCS Field Office Technical Guides. Per-unit costs from these sources often vary, reflecting regional differences in costs or differences

Figure 11 CNMP farms with less than 35 animal units of milk cows, swine, poultry, or fattened cattle (42,565 farms)



in how livestock operations are managed. The approach taken in this study was to select or derive per-unit cost values that would generally be representative of the livestock industry as a whole, and avoid per-unit cost estimates that were specific to a small set of operations. An effort was also made to keep per-unit costs consistent among the various items and activities so that differences in CNMP-related costs would be clearly attributable to differences in CNMP needs among livestock operations. The resulting cost estimates for a particular farm as estimated in this study are therefore not expected to correspond exactly to observed CNMP-related costs for individual operations. It is expected, however, that per-farm cost estimates overall will be reasonable approximations of the average CNMP costs for a group of livestock operations.

For the most part, per-unit cost estimates used in this study correspond to prices for the period 1995 to 2000. Wherever possible, per-unit costs were taken from the most recent sources. When older sources were all that were available, costs were converted to the year 2000 prices.

Conventions were adopted for per-unit costs related to labor and capital investment. The per-unit cost for labor was set at $10 per hour for all activities. The $10 per hour labor rate is intended to represent a low-skill, full time permanent employee's salary. Many of the smaller livestock operations, however, will not employ hired labor, and the activities will be performed by the operator who could have a much higher opportunity cost for time than $10 per hour.

All costs reported in the paper are annual costs. Capital costs for equipment and installed structures were converted to annual costs by amortizing the total cost over a 10-year period assuming a discount rate of 8 percent. To the extent that livestock operations receive subsidies from government programs to purchase or finance capital investment, the CNMP costs estimated in this study will be somewhat overstated.

Economies of scale are expected for most per-unit costs. Larger operations often can conduct an activity for less cost per animal unit than smaller operations. Adjustments were made for economies of scale in the per-unit cost estimates used in the study where there was a reasonable basis for making the adjustment.

Reporting results

This cost assessment was designed to provide estimates of CNMP-related costs at the national and regional level and for major livestock production regions. Whereas estimates of manure production and acres needed for manure application are reasonable estimates at the county level, the assumptions and information pertaining to CNMP needs and costs are too generalized to provide cost estimates at the county or even the state level. Extrapolation of CNMP cost estimates to states and counties is therefore not an appropriate application of the cost assessment.

CNMP cost estimates are summarized and reported by dominant livestock type, by farm size, and by the 10 USDA farm production regions.

Three size classes of farms were derived based on the amount of manure phosphorus produced on each farm. Farms producing more than 10 tons (20,000 pounds) of manure phosphorus annually were categorized as large farms, shown in figure 12. Farms producing 4 to 10 tons (8,000 to 20,000 pounds) of manure phosphorus annually were categorized as medium farms, shown in figure 13. Farms with less than 4 tons of manure phosphorus were categorized as small farms. The number of CNMP farms by farm size and dominant livestock type is presented in table 6. The set of large farms includes most of the census farms identified in appendix A as potential concentrated animal feeding operations (CAFOs) with more than 1,000 EPA animal units, plus additional farms that produce an equivalent amount of manure nutrients. The 4-ton limit used to define the set of medium-size farms corresponds roughly to the 300 EPA animal unit threshold. (A comparison to the EPA size class categories is presented in appendix C.)

States and CNMP farm counts corresponding to the 10 farm production regions are shown in table 7.

Maps of county-level estimates of farm counts, acres required for land application, and recoverable manure nutrients are also presented in this publication. Since these variables were calculated directly from data elements in the Census of Agriculture or the NRI, it is appropriate to present these data at the county level. Dots are used in these maps to represent the number of farms, acres, or amount of manure nutrients. For

example, each dot in most of the farm count maps represents 10 farms. In constructing the maps, the dots are distributed randomly throughout the county. Residuals for each county are combined with residuals for other counties and assigned to a county using a ranking system. Some counties with variable values less than the limit represented by the dot appear to have zero farms, acres, or recoverable manure.

The farm-level Census of Agriculture data are protected to assure the confidentiality of respondents. All estimates reported in this paper conform to disclosure criteria.

Table 6 Number of CNMP farms by dominant livestock type and farm size class*

Livestock operations	All farms	Large farms (>10 tons manure P)	Medium-size farms (4–10 tons manure P)	Small farms (<4 tons manure P)
Farms with more than 35 AU of the dominant livestock type				
Fattened cattle	10,159	2,372	3,248	4,539
Milk cows	79,318	2,798	7,650	68,870
Swine	32,955	3,560	8,654	20,741
Turkeys	3,213	2,685	460	68
Broilers	16,251	5,032	8,773	2,446
Layers/pullets	5,326	1,376	2,336	1,614
Confined heifers/veal	4,011	317	710	2,984
Small farms with confined livestock types dominant	42,565	0	91	42,474
Farms with pastured livestock types dominant	61,272	1,606	7,515	52,151
All CNMP farms	255,070	19,746	39,437	195,887
Percent of all CNMP farms	100	8	15	77

* Excludes specialty livestock farms.
Note: Farm size classes are based on the total amount of manure phosphorus *as excreted* produced on each farm annually.

Table 7 States and number of CNMP farms corresponding to USDA Farm Production Regions

Farm production region	States	All CNMP farms	--Large farms--		Medium-size farms		--Small farms --	
		#	#	%	#	%	#	%
Appalachia States	Tennessee, Kentucky, West Virginia, North Carolina, Virginia	22,899	2,992	13.1	4,546	19.9	15,361	67.1
Corn Belt States	Iowa, Illinois, Missouri, Indiana, Ohio	71,540	3,094	4.3	9,190	12.8	59,256	82.8
Delta States	Arkansas, Louisiana, Mississippi	12,352	2,035	16.5	3,900	31.6	6,417	52.0
Lake States	Minnesota, Wisconsin, Michigan	52,817	1,155	2.2	3,358	6.4	48,304	91.5
Mountain States	Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico	7,964	1,226	15.4	1,745	21.9	4,993	62.7
Northeast States	Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, Delaware, Maryland	31,598	1,016	3.2	2,872	9.1	27,710	87.7
Northern Plains States	North Dakota, South Dakota, Nebraska, Kansas	26,309	2,230	8.5	5,226	19.9	18,853	71.7
Pacific States	Washington, Oregon, California, Hawaii, Alaska	7,974	1,982	24.9	1,682	21.1	4,310	54.1
Southeast States	Alabama, Georgia, South Carolina, Florida	12,807	2,532	19.8	4,392	34.3	5,883	45.9
Southern Plains States	Oklahoma, Texas	10,941	1,484	13.6	2,526	23.1	6,931	63.3
All regions		257,201	19,746	7.7	39,437	15.3	198,018	77.0

Note: Large farms are farms that produce more than 10 tons of manure phosphorus *as excreted* annually, medium-size farms produce 4 to 10 tons annually, and small farms produce less than 4 tons annually.

Figure 12 CNMP farms that produce more than 10 tons of phosphorus per year (19,746 farms)

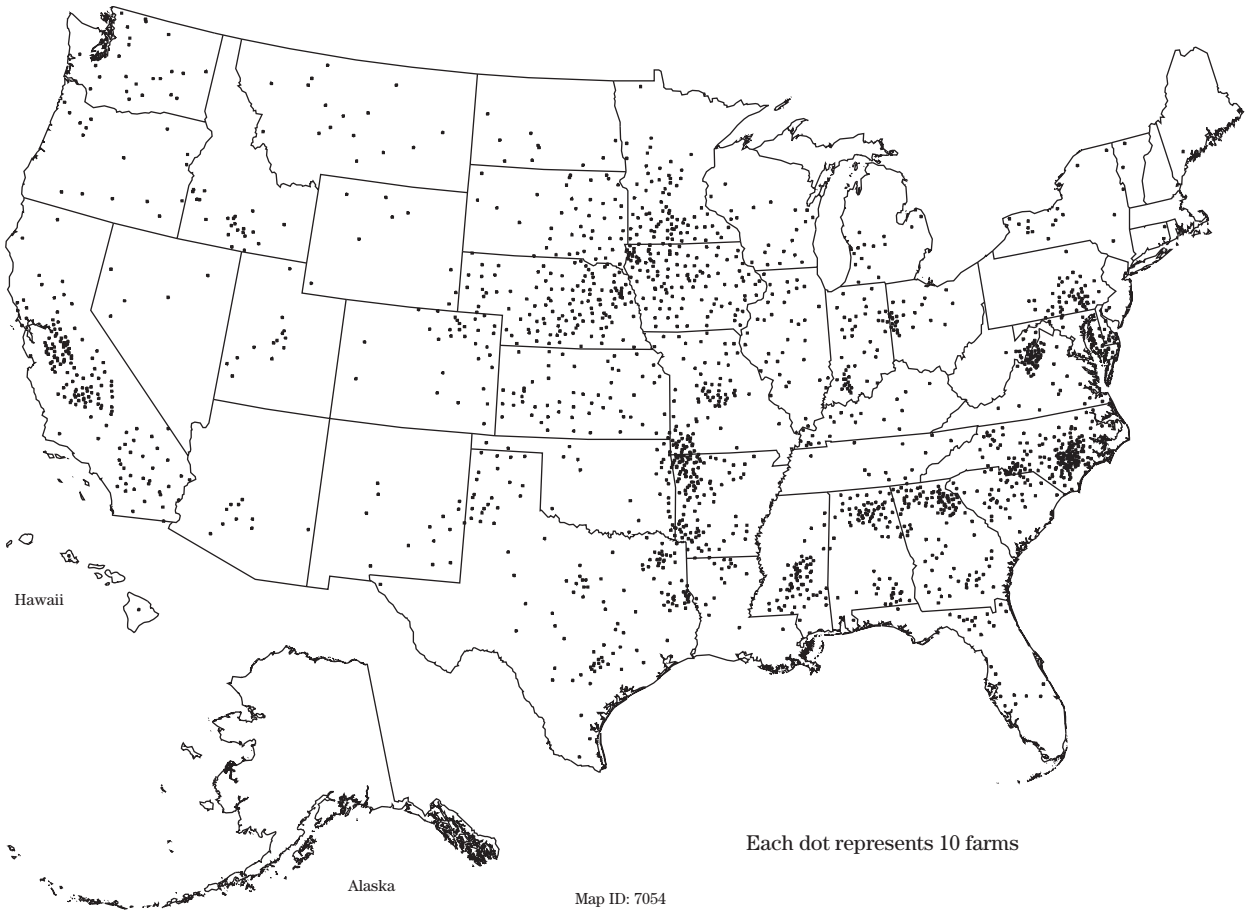


Figure 13 CNMP farms that produce 4 to 10 tons of phosphorus per year (39,437 farms)