POTASH & PHOSPHATE INSTITUTE

P.O. Drawer 2440
Conway, AR 72033-2440
Phone: 501-336-8110
Fax: 501-329-2318
csnyder@ppi-far.org

July 29, 1999

John Field
National Ocean Service
National Centers for Coastal Ocean Science
WS 13446 SSMC4
1305 East-West Highway
Silver Spring, MD 20910

Dear Mr. Field:

Enclosed with this cover are general and specific comments on the Topical Scientific Reports for an Integrated Assessment of the Causes and Consequences of Hypoxia in the Gulf of Mexico. Our technical comments have also been sent to The Fertilizer Institute for their consideration in responding to the six CENR reports.

We have specifically addressed Topics 3, 4 and 5. Topic 6 authors used a macro-economic modeling approach to look at costs and benefits for reducing nutrient loads to the Gulf of Mexico. The model will likely be challenged by agricultural economists and others who may be more familiar with the impact of crop acreage reductions and nutrient-use reductions in a global farming economy. There are numerous assumptions in the model that just do not agree with conventional agricultural wisdom and we formally register concern about the potentially inaccurate model projections.

Please record our comments, reply to confirm receipt, and forward our comments to authorities within EPA, NOAA, and the Office of Science and Technology. If you have any questions please feel free to call me at 501-336-8110.

Sincerely,

Clifford S. Snyder

Clifford S. Snyder, Ph.D.
Midsouth Director

Enclosures

CC: Dr. Tom Bruulsema
Dr. Paul Fixen
Dr. Scott Murrell

FERTILIZER N EFFICIENCY FOR CORN

Potash & Phosphate Institute
June 7, 1999

U.S. farmers have been improving their nitrogen (N) fertilizer efficiency for the last two decades. Average fertilizer use per acre on corn in the U.S. has been essentially constant since the late 1970's (Figure 1). However, corn yields have continued to climb resulting in an increase in the bushels of corn produced per unit of fertilizer N applied (Figure 2).

Farmers have increased the amount of grain produced per unit of N from 0.76 bushels per pound of N in the late 1970's to approximately one bushel per pound of N today. That represents an efficiency increase of 32%.

Grain production per unit of fertilizer N applied will never increase to what it was in the early 1960's. Farmers today are rebuilding soil organic matter and soil organic N with conservation tillage systems. These systems do not mine soil N like the plowed systems of the 1960's did. Instead, they fix atmospheric carbon and in so doing reduce carbon dioxide emissions by the U.S. Farmers in the 1960's could use less fertilizer N because of the soil N released by their intensive tillage systems. Changes in crop rotation practices have also impacted N need.

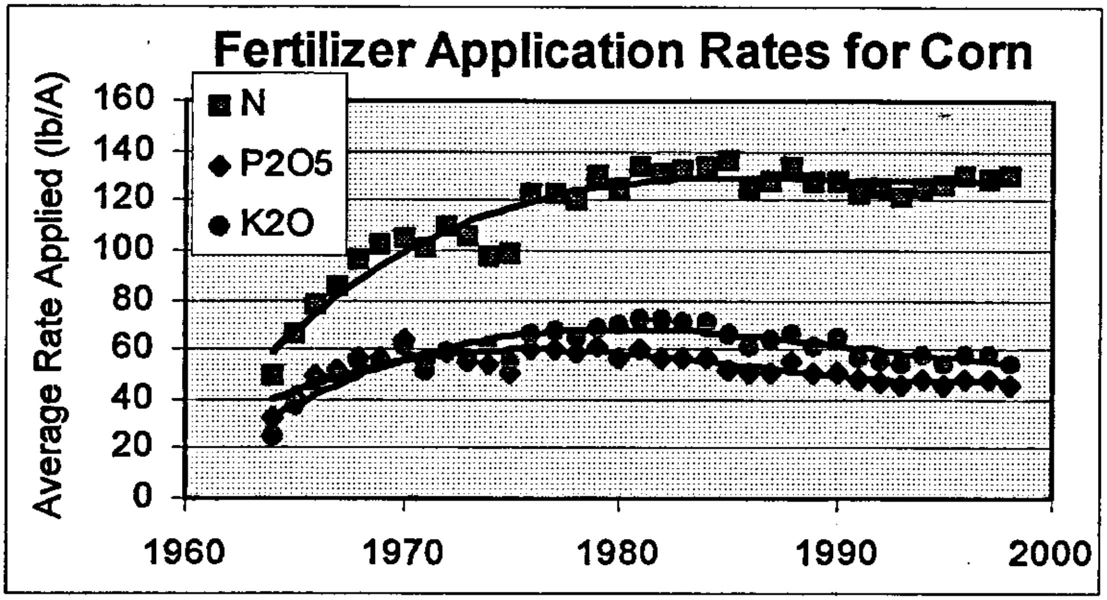
A recent survey of Iowa farmers gives additional insight into today's N management practices (Table 1). Where no manure was available, fertilizer N use for a corn-soybean rotation averaged in the middle of Iowa State University's recommended use range. For continuous corn without manure, farmers averaged less than the recommended range and may have been losing yield from insufficient N. Fertilizer N use where manure was applied was less than where it was not applied but exceeded recommended rates. Farmers generally took less N credit for the manure than was recommended probably due to uncertainty about the actual N content of the applied manure. Although, there is still room for improvement in N management practices, especially where manure is involved, this survey does not support an across the board mandatory reduction in fertilizer N use.

Table 1. Nitrogen use on corn in Iowa in 1996, with and without manure.

	Manure used		Manure not used	
Parameter	Corn/corn	Corn/soybean	Corn/corn	Corn/soybean
Corn yield, bu/A	142	143	131	142
N fertilizer use, lb/A	121	119	135	129
ISU recom., lb/A*	0-90	0-90	150-200	100-150

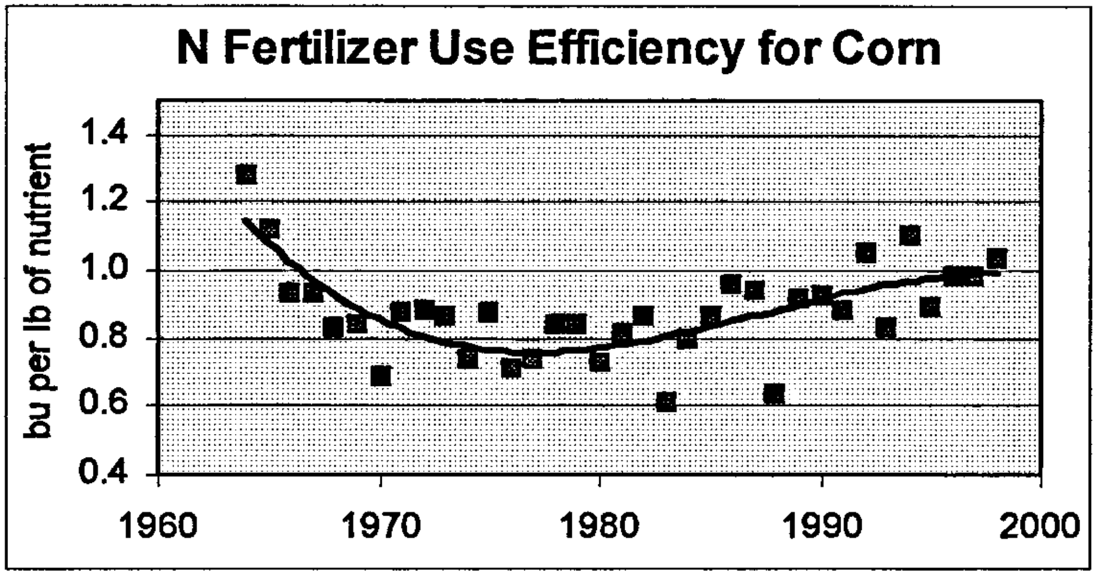
*Iowa State University 1997 N recommendations where all N is applied before emergence.
Data source: M. Duffy, Iowa State University, personal communication.

Figure 1



Data source: National Agricultural Statistics Service and Harold Taylor, Personal Communications.

Figure 2



Data source: National Agricultural Statistics Service and Harold Taylor, Personal Communications.

REVIEW OF THE HYPOXIA ASSESSMENT REPORTS FROM THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES HYPOXIA WORK GROUP MAY 1999

Topic 3. Flux and sources of nutrients in the Mississippi Atchafalaya River Basin

Topic 4. Effects of Reducing Nutrient Loads to Surface Waters within the Mississippi River Basin and the Gulf of Mexico

Topic 5. Reducing nutrient loads, especially nitrate-nitrogen, to surface water, groundwater, and the Gulf of Mexico

BY THE POTASH & PHOSPHATE INSTITUTE

June 7, 1999

REVIEW OF TOPIC 3 REPORT: FLUX AND SOURCES OF NUTRIENTS IN THE MISSISSIPPI ATCHAFALAYA RIVER BASIN (MARB).

Tom W. Bruulsema, Ph.D., Potash & Phosphate Institute

The topic 3 report is very detailed and comprehensive. However the problem addressed demands extreme attention to detail and rigorous analysis. While the report provides and summarizes much useful information, its conclusions are not supported by the science presented. In fact, there unfortunately appears to be a bias within the study toward attributing modern row crop production practices with most of the responsibility for the current level of nitrogen (N) loading. While that premise may indeed be true, the appearance of bias detracts from the acceptability of the report.

Conclusions that must be taken seriously include:

1. The average total N yield for the basin of 4.97 kg/ha/yr is quite conceivable. Most agronomists would agree that this rate of leakage of N from most row crop production systems could be occurring, even when averaged over non-cropped land in many parts of the basin.
2. The major nitrate and nitrogen loads in the basin come from the geographical area of the Corn Belt, as illustrated clearly in Fig. 4.5.

General weaknesses in the report include:

1. Data interpretation is often questionable. For instance, on page 24 Fig 3.3 is interpreted as a "direct relation" between nitrate concentration and streamflow. The fit is not nearly that tight. Visual examination of Fig 3.3 hardly supports a positive association between the two, as there are times of high concentration at low streamflow. This important association, considering its use in the flux estimates, is not reported to have been rigorously analyzed with statistical methods, even methods as simple as a Pearson correlation coefficient. It would seem that these data should be analyzed by more advanced statistical methods including spectral analysis, as there appear to be significant cycles in the data.
2. The statement in the executive summary on page 13 that nitrate flux is about three times larger than it was 30 years ago is an exaggeration of data shown in Fig 4.2, where the increase appears to be no greater than 2.5 times.
3. On page 31, it is stated that the average total N yield for the MARB had increased 3 fold over the past 40 years. Figure 4.2 indicates no measure of total N prior to 1967 and therefore cannot support that statement. In fact a visual assessment of the trend in Fig. 4.2 would suggest an increase of roughly 2 fold over the past 40 years.
4. In the same paragraph on p.32, current MARB N yields are compared with "pristine" North Atlantic basin yields. The comparison is not meaningful, as many of the non-MARB watersheds of the North Atlantic consist of acid soils and soils of lower natural fertility than those of the MARB. It is likely that "pristine" MARB N yields

were higher than those for the North Atlantic basin, as the soils of the MARB have above average organic matter content.

5. Page 15 states that N input from animal manures has decreased slightly over the last 40 years. However, this assessment was made assuming constant per-head manure nutrient output. The livestock industry has made dramatic changes in per animal output in the past 40 years. Dairy cows now produce much more milk per animal. Swine and poultry are produced in much shorter production cycles. One cannot assume that manure output per animal has not changed; it is very likely to have increased significantly.
6. In several places (p. 31, 36), the report emphasizes the importance of ortho phosphorus (P) over total P and considers it more available to algae and aquatic plants, citing Correll (1998). However, the same report by Correll (1998) emphasizes that total P is the more important quantity to measure and regulate in terms of its impact on eutrophication.
7. The choice of nutrients was rather limited. Certainly N, P and silica may be important, but how can their relative importance be assessed when no consideration is given nutrients like organic carbon (C) and its impact on BOD? Given its interactions with sediment, how can P be interpreted without consideration of sediment loads and concentrations?
8. The regression model predicting annual flux and yield of P (p.35) assumes zero net sedimentation in the entire Mississippi river. Most rivers do have continual sedimentation, and this is normally a large sink or loss mechanism for P. The statement on p. 36 that deposition of sediment does not occur except in basins with large main stem reservoirs appears questionable. Consultation with river management hydrologists and US Army Corps of Engineers is suggested to verify this point.

The calculation of "soil mineralization" as a N source has several major problems.

1. Separation of mineralization from immobilization as inputs and outputs from the system on this scale is inappropriate. Current models of soil organic matter and N transformations recognize mineralization-immobilization turnover (MIT) as a continuous internal cycling (Jansson and Persson, 1982). Instead of considering gross mineralization and gross immobilization, the report should have focussed on the net mineralization or immobilization of nitrogen produced by MIT in MARB soils.
2. Current evidence indicates that agricultural soils have switched in the last 15 years from being net producers of carbon dioxide to being net accumulators (Allmaras, 1999). In other words, soil organic matter is no longer undergoing net loss; it is increasing. Soil organic matter stabilizes with a C:N ratio of 10:1. The new evidence on C balance suggests that the current balance of MIT in agricultural soils results in no net loss of N. The model in the report implies a mineralization rate more than twice that of immobilization, a situation that is not compatible with stabilized soil organic matter levels (unless soil OM C:N is increasing, of which there is no evidence). In fact, limiting N inputs to agricultural soils could potentially threaten this C accumulation capacity, as N is critical for stabilizing increased soil

organic matter (Paustian and others, 1992; 1997) as well as for increasing crop yield and crop C contribution to the soil to build up soil organic matter (Nyborg and others, 1995).

3. The soil mineralization calculation involves a multiplication by cropped land area, assuming that only cropped land mineralizes N (p. 48). As the amount of cropped land is correlated to N fertilizer use, it is not surprising that the regression model finds these two variables correlated and cannot distinguish between their contributions to the flux of N in the rivers (p. 67).
4. The report cites literature on the so-called "priming effect" whereby N fertilizer additions stimulate N mineralization (page 48). This priming effect has been debated extensively in the literature, and many reports are based on erroneous interpretation of 15N tracer experiments (Jansson and Persson, 1982). In most agricultural soils, available C rather than N limits microbial decomposition of organic matter and hence N mineralization. In fact, lack of N may limit C accumulation in soils (Paustian and others, 1992; 1997; Nyborg and others, 1995).

The bias against modern row crop production practices is demonstrated in the following.

1. While all aspects of agriculture that could lead to potential losses are considered, the consideration of other sources is much more limited. For example, the estimates of N and P from point sources are limited to permitted discharge from facilities in the NPDES database (p.53 section 5.3.1). Violations of current regulatory limits and illegal dumping are ignored and are, in effect, estimated to be zero. Point sources from facilities outside the NPDES database are not considered.
2. Land uses other than agriculture, including forestry, municipal landfills, urban run-off, geological nitrate etc. are simply assumed to contribute little and are not investigated in any degree of detail. Therefore it is not surprising that agriculture appears to be the larger contributor.
3. The N contribution from legumes is underestimated. In Minnesota, Dr. M.P. Russelle's recent work with alfalfa indicates that substantial N fixation takes place even when soil nitrate is high. This work was ignored in the model, and it was assumed that legumes never fix more N than needed (p.45). Yet it is well known that when forage legumes are plowed down or killed, N mineralization is enhanced and nitrate can accumulate. The estimates used for the most important legumes, soybeans and alfalfa, are considerably below the middle of the range of literature values (Table 5.4). In fact, estimated N fixation for soybeans works out to 78 kg/ha/yr, while a crude N balance for 1998 suggests U.S. harvested soybeans removed 170 kg/ha/yr more than was applied as fertilizer N. It is highly likely, though difficult to substantiate, that soybean N fixation is considerably higher than 78 kg/ha/yr.
4. The most precisely known variable in the regression model is fertilizer N sales, as disclosed on p. 66. It is not surprising that the variable with the least amount of error would explain the greatest amount of variation in the regression model.

5. The soil mineralization calculation assumes that only cropped land mineralizes N. Thus it is not surprising that soil mineralization is correlated to N fertilizer use, and to crop agriculture in general.

Problems with the regression model used to attribute sources of nutrient loading (pages 67-74 section 6.3) include:

1. The 42 basins are not all independent. Several are inclusive of a separate upriver basin (examples include 17-18, 20-21, 25-26, 27-28). This leads to autocorrelation within the data and thus underestimation of error variance. No mention is made in the report of use the Durbin-Watson *d* statistic to test for autocorrelation.
2. The dependent variable, nutrient flux, is an average of the 17-year period 1980 to 1996. The independent variables are estimated from the 1992 census. While the appropriate time lag is an unknown, it would seem obviously invalid to argue that independent variables (nutrient inputs) in 1992 were causes of effects on the dependent variable in 1980 to 1991.
3. A preferred method of computing the relative contribution of each variable in the regression model would be to use the various types of sums of squares in SAS to estimate proportion of variation explained, rather than basing all conclusions on the size of the coefficients relative to the mean input values of the independent variables.
4. The large negative intercept of the final model contradicts the initial assumption of limited in-river losses of N by denitrification and other processes.

Finally, the report provides very little discussion of the decline in the residual surplus of the calculated N balance over the past 40 years (Figure 6.4A). It would seem to contradict the increasing trend in measured N and nitrate flux over the same time period. Examination of cumulative residuals (Figure 6.4B) implies a long-term storage pool of N, filled to a "steady-state" capacity (page 65) over the course of 20 years or more. However it is extremely difficult to conceptualize where such a large pool of N might be stored. It was not soil organic N (which did not likely increase between 1955 and 1975). Possibly this huge pool could be groundwater nitrate, but the report gives no discussion of the contribution of baseflow relative to that from surface runoff and tile drainage. It is difficult to imagine that baseflow from deep groundwater sources could be a major contributor. It is recommended that experienced hydrologists be consulted on this question.

The report's first objective, to identify where the most significant nutrient additions to surface water occur, was achieved. However, its second and admittedly more difficult objective, to estimate the relative importance of specific human activities, was not achieved. It is unfortunate that the report's conclusions neglect this and make estimates of the latter without scientific grounds.

Literature Cited

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Correll, D. 1998. The role of phosphorus in the eutrophication of receiving waters: a review. J. Environ. Qual. 27:261-266.

Jansson, S.L., and J. Persson. Mineralization and Immobilization of Soil Nitrogen. Ch. 6 in Nitrogen in Agricultural Soils, F.J. Stevenson, ed. ASA Monograph No. 22.

Nyborg, M., E.D. Solberg, S.S. Malhi, and R.C. Izzauralde. Fertilizer N, Crop Residue, and Tillage Alter Soil C and N Content in a Decade. p. 69-83, Chapt. 6 in: R. Lal, J. Kimble, E. Levine, B.A. Stewart (eds.) Soil Management and Greenhouse Effect, CRC Press, Inc.

Paustian, K., W.J. Parton, and J. Persson. 1992. Modeling soil organic matter in organic-amended and N-fertilized long-term plots. Soil Sci. Soc. Am. J. 56: 476-488.

Paustian, K., H.P. Collins, and E.A. Paul. 1997. Management controls on soil carbon. p. 39-41, Chpt. 2 in: E.A. Paul, K. Paustian, E.T. Elliot, C.V. Cole (eds.) Soil Organic Matter in Temperate Agroecosystems, CRC Press, Inc.

REVIEW OF TOPIC 4 REPORT:

EFFECTS OF REDUCING NUTRIENT LOADS TO SURFACE WATERS WITHIN THE MISSISSIPPI RIVER BASIN AND THE GULF OF MEXICO

Cliff S. Snyder, Ph.D., Potash & Phosphate Institute

Page 6, Section 2.3.1
The authors state that N and P loadings to the Gulf have increased and silica loading has decreased this century, and that the trends have accelerated since the 1950s. **These statements are not accurate.** Considering the 1993 record flood year an aberration from the norm, and excluding 1993 data from the years 1983 to 1996, the trend in nitrate-N flux to the Gulf since 1985 has been clearly downward. Further, based on National Agricultural Statistics Service and Economic Research Service data, there has been an improved efficiency of N, P and K utilization by corn, per bushel of production, since the early 1980s.

These data support the fact that there has not been an increased nitrate-N flux to the Gulf Mexico since 1983. (See supporting Figures 1 and 2).

Page 11, 2nd paragraph
The authors state that in 1985 and 1990, Mississippi River flow was above the long-term flow of 664,000 cubic feet per second. On a percentage basis, the 1985 flow was 31 percent above the long-term average, and the 1990 flow was 36 percent above the long-term average. Comparisons of flow in 1985 and 1990 with the flow in 1988 (Table 2.1), show that the combined Mississippi and Atchafalaya inflow to the Gulf was 83% greater in 1985 and 49% greater in 1990, than in 1988. Total N loading to the Mississippi –Atchafalaya Basin was 487% greater in 1985 than in 1988, and 356% greater in 1990 than in 1988. Similarly, total P loading was 357% greater in 1985 and 423% greater in 1990, than in 1988.

Peak Gulf of Mexico inflow, via the Mississippi and Atchafalaya discharges, in 1990 was measured in June rather than in April, the historic norm. This change in peak flow occurred after much of the N for corn had already been applied in the Cornbelt states. Consequently, the "flushing" of nitrate-N from farm fields in the Cornbelt states in 1990, may have represented the worst-case scenario for loss of N from the Cornbelt states. The record rainfall and flooding experienced in 1993 in the Cornbelt states, and the consequential increased flow and N discharge to the Gulf of Mexico in 1993, suggest that trends observed from 1985 to 1995 may therefore represent aberrations in the long-term rainfall and river discharge trends. Since about 1970, the total water discharge to the Gulf appears to have increased compared to data from 1900 to 1970 (see Figure 32 on page 47 of the Report by Rabalais et al., CENR Topic#1. Characterization of hypoxia. May 1999). These facts, plus the statements by the authors in the second paragraph on page xvi, indicate that hypoxia development and persistence may not be affected by nutrient loadings as much as by water flux to the Gulf, water movement and other physical processes on the Louisiana Intercontinental Shelf.

Page 21, 3rd paragraph
The statement that P is transported to surface waters by direct discharge from animal waste storage lagoons, implies that the majority of these lagoons breach or overflow. While there have been accidents highly publicized by the media, the majority of animal waste lagoons do not directly discharge to surface waters. Instead the lagoon contents are land-applied though irrigation systems or by manure spreaders. Such discharges are regulated as point sources by EPA and state water quality authorities.

Page 21, 4th paragraph
Dr. John Lory, at the University of Missouri, has submitted a manuscript to the Journal of Environmental Quality, in which he and colleagues review the science behind "critical" soil test P levels. His paper provides solid evidence that such limits ignore the major influence on the potential for loss of P from land surfaces: water flow. Mention of the Sharpley et al. (1994) paper, is of interest, but the authors should also mention the need to identify critical source areas and potential for transport losses. This point is reinforced by the author's statements in the first paragraph, on page 23.

Page 28, section on N and manure application
The geographic pattern of precipitation is cited as THE major influence on nitrate loading to rivers and land-use characteristics were secondary. This reinforces the transport considerations mentioned in the review comment above, regarding page 21.

Page 29, section on mineralization of organic matter.
The contribution of N from soil organic matter mineralization is related accurately in this section. As pointed out in the review comments for the Topic 3 Report, soil organic matter levels have likely either stabilized or are generally increasing on a time scale of many years. However, year to year and field to field fluctuations in soil conditions can result in substantial release of inorganic N, at times under conditions where the N cannot be efficiently used by plants. A more recent publication reinforces the scientific acceptance of soil organic matter as a major source of nitrate-N in the Mississippi River basin (Burkart and James, 1999).

Pages 30 and 31
Is it valid to use the results of Randall and Iragavarapu (1995), which involved a single rate of 200 kg N/ha, to "calibrate and validate" the ADAPT model developed by Davis (1998)? Can Davis'results be used to extrapolate to a range of N application rates? More information should be provided regarding the independent data used to develop the ADAPT model.

Page 32, 2nd paragraph
The authors contrast loss of N from forested watersheds with loss from agricultural watersheds. However, they fail to mention that forested watersheds often involve Land Capability classes V, VI, and VII. The NRCS and most university agronomists recognize that agricultural crops are typically found on Land Capability Classes I

through IV. Cropped lands (i.e. Land Capability Classes I-IV) are inherently more productive, usually more fertile, and may frequently have a higher actinomycete and bacterial population. These charactersitics contribute to a higher nitrification potential than in many forest soils. Comparisons of nitrate losses between forested watersheds and cropped agricultural watersheds, without regard to Land Capability Class or soil characteristics, is risky at best. Perhaps the authors considered these factors, but they should explain the similarities or differences in soil characteristics, which may influence nitrification potentials and interpretations regarding BMPs for reductions in nitrate losses.

Page 33, 2nd paragraph

The authors should also mention that soils in the Eastern and Southern sub-basins usually have lower soil organic matter levels than soils in the Midwest and Northcentral states. Differences in soil organic matter and climate may also explain a large portion of the variation in nitrate yields among the sub-basins.

Page 33, 3rd paragraph

The authors' statement that nutrient inputs from the lower Mississippi states (i.e. Arkansas, Louisiana, and Mississippi) flow directly into the Mississippi is **grossly inaccurate**. The large majority of the cropped acreage in the lower basin is actually separated from the Mississippi River by the Corps of Engineer's levee system. Consequently, surface and subsurface drainage must take a tortuous path before reaching the Mississippi River.

Page 33 through 37

The HUMUS model developed at Temple, TX apparently has not been subjected to independent validation, nor has it been published or peer reviewed in refereed journals. The authors state, "There are many reasons why the results from these two studies may not directly correspond to the results of other studies, especially results of studies of specific local sites and watersheds." As a result, the discussions on these pages should be considered preliminary and quite tentative, at best.

It is highly unlikely that a 30% reduction in N inputs in the Cornbelt states would reduce the national corn production by less than 1.5%. Further, how can a 30% reduction in N use on sorghum *increase* yields by 2.2%? The U.S. currently uses about 1.1 lb N in producing a bushel of corn. The long-term data indicate that corn N–use efficiency has been improving since the early 1980s. Nationally, corn yields have been increasing. The authors have not considered the impact of nitrogen use restrictions on the future opportunity of farmers to capture improved genetic yield potential. The authors also fail to consider the farmer's ability to improve production efficiency and yield potential with better management (e.g site specific crop management). Failure to consider these factors in the model can result in false conclusions and destine the American farmer to failure by destroying his/her ability to compete in the global market.

The authors assume that farmers are applying too much N. The authors also imply in Table 3.3 that a reduction in N use would result in higher crop prices. How is it possible that such a small change in total corn production (1.5%) could have any impact on corn price? Table 3.3 also shows that 41 to 56% of the farmers would lose profits due to imposing N stress-based restrictions on N rates. The remaining percentage of farmers presumably would have increased profits. The authors suggest a 34% reduction in N use will result in only a 2 to 5% decrease in N discharge from the Upper Mississippi and Ohio Rivers. **This further supports the evidence, which indicates the principal source of N losses from farm fields, in these same sub-basins, is nitrate derived from soil organic matter mineralization.**

Page 54

Figures 3.29 and 3.30 indicate there is a poor relationship between growing season mean total P concentration and chlorophyll *a* concentration in the Mississippi River itself. This appears to contrast with data from other rivers (Figure 3.30). The authors do admit that there is " considerable scatter " in the relationship between all chlorophyll *a* and total P data. Certainly, Figure 3.30 illustrates that it is not valid to transpose the relationship between chlorophyll *a* and total P in reservoirs, to chlorophyll *a* and total P concentration in the Mississippi River. These graphs illustrate that the Mississippi River behaves differently from other monitored rivers and especially differently from reservoirs. Relationships in lakes and reservoirs should not be extrapolated to rivers, ... and especially not to the Mississippi River.

Page 60

The authors state that Task Group 5 concluded that more than 50% of the N loading to the Gulf could be achieved through implementation of a number of proven best management practices working in concert. This statement negates the need for imposed N-use- reductions to achieve water quality goals in the Mississippi River and the Gulf of Mexico.

Page 62, 1st paragraph

The authors admit the forecast results ...."do not contain any information on the time frame required for the system to fully respond to imposed changes in nutrient loadings".

Page 62 and page 63

The authors state, that a simulated 50% N loading reduction for 1985 conditions, increased dissolved oxygen conditions in the Gulf of Mexico by less than 5% for constant boundary layer conditions, and 45% for reduced boundary layer conditions. The authors further state that, "Differences in responses of average dissolved oxygen concentrations between constant and reduced boundary layer conditions are not constant among different years." These differences are illustrated as follows:

Effects of nutrient load reductions on percentage changes in dissolved oxygen (under reduced boundary layer conditions)

	Nutrient Load Reduction	
Year	20%	50%
1985	25	45
1990	60	140

Modeling of the 1985 and 1990 data indicates chlorophyll *a* response to nutrient load reductions is similar between years. However, there are marked differences and considerable variations in load reduction effects on dissolved oxygen. The absolute differences in predicted percentage effects on dissolved oxygen approach 100%, as illustrated above. The authors state that chlorophyll *a* is coupled to nutrient concentrations in Gulf waters, but that phytoplankton growth rate is controlled by underwater light attenuation.

These modeling results indicate the effects of nutrient load reductions on dissolved oxygen levels in the Gulf of Mexico, 1) can not be accurately predicted, and/or 2) they are <u>not</u> predominantly under influence by N loading. Dissolved oxygen levels appear to be under greater effect from advective flow and flow direction along the Louisiana Intercontinental Shelf, than from nutrient loading.

CONCLUSIONS on page 79

To quote the authors, "Violations of numerical water quality standards for dissolved oxygen, pH, nitrate, and un-ionized ammonia are uncommon in MRB rivers and streams under current and recent conditions. It should be noted however, that there are no numerical standards for nutrients in water bodies relative to their potential to cause eutrophication problems (e.g. the nitrate standard applies to drinking water)". The authors go on to state, that about 30 to 55% of the HCUs of the Ohio, Lower Mississippi, and Tennessee basins exceed a recently proposed eutrophication criterion (Dodds et al., 1998) for total P in flowing waters, and 16-40% exceed the total N criterion.

Conclusions page 80

To quote the authors again, "For a given reduction in MAR (Mississippi and Atchafalaya River) N or P loadings, there are large uncertainties in the magnitudes of dissolved oxygen and chlorophyll concentration responses."

<u>This reviewer is in complete agreement with the final paragraph on page 82.</u>

"Results presented in this report are from an ongoing research program and should be considered preliminary and provisional in nature. To reduce uncertainties in these results, future modeling should include linkage of the water quality model with a hydrodynamic model of the Gulf of Mexico circulation, expansion of the model spatial domain, and refinement of the horizontal and vertical spatial resolution of the model. The water quality model itself should be expanded to include a sediment diagenesis submodel, multiple phytoplankton groups and silica as a limiting nutrient."

Literature Cited

Burkart, M. R. and D. E. James, 1999. Agricultural-nitrogen contributions to hypoxia in the Gulf of Mexico. J. Environ. Qual. 25:850-859.

Figure 1. Hypoxic Area in Gulf of Mexico Declined Since 1993 Floods
N. Rabalais, LUMCON

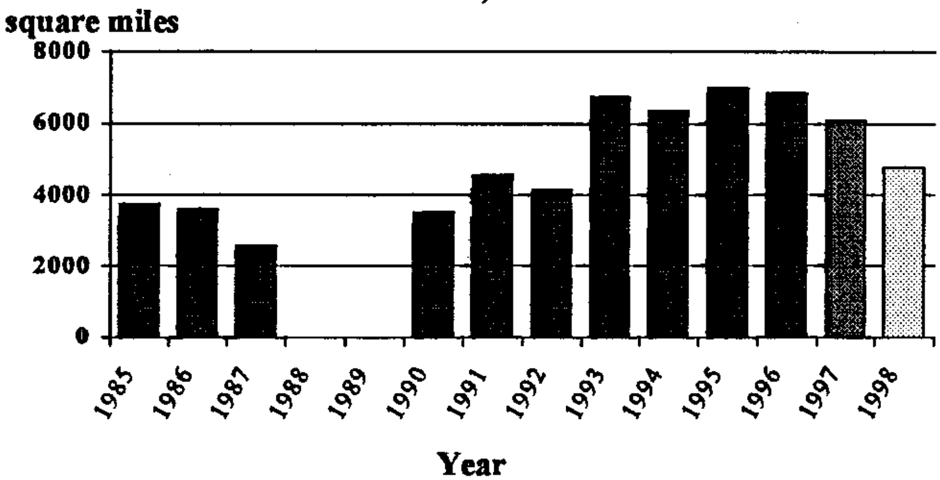
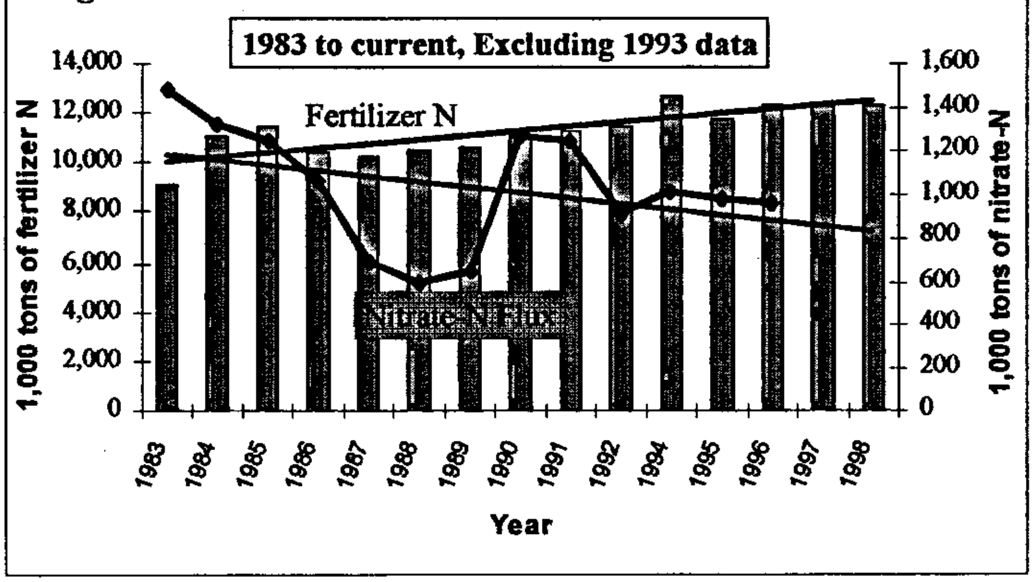


Figure 2. Fertilizer N Use and Nitrate-N Load to the GOM



REVIEWED OF TOPIC 5 REPORT: REDUCING NUTRIENT LOADS, ESPECIALLY NITRATE-NITROGEN, TO SURFACE WATER, GROUNDWATER, AND THE GULF OF MEXICO

T. Scott Murrell, Ph.D., Potash & Phosphate Institute

Preliminary Comments

The goal of theTopic 5 Report was to devise possible strategies and outline further needed research to reduce nutrient loads to the Gulf of Mexico. The executive summary (pp. xi-xiii) contained 8 recommendations specific to this goal. This review will focus on only one of these recommendations, #1 (pp. xi-xii) which states:

> Several on-farm practices for the reduction of discharges of nitrogen to streams and rivers should be implemented. These practices, which could lead to reduction of 15-20% of nitrogen sources, include 20% reduction in fertilizer nitrogen application, optimum timing of fertilizer application, use of alternative crops such as perennials, wider spacing of subsurface drains, and better management of livestock manures whether stored or applied to the land.

The wording of this recommendation in the executive summary is essentially the same as the wording in the Sec. 6.2, Recommendations (p. 101).

In conducting this review, the assistance of other soil fertility researchers who have been involved in N research and recommendations in the Northcentral US was requested. Only 2 of the 14 researchers had time to respond to this request. More would have responded, given more time (2 not providing comments specifically stated this). It should be noted that the review period corresponded to spring planting and treatment applications, leaving researchers with great expertise little time to provide in-depth comments on this important document. The two researchers who were able to provide information are both from the University of Minnesota and have been involved in the N recommendations for the state. They commented specifically on the content in Sec. 3.1 (pp. 12-26) and Secs. 6.1 and 6.2 (pp. 100-103). The comments they provided are incorporated into the following review.

Review of the recommendation "20% reduction in fertilizer nitrogen application"

This recommendation appears to have been constructed from data presented in Sec. 3.1.3 "Reducing Nitrogen Fertilizer Application Rates" and Sec. 3.1.5 "Managing the Time of Nitrogen Application". The main points in both sections are summarized below.

Section 3.1.3

1. *Many farmers use excess N (p. 19).*
   Sec. 3.1.3 begins by stating that many farmers choose to use "extra" N as "insurance". Too little N results in lower yields, poorer grain quality, and reduced

profits. Too much N results in no yield or quality reductions but can negatively impact the environment (p. 19). Legg et al., 1989 is used to support the statement that farmers use excess N as insurance.

2. *Use of insurance N increases nitrate levels in drainage water (pp20-22).*
   Data from 1974-79 were presented from Lamberton, MN that showed high nitrate concentrations in drainage water from plots receiving large fertilizer N rates (224 and 448 kg N ha^{-1}) each year for 6 years. These data were used to estimate increased nitrate concentrations in drainage water of 6-20 mg N L^{-1} from insurance N applications applied for 6 consecutive years. Applying manure at 100 kg N ha^{-1} above recommended rates was estimated to increase drainage water N concentrations by 25 mg N L^{-1} over the 6 year period.

   Data from 1977-79 from Waseca, MN showed 16-20 mg N L^{-1} increased nitrate concentrations in drainage water when higher (224 and 336 kg N ha^{-1}) fertilizer N rates were applied. Applying insurance N 45 kg N ha^{-1} above the currently recommended 190 kg ha^{-1} rate was estimated to produce a 7 mg N L^{-1} increase in drainage water nitrate concentration. Applying manure at 100 kg N ha^{-1} above the recommended rate was expected to increase drainage water nitrate concentrations by about 17 mg N L^{-1}.

3. *Reducing N rates by 10% from recommended rates produces modest yield losses and reduces nitrate concentration in drainage water (pp20-22).*
   Estimates from corn response to fertilizer N at Lamberton and Waseca were used to predict effects of lower N rates upon yield and drainage water nitrate concentration. At Lamberton, reducing N rates by 10% compared to currently recommended rates would reduce yields only slightly and decrease drainage water nitrate concentrations by 3 mg N L^{-1}. Reducing N rates 10% from currently recommended rates at Waseca was predicted to reduce corn yields by 0.3-0.4 metric ton/ha (5-6 bu/A) and decrease drainage water nitrate concentrations by 3 mg N L^{-1}.

Section 3.1.5

The three points developed for Section 3.1.3 were reiterated for another study at Waseca (pp. 23-24). Nitrogen response data from 6 years of a continuous corn experiment were used to predict that 10% and 20% reductions from currently recommended N rates would produce 0.3-0.4 metric ton ha^{-1} (5-12 bu/A) corn yield reductions and 2.5-5.0 kg N ha^{-1} yr^{-1} reductions in nitrate losses.

Comments

1. *The practice of applying insurance fertilizer N is not supported by the cited paper.*
   The paper cited (Legg, T.D., J.L. Fletcher, and K.W. Easter. 1989. Nitrogen budgets for economic efficiency: A case study fo southeastern Minnesota. J. Prod. Agric. 2:110-116) examines the fertilization practices of 4 farmers. Three of the farmers had livestock, the fourth did not. The 3 livestock producers had approximately 25% of their land area in corn. Tables 1 and 2 of the paper indicated that:

fertilizer and legume credits roughly meet the N requirements of the corn crop. Excesses in each case are approximately equal to the N applied as manure.

This statement indicates that over-applications did not result from intentionally applying fertilizer N at rates above those recommended but from failure to consider manure as a nutrient source. The paper also points out that the farmer who did not raise any livestock did not apply enough fertilizer N to meet currently recommended rates.

2. *Over-applications of N occur for many reasons*
   It must be remembered that farmers are most concerned with maximizing their profit. Where it occurs, N is over-applied because 1) farmers do not believe that current recommendations are appropriate for their production levels, 2) local data needed to refine university recommendations are not available or do not exist, 3) university recommendations are based upon yield goals and farmers may set yield goals based on the yields of their best, rather than their average years, 4) dealers, agronomists, or other consultants do not have good guidance on how to incorporate manure as a nutrient source into the nutrient management plans they create for growers.

   Farmers understand that local conditions can lead to best management practices (BMPs) different from university BMPs. Most farmers want data upon which to base their decisions. However, the data they want is local data specific to their situations. Without such data, farmers will try their own refinements in attempts to increase their production levels and profitability. Increased N rates have been a part of such strategies in some cases.

   An example of the effectiveness of local data comes from Indiana from an agronomist who has conducted small plot research to refine local N recommendations. He observed that soil types differed in their response to N. He conducted a split-plot experiment (2 soil mapping units (whole plot), 4 N rates (sub-plots), replicated 4 times, conducted for 5 years) to examine how N response in corn differed between soil mapping units. He concluded that optimum N rates did differ for the two soils studied. He created his own local recommendations based upon soil type, rather than yield goal, the current university guideline. The result: reductions of 10-40 lb N/A compared to current university recommendations. Productivity has remained the same or increased and profitability has increased. Farmers in the agronomist's trade territory use his recommendations exclusively. This has led to reduced N applications on thousands of acres. This example shows that solid local data, produced by reputable agronomists, is the key to creating N recommendations that 1) fertilize a crop appropriately and 2) are accepted and used by farmers.

3. *Recommending a 20% reduction in N fertilizer for the Mississippi basin extrapolates well beyond the inference space of the data presented.*
   The effects of a 20% reduction in N fertilizer (from recommended rates) were estimated only for one site (Waseca, MN) in one experiment (6 site-years total). Only 10% reductions were investigated in the other two cited studies (2 sites in

Minnesota totaling 9 site years). The Waseca study where the 20% reduction was investigated was in a continuous corn rotation. The predominant rotation in the Mississippi basin is corn/soybean, not continuous corn. A corn/soybean rotation is fertilized with N once every 2 years, not every year as in a continuous corn rotation. Thus, the predominant rotation in the basin uses N half as often as the rotation used as the basis for the 20% reduction. In addition, the paper also states on p. 19 that higher nitrate losses were found in one study from a continuous corn rotation compared to a corn/soybean rotation. All of this would lead one to conclude that the predominant corn/soybean rotation is capable of producing lower nitrate losses than those from this study in Minnesota.

The more conservative recommendation of a 10% reduction in N fertilizer use is not well-supported either. Only 15 site-years of data from 2 sites in Minnesota were used to create this recommendation for the Mississippi basin. Normally, university recommendations for a state are based on many more sites and years of data than presented here. It is logical to expect that a blanket recommendation for the Mississippi basin would be based on hundreds of site-years collected from all of the states in the basin, rather than 15 site-years from one state.

4. *The N rate reduction analysis is flawed.*
   The components of the analysis were: 1) create equations from corn and drainage water nitrate responses to fertilizer nitrogen, 2) look up currently-used N recommendations for yield goals appropriate to the experiment, 3) estimate yield and drainage water nitrate concentrations from recommended N rates, 4) estimate yield and drainage water nitrate concentrations from a reduced (10-20%) N rate, 5) determine reductions in yield and drainage water nitrate from using reduced N rates.

   In the analysis for Lamberton, MN, the optimum rate of N was calculated to be 112 kg N ha^{-1} (p. 20). Optimum usually implies an economic optimum. This is normally determined from N response equations by finding the rate producing $1 net return for the last $1 increment spent on N fertilizer. It is widely accepted that the economic optimum rate is best for the producer, since it maximizes profits. Rates greater than the optimum may produce slight yield increases, but such increases produce negative net returns and are not profitable for the farmer. The recommended rate used for the N reduction calculation was 135 kg N ha^{-1}, a rate 23 kg N ha^{-1} greater than the optimum for the site. The 10% reduction examined used 125 kg N ha^{-1}, a rate still 13 kg N ha^{-1} greater than the optimum. This discussion shows that the N reductions examined were not appropriate for this site and were not expected to impact yields or profitability. This site should not have been 40% of the data used for the rate reduction recommendation. This site demonstrates the variability in response possible at different locations and different years. Recent data from Windom, MN demonstrates that the same rate reductions showing no impact at the Lamberton site could produce large impacts at other sites that are more responsive to N fertilization.

   Drainage water N concentrations at the sites studied do not accurately assess current recommendations. These studies examined the impacts of the same N rates applied every year, without regard to residual soil nitrate levels. Current university recommendations adjust N rates based upon residual nitrate concentrations in the soil profile.

5. *The 20% rate reduction does not consider the influence of other factors.* Balanced nutrition has always been the key to optimizing nutrient management. It is not known if the studies considered in the paper examined the effects of other factors. If they did, those factors should be included in the discussion. If they did not, they were too narrowly focused to apply to all of the conditions existing in the Mississippi watershed. An example showing the importance of examining interacting factors comes from Johnson et al. (J.W. Johnson, T.S. Murrell, and H.F. Reetz, Jr. 1997. Better Crops 81:3-5). This study demonstrated that higher levels of soil test K led to lower economic optimum N rates and reduced residual soil nitrate concentrations. Focusing on N alone will lead to recommendations not appropriate when other factors interact.

   The possibility of other interacting factors is demonstrated in a recent survey of soil test levels in North America. This survey determined the percentage of soil samples tested by laboratories that are expected to respond to P, K, and lime additions. These percentages were, for the states in the Mississippi watershed, 35-77%, 7-69%, and 1-63%, respectively, for P, K, and pH. These data demonstrate that N interaction with other nutrients are expected in areas of all of the states in the basin. None of the data presented in the paper accounted for the effects of applications of P, K, or lime on optimum N rates.

Review of the recommendation "use of alternative crops such as perennials"

This recommendation was constructed from data presented in Sec. 3.1.2 "Changing Cropping Systems". In this section, data were presented that showed lower soil nitrate concentrations with alfalfa and a grass/alfalfa mix compared to row crops.

This recommendation does not account for the management strategy needed by many livestock producers. As manure is increasingly being used as a nutrient source, more acres will have to be located to spread manure. A manure application prioritization scheme created by the University of Wisconsin (R.P. Wolkowski, K.A. Kelling, L.R. Massie, and S.M. Combs. Developing a plan for assigning manure spreading priorities. University of Wisconsin Extension Publication A3626) reduces priorities for fields with legumes. Therefore, it seems inconsistent for livestock producers, some of whom have been identified as over-applying N, to increase their legume acres as they have an increased need to find fields on which to apply manure in an agronomic manner. What livestock producers need is a cropping sequence that takes up and removes large amounts of N and P from manure applications. Leguminous perennials would be counter to the N removal needs of these producers. Grass cover crops would be a more reasonable focus.

Review of the recommendation "better management of livestock manures whether stored or applied to the land"

This recommendation was constructed from data presented in Sec. 3.1.4 "Managing Manure Spreading". The discussion in this section centered around using manure as a nutrient source. There are many considerations for using manure as a source of nutrients. The best management practice in a corn/soybean rotation is to store manure in a covered storage facility and empty it once a year by injecting the manure in the spring on corn acreage at rates needed to meet either the N or P needs of the crop. Few producers have the facilities or equipment to manage manure in this fashion. Adjustments to manure management will require large capital investments in storage facilities, injection equipment, and other needed equipment. Besides the initial capital investments, manure has a variable nutrient analysis. The nutrient content of a single load of manure can vary widely (Dr. Brad Joern, Purdue University, personal communication). Many producers are concerned that because of variable analyses, N or P needs of the crop may not be met, even with calibrated applications. The advantages to commercial fertilizers are 1) guaranteed analysis, 2) the ability to blend fertilizer sources to meet specific needs of more than one nutrient, and 3) ease and uniformity of application. It should be recognized that using manure as a nutrient source is a very complicated process with many obstacles. Definition and implementation of BMPs will require time.

General Comments

The recommendations in this section have not been considered in the context of their interaction. There are some rather significant management practice changes that producers will incur if this document becomes the basis for regulations. Producers will have to take on costs associated with 1) reduced crop yields from lower N rates, 2) reduced crop acreage from restoration of wetlands and the establishment of riparian zones, 3) reduced acreage for applying manure from use of rotations involving leguminous perennials, 4) higher capital investments in manure storage and application equipment, 5) increased hiring of labor to accomplish a large number of tasks during a short time period in the spring. All of these costs will lead to a significant management decision: increase the acreage in the farm. Increased acreage will allow the producer to 1) maintain current farm production levels with lower corn yields and reduced crop acreage per field, 2) apply more manure on the land in the farm, 3) spread increased overhead costs over more acres. Certainly, this proposal favors farms with large working capital to make these needed investments. Farmers with smaller working capital are less likely to be able to afford these changes. It is necessary to put these proposed changes in front of economists to determine their efficacy and who is likely to benefit most.

If large sums of money are to be spent on the Mississippi basin, there are a few efforts that should be supported. They are:

1. Increased funding for basic fertility research. This review has shown the need to account for interacting variables in fertility recommendations as well as the need for local refinements. Currently, research for comprising recommendations is too

limited. There are many researchers willing to do significant projects if money were available.

2. Train and use county extension agents, consultants, and dealers to conduct local research on best management practices. These professionals could receive guidance from university personnel to create meaningful local BMPs based upon local research.
3. Educate those creating nutrient management plans, specifically in techniques for using manure as a nutrient source.
4. Although this requires no money, the NRCS, USDA, and EPA must recognize local modifications in recommendations as BMPs if they meet current scientific standards.