

Off-farm transport costs

Farms with excess manure after CNMPs are implemented need to transport the excess manure to surrounding properties for land application. Although the cost of off-farm land application is not included as a direct CNMP-related cost, it is assumed in this assessment that the livestock operation would bear the cost of off-farm transport.

As shown in table 8 and figure 15, 71,999 farms have CNMP-related off-farm transport costs. About two-thirds of these farms were already exporting some or all of their manure off the farm in the baseline scenario. As shown in the previous section, some of these farms exhibited a "cost savings" in terms of onfarm transport costs because the amount of manure applied on the farm decreased as producers shifted from current application rates to lower application rates in the after-CNMP scenario. This cost savings is offset by higher off-farm transport costs.

Off-farm transport costs are determined by the amount of manure to be exported and the off-farm distance the manure is transported. The distance manure is transported is a function of the acres required for manure application on manure receiving farms, which in turn is determined by the number of acres available for manure application and the application rate criteria. Application rate criteria for manure receiving farms were modeled the same as for CNMP farms in the after-CNMP scenario—application at nitrogen-standard rates. These application rate criteria for manure receiving farms were the same for both land application scenarios. (For details on land available for manure application and application rate criteria for manure receiving farms, see appendix B.)

In most counties sufficient acreage exists for off-farm land application of manure in accordance with NRCS nutrient management criteria. However, in some areas of the country the production of manure nutrients is so large that even if all the land available for manure application (under the assumptions of the model simulation) had manure applied, there would still be excess manure. This excess manure is categorized as county-level excess manure. There were 248 counties that had county-level excess manure in the after-CNMP

scenario. (For more details on the calculation of county-level excess manure and the counties with excess manure, see appendix B.)

Altogether, the 71,999 farms without enough acres to meet CNMP application criteria export off the farm about two-thirds of all the recoverable manure produced after CNMPs are implemented (see appendix B, table B-13). About half of the recoverable manure nutrients are transported off the farm for application on surrounding properties within the county, and the remainder—about 16 percent—is county-level excess. Costs associated with manure exported off the farm for land application are called **within-county transport costs**.

County-level excess manure cannot be land applied within the county, but in most cases still must be transported off the farm. Costs associated with disposal and utilization of this county-level excess manure will be evaluated in Part II of this study, forthcoming. For the present study, however, a rough estimate is made for the costs of transporting the manure off the farm to a central processing facility in an adjacent county. Costs associated with export of county-level excess manure are called **out-of-county transport costs**.

Estimating off-farm transport costs

Off-farm transport costs were estimated for the baseline scenario and for the after-CNMP scenario, and the difference was used to represent expected off-farm transport costs associated with CNMP implementation. This approach was modified for farms in counties with excess manure. In these counties each farm's share of the county-level excess manure in the after-CNMP scenario was estimated and used to calculate out-of-county transport costs for each farm. For the portion of manure applied within the county, off-farm export costs were calculated as the difference between the baseline scenario and the after-CNMP scenario, as in counties without excess manure. For county-level excess manure, however, off-farm transport costs were based on **all** of the county-level excess manure estimated for each farm in the after-CNMP scenario. The transport distance used in the calculation for out-of-county export was the maximum off-

farm transport distance in the county increased by 25 percent to simulate transporting the waste to a central processing facility in an adjacent county.

Separate cost estimates were made for solids and for manure and wastewater handled as a liquid or slurry using the same costs used to estimate onfarm transport costs. Within-county transport costs for solids were determined for each CNMP farm as follows:

$$\text{Within-county transport costs} = \text{loading cost} + (\text{ton-miles})(\text{cost per ton-mile})$$

where ton-miles is the average off-farm transport distance in miles multiplied times the tons of manure for within-county transport. Out-of-county transport costs for solids are calculated in the same manner except that the transport distance was based on the maximum off-farm transport distance increased by 25 percent and the tons of manure for out-of-county transport. The cost per ton mile is the same as for onfarm transport.

Off-farm transport costs for manure as a liquid or slurry, including wastewater from runoff storage ponds, were also calculated in the same manner as for onfarm transport costs. For the larger farms where pumping is used to transport liquids, off-farm transport costs are estimated as the cost per mile of pipe multiplied by the maximum distance that the wastewater is transported, and then increasing that estimate by 25 percent.

The average off-farm hauling distance was calculated for each farm using the same formula used to calculate onfarm hauling distance, but the terms in the equation were estimated differently. The term $N_M \times Q$, the amount of manure nutrients available for application, was estimated as the amount of farm-level excess manure nitrogen for each farm **excluding** the farm's share of county-level excess manure nitrogen. N_C is the average nitrogen application rate on acres in the county receiving manure. Since manure-receiving farms applied manure at nitrogen-standard rates in both scenarios, this term is about the same for both scenarios. (The after-CNMP scenario included additional acres on manure-receiving farms that could have yields different from the acres included in the baseline scenario, thus resulting in slightly different values of N_C for the two scenarios.) The willingness to accept manure, measured by γ was set at 0.5 to simu-

late that only 50 percent of the suitable manure-receiving farm acres in the county were used for manure

application in the model simulation. The $\frac{1}{\alpha \times \beta}$ term was estimated using county-level statistics on total acres and cropland and pastureland acres available for land application of manure.

The willingness to accept manure can have a significant impact on the off-farm transport distance calculation, and thus on off-farm transport costs. It is not known what the willingness to accept is, but it is unlikely that it will be much higher than 50 percent in most areas of the country. Farmer survey results suggest that the percentage of acres actually receiving manure is much lower (Padgitt et al., 2000). In areas of high livestock production, however, the willingness to accept manure by nonlivestock producers is expected to be higher than in other areas because manure has been exported to surrounding properties for several years. To the extent that the 50 percent level is too high, these estimates of transport costs will be understated.

In counties with concentrated livestock production, the distance estimates are also likely to be understated. Livestock operations will be competing for a relatively scarce supply of off-farm acres available for application. The distance function does not account for this competition; it implicitly assumes that livestock operations are dispersed enough so that the off-farm acres needed would not be in use by another livestock operation.

Average off-farm transport distances were calculated for both the baseline scenario and the after-CNMP scenario. Table 16 summarizes the off-farm transport distance for counties with and without enough land. Farms **without** excess manure in the baseline scenario did not export manure off the farm prior to implementing a CNMP, so transport distance for the baseline scenario was zero. The median transport distance for these farms after CNMP implementation was about 0.4 mile both in counties with and without enough land. Farms **with** excess manure in the baseline scenario were already exporting manure off the farm, and needed to increase the amount exported after CNMP implementation. Median off-farm transport distance for farms with excess manure in the baseline scenario was higher—0.6 mile in counties with enough land and 0.8 mile in counties without

enough land. Farms with excess manure in the baseline scenario in counties without enough land had almost no increase in transport distance because all of the available land was already receiving manure. (There were 64 counties without enough land after CNMPs were implemented that had enough land in the baseline scenario; farms in these counties had some off-farm capacity for land application, thus explaining the slight increase in transport distance for these farms. See appendix B for more details on off-farm land application.) Farm-level excess manure on farms in counties without enough land was exported out of the county in the simulation model using the maximum transport distance in the county, which ranged from 0.7 to 12.6 miles among counties without enough land. (These estimates do not include the 25 percent increase used for the cost calculations.)

The amount of manure to be transported off the farm was calculated as the difference between total manure produced and the amount applied on the farm. The out-of-county portion was calculated for each farm by distributing the total amount for the county to each farm in proportion to the amount of recoverable manure produced on each farm. Table 17 presents per-farm estimates of the tons of manure for off-farm transport both within the county and out of the county. (For farms with excess manure in the baseline scenario in counties without enough land, there was a slight decrease in the solids exported within the county, reflecting a change in the consistency of manure for some dairies as a result of CNMP implementation. The increase in liquid and slurry manure exported for application within the county for these farms reflects the additional land application capacity in the 64 additional counties without enough land in the after-CNMP scenario.)

Table 16 Off-farm transport distance*

| Farm group | Number of farms | Baseline scenario, median transport distance (miles) | Baseline scenario, range of transport distance (miles) | After-CNMP scenario, median transport distance (miles) | After-CNMP scenario, range of transport distance (miles) | Increase in the median transport distance (miles) | Maximum transport distance in county, median (miles) | Maximum transport distance in county, range (miles) |
|---|-----------------|--|--|--|--|---|--|---|
| Farms without excess manure in the baseline scenario | | | | | | | | |
| Counties with enough land | 18,481 | 0 | 0 | 0.38 | 0.06-2.71 | 0.38 | NA | NA |
| Counties without enough land | 5,956 | 0 | 0 | 0.37 | 0.04-1.98 | 0.37 | 3.31 | 0.69-12.62 |
| Farms with excess manure in the baseline scenario | | | | | | | | |
| Counties with enough land | 28,362 | 0.46 | 0.08-5.63 | 0.57 | 0.09-6.52 | 0.11 | NA | NA |
| Counties without enough land** | 19,200 | 0.76 | 0.10-3.59 | 0.77 | 0.11-3.52 | 0.01 | 2.68 | 0.95-12.62 |

* Excludes CNMP farms with specialty livestock types.

** 64 of these counties did not have county-level excess manure in the baseline scenario and so had some additional capacity to receive off-farm manure applications in the after-CNMP scenario, explaining the slight increase in the average transport distance for this group.

Notes: Counties without enough land pertain to the after-CNMP scenario.
 NA=not applicable.
 Range is 1 percentile to 99th percentile.

Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plans
Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping

Table 17 Amount of manure for off-farm transport*

| | Number of CNMP farms | ----- Within county transport ----- | | | | | | Out-of-county transport | |
|---|----------------------------|-------------------------------------|------------------------|------------|-------------------------------|--------------------------|-------------|----------------------------------|--|
| | | ----- Solids ----- | | | ----- Liquid and slurry ----- | | | Solids after-CNMP scenario | Liquid and slurry after-CNMP scenario** |
| | | baseline scenario | after-CNMP scenario | change | baseline scenario | after-CNMP scenario** | change | | |
| All CNMP farms | | | | | | | | | |
| Total | 71,999 | 25,502,456 | 38,154,690 | 12,652,234 | 128,457,934 | 523,834,330 | 395,376,396 | 9,476,428 | 127,555,359 |
| Per farm | | 354 | 530 | 176 | 1,784 | 7,276 | 5,491 | 132 | 1,772 |
| Farms without excess manure in the baseline scenario | | | | | | | | | |
| Counties with enough land | | | | | | | | | |
| Total | 18,481 | 0 | 4,615,217 | 4,615,217 | 0 | 122,611,788 | 122,611,788 | 0 | 0 |
| Per farm | | 0 | 250 | 250 | 0 | 6,634 | 6,634 | 0 | 0 |
| Counties without enough land | | | | | | | | | |
| Total | 5,956 | 0 | 701,805 | 701,805 | 0 | 23,658,990 | 23,658,990 | 813,336 | 26,328,966 |
| Per farm | | 0 | 118 | 118 | 0 | 3,972 | 3,972 | 137 | 4,421 |
| Farms with excess manure in the baseline scenario | | | | | | | | | |
| Counties with enough land | | | | | | | | | |
| Total | 28,362 | 19,895,674 | 27,258,182 | 7,362,509 | 96,025,905 | 306,936,870 | 210,910,965 | 0 | 0 |
| Per farm | | 701 | 961 | 260 | 3,386 | 10,822 | 7,436 | 0 | 0 |
| Counties without enough land*** | | | | | | | | | |
| Total | 19,200 | 5,606,081 | 5,578,158 | -27,924 | 32,428,643 | 70,605,252 | 38,176,609 | 8,662,956 | 101,221,972 |
| Per farm | | 292 | 291 | -1 | 1,689 | 3,677 | 1,988 | 451 | 5,272 |

* Excludes CNMP farms with specialty livestock types.

** Includes additional tons of wastewater from runoff storage ponds installed to meet CNMP criteria.

*** 64 of these counties did not have county-level excess manure in the baseline scenario and so had some additional capacity to receive off-farm manure applications in the after-CNMP scenario.

Note: Counties without enough land pertain to the after-CNMP scenario.

Summary of CNMP costs for off-farm transport

The annual average cost for the additional off-farm export of manure that would occur because of CNMP implementation was estimated to be \$1,358 per farm averaged over all CNMP farms (table 18), although as shown previously, only 28 percent of CNMP farms would have off-farm transport costs. When averaged over only the farms with off-farm transport costs, the average annual cost per farm was \$4,851. Less than half of this cost was for within-county transport—\$509 per farm averaged over all farms, or \$1,818 per farm for the 71,999 farms with off-farm export. The majority of the cost was for out-of-county transport of county-level excess manure, averaging \$849 per farm when averaged over all CNMP farms and averaging \$8,680 per farm for the 25,156 farms with off-farm export in the 248 counties without enough land.

Poultry farms had the largest off-farm transport costs when averaged over all CNMP farms because most of the poultry farms had excess manure, as shown in table 10. The annual average cost was \$7,414 per farm for layer and pullet farms, \$6,169 per farm for turkey farms, and \$1,667 per farm for broiler farms (table 18). The per-farm cost for broilers was much lower than that for layers, pullets, and turkeys because the average broiler farm is much smaller. When adjusted for the number of animal units on the farm, the broiler costs were similar to the costs for turkey farms (see appendix B, table B-8 for estimates of AU per farm.) These high off-farm export costs more than offset the "savings" calculated for onfarm transport costs for poultry. The highest annual off-farm transport costs for farms with excess manure were for fattened cattle, averaging \$23,297 for the 2,026 fattened cattle farms with excess manure.

Table 18 Annual off-farm transport costs per farm, by livestock type and farm size

| Dominant livestock type or farm size class | Number of farms | In-county off-farm transport costs, baseline scenario | In-county off-farm transport costs, after-CNMP scenario | CNMP-related in-county off-farm transport costs | Transport costs for county-level excess manure | Total off-farm transport cost, projected over all CNMP farms | Total off-farm transport cost, projected over CNMP farms with excess manure |
|--|-----------------|---|---|---|--|--|---|
| Fattened cattle | 10,159 | 2,984 | 7,326 | 4,342 | 304 | 4,646 | 23,297 |
| Milk cows | 79,318 | 418 | 916 | 497 | 1,121 | 1,619 | 9,487 |
| Swine | 32,955 | 1,053 | 1,876 | 823 | 1,627 | 2,450 | 6,343 |
| Turkeys | 3,213 | 2,828 | 4,774 | 1,946 | 4,223 | 6,169 | 6,253 |
| Broilers | 16,251 | 764 | 961 | 197 | 1,470 | 1,667 | 1,723 |
| Layers/Pullets | 5,326 | 2,990 | 4,141 | 1,151 | 6,263 | 7,414 | 7,864 |
| Confined heifers/veal | 4,011 | 525 | 1,633 | 1,108 | 302 | 1,410 | 3,130 |
| Small farms with confined livestock types | 42,565 | 9 | 12 | 3 | 13 | 16 | 59 |
| Pastured livestock types | 61,272 | 4 | 6 | 1 | 2 | 3 | 29 |
| Specialty livestock types | 2,131 | 0 | 0 | 0 | 0 | 0 | 0 |
| Large farms (>10 tons P) | 19,746 | 5,125 | 9,493 | 4,368 | 5,311 | 9,679 | 12,218 |
| Medium-size farms (4–10 tons P) | 39,437 | 572 | 1,114 | 542 | 1,739 | 2,281 | 4,743 |
| Small farms (<4 tons P) | 198,018 | 75 | 193 | 118 | 227 | 345 | 1,827 |
| All CNMP farms | 257,201 | 539 | 1,049 | 509 | 849 | 1,358 | 4,851 |

Large farms had the highest off-farm transport costs. Farms that produce more than 10 tons of phosphorus annually had an annual average off-farm transport cost of \$9,679 (table 18). The annual average cost was \$2,281 per farm for medium-size farms and \$345 per farm for small farms. When projected only over the farms with excess manure, the annual average cost was \$12,218 per farm for large farms, \$4,743 per farm for medium-size farms, and \$1,827 per farm for small farms.

The regional distribution of off-farm transport costs is presented in table 19. The highest average cost was for livestock operations in the Pacific region, which proportionately has more large farms than other

regions. (About 25 percent of the 7,974 CNMP farms in the Pacific States are large farms, which is three times the national percentage. See table 6.). The lowest off-farm transport costs were in the Lake States, the Corn Belt, the Northern Plains, and the Northeast, where there is generally more land available for manure application on livestock operations and the proportion of large farms is low (less than 9 percent for all four regions).

Overall, annual off-farm transport costs totaled \$349 million. Costs in the Pacific region, the Southeast region, and the Appalachian region comprised over half of this total cost.

Table 19 Annual off-farm transport costs per farm, by farm production region

| Farm production region | Number of farms | In-county off-farm transport costs, baseline scenario | In-county off-farm transport costs, after-CNMP scenario | CNMP-related in-county off-farm transport costs | Transport costs for county-level excess manure | Total off-farm transport cost |
|------------------------|-----------------|---|---|---|--|-------------------------------|
| Appalachian | 22,899 | 527 | 832 | 305 | 2,417 | 2,722 |
| Corn Belt | 71,540 | 270 | 572 | 302 | 78 | 380 |
| Delta States | 12,352 | 449 | 678 | 229 | 1,637 | 1,865 |
| Lake States | 52,817 | 162 | 372 | 210 | 48 | 258 |
| Mountain | 7,964 | 2,579 | 4,729 | 2,150 | 123 | 2,274 |
| Northeast | 31,598 | 127 | 367 | 241 | 790 | 1,031 |
| Northern Plains | 26,309 | 598 | 1,468 | 870 | 107 | 977 |
| Pacific | 7,974 | 2,870 | 5,004 | 2,134 | 8,564 | 10,698 |
| Southeast | 12,807 | 906 | 1,303 | 397 | 2,556 | 2,953 |
| Southern Plains | 10,941 | 1,686 | 3,400 | 1,714 | 450 | 2,164 |
| All CNMP farms | 257,201 | 539 | 1,049 | 509 | 849 | 1,358 |