UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

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[Date]

EPA-COUNCIL-10-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject:

Dear Administrator Jackson:

[To be developed]

Sincerely,

Dr. James K. Hammitt, Chair
Advisory Council on Clean Air
Compliance Analysis

Dr. Ivan J. Fernandez, Chair
Ecological Effects Subcommittee

NOTICE

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U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis
Ecological Effects Subcommittee
Augmented for Review of the Second 812 Prospective Study

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1. EXECUTIVE SUMMARY

- [To be developed]

2. INTRODUCTION

2.1. Background

Section 812 of the Clean Air Act Amendments (CAAA) of 1990 directed the U.S. Environmental Protection Agency (EPA) to periodically evaluate the costs, benefits and other effects of compliance with the Clean Air Act. Section 812 further directed the Agency to establish the Advisory Council on Clean Air Compliance (Council) and to seek the Council's review of Agency analyses prepared under the Section. The Council and its Subcommittees have reviewed previous reports prepared for a retrospective analysis of the impacts of the Clean Air Act (for 1970-1990) and a prospective analysis (for 1990-2010). For the current review, the Council's Ecological Effects Subcommittee (EES) was asked to evaluate the ecological effects analyses conducted for the second prospective analysis, covering the period 1990-2020.

The draft report, *Effects of Air Pollutants on Ecological Resources: Literature Review and Case Studies*, summarizes literature on the impacts on ecological resources of acid deposition, nitrogen deposition, trophospheric ozone, and hazardous air pollutants such as mercury. In addition, the report uses case studies to describe benefits of reduced acid deposition for recreational fishing and the timber industry in the Adirondacks region of New York State. The Subcommittee also reviewed an excerpt from the draft report, *Benefits Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act*, which estimates benefits of reduced trophospheric ozone exposures for agricultural crops and commercial timber. Ambient concentrations of sulfur and nitrogen oxides (SOx and NOx) and ozone were modeled using the Community Multiscale Air Quality Model (CMAQ) for scenarios with and without the CAAA. For ozone, the model estimates were adjusted using monitored ozone data and the eVNA interpolation technique. The emissions inventories and air quality modeling components of the 812 study have been reviewed by the Air Quality Modeling Subcommittee of the Council, and are not addressed in the EES report.

2.2. Charge to the Subcommittee

The Ecological Effects Subcommittee was asked to review the draft report, *Effects of Air Pollutants on Ecological Resources: Literature Review and Case Studies*, and *Chapter 4: Agricultural and Forest Productivity Benefits of the CAAA*, and to address three Charge Questions. The three questions pertained to the (1) Appropriateness of the choices of the data used, (2) Methodological choices, and possible alternatives, and (3) Validity and utility of the results, and what changes should be considered for the present or future analyses. In addition to the draft reports, the following background materials were provided to the Subcommittee:

- *Chapter 3: Emissions and Air Quality Modeling Uncertainty* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. February 2010)
- *Appendix B: Uncertainty Analysis of the Integrated Air Quality Modeling System* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. February 2010)
- *Appendix C: Qualitative Uncertainty Summary Tables for Second Section 812 Prospective Analysis of the Clean Air Act* (excerpt from the draft stand-alone report on uncertainty to accompany the 812 Prospective Study. November 2009)

The following sections provide the Subcommittee’s general comments regarding the draft reports, as well as specific responses to each of the Charge Questions.

…

3. General Comments

The Agency is to be applauded for including ecological effects in the evaluation of the efficacy of the CAAA. Extensive research has been conducted over the past 30 years on air pollution effects on ecological resources and significant benefits from improvements in air quality have been evident in ecosystem condition. These improvements in air quality have reduced ecosystem stressors for many of the effected CAAA priority pollutants, which has had a positive impact on the flow of ecosystem services to society. There are several overall observations that are useful to articulate at the outset that emerged when reviewing these materials.

- There is a lack of an *overarching framework* to this second prospective. The work at its core is an ecological risk assessment. Clearly it is also an attempt to estimate the economic value resulting from a risk-management action, the Clean Air Act. This analysis, and perhaps the Second Prospective Study itself, should consider a presentation framework indicating that in a broad context, a risk-based approach is being taken.
- Although recognizing that the specific objectives of the Section 812 analysis focused on CAAA benefits, the report should clearly articulate the importance of *climate change* in evaluating ecosystem function during the same study time period and into the future. There are demonstrable trajectories of change, including warming, that simultaneously impact ecosystem function during the study period. These changes, such as warming and rising atmospheric CO_2 concentrations, are highly interactive with the ecological effects of individual priority pollutants.
- The report emphasizes issues of acidification and ozone, but recognition for the importance of *nitrogen* deposition in ecological response is significantly understated. Nitrogen contributes to ecosystem response both through (1) its contributions to acidification, and (2) its role as a nutrient. Specifically, the report should highlight the importance of nitrogen in stimulating forest growth, influencing carbon sequestration, and altering the ecological stoichiometry of natural systems.

- The report should serve as a *gateway to information on ecological effects* relevant to CAAA priority pollutants. While the literature review provides support for the specific analyses conducted under this second prospective, it was unclear what other work on ecological assessment was ongoing or recently completed within the Agency or elsewhere that is relevant to this analysis. The report should begin by clearly identifying other ongoing Agency activities (e.g., ISA, SAB Nr, ?????), reports (e.g., Valuing Eco report, ????) and historically important programs (e.g., NAPAP, NCLAN, ????) that provide a framework and context for this study. This should include earlier EPA reports upon which this effort builds.

The following comments respond directly to the charge questions in the context of the overall Section 812 second prospective reports provided to the EES for review. This is followed by more detailed discussion sections for each major component and case study.

General Charge. EPA requests that the Council EES review the draft of the stand-alone Section 812 Second Prospective Study report on the effects of air pollutants on ecological resources, including both the updated literature review and the case studies examining effects of CAAA-related pollution reductions on particular ecological resources in select ecosystems. In addition, EPA believes the Council would benefit from a review by the EES of the physical effects estimation aspects of the agricultural and forestry effects economic analyses(?). Consistent with the statutory language defining the role of the Council in reviewing the 812 studies—and consistent with the role of the EES as advisor to the Council on ecological effects assessment—EPA respectfully submits the following general charge questions to the EES:

1. Does the EES support the data choices made by the 812 Project Team for the development of the ecological effects assessments documented in the draft ecological effects report and in the partial draft Chapter 4 of the main benefits report? If not, are there alternative data sets that should have been used?

The data chosen for the overall report were appropriate within the limitations of the available data and tasks to be performed in this analysis. The challenge of providing suitable data to an ecological assessment that result in the economic valuation of ecosystem services necessitates data selection for modeling objectives that would best achieve those objectives. This may not always be the best data for an individual segment of the analysis. The data chosen appear to be appropriately selected based on the availability of data and modeling tools at this time.

2. Does the EES support the methodological choices made for analyzing those data and developing the estimated changes in ecological conditions between the *with-CAAA90* and *without-CAAA90* core scenarios? If not, are there alternative methodologies that should have been used?

The methodology of modeling with and without CAAA90 scenarios was a sound approach for identifying the benefits of CAAA90 implementation. There are several aspects of the methodology that are critical to the overall analysis and presentation.

- The modeling outcomes for nearly all of the analyses require a discussion, and where possible, a quantification of ***uncertainty***. While the EES is cognizant of the draft Chapter 3 on Emissions and Air Quality Modeling Uncertainty, no similar uncertainty analyses were presented on the ecological and economic outcomes. This shortcoming was most evident in partial Chapter 4 of the main report. The projected reductions in impacts resulting from CAA regulatory mandates, particularly in the out-years, (i.e., the with and without CAA calculations) need to be bounded. There is precision implied in the current estimates that could be misleading and should be corrected in the final draft. The case study on recreational fishing in the Adirondacks did a better job, but still did not attempt to quantify the uncertainties in the results.

- There was a lack of ***validation*** throughout the analyses that the EES believes could be critical in demonstrating the value of these assessments. Given the time period covered in the second prospective study, it is possible to draw on both exposure and response data available from the first two decades (i.e., 1990 to 2000 and 2000 to 2010). We recognize that data up to 2010 are not available in the same year, but trajectories of change for much of the decade are available that could be compared to the modeled responses. Similarly, there is a need for economic validation to avoid, for example, assigning damages to a particular ecosystem service that might exceed the value of the overall service.
- There was a lack of ***transparency*** for many components of the modeling. Information should be included, or readily available, to define assumptions and parameterization of models so that others might be able to better interpret the outcomes. For example, numerous parameters had to be assigned values in MAGIC that would have a major impact on model outcomes. This information should be accessible.
- There were a number of critical concerns regarding the ***form of data*** presented (e.g., acidity deposition in kg/ha, ozone ppm vs ppmh) and therefore the utility of the analyses to the Agency and future readers. Specific recommendations for corrective action are included in the specific comments in this report.
- The EES was most concerned where analyses were carried out in an attempt to achieve the cost-benefit analysis without a clear C-R function available (e.g., base saturation and forest response). Where possible, case studies could be modified to focus on the elements of the analysis most strongly grounded in available C-R functions. At a minimum, the assumptions made in order to complete the analyses must be clearly defined to avoid leaving a false impression on the behavior of the natural world due to constructs created for modeling objectives.

The discussion below provides more detailed discussion of these issues for the relevant sections and case studies.

3. What advice does the EES have for the Council regarding the validity and utility of the evaluation of effects of CAAA-related pollution reductions on ecological resources – including the updated literature review and the case studies—and the validity and utility of the physical effects estimation aspects of the agricultural and forestry effects economic analyses? What specific improvements does the Council EES recommend that the 812 Project Team consider, either for the present analysis or as part of a longer term research and development program?

The EES believes that the importance of valuing ecosystem services has never been greater, and this need will only become more pressing as issues of population growth and climate change increasingly challenge the integrity of our environment. This report provides valuable analyses on the effects of specific CAAA90 priority pollutants, and demonstrates tremendous progress over the past decade in both our understanding of ecosystem response to air pollution, and our emerging capacity to define the economic benefits attributable to specific pollutants. While the complexity of ecosystem function and response often defies our ability to achieve simple cost-benefit analyses, the analyses conducted for the second prospective study demonstrates clear benefits to society for specific examples. This approach should continue, and our ability to value the ecological benefits of priority pollutant regulation will also continue to improve into the future.

Recommendations

- EPA should identify research that couples ecological effects and economic outcomes as a priority for both Agency-supported research and the research community in general. There continues to be an increasing emphasis on interdisciplinary research linking ecological function to social values. Critical within this framework is the need to define better C-R functions for priority species and ecosystem services. Identifying the need for research on defining the ecological response and valuing the ecological benefits of particular air pollutants and their interactions can shape the direction of research to provide the tools needed to more rigorously carry out these types of analyses.
- There is no question that changing trends in environmental priorities and our economy have profound influences on our ability to support long-term environmental monitoring. Yet these data are essential to establishing trajectories of change in response to environmental regulation. Many of the uncertainties we have today with respect to the efficacy of the CAAA reflect a lack of time series data on important ecological metrics. To that end, the EES urges EPA to maintain, support, and promote essential environmental monitoring programs. This should go beyond the spatially extensive monitoring networks (e.g., NADP/NTN, surface water surveys) but should include the support of key long-term ecosystem studies that allow us to understand mechanisms of ecosystem response on decadal time scales and beyond. These networks and study sites serve not only to define changes in the pollutant effects we know about today, but provide a framework to understand those we do not yet know about in the future.
- Climate change effects on ecosystems have profound implications for ecosystem response to CAAA priority pollutants. There is a clear priority for research to define the implications of climate change for ecosystem function. In the context of this review, research is essential that focuses on understanding the implications of climate change for analyses such as the comparison of the with and without CAAA scenario. There is no question that emerging patterns of, for example, atmospheric warming, earlier ice-out in lakes, longer growing seasons, increasing atmospheric CO_2 concentrations, altered phenology, decreasing snow pack and cover, rising sea level, and ocean acidification profoundly influence the way farms, forests, lakes, streams, estuaries and oceans respond to CAAA priority pollutants and their regulation.

4. &&other &&

4.1. Literature Review

1. A review of the literature in any given subject area is an important contextual element in a science-based report. The authors of the draft report are to be commended for recognizing this need. That being said, it is very unfortunate that the authors chose to approach the review of the literature by focusing on reviews of reviews rather than a focussed in-depth review of the literature. This review of the reviews approach leads to a dated literature review which is the case in this draft report. It is also evident that the authors of the review of the literature were not as familiar with some of the important nuances of the literature that they were interpreting as they should have been.

This point is illustrated by a statement made on page 2-21 in the last three lines of the first paragraph where it is noted that "--- worldwide average tropospheric ozone levels were approximately 25 percent above threshold values established for damage to sensitive plants (Fiscus et al., 2005)." This is actually taken by Fiscus et al. from a paper by Furher et al. (1997) where the ozone metric of AOT40 (accumulated ozone concentrations above a threshold of 40 parts per billion) has been used. This initial simple ozone metric has subsequently been shown to be an inadequate measure of plant response to ozone stress by Fuhrer(1999).
Fuhrer, J., Skarby , L. and Ashmore , M. 1997. Critical levels for ozone effects on vegetation in Europe. Environmental Pollution 97: 91-106.
Fuhrer, J. and Achermann, B. 1999. Workshop Summary. Critical Levels for Ozone - Level II. Workshop under the Convention on Long-Range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UN/ECE), Gerzensee, Switzerland 11-15 April 1999, pages 13-15.

2. The uncertainties which are potentially present in the various models and assumptions used, need to be directly addressed, clearly laid and clearly explained to the reader. When the output from air quality models is used in the Ecological Effects portion of the draft, a cross-reference in the text indicating where the uncertainty information can be found would be extremely useful. It is also important that an adequate characterization be provided for each of the models used which provides sufficient detail to justify their choice. (e.g. Why use the MAGIC Model).

3. There needs to be a discussion with some background provided as to the reasoning behind why the ozone metrics such as W126, 7-hour average and 12-hour average have been used. It is also critically important to explain the uncertainties associated with the use of these indices. Each of these indices is an expression of the ozone air quality over a defined time frame which is then related to a specific plant response such as growth and/or yield. An important uncertainty which must be clearly mentioned for crop plants is that the concentration/response functions (C/Rs) which are used are based upon controlled ozone experiments carried out in open-top chambers. These experiments did not reflect the reality of ambient real world ozone exposure. Further, the selected crop plant cultivars which were utilized in the NCLAN Program (National

Crop Loss Assessment Network) in the late 1970's and 1980's no longer exist today. The extent to which the responses from these cultivars reflect the response of the crops plants today is highly questionable. The selected tree species ozone C/Rs were also developed in open-top chambers with controlled ozone exposures with seedlings grown in pots. The extent to which a seedling response can be extrapolated to a mature tree response is also highly questionable. The key point here is that these uncertainties must be made clear to the reader as they have a bearing on the estimated valuations presented.

4. The needs to be a coordinated effort on the part of all the authors to make certain that all of the reference are complete, consistent and cited the same way and correctly in both the text and the various reference sections.
The reference by Allen et al is cited as 'undated' as well as 2005 with the complete citation with different iterations. The following is the correct citation which was obtained from one of the authors:
Allen, E.B., Sirulnik, A.G., Edgerton-Warburton, L., Kee, S. N., Bytnerowicz, A., Padgett, P.E., Temple, P.J., Fenn, M.E., Poth, M.A. and Meixner, T. 2005. Air pollution and vegetation change in California shrublands. pp. 79-96. IN: B.E. Kus and J.L. Beyers, Technical Coordinators. Planning for Biodiversity: Bringing Research and Management Together. General Technical Report PSW-GTR-195. Albany, California, Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 274 p.

5. The units for the cumulative ozone metric are ppm-hours not just ppm. This needs to be clearly indicated in the Exhibits and text where appropriate. One example is seen in the Exhibit 4-6 (table) under the column heading 'A' where everything in the column is indicated as having 'ppm' units. A similar situation exists in Exhibit 4-4 (figure) where the legend shows W126 in 'ppm' and not 'ppm -hours'.

6. The authors must make certain that the abbreviations used in all Exhibits are defined for the reader. In Exhibit 4-4, for example, the column heading 'B' is not defined.

7. The review draft was supposed to be a final draft and it is far from that at this point. It needs a great deal of work to clean up the various Chapters and pull the various parts of the draft document together so that the presentations are logical and the conclusions as soundly based in fact as possible.

8. A retrospective assessment of the First Prospective Study done would be very informative as part of the current study. The reason for this is simple. A Prospective Study is largely based upon a range of assumptions and a series of model runs based upon those assumptions. How good were the assumptions in hindsight and how have we improved these assumptions' and model runs in the Second Study? Put another way, how real were those cost and benefit estimates? It can help illustrate that the a 'Prospective Study' is worth doing.

9. The underlying uncertainties in the various levels of the Prospective Analysis need to be clearly laid out. This is particularly the case with respect to the material presented related to ozone. For example, what are the implications to level of uncertainty by utilizing the modelling

approach and the selected interrelated models which were used based upon Abt Associates (2007). This is important because the reader needs to be assured that the relative yield losses which are used in the end for the cost benefit analyses that the relative 'estimates' are at least somewhat valid.

10. It is recommended that in the future that much more thought is required to be able to appropriately link ecological effects and economic valuation. This will require a broader selection of ecological endpoints for which adequate data exist. That being said, it is important at this point for the authors to clearly identify the information/research needs which have become apparent during the preparation of the Second Prospective Study to be better prepared for the Third Prospective Study when it is initiated in the future.

4.2. <u>Mapping Air Pollutants to Sensitive Ecosystems</u>

4.3. <u>Adirondacks Recreational Fishing Case Study</u>

[DFO note: start with a brief statement of what was done, and what was useful about it…]

The extrapolation of modeled lakes to the Adirondack or New York population is seriously flawed. First there is a problem with the analysis is the use of physical characteristics of the modeled lakes to extrapolate to the population (e.g., elevation, area). None of the relationships are very good. It is not clear what the authors mean by area, watershed area or lake area? There is no indication as to how the time analysis was done. A more detailed description of the approach used should be provided. There also is a question if the statistical analysis of physical characteristics was made against current modeled ANC. An alternative approach could be used. Previous efforts have used lake population weighting factors developed based on lake ANC classes to extrapolate to the entire population of lakes (e.g.,Warby *et al.* 2005). There are considerable lake chemistry data available for the Adirondacks. It would be good for the authors to evaluate how good their extrapolation is for the region. The extrapolation of modeled results from 35 Adirondack lakes to all of New York State is a serious error. Most New York lakes outside of the Adirondacks and Catskills have high values of ANC and are not sensitive to acidic deposition. To extrapolate modeled lake trends from a sensitive region like the Adirondacks to an insensitive region like most of New York outside of the Adirondacks is not appropriate. The authors undoubtedly greatly overstate the by making this poor assumption.

Although the 1990 CAAA Amendments were passed in 1990, emission control programs were not started until 1995. Benefits from the 1990 CAAA would not start until 1995. This should be clarified.

There needs to be more detail provided on the 44 MAGIC modeled site. It is unclear if the analysis done for another purpose or if it was done expressly for this analysis. Also, there needs to be a discussion on how the sites were selected for model application

Recently, there was a substantial effort directed at using MAGIC to quantify the chemical effects of acidic deposition across the Adirondacks as part of the Risk and Exposure Assessment (REA) for Review of Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and oxides of Sulfur (USEPA 2009). A goal of this initiative was to characterize and quantify these effects on ecosystem services. It seems that this Section 812 Prospective analyses could have benefited for interactions with personnel conducting the REA analyses and vice versa. In the future, if parallel efforts on quantifying impacts of air pollution on ecosystems are in progress, it would seem that there would be benefits in coordination of efforts, even though the objectives and the atmospheric endpoints are somewhat different.

The summarizations of the assumptions and caveats used in Chapter 4 are useful. However, this information does point out that both case studies employed ecological models that are based on a series of assumptions, which in some instances do not have all the desired data available and/or are based on a series of other assumptions that have not been validated over time. In order to be useful to the development of a reliable and consistent predictive tool for the evaluation of ecological effects of the CAAA, many of the assumptions should be validated through additional field "ground-truthing" research and the models tested over known time periods (e.g., can the model predict changes in the environment that actually were observed in 2000, 2005, and 2010?).

A disturbing aspect of the chapter was the input variable used with economic model. This case study used a 1989 repeat-contact telephone survey of New York residents that was conducted as part of the National Acid Precipitation and Assessment Program to collect data used to estimate the economic random utility model (RUM). There may not be anything wrong with this survey tool, but it is outdated and it was conducted only once. Consequently, the survey has never been replicated to ensure its efficacy for use with the RUM and there is considerable question of it capability to reflect current economic conditions. Given this concern and also recognizing the issues of lack of funds and time to design, commission, and conduct new surveys to fill these important gaps in the data, additional text should be provided to discussing the strengths and weaknesses of these "old" study. Without that detailed discussion, there is likely to be little confidence placed in the conclusions drawn from them, particularly by readers knowledgeable in these matters.

Alternative for consideration:

This chapter examined the effect of the Clean Air Act Amendments (CAAA) on recreational fishing in the Adirondack Region of New York State. However, there may be a more defensible approach to address this question.

Driscoll: [explanation of approach needed here] Within the Adirondacks, surveys of all lakes in the 1980's showed ANC strongly correlated with calcium. Driscoll (date) did some work with an empirical relationship between ANC and species richness. Species richness could then translated into fishing desirability.

[Put this concept here somewhere] *There also is a concern (from both an ecological and economic perspective) as to what constitutes fishable and non-fishable thresholds and the issue that this is a binary choice.*

Polasky [explanation of economic application needed here]. try linear loss function and see what the effect is? Look at how alternative assumptions affect the result.

4.4. Adirondacks Timber Case Study

Overview: This chapter is composed of three main sections: the first 8-9 pg cover timber resources in the Adirondacks; the second section, in ~11 pg, covers extrapolation of modeled simulations of changes in soil base saturation in response to the CAAA; the last ~3.5 pg discuss the potential importance of these modeled changes in base saturation to the region's timber productivity.

General comments:

Content: Overall, the subcommittee liked the approach of comparing deposition and ecosystem response scenarios with and without the CAAA, especially focused on future forest growth and timber production. [We defer discussion of other potential ecosystem services to the general overview section.] The subcommittee's overarching concerns on the chapter's data and methodological choices included (A) concern over omission of a major topic area as well as (B) some concerns on the analyses that were presented.

We found the lack of discussion of N as a nutrient to be a major omission. That is, CAAA pollutants affect tree growth not only by means of soil acidification, but through ozone exposure (Chp. 4), and through inadvertent fertilization effects from N deposition, an important topic wholly lacking any discussion. These fertilization effects are complex: they do not persist at high N deposition loads, and chronic exposure to high rates of N deposition can push forests into a condition of N saturation and eventual declines in forest productivity (Aber et al. 1989, 1998). Nor will all tree species (e.g., red pine, red spruce) or forest types (old-growth) experience the growth enhancement phase; these forests are especially vulnerable to N saturation. There is a rich literature on this topic in both the eastern U.S. and western Europe. For example, there are long-term N-addition experiments at the Harvard Forest, Massachusetts (e.g., Magill et al. 2004), Mt. Ascutney, Vermont (McNulty et al. 2005), and Millbrook, New York (Wallace et al. 2007) that provide considerable information on the response of forest growth to chronic N loading, a literature touched on only briefly here. The long-term experimental additions of ammonium sulfate at Bear Brook, Maine (Elvir et al. 200X, 200Y) and Fernow Forest, West Virginia (Adams et al. 2007) provide data on forest growth responses to combined N and S deposition. Both $(NH_4)_2SO_4$-addition sites demonstrate early growth enhancement from N enrichment in some species but not others, along with later-stage growth declines. Although none of the above sites are in the Adirondacks, they contain representative forest types (spruce-fir, red- and white-pine, northern hardwood, central hardwood). In addition, in the time since this chapter was drafted, a new analysis has been published showing growth- and mortality response functions by tree species in response to regional variations in N deposition (that is, NADP + CASTNET N deposition, not CMAQ N deposition) across the Northeastern U.S. (Thomas et al. 2010). These responses can help identify which species are likely to respond, and how, to various rates of N deposition projected for the future under various emissions scenarios.

Discussion on the analyses that were presented identified three areas of concern or need for further work. First, we found insufficient explanation of the MAGIC model's structure, assumptions, and primary uncertainties, information essential to anyone evaluating the reliability of its simulations of future changes in base saturation. Our second concern relates closely to the first but is of such importance that we highlight it separately: we wished for at least some inclusion of demonstration of how these model simulations compared with observations of soil base saturation. Sullivan et al. (2006) have published detailed measurements of soil base saturation for sites across the Adirondack region; this data set, and perhaps others, ought to be used for model testing prior to any model extrapolation. The chapter might condense its current detailed discussion of model extrapolation by way of multiple regression and instead focus on this model description and testing. The third concern pertained to the assumption that growth relates directly to gradational changes in soil base saturation in a dose-response type relationship. We are sympathetic to the lack of availability of empirical response functions that might be used to make quantitative extrapolations into the future. Nonetheless, because this is the foundation upon which the analysis rests, the chapter needs to present the evidence that does exist relating base saturation to growth. [can Charley or Ivan recall PA, Quebec, or other refs to suggest?] Moreover, these responses are likely to be better re-considered in terms of crossing specific quantitative thresholds rather than continuous growth response to gradients in base saturation.

<u>Document structure</u>: The introductory paragraph provides a helpful roadmap for the chapter's content. A small, simple flowchart might provide further clarity on the route taken here. However, per above, we suggest shifting the balance of the document's content from relatively lengthy discussion of extrapolation procedures for model results in favor of more detailed discussion of the structure, assumptions, and testing of the model itself. That said, the chapter ought to shift focus from solely considering model results to include observations from field measurements, monitoring data, and experimental manipulations.

The literature cited in this chapter appears to be missing recent literature and various relevant experimental results. The ISA on SOx and NOx provides many of these.

Detailed Comments:

p. 5-1. The introduction starts with the assertion "Reductions in soil acidity have been shown by scientists to increase tree growth and improve overall forest health." As this is the foundation of the chapter, it needs to be supported by named references rather than anonymous "scientists."

p. 5-2 to 5.7. The section describing the forest resource relies heavily on an oft-cited "personal communication", and would benefit greatly from support from discernable references.

p. 5-6. The assertion that harvest rates between 1979 and 1992 are representative of current harvest rates is unsupported, and is likely to be untrue. The forest industry in the Northeast has undergone tremendous shifts over the last two decades and will face new harvest pressures for energy production in coming years.

p. 5-8. Deposition: Some of these comments also pertain more generally to Chp 3 maps.

There should be explicit clarity on the forms of deposition reported here. The CMAQ model simulations of "total N" (and possibly S) deposition rates differ markedly from those often used in the literature, that often consider wet-only deposition (NADP) or wet with some forms of dry deposition (from CASTNET), but nearly always exclude NH_3, NO, NO_2, and organic N deposition. Hence, there are important biases that need to be recognized and it should be clear as to which deposition terms are considered where.

The assertion that within New York State, acidic deposition is highest in the western portion relative to the Adirondacks is frankly suspicious (and p. 5-10, top). If CMAQ fails to include an elevation-driven increase in precipitation (?), it will substantially underestimate deposition to mountainous regions in general and the Adirondacks in particular. These model assumptions ought to be checked, and the spatial patterns of deposition ought to be confirmed with, for example, with observed patterns of deposition from NADP (but see next point).

p. 5-8. S and N (or SO_4^{2-} and NO_3^-) deposition emphatically should not be added together as kg/ha. If S and N deposition are to be combined, they must be converted to units of equivalents. Also, deposition is a rate: it should be reported as kg N ha^{-1} yr^{-1} (or keq ha^{-1} yr^{-1}) not kg ha^{-1}. Nitrogen deposition can be measured at best to the nearest 0.1 kg N ha^{-1}, and should not be reported with any greater implied level of accuracy. Given the need to discuss both the nutrient effects of N and the effects of acidification, it would be useful to report the N-only deposition from total acid deposition.

p. 5-8 to 5-9. Base saturation and growth.
Explicit citations from the primary literature are needed to support the assertion connecting growth and acid deposition, as this is the central point of this chapter.

Base cations can be leached during general percolation of water through the soil, not solely during storm events.

The first paragraph on p.5-9 is not necessarily true and is poorly worded (e.g., "chemical processes"). Change to something like "Acidic deposition depletes the pool of available basic cations in soil increasing the quantity of exchangeable hydrogen ion and aluminum" (Warby et al. 2009).

The second paragraph on p. 5-9 states that "Recent research indicates that the dominant tree species in the Adirondack Region are sensitive to the effects of elevated soil acidity levels." It is essential that this research be cited and that work since 2002 be included (e.g., Juice et al. 200X).

p. 5-10, bottom. Much more description of the MAGIC model is required here, articulating its key assumptions, parameterization or calibration, and testing against observational data.

p. 5-11 to 5-14. The detailed coefficients on extrapolation MAGIC results are less important than the comparison of these extrapolations with observed values.

p. 5-14 to 5-16. Why is a dose-response function assumed for growth response to base saturation? It may well be more of a threshold response, i.e., with growth declines occurring only when soil base saturation decreases below a specific quantitative threshold. It might be beneficial to revisit the work on critical loads for growth responses to acidification. Moreover, it would be useful to present base saturation results in terms of actual values rather than differences (e.g., Table 5-7).

p. 5-15. Be absolutely clear which results pertain to modeled expectations versus those obtained from observations. These are MAGIC simulations, not observed increases in base saturation. They should be clearly identified as such in text, tables, and figures.

A note on precision (e.g,. Table 5-9): Base saturation is typically measured with a coefficient of variation of +/- 15% -- that is % of the measurement, which itself is typically reported in units of %. Percent base saturation should be reported to the nearest % or at most 0.1%, not 0.001%. Substantively, this means that nearly all of the reported difference in modeled % base saturation across forest types (Table 5-9) are well below anything detectable or ecological meaningful, and the differences through time are rather small. [please confirm/check Charley & Ivan]

p. 5-20. The extrapolation on spruce decline from the Mt. Ascutney experiments is a great idea, one we'd encourage. Nonetheless, this particular extrapolation appears to fail to account for atmospheric N deposition as well as the experimental treatments. That is, 16 and 31 kg N ha^{-1} yr^{-1} were added by treatment on top of background deposition of perhaps 10 or so kg N ha^{-1} yr^{-1}, which would yield total N inputs to these plots of ~26 and 51 kg N ha^{-1} yr^{-1}. Forest decline is explicitly a non-linear process by which much sharper growth declines are expected at 50 than 20 kg N ha^{-1} yr^{-1} . Any scaling of the Mt Ascutney results should account for this shape of response.

References (incomplete)

Aber et al. 1989
Aber et al. 1998
Adams et al. 2007. (Fernow book)
Elvir et al. XXX (several)
Juice et al. 200X Ecology

Magill et al. 2004 Forest Ecology & Mgt special issue
McNulty et al. 2005
Thomas, R. Q., C. D. Canham, K. C. Weathers, and C. L. Goodale. 2010. Increased tree carbon storage in response to nitrogen deposition in the US. Nature Geosciences **3**:13-17.

USEPA. 2009. Risk and Exposure Assessment for Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur. EPA-452/P-09-004a.

Wallace et al. 2007 FE&M

4.5. <u>Agricultural and Forest Productivity Benefits</u>

The chapter provides a clear description of the steps used to evaluate the benefits of reduction in ozone on agricultural and forest productivity. Compared to many of the other case studies on the ecological effects of the CAAA, the impact of ozone reductions on agricultural crop yields and forest productivity involves cause-and-effect relationships that are better understood.

There are several general comments that pertain to the chapter as whole. Overall, the chapter would be improved by:

- Inclusion of more description on the links between models and specifically on how the issue of disparate spatial resolution of models (e.g., difference between CMAQ and FASOM) is addressed;
- Clearer description of data and methods within each section (particularly on the exposure-response functions and the economic analysis);
- More effort to ground-truth or validate results by comparing model predictions with empirical evidence (particularly for the exposure-response functions).
- Discussion of uncertainty and specifically how errors propagate from ozone exposure predictions through exposure-response function to manager decisions and estimates of economic effects.

The remaining comments will be structured following the three main steps in the analysis

- Air quality modeling
- Exposure-response functions
- Economic effects

A. Air quality modeling: improvement in ozone levels *with CAAA* versus *without CAAA*

The analysis in this chapter focuses on ozone exposure. The outputs needed from the air quality model are ozone levels for different crop and forest regions as defined in the third stage economic effects model. The air quality modeling uses the same model (CMAQ) and approach used elsewhere to evaluate health and other ecosystem effects so many of the issues with regard to this chapter are not unique. As elsewhere, more discussion of key uncertainties in predictions of ozone levels should be included in the chapter or references provided to discussion of uncertainty included elsewhere in the report.

B. Exposure-response functions

The exposure-response functions for crops and trees provide vital relationships that allow the linkage to be made between exposure to pollution and the economic benefits. These exposure-response functions are where the analysis is on the weakest ground. The approach relies on experimental evidence from Lee and Hogsett (1996). Given the heavy reliance on this work, it is unfortunate that there was little or no discussion of the improvements in data since the 1996 report was written. There is a large body of relevant work beyond Lee and Hogsett that pertains to the issue of exposure-response functions in crops and forests. For example, Karnovsky et al. (2007) provides a review of the effects of ozone pollution on forests in the US that is highly relevant for effects on forest productivity. Since this appears to be the single source of a significant amount of data, and stems from work conducted quite a while ago, at a minimum there should be a discussion of the strengths and weaknesses of this work, and areas of uncertainty with respect to the work.

It is not possible to evaluate the accuracy or validity of the exposure-response functions based on information provided in the chapter (primarily contained in Table 4-6). More description of the data sources and key assumptions is needed in the chapter. Table headings need to be defined clearly and the importance of the inclusion of table should be included in the text.

The key unknowns and uncertainties should be discussed more fully. There is not a clear explanation in the chapter of how uncertainty was estimated. While min, max and average information (relative yield loss for crops and hardwoods/softwoods) is shown in the tables, it would be more appropriate to present a distribution rather than a range of point estimates. There appears to be sufficient data to allow the development of distributions, and there should not be a lack of technical capabilities to accomplish this with the contractor IEC or within US EPA.

In addition, some effort should be made to compare the model predictions with evidence from field data on crop yields and forest productivity ("ground truthing"). For example, how well do the assumed functional forms for yield loss match the experimental evidence? Doing these comparisons would provide more confidence in the results and help validate the functions.

Some specific concerns about the exposure-response functions highlighted by the committee include the following:

- These functions are based on experimental conditions that may not accurately represent responses of crops or trees in the field.
- Results are based on crop cultivars that are no longer being used. New crop cultivars developed for current conditions may be more ozone tolerant.
- Ozone data from monitoring stations measure ozone concentrations at different height than crop height so that exposure levels for crops may differ from measured ozone levels.
- Results for trees appear to overstate the exposure-response relationship.

C. Economic effects

The economic analysis had not been done at the time of this review so the committee comments had limited ability to comment on this section. However, we have some comments based on the description of methods. The economic model (FASOM) uses the assumption that managers maximize profits. The chapter should indicate whether subsidies and other government policies that impact on the bottom-line are included in the analysis. The analysis also should include a discussion of how actual behavior—influenced by inertia, lack of information, risk tolerance, or constraints such as zoning or other laws—may make the outcome differ from predictions of pure (expected) profit maximization. FASOM uses more highly aggregated spatial scales, typically a whole state, as compared to the more spatially disaggregated air quality modeling scales from CMAQ. Is it possible to include more spatial resolution in FASOM? If not, then the chapter should discuss how inclusion or exclusive of more detailed spatial resolution affects the results. Finally, the chapter should include analysis of how errors in predictions of yield loss arising either from errors in air quality modeling or exposure-response functions will likely affect profit maximizing decisions and estimates of economic benefits.

4.6. <u>Recommendations for Future Analyses (Research Priorities to Enhance Future Analyses..)</u>

REFERENCES

Karnovsky D.F., J.M. Skelly K.E. Percy and A.H. Chappelka. 2007. Perspectives regarding 50 years of research on effects of tropospheric ozone air pollution on U.S. forests. Environmental Pollution 147: 489-506.

Science Advisory Board (SAB). 2009. Valuing the Protection of Ecological Systems and Services. A Report of the EPA Science Advisory Board. EPA-SAB-09-012. 121p.

USEPA. 2009. Risk and Exposure Assessment for Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur. EPA-452/P-09-004a.

Warby, R. A. F., C. E. Johnson, and C. T. Driscoll. 2005. Chemical recovery of surface waters across the northeastern United States from reduced inputs of acidic deposition: 1984-2001. Environmental Science and Technology, **39**:6548-6554.

APPENDIX A: TECHNICAL CORRECTIONS

The Subcommittee's advice and responses to the charge questions are contained in the body of this report. However, in the course of the review, the following technical errors were noted in the materials provided by the Agency. This is not intended to be an exhaustive list.

Regarding the *Effects of Air Pollutants on Ecological Resources: Literature Review and Case Studies*, February 2008:

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Regarding *Chapter 4: Agricultural and Forest Productivity Benefits of the CAAA*, draft of February 22, 2010:

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APPENDIX B: BIOSKETCHES

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