Data and Methodology

Our analysis estimates the onfarm balance of manure nutrient production relative to the farm's potential to use the nutrients for crop production based on farm-level data collected for the 1982, 1987, 1992, and 1997 Censuses of Agriculture. We then calculate regional assimilative capacity.

Our methodology is direct. First, we estimate manure nutrient production on farms with confined livestock. Second, we use the reported onfarm production of major field crops and pastureland to calculate the potential nutrient assimilative capacity.[6] Third, we examine the balance between manure nutrient production and nutrient need measured by crop uptake and pastureland applications at the farm level, **assuming no supplementary commercial fertilizer use** (see box, "Computation Methods," p. 9). Results based on the farm-level information are then aggregated to geographic units and across animal type.[7] With farm-level data, we evaluate production characteristics of confined-animal producers such as cropland acres, crop production levels, and potential manure nutrient use for crop production. We estimate all parameters at the farm level—to characterize how individual decisions are made—before aggregating.

Estimates presented here were a joint effort of three USDA agencies: Economic Research Service (ERS), Natural Resources Conservation Service (NRCS), and National Agricultural Statistics Service (NASS).

We used a biologically based definition of an animal unit (AU) of 1,000 pounds of live animal weight[8] to calculate manure production and manure nutrients. We applied this definition to feedlot beef, dairy, swine, and poultry, using average animal weights (table 1). Estimates of annual average AU per farm were obtained using census data on end-of-year inventory and sales. The details of the computation methods may be found in a companion NRCS report (Kellogg *et al*., 2000).

We examined operations of different sizes to observe changes in industry structure and to evaluate the distribution of impacts of potential regulatory changes. Operation size was based on the total number of animals on the farm, not acreage. We report results for a distribution of operation sizes and for those potentially subject to regulation. In order to study farms that may be regulated under current CWA rules, we constructed a category ("Potential CAFO" farms) using the CWA "number-of–head" definitions that includes all of our large category and part of our medium category. It is not possible to precisely identify a livestock operation as a CAFO using the infor-

Livestock operation size categories

Based on 1 AU = 1,000 pounds live weight:

Very small	< 50 AU
Small	50 to 300 AU
Medium	300 to 1,000 AU
Large	>1,000 AU

Based on number of animals from the CWA:

Potential CAFO	CWA specification

[6] For crops, this is the amount of nutrients taken up by the plant and removed from the field at harvest, and represents the quantity that can be applied each year without accumulating nutrients in the soil. This assumes that the nutrients in the nonharvestable portion of the plant are returned to the soil and thus available for future plant growth. Per-acre nutrient applications were assumed for cropland used as pasture and permanent pasture based on their relative productivity and the nutrients removed by grazing animals.

[7] Our analysis meets all respondent confidentiality assurances that are required to publish census of agriculture values.

[8] Our definition of an animal unit based on 1,000 pounds of live weight should not be confused with the Clean Water Act (CWA) specification of "1,000 animal units." The CWA specified that a farm producing more than one animal type could be a CAFO if the sum on the animals totaled "1,000 animal units." The act specified an animal per animal unit conversion only for that purpose and only for slaughter and feeder cattle, mature dairy cows, swine, sheep, and horses. No conversions were specified for any type of poultry. These specifications of animals per animal unit have proven to be confusing because they are not complete and are not based on a common specification (such as 1,000 pounds of live weight). Proposed revisions of the regulations drop this terminology and rely only on numbers of animals to specify CAFOs.

mation available in the census of agriculture. Instead, data on "potential CAFOs" were constructed based on current regulations and estimates of the annual average number of livestock on the farm, derived from annual sales data and year-end inventories.[9]

[9] The following rules were used to identify potential CAFOs: (1) farms with fattened cattle sales of 1,000 head or more, (2) farms with milk cow end-of-year inventory of 750 or more, (3) farms with combined sow inventory and hogs on feed (average annual number based on inventory and sales) of 2,500 or more, (4) farms with an average annual number of pullets and layers (based on inventory and sales) of 100,000 or more, (5) farms with an average annual number of broilers (based on inventory and sales) of 100,000 or more, and (6) farms with an average annual number of turkey hens and turkeys for slaughter (based on inventory and sales) of 55,000 or more. No attempt was made to identify CAFOs based on a mixture of these six livestock types.

Table 1—Definitions of animal units (AU) and specification of minimum size for inclusion

Animal type	Number of animals per animal unit[1]	Minimum number of head to be included in the study
Feedlot beef	1.14	15
Dairy cows	0.74	20
Swine for breeding	2.67	10
Swine for slaughter	9.09	50
Laying hens & pullets > 3 mo.	250	50
Broilers & pullets < 3 mo.	455	100
Turkeys for breeding	50	50
Turkeys for slaughter	67	50

[1] Based on 1 AU equaling 1,000 pounds of live animal weight. These values differ from the definition used by EPA to combine animal types in administering the CWA.

Computation Methods

This report examines manure management in the current and the likely future policy context. The data set only included farms with confined animal types operating above a minimum scale (table 1) to reflect commercial operations.* Thus, these estimates are most useful for examining currently regulated CAFO farms, and farms that might be regulated in the future under the CWA, CZARA, or some other authority. This subset of farms does not represent the total production of manure nutrients (see Kellogg *et al*., (2000) for estimates that include beef cows and bulls, replacement heifers, and calves not in a feedlot), but rather the nutrient production for which policies will most likely be relevant.

Computation of manure nutrients was a three-step process. First, we converted animal numbers to an average annual AU inventory from reported end-of-year inventory and annual sales data. Second, we computed quantities of manure by applying coefficients of manure production by animal type based on the biological definitions of AU. Third, we computed the recoverable portion of the manure nutrients per ton of manure by animal type after adjusting for losses during collection, transfer, and storage. Recoverable manure nutrients represent that portion of manure that can be collected and applied to land net of losses. See Kellogg *et al*. (2000) for details of the estimation process and manure and nutrient production coefficients.

Potential manure nutrient use by the farms on which the nutrients were produced was also estimated. In these calculations, the land area and the per-acre nutrient uptake for the production of 24 major field crops and pastureland applications were computed for each farm in the census based on reported yields and acres. Manure nutrient production on confined livestock farms was compared with crop and pasture assimilative capacity on those same farms to compute a farm-level "excess" of manure nutrients. We recognize this calculation process may overstate excess manure nutrient in some cases because some manure is moved off many production farms. However, total excess nutrients were more likely to be understated because neither commercial fertilizer applications nor atmospheric deposition of nutrients were considered in this analysis. Most crop farms without livestock, and many farms with livestock, use chemical fertilizers because they are less bulky, easier to apply, and have a more predictable nutrient content than manure. The convenience of commercial fertilizers often outweighs the value of manure as a soil amendment that can improve physical and chemical properties of cropland.

Additional analysis shows which geographical areas have sufficient cropland associated with the livestock operation to use all the manure nutrients at an agronomic rate. Manure nutrient production from confined livestock was compared to total county nutrient needs to help identify areas where manure nutrients could provide a major portion of the county's nutrient needs from all farms. The excess values calculated here for a county represent a consistent, national estimate of the manure nutrients that would need to be transported relatively long distances, or transformed into other products, in order to reduce the potential for nutrient flows into the environment. Regional excess is underestimated because small livestock farms are not included and commercial fertilizer use is not accounted for. Partially offsetting the underestimation is the possibility of applying manure to public lands, golf courses, or other nonagricultural land. This option was not considered for several reasons: The census of agriculture data do not include these other land uses; there are few identified areas with animal concentrations and the proximity of accessible public lands; and manure application is often incompatible with multiple uses of land without extensive processing. By using data from several census of agriculture years, we show how the potential excess-nutrient problem has changed over time. See Kellogg *et al*. (2000) for details of the estimation process and crop nutrient needs.

* Confined animal types include feedlot beef, dairy, swine, and poultry. These data do not include estimates of the recoverable portion of manure from cattle, other than fattened cattle and milk cows (bulls, beef cows, dairy and beef replacement heifers, calves less than 500 pounds, and calves greater than 500 pounds not in a feedlot). If cattle other than fattened cattle and milk cows were included in the analysis, farm numbers would double, the number of AU would increase by only 6 percent, and recoverable manure nitrogen would increase by about 5 percent. Restricting the data to commercial operations—$2,000 in sales or at least 3 AU—removed only 2,500 farms (1 percent of operations) with less than 1,000 AU.