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

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Executive Summary

The epidemiological and economic modeling of poultry diseases requires knowing the size, location, and operational type of each poultry type operation within the US. At the present time, the only national database of poultry operations 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 census data at the county level on poultry operations for various operation types (i.e., layers, broilers, turkeys, ducks, geese). However, the number of farms and sizes of farms for the various types are not independent since some facilities have more than one type of operation. Furthermore, some data on the number of birds represents the number sold, which does not represent the number of birds present at any given time. In addition, any data tabulated by NASS that could identify numbers of birds 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 birds. At the same time, it must account for all the birds, 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 poultry operations.

This technical report documents data processing steps that were used to convert the NASS data into a national poultry facility database with twenty-six facility types (7 egg-laying, 6 broiler, 1 backyard, 3 turkey, and 9 others, representing ducks, geese, ostriches, emus, pigeons, pheasants, quail, game fowl breeders and "other"). 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 first step is similar to the first step used to estimate suppressed data for livestock [Melius et al (2006)]. The second step converts the NASS poultry types into the operational facility types used by the epidemiological and economic model.

We also define two additional facility types for high and low risk poultry backyards, and an additional two facility types for live bird markets and swap meets. The distribution of these additional facility types among counties is based on US population census data. The algorithm defining the number of premises and the corresponding distribution among counties and the resulting premises density plots for the continental US are provided.

1. Introduction

Lawrence Livermore National Laboratory, in collaboration with several academic and federal partners, is developing a nationwide, coupled economic and epidemiological model to analyze potential response strategies to outbreaks caused by foreign animal diseases. The model has been designed to simulate disease transmission, while simultaneously accounting for costs due to disease control measures, such as vaccination, slaughter, and animal movement restrictions.

The epidemiological and economic modeling of animal diseases requires knowing the operation type and size of each individual facility (premises). The accuracy of the disease control and cost simulations depends on the use of representative data for US poultry operations. At the present time, the only national database of poultry 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 census data at the county level on poultry types and sizes. The NASS data defines poultry according to species type (chickens, turkeys, ducks, geese, ostriches, emus, pigeons, pheasants, quail, and others) and by various operational types, i.e., layers, broilers, and hatcheries. However, in some cases, only the number of farms selling birds and number sold is presented, not the number of farms/birds present at a given time. In other cases, both the number of farms having birds of a given type and the number of farms selling birds of a given type are presented, but do not match. While the number of farms selling birds in a given county may be smaller than the number of farms having birds, the number of farms selling birds may also be larger. Many farms may contain more than one type of poultry. This can be particularly true for small farms, which may have egg-laying as well as broiler chickens, and may also have ducks or geese. 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 poultry operations. First, estimation steps are needed to replace data that have been suppressed in the NASS data. Then, the NASS poultry types must be converted into a set of distinct poultry operation types that can be used by the epidemiological and economic model.

This technical report documents the data processing steps that were used to develop a national database of poultry 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 poultry facilities of each type in the US, and poultry density maps by county location. Section 5 compares the database derived from the NASS data with data for North Carolina. Section 6 discusses directions for future work.

2. NASS data

This section describes the NASS data, and presents the rules that were used to estimate the data that are suppressed and coded with a “D” in the NASS tables. The process is similar to that used to estimate suppressed data for the livestock industry [Melius et al (2006)].

2.1. NASS data description

The NASS data comprise a consistent set of farm and poultry data for each county in the United States. The data are available from the USDA National Agricultural Statistics Service (NASS) website: www.usda.nass.gov. The NASS data are organized in tabular form as follows:

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

The NASS data includes both inventory and sales of poultry. Inventory is reported as the number of poultry of each type that was present on December 31, 2002, and sales is reported as the number of poultry of each type that was sold during the 2002 calendar year. Both NASS inventory and sales data is used to derive a national database for use in epidemiological and economic models. When inventory data is available, it was used. For some cases, break down by farm size range was withheld, and sales data was used to estimate the inventory size range. In other cases, the detailed size range was only available at the state level, so state data was used to estimate subdivision into size ranges. NASS provides a more detailed breakdown of poultry types at the state level than at the county level. Table 1 lists the categories for number and type of poultry available at the county level. Table 2 lists the categories for number and type of poultry available at the state level. The tables also list the national totals of farms/birds for each of these categories.

Table 1. NASS categories at the county level and US totals.

Category	Number of farms or birds in the United States
Inventory \ Any poultry (farms, 2002)	146,206
Inventory \ Any poultry \ Layers 20 weeks old and older (farms, 2002)	98,315
Inventory \ Any poultry \ Layers 20 weeks old and older (number, 2002)	334,435,155
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 1 to 49	82,693
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 50 to 99	7,431
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 100 to 399	3,684
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 400 to 3,199	487
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 3,200 to 9,999	672
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 10,000 to 19,999	1,421
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 20,000 to 49,999	1,127
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 50,000 to 99,999	302
Inventory \ Any poultry \ Layers 20 weeks old and older \ 2002 farms by inventory \ 100,000 or more	498
Inventory \ Any poultry \ Pullets for laying flock replacement (farms, 2002)	25,624
Inventory \ Any poultry \ Pullets for laying flock replacement (number, 2002)	94,882,450
Inventory \ Any poultry \ Broilers and other meat-type chickens (farms, 2002)	37,937
Inventory \ Any poultry \ Broilers and other meat-type chickens (number, 2002)	1,389,279,047
Inventory \ Any poultry \ Turkeys (farms, 2002)	16,586
Inventory \ Any poultry \ Turkeys (number, 2002)	93,028,191
Inventory \ Any poultry \ Ducks, geese, and other poultry 1/ (farms, 2002)	49,724
Sales \ Any poultry sold (farms, 2002)	83,383
Sales \ Any poultry sold \ Layers and pullets sold (farms, 2002)	23,993
Sales \ Any poultry sold \ Layers and pullets sold (number, 2002)	377,864,191
Sales \ Any poultry sold \ Layers and pullets sold \ Layers 20 weeks old and older sold (farms, 2002)	18,621
Sales \ Any poultry sold \ Layers and pullets sold \ Layers 20 weeks old and older sold (number, 2002)	202,947,490
Sales \ Any poultry sold \ Layers and pullets sold \ Pullets for laying flock replacement sold (farms, 2002)	8,193

Sales \ Any poultry sold \ Layers and pullets sold \ Pullets for laying flock replacement sold (number, 2002)	174,916,701
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold (farms, 2002)	32,006
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold (number, 2002)	8,500,313,357
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 1 to 1,999	10,869
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 2,000 to 59,999	1,056
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 60,000 to 99,999	1,060
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 100,000 to 199,999	3,311
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 200,000 to 499,999	10,407
Sales \ Any poultry sold \ Broilers and other meat-type chickens sold \ 2002 farms by number sold \ 500,000 or more	5,303
Sales \ Any poultry sold \ Turkeys sold (farms, 2002)	8,436
Sales \ Any poultry sold \ Turkeys sold (number, 2002)	283,247,649
Sales \ Any poultry sold \ Ducks, geese, and other poultry sold 1/ (farms, 2002)	15,165
	0
DUCKS Farms	26,140
DUCKS Animals	3,823,629
DUCKS Farms Selling	5,835
DUCKS Animals Sold	24,143,066
EMUS Farms	5,224
EMUS Animals	48,221
EMUS Farms Selling	1,143
EMUS Animals Sold	15,682
GEESE Farms	17,110
GEESE Animals	173,000
GEESE Farms Selling	2,920
GEESE Animals Sold	200,564
OSTRICHES Farms	1,643
OSTRICHES Animals	20,560
OSTRICHES Farms Selling	472
OSTRICHES Animals Sold	16,038
PHEASANTS Farms	4,977
PHEASANTS Animals	2,267,136
PHEASANTS Farms Selling	2,519
PHEASANTS Animals Sold	7,206,460
PIGEONS OR SQUAB Farms	4,405
PIGEONS OR SQUAB Animals	449,255
PIGEONS OR SQUAB Farms Selling	1,309
PIGEONS OR SQUAB Animals Sold	1,160,364
QUAIL Farms	3,742
QUAIL Animals	4,888,196
QUAIL Farms Selling	1,907

QUAIL Animals Sold	19,157,803
OTHER POULTRY Farms	13,790
OTHER POULTRY Animals	1,629,522
OTHER POULTRY Farms Selling	3,627
OTHER POULTRY Animals Sold	3,111,544
POULTRY HATCHED Farms	0
POULTRY HATCHED Animals	0
POULTRY HATCHED Farms Selling	31,824
POULTRY HATCHED Animals Sold	10,186,919,783

Source: USDA NASS

Table 2. NASS categories at the state level and US totals.

Category	Number of farms or birds in the United States
Inventory \ Layers 20 weeks old and older Farms	98,315
Inventory \ Layers 20 weeks old and older Animals	334,435,155
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 1 to 49 Farms	82,693
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 1 to 49 Animals	1,366,625
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 50 to 99 Farms	7,431
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 50 to 99 Animals	443,106
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 100 to 399 Farms	3,684
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 100 to 399 Animals	557,490
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 400 to 3,199 Farms	487
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 400 to 3,199 Animals	507,033
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 3,200 to 9,999 Farms	672
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 3,200 to 9,999 Animals	5,051,441
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 10,000 to 19,999 Farms	1,421
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 10,000 to 19,999 Animals	20,695,146
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 20,000 to 49,999 Farms	1,127
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 20,000 to 49,999 Animals	31,665,909
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 50,000 to 99,999 Farms	302
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 50,000 to 99,999 Animals	21,436,185
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 100,000	498

or more Farms	
Inventory \ Layers 20 weeks old and older \ Farms with inventory of 100,000 or more Animals	252,712,220
Inventory \ Pullets for laying flock replacement Farms	25,624
Inventory \ Pullets for laying flock replacement Animals	94,882,450
Inventory \ Broilers and other meat-type chickens Farms	37,937
Inventory \ Broilers and other meat-type chickens Animals	1,389,279,047
Inventory \ Turkeys Farms	16,586
Inventory \ Turkeys Animals	93,028,191
Inventory \ Emus Farms	5,224
Inventory \ Emus Animals	48,221
Inventory \ Ostriches Farms	1,643
Inventory \ Ostriches Animals	20,560
Inventory \ Ducks, geese, and other poultry 1/ Farms	49,724
Inventory \ Ducks, geese, and other poultry 1/ Animals	0
Number sold \ Layers 20 weeks old and older Farms	18,621
Number sold \ Layers 20 weeks old and older Animals	202,947,490
Number sold \ Pullets for laying flock replacement Farms	8,193
Number sold \ Pullets for laying flock replacement Animals	174,916,701
Number sold \ Number sold \ Broilers and other meat-type chickens Farms	32,006
Number sold \ Number sold \ Broilers and other meat-type chickens Animals	8,500,313,357
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 1 to 1,999 Farms	10,869
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 1 to 1,999 Animals	1,146,308
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 2,000 to 15,999 Farms	406
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 2,000 to 15,999 Animals	2,871,466
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 16,000 to 29,999 Farms	206
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 16,000 to 29,999 Animals	4,420,530
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 30,000 to 59,999 Farms	444
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 30,000 to 59,999 Animals	19,732,838
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 60,000 to 99,999 Farms	1,060
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 60,000 to 99,999 Animals	84,498,647
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 100,000 to 199,999 Farms	3,311
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 100,000 to 199,999 Animals	498,386,958
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 200,000 to 299,999 Farms	4,653
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 200,000 to 299,999 Animals	1,137,668,155
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms	5,754

by number sold 300,000 to 499,999 Farms	
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 300,000 to 499,999 Animals	2,191,324,340
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 500,000 or more Farms	5,303
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 500,000 or more Animals	4,560,264,115
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 500,000 to 749,999 Farms	3,092
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 500,000 to 749,999 Animals	1,836,915,969
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 750,000 or more Farms	2,211
Number sold \ Number sold \ Broilers and other meat-type chickens \ Farms by number sold 750,000 or more Animals	2,723,348,146
Number sold \ Number sold \ Turkeys Farms	8,436
Number sold \ Number sold \ Turkeys Animals	283,247,649
Number sold \ Number sold \ Turkeys \ Farms by number sold 1 to 1,999 Farms	5,590
Number sold \ Number sold \ Turkeys \ Farms by number sold 1 to 1,999 Animals	217,182
Number sold \ Number sold \ Turkeys \ Farms by number sold 2,000 to 7,999 Farms	93
Number sold \ Number sold \ Turkeys \ Farms by number sold 2,000 to 7,999 Animals	429,577
Number sold \ Number sold \ Turkeys \ Farms by number sold 8,000 to 15,999 Farms	126
Number sold \ Number sold \ Turkeys \ Farms by number sold 8,000 to 15,999 Animals	1,527,243
Number sold \ Number sold \ Turkeys \ Farms by number sold 16,000 to 29,999 Farms	290
Number sold \ Number sold \ Turkeys \ Farms by number sold 16,000 to 29,999 Animals	6,485,730
Number sold \ Number sold \ Turkeys \ Farms by number sold 30,000 to 59,999 Farms	789
Number sold \ Number sold \ Turkeys \ Farms by number sold 30,000 to 59,999 Animals	34,005,988
Number sold \ Number sold \ Turkeys \ Farms by number sold 60,000 to 99,999 Farms	748
Number sold \ Number sold \ Turkeys \ Farms by number sold 60,000 to 99,999 Animals	55,689,033
Number sold \ Number sold \ Turkeys \ Farms by number sold 100,000 or more Farms	800
Number sold \ Number sold \ Turkeys \ Farms by number sold 100,000 or more Animals	184,892,896
Number sold \ Number sold \ Emus Farms	1,143
Number sold \ Number sold \ Emus Animals	15,682
Number sold \ Number sold \ Ostriches Farms	472
Number sold \ Number sold \ Ostriches Animals	16,038
Number sold \ Number sold \ Ducks, geese, and other poultry 1/ Farms	15,165
Number sold \ Number sold \ Ducks, geese, and other poultry 1/ Animals	0
Layers 20 weeks old and older Farms	18,621
Layers 20 weeks old and older Animals	202,947,490

Layers 20 weeks old and older - Farms by number sold 1 to 99 Farms	13,776
Layers 20 weeks old and older - Farms by number sold 1 to 99 Animals	282,433
Layers 20 weeks old and older - Farms by number sold 100 to 399 Farms	1,150
Layers 20 weeks old and older - Farms by number sold 100 to 399 Animals	180,715
Layers 20 weeks old and older - Farms by number sold 400 to 3,199 Farms	294
Layers 20 weeks old and older - Farms by number sold 400 to 3,199 Animals	318,466
Layers 20 weeks old and older - Farms by number sold 3,200 to 9,999 Farms	605
Layers 20 weeks old and older - Farms by number sold 3,200 to 9,999 Animals	4,457,915
Layers 20 weeks old and older - Farms by number sold 10,000 to 19,999 Farms	1,223
Layers 20 weeks old and older - Farms by number sold 10,000 to 19,999 Animals	17,758,088
Layers 20 weeks old and older - Farms by number sold 20,000 to 49,999 Farms	895
Layers 20 weeks old and older - Farms by number sold 20,000 to 49,999 Animals	25,984,561
Layers 20 weeks old and older - Farms by number sold 50,000 to 99,999 Farms	305
Layers 20 weeks old and older - Farms by number sold 50,000 to 99,999 Animals	21,684,118
Layers 20 weeks old and older - Farms by number sold 100,000 or more Farms	373
Layers 20 weeks old and older - Farms by number sold 100,000 or more Animals	132,281,194
Pullets for laying flock replacement Farms	8,193
Pullets for laying flock replacement Animals	174,916,701
Pullets for laying flock replacement - Farms by number sold 1 to 1,999 Farms	6,337
Pullets for laying flock replacement - Farms by number sold 1 to 1,999 Animals	284,617
Pullets for laying flock replacement - Farms by number sold 2,000 to 15,999 Farms	135
Pullets for laying flock replacement - Farms by number sold 2,000 to 15,999 Animals	1,182,881
Pullets for laying flock replacement - Farms by number sold 16,000 to 29,999 Farms	256
Pullets for laying flock replacement - Farms by number sold 16,000 to 29,999 Animals	5,575,458
Pullets for laying flock replacement - Farms by number sold 30,000 to 59,999 Farms	662
Pullets for laying flock replacement - Farms by number sold 30,000 to 59,999 Animals	28,218,548
Pullets for laying flock replacement - Farms by number sold 60,000 to 99,999 Farms	425
Pullets for laying flock replacement - Farms by number sold 60,000 to 99,999 Animals	31,101,790
Pullets for laying flock replacement - Farms by number sold 100,000 or more Farms	378
Pullets for laying flock replacement - Farms by number sold 100,000 or more Animals	108,553,407

Source: USDA NASS

2.2. Estimating suppressed data for number of birds for tables at the county level

We first outline the procedure for estimating suppressed data for the tables representing county-level data. Certain entries of the NASS data for number of birds 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

First, for a given type of poultry operation and size category of bounded range (i.e., 1-49, 50-99, ..., 50,000-99,999, 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 birds to counties proportional to number of farms having missing data.
- 1.2 If state total is missing, assign the average farm 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):

- 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 birds for all farms in the county and numbers of birds 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 poultry operation and size category. If so, assign missing data to the difference of the state total and the sum for counties reporting poultry inventory. If data are missing for multiple counties, assign birds 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 poultry operations (Table 2).^c

^aThe largest NASS size categories are 100,000 or more birds for layers in inventory, 500,000 or more head for broilers sold, 100,000 layers, pullets, or turkeys sold. (cf. Tables 1 and 2).

^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.

Step 2: Fix the sum of the size subcategories

For each county, reassign the total number of birds for a given category to be the sum of the individual size subcategories (e.g., the sum of subcategories with 1-49, 50-99, ..., 100,000+). Note that step 1.3 above reduces the likelihood that the sum will change significantly, if it had already been provided previously.

Step 3: Fix the state and US data within the county-level tables

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

Steps 1-3 are applied to each of the inventory and sales categories within the NASS data. For those categories that only have only a single size representing the total, only step 1.4 of step 1 and step 3 are applied.

2.3. Estimating suppressed data for number of birds for tables at the state level

The procedure outlined above for the county level data is also used for estimating suppressed data for the tables representing state-level data. The major difference is that the US total is not suppressed for any of the categories. Thus, step 3 is not needed. The process that was used to estimate the suppressed data is described by the following three steps:

Step 1: Develop estimates for state totals

First, for a given type of poultry operation and size category of bounded range (i.e., 1-49, 50-99, ..., 50,000-99,999, but excluding the largest size range, which is unbounded)^d:

- 1.1 Assign missing data to the difference of the US total and the sum of known state data. If data are missing for more than one state, assign numbers of birds to states proportional to number of farms having missing data.

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

- 1.2 Check if the state total is available for the sum of all size categories. If so, assign missing data to difference of total number of birds for all farms in the state and numbers of birds for farms in the state that are in smaller size

^dThe largest NASS size categories are 100,000 or more birds for layers in inventory, 500,000 or more birds for broilers sold, 100,000 or more birds for layers, pullets, or turkeys sold. (cf. Tables 1 and 2).

- 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.
- 1.3 If the state total for the sum of all size categories is missing, assign missing data to the difference of the US total and the sum for states reporting poultry inventory. If data are missing for multiple states, assign birds to these states proportional to the number of farms of the type and size in each of the states.
 - 1.4 If the state total for the sum of all size categories is missing, assign missing data to the difference of the US total and the sum for states reporting poultry inventory. If data are missing for multiple counties, assign birds to these states proportional to the number of farms of the type and size in each of the states^e.

For ducks, geese, pheasants, pigeons, quail, and other categories, if no information on flock size is available, the flock size was arbitrarily set to be 200 birds per farm.

Step 2: Fix the sum of the size subcategories

For each state, reassign the total number of birds for a given category to be the sum of the individual size subcategories (e.g., the sum of subcategories with 1-49, 50-99, ..., 100,000+).

Steps 1 and 2 are applied to each of the inventory and sales categories within the NASS data. For those categories that only have only a single size representing the total, only step 1.4 of step 1 is applied.

3. Defining types of poultry facilities

Section 3 reports the steps used to define the NASS operational facility types used by the epidemiological/economic model. Estimates of the number of farms and birds for each type were developed using the converted NASS data as defined in Section 2. A separate process was used for layers, broilers, hatcheries, turkeys, and others.

3.1 Defining table-egg-laying facilities

The NASS data for inventory of layers 20 weeks old and older was mapped into the following poultry operation types: table-egg layers, breeders for table egg layers, and breeders for broilers.

The inventory of layers 20 weeks old and older is subdivided into size ranges of 1-49, 50-99, 100-399, 400-3,199, 3,200-9,999, 10,000-19,999, 20,000-49,999, 50,000-99,999, and 100,000 or more. For use in the epidemiological and economic models, the size ranges were divided into three subgroups, large, denoted Layer(L), small, denoted Layer(S), and backyard, denoted Layer(B). The backyard layers represent the size range 1-49, the large

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

layers represent the size range 100,000 or more, with the remaining assigned to the small layers category.

As described below, a subset of the layers category was extracted to represent breeders for the table egg layers and broilers.

3.2 Defining broiler growout facilities

The NASS data for broilers was mapped into the broiler growout operation type. For use in the epidemiological and economic models, the size ranges were divided into three subgroups, large, denoted Broiler(L), small, denoted Broiler(S), and backyard, denoted Broiler(B).

Since the NASS tables do not subdivide broiler inventory by size range, the data representing the number of broilers sold was used^f. The number of broilers sold is subdivided into size ranges of 1-1,999, 2,000-59,999, 60,000-99,999, 100,000-199,999, 200,000-499,999, and 500,000 or more.

The backyard broilers represent the size range 1-1,999 sold, the large broilers represent the size range 500,000 or more sold, with the remaining assigned to the small broilers category. The number of birds present on the farms was estimated by dividing the number of birds sold by a factor of six, i.e., that the average growout farm raises a broiler for approximately 2 months before selling it.

3.3 Defining pullets for table-egg-laying facilities

The NASS data for pullets for laying flock replacement was mapped into the pullet operation type. For use in the epidemiological and economic models, the size ranges were divided into three subgroups, large, denoted Pullet(L), small, denoted Pullet(S), and backyard, denoted Pullet(B).

Since the NASS tables do not subdivide pullet inventory by size range, the data representing the number of pullets sold at the state level was used^g. In the NASS data, the number of pullets sold is subdivided into size ranges of 1-1,999, 2,000-15,999, 16,000-29,999, 30,000-99,999, 60,000-99,999, and 100,000 or more pullets sold. It was assumed that 100,000 or more pullets sold represent a large pullet farm, Pullet(L), having 30,000 or more birds, assuming approximately 17 weeks to raise a pullet before it is shipped to a layer facility for preconditioning. A farm having 2,000 or fewer birds sold was assigned to the small backyard pullet farm category, Pullet(B).

^f The number of farms selling broilers in a given county in the NASS data may be greater than or less than the number of farms having broilers as inventory. One normally prefers to use inventory data, but inventory data by size range was not made available.

^g One normally prefers to use inventory data, but inventory data by size range, even at the state level, was not made available.

For a given county, the fraction of birds on large or backyard farms was taken to be the same fraction as that of the state. However, a county was required to have at least 30,000 birds to qualify as having farms in the Pullet(L) category.

3.4 Defining hatchery facilities

The NASS data for hatcheries was mapped into the broiler hatchery and layer hatchery operation types. For use in the epidemiological and economic models, the categories were divided into three subgroups, large, small, and backyard. Since the NASS tables do not define hatchery inventory, the number of chicks hatched category was used. The number of chicks present at the facility at a given time was estimated by dividing the number of chicks hatched by a factor of twelve, i.e., the average turn-over rate is one month (3 weeks for hatching plus one week for eggs waiting to be hatched).

First, the hatcheries in each county were subdivided into size ranges. A group of large hatcheries, representing ~300 large hatcheries, were created by extracting chunks of size 900,000 to 2,800,000 chicks sold from any county having at least that many chicks. If the remaining farms in a county had an average size of less than 2,000 chicks sold, the farms were assigned to the backyard category, Hatchery(B).

The large and small hatchery categories were then divided into hatcheries for table-egg layers and hatcheries for broiler growouts. For the large hatcheries, the NPIP (National Poultry Improvement Plan) list of hatcheries for egg-laying operation types, at <http://www.aphis.usda.gov/vs/nPIP/search-dir.html>, was used to identify eleven specific counties in the NASS data that came close to matching the hatcheries identified in the NPIP data. These facilities are denoted LayerHatchery(L). The remaining large hatcheries were assigned to the BroilerHatchery(L) facility type. For the small hatchery category, the hatcheries were divided into broiler hatcheries, BroilerHatchery(S), and layer hatcheries, LayerHatchery(S), based on the fraction of broiler hatcheries and layer hatcheries in each state.

The fraction of egg-laying vs broiler chicks hatched in each state is estimated from data in the “Hatchery Production 2005 Summary” report. States having significant egg-laying hatcheries (Florida, Georgia, Indiana, Iowa, Minnesota, and Pennsylvania) are used to directly determine the fraction. The remaining states are assigned ratios based on fractions of the remaining egg-laying vs broiler fractions for the total US.

3.5 Defining breeder facilities

NASS does not specifically identify breeding facilities. Breeders were estimated from the number of hatching type eggs at the state level needed to provide hatched chicks. The number of hatching type eggs laid in each state is obtained from the “Chickens and Eggs 2005 Summary” report. The number of breeders was taken to be a subset of the total number of layers. The breeders were mapped into large and small broiler breeder (BroilerBreeder) and large and small layer breeder (LayerBreeder) operation types. Only

the small category of layers (Layers(S)) was used for table egg layers, since the number of large layers was limited.

The fraction of table eggs layed vs eggs for hatching in each state is estimated from data in the “Chicken and Eggs 2005 Summary” report. For states for which the data is suppressed, the ratios are based on fractions of the remaining egg-laying vs broiler fractions for the total US. To estimate the number of hatching eggs needed, the number of hatching eggs layed was reduced by the fraction of eggs set / eggs laid (165 per year / 219 per year) and by the number of eggs placed in brood houses / eggs set (178 million /216 million) and by number raised per number placed (95 out of 100). Large breeder farms were taken to have 160,000 layers per farm.

3.6 Defining facility types for turkeys

The NASS data for turkeys was mapped into the turkey operation type. For use in the epidemiological and economic models, the size ranges were divided into three subgroups, large, denoted Turkey(L), small, denoted Turkey(S), and backyard, denoted Turkey(B).

Since the NASS tables do not subdivide turkey inventory by size range, the data representing the number of turkeys sold at the state level was used^h. In the NASS data, the number of turkeys sold is subdivided into size ranges of 1-1,999, 2,000-7,999, 8,000-15,999, 16,000-29,999, 30,000-99,999, 60,000-99,999, and 100,000 or more turkeys sold.

It was assumed that 100,000 or more turkeys sold represent a large turkey farm, Turkey(L), having 30,000 or more birds, assuming approximately 15 weeks to raise a turkey. A farm having 2,000 or fewer birds sold was assigned to the small turkey farm category, Turkey(B).

For a given county, the fraction of birds on large or backyard farms was first taken to be the same fraction as that of the state. However, a county was required to have at least 30,000 birds to qualify as having farms in the Turkey(L) category.

3.7 Defining facility types for other poultry types

The NASS data for the other poultry types are taken for each of the categories provided, ducks, geese, emus, ostriches, pheasants, pigeons, and quail. No subdivisions into size ranges, such as backyards, were made. In addition, the “OTHER POULTRY” category was subdivided into two facility types, GameFowlBreeder and Other. The estimation of game fowl breeders is presented below.

3.8 Defining facility types for backyards

^h One normally prefers to use inventory data, but inventory data by size range, even at the state level, was not made available.

The NASS data representing backyard commercial flocks for Layer(B), Broiler(B), Pullets(B), and Hatcheries(B) were combined into a single backyard category denoted BackyardNASS. Two separate categories representing non-commercial high and low risk backyards, denoted BackyardHighRisk and BackyardLowRisk, are addressed in the next subsection. The high-risk backyards are meant to represent backyards with fighting cocks.

No attempt was made to remove double counting of farms within the NASS data. The double counting is most likely to occur for the smallest farms. This is particularly true for counties that have large numbers of both layers and broilers. There is also double counting in the “other poultry” types, such as ducks geese, etc. In particular, the “mixed” category represents farms already included in the various other categories.

Given that the number of commercial backyards, BackyardNASS is much less than the total number of backyards, BackyardNASS + BackyardLowRisk + BackyardHighRisk, the double counting should not be a major factor in determining the total number of poultry premises.

3.9 Defining facility types for live bird markets, game fowl breeders, and additional backyard flocks

The NASS data represents only commercial poultry farms. It does not include live bird markets or non-commercial backyards.¹ Non-commercial flocks are not included in the NASS data. Census Bureau data at the county tract level was therefore used to estimate additional backyard poultry throughout the country. Two sets of backyard facilities were estimated, representing low risk (denoted BackyardLowRisk), and high risk (denoted BackyardHighRisk). The Census Bureau data was also used to estimate game fowl breeder (denoted GameFowlBreeder) and live bird markets. The live bird markets were divided into two groups, permanent housing (denoted LiveBirdMarket), and swap meets (denoted SwapMeet).

For each of these facility types, BackyardLowRisk, BackyardHighRisk, GameFowlBreeder, LiveBirdMarket, and SwapMeet, a population-dependent algorithm was applied to determine the number of premises in a given county. The basic concept is that the number of premises is proportional to the number of people (~ households) in a given region until the amount of available area becomes too small to maintain a flock. This is equivalent to stating that the likelihood of having a poultry premises decreases at high population densities.

The formula for the number of premises in a county tract is:

$$\text{numberInTract} = \text{populationFactor} \\ * \text{densityFactor}$$

¹ Commercial operations containing less than 50 layers are likely to be livestock operations or duck, geese, or other mixed operations containing a few laying chickens.

- * cultureFactor
- * incomeFactor
- * latitudeFactor
- * longitudeFactor

where

$$\text{populationFactor} = \text{flocksPerPopulation} * \text{population}$$

$$\text{densityFactor} = 1 / (1 + (\text{density} / \text{populationDensityFactor})^2)$$

and

$$\text{density} = \text{population} / \text{area}$$

$$\text{cultureFactor} = (\text{population} + \text{cultureWeightingFactor1} * \text{populationCulture1} + \text{cultureWeightingFactor2} * \text{populationCulture2}) / \text{population}$$

$$\text{incomeFactor} = 1 / (1 + \text{income} / \text{incomeWeightingFactor}).$$

latitudeFactor = decreasing function as one moves north in latitude, where the default is

factor30 if latitude <= 30,
 factor40 if latitude = 40,
 factor50 if latitude >= 50,
 and linear interpolation for in between points

longitudeFactor = increased weight is a premise is east of a given longitude (default is -83.0) or west of a given longitude (default is -117.)

Backyards, game fowl, and live bird markets use the same formula but with different parameters.

Currently, the latitude factor, decreasing as one moves north, has non-unity weight only for backyards.

Currently, the longitude factor, weighting east and west coasts differently from the Midwest, is only used for live bird markets.

Table 3. Parameters used in estimating backyard, game fowl, and live bird markets.

Facility type / Parameter	Backyard Low Risk	Backyard High Risk	Game Fowl Breeder	Live Bird Market	Swap Meets
Birds per flock	20	20	100	1000	1000
Flocks per population	0.0045	0.0014	0.00018	0.0000011	0.0000006
Population density factor	250	250	250	100000	100000
Culture weighting factor1	3	3	0	5	5
Culture weighting factor2	3	3	0	5	5
Income weighting factor	30000	20000	90000	120000	120000
Latitude 40 factor	1	1	1	1	0.4
Latitude 50 factor	1	1	1	1	0
Longitude East factor	1	1	1	3	2
Longitude West factor	1	1	1	1	1

The resulting premises for game fowl breeders were subtracted from the “other” category.

4. Results

The redefinition of the NASS data resulted in 26 facility types (7 egg-laying, 6 broiler, 1 backyard, 3 turkey, and 9 others, representing ducks, geese, ostriches, emus, pigeons, pheasants, quail, game fowl breeders and “other”). In addition, 2 additional facility types were estimated for high and low risk poultry backyards, while 2 additional types were estimated for live bird markets and swap meets. The resulting facility types, along with the total number of farms and birds within the continental US represented by each facility type, is presented in Table 4. The distribution of farms / birds within the US by county for each of the facility types are shown in Figs. 1-14.

Table 4 – Number of premises and corresponding number of birds in the US for the various facility types derived from the NASS 2002 Agricultural Census data along estimated backyard poultry and live bird markets / swap meets.

Facility Type	# Premises	# Birds	Size range per premises
Total Farms	459760	2,800,862,303	
Layer(L)	424	225,833,711	> 100,000 hens
Layer(S)	12740	53,441,753	50 – 100,000 hens
Pullet(L)	137	24,659,835	> 100,000 sold
Pullet(S)	12077	68,541,400	2,000 – 100,000 sold
LayerBreeder(S)	168	2,016,000	50 – 100,000 hens
LayerHatchery(L)	11	22,644,047	> 900,000 hatched
LayerHatchery(S)	931	14,992,839	2,000 – 900,000 sold
Broiler(L)	5303	760,046,588	> 500,000 sold
Broiler(S)	15838	656,340,139	2000 – 500,000 sold
BroilerBreeder(L)	162	25,920,000	~160,000 hens
BroilerBreeder(S)	2256	24,652,303	50 – 100,000 hens

BroilerHatchery(L)	321	666,099,154	> 900,000 hatched
BroilerHatchery(S)	5004	143,058,315	2,000 – 900,000 sold
Turkey(L)	710	47,920,867	> 100,000 sold
Turkey(S)	9209	44,782,165	2,000 – 100,000 sold
Turkey(B)	6851	323,034	< 2,000 sold
BackyardNASS	87531	1,476,352	< 50 birds or < 2,000 sold
BackyardLowRisk	170441	3,408,956	20 chickens
BackyardHighRisk	52329	1,046,444	20 chickens
Ducks	26065	3,820,559	
Geese	17060	171,937	
Emus	5224	47,608	
Ostriches	1643	20,206	
Pheasants	4965	2,267,282	
Pigeons	4402	448,409	
Quail	3733	4,824,068	
Other	7722	710,888	
GameFowlBreeder	6018	862,444	
LiveBirdMarket	396	396,000	1000 birds
SwapMeet	89	89,000	1000 birds

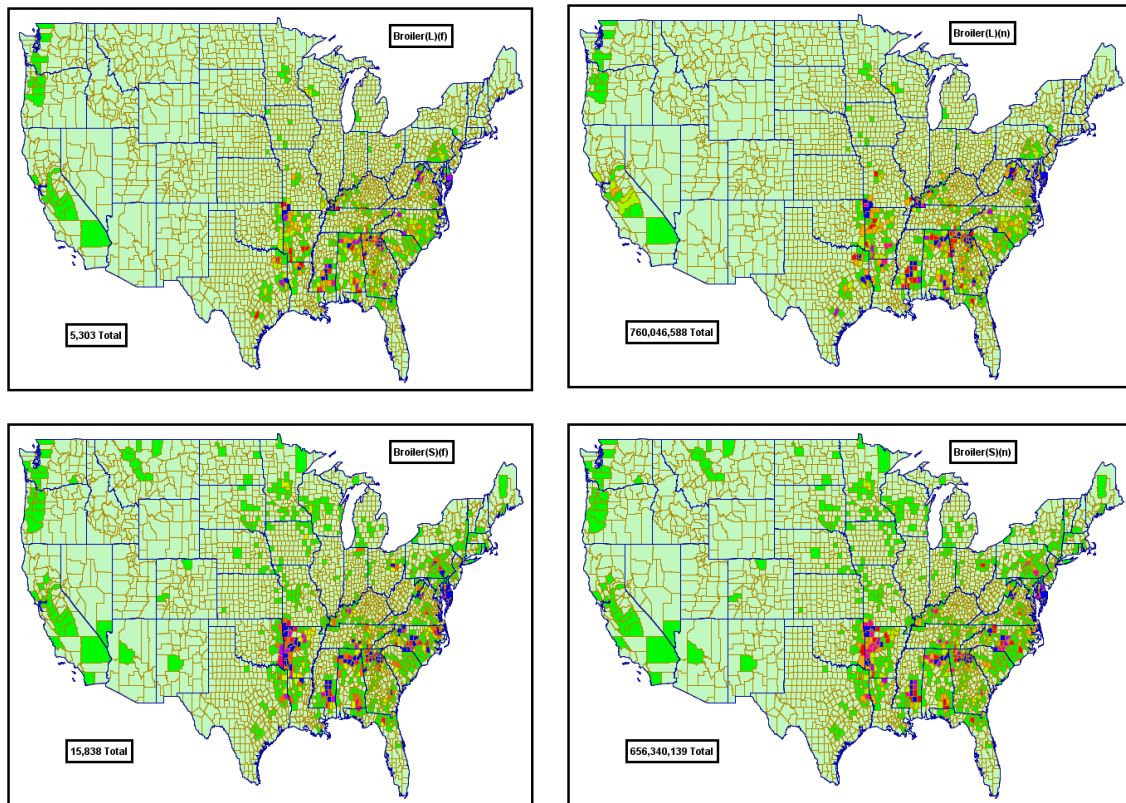


Fig. 1. – Distribution of broiler growout facilities in the US (density of premises/birds by county).

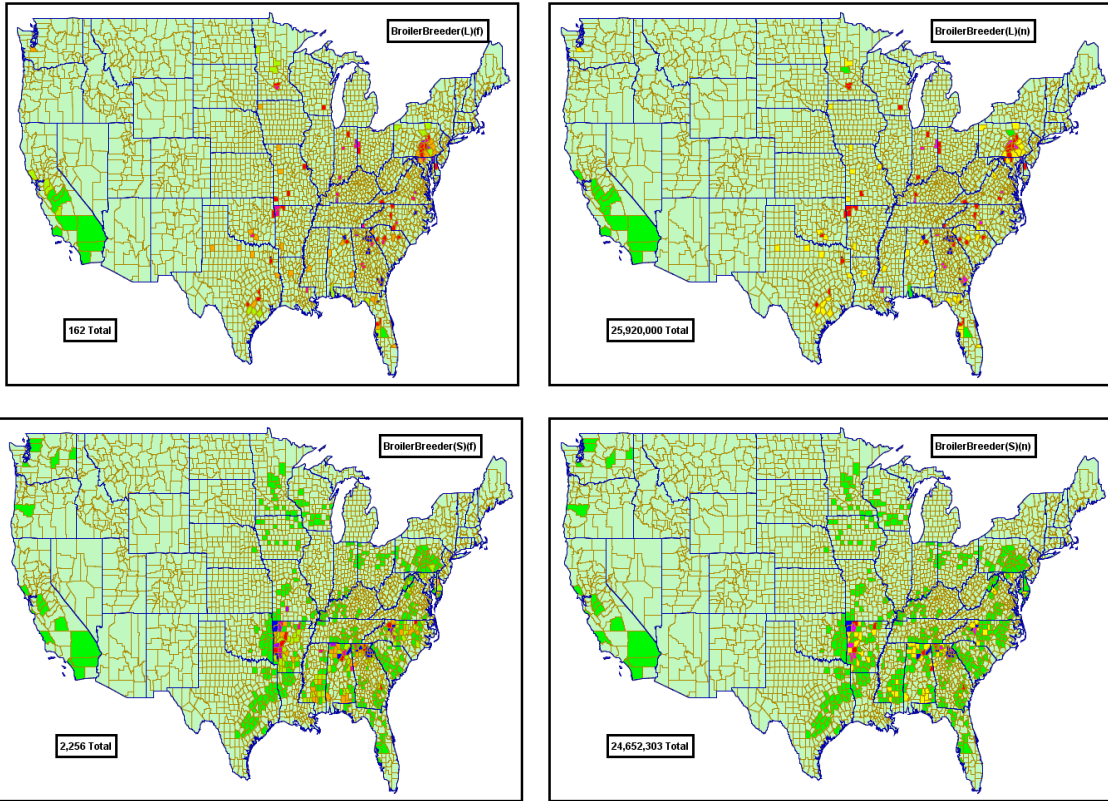


Fig. 2. – Distribution of broiler breeder facilities in the US (density of premises/birds by county).

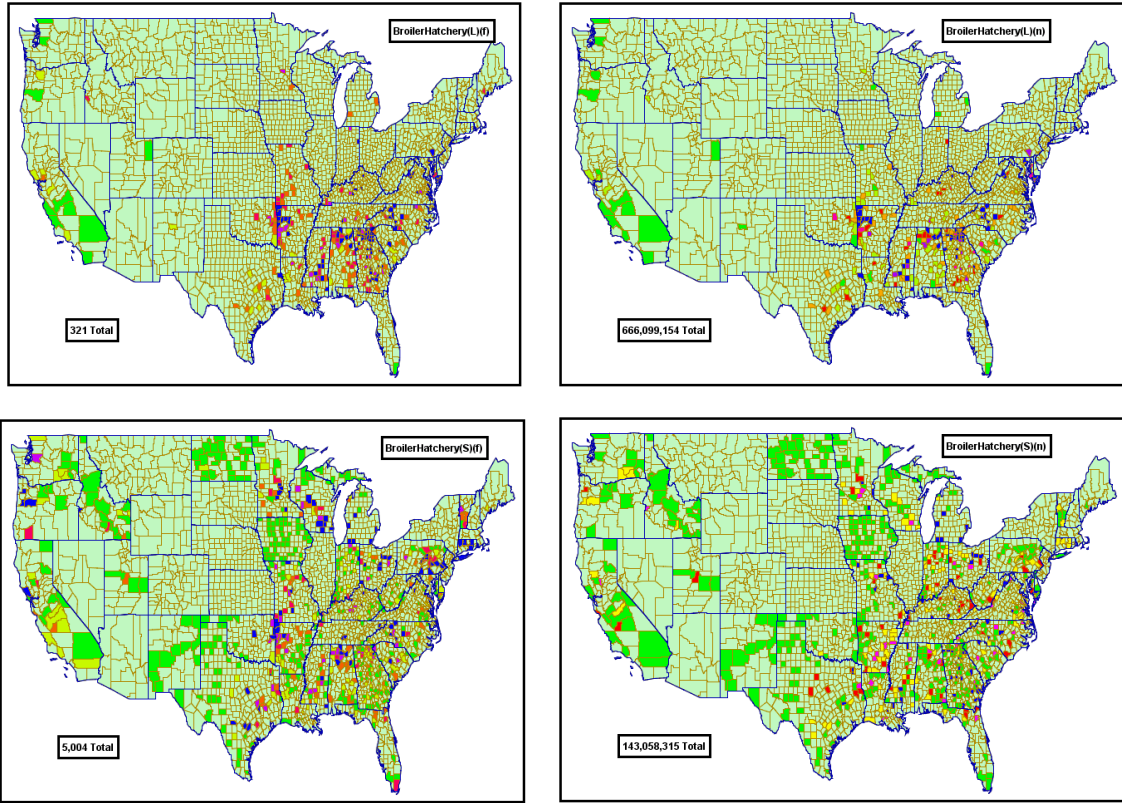


Fig. 3. – Distribution of broiler-hatcheries in the US (density of premises/birds by county).

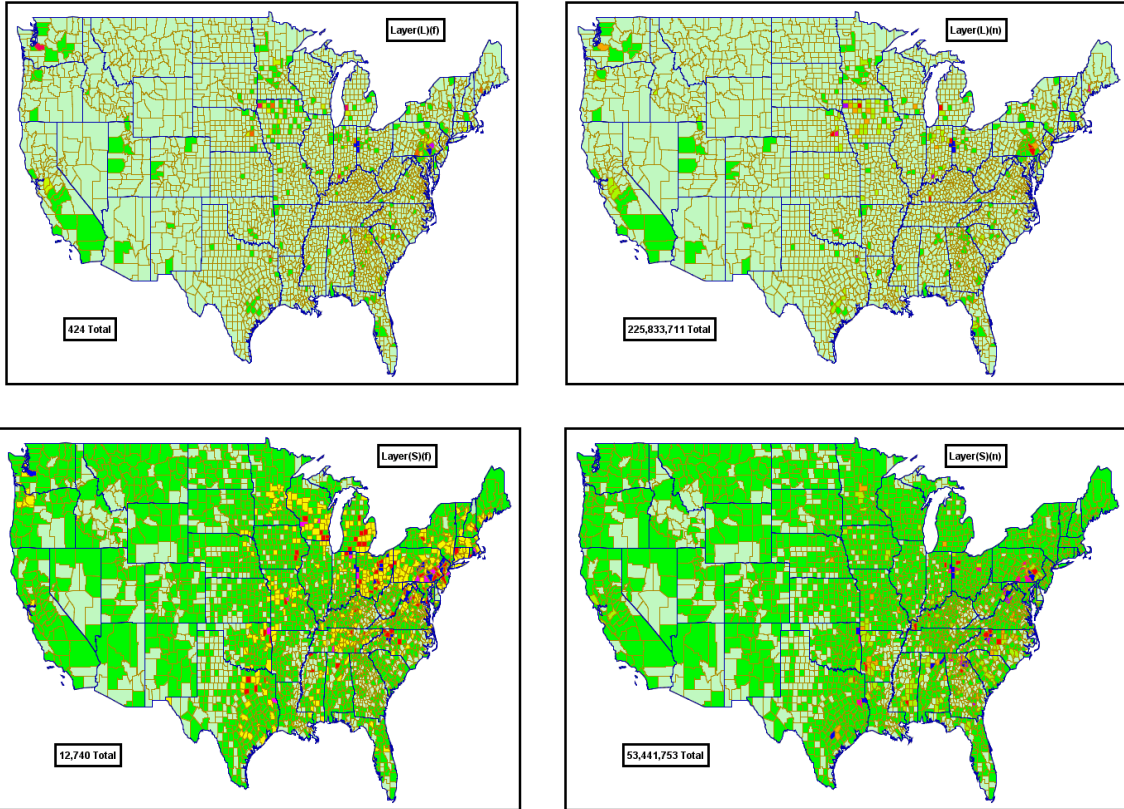


Fig. 4. – Distribution of table egg layers in the US (density of premises/birds by county).

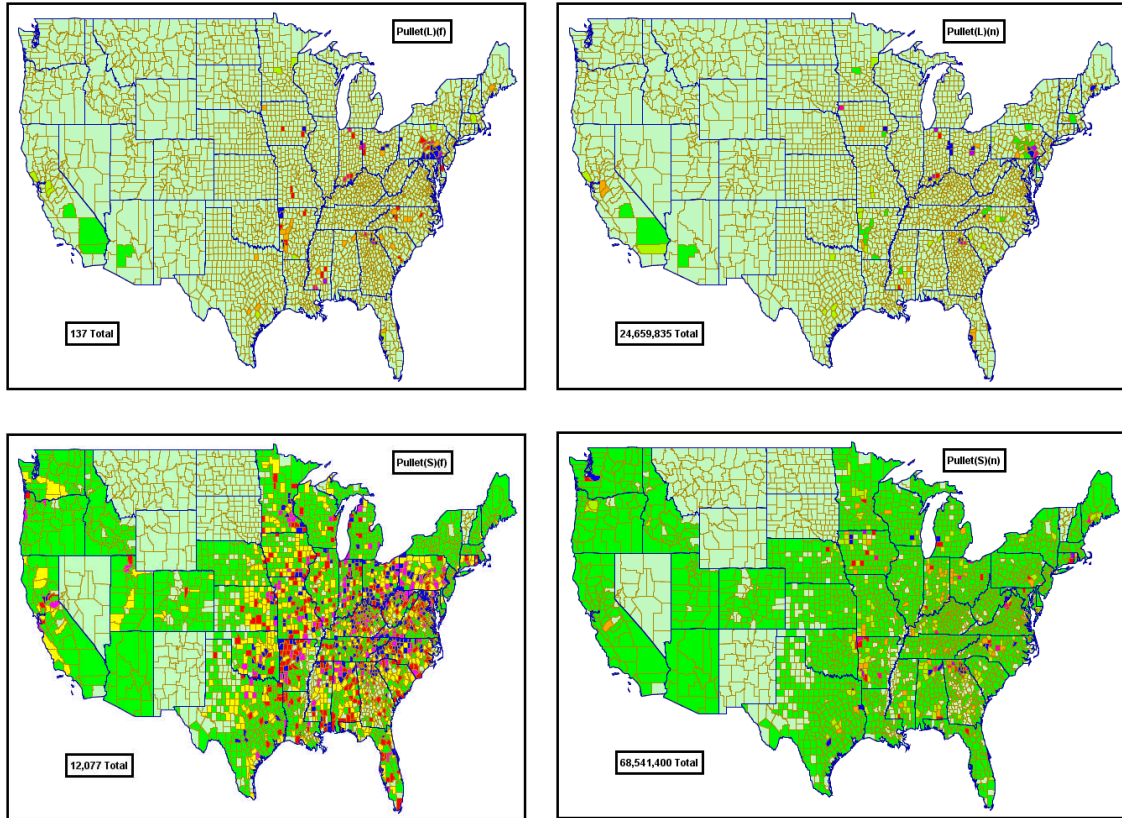


Fig. 5. – Distribution of pullets in the US (density of premises/birds by county).

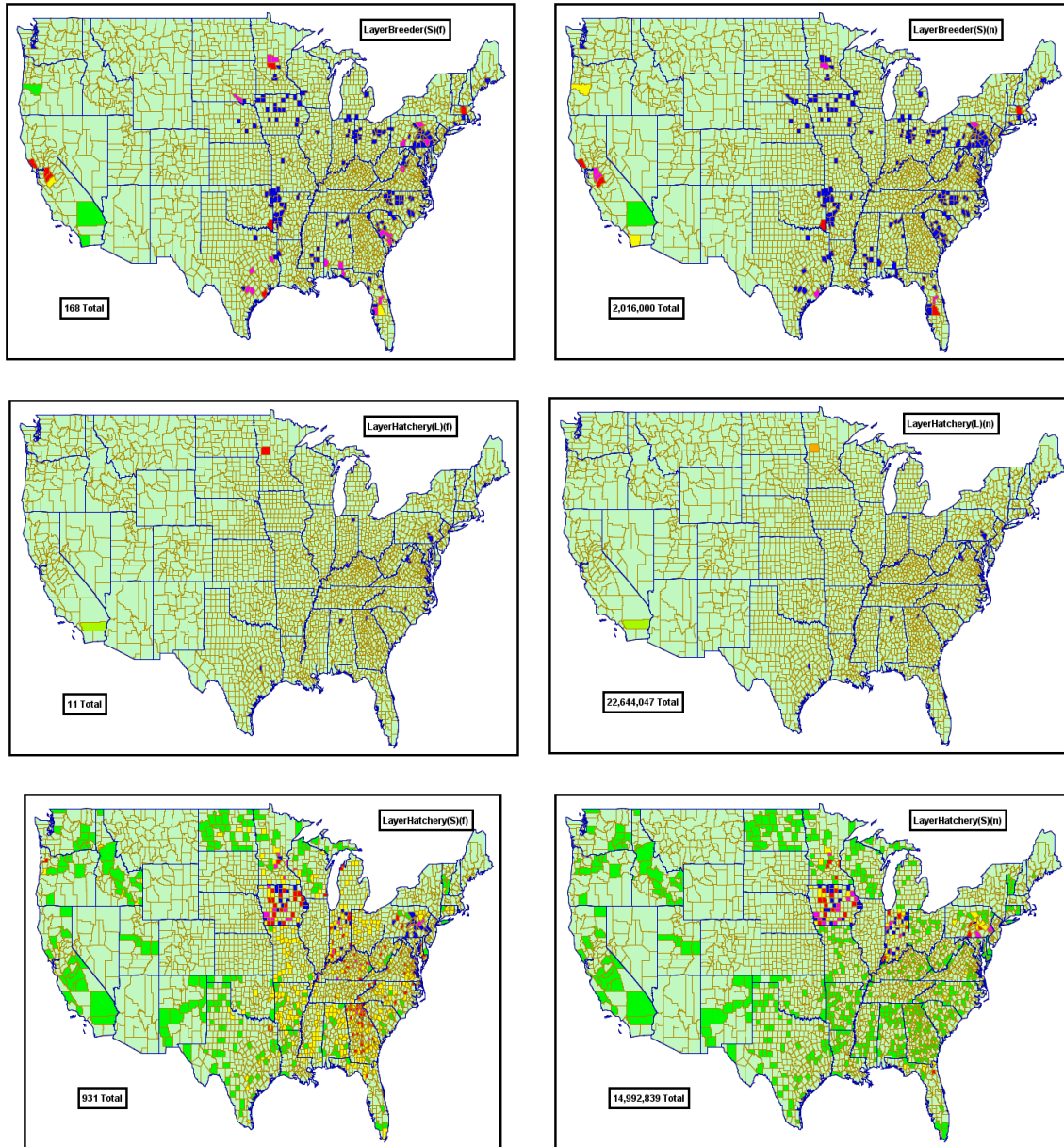


Fig. 6. – Distribution of associated egg-layer-related breeders and hatcheries in the US (density of premises/birds by county).

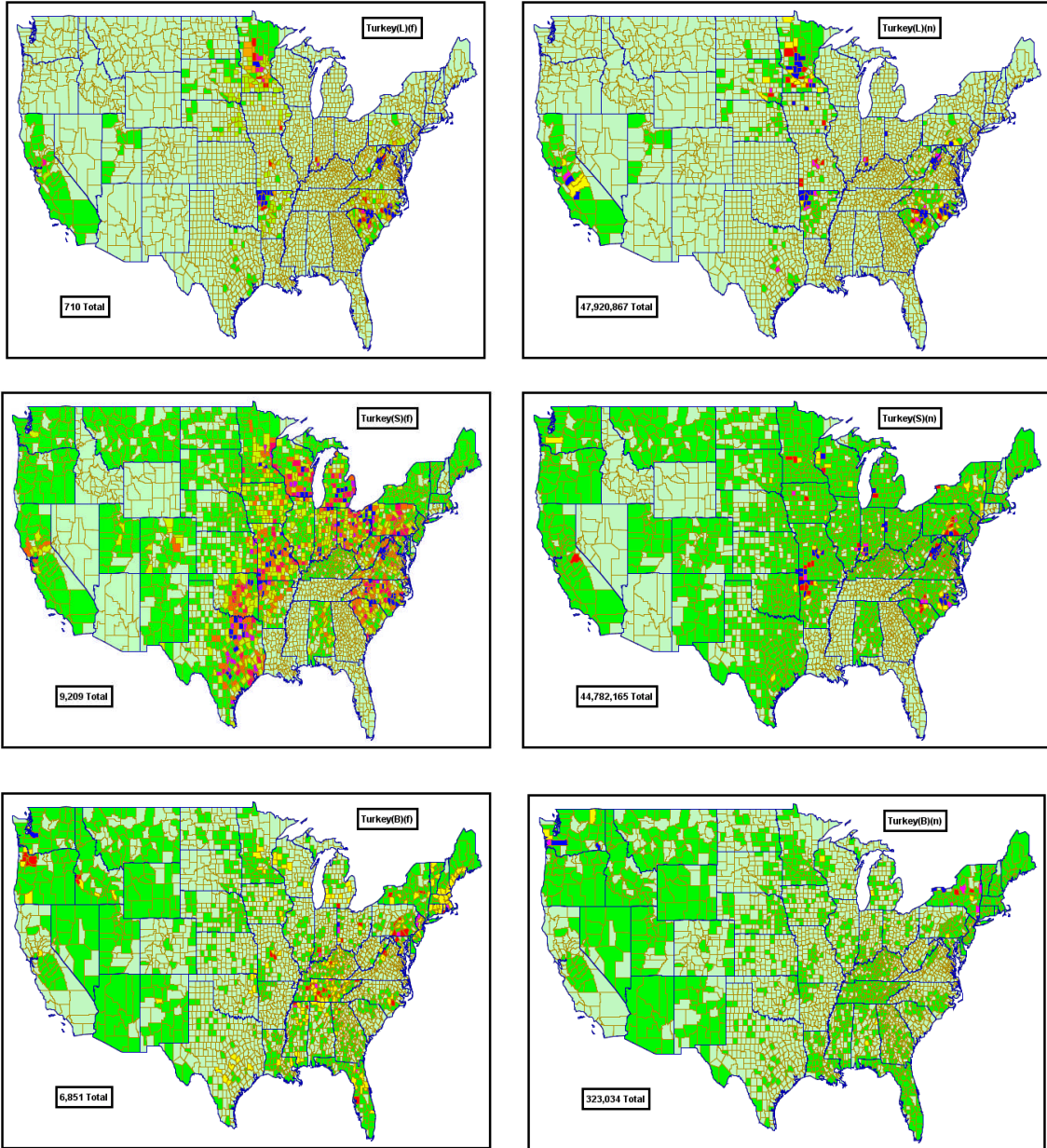


Fig. 7. – Distribution of turkey facilities in the US (density of premises/birdsby county).

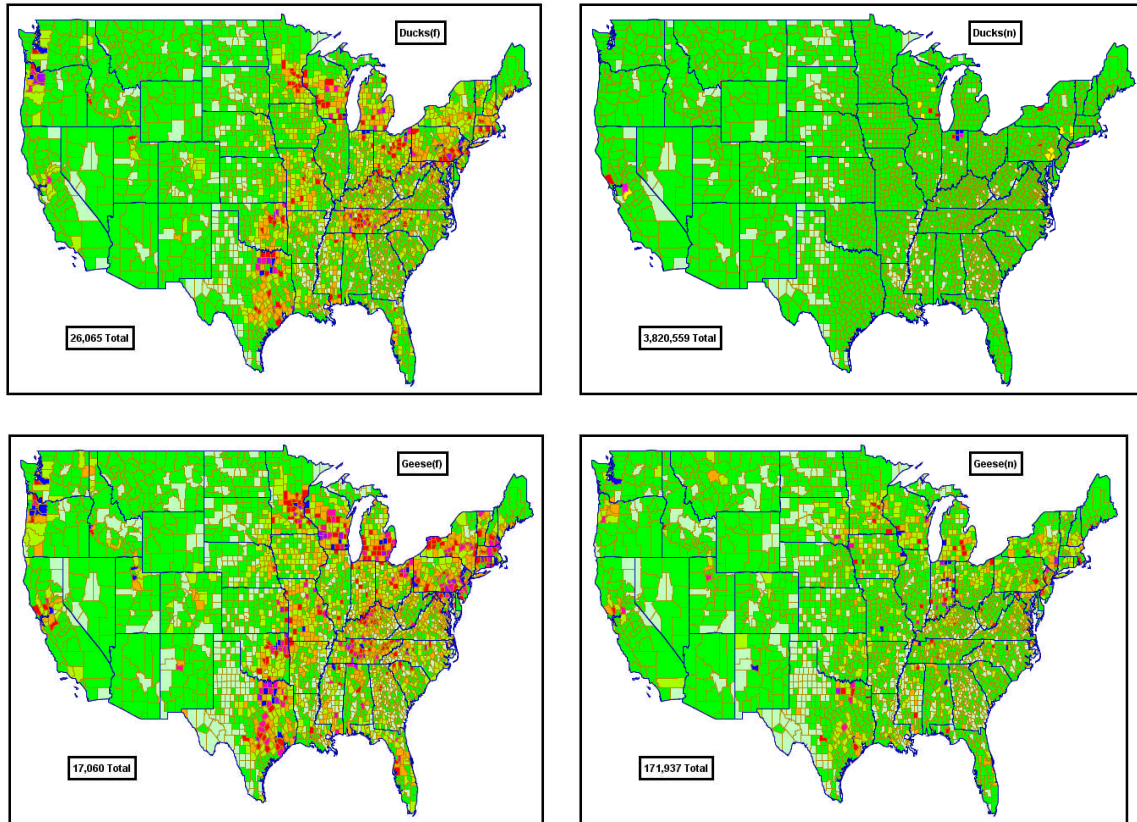


Fig. 8. – Distribution of ducks & geese facilities in the US (density of premises/birds by county).

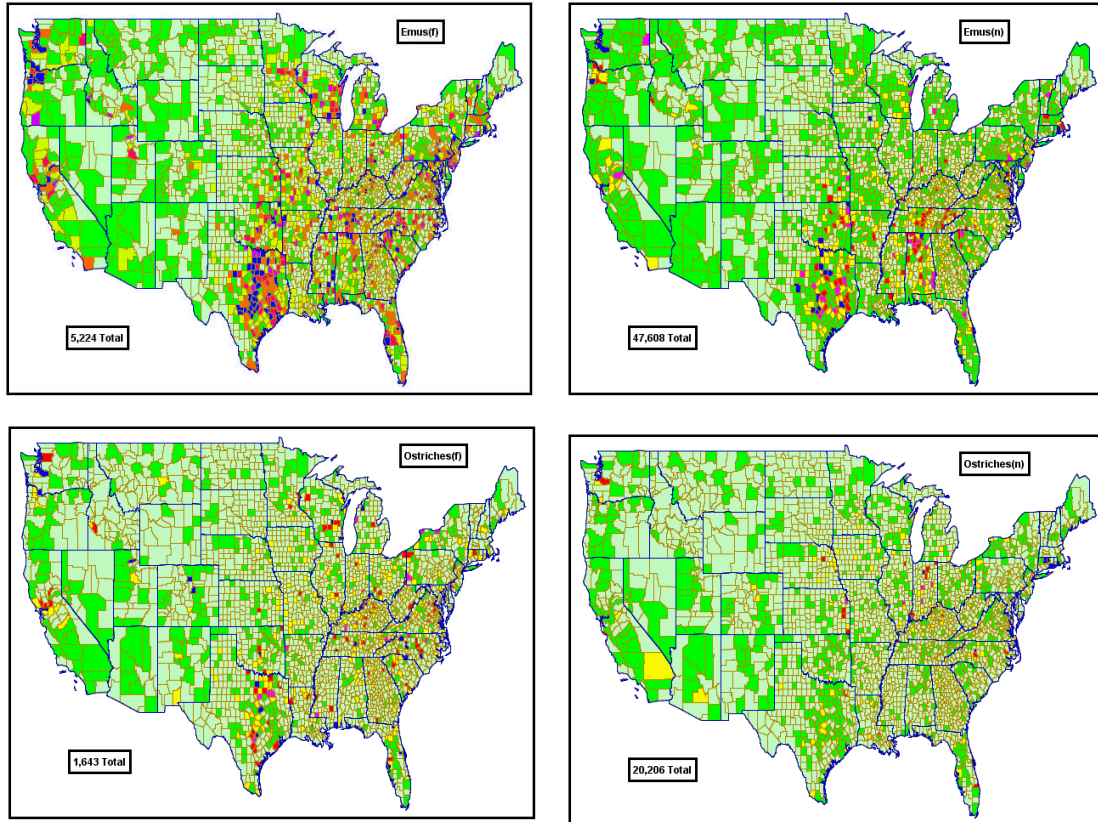


Fig. 9. – Distribution of emus and ostriches in the US (density of premises/birds by county).

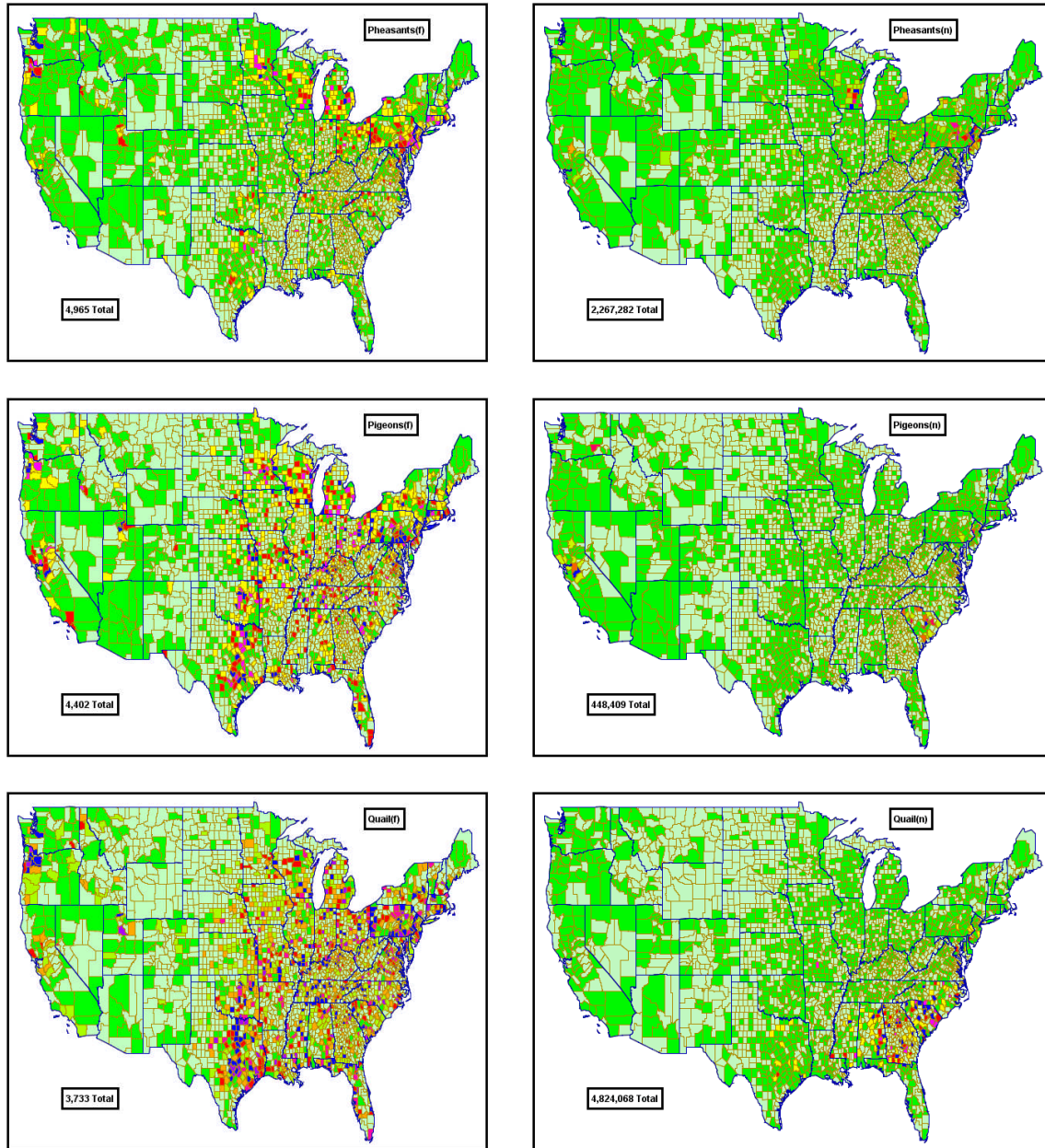


Fig. 10. – Distribution of pheasants, pigeons, and quail in the US (density of premises/birds by county).

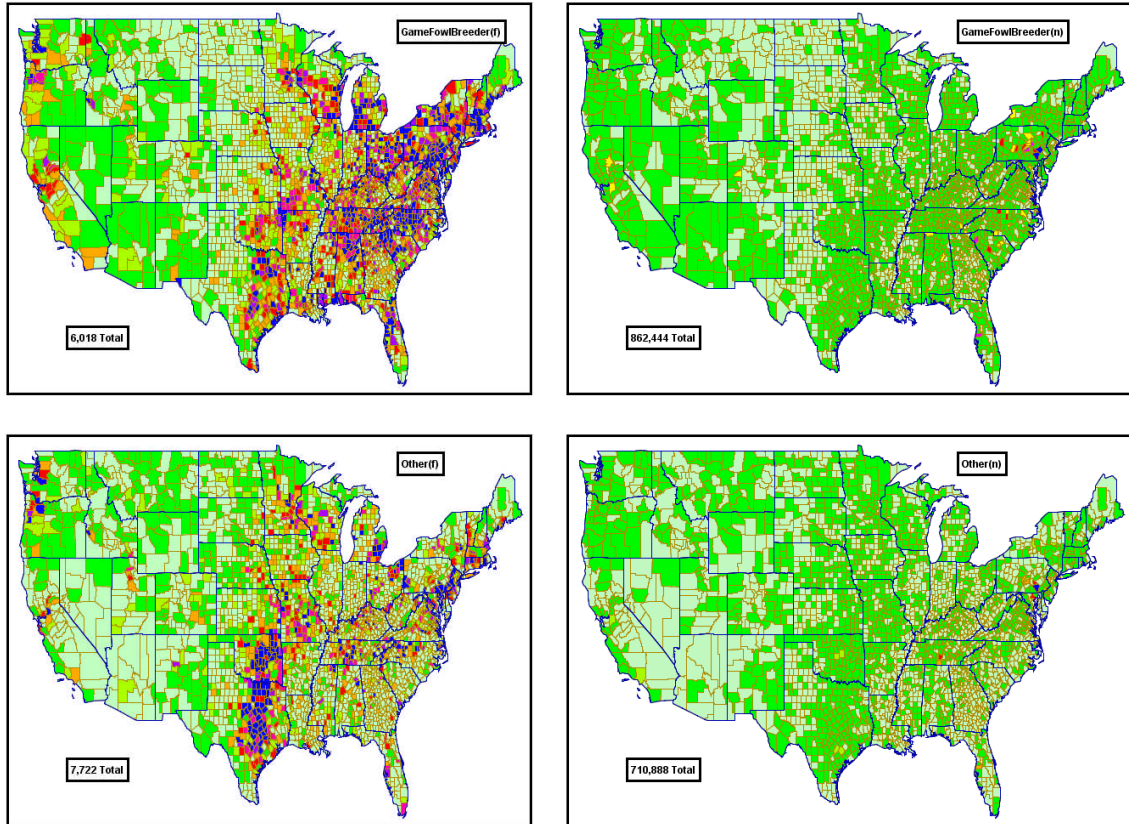


Fig. 11. – Distribution of game fowl and “other” facilities in the US (density of premises/birds by county).

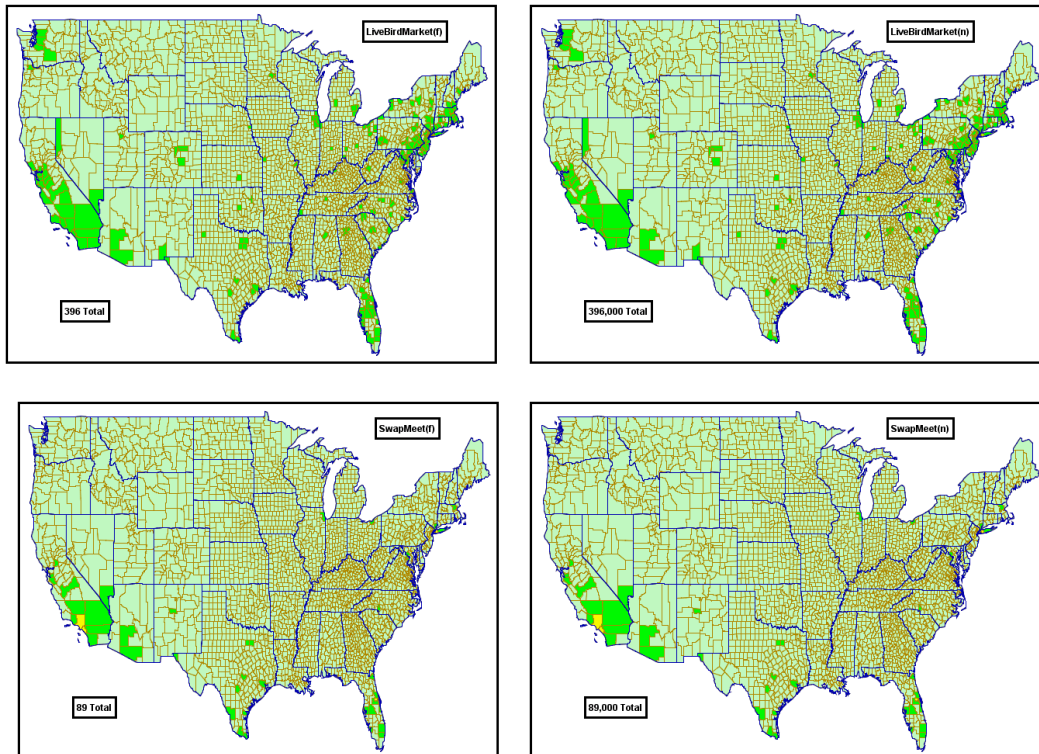


Fig. 12. – Distribution of live bird market and swap meet facilities in the US (density of premises/birds by county).

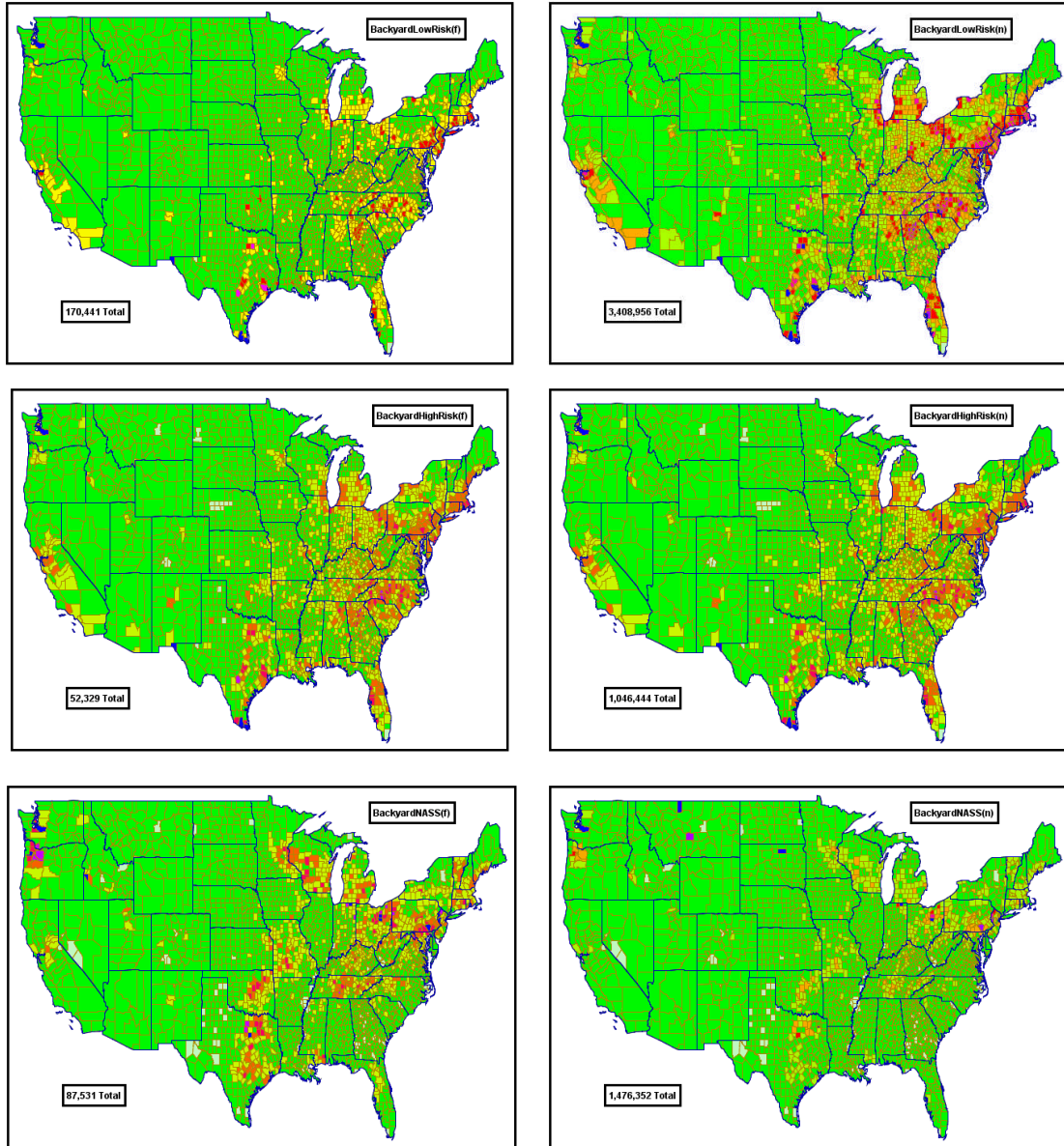


Fig. 13. – Distribution of backyard facilities in the US (density of premises/birds by county).

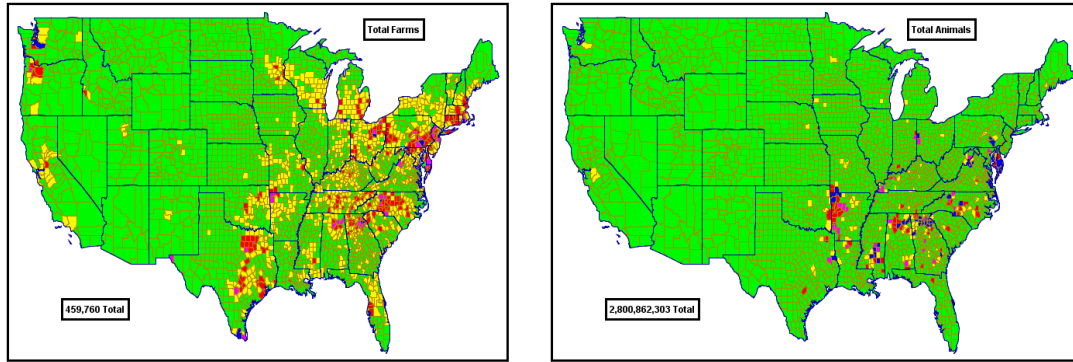


Fig. 14. – Distribution of total facilities in the US (density of premises/birds by county).

5. Directions for future work

The current partitioning of the NASS data into the twenty-six facility types is restricted by the categories provided by the NASS survey. It would be desirable to further partition the turkey industry into breeders, poults, and growouts. In addition, there are a significant number of pullets needed to supply the breeders. The required fraction of pullets should be allocated to the breeder industry, both for layers and broilers.

The current subdivision of sizes was to allocate the backyards to be less than 50 layers or less than 2000 pullets or broilers sold, with the larger premises assigned to “small” or “large.” The “small” category should be further subdivided into “commercial” and “non-commercial” to enable better application of resources, particularly with respect to diagnostics.

A better estimate of the number of backyards in the US is needed. The current algorithm may underestimate the number of backyards.

No information is available in the NASS data to uniquely identify breeder flocks. The current approach estimates breeders as a subset of egg-layers. Better data is needed to define where the actual breeders are located. Data is also needed to identify grandparent flocks. Additional efforts are also needed to compartmentalize the farms into groups defined by business ownerships.

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