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Review Comments on SAB Draft Report “Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences and Management Options.
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General comments:

The report compiles an extensive amount of information on Nr, which I consider to be largely accurate and the recommendations reasonable. I think the report could benefit from some thoughtful editing, with an eye towards organizing the technical information so that it most efficiently and effectively supports the recommendations. There are places where I found the text confusing or unnecessary, or providing potential for confusion.

One of my main technical concerns involves the attempt to develop separate N budgets for Agricultural, Vegetated and Populated landscapes, discussed on pages 80-83. In this analysis manure and sewage N are treated as inputs, but they are really transformations of other inputs.

Elsewhere in the report, claims are made about how much Nr is transported from agriculture to the environment but it is not always clear how these estimates were made.

I think this draft report represents a useful step in the process of improving understanding and management of Nr. The following comments on specific portions of the document are offered to help improve future drafts.

Comments on specific passages:

Page 6, line 9 (and throughout most of the report): The report identifies combustion of fossil fuels as a source of NO_x, suggesting that combustion of non-fossil fuels is not a source of NO_x. There are only one or two places (such as page 112, line 32) where combustion of biomass is identified as a source of NO_x.

Page 11, line 16: identifies stationary fossil fuel sources as power plants and industrial boilers. What about domestic heating?

Page 16, line 7: the claim is made that a “large part of the land surface in the northern hemisphere” has Nr deposition rates in the range of 10 to 20 kg N/ha-yr. This point could be made more explicit by estimating the proportion of land area in the US that receive deposition in this range.

Page 19, line 32: refers to “other unregulated mobile and stationary sources”. This is elaborated in the body of the report but I think it would be helpful to give examples of these sources here (e.g., off road vehicles).

Page 25, Figure 3: All aquatic and terrestrial systems are identified as having some denitrification potential, except for oceans. But denitrification does occur in the oceans. ¹

This seems to be an oversight because later on page 85, the report mentions that deposition of Nr to the oceans results in some N₂O production, presumably from denitrification.

Page 26, lines 11-14 and 20 -22: These statements identify “losses” of Nr from aquatic and terrestrial systems that do not include conversion of Nr to N₂, and then indicate that there is “potential” for conversion of Nr to N₂. But conversion of Nr to N₂ occurs in these systems and it does represent an important loss from those systems. The language is potentially confusing. I’d recommend changing the word “losses” to “transfers” or “exchanges” of Nr from one system to another, and conversion of Nr to N₂ be considered a loss of Nr.

Page 35, figure 4: The horizontal scale is not arithmetic. The 20 years from 1970 to 1990 represents 5 units (four years per unit), but after 1990, each year represents a one unit on the horizontal scale. This appears to be an excel line graph. I’d recommend changing it and excel XY graph or some other format so that the horizontal scale is proportional to time.

Page 37, line 12: In discussing Table 5, the text refers to Louisiana even though data from Louisiana is not presented in Table 5.

Page 39, line 15: it would be nice to have a citation to the recommendations referred to.

Page 42, line 3: the statement is made that 7.6 Tg of Nr is transferred from agriculture to aquatic and atmospheric systems. It was not clear how this value was calculated.

Page 43, line 14: the statement is made that maize receives the largest share of fertilizer N in the US. It would be helpful to state this percentage.

Page 44, Figure 7: This figure is based on readily available USDA data, and could easily be extended from 2000 to include more recent years. This was apparently done to create Figure 25 on page 127.

Page 46, lines 4-6: It might be helpful to mention here that many legume crops will tend to scavenge inorganic N out of the soil before investing resources in N fixation. This is why they have some potential to be more efficient than inorganic fertilizer. I am not sure if this is the best place to mention this but I think it should be somewhere in the report.

Page 47, line 3: I think “prevention... of Nr applied to agricultural systems” is not the best word choice. Better choices might be “..prevention of unneeded Nr..” or “efficient use and mitigation of Nr...”

Page 51, line 28: there is an extra comma in this line.

Page 51, line 29: “will be used ... in 2008” should be “...was used...”

Page 57, lines 15-16: explain how are aerosol formation and neutralization of acids produced by sulfur and nitrogen oxides are adverse effects.

Page 59: a table that shows how the N excretion has changed per animal would be useful.

Page 60, line 18-91: the language describing the ammonia equilibrium is presented as if volatilization is either “allowed” above pH 7, or not allowed below pH 7. I think it is more accurate to present it as a continuous function, with very low quantities of NH₃ available for volatilization below pH 7 and increasing quantities above pH 7. Also, there is a reference to Arogo et al (2006) here but no Arogo et al. citation appears in the reference list at the end.

Page 61, line 18: the “finding” is made that there are no regulations to decrease Nr losses from manure, but many states do have laws governing the management of manure from larger farms. The report recognizes this on page 124, lines 14-15.

Page 64, Table 9: It looks like the left column is messed up. I think the top left box should say “Type of turf fertilized” the second box should say “nominal fertilization”, the third “Professional lawn care” and the fourth “high maintenance areas”.

Page 69, Figure 14: I think it is dangerous to presume a trend from two data points (the 1985 and 2005 maps). I have looked at the full series of maps available on the web, and I agree that there probably is a real trend, but I think it would be better to present and analyze the annual time series, as was done for nitrate.

Page 72, lines 14-15: I don’t understand what is meant by foliar resistance to NO, nor how it explains why dry deposition of NO₃⁻ is 39% off the total NO₃⁻ deposition.

Page 73, lines 8-21: I think an additional source of uncertainty in these estimates of Nr deposition is locally recycled NH₃/NH₄ and perhaps some other N compounds. Plants emit NH₃ but they also absorb it from the surroundings. Similarly a dust storm may lead to some local deposition of particulate N, but also some local removal. The monitored deposition may include some of this locally derived Nr, or be replacing Nr that is being emitted and thus in may not necessarily represent a net of new Nr input to the region. It may also be worth repeating in this section that the sampling networks have not been tested for spatial bias (as stated on page 68). I believe most of the monitoring locations are in rural areas, and thus may under represent deposition in and near urban areas.

Page 76, Figure 16. The legend on this graph is rather cryptic, and the graph basically provides only 4 percentages for each year, and there is not much difference between the two years. I think the essential information from the graph could just as easily be presented in the text or a small table.

Page 76, line 11: I think there is a need to insert after NH_x the phrase "...emissions are..."

Page 76, line 21: delete "the" before 1985.

Page 77, line 24: I think "within" should be changed to "with" and probably should be preceded with a comma.

Page 78, line 9: "a fair fraction" ought to be changed to something more precise.

Page 79, line 22-23: this statement comes out of the blue. There was no discussion of this in the preceding text.

Page 80, lines 29-33: I think it is worth mentioning that much of the unharvested N is retained in the unharvested portions of the crop: leaves, stems and roots, which can protect the soil and contribute to soil organic matter, if properly managed.

Page 81, table 13 and line 15: Animals don't manufacture N_r, but they transform it. Grazing animals consume N in the grasslands and a portion of that N becomes manure. So, it is recycled N and not a separate input. Humans and confined livestock are consuming grain and feed produced with fertilizer and BNF. To count manure and sewage as inputs involves double counting some of the N_r. Also, the portion of atmospheric deposition that is reduced may have derived from animal manure or fertilizer emissions, and thus would also be double counting. I can see the point of looking at transfers from one system to the other, but it seems that this analysis does not give enough attention to the difference between new N_r and recycled N_r. Adding up the totals in the far right column certainly involves double counting.

Page 81, line 8: I am not sure what the phrase "the remaining N" refers to. I am also not sure why 1.2 Tg of manure N in agricultural lands, and 3.8 Tg of manure in grasslands adds up to 6 Tg total. Maybe the difference is the "remaining" manure?

Page 82, line 16: section 3.2.5.1 appears to be incorrect.

Pages 82 and 83. I found this discussion rather confusing. Perhaps a diagram would help.

Page 85, line 4: "higher ranked consumers"? Maybe "animals and aerobic microorganisms"?

Page 86, line 2: insert "of" after movement

Page 87, line 34: ES = environmental system?

Page 88, lines, 27-39. The lengthy footnote found on page 91 that discusses this issue should be part of this section, rather than a footnote, except that the phrase "may need to

be reconsidered” should be changed to “need to be reconsidered”. Also, consider the following paper that showed no change in soil C over the last 50 years in central IL:

David, M.B., G.F. McIsaac, R.G. Darmody, and R.A. Omonode. 2009. Long-term changes in Mollisol organic carbon and nitrogen. *Journal of Environmental Quality* 38:200-211.

Page 94, line 28, through page 95, line 15 is a duplication of section 2.3.4.

Page 96, line 20: “ the ideal framework” seems overly promotional for a scientific document. I think it would be better to state that it provides “a comprehensive framework”

Pages 97-8, section 2.4.2.2: I did not see much value or relevance to this section. I think it could be deleted.

Page 99, line 28: refers to Figure 20 should be Figure 19. From this point on, the figure numbers identified in the text does not match the actual figure number.

Page 106, Figure 21. I did not see much value in reproducing this figure.

Page 109, Table 18: I think it should be more clear what the percentages in the Nitrogen Management Target column represent. They seem to be percent reductions of current or recent Nr loadings, but it would be helpful to make that more explicit.

Page 109, line 15: is “disproportionate” the correct word? I think they meant “disappointing”

Page 110, lines 14-15: N causes “substandard levels of dissolved sewage treatment plants in LI Sound” ? Some words got deleted or mixed up there

Page 119, line 14: I think there should be the word “at” inserted after “aimed”.

Page 121, line 9-12: This sentence is confusing. I suggest it should be modified as follows:

“The only way to determine the extent that critical thresholds are limiting is by overlaying them for different regions and determining by monitoring data or by model exercises where and which sources contribute to exceeding the critical threshold ~~is the limiting factor, and then identifying the best methods for~~ putting caps on ~~losses from relevant~~ sources.”

Page 123, Table 21: In the middle column several of the entries are “NR” and should be Nr.

Page 125, line 4: delete “neither”

Page 126, line 2: Danish cereal crop yields are described as remaining relatively constant in Figure 24, but Figure 23 shows cereal crop production over time, and there appears to be an increasing trend.

Page 127, Figure 25: the figure caption references a 2002 publication but the data in the figure go through 2005. Several authors have presented similar analysis based on USDA data. I think the report can simply cite USDA data. Figure 25 presents an updated version of a grain yield per unit of fertilizer input that was presented in Figure 7.

Page 128: It could perhaps be mentioned that Duvick et al (2005) and Duvick (1997) have reported declining protein content of corn hybrids in the US.

Duvick, D.N., J.S.C. Smith, and M. Cooper. (2005). Changes in performance, parentage, and genetic diversity of successful corn hybrids, from 1930 to 2000. In C. W. Smith, F.J. Betrán and E. Runge (eds). *Corn: Origin, History, Technology and Production*. John Wiley & Sons, Inc., New York.

Duvick, D. N. (1997). What is yield ? In *Proceedings of a Symposium for Developing Drought and Low N-Tolerant Maize* (Eds G. O. Edmeades, B. Banzinger, H. R. Mickelson & C. B. Pena-Valdivia), March 25±29, 1996, CIMMYT, El Batan, Mexico. CIMMYT, Mexico, D. F.

Page 143, line 14: delete “for the WRP” as this was mentioned at the beginning of the sentence.

Page 151, line 11: The assessment of Cassman et al. (2002) was based on data collected from the 1995-1999 growing seasons, not the 2000 growing season as stated on line 12. It may also be relevant that Cassman was using a different definition of NFUE than was defined in this report on page 43 (footnote 5). As defined on page 43, NFUE has units of kg grain per unit of N fertilizer applied. Cassman et al. defined a recovery efficiency as the difference in above ground N between a fertilized and unfertilized crop divided by the quantity of fertilizer applied. A problem with this approach is the unfertilized baseline is an artificial condition influenced by the prior crop residues.

Page 152, lines 15-17: some citations that describe the storage systems would be valuable.

Page 152, line 21: “bemoaned” does not seem to be an appropriate descriptor of an NRC report.

Page 153, lines 29-30: there appears to be some words missing in the sentence starting with “Sommer”.

Page 153, line 34-36: This sentence states that all unused fertilizer plus some of the N fixed by soybeans moves to surface and groundwater and ignores denitrification and long term storage. This statement, and the entire report also ignores the fact that soybeans in much of the Midwest are a net sink of N. Like many legumes, soybeans can reduce their investment in fixation if there is an abundant supply of soil N, and much of the plant N is transferred to the bean. In most years, soybeans remove more N from the soil than they leave behind in crop residues.

Page 156, line 2: “a side reaction for the ... catalyst system is ammonia” probably should be “...produces ammonia”

Page 157, lines 5-7 are duplicated by lines 8-10.

Page 157, line 18, NR should be changed to Nr.

Page 159, Target Recommendation 2 seems to fit with the text of Target Goal 3 (page 161), and Target Goal 2 fits with the text of Target Recommendation 3.