The Fertilizer Institute

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President

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Mr. John Field
Gulf of Mexico Hypoxia Working Group
National Centers for Coastal Ocean Science
WE 13446 SSMC4
1305 East-West Highway
Silver Spring, MD 20910

RE: TFI Comments on the Integrated Assessment of the Causes and Consequences of Hypoxia in the Gulf of Mexico

Dear Mr. Field:

The Fertilizer Institute (TFI), on behalf of its member companies, submits these comments in response to a Environmental Protection Agency (EPA) notice regarding the six topical scientific reports by the National Science and Technology Council's Committee on Environment and Natural Resources for an assessment of the causes and consequences of hypoxia in the Gulf of Mexico.

TFI is a voluntary, non-profit trade association of the fertilizer industry. TFI's nearly 250 member companies manufacture more than 90 percent of the domestically produced fertilizer. TFI's membership includes producers, manufacturers, distributors, transporters, and retail dealers of fertilizer and fertilizer materials.

Our comments begin with a section of general comments, a section of specific comments on the six reports, and finally our recommendations. In addition, we submit to you as part of our comments a report on the Role of the Mississippi River in Gulf of Mexico Hypoxia, published by the University of Alabama Environmental Institute. TFI appreciates the opportunity to submit these comments and we look forward to working with EPA throughout this process.

Sincerely,

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Section 1: General Comments

1. Voluntary changes in farming practices are reducing nutrient losses.

Farmers have an economic self-interest in achieving the goal, stated in the six assessments, of reducing nutrient losses. Farmers have made great progress in this area and will continue to make improvements. These improvements in management practices will ultimately serve the dual purpose of making farmers more efficient and reducing nutrient loads to the Gulf.

We fully support the goal of reducing nutrient losses from fields. Farmers have an economic self-interest in achieving this goal: nutrient losses from fields represent lost production and lost money to farmers. This incentive to reduce losses is at odds with the viewpoint expressed in reports 5 and 6 that farmers have an economic incentive to apply too much nitrogen. Farmers do not have an economic incentive to over apply – overapplication represents money that will surely be lost in the form of nutrient losses. Farmers have an incentive to maximize production, meaning get the most possible production out of the least possible input.

Nutrient loss reduction is the result of many complex, site-specific factors, including application rates, nutrient sources, soil types, and precipitation. Thus, mandated use restrictions, such as those suggested in Reports 5 and 6, are unlikely to achieve loss reductions and are certainly not the most efficient way to achieve loss reduction. Rather, loss reductions can be best achieved and are being achieved over time by farmers adopting new methods and new technologies that make them more efficient.

Farmers are making gains in efficiency by implementing a number of practices. Some of these practices are purely voluntary and the result of technological advances and farmer education. Others are being accomplished in partnerships with federal, state and local governments. What follows is a discussion of efficiencies that have been achieved and some of the major practices being used to achieve those efficiencies.

<u>Fertilizer N Efficiency for Corn</u>

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.

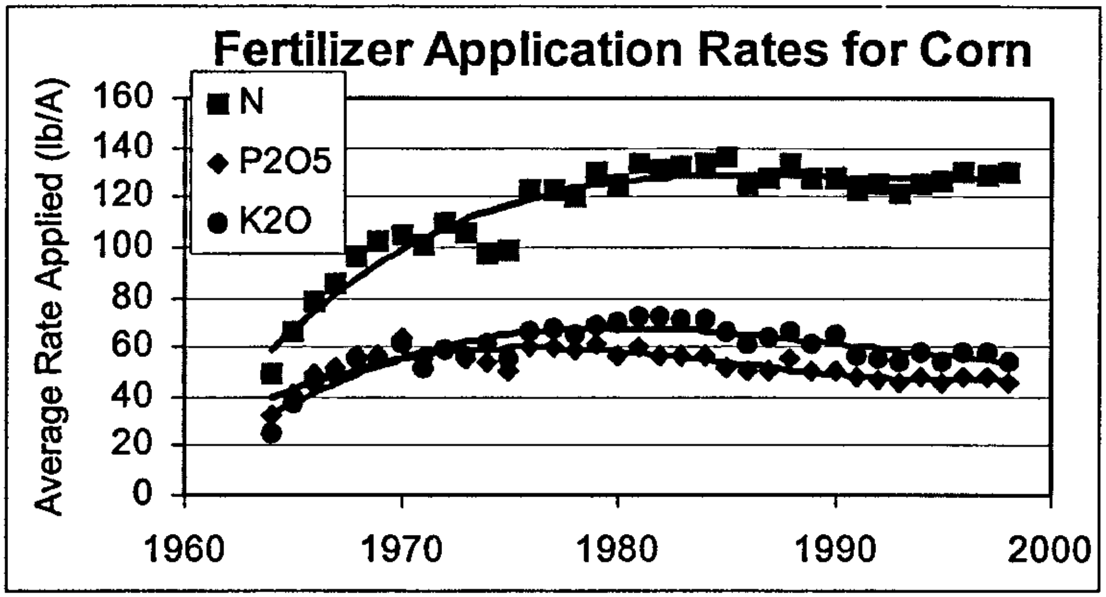
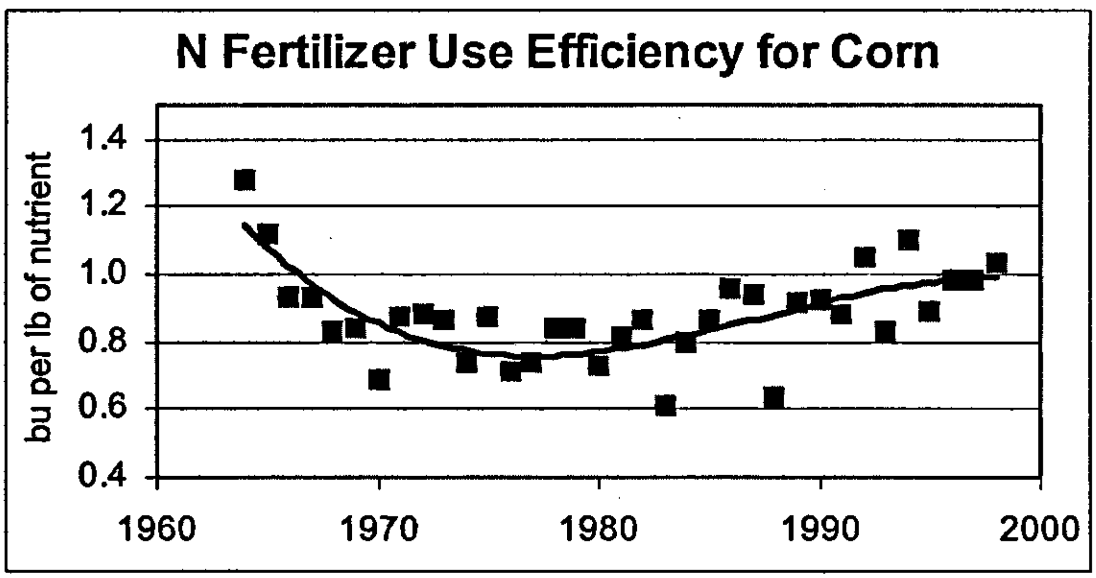


Figure 1
Data source: National Agricultural Statistics Service and Harold Taylor, Personal Communications.

Figure 2



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

Nutrient management planning

The practice of preparing and following written, flexible, voluntary crop nutrient management plans is a growing one in U.S. agriculture. This stewardship practice enables farmers to be better managers, minimizes costs, increases efficiency and reduces nutrient loss.

An effort to bring greater professionalism into this process was a major reason the fertilizer industry was supportive of the efforts of the American Society of Agronomy to start the Certified Crop Advisor program. This program requires an application to demonstrate a knowledge base necessary for assisting farmers in an advisory capacity. To date, more than 12,000 individuals have passed the rigorous testing and background requirements and have maintained their certification through a program of continuing education.

Measurement of crop nutrient management planning is elusive. TFI and many of the agricultural farm and commodity organizations participate in the Core 4 program of the Conservation Technology Information Center. The nutrient management component of Core 4 has two objectives: 1) market nutrient management planning to farmers by educating them about the components and benefits; and 2) measure the increased adoption of nutrient management planning. Voluntary efforts such as this are the best and most effective way to increase nutrient management planning.

Conservation Buffers

The installation of conservation buffer strips is a growing success story that involves commitments from both the private and public sectors. The U.S. Department of Agriculture has set a target of 2 million acres of buffer strips in the Conservation Reserve Program by 2002. There is widespread support of that goal and independent efforts to implement buffers among farmers and agribusiness.

Research demonstrates the effectiveness of these conservation buffers. Research by Leeds et. al. at The Ohio State University summarizes field research done in Indiana, Iowa, Maryland and Virginia. The results show filter strips reduce sediment between 56 and 95 percent, depending upon soil characteristics, slope, rainfall and runoff conditions and filter width. Results for nitrogen and phosphorus removal were highly variable, ranging from 0 to 83 percent for phosphorus and 27 to 87 percent for nitrogen.

In addition to demonstrating successful removal of nutrients and sediments, this work demonstrates the variability that exists across the agricultural landscape. This variability demands local control and flexibility in order to achieve nutrient loss reductions. One-size-fits-all regulatory approaches cannot succeed.

2. The CENR process has been closed to public input

These reports, like the overall Gulf of Mexico Hypoxia Assessment Plan, are closed federal efforts that would benefit from the inclusion of the wider stakeholder community.

The assessment plan and the writing of the six reports are under the control of federal agencies. After giving a team of about 35 authors more than a year to write the six assessment reports, a 90-day comment period for stakeholders is insufficient opportunity for input. While it is currently unclear who will write the integrated assessment and when, that effort should be broadened to include scientists and others from the private sector who have studied the issue of hypoxia.

Attached as appendix A is a report entitled "The Role of Solutes in Gulf of Mexico Hypoxia" ("Alabama Report") published by a group of researchers at the University of Alabama with a grant from TFI. This report serves as an independent review of many of the issues addressed in the six assessment reports. It recognizes that some of the contributing factors mentioned in the assessments, including the role of terrestrial organic carbon, the channelization of the river, and increased precipitation in the Mississippi River basin, have a greater impact on hypoxia than recognized in the six assessments. It also suggests areas for additional research as we try to learn more about the causes and cures for Gulf hypoxia.

3. The six assessments are inconclusive and fail to consider multiple hypotheses for causes of hypoxia.

The federal assessments focused narrowly on a single cause of Gulf hypoxia and failed to prove the stated hypothesis. Thus, they serve as interesting scientific inquiry but fail to provide a foundation for regulatory efforts to "solve" hypoxia.

On the fundamental question of what causes Gulf hypoxia, the reports are highly inconclusive. Thus, the underlying hypothesis of nutrient additions being responsible for hypoxia is not proven. Clearly, the authors of report number 1 make a heroic effort to attribute the cause to nutrients and increased concentrations of nitrate in the Mississippi River. However, in addition to their pointed avoidance of using the term "cause," their conclusions are contradicted both by the Alabama report and report number 4, which cite increased precipitation and increased river flows over the past three decades as a major contributor to increased nitrate flux.

A careful reading of all the reports reveals that hypoxia in the Gulf of Mexico is a naturally occurring phenomenon that possibly has been enlarged over time by a complex series of anthropogenic activity. So what factors contribute to Gulf hypoxia?

- Natural processes that occur when freshwater flows into salt water bodies. As the Alabama report points out, increased freshwater flow from the late '60s until today has increased the stratification that sets the stage for hypoxia.

- Nutrient additions. The nitrogen cycle is not leak-proof, and more people living in the Mississippi River Basin (MRB) inevitably mean more nitrogen cycling through and leaking from the system. The heavy reliance on this single factor, however, is not borne out. There is a consistent view across the reports that nitrogen concentrations in the river have increased, but that virtually all of the increase took place in the late 1950s and early 1960s. Since that time, concentrations have been flat to slightly lower. Thus, the increased flux and increased size of the hypoxic zone observed in 1993 can only be attributable to increased river flow.

- "Channelization of the river." Certainly changes made to the river over the past century to enhance navigability of the river have had a dramatic impact on nutrient flux. These changes have had the greatest impact in the delta region, where the channelization of the river has deprived the coastal marshlands of the steady supply of the nutrients and sediments that built and are utilized by the marshes.

  In addition, the channelization of the river results in more rapid and direct delivery of solutes into the Gulf and less interaction with historical wetlands and the floodplain where nitrate can be removed. As a result, the physical changes made to the river to enhance navigation also enhance nitrate delivery into the Gulf.

- Organic Carbon. A significant finding of the Alabama report is the potential role of terrigenous organic carbon in oxygen loss in Gulf waters. Calculations performed for that study indicate a major portion of the hypoxic area could be the result of organic matter being delivered to the Gulf by the river.

All of these factors are mentioned in the CENR reports, but only major consideration is given to nutrient loading. Even so, the authors of report 4 who modeled the effect of nutrient reductions on hypoxia said "there are large uncertainties in the magnitudes of these responses." Clearly, the anthropogenic contribution to Gulf hypoxia is not well understood; we do not know the extent of natural vs. manmade contributions, and there is not a clear understanding of the relative contributions of a complex set of factors. Thus the reports are inconclusive. They fail to prove the hypothesis, and raise many questions and research opportunities about the complex set of contributing factors.

4. The variability among the six assessments results in an inconsistent and disconnected line of reasoning.

Report 1 clearly attempts to make the case for nutrients as the sole cause of hypoxia, but fails in light of factors discussed elsewhere. Report 2 contains the clearest conclusion in all the assessments: "The economic assessment based on fisheries data, however, failed to detect effects attributable to hypoxia." This conclusion proved most troublesome to the authors of report 6, who were asked to weigh the costs and benefits of reducing hypoxia after being given "zero" as the benefit. And yet they went on to suggest an "affordable" program that combines a 20 percent reduction in fertilizer use with a 5 million acre wetlands restoration program. There are two huge flaws with this recommendation:

First, it does nothing to reduce hypoxia. The authors of report 4 question the effectiveness of reduced applications of fertilizer on water quality. "Among the controllable measures, fertilizer application rate is a major factor, but the effectiveness of reducing rates depends on climactic conditions and the extent to which baseline applications exceed recommended rates." In other words, reduced application rates only reduce nutrients in water when two other factors are in play: one, farmers are applying fertilizer above agronomic rates, and two, it does not rain.

There are also major uncertainties about the effects of nutrient loss reductions on Gulf hypoxia. Again, from report 4: "It was found that dissolved oxygen and chlorophyll concentrations on the LIS *do appear* (emphasis added) to be responsive to reductions in nutrient loadings from the MAR; however, there are large uncertainties in the magnitudes of these responses for a given nutrient loading reduction. These uncertainties are due to lack of information on controlling physical, chemical and biological processes, and to natural variability in hydrometeorological conditions in the northern Gulf of Mexico."

Thus, the recommendation to reduce fertilizer application by 20 percent is made not on the basis of ecological impact, but on the basis of "affordability." The recommendation does not achieve the previously stated goal of 20 percent reduction in nutrient flux, and there is no confidence that this reduction leads to improvement in Gulf hypoxia.

The second flaw in the recommendation is its definition of affordability. Report 6 states "Our analysis accounts for economic impacts on the producers and keeps changes in acreage and exports within historic bounds of recent past adjustments, something of concern to many in the agricultural sector."

It appears the recommendations are judged affordable because they would keep the number of acres and exports within the bounds of what farmers have experienced in the past. Thus, farmers will be limited to the low end of their economic experience. A cap will be placed on their income, and that cap will be at the low end of their recent experience. The recommendations would relegate farmers to economic poverty and the benefit of this policy is a complete unknown. There is no indication it would reduce hypoxia, and we know hypoxia reduction would not have an economic benefit to the fishing industries. This does not make sense.

Section 2: Specific comments on individual reports

The comments in this six are the result of TFI seeking reviews from several scientists within the industry and from the Potash and Phosphate Institute. The varying styles and formats are the result of variations among those individuals. While these could have been submitted individually, we thought it useful to package them together for convenience.

Report 1

1. **The area of hypoxia in the Gulf of Mexico is not static and is not growing** (p. xvii). Data presented in the body of the report (Section 3.0 Dimensions and Variability of Hypoxia) do not support the summarization of the aerial extent in terms of an average range of 8,000 to 9,000km^2 or 16,000 to 18,000 km^2. Figure 2 (p. 6) presents a more comprehensive snapshot of the hypoxic zone during time of "expected maximal extent." However, neither Figure 2 nor the associated text provides square kilometer ranges for the frequency quartiles. *Please provide these ranges, and incorporate these estimates into the summary of the general dimensions of the hypoxic zone.*

   In addition, the aerial estimate of the "maximal extent" of the hypoxic zone for 1998 is listed as 12,500 km^2 (p. xvii), yet is not used to calculate average values, or in Figures 2 or 3. The only mention of this estimate in the text of the report is to say that the 1998 aerial extent was similar to 1992. . Inclusion of 1998 data shows that the aerial extent of hypoxia is not growing. *Please incorporate the 1998 estimate into any calculations of average aerial extent, depiction and calculations of extent quartiles, and in any text discussing the long-term trend in hypoxic conditions in the Gulf of Mexico.*

2. **The area of hypoxia is influenced by several natural, physical and chemical parameters that constantly refine the aerial and vertical extent of hypoxia.** The data presented represent the aerial reach of hypoxia during the "expected maximal extent" of the condition. Section 3.2 discusses variability in the mid-summer hypoxic zone, including Figure 4 that shows shifts in the extent of the hypoxic zone. The report discusses localized weather patterns, current patterns, tidal influences and diurnal patterns in qualitative terms in relation to the vertical and aerial extent of hypoxic waters. *Please provide the aerial extent of the hypoxic zone over the three observation periods, as well as some estimate of the geographic shift of the*

zone over the three periods. Please discuss the change in extent and location in terms of applicable physical parameters and how (a)typical these types of changes are over the course of a summer.

Please provide relevant literature citations, gathered data, and/or modeling results that describe the relative effects of these factors over a given time period. This discussion should then be tied to descriptions of the mid-summer snapshot data provided for 1985-1998 and especially how these factors can be expected to influence the distribution of the frequency of occurrence of mid-summer hypoxia.

Temporal variability is described quantitatively using data from continuous recording oxygen meters at Stations C6A or C6B. These meters are located in an area identified in Figure 2 as being >75% hypoxic frequency. Therefore, these meters are situated in the most stable area of the hypoxic zone. Please provide *relevant literature citations, gathered data, and/or modeling results that discuss the representativeness and uncertainty associated with using these data to describe the full aerial extent of the hypoxic zone. Given the fact that there are no data available for May, June, mid to late August, no hypoxic conditions recorded after the first week of October and only limited data for April, please provide relevant literature citations, gathered data, and/or modeling results that quantify the confidence limits of the estimated six month hypoxic period, over the entire aerial extent estimates provided, based on data from Station 6.*

Carey et al. recently published "The Role of the Mississippi River in Gulf of Mexico Hypoxia" (Alabama report). This report, which we are attaching as an official part of our comments, concludes that hypoxic episodes are a natural phenomenon caused by a variety of factors, including physical, chemical, biological and meteorological conditions. Specifically, the roles of increased rainfall patterns in the upper Mississippi Valley, increased organic carbon loading, and increased flow in the Mississippi River are not yet fully understood. *Please integrate the findings of this study into Report 1, as appropriate and provide some qualitative or quantitative estimation of the proportional influence each exerts in causing hypoxia. We further request the integrated assessment writing process be opened to scientists such as Dr. Carey who have made important contributions to the understanding of Gulf hypoxia.*

Report 2

1. **The evidence provided in Report 2 of hypoxia dating back to the early 1960s seems to contradict evidence provided in Report 1.** Specifically, the INDEX generated for Figure 2.1 seems to indicate that some evidence of hypoxia existed in the early 1960s, while Report 1 states that the first credible reports of hypoxia were anecdotally mentioned in the 1970s and that the first true measurements were in 1985. Please provide *relevant literature citations, gathered data, and/or modeling results that determine with some confidence level the time frame of nutrient-induced hypoxia, or (suggested) re-examine the evidence that hypoxia may be a natural phenomenon.*

2. **Report 2 seems to discount the relationship between hypoxia and nutrient enrichment.** It is stated that "...the correlation between the time series of AREA with time itself is nearly 0.8, so that any other time series exhibiting a secular change over this relatively short time period will be correlated with AREA" (p. 19). Based on this comment, *please present relevant literature citations, gathered data, and/or modeling results that explain the uncertainty associated with correlating nitrogen production and use data with hypoxic conditions in the Gulf of Mexico. Also, please explain the uncertainty associated with using an "assume[d] 2% growth rate of nutrient concentration" for the INDEX equation.*

3. **Report 2 indicates that the area data for the period 1985 to 1997 is "too short to establish a credible relationship between the severity of hypoxia and variables relating to fisheries" (p. 14).** Given this statement, *please provide relevant literature citations, gathered data, and/or modeling results that quantify the uncertainty of using this time series establish a credible relationship between hypoxia severity and any variable—especially nutrients.*

4. **Report 2 indicates that unlike any other hypoxic area in the world, the Gulf of Mexico seems to rebound ecologically each year.** *Please relevant literature citations, gathered data, and/or modeling results that explain how the largest hypoxic zone in the world can be so apparently benign to the affected ecosystem. Please indicate how these data affect the uncertainty of the use of area data for establishing establish a credible relationship between hypoxia severity and any variable—especially nutrients.*

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.

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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 characteristics 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 <u>grossly inaccurate</u>. 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 <u>not</u> 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. Th 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 indicate 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

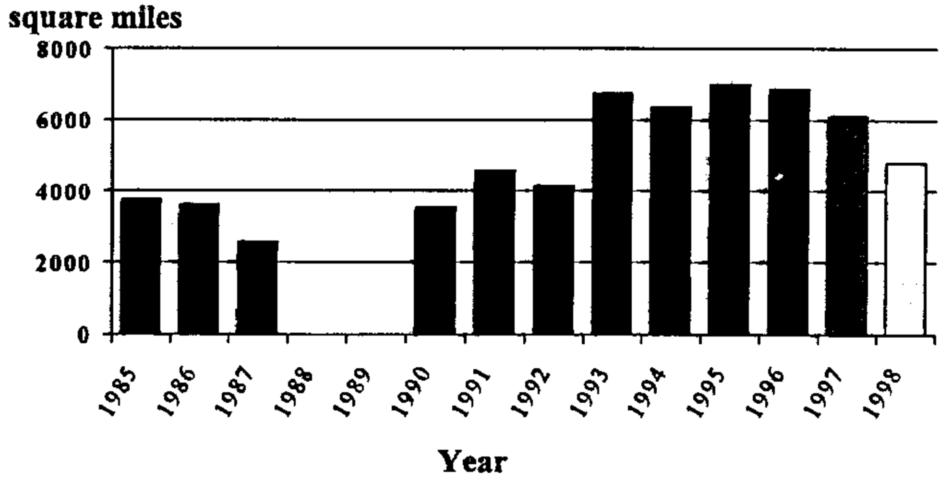
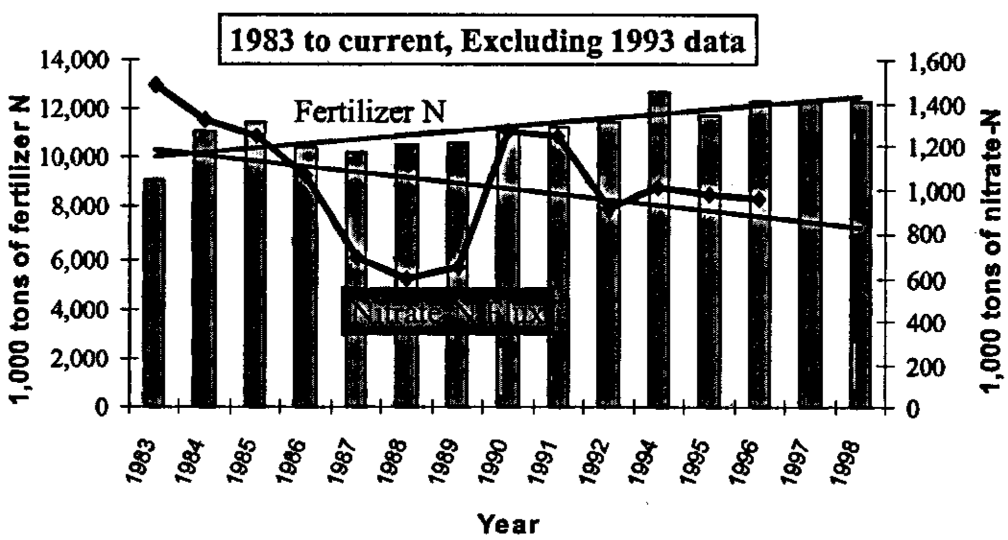


Figure 2. Fertilizer N Use and Nitrate-N Load to the GOM



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

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Preliminary Comments

The goal of Topic 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 of 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.

Report 6

Comments on "Evaluation of Economic Costs and Benefits of Methods for Reducing Nutrient Loads to the Gulf of Mexico"

The authors of the paper "Evaluation of Economic Costs and Benefits of Methods for Reducing Nutrient Loads to the Gulf of Mexico" quote many relevant articles and, in a few cases, make some good points. However, they skip over certain key factors or make incorrect assumptions concerning some of the most basic building blocks of their conclusions. In addition, they use a model that is inappropriate for the task at hand. The result is a study that identifies few, if any, benefits from a proposed 20% reduction in N use in the MB, and significantly underestimates the total cost of such a proposal. Specific comments regarding the study follow.

1. The economic costs of a 20% reduction in N use in the MB are estimated using the USMP model. On page 32, the authors note, "In addition, the results of a model such as USMP are not detailed enough for a real application of the results to the ground." This is a crucial point and a very significant limitation of the USMP model with respect to the analysis in question. The reason is that it is the ground, or the micro-level, where the initial impacts of a 20% reduction in N use in the MB would actually take place. If the initial impacts are not measured correctly (i.e., changes in crop yields), then all other downstream impacts of a 20% reduction in N use will also be miscalculated.

2. The paper concludes by stating that "The bottom line is that nitrogen loss reduction in the 20% range is doable and there are relatively cost effective ways to achieve it" (p.50). In addition to the results of the USMP model, the authors note the results of economic studies to argue that the 20% goal is doable. For example, on page 11 the paper notes, "Based on ERS surveys of Nebraska farmers, Fuglie and Bosch found that nearly half of the surveyed farmers used N fertilizer recommendations from a preplant N test and were achieving N fertilizer reductions of 18 to 33 percent with no loss in yield. Shortle, et. al., found that 36 percent of farmers used late spring soil tests, and were able to reduce N fertilizer use 40 percent." The authors use these case studies to imply that since these farmers reduced their use of N fertilizer without any reduction in yields, it would not be an economic hardship for all farmers to do so. However, they are missing the point. The point is, **farmers have already and continue to reduce the amount of N they use per unit**

<u>of output produced. That is, they have and continue to increase their efficiency!</u>

The information put together by PPI, included earlier in these comments, clearly demonstrates that U.S. corn farmers, who account for over 40 percent of U.S. N use, **<u>have increased their efficiency by 32% since the late 1970's</u>**. This increase in efficiency can be demonstrated in another way. In 1980, U.S. corn farmers used 5.2443 million tons of N to produce 6.395 billion bushels of corn. In 1998, they produced 9.738 billion bushels, a 52 % increase in production over the 1980 level, with approximately the same amount of N (5.2668 million tons). If farmers were still using 1980 cropping practices with respect to N use, it would have taken an additional 2.7415 million tons of N to produce the 9.738 billion bushels of corn produced in 1998. That is, N use efficiency in corn production increased by over 34 percent from 1980 to 1998 without any laws requiring this to take place. The laws of economics, which encourage farmers to maximize their profits, as well as voluntary best management practices, have resulted in these efficiency gains. Placing an additional constraint of a 20% reduction in N use on a system **<u>that has already experienced a 32-34 percent increase in efficiency since 1980</u>** would surely have significant consequences for crop yields and production. To argue otherwise would be to ignore the law of diminishing returns.

3. The paper suggests that the large majority of farmers in the MB region apply 20% more nitrogen than required on a regular basis. The authors admit, "the extent to which producers are currently over-fertilizing is unknown." While some farmers apply more nitrogen than is recommended or optimal, it has not been demonstrated that this practice is common in the MB region. As a matter of fact, the 1997 AREI nutrient use report indicates that 47% of corn farmers conduct soil tests for nitrogen. Of those that do, 69% report they apply the recommended level, 18% apply less than the recommended level and only 13% report they apply more than the recommended level. The 20% over-utilization figure quoted throughout the study would imply that corn farmers apply over **27 lbs of N per acre** more than needed (average nitrogen rate was 136 lbs/acre in 1996). This is a key "assumption" of the report since the study seems to imply that there would be little negative impact on crop yields over the long term with farmers lowering application rates of N by 27 lbs. per acre on corn, and similar reduction in other crops. At the $0.18 per lb. cost of N quoted in the paper, it also implies that farmers throw away $5/acre in N costs (plus their time and expense of purchasing the product). A full review of the literature, and possibly additional studies, on how much nitrogen farmers should and do apply is a key piece of information that has not been adequately addressed in this paper. Also missing from the paper is a discussion of the role of state land-grant university recommendations, and the variability of those recommendations from state to state. This has been a subject of many agronomic debates over many decades. If bordering states

have different recommendations, how can charges of "overapplication" be assumed for the entire basin?

4. A related factor is that there have not been any long term studies showing that a permanent 20% reduction in N use across the MB would not have any long term impacts on yields. While some studies may show that a decrease in nutrient applications for a year or two show no significant decrease in yields there is an issue of "mining the soil" over the long run and its potential negative impact on soil quality.

5. On page 30, the authors state that net farm incomes actually increase after forcing farmers to lower N use by 20% and forcing 6% of land out of production in the MB region. Even taking into account slightly higher farm incomes outside of the MB region, this result is counter-intuitive. It appears to be based entirely on the assumption that virtually all farmers could reduce N application rates by 20% with little or no impact on yield, which is not supported by the analysis. It appears (the paper doesn't provide the information) that the crop price elasticity used from the model is a short term one rather than the long term elasticity. It is unlikely a 6% reduction in cropped land in the Mississippi Basin would result in a 9% increase in average US corn prices over the long term (and a 5% increase in wheat and 19% increase in sorghum). This is an important assumption in order to get an increase in farm income in their 20% scenario and could be checked fairly easily with USDA, FAPRI or WEFA. Furthermore, it is questionable whether the model accurately estimates the impact on crop yields from shifting crop rotations to the extent shown in the model (more continuous cropping of soybeans, rather than corn/wheat with soya rotations). Also questionable is the yield impact of lower nitrogen application rates by 20%. Why is there no table showing the yield impact and are their results similar to other yield models that are available?

6. The whole issue of lower quality soil by lowering fertilizer application rates is one that may need to be examined. The lowering of N in the soil also reduces its ability to sequester carbon (fixed ratio). This would increase carbon dioxide in the air, thus exacerbating the problem of carbon dioxide in the atmosphere, thus moving the U.S. away from Kyoto Treaty goals.

7. It is interesting that at the beginning of the paper there is a recognition that precision agriculture could help to reduce nitrogen run-off (see Precision Nitrogen Application section). The discussion ends with the comment that "Despite the intuitive logic of matching N application to site-specific crop needs, variable application was not uniformly superior to uniform application in terms of increasing net returns and improving water quality in Goodwater watershed." There is no further discussion of how precision agriculture might be used to reduce nutrient run-off without attempting to legislate lower application rates. Nor is there any discussion about other technologies that

may also help lower nitrogen run-off without the need for evasive government regulations/controls on individual farmer's management practices. Precision agriculture is a potentially very important tool, but other technologies such as controlled released nitrogen fertilizers are not even mentioned. Furthermore, the potential to better utilize manure (using new techniques) so that nutrient run-off is reduced from this agricultural source is also barely mentioned. Surely these are important possible avenues which should be studied/supported for their potential to lower excess nutrient run-off without attempting to legislate something as variable and field specific as nutrient application rates.

8. Technical difficulties of somehow forcing farmers to apply less nitrogen fertilizer are not addressed. This is a very important factor. The authors seem to imply that the government can go to individual farmers and tell them to apply 20% less nitrogen than they have been using. They admit a tax on fertilizer is not a viable option, largely due to the very inelastic demand for fertilizers. The last decade has seen a shift away from the government getting directly involved in farmers production decisions, and this would be an extremely difficult task to accomplish considering the recent trend. The enormous drain on public resources seems not to have been considered in the cost equation.

9. Comments are made throughout the paper that there is no firm method of determining the extent to which fertilizers may have contributed to hypoxia and they acknowledge that this condition happens naturally to a certain extent. They also recognize that there is no way of measuring the success of any program, as there are many variables that contribute to hypoxia. Furthermore, they recognize that there are limited financial returns to lowering nutrient levels in water, even if it could be done and measured. "The assessment suggested that given the available data, there was no effect in the shrimp, snapper, or menhaden fisheries data that could be attributed with high confidence to hypoxia" (pg. 24). Then they go on to say that " The fixed target level of nitrogen loss reduction, 20%, was suggested by Topic Group 5 as a reasonable level that could attained given current technology and would have the potential to decrease the incidence of hypoxia in the Gulf.

10. This paper appears to be intentionally "naive" as the consequences of such a policy. The economic impacts would be hugely negative to the farm sector (not positive). There would also be major political and policy problems which are not even raised with such a new fertilizer control policy for a problem which is not well defined and potential future benefits which cannot be directly measured.

11. There is no evaluation of the economic benefits of reducing nutrient loads and the study should not be titled and advertised as such. It is just a cost assessment of achieving arbitrary reductions in nutrient loads through a very

limited set of policies targeted at reduced nitrogen application rates. It identifies very high direct costs yet ignores potentially high indirect costs on employment and output in the input supply industry, the livestock sector, and the grain handling and processing industries. It identifies no significant economic benefits to fisheries in the gulf region, but implies significant other unmeasurable benefits. It would require a tremendous leap of faith to accept that such unidentifiable benefits would come remotely close to exceeding even the partial costs identified in the study.

12. Modeling is an imprecise art, particularly the modeling of a complex relationship such as nitrogen application rates and nitrogen loads. Do the lead authors understand the model and how confident are they of the results as a firm basis for the kind of regulation that is being suggested?

13. The nitrogen balance table reported on page 3 reports that fertilizer accounts for 30% of the total annual nitrogen input into the MB. Even if nitrogen fertilizer did account for 30% of the total load, then simple math implies that reducing the load from fertilizer by 20% would result in a 6% drop in the total load. That relatively small drop raises big questions about the potential and unmeasurable benefits of such a decline relative to the large and identifiable direct, and even larger indirect, costs.

14. Section 2.3 (pp. 9-13) is especially weak, completely ungrounded and contradictory. The example used in the first two paragraphs on page 9 suggests farmers are way down the yield response curve or production function (Stage I) and that they are grossly under-utilizing nitrogen fertilizer (e.g. implied marginal factor cost of $.18 per acre vs marginal revenue of $2.00 per acre in the first paragraph and implied marginal factor cost of $1.80 to $3.60 per acre Vs marginal revenue of $20.00 to $30.00 per acre in the second paragraph). Five paragraphs later, the authors indicate that nitrogen application rates are excessive and imply that farmers are operating at stage III on the yield response or production function and are maximizing physical yield rather than economic yield. The conclusion is that farmers are grossly over-using fertilizer (even though as they note most production decisions are based on fertilizer recommendations from university agricultural extension personnel!). Which is the case? This is a good illustration of the lack of rigor and grounding in the analysis. Data do exist and they show that nitrogen application rates generally have stayed flat even as yields have increased during the last 20 years. Farmers have become more efficient and no doubt have moved close to maximizing economic yields. The implication of gross under- and over-use is not supported by the numbers. There may be further efficiency gains possible (e.g. Blackmer's late spring nitrogen soil tests), but additional costs may outweighed incremental benefits and explain why these technologies have not been widely adopted by U.S. farmers.

15. The FAIR Act has reduced incentives to crop as intensively as in the past. Therefore, some of the adjustments discussed in the paper may already have occurred or will occur in the near future. It seems (again, no detail is given) the base case is of a 1995/96 vintage and we know that conditions have changed radically since then.

16. The authors appear content to shift potential "problems" or "risks" to other regions. The increase in commodity prices causes more intensive input use outside the MB, but that apparently is OK.

17. Costs of $4.9 billion to achieve the 18.8% reduction from fertilizer sources (or a 5.6% reduction in total loadings) seem very high relative to the lack of benefits identified by the authors. In addition, other indirect costs noted above are ignored.

18. Report 6 calls for a 20% nitrogen use reduction and the reclamation or creation of five million acres of wetlands as the solution for the hypoxic zone.

    Please provide the regulatory authority options that the Federal government would have to pursue these policies.

19. The cost of wetlands construction is lowered in Report 6 by counterbalancing secondary benefits of wetlands, such as increased habitat for flora and fauna. However, no mention is given to the cost of establishing, monitoring and complying with a 20% fertilizer use reduction. For each regulatory authority listed in response to the comment above, *please provide an estimate of the cost of establishing, monitoring and complying with a 20% fertilizer use reduction. Please integrate these estimates into the brief discussion of costs versus benefits in Report 6.*

20. EPA is currently preparing Guidance for establishing nutrient criteria guidance and TMDLs for nutrient-impaired waters. There is no discussion in Report 6 of how the proposed 20% nitrogen use reduction and the reclamation or creation of five million acres of wetlands would be integrated with these two initiatives. It can be argued that the policies suggested in Report 6 would establish a nutrient criterion for nitrogen in the Mississippi River and artificially set agriculture's maximum allowable daily contribution across 41% of the landscape. *Please explain how these would be integrated and, specifically, justify the selection of a 20% nitrogen use reduction and the reclamation or creation of five million acres of wetlands in terms of superceding expected establishment of eco-region or watershed based nutrient criteria and the individual states' right to partition the TMDL across point and non-point sources.*

Section 3: Additional Recommendations

1. Make the process more open. The integrated assessment writing team should include scientists outside the federal structure who have done work on Gulf hypoxia. This would bring the broader scientific viewpoints and hypotheses to bear on the process. The integrated assessment must acknowledge the existence of other contributing factors and not be limited to examining only the role of nutrients.

2. Make the peer reviews from the six scientific assessments publicly available. The scientific process is known for being an open search for the truth. The public should also have access to the data and viewpoints expressed in those reviews.

3. The integrated assessment should include the conservation achievements of farmers that have been made to date.

4. The integrated assessment should examine the additional federal and private resources that can be used to achieve more farm-level conservation.

5. The integrated assessment and action plan developed should rely heavily on existing conservation programs, including CRP, EQIP, WRP and CTA. Currently, these programs do not have the funding or manpower necessary to meet farmer demand. It is through incentives and partnerships in these types of programs that farmer practices will be changed in ways that reduce nutrient losses.

6. The integrated assessment and action plan must recognize the need to increase agricultural productivity, not limit it. In addition to a growing world population and overseas markets that will enable farmers to achieve greater market income, there are federal programs that are creating increased demand for agricultural products. Commodities such as corn and soybeans are being touted as sustainable, renewable sources of fuel and motor oil, and will soon assist in the reduction of carcinogens and greenhouse gases. The action plan should envision a growing agricultural production base.

7. Significant data gaps are acknowledged in the six assessments and noted here. The action plan should include requests for money for additional research and water quality monitoring. Monitoring of Gulf hypoxia should continue due to the very limited data currently available.

8. The U.S. Department of Agriculture should be the lead agency in assembling the Action Plan. Successes in achieving nutrient loss reductions are dependent upon the individual behavior of millions of landowners and operators. It is USDA that operates the programs and has the personnel with the expertise to deliver the assistance farmers will rely upon.