External Review of
"Reactive Nitrogen in the United States; An Analysis of Inputs, Flows, Consequences, and Management Option"

by
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GENERAL COMMENTS

This was the most comprehensive, holistic document on nitrogen that I've read. It was quite well organized and for the most part was well written. After page 90, it did appear to be more hastily assembled with some sections repeated, poor agreement between figure citation in the text and the actual figure, incomplete sentences, unreferenced citations, etc.

SPECIFIC COMMENTS

page	line	
6-20	all	The Executive Summary provides a good overview of the report. The sections dealing with "human activity creating reactive N", the "N cascade," and "sources of reactive N" were particularly helpful. The major findings and recommendations shown on pages 18-20 also set-the-stage quite well.
25-26	all	Figure 3 and the accompanying text was well done.
38-41	all	Section 2.2.3.1 on "Nitrogen Fertilizer Use" was very informative and clearly sets the stage for Recommendation 1 on page 42. This is critical for enabling a better understanding of the cause and effects of N on a landscape scale.
41	Table 3	The table heading and column heading (Tg/year) indicates or at least implies that these data are the amount of N fertilizer (sources) and not the amount of N coming from each source. Because the N concentration in the sources ranges from <20 to 82% N, it is important to clearly indicate this is the amount of fertilizer N from each source. Changing "Tg/year to Tg N/year would help.
42	12-22	This paragraph can be very confusing to the non-N-trained audience. The lead sentence highlights nitrogen fertilizer use efficiency (NFUE). The second sentence (i) defines NFUE in terms of recovery efficiency (RE) in kg N uptake per kg N <u>applied</u>. However, (ii) describes physiological efficiency (PE), which is kg yield per kg N uptake where yield and N uptake are from both N

		fertilizer and soil N. Thus, (ii) really does not relate to NFUE because soil N taken up by the corn plant may account for anywhere between 25 and 100% of the yield given in the numerator. This is important for a couple of reasons. First, the proportion of corn yield produced by soil N is affected substantially by previous crop and geographic location. In Minnesota when using an optimum rate of fertilizer N, about 60% and 76% of the corn yield is produced by soil N for corn that follows corn and soybeans, respectively. In Illinois, those values are 54 and 64%, respectively. The means across 271 corn after corn sites and 427 corn after soybean sites in Illinois, Iowa, Minnesota, and Wisconsin are 56% for corn after corn and 70% for corn after soybean. (Reference = Sawyer, John, Emerson Nafziger, Gyles Randall, Larry Bundy, George Rehm, and Brad Joern. 2006. Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn. Iowa State Extension PM 2015 or on the web at www.extension.iastate.edu/Publications/2015.pdf). When RE is calculated, the N uptake in the corn from the zero fertilizer plots or area is subtracted from the total N uptake to get N uptake from the fertilizer. This is true NFUE and the term we need to address if we are to improve fertilizer N efficiency. In line 30, page 42, it states that “relatively few data that provide measurement of fertilizer N recoveries by our major field crops. . . .”. This is because very few growers will leave an unfertilized area or two in their fields to provide this “zero fertilizer N” number. Also, few growers have the capability to measure N uptake; it is much easier for them to measure corn yield. Thus, a surrogate for NFUE can be kg yield per kg N applied. The confusing part of this surrogate is that it presents a yield value for only the fertilizer N per amount of applied N; whereas, PE described in (ii) presents a yield value for both soil N plus fertilizer N per amount of N. This is the second reason this distinction is important. This report (p.42 lines 12-22, p. 127 Figure 25, and p. 151 lines 4-15) and various reports in the literature have confused NFUE, which addresses efficiency of fertilizer N only, with NUE, which often addresses soil & fertilizer N.
42	23-29	I have no problem with what is said in this paragraph as long as one recognizes that RE can be affected greatly by previous crop and that RE is dependent on the rate of N applied because that term is in the demoninator. From a science perspective, it is always important to calculate RE and PE at the optimum rate of fertilizer applied (EONR) over a long period of time. Otherwise, one does not know if NFUE is truly being improved by management shifts or new genetic materials being planted.

43	9	Insert “may” between “that” and “improve”. The technologies that we currently have available and mentioned in lines 10-13 perform best in very site-specific instances and will not show N improvement across the board.
44	6-18	This paragraph contains some generalizations that need comment. Even though I am not a big fan of fall fertilization, due to our highest consistent yields occurring for spring preplant N application, I do recognize the logistical and economic factors that drive fall N application, especially in the Northern Corn Belt. Fall N application in late October or early November in Minnesota where the soils are frozen from early December through the end of March is much different than N being applied in mid-October in southern Iowa, Illinois, Indiana, Ohio and Missouri when the period of frozen soils is much shorter or absent. The potential for improving NFUE for spring compared to fall application is much greater in the mid-to southern Corn Belt than in the Northern Corn Belt.
44	14-18	The “smart” fertilizers work well when the risk of N loss is high. Unfortunately, weather, e.g. precipitation in the spring, has much to do with that risk; precipitation is an uncontrollable factor. These fertilizers are more expensive, which is huge factor reducing their acceptance among farmers.
45	1-3	See the reference mentioned earlier (p. 42, lines 12-22). This is not true in the Corn Belt (see the Corn N Rate Calculator on the Iowa State Extension Web site).
45	8-18	This paragraph illustrates the confusion between NFUE or RE and NUE or PE. The first line says NFUE yet the values are NUE/PE.
45	19-30	Hurricane Katrina had little to do with higher N costs. The greater N costs were due to higher natural gas prices and off-shore production and transportation. N prices are largely driven by energy costs.
45 46	35- 2	Cassman, who has done very good work, is frequently cited in this report. However, much of his work has been done on irrigated soils which are much different than rainfed crop production. The in-season decision-making tools described have a much greater probability of being successful in irrigated production, where N can be combined with water and delivered to the root system, compared to rainfed conditions where one needs to depend on Mother Nature to deliver that “timely rain”.
46	29-32	Zero-N control areas need to be implemented in production-scale

		fields to really get a handle on long-term N management.
46	33	include “land-grant Universities”
47	1-3	“ “ “ “
50	10-12	The values of 10% and 20% seem high to me considering the amount of each source that is incorporated during or soon after application.
51	9-12	include “land-grant Universities”
51	32	“increasing corn acreage by millions of acres” seems to be pulled out of the air. There are resources available to document how many acres of corn are planted each year. This statement is clearly an exception to the rest of this report.
57	16	“neutralization of acids produced by sulfur and N oxides”. Does this really occur to any significant amount?
57	20	I’m not aware of nitrate causing soil acidification.
58	28	NRC 2996?
52 61	all- all	Seems like a lot of attention to devoted to animal agriculture. Maybe that is fine from an atmospheric perspective, but in my opinion not from a water perspective.
64	Table 9	Table 9 is incomplete. The “High Maintenance Areas” has been omitted from the left-hand column.
67	15	“in” Recommendation D
80	25-33	This is the first place in the report where the mineralization of soil N is referred to as a source of N for plant use. This is a major source of non-controllable plant-available N, and it greatly affects NFUE. Thus, I feel that the concept should be introduced on page 42, lines 12-22 in addition to the few lines stated here.
81	Table 13	6.4 Tg N/y from N fixation in vegetated grasslands seems quite high when comparing it to the millions of acres of very efficient N fixing plants (alfalfa and soybeans) in agricultural systems! What leads to this high value. I know there are lots of areas of grasslands, but one does not visualize a significant amount of N fixation occurring in these grass-based systems.

83	16-23	I endorse this finding, the recommendation, and the inclusion of universities in the research effort.
86	3-24	This is a tricky section. The document has solely been directed toward N. Now P is being co-mingled with N. We know that algal growth is dependent on both N & P; but my knowledge indicates that N tends to be the driver in marine waters and P in fresh waters. Therefore, I'd recommend more text defining these differences. For most citizens who don't live next to marine waters, P is assumed to be the reason for algal blooms and associated taste and odor problems. Furthermore, aren't most of the 303 (d) listings and WQ nutrient pollution impairments due to P? The issue of N vs. P causing algal blooms is a real contentious issue among many, depending on how it affects their particular situation. This section as presently written only feeds that contensciousness. The section should be rewritten in a manner that focuses on N as a contributor to algal blooms and not using P to make the point. In my opinion, using P only discredits the report.
85	9-13	This section is fine as it concentrates on marine systems. Thus, distinguishing between marine and fresh water systems seems important.
86	2	sentence is unclear
86	18-20	For those of us who live in fresh water areas, chlorophyll *a* is always associated with P.
88	33	Recent information from Minnesota questions the role of conservation tillage as a factor for greater SOC accumulation.
91	Table 15	Table 15 and footnote 7 are valuable
93	9-13	This is an important paragraph. There are volumes of this information in the scientific literature, but perhaps it is too detailed and site-specific for this report.
94	2-27	A very important section!
94 95	28-15	This section was repeated earlier on p. 94.
95	16	Fig. 18 is not very instructive. Also, I could not find where it fits in or where it was discussed in the text.
98	2-20	Are cost: benefit ratios appropriate for measuring these impacts?

99 102	24- 18	Text Box 2, its text, figures and tables was an excellent instructive section.
125	15-18	“decreasing N fertilizer application rates 10 to 50% . . . . would decrease nitrate output to the river by 10 to 43%”. Compared to what rate? One always needs to be careful when making these kinds of statements without defining the boundaries. We have data showing that when N application rate is reduced from 160 lb N/A to 120 lb N/A (a 25% reduction) that nitrate-N concentrations in drainage water are reduced by about 30% without losing crop yield. When reducing the N application rate to 80 lb/A from the Univ. of Minn. N recommendation of 120 lb/A, nitrate-N concentrations were reduced only about 10%, but crop yields were significantly reduced. Bottom line: one needs to state what the starting point or comparison value is to make these kinds of statements valid.
125	30	Jaynes and Karlen (2005) not found in Reference section.
126	2	Fig. 24 should correspond to Fig. 22 or 23
	18	“ 25 “ “ “ “ 24.
	19	“ 26 ” “ “ “ 25.
127	Fig. 25	Fig. 25 shows how corn grain yield per kg N changes with time. This “kg grain per kg N” relates to both the N from the soil and from the fertilizer. Thus, it does not specifically relate to NFUE (line 17, p. 126).
128	1-3	What is the N rate starting point or N rate range starting point? (same concern as above for p. 125 lines 15-18).
128	5	Fig. 27 should be Fig. 26.
129	14	“ 28 “ “ 27.
131	2 & 7 8	“ 30 “ “ 29. “ 32 “ “ ??.
131	Fig. 28	no discussion found in text
142	27	Fig.29 should be Fig. 32.
150	12	“ the most leaky lands should be taken out of production “. I find this statement to be most interesting. In this whole document it is the only sentence that relates to changing from a row-crop (corn & soybean) system to a non-row crop system (perhaps a perennial

		grass or alfalfa system. Minnesota research has shown nitrate-N losses to drainage water to be reduced by 30 to 50 times when converting from a corn and soybean system to a perennial grass or alfalfa system. The effect of changing to a different cropping system has a greater effect on reducing nitrate losses to drainage water than combining all BMP factors for N management mentioned in this report.
150	23-39	It is not surprising that watersheds of the MRB with the highest rates of fertilizer runoff had the lowest amount of land enrolled in federal conservation programs. Lands enrolled in conservation programs are usually highly erodible with significant sediment loss potential; whereas the MRB watershed with higher nitrate runoff are generally flat and “non-erodible”. So this could be an issue of taking flat non-erodible areas out of production to minimize nitrate loss and then replacing corn production on to areas much more vulnerable to soil erosion. It would be exchanging nitrate loss for sediment and P loss. Not a good trade.
151	7-10	This wording suggests that this is a NFUE calculation (kg grain produced per kg of N applied). However, the values of 42 to 57 kg grain/kg of N convert to 0.75 bu to 1.00 bu of grain per pound of applied N; these values far exceed NFUE values and lead me to suspect that they are merely NUE (PE) values, which combines the yield from soil N with that from fertilizer N. Thus, this is <u>not</u> an illustration of NFUE. It is a 35% yield efficiency gain but it cannot be specifically related to improved N fertilizer use efficiency (NFUE).
151	10-12	The next sentence relates this as NFUE and compares it to NFUE of 37%; it is like comparing apples and oranges. Furthermore, in Fig. 25 on page 127, Fixen and West did not subtract grain produced from soil N from the grain produced from soil + fertilizer N – a requirement for NFUE.
151	10	Fixen and West (2002) was not found in References section.
151	37-39	More than a “large investment in research, extension education, and technology transfer” will be needed to obtain substantial improvements in NFUE. In 1991, the State of Minnesota appointed a Nitrogen Fertilizer Task Force, which developed a N Management Plan for the state. This consisted of a 3-phase plan leading up to N regulations and the development of BMPs for N in six different areas of the state. Seven UM Extension bulletins (one for each of the areas and one for overall N mgmt) based on University research were published in 1993. Countless N management extension meetings were held and thousands of bulletin/fact sheets

		were distributed over the next 15 years with astonishing little implementation. The bulletins were revised in 2008. In my opinion one needs more than “volunteerism” before BMPs are widely practical. Incentives, disincentives and a “stick” approach is needed in conjunction with state-of-the-art research. The increased price of fertilizer N did more to change grower behavior with respect to N than did all of the extension bulletins distributed and meetings held.
153	29	sentence unclear
153	32	BMPs to minimize NH_3 emissions were not found in section 3.2
153	34-41	More N is removed in harvested soybean grain than is fixed by the plant. Also nitrate leached into drainage under soybeans comes primarily from the soil N and from fertilizer applied to corn the previous year. Nitrate leaching losses in a corn-soybean system are more complex than described in this paragraph.
153	38-39	Del Grosso et al. (2006) not found in Reference section.
154	35-39	This is an extremely important statement.
155	6	Section 3.3.1 did not address NO_X emissions declining in the U.S.
156	14	include “Universities”
157	20-28	BMPs based on excellent research and vigorously extended are not enough to change grower behavior AND industry sales/marketing when it comes to N. Tradition and the strong role of the fertilizer dealer are powerful forces opposing the implementation of N BMPs. As stated earlier incentives and disincentives are needed to accompany the BMP process.
159	6-7	There is lots of talk and enthusiastic, optimistic marketing for improved tile-drainage systems, but in my opinion, there are numerous practical and logistical obstacles that are not discussed. Reducing tile drain depth from 3.5’ to 2.5’ will be helpful due to the large area of drained soils where this kind of management is suitable. But, I am not that optimistic about significant nitrate mitigation across the landscape with controlled drainage, wood chips for denitrification in the tile lines, and riparian buffers in most Corn Belt land.
159	10-11	Advances in fertilizer technology will be helpful in certain specific areas but in the big picture will have a limited effect on mitigating nitrate loss to water.

159	22	Simpson et al. (2008) not found in Reference section.
159	36-41	Target recommendation 2 text should be under Target recommendation 3.
160 161	34- 10	Target rec. 3 text should be under target rec 2.
161	7-9	Decreasing Nr by up to 20% may be possible on average but the range is likely 0 to 100%. Again, what is the starting or reference point for the 20% reduction?
170	12-18	Does not agree with Target Goal 2.
170	20-34	Agrees with Target Goal 2.

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