TECHNOLOGIES FOR EFFICIENT MANURE UTILIZATION AND NUTRIENT MANAGEMENT

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Manure brokering and Nutrient Best Management Practice (N-BMP) crop insurance provide incentives for animal feeding operators and crop producers to utilize manure efficiently. Efficient use of manure nitrogen can replace synthetic fertilizers and reduce overall N_2O emissions.

Manure brokering matches livestock producers who have excess manure with grain farmers who can utilize the manure as a fertilizer. Manure brokering allows both the livestock and crop producer to experience an economic return, utilize manure nutrients efficiently, and reduce reliance on synthetic fertilizers.

N-BMP crop insurance is based on the proven concept that risk is a major reason that farmers are not adopting conservation technologies such as nutrient management and other best management practices (NRC, 1996). Farmers need assurance that the occasional failure of best management practices will not cause significant loss of income. In practice, farmers often get this assurance by applying extra inputs. N-BMP insurance protects crop producers against the risk of insufficient nitrogen and phosphorus and provides technical assistance when crediting manure and legume nutrients. N-BMP Insurance may be used in tandem with manure brokering, in addition to its other applications (e.g., legume crediting).

1.0 INTRODUCTION

Profitable crop production requires significant nutrient inputs from synthetic fertilizers, animal manures, and legumes. Nitrogen (N) in particular is often required in considerable quantities, and its application contributes significantly to the production of N_2O, a potent greenhouse gas (GHG), by agricultural soils. Manure can replace the use of synthetic fertilizer when it is properly tested, credited, and applied. Manure brokering and Nutrient Best Management Practice (N-BMP) crop insurance provide incentives for animal feeding operators and crop producers to utilize manure efficiently. They may be employed separately or together. While N of manure origin also contributes to N_2O production, through displacement of commercial fertilizers, a marked reduction in N_2O emissions may be achieved.

2.0 MANURE BROKERING

2.1 BACKGROUND AND RATIONALE

Properly applied, manure provides sufficient nutrients for crop production and can replace the use of synthetic fertilizers (Chase et al., 1991). Furthermore, manure improves soil structure and increases organic matter content, enhancing crop production capacity as well as soil quality (Sharpley et al., 1998). Field trials conducted by the University of Minnesota showed a substantial yield increase on manured plots relative to those fertilized with commercial N (Randall, 1997). Additionally, soils with improved soil tilth and higher organic matter content retain more water and make it more available to plants (Hudson, 1994).

Manure currently supplements or replaces the use of synthetic fertilizers on 17 percent of corn acreage and 2 to 9 percent of soybean acreage in the United States (U.S. Department of Agriculture Economic Research Service(USDA ERS), 2000). However, Ribaudo et al. (2003) estimate that less than half of swine farms are following the nitrogen best management practice (BMP) recommendation, resulting in over application of N to cropland. Additionally, most hog farms do not operate enough land to apply all of the manure they have available at the BMP recommended rate. These farms are applying manure at greater than the recommended rate and are not fully utilizing the nutrients in their manure.

This widespread over application of agricultural N has measurable consequences to atmospheric N_2O concentrations, as agricultural N_2O emissions represent a key source of U.S. GHG emissions (U.S. Environmental Protection Agency, 2003). Therefore, meeting comprehensive GHG management and emission reduction targets will require the judicious application of agricultural N, including manure. Manure brokering and N-BMP insurance are potential means for improving the efficiency of necessary agricultural N inputs, allowing for the simultaneous mitigation of production costs and reduction in GHG emissions.

2.2 THE MANURE BROKERING PROCESS

Manure brokering matches livestock producers (exporters) who have excess manure with grain farmers (importers) who can utilize the manure as a fertilizer. Manure brokering allows both the livestock and crop producer to experience an economic return, utilize manure nutrients efficiently, and reduce reliance on synthetic fertilizers.

Key steps in Agren’s manure brokering process include communicating the value of the manure to both the exporter and importer, negotiating a fair price for the product, and providing technical assistance on nutrient crediting. A survey administered to central Iowa landowners and animal feeding operators documented that the manure broker must take an active role in bringing together exporters and importers for the service to be successful. Furthermore, the broker must provide technical assistance in order to ensure proper nutrient crediting and manure application methods (Agren, Inc., 1997).

2.3 FACTORS INFLUENCING THE FEASIBILITY OF MANURE BROKERING

2.3.1 REGIONAL ASSESSMENT

On a regional basis, the economic feasibility of manure brokering is primarily based on three factors: extent to which animal feeding operations are integrated with grain production; land use in the region; and recommended nutrient application rates (a factor of crops produced and yield potential).

Manure brokering in the U.S. is clearly most feasible in the Corn Belt. Net costs for manure transportation and application are consistently lower in the Corn Belt than any other region in the United States. Animal feeding operations in the Corn Belt region tend to be more integrated with grain production, so there is generally more land available for application of manure per animal unit. Secondly, more land is used for grain production in the Corn Belt than other regions of the U.S. Therefore, the availability of suitable land off farm is higher than other regions, reducing the distance manure must be transported. Finally, a large portion of the crops grown in the Corn Belt region utilize significant rates of nitrogen (particularly corn), and crop yields in the region tend to be higher when compared to other regions (Ribaudo et al., 2003).

2.3.2 FARM LEVEL ASSESSMENT

Figure 1 summarizes a number of factors that may affect the feasibility of manure brokering on a farm level.

FIGURE 1. FACTORS IMPACTING THE FARM LEVEL FEASIBILITY OF BROKERING

- Distance to available cropland and competition for available land
- Willingness of cropland operators to accept manure
    - Deterrents include uncertain nutrient content and availability, soil compaction due to heavy application equipment, weed pressure, odor, social issues
- Moisture content of manure
- Manure type (species)
- Manure handling system
- Nutrient content of manure
- Nutrient requirements of crop
- Price volatility of synthetic fertilizers
- Size of animal feeding operation (regulated vs. unregulated)
- Local/state land application regulations
- Conservation compliance requirements
- Method and timing of application
- Seasonal land availability vs. storage capacity

2.4 EVALUATING N_2O REDUCTIONS

Potential N_2O reductions from the use of manure brokering to offset synthetic N fertilizer use have been calculated according to the methods of the Inventory of U.S. Greenhouse Gas Emissions and Sinks and are consistent with IPCC Guidelines (IPCC/UNEP/OECD/IEA, 1997). Although this method is intended for application to national-scale greenhouse gas inventories and not at the project-level, we apply it here simply to demonstrate in a gross way the potential mitigative capacity for this technology, rather than as a true-to-life emission estimate. Should a more detailed analysis prove worthwhile, we recommend a more site-specific approach to emissions evaluation. Incorporating location-specific environmental and management factors into a dynamic simulation modeling scenario (e.g., DAYCENT, as described by DelGrosso et al., 2001) is one approach. It should also be noted that no attempt was made here to perform a comprehensive GHG life-cycle analysis. For example, the energetic costs of synthetic fertilizer manufacturing and the resulting CO_2 emissions are substantial. Their displacements by the methods described here, when those fertilizers are never manufactured, are not accounted for in the GHG analysis. Similarly, GHG differences involved in the transportation and distribution of manure versus synthetic fertilizers are likely to be noteworthy, but are not evaluated here. Also, differences in emissions for GHGs other than N_2O (e.g., CH_4), whose emissions patterns may be altered based on the fertilizer source, are not considered.

Nitrogen from synthetic fertilizer in this scenario was replaced with equal amounts of manure N, as is consistent with Iowa's BMP recommendation (Iowa State University, 1999). The fate of the N depends on its original source. Synthetic fertilizers, according to the IPCC Guidelines, volatilize 10 percent of the total N application; 20 percent of manure N is volatilized. Of the volatilized N, 1 percent becomes N_2O indirectly following off-site deposition. Of the N remaining in the soil, 1.25 percent becomes N_2O directly through soil microbial processes for both synthetic fertilizer and manure nitrogen. However, as the amount of nitrogen remaining in the soil differs following volatilization, these direct emissions from manure are smaller than those of synthetic fertilizer. Finally, 30 percent of the total application is assumed to leach or run off, of which 2.5 percent of the total N is converted to N_2O. Because the total N application is identical in either case, the leaching and runoff contributions to N_2O production are the same. This is documented in Figure 2.

In addition to differences in emissions from direct applications, the displacement of synthetic fertilizers is explicitly accounted for here, as well, because manure nitrogen will emit N_2O whether it is applied at BMP (crop utilization) rates or over applied. For ease of calculation, we assume here that emissions of unused manure would be the same if the manure were applied to these soils or not, though it should be noted that many environmental or management situations could in reality alter that condition substantially. For the purposes of these calculations, manure management related emissions (e.g., lagooning) will be equivalent whether the manure is eventually over applied or not. Application rates do not affect past management. Manure that is treated as waste and does not enter a management system, is likely to be land applied eventually, and therefore the application of soil emission calculations is more valid than any other. While actual emissions are sensitive to a variety of specific conditions, the assumption of emission parity is both necessary and valid in this application.

FIGURE 2. N_2O EMISSION CALCULATIONS

Commercial Fertilizer N_2O Emission Calculation

$N_{COMMERCIAL}$ is the total nitrogen applied as commercial synthetic fertilizer.

Direct N_2O-N Emissions from Applied Fertilizer = $(0.9 * N_{COMMERCIAL}) * 0.0125$
Indirect N_2O-N Emissions from Volatilized Fertilizer = $(0.1 * N_{COMMERCIAL}) * 0.01$
Indirect N_2O-N Emissions from Leached/Runoff Fertilizer = $(0.3 * N_{COMMERCIAL}) * 0.025$
Total Commercial N_2O Emissions = (Direct N_2O-N + Indirect Volatilization N_2O-N + Indirect Leaching/Runoff N_2O-N) * 44/28

Manure N_2O Emission Calculation

N_{MANURE} is the total manure nitrogen applied.

Direct N_2O-N Emissions from Applied Manure = $(0.8 * N_{MANURE}) * 0.0125$
Indirect N_2O-N Emissions from Volatilized Manure = $(0.2 * N_{MANURE}) * 0.01$
Indirect N_2O-N Emissions from Leached/Runoff Manure=$(0.3 * N_{MANURE}) * 0.025$

Total Manure N_2O Emissions = (Direct N_2O-N+ Indirect Volatilization N_2O-N + Indirect Leaching/Runoff N_2O-N) * 44/28

2.5 COST SAVINGS POTENTIALLY REALIZED BY CROP AND LIVESTOCK PRODUCERS

A successful manure brokering agreement allows both the crop and livestock producer to realize a profit by avoiding costs. The crop producer replaces the cost of synthetic fertilizers with the lower expense of transporting and applying the manure. As implied in this example, the livestock producer can reduce or eliminate the cost of manure disposal through manure brokering. See figure 3.

FIGURE 3. MANURE BROKERING COST & N_20 EMISSION SAVINGS: A CASE STUDY

Tom Allen contacted Agren about brokering all of the manure from his 6000 head swine finishing units in central Iowa. The operation generated about 9.8 million L of liquid manure annually and Allen did not own or operate any cropland. When Allen contacted Agren, he was paying for the full cost of manure application. Agren located three landowners near the facility willing to pay a portion of the application costs to have the manure properly applied to their land. Currently, Allen is recouping all of the application costs of his manure and is unable to fully accommodate the demand from his neighbors. The following table summarizes cost savings realized by Allen and his neighbors.

Year	Cost of manure application paid by Exporter	Cost of synthetic fertilizer paid by Importers	Savings realized by Exporter as a result of brokering	Savings realized by Importers based on replacement of synthetic fertilizer
1997 (Prior to Manure Brokering)	\$38,740	\$74,180	0	0
2003	0	0	\$38,740	\$35,110 (\$100.3 ha^{-1})

Application of 9.8 million liters of manure with a N-content of 6.1 g l^{-1} would emit 1.83 t N_2O. The equivalent amount of synthetic N emits 1.86 t N_2O. Because the manure is going to emit N_2O whether it is applied at the BMP rate or not, however, the actual "business as usual" emissions would be 3.69 t N_2O, indicating a real greenhouse gas savings in this case of 1.86 t N_2O.

2.6 POTENTIAL N_2O SAVINGS FROM MANURE BROKERING

Gollehon et al. (2001) used U.S. Census of Agriculture data to estimate manure nutrient production and the capacity of cropland and pastureland to assimilate nutrients. Their report concludes that, nationally, 60 percent of manure nitrogen cannot be properly utilized on the farm where it was produced. In the Heartland Region (similar in size and location to the Corn Belt region discussed above), recoverable nitrogen exceeds the level of crop uptake on the farm where it was produced by 81,278 t or about 40 percent. The same report contends that each county in the Heartland Region produces 25 percent or less of the county's assimilative capacity of manure nitrogen. Therefore, it is reasonable to assume that excess manure nitrogen in a particular county could be exported by livestock producers and properly applied within that same county. This estimate does not account for farm level variables such as the importer's willingness to accept the manure, nor the costs or benefits associated with its use on operations where it is not now used. In the assessment shown as Table A, we will use a factor of 50 percent to account for variables in farm level feasibility.

TABLE A. POTENTIAL NITROGEN AND GHG SAVINGS IN THE HEARTLAND REGION USING MANURE BROKERING

Excess N (t)	Percent available for within county transfer	Farm-level feasibility factor	Potential N Savings (t N)	Potential N_2O Reduction (t N_2O)
81,278	100%	50%	40,639	1261

TABLE B. N_2O EMISSIONS FOR U.S. MANURE BROKERING.

EMISSION TYPE	Synthetic Fertilizer (t N_2O)	Manure Nitrogen (t N_2O)
Direct N_2O	718	639
N_2O from Volatilization	64	128
N_2O from Leaching and Runoff	479	479
Total N_2O Emissions	1261	1245

Note: Totals may not sum exactly due to independent rounding.

Table B provides an estimate of potential N_2O savings calculated for manure brokering in the U.S. Manure N emissions are approximately 16 t N_2O smaller than those from synthetic fertilizers. As explained in Section 2.5, however, the total emissions associated with the use of synthetic fertilizers are the sum of the commercial fertilizer plus the manure emissions, or 2,507 t N_2O. If, however, we are replacing synthetic fertilizer with manure, the synthetic fertilizer need never be applied, and total emissions are those resulting from the applied manure alone, or 1245 t N_2O, indicating a potential real N_2O reduction of 1261 t N_2O, or 0.39 Tg CO_2-Eq. This value is similar to the amount of N_2O produced though agricultural burning in the U.S. in 2001 (0.46 Tg CO_2-Eq.) (U.S. Environmental Protection Agency, 2003).

3.0 NUTRIENT BMP INSURANCE

3.1 BACKGROUND AND RATIONALE

The growing concern over the affect of agriculture on air, water, and soils has increased the interest of researchers in developing nutrient BMPs. In theory, farmers will increase management efficiency and decrease negative environmental impacts by implementing BMPs. Although nutrient BMPs have been developed and are widely recognized, the adoption of many of these practices remains slow (Nowak et al., 1998).

A number of studies highlight the reluctance of producers to implement BMPs for crediting manure nutrients. A recent survey of 1,928 farms in Wisconsin found that two out of three farmers apply nitrogen for corn production in excess of the University of Wisconsin's BMP recommendation. Data collected between 1990 and 1998 indicated only 36 percent of all the producers applying animal manure made an effort to credit or account for the value of manure nitrogen. Of those attempting to credit manure, 83 percent underestimated manure nitrogen by greater than 10 percent. Only 3 percent of the farmers who credited manure did so within 10 percent of University of Wisconsin recommendations. Researchers concluded that less than 2 percent of producers applying manure on cornfields do so with any degree of accuracy (Shepard, 2000).

Similarly, the 1995 Iowa Farm and Rural Life Poll found that greater than one-half of producers applying manure to their land did not adjust the synthetic fertilizer rate to account for the nutrients in the manure. Only one percent of livestock producers used manure nutrient analysis as a major factor in determining the manure application rate. Sixty percent of producers relied on their own judgment as the major factor in determining the correct application rate (Lasley, 1995).

United States Department of Agriculture (USDA) Economic Research Service (ERS) states that one of the most important barriers to nutrient BMP adoption by farmers is risk of failure (Feather, 1995). Farmers' perception of the risk prevents adoption of BMPs, even when farmers believe they may be profitable (NRC, 1996). Feather (1995) further concludes that although farmers may understand the practices and believe they are economical, they still do not adopt them.

Farmers rely on fertilizers and other agricultural inputs to protect and increase crop yields. In practice, farmers over apply nutrients as a form of "product insurance", rather than testing and evaluating actual input needs. Farmers believe that in order to calculate nutrient availability from animal manure it entails greater risk and requires more time and knowledge than simply over applying manure or synthetic fertilizer. In order for appropriate manure crediting to take place a farmer must have a comprehensive understanding of nutrient management and manure crediting, as well as trust measured manure nutrient values and the opinion of an expert.

The risk of following nitrogen BMPs is not merely perception. One of the most difficult challenges facing agriculture is determining the optimal rate of nitrogen fertilizer application (Schepers et al., 1992). The problem is one of synchronizing soil nitrogen availability (from all sources) with crop needs. Even within a single field, variation such as changes in soil type, soil moisture, landscape position, and weed pressure can confound the effects that nitrogen alone would have on crop production (Englehardt et al., 2001). These unknowns translate to real economic risk. Bock (1991) has demonstrated that when the optimal nitrogen application rate is underestimated, the resulting nutrient deficiency can significantly reduce a farm's profit margin.

3.2 NUTRIENT BMP INSURANCE AS A RISK MANAGEMENT TOOL

Farmers need assurance that the occasional failure of BMPs will not cause a significant loss of income. Nutrient BMP (N-BMP) insurance is a form of financial insurance that protects farmers against the risk of insufficient nitrogen and phosphorus for crop growth and provides technical assistance for crediting manure and legume nutrients. The policy permits farmers to lower their inputs and operating costs by avoiding application of excess fertilizer. Farmers apply the amount of nitrogen recommended by their local expert institution, such as the state University and Extension system. Depending on the state, this BMP recommendation is calculated from field specific information such as soil test data, yield goals, and previous manure or legume history.

To determine whether insufficient fertilization actually diminished yield, the yield of an over-fertilized area or "check strip" is compared to that of directly adjacent BMP-managed land. If the yield of the check strip is greater than the yield on the adjacent BMP-managed land, the diminished yield is declared to have resulted from inadequate nutrition due to BMP management, and the insurance policy compensates the farmer for the loss, excluding a 5 percent deductible.

In many cases, applying recommended rates of manure and purchasing BMP insurance is the least costly alternative for farmers that are unsure of manure crediting recommendations. Figure 4 demonstrates how Nutrient BMP Insurance can provide significant cost savings to farmers. Nutrient BMP coverage will be offered as an endorsement to federal crop insurance through the U.S. Federal Crop Insurance Corporation and participating companies on a pilot basis in the states of Iowa, Wisconsin, Minnesota, and Pennsylvania for the 2004 crop year.

FIGURE 4. N-BMP INSURANCE COST AND N_2O-EMISSION SAVINGS: A CASE STUDY

The Ridgely family farms 535 hectares in north central Iowa in a corn/soybean rotation. They currently fertilize their crops exclusively with synthetic fertilizer, but may purchase liquid swine manure for 176 ha of their farm (nutrient requirements for meeting the farm's yield goals are 171 kg N ha^{-1}, 123 kg P_2O_5 ha^{-1}, and 95 kg K_20 ha^{-1}). The Ridgelys are interested in taking the manure, but do not trust that the BMP recommended rate of manure will provide adequate nitrogen to the crop. The Ridgelys are considering three options:

Option 1) Commercial Fertilizer

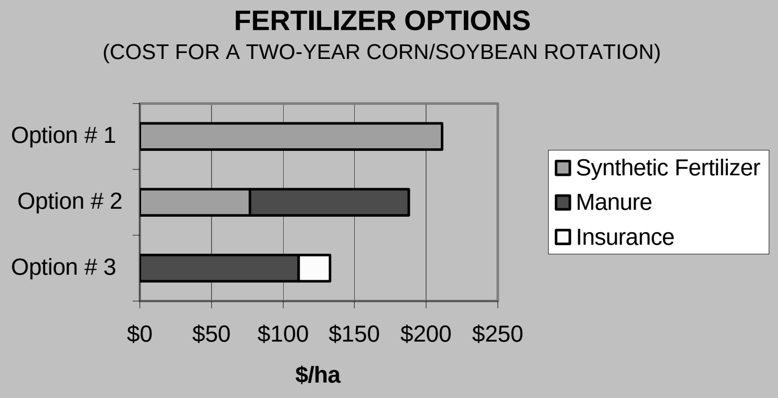
- Continue historic application rates of synthetic fertilizers at 171 kg N ha^{-1} (\$0.55 kg^{-1}), 123 kg P_2O_5 ha^{-1} (\$0.59 kg^{-1}), and 95 kg K_20 ha^{-1} (\$0.31 kg^{-1}) for a total cost, including application, of \$211 ha^{-1}.

Option 2) Manure + Extra Commercial Fertilizer

- Nutrient analysis of the liquid swine manure is 6.1 g N L^{-1}, 5.8 g P_2O_5 L^{-1}, and 3.59 g K_20 L^{-1}.
- Apply 28,050 L ha^{-1} by subsurface injection, as per Iowa State University BMP recommendation for an application cost of \$111 ha^{-1}.
- Apply an additional 112 kg ha^{-1} (100 lbs. ac.$^{-1}$) synthetic N to ensure sufficient nitrogen at a cost, including application, of \$77 ha^{-1}.

Option 3) Manure + N-BMP insurance

- Apply 28,050 L ha^{-1} by subsurface injection, as per Iowa State University BMP recommendation, for an application cost of \$111 ha^{-1}.
- Purchase N-BMP insurance for \$22 ha^{-1}.


FERTILIZER OPTIONS

(COST FOR A TWO-YEAR CORN/SOYBEAN ROTATION)

Result: By selecting Option 3, the Ridgely family can save \$78 ha^{-1}, (the cost of Option 1 minus the cost of Option 3) amounting to an annual savings of nearly \$14,000.

MITIGATED GREENHOUSE GAS EMISSIONS

Potential N_2O reduction for the Ridgely farm was calculated based on those methods described under Section 2.5.

N_2O EMISSIONS FOR THE RIDGELYS

SCENARIO	Emissions ($t\ N_2O$)
Option 1: Synthetic Fertilizer	1.86
Option 2: Manure + Synthetic Fertilizer	2.14
Option 3: Manure + N-BMP Insurance	0.92

Note: Totals may not sum exactly due to independent rounding.

The use of Option 3 rather than Options 1 or 2 results in an overall N_2O-savings of 0.94 and 1.22 t N_2O, respectively. N-BMP insurance allows the Ridgelys to adopt this practice and simultaneously mitigate the risk of insufficient N and any resulting loss of yield.

3.3 POTENTIAL N_2O SAVINGS FROM N-BMP INSURANCE

Farmers may decide to change their fertilization practices and follow a BMP for many reasons, including regulatory pressure, environmental stewardship, improved operating efficiency, and improved net return.

The USDA ERS annually computes nutrient mass balances for major U.S. crops. A nutrient mass balance indicates how closely the nutrient inputs (synthetic fertilizer, legumes, manure) compare with crop nutrient removal. A positive nitrogen mass balance implies that nitrogen remains in the soil after the crop has used what it needs for growth. Using nitrogen mass balance estimates for the Corn Belt Region, USDA ERS reviewers of the N-BMP policy estimate the land potentially benefiting from the policy to be 27 percent of corn-cropped area, or 6.1 million hectares. We include this as an estimated land area for N-BMP insurance implementation.

Shepard (2000) documented in his survey of Wisconsin farmers that two of three farmers apply excess nitrogen for corn production, and on average, farmers used an excess of 42.6 kg N ha^{-1}. Furthermore, in nearly 7 percent of the cases, nitrogen application rates exceeded 448 kg N ha^{-1} or nearly 280 kg N ha^{-1} more than the recommended rate. Similarly, a confidential and unpublished survey in Illinois indicated that 13 percent of farmers apply an excess of 44.8 kg N ha^{-1} or more beyond the state BMP recommendation (Greene, 2001). We include 44.8 kg N ha^{-1} as an estimate of average over-application rate based on these studies and an appreciation that farmers over applying to the greatest extent will be those with the greatest financial incentive to purchase N-BMP insurance. Table C provides a national gross assessment of the nitrogen that could be potentially saved with the N-BMP insurance, along with resulting N_2O reductions.

TABLE C. POTENTIAL NITROGEN AND GHG SAVINGS USING N-BMP INSURANCE

Hectares targeted for Insurance policy sales (millions of hectares)	Average nitrogen over- applied (kg ha^{-1})	Potential nitrogen savings (t N)	Potential N_2O Reduction (t N_2O)
6.07	44.8	271,936	8440

Potential N_2O reduction for implementation of N-BMP Insurance was calculated based on those methods described under Section 2.4 and is documented in Table D.

TABLE D. N_2O EMISSIONS FOR N-BMP INSURANCE

EMISSION TYPE	Synthetic Fertilizer (t N_2O)	Manure Nitrogen (t N_2O)
Direct N_2O	4807	4273
N_2O from Volatilization	472	855
N_2O from Leaching and Runoff	3205	3205
Total N_2O Emissions	8440	8333

Note: Totals may not sum exactly due to independent rounding.

Manure emissions are approximately 107 t N_2O less than those of emissions associated with synthetic fertilizers. The total business as usual emissions, however, accounting for both the synthetic and the manure N_2O emissions, totals 16,773 t N_2O, indicating an overall emission reduction of 8440 t N_2O, or 2.6 Tg CO_2-Eq. This is most comparable in magnitude to SF_6 emissions from magnesium production in the U.S. in 2001 (2.53 Tg CO_2-Eq.) (U.S. Environmental Protection Agency, 2003).

4.0 CONCLUSIONS

Manure brokering and N-BMP insurance used independently or in combination form a valuable tool for animal feeding operators with a limited land-base to apply manure nutrients. Livestock and poultry producers can, in effect, sell the nutrients along with a warranty on the nutrient content and performance of the manure.

Given that manure brokering and N-BMP Insurance may be used in tandem, it would be inappropriate to treat their overall N_2O emissions savings additively. Either, however, is comparable in magnitude to some of the smaller component sources of the U.S. Greenhouse Gas Inventory. While the emission savings estimates arrived at are preliminary and based on national-level information, we believe they highlight the importance of further analysis and consideration of these programs under a comprehensive greenhouse gas emission reduction plan.

Project level benefits to individual farm operations are measurable both from an environmental viewpoint and with respect to cost of production. We believe this preliminary examination provides evidence of sufficient potential to encourage further inquiries into the applications of manure brokering and N-BMP insurance in meeting agronomic needs and environmental agreements, reducing greenhouse gas emissions and exploring benefits to farmers such as risk mitigation.

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