

U.S. Environmental Protection Agency
Science Advisory Board
Integrated Nitrogen Committee
December 8, 2008 INC Teleconference
Final Minutes

Date and Time: December 8, 2008 from 2-5 p.m. (Eastern Time).

Location: by telephone only.

Purpose: As announced in Vol 73 Number 185 Pages 54803-54804 on September 23, 2008, the purpose of this teleconference is for the committee to discuss the first external review draft of its report.

Materials Available: Materials made available for the INC's earlier meetings and teleconferences are identified in the minutes for those meetings. The first external review draft and three public comments on it were circulated to the INC and posted at the SAB website (Robbins Church, Dan Jaynes, and Kapichak) in advance of the teleconference. Joseph Rudek's comments were received the day of the call. These will be circulated and posted at the SAB's website (www.epa.gov/sab).

Attendees: INC members Aneja, Boyer, Cassman, Cowling, Dickerson, Doering, Galloway, Hey, Mosier, Shaw, Stacey and Theis were present on the call along with the Committee's Designated Federal Officer Kathleen White. Andrew Manale and Randy Waite of EPA were on the call as were Charles Kovich (Florida), Joseph Rudek (EDF), Penelope Whitney, and Pauley Bradley (John Deere)

Summary:

There were no "show stoppers". The INC members decided how to address, and who would address, comments from Church, Jaynes, and Kapichak. The DFO was directed to summarize the assignments for the Committee. The chair will send Joe Rudek's comments to INC and DFO.

After a review of the teleconference agenda for December 9 and member's schedule conflicts, the INC decided to begin the call an hour late. The DFO will be on the call from the announced time onwards to share this news with people who were not on today's call. INC and others will join at 3 p.m.

Even if the INC completes its business by 5 Tuesday December 9, the Committee will be on the call Wednesday December 10 at 2 in case there is a public comment of which we do not yet have notice.

Details

After the DFO called the roll, James Galloway welcomed those present, reminding them that this is the first in a series of three teleconferences to review the first external review draft of the Committee's report. He asked if there were procedural comments and received none.

Public Comments

Galloway noted that four individuals have provided comments on the first external review draft (M. Church, D. Jaynes, R. Kapichak and J. Rudek). The last has just arrived and had not been posted at the SAB website at the time of this teleconference.

Joe Rudek highlighted two items from his written comments and expressed a hope that he could comment further on December 9. First, he would like to see the public included in the recommendation for an intra- and inter-agency task force. Second, while he commended the Committee for making numerical goals, he didn't see the support for them. There will be a lot of debate on the goals and discussion can be elevated by making the reasoning and calculations public.

Charles Kovack thinks the draft report is excellent. He will provide two papers that he believes could provide an approach to reconciling the tables in the INC report. INC has done a good job being clear that they are looking at global and national scale issues. He would like the ability of locals to address regional variability not to be further constrained. He noted that TMDLs are being developed for mercury in the Greater Mississippi River Basin and wetlands are a primary point of mercury methylation. In cautioning readers to balance effects of various approaches, INC might want to provide some examples.

Overarching Committee Comments

Galloway polled the INC by chapter about whether they had found any "show stoppers" - "show stoppers" being serious flaws which would require a fundamental change to the document.

Chapter 1 is the Executive Summary containing material from the rest of the report. The Committee members had no comments.

Chapter 2 is pretty straight forward general background on the environmental impacts of nitrogen loading. The Committee members had no comments.

Chapter 3, Section 3.1 is an introduction but it contains the most important table in the entire report. The Committee members had no comments.

Chapter 3, Section 3.2 discusses the sources of reactive nitrogen. Otto Doering reported he provided Cassman with comments on the Carbon-Nitrogen cycle. Ken Cassman sees Doering's comments as

clarifying, not show-stopping. Aneja concurs that minor adjustments are needed, but there are no show-stoppers. There were no further comments.

Chapter 3, Section 3.3 -- The Committee members had no comments on Section 3.3.

Chapter 3, Section 3.4 addresses impacts and metrics. The Committee members had no comments.

Chapter 4 addresses risk reduction options.

Tom Theis referred to earlier comments on the basis for the INC's reduction targets and observed that, while this is not a show-stopper, it is clear that INC didn't explain the basis as well as it should have. INC applied existing technology to develop the targets. INC thought that, since technology-based standards are quite common at EPA, this would be a comfortable way to approach to problem, given the constraint of needing to provide protein to the US and the world. He noted that neither section 3.4 nor Chapter 4 applies the approach Moomaw took to the Chesapeake Bay. INC views this as beyond its scope because it is so site-specific.

Bryan Shaw expressed concern over the basis for the target numbers. He urged caution to avoid the appearance of setting arbitrarily goals. He is also concerned that the targets are somewhat misleading because the nature of Nr is that you have to look at it holistically. Galloway asked that Shaw write what he said and send to DFO and chair; he agreed.

Discussion of the Chapter 3 by Section

Section 3.2

Viney Aneja and Ken Cassman developed Section 3.2 with other members of Working Group #1. Dan Jaynes of USDA had provided written comments on Section 3.2 to which Drs. Aneja, Dr. Cassman, and other INC members responded.

Regarding Jaynes comment, "C1-6. Either combine or more clearly delineate the differences between OR 1-2 and OR 1-3. Currently, there appears to be much overlap between these two recommendations and I'm not clear how they differ or why they can't be combined into one," Drs. Aneja and Cassman respectfully disagree.

Aneja and Cassman agree with the following comment, "C1-8. Recommendation R1-3. The other three recommendations include a "through" statement that at least gives some indication as to how the committee believes the goal can be attained. No such statement is included for this recommendation – perhaps because the committee is unsure if/how it can be accomplished in a realistic manner. Also, little justification is given in the text to support the 20% reduction value (or for the 20% reduction value in R1-2). Setting these reductions as goals may be worthwhile, but a realistic accounting of the

risks, costs, and mechanisms for attaining these reductions needs to be provided,” and will implement it.

Aneja agrees the committee has not addressed the topic addressed by this comment, “C3-8. Recommendation R3-1. Can the panel estimate what the magnitude of savings would be for control of off highway sources within the U.S.? If substantial, I’m surprised that control of this source of Nr combined with ramping down further emissions from highway and industry sources is not a priority for the panel as Nr production from these sources is completely a waste product. I came away from the November panel meeting thinking that control of this source would be emphasized, but its not isn’t listed on p. C1-7 with the other 4 highlighted Recommendations.” He is not sure INC can. Dr. Dickerson said he and Dr. Lighty will provide on what fractions of NOx can be removed from off-road diesel. In sum, INC agrees and will address.

Jaynes commented, “C3-13 Finding F3-3. It is impossible to determine that farmers don’t follow BMPs by just using USDA statistics as these only report average use rates etc. and it is not possible to pick out the farmers over applying. Also it is unclear what the panel means by BMPs for N, as many farmers currently follow state extension guidelines for N use, but these may not be the best methods known for optimizing NUE – only the most cost effective or practical.” Aneja believes this is a good comment and can be addressed. Cassman doesn’t understand the comment. Cassman thinks Jaynes is saying that other approaches are even better than BMPs, but INC’s approach to risk reduction is to use existing BMPs. Aneja, reminded us that the INC draft says, “a large proportion of farmers do not follow the BMPs for N.” Cassman said that INC got the statistics from USDA and they do show relatively low adoption rates. Cassman disagrees with the comment and thinks the solution is to clarify it. Aneja summarized that they will clarify with input from other INC members.

Aneja disagrees with this comment, “C3-13 Recommendation R3-3. While these may or may not be viable recommendations, none are supported by the narrative immediately preceding this recommendation. How would NRDs (#1) improve N use or are you assuming a regulatory function for these? Subsidizing EE fertilizer products (#2) will certainly be needed if they are to be widely used, but first these products must be shown effective and the management schemes developed for the major commodity crops. The science isn’t currently there yet. Improving education and extension is desirable (#4) and on-farm networks can be effective, but remember that most farmers get their fertilizer information from coops, crop consultants, and fertilizer dealers and not from University Extension. How does the panel recommend the enlistment of these groups in improving N recommendations?” Cassman thinks the difficulty is that INC did not say why the natural resource district system works. Cassman says the theory of how to improve efficiency is robust and we should encourage research, development, demonstration and adoption. Aneja sees this as encouraging the agricultural community and should be said. He summarized that they will clarify the text to address what is being asked as appropriate or respond to the comment.

Aneja agrees with this comment, “C3-16. Recommendation R3-4. Overall, these recommendations are not substantiated by the text immediately preceding them. Also, (1) NUE as defined in this report “grain yield per unit N applied” is quite easily determined at least on average using NASS statistics. What is not easily determined is “grain yield per unit total N” that includes mining of soil N, manure, fixed N from legumes, etc. (2) No citations are given regarding the use of “smart” N fertilizers on the main commodity crops, probably because there are few to none showing both yield returns and water and air quality benefits. While there may be a potential for these products (if subsidized) research clearly showing their benefits is required first. (3) I agree with this statement and there is research currently being conducted in this area. That is why I’m surprised that your main Recommendation R1-3 states “crop output (can) be increased while reducing ... by ... 20% ... applied artificial Nr” as there are still numerous research and infrastructure barriers to be overcome.”

Cassman feels that doing a detailed review of the literature for this is beyond the scope of the INC. INC is trying to distill it down; the details are in the references. He thinks adding more detail will make the report less readable. Galloway agrees in principle, but would consider a few tweaks here and there to help the reader find the relevant literature. Cassman says the big picture is to link supply with demand. Smart fertilizers are one tool within that approach.

Aneja says that they can add the sentence and text recommended in this comment, “C3-17, 130. N₂O losses may be < 1% of N applied in many fields, but in the higher soil organic soils of the Midwest corn belt these losses can approach 7% and occur in both the corn year (when N is applied) and in the soybean year (when N is not applied). See Parkin and Kaspar, JEQ 35:1496-1506,” but he thinks the text is clear as it is. Cassman thinks the comment is based on a mis-reading. Jaynes is focused on the 0.3-3.1%. This suggested adding the new reference and leaving the text. Cassman doesn’t want to add a reference they haven’t looked at. INC’s job is to be integrators and sifters. If it is a good study, we can add it, but it has to be well done.

Aneja said both Cassman and Doering have discussed the biofuels topic extensively. He thinks the reviewer’s comments below are based on a snapshot.

C3-20 11. While there was a jump in corn acres in the U.S. in 2007, 2008 data show that at least half this gain in acres has been taken back out of corn. Also corn prices have moderated extensively, so statement on price increases in previous sentences is also obsolete. Perhaps it would be better to point out how corn for ethanol and corn prices will be intimately tied to world wide oil prices now and in the future.

C3-20 Finding F3-6. Again, this conclusion is inaccurate given current developments in the biofuel, corn, and fertilizer markets. The fertilizer cost (\$0.61/lbs NH₃) to grain price (\$3.54/bu) ratio is currently in favor of reduced N inputs, but all of these markets are volatile.

Aneja defers, therefore, to Cassman and Doering. Doering is providing language to update the text based on what has happened in the last three months. Cassman will work with Doering to update along the current lines of the report.

Aneja is willing to make this suggested change, “C3-22 Recommendation R3-7. I’d change the wording to “ammonia/ammonium *should* be monitored nationwide” given their importance and uncertainty.”

Aneja finds the following comment thought-provoking, “C3-28 I31. Much of the N deposited in pastures and rangelands is taken up by the grasses growing there so that it is inaccurate to say that this N “was not recovered for further use”. Cassman agrees the nitrogen contributes to the range system and the language needs to be amended. Dickerson asked whether the problem is when Nr doesn’t fall on pastures and rangelands, it is a pollutant. Aneja summarized that they will accept the comment.

Aneja agrees with the comment, “C3-29. Finding F3-8. Farm level improvements may be helpful, but this finding would carry more weight if the preceding section gave examples of technologies that have been shown to be effective and an estimate of the additional costs involved.” He will work with other INC members to get those examples.

Aneja and Stacey agree with, “C3-30 I23. Should reference the research cited illustrating N leaching in turf,” and will add references. Mosier said he and Cassman wrote this and have the references. He’ll fix it and pass by Stacey.

Galloway asked if anyone wanted to add anything else about Section 3.2. No one had any other comments.

Section 3.3

Arvin Mosier and Russ Dickerson, co-leads for Working Group #2, lead the discussion of Section 3.3

“C3-47 Finding F3-10. I did not see any evidence to increasing NH₃ emissions presented in the previous section and question this finding for accuracy.” Aneja thinks the existing finding is OK. Theis agrees. While we may lack direct ammonia emissions data, where else could it come from? Galloway thinks the finding should be refined to say something about regional nitrogen emissions are going up. Theis thought INC was on record as favoring a regulatory scheme for ammonia. Now it sounds like we are backing off from that. Dickerson disagrees that they are weakening on that issue. There are regional increases, but this discussion is about the national values. Galloway asked Aneja, Dickerson and Mosier to work together on this.

Mosier sees no problem with this, “C3-48 I20. A more accurate phrase would be “provide nutrients” instead of “provide fertilizer”. Dickerson said that, given the absence of ammonia measurements, this is true. “

Mosier thinks a couple of sentences explaining where the numbers come from and a few sentences linking the section of the reports where it is addressed should be adequate to address, “C3-51 Fig. 3-13. I don’t understand the N storage component of these systems. As this is a continuous annual budget, new storage in soils implies an ever increasing soil organic matter content or a decreasing soil C:N ratio. Neither has much credence in the literature. It is probably best to assume a long term steady state in soil organic matter and thus no new net storage in your budget. Also the inputs and outputs do not balance in the different. I suspect that the 2.0 Tg N Transfer term should be balanced by a decrease in the Products term.” He thinks rounding errors might account for the rest and he will check.

Mosier thinks this comment, “C3-57 Table 3-15. Do not confuse no-till with conservation tillage. No-till and reduced tillage are forms of conservation tillage but the converse is not true. Baker et al, 2007 based on the study by West and Post, 2002 looked specifically at no-till not all conservation tillage. Also, I would question the panel’s conclusion that any N is being newly stored in agricultural lands, i.e. that soil C stocks are increasing. This needs to be better substantiated in the text,” can be addressed through more careful references to table 3-15 about how the numbers were derived and a slight modification to the statement in table 3-15 where the asterisk refers to the amount of soil carbon stored.

Regarding, “C3-60 Section 3.3.3.1. It is confusing how you interchange the use of watershed and catchment in this section. Please use catchment consistently when referring to the 16 catchments, e.g. caption for Fig 3-14 should read in part “using weighted averages for all 16 catchments)” not watersheds,” watersheds is the appropriate terminology based on the paper by van Bremen et al where they address 16 northeastern watersheds.

Mosier says that there isn’t a conflict but different points of view in “C3-62 Tables 3-19 and 3-20. I find the numbers in these tables confusing, especially when compared to those used in the Nr cascade (p C3-64) or Figure 4-2. Different break downs of the components are used and categories are mixed making it difficult to impossible to compare the different representations of Nr. Other features are also confusing, in Table 3-19 if 4.4 Tg N comes from crop residues and 4.7 Tg comes from SOC does this imply that SOC is decreasing over the long term? Likewise in Table 3-20 if 4.7 Tg N goes from soil to crop where is the return N to the soil so that SOC does not decrease dramatically over the short term? Finally, the values in the tables do not agree with the value given in lines 1-12 on p. C3-63 (e.g. 5.9 Tg atmospheric deposition on p. C3-63 but 5.4 Tg in table). I’d urge care and greater uniformity in the portrayal of the N budgets among all sections of the report.” Mosier thinks they may need to eliminate some of the tables to make it clear. Galloway thinks this isn’t just a problem with these two tables, but a larger issue. He and Mosier will work on making the foundation numbers in the report traceable throughout.

Mosier referred to Cassman about this comment, “C3-67. Interesting that Booth and Campbell recommend that the most productive agricultural land, the land that is most intensively cropped, should be the land targeted for land retirement. This appears to be counter to your “intensification” argument made earlier.” They spoke of the Booth and Campbell reference. Doering noted the other references is the initial hypoxia assessment which reached the same conclusion – if you are going to cut back on excess nitrogen flows a key component is retiring leaky lands. Cassman sees no disagreement about that. He thinks the challenge is that, if retirement of that land means that other, even leakier land, comes into production, then there is no net benefit and there may even be a worsening. Stacey thought the issue was that Booth and Campbell indicate a small, but intensively cropped area of the Mississippi River Basin, are the source of most of the Nr. He asked whether this is because of the nature of the soils? The intensive cropping? Or what? Cassman says we need to find out what land they are talking about, where, and the kind of soils. Because of their biophysical properties, sandy soils will leak. Other data show that, if you address the 10% most vulnerable land along waterways, you will have a great impact. Similarly, the wetlands people suggest that turning the most vulnerable lands into wetlands will reduce Nr releases to water. Doering thinks the lands discussed were on the fringe of the corn belt and both leaky and not very productive. Over time, more food will have to be produced for more people, which means intensification of farming. Cassman, Doering and Mosier will discuss.

Mosier thinks that, “C3-67 143. Conservation has little direct effect on increasing crop yields. Only in the long term can one argue that conservation tillage, by saving topsoil, would impact yields and this benefit has been poorly if at all substantiated by field observations,” can be addressed by using the words “conservation tillage” and Stacey agrees. Cassman says it depends on where you are in the corn belt. In the western portion, conservation tillage is a great benefit; in Iowa not so much, but on average, it increases yields. Mosier says they can respond that there are very different regional differences and leave it be.

Jaynes next comment was, “C3-68 118. I agree that the goal is greater synchrony between N application and N need by the crop. We already know for example that side dressing N in response to a soils test or perhaps in response to a sensed N deficiency in lieu of fall N application can improve N use and decrease N losses. But the challenge is addressing the numerous institutional and logistic roadblocks to farmer adoption of these practices. Farmers apply N in the fall for many reasons (lower N prices, favorable soil conditions, opportunity time). These will have to be overcome to move farmers away from this practice. Institutional roadblocks also exist, such as the requirement by fertilizer dealers for farmers to preorder N fertilizer, making adaptive N application impossible or inability of coops to provide N for all farmers in the spring. Only a concerted, well coordinated, sustained effort can move the entire industry to a more effective N application regime. The question is how can EPA and other federal and state agencies help this effort? “ Cassman said Jaynes is saying there are reasons why farmers haven’t adopted some of the BMPs. Doering thinks INC understands that. Cassman thinks INC needs to mention them, say INC understands them, and they should be addressed – perhaps in Section 3.2. Mosier will draft edits with Cassman and Doering.

Cassman thinks INC is saying you can increase NUE, reduce Nr, and still increase yields. The only way forward is to increase BOTH efficiency and yield together. He doesn't agree with the assumption that reducing fertilizer means reduced yield underlying, "C3-68 125. I assume you mean "decreases in yield" rather than "increases". NUE is not what the farmer is looking at but rather maximum return to investment. The greatest NUE comes from the first unit of N applied and decreases thereafter, but this is not the point of maximum profit. Reducing N applied always increases NUE for a nutrient that follows a diminishing returns response function."

Mosier says this comment, "C3-69 Finding F3-13 and Recommendation R3-19. No mention of biofuels and especially use of biofuel coproducts was made in preceding section so I do not know what this finding and recommendation is based on," is correct. But there are discussions in 3.2 and 3.4. Perhaps the solution is to move this finding to one of those sections. Cassman thinks this is already covered elsewhere and could be deleted. This mentioned the Energy Independence and Security Act. Cassman thinks the findings and recommendations should be merged someplace where they follow a discussion of biofuels. Mosier will work with Cassman, Doering, Kohn, Shaw, and This to resolve. Kohn and Shaw because of the livestock dimension.

Mosier wouldn't argue with this comment, "C3-74. #5. Rates of ammonia emissions need to be quantified, but so too do the rates of ammonia uptake by crops and forests. Much of the ammonia emitted from soil is rapidly taken up by crops and does not travel far from its origin."

Doering asked whether it has to be said explicitly. Galloway asked whether the statement is true. There was no reference provided. Aneja gave his insight; there are two schools of thought. Researchers in the US, such as Robin Denis, think that what is released converts to ammonium and some fraction travels long distances. The Europeans generally see it like the commenter (Jaynes). There is a dichotomy of opinion. Galloway asked how INC should deal with it. We could keep adding more and more things. Jaynes is not contesting #5. One possible response is leaving #5 as it is and adding a comment about the uncertainty about ammonia. Mosier suggests a sentence saying that due to the differences in opinion, INC has decided not to discuss at length. Dickerson agrees nothing needs to be changed as ammonia deposition is discussed elsewhere in the report. Boyer says this is not just an ammonia issue, but a broader one. It is hard to understand; the variance over space and time is complex and discussed in the atmospheric deposition section. Mosier will work with Aneja, Boyer, and Dickerson. Cassman notes that, in general, average wind speeds in America are higher than in Europe which may account for the difference.

Section 3.4

There were no public or other comments on Section 3.4 to discuss.

Chapter 4

Galloway asked Theis to address the last comment from Jaynes, “C4-11 | 20. As noted above the 10% increase in crop acreage for corn is out of date. Perhaps a more general statement about the volatility of corn for biofuels and its linkage to global oil markets would be more appropriate.” Crop yields and prices rise and fall, but the medium-term demand for corn is only going to grow, so that the INC statement is true. EISA takes us through 2015. He thinks this is a mismatch between the reviewer’s comments and what the INC is writing about. Perhaps the language can be clarified. Cassman addressed the 10% acreage increase saying it is the same one Doering will be addressing. Perhaps he could broaden it out and say that corn acreage will increase due to EISA. Doering and Theis will work on this to get consistent language in both places.

After observing that Jaynes had the most extensive specific comments and they have now been dealt with, Galloway turned to the comments of Church and Kapichak.

Commenter #1, Robbins Church from EPA has three comments. One is stylistic and Galloway will address. The second asks for a definition of “excess” which is not simple. Cassman agrees this is important and should be fixed in Chapter 1 or 2. Galloway will draft language and run it past INC. Church’s final comment is a slight wording change which Galloway will look at.

Commenter #3, Rudy Kapichak, suggested a working change on page C3-110. Dickerson thinks this is EPA worrying and it wouldn’t be much of a problem to fix. He thinks INC can make the changes. Theis agrees in general, but doesn’t know about the paint part; Dickerson said that deals with smog, not Nr. Doering saw no obvious problem with adopting Kapichak’s comment.

Galloway returned to Jayne’s general comments:

The first has been addressed. It is, “The draft is an excellent summary of the national Nr budgets and the consequences of Nr enrichment of air, water, and land resources. The national Nr budget is presented several times and in several different ways and it is not always clear how these various budgets relate to each other as various sources and sinks are alternately combined or split out. Multiple presentations of the Nr budget make the draft repetitious. This has probably resulted from the document being written by various teams, but these inconsistencies and repetitions need to be corrected before the final document.”

Galloway asked the co-leads to check and be sure that the findings and recommendations in their sections are substantiated. This is to address Jayne’s comment, “Many of the Findings and Recommendations within the body of the report are not substantiated by the text in the section preceding their listing. They may not be wrong or misleading; they just don’t follow logically from the discussion in the preceding text.

This would be a much stronger and influential document if the Findings and Recommendations are drawn directly from pertinent cited research. Many of the solutions proposed are poorly documented. The use of EE N fertilizers is a prime example as they are presented as having a great potential to reduce Nr losses, but no research is presented showing their efficacy or practicality in the production of the major commodity crops, where the vast majority of N fertilizer is used and lost. And in fact, there exists little data showing their efficacy in producing good crop yields while reducing losses of Nr. Improved tile drainage systems are also cited as possible solutions (C1-7 143) and while I agree with this assessment, nowhere in the draft do you explain what is meant by improved drainage systems or research cited where they have been proven effective.”

Glossary

Galloway thinks they will have to return to this issue, “A glossary of terms and acronyms needs to be included. For example the definition for NOx and NOy is never given. Likewise jargon such as “ammonia slip” need to be defined. Acronyms such as PBL are used and never defined.” Galloway asked the co-leads to send the DFO the terms and definitions which need to be in the glossary with their definitions.

Next Calls

Galloway reviewed the agenda for the December 9 teleconference with the Committee. Because several members are not available until 3 p.m. Eastern and the Committee made more progress than expected on December 8, the start time for the December 9 call will be moved to 3 p.m. The DFO will be present on the line from 2 p.m. onward in case people who have not heard today’s discussion participate on the 9th.

Even if INC completes its business by 5 on December 9, the INC will be on the call December 10 at 2 in case there is a public comment of which we do not yet have notice.

Summary

Galloway assigned the DFO to draft a summary of today’s discussion and assignments. Galloway will send Rudek’s comments to INC and White; DFO will send to the Committee.

The teleconference adjourned at 5:00 p.m. Eastern.

Respectfully Submitted:

/ s /

Ms. Kathleen E. White
Designated Federal Official

Certified as True:

/ s /

Dr. James N. Galloway, Chair
SAB Integrated Nitrogen Committee