Manure Loadings Used to Simulate Pastureland and Hay Land in CEAP HUMUS/SWAT Modeling

November 7, 2011

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Introduction

Manure nutrients were estimated for CEAP simulation modeling using livestock population data from the 2002 Census of Agriculture.[1] Estimation procedures are about the same as those published previously in USDA/NRCS (2003) and Kellogg et al. (2000) for 1997. Coefficients were adjusted in some cases to better reflect 2002 conditions for animal feeding operations. This report documents the methods used to make these estimates.

Electronic databases of farm-level responses were used to make the calculations at the farm level and then aggregated to the 6-digit HUCs (Hydrologic Unit Code) for use in water quality modeling. Access to the farm-level data base is restricted to protect the confidentiality of respondents. All estimates published in this document meet the disclosure criteria used by NASS to assure confidentiality.

Livestock populations reported in the 2002 Census of Agriculture were used to estimate total manure and manure nutrients *as excreted*, which were then disaggregated into two parts:

- recoverable manure from animal feeding operations (AFOs), and
- non-recoverable manure from all farms with livestock, including AFOs.

All recoverable manure is assumed to be land applied. In the CEAP simulation modeling, recoverable manure applied to cultivated cropland was estimated using the CEAP farmer survey, where farmers reported whether or not they applied manure, when it was applied, and how much manure was applied. However, some recoverable manure is also land applied on permanent pasture and permanent hay land, for which information was not obtained in the CEAP farmer survey. In the simulation modeling, manure was applied to permanent hay land and permanent pastureland at rates estimated from probable land application of manure derived from the 2002 Census of Agriculture. The methods and assumptions used to generate these estimates by 6-digit HUC are addressed in this documentation report.

Non-recoverable manure includes manure deposited by pastured animals and manure nutrients from AFOs that were not recoverable. Manure from livestock on farms too small to qualify as an AFO were included with pastured livestock, representing nutrient loadings on farmland in the vicinity of livestock operations. Non-recoverable manure loadings were estimated by subtracting recoverable manure available for land application from the total manure nutrients (*as excreted*) for all livestock. Volatilization losses of nitrogen were excluded. All non-recoverable manure nutrients were allocated to grazing land (pastureland and rangeland) in the CEAP HUMUS/SWAT modeling.[2] The methods and assumptions used to generate these estimates by 6-digit HUC are also addressed in this documentation report.

Thus, all sources of manure based on livestock population estimates from the 2002 Census were included in the CEAP model simulations, except that instead of using the census-based estimate of recoverable manure applied to cultivated cropland, estimates based on the CEAP farmer survey were used. (The estimates of land application of manure on cultivated cropland based on the CEAP farmer survey are considered to be superior to estimates derived from the 2002 Census of Agriculture data on livestock populations.)

[1] Estimates of manure nutrients were obtained using version 6 of the SAS program, which was run August 10, 2009. Subsequently, a few relatively minor refinements were incorporated into the SAS program; version 8 was used to make the final estimates in November, 2011. Consequently, the final estimates of manure nutrients for 2002 differ slightly from results used in the simulation model and presented in this documentation report.

[2] Included in the allocation of manure loadings to pastureland are manure nutrients from AFOs that were not recoverable. These manure nutrients either remain on site or are lost to the environment in the vicinity of the animal feeding operation. Over time, a portion of these manure nutrients would be transported to lakes, rivers, and streams. By allocating these loadings to pastureland, the simulation model accounts for these loadings through transport processes characteristic of areas with grass cover. An alternative approach would be to model these loadings as point sources, but the capability to do that has not yet been developed.

The basic steps involved in estimating recoverable and non-recoverable manure nutrient loadings for CEAP simulation modeling, summarized in the following sections of this documentation report, include—

1. Estimation of the average annual on-farm livestock population in terms of animal units (AU, equal to 1,000 pounds of live animal weight).
2. Estimation of the quantity of manure and manure nutrients produced.
3. Identification of AFOs (the source of recoverable manure) and estimation of quantities of recoverable manure nutrients.
4. Estimation of the potential application rates of recoverable manure on permanent hay land and pastureland.
5. Estimation of the quantity of non-recoverable manure nutrients.

Census Database Includes Hydrologic Unit Codes (HUCs)

Beginning in 2007, the National Agricultural Statistics Service (NASS) assigned Hydrologic Unit Codes (HUCs) to all farms. Initial watershed assignments were made based on the principal state, principal county, and zip code for each operation. If the principal county was contained completely within a watershed and the zip code was valid for the principal county, the operation was deterministically assigned to that watershed. Operations that could not be deterministically assigned were probabilistically assigned. Probabilistic assignments were made based on the proportion of agricultural land each watershed had within the principal county. For example, if a watershed represents 60 percent of the agricultural land in a county, a record would have had a 6 out of 10 chance of being assigned to that watershed. HUCs at the 2-, 4-, and 6-digit level were assigned. There are a total of 334 6-digit HUCs for the 48 states. All large farms and ranches that were probabilistically assigned were examined by NASS Field Office staff to verify or correct the 6-digit HUC assignments.

In order to provide a comparative history, NASS also made 6-digit HUC assignments to all 2002 Census of Agriculture farms. Forty-one percent of the farms reporting in 2002 could be matched to a 2007 response, and these were given the same 6-digit HUC as the 2007 record. The remaining records went through the assignment algorithm to establish a 6-digit HUC.

This information was excerpted from a NASS summary of the methodology at http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Watersheds/wtrsheds.txt

Estimating Animal Units

The basic building block of the estimation process is an animal unit (AU). An animal unit represents 1,000 pounds of live animal weight and serves as a common unit for aggregating over different types of livestock. The census of agriculture does not report the average number of animals on a farm during the year, which is needed to calculate animal units (and ultimately manure nutrients). The annual average number of animal units on each farm was estimated using census information on sales and end-of-year inventories.

The annual average number of animal units on each farm was derived from the following census data on number of livestock sold or on hand at the end of the year.

- Cattle and calves:
    - Beef cows, end-of-year inventory (including heifers that had calved)
    - Milk cows, end-of-year inventory (including dry milk cows and milk heifers that had calved)
    - Other cattle, end-of-year inventory (heifers, steers, calves, and bulls combined)
    - Cattle and calves on feed, end-of-year inventory
    - Calves sold weighing less than 500 pounds
    - Cattle and calves sold weighing more than 500 pounds
    - Number of fattened cattle sold
- Hogs and pigs:
    - Hogs and pigs used for breeding, end-of-year inventory
    - Other hogs and pigs, end-of-year inventory
    - Hogs and pigs sold, including feeder pigs
    - Type of operation (more than one could be recorded)—
        - Farrow to wean
        - Farrow to feeder
        - Farrow to finish
        - Finish only
        - Nursery
        - Other
- Poultry:
    - Chicken layers 20 weeks old and older, end-of-year inventory and number sold
    - Pullets for laying flock replacement, end-of-year inventory and number sold
    - Chicken broilers, fryers, and other meat-type chickens, end-of-year inventory and number sold
    - All turkeys, end-of-year inventory and number sold (2002 data were not broken down into turkeys for slaughter and turkeys for breeding, as was done in other census years)
    - Ducks, end-of-year inventory and number sold
- Horses, sheep, and goats:
    - Horses and ponies, end-of-year inventory
    - Mules, burros, and donkeys, end-of-year inventory
    - Sheep and lambs, end-of-year inventory
    - Goats, all types, end-of-year inventory

To convert head-count data reported in the Census of Agriculture to animal units, assumptions are needed on how long the animals are kept on the farm and the average weight of the animal. For cattle, this required deconstructing the "other cattle" inventory and the non-fattened cattle sold into the following categories:

- Veal (calves sold from operations without sufficient on-farm pastureland to support grazing)
- Beef calves
- Beef heifers
- Beef stockers and grass-fed beef
- Beef breeding cows and bulls
- Dairy calves
- Dairy heifers for herd replacement
- Dairy stockers sold as beef

Assumptions used to calculate animal units are summarized in table 1. Animal unit conversions (number of animals per AU) shown in table 1 were based on determinations of the *average* live weight associated with each livestock category**.** For some livestock categories (such as poultry), the animal unit conversion represents the average weight from birth to market. For others, such as beef and dairy calves, it represents the average weight for the time period that the animal was assumed to be in the specified category. Average animal weights were derived using two primary sources: 1) the NRCS Agricultural Waste Management Field Handbook (USDA-NRCS, 1992), and 2) the American Society of Agricultural and Biological Engineers' (ASABE) Standard D384.2 "Manure Production and Characteristics" (ASABE, 2005; ASAE, 1995). Average animal weights for 2002 were primarily based on ASABE Standards revised and published in 2005 (ASABE, 2005). These sources did not include data on all of the specific livestock types and ages of animals for which Census of Agriculture data were available, so in several cases the published values were adapted to conform to the type and size of animal for which head counts were available or could be derived.

An important aspect of the animal unit calculation is the amount of time that an animal is assumed to be on the farm during the year. For fattened cattle, hogs for slaughter, and poultry other than breeding stock, it was assumed that the animals were raised in multiple cycles per year, resulting in continuous production throughout the year. Assumptions used for the number of cycles per year are included in table 1. For the various cattle categories (calves, heifers, stockers), the animal unit calculation was based on the proportion of the year that the animals were in the specified category, also included in table 1. Animal units for breeding stock and chicken layers were estimated based only on end-of-year inventory. For these categories, it was assumed that the animal was present throughout the year or there was continuous replacement.

The parameters in table 1were derived to represent general production practices across the Nation for all operations, both large and small. For any specific part of the country, farm size, or time period, prevailing practices could result in different values for these parameters. For example, industry sources indicate that the time in a confined setting for fattened cattle ranges from 60 to 200 days, depending on season, cost of feed, and changes in sale price. The typical time in confinement for fattened cattle is 120 to180 days. A value of 2.5 cycles (146 days) was selected to estimate fattened cattle animal units for all operations. Similar information was evaluated to set these parameters for other livestock categories.

For categories with both sales and inventory data, a combination of data from end-of-year inventory and annual sales was used to estimate animal units. The general algorithm was obtained using the following simplifying assumptions:

- End-of-year inventory represents the partial cycle at the end of the year and the partial cycle at the beginning of the year, comprising a full cycle.
- Sales throughout the year do not fluctuate (i.e., no seasonal variation), and thus the average sales per cycle can be used to estimate the number of animals on the farm in each of the remaining cycles.

The general formula used is:

Equation 1*: Annual average AU= {(inventory x 1/cycles) + [sales/cycles x ((cycles-1)/cycles)]} x (1/animals per AU)*

Equation 1 estimates the average number of animal units on the farm throughout the year. Inventory data are used to estimate the average AU for one cycle, and average sales data (sales per cycle) were used to estimate the average AU for the remaining cycles.

For example, in the hypothetical case where three cycles of production are probable during a year and the livestock category spans from birth to market, equation 1 reduces to equation 2.

Equation 2*: Annual average AU= {(inventory x 1/3) + [sales/3 x (2/3)]} x (1/animals per AU)*

Because the production cycle for a given farm probably did not begin exactly on the first day of the year, some of the sales represent animals that were on the farm for a portion of the last cycle of the previous year. These animals should not be counted as full AU for the current year. Similarly, the inventory present at the end of the year may be at the beginning of a cycle or near the end of a cycle. It is clear, however, that of the three cycles possible during a year, sales from two of the cycles were present on the farm from birth to market.

Not all farms had both inventory and sales. Farms starting up a livestock operation sometimes had only end-of-year inventory, and farms going out of business or with production during times of the year other than the December 31 inventory date had sales, but no end-of-year inventory.

For farms with inventory only, the animals were assumed to be in mid-cycle at the end of the year, and annual average AU was calculated as shown in equation 3.

***Equation 3**: Annual average AU= {inventory x ½ x 1/cycles} x (1/animals per AU)*

For farms that have only sales data and no inventory data, it was assumed that all the animals represented by sales were present on the farm throughout the period associated with the livestock category (e.g., from birth to market), and annual average AU was calculated as shown in equation 4.

***Equation 4**: Annual average AU= {sales/cycles} x (1/animals per AU)*

Table 1. Parameters used to calculate animal units*

Livestock category	Source of data for number of head present on farm	Animals per animal unit 2002	Number of cycles per year	Proportion of year on the farm
Confined livestock types				
Fattened cattle	Year-end inventory and sales	1.02	2.5	--
Veal	Derived from cattle sales	4.4	--	3.5/12
Milk cows	Year-end inventory	0.73	NA	1
Breeding hogs	Year-end inventory	2.27	NA	1
Hogs for slaughter	Year-end inventory and sales	NA	2	--
Farrow to wean	Year-end inventory and sales	143	18	--
Farrow to finish	Year-end inventory and sales	7.4	2	--
Finish only	Year-end inventory and sales	6.7	2.6	--
Farrow to feeder	Year-end inventory and sales	50	8	--
Nursery	Year-end inventory and sales	37	13	--
Chickens, layers	Year-end inventory	293	NA	1
Chickens, pullets	Year-end inventory and sales	350	2.25	--
Chickens, broilers	Year-end inventory and sales	382	5.5	--
Turkeys	Year-end inventory and sales	59	2	--
Ducks	Year-end inventory and sales	286	6	--
Pastured livestock types				
Beef calves	Based on calving rate	4	--	5/12
Beef heifers for replacement herds	Based on replacement rate	1.14	--	5/12
Beef breeding herds (cows and bulls)	Year-end inventory	1	--	1
Beef stockers and grass fed beef	Derived	1.73	--2	--
Dairy calves	Based on calving rate	4	--	5/12
Dairy heifers for replacement herds	Based on replacement rate	1.04	--	5/12
Dairy stockers and grass fed animals marketed as beef	Derived	1.73	2	--
Horses and ponies	Year-end inventory	0.9	--	1
Mules, burros, and donkeys	Year-end inventory	1.8	--	1
Sheep and goats	Year-end inventory	8	--	1

* Represents coefficients for version 6 of the model, which was run August 10, 2009. Chicken broiler cycles were later changed from 5.5 to 6. Turkeys were later broken down into turkeys for breeding and turkeys for slaughter using the 2007 county proportions. Criteria for veal AUs were also adjusted later.

Estimating the Quantity of Manure and Manure Nutrients Produced

The amount of manure *as excreted* that is produced on a farm annually is calculated as the number of animal units times the amount of manure produced by an animal unit. Manure nitrogen and manure phosphorus *as excreted* were calculated by multiplying the tons of manure (wet weight) by standard values for the pounds of elemental nutrients per ton of manure (wet weight) as excreted.

The amount of manure produced and the amount of manure nutrients produced per animal varies among livestock types and from farm to farm depending on how much and how often the animals are fed, the quality of the feed and grazing materials (especially the nitrogen and phosphorus content), the extent to which the animals are held in confinement, and the extent to which animals are allowed access to grazing land. The American Society of Agricultural and Biological Engineers' (ASABE) Standard D384.2 "Manure Production and Characteristics" (ASABE, 2005; ASAE, 1995) provides estimates of manure characteristics, including the amount of nitrogen and phosphorus, for a variety of livestock types and ages. These data were adapted to correspond to the livestock types and ages used in the estimation. For 2002 estimates, manure characteristics based on the current ASABE Standards published in 2005 (ASABE, 2005) were used along with other sources to reflect current livestock production technologies, feeding regimens, and feed characteristics.

Parameters used to calculate the quantity of manure and manure nutrients are presented in table 2 for 2002. All measures of nitrogen and phosphorus in the table are in terms of elemental nitrogen and elemental phosphorus.

The quantity of manure at hauling weight was also estimated, assuming all manure was in solid form. The quantity of manure at hauling weight was used in part to identify Animal Feeding Operations (AFOs). (See next section.) For all livestock types except chicken broilers, ducks, and turkeys, the quantity of manure at hauling weight was estimated at two times the oven dry weight of manure as excreted. For chicken broilers and ducks, it was estimated at 1.3 times the oven dry weight of manure as excreted, and for turkeys it was estimated at 1.5 times the oven dry weight of manure as excreted.

Estimating Recoverable Manure and Manure Nutrients

Recoverable manure is the portion of manure that could be collected from buildings and lots where livestock are held. Recoverable manure nutrients are the nitrogen and phosphorus content of recoverable manure, adjusted for losses during collection, transfer, storage, and treatment. Recoverable manure nutrients are not adjusted for losses of nutrients during the process of land application.

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

Instead, criteria were developed based on the number of confined AUs and the amount of manure generated on the farm during a year of operation. Farms were considered AFOs if the population of livestock on the farm was large enough to require manure handling equipment and storage facilities on the farm, and where manure collection and removal from the animal holding facilities would be expected to occur on a regular basis. For this study, a farm was defined to be an AFO if there were:

1. more than 12 AU of confined livestock types, including the portion of pastured livestock that were assumed to be confined, or
2. more than 40 tons of manure at hauling weight produced by confined livestock AU on the farm in a year.

Farms that do not meet these criteria would be expected to have manure that would require removal and disposal if the animals were confined or partly confined, but the volume of manure would be too small for there to be manure handling equipment other than a tractor with a loader or scraper. It is likely that these farms with small livestock populations could be maintained on only a few acres (10-15) and not meet the EPA definition of an AFO.

Table 2. Parameters used to calculate the quantity of manure and manure nutrients for 2002.

Livestock category	Tons of manure per AU per year				
	Wet weight	Oven-dry weight	Pounds of nitrogen/ton wet weight**	Pounds of phosphorus/ton wet weight**	Ratio of phosphorus to nitrogen
Confined livestock types					
Fattened cattle	11.7	0.94	11.08	1.35	0.122
Veal	11.1	0.28	6.60	1.32	0.200
Milk cows	20.34	2.64	12.92	2.30	0.178
Breeding hogs	5.38	0.54	13.38	4.01	0.300
Hogs for slaughter					
Farrow to wean	16.2	2.1	20.55	3.29	0.160
Farrow to finish	13.5	1.62	16.00	2.65	0.166
Finish only	12.2	1.46	17.70	2.95	0.167
Farrow to feeder	17.1	2.22	19.35	3.1	0.160
Nursery	18	2.34	18.39	2.95	0.160
Chickens, layers	11.39	2.85	36.97	11.69	0.316
Chickens, pullets	8.21	2.13	27.19	10.53	0.387
Chickens, broilers	15.97	4.15	21.87	6.31	0.289
Turkeys	6.83	1.78	32.67	9.48	0.290
Ducks	18.4	4.8	19.60	6.8	0.347
Partially confined pastured livestock types					
Beef calves	14.94	1.79	11.57	2.17	0.188
Beef heifers for replacement herds	18.72	2.25	6.73	1.54	0.229
Beef breeding herds (cows and bulls)	18.72	2.25	6.73	1.54	0.229
Beef stockers and grass fed beef	18.72	2.25	6.73	1.54	0.229
Dairy calves	14.91	2.54	10.14	1.21	0.119
Dairy heifers for replacement herds	10.02	1.70	9.7	1.80	0.186
Dairy stockers and grass fed beef	18.75	2.25	6.73	1.54	0.229
Horses and ponies	9.25	1.39	9.34	1.79	0.192
Mules, burros, and donkeys	9.25	1.39	9.34	1.79	0.192
Sheep and goats	7.20	1.80	22.50	3.50	0.156
Pastured livestock types					
Beef calves	11.7	1.8	12	5	0.417
Beef heifers for replacement herds	11.7	1.8	12	5	0.417
Beef breeding herds (cows and bulls)	11.7	1.8	12	5	0.417
Beef stockers and grass fed beef	11.7	1.8	12	5	0.417
Dairy calves	11.7	1.8	12	5	0.417
Dairy heifers for replacement herds	11.7	1.8	12	5	0.417
Dairy stockers and grass fed beef	11.7	1.8	12	5	0.417
Horses and ponies	9	2.6	12	2.7	0.225
Mules, burros, and donkeys	9	2.6	12	2.7	0.225
Sheep and goats	7.2	1.8	22.5	3.5	0.156

* Represents coefficients for version 6 of the model, which was run August 10, 2009. Turkeys were later broken down into turkeys for breeding and turkeys for slaughter using the 2007 county proportions.

** Amounts of nitrogen and phosphorus are in terms of elemental nitrogen and elemental phosphorus. Includes nitrogen and phosphorus in urine.

For farms that meet these criteria for an AFO, all manure produced by confined livestock types on the farm was considered recoverable, regardless of how small the population. (On a dairy farm with a few chickens for private use, for example, the chicken manure was also treated as recoverable manure. Manure from any pastured livestock types that were also on this farm, such as horses or goats, was treated as non-recoverable.)

Manure produced by pastured livestock types was NOT included in the calculation of recoverable manure except in cases where the Census of Agriculture data on potential grazing land on the farm indicated that some degree of confinement was likely. Criteria for determining partial or complete confinement of pastured livestock types was based on the number of pastured livestock type AU per acre of grazing land on the farm, as follows:

- If the ratio of pastured livestock type AU to acres of grazing land on the farm was less than 8, no pastured livestock types were assumed to be confined.
- If the ratio of pastured livestock type AU to acres of grazing land on the farm was between 8 and 13, pastured livestock types were assumed to be 25 percent confined.
- If the ratio of pastured livestock type AU to acres of grazing land on the farm was between 13 and 18, pastured livestock types were assumed to be 50 percent confined.
- If the ratio of pastured livestock type AU to acres of grazing land the farm was greater than 18, pastured livestock types were assumed to be 75 percent confined.
- If there was no grazing land on the farm, all pastured livestock types were assumed to be confined.

Grazing land on the farm included three Census of Agriculture land use categories:

1. Acres of permanent pasture and rangeland
2. Acres of woodland pastured
3. Cropland acres used only for pasture or grazing

Recoverable manure is thus the portion of "as-excreted" manure that would be expected to be removed from an AFO and be available for land application. Estimates of manure produced *as excreted* were converted to estimates of recoverable manure by multiplying the amount of excreted manure by recoverability factors specific to each livestock type, farm size, and region of the country.

Recoverability factors would be expected to increase over time as improved manure management systems were used. Since 1997, most large operations have CAFO permits and over 35,000 Comprehensive Nutrient Management Plans have been prepared. Consequently, operations with improved manure handling and management capabilities have been replacing older, less efficient, operations over time.

Recoverability factors for 1982-2007 were derived from recoverability factors used with the 1997 Census of Agriculture database in USDA-NRCS (2003). In that study, model farms were defined, each with a specific manure management and handling system for which a recoverability factor was estimated. Since the occurrence of these model farms was defined only for 1997, recoverability factors reported in USDA-NRCS (2003) were generalized by livestock type, region, and operation size to represent the most typical manure management and handling systems. USDA-NRCS (2003) also projected what recoverability factors would be if all farms had a CNMP. Using these estimates, a time trend of recoverability factors was generated spanning from 1997 through 2017 under the assumption that all AFOs would have CNMPS by 2017. Estimates of recoverability factors for specific years were made as follows (table 3):

- For 1997, recoverability factors were the same as was used in USDA-NRCS (2003) for the baseline, or "before CNMP," scenario. (See appendix B, table B3, in USDA-NRCS (2003).)
- For 2017, recoverability factors were the same as was used in USDA-NRCS (2003) for the "after CNMP" scenario.
- For 2002-2007, recoverability factors were increased according to the 1997-2017 upward trend.
- For 1982-1992, recoverability factors were decreased relative to the 1997 estimates at half the rate of the 1997-2017 trend, representing a slower pace of CNMP implementation or practice adoption.

After estimating the amount of manure that was recoverable using the coefficients in table 3, recoverable manure nutrients were derived by:

1. multiplying the quantity of recoverable manure as excreted by the nutrient content of manure as excreted, and then
2. adjusting for losses during collection, transfer, storage, and treatment, including nitrogen volatilization.

Estimates of the proportion of nutrients retained in the recoverable fraction of manure are presented in table 4 for each livestock type. One minus the proportion of nutrients retained in the recoverable fraction of manure represents nitrogen volatilization and other losses during collection, transfer, storage, and treatment. Losses vary according to the type of manure handling, storage, and treatment system in use. These loss estimates are the same as or consistent with nutrient loss estimates used in USDA-NRCS (2003), which represent manure management systems in common use for the bulk of the livestock populations.[3]

Potential Application Rates of Recoverable Manure on Hay Land and Pastureland

In the CEAP HUMUS/SWAT modeling, manure was applied to permanent hay land and permanent pastureland at rates estimated from probable land application of recoverable manure estimated using the 2002 Census of Agriculture data. (Recoverable manure applied to cultivated cropland was estimated using the CEAP farmer survey, where farmers reported whether or not they applied manure, when it was applied, and how much manure was applied.)

Probable land application of recoverable manure was simulated on a crop-by-crop basis. In the simulation, manure was first applied on the land available on manure producing farms (AFOs). The simulation was conducted individually for each AFO using data on recoverable manure and crops grown that were specific to each individual farm.

When available on-farm land was insufficient for land application of the full amount of recoverable manure produced on the farm, the farm-level excess recoverable manure was simulated as off-farm land application. Off-farm applications were simulated for available land on farms other than on AFOs using data on crops grown that were specific to each area defined by the intersection of county boundaries and 6-digit HUC boundaries.[4] If there was insufficient land within an area for off-farm land application of the farm-level excess manure, the remaining manure was designated as excess manure and was not land applied.

Assumptions required for simulating land application of recoverable manure using Census of Agriculture data are required for:

1. The amount of manure applied relative to the uptake and removal of nitrogen with the crop yield.
2. The percentage of land available for land application of manure.
3. The priority order in which crops would receive manure applications.

Rates of manure applied

For these estimates, the ratio of the manure nitrogen application rate to nitrogen uptake and removal was used to determine the amount of manure applied per crop acre. Twenty-one crops, listed in table 5, and pastureland were used to simulate land application of recoverable manure. For each of the 21 crops, manure was applied at a rate equal to 2 times the uptake and removal of nitrogen for both on-farm and off-farm applications.[5] Nitrogen uptake coefficients in terms of pounds per unit of yield are shown in table 5.

Manure applications were also simulated for two types of pastureland—cropland used as pasture and permanent pasture.[6] For these two categories of pastureland, manure was applied at rates expected to provide the nutrients necessary for good levels of grass production assuming the pastureland is being grazed and accounting for the additional manure nutrients contributed by manure produced by the grazing animals. Manure was applied in amounts that resulted in application of 75 pounds of nitrogen per acre for cropland used as pasture and 30 pounds of nitrogen per acre for permanent pastureland. The lower rate for permanent pastureland reflects the generally lower productivity and level of management associated with permanent pastureland as compared to cropland used as pasture.

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[3] The phosphorus retention percentage for swine operations was adjusted upward to 90 percent under the assumption that the majority of lagoon sludge, which contains the bulk of the manure phosphorus in lagoon systems, is land applied when the lagoons are emptied.

[4] Areas defined by the intersection of county boundaries and 6-digit HUC boundaries were used in this application so as to provide estimates that could be aggregated to 6-digit HUCs for use in the CEAP HUMUS/SWAT modeling. The modeling requires data by watershed, rather than by county. However, the traditional application is to simulate off-farm land application of manure by counties under the assumption that manure would not be transported distances exceeding transport outside of the county where the recoverable manure originated. The areas used here are smaller than counties, as some counties would be dissected by a 6-digit HUC boundary.

[5] Simulation of land application of manure for off-farm applications in the final report uses a slightly lower nitrogen application rate-uptake ratio for 2002— manure was applied at a rate equal to 1.8 times the uptake and removal of nitrogen for off-farm applications.

[6] The Census reports acres of permanent pastureland and rangeland combined. Permanent pastureland was estimated separately using the percentage of pastureland and rangeland that is pastureland for each county as determined by the 1997 National Resources Inventory (NRI). This percentage was then applied to the census acres for pastureland and rangeland combined for each farm to estimate the acres of permanent pastureland on each farm.

Table 3. Manure recoverability factors expressed as the percent of manure *as excreted* that is recoverable, by year

	Size group	1982	1987	1992	1997	**2002**	2007	2012	2017
Livestock type and region	AUs	%	%	%	%	**%**	%	%	%
Milk Cows									
All	<35	43	44	45	45	**46**	48	49	50
North Central, NE	35-135	51	52	54	55	**58**	62	65	68
	135-270	50	52	54	56	**60**	63	67	71
	>270	47	49	52	54	**59**	64	70	75
Southeast	35-135	46	48	50	52	**56**	59	63	67
	>135	47	49	52	54	**57**	61	64	68
West	35-135	46	48	50	52	**56**	60	64	68
	135-270	47	49	52	54	**59**	64	69	74
	>270	54	56	58	60	**64**	68	71	75
Fattened Cattle									
All	<35	48	50	53	55	**60**	65	70	75
New England	>35	48	50	53	55	**60**	65	70	75
PA, NY, NJ	>35	54	56	58	60	**64**	68	72	76
Southeast	>35	52	54	57	59	**64**	69	74	78
Midwest	35-500	54	56	58	60	**64**	69	74	78
	>500	59	61	63	65	**69**	73	76	80
MT, WY, SD, MN	35-500	52	55	57	60	**65**	70	75	80
	>500	59	61	63	65	**69**	73	76	80
CO, KS, NE, SD	35-1000	52	55	57	60	**65**	70	75	80
	>1000	52	55	57	60	**65**	70	75	80
TX, OK, NM	35-1000	52	55	57	60	**65**	70	75	80
	>1000	52	55	57	60	**65**	70	75	80
West	35-500	52	55	57	60	**65**	70	75	80
	>500	52	55	57	60	**65**	70	75	80
All Partially Confined Pastured Livestock Types									
Northeast	All	57	59	62	64	**69**	74	78	83
Midwest	All	59	61	63	65	**69**	73	78	82
Southeast	All	59	61	63	65	**69**	73	77	80
West	All	59	61	63	65	**69**	73	77	80
Veal									
All Regions	All	68	70	73	75	**80**	85	90	95
Broilers									
Northeast	All	66	69	72	75	**81**	87	93	98
Southeast	All	80	82	84	85	**88**	91	95	98
Northwest	All	66	69	72	75	**81**	87	93	98
Southwest	All	66	69	72	75	**81**	87	93	98
Layers									
All Regions	<35	67	70	72	75	**80**	85	90	95
Southeast	35-400	70	72	75	77	**82**	86	91	95
	>400	70	72	75	77	**82**	86	91	95
West	35-400	76	77	79	80	**84**	88	91	95
	>400	67	70	72	75	**80**	85	90	95
South Central	35-400	67	70	72	75	**80**	85	90	95
	>400	76	77	79	80	**84**	88	91	95
North Central & NE	35-400	81	82	84	85	**87**	90	92	95
	>400	81	82	84	85	**87**	90	92	95
Pullets									
North Cen & NE	All	81	82	84	85	**87**	90	92	95
Southeast	All	76	77	79	80	**84**	88	91	95
West	All	76	77	79	80	**84**	88	91	95
South Central	All	76	77	79	80	**84**	88	91	95

Table 3. --continued

Livestock type and region	Size group	1982	1987	1992	1997	**2002**	2007	2012	2017
	AUs	%	%	%	%	**%**	%	%	%
Turkeys									
All Regions	<35	42	43	44	45	**46**	47	49	50
East	>35	70	72	74	76	**80**	84	89	93
South Central	>35	74	76	78	80	**84**	89	94	98
North Central	>35	70	72	74	76	**80**	84	89	93
West w/o CA	>35	56	57	59	60	**64**	67	70	74
CA	>35	66	68	70	72	**76**	80	84	88
Ducks									
All regions	<35	42	43	44	45	**46**	47	49	50
Hogs for breeding									
All Regions	<35	50	50	50	50	**50**	50	50	50
North Cen & NE	35-500	74	76	78	80	**84**	88	92	96
	>500	78	80	82	84	**87**	90	93	97
Southeast	35-100	73	74	75	76	**78**	81	83	85
	>100	80	82	83	85	**88**	91	94	97
West	35-500	70	71	72	73	**75**	78	80	83
	>500	78	80	81	83	**86**	90	94	97
Hogs for slaughter									
All Regions	<35	69	71	73	75	**79**	83	87	90
North Central & NE	35-500	69	70	72	73	**76**	79	82	95
	>500	75	77	79	81	**85**	89	93	97
Southeast	35-100	81	82	83	84	**87**	90	94	97
	>100	81	82	84	85	**88**	91	94	97
West	35-500	76	78	80	82	**86**	90	93	97
	>500	76	78	80	82	**86**	90	93	97

Note: Estimates for 1982-1992 and 2002-2007 were derived from recoverability estimates developed for 1997 in USDA-NRCS (2003). See text.

Table 4. Proportion of manure nutrients retained in recoverable fraction for AFOs for 2002.

Livestock category	Nitrogen	Phosphorus
Confined livestock types		
Fattened cattle	0.40	0.90
Veal	0.39	0.95
Milk cows	0.40	0.95
Breeding hogs	0.25	0.90
Hogs for slaughter, all types	0.25	0.90
Chickens, layers	0.69	0.85
Chickens, pullets	0.50	0.95
Chickens, broilers	0.60	0.95
Turkeys	0.53	0.95
Ducks	0.50	0.95
All Partially confined pastured livestock types	0.30	0.90

Table 5. Nutrient uptake coefficients for 21 crops used to simulate land application of recoverable manure by crop

Crop	Per-acre yield unit	Nitrogen	Phosphorus
Corn for grain	bushels	0.80	0.15
Corn for silage	tons	7.09	1.05
Soybeans	bushels	3.55	0.36
Sorghum for grain	bushels	0.98	0.18
Sorghum for silage	tons	14.76	2.44
Cotton (lint and seed)	500 pound bales	15.19	1.89
Barley	bushels	0.90	0.18
Winter wheat	bushels	1.02	0.20
Durum wheat	bushels	1.29	0.22
Other spring wheat	bushels	1.39	0.23
Oats	bushels	0.59	0.11
Rye for grain	bushels	1.07	0.18
Rice	100 pound bags	1.25	0.29
Peanuts for nuts (with pods)	pounds	0.040	0.003
Sugar beets for sugar	tons	4.76	0.94
Tobacco	pounds	0.030	0.002
Alfalfa hay	tons	50.40	4.72
Small grain hay	tons	25.60	4.48
Other tame hay	tons	19.80	15.30
Wild hay, including sorghum hay	tons	19.80	15.30
Grass silage	tons	13.60	1.60

The phosphorus application rate was implicitly set by the ratio of phosphorus to nitrogen in the manure applied. This ratio varies by livestock type (table 2).

(The census does not identify the acreage of crops that are double cropped. Where double cropping occurs, it is assumed that each crop would be potentially available for manure application, which may result in more than one manure application per field in the manure application simulation.)

Land available for manure application

The land base defined to be potentially available for manure application consisted of the 21 crops listed in table 4, cropland used as pasture, and half of permanent pasture. It was assumed that one-half of the permanent pastureland would not be accessible by manure spreading equipment because of location, terrain, or trees and other plant growth. All of the acres of the 21 crops were assumed to be available for both on-farm and off-farm application.[7]

Priority order in which land would receive manure applications

The simulation routine first applies recoverable manure to crops and pastureland on the farms producing manure (AFOs). AFOs that do not have enough acres available to meet the land application criteria have farm-level excess manure. All farm-level excess manure is assumed to be available for export off the farm for land application on surrounding properties.

[7] Simulation of land application of manure for off-farm applications in the final report assumed that only 50% of the acres would be available for land application because of an unwillingness to accept manure. Simulation of land application of manure for on-farm applications in the final report was adjusted to 90% of the on-farm acres for 2002 to account for limitations due to high phosphorus levels in the soil from past applications.

For on-farm applications, the simulation routine allocates manure to the highest priority crop present on the farm and applies manure to that crop according to the application rate criteria previously described. If the acres of the first priority crop are insufficient to assimilate all of the manure produced on the farm, the routine allocates manure to the next priority crop. This allocation process is repeated for each of the 21 crops and pastureland on each AFO or until all of the recoverable manure has been allocated. The farm-level excess manure is allocated in the same way to acres by crop in each area defined by the intersection of county boundaries and 6-digit HUC boundaries, except that the allocation is done on the total acres by crop within the area, rather than at the farm level.

The priority order for crops and pastureland receiving manure for both on-farm and off-farm application is as follows, with the highest priority for feed and forage crops:[8]

1. corn for silage
2. corn for grain
3. small grain hay
4. other tame hay
5. wild hay
6. grass silage
7. winter wheat
8. cropland used as pasture
9. permanent pasture
10. sorghum for silage
11. sorghum for grain
12. alfalfa hay
13. rye
14. barley
15. durum wheat
16. other spring wheat
17. oats
18. soybeans
19. cotton
20. sugar beets
21. rice
22. peanuts
23. tobacco

In most areas defined by the intersection of county boundaries and 6-digit HUC boundaries, sufficient acreage exists for off-farm land application of manure in accordance with the application criteria used. In some areas, however, the production of manure nutrients exceeds the capacity of the land to assimilate nutrients under the assumptions of the simulation, resulting in excess manure. This excess manure was assumed to not be land applied.

Per-acre rates of manure application on hayland and pastureland

The simulation estimated the pounds of manure nitrogen and phosphorus applied to each crop and to the two types of pastureland as well as the acres receiving manure for each. These estimates were then aggregated within each 6-digit HUC and used to estimate:

1. The proportion of legume hayland, non-legume hayland, and pastureland acres receiving manure, and
2. The nitrogen and phosphorus application rate (pounds/acre) for legume hayland, non-legume hayland, and pastureland for the acres that received manure.

Per-acre rates of land application of recoverable manure on hayland and pastureland and the proportion of acres receiving manure by 6-digit HUC that were used in the CEAP HUMUS/SWAT modeling are presented in Appendix A.

[8] A slightly different priority order was used in the final report.

Estimating Non-Recoverable Manure Nutrients

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

1. Nutrients in manure *as excreted* for all livestock types on farms NOT identified in this study as AFOs, excluding nitrogen volatilization. Manure nutrients originate from all pastured and confined livestock types on these farms.
2. Nutrients in manure *as excreted* for all non-confined livestock types on AFOs, excluding nitrogen volatilization. This consists of manure from pastured livestock types on AFOs.
3. Nutrients in the non-recoverable fraction of manure from confined livestock on AFOs, excluding nitrogen volatilization and nutrient losses during manure treatment, storage, collection, and transfer.
4. Nitrogen volatilization losses associated with items 1 and 2.
5. Nitrogen volatilization losses and other nutrient losses during manure treatment, storage, collection, and transfer of manure from confined livestock on AFOs (item 3).

These five sources of non-recoverable manure nutrients are calculated separately.

Nutrients in manure as excreted for all livestock not on AFOs and all non-confined livestock on AFOs (items 1 and 2 in the above list) were estimated by multiplying the quantity of manure as excreted (wet weight) times the nutrient content of manure as excreted. The nutrient content coefficients for each livestock type are shown in table 2. The nitrogen estimates were further adjusted to account for nitrogen lost to the atmosphere through volatilization, primarily as ammonia. For all livestock types and regions of the country, it was assumed that 35 percent of the non-recoverable manure nitrogen as excreted would volatilize and thus would not be part of the manure nitrogen loadings on agricultural land.

Nutrients in the non-recoverable fraction of manure from confined livestock on AFOs (item 3 in the above list) were estimated using the same nutrient content coefficients as used to estimate manure nutrients in the recoverable fraction (table 2). The nitrogen estimates were further adjusted to account for nitrogen lost to the atmosphere through volatilization, primarily as ammonia, which was assumed to be 35 percent of the as-excreted amount of manure nitrogen.

Per-acre rates of non-recoverable manure nutrients used for modeling

For use in CEAP HUMUS/SWAT modeling, non-recoverable manure nutrients consist of the manure nutrient components in the first 3 items listed above. Non-recoverable manure was allocated to pastureland and rangeland (range grass and range shrub) in the CEAP HUMUS/SWAT model. Since the model requires inputs at the 8-digit level, the 6-digit HUC estimates were used for each of the 8-digit HUCs within the corresponding 6-digit HUC.

Nutrient losses were not included in the loadings, as these would not generally be used in watershed modeling. The bulk of these losses for nitrogen represent volatilization losses, mostly as ammonia, which would not be expected to contribute to runoff or leaching. Double-counting of nitrogen sources would occur if these volatilization losses were included in the manure nutrient inputs, as atmospheric deposition is already included in the HUMUS modeling as a nitrogen source. Small amounts of phosphorus and nitrogen are also lost during the collection, transfer, storage, and treatment of recoverable manure (transport off-site by wind or water, biological activity, on-site accumulation), a portion of which also would not contribute to leaching or runoff.

Average per acre rates for nitrogen and phosphorus for each 6-digit HUC are shown in appendix B. The rates presented in appendix B are the ratio of the pounds of non-recoverable manure nitrogen or phosphorus derived from the 2002 Census database to the acres of grazing land on farms as reported in the 2002 Census database. Appendix B excludes estimates for 2-digit HUCS 13–16 and 18 (Western and Southwestern basins) because CEAP HUMUS simulations were not conducted for those basins.

An adjustment factor (shown in appendix B) was applied to the per-acre rates in appendix B to obtain grassland nutrient application rates used in the HUMUS model to correct for differences in estimated grassland area. The application rates presented in appendix B are based on grazing land acres on farms, which include permanent pasture and rangeland, pastured woodland, and cropland used as pasture as reported in the 2002 Census database. However, the acres

designated as pastureland and rangeland used in the HUMUS modeling were based on the Multi-Resolution Land Characterization (MRLC) consortium National Land Cover Database (NLCD) for 2001, which was not restricted to land on farms and also would not likely have included a portion of the pastured woodland. The adjustment factor is the ratio of census acres (used to calculate the rate) to the acres of pastureland and rangeland used in the HUMUS modeling. In most cases, this ratio was less than 1 because the land-cover database included grassed areas not on farms. In these cases, application of the adjustment factor assures that the nutrient loadings used in HUMUS are equal to the total amount of non-recoverable manure nutrients estimated using census data.

In some cases, however, the initial adjustment factor exceeded 1, indicating that the census acreage exceeded the land-cover acreage estimate. In most of these cases, the two estimates were close. The adjustment factor was capped at 1 for these cases to prevent over-application on a per-acre basis, which can lead to exaggerated estimates of leaching and runoff for those areas. The total manure nutrient loading for these 6-digit HUCs, however, is somewhat less than the amount of non-recoverable manure produced by the 2002 livestock population.

Organic and inorganic components of non-recoverable manure nutrients

In addition to the total nitrogen and phosphorus loadings, the CEAP HUMUS/SWAT model requires a breakdown of the organic and inorganic (mineral) fractions, and a further breakdown of the mineral nitrogen fraction into ammonia or ammonium and less volatile forms of nitrogen inorganic compounds. The coefficients used to estimate these components of manure nitrogen and phosphorus loadings are presented in table 6.

Table 6. Coefficients used to calculate the breakdown of non-recoverable manure nutrients into organic and inorganic (mineral) fractions

	Proportion of manure nitrogen in organic form	Proportion of manure nitrogen in inorganic form	Proportion of inorganic manure nitrogen as ammonia-ammonium	Proportion of manure phosphorus in organic form	Proportion of manure phosphorus in inorganic form
Confined livestock types					
Fattened cattle	0.8	0.2	0.7	0.4	0.6
Veal	0.5	0.5	1.0	0.4	0.6
Milk cows	0.6	0.4	0.7	0.3	0.7
Breeding hogs	0.4	0.6	1.0	0.4	0.6
Hogs for slaughter					
All types except nursery pigs	0.2	0.8	1.0	0.4	0.6
Nursery pigs	0.4	0.6	1.0	0.4	0.6
Chicken layers	0.3	0.7	1.0	0.4	0.6
Chicken pullets and broilers	0.9	0.1	1.0	0.4	0.6
Turkeys and ducks	0.9	0.1	1.0	0.4	0.6
Partially confined pastured livestock types					
Beef calves, heifers, breeding stock, beef stockers, grass-fed beef and dairy calves	0.6	0.4	0.5	0.4	0.6
Dairy heifers and dairy stockers	0.6	0.4	0.5	0.3	0.7
Horses, ponies, mules, burrow, and donkeys	0.9	0.1	0.6	0.4	0.6
Sheep and goats	0.8	0.2	0.6	0.4	0.6
Pastured livestock types					
Beef calves, heifers, breeding stock, beef stockers, and grass-fed beef	0.5	0.5	0.67	0.4	0.6
Dairy calves, heifers, and stockers	0.8	0.2	1.0	0.3	0.7
Horses, ponies, mules, burrow, and donkeys	0.9	0.1	1.0	0.3	0.7
Sheep and goats	0.7	0.3	1.0	0.4	0.6

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Appendix A. Land application of recoverable manure on hayland and pastureland, by 6-digit HUC

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
10100	0.01480	0.00000	0.00006	93.7	0.0	75.0	37.8	0.0	20.6
10200	0.03350	0.05262	0.00349	67.8	31.6	57.1	28.9	13.9	24.7
10300	0.06067	0.00084	0.01091	66.9	262.1	66.9	28.5	110.8	28.9
10400	0.17506	0.11261	0.17987	81.7	206.5	60.2	34.2	100.5	24.2
10500	0.07390	0.00235	0.00523	72.3	212.2	65.0	37.0	89.7	27.8
10600	0.03271	0.00297	0.01063	74.5	29.4	35.5	33.0	15.6	15.1
10700	0.05070	0.00235	0.00940	71.9	165.8	46.5	31.3	77.1	21.6
10801	0.07340	0.00651	0.01053	74.8	194.4	68.7	32.2	87.2	29.3
10802	0.02973	0.00229	0.01499	85.2	243.5	57.1	36.8	105.6	24.4
10900	0.04698	0.00517	0.01353	73.6	141.6	53.1	34.0	61.0	23.0
11000	0.01831	0.00269	0.00777	80.7	212.9	68.8	35.5	92.3	29.8
11100	0.11996	0.00689	0.01852	113.3	166.7	51.3	47.9	70.5	21.6
20100	0.07676	0.00517	0.02570	87.5	105.2	59.3	36.9	45.6	25.1
20200	0.03470	0.00300	0.01655	66.9	197.2	54.3	28.4	88.3	22.6
20301	0.00559	0.00191	0.00130	73.2	150.1	62.4	35.0	73.4	30.2
20302	0.00154	0.00000	0.03077	39.6	0.0	40.7	22.8	0.0	23.2
20401	0.10587	0.00675	0.01290	59.4	241.4	48.7	25.5	106.1	20.3
20402	0.08825	0.01235	0.02467	84.0	294.1	51.0	38.3	144.2	23.1
20403	0.14264	0.00053	0.00878	68.8	252.0	39.4	29.6	161.3	21.7
20501	0.05926	0.00523	0.01725	67.6	195.2	56.2	29.1	87.1	23.6
20502	0.05901	0.01126	0.02390	72.3	170.2	59.9	34.8	77.1	25.7
20503	0.11476	0.03829	0.07896	84.6	230.1	57.9	40.0	104.3	25.7
20600	0.09385	0.06100	0.06494	86.8	278.4	60.8	40.2	127.3	27.6
20700	0.20147	0.07015	0.13834	75.8	242.2	56.0	36.1	115.9	26.6
20801	0.02274	0.00531	0.00415	62.2	102.1	44.5	32.8	57.5	19.3
20802	0.11051	0.03535	0.03811	63.8	156.9	60.1	30.5	71.9	27.8
30101	0.02494	0.00248	0.00736	58.9	148.4	59.1	30.8	82.6	28.0
30102	0.06789	0.03479	0.02974	84.6	213.6	62.6	46.0	94.3	31.7
30201	0.18001	0.28358	0.10168	82.8	137.9	62.6	45.5	70.7	31.9
30202	0.32255	0.10328	0.17024	89.4	194.6	66.9	50.6	98.9	35.7
30300	0.35108	0.23074	0.23130	91.9	173.3	59.9	49.8	85.5	30.5
30401	0.24513	0.08771	0.17154	74.2	193.8	59.9	35.1	90.9	27.6
30402	0.32218	0.28469	0.19710	82.6	161.2	55.9	44.2	87.1	28.9
30501	0.27981	0.03364	0.09879	78.0	234.2	65.9	37.6	113.5	31.7
30502	0.18793	0.07850	0.14795	78.5	118.3	59.2	36.4	53.8	26.9
30601	0.28178	0.16876	0.19673	86.5	165.1	56.8	39.5	74.4	25.8
30602	0.14289	0.00000	0.07431	89.1	0.0	47.0	41.7	0.0	21.6
30701	0.33353	0.07895	0.21478	85.8	100.8	59.5	38.8	45.3	26.6
30702	0.33286	0.81250	0.27286	128.1	100.8	51.4	59.1	46.0	23.5
30801	0.09280	0.06594	0.00795	103.5	100.8	50.1	46.0	44.8	22.1
30802	0.08937	0.00000	0.00724	264.4	0.0	70.8	113.3	0.0	30.3
30901	0.26853	0.00000	0.01077	145.9	0.0	61.9	62.9	0.0	25.7
30902	0.26642	0.00000	0.00952	141.7	0.0	63.7	61.7	0.0	27.3
31001	0.07704	0.00000	0.00391	213.9	0.0	66.4	92.8	0.0	28.4
31002	0.09761	0.00000	0.00697	101.0	0.0	45.1	43.8	0.0	19.0
31101	0.18371	0.00937	0.02297	138.9	100.8	55.7	63.4	68.0	24.4
31102	0.23533	0.00613	0.13814	141.6	422.5	51.8	63.8	201.3	22.8
31200	0.06457	0.00000	0.05529	110.3	0.0	58.8	53.1	0.0	26.4
31300	0.16873	0.04157	0.08921	96.5	100.8	57.2	44.4	44.7	26.0

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
31401	0.25165	0.00000	0.08794	90.7	0.0	70.2	40.6	0.0	32.1
31402	0.49376	0.25963	0.29936	100.2	205.2	61.4	46.1	98.4	28.1
31403	0.25095	0.36364	0.14097	104.0	201.6	61.4	47.9	91.9	28.0
31501	0.34971	0.09525	0.22475	83.2	327.4	59.4	38.2	167.2	27.0
31502	0.05259	0.04211	0.01092	74.6	504.0	58.2	36.4	228.8	26.7
31601	0.23462	0.34138	0.17421	99.6	226.3	58.1	45.9	103.4	26.5
31602	0.08472	0.00000	0.00705	100.0	0.0	51.3	46.5	0.0	23.6
31700	0.36983	0.00000	0.24218	101.0	0.0	60.1	46.4	0.0	27.5
31800	0.44836	0.19083	0.28693	101.3	260.7	58.6	46.4	111.5	26.9
40101	0.01176	0.00000	0.00000	19.8	0.0	0.0	13.4	0.0	0.0
40102	0.02283	0.00000	0.00371	62.4	0.0	71.5	28.1	0.0	32.0
40103	0.04236	0.00015	0.00549	62.2	339.1	47.5	26.7	143.4	20.1
40201	0.04454	0.00199	0.01559	76.0	236.2	69.1	32.2	105.6	29.3
40202	0.02445	0.00072	0.00516	82.1	148.2	60.8	34.8	93.0	25.4
40203	0.00000	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0
40301	0.01570	0.00442	0.02281	108.2	190.8	63.7	46.5	85.2	27.2
40302	0.01118	0.00217	0.01813	101.3	234.5	57.5	43.8	109.3	24.3
40400	0.01602	0.00320	0.01012	132.9	234.7	59.3	56.9	109.1	23.5
40500	0.03720	0.00444	0.03164	89.9	308.8	68.3	43.2	154.7	33.0
40601	0.01990	0.00304	0.01276	74.5	251.4	63.0	33.5	122.7	26.1
40602	0.00000	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0
40700	0.04195	0.00139	0.01438	95.3	188.5	63.5	41.1	95.5	25.5
40801	0.01450	0.00202	0.06513	125.7	342.1	66.7	53.8	128.1	19.9
40802	0.01073	0.00169	0.00944	92.3	257.6	67.6	41.7	124.0	25.1
40803	0.01874	0.00000	0.00000	75.0	0.0	0.0	32.6	0.0	0.0
40900	0.01784	0.00171	0.00673	53.0	245.5	50.1	23.6	113.6	18.8
41000	0.03447	0.00654	0.01951	111.2	218.2	58.8	46.6	105.0	25.5
41100	0.01939	0.00245	0.01121	80.4	275.6	55.8	33.8	116.5	23.3
41201	0.02143	0.00462	0.01505	75.3	138.9	47.4	32.4	60.3	18.5
41202	0.02039	0.00000	0.14671	55.0	0.0	60.6	22.4	0.0	24.7
41300	0.02587	0.01044	0.02147	84.4	157.2	61.3	35.3	62.0	25.1
41401	0.04065	0.00119	0.01175	73.5	219.1	58.7	31.1	89.4	24.3
41402	0.02615	0.00195	0.02214	86.6	141.8	53.5	36.7	65.4	22.0
41501	0.06385	0.00970	0.03737	71.8	96.0	55.7	29.9	47.2	23.5
41502	0.09960	0.00000	0.04051	46.1	0.0	75.0	19.5	0.0	31.7
41503	0.08417	0.00993	0.02355	67.0	154.1	58.8	28.7	67.3	24.8
50100	0.02704	0.00153	0.00878	70.6	188.0	54.8	30.7	89.5	23.1
50200	0.01136	0.00290	0.00257	61.3	134.4	63.4	29.6	71.5	25.5
50301	0.01971	0.00269	0.01776	74.0	181.5	38.0	32.8	83.7	13.7
50302	0.00665	0.00166	0.00246	69.3	91.9	42.9	33.0	50.9	16.9
50400	0.05759	0.00864	0.01571	77.6	227.9	55.3	33.0	100.8	23.5
50500	0.01500	0.00450	0.00397	60.2	139.0	56.7	28.4	80.8	21.6
50600	0.01331	0.00362	0.00689	84.2	225.6	55.2	36.3	106.6	29.1
50701	0.00148	0.00000	0.00000	106.1	0.0	0.0	71.9	0.0	0.0
50702	0.01273	0.00109	0.00156	52.0	302.4	75.0	34.1	128.3	20.9
50800	0.02978	0.00980	0.01084	62.8	184.9	52.9	28.3	85.1	22.8
50901	0.00730	0.00141	0.00115	71.0	160.2	67.2	35.9	108.2	28.3
50902	0.01842	0.00428	0.00532	66.0	109.6	54.9	31.1	54.2	22.4
51001	0.01321	0.00353	0.00307	55.7	291.6	62.5	27.8	138.5	26.2
51002	0.00832	0.00119	0.00096	60.7	221.4	56.7	32.3	126.6	23.2
51100	0.02333	0.00388	0.00806	76.0	219.4	61.3	37.3	107.5	27.1

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
51201	0.02775	0.01469	0.01468	81.8	230.3	52.4	39.6	104.0	23.0
51202	0.04932	0.00413	0.00972	77.5	191.5	59.5	38.7	97.3	28.7
51301	0.04754	0.00331	0.00868	84.1	343.8	60.9	39.7	174.7	27.3
51302	0.00943	0.00176	0.00111	59.9	301.9	48.3	33.2	152.3	21.3
51401	0.01441	0.00354	0.00492	61.3	210.6	56.0	31.4	110.9	24.7
51402	0.01347	0.00666	0.00333	73.2	208.4	58.4	40.0	107.8	29.7
60101	0.03340	0.00714	0.00509	82.6	223.9	62.8	38.0	108.9	26.8
60102	0.01263	0.00341	0.00137	64.4	151.2	56.0	33.2	98.4	23.2
60200	0.20287	0.07027	0.08790	76.1	223.1	63.0	34.8	97.9	28.2
60300	0.14386	0.13227	0.10317	92.3	224.7	58.7	43.0	102.6	26.9
60400	0.04145	0.00983	0.00498	83.9	266.8	55.2	40.1	114.8	25.3
70101	0.01314	0.00337	0.00748	65.1	227.6	42.3	32.2	114.3	17.8
70102	0.01852	0.00639	0.01857	88.9	212.9	44.2	39.8	97.0	19.4
70200	0.01466	0.00287	0.01225	98.8	203.7	40.8	45.2	105.4	15.9
70300	0.01588	0.00194	0.00616	67.2	166.8	58.0	30.4	81.5	24.1
70400	0.01740	0.00366	0.01464	97.2	253.3	54.4	42.0	117.6	24.1
70500	0.02096	0.00165	0.01354	80.8	189.7	54.6	34.7	86.7	23.1
70600	0.01034	0.00244	0.01461	136.0	300.8	48.7	57.6	129.3	19.7
70700	0.02018	0.00211	0.01416	91.2	175.9	53.9	39.3	81.8	22.7
70801	0.01262	0.00295	0.00590	99.9	206.4	44.0	45.8	110.6	21.1
70802	0.01867	0.00383	0.00801	85.7	245.9	50.4	39.8	127.9	22.6
70900	0.01237	0.00431	0.01998	118.5	196.7	43.6	50.4	90.9	18.1
71000	0.01761	0.00336	0.00385	50.5	170.6	49.9	24.5	82.9	19.9
71100	0.01414	0.00443	0.00401	60.4	101.4	60.7	30.7	63.7	27.2
71200	0.01731	0.00194	0.01233	117.4	183.0	57.1	54.4	91.5	24.8
71300	0.00898	0.00290	0.00397	94.7	233.1	53.7	55.3	115.1	23.0
71401	0.01295	0.00228	0.00253	69.2	163.4	51.7	34.5	91.9	25.2
71402	0.01328	0.00610	0.00476	46.6	135.7	47.6	23.0	65.3	20.8
80101	0.03899	0.25000	0.02409	129.3	304.4	68.2	61.4	139.1	31.0
80102	0.01307	0.00372	0.00363	76.2	381.8	62.4	41.3	175.3	28.9
80201	0.07308	0.00000	0.00000	39.6	0.0	0.0	26.7	0.0	0.0
80202	0.03126	0.02653	0.00542	63.3	164.9	47.0	34.0	79.6	20.3
80203	0.02610	0.00000	0.00867	84.3	0.0	65.6	41.4	0.0	27.5
80204	0.04330	0.00000	0.00206	74.9	0.0	52.0	42.5	0.0	20.8
80301	0.00000	0.00000	0.00000	0.0	0.0	0.0	0.0	0.0	0.0
80302	0.01165	0.00000	0.00148	64.1	0.0	50.2	38.8	0.0	21.4
80401	0.38449	0.11913	0.12851	85.6	277.7	64.8	39.5	136.3	30.0
80402	0.28195	0.13007	0.24985	102.1	330.8	58.8	47.0	152.4	26.9
80403	0.16518	0.33333	0.08397	111.6	890.4	60.3	50.1	406.4	27.5
80500	0.01391	0.00000	0.00033	99.8	0.0	48.0	62.2	0.0	17.1
80601	0.00497	0.00000	0.00000	93.9	0.0	0.0	63.6	0.0	0.0
80602	0.10245	0.00000	0.01794	88.2	0.0	59.9	42.4	0.0	26.8
80701	0.04284	0.00000	0.00417	122.3	0.0	61.2	80.5	0.0	27.0
80702	0.22368	0.20423	0.03499	89.3	225.5	66.8	39.7	92.5	29.4
80703	0.01569	0.00000	0.00116	65.2	0.0	75.0	43.4	0.0	50.1
80801	0.01578	0.00000	0.00098	73.2	0.0	48.1	40.5	0.0	17.2
80802	0.03742	0.00475	0.00079	78.7	325.1	53.8	40.6	217.9	24.0
80901	0.02313	0.00000	0.00000	72.6	0.0	0.0	47.5	0.0	0.0
80902	0.14910	0.00000	0.02461	100.8	0.0	50.4	43.2	0.0	21.3
80903	0.02403	0.00000	0.00137	77.3	0.0	28.7	47.9	0.0	13.3
90100	0.00822	0.00078	0.00124	46.2	159.0	69.4	24.3	92.0	29.5

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
90201	0.01795	0.00342	0.00612	56.9	197.0	50.8	24.3	91.9	18.1
90202	0.01095	0.00334	0.00244	50.1	81.7	48.2	26.3	48.3	17.4
90203	0.05805	0.00235	0.00549	59.5	132.1	53.7	31.1	74.0	22.7
90300	0.01977	0.00063	0.00089	37.5	165.1	75.0	19.0	100.9	31.7
100100	0.03418	0.00000	0.00000	32.5	0.0	0.0	18.1	0.0	0.0
100200	0.01029	0.00162	0.00165	149.8	307.4	55.6	73.5	144.3	22.5
100301	0.02169	0.00162	0.00206	65.9	183.3	45.7	31.6	105.5	17.7
100302	0.03046	0.00448	0.01259	83.2	179.1	50.8	42.8	90.5	24.0
100401	0.01465	0.00143	0.00054	55.6	77.7	41.2	25.2	52.3	12.5
100402	0.00954	0.00418	0.00236	56.3	78.4	29.7	28.5	45.9	13.6
100500	0.00782	0.00224	0.00124	55.4	164.2	33.7	31.7	86.2	14.2
100600	0.00458	0.00120	0.00036	50.2	110.2	28.0	31.7	73.9	9.6
100700	0.00566	0.00065	0.00122	74.3	184.2	54.5	32.2	111.1	16.9
100800	0.00745	0.00321	0.00106	74.0	150.2	58.3	38.5	93.8	18.9
100901	0.02541	0.00809	0.00013	51.2	59.8	38.3	32.1	38.5	14.5
100902	0.01183	0.00280	0.00030	34.1	102.1	45.9	15.3	63.9	14.4
101000	0.01225	0.00266	0.00160	41.1	94.7	31.4	25.9	52.5	9.4
101101	0.01200	0.00229	0.00050	46.4	128.7	31.3	24.9	83.5	9.4
101102	0.00958	0.00446	0.00125	27.4	35.5	42.8	15.3	20.9	12.9
101201	0.01858	0.00779	0.00266	29.5	44.6	49.7	15.5	26.6	16.3
101202	0.06111	0.00735	0.00224	29.1	61.8	49.2	14.8	37.4	19.3
101301	0.01794	0.00577	0.00293	31.2	56.5	53.2	15.6	28.5	19.9
101302	0.02142	0.00525	0.00317	39.3	60.4	46.2	18.0	31.7	18.8
101303	0.04141	0.00824	0.00200	27.2	73.4	35.2	14.6	43.0	12.1
101401	0.02777	0.00331	0.00394	36.6	97.0	43.3	19.4	49.8	15.9
101402	0.05656	0.01184	0.00333	33.3	22.8	48.6	16.8	14.1	14.1
101500	0.02029	0.00659	0.00314	30.7	114.1	45.0	12.6	45.1	15.4
101600	0.01490	0.00190	0.00543	49.3	124.0	57.0	22.3	57.8	20.7
101701	0.07919	0.00205	0.00656	42.8	163.9	45.2	18.0	73.6	17.2
101702	0.01601	0.00446	0.00952	82.9	216.4	45.0	39.6	103.8	17.7
101800	0.01533	0.00430	0.00340	41.1	290.8	51.2	13.7	105.4	14.5
101900	0.02975	0.01275	0.00542	47.3	314.2	51.2	23.0	122.3	18.2
102001	0.01824	0.00938	0.00490	52.8	366.9	54.1	22.6	110.0	16.2
102002	0.01373	0.00342	0.00489	57.4	278.5	40.7	24.4	98.9	16.4
102100	0.01417	0.00543	0.00310	27.0	196.7	53.5	9.5	63.5	17.4
102200	0.01606	0.00777	0.00854	54.2	403.3	46.8	22.5	126.5	16.5
102300	0.02609	0.00785	0.01269	140.6	341.6	45.8	76.7	130.8	16.8
102400	0.01207	0.00425	0.00507	55.0	165.8	46.1	28.0	81.6	18.1
102500	0.02125	0.00309	0.00347	57.6	356.0	55.5	21.4	118.9	17.9
102600	0.02731	0.00200	0.00183	49.3	294.0	69.3	21.5	97.2	21.8
102701	0.01250	0.00261	0.00310	55.1	149.1	45.7	23.7	57.4	16.0
102702	0.02094	0.00499	0.00652	66.6	253.1	52.0	28.2	93.5	17.5
102801	0.03903	0.00400	0.00386	66.2	267.9	60.1	37.7	130.0	26.8
102802	0.00873	0.00773	0.00511	65.3	203.2	56.3	37.0	130.9	28.1
102901	0.04591	0.00929	0.00673	69.3	179.8	56.8	34.9	113.0	28.9
102902	0.06511	0.01529	0.01414	79.1	86.8	56.0	36.0	43.2	24.6
103001	0.03677	0.00667	0.00862	66.7	116.8	57.8	34.1	60.7	28.5
103002	0.01089	0.00131	0.00578	66.8	317.2	61.1	34.7	256.3	28.3
110100	0.19629	0.01380	0.04782	84.4	203.5	63.3	39.7	98.8	29.4
110200	0.11456	0.00611	0.01652	53.8	124.7	69.7	20.5	77.5	28.0
110300	0.03384	0.00834	0.01199	92.6	425.4	70.5	34.9	125.8	20.9

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
110400	0.02045	0.00317	0.00953	109.0	170.5	71.5	42.4	60.1	20.7
110500	0.04021	0.00020	0.00417	67.2	276.6	69.8	29.5	132.0	36.1
110600	0.01512	0.00144	0.00083	63.4	169.0	52.1	32.8	84.9	20.0
110701	0.01411	0.00022	0.00177	50.6	234.3	37.2	25.2	99.1	14.0
110702	0.14072	0.01023	0.07085	81.0	261.1	58.0	37.7	116.9	26.8
110800	0.07878	0.00921	0.00229	146.6	792.4	47.8	47.4	224.0	13.5
110901	0.02892	0.00153	0.02582	47.5	100.8	74.1	22.5	68.0	20.6
110902	0.01876	0.00256	0.00342	65.3	395.4	58.4	40.8	158.6	27.1
111001	0.04707	0.00309	0.01301	92.5	412.3	72.2	35.2	155.2	21.7
111002	0.22525	0.00254	0.00249	52.9	464.5	61.6	21.9	237.0	28.0
111003	0.01585	0.00087	0.00169	61.3	125.4	50.4	35.6	73.7	24.7
111101	0.25047	0.04658	0.09835	85.1	272.6	58.8	39.8	128.2	27.5
111102	0.42151	0.07134	0.14653	88.1	219.7	63.7	41.8	103.4	30.1
111201	0.25068	0.00025	0.09813	93.9	94.5	74.6	27.5	63.6	21.1
111202	0.14520	0.00059	0.00250	87.5	90.7	64.7	27.2	60.7	19.0
111203	0.08010	0.00008	0.00478	60.6	194.8	70.9	18.3	131.9	19.7
111301	0.02181	0.00034	0.00210	57.0	39.7	36.3	26.5	26.8	12.1
111302	0.03129	0.00178	0.00264	96.9	162.6	69.4	43.7	72.7	27.3
111303	0.02825	0.00173	0.00909	57.9	167.2	70.3	27.0	85.1	23.7
111401	0.11220	0.05106	0.04438	84.9	304.0	61.2	40.2	134.4	28.5
111402	0.22365	0.11648	0.09342	99.4	269.2	54.5	45.9	135.2	24.8
111403	0.13426	0.02304	0.03515	101.7	285.1	58.0	45.9	123.4	26.0
120100	0.13602	0.04061	0.05627	108.6	357.8	54.8	49.5	165.7	24.8
120200	0.14262	0.02420	0.09465	102.1	87.3	53.2	46.8	42.7	24.2
120301	0.01703	0.05189	0.00276	72.1	308.8	60.4	34.7	130.1	23.6
120302	0.01453	0.00485	0.00208	65.7	215.1	44.5	35.1	146.0	18.2
120401	0.01806	0.00273	0.00196	81.4	151.8	46.8	39.1	100.2	19.0
120402	0.01369	0.00260	0.00051	50.4	220.8	65.1	30.2	146.0	24.6
120500	0.13586	0.00921	0.02444	102.0	405.3	74.6	36.9	189.2	22.0
120601	0.03644	0.00204	0.00087	64.6	463.7	68.5	24.8	195.3	23.6
120602	0.04248	0.00434	0.00616	109.6	121.3	65.3	47.7	76.7	26.9
120701	0.01836	0.02499	0.00181	72.6	42.3	54.8	36.9	27.8	23.9
120702	0.03764	0.04870	0.00543	103.5	313.9	64.6	47.0	135.2	27.1
120800	0.04111	0.00017	0.00213	88.1	799.4	72.5	31.8	458.3	26.2
120901	0.05045	0.01352	0.00193	73.7	89.0	56.1	27.6	44.2	21.0
120902	0.01567	0.00000	0.00072	43.0	0.0	40.6	21.6	0.0	15.7
120903	0.01610	0.00319	0.00085	74.9	270.3	38.5	40.4	182.4	15.5
120904	0.01719	0.00000	0.00021	42.6	0.0	35.5	20.9	0.0	11.4
121001	0.05226	0.00000	0.00360	100.4	0.0	69.0	42.7	0.0	31.1
121002	0.12054	0.01031	0.08274	90.5	272.2	72.2	40.8	124.3	32.2
121003	0.01699	0.00000	0.00281	75.1	0.0	49.9	35.2	0.0	19.5
121004	0.01400	0.00000	0.00086	71.7	0.0	31.7	42.5	0.0	9.3
121101	0.02338	0.00000	0.00401	58.4	0.0	65.5	23.7	0.0	20.5
121102	0.01625	0.00043	0.00018	58.6	643.5	42.4	36.5	415.8	17.7
130100	0.01584	0.00259	0.00054	70.0	82.6	60.1	39.7	50.8	18.5
130201	0.02853	0.00554	0.00019	36.2	126.7	75.0	22.9	82.5	33.6
130202	0.02986	0.01212	0.00409	98.3	295.3	65.2	52.6	126.8	27.0
130301	0.13186	0.01066	0.00825	96.6	661.5	59.2	43.6	290.8	24.8
130302	0.08368	0.15008	0.01968	148.8	795.0	72.8	64.7	337.3	30.7
130401	0.01930	0.00178	0.00074	84.6	372.5	41.3	57.4	241.7	20.4
130402	0.02248	0.01223	0.00026	96.1	58.6	75.0	42.8	38.5	23.3

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
130403	0.04520	0.00000	0.00000	33.8	0.0	0.0	13.6	0.0	0.0
130500	0.02063	0.02732	0.00461	94.0	592.0	67.2	45.6	241.8	27.7
130600	0.24950	0.01293	0.00279	184.0	620.8	71.8	78.1	267.5	28.8
130700	0.11555	0.01407	0.00544	136.7	497.8	71.0	61.0	210.5	29.9
130800	0.14987	0.00000	0.02161	108.1	0.0	74.9	32.9	0.0	20.9
130900	0.02235	0.00000	0.01434	186.7	0.0	74.6	57.1	0.0	20.5
140100	0.02051	0.00844	0.00136	50.5	64.4	67.3	28.3	41.5	20.5
140200	0.01611	0.00913	0.00216	46.1	143.9	53.2	25.1	88.3	17.4
140300	0.03668	0.00764	0.00280	56.0	151.7	66.7	33.4	88.2	28.7
140401	0.01099	0.00467	0.00072	22.8	128.0	62.3	10.4	71.7	18.3
140402	0.01461	0.00000	0.00352	81.6	0.0	52.4	50.5	0.0	14.4
140500	0.01728	0.00559	0.00023	36.7	128.3	63.4	20.1	73.9	20.0
140600	0.09822	0.00723	0.01020	94.0	217.5	73.2	40.3	109.8	29.5
140700	0.20483	0.01634	0.01913	128.8	179.6	72.7	61.1	110.4	33.5
140801	0.01778	0.00208	0.00045	30.2	116.7	34.9	14.4	72.7	10.1
140802	0.10676	0.00651	0.00255	50.8	47.4	72.8	27.0	31.6	46.1
150100	0.14764	0.01158	0.00387	173.7	630.7	68.1	90.8	284.5	31.5
150200	0.21290	0.00377	0.03418	81.1	759.2	75.0	50.5	505.8	49.2
150301	0.03625	0.00010	0.04952	129.9	665.0	75.0	59.5	439.9	30.8
150302	0.00000	0.00303	0.00240	0.0	705.1	75.0	0.0	473.6	47.9
150400	0.02137	0.00427	0.00109	106.1	477.2	75.0	71.1	316.9	45.8
150501	0.00481	0.01189	0.02372	105.6	777.8	74.6	63.6	333.0	32.9
150502	0.02633	0.00016	0.00697	183.6	332.2	71.0	126.0	155.4	46.0
150503	0.44205	0.10785	0.07580	87.8	796.6	64.9	28.4	255.9	20.2
150601	0.02200	0.00010	0.00118	152.7	834.6	73.5	90.1	520.6	21.3
150602	0.03213	0.00660	0.00547	61.7	731.4	71.6	40.7	489.7	25.9
150701	0.10785	0.01505	0.15725	207.9	756.8	72.6	90.4	321.8	31.8
150702	0.46876	0.01995	0.34787	118.2	839.0	75.0	36.7	234.2	23.3
150801	0.05128	0.00028	0.01033	79.2	806.4	75.0	40.4	463.6	38.2
150802	0.00000	0.00000	0.46303	0.0	0.0	75.0	0.0	0.0	50.6
150803	0.00000	0.00000	0.00067	0.0	0.0	75.0	0.0	0.0	49.9
160101	0.02450	0.01455	0.00195	50.0	96.0	60.3	23.7	41.9	22.7
160102	0.07789	0.01123	0.01880	87.7	256.9	56.6	39.9	117.8	23.7
160201	0.06329	0.00572	0.00850	87.8	164.2	70.6	31.6	81.3	28.3
160202	0.06116	0.00793	0.01516	126.7	267.8	63.7	58.4	129.7	22.0
160203	0.17302	0.00300	0.01345	105.1	186.2	71.1	45.3	95.8	29.3
160300	0.31168	0.01141	0.07700	122.3	364.6	70.0	67.9	185.1	38.3
160401	0.00521	0.00451	0.00166	58.5	259.2	75.0	21.8	123.0	27.3
160402	0.02825	0.00012	0.00335	66.8	270.1	43.1	42.1	158.0	11.8
160501	0.03781	0.02016	0.00210	84.0	231.2	75.0	49.7	125.5	26.5
160502	0.04603	0.01151	0.00337	219.9	549.8	74.8	95.2	260.9	30.4
160503	0.09004	0.00058	0.01489	89.7	455.0	74.9	51.2	239.6	20.6
160600	0.05838	0.00302	0.00304	87.6	348.5	63.3	41.8	219.9	36.2
170101	0.01288	0.00191	0.00198	71.8	236.2	75.0	44.1	122.8	32.2
170102	0.00861	0.00122	0.00222	92.5	219.6	52.6	45.8	108.7	21.7
170103	0.02246	0.00215	0.00321	89.3	263.7	69.5	39.3	117.9	29.0
170200	0.02598	0.00194	0.00391	130.4	429.4	52.9	57.7	185.6	19.6
170300	0.03316	0.02488	0.03389	225.2	563.5	69.8	99.0	238.1	21.9
170401	0.03016	0.00627	0.00876	68.9	162.9	71.6	31.4	83.6	27.9
170402	0.08098	0.00990	0.01365	182.1	437.4	64.5	76.8	180.2	26.8
170501	0.05747	0.00487	0.02286	206.2	469.9	69.9	69.6	214.2	20.5

6-digit HUC	Proportion of acres receiving manure			Manure nitrogen application rate for acres receiving manure (pounds/acre)			Manure phosphorus application rate for acres receiving manure (pounds/acre)		
	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland	Non-legume hay	Legume hay	Pastureland
170502	0.01236	0.00132	0.00124	86.6	381.7	47.0	43.4	230.2	14.7
170601	0.01138	0.00115	0.00131	100.6	216.3	53.0	54.2	130.3	19.5
170602	0.00971	0.00085	0.00083	93.1	206.9	74.5	46.5	136.3	30.8
170603	0.01086	0.00079	0.00065	60.8	182.8	62.6	34.6	116.6	25.4
170701	0.13766	0.00089	0.00196	169.7	136.1	43.0	65.2	68.4	14.7
170702	0.01343	0.00097	0.00035	66.1	189.9	50.6	29.7	109.4	15.3
170703	0.01234	0.00136	0.00414	109.3	287.5	63.9	62.5	179.6	25.2
170800	0.27863	0.01552	0.03656	104.8	134.1	64.1	46.7	62.4	27.8
170900	0.15427	0.01252	0.01367	101.0	310.5	57.7	43.5	133.7	23.5
171001	0.27267	0.14480	0.15649	99.2	312.5	51.4	42.6	131.3	21.2
171002	0.13953	0.06506	0.20814	163.7	207.2	62.8	69.6	92.5	26.6
171003	0.03866	0.00234	0.00369	95.0	198.3	42.4	43.5	112.4	15.4
171100	0.17421	0.00438	0.06261	141.5	105.7	67.9	60.1	69.2	28.2
171200	0.00709	0.00054	0.00042	71.4	260.3	44.4	37.4	169.5	16.0
180101	0.27552	0.02417	0.09840	174.5	76.3	73.1	74.5	32.2	31.0
180102	0.02196	0.00052	0.00572	150.2	355.8	65.6	69.6	223.0	26.8
180200	0.01499	0.00025	0.00202	54.6	491.7	37.5	34.4	320.3	12.2
180201	0.02654	0.00057	0.00577	127.5	681.6	64.1	61.4	307.8	25.6
180300	0.13915	0.02178	0.15438	212.2	649.7	60.0	90.1	276.6	25.1
180400	0.20681	0.00805	0.06509	189.1	643.7	72.9	83.8	274.8	33.8
180500	0.15964	0.00037	0.02954	150.1	100.8	69.1	64.9	58.0	29.0
180600	0.11525	0.00559	0.00317	89.0	448.6	67.9	39.2	218.3	27.0
180701	0.28627	0.00130	0.00035	103.6	680.8	74.7	58.4	310.0	42.9
180702	0.51504	0.48218	0.43402	220.4	738.5	69.9	93.2	309.4	29.5
180703	0.08745	0.23750	0.03573	276.6	899.6	72.8	120.9	395.1	32.0
180800	0.01223	0.00061	0.00023	59.6	250.4	74.0	39.7	161.7	20.5
180901	0.00297	0.00000	0.00000	143.2	0.0	0.0	88.6	0.0	0.0
180902	0.30301	0.15387	0.02003	149.0	659.8	52.8	65.7	295.3	24.4
181001	0.50000	0.13431	0.46465	159.5	700.9	31.7	66.2	291.2	13.2
181002	0.14945	0.00777	0.19930	203.8	812.3	65.3	65.4	265.1	26.7

Appendix B. Per-acre loadings of non-recoverable manure on pastureland and rangeland, by 6-digit HUC

	Phosphorus (pounds/acre)			Nitrogen (pounds/acre)				Acres of rangeland and pastureland		
6-digit HUC	Total	Organic fraction	Mineral fraction	Total	Organic fraction	Ammonia-ammonium fraction	Other mineral fraction	2002 Census of Agriculture	HUMUS	Adjustment factor
10100	9.9	4.3	5.6	20.5	11.2	6.3	2.9	15,795	518,306	0.030
10200	22.4	8.5	13.9	63.8	36.2	19.1	8.4	13,449	429,667	0.031
10300	31.3	11.8	19.5	87.8	50.0	26.2	11.5	21,930	371,974	0.059
10400	36.0	14.6	21.4	84.5	40.8	36.3	7.4	12,552	111,746	0.112
10500	12.6	5.8	6.8	30.8	16.8	9.9	4.2	13,488	262,620	0.051
10600	20.5	9.2	11.2	51.3	27.5	16.5	7.2	18,245	164,398	0.111
10700	17.6	8.1	9.5	45.4	24.3	14.9	6.1	24,822	155,325	0.160
10801	23.9	9.1	14.9	66.7	37.9	20.0	8.7	60,051	132,859	0.452
10802	19.7	8.4	11.4	52.4	29.0	16.4	7.0	42,316	165,914	0.255
10900	22.3	10.1	12.2	56.3	30.0	18.5	7.8	24,512	162,729	0.151
11000	26.2	10.5	15.7	69.5	37.9	23.1	8.5	48,283	203,107	0.238
11100	35.9	12.2	23.7	110.0	64.3	31.8	13.9	14,012	8,530	**1.000**
20100	29.4	10.3	19.1	87.2	50.4	25.7	11.1	137,200	279,489	0.491
20200	21.8	8.3	13.5	60.4	34.3	18.1	8.0	245,918	599,760	0.410
20301	12.7	5.8	7.0	31.3	16.1	10.4	4.7	37,248	67,382	0.553
20302	41.2	20.7	20.5	98.6	64.7	25.0	9.0	1,803	44,291	0.041
20401	18.1	7.4	10.7	47.0	26.2	14.8	6.0	115,633	227,721	0.508
20402	41.4	16.7	24.7	112.0	64.6	35.0	12.4	97,039	465,977	0.208
20403	17.3	8.5	8.8	47.7	23.7	17.3	6.8	9,304	19,464	0.478
20501	21.7	8.2	13.5	58.0	32.9	17.5	7.6	389,842	683,772	0.570
20502	32.2	13.0	19.2	83.0	46.3	26.4	10.3	88,351	318,010	0.278
20503	62.3	23.9	38.3	170.7	97.6	54.8	18.3	269,451	736,786	0.366
20600	68.7	27.8	40.9	157.2	118.6	30.1	8.4	91,147	757,794	0.120
20700	27.0	10.7	16.2	55.2	32.6	15.8	6.7	993,178	1,516,596	0.655
20801	23.9	9.7	14.2	43.0	23.1	13.5	6.4	276,381	679,802	0.407
20802	18.8	7.7	11.1	32.7	17.3	10.5	4.8	514,963	749,821	0.687
30101	19.0	7.7	11.3	32.9	16.9	10.9	5.1	517,673	1,169,904	0.442
30102	21.7	9.0	12.7	42.3	22.1	15.6	4.6	95,896	652,467	0.147
30201	21.6	8.8	12.8	41.9	20.5	16.8	4.6	73,844	630,548	0.117
30202	37.2	15.2	22.0	83.5	44.5	33.5	5.5	91,125	567,021	0.161
30300	45.7	18.5	27.2	99.6	53.3	39.3	7.0	233,204	1,210,223	0.193
30401	31.5	12.7	18.8	58.5	33.9	17.5	7.1	354,237	1,149,701	0.308
30402	26.9	11.1	15.8	54.3	31.7	18.1	4.5	167,659	1,254,733	0.134
30501	20.6	8.4	12.3	37.3	20.8	11.5	5.0	560,880	2,490,849	0.225
30502	14.5	6.1	8.4	28.0	15.4	8.9	3.7	110,884	887,060	0.125
30601	24.0	9.7	14.3	42.4	23.9	13.0	5.5	504,860	1,378,572	0.366
30602	19.0	7.7	11.3	33.7	17.8	10.9	5.0	122,507	544,974	0.225
30701	19.8	8.0	11.8	35.6	19.4	11.5	4.8	537,410	1,724,005	0.312
30702	24.2	9.8	14.4	45.3	25.8	14.0	5.5	100,139	646,612	0.155
30801	11.1	4.5	6.6	19.1	9.7	6.4	3.1	870,799	1,212,568	0.718
30802	11.3	4.5	6.7	18.7	9.4	6.2	3.0	97,475	128,456	0.759
30901	13.1	5.2	7.9	22.3	11.4	7.4	3.5	869,308	1,003,267	0.866
30902	12.7	5.1	7.6	21.0	10.6	7.0	3.4	719,351	505,030	**1.000**
31001	15.8	6.3	9.5	25.8	13.1	8.6	4.2	653,935	551,279	**1.000**
31002	15.7	6.3	9.4	27.1	13.7	9.2	4.2	654,323	685,829	0.954
31101	13.2	5.1	8.1	26.6	14.3	8.5	3.8	145,522	358,034	0.406
31102	19.5	7.8	11.7	35.6	18.9	11.7	5.1	407,707	1,130,955	0.360
31200	19.8	8.0	11.8	36.4	19.5	11.6	5.4	74,231	226,861	0.327
31300	19.5	7.9	11.6	34.2	18.6	10.8	4.8	680,426	2,093,766	0.325
31401	22.6	9.3	13.4	38.9	20.1	12.9	5.9	85,479	749,849	0.114
31402	23.5	9.5	14.1	40.7	23.2	12.1	5.5	245,846	641,045	0.384
31403	21.4	8.6	12.8	36.1	19.9	11.1	5.1	141,850	520,548	0.273
31501	22.1	8.9	13.2	38.2	21.6	11.5	5.1	757,717	1,837,405	0.412
31502	15.6	6.3	9.3	25.3	12.9	8.3	4.1	453,870	914,706	0.496
31601	19.8	8.0	11.8	34.1	18.6	10.7	4.7	865,327	1,970,756	0.439
31602	14.9	6.0	8.9	24.6	12.6	8.2	3.9	193,260	628,394	0.308

6-digit HUC	Phosphorus (pounds/acre)			Nitrogen (pounds/acre)				Acres of rangeland and pastureland		Adjustment factor
	Total	Organic fraction	Mineral fraction	Total	Organic fraction	Ammonia-ammonium fraction	other mineral fraction	2002 Census of Agriculture	HUMUS	
31700	24.1	9.8	14.3	42.0	23.9	12.5	5.6	423,324	1,704,781	0.248
31800	23.0	9.2	13.8	42.1	24.8	12.0	5.3	469,266	1,356,757	0.346
40101	10.3	4.6	5.7	18.1	9.1	6.1	2.8	1,608	61,066	0.026
40102	12.8	5.5	7.3	25.1	13.1	8.2	3.8	26,628	180,870	0.147
40103	15.0	6.0	9.0	31.1	16.6	9.9	4.6	37,627	72,729	0.517
40201	11.6	4.8	6.8	24.2	12.9	7.7	3.6	15,552	70,075	0.222
40202	16.7	6.9	9.9	33.5	17.7	10.8	5.0	9,658	80,581	0.120
40203	8.8	3.5	5.3	16.7	8.4	5.6	2.8	0	8,553	0.000
40301	56.0	20.5	35.6	166.9	97.3	48.3	21.3	121,641	370,380	0.328
40302	58.2	21.4	36.8	176.7	103.4	51.0	22.4	104,779	98,701	**1.000**
40400	65.8	25.1	40.7	200.7	116.8	58.8	25.1	18,866	108,783	0.173
40500	42.1	17.3	24.7	115.8	62.9	39.9	13.0	269,400	858,987	0.314
40601	21.2	8.8	12.4	53.5	29.7	16.7	7.1	131,804	833,080	0.158
40602	23.3	8.1	15.2	68.6	39.5	20.1	9.0	553	56,145	0.010
40700	16.9	7.2	9.7	36.1	19.6	11.4	5.2	63,483	501,717	0.127
40801	44.5	17.1	27.4	137.9	82.4	40.0	15.5	29,608	162,164	0.183
40802	29.5	12.6	16.8	79.3	44.7	24.4	10.1	95,292	521,890	0.183
40803	12.8	5.3	7.5	23.1	11.8	7.6	3.6	2,154	596,137	0.004
40900	26.6	12.1	14.4	71.1	39.9	21.7	9.5	43,919	223,470	0.197
41000	43.8	20.7	23.1	129.6	67.5	49.9	12.2	123,453	212,002	0.582
41100	24.2	11.2	13.0	65.8	36.5	20.6	8.7	51,008	153,382	0.333
41201	39.0	14.4	24.6	111.5	63.8	33.4	14.3	57,704	237,958	0.242
41202	21.0	8.2	12.8	43.6	23.8	13.6	6.2	262	0	**1.000**
41300	39.7	14.5	25.2	114.6	66.1	33.7	14.8	88,951	441,509	0.201
41401	28.5	10.7	17.9	79.5	45.2	23.9	10.4	24,677	219,498	0.112
41402	38.1	13.8	24.3	110.9	64.0	32.9	14.1	120,731	620,713	0.195
41501	26.2	9.0	17.2	79.1	46.2	22.8	10.1	37,050	186,056	0.199
41502	34.7	11.8	22.9	98.1	56.7	28.6	12.8	1,274	154,205	0.008
41503	21.6	7.7	13.9	63.0	36.5	18.4	8.1	112,102	133,908	0.837
50100	23.6	9.6	14.0	58.3	32.5	17.9	7.9	256,200	670,632	0.382
50200	13.8	5.7	8.1	26.1	13.7	8.5	4.0	419,501	266,839	**1.000**
50301	17.7	7.5	10.2	39.6	21.5	12.5	5.6	315,410	364,112	0.866
50302	10.4	4.4	6.0	18.6	9.5	6.1	2.9	433,778	246,920	**1.000**
50400	21.6	8.9	12.7	50.2	27.5	16.2	6.6	536,554	510,861	**1.000**
50500	15.9	6.4	9.4	27.2	13.9	8.9	4.3	787,843	829,687	0.950
50600	19.7	8.8	10.9	43.1	22.1	15.5	5.5	180,660	309,594	0.584
50701	6.7	2.9	3.8	11.7	5.9	4.0	1.9	17,603	76,965	0.229
50702	9.7	4.1	5.6	16.3	8.3	5.5	2.6	55,054	296,918	0.185
50800	30.4	13.7	16.8	73.4	37.8	28.2	7.4	150,700	260,354	0.579
50901	10.9	4.6	6.3	19.1	9.8	6.3	3.0	215,123	316,118	0.681
50902	15.3	6.5	8.7	29.0	14.9	9.8	4.3	320,107	442,551	0.723
51001	17.6	7.2	10.5	29.9	15.2	9.9	4.8	665,440	619,970	**1.000**
51002	17.7	7.2	10.5	30.0	15.2	10.0	4.9	860,882	976,685	0.881
51100	25.4	10.2	15.1	43.8	22.8	14.3	6.7	1,096,871	1,085,295	**1.000**
51201	34.9	15.2	19.7	84.8	39.6	37.9	7.3	332,789	508,782	0.654
51202	27.1	11.9	15.2	57.5	29.6	21.5	6.4	345,837	538,772	0.642
51301	22.9	9.3	13.7	38.7	19.9	12.7	6.1	893,878	924,165	0.967
51302	18.9	7.6	11.3	32.0	16.1	10.8	5.1	875,469	726,949	**1.000**
51401	22.2	9.1	13.1	38.8	20.0	12.7	6.0	649,617	713,635	0.910
51402	21.7	8.9	12.8	37.9	19.5	12.8	5.6	321,593	401,987	0.800
60101	23.0	9.3	13.7	39.4	20.2	13.0	6.2	810,030	980,241	0.826
60102	20.8	8.4	12.3	35.1	17.9	11.6	5.6	585,057	787,214	0.743
60200	25.9	10.4	15.5	45.4	24.2	14.5	6.7	304,854	476,607	0.640
60300	23.0	9.3	13.7	39.1	21.0	12.4	5.7	1,068,226	1,767,744	0.604
60400	18.1	7.3	10.8	30.7	15.8	10.1	4.8	738,317	781,387	0.945
70101	16.6	6.7	9.9	33.8	19.0	10.3	4.5	339,741	708,371	0.480
70102	35.5	14.0	21.5	93.1	56.4	26.8	10.0	249,544	685,796	0.364

6-digit HUC	Phosphorus (pounds/acre)			Nitrogen (pounds/acre)				Acres of rangeland and pastureland		Adjustment factor
	Total	Organic fraction	Mineral fraction	Total	Organic fraction	Ammonia-ammonium fraction	other mineral fraction	2002 Census of Agriculture	HUMUS	
70200	32.0	13.1	18.9	86.3	42.7	36.5	7.1	492,223	567,139	0.868
70300	18.5	7.5	11.0	42.0	23.2	13.0	5.8	217,776	623,919	0.349
70400	30.6	11.8	18.7	79.5	44.7	25.2	9.5	442,105	456,909	0.968
70500	25.0	9.4	15.6	66.1	38.6	19.1	8.3	261,354	129,306	**1.000**
70600	29.3	11.5	17.8	68.6	36.6	23.6	8.4	538,158	615,662	0.874
70700	23.6	8.9	14.7	61.5	34.8	18.5	8.1	403,753	214,358	**1.000**
70801	29.4	12.3	17.1	65.1	31.4	26.8	6.9	412,906	530,023	0.779
70802	38.8	16.4	22.5	94.0	42.2	43.4	8.4	381,233	518,477	0.735
70900	44.1	17.3	26.7	122.2	68.8	39.1	14.3	299,260	362,079	0.827
71000	27.3	11.3	16.1	59.3	27.1	26.3	5.9	765,076	833,684	0.918
71100	18.5	7.6	10.9	33.0	16.5	11.7	4.9	884,359	1,164,585	0.759
71200	44.7	19.0	25.8	123.4	65.6	44.7	13.1	86,243	317,973	0.271
71300	23.1	9.9	13.3	47.0	22.3	19.1	5.6	435,781	490,323	0.889
71401	17.0	7.0	10.0	29.1	14.8	9.8	4.5	748,752	1,104,640	0.678
71402	33.3	14.0	19.3	79.2	40.2	29.8	9.2	114,870	384,436	0.299
80101	20.0	8.2	11.8	35.9	19.1	11.7	5.0	21,679	11,844	**1.000**
80102	16.9	6.9	10.0	29.3	15.3	9.6	4.4	562,713	726,199	0.775
80201	11.4	5.2	6.2	19.9	9.8	6.9	3.1	1,785	2,529	0.706
80202	15.9	6.5	9.4	27.6	15.1	8.6	4.0	206,413	205,389	**1.000**
80203	15.3	6.2	9.0	26.0	13.3	8.5	4.1	142,337	116,387	**1.000**
80204	14.4	5.9	8.5	25.2	13.1	8.2	3.9	29,532	30,224	0.977
80301	11.7	4.8	6.9	19.7	9.8	6.7	3.2	2,705	678	**1.000**
80302	12.9	5.2	7.7	21.4	10.8	7.1	3.5	552,345	1,019,824	0.542
80401	21.7	8.7	12.9	36.5	19.3	12.0	5.2	267,233	445,310	0.600
80402	24.3	9.8	14.4	42.7	25.3	12.2	5.2	243,272	976,594	0.249
80403	21.4	8.7	12.7	35.7	19.2	11.4	5.2	76,838	320,655	0.240
80500	17.3	7.0	10.3	28.0	14.1	9.3	4.6	157,306	10,147	**1.000**
80601	10.8	4.4	6.4	17.3	8.7	5.8	2.8	13,129	17,600	0.746
80602	12.5	5.1	7.5	21.1	10.7	7.2	3.3	381,445	864,592	0.441
80701	28.1	11.5	16.6	46.2	23.3	15.3	7.6	11,478	292	**1.000**
80702	20.6	8.1	12.5	38.0	20.0	12.3	5.7	269,655	699,153	0.386
80703	26.4	10.7	15.7	42.5	21.4	14.2	7.0	35,346	49,034	0.721
80801	20.1	8.2	11.9	33.0	16.6	11.0	5.4	216,334	361,746	0.598
80802	12.1	4.9	7.2	19.6	9.9	6.6	3.2	686,586	987,547	0.695
80901	19.7	8.1	11.7	33.2	16.6	11.2	5.4	3,781	265	**1.000**
80902	21.8	8.6	13.2	42.4	22.1	13.7	6.5	30,696	154,101	0.199
80903	18.3	7.3	10.9	29.2	14.7	9.7	4.8	85,548	61,169	**1.000**
90100	8.7	3.5	5.2	14.2	7.2	4.7	2.3	1,070,200	936,118	**1.000**
90201	17.5	7.1	10.4	35.2	19.4	11.0	4.7	408,594	373,857	**1.000**
90202	9.7	3.9	5.8	16.2	8.3	5.4	2.6	767,236	1,065,967	0.720
90203	12.2	5.0	7.3	21.8	11.4	7.1	3.3	409,327	324,679	**1.000**
90300	10.3	4.3	6.0	18.0	9.2	6.0	2.9	51,430	319,927	0.161
100100	3.0	1.2	1.8	5.0	2.5	1.7	0.8	78,361	131,586	0.596
100200	5.2	2.1	3.1	8.5	4.3	2.8	1.4	2,677,086	5,034,601	0.532
100301	3.3	1.4	2.0	5.5	2.8	1.8	0.9	2,926,784	3,533,470	0.828
100302	2.8	1.1	1.7	4.6	2.3	1.6	0.7	2,356,534	2,175,092	**1.000**
100401	2.8	1.1	1.7	4.5	2.3	1.5	0.7	3,697,809	5,988,440	0.617
100402	2.4	0.9	1.4	3.8	1.9	1.3	0.6	3,423,109	4,428,767	0.773
100500	2.6	1.1	1.6	4.2	2.1	1.4	0.7	4,661,379	5,725,018	0.814
100600	3.0	1.2	1.8	4.9	2.4	1.6	0.8	2,490,919	2,526,844	0.986
100700	3.4	1.4	2.0	5.7	2.9	1.9	0.9	3,842,057	5,676,880	0.677
100800	2.2	0.9	1.3	3.7	1.9	1.2	0.6	6,232,116	11,453,720	0.544
100901	2.3	0.9	1.4	3.8	1.9	1.3	0.6	2,006,070	2,598,655	0.772
100902	1.9	0.8	1.1	3.1	1.6	1.0	0.5	6,576,108	7,670,075	0.857
101000	2.6	1.0	1.5	4.1	2.1	1.4	0.7	5,907,226	6,843,823	0.863
101101	5.6	2.2	3.3	8.9	4.5	3.0	1.5	1,299,236	1,622,878	0.801
101102	2.7	1.1	1.6	4.5	2.2	1.5	0.7	4,004,577	4,576,741	0.875

6-digit HUC	Phosphorus (pounds/acre)			Nitrogen (pounds/acre)				Acres of rangeland and pastureland		Adjustment factor
	Total	Organic fraction	Mineral fraction	Total	Organic fraction	Ammonia-ammonium fraction	other mineral fraction	2002 Census of Agriculture	HUMUS	
101201	2.5	1.0	1.5	4.1	2.1	1.4	0.7	8,297,164	8,769,073	0.946
101202	2.6	1.0	1.5	4.4	2.2	1.4	0.7	3,725,828	3,448,466	**1.000**
101301	6.6	2.6	3.9	10.7	5.4	3.5	1.7	4,317,207	5,657,857	0.763
101302	6.3	2.5	3.8	10.3	5.2	3.4	1.7	3,242,195	2,889,223	**1.000**
101303	3.0	1.2	1.8	5.0	2.5	1.7	0.8	5,215,240	5,152,418	**1.000**
101401	6.2	2.5	3.7	10.4	5.3	3.4	1.6	3,293,586	3,789,568	0.869
101402	3.9	1.6	2.3	6.4	3.2	2.1	1.0	4,489,779	4,691,173	0.957
101500	5.2	2.1	3.1	8.6	4.5	2.8	1.4	6,127,511	6,873,953	0.891
101600	12.9	5.2	7.7	22.3	11.5	7.3	3.4	3,566,564	3,698,937	0.964
101701	19.2	7.8	11.4	36.5	19.1	12.4	5.0	789,858	538,116	**1.000**
101702	25.2	10.2	15.0	56.8	29.2	21.1	6.5	758,208	570,363	**1.000**
101800	2.5	1.0	1.5	4.5	2.4	1.4	0.7	12,944,952	15,324,396	0.845
101900	4.8	1.9	2.9	11.2	6.9	3.0	1.4	5,688,645	7,364,318	0.772
102001	10.3	4.2	6.2	21.6	12.8	6.0	2.8	1,400,502	1,313,128	**1.000**
102002	21.5	9.0	12.5	46.9	26.3	15.2	5.5	222,863	339,190	0.657
102100	6.5	2.6	3.9	11.4	6.1	3.7	1.7	6,782,730	7,529,664	0.901
102200	15.3	6.2	9.1	34.1	19.9	10.2	4.0	1,341,862	1,382,737	0.970
102300	35.6	14.6	21.0	87.7	43.3	36.1	8.3	384,895	415,696	0.926
102400	19.6	8.0	11.5	35.4	18.0	12.4	5.0	1,279,227	1,345,960	0.950
102500	7.3	2.9	4.4	14.2	7.9	4.3	1.9	5,867,659	6,174,153	0.950
102600	8.1	3.2	4.8	14.7	8.1	4.5	2.1	4,383,554	5,222,500	0.839
102701	10.9	4.4	6.5	18.4	9.4	6.1	2.9	1,265,987	1,590,739	0.796
102702	14.9	6.0	8.8	29.9	16.4	9.6	3.9	1,228,816	1,320,119	0.931
102801	17.8	7.2	10.6	30.7	14.8	11.5	4.5	1,320,939	1,365,069	0.968
102802	15.6	6.3	9.3	26.0	12.9	9.1	4.0	520,461	562,109	0.926
102901	16.3	6.6	9.7	27.2	13.9	9.0	4.3	2,895,711	2,916,252	0.993
102902	14.5	5.8	8.6	25.4	13.2	8.3	3.9	605,001	463,883	**1.000**
103001	19.4	7.9	11.5	32.9	16.9	11.1	4.9	1,151,600	1,202,073	0.958
103002	18.9	7.8	11.1	33.2	16.6	11.7	5.0	102,302	120,791	0.847
110100	15.5	6.3	9.3	26.2	14.0	8.3	3.9	3,017,633	2,448,559	**1.000**
110200	2.0	0.8	1.2	3.7	2.0	1.2	0.6	7,759,904	10,972,544	0.707
110300	10.0	4.0	6.0	22.8	14.0	6.1	2.8	3,620,262	3,223,753	**1.000**
110400	5.1	2.0	3.1	13.4	8.6	3.4	1.4	2,775,839	3,240,490	0.857
110500	9.4	3.8	5.6	15.9	8.1	5.3	2.5	2,430,990	2,149,104	**1.000**
110600	8.4	3.4	5.0	13.5	6.8	4.5	2.2	2,675,266	2,834,149	0.944
110701	8.2	3.3	4.9	13.3	6.7	4.4	2.2	3,025,338	3,184,290	0.950
110702	15.6	6.3	9.3	26.5	14.2	8.4	3.9	3,044,077	3,461,237	0.879
110800	1.3	0.5	0.8	2.1	1.1	0.7	0.3	5,465,106	6,451,056	0.847
110901	3.0	1.2	1.8	6.1	3.6	1.7	0.8	4,551,590	5,586,135	0.815
110902	9.2	3.7	5.5	15.3	7.7	5.1	2.4	1,794,852	1,865,938	0.962
111001	5.7	2.3	3.4	15.0	9.3	4.2	1.5	2,630,986	2,562,142	**1.000**
111002	5.0	2.0	3.0	10.0	5.5	3.2	1.3	1,546,723	1,547,476	1.000
111003	8.8	3.6	5.2	14.5	7.3	4.9	2.3	1,914,244	1,540,073	**1.000**
111101	17.0	6.9	10.1	29.0	15.5	9.3	4.2	1,364,475	1,500,770	0.909
111102	22.8	9.2	13.6	39.4	22.2	11.9	5.3	720,989	902,227	0.799
111201	7.2	2.9	4.3	18.0	11.8	4.2	2.0	2,627,650	2,470,623	**1.000**
111202	4.7	1.9	2.8	8.3	4.5	2.6	1.3	794,222	829,032	0.958
111203	6.3	2.6	3.8	11.3	6.2	3.5	1.7	1,654,435	1,949,205	0.849
111301	3.9	1.6	2.3	6.3	3.2	2.1	1.0	1,981,375	2,038,282	0.972
111302	7.1	2.8	4.2	11.5	5.8	3.8	1.9	4,175,449	4,429,125	0.943
111303	8.7	3.5	5.2	14.4	7.3	4.8	2.3	3,276,354	2,789,869	**1.000**
111401	13.2	5.3	7.8	21.7	11.2	7.1	3.3	2,466,416	2,386,356	**1.000**
111402	19.6	7.9	11.7	32.8	17.7	10.3	4.8	458,843	1,055,500	0.435
111403	16.3	6.5	9.8	27.9	14.7	9.0	4.2	1,344,234	1,399,823	0.960
120100	16.2	6.5	9.6	27.7	14.6	8.9	4.2	1,185,934	1,670,487	0.710
120200	15.8	6.4	9.4	26.5	13.9	8.5	4.0	1,114,234	1,540,679	0.723
120301	10.1	4.1	6.0	16.9	8.6	5.6	2.7	3,373,424	3,542,795	0.952

6-digit HUC	Phosphorus (pounds/acre)			Nitrogen (pounds/acre)				Acres of rangeland and pastureland		Adjustment factor
	Total	Organic fraction	Mineral fraction	Total	Organic fraction	Ammonia-ammonium fraction	other mineral fraction	2002 Census of Agriculture	HUMUS	
120302	13.0	5.3	7.8	20.8	10.5	6.9	3.4	1,510,453	1,489,858	**1.000**
120401	11.9	4.9	7.0	19.7	9.9	6.6	3.2	631,514	594,239	**1.000**
120402	10.2	4.1	6.0	16.5	8.3	5.5	2.7	704,836	622,490	**1.000**
120500	5.1	2.0	3.1	12.4	7.7	3.2	1.5	4,311,526	4,059,586	**1.000**
120601	4.0	1.6	2.4	6.5	3.3	2.1	1.1	3,567,494	3,372,431	**1.000**
120602	7.8	3.1	4.7	14.0	7.2	4.5	2.2	2,705,820	2,592,576	**1.000**
120701	13.9	5.6	8.3	22.2	11.2	7.4	3.6	2,942,029	2,393,306	**1.000**
120702	8.0	3.2	4.8	14.1	7.3	4.6	2.2	2,805,956	2,828,380	0.992
120800	1.7	0.7	1.0	3.0	1.6	1.0	0.5	5,583,729	6,536,911	0.854
120901	2.5	1.0	1.5	4.8	2.4	1.6	0.8	6,980,941	8,277,473	0.843
120902	3.3	1.3	1.9	5.8	2.9	1.9	1.0	3,877,275	3,608,828	**1.000**
120903	12.5	5.1	7.5	20.1	10.0	6.7	3.3	1,034,596	795,182	**1.000**
120904	11.8	4.8	7.0	18.9	9.4	6.5	3.0	593,996	370,018	**1.000**
121001	11.7	4.7	7.0	18.6	9.3	6.3	3.0	856,034	650,854	**1.000**
121002	8.5	3.5	5.1	14.2	7.3	4.7	2.2	2,542,816	2,154,587	**1.000**
121003	7.4	3.0	4.4	12.2	6.2	4.1	2.0	1,574,686	1,359,646	**1.000**
121004	7.4	3.0	4.4	11.8	6.0	3.9	1.9	1,655,513	1,558,250	**1.000**
121101	2.9	1.2	1.8	5.0	2.6	1.6	0.8	7,484,554	8,414,272	0.890
121102	3.5	1.4	2.1	5.7	2.9	1.9	0.9	3,976,879	4,233,665	0.939
170101	8.6	3.7	4.9	15.7	7.9	5.3	2.5	28,022	457,361	0.061
170102	5.4	2.2	3.2	9.0	4.6	3.0	1.5	1,614,809	3,411,823	0.473
170103	3.7	1.6	2.1	7.1	3.7	2.4	1.1	219,295	878,788	0.250
170200	3.1	1.2	1.8	6.2	3.4	1.9	0.9	2,343,944	5,197,921	0.451
170300	3.9	1.5	2.4	9.3	5.3	2.7	1.3	68,978	1,897,326	0.036
170401	9.4	3.8	5.6	16.5	8.4	5.5	2.7	234,242	1,549,837	0.151
170402	12.6	4.8	7.8	28.5	15.9	8.5	4.1	2,324,321	11,575,554	0.201
170501	7.2	2.9	4.3	14.4	8.0	4.3	2.1	3,409,800	16,764,596	0.203
170502	5.2	2.1	3.1	8.6	4.3	2.9	1.4	878,183	1,524,249	0.576
170601	4.4	1.8	2.6	7.3	3.7	2.4	1.2	1,171,141	2,656,107	0.441
170602	9.9	4.0	5.9	16.0	8.0	5.4	2.6	341,414	3,894,793	0.088
170603	4.5	1.8	2.7	7.5	3.8	2.5	1.2	355,472	1,235,781	0.288
170701	4.0	1.6	2.4	8.1	4.6	2.4	1.1	1,547,259	2,407,636	0.643
170702	1.9	0.8	1.1	3.1	1.5	1.0	0.5	1,688,448	2,808,608	0.601
170703	2.8	1.2	1.6	4.8	2.4	1.6	0.8	1,611,932	4,037,143	0.399
170800	22.9	9.5	13.4	49.0	28.0	14.6	6.5	70,753	741,330	0.095
170900	16.5	7.1	9.4	37.5	20.1	12.2	5.1	312,647	1,664,381	0.188
171001	22.7	9.0	13.7	50.9	27.6	16.7	6.6	56,250	545,447	0.103
171002	22.0	8.4	13.6	54.8	30.6	16.6	7.5	58,267	394,115	0.148
171003	9.0	3.8	5.2	16.5	8.4	5.5	2.6	419,172	1,821,084	0.230
171100	31.0	11.9	19.1	80.4	45.0	24.8	10.7	174,921	1,401,724	0.125
171200	4.5	1.8	2.7	7.2	3.6	2.4	1.2	1,805,497	8,732,269	0.207