Minutes of the U.S. Environmental Protection Agency
Clean Air Scientific Advisory Committee
NO_X & SO_X Secondary NAAQS Review Panel Meeting

Panel Members:

Dr. Armistead (Ted) Russell, Chair
Dr. Praveen Amar
Dr. Andrzej Bytnerowicz
Ms. Lauraine Chestnut
Dr. Ellis Cowling
Dr. Douglas Crawford-Brown
Dr. Charles Driscoll
Dr. Paul Hanson
Dr. Rudolf Husar
Dr. Dale Johnson
Dr. Donna Kenski
Dr. Naresh Kumar
Dr. Myron Mitchell
Mr. Richard Poirot
Mr. David Shaw
Dr. Kathleen Weathers

Date and Time: October 30, 2007

Purpose: The Panel conducted a consultation on EPA's *Draft Plan for Review of the Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide.*

SAB Staff:

Dr. Vanessa Vu, Director SAB Staff Office
Ms. Kyndall Barry, Designated Federal Officer
Mr. Fred Butterfield, Designated Federal Officer
Dr. Holly Stallworth, Designated Federal Officer

EPA Staff:

Office of Air Quality Planning & Standards:

Ms. Lydia Wegman
Dr. Anne Rea
Dr. Dave Guinnup
Dr. Karen Martin
Dr. Bryan Hubbell
Mr. Randy Waite
Ms. Vicki Sandiford

National Center for Environmental Assessment:

Dr. Tara Greaver
Ms. Debra Walsh
Dr. Jeff Herrick
Dr. Jeff Arnold
Dr. Paul Wagner

Attachments: Agenda, "Draft Integrated Review Plan for NO_2/SO_2 Secondary NAAQS" presentation by OAQPS, and individual comments by the Panel.

Meeting Summary:

Ms. Kyndall Barry convened the meeting and explained the CASAC NO_x & SO_x Secondary NAAQS Review Panel will operate under the Federal Advisory Committee Act. Dr. Vanessa Vu, Director SAB Staff Office, welcomed all attendees to the meeting and thanked the Panel for their individual comments as developed for the consultation. Dr. Ted Russell, the Panel Chair, moderated the introduction of the Panel. All Panelists were in attendance and briefly described their area of expertise and historical work with CASAC.

Dr. Russell explained the purpose for the meeting was for the Panel to conduct a consultation on the Agency's draft review plan. Consensus would not be sought amongst the members because a consultation differs from a peer review and the Panel will have opportunities to review and provide more detailed input later in the review process. Dr. Russell explained that subsequent to the meeting, a letter to the Administrator would be written for his signature, to which each member's individual comments would be appended. The letter and attachments would be provided to the chartered CASAC, as well.

An overview of the Agency's new NAAQS review process was then presented by Ms. Lydia Wegman. Ms. Wegman highlighted the dates which have been mandated by court order for the NO_2 & SO_2 Secondary NAAQS Review: the final Integrated Science Assessment by 12 December 2008; Notice of Proposed Rulemaking by 12 February 2010; and final rule by 19 October 2010. Dr. Anne Rea then summarized the regulatory history of the standards and outlined the draft plan. Although Ted Steichen from API requested time to make oral comments, he was not present on the call, and the Panel moved on to their individual review comments with Dr. Russell as moderator.

The discussion topics generally followed the Agenda with a few modifications. For the consultation on EPA's *Draft Plan for Review of the Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide*, the chapter review assignments were divided amongst the Panel. The key policy-relevant questions presented in Chapter 3 were discussed by Ms. Chestnut, Dr. Cowling, and Mr. Rich Poirot. The scope of science assessment and methodology of literature search which will become the annexes to the Integrated Science Assessment were discussed in Chapter 4. The lead discussants for Chapter 4 were Drs. Bytnerowicz, Driscoll, Hanson, Johnson, and Mitchell. In Chapter 5, the risk/exposure assessment for the NO_X and SO_X welfare effects was discussed by Drs. Crawford-Brown, Husar, Kumar, and Weathers. Mr. Shaw and Drs. Amar and Kenski weighed in on the final chapter, Policy Assessment.

During his comments, Dr. Cowling presented a resolution passed by the Integrated Nitrogen Committee (INC) of EPA's Science Advisory Board. The INC's recommendation to the Agency is that:

> "The current air pollution indicator for oxides of nitrogen, NOx, is an inadequate measure of reactive nitrogen in the atmospheric environment. The SAB's Integrated Nitrogen Committee recommends that inorganic reduced nitrogen

(ammonia plus ammonium) and total oxidized nitrogen, NOy, be monitored as indicators of total chemically reactive nitrogen."

The resolution was passed during the INC meeting which was being held concurrent to the CASAC NO_x & SO_x Secondary NAAQS Review Panel meeting. Attendees were informed that additional information on the INC resolution would be available in the INC meeting minutes or in Dr. Cowling's written comments.

The Panel sought clarification on a few points including the Agency's decision making policy, to which the Agency asserted that both the Panel and public at-large will have multiple opportunities to comment and factor into the ultimate decision; the inclusion of additional indicators (e.g. ammonia, ammonium, total reactive nitrogen, etc.); and the overlap between PM and NO_X/SO_X secondary effects on visibility. A potential gap between 1991 and 1995 in the comprehensive literature search for NO_x was identified by Dr. Hanson. Dr. Russell challenged the Panel to provide suggestions to the Agency on how the cumulative welfare effects of NO_x and SO_x can be assessed and what forms a revised standard might take.

The following issues recurred in the Panel's discussions: inclusion of all reactive forms of nitrogen in a standard; deposition effects; visibility; the disparity in what is known of the nitrogen and sulfur reactions; critical loads; appropriateness of CMAQ; and potential inclusion of a GIS component. Dr. Russell thanked everyone for their participation. Ms. Barry requested members' revised comments by Friday, November 9th and the meeting adjourned at 3:26 PM (EDT).

Respectfully Submitted:	Certified as True:
/Signed/	/Signed/
Ms. Kyndall Barry Designated Federal Officer	Dr. Ted Russell, Chair CASAC NO_x & SO_x Secondary NAAQS Review Panel

NOTE AND DISCLAIMER: The minutes of this public meeting reflect diverse ideas and suggestions offered by committee members during the course of deliberations within the meeting. Such ideas, suggestions, and deliberations do not necessarily reflect definitive consensus advice from the panel members. The reader is cautioned to not rely on the minutes to represent final, approved, consensus advice and recommendations offered to the Agency. Such advice and recommendations may be found in the final advisories, commentaries, letters, or reports prepared and transmitted to the EPA Administrator following the public meetings.

Attachment A: Agenda for CASAC NO_X & SO_X Secondary NAAQS Review Panel Meeting to Conduct a Consultation on EPA's *Draft Plan for Review of the Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide*

EPA Science Advisory Board Staff Office
Clean Air Scientific Advisory Committee (CASAC)
NO_X & SO_X Secondary NAAQS Review Panel

Agenda: Public Teleconference Meeting

Tuesday, October 30, 2007 – 1:00 to 5:00 p.m. Eastern Time

Advisory Meeting to Conduct a Consultation on
EPA's *Draft Plan for Review of the*
Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide

1:00 p.m.	Convene Teleconference	Ms. Kyndall Barry, DFO
1:10 p.m.	Introductory Remarks	Dr. Ted Russell, Chair
1:15 p.m.	Overview of the Draft Plan from EPA's National Center for Environmental Assessment and Office of Air Quality Planning & Standards	Ms. Lydia Wegman, OAQPS
1:30 p.m.	Public Comment Period	Ms. Barry (Facilitator)
1:45 p.m.	Panel Discussion	Chair and Panel
	Topic	**Lead Discussant(s)**
	▪ **Policy-relevant Issues**	**Mr. Rich Poirot** Ms. Lauraine Chestnut Dr. Ellis Cowling
	▪ **Science Assessment**	**Dr. Charles Driscoll** Dr. Andrzej Bytnerowicz Dr. Paul Hanson Dr. Dale Johnson Dr. Myron Mitchell
	▪ **Risk/Exposure Assessment**	**Dr. Kathleen Weathers** Dr. Naresh Kumar
	▪ **Policy and General Comments**	**Dr. Donna Kenski** Dr. Praveen Amar
4:30 p.m.	Summary and Next Steps	Dr. Russell
5:00 p.m.	Adjournment	Ms. Barry

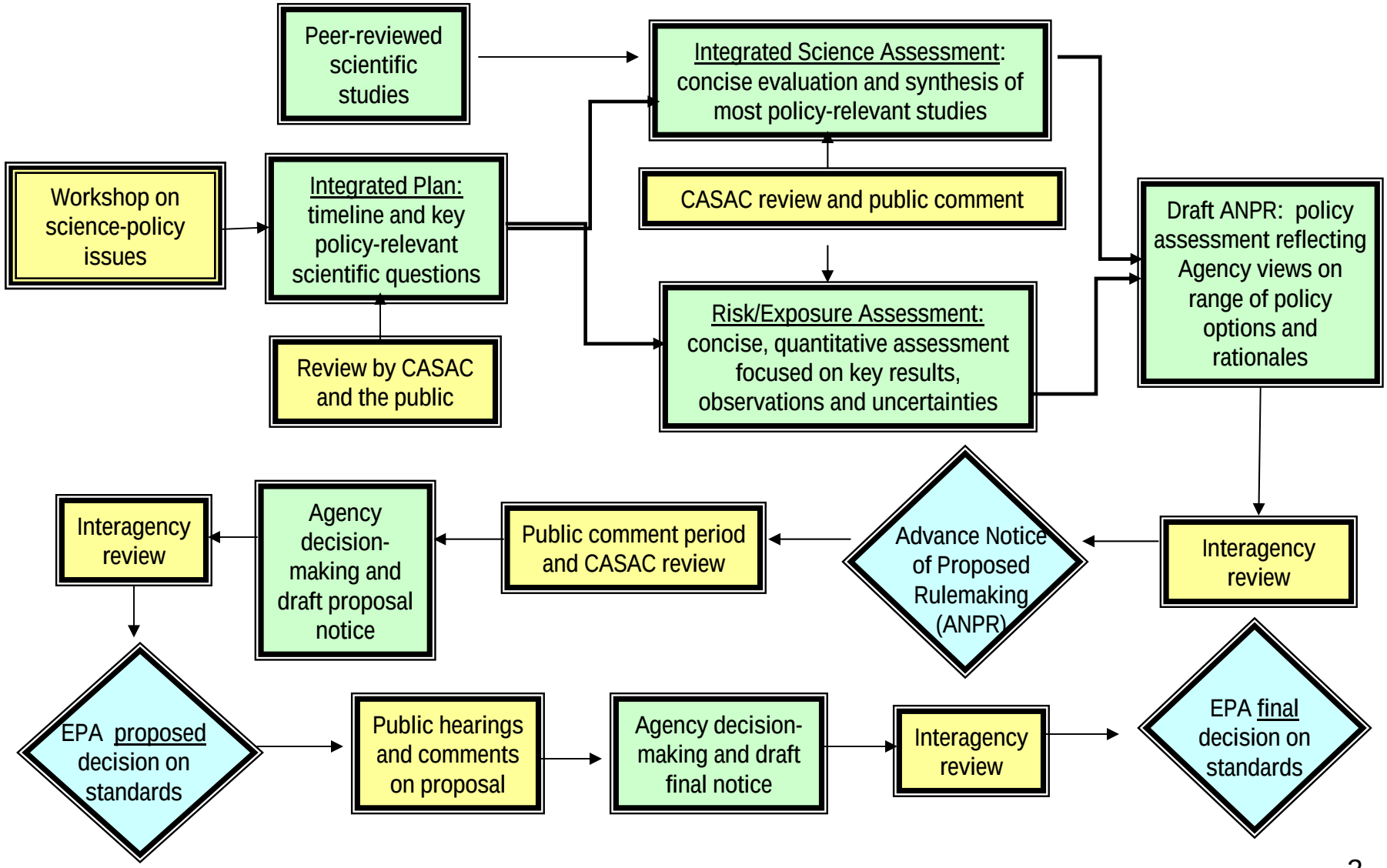
Attachment B: Presentation by OAQPS, "Draft Integrated Review Plan for NO_2/SO_2 Secondary NAAQS"

Draft Integrated Review Plan for NO_2/SO_2 Secondary NAAQS

Lydia Wegman

October 30, 2007

New NAAQS Review Process



Stage of Review	Major Milestone	NO_2/SO_2 Secondary
Integrated Review Plan	Call for information Workshop **Draft Integrated Review Plan** CASAC/public review **Final Integrated Review Plan**	Dec 2005 July 2007 **Sept 2007** Oct 30, 2007 **Dec 2007**
Integrated Science Assessment (ISA)	1st Draft ISA CASAC/public review 2nd Draft ISA CASAC/public review Final ISA	Dec 2007 Mar 2008 Aug 2008 Oct 2008 Dec 12, 2008
Risk/Exposure Assessment (R/EA)	**R/EA scope/methods plan** CASAC/public review 1st Draft R/EA CASAC/public review 2nd Draft R/EA CASAC/public review Final R/EA	**Jan 2008** Mar 2008 Aug 2008 Oct 2008 Mar 2009 May 2009 Jul 2009
Policy Assessment/ Rulemaking	ANPR CASAC/public review NPRM FRM	Aug 2009 Oct 2009 Feb 12, 2010 Oct 19, 2010

Why take the multi-pollutant approach?

- National Academy of Sciences, Clean Air Act Advisory Committee have encouraged EPA to take a multi-pollutant approach in setting air standards where possible
- The chemical transformations of NOx and SOx in the atmosphere and the environment are strongly linked together
- The environmental effects of these two pollutants are also linked
  - **Acidification** of ecosystems due to both nitrogen and sulfur
  - **Nutrient Enrichment** of ecosystems due to excess nitrogen (eutrophication)

Regulatory History of NO_2 and SO_2

- NO_2 and SO_2 secondary standards are the same as those set in 1971:
- Previous reviews have discussed the importance of environmental effects of NOx and SOx, but science has not been adequate to support revision of secondary NAAQS
- First time the Agency has taken a multi-pollutant approach and reviewed secondary standards separate from the primary standards

Outline of Review Plan

- Regulatory History
- Primer on the NOx/SOx Problem
- Schedule
- Key Policy Relevant Questions
- Science Assessment
- Risk/Exposure Assessment
- Policy Assessment

Attachment C: Compilation of Individual Panel Member Comments on EPA's *Draft Plan for Review of the Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide* (September 2007 Draft)

Comments from CASAC NO_X & SO_X Secondary NAAQS Review Panel on EPA's *Draft Plan for Review of the Secondary NAAQS for Nitrogen Dioxide and Sulfur Dioxide* (September 2007 Draft)

Comments from Dr. Praveen Amar .....
Comments from Dr. Andrzej Bytnerowicz .....
Comments from Ms. Lauraine Chestnut .....
Comments from Dr. Ellis Cowling .....
Comments from Dr. Douglas Crawford Brown .....
Comments from Dr. Charles Driscoll .....
Comments from Dr. Paul Hanson .....
Comments from Dr. Rudolf Husar .....
Comments from Dr. Dale Johnson .....
Comments from Dr. Donna Kenski .....
Comments from Dr. Myron Mitchell .....
Comments from Mr. Richard Poirot .....
Comments from Mr. David Shaw .....
Comments from Dr. Kathleen Weathers .....

Comments from 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 NO_2 and SO_2.

The draft plan, to its credit, recognizes that we have arrived at the current state of affairs in establishing separate NAAQS for SO_2 and NO_2 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 NO_2 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 SO_2/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 SO_2 and NO_2, 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.

Comments from Dr. Andrzej Bytnerowicz

General Comments

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 **NOx** (which is just a sum of NO2 and NO), but rather **NOy**, which includes NOx 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).

Changing climate should be considered in development of the secondary NO2 & SO2 NAAQS as a modifier of the ecological effects of N and S deposition. For example, in western ecosystems the effects of elevated levels of N deposition or ambient ozone (increased above-ground biomass production, reduced water availability, premature foliar senescence) can be enhanced by elevated temperatures, drought or winds of higher speed and frequency. All these factors may lead to catastrophic fires as those from 2003 and these recently observed in southern California.

Specific Comments

1. Introduction

Generally Introduction is well written and offers a good basis for the rest of the document.

However, in reference to my above statement, I suggest that on page 1-10, line 5, a change is made: "In addition to acidification, NOx and **HNO3** act with …". Alternatively, it could be changed to: "In addition to acidification, **NOy** acts with…"

Page 1-12, line 12 –instead of considering NO2 and its transformation products, it could be better to stress that NOy 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 et al., 2007).

3. Key Policy-Relevant Issues

Page 3-1, line 21 – it is not scientifically correct to say "particulate NOx and SOx". 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, more precision is using various chemical terms is needed. Criteria pollutants are SO2 and NO2, not NOx and SOx. 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 Modelling 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 Modelling 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 ands 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.

Literature:

Rosenfeld, D., J. Dai, X. Yu, Z. Yao, X. Xu, X Yang, C. Du. 2007. Inverse relationsjip between amounts of air pollution and orographic precipitation. *Science*, 315, 9 March 2007, 1396-1398.

Seinfeld, J., & S. N. Pandis. 1998. *Atmospheric Chemistry and Physics - from Air pollution to Climate Change*. John Wiley and Sons, Inc., New York, 1326 pp.

Comments from Ms. Lauraine Chestnut

The draft plan gives a comprehensive overview of the ambitious 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 NOx and SOx. 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 for the deposition-related effects of NOx and SOx?

If all the questions articulated here could be answered then the decisions about standards would be fairly straightforward. Difficulties will arise, of course, 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 selecting 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?

The plan mentions the need to assess the progress expected in reducing deposition precursors as a result of the primary NAAQS (e.g., for PM and ozone) and current regulations (e.g., CAIR), but this is an important issue that perhaps deserves more attention. This review of a potential secondary standard needs to acknowledge that other standards and regulatory efforts are already underway that have reduced deposition precursors and will reduce them further in the future. Theoretically, a secondary standard could be based on a simple determination of what level of exposure is sufficient to prevent adverse environmental effects, independent of expected future emission levels. However, it is a relevant policy question whether such standards are needed to prevent expected future adverse effects or whether current standards and regulatory efforts are sufficiently protective.

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. For example, acidification of lakes and streams to the point that some aquatic species cannot survive in those waters could be established to be an adverse effect without necessarily having estimates of society's

monetary valuation for preventing such effects. I think the assessment will have to make the case regarding what constitutes an adverse effect on the biological level regardless of what valuation information may or may not be available.

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. However, the assessment process will have to take into consideration the practical policy implications of the long-range transport of the pollutants in this case. Meeting a deposition-related standard in one location would necessitate emission controls in many distant locations and this may limit the practicality of having very fine tuned location specific standards.

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 emissions of NOx and SOx. Although a full quantitative benefits assessment would be nice, it is going to be very difficult to do and may not be necessary. Perhaps standards could be reasonably established based on less than a full benefits assessment. This might be the case, for example, 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. This would not necessarily require, however, the full quantification of the dose-response relationship between levels of deposition and levels of environmental response. The linkages between emissions and environmental effects would have to be sufficient, however, to establish that there is a causal link between anthropogenic emissions and adverse environmental effects of deposition.

Comments from Dr. Ellis Cowling

Very General Comments on these NAAQS Review Processes

Before dealing with the details of my specific assignment during the October 30, 2007 CASAC Consultation on the Secondary (public-welfare based) NAAQS for NOx and SOx, I would like to offer a few general comments about these periodic NAQQS Review processes and the changes that are being made in both the organization and focus of these reviews.

As described on pages 1-2 of the "Draft Plan" for the NOx and SOx Secondary standards, the Clean Air Act of 1970 established two general goals for management of air quality in the United States -- protection of human health and protection of public welfare. Section 108 of the CAA directs the Administrator of EPA to identify and list "air pollutants" that "in his judgment may reasonably be anticipated to endanger public health and welfare" and to issue air quality criteria for those that are listed – hence the term "Criteria Pollutants."

Section 109 of the CAA further directs the Administrator of EPA to propose and promulgate "Primary" National Ambient Air Quality Standards to protect public health and "Secondary" National Ambient Air Quality Standards to protect public welfare.

A secondary standard, as defined in Section 109, must "specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on such criteria, is required to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air …" The welfare effects of concern include, but are not limited to "effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

So far, the several Administrators of EPA since 1970 have:

1) Identified six specific "Criteria Pollutants" – carbon monoxide, ozone and other photochemical oxidants, sulfur dioxide, oxides of nitrogen, particulate matter, and lead – which have thus been designated officially as requiring development and implementation of National Ambient Air Quality Standards;
2) Emphasized protection of public health as the principal (and overwhelmingly important) *de facto* focus of concern within the Agency, and public welfare as a (rarely openly acknowledged) but distinctly less important *de facto* focus of concern;
3) Established Secondary (public-welfare-based) NAAQS standards for all six criteria pollutants that almost always were identical in form (including level, indicator, statistical form, and averaging time) to the Primary (public- health based) NAAQS standards for each of these six criteria pollutants;
4) Developed a long-standing tradition of dealing with these six specific air pollutants mainly on a "one-at-a-time" basis rather than collectively – i.e., without strong attention to the frequent interactions and simultaneous occurrence of some of these pollutants as mixtures within the air in various parts of our country;

5) Maintained a reluctant attitude about the concepts of ecologically based "Critical Loads and Critical Levels" developed in Europe as possible alternative or additional approaches to air-quality management in the US; and
6) Maintained a long-standing general focus on the related concepts of:
   a) "attainment counties and non-attainment counties,"
   b) "attainment demonstrations" based on mathematical modeling of a limited number of exceedance events under extreme weather conditions, and
   c) "local anthropogenic sources" as opposed to "both local and regional biogenic and anthropogenic sources of emissions."

In recent years, in contrast to several of the six ideas listed above, EPA has shown increased willingness to think more holistically – and in more fully integrated ways – about both the policy-relevant science and the practical arts of air quality management aimed at protection of both public welfare and public health. These shifts in both emphasis and approach have included:

1) Participation with other federal agencies and international bodies in discussions about the "One Atmosphere," "Critical Loads–Critical Levels," and "Multiple-Pollutant–Multiple Effects" concepts;
2) Adoption of the "NOx SIP Call" in 1999 and both the "Clean Air Interstate Rule" (CAIR) and the "Clean Air Mercury Rule" (CAMR) in 2005 with their more balanced perspectives about both regional (interstate) and local sources of emissions and interactions among NOx, SOx, VOCs, "air toxics," and mercury in the formation, accumulation, and biological effects of "ozone and other photochemical oxidants," and fine, coarse, thoracic, and secondary aerosol particles;
3) Recognition of both fine and coarse PM as complex and geographically variable mixtures of sulfate-, nitrate-, and ammonium-dominated aerosols; natural biogenic and anthropogenic organic substances; heavy metals including cadmium, copper, zinc, lead, and mercury; and some other miscellaneous substances;
4) More frequent discussion about of the occurrence and both ecologically-important and public-health impacts of mixtures of air pollutants; and, most recently
5) The unprecedented decisions to:
   A) Prepare and publish in September 2007 a "*Draft Plan for* [simultaneous] *Review of the Secondary National Ambient Air Quality Standards for Nitrogen Dioxide and Sulfur Dioxide;*"
   B) Include on page 2-1 of this "*Draft Plan*" a "*Proposed Schedule for Joint NOx and SOx Secondary Standard Review"* with a *"Final Integrated NO_2/SO_2 NAAQS Work Plan*" in December 2007 to be followed by preparation and CASAC review of similarly integrated NOx/SOx documents including:
      i) an Integrated Science Assessment (ISA) to be issued in December 2008,
      ii) a Risk/Exposure Assessment (R/EA) to be completed by July 2009,
      iii) a Policy Assessment/Rulemaking document prepared in the form of an Advanced Notice of Proposed Rule Making (ANPR) in August 2009 and Final Rule Making to be completed by October 19, 2010; and
   C) Separate the preparation and review of documentation, the required CASAC and public reviews, and (possibly also) the final decision-making processes

for a Secondary (public-welfare-based) NAAQS from the (previously always dominating) Primary (public-health-based) NAAQS review processes.

Need for Policy Relevancy as the Dominant Concern in NAAQS Review Processes

In a May 12 2006 summary letter to Administrator Johnson, CASAC Chair, Dr. Rogene Henderson, provided the following statement of purpose for these periodic NAAQS review processes.

> "CASAC understands the goal of the NAAQS review process is to answer a critical scientific question: *"What evidence has been developed since the last review to indicate if the current primary and/or secondary NAAQS need to be revised or if an alternative level or form of these standards is needed to protect public health and/or public welfare?"*

During the past 18 months, CASAC has participated in reviews of three of the existing six criteria pollutants – particulate matter, ozone, and lead. CASAC has also joined with senior EPA administrators in a "top-to-bottom review" and the resulting recently-completed revision of the NAAQS review processes. These two experiences have led to a seemingly slight but important need for rephrasing and refocusing of this very important "critical scientific question:"

> ***"What scientific evidence and/or scientific insights have been developed since the last review to indicate if the current public-health based and/or the current public-welfare based NAAQS need to be revised or if alternative levels, indicators, statistical forms, or averaging times of these standards are needed to protect public health with an adequate margin of safety and to protect public welfare?"***

With regard to the important distinction in purpose of the primary (public health) and secondary (public welfare) NAAQS standards, it is noteworthy that in all five cases in which a secondary NAAQS standard has been established, the secondary standard has been set "Same as Primary."

Thus, a second very critical scientific question that needs to be answered -- especially with regard to the present Joint Review of the Secondary Standards for NOx and SOx, as well as the other four criteria air pollutants is:

> ***"What scientific evidence and/or scientific insights have been developed since the last review to indicate whether, and if so, what particular ecosystem components or other air-quality-related public welfare values, are more or less sensitive than the populations of humans for which primary standards are established and for this reason may require a different level, indicator, statistical form, or averaging time of a secondary standard in order to protect public welfare."***

I hope these two "critical scientific questions" will be borne in mind carefully as CASAC joins with the various relevant parts of the Environmental Protection Agency in completing the upcoming reviews of both the primary and secondary National Ambient Air Quality Standards for NOx and SOx.

We now have the considerable advantage that a much more complete focus can be achieved in the Integrated Science Assessment than has historically been achieved in the encyclopedic Criteria Documents that have been prepared during the years since 1970.

Thus, I recommend that every chapter of the soon to be completed NOx/SOx Integrated Science Assessment, the Risk/Exposure Assessment, and the Policy Assessment/Rule Making documents contain a summary section composed almost entirely of a series of very carefully crafted statements of Conclusions and Scientific Findings that:

1) **Contain the distilled essence of the most important topics covered in each chapter, and**
2) **Are as directly relevant as possible to the two Critically Important Scientific Questions written in bold italic type above**.

In this connection, I call attention once again to the attached "*Guideline for Formulation of Statements of Scientific Findings to be Used for Policy Purposes.*" These guidelines were developed and published in 1991 by the Oversight Review Board for the National Acid Precipitation Assessment Program. They are the best guides that I know of for formulation of scientific findings to be used for policy purposes.

GUIDELINES FOR FORMULATION OF SCIENTIFIC FINDINGS

TO BE USED FOR POLICY PURPOSES

The following guidelines in the form of checklist questions were developed by the NAPAP Oversight Review Board to assist scientists in formulating presentations of research results to be used in policy decision processes.

1) **IS THE STATEMENT SOUND?** Have the central issues been clearly identified? Does each statement contain the distilled essence of present scientific and technical understanding of the phenomenon or process to which it applies? Is the statement consistent with all relevant evidence – evidence developed either through NAPAP research or through analysis of research conducted outside of NAPAP? Is the statement contradicted by any important evidence developed through research inside or outside of NAPAP? Have apparent contradictions or interpretations of available evidence been considered in formulating the statement of principal findings?

2) **IS THE STATEMENT DIRECTIONAL AND, WHERE APPROPRIATE, QUANTITATIVE?** Does the statement correctly quantify both the direction and magnitude of trends and relationships in the phenomenon or process to which the statement is relevant? When possible, is a range of uncertainty given for each quantitative result? Have various sources of uncertainty been identified and quantified, for example, does the statement include or acknowledge errors in actual measurements, standard errors of estimate, possible biases in the availability of data, extrapolation of results beyond the mathematical, geographical, or temporal relevancy of available information, etc. In short, are there numbers in the statement? Are the numbers correct? Are the numbers relevant to the general meaning of the statement?

3) **IS THE DEGREE OF CERTAINTY OR UNCERTAINTY OF THE STATEMENT INDICATED CLEARLY?** Have appropriate statistical tests been applied to the data used in drawing the conclusion set forth in the statement? If the statement is based on a mathematical or novel conceptual model, has the model or concept been validated? Does the statement describe the model or concept on which it is based and the degree of validity of that model or concept?

4) **IS THE STATEMENT CORRECT WITHOUT QUALIFICATION?** Are there limitations of time, space, or other special circumstances in which the statement is true? If the statement is true only in some circumstances, are these limitations described adequately and briefly?

5) **IS THE STATEMENT CLEAR AND UNAMBIGUOUS?** Are the words and phrases used in the statement understandable by the decision makers of our society? Is the statement free of specialized jargon? Will too many people misunderstand its meaning?

6) **IS THE STATEMENT AS CONCISE AS IT CAN BE MADE WITHOUT RISK OF MISUNDERSTANDING?** Are there any excess words, phrases, or ideas in the statement which are not necessary to communicate the meaning of the statement? Are there so many caveats in the statement that the statement itself is trivial, confusing, or ambiguous?

7) **IS THE STATEMENT FREE OF SCIENTIFIC OR OTHER BIASES OR IMPLICATIONS OF SOCIETAL VALUE JUDGMENTS?** Is the statement free of influence by specific schools of scientific thought? Is the statement also free of words, phrases, or concepts that have political, economic, ideological, religious, moral, or other personal-, agency-, or organization-specific values, overtones, or implications? Does the choice of how the statement is expressed rather than its specific words suggest underlying biases or value judgments? Is the tone impartial and free of special pleading? If societal value judgments have been discussed, have these judgments been identified as such and described both clearly and objectively?

8) **HAVE SOCIETAL IMPLICATIONS BEEN DESCRIBED OBJECTIVELY?** Consideration of alternative courses of action and their consequences inherently involves judgments of their feasibility and the importance of effects. For this reason, it is important to ask if a reasonable range of alternative policies or courses of action have been evaluated? Have societal implications of alternative courses of action been stated in the following general form?:

   "If this [particular option] were adopted then that [particular outcome] would be expected."

9) **HAVE THE PROFESSIONAL BIASES OF AUTHORS AND REVIEWERS BEEN DESCRIBED OPENLY?** Acknowledgment of potential sources of bias is important so that readers can judge for themselves the credibility of reports and assessments.

My Assignment in this CASAC Consultation on the Draft Plan for Review of the Secondary Standards for Nitrogen Dioxide and Sulfur Dioxide

My specific assignment in preparation for the October 30 , 2007 CASAC Consultation on the Draft Plan as outlined in Chairman Ted Russell's memo of 11 October 2007 is -- *Key Policy Relevant Issues*. These topics are covered primarily in Chapter 3 of the Draft Plan and are summarized in the five Overarching Policy-Relevant Questions on pages 3-1 and 3-2 and the additional policy relevant scientific questions presented in Chapters 4-6.

Chairman Russell also gave this same assignment to two other CASAC panel colleagues -- Lauraine Chestnut and Rich Poirot. Thus, I am very much looking forward to comparing notes with both Lauraine and Rich during our Consultation on October 30.

There are many parts of Chapter 3 and other parts of this Draft Plan showing that both gaseous and particulate forms of the various oxides of nitrogen and sulfur should be included among the "Pollutants of Concern" in this review of the NOx and SOx Secondary standards. That is good.

As an ecologist, who is aware of the many different and important adverse public-welfare effects of both oxidized and reduced forms of reactive nitrogen, I was pleased to find that section 1.4.3 of Chapter 1 is titled "Ammonia" At first, I thought this might mean that EPA would be willing to broaden its perspectives about the many, diverse, and very significant adverse welfare effects of reactive nitrogen pollution by adding ammonia, ammonium ion, and other reduced forms of reactive nitrogen to the "Indicators of Concern" in this nitrogen and sulfur NOx and SOx joint NAAQS review. But my hopes were quickly dashed by EPA's apparent continuing preference (see page 1-13) to consider reduced forms of nitrogen almost exclusively in the context of the PM review.

Many of us in the ecological community are well aware that atmospheric deposition of nitrogen and sulfur oxides – but also atmospheric deposition of chemically reduced forms of these same elements (especially ammonia and ammonium ion) -- are causing a wide variety of sometimes beneficial and sometimes adverse effects on terrestrial and aquatic ecosystems in many parts of our country. These effects include:

1) acidification of lakes, streams, soils, and both surface and ground waters;
2) eutrophication of lakes, streams, and estuaries,
3) hypoxia in some coastal and marine ecosystems,
4) changes in biodiversity within some aquatic and terrestrial ecosystems,
5) changes in reproduction and age-class distributions of fish populations,
6) changes in the nutrient status of forest trees and natural grasslands that sometimes lead to increased growth and productivity but sometimes also cause increased susceptibility to pest and pathogens,
7) decreases in frost hardiness in some forest tree species such as red spruce,
8) nitrogen saturation of some forest soils, as well as
9) decreases in visibility and increases in regional haze in urban and rural locations as well as in scenic vistas in wilderness areas and airports, and

10) increased deleterious effects on some building materials and historical monuments of various types.

These many and varied ecological and other public-welfare consequences of nitrogen and sulfur pollution provide strong justification for reexamination of the secondary NAAQS standards for both nitrogen and sulfur. To be sure, inclusion of reduced as well as oxidized forms of nitrogen and sulfur would require a very significant change in the "Indicators of Concern" for either or both of the NOx and/or SOx NAAQS standards.

But it is very clear that the wide range of adverse effects listed above fit very well with the definition of "welfare effects" specified in section 109 of the Clean Air Act -- "effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

Also, there is a very large body of accumulated scientific evidence about many of the 10 different welfare effects listed above that have been shown to be attributable to exposures to reduced as well as oxidized forms of both nitrogen and sulfur. In fact, essentially all 10 of the important "Effects of Concern" listed above have been attributed to- or at least are significantly influenced by- both reduced and oxidized forms of nitrogen. Some of these same "Effects of Concern" also are influenced by both reduced and oxidized forms of sulfur. This is true for the 1st, 5th, 6th, 7th, 9th, and 10th effects listed above. Thus, it makes much logical sense – and well-justified scientific sense as well -- for EPA to carefully consider the possibility of broadening the definition of the "Indicators of Concern" for the NAAQS for NOx and SOx to include both reduced and oxidized forms of nitrogen -- and perhaps also both reduced and oxidized forms of sulfur -- as a part of the presently proposed joint science assessment for the secondary NAAQS for NOx and SOx.

Section 4.1 of this Draft Plan makes an important and well-reasoned distinction between how the Agency plans to include welfare effects caused by NOx and SOx "and their transformation products while still residing in the ambient air" in the secondary PM NAAQS review, and thus to include in the present "NOx and SOx secondary NAAQS joint science assessment" the "welfare effects driven by the[se] pollutants or their transformation products once deposited into the environment."

For all of the reasons outlined above, many of us in the ecological community continue to believe that the US and other developed countries of the world need to consider the establishment of an integrated total reactive nitrogen approach in air-quality management.

Such an integrated total reactive nitrogen idea was considered in a 1997 EPA report titled "Nitrogen Oxides: Impacts on Public Health and the Environment." This document was prepared by a team of scientists and engineers led by Doug Grano in EPA's Office of Air and Radiation. Such an integrated approach was also recommended in a 1998 review paper titled "Optimizing air quality management in Europe and North America: Justification for integrated management of both oxidized and reduced forms of nitrogen" by Cowling et al (Environmental Pollution 102 S1 (1998) 599-608).

During the intervening years, a solid foundation of experimental work and periodic reassessments of integrated total reactive nitrogen approaches have been presented in a series of peer reviewed journal articles and focused workshop and international conference reports developed under the auspices of:

- the 1st, 2nd, 3rd, and 4th International Nitrogen Conferences held in the US and abroad,
- the International Fertilizer Industry Association,
- the UN ECE Convention on Long Range Transboundary Air Pollution (LRTAP),
- the European Commission's Clean Air for Europe program (CAFE),
- the Nordic Council of Ministers, and
- the International Nitrogen Initiative (INI).

The International Nitrogen Initiative (www.initrogen.org) was started in 2002 as an outgrowth of the 2nd International Nitrogen Conference. An integrated nitrogen approach and management of nitrogen was proposed in the Nanjing Declaration, which was an outgrowth of the 3rd International Nitrogen Conference held in Nanjing in 2004.

The following peer reviewed articles and both workshop and conference reports provide important parts of the scientific background for consideration of integrated total reactive nitrogen strategies:

Erisman, J. W., W. de Vries, H. Kros, Oene Oenema, L. van der Eerden, H. van Zeijts, and S. Smeulders. 2001. An outlook for an integrated nitrogen policy. Environmental Pollution and Policy 4:87-95.

Galloway, J.N., J. D. Aber, J.W. Erisman, S.P. Seitzinger, R.W. Howarth, and E.B. Cowling. 2003. The Nitrogen Cascade. Bioscience 53:341-356.

Erisman, J. W., P. Grennfelt, and M. Sutton. 2003. The European perspective on nitrogen emission and deposition. Environment International 29:311-325.

Erisman JW. 2004. The Nanjing Declaration on management of reactive nitrogen. *BioScience* 54, 286-287.

Erisman, J.W., N. Domburg, W. deVries, B. deHaan, B., and K. Sanders. 2005. The Dutch N-Cascade in the European Perspective. Science in China Series C. Life Sciences, 48(1): 1-10.

Erisman, J.W. 2007. Nitrogen and the Convention on Long-Range Transport of Air Pollution. http://asta.ivl.se/Workshops/Saltsjobaden3/Background%20material/JWE_nitrogen%20and%20clrtap.doc

Erisman, J.W., T. Spanger, M.A. Sutton, C. Askelssson, S. Amin-Hansjani, H.V. Anderson, H. Apsimon, S. Belyazid, H. Fagerli, H. Harmens, M. Havlikova, J.P. Hettelingh, K. Hicks, L. Horvath, N. Hutchings, M. Maasikmets, M. Maione, S. Reis, and C. Stenby. 2007. Nitrogen – integrated environmental policies. Working Group 5 Report, http://asta.ivl.se/Workshops/Saltsjobaden3/Conclusions/WG5.pdf

Grennfelt, P., L. Lindau,. and J. Arnell. 2007. Air pollution and its relationship to climate change and sustainable development: Linking immediate needs with long term challenges. Main Conclusions from "Saltsjöbaden 3" Workshop, Göteborg, Sweden, 12-14 March 2007. http://asta.ivl.se/Workshops/Saltjoboden3/Conclusions/Salt3_Final_conclusions_rev8juni.pdf

Sutton, M.A., J. W. Erisman, and O. Oenema. 2007. Strategies for controlling nitrogen emissions from agriculture: Regulatory, voluntary and economic approaches. International Fertilizer Industry Association International Workshop on Fertilization Best Management Practices, Brussels, Belgium. March 2007. http://www.fertilizer.org/ifa/publicat/bap/2007_brussels_fbmp.asp

Only one of these peer reviewed publications and detailed workshop and conference reports are included among the References listed in Chapter 7 of the Draft Plan for Review of the Secondary NAAQS for NOx and SOx.

It is important to note that these emerging ideas about the need for an "integrated total reactive nitrogen" approach also led to a recent decision by the Science Advisory Board (SAB) of the USEPA to establish a special committee of the Board to make a thorough study of reactive nitrogen and its effects on public health and welfare. This committee is titled the Integrated Nitrogen Committee (INC). It has been at work for most of the past year and is led by Dr. James Galloway of the University of Virginia. The 18 current members of the INC include a carefully selected group of scientists and engineers with broad experience in both air quality and water quality aspects of nitrogen pollution and its management.

It is also noteworthy that during the 2007 "Solsjöbaden 3 Workshop" cited above, the USEPA joined with other LRTAP signatory organizations in proposing that a "Taskforce on Integrated Nitrogen" should be established within the LRTAP Convention to explore integrated reactive nitrogen strategies under the auspices of the LRTAP Working Group on Strategies. In April 2007 the Executive Body of LRTAP decided to implement this proposal in 2008 with leaders from the UK and the Netherlands as co-chairs. This is the first time that an integrated nitrogen approach has been approved for consideration on a political level.

Other Suggestions for Improvement of the Secondary NAAQS NOx and SOx Documents Yet to Come

Finally, permit me to offer the following additional suggestions for improvement of the Integrated Science Assessment, Risk/Exposure Assessment, and Policy Assessment/Rulemaking documents to be completed with the present Draft Plan as an initial guide:

1) The term "acidic deposition" used frequently in Chapter 1 should be replaced by the more accurate term "acidifying deposition" or at least the less misleading term "acid deposition." Gaseous ammonia, ammonium ion, and both ammonium sulfate and ammonium nitrate are all acidifying substances even though some are not acidic when they are being deposited from the atmosphere into ecosystems.

2) The answers that will be given to the well-formulated and well-focused "overarching policy-relevant questions" listed on pages 3-1 and 3-2 in Chapter 3 and the more detailed "policy-relevant questions" listed on pages 4-4 and 4-5, pages 5-5 and 5-6, and page 6-3 will inevitably be incomplete and or misleading with regard to quantitative interpretation of the causal "Pollutants of Concern" and the principal "Effects of Concern" if gaseous ammonia, ammonium ion, and other reduced forms of reactive nitrogen in both wet and dry deposition are not included in the science assessment, risk assessment, and proposed rulemaking documents.

Resolution from the Integrated Nitrogen Committee of the Science Advisory Board for Consideration by the CASAC Secondary NAAQS NOx and SOx Review Panel

During the ongoing meeting of the EPA Science Advisory Board's Integrated Nitrogen Committee (INC) -- meeting at SAB Headquarters in Washington DC on October 29-31, 2007 -- the several members and Chair of the INC, Dr. James Galloway of the University of Virginia, asked me (as the CASAC-designated liaison person to the Science Advisory Board's Integrated Nitrogen Committee) to present the following Resolution (which was developed and approved by the INC) for consideration during the CASAC review of the NAAQS for NOx and SOx during our CASAC Conference Call Consultation on October 30, 2007.

Resolution

The current air pollution indicator for oxides of nitrogen, NOx, is an inadequate measure of reactive nitrogen in the atmospheric environment. The SAB's Integrated Nitrogen Committee recommends that inorganic reduced nitrogen (ammonia plus ammonium) and total oxidized nitrogen, NOy, be monitored as indicators of total chemically reactive nitrogen.

Comments from 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 include in the PM assessment, although I believe it will be VERY difficult to separate out the effects of the gaseous and particulate phase NOx and SOx. 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 NOx and SOx 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 NOx and SOx 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..

Comments from Dr. Charles Driscoll

I appreciate the opportunity to comments on the EPA Draft Plan for Review of the Secondary National Ambient Air Quality Standards for Nitrogen Dioxide and Sulfur Dioxide. I received this document late (only yesterday). The advantage is that I have had the opportunity to read everyone else's comments. Many of the comments and thoughts that I have are similar to those of others on the panel.

In general I am supportive of the document and approach. Some of these comments amplify some of the comments of others on the panel.

Reduced nitrogen. I agree with the comments of many of the committee members that reduced nitrogen should be included in the assessment. Reduced nitrogen species (NH_4^+, NH_3, organic N) make substantial contributions to particulate matter in the atmosphere and to the total nitrogen loading to ecosystems. Given the magnitude of these contributions it seems that we should consider these emissions and deposition as part of this assessment.

Linked assessment of nitrogen and sulfur emissions. I also agree with the comments of many of the panel members that I very much support the linked assessment of sulfur and nitrogen deposition, as there are similar pathways for these materials and acidification effects are related to the combined impacts of sulfur and nitrogen. That said in addition to acidification effects, there are fertilization effects associated with nitrogen that need to be assessed separately. Another issue that may challenge the linked assessment of sulfur and nitrogen may be how well the science is developed for each of these elements. I may be off base here but my sense is that the science may be more definitive for sulfur effects than nitrogen effects. This may be due to the longer residence time of nitrogen in ecosystems and the more complex ecosystem cycling of nitrogen.

National vs regional control strategies. I agree with some of the panel members that there may be some advantages associated with a regional approach to air quality management in the U.S. concerning ecosystem effects. This approach was suggested by the NRC (2004). However, there also appear to be disadvantages to this approach. I am specifically thinking about the recent NO_x Budget Trading Program (NBP) to control NOx emissions in the eastern U.S. I believe that this rule was directed to control ozone in the East. However, there is a fair amount of scientific literature suggesting nitrogen deposition effects on the West. While there are some advantages associated with these regional rules they rule the risk of ignoring environmental issues in areas of the country where emissions are not controlled.

Positive vs negative effects. I endorse Dale Johnson's comments about positive and negative effects. It is difficult to pass judgement on what are positive and negative effects. I think we should simply document change and let others decide what are the positive and negative effects.

Extent and rate of recovery. One issue that I can imagine that will be difficult to address is the extent and rate of "ecosystem recovery" following reductions in emissions. There is a wide range of sensitivity of ecosystems to inputs of atmospheric sulfur and nitrogen deposition. With respect to acidification many ecosystems are naturally acidic due to inputs of organic acids. In addition, the long-term monitoring studies and modeling studies suggest that the recovery of ecosystems following reductions will occur over extended time scales (e.g., many decades). These two interrelated considerations will challenge our ability to establish secondary standards for sulfur and nitrogen. Some ecosystems are so sensitive that it is unlikely that they will ever "recover" from emission reductions. Likewise, the recovery period for some ecosystems will likely be so extended that this will create a difficult situation.

Methylation of mercury. There is a bit of text on the linkage between methylation of mercury and sulfur deposition, but this effect and relative pH effect on fish should be addressed in the assessment.

Specific comments

1-9, line 28 I don't like the term occult deposition. Can this be changed to cloud and fog deposition?

1-9, line 31 Should this be bio*geo*chemistry?

1-9, line 32 and below. Font change?

1-11 Figure title. Should the figure title be in caps or lower case?

1-11, line 12 Change levels to concentrations.

1-12, line 5 Decreases in *available* base cations…

1-12, line 11 and elsewhere Should section titles be in caps or lower case.

1-12, line 21 On an annual basis, *atmospheric nitrogen deposition may contribute* up to 40%....

1-12, line 22-24. I do not understand these sentences.

1-12, line 29. …addition, *increased phytoplankton growth in the water column and on surfaces can attenuate light causing declines in* submerged…

Comments from 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 NOx and SOx. 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 NOx science, the current science reviews should go back prior to 1995 to around 1991. Much of the research summarized in the previous NOx 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 NOx and SOx contributions to particulate matter issues (it is summarized elsewhere), Section 4.2 should also describe the issue of NOx as a tropospheric ozone precursor. I assume that such a summary statement would conclude that NOx as an ozone precursor is/ handled and discussed in the context of the recent review and AQCD for photochemical oxidants. The dominant role of NOx as an ozone precursor may, however, still be relevant in the context a standard setting process for NOx 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.

Comments from Dr. Rudolf Husar

Overall, the draft review plan for the Secondary NAAQS for NOx and SOx is sound and executable. In particular, the combination of NOx and SOx 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 NOy 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.

Comments from 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 SOx and NOx, 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 NOx, 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 anthropgenic 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 Magnini 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 give a balanced view of the effects of these pollutants and consider 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.

Comments from Dr. Donna Kenski

Overall, this was an excellent plan for moving forward with a comprehensive review of NOx and SOx effects on ecosystems. It was well written and logically presented. I thought the posing of policy relevant issues in Sec. 3 was particularly well done. There were two significant shortcomings that I hope are addressed in the ISA. First, this plan didn't explicitly mention any assessment of the spatial scales of susceptible ecosystems. Some ecosystems and parts of the country are more vulnerable than others to the effects of acidification and deposition. These should be clearly identified and their degree of susceptibility depicted, ideally with maps. Conceivably, a secondary standard for deposition might be different for various parts of the country, to adequately protect sensitive ecosystems but allow flexibility for regions with more ecological resilience. The whole process is crying out for a GIS analysis that could overlay and *really* integrate the deposition data with the ecosystem data, emissions data, valuation data, etc. – i.e., build an atlas of relevant information. Once that information is gathered together, GIS-based spatial analysis tools can be used to extract many more insights from the collection of data. Note that uncertainty in this spatial information can be incorporated into this kind of analysis. Section 5.3 does mention that a GIS approach will be used, but almost as an aside. It should play a much more central role in the presentation and integration of findings in the ISA.

Second, I'm confused about the extent to which NH3/NHx will be addressed in the ISA. It rates a paragraph in section 1.4.3 that announces it will be 'considered', but then it is barely mentioned again. It is unrealistic to consider acidification effects of NOx and SOx without NHx, which also plays an important role in acidification. Because the chemistry of NOx and SOx are inextricably linked to NHx, it needs to be addressed explicitly. I do not believe that it can be dismissed by noting that its role in aerosol formation will be addressed in the PM ISA. It plays an important role in total nitrogen deposition that has to be discussed in detail here, in the context of all the important species. It may well be that a more suitable secondary standard includes all nitrogen species, not just NOx; thus to leave it out of the ISA process would be a serious omission.

Science Assessment, p. 4-1, 2nd and 3rd paragraphs: It's not very clear how this organization of the annexes will be done, with respect to summarizing the thousands of studies. There is bound to be a good deal of overlap among studies (since some studies will address more than one effect being summarized—e.g., both acidification and nonacidification effects) so having a well-thought out plan for presenting these that minimizes duplication among the various annexes would be useful. Another suggestion is to be rigorous in separating the discussion of new data from the review of old studies – this was a minor shortcoming CASAC identified in the recent review of the NOx primary ISA that could be avoided here.

Section 4.2.2: These criteria for evaluating the studies are eminently reasonable. I would urge the authors to err on the side of being more selective, rather than more inclusive, to keep the ISA and annexes to a manageable size if there really are thousands of studies to review.

p. 4-5: Is there a particular significance to the underscored text? Item 2.g needs to be reworded; insert 'and' between pollution and variations?

Sec. 5 and App. B: In several places this plan emphasizes that the Administrator will make the final decision on the standard and judge whether an effect is significantly adverse, factoring in the inherent uncertainty in the information. Yet there doesn't seem to be a clear plan for describing and quantifying uncertainty at the various stages of this process, integrating that uncertainty across the process, or for clearly identifying what is and isn't an adverse effect. Reasonable people might disagree about what constitutes an adverse effect and how to value it – nitrogen deposition on a farm field might be seen as favorable, while the same nitrogen deposition on an adjacent forest might be considered adverse. The information in Appendix B on ecosystem services and valuation presented an interesting framework for beginning to make these assessments, but it wasn't clear who gets to make the valuation decisions. Is EPA planning to conduct a survey? Or is this data that's already been collected? If the valuation part of the assessment is carried out correctly, it shouldn't be up to the Administrator to judge whether an effect is adverse or not. The point of the exercise is to take this judgment out of the policy realm and apply a quantitative and nonsubjective method to determining value.

Sec. 6: Does this first paragraph (p. 6-1) mean that discussion of the possible form of the standard won't be discussed in the ISA or REA? If so, that is a distinct shortcoming. Analysis of the many options for regulating deposition needs to be part of the ISA. There is no reason to put it off to the last part of the process. It is nice to see that total nitrogen is considered as a possible indicator, and that the seasonal variability of deposition might justify a seasonal standard; temporal variability was only briefly mentioned in the rest of the plan and yet it might be an important risk driver. Similarly, as I noted above, it seems reasonable to think that a standard might differ regionally due to broad differences in ecosystem susceptibility. This concept is touched on as well on p. 6-3, but the sooner these possible forms of the standard are discussed the better.

Appendix B: This was a helpful description of the various tools, but it's not clear how they all fit together, since the models cover a broad range of spatial and temporal scales. Perhaps a schematic of the modeling process would be useful.

p. B-5: Not clear why this section on AIRQuest is here, whether AIRQuest exists, or whether it is being developed as part of this process. In any event, a database of national air quality monitoring data already exists (EPA's AQS). However, it does not include much data on non-criteria species like NH3, NO, NOx, etc. Those might need to be gathered from other sources. In particular, data from Canada might be useful, as well as satellite observations or special study data. The Midwest RPO has collected ambient NH3 data for several years.

p. B-14, line 18: what is WTP?

Comments from Dr. Myron Mitchell

GENERAL COMMENTS

The document generally does a very good job of developing a protocol for developing secondary national ambient air quality standards for nitrogen dioxide and sulfur dioxide. The rationale for evaluating concomitantly the interactions of nitrogen dioxide and sulfur dioxide needs to be separated with respect to atmospheric versus other ecosystem processes. Examining together sulfur and nitrogen chemical species in the atmosphere due to the important linkages of these chemical species is a useful approach.

Careful attention will be needed for quantifying the differential effects of nitrogen and sulfur atmospheric inputs on ecosystem response. The interactions of nitrogen and sulfur inputs in affecting soil, microbial and plant processes differ between these elements. Their respective biogeochemical transformations and fluxes are relatively distinct from each other. It will be challenging to develop appropriate metrics that capture the essential ecosystem features that determine: 1) whether nitrogen and sulfur inputs by atmospheric deposition will be lost or retained; and 2) the influence of these two elements and their different chemical species on other factors including recovery from acidification and loss of nutrients. This will be particularly important for evaluating long-term effects on the availability of base cation nutrients including calcium and magnesium.

The current document does not clearly address which soil chemical and physical characteristics need to receive particular attention in the development of standards and how spatial variation in these characteristics will be incorporated in the determinations. For sulfur, attention will be needed on the adsorption/desorption responses in soils. In addition, the contribution of any internal S sources (both organic sulfur mineralization and inorganic sulfur mineral weathering) to sulfate fluxes in soil and the resultant differences in responses to decreases in sulfur deposition in surface and ground waters will need some consideration. In contrast for nitrogen, more attention will need to focus on what soil features including how organic matter quality affects microbial processes. This assessment will also need to be linked to the role of vegetation both with respect to nitrogen cycling, but also in affecting organic matter quality via organic matter inputs to the soil.

It will be critical to look at other factors including climate change, invasions of exotic species and the alterations of species composition (especially wood vegetation) that will be occurring concomitantly with changes in atmospheric deposition of sulfur and nitrogen. Such considerations will be needed to help clarify other factors that will be separating how other long-term trends are influencing ecosystem response.

Information is provided on the CMAQ (Community Multi-Scale Air Quality) model especially in Appendix B. A clear delineation of how the CMAQ model compares and/or differ from other models including that being used by CASTNET for estimating deposition at individual sites would help unify various approaches that are evaluating atmospheric deposition. It may also be useful to include some review of how these

efforts compliment or differ from efforts in other regions including those taking place in Europe.

The consideration of ecosystem services as a factor to be evaluated in developing the standards could be helpful. However, it will likely be necessary to clearly identify early in the process of developing these new standards those services that are most relevant with respect to the effects of nitrogen and sulfur deposition.

DETAILED COMMENTS

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?

Page1-8, line 1: subscripts here and throughout document.

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

Page 1-9, line15: 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?

Comments from 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 SOx and NOx, 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 NOy & 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 CAAAA ("…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. 6-1ines 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 SOx/NOx 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 PM2.5 or secondary SOx & NOx 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 PM2.5 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 unspeciated PM2.5 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 NOx 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 SOx/NOx 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 "NOx and SOx" here to mean all gaseous precursors and gaseous transformation products, then this is inconsistent with the term "NOx and SOx 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 <u>any</u> 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 SO_2 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 NOx 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 SOx and especially NOx 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/NOx 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 PM2.5 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 <u>and reduced</u> 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?

Comments from Mr. 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.

Comments from 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. It will be, ultimately, the synthesis of research findings and understanding. Thus, among other things, the development of a conceptual model as well as clearly defining 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 NOx and SOx. 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 NOx and SOx 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 SOx and NOx 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 SOx and NOx 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 NHx)" 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 NOx/SOx 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 SOx and NOx 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