



LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Developing Livestock Facility Type Information from USDA Agricultural Census Data for Use in Epidemiological and Economic Models

Carl Melius, Alix Robertson, Pam Hullinger

November 10, 2006

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Developing Livestock Facility Type Information from USDA Agricultural Census Data for Use in Epidemiological and Economic Models



Homeland
Security

October 2006

*Carl Melius**

Alix Robertson

Pam Hullinger

UCRL-TR-XXXXXX

*925-422-3753, melius1@llnl.gov

Lawrence Livermore National Laboratory
P.O. Box 808 · Livermore, CA 94551-0808

Developing Livestock Facility Type Information from USDA Agricultural Census Data for Use in Epidemiological and Economic Models

Executive Summary

The epidemiological and economic modeling of livestock diseases requires knowing the size, location, and operational type of each livestock facility within the US. At the present time, the only national database of livestock facilities that is available to the general public is the USDA's 2002 Agricultural Census data, published by the National Agricultural Statistics Service (http://www.nass.usda.gov/Census_of_Agriculture), herein referred to as the "NASS data." The NASS data provides facility data at the county level for various livestock types (i.e., beef cows, milk cows, cattle on feed, other cattle, total hogs and pigs, sheep and lambs, milk goats, and angora goats). However, the number and sizes of facilities for the various livestock types are not independent since some facilities have more than one type of livestock, and some livestock are of more than one type (e.g., "other cattle" that are being fed for slaughter are also "cattle on feed"). In addition, any data tabulated by NASS that could identify numbers of animals or other data reported by an individual respondent is suppressed by NASS and coded with a "D."

To be useful for epidemiological and economic modeling, the NASS data must be converted into a unique set of facility types (farms having similar operational characteristics). The unique set must not double count facilities or animals. At the same time, it must account for all the animals, including those for which the data has been suppressed. Therefore, several data processing steps are required to work back from the published NASS data to obtain a consistent database for individual livestock operations.

This technical report documents data processing steps that were used to convert the NASS data into a national livestock facility database with twenty-eight facility types. The process involves two major steps. The first step defines the rules used to estimate the data that is suppressed within the NASS database. The second step converts the NASS livestock types into the operational facility types used by the epidemiological and economic model.

Comparison of the resulting database with an independent survey of farms in central California shows excellent agreement between the numbers of farms for the various facility types. This suggests that the NASS data are well suited for providing a consistent set of county-level information on facility numbers and sizes that can be used in epidemiological and economic models.

1. Introduction

With funding from DHS, Lawrence Livermore National Laboratory (LLNL), in collaboration with several academic and federal partners, is developing a nationwide, coupled epidemiological and economic model to analyze potential response strategies to an outbreak of foot-and-mouth disease in US livestock. The model has been designed to simulate disease transmission, while simultaneously accounting for costs due to disease control measures, such as vaccination, slaughter, and livestock movement restrictions. The model simulates disease transmission and costs of control acting on individual livestock operations.

The epidemiological and economic modeling of livestock diseases requires knowledge of the operation type and size of each individual facility. At the present time, the only national database of livestock operations that is available to the general public is the published data from the 2002 Agricultural Census, referred to as the “NASS data.” The NASS data provides facility data at the county level for various livestock types (i.e., beef cows, milk cows, cattle on feed, other cattle, total hogs and pigs, sheep and lambs, milk goats, and angora goats). However, the number and sizes of facilities for the various livestock types are not independent since some facilities have more than one type of livestock, and some livestock are of more than one type (e.g., “other cattle” that are being fed for slaughter are also “cattle on feed”). In addition, any data tabulated by NASS that could identify numbers of animals or other data reported by an individual respondent is suppressed by NASS and coded with a “D.”

Thus, several data processing steps are required to work back from the published data to obtain a representative national database for individual livestock operations. First, estimation steps are needed to replace data that have been suppressed in the NASS data. Then, the NASS livestock types must be converted into a set of distinct and non-overlapping types of livestock operation that can be used by the epidemiological and economic model.

This technical report documents the data processing steps that were used by LLNL to develop a national database of livestock facilities by county location for use in epidemiological and economic simulations. The report is organized into six sections. Section 2 defines the steps used to access the NASS data, and describes the structure of the single database that was compiled from the various NASS data files. Section 2 also presents the rules that were used to estimate the data that are suppressed and coded with a “D” in the NASS tables. Section 3 presents the steps used to define the unique operational facility types that are used by the epidemiological and economic model. Section 4 presents a summary of the resulting national database, including the total number of livestock facilities of each type in the US, and livestock density maps by county location. Section 5 compares the database derived from the NASS data with an independent survey of livestock in the Fresno/Kings/Tulare tri-county region of California. Section 6 discusses additional data comparisons and other directions for future work.

2. NASS data

This section defines the steps used to access the NASS data, and describes the structure of the single database that was compiled from the various NASS data files. This section also presents the rules that were used to estimate the data that are suppressed and coded with a “D” in the NASS tables.

2.1 NASS data description

The NASS data constitute a consistent set of farm and livestock data for each county in the United States. The NASS data are presented in tables as follows:

- Rows report data by county.
- Columns report data by number and type of livestock.
- Columns are organized into pairs: the first column in each pair reports the number of farms, and the second column reports the number of animals, for the number and type of livestock.

The NASS data includes both inventory and sales of livestock. Inventory is reported as the number of livestock of each type that was present on December 31, 2002, and sales is reported as the number of livestock of each type that was sold during the 2002 calendar year. LLNL used the NASS inventory data to derive a national database for use in epidemiological and economic models..

The NASS inventory data are reported by county location in over 200 files, including one file for each of the major livestock species (cattle, swine, sheep, and goats) in each of the 50 US states. LLNL downloaded these 200+ files individually from the USDA National Agricultural Statistics Service (NASS) website, www.usda.nass.gov, and compiled them into the single file, AgCensus2002DataLivestock.csv. Table 1 lists the categories for number and type of livestock that are compiled into the file AgCensus2002DataLivestock.csv. Table 1 also lists the total number of US farms for each of these livestock categories.

NASS provides a more detailed breakdown of livestock types at the state level than at the county level. In particular, NASS provides information of stages of swine operations at the state level that is not made available by county location. These data are reported in some 50 files, one for each state. As an example of NASS data that are reported at the state level, Table 2 shows the NASS data for numbers of swine in California by type and size of swine facility.

Table 1 - Numbers of US farms by type and size categories reported by NASS

NASS farm category (defined by type and number of livestock present)	Number of US farms
Cattle and calves (farms, 2002)	1,018,359
Cattle and calves \ Farms by inventory \ 1 to 9 (farms, 2002)	211,030
Cattle and calves \ Farms by inventory \ 10 to 19 (farms, 2002)	189,193
Cattle and calves \ Farms by inventory \ 20 to 49 (farms, 2002)	271,202
Cattle and calves \ Farms by inventory \ 50 to 99 (farms, 2002)	153,618
Cattle and calves \ Farms by inventory \ 100 to 199 (farms, 2002)	103,513
Cattle and calves \ Farms by inventory \ 200 to 499 (farms, 2002)	62,774
Cattle and calves \ Farms by inventory \ 500 or more (farms, 2002)	27,029
Cattle and calves \ Cows and heifers that had calved (farms, 2002)	864,823
Cattle and calves \ Cows and heifers that had calved \ Beef cows (farms, 2002)	796,436
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 1 to 9 (farms)	239,452
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 10 to 19 (farms)	178,038
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 20 to 49 (farms)	215,320
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 50 to 99 (farms)	89,874
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 100 to 199 (farms)	45,354
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 200 to 499 (farms)	23,126
Cattle and calves \ Cows and heifers that had calved \ Beef cows \ 2002 farms by inventory \ 500 or more (farms)	5,272
Cattle and calves \ Cows and heifers that had calved \ Milk cows (farms, 2002)	91,989
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 1 to 9 (farms)	21,016
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 10 to 19 (farms)	5,270
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 20 to 49 (farms)	21,974
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 50 to 99 (farms)	25,465
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 100 to 199 (farms)	10,816
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 200 to 499 (farms)	4,546
Cattle and calves \ Cows and heifers that had calved \ Milk cows \ 2002 farms by inventory \ 500 or more (farms)	2,902
Cattle and calves \ Cattle on feed (see text) (farms, 2002)	80,743
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 1 to 9 (farms)	30,409
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 10 to 19 (farms)	13,778
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 20 to 49 (farms)	14,552
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 50 to 99 (farms)	9,207
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 100 to 199 (farms)	5,889
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 200 to 499 (farms)	4,139
Cattle and calves \ Cattle on feed (see text) \ 2002 farms by inventory \ 500 or more (farms)	2,769
Cattle and calves \ Other cattle (see text) (farms, 2002)	875,850
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 1 to 9 (farms)	348,102
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 10 to 19 (farms)	173,744
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 20 to 49 (farms)	183,102
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 50 to 99 (farms)	84,287
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 100 to 199 (farms)	45,719
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 200 to 499 (farms)	27,595
Cattle and calves \ Other cattle (see text) \ 2002 farms by inventory \ 500 or more (farms)	13,301
Total hogs and pigs (farms, 2002)	78,895
Total hogs and pigs \ Farms by inventory \ 1 to 24 (farms, 2002)	38,303
Total hogs and pigs \ Farms by inventory \ 25 to 49 (farms, 2002)	5,650
Total hogs and pigs \ Farms by inventory \ 50 to 99 (farms, 2002)	4,682
Total hogs and pigs \ Farms by inventory \ 100 to 199 (farms, 2002)	4,611
Total hogs and pigs \ Farms by inventory \ 200 to 499 (farms, 2002)	7,755
Total hogs and pigs \ Farms by inventory \ 500 to 999 (farms, 2002)	6,010
Total hogs and pigs \ Farms by inventory \ 1,000 or more (farms, 2002)	11,884
Total hogs and pigs \ Hogs and pigs used or to be used for breeding (farms, 2002)	39,367
Total hogs and pigs \ Hogs and pigs used or to be used for breeding \ 2002 farms by inventory \ 1 to 24	24,794
Total hogs and pigs \ Hogs and pigs used or to be used for breeding \ 2002 farms by inventory \ 50 to 99	3,660
Total hogs and pigs \ Other hogs and pigs (farms, 2002)	71,923
Sheep and lambs inventory (see text) (farms, 2002)	73,814
Sheep and lambs inventory (see text) \ 2002 farms by inventory \ 1 to 24 (farms)	44,562
Sheep and lambs inventory (see text) \ 2002 farms by inventory \ 25 to 99 (farms)	20,694
Sheep and lambs inventory (see text) \ 2002 farms by inventory \ 100 to 299 (farms)	5,670
Sheep and lambs inventory (see text) \ 2002 farms by inventory \ 300 to 999 (farms)	1,995
Sheep and lambs inventory (see text) \ 2002 farms by inventory \ 1,000 or more (farms)	893
Sheep and lambs inventory (see text) \ Ewes 1 year old or older (farms, 2002)	66,769
Milk Goats Inventory Farms	22,389
Goats-Angora-Farms	1,756

Source: USDA NASS

Table 2 - Numbers of swine in California by facility type and size as reported by NASS

Herd size	Farrow to wean Farms	Farrow to wean Number	Farrow to finish Farms	Farrow to finish Number	Finish only Farms	Finish only Number	Farrow to feeder Farms	Farrow to feeder Number	Nursery Farms	Nursery Number
Any	207	9,034	439	125,014	431	4,570	255	24,290	3	72
1 to 24	147	1,373	332	2,136	404	2,081	181	1,305	3	72
25 to 49	26	(D)	34	1,161	13	447	29	986	-	-
50 to 99	16	1,037	26	1,947	6	382	21	1,434	-	-
100 to 199	8	973	23	2,955	3	360	15	(D)	-	-
200 to 499	9	3,256	11	3,348	5	1,300	6	1,985	-	-
500 to 999	-	-	5	3,663	-	-	2	(D)	-	-
1,000 to 1,999	1	(D)	3	4,120	-	-	-	-	-	-
2,000 to 4,999	-	-	2	(D)	-	-	-	-	-	-
5,000 or more	-	-	3	(D)	-	-	1	(D)	-	-
5,000 to 7,499	-	-	1	(D)	-	-	-	-	-	-
7,500 or more	-	-	2	(D)	-	-	1	(D)	-	-

The following footnotes, headnotes, abbreviations and symbols are used throughout this table:

(D) Withheld to avoid disclosing data for individual farms.

- Represents zero.

Farm counts and inventories may be included in more than one operation type.

2.2 Process to develop estimates for suppressed data

Certain entries of the NASS data for number of animals are suppressed and coded as “D” in order to protect confidential business information. The process that was used to estimate the suppressed data is described by the following three steps:

Step 1: Develop estimates for county totals

Estimates were first developed within each of the NASS livestock categories that are reported at the county level. These categories are listed in Table 1. As an example, one category reported at the county level is “Cattle and calves \ Cows and heifers that had calved \ Beef cows):

First, for a given type of livestock and herd size category of bounded range (i.e., 1-9, 10-19, ..., 200-499, but excluding the largest size range, which is unbounded)^a:

- 1.1 Check if the state total for that size facility is available. If so, assign missing data to the difference of the state total and the sum of known county data. If data are missing for more than one county in the state, assign numbers of animals to counties proportional to number of farms having missing data.
- 1.2 If state total is missing, assign the average herd size to be the midpoint of the size range.

Next, for the largest size range (no mid-range value available, since size range is unbounded):

^a The largest NASS size categories are 500 or more head for cattle and 1,000 or more head for swine and sheep (cf. Table 1).

- 1.3 Check if the county total is available for the sum of all size categories. If so, assign missing data to difference of total number of animals for all farms in the county and numbers of animals for farms in the county that are in smaller size categories (smaller sizes should now be defined due to the previous step). If the resulting size is less than the minimum of the range, assign the minimum value.
- 1.4 If the county total for the sum of all size categories is missing, check if the state total is available for the livestock type and herd size category. If so, assign missing data to the difference of the state total and the sum for counties reporting livestock inventory. If data are missing for multiple counties, assign animals to these counties proportional to the number of farms of the type and size in each of the counties.^b
- 1.5 If the state total for the largest size category is missing, assign the missing data to be twice the minimum size of the range. Note that this is a “last resort” procedure. Fortunately, state totals for large farms were reported for most states with major livestock production (Table 3).^c

Step 2: Fix the sum of the size subcategories

For each county, reassign the total number of animals for a given category to be the sum of the individual size subcategories (e.g., the sum of subcategories with 1-9, 10-19, ..., and 500+ animals). Note that Step 1.3 above reduces the likelihood that the sum will change significantly, if the sum had already been reported in the NASS tables.

Step 3: Fix the state and US data

For each of the size subcategories as well as for the livestock category as a whole, sum over all of the counties in the state and reassign the total for the given state. Then sum over the states to obtain the total for the US.

^b Step 1.4 for the largest size category is analogous to step 1.1 used for the smaller size categories.

^c Step 1.5 for the largest size category is analogous to step 1.2 used for the smaller size categories, except that no mid-range exists.

Table 3 – Numbers of animals reported by NASS for farms in the largest size category

State	Cattle	Beef cows	Milk cows	Cattle on feed	Other cattle	Hogs and pigs	Sheep and lambs
Alabama	247,918	40,928	5,033	(D)	91,046	145,632	-
Alaska	7,913	(D)	-	-	(D)	-	-
Arizona	703,116	65,994	150,659	287,800	437,786	(D)	105,809
Arkansas	270,645	37,176	(D)	(D)	127,158	247,951	-
California	4,438,463	252,744	1,434,748	519,074	2,298,114	126,594	589,507
Colorado	1,857,830	151,036	75,316	1,062,357	1,437,244	720,279	312,286
Connecticut	14,897	-	3,580	(D)	(D)	-	-
Delaware	3,723	-	(D)	-	(D)	7,388	-
Florida	918,365	427,147	116,235	-	193,702	(D)	(D)
Georgia	221,636	21,011	33,859	-	77,636	271,607	(D)
Hawaii	115,668	58,338	6,341	(D)	43,061	5,312	(D)
Idaho	1,371,120	139,471	318,022	299,971	731,976	8,591	211,148
Illinois	244,071	5,003	11,883	124,366	171,508	3,352,399	(D)
Indiana	121,750	1,850	40,930	16,804	54,612	2,820,959	(D)
Iowa	1,063,408	27,236	33,566	606,648	823,391	13,263,736	43,787
Kansas	3,813,504	124,521	70,262	2,223,850	3,223,386	1,374,702	13,295
Kentucky	278,048	19,454	(D)	2,650	151,562	304,354	-
Louisiana	147,203	53,869	2,547	-	20,342	5,286	-
Maine	16,996	-	3,999	(D)	3,879	-	-
Maryland	35,118	-	9,039	(D)	10,761	(D)	(D)
Massachusetts	4,128	-	(D)	-	(D)	(D)	-
Michigan	311,090	(D)	84,103	66,120	132,801	780,267	12,779
Minnesota	420,141	8,642	52,781	150,763	249,393	5,534,015	14,445
Mississippi	182,457	29,099	2,660	-	95,096	285,858	-
Missouri	694,764	91,157	6,464	28,096	328,829	2,493,691	-
Montana	1,200,925	446,640	(D)	52,884	402,647	149,671	109,767
Nebraska	3,930,038	461,513	22,131	2,173,979	2,906,115	2,329,322	11,625
Nevada	358,020	156,713	23,734	19,463	111,014	(D)	67,917
New Hampshire	6,587	-	(D)	-	(D)	-	-
New Jersey	3,815	-	(D)	-	-	5,952	-
New Mexico	1,157,022	176,068	308,530	126,950	512,933	-	114,482
New York	419,167	-	153,036	10,010	129,718	51,194	6,847
North Carolina	95,869	9,760	9,800	-	30,699	9,803,370	-
North Dakota	526,552	59,899	4,471	30,069	173,834	92,530	20,300
Ohio	185,347	4,222	25,570	45,591	94,194	1,024,696	8,684
Oklahoma	1,971,772	163,279	25,702	343,350	1,432,604	2,183,182	(D)
Oregon	795,957	209,255	61,128	71,226	346,232	(D)	96,476
Pennsylvania	179,608	-	33,678	20,608	80,720	971,534	5,100
Rhode Island	-	-	-	-	-	-	-
South Carolina	60,419	6,949	3,235	(D)	15,621	251,158	-
South Dakota	1,643,475	282,618	21,242	276,715	760,971	1,123,301	116,338
Tennessee	237,377	17,112	5,594	-	125,104	160,466	-
Texas	6,842,905	836,077	184,149	2,644,450	4,825,394	856,624	534,372
Utah	429,949	91,070	39,941	33,363	181,730	659,169	233,579
Vermont	84,865	-	27,337	(D)	20,026	-	(D)
Virginia	280,996	22,493	8,321	16,218	115,769	387,054	3,764
Washington	650,052	47,893	150,214	197,095	360,275	13,564	11,990
West Virginia	34,191	1,685	(D)	1,840	11,776	(D)	-
Wisconsin	620,750	3,120	160,052	19,178	218,625	278,781	3,531
Wyoming	795,410	282,748	-	69,121	307,901	104,635	363,422

Steps 1 through 3 are applied to each of the livestock categories within the NASS data, i.e., beef cows, milk cows, cattle on feed, other cattle, total hogs and pigs (but not swine used for breeding, which was not used), sheep and lambs, milk goats, and Angora goats.

To illustrate the procedure, Table 4 presents estimates for suppressed data for cattle in Fresno County, California. These estimates were calculated as follows:

1. The inventory of cattle on feed was estimated for three large feedlots in Fresno County using California state and county data for cattle on feed in large feedlots. Based on the difference between state and reported county inventories, there was an average of 11,718 cattle on feed for each of fourteen feedlots in California for which livestock inventories were suppressed. Since there were three large feedlots in Fresno County, the estimated number of cattle on feed in Fresno County was 35,154.
2. Similarly the numbers of milk cows on small farms (in the subcategories of farms with 1-9 and 20-49 milk cows) were calculated based on the difference of state and reported county totals for numbers of farms and numbers of milk cows on farms in these size ranges.

Table 4 - Numbers of cattle in Fresno, California as reported by NASS and with suppressed data replaced by estimates

Farm size / type	Milk cows	Beef cows	Cattle on feed	"Other cattle"
Number of animals reported by NASS				
1 to 9	(D)	1,348	87	1,358
10 to 19	146	1,339	45	1,594
20 to 49	(D)	2,805	-	1,797
50 to 99	184	2,201	-	2,162
100 to 199	986	3,112	-	3,925
200 to 499	10,386	7,726	-	11,798
500 or more	78,757	4,891	(D)	259,913
all	90,550	23,422	(D)	282,547
Number of animals reported by NASS with suppressed data replaced by estimates				
1 to 9	46	1,348	87	1,358
10 to 19	146	1,339	45	1,594
20 to 49	22	2,805	-	1,797
50 to 99	184	2,201	-	2,162
100 to 199	986	3,112	-	3,925
200 to 499	10,386	7,726	-	11,798
500 or more	78,757	4,891	35,151	259,913
all	90,527	23,422	35,283	282,547

3. Redefining types of farm facilities

This section presents the steps that were used to define the unique operational facility types that are used by the epidemiological and economic model. These steps also define estimates for the size of individual operations of each type. A separate process was used to define unique operational facilities for each of the major livestock types. Section 3.1 reports steps used for defining cattle facilities, Section 3.2 reports steps for defining swine facilities, Section 3.3 reports steps for defining sheep facilities, and Section 3.4 reports steps for defining facilities with goats.

3.1 Redefining types of cattle facilities

The NASS data for cattle were redefined based on the following observations on the NASS data.

1. The NASS data divides all cattle and calves into three distinct types:
 - a. milk cows,
 - b. beef cows, and
 - c. other cattle.
2. The “other cattle” type includes calves and replacement heifers on dairy ranches; calves, bulls, and heifers on cow-calf operations; and steers and heifers on feedlots.
3. NASS also reports cattle on feed. These are cattle that were fed for direct shipment to slaughter on the survey date of December 31, 2002. Most cattle on feed are steers and heifers, all of whom are “other cattle,” i.e., cattle other than beef cows and milk cows. Therefore “cattle on feed” is a subset of “other cattle.”
4. There is overlap in farm types since, e.g., farms that have dairy cows may also have other cattle including dairy replacement heifers and calves.
5. NASS further divides cattle farms in each category into size ranges of 1-9, 10-19, 20-49, 50-99, 100-199, 200-499, and 500 or more cattle of the specified type.
6. The meaning of farm size category depends on the type of livestock. For example, a beef cow-calf operation with 20 cows, 17 calves, and one bull belongs to both of the following size subcategories:
 - a. 20 to 49 beef cows, and
 - b. 10 to 19 other cattle.
7. Due to the overlap between farm types in the NASS data, only three types of farms are distinctly identified by the reported livestock inventory:
 - a. Presence of beef cows identifies cow-calf operations, since beef cows are present on all cow-calf operations and are seldom present on either dairies or feedlots;
 - b. Presence of milk cows identifies dairies; and
 - c. Presence of large numbers of cattle on feed identifies feedlots.
8. A fourth type of farm is indirectly identified from the difference between the number of cattle farms and the sum of dairy, cow-calf, and feedlot type farms. Farms of this type (without either breeding cattle or cattle on feed) include stocker grazing operations and specialized dairy calf raisers.

Based on the above observations, the following rules were developed to redefine the NASS data for cattle. Each of the rules for defining the operational types was applied on a county by county basis, and within each size subcategory of 1-9, 10-19, 20-49, 50-99, 100-199, 200-499, and 500 or more cattle.

1. Distinct farm types were identified:
 - a. Farms with milk cows were classified as “dairies.”
 - b. Farms with cattle on feed were classified as “feedlots.”
 - c. Of the total number of cattle farms, the farms not categorized as either “dairies” or “feedlots” were categorized as “grazers.”
 - d. Farms with beef cows were classified as cow-calf operations.
2. Feedlots were removed from the category of “other cattle,” and the residual was defined as the “remaining others” category.
3. Farm sizes were resized to include all cattle assumed to be present on each farm.
 - a. Farms with milk cows (“dairies”) were resized to include one calf or replacement heifer for each milk cow. Cattle were taken from the “remaining others” category in the same size subcategory. If insufficient animals were available, all the available animals from that size subcategory were taken. Dairy farms were reassigned to the next larger size subcategory as needed when animals were added. Farms in the “remaining others” category were reassigned to the next smaller size subcategory, as needed, when animals were removed.
 - b. Farms with beef cows (“cow calf” operations) were resized to include 0.5 other cattle for each beef cow, and these cattle were subtracted from the “remaining others.” Beef cow calf farms were reassigned to the next larger size subcategory as needed when animals were added. Farms in the “remaining others” category were reassigned to the next smaller size subcategory as needed when animals were removed. The ratio of 1.5 cattle to cows was chosen to represent an annual average for the number of calves that would be present on cow-calf operations, based on calf weaning at six months.
4. The “grazers” category was subdivided into “cow/calf,” “stocker,” and “dairy calf ranch” categories.
 - a. Stockers were taken to be the remainder of the “grazers” that were not “cow/calf” operations. If the number of stocker operations produced by the subtraction was less than zero, it was set to zero. This happened occasionally for the small herds, and is possibly due to the fact that small herds tend to have multiple types of cattle grazing and feeding operations.
 - b. The “stockers” category was further subdivided into “dairy calf ranch” operations (denoted “DCalfHeifer”) and remaining stockers. The number of dairy calf ranches was estimated by multiplying the number of large dairies (those with more than 500 milk cows) by the factor of seven calf ranches per 100 large dairies.

Finally, the dairy, feedlot, cow/calf, dairy calf ranch, and stocker operations were subdivided by sizes into large, medium, small, and backyard size subcategories.

1. For all facility types, the smallest size subcategory (with 1 to 9 animals of the specified type) was assigned to backyards:
 - a. Dairies with 1 to 9 animals were classified as “backyard dairy.”
 - b. Cow calf, stocker, and feedlot facilities with fewer than ten animals were all classified as “backyard beef.”
2. Farms with more than 500 animals (the maximum size range reported by NASS at the county level) were assigned to the “large” category.
3. For dairies, farms with 200 to 499 animals were assigned to the “medium” size subcategory.
4. For all facility types, farms not assigned to the large, medium, or backyard size subcategories were assigned to the “small” size subcategory.

3.2 Redefining types of swine facilities

The NASS data for swine (total hogs and pigs) were mapped into the following facility operation types: farrow to wean, nursery, farrow to feed, swine finisher, and farrow to finish. These facility operations were further subdivided into large, small, and backyard size subcategories.

The types of swine facilities were redefined based on the following observations on the NASS data.

1. The NASS data divides swine facilities into groups by stage of production. Although the NASS facility definitions allow some overlap of production stages, we assumed that the NASS data represent three stages of production that are typically non-overlapping, as follows: piglets in the “farrow to wean” stage, weaned pigs to 50-lb feeders in the “nursery” stage, feeder pigs to market hogs in the “swine finisher” stage.
2. In addition, NASS reports two types of swine operations that combine multiple stages of production. These are the “farrow to feeder” and “farrow to finish” operations.
3. NASS also reports the number of swine used for breeding. Swine used for breeding are primarily sows that are present as a small subset of the total number of swine on farms that conduct breeding along with other operations, i.e., farrow to wean, farrow to feeder, and farrow to finish farms. The NASS data does not distinguish the number of sows from the number of other swine on these facilities.
4. NASS divides the swine facilities of each type into size subcategories (1-24, 25-49, 50-99, 100-199, 200-499, 500-999, and 1000 or more swine).
5. NASS tabulates the number of farms and the number of swine for the five distinct types of swine facility: farrow to wean, nursery, farrow to feed, swine finisher, and farrow to finish. However, these data are only provided at the state level, so the county locations are withheld from the public.

Based on the above, the following rules were developed to redefine the NASS data for swine. Each of the rules for defining the operational types was applied on a county by county basis.

First, farms with swine of any kind were subdivided into large, small, and backyard size subcategories, as follows:

1. Farms with 1 to 24 swine were assigned to the “backyard” size subcategory.
2. Farms with more than 1,000 swine (the maximum size range available at the county level) were assigned to the “large” size subcategory.
3. The remaining farms were assigned to the “small” size subcategory.

Next, the swine farms in each size category were subdivided into the five operational types: farrow to wean, nursery, farrow to feed, swine finisher, and farrow to finish. The state breakdown by operation was used to estimate the breakdown at the county level, as follows:

1. The fraction of the number of farms of each type within a county was taken to be the same as that at the state level.
2. In treating small numbers of farms in a county, for breaking ties, farrow to finish gets precedence, then swine finisher, then farrow to feed, then farrow to wean, then nurseries.
3. Backyard operations were not subdivided by operational type.

3.3 Redefining types of sheep facilities

The types of sheep facilities were redefined based on the following observations on the NASS data.

1. The NASS county data tabulates the total number of sheep facilities and number of sheep in each county.
2. The NASS data divides sheep farms into size ranges of 1-24, 25-99, 100-299, 300-999, and 1,000 or more sheep present on the farm.

Based on the above, the following rules were developed to redefine the NASS data for sheep. Each of the rules for defining the operational types was applied on a county by county basis.

Farms with sheep of any kind (sheep and lambs) were subdivided into large, small, and backyard size subcategories, as follows:

1. The smallest farms (with 1 to 24 sheep) were assigned to the “backyard” size subcategory.
2. Farms with more than 1,000 sheep (the maximum size range available at the county level) were assigned to the “large” size subcategory.

3. The remaining farms were assigned to the “small” size subcategory.

3.4 Redefining types of goat facilities

The types of goat facilities were redefined based on the following observations on the NASS data.

1. The NASS data tabulates the total number of goat facilities and number of goats in various counties, but not all.
2. NASS tabulates separate data for milk goats and Angora goats.
3. NASS does not divide goat farms into size ranges.

Based on the above, the following rules were developed to redefine the NASS data for goats. Each of the rules for defining the operational types was applied on a county by county basis.

1. Milk goat and Angora goat facilities were combined into one goat facility type.
2. The combined goat facility type was subdivided into backyard and remainder.
 - a. The average backyard size was taken to be 10 goats.
 - b. The fraction of backyard goat farms to the total number of goat farms in the county was taken to be the ratio of the assumed average backyard size (10 goats) to the average goat farm size in the county.
3. The remaining goat farms not assigned to the “backyard” category were assigned to the general goat category.

4. Results

The redefinition of the NASS data resulted in twenty-eight facility types (twelve cattle, eleven swine, three sheep, and two goat). The resulting facility types, along with the total number of farms and animals within the continental US represented by each facility type, is presented in Table 5. The geographic distribution of farm animals by facility type and county location within the US is shown in Figures 1 through 5.

Table 5 – Number of farms and corresponding number of animals in the US by the twenty-eight facility types derived from the NASS 2002 Agricultural Census data

Facility Type	Farms	Animals	Size Range	Description
Dairy(L)	5,957	6,833,149	> 500	Large milk cows plus calves
Dairy(M)	9,034	2,444,784	200 - 500	Medium-size milk cows plus calves
Dairy(S)	56,642	4,641,644	10 - 200	Large milk cows plus calves
Dairy(B)	20,298	91,013	< 10	Backyard milk cows plus calves
Feedlot(L)	2,768	11,554,023	> 500	Large cattle on feed
Feedlot(S)	47,549	3,218,805	10 - 500	Small cattle on feed
CowCalf(L)	5,479	5,942,172	> 500	Large beef cows plus calves
CowCalf(S)	489,194	30,375,838	10 – 500	Small beef cows plus calves
Stocker(L)	10,611	9,065,378	> 500	Remaining cattle not beef cows, milk cows, cattle on feed. Excludes calves moved to dairies and cow/calf operations. Excludes stockers reassigned to dairy calf/heifer operations.
Stocker(S)	152,917	13,044,973	10 – 500	Remaining cattle not beef cows, milk cows, cattle on feed. Excludes calves moved to dairies and cow/calf operations.
DCalfHeifer(L)	83	1,007,064	> 500	Calf ranches, large stocker operations having large dairies in the immediate area
Beef(B)	190,727	1,543,662	< 10	Backyard beef cattle (combined cow/calf, feedlot, and stocker operations) < 10 animals
SwineFarFin(L)	3,503	15,522,560	> 1000	Large farrow to finish operations
SwineFinish(L)	5,841	24,699,233	> 1000	Large finishing operations
SwineFFeeder(L)	321	1,443,780	> 1000	Large farrow to feeder operations
SwineNursery(L)	1,361	5,896,355	> 1000	Large nursery operations
SwineFWean(L)	855	4,676,862	> 1000	Large farrow to wean operations
SwineFarFin(S)	12,490	3,417,573	25 - 1000	Small farrow to finish operations
SwineFinish(S)	11,076	3,066,792	25 - 1000	Small finishing operations
SwineFFeeder(S)	2,854	685,201	25 - 1000	Small farrow to feeder operations
SwineNursery(S)	512	188,728	25 - 1000	Small nursery operations
SwineFWean(S)	1,677	402,903	25 - 1000	Small farrow to wean operations
Swine(B)	38,153	256,378	< 25	All swine operations < 25 animals
Sheep(L)	891	3,031,163	>1000	Large sheep farms
Sheep(S)	28,325	2,911,989	25 - 1000	Small sheep farms
Sheep(B)	44,459	392,754	< 25	Backyard sheep < 25 animals
Goats	4,596	403,982	>10	All goat operations excluding backyard goats
Goats(B)	19,774	157,100	~10	Backyard goats having average of 10 or less goats

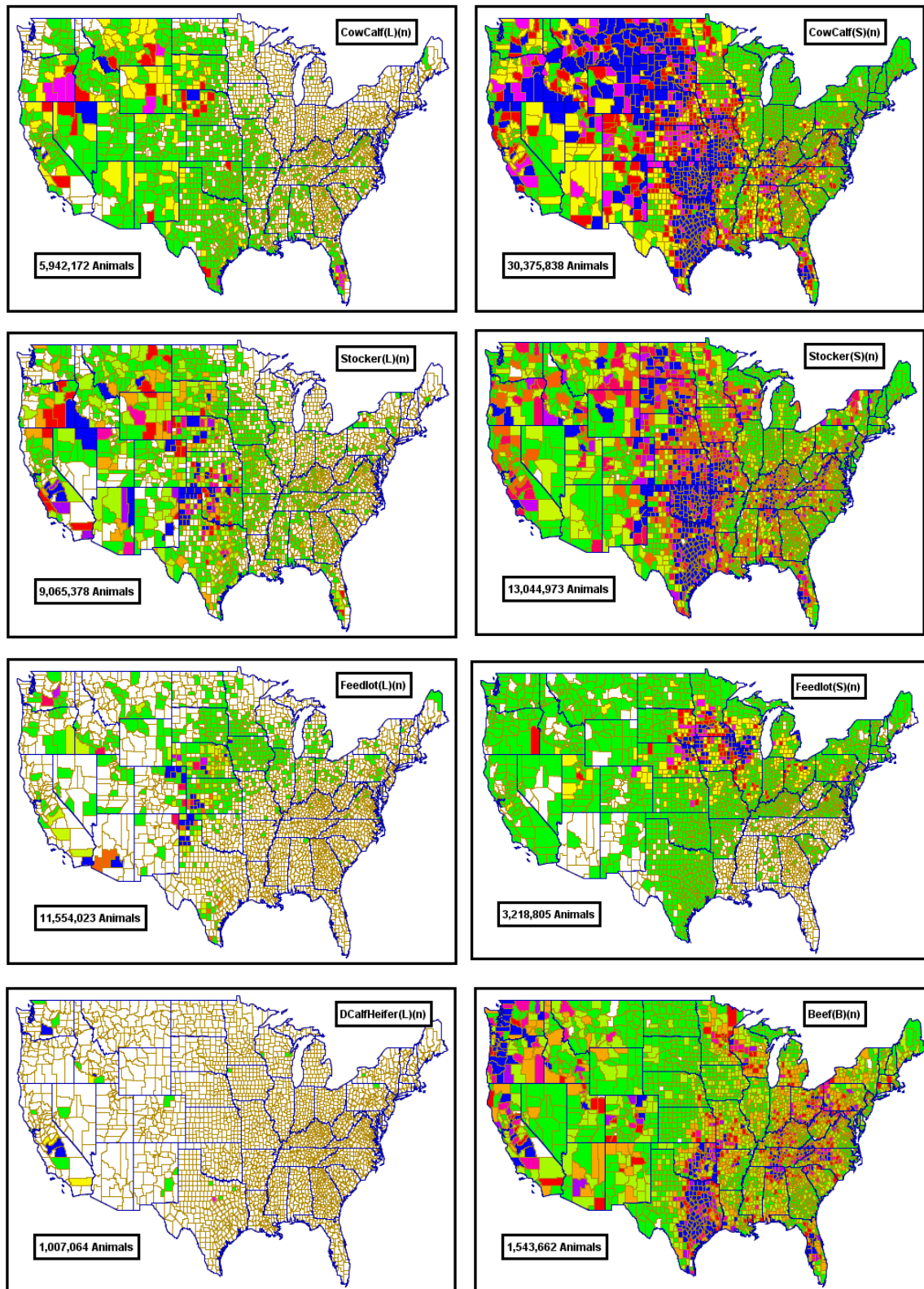


Figure 1 – Distribution of beef cattle facilities in the US (number of animals by county)

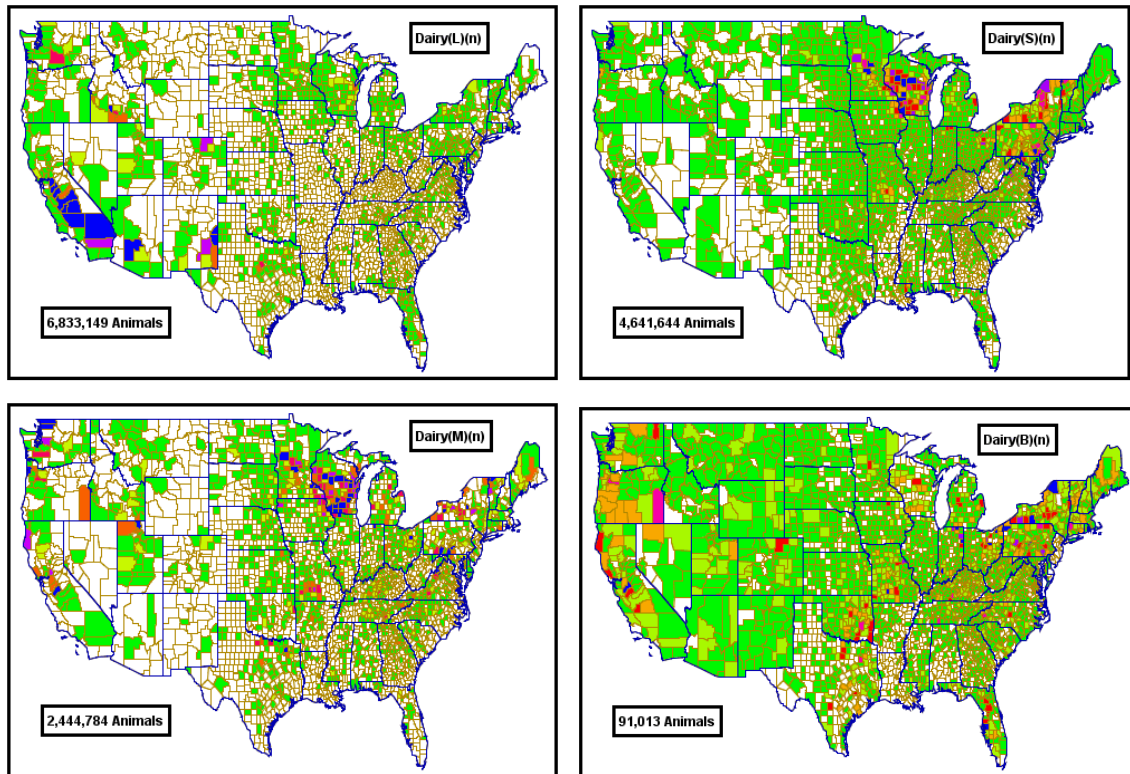
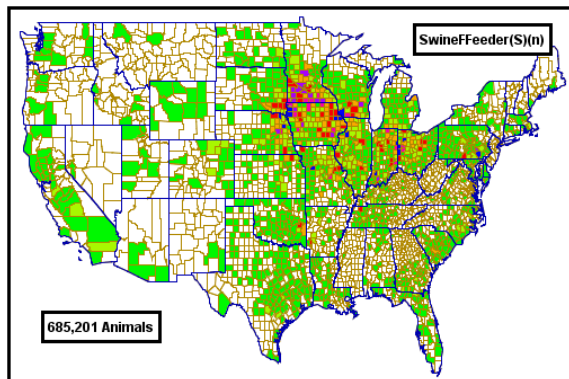
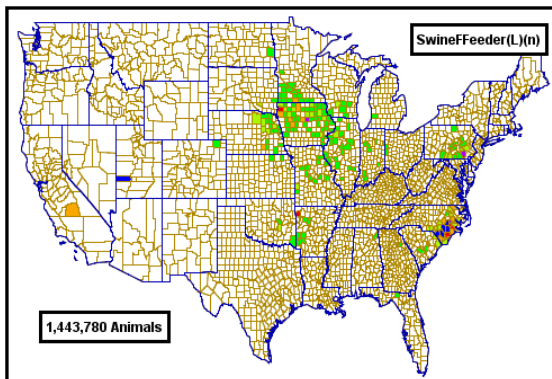
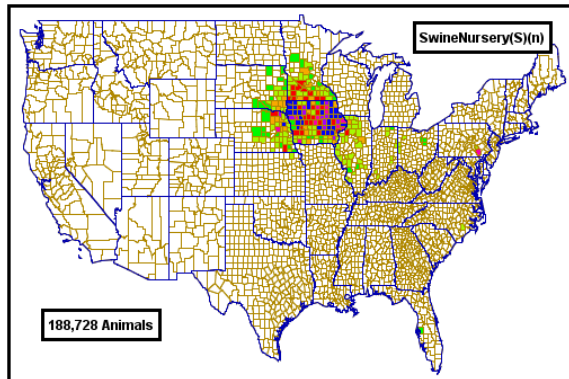
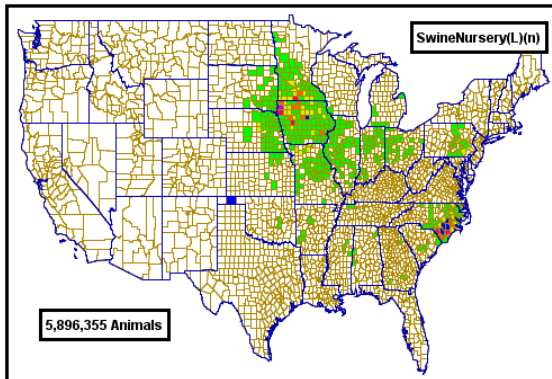
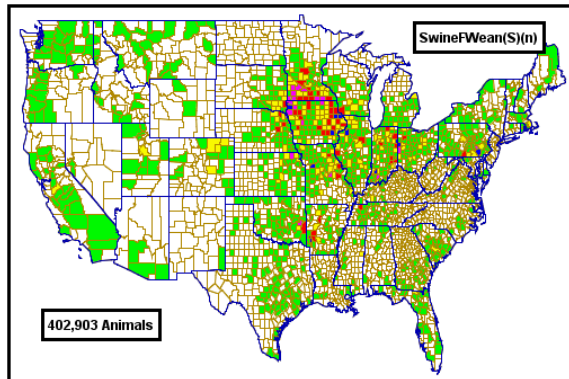
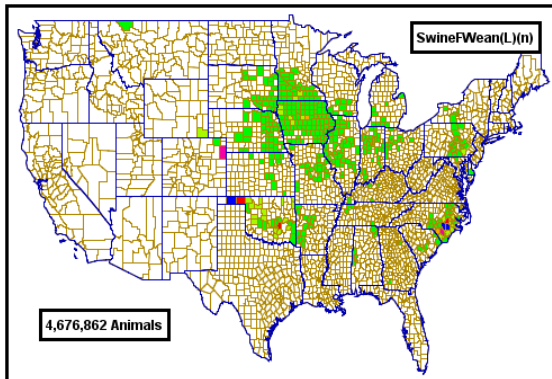


Figure 2 – Distribution of dairy facilities in the US (number of animals by county)



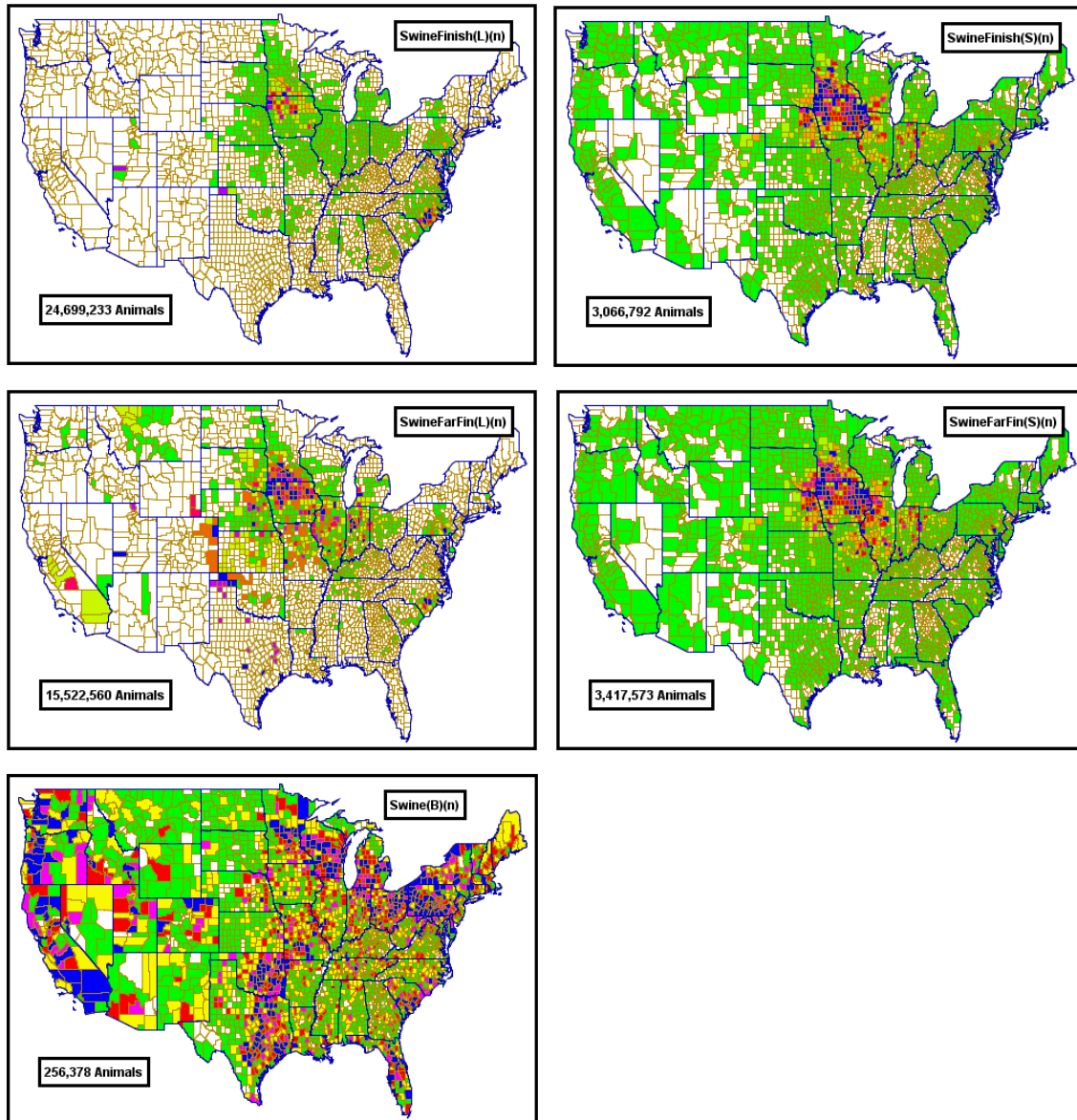


Figure 3 – Distribution of swine facilities in the US (number of animals by county).

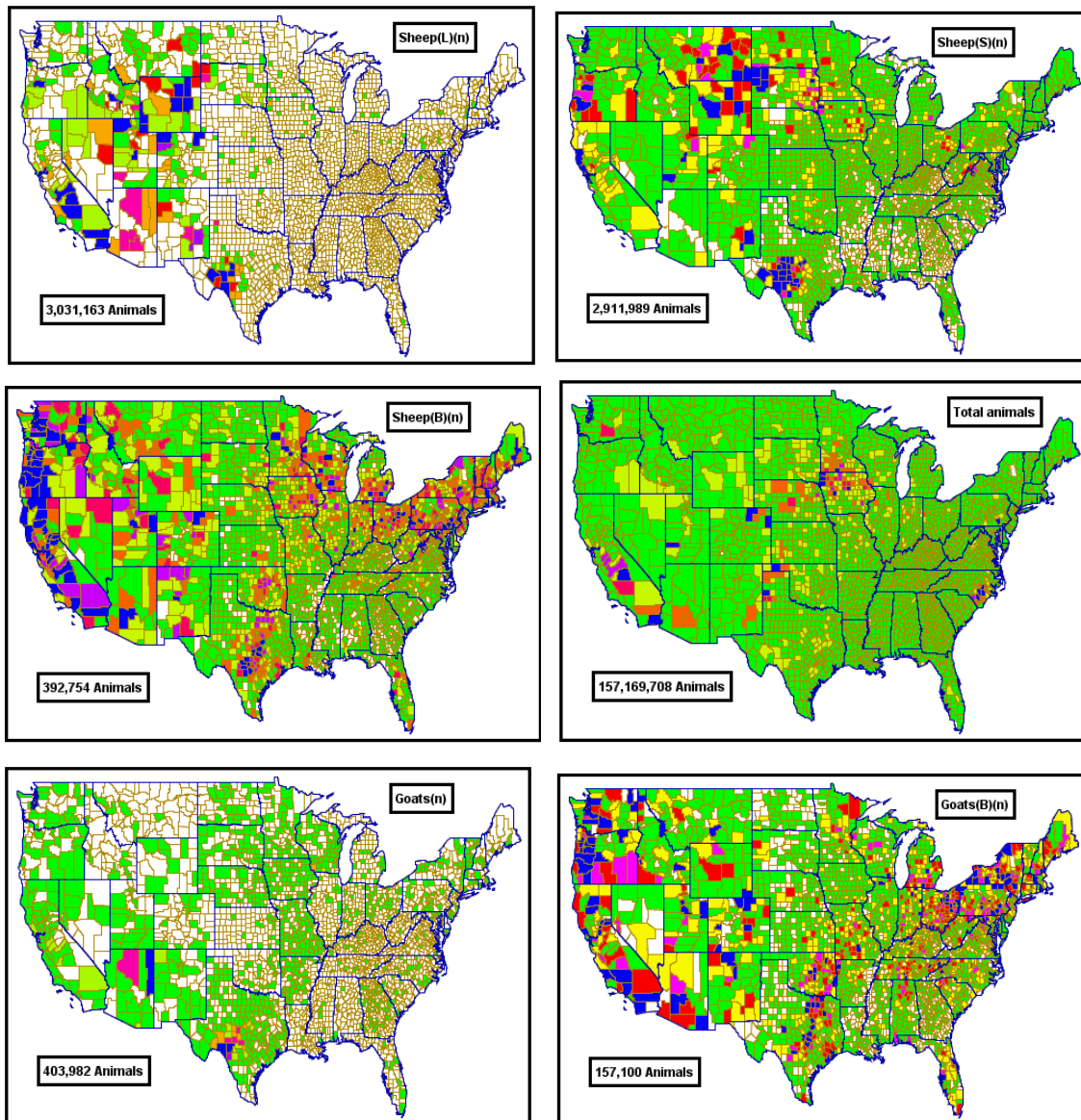


Figure 4 – Distribution of sheep and goat facilities in the US (number of animals by county)

5. Comparison to survey data

In this section, we compare the resulting database derived from the NASS data with a survey of farms in the Central Valley of California undertaken by Bates et al. (2001). The survey data represents the tri-county region of Kings, Fresno, and Tulare County, California. Bates et al. defined 11 categories of various species types and size ranges, representing dairy, beef, dairy calf/heifer, swine, sheep, and goats. Dairy size ranges defined by Bates et al. are fewer than 1,000 cows, 1,000 to 2,000 cows, and more than 2,000 cows. Hence all dairies in the Bates survey fall in the range of the largest dairy size category defined by the NASS data (more than 500 cows). Similarly, the size ranges that were defined by Bates et al. for swine are fewer than 2,000 swine, and more than 2,000 swine. Hence both fall within the largest size category in the NASS data of more than 1,000 swine. In addition, in the Bates data, backyards represent premises with 10 or fewer animals of any kind, while for the database derived from the NASS data, backyards are premises with fewer than ten dairy or beef cows, or fewer than 25 swine, or fewer than 25 sheep, or fewer than 20 goats. No attempt was made to account for double counting of backyards (and larger herds) due to multiple species on single premises in the database derived from the NASS data.

To enable comparison between datasets, each set of data was normalized to a consistent set of facility types.

For data reported by Bates et al. (2001), the comparison dataset was defined as follows:

1. The facility type “dairy” was defined to represent the sum of dairies (in size ranges of fewer than 1,000 cows, 1,000 to 2,000 cows, and more than 2,000 cows).
2. The facility type “beef” was defined to represent the sum of beef herds (in size categories of fewer than 250 cattle, and more than 250 cattle) and dairy calf/heifer ranches (in size categories of fewer than 250 cattle and more than 250 cattle).
3. The facility type “swine” was defined to represent the sum of swine facilities (in size ranges of fewer than 2,000 swine and more than 2,000 swine).
4. The facility type “sheep” was defined to represent facilities with sheep.
5. The facility type “goats” was defined to represent facilities with goats.
6. The facility type “backyards” was defined to represent premises with fewer than 10 animals (cattle, swine, sheep, and/or goats), which were classified as backyards by Bates et al. (2001).

For the database derived from the NASS data, the comparison dataset was defined as follows:

1. The facility type “dairy” was defined to represent the sum of the small, medium, and large dairies (Dairy(S), Dairy(M) and Dairy(L)) and to exclude the backyard dairies (Dairy(B)).
2. The facility type “beef” was defined to represent the sum of the small, medium, and large cow calf, stocker, feedlot, and dairy calf facilities (Cow/Calf(S), Cow/Calf(L), Stocker(S), Stocker(L), Feedlot(S), Feedlot(L), and Dairy

- Calf/Heifer(L)) and to exclude backyard dairy and beef herds (Dairy(B) and Beef(B)).
3. The facility type “swine” was defined to represent the sum of small and large farrow to wean, nursery, farrow to feeder, swine finisher, and farrow to finish facilities (SwineFWean(S), SwineFWean(L), SwineNursery(S), SwineNursery(L), SwineFFeeder(S), SwineFFeeder(L), SwineFinish(S), SwineFinish(L), SwineFarFin(S), SwineFarFin(L)) and to include 50 percent of the backyard swine herds (Swine(B)).
 4. The facility type “sheep” was defined to represent the sum of small and large sheep herds (Sheep(S) and Sheep(L)) and to include 50 percent of the backyard sheep herds (Sheep(B)).
 5. The facility type “goats” was defined to represent the goat herds (Goats) plus 50 percent of the backyard goat herds (Goats(B)).

Table 6 compares survey results from the combined Fresno-Kings-Tulare tri-county region of California to the database derived here from the NASS data. Overall, the comparisons indicate remarkably good agreement, both in the total number of farms and in the breakup by species type. The number of dairies and swine facilities is nearly identical. The agreement with respect to the fraction assigned to backyards is also quite good. The overall number of farms is 14 percent larger for the NASS data, which reported 2,562 premises vs. 2,238 in the Bates et al. (2001) survey. Some of the NASS farms could represent double counting of premises that reported multiple species.

Table 6 – Comparison of the database derived from the NASS data and survey data reported by Bates et al. (2001) for the Fresno-Kings-Tulare tri-county region of California

Facility Type	Bates	NASS
Backyard	788	817.5
Beef	693	845
Dairy	547	546
Swine	79	79.5
Sheep	69	171
Goats	62	103
Total	2,238	2,562

6. Conclusions and directions for future work

To determine the accuracy, consistency, and thoroughness of the database derived here from the NASS data, it is important to compare with other survey data. In the previous section, we compared our data with independent survey data from central California. The database derived from the NASS data appears to provide a complete and consistent set of livestock facilities for the central California region. However future work should entail comparisons with other surveys, such as that developed for North Carolina. Comparisons with various regions will help identify any inconsistencies as well as the degree of completeness in the various data.

In addition, the NASS data only reports the locations of livestock facilities to within the county. Ultimately, one would like to have geospatial locations (including latitude and longitude and premises boundaries) of individual farms for the entire United States. Although some of these data are available for limited areas of the United States, incorporating these data into the database derived from the NASS data will require reconciliation of differences in the different national (NASS) and local surveys.

A further question that should be addressed is the impact of precise geographic locations of livestock premises on the epidemiological and economic model results. This question is being investigated by comparison of model results for the NASS data with random vs. non-random assignments of premises locations within counties in Texas. Findings of the study to date indicate that epidemiological model results for foot-and-mouth disease are relatively insensitive to precise locations within the county. However, further work is needed for other regions, especially in the western states, where counties are larger.

A similar procedure to the one outlined above is being applied to the NASS data for the poultry industry. In particular, the process described in Section 2 is being used to estimate the data for chicken and turkey operations that is suppressed by NASS to protect privacy.

References

Bates TW, Thurmond MC, Carpenter TE, 2001, *Direct and indirect contact rates among beef, dairy, goat, sheep, and swine herds in three California counties, with reference to control of potential foot-and-mouth disease transmission*, American Journal of Veterinary Research, 62 (7): 1121-1129.

United States Department of Agriculture (USDA), 2002 Census of Agricultural Census, National Agricultural Statistics Service (http://www.nass.usda.gov/Census_of_Agriculture).