

Comments from CASAC NO_x & SO_x Secondary NAAQS Review Panel on
EPA's *Draft Plan for Review of the Secondary National Ambient Air Quality
Standards for Nitrogen Dioxide and Sulfur Dioxide* (September 2007)

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Dr. Praveen Amar

EPA's Draft plan is a commendable effort on the part of EPA staff to present in a short document the key policy-relevant issues, and then describe how it will assess issues related to (1) science, (2) risk-exposure, and (3) policy, as they inform the complex process of establishing secondary standards for both NO₂ and SO₂.

The draft plan, to its credit, recognizes that we have arrived at the current state of affairs in establishing separate NAAQS for SO₂ and NO₂ in an ad hoc manner by historically considering "one pollutant" or "one atmospheric or ecological issue" at a time. The goal of considering the two pollutants in a joint "integrated" manner under the current review process, because of the "science-entanglement" of both the atmospheric processes and ecological effects of the two pollutants, is worthwhile, but not without its own set of policy-related problems. For example, such a "multi-pollutant/one atmosphere/diverse and variable ecosystems" approach can easily lead to a policy-situation where one can not make "some" necessary policy decisions unless one is ready to make "all" decisions. For example, we should be careful that such an "integrated" approach does not lead to *not* setting a nitrogen-based standard in the context of eutrophication of water bodies in certain regions of the US in the absence of complete information relating to sulfur-based impacts.

The Draft Plan (page 1-13) notes that the role of ammonia "will be considered," while it is "not the focus of this review." It goes on to state that "a detailed discuss (sic) of these processes is included in the PM review." I think it is important that ammonia also be the focus of this review in the context of "total nitrogen and total sulfur", and not just the oxidized forms of nitrogen and sulfur. This means that its emissions at about five million tons per year in the US (there is high level of uncertainty associated with this estimate), location of its major sources in the US, its role in long-range atmospheric transport and then deposition as ammonium sulfate and ammonium nitrate, its chemistry in the atmosphere and in soils, and its ecological impacts, all of these factors need to be the focus of this effort. For example, questions like "Is NO₂ a good indicator of oxidized nitrogen in the atmosphere? Are there others?" may not even be the right questions to ask if the focus is on total nitrogen and its deposition to the ecosystems (oxidized and reduced). Same reasoning may also be applicable to SO₂/total sulfur.

The Draft Plan in all of its major Sections (key policy-relevant issues, science assessment, risk/exposure assessment, and policy assessment) does not discuss the issue of how the review process would evaluate the critical load-based approach as an alternative to promulgating ambient concentration-based standards. It appears to me that this is a major oversight of the Draft Plan. For example, Chapter 8 (the science annex on critical loads, July 2007 draft version) quotes the 2004 National Research Council (NRC) report, "... However, concentration-based standards are inappropriate for some resources at risk from air pollutants, including soils, groundwater, surface waters, and coastal ecosystems. For such resources, a deposition-based standard would be more appropriate. One approach for establishing such a deposition-based standard is through the use of so-

called “critical loads.” At a minimum, the Draft Plan should be revised to describe how it would address critical load-based approach.

Finally, I will like the Draft Plan to be more explicit in how the process of establishing secondary standards will address uncertainties in inputs and outputs (emissions, CMAQ models, rate constants in atmospheric chemistry processes, deposition maps, ecosystems modeling, etc.) and how these uncertainties would affect the judgments that must be made in recommending standards or range of standards. Each of the many models that would be used in this process would generate outputs with associated uncertainties that then will be used as inputs for subsequent models across a set of linked modules (Appendix B of the Draft Plan describes this process but at a very cursory level). There are numerical and analytical methods available for propagating uncertainty across modules for quantifiable sources of uncertainties. For uncertainties that are difficult to quantify, there are “scenario-based” methods that can be used to bound the results. However, propagating uncertainty across models and modules represents only one part of the puzzle: the results of these analyses require communication to policy-makers and other interested stakeholders. Uncertainty analyses, particularly multi-dimensional ones necessary for establishing secondary standards for SO₂ and NO₂, can be difficult to communicate and to understand, hindering their use in policy-making. To address this, I suggest that the Draft Plan address the issue of quantifying uncertainty in several models used in the review process and develop an integrated uncertainty analyses and also develop communication tools to explain the implications of uncertainty in decision making.

Dr. Andrzej Bytnerowicz

Generally, the document is well written, logically structured, and can serve as a good start of discussions on possible revision of the NO₂ and SO₂ NAAQS. The first phase of the process (integrated review plan), as well as three other phases (Integrated Science Assessment, risk exposure assessment and policy assessment and rulemaking) are logically and clearly presented.

It would be helpful to clarify what N pollutants should be discussed as those which may have secondary (welfare) effects. In my opinion, in regard to the oxidized N compounds, we should not discuss only NO_x (which is just a sum of NO₂ and NO), but rather NO_y, which includes NO_x and also other gases of a potential ecological importance such as nitric acid vapor (HNO₃) or peroxyacetyl nitrate (PAN) (Seinfeld and Pandis, 1998, p. 71). It would be even better if we could use a term “N gaseous compounds”, since reduced species such as NH₃ also have pronounced ecological effects.

I would be even more comfortable with a term “welfare effects resulting from deposition of criteria pollutants (NO₂ and SO₂) and their transformation products” (p. 1-7, lines 22-23).

Specific Comments

1. Introduction

Generally Introduction is well written and offers a good basis for the rest of the document. However, I suggest that on page 1-10, line 5, a change is made: “In addition to acidification, NO_x and HNO₃ act with ...” Alternatively, it could be changed to: “In addition to acidification, NO_y acts with...”

Page 1-12, line 12 –instead of considering NO₂ and its transformation products, it could be better to stress that NO_y contributes to N loading of ecosystems. If such a change is made, than HNO₃, which provides large proportion of oxidized N to ecosystems, especially in dry climate, would be automatically included.

Page 1-13. It is a very important section emphasizing a need for including reduced N compounds if deposition and ecological effects are concerned.

Page 1-13, line 14 – recent evidence suggests that fine particulate matter can also reduce precipitation in mountainous areas of California and elsewhere (Rosenfeld, 2000).

3. Key Policy-Relevant Issues

Page 3-1, line 21 – it is not scientifically correct to say “particulate NO_x and SO_x”. The authors probably had in mind N and S aerosols, including fine particulate nitrate and sulfate.

4. Science Assessment

Page 4-1, line 5, and the following text. Again, I think more precision in using various chemical terms is needed. Criteria pollutants are SO and NO₂, not NO_x and SO_x. Maybe a term “SO₂ & NO₂ and their transformation products” would be more appropriate.

Page 4-2 lines 4 and 5. I would like to suggest that also “gray” literature, specifically reports, such as those from the UN ECE ICP Forest and ICP Mapping and Modeling, especially those dealing with issues of Critical Loads for S, N and acidity could also be considered. These reports have been internally reviewed and may have an important practical value for developing similar approaches in the US.

Page 4-1, lines 9 and 10: I would also consider recent information from CASTNET and various passive sampler networks in US and Europe, on HNO₃ concentrations. In some areas, information of ambient NH₃ is also becoming available (mostly from large-scale passive sampler networks). Information on these two gases, which due to their high deposition velocity provide significant amounts of N to ecosystems, could be quite valuable.

Page 4-2, line 25 and 26: Ammonia (NH₃) should also be added to the proposed literature search.

Page 4-3, lines 8-21: Again, I would like to emphasize again a potential value of the ICP Mapping and Modeling and ICP Forests annual reports.

Page 4-3, lines 18 and 19: Modifying effects of the changing climatic conditions (in western conditions, increasing temperature, reduced precipitation and long – term drought) or increasing background concentrations of ambient ozone should be considered.

Page 4-5, lines 1 – 16: Passive sampler networks (for HNO₃, NH₃, NO, NO₂ or SO₂) can provide the receptor-level data that can be used for validation of the deposition models. Use of geostatistics (such as ArcGIS Geostatistical Analyst) may greatly help in translating point data into landscape-level concentration surfaces.

5. Risk /Exposure Assessment

Page 5-1, line 8: the recommended by NRC (2004) critical loads approach for N, S and acidity (already widely used in Europe) could be considered. The US FS is already developing a strategy for measuring parameters needed for calculation of CL for N & S on a network of experimental forest and FS-managed LTER sites (21 sites altogether nationwide).

Page 5-2, lines 5-10: Air pollution gradient studies or large-scale monitoring/research networks linking information on air chemistry, deposition and ecological responses could be considered.

Page 5-2, lines 11-15: Responses of ecosystems to N and S deposition in mesic (East) and arid (West) climates are quite different and should be better studied. Due to high diversity of the US ecosystems, an understanding of the occurring changes on a continental scale may be more difficult than in Europe. International cooperation with partners in Europe and Asia may greatly help in understanding of N deposition responses in two types of climate. In addition, responses of mountain ecosystems (forests, sub-alpine and alpine) should be taken into serious consideration. Since ecological effects of climate change in high elevation forests have been very strong in recent years, interactions with elevated N & S deposition and increasing background ozone concentrations should be investigated.

Ms. Lauraine Chestnut

The draft plan gives a comprehensive overview of the ambitious plan for scientific review and policy assessment process planned by EPA for determining what secondary standard might be appropriate, if any, for the deposition related effects of NO_x and SO_x. I have just a few questions and comments on the policy aspects of this plan.

How much needs to be known to provide a defensible basis for setting a secondary standard.

If all the questions articulated here can be answered, then the decisions about standards will be fairly straightforward. Difficulties, of course, will arise because current science and analysis tools will not be able to answer many of these important questions. Judgments will be necessary about whether there is sufficient information to provide a defensible basis for a secondary standard. Does the secondary standard language provide guidance on this issue? With the primary standards, the presumption is to be protective of human health, but with public welfare is the presumption the same? Public welfare is definitely impacted by standards that impose costs, so how firm must the evidence be that the standards prevent an adverse impact?

Defining what makes an effect “adverse.”

Obviously, a key step in the standard setting process is determining what effects are adverse. The draft mentions valuation studies as one way to assess how adverse an effect may be. Although valuation (either monetary or non-monetary) studies provide some metrics to measure strength of preference, they do not alone provide sufficient information about what effect may be adverse. Just because an effect has some monetary value (either use or nonuse value), it is not necessarily adverse.

The draft says little about what other methods may be useful in assessing whether an effect is adverse. It seems like there may be many ways to assess this from a biological perspective that would not necessitate valuation.

Related to this is, I think, the issue of variations in sensitivity to pollutants in different locations. Providing all locations the same level of protection may well necessitate different standards in different locations. Setting a uniform national standard at a level to protect the most sensitive locations would likely be unnecessarily costly. I’m glad to see language in the draft that seems to allow for the possibility of standards that vary by location.

Repairing current injury versus maintaining current quality.

The draft mentions the need to assess how beneficial a standard might be in terms of preventing or reducing ecological effects. This raises some questions about how the standard setting process should take into account ecological injury that has already occurred. With pollutants that bioaccumulate or persist in the system for long periods of time, it seems that a different standard might be needed in locations where injury is already significant because lower exposures might be needed to allow recovery to occur.

Critical load/carrying capacity versus full dose-response.

The draft plan describes all the information that would be needed for a full assessment of the ecological benefits of changes in ambient concentrations. Perhaps standards could be reasonably established based on less than a full benefits assessment. This might be the case if thresholds or limits could be determined based on the amount of exposure a system could tolerate without suffering adverse effects. This would need to be assessed in terms of ecosystem services and at what levels of exposure these services could still be maintained by the system.

Dr. Douglas Crawford-Brown

I am generally supportive of the plan laid out here. This is in part because it is only a sketch of what will be done, and so there is little with which I might disagree with respect to details, but also because I think the choices made are wise ones. I agree with the plan to focus on gaseous phase contaminants since the particulate ones are included in the PM assessment, although I believe it will be VERY difficult to separate out the effects of the gaseous and particulate phase NO_x and SO_x. I agree with the effects being considered, including the decision to reflect both direct effects and effects on natural services (although the latter is by far the more contentious of these two classes of effects). The stages of the assessment are also properly outlined.

I have some specific comments to offer at this point:

1. I agree with the decision, outlined on pages 1-7 and 1-8, to bring NO_x and SO_x into a linked assessment, as it will not be possible (I believe) to separate their effects in any studies. But I also mentioned above that it will prove equally difficult to separate the gaseous and particulate phase effects.
2. I was not completely clear, even after reading the document several times, how atmospheric and non-atmospheric loadings will be assessed and incorporated into the analysis. This includes the difficulty of separating their attributable risks in the ecological studies that have been conducted. But I agree with the need to focus on the atmospheric loading, so long as this also includes loadings onto a surface that are then washed to an ecosystem through run-off.
3. On page 1-12, it seems to me that there is an assumption (lines 12-18) that all ecosystem changes that cause a shift in species are adverse. I don't agree with this, and this will be a central question when the assessment is performed.
4. I liked the fact that the review is to be focused around a series of "policy relevant questions" (as stated on page 3-1 at the top). This is a wise choice because it will result in a document that can serve as the basis for subsequent parts of the NAAQS process. The particular issues described later in that paragraph are also the appropriate ones.
5. Later on page 3-1, shouldn't the questions all make reference to "gaseous phase ambient..." rather than the larger "ambient"?
6. In the questions at the top of page 3-2, the authors mention "effects we are trying to protect..." I assume they mean "effects we are trying to protect against".
7. On page 4-1, it is claimed that thousands of papers will be evaluated. I rather doubt this. On page 4-2, some of the search terms are "terrestrial ecosystems", "aquatic ecosystems", etc. These will return very large pools of studies, and so I wonder whether they shouldn't always be paired by NO_x and SO_x in the search.

8. The criteria on page 4-3 are good, although I note that criterion 6 is both the most important and by the far the most difficult to specify procedurally.
9. On page 4-4, there is mention (and on other pages later) of climate change. It was not clear whether this was being included to try to assess impacts in the future. If so, it must also be noted that climate change will change transport patterns for pollutants.
10. There are very strong reasons economists give for not believing procedures that estimate the economic values of natural services (as they have discussed with respect to the kind of assessments performed by Bob Costanza). The Agency should be prepared to offer some counter arguments to these critiques. Most of the critiques center on the fact that existing natural services valuations are not actually rooted in market phenomena.
11. On page 5-1, lines 19 and 20, the claim is made that the Administrator must make the final decision as to whether a given effect is significantly adverse to warrant changing the standard. While I might agree with this to some degree, I question whether the policy side will understand the science well enough to know HOW adverse a given ecological effect is. The science papers must present this case as well, from a scientific perspective.
12. On page 5-2, the authors ask “To what degree can assumptions be made...” I don’t know what this means. Assumptions can always be made. I presume they mean “To what degree are assumptions supported by the available science”?
13. On page 5-3 (line 22), the authors mention normalizing all ecosystems. I have no idea what this means. It is not the proper phrase.
14. On page 5-4 (lines 25-30), the discussion of overlaying deposition and impacts in GIS seems to me much too simplistic. At the least, some sort of spatial correlational methodology will be needed.
15. On page 6-1, lines 21-31, the issues being raised appear to me all science questions, not policy questions. But the bulleted questions presented on the next pages of this chapter are the appropriate ones for the policy maker to ask of the science.

Dr. Paul Hanson

I found the draft plan to be a concise yet fully developed plan for the review of the policy-issues, science, and risk/exposure/policy assessment of the welfare effects of NO_x and SO_x. The following comments provide editorial comments and address some specific issues that should be considered in the implementation of the final plan.

Specific comments:

Pages iv and v:

In the listing of terms the EPA might denote which terms represent legal definitions within the context of the Clean Air Act or other regulatory statutes versus those that are scientific consensus definitions.

The definition of biologically relevant indicator should be expanded and clarified. As I read it I wondered if it might alternatively be a measure of organism response to a stressor (essentially the opposite of what is presented)? On the other hand, if it is intended to denote an indicator of pollutant occurrence or exposure to which biological system are known to respond this should be clarified. Is a biologically relevant indicator the generic version of the chosen statutory 'form' of NAAQS standards?

Page 1-1 lines 16 and 17 (also relevant to 1-8 line 20):

To avoid missing key science products that might be relevant to the current evaluation of NO_x science, the current science reviews should go back prior to 1995 to around 1991. Much of the research summarized in the previous NO_x Air Quality Criteria Document was written and summarized several years prior to the final publication data of 1995.

Section 1.4

Somewhere in this section the fertilization potential of forms of N deposition for terrestrial ecosystems should be acknowledged. An evaluation of the impacts of N deposition on organisms and ecosystems will need to recognize that N-deposition responses through time can proceed along a continuum of response from growth enhancing fertilization to growth depressing conditions associate with advanced level of N inputs. Excess N-deposition results when available N can't be assimilated by existing vegetation or immobilized via soil buffering capacities.

Figure 1-1 should include plant fertilization as an end point.

Section 1.4.2

The concept of 'excess N' demands a comprehensive understanding of the biogeochemical cycle of N that will be location specific and able to capture complex interplay between biological productivity and N uptake potential and the biogeophysical processes that store and release forms of N and acidity in soils. A key question for the science assessments will be -- Do current models have the capacity to handle this complexity?

Section 4.1

Similar to the manner in which this section deals with NO_x and SO_x contributions to particulate matter issues (it is summarized elsewhere), Section 4.2 should also describe the issue of NO_x as a tropospheric ozone precursor. I assume that such a summary statement would conclude that NO_x as an ozone precursor is/ handled and discussed in the context of the recent review and AQCD for photochemical oxidants. The dominant role of NO_x as an ozone precursor may, however, still be relevant in the context a standard setting process for NO_x and perhaps shouldn't be completely excluded during this review.

Page 4-4 lines 25 and 26:

This statement seemed vague. I wasn't sure of the intent.

Page 4-5 lines 1 to 16:

A separate bullet on the nature and impacts of wet and dry deposition might be highlighted. Some forms of wet and dry (gaseous) deposition have direct access to biologically active plant interiors through surface or stomatal uptake. This pathway should be contrasted with the soil-mediated pathway for biological response.

Section 5.3

Section 5.3 and the questions it raises are very important and should be fully evaluated by EPA and vetted in the review processes. As with other criteria pollutants, it is an unfortunate fact that funding for the continued development of mechanistic understanding of welfare effects is limited. A comprehensive description of critical data gaps and research needs is essential to justify and prioritize future research needs for NO_x and SO_x welfare effects.

Dr. Rudolf Husar

Overall, the draft review plan for the Secondary NAAQS for NO_x and SO_x is sound and executable. In particular, the combination of NO_x and SO_x review process is commendable. In essence, such an integrated review plan is consistent with the multifaceted nature of welfare impacts. Also, dividing the review into the four activities: integrated review plan, science assessment, risk assessment and policy assessment is appropriate. Below are specific comments and suggestions regarding the draft plan:

Linking of Science, Risk and Policy Assessments:

In the review process, additional consideration should be given to the interaction between the science, risk and policy assessments. In past NAAQS assessments, these three assessments were conducted somewhat independently following a linear causality chain: (1) Science assessment determines the nature of the pollutants and their effects; (2) Risk assessment draws on the science to quantify the risk; Policy/Regulation is then developed based on the science and risk assessments. However, policy making includes many other considerations beyond the science and quantitative risk assessment. Therefore, in developing a policy-relevant science and risk assessments could benefit from a more iterative approach among these assessments. For example, the selection of appropriate indicators might be influenced by the policy options that are being considered.

Comments on Science Assessment:

- In updating the observational evidence since the last NAAQS science review, special consideration should be given for the new satellite-based observations of NO₂ and to a lesser degree SO₂.
- Similarly, the observational databases from surface monitoring networks should incorporate new data from the aerosol Speciation, AIRNOW and NO_y networks.
- The above new observations are of particular importance for the validation and improvement of the regional chemical transport models used in the assessments (CMAQ).

Comments on Risk/Exposure Assessments:

- The heavy reliance on CMAQ model for assessment necessitates the validation and improvement of the CMAQ model performance. The marginal performance of CMAQ for non-sulfur species suggests considerable room for improvement.
- The statistical analysis to generate concentration-deposition relationships is unclear. Providing further rationale for the approach would be beneficial.

Comments on Policy Assessment:

As indicated earlier, the policy assessment could provide considerable guidance on both identifying policy relevant science, as well as policy-relevant risk assessment. Therefore, making the policy assessment more transparent and also more closely linked to other assessments would be desirable.

Dr. Dale Johnson

I have reviewed the Draft Plan for Review of the Secondary National Ambient Air Quality Standards for Nitrogen Dioxide and Sulfur Dioxide, and I have some substantial problems with this document as written. Specifically, I find that the tone is entirely biased toward the negative impacts of both SO_x and NO_x, whereas we have known for decades that there are positive effects as well. I am more than a little amazed that these considerations continue to fail to make it into review papers and documents like this. In particular, I find absolutely no reference to the possibility that increased deposition of NO_x, which delivers the one nutrient most commonly limiting to terrestrial vegetation, to increased growth and/or ecosystem “health”. This possibility has been raised many times in various reviews (including some of my own, which I am not pushing here, as they are now quite old). I can refer you to two publications that have appeared on the scene since the 1990’s that I think are particularly significant. Kauppi et al (1992) evaluated forest mensurational data for Europe over the period 1970 to 1990, and found, contrary to what we were being told in the 1980’s, that the growth of European forests had been increasing, not decreasing, over this period. They speculated that this could be due to better silviculture, increased nitrogen deposition, and perhaps increasing levels of atmospheric carbon dioxide. More recently, Magnani et al (2007) concluded that forest net carbon sequestration in the Northern Hemisphere “is found to be overwhelmingly driven by nitrogen deposition, largely the result of anthropogenic activities”. Given the high visibility of increasing atmospheric carbon dioxide levels and climate change, I am amazed that this kind of consideration is lacking in the document. Yes, one could argue that the Magnani article is too new to have made it in yet, but there is the Kauppi article as well as several other older ones suggesting that N deposition enhances forest C sequestration (see the Magnani article for these references). To be even handed, the report should also consider the Nadelhoffer et al (1999) article, which dismisses the possibility of nitrogen deposition increasing forest growth by contending that it is mostly tied up in the soil, given our experience in fertilizer studies. (I personally dispute that, as nitrogen deposition, unlike fertilizer applied nitrogen, can be directly taken up by foliage.)

I make these statements with absolutely no political axe to grind at all – I am NOT anti-environmentalist, and I am NOT in favor of allowing pollutants to run rampant. And I most certainly do not deny the existence of N-saturation and negative effects of too much N deposition – I have seen such things in my own research. My only motivation is that this document gives a balanced view of the effects of these pollutants and considers both the pluses and minuses of them. I have been making the same point in various meetings and reviews for a couple of decades now. To not do so is to invite even more scathing review comments from its detractors at a later time.

Specific Comments:

p. 1-10, lines 5-8: Fertilizer is mentioned here, but only in a negative context – why do you suppose that people bother to manufacture fertilizer then? To poison the environment or to promote positive growth responses?

p. 4-2, lines 24-26: I believe that the key words should include “sulfur” and “nitrogen” as well. The key words listed here will automatically steer toward negative pollutant effects and leave out basics.

p. 5-3, lines 21-32: This section comes the closest to an objective evaluation in that it least considers the potential for nitrogen uptake.

p. B-9, lines 11-23: Should include potential increases in C sequestration here.

p. B-14, Diagram: Amazing that the “Altering plant nutrients” box mentions Ca, but not N! “Altering of Production” “Food and Fiber” and “Carbon sequestration” are all shown here, but given that the only reference is to Ca (presumably in a negative context), I presume that only negative effects of N on all these results are being considered.

p. B-16, Diagram: This diagram makes the most sense of anything I have seen so far – crop (or forest) yield increases with N fertilization, but, inevitably, so does nitrate pollution. This is the kind of balance that ought to be present in the entire document.

References:

Kauppi, P.E., Mielikäinen, K. and Kuusela, K., 1992. Biomass and carbon budget of European Forests, 1971 to 1990. *Science*, 256: 70-74.

Högberg, P. 2007. Nitrogen impacts on forest carbon. *Nature* 447: 781-782.

Magnini, F., Mencuccini, M., Borghetti, M., Berbigier, P., Beringer, P., Delzon, S., Grelle, A., Hari, P., Jarvis, P.G., Kolari, P., Kowalski, A.S., Lankreijer, H. Law. B.E., Lindroth, A., Loustau, D., Giovanni, M., Moncreiff, J.B., Rayment, M., Tedeschi, V., Valentini, R. and Grace, J. 2007. The human footprint in the carbon cycle of temperate and boreal forests. *Nature* 447: 848-850.

Nadelhoffer, K. J., B. A. Emmett, P. Gundersen, O. J. Kjønaas, C. J. Koopmans, P. Schleppi, A. Tietema, and R. F. Wright. 1999. Nitrogen deposition makes a minor contribution to carbon sequestration in temperate forests. *Nature* 398:145-148.

Dr. Myron Mitchell

Page 1-2, line 7: "whose" should generally be reserved for reference to individuals. Replace with "of which".

Page 1-3, line 9: subscript x

Page 1-5, line 6: insert "ic" (acidic vs. acid)

Page 1-6, line 6: where is the beginning of the quoted statement?

Page 1-8, line 1: subscripts here and throughout document.

Page 1-9, line 2: add an "s" to detail

Page 1-9, line 15: replace "Once" with "After" and "complete" with "completed"

Page 1-9, line 28: replace "or" with "and"

Page 1-9, line 30: consider "Deposition of other chemical species..."

Page 1-9, line 31: replace "biochemistry" with "biogeochemistry"

Page 1-9, line 32: from this point on the font changes through line 8 of page 1-10.

Page 1-10, lines 1-3: consider separating these statements to read as
"Acidification results in a cascade of effects that alter biogeochemical cycles and harm terrestrial and aquatic ecosystems. These effects include slower growth, the death of forest vegetation, and ..."

Page 1-10, line 5: replace "such as" with "including"

Page 1-10, line 8: disease is a very general term. Either be more specific or delete.

Page 1-11: in the figure also include the charge on SO₄ for soil processes.

Page 1-11, line 9: should read "Acidic deposition"

Page 1-11, line 12: consider "toxic to both terrestrial and aquatic biota"

Page 1-12, line 1: consider "organisms" vs. "species"

Page 1-12, line 7: could read "in the case of Ca, Mg and K, the role of these essential..."

Page 1-12, line 8: could read "... nutrients especially in comparison with Al concentrations have..."

Page 1-12, line 15: change to "more nitrogen-limited"

Page 1-12, line 16: could read "... changes in the ability of invasive species to colonize..."

Page 1-12, line 20: "that is ultimately..."

Page 1-12, line 23: replace "places" with "locations"

Page 1-12, line 24-25: could read "... ecologically important, may play a more important role than indicated by the annual average concentrations."

Page 1-12, line 28: could read "other population changes which can cascade throughout the food web."

Page 1-12, line 29: omit "off"

Page 1-12, line 30: "...which serves as an important..."

Page 1-13, line 7: replace "nitrogen" with "ammonium"

Page 1-13, line 10: replace "gives" with "increases"

Page 3-1, line 4: could read "In this review of the ecosystem-related effects on public welfare related to NO_x and SO_x..."

Page 3-1, line 6: replace "the" with "this"

Page 3-1, line 16: insert comma after "i.e."

Page 4-3, 4.2.2 includes questions so should this paragraph end with a question mark?

Page 5-3, line 9: "correlation" would suggest a somewhat weak statistical approach. Consider changing to "relationships"

Page 5-3, line 10: This would suggest a strong approach; see previous comment.

Page 5-3, line 12: insert comma after "i.e."

Page 5-3, line 28: What is implied by soil type and characteristics? Wouldn't it be better to use the more general term of "soil properties"?

Page 5-3, lines 30-31: should read "... characteristics, which may help assess sensitivities, include..."

Page 5-4, line 2: omit "a"

Page 5-4, line 26: replace "numerical" with "simulation"

Page 5-4, line 30: insert comma after "i.e."

Page 5-5, line 12: should read "Can deposition models..."

Page 5-5, line 12: Shouldn't occult deposition be included as well?

Page 5-5, line 26: should read "... into services being beneficial to ecosystems."

Page 5-5, line 30: should read "... results in specific benefit to ecosystems?"

Page 6-1, line 23: Abundance is a weak term. Would nitrogen availability or another term be better?

Page 6-1, line 25: Can this be made more explicit.

Page 6-1, line 26: replace "depth of soils" with "soil characteristics"

Page 6-2, line 1: should read "... sulfate and other acidifying components..."

Page 6-2, line 2: should read "soil constituents including sulfate..."

Page B-2: How does CMAQ compare and/or differ from the model being used by CASTNET for estimating deposition at individual sites? Shouldn't the document be consistent with respect to use of SI versus English units? Elsewhere in the document "miles" are used.

Page B-9: paragraph B.1.3: Shouldn't those ecosystem services that will be evaluated be clearly identified early in the process of developing the new standards?

Mr. Richard Poirot

Comments on Chapter 3. (Key Policy-Relevant Issues)

1. Alternative Indicators. There is very encouraging discussion in Chapter 3 and elsewhere advocating broadened definitions of SO_x and NO_x, and of possible new (secondary NAAQS) indicators for these pollutants – separately or combined - to specifically include not just gaseous NO₂ and SO₂, but also (some of) their various transformation products. However, the discussion of alternative indicators seems unnecessarily vague, and might benefit from more specific examples. It's not clear how far the Agency might actually be able (or willing) to depart from the traditional practices of considering only direct effects of and/or indicators based on gaseous NO₂ and SO₂. Could, for example, a new indicator be:

- Total atmospheric oxidized sulfur (sum of S from airborne SO₂ and SO₄)?
- Total atmospheric oxidized nitrogen (sum of N from NO_y & NH₄NO₃)?
- Total (wet, dry and occult) deposition of oxidized atmospheric sulfur?
- Total deposition of atmospheric nitrogen (or at least oxidized nitrogen)?
- Exceedance (by X %) of critical load for atmospheric sulfur deposition?
- Exceedance (by X %) of critical load for total sulfur + nitrogen deposition?

Has this current consideration of NAAQS indicators based on transformation products of “criteria” pollutants has always been an option, or is it inspired by the clarifying definition of welfare effects added to Section 302 (h) of the 1990 CAAA (“...whether caused by transformation, conversion, or combination with other air pollutants”)?

The question of whether “total nitrogen deposition” – including both reduced and oxidized forms – is on (or off) the table as a potential indicator is of particular interest. Discussion under “Policy Assessment” in Chapter 6 (P. 6-lines 21-31) suggest that yes, it's on the table (i.e. there's a potential to consider and possibly control ammonia emissions here). If so, this should be identified up front as a key science/policy issue in the ISI and not withheld from public discussion until the (policy assessment) ANPR.

The possible use of critical loads (also explored in more detail in the Chapter 6 discussion of the planned policy assessment) raises an important question of whether site-specific conditions of receptor locations could be incorporated as a component of a secondary NAAQS indicator. Expressing a secondary NAAQS as a limit (absolute or %) by which a critical load for S (or N or S+N) should not be exceeded might allow for a “uniform” number to be applied nationally which would have substantially different regional implications. Is this option on the table?

A related question is whether separate standards might be applied to different areas (for example Class 1 Wilderness areas as suggested on p. 5-3, line 32). Conceivably, it might be possible to specify, or propose a process for identifying, “sensitive areas” where more stringent standards might apply. This reminds me to point to an informative new Forest Service-supported critical loads web resource at: <http://nrs.fs.fed.us/tools/cl/home.htm>

and to suggest that EPA might do well to seek collaborative assistance from the FS and NPS in this secondary NAAQS review.

2. Sulfate & Nitrate Aerosols. There's a clearly stated intention to avoid consideration of public welfare (primarily visibility) effects of sulfate and nitrate aerosols in this review – but rather to address these only in the upcoming PM review. The details of and reasons for this separation aren't clear, and I don't see why a section focusing on “the visibility effects of sulfate and nitrate aerosols” couldn't be developed and copy/pasted into both the secondary SO_x/NO_x and the PM ISIs (and environmental risk assessments). Good arguments could be made on both sides of the issue of whether visibility effects can best be addressed through secondary PM_{2.5} or secondary SO_x & NO_x standards (or especially the combined sulfate+nitrate standards that seem to be on the table here for deposition-related effects). But this interesting and potentially illuminating science/policy discussion (and resulting policy options) would be precluded by an advance decision that only one approach will be considered.

The nature and logic of this division isn't stated very clearly. Page 3-1, lines 19-21, indicate that “this review will focus on the ecosystem-related welfare effects that result from the deposition of these pollutants and transformation products in the gas-phase....” Does this mean that wet, occult and particle-phase deposition of these pollutants will not be considered here? Do visibility effects from light absorption by gaseous NO₂ belong in the PM review? The first paragraph on page 4-1 describes somewhat more clearly the intended division of effects associated with pollutants suspended in the ambient air (only considered under PM) vs. pollutants which have been deposited to the environment (considered here). However, no justification is provided for this division. Babs by NO₂ still falls through the cracks, particulate-phase NH₄NO₃ is often partially lost by PM_{2.5} mass measurement methods and undergoes rapid and frequent transformations to and from the gas phase. Sulfates + nitrates account for a majority of visibility impairment nationally, are typically the most “anthropogenic” (and controllable) of major PM and visibility-impairing species, are (nearly) unique as water-absorbing PM species, greatly enhancing their scattering efficiencies compared to most other species (although water is intentionally disregarded in PM measurements). The aerosol information is also a critical component of the S & N transformation, transport, air quality characterization and deposition stories – all of which need to be included here even if aerosol effects are disregarded. Conceivably a gas+aerosol, S+N indicator might correlate well with but be easier to implement than one based on deposition or critical loads.

At a minimum, there needs to be a more clearly-stated (and convincing) rationale for the predetermined avoidance of secondary aerosol effects. A section focused specifically on sulfate+nitrate visibility effects (& pro & con vs. an unspesiated PM_{2.5} indicator) should be included in the PM document (and given high time priority, since that review lags this one). This review should include a pointer to that section in the PM doc (or just include it as an appendix here). But most importantly, there needs to be a way to include consideration of aerosol effects in developing alternative environmental exposure characterization and risk assessments, such that a policy decision can be based on

understanding aerosol and other benefits of alternative deposition-based standards (or deposition benefits of speciated aerosol + gaseous standards, etc.)

3. Title IV and CAIR. The CAA Title IV SO₂ and NO₂ emission cap and trade program with its pending CAIR extension is the 800 lb. gorilla lurking in the corner of the room, while the plan avoids making eye contact. I think it would be important to include a discussion of these programs in the Chapter 1 review of regulatory history, and to then address some associated policy-relevant issues in Chapter 3. SO₂ NAAQS were last reviewed in 1988, following a decade of extensive, prioritized acid rain research and just as the 1990 CAA details were being developed. A (much) tighter secondary (and/or primary) NAAQS (for SO₂ and/or its transformation products) would have been an effective way to achieve the same emission reductions that have been achieved by Title IV – perhaps in a shorter time frame or in a way where environmental benefits rather than polluter’s profit margins were maximized. We seem however to now be stuck indefinitely with an allowance-based cap and trade program as the only way that SO₂ and NO_x emissions will be controlled in the future (and EPA’s former “Acid Rain” Division is now the “Clean Air Markets” Division).

Air quality-based, deposition-based or effects-based standards are at odds with an emissions-based trading program, since the latter approach assumes all emissions are equal in space and time, while the former approaches assume some locations or times are more important than others. How revised NAAQS for SO_x/NO_x and transformation products might interact with, complement or modify existing and future emissions trading programs could be an interesting and informative area for future science/policy discussions, and should be emphasized in this NAAQS review cycle rather than avoided. Even if cap & trade remains our preferred or exclusive control approach in the future, the timing and magnitude of the cap(s) could and should be guided by health, welfare and environmental protection needs. Consideration should also be given to extension of or alternatives to these programs for the Western half of the country, for which Title IV and CAIR have not reduced emissions.

In considering current and projected future environmental and other welfare effects, and associated alternative secondary NAAQS, the Agency will want to consider historical deposition burdens (generally declining since the mid 1970s, well before Title IV) and projected future reductions from CAIR (or other on-the-way programs). The environmental responses – first in concentration and deposition and later in biological indices – to recent (primarily) downward trends in emissions can provide compelling evidence of causal relationships. And evaluation of the rates and extent of biological recovery will want to take into account both current and projected future loading rates.

Specific Comments on Chapter 3

P. 3-1, lines 17-24: You could change “particulates” in line 18 to “transformation products” for a more inclusive term. Or if you intend “NO_x and SO_x” here to mean all gaseous precursors and gaseous transformation products, then this is inconsistent with the term “NO_x and SO_x particles” in line 22. It’s also unclear what “gas-phase” in line 20

applies to. I assume you plan to consider effects contributed by deposition of gaseous, particulate and precipitation-bound pollutants.

P. 3-1, lines 26&27: The term “ambient” on line 26 isn’t quite right unless you add “and their transformation and deposition products” after “SOx” on line 27. I think you want to specifically include deposition effects but avoid considering effects from the pollutants in the “ambient” air (or at least that’s what you say on page 4-1).

P. 3-2, line 1: You could add “soil and bedrock geology,” after “conditions,”.

P. 3-2, line 6: You could add “or deposition” after “air quality”.

P. 3-2, line 22: You could add “effects from” before “deposition” and change “sulfates” to “sulfur compounds” (presumably you intend to include effects from SO₂ deposition).

P. 32, lines 30-31: The parenthetical expression relating to long-term impacts from current and cumulative loadings is clearly relevant to a NAAQS review, but isn’t necessarily a subset of this bullet on effects of varying meteorological & climatic conditions. I suggest breaking it out as a separate bullet and putting it before the one that considers met & climate variability (or long-term change).

Comments on other sections

Chapter 1

P. 1-4, lines 25-27: This ‘logic’ – that there were insufficient data to establish a quantitative relationship between SO₂ and vegetation effects – seems to be necessarily based on an assumption that it was necessary that gaseous SO₂ be the indicator. Has this assumption changed and why?

P. 1-5, lines 25-26: I don’t think “premature and unwise” are accurate descriptors (unless modified by the term “politically”) for EPA’s reluctance to prescribe any regulatory control program for sulfur oxides in 1988 - considering that the Agency has estimated (midrange estimate in 1999 report) economic benefits of the 1990 CAA Amendments (which included the 10 million ton cap and trade SO₂ reduction) of \$110 Billion, and currently estimates that incremental benefits from additional future SO₂ and NO_x reductions in from the Clean Air Interstate Rule (CAIR) “will result in \$85 to \$100 billion in health benefits and nearly \$2 billion in visibility benefits per year by 2015 and will substantially reduce premature mortality in the eastern United States.”

(<http://www.epa.gov/interstateairquality/>).

I do think that at that point in time (1988), the Agency was (understandably) politically reluctant to act because Congress was actively debating ‘acid rain control legislation’ (& had been for the preceding decade), and the Agency was working on an internal plan that became the basis for the Title IV cap & trade provisions of the 1990 CAA Amendments. Twenty years later, it appears that the predetermined policy is that SO₂ and NO_x should

be controlled primarily through emissions-based cap & trade and not by effects-based NAAQS.

P.1-9, line 18: Generally, the clarity of this “science primer” section would benefit from some editing, for example:

P.1-9, line 21: Change “generally accepted science” to something like “the more recent peer-reviewed scientific literature”...

P. 1-9, line 25: You could delete “most”, since air masses & met influences acting on the formation of ozone are limited primarily to sunny summer days, while reactions of SO_x and especially NO_x are also important in clouds, at night, during winter, etc.

P. 1-10, line 2: You need something like “with” before “effects”.

P. 1-11, line 11: add “,” after “sediments”.

P. 1-12, line 3: Add something like “Research on” before “Effects”.

P. 1-12, line 7: Change “... and in the case of calcium, magnesium and potassium, are essential ...” to something like “... and because calcium, magnesium and potassium are essential ...”

P. 1-12, line 9: “correlated” is pretty weak. Could maybe change it to “associated”.

P.1-12, lines 22 & 23: No idea what the point is here, but I’m sure it’s not the “uncertainties” that cause greater relative contributions...

P. 1-12, line 24: I would change “... may be higher” to “can be substantially higher” (of course episodic extremes are higher than averages. Ain’t no “may” about it).

P. 1-12, line 25: You could delete “over-“ (or else delete “often”).

P. 1-13, lines 7-9: This observation that formation of ammoniated nitrate & sulfate aerosols extends the atmospheric lifetime (& transport) of NH₃/4 from a day to more than a week (prior to deposition), helps illustrate the problem of avoiding discussion of sulfate & nitrate aerosols from this NAAQS Review process.

Chapter 4

P. 4-1, lines 3-4: As indicated elsewhere, avoiding any “duplicating” of topics intended to be addressed in the PM review doesn’t necessarily save any staff resources. A ‘portable’ section on the visibility effects of sulfate and nitrate aerosols could be cheaply “duplicated” and copy/pasted in both the SO₂/NO_x ISA and the PM ISA. It would make for some interesting policy discussion (to include either here or in PM ISA or both) to consider whether future visibility might be most efficiently improved by secondary PM_{2.5} standards or by alternative secondary indicators for sulfur & nitrogen oxides and

their transformation products. For example, an indicator of total oxidized atmospheric sulfur (S from SO₂ + SO₄) might be worth considering (and would likely correlate well with total S deposition), but may be precluded by this a priori decision to separate aerosol phase transformation products of S & N from their precursor gases and their deposition products.

P. 4-1 lines 9-12: This sentence needs work. If the subject is “category”, the (line 9) verb (line 10) should be “is” not “are”, but how does this category get to be “these processes” (line 11), and what is it that “interacts” (line 12) with other PM components?

P. 4-3 line 8: Why not include “and Canadian”, since their deposition is often predominantly from US sources and we do have an AQ Agreement on acid deposition. Generally, I think there will be a very useful body of historical and continuing recent literature relating to critical loads and similar approaches from both Canadian and European research groups – who are more generally more advanced in this area than we are. It could be an especially limiting approach to focus here primarily on US studies.

P. 4-5, line 15: You could add “, transport” after “chemistry”

P. 4-5, line 48: Might add a bullet or two relating to the (time lags and) physical, chemical and ecological characteristics of “recovery” from acidification and how the end points might differ from pre-acidification conditions.

Chapter 5

P. 5-2, line 7: Might also consider including Southern Canada in some of the US “mapping” exercises (for example forest sensitivity and surface water mapping by NE Governors & Eastern Canadian Premiers).

P. 5-3, lines 10-20: In developing and comparing these gridded layers of ambient concentration and deposition, it would be useful to include grid layers aerosol SO₄, NO₃ & NH₄ (regardless of whether visibility effects are considered here), and might also be informative to include similar gridded emission data and analyses (i.e. plots of the ratios of deposition to emissions).

P. 5-3, line 29: Could add “current and historical” after “including”.

P. 5-3, line 32: Could add “, National Parks and Fish and Wildlife Refuges and National” between “Class I” and “Wilderness”.

Chapter 6

P. 6-1, line 6-1: It’s very encouraging to see the option of a “total nitrogen” indicator (presumably to include deposition of all oxidized and reduced N). It’s not clear in earlier sections of the plan that this option is actually on the table, and that effects of NH₃ & NH₄ deposition will be fully considered. An interesting range of other optional indicators (and receptor-specific modifiers) for biological sensitivity to fertilization or acidification also seem to be presented here for the first time (as exclusively policy

considerations). The technical foundations for use of these potential indicators should be presented up front and in public in the ISI and evaluated in the ecological risk assessment – rather than considered only in the Agency’s internal policy assessment discussions.

P. 6-2, line 8: I’m not sure that determination of “adversity” is exclusively a policy decision. Many of the various tools and methods for assessing adversity are developed and evaluated in the scientific realm and associated literature (albeit the dismal science). Presentation of these techniques and their associated results should not be withheld until the last-minute ANPR.

The concept of “sustainability” is a related topic which is a policy consideration that would benefit from advance scientific illumination (in might conceptually add a time dimension to the concept of “adversity”). Are there ecosystems where the present state of acidification is not currently resulting in “adverse” ecological effects, but where the net rate of base cation removal from acid deposition can’t be sustained in the future?

Dr. David Shaw

I believe EPA's Draft Plan fairly presents the key policy-relevant issues and the proposed method to review issues related to science, risk-exposure and policy. The Draft Plan also recognizes the significant regional variability in effects associated with this issue.

The Draft Plan states that the role of ammonia will be considered as part of the analysis but does not contain specifics on how the role of ammonia will be evaluated. The level of ammonia emissions in the United States is substantial and in order to fully review the secondary NAAQS for SO₂ and NO₂, its role in transport and subsequent deposition formation needs to be fully understood and evaluated.

Substantial data from current studies of various ecosystems exists and should be used as part of this review. Current data shows small, but improved trends in aquatic chemistry and species. A thorough analysis of these trends should be included in this review and factored into any modeling provided as part of EPA's analysis.

Dr. Kathleen Weathers

This draft plan is, in places specific and in others quite vague, necessarily; it is a draft plan. Nonetheless, while some of the sections are rather straightforward and reasonably clear, the Risk/Exposure section is significantly underdeveloped. Among other things, a conceptual model as well as some specific response variables will be critical to developing a credible analysis to support this area of inquiry.

Below I have listed general as well as many specific comments on this version of the draft.

First, I am encouraged that in 1995 the Acid Deposition Standard Feasibility Report to Congress concluded that “establishing acid deposition standards for sulfur and nitrogen deposition may at some point in the future be technically feasible...” The ability to relate emissions, deposition and ecosystem effects seems to me still at the core of the secondary effects assessment (see below).

A primary science and policy-relevant “tool” that was not explicitly addressed is the importance of the environmental monitoring data and programs that have been and will be necessary to detect long-term and short-term secondary effects of NO_x and SO_x. Ultimately, this document should identify what monitoring programs are necessary to determine the efficacy of air quality related policy.

I applaud the efforts to combine the effects of pollutants. That said, I think it very important to consider the emissions, deposition and ecosystem effects of ammonia and ammonium as well, as was pointed to in section 1.4.3. This review should continue to underscore the importance of linked biogeochemical processes in considering effects of NO_x and SO_x on ecosystems. Compartmentalizing analyses/assessment by chemical species or particle size makes little sense from an ecosystem effects standpoint.

Throughout (page 3-2 and beyond) the document, the importance of receptor surfaces (i.e., landuse/landcover) in influencing atmospheric deposition is under realized. “Ecosystem receptors” are considered important to identify for their susceptibility to SO_x and NO_x in this report, however, it is also important to recognize the importance of receptor surfaces in affecting the deposition of gases and particles (dry deposition), since dry deposition can contribute significantly to total deposition (in many locations and for many chemical species $\geq 50\%$ of total deposition).

Introduction:

The relative influence of ground-based vs. tall stack-emitted SO_x and NO_x vis-à-vis deposition should be noted.

The background (history) section is quite useful. Thank you for including it.

Section 1:

1.4 Science Primer

line 21: what's the definition of "generally accepted science?" By whom? How is it determined?

line 31: ..."can initiate changes in..."

Figure 1.1 might be modified for clarity. For example, the use of the word "soil processes (e.g., nitrate, sulfate and NH_x)" is confusing; processes within the soil influence the rate of production or movement of these ions. The arrow showing dry deposition depositing vertically to land surface could be modified to indicate more realistic transfers (horizontal deposition and/or deposition to trees). It might also be worth modifying the size of the arrows (for fluxes) to indicate (broadly) proportional contribution.

1.4.1

The beginning of this section could be made clearer and more linear.

1.4.3

I think it very important to include ammonia/ammonium as part of discussion on nitrogen deposition, especially since it is becoming an increasing issue in parts of the US (e.g., southeastern US). Salient points from the PM review should be cross referenced in the NO_x/SO_x report, at a minimum.

Section 3: It is important that dry deposition is considered part of this review (the deposition of gases and particles).

Section 4: It would be helpful to include a list of the related topics that will be addressed by the PM science assessment, just for references.

Page 4-1. I assume that the data from US and Canadian federal monitoring networks will be used as a basis to help..."provide a better understanding of the nature, sources, distribution..." of air and precipitation chemistry and deposition. If so, they should be noted as a source of information in addition to peer reviewed literature.

How will the vast literature be distilled and/or weighted?

Give dates for the window in which published literature will be considered (page 4-1).

Page 4-2: Deposition (atmospheric and acid deposition) should be used as a search term. Also, a brief accounting of the relative numbers of papers in each of the search categories would be instructive.

Page 4-3: I think the focus should be explicitly expanded to recent studies in the US and

abroad, especially like ecosystems in other countries (Canada and the UK, for example).

It seems to me that the assessment of the scientific quality of studies is redundant, at best, with peer review and may lead to subjectivity and/or bias in deciding which studies are considered high quality and which are not.

Section 5: This section's title addresses exposure (often synonymous with deposition, it appears) and risk. The title is inconsistent with the discussion below and should more accurately read: Exposure and Risk.

Page 5-1: The introductory paragraphs to this section are quite unclear. Creating a conceptual model (i.e., figure) depicting the proposed steps of the assessment would help. As I understand it, the goals are to consider the effects of nitrogen and sulfur deposition (aka inputs) to ecosystems. The response variables for ecosystems are functions (such as productivity, rates of nutrient cycling), and the more general ability of the ecosystem to produce clean water/air (i.e., goods and services via the ecosystem functions noted above), and that these ecosystem functions and services will be valued.

I could not tell what long-term trends would be assessed (line 14), nor how such things as "biologically-relevant" indices or "sensitive" ecosystems will be defined. Furthermore, in developing indices for assessment, it would be useful to know what scientific criteria are likely to be used by the Administrator when s/he makes "the final decision as to whether an effect is significantly adverse," so that this section can be made most useful and relevant to the process.

There is confusion throughout this section in regard to the use of the terms exposure (does this mean ambient air concentrations of SO_x and NO_x and their effects on ecosystems?) and deposition, and the quantity of N and/or S delivered to ecosystems. Demonstrating the link between air concentrations and deposition is of course critical to both exposure and risk assessments and is a topic that it being actively researched.

Once again, the scope section might reiterate what the response variables are. (Many of the potential questions to be posed are also active areas of research.)

The topic of ecological recovery is a challenge. First, it must be defined—is it biological? chemical? What are the measures? Recover to what? Next, in regard to assessing standards, recovery may be especially relevant in regard to thresholds: are there demonstrated exposures and levels of deposition beyond which ecological recovery can, or cannot, be achieved? Examining the literature for this country and abroad on the determination of environmental thresholds for N and S deposition and exposure will be important.

5.1 Assessment Approach

The goals here, once again, are to examine the relationships between emission and deposition, and deposition and ecosystem effects (this goal is stated in the Appendices, and see above). Thus, it seems important to be clear, from the outset, about the suite of

ecosystem effects (response variables) to be considered (see comments above). Also, bringing to bear all of the data and analyses available, from process models as well as from monitoring programs and specific research projects will be important, as suggested. There are published studies for areas of the country showing relationships between emissions and air/rain concentrations and, in some cases, wet deposition. As noted in this document, deciding on the relevant time step for this analysis will be important. For example, is annual or seasonal deposition sufficient to determine welfare effects, or are hourly or daily data necessary? For evaluating many ecosystem responses, the former might be the focus.

How does the CMAQ model compare to other estimates of total deposition based on monitoring data? Does CMAQ take into account land use/land cover? Do regions of high and low deposition line up, especially for sensitive ecosystems, using different approaches?

Page 5-3, lines 10-20: It is unclear to me what analyses are being proposed and how other data might be used in these analyses (e.g., precipitation, relative humidity, etc.).

There exist GIS-based maps of sensitive ecosystems as well as of atmospheric deposition (e.g., www.ecosystems-research.com/fmi/reports). Although I think that the idea of “normalizing” ecosystems is interesting, data for the types of characteristics identified are unlikely to be widely available and/or published. It may be instructive to look at the BioScience articles on acid rain (2001) and nitrogen (2003) that are a result of the ScienceLinks program as models for synthesis.

Although the cluster analysis can group ecosystems together based on certain characteristics, I underscore that it is critical that those characteristics are relevant to the questions being asked. (I have seen the method used in ways that are completely irrelevant to the process being addressed).

Models

I think it important to preface a model results or modeling section with a general discussion on the purpose, utility, strengths and limitations of the models used as part of this analysis. Rather than being predictive, most models are best exercised as heuristic tools.

Also, there is no mention of the potential use of Day-Cent-Chem except as part of a list. Further analysis of and emphasis on GIS-based models should be considered.