International Fertilizer Industry Association

IFA Technical Conference

New Orleans, Louisiana, USA
1-4 October 2000

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

Hypoxia in the Gulf of Mexico and Fertilization Facts

C.S. Snyder[1], T.W. Bruulssema[2], A.E. Ludwick[3], T.S. Murrell[4], H.F Reetz[5], W.M. Stewart[6], N.R. Usherwood[7], P.E. Fixen[8]
Potash and Phosphate Institute

L'hypoxia dans le Golf du Mexique est le résultat d'interactions complexes de facteurs chimiques physiques et biologiques. Il y a de nombreuses sources de nutriments susceptibles de contribuer au chargement du Mississipi. Les engrais N sont un intrant important pour la production agricole du bassin du Mississipi mais il trouve plus probablement son chemin vers le Mississipi par le ruissellement et le drainage profond plutôt que d'autres sources de N comme les précipitations, les résidus de récolte et la décomposition de la matière organique du sol, les déchets animaux, les boues d'épuration et les effluents et les matières compostées contenant N

En général les agriculteurs veillent bien à réduire les pertes de nutriments, mais pourraient améliorer l'efficacité de la fertilisation. Certains changements opératoires pour la protection/amélioration de la qualité de l'eau entraîneront une augmentation des dépenses et une perte des profits. L'approche volontaire en vue de minimiser les pertes de nutriments dans les eaux de surface et le Golf du Mexique seront probablement plus efficaces. L'éducation et la recherche en matière de maîtrise des nutriments peuvent identifier des possibilités d'amélioration. Une gestion des nutriments spécifique au site considérant toutes les sources de nutriments à côté d'autres BMPs peut significativement réduire le risque de perte de nutriment de nombreuses parcelles. Des conseillers certifiés par culture (CCAs) et d'autres consultants par culture peuvent aider les agriculteurs à obtenir le meilleur profit agronomique, économique et environnemental de l'application des nutriments. Ces mêmes principes peuvent aussi servir à réduire les pertes diffuses de nutriments dans un cadre urbain.

Un Plan d'action est mis au point par la Mississipi River/Golf of Mexico Watershed Nutrient Task Force (y-compris des autorités fédérales et d'Etat sur la qualité de l'eau et des représentants de l'agence) pour réduire les pertes de nutriments vers le golf du Mexique et pour diminuer le risque de développement de l'Hypoxia. Des discussions préliminaires comportaient des recommandations possibles pour une réduction de 20 à 25% de rejet de nutriments vers le Golf via les rivières Mississipi et Atchafalaya et 2 millions d'ha de marécages réhabilités dans le bassin du Mississipi. Si les autorités fédérales et d'Etat interprètent les recommandations de réduction de pertes de nutriments comme une réduction de doses appliquées, alors l'industrie Nord-Américaine des engrais pourrait perdre 1'3 milliards estimés de ventes. Un article publié dans Forbe's Magazine en novembre 1999 estimait que le coût estimé pour le public pour la réduction du transport de nutriments et l'établissement de nouveaux marécages serait de $ 4'9 milliards par an. Le souci de la qualité de l'eau et les pressions économiques exercées par le lobby agricole dans une économie globale exigeront des améliorations continues dans l'efficacité des nutriments en particulier dans le bassin de réception du Mississipi.

1 Midsouth Director, 2 Eastern Canada and Northeast U.S. Director, 3 Western Director, 4 Northcentral Director, 5 Midwest Director, 6 Great Plains Director, 7 Southeast Director, 8 Senior V.P. and Director of Research North American Program
Email : 1 csnyder@ppi-far.org 5 hreetz@ppi-far.org
2 bruulsem@ppi-far.org 6 mstewart@ppi-far.org
3 aludwick@ppi-far.org 7 usherwood@ppi-far.org
4 smurrell@ppi-far.org 8 pfixen@ppi-fat.org

Summary

Hypoxia in the Gulf of Mexico is a result of complex interactions among chemical, physical, and biological factors. There are numerous sources of nutrients which may contribute to loading in the Mississippi River. Fertilizer N is an important input for crop production in the Mississippi River Basin, but it is no more likely to find its way to the Mississippi River in runoff and subsurface drainage than other N sources such as precipitation, crop residue and soil organic matter decomposition, animal wastes, sewage sludge and effluent, and composted materials containing N.

In general, farmers are doing a good job of minimizing nutrient losses, but may be able to improve nutrient use efficiencies. Some management changes, for water quality protection/improvement, will result in an increase in expenses and a loss in profits. The voluntary approach to minimizing loss of nutrients to surface waters and the Gulf of Mexico will likely be the most successful. Nutrient management education and research can identify opportunities for improvement. Site-specific nutrient management, considering all nutrient sources in conjunction with other Best Management Practices, can significantly reduce the risk of nutrient loss from many fields. Certified Crop Advisers (CCAs) and other crop consultants can assist farmers in getting the greatest agronomic, economic, and environmental benefits from nutrient applications. These same principles can also be used to reduce nonpoint source nutrient losses in urban settings.

An Action Plan is being developed by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (includes federal and state water quality authorities and agency representatives) to reduce nutrient losses to the Gulf of Mexico, and to decrease the risk of hypoxia development. Previous discussions included possible recommendations for a 20 to 25 percent reduction in nutrient discharge to the Gulf, via the Mississippi and Atchafalaya Rivers, and 5 million acres of restored wetlands in the Mississippi River Basin. If federal and state water quality authorities interpret the recommendations for nutrient loss reductions as nutrient input reductions, the North American fertilizer industry could lose an estimated $1.3 billion in sales. An article published in Forbe's magazine in November 1999 estimated that the cost to the public for the reduction in nutrient transport and the establishment of the new wetlands would be $4.9 billion per year. Water quality concerns and the economic pressures of farming in a global economy will require continued improvements in nutrient use-efficiencies, particularly in the Mississippi River drainage basin.

What is hypoxia?

In the Gulf of Mexico, hypoxia has been operationally defined as that condition in which dissolved oxygen (O_2) concentrations are less than 2 parts per million (ppm or mg/L) of water. Marine scientists have chosen this definition because it is the level of O_2 at which there are anecdotal reports of reduced captures of shrimp in trawler nets. ***It should be pointed out, however, that there has been no measured economic effect of hypoxia on the Gulf of Mexico fisheries to date.***

According to scientists at the University of Alabama Environmental Institute, there are at least three processes, operating independently or in concert, which contribute to the potential for hypoxia development in the Gulf of Mexico:

1. **Eutrophication**—The process of being enriched in dissolved nutrients, especially nitrate (NO_3) and phosphate. Eutrophication can enhance phytoplankton (microscopic, passively floating plants) growth. This increased growth can cause an increase in organic matter deposition. As the organic matter from dead phytoplankton and fecal residues from zooplankton (which feed on the phytoplankton) drops to the bottom waters, microorganisms decompose it and deplete dissolved O_2 from the water.
2. **Organic matter deposition**—When organic matter from land surfaces is deposited in a water body, the activity of organisms in the bottom waters increases and causes consumption of dissolved O_2. However, a large percentage of the organic matter derived from land surfaces is usually not "available" for rapid microbial decomposition because it often has a high concentration of lignin and cellulose.
3. **Physical stratification** of fresh waters over heavier salt water—In the absence of significant winds or tidal mixing, the stratification may become stable. Continued deposition of organic matter from the surface to bottom waters can occur without the re-supplying of O_2 from surface waters to bottom waters.

For centuries, these same processes of sediment and nutrient delivery and stratification have resulted in the Gulf of Mexico being one of the most productive fisheries in the world.

Some important facts about the Mississippi River and the Gulf of Mexico

The Mississippi River

- contributes over 90 percent of the fresh water to the Gulf
- ranks among the world's top 10 rivers in fresh water and sediment inputs to the coastal ocean
- has been shortened by 88 miles and is navigable from Minneapolis, MN to the Gulf of Mexico
- has constructed levees along much of its length to protect adjacent lands from flooding
- deposits over 3.3 million gallons of water per second into the Gulf of Mexico
- is the drinking water source for over 70 cities and towns

The Mississippi River Basin

- drains 41 percent of the contiguous U.S.
- covers 55 percent of U.S. agricultural lands
- includes 33 major river systems and 207 estuaries
- includes 27 percent of U.S. population
- includes about 80 percent of U.S. corn and soybean acreages, and much of the cotton, rice, sorghum, wheat, and forage lands
- has an estimated value of agricultural production close to $100 billion annually

The Gulf of Mexico

- is the source of 72 percent of U.S. harvested shrimp, 66 percent of the harvested oysters, and 16 percent of the U.S. commercial fish harvest
- has fisheries valued annually at over $700 million at dockside. Its commercial and recreational fisheries have a combined value of $2.4 billion per year
- currently receives an average of about 1.7 million tons of N annually from the Mississippi River, with about 60 percent of the N in the NO_3 form
- has had no change in phosphorus (P) loading from the Mississippi River since the early 1970s when record-keeping began
- has experienced no change in the loading of silica (Si) via the Mississippi River since the 1950s when records began

Where is the hypoxic zone, how big is it now, and how long has the zone been present?

Large areas in shallow coastal waters around North America and other continents, have often been hypoxic in the geologic past. An hypoxic zone has been known to occur regularly in waters from about 15 to 90 feet deep off the Louisiana-Texas shelf in the northern Gulf of Mexico since the 1970s (see slides 9-10). During high-flow years of the Mississippi River, the area can extend from the Mississippi River discharge off southeast Louisiana to just east of Galveston Bay, Texas. In low-flow years, the area is primarily confined to the vicinity of the Mississippi River discharge, referred to as the Mississippi River Bight. The size, location and duration of the hypoxic zone vary within a year and among years. In 1988 and 1989, there was hardly any hypoxic area measured, presumably because of low flow from the Mississippi River. In contrast, following the "Great Flood of 1993", the hypoxic zone was measured at a little over 7,000 square miles. In midsummer 1998, the hypoxic zone decreased to about 4,800 square miles, but increased again to 7,728 square miles in midsummer 1999. This represents a little more than one percent of the Gulf of Mexico.
Low subsurface O_2 was documented in locations further offshore in the 1930s. Based on sediment records and historical reports of red and brown (algae/phytoplankton) tides, hypoxia may have been present in the Gulf much longer. The hypoxic zone has been annually monitored off the coast of Louisiana since 1985. A once-per-year, systematic sampling of bottom waters has been conducted in mid to late July because it is thought to be the time of the maximum size of the hypoxic zone and easiest detection.

Is N discharge from the Mississippi River to the Gulf the cause of hypoxia?

Some marine scientists have suggested that the principal cause of the hypoxic zone in the Gulf of Mexico is NO_3-N discharge from the Mississippi River. One hypothesis promoted is that increased NO_3-N concentration in the lower Mississippi River contributes to an increased biological productivity in the Gulf. The consequence of the increased biological productivity is an increase in organic matter, which falls to the bottom and consumes O_2 during microbial decomposition. These scientists have reported a strong correlation between long-term (1930s to 1988) annual fertilizer N consumption and NO_3-N concentration in the lower Mississippi River (see slide 12). Contrary to the position advanced by some of the more outspoken marine scientists, this strong relationship does **not** mean there is a cause and effect relationship between U.S. fertilizer N consumption and the total quantity of NO_3-N delivered to the Gulf (see slide18). Neither is there a significant relationship between N fertilizer consumption and the size of the hypoxic zone measured since 1985, especially when the 1993 flood year is considered an aberration from the recent trends (see slide 19). These data imply that other factors may be more important in affecting the development of Gulf hypoxia than is the N discharge via the Mississippi River. Some of these other factors include:

- changes in precipitation patterns and quantities within the Mississippi River Basin
- increased Mississippi River flow and fresh water stratification over salt water
- complex interactions among marine organisms
- increased or sustained large fisheries harvests
- gulf storms and hurricanes
- tidal currents and their characteristics (temperature, circulation, etc.)
- loss of coastal wetlands (25-35 square miles/year in Louisiana alone)
- nutrients from re-suspended N sediments and upwelling off the Yucatan Peninsula

According to the USGS, the discharge of N from the Mississippi River increased 2 to 5-fold between 1900 and the last decade. The annual total N discharge to the Gulf tripled in the last 30 years, with most of the increase occurring from 1970 to 1983. However, the average annual discharge of N has changed very little since the early 1980s. Large year-to-year variations in discharge of N are caused by large variations in precipitation within the Mississippi River Basin (e.g. 1993).

What are all the sources of N to the Mississippi River Basin?

U.S. Geological Survey (USGS) estimates of annual N inputs to the Mississippi River Basin are shown in **Table 1.**

Table 1. Nitrogen Inputs to the Mississippi River Basin.

N Source	Short Tons
Mineralized soil N	7,497,404
Fertilizer N	7,497,094
Legume N fixation	4,445,155
All manure N	3,582,911
Atmosphericwet and dry deposition of nitrate-N	1,461,656
Atmospheric deposition of ammonium-N	663,497
Municipal point sources of N	221,266
Industrial point sources of N	94,370

Based on the USGS model of balancing inputs and outputs of N, estimated annual average output from the Mississippi River Basin is about equal to the average annual inputs (see slide 17). The largest output (removal) of N from the Basin is in harvested crops and pastures. Nitrogen in crop harvests accounts for about 46 percent of the total outputs and is nearly 50 percent larger than the fertilizer N inputs.

There is some concern that USGS estimates may involve some "double-counting" for inputs such as soil mineralization and atmospheric deposition, as well as minimum estimates for point source discharges from municipalities and industries. Some evidence shows that agricultural soils are currently net carbon (C) accumulators. As the soil organic C (organic matter) increases, the storage of N must also increase because the C to N ratio of stable soil organic matter is about 10:1. These facts raise questions about the actual quantity of N released through organic matter mineralization.

Six scientific reports have been written for the National Science and Technology Council's Committee on Environment and Natural Resources (CENR) on the causes and consequences of hypoxia in the Gulf of Mexico. According to one of the reports (*Report 3: Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin*), the average Basin discharge of N is estimated at about 4.4 lb/A per year. The magnitude is about three times smaller than the N loss required to raise groundwater NO_3-N levels above current drinking water standards. Thus, the hypoxia concern potentially could demand more conservative use of N than required for protection of groundwater quality.

How much N and P are being lost from farm fields and possibly making their way to the Mississippi River and the Gulf of Mexico?

Surface runoff

Without BMPs, the research literature indicates that an average of about 12 percent of the applied N and 8 percent of the applied P may be lost from fields in surface runoff. Stated another way, an average of 88 percent of the applied N and 92 percent of the applied P is not lost in surface runoff. Based on numerous studies, measured losses of N and P in surface runoff are often below 4 and 1 lb/A, respectively, whether applied as fertilizer or as animal wastes. With BMPs (e.g. soil testing, nutrient management planning, appropriate application timing and placement, conservation tillage, vegetative buffers, riparian zones, etc.), the potential for loss from fields can be minimized. Recent work by the USDA-ARS and the University of Missouri has shown that method of incorporation, runoff volume, and timing of runoff relative to date of application had a greater influence on loss of NO_3-N to surface runoff than did application rate (0 to 170 lb/A of N). On average, 6 percent of the applied N was lost in surface runoff. More than 75 percent of the loss occurred within 6 weeks after application on a claypan soil in north-central Missouri with field slopes ranging from 0 to 4 percent.

Placement of P below the zone where the surface soil and runoff water interface minimizes the potential for P loss. Scientists at Kansas State University recently demonstrated that surface runoff loss of P was affected more by placement than by rainfall, tillage system, or time. Among three tillage systems, surface broadcast application resulted in the greatest P runoff loss, while deep-banding resulted in average total P losses only slightly more than the control.

The amount of N in wet atmospheric deposition in the Mississippi River Basin (as reported by the National Atmospheric Deposition/National Trends Program) ranges from 0 to 6 lb/A per year. The amount of N deposited by all precipitation in the Mississippi River Basin varies, but often ranges from 10 to 16 lb/A per year, according to other published reports. Considering the average amount of N lost in surface runoff, it appears that agricultural lands are frequently absorbing/utilizing N deposited by precipitation. Otherwise, the discharge to surface waters would be greater than the amount delivered in precipitation. This has been observed in a 2,775-acre watershed devoted to crop production in the Texas Coastal Bend region. Total rainfall over a three-year period contained 5.5 times more total N than was measured in runoff over the same period.

Subsurface Drainage

The percentage of cropland which is drained in Indiana, Ohio, Illinois, Michigan, Iowa, Missouri, and Minnesota, ranges from 10 to 60 percent, according to a 1998 survey. Research in some of these states indicates significant losses of NO_3-N can occur through subsurface tile drainage. Nitrate-nitrogen losses on the order of 7 to 34 lb/A have been measured in research plots, depending on the N application rate and application timing (fall or spring). Research in Minnesota showed that if wet years follow dry years, the loss of NO_3-N in tile drainage can exceed 40 lb/A per year, when N rates of 150 lb/A were applied yearly. The amount of NO_3-N lost in drainage is directly affected by the amount of precipitation, and when it occurs, relative to the time of N application.

What can be done to maximize uptake of applied N to minimize potential losses to water resources?

If the N rate exceeds the crop uptake demand, the potential for loss increases. Nutrient management planning, based on site-specific yield goals and soil physical and chemical characteristics, can help minimize the potential for loss to surface and ground waters. Keeping P and K levels in the high range ensures optimum N use efficiency by the cropping system and helps to minimize the potential for surface and drainage losses of N.

Conservation tillage, nutrient placement, vegetative buffers, riparian zone establishment, and wetland restoration in strategic locations are other BMPs which complement the basics of site-specific soil testing and nutrient management planning. Nutrient applications can be timed to minimize the potential loss of the more soluble forms of N and P, by avoiding periods of intense rainfall which produce significant runoff. Nitrogen stabilizers may be added to fertilizers to slow soil microbial conversion of ammonium (NH_4) forms to NO_3, but should be evaluated based on local research experience and economics.

Recent soil testing summaries compiled for North America by PPI indicate that 46 percent and 44 percent of the samples submitted to participating private and public laboratories test medium or lower in P and K, respectively. Considerable variation exists among states and provinces, as well as among individual farms, fields, and portions of fields. Data from the National Agricultural Statistics Service show that N, P, and K use efficiency by corn in the U.S. has improved in the last 10 to 20 years (see slide 36). With greater attention to balanced plant nutrition and more skillful management, nutrient use efficiency will probably continue to improve.

Selected References

Antweiler, R. C., D. A. Goolsby, and H. E. Taylor. 1995. Nutrients in the Mississippi River. In: R. H. Meade (ed.), Contaminants in the Mississippi River, 1987-1992. USGS Circ. 1133.

Burkart, M. R. and D. E. James. 1999. Agricultural–nitrogen contributions to hypoxia in the Gulf of Mexico. J. Environ. Qual. 28:850-859.

Carey, A. E., J. R. Pennock, J. C. Lehrter, W. B. Lyons, W. W. Schroeder and J. C. Bonzongo. 1999. The Role of the Mississippi River in Gulf of Mexico Hypoxia. Report Number 70. University of Alabama, Environmental Institute.

CAST. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134. Council for Agricultural Science and Technology.

Committee on the Environment and Natural Resources. Six topic reports on causes and consequences of hypoxia in the Gulf of Mexico. See the reports at: http://www.nos.noaa.gov/products/pubs_hypox.html. Additional information and copies of the reports can be also obtained from the Environmental Protection Agency web site at: http://www.epa.gov/mbasin/.

Ghidey, F., E. E. Alberts, N. R. Kitchen, and R. N. Lerch. 1999. Farming system effects on nitrate loss to surface runoff. Paper 99-2189. American Society of Agricultural Engineers Annual Meeting. Toronto, Ontario Canada. July 18-21, 1999.

Janssen, K. A., G. M.. Pierzynski, P. L. Barnes, and R. G. Meyers. 1999. Best management practices to minimize phosphorus runoff losses from cropland. Better Crops. 83 (2):12-14.

PPI/PPIC/FAR. 1998. Soil Test Levels in North America: Summary Update. Technical Bulletin 1998-3. Potash and Phosphate Institute.

Rabalais, N. N., R. E. Turner, D. Justic, Q. Dortch, W. J. Wiseman, Jr. and B. K. Sen Gupta. 1996. Nutrient changes in the Mississippi River and system responses on the adjacent continental shelf. Estuaries 19:386-407.

Randall, G. W. and D. J. Mulla. (in press). Nitrate-N in surface waters as influenced by climatic conditions and agricultural practices. In: Hypoxia Around the World: Causes and Solutions. J. S. Schepers et al. (eds.). American Society of Agronomy, Anaheim, CA. October 30-31, 1997.

Randall, G. W. and J. S. Schepers. 1997. Nitrogen in the Mississippi River Basin: Sources, and factors affecting loss of nitrate to the river. pp 85-93 . In: Proc. North Central Extension-Industry Soil Fertility Conference. Vol. 13. St. Louis, MO. November 19-20, 1997.

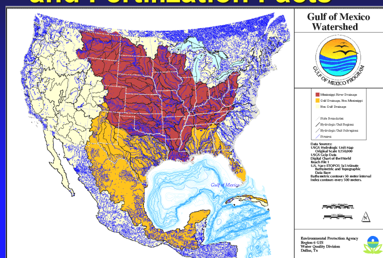
Randall, G. W., D. R. Huggins, M. P. Russelle, D. J. Fuchs, W. W. Nelson and J. L. Anderson. 1997. Nitrate losses through subsurface tile drainage in conservation reserve program, alfalfa, and row crop systems. J. Environ. Qual. 26:1240-1247.

Snyder, C. S., P. E. Fixen and W. K. Griffith. 1999. A Review of the Effectiveness of Reduced Tillage, Nutrient Management, and Vegetative Filters in Reducing Runoff Losses of Nitrogen and Phosphorus. Pages 71-73. In: Third National Workshop on Constructed Wetlands/BMPs for Nutrient Reduction and Coastal Water Protection. Abstracts: Oral Presentations and Posters. June 9-12, 1999. New Orleans, LA.

Turner, R. E. and N. N. Rabalais. 1991. Changes in Mississippi River water quality this century. Implications for coastal food webs. BioScience 41:140-148.

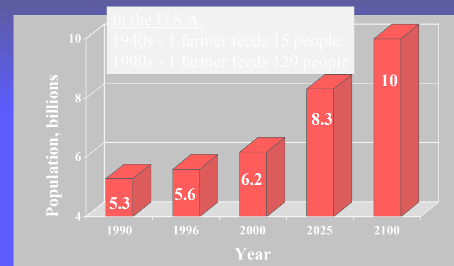
Zucker, L. A. and L. C. Brown (Eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871.

Hypoxia in the Gulf of Mexico and Fertilization Facts



Presented by:Cliff Snyder, Ph.D.
Midsouth Director

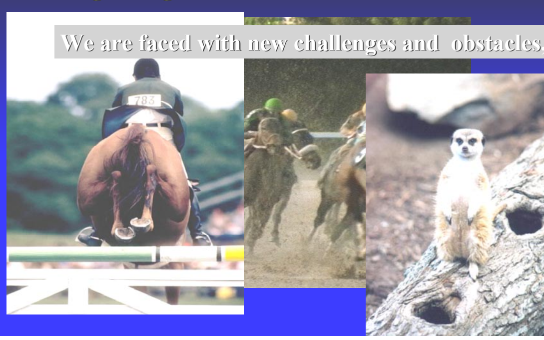
World Population Projections



24% of new world food demands will come from newly developed land
Remaining 76% must come from existing agricultural land (FAO/UN) 2

In the race to meet the nutrient requirements for a growing world food and fiber demand

We are faced with new challenges and obstacles



Multiple Sensitive Environments

- Ecological environment
  - Hypoxia
  - Pfiesteria
  - Frogs
- Economic environment
  - Low commodity prices
  - Adequate net farm income dependent on government bail out programs
- Political environment
  - Election year
  - Tax revenue surplus
  - Perceptions are critical

4

Mississippi River and Basin Facts

- Mississippi River Drainage Basin
  - largest drainage in N. America, 3rd largest in world
  - covers more than 60% of U.S. (1.15 million square miles)
  - 33 major river systems and 207 estuaries
  - 27% of U.S. population
  - 80% of U.S. corn & soybeans, much of the cotton, rice, sorghum, wheat and forage lands(valued at $100 billion/yr)
- The Mississippi River
  - 2340 miles long
  - drinking water source for 70 cities and towns
  - deposits 3.3 million gallons of water per second into the Gulf, or 80% of water reaching the Gulf

5

Hypoxia in the Gulf of Mexico

- Very low dissolved oxygen (less than 2 mg/L)
  - Bottom-dwelling organisms, crab and shrimp potentially harmed
- Result of complex processes: eutrophication, organic matter deposition, physical stratification
- Other factors
  - from 1900 to 1970 flow of Atchafalaya River increased from 15% to 35% of total MS River discharge. Since 1977, discharge of Atchafalaya has been regulated at 30% of total MS River flow
  - Mississippi River flow since 1967 increased
    - approximately 11% more water discharge (measured at Vicksburg, MS by US Army Corps of Engineers)
  - Coastal wetland loss in Louisiana is 25 to 35 square miles per year

6

Gulf of Mexico Facts

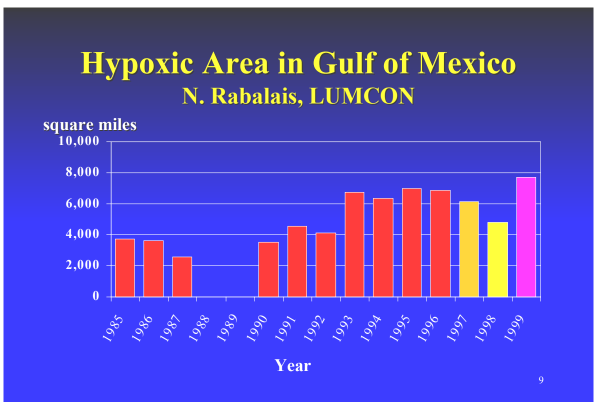
- 617,600 square miles
- Receives about 1.7 million tons of N per year, 60% is nitrate-N (equates to ~ 14% of US annual N sales)
- No change in P loading since early 1970s
- No change in silica loading since 1950s

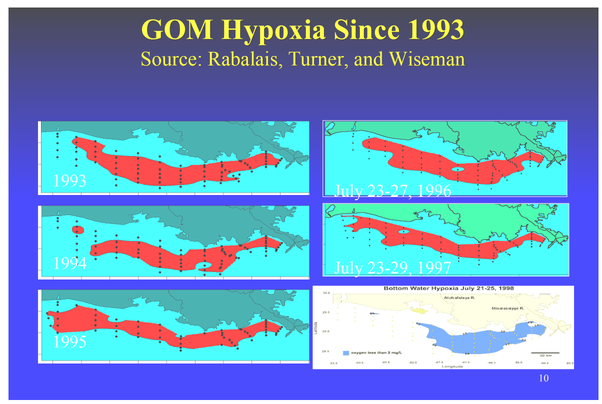
7

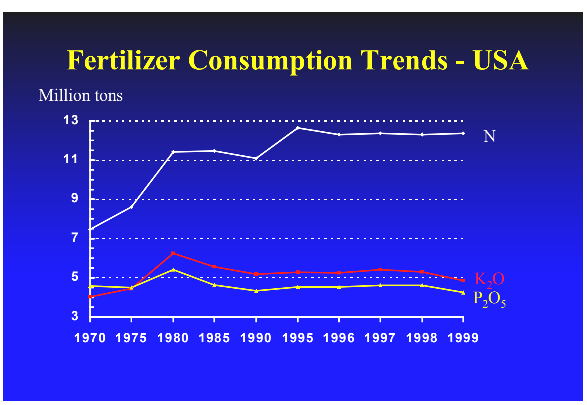
Hypoxia in the Gulf of Mexico

- Some marine scientists & others claim
  - Ecological health of Gulf fisheries (2/3 of oysters, 3/4 of shrimp, 1/5 of fish in US) is threatened
  - Gulf fisheries ($2.4 billion) and tourism economies are also threatened
  - N fertilizer use in the Mississippi Basin is the principal cause for hypoxia
- No measured economic effect of hypoxia on GOM fisheries to date

8







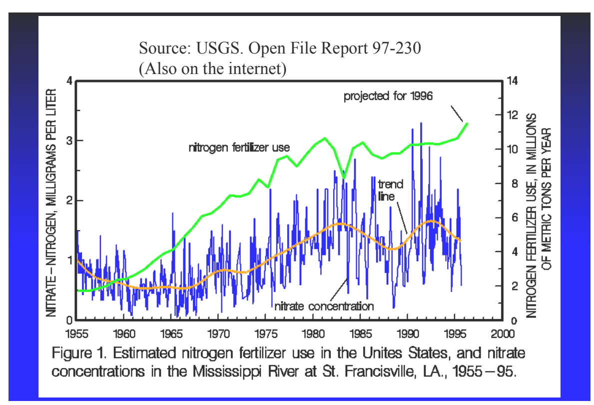
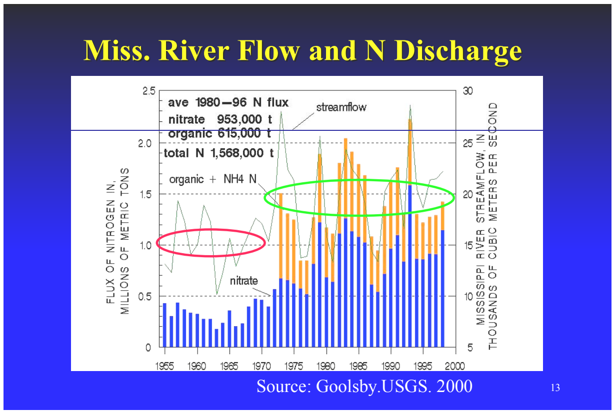
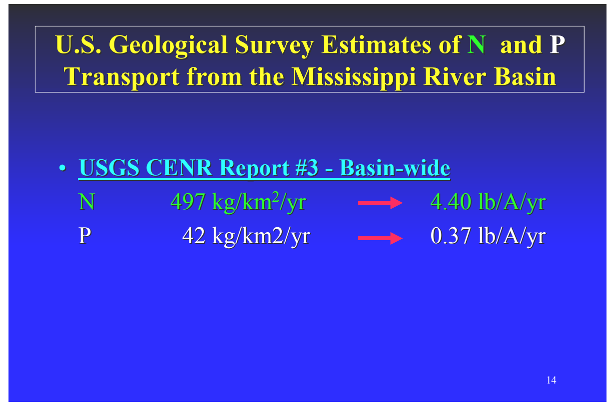
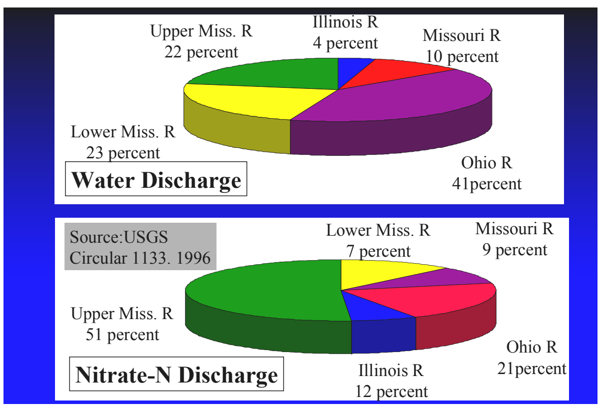
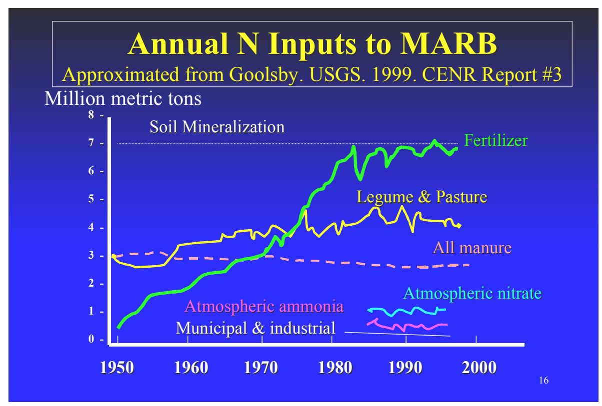


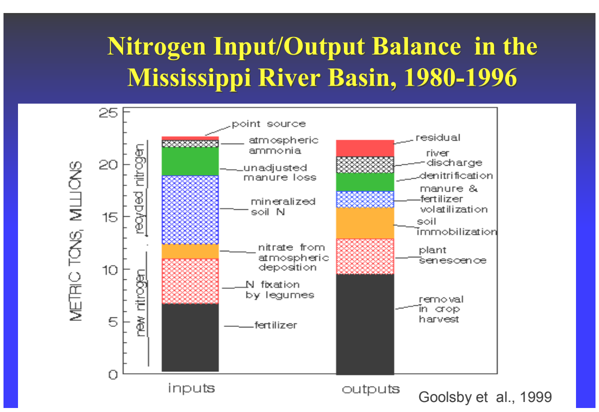
Figure 1. Estimated nitrogen fertilizer use in the Unites States, and nitrate concentrations in the Mississippi River at St. Francisville, LA., 1955 – 95.

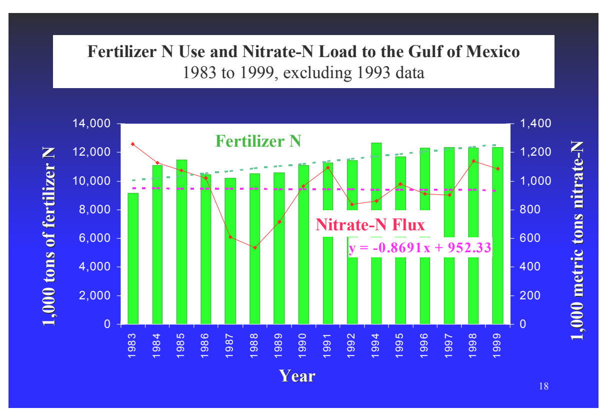

Miss. River Flow and N Discharge
ave 1980—96 N flux
nitrate 953,000 t
organic 615,000 t
total N 1,568,000 t
streamflow
organic + NH4 N
nitrate
FLUX OF NITROGEN IN, MILLIONS OF METRIC TONS
MISSISSIPPI RIVER STREAMFLOW, IN THOUSANDS OF CUBIC METERS PER SECOND
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000
Source: Goolsby.USGS. 2000
13


U.S. Geological Survey Estimates of N and P Transport from the Mississippi River Basin
• USGS CENR Report #3 - Basin-wide
N 497 kg/km²/yr → 4.40 lb/A/yr
P 42 kg/km2/yr → 0.37 lb/A/yr
14


Upper Miss. R 22 percent
Illinois R 4 percent
Missouri R 10 percent
Lower Miss. R 23 percent
Ohio R 41percent
Water Discharge
Source:USGS Circular 1133. 1996
Lower Miss. R 7 percent
Missouri R 9 percent
Upper Miss. R 51 percent
Ohio R 21percent
Illinois R 12 percent
Nitrate-N Discharge

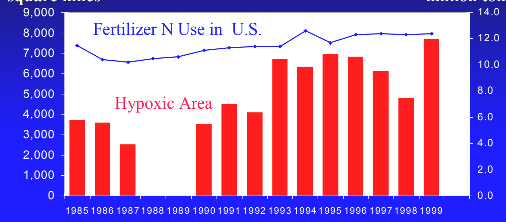

Annual N Inputs to MARB
Approximated from Goolsby. USGS. 1999. CENR Report #3
Million metric tons
Soil Mineralization
Fertilizer
Legume & Pasture
All manure
Atmospheric nitrate
Atmospheric ammonia
Municipal & industrial
1950 1960 1970 1980 1990 2000
16


Nitrogen Input/Output Balance in the Mississippi River Basin, 1980-1996
METRIC TONS, MILLIONS
recycled nitrogen
new nitrogen
point source
atmospheric ammonia
unadjusted manure loss
mineralized soil N
nitrate from atmospheric deposition
N fixation by legumes
fertilizer
residual
river discharge
denitrification
manure & fertilizer volatilization
soil immobilization
plant senescence
removal in crop harvest
inputs
outputs
Goolsby et al., 1999


Fertilizer N Use and Nitrate-N Load to the Gulf of Mexico
1983 to 1999, excluding 1993 data
Fertilizer N
Nitrate-N Flux
y = -0.8691x + 952.33
1,000 tons of fertilizer N
1,000 metric tons nitrate-N
Year
18

Hypoxic Area in Gulf of Mexico

N. Rabalais, LUMCON



19

Harmful Algal Bloom & Hypoxia Legislation

- Assessment Report - required to Congress and President by May 30, 1999
- Submission of Plan - no later than March 30, 2000
- Authorized for appropriation to Sec. Of Commerce - most for NOAA National Ocean Service
  - $15 million for FY 1999
  - $18 million for FY 2000
  - $19 million for FY 2001

20

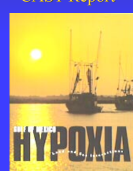
Committee on Environment & Natural Resources (CENR) Gulf Hypoxia Reports

www.nal.usda.gov/wqic/

www.nos.noaa.gov/Products/pubs_hypox.html

May 1999
University of Alabama
Environmental Institute

June 1999
CAST Report



21

Mississippi River Watershed Nutrient Task Force 5th Meeting

- **Rosemont, IL November 18, 1999**
- **Review of Integrated Assessment of CENR reports (led by NOAA)**
- **Discussion/development of possible Action Plan**
  - **20 percent reduction in transport of N to the GOM and at least 5 million acres of restored wetlands**
- **COST ~ $ 4.9 billion/year**
  (M. Fumento, Forbes Magazine, Nov. 1999)
- **6th Task Force meeting June 15, St. Louis, MO**
  - **Action Plan exposed for comment**

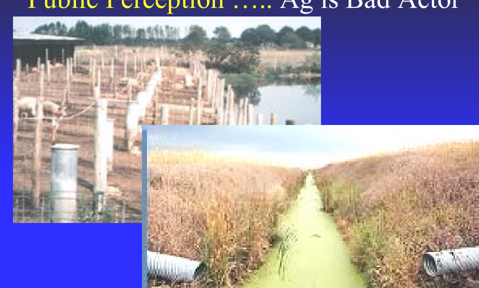
22

Impact of 20% Reduction in Mississippi Basin Fertilizer Sales

Tons	N	P_2O_5	K_2O	Total
U.S.	12,304,924	4,624,031	5,621,150	22,190,105
MS Basin	10,218,277	3,720,648	4,149,394	18,088,319
Basin % of U.S.	83%	81%	79%	82%
Lost @20% reduction	2,043,655	744,130	829,879	3,617,664
Million $ in Lost sales	$691	$385	$235	$1,311

23

Public Perception ….. Ag is Bad Actor

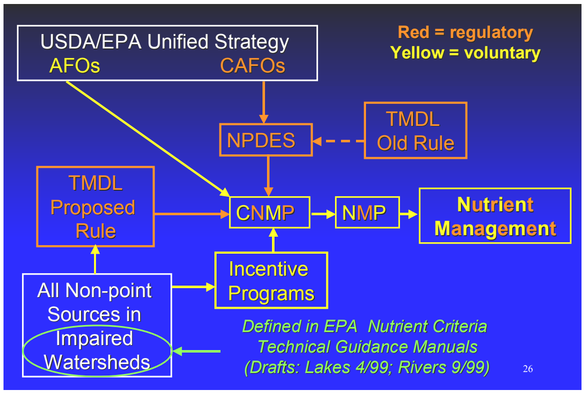


24

USDA & EPA Agree on Comprehensive Nutrient Management Plan (CNMP) Components

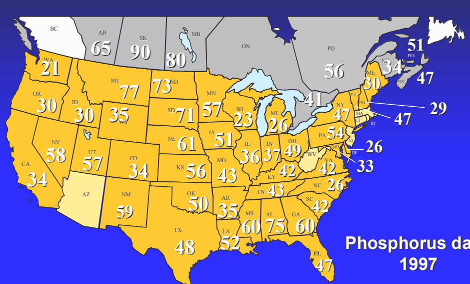
- **Feed management** - To reduce nutrients in manure (e.g. phytase enzyme in feed, low phytate corn, etc.)
- **Manure handling and storage**
- **Land application of manure** - nutrient balance, timing and methods of application
- **Land management** - Tillage, vegetative buffers, etc.
- **Record keeping** - soil & manure tests, nutrient utilization
- **Other options** - Sale of manure

25



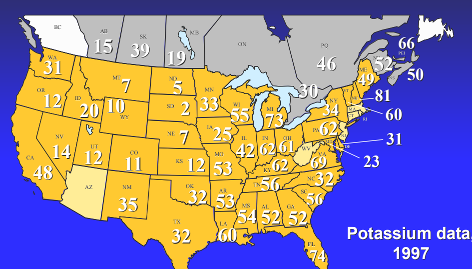
26

46% of Soils Test Medium or Lower in P



27

44% of Soils Test Medium or Lower in K



28

A Review of the Effectiveness of Reduced Tillage, Nutrient Management and Vegetative Buffers in Reducing Runoff Losses of N and P

by

Cliff Snyder, Ph.D. Midsouth Director, PPI
Paul Fixen, Ph.D. Sr. V.P. & Director of Research, PPI
Bill Griffith, Ph.D. Agronomic Management Systems

June 1999
New Orleans

29

SUMMARY - N & P Runoff

- Without BMPs, N & P runoff loss averaged 12 & 8 %
- Average reductions in loss with conservation tillage:
  - reduced tillage N= -0.3 to 74% P=11 to 82%
  - no-till N=12 to 82% P=3 to 82%
- Nutrient management
  - balanced nutrition increases N use-efficiency
  - subsurface fertilizer placement reductions in loss vary:
    - N= -19 to 57% P= -233 to 55%
  - timing to avoid runoff-producing rains for 4 to 14 days after application can reduce N and P losses by 70 and 30%
- Vegetative filters - can reduce N and P loss 40 to 90%

30

N and P Transport from the Mississippi River Basin and Natural Runoff Examples

- USGS CENR Report #3 - Basin-wide

N	497 kg/km^2/yr	→	4.40 lb/A/yr
P	42 kg/km2/yr	→	0.37 lb/A/yr

- Natural N and P Runoff Losses

N	grasslands (OH, OK, TX,)	0.81 lb/A/yr
	forests (MS, OH)	4.77 lb/A/yr
P	grasslands (OH, OK,TX)	0.13 lb/A/yr
	forests (MS,MN,NH,OH,WA, WI)	0.42 lb/A/yr

31

Annual Precipitation and Natural Losses of N and P .... in Perspective

Precipitation Input, lb/A	Natural Loss from Vegetation Type, lb/A		
	-------------- N -------------		
12.45	Grassland	0.81	Sinks
	Forest	4.77	
	-------------- P -------------		
0.30	Grassland	0.13	Sinks
	Forest	0.42	

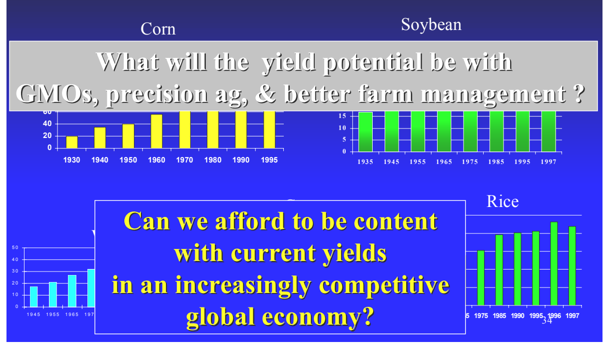
32

Subsurface Drainage Losses of N

- % of cropland drained in IN, OH, IL, MI, IA, MO, and MN ranges from 10 to 60%
- Drainage loss of N can be greater than surface runoff loss
- Nitrate-N losses
  - 7 to 34 lb/A are not uncommon
  - can exceed 40 lb/A/year, in wet years after dry years

33

Crop Yields Are Increasing

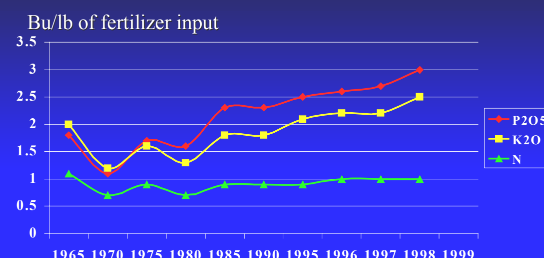


34

Nutrient Uptake for Selected Crops

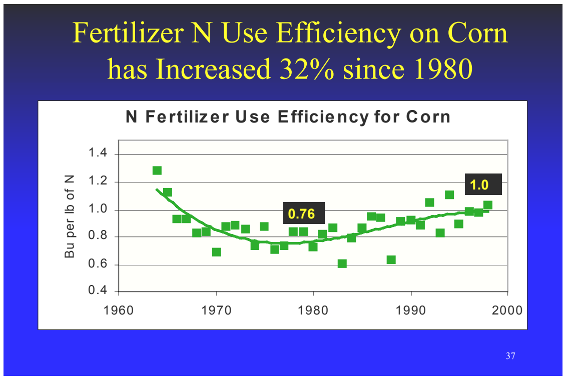
Crop	Yield	N	P_2O_5	K_2O	S	Mg
	Bu or Lb/A	-----------	Lb/A	---------------		
Corn	180	240	102	240	30	58
Soybeans	55	288	54	188	18	22
Wheat	70	130	48	142	18	22
Cotton	1000	160	48	140	24	22
Rice	7000	112	60	168	12	14

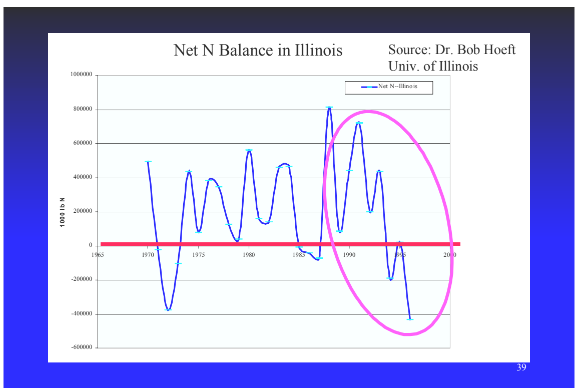
Corn Nutrient Use Efficiency -(NASS)



Source: T. Bruulsema, PPI

36



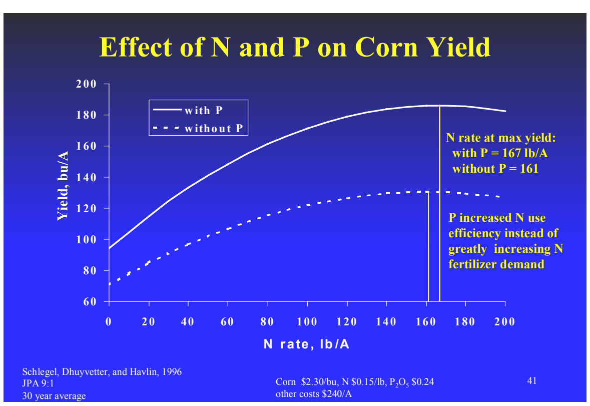


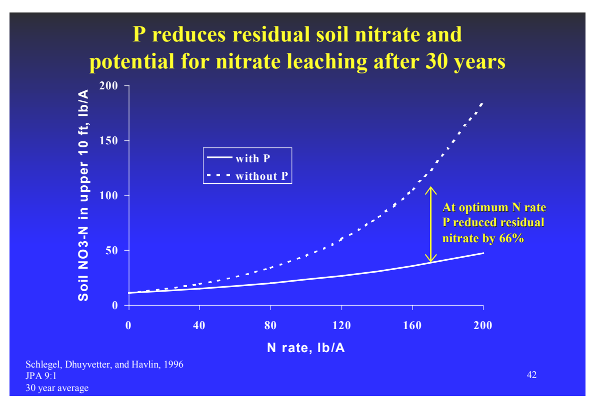
Illinois P Budgets, 1982-1996.

	Removal		Inputs			Rem/
Years	Crop	Animal*	Fertilizer	Manure	Human	inputs
			Short tons, thousands			%
82-86	517	8	466	112	16	88
87-91	498	8	385	106	16	100
92-96	574	8	381	101	16	117

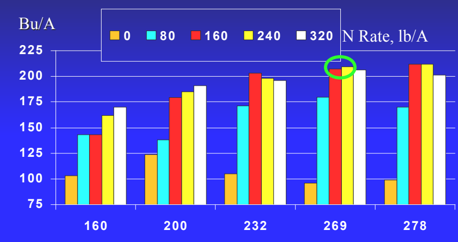
* Meat, eggs, milk. R. Hoeft, U. of Illinois.

40



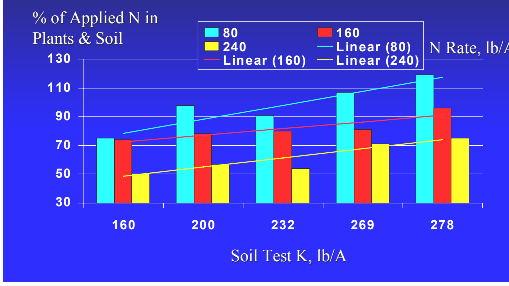


Adequate Soil K Level Increases Corn Yield (Johnson & others, Ohio. 1992-95)



Adequate Soil K Increases Apparent N Recovery by Corn Plants and Soil (0-3 ft.)

(Johnson & others, Ohio. 1992-95)



Info Presented to: Gulf of Mexico Nutrient Enrichment Focus Team, LSU Ag Center Faculty, APFES/ACPA, MAICC, SWFC, LAIA, TAPA, GOM 2000 Mtg., etc.

- Agriculture is improving nutrient use efficiency
- More nutrients are being used in the standing crop
- Nutrient balance in key ag states shows a trend for nutrient deficit
- State and private lab soil test results show continued need for improved P and K nutrition
- Improved P and K nutrition increases yields and improves N utilization efficiency

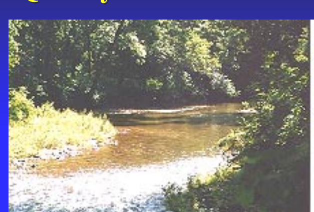
45

Everybody Wants Clean Water

Crop and Animal Agriculture Included

46

We Can Improve and Protect Water Quality with BMPs

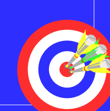


Nutrient Management Planning is a key BMP

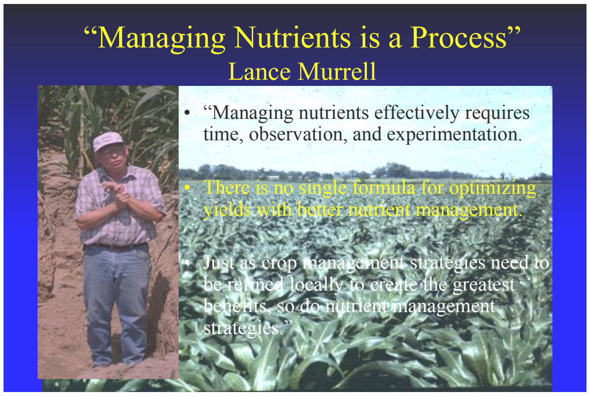
47

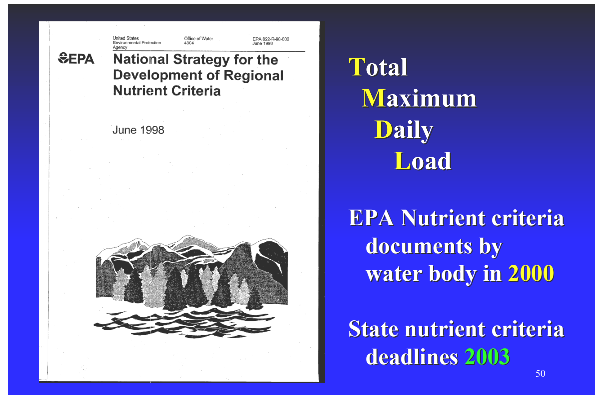
Nutrient Management Plans - Components

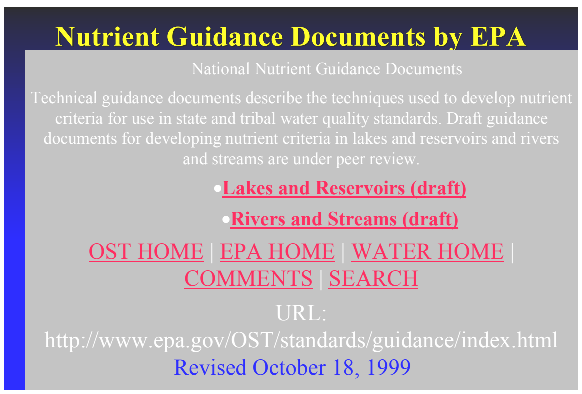
- Field maps - aerial photos
- Acres in fields
- Crop, crop rotation
- Representative soil tests
- Soil survey manual info.
- Realistic yield goal
  - e.g. best 3-year average
- Nutrient sources
- Recommended nutrient rates, timing, placement
- Nutrient carryover
- Location & management of sensitive areas of fields
- Economic considerations
- Narrative
- Annual review
- Disclaimer



48


"Managing Nutrients is a Process"
Lance Murrell
• "Managing nutrients effectively requires time, observation, and experimentation.
• There is no single formula for optimizing yields with better nutrient management.
• Just as crop management strategies need to be refined locally to create the greatest benefits, so do nutrient management strategies."


EPA
National Strategy for the Development of Regional Nutrient Criteria
June 1998
Total
Maximum
Daily
Load
EPA Nutrient criteria documents by water body in 2000
State nutrient criteria deadlines 2003
50


Nutrient Guidance Documents by EPA
National Nutrient Guidance Documents
Technical guidance documents describe the techniques used to develop nutrient criteria for use in state and tribal water quality standards. Draft guidance documents for developing nutrient criteria in lakes and reservoirs and rivers and streams are under peer review.
•Lakes and Reservoirs (draft)
•Rivers and Streams (draft)
OST HOME | EPA HOME | WATER HOME |
COMMENTS | SEARCH
URL:
http://www.epa.gov/OST/standards/guidance/index.html
Revised October 18, 1999


Thank You !
52