Response to external reviewers' comments discussed at the May 14-15, 2009 SAB Integrated Nitrogen Committee

External review comments organized by section of the INC Report (Page numbers refer to the March 19, 2009 Review Draft)

Comments	Response
General Comments	
From Dr. John Day	
Review of EPA Nitrogen Report	
The report is a detailed treatment of reactive nitrogen in the US. It is comprehensive and a wealth of detail is provided. But the report suffers because different topics are treated in different detail. Many of the conclusions and recommendations are so general that they don't provide a clear idea of what should be done next.	No change required ES identifies overarching and 3 major recommendations
Climate change is dealt with very briefly in spite of the fact that climate will certainly have a dramatic impact on nitrogen dynamics. The loss of nitrogen from agricultural watersheds is strongly dependent on rainfall. Predicted increases and decreases in rainfall will likely have a dramatic impact on nitrogen export from ag fields. For example, precipitation is predicted to increase in the upper Mississippi watershed, and other factors being equal (but see below), N export should increase (e.g., Justic et al.). In the southwest, more winter precipitation is expected to fall as rain rather than snow. This may impact agriculture	New section of report added for interaction of C and N. Committee will consider whether recommendations Report adds sentence defining climate variability and providing short discussion Additional text introduced by Viney and Ken "The loss of nitrogen from agricultural watersheds is strongly dependent on rainfall. Predicted increases and decreases in rainfall will likely have a dramatic impact on nitrogen export from ag fields. For example, precipitation is predicted to increase in the upper

Comments	Response
throughout the region and lower N export. The southeast may also have lower rainfall. Such topics should be dealt with in more detail because climate change may increase or decrease the need for dealing with excessive N in rivers. There is an extensive literature on this topic much of which is summarized in a series of PEW Center reports.	Mississippi watershed, and other factors being equal (but see below), N export should increase (e.g., Justic et al.)."
Energy is a topic that is not covered at all in the report but which will likely have dramatic impacts on both N dynamics and our ability to study them. There is a growing consensus that the world society is transitioning from a century of relatively cheap energy to a future where energy will be much more expensive and scarce. There is strong evidence that conventional world oil production has peaked or will peak soon. There is a quite robust literature on this subject that the report should refer to and analyze. In a time of energy scarcity, natural resource management will have to change to a less energy intensive approach. And the kinds of studies that scientists do will also be constrained by energy availability. For example, during the run up in oil prices last year, the price of fertilizer increased substantially. Although oil prices have fallen, the long-term trend is certainly for increasing energy prices. It is likely that in a decade or two, the price of fertilizer will be so high that farmers will be very efficient in its use resulting in greatly reduced fertilizer runoff from farm fields. When the economy of Eastern Europe collapsed in the 1990s, fertilizer use declined dramatically and Mee reported that hypoxic conditions in the Black Sea nearly disappeared in a short time period. It is likely that agriculture will return to what Boody et al. (Boody et al. 2005 BioScience) called multifunctional agriculture. The implication of this is that problems related to fertilizer runoff from ag fields	Text drafted text for ES, Introduction Response to statement about Boody et al.: This statement is not correct. Boody et al ignore the tradeoffs between productivity and multifunctionality. In fact, there is a strong trend globally towards simplification and intensification of cropping systems because of limited availability of good arable land for agriculture. And, as urbanization, industrialization, and land uses other than agriculture continue to expand, these pressures will rise. Without continued intensification of staple crop production on existing farmland (intensification = more crops per year on the same land, and/or higher yields), global crop production area must expand massively at the expense of rainforest, wetlands, and grassland savannahs. The challenge is therefore to achieve intensification in an ecologically sustainable manner, which means achieving much higher NFUE to greatly reduce Nr losses. We do mention the possibility of more diverse ag systems, but only if they do not reduce productivity of food production per unit area and time. Bottom line—no need revise text or address this comment.)

Comments	Response
(eutrophication of rivers, streams, and coastal waters, hypoxia, etc.) are likely to decrease. This information should be included in the report as possible future scenarios.	
I suggest that the role of wetlands in controlling N pollution should be treated more extensively and comprehensively in the report. There is some mention of this subject but in not much detail and it is scattered throughout the report. I suggest that it should be treated in its own chapter and this could be referred to throughout the report. Mitsch and colleagues have proposed a comprehensive program for the Mississippi basin. This should be discussed as an example of what can be done.	New text provided for ES, Introduction, and other sections of the report
From Dr. Elizabeth Holland:	
The basic premise of moving towards a comprehensive holistic view of the environmental consequences of the ongoing dramatic increase in the use of nitrogen and the atmospheric-land-water exchanges of reactive nitrogen is one that I support enthusiastically. However, the draft report falls well short of its intended mark. Future versions of the report need to build more strongly on the published literature and must include a clearly articulated plan for integration of the work with strong emphasis on both models and data.	ES revised to describe more clearly how the cascade relates to drivers and effects
The report does not adequately take into account its ambitious holistic scope. Instead it comes across as series of research recommendations that interest the people who wrote the report. The report does not adequately build on the underlying science. Much of the science cited is old parts of the literature and has not been updated to the	The INC respectfully disagrees that modern literature as not been used. Agree on importance of collaboration with USDA and have included it as overarching recommendation Revised executive summary expands on importance of collaboration.

Comments	Response
modern literature. Because agriculture is at the center of the problem, I suggest that subsequent versions of the report build strongly on interactions with the agriculture community laying the groundwork for the strong interactions with USDA called for in the report.	
A striking omission of the report is the connection between the climate system and the nitrogen cycle. The EU is currently funding Nitro-Euro, a multi-million dollar project that was motivated by this connection. A Science paper by Hungate et al in 2002, a series of ongoing studies by MIT (Sokolov et al. Journal of Climate 2008), Princeton (Levy, and others) and NCAR (Thornton et al 2008) underscore the importance of the links between the carbon and nitrogen cycle. The centrality of the carbon cycle to climate change and the impact of the N cycle on carbon uptake are the top of the list, followed by N2O, NO and its role in tropospheric ozone production, and the increasing importance of N containing aerosols that play a role in global warming make a compelling case for addressing the connection between the changing nitrogen cycle and climate change in this report.	New section developed
Recent work suggests that the ongoing declines in fertilizer use throughout the mid-west are not sufficient to decrease the ongoing recurrence of hypoxia in the Gulf of Mexico. See particularly work by Laurie Drinkwater and Mark Davids of Cornell and a paper by Vitousek et al. submitted to Science (The manuscript may be available directly from Peter Vitousek at Stanford). The body of work suggests that years of excess fertilizer use may have sufficiently bolster soil organic nitrogen content to compensate for reductions in fertilizer use and provide an ongoing source of reactive nitrogen N to downstream ecosystems.	The INC respectfully disagrees. *Response: We examined the Drinkwater/David papers. They are modeling studies that show existing models do not do a good job of predicting nitrous oxide losses from agriculture. Nothing new here. The Vitousek paper mentioned is submitted to a journal, which means it has not completed peer review. But the premise of the paper, as state by this reviewer, simply does not make sense. If we are prepared to accept a reduction in soil organic matter by "mining it down" from present levels as a source of N for crop production, this means a huge flux of CO2 to the atmosphere, which will accelerate climate change. Likewise, it makes no sense to replace N supply from mineralization of*

Comments	Response
	soil organic matter, which is relatively slow and synchronous with crop demand, with fertilizer N, which is more difficult to control in the environment—eventually the reduced soil N supply must be made up for with applied N, especially as there is a need to increase yields on existing farm land to avoid indirect land use change . Bottom line, no need to make revisions in response to this comment.
The report requires a strong editorial hand to remove redundancy, increase the precision of the wording in the findings, recommendations and executive summary, and standardize the report throughout is needed. The current report is quite variable across the sections and needs considerable strengthening.	Report was edited to address these ribkens.
<u>From Dr. Gregory McIsaac</u>	
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.	Report was edited and revised in light of detailed suggestions from this reviewer
I think this draft report represents a useful step in the process of improving understanding and management of Nr.	
<u>From Dr. Jerry Melillo</u>	
Preliminary review comments on *Reactive Nitrogen in the*	

Comments	**Response**
United States; An Analysis of Inputs, Flows, Consequences, and Management Option (March 19, 2009 draft)	
General comments (to be supplemented by more detailed comments by May 11th)	
• Overall, the report is terrific. It is valuable because it conveys the nitrogen cycle and its implications to the general public in an easy to grasp way – a difficult job well done.	
• The document frequently uses the verb "must," a word to be used carefully in science and science policy contexts. A careful examination of the entire document to ensure that the recommendations reflect exactly the committee's intentions would strengthen the report.	Document was carefully examined for the use of this word.
• The report would benefit from copy editing to ensure standard usage(commas, hyphen use and so on) throughout the document.	Report was copy edited; additional editing will happen after the chartered SAB quality review..
From Dr. Giles Randall	
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 noted. Report revised to correct inconsistencies
From Dr. James Schauer	
The subject report is well organized and well written. It	

Comments	Response
contains excellent background material on the nitrogen cascade, sources of reactive nitrogen, and the flows and inventories of reactive nitrogen in the environment. The analysis appears sound and the recommendations are appear to be scientifically robust. As my expertise is in the atmospheric science and combustion related fields, my review and comments largely focused on these components of the report. I do have several comments that should be addressed before the report is finalized and distributed. I do have several comments that should be addressed before the report is finalized and distributed. These commented are as follows:	
1) The framework for discussing the transport and inventory of reactive nitrogen across environmental compartments is somewhat deceptive in terms of the atmosphere. Due to the timescale of mixing across the global troposphere, it is not reasonable to view the US atmosphere as a well defined entity. It appears that the export of reactive nitrogen from the US via the atmosphere is considered in the analysis and mass balance but that the import of reactive nitrogen to the US via the atmosphere is not considered. I think the reader would greatly benefit from a clearer presentation of the atmosphere as only a global atmosphere, which provides a transport mechanism for deposition in other areas and transport to the stratosphere.	The INC notes that the charge was to examine fluxes among systems in US. Sentence added regarding Canada and Mexico and an uncertainty characterization discussion
2) The inclusion of N2O in reactive nitrogen is understandable from a chemistry perspective but clearly the role of N2O in the context of the nitrogen cascade is very different from other species included in the report. N2O is basically inert until it reaches the largely isolated	Footnote for figure 2 and 3 added to discuss how N_20 is different from other Nr compounds (NOx and ammonia)

Comments	Response
stratosphere, where it is an import species in stratospheric ozone depletion. The integration of N2O with all other reactive nitrogen species will be confusion to many readers. I think a separate section on N2O is needed to clearly explain N2O in the context of the nitrogen cascade and the report. This is particularly important in Figure 2 and 3, which implies that N2O has similar biogeochemistry to other species discussed in the report. As shown in Figure 2, the fate of NOy and NH3 are the same as N2O, which is not correct. It is unclear how the recommendations on page 18 related to N2O.	
3) Throughout the report, one of the impacts of the nitrogen cascade is "global warming." I would strongly recommend to not use the term "global warming" as the impacts of the nitrogen cascade have important impacts on climate forcing that are positive and negative forcings. I would recommend the use of the term "climate change." As written, the report seems to use the term global warming with little explanation and some discussion of direct and indirect effects should be briefly discussed.	Comment accepted – report will use term "climate change"
3) The discussion of mobile sources is a very stagnant perspective on emissions. The discussion of recommended reductions from mobile sources, and which feed into the overall recommendations, due not properly address the growth in mobile source VMT (Vehicles Miles Traveled) and already existing diesel engine emissions regulations that will go into place in 2010 for on-road engines and they are being phased in for off-road engines. The recommendations need to be placed into context of expected growth in emissions and existing regulations that are currently being	Clarification added to the the ES regarding a reference year. Report already acknowledges that EPA is moving toward a high level of NOx control will be more technologically demanding than addressing other sources. Section on diesel regulations updated to refer to 2010 regulations

Comments	Response
implemented.	
From Dr. Stuart Weiss	
First, this document an excellent holistic view of the N-cascade and numerous negative environmental impacts of excess N in air, land, and water, and will be a foundation for finally addressing the issues in a comprehensive and effective manner.	
As a reviewer, my main area of expertise is the impacts of atmospheric N-deposition on biodiversity (mainly in California) and the practical means to address the impacts in the short-term and long-term. I think a little more material on biodiversity impacts and policy responses would be a critical addition to the document, since the effects are a "1" in relevance. There is also some innovative processes, including Endangered Species Act consultations, underway that should be noted somewhere in the report (but I realize that I am providing far more background than could go into the document itself).	
Review work by Fenn et al. (2003) compiled numerous impacts of N-deposition on biodiversity in the western US. Some of these include:	
1) Loss of coastal sage scrub (CSS) in Southern California to invasions by annual grasses and subsequent changes in fire frequency, leading to losses of shrub cover and conversion to weedy annual grassland. CSS has already been reduced by ~90% due to urban and agricultural development and supports dozens of threatened and endangered	

Comments	Response
species.	
2) Invasion of desert scrub by annual grasses that create fine fuel loads that can carry fire across miles of desert lands, in places where such fires were nearly unheard of until recent decades. These fires threaten life and property in addition to converting rich desert scrub to weedy annual desert grassland.	
3) Combined effects of ozone and N-deposition in Southern California montane conifer forests lead to changes in species composition, physiological disruption (needle lifetimes of < 1 year and continual buildup of litter), and increased fire risk, on top of climatic stresses.	
4) Groundwater and surface discharges from heavily polluted watersheds in the LA Basin have extremely high levels of nitrate, including storm pulses and baseflow.	
5) Atmospheric deposition on the order of 8-20 kg-N/ha/yr in the San Francisco Bay Area leads to annual grass invasions of nutrient-poor serpentine soils (Weiss 1999) that lead to losses of biodiversity, most notably the threatened Bay checkerspot butterfly (*Euphydryas editha bayensis*).	
6) Montane meadows in Rocky Mountain National Park are losing wildflowers to native perennial grasses.	
7) Aquatic biodiversity in ultra-oligotrophic lakes in western mountains is affected by quite low levels of atmospheric deposition (1.5 kg-N/ha/year wet).	
A screening of the N-deposition exposure of listed (endangered, threatened, and rare) plants in California	

Comments	Response
(Weiss 2006), suggests that a substantial fraction (~40%) of the listed flora in the state is exposed to > 5 kg-N/ha/year (from a 36 km CMAQ run for 2002). Many of these plants are on nutrient deficient soils such as serpentine. Many others are in vernal pools (seasonal wetlands). Grass and weed invasions are the primary mechanism of biodiversity loss. Many of the species are small annual forbs that are prone to being crowded out by increased grass and weed growth in many ecosystems.	
There are many other examples outside of the Western US that need to be compiled, and I would suggest as a recommendation that a national N-deposition/biodiversity screening and assessment are needed.	
Executive Summary	
From Dr. John Day	
13, fig 2. Denitrification doesn't seem to be a pathway.	Figure revised
16, Management strategies. Nutrient removal by wetlands should be specifically included in this list.	Text revised
18, Recommenation C. Academic scientists should be included in the task force. It is clear from the literature that the great majority of work done on Nr has been done by academic scientists and they should be integrally involved in all stages of the effort.	Text adds universities to recommendation A. Text adds FEMA, FWS to recommendation C (Jim)
19. Wetlands should be included in best mgt practices.	Text revised

Comments	**Response**
From Dr. Elizabeth Holland	
The executive summary must refer to the correct section of the science portion of the report so that it is obvious to the reader where to find the supporting science. As written, it is not substantiated by the science.	Committee disagrees - ES should be a stand-alone document
While I agree with the intent of the N cascade framework—to integrate the various system components into a whole—I am unconvinced that continuing use of the term *N cascade* is useful to convey the importance and usefulness of a holistic N budgeting to the community outside of the relatively small community of scientists who are doing N cycling work.	Revised text added to relate science findings, especially on impacts, to cascade more consistently (e.g., climate, economic impacts)
From Dr. Gregory McIsaac	
Page 6, line 9 (and throughout most of the report): The report identifies combustion of fossil fuels as a source of NOx, suggesting that combustion of non-fossil fuels is not a source of NOx. There are only one or two places (such as page 112, line 32) where combustion of biomass is identified as a source of NOx.	Text revised to clarify and update
Page 11, line 16: identifies stationary fossil fuel sources as power plants and industrial boilers. What about domestic heating?	No change, because it's a small piece of nitrogen budget
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.	Text revised to note that "large areas of the land surface in the contiguous US receives N deposition in that range

Comments	Response
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).	Clarifying text added
From Dr. Jerry Melillo	
P13 – why not show delta of 5 Tg N/yr in veg., soil and groundwater, as well as denitrification estimate of 16 Tg N/yr in the figure to complete the mass balance?	Graphic revised for clarity
P14, L10-11 – by adding "fiver and fuel crops" the "issue" expands to "national energy security and a sustainable supply of fiber	Word "wholesome"removed
P15, L5 – hyphen needed, "service-based"	Change made
P16, L19 – check punctuation sequence	Change made
P22 – hyphen needed, "land-use"	Change made
P17, L31 – change "must" to "will likely" – generally be careful about using the word "must"	Change made
P17 – hyphen needed, "risk-reduction"	Change made
Comments from Dr. Giles Randall	
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	

Comments	Response
of reactive N" were particularly helpful. The major findings and recommendations shown on pages 18-20 also set-the-stage quite well.	
Comments from Dr. James Schauer	
1) Page 11 lines 5-7 and Page 12 lines 1-3 – The text does not seem consistent with Figure 1. According to the Figure 1, Cultivated BNF seems to be the second largest sources and Fossil Fuel Combustion is the third largest source. This figure and associated text would gain from a clear discussion of the contributions by sector and process.	Text revised to clarify.
2) Page 17, line 1 – I am not sure what is meant by "more efficient diesel engines" but I think this should be engines with lower emissions or after-treatment controls. Engine efficiency usually does not mean the degree of NOX emissions.	Text changed "more efficient" to "improved"
3) Page 19, line 31 – The term "passenger cars" needs to be checked. I assume that this is on-road vehicles or mobile sources.	Text changed "passenger cars" to "light duty vehicles (including passenger cars)"
Chapter 1: Introduction	
Comments from Dr. John Day	
22. An discussion of the role of cheap energy, especially oil, in the agricultural revolution is completely lacking. The globalized food system uses about 10 cal of oil (or its	Text revised to discuss extent to which nitrogen enters the cascade is partially due to the increase in price of energy.

Comments	Response
equivalent) to produce one cal of food. N pollution is likewise a result of cheap energy. Energy is central to understanding this whole problem and it must be dealt with.	
Comments from Dr. Gregory McIsaac	
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.	Graphic revised to include sink symbol for open oceans (or just show symbol at the atmospheric, terrestrial, and aquatic levels)
This seems to be an oversight because later on page 85, the report mentions that deposition of Nr to the oceans results in some N20 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.	Text changed.
From Dr. Jerry Melilllo	
P23, L14 – change 'between" to "among"	Text changed.
L24 – change "all" to "most"	Text changed.
	Text changed.
P24, L1-2 – punctuation "…molecule can, in sequence, contribute…."	Text changed.

Comments	Response
cascade, underscore…."	Text changed.
L27 – punctuation "…and water, as exhibited in the n	
P25, figure –make it larger	Make change (Jim)
L4 – eliminate "popular"	Text changed.
L11 – eliminate "important"	Text changed.
Comments from Dr. Giles Randall	
25-26 | all | Figure 3 and the accompanying text was well done.	
Chapter 2 Behavior of Reactive Nitrogen in the Environment	
2.1. Introduction	
2.2. Sources of NR new to the US Environment	
2.3. Nr Transfer and Transformation in and between Environmental Systems	
2.4. Impacts, Metrics, and Current Risk Reduction Strategies	
From Dr. John Day	
79-80. Recommendations. A comprehensive scientific program of the role of wetlands as sinks should be included in this list. For example, Mitsch and colleagues (refs cited in the report) called for a comprehensive research effort in the Miss basin on the use of wetlands. This could be cited here as an example of what needs to be done.	Finding and recommendation included.

Comments	Response
In a broader sense, these recommendations will require considerable funds (and energy). In an energy scarce future, hard decisions will have to be made about what is done. Study efforts should be directed at energy efficient approaches for controlling N pollution.	
89. Forests. The sentence on lines 22-23 "Changes in C…" is awkward. The statement is that the highest rate of tree growth is in the Pacific northwest. Is the rate of growth higher than cypress forests in the southeast. In addition, there is a climate aspect here. A recent study (van Mantgen et al. 2009. Science. 323:521) reported that tree mortality in the west had increased as a result of climate change. This is another way that climate may impact N dynamics if trees are dying more rapidly.	Text revised. New section of report addressing relationship of N and climate change added
106. It is interesting to note that in fig. 21, the Everglades is treated as a separate unit while the Miss delta is grouped with arid south Texas. Likewise, the wet northwest is grouped with parts of arid southern CA.	Figure dropped and text adjusted
From Dr. Elizabeth Holland	
The atmosphere land section of the report is one of the better substantiated portion of the report, but the section is characterized by an overreliance on unpublished and unevaluated runs CEMAQ. The section also overlooks key papers like the US N budget done by Holland et al. 2005, published in Ecological Applications. The section also overlooks a series of important studies linking N deposition/fertilization to increased NO and N2O emissions published by Butterbach-Bahl and Papen in the European literature.	Text revised to cite Holland paper ; analysis of published studies of CMAQ, specific to deposition analysis integrated into the discussion

Comments	**Response**
From Dr. Jerry Melillo	
P31, L32 – would it be possible to add a column to indicate primary sources of this information?	References added to notes for ta ble
P42, L7-11 – at what spatial scale? Country or watershed suggested, but no actual area suggested, e.g., km2	*Text changes: After line 8 "agricultural crops" text has added"in terms of timing and at a sufficiently small application scale to better inform decision-making…."*
L12 – make it clear that NFUE discussion starts a new section – add section label "2.2.3.2"	*Text now includesa new section "2.2.3.2". All the later section numbers have been modified appropriately.*
P49, L16 – a more complete discussion of the Crutzen et al. discussion would be useful here. Also, see the results from Scanlon et al. 2003, where diode laser and eddy flux were used	*INC disagrees. We note the discrepancy with other estimates, and then highlight the need for better predictions of N2O emissions from agroecosystems and the factors responsible for them. We looked at the paper by Scanlon et al. (2003) and it is based on measurements from intensive pasture systems in Europe where they apply heavy amounts of both N fertilizer and pig slurry. Such systems are not widespread globally, and they have a very small extent in the U.S. Bottom line, we do not recommend any changes to the text in question.*
P51 – biofuels discussion should note that if biofuels feedstocks are going to be grown on marginal lands, additional N inputs and irrigation may be needed.	*See Recommendation 3 and related text revised to address this issue.*
P64, L6 – why no finding for this topic? a big deal at the local level.	*A new finding and recommendations are now provided.*

Comments	Response
P83, L21-23 – awkwardly stated – revise to read "EPA should work with USDAS, DOE and universities to ensure that …."	Change made
P87, L31-33 – recommendation is vague – make clearer	Recommendation revised
P94, L28 onward – section repeated	Redundant section removed
P97, table – a better table can be taken from the Millennium Ecosystem Assessment	On consideration, the INC decided to retain Costanza table
From Dr. Gregory McIsaac	
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.	Table notes revised.
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.	*The figure has been revised.*
Page 37, line 12: In discussing Table 2, the text refers to Louisiana even though data from Louisiana is not presented in Table 5.	*The paragraph and table title have been modified.*

Comments	Response
Page 39, line 15: it would be nice to have a citation to the recommendations referred to.	*Text revised to provide citation*
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.	*Notes for Table 1 revised to explain the source of the number.*
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.	Text revised to include 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.	Text reference to figures were updated.
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.	*The INC respectfully disagrees.* *It is true that legumes "prefer" to use available soil and residual fertilizer inorganic N before investing in the symbiosis, but this point provides additional detail not needed for our report. The statement by this reviewer that "this is why they (i.e. legumes) have some potential to be more efficient than fertilizer" does not make sense. Instead, the point currently made in the report is the key issue, namely, they can provide N input to cropping systems that can replace a portion of the total N requirement of a system. No change is necessary.*
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	*The following change has now been made:* *c) EPA should work closely with the US Department of Agriculture (USDA), Department of Energy (DOE), the National Science*

Comments	Response
"efficient use and mitigation of Nr…"	*Foundation (NSF), and land grant universities to help identify research and education priorities for efficient use and mitigation of Nr applied to agricultural systems.*
Page 51, line 28: there is an extra comma in this line.	*The extra comma has been deleted.*
Page 51, line 29: "will be used … in 2008" should be "…was used…"	*Change has been made.*
Page 57, lines 15-16: explain how are aerosol formation and neutralization of acids produced by sulfur and nitrogen oxides are adverse effects.	New text developed to address this point
Page 59: a table that shows how the N excretion has changed per animal would be useful.	No change required Per unit per animal not useful; what's important is per unit of milk. Report uses the right metrics. Section 2.2.4.4 title changed to include the word "efficiency" and Table 6 changed to include term "efficiency" Total US chapter heading should be g/kg; all heading should include reference to N
Page 60, line 18-19: 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	*. The paragraph has been replaced as follows:* *Ammonia-ammonium equilibrium [NH4+(l)↔NH3(l) + H+] is affected by temperature influencing the dissociation constant Ka [Ka= (NH3)(H3O+)/(NH4+)] and pH (Arogo et al., 2006; James, 2008). At pH 9.2 a solution contains approximately equal amounts of*

Comments	Response
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.	*solution NH4+ and solution NH3. At pH 7.2 the solution contains approximately 99% solution NH4+ and 1% NH3. Thus NH3 emissions are typically higher in more basic soils. Chemical equilibria dictate that an aqueous solution will hold less NH3 with increasing temperature so, temperature affects solution-atmosphere NH3 exchange as well (Freney et al. 1983)* *Freney, J.R., J.R. Simpson, and O.T. Denmead. 1983. Volatilization of ammonia. In J.R. Freney and J.R. Simpson (eds.) pp. 1-32. Gaseous Loss of Nitrogen from Plant-Soil Systems. Kluwer Academic Publishers, The Hague.*
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.	*The tabl has been modified and language in the section modified to replace "loss" with "transfer" to more accurately explain the Nr reduction process.*
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".	*The table has been modified and the following changes have been incorporated in the text:* *In recent years, about 11Tg of fertilizer N /year was used in the US. The above numbers convert to 1.1 Tg/year of N being used on turf (roughly 10% of US Total)* *Finding 7* *Synthetic N fertilizer application to urban gardens and lawns amounts to approximately 10% of the total annual synthetic N fertilizer used in the U.S. Even though this N is a large part of N fertilizer used little attention is paid to how efficiently it is used.* *Recommendation 7: To ensure that urban fertilizer is used as efficiently as possible, the committee recommends that EPA work with other agencies such as USDA as well as state and local extension organizations to coordinate research and promote awareness of the*

Comments	Response
	issue.
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.	Report revised to include time series and ie contemporary figure showing spatial patter.
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.	Type fixed so text reads – "should be dry deposition of NO" Text clarified to explain foliar resistance
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.	Sentence added to acknowledge complexity and sampling issues.
Page 76, Figure 16. The legend on this graph is rather cryptic, and the graph basically provides only 4 percentages	Text developed to replace graph.

Comments	Response
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 NHx the phrase "…emissions are…"	Change made.
Page 76, line 21: delete "the" before 1985.	Change made.
Page 77, line 24: I think "within" should be changed to "with" and probably should be preceded with a comma.	Change made.
Page 78, line 9: "a fair fraction" ought to be changed to something more precise.	Change made.
Page 79, line 22-23: this statement comes out of the blue. There was no discussion of this in the preceding text.	Text added that NO2 is small proportion of nitrogen budget and NO2 is the only N compound monitored.
Page 80-83 issue of separate N budgets	Text added to discuss relationship of table to table 1; table notes reviseds
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.	Text added
Page 81, table 13 and line 15: Animals don't manufacture Nr, 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 Nr. Also, the	Table language modified

Comments	Response
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 Nr and recycled Nr. 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?	Text modified
Page 82, line 16: section 3.2.5.1 appears to be incorrect.	Text modified
Pages 82 and 83. I found this discussion rather confusing. Perhaps a diagram would help.	Text revised
Page 85, line 4: "higher ranked consumers"? Maybe "animals and aerobic microorganisms"?	Change made
	Change made
Page 86, line 2: insert "of" after movement	
Page 87, line 34: ES = environmental system?	Change made
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	Change made

Comments	Response
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.	Text revised
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"	Change made
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.	Text inserted discussing EPA using N as a focus for research on ecosystem services.
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.	References corrected
Page 106, Figure 21. I did not see much value in reproducing this figure.	Figure deleted
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.	Column title revised

Comments	Response
Page 109, line 15: is “disproportionate” the correct word? I think they meant “disappointing”	Change made
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	Change made
Page 119, line 14: I think there should be the word “at” inserted after “aimed”.	Change made
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.”	Change made
Page 123, Table 21: In the middle column several of the entries are “NR” and should be Nr.	Change made
Page 125, line 4: delete “neither”	Change made
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.	Changes made to figures and references
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	Figure 25 dropped; text revised to reference Fig 7 (Tom)

Comments	Response
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.	Change made
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.	Text inserted
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.	

Comments from Dr. Giles Randall

		Comment	Response
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	This change has been made.

		Comment	Response
		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 applied. 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.	Response: It will be difficult to go into a lot more detail about N fertilizer efficiency without adding several pages of text. However, this reviewer agrees that there are indeed few data on actual on-farm measurements of N fertilizer efficiency, and the publication he cites that gives soil N uptake data is based on field research conducted in replicated field studies in relatively small plots with uniform soil conditions compared to production fields. So, the only good, direct measure of N fertilizer efficiency from farmer's fields is the NFUE, which indeed is a surrogate. Still, there is a good point in this comment. We have now added additional material to the text. In most cropping systems, RE is the most important determinant of NFUE. A recent review of RE for cereals based on field studies around the world, mostly conducted on "small-plot" experiments at research stations, reported mean single year RE values for maize, wheat and rice of 65%, 57% and 46%, respectively (Ladha et al., 2005). However, crop RE values based on actual measurements in production-scale fields are seldom greater than 50% and often less than 33%. For example, a review of RE in different cropping systems, estimated average recoveries of 37% for maize in the north central US (Cassman et al., 2002). It is also important to note that soil N provides the majority of the N taken up by most crops grown on soils with moderate to good soil fertility. For maize in the U.S.

		Comment	**Response**
		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.	corn belt, for example, 45-77% of total N uptake was estimated to come from soil N reserves based on experiments from research stations (Sawyer J, Nafziger E, Randall G, Bundy L, Rehm G, and Joern B. 2006. Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn. Iowa State Extension PM 2015, www.extension.iastate.edu/Publications/2015.pdf). Therefore highest N efficiency and economic return on N inputs are achieved when the amount and timing of applied N is synchronized with the availability of soil N throughout the growing season to minimize both the quantity of N input required and the N losses from soil and applied N sources.
43	9	Insert "may" between "that" and "improve". The	The change is now made.

		Comment	Response
		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.	: The statement has now been modified as follows: This situation suggests substantial potential for improvement in NFUE and 13 an associated reduction in Nr losses from crop agriculture, especially for maize in the warmer portions of the Corn Belt and other southern and southeast areas where maize is grown.
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.	INC gase modified “Smart Fertilizer” to “enhanced efficiency fertilizer”.

		Comment	**Response**
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).	No response required. The citation in question is based mostly on field experiments conducted at research stations and not in farmer's fields. As explained elsewhere in the text, it is crucial to rigorously validate N recommendations in farmer's fields – (Ken and Viney)
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.	NUE added to Table of Abbreviations
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.	The text has now been modified as follows: Nitrogen costs have become extremely volatile, mirroring natural gas prices. In late 2008, Nitrogen fertilizer prices were more than double 2006/7 Nitrogen prices. More recently, Nitrogen fertilizer prices have fallen back to two thirds of the high following the decline of natural gas prices.
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".	This is not true. While it may be more challenging to synchronize N applications with crop demand in rainfed systems, it is not impossible and our current text calls for development of appropriate techniques. No changes are needed.
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.	No change. Response: The committee agrees, but other research approaches are needed as well. No need to stipulate how the research should be conducted. Therefore,

		Comment	Response
			no change to existing text is needed
46	33		
47	1-3		
50	10-12		
51	9-12		
51	32		
57	16		
57	20	I'm not aware of nitrate causing soil acidification.	Text change :nitrate to "HNO3"
58	28	NRC 2996?	Change made
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.	No change. Animal agriculture provides much of the sources overall
64	Table 9	Table 9 is incomplete. The "High Maintenance Areas" has been omitted from the left-hand column.	Table updated
67	15	"in" Recommendation D	Reference to recommendation D removed
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.	Text revised to provide earlier mention
81	Table 13	6.4 Tg N/y from N fixation in vegetated grasslands seems quite high when comparing it to the millions	Table 13, revised the N fixation line to reflect table 1

		Comment	Response
		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.	The committee disagrees with the comment. The world is more complex than what he prescribes. There are important systems in which BOTH N and P inputs need to be controlled, and it doesn't dilute the take home message of our report to mention this (i.e. it doesn't minimize the overall importance of controlling N inputs to these and other estuarine and coastal waters). Recently, a paper by Schindler et al. (PNAS 2008; attached) fanned the flames of having to be absolute about P limitation being the be-all, do-all limiting nutrient in aquatic systems (based on a purely freshwater interpretation. There have now been two replies to help clarify the point of why BOTH N and P input constraints are needed in many estuarine, coastal (and even freshwater) systems threatened by the adverse impacts of eutrophication. The Conley et al. (2009) and Paerl (2009) manuscripts as examples..
85	9-13	This section is fine as it concentrates on marine	

		Comment	Response
		systems. Thus, distinguishing between marine and fresh water systems seems important.	
86	2	sentence is unclear	Sentence revised
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.	Footnote for table 15 will be moved close to p. 88
91	Table 15	Table 15 and footnote 7 are valuable	Addressed above
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.	Panel concurs
94	2-27	A very important section!	Panel concurs
94 95	28-15	This section was repeated earlier on p. 94.	Repeated text removed
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.	Figure 18 removed
98	2-20	Are cost: benefit ratios appropriate for measuring these impacts?	Section is about damage costs, a metric other than not cost-benefit. No change needed
99	24-	Text Box 2, its text, figures and tables was an	

		Comment	Response
102	18	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 l Make change (Tom)b/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.	Sentence inserted, effects depend on starting point
125	30	Jaynes and Karlen (2005) not found in Reference section.	Reference added
126	2	Fig. 24 should correspond to Fig. 22 or 23	Change made
	18	" 25 " " " " 24.	Change made
	19	" 26 " " " " 25.	Change made
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	Change made

		Comment	Response
		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).	Change made
128	5	Fig. 27 should be Fig. 26.	Change made
129	14	" 28 " " 27.	Change made
131	2 & 7 8	" 30 " " 29. " 32 " " ??.	Change made
131	Fig. 28	no discussion found in text	Change made - Bottom of page 130, line 35 should reference figure 28

Comments from Dr. James Schauer

Comment	**Response**
4) Page 58, lines 10-12 - Recommendation 5 is really not a feasible recommendation. It is not really possible to measure trends in fugitive or areas sources. Networks like NADP are used as an assessment tool to study trends in emissions. A better recommendation may to be expand the locations or measurements of the NADP and STN networks.	*RText has been modified as follows: "...should be monitored and assessed utilizing a nationwide network of monitoring stations."* *Insert mention of NEON in Finding 5. Note that EPA and NSF should work with USDA. Bill Moomaw to provide suggested language to Viney*
Chapter 3: Integrated Risk Reduction Strategies for Reactive Nitrogen	
From Dr. Elizabeth Holland	
The recommendations as currently constructed are likely to result in a series of independent studies that do not make substantial progress	Text revised so Recommendation and Finding 19 should be moved to Thresholds and critical loads discussion 118-

Comment	**Response**
towards solving problems on larger spatial scale. Careful thought and substantial revision of the current plan is required to ensure that the studies and integration achieve the desired environmental and policy outcomes.	131. Finding and Recommendation 16 and 19 merged . Recommendations A-C are meant to be overarching recommendations to encompass both research and risk management recommendations. No change
From Dr. Gregory McIsaacs	
Page 143, line 14: delete "for the WRP" as this was mentioned at the beginning of the sentence.	Change made
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.	*This reviewer seems to be confused. The values for NFUE are taken directly from the data presented in Fig 7 in Section 2.2. In fact, these values do transform into 0.8 to 1.0 bu of corn/pound of N applied as fertilizer. Perhaps we need to modify the text as follows to make the units for NFUE clearer (red text is new):* From 1980 to 2000, N-fertilizer use efficiency (NFUE, kg grain produced per kg applied N, hereafter expressed as kg grain / kg N applied as fertilizer) increased from 42 to 57 kg grain / kg N, a 35% efficiency gain during a period when average U.S. corn yields increased by 40% (Fixen and West, 2002).
Page 152, lines 15-17: some citations that describe the storage systems would be valuable.	Change made
Page 152, line 21: "bemoaned" does not seem to be an appropriate descriptor of an NRC report.	Change made

Comment	**Response**
Page 153, lines 29-30: there appears to be some words missing in the sentence starting with "Sommer".	Change made
	Text revised re:finding and recommendation relating to manure or pointing to recommendation in section 2.2 (Arvin and Tom)
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.	Text revised Move wetlands heading (line 34) prior to last sentence, beginning on line 40 and flowing into next paragraph Wetlands would begin new subsection Remove sentences lines 34-40 Line 41 wetlands should be "natural, created, or referred"
Page 156, line 2: "a side reaction for the … catalyst system is ammonia" probably should be "…produces ammonia"	Change made
Page 157, lines 5-7 are duplicated by lines 8-10.	Change made
Page 157, line 18, NR should be changed to Nr.	Change made
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.	Change made
From Dr. Jerry Melillo	
P125, L13 – confusing sentence, clarify	Text revised
P131, figure – not very informative, clarify	Text revised

Comment	**Response**
P154, L26 – sentence does not make sense, re write	Text revised

From Dr. Giles Randall

		Comment	**Response**
142	27	Fig.29 should be Fig. 32.	Text revised
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.	Text revised
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	Text was revised to describe intended trade-off more clearly

		Comment	Response
		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 not an illustration of NFUE. It is a 35% yield efficiency gain but it cannot be specifically related to improved N fertilizer use efficiency (NFUE).	*This reviewer seems to be confused. The values for NFUE are taken directly from the data presented in Fig 7 in Section 2.2. In fact, these values do transform into 0.8 to 1.0 bu of corn/pound of N applied as fertilizer. Perhaps we need to modify the text as follows to make the units for NFUE clearer (red text is new):* From 1980 to 2000, N-fertilizer use efficiency (NFUE, kg grain produced per kg applied N, hereafter expressed as kg grain / kg N applied as fertilizer) increased from 42 to 57 kg grain / kg N, a 35% efficiency gain during a period when average U.S. corn yields increased by 40% (Fixen and West, 2002).
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.	See above
151	10	Fixen and West (2002) was not found in References section.	See above
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	Text revised

		Comment	Response
		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	Text revised
153	32	BMPs to minimize NH3 emissions were not found in section 3.2	Text revised
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.	See immediately above

		Comment	Response
153	38-39	Del Grosso et al. (2006) not found in Reference section.	Text revised
154	35-39	This is an extremely important statement.	
155	6	Section 3.3.1 did not address NOX emissions declining in the U.S.	Text revised to refer to is section 2.2.2
156	14	include “Universities”	Text revised
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.	Text revised to include bullets on BMP on stormwater and bullets on BMPs for wetlands
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.	No change. Acknowledging difficulty, but approach remains part of the potential suite of BMPs to be considered.
159	10-11	Advances in fertilizer technology will be helpful in	No change.

		Comment	Response
		certain specific areas but in the big picture will have a limited effect on mitigating nitrate loss to water.	Approach remains part of the potential suite of BMPs to be considered
159	22	Simpson et al. (2008) not found in Reference section.	Text revised
159	36-41	Target recommendation 2 text should be under Target recommendation 3.	Text revised
160 161	34- 10	Target rec. 3 text should be under target rec 2.	Text revised
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?	Text does refer to "below current amounts". No change
170	12-18	Does not agree with Target Goal 2.	Text revised
170	20-34	Agrees with Target Goal 2.	Text revised

From Dr. Swuart Weiss

Comment	Response
Policy responses:	
Overall, the ongoing critical loads process (CLAD) provides a means for addressing this problem in the long run. Note regional efforts like that at Rocky Mountain National Park to reduce emissions are starting, based on a finding of critical load for alpine lakes.	Report already addresses critical load

Comment	Response
Impacts on threatened and endangered species fall under the jurisdiction of the US Fish and Wildlife Service. Since 1999, mitigation for impacts of powerplants, road widening, and urban development on Bay checkerspot butterflies and serpentine grasslands include land acquisition and management/monitoring endowments and the development of a regional Habitat Conservation Plan. The Endangered Species Act may be a powerful means for identifying and mitigating N-deposition impacts on protected species	Text revised to discuss partnering with FWS.
It is the short-term mitigation and management needs of these ecosystems that desperately need attention, especially control of invasive species. In California cattle grazing has been effective in maintaining serpentine grasslands and vernal pools. Management of many ecosystems remains problematic- wildland weeds are hard to control and substantial resources are needed on the ground.	Biodiversity already mentioned, but this level of discussion not needed
The emissions of ammonia from vehicles (catalytic converters) along heavily traveled roads creates high deposition corridors. Vehicular ammonia may be one of the more readily controllable sources, and the call for ammonia to be considered as a regulated pollutant	Text revised to address possible ammonia effects in some corridors.

Comment	Response
Measurement and modeling of N-deposition loads is critical for understanding highly local effects, such as roadsides, as well as regional plumes. Passive samplers provide inexpensive means for monitoring time-averaged concentrations. A 4 km CMAQ run for the California (Tonnesen et al 2006) has proven immensely valuable for N-deposition assessments at regional levels. Standards for project-based and cumulative impact assessments need to be developed. Fenn, M. E., J. S. Baron, et al. (2003). "Ecological Effects of Nitrogen Deposition in the Western United States." Bioscience 53: 404-420. Tonnesen, G., Z. Wang, et al. (2006). Assessment of Nitrogen Deposition: Modeling and Habitat Assessment. Sacramento, CA, California Energy Commission, PIER Energy Related Environmental Research CEC-500-2006-032. Weiss, S. B. (1999). "Cars, Cows, and Checkerspot Butterflies: Nitrogen Deposition and Management of Nutrient-Poor Grasslands for a Threatened Species." Conservation Biology 13(6): 1476-1486.	This level of discussion not needed
Weiss, S. B. (2006). Impacts of nitrogen deposition on California ecosystems and biodiversity. Sacramento, CA, California Energy Commission, PIER Energy- Related Environmental Research CEC-500-2005-165.	