Preliminary Individual Comments on Ozone NAAQS: Scope and Methods Plan for Welfare Risk and Exposure Assessment (April 2011)

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Dr. John Bailar

OZONE NATIONAL AIR QUALITY STANDARDS: SCOPE AND METHODS PLAN FOR **WELFARE** RISK AND EXPOSURE ASSESSMENT

I have not reviewed this document is detail, but a survey shows a few points that might be strengthened.

Page 5-3, first bullet. Averages are generally fine when responses are linear in dose or exposure, but may be quite misleading when a dose-response curve (or equivalent) is non-linear. This should be discussed, with some comment on whether average (rather than, say, median, or some percentile) will serve the public best.

Page 5-3, second bullet. Please say more about how the areas will be selected, with special attention to the choice of areas thought to be "representative" in the sense that results can be used elsewhere vs. areas thought to present a special problem (which should not be generalized except perhaps to other areas of the same nature).

Page 5-4, second bullet. The analysis should be explicit in examining the role of co-pollutants as confounders (which could be dealt with by such methods as standardization or stratification) vs. those that may act in synergy with ozone (which cannot be dealt with that way).

The document should say that there are no other known welfare issues, or say what is being omitted.

The dearth of measurements in rural areas, at high altitudes, and elsewhere is a serious impediment to analysis. I would like to see a short section on what the review team sees as the most important areas for research before the next assessment.

Dr. David Grantz

Comments on Welfare Scope and Methods Plan. May 2011.

Note: Locations in the text are referenced as [chapter-page/line].

Overview

The approach is reasonable. It is clear that data will not be available to quantify ozone-induced losses in many of the metrics to be evaluated. However, it may not be sufficient to catalog the level of services currently available and thus potentially at risk. More attention should be paid to estimation of loss, even by qualitative means.

In many cases there is a stated intent to evaluate various contrasting methods. In each case it would be useful to describe the criteria upon which the decision would be made. This applies particularly to the various modeling paradigms suggested for air quality interpolation, crop and forest impacts, and crop and forest valuation

Air Quality

The GIS based national ozone layer is an important goal. The Voronoi nearest neighbor approach may be suitable in the Eastern US, but some reason might be presented to reject the use of a monitor-adjusted CMAQ approach. A uniform paradigm across the country might have certain advantages.

A county scale air quality matrix is adequate in many areas, but in mountainous areas a unit based on an air basin or region (for example in partly mountainous counties of California) might be preferable.

Ecological Effects of Exposure

The use of NHEERL and NCLAN C-R functions for tree and crop species, derived from OTCs, is appropriate and well justified in the draft ISA. It seems awkward to separate the nearly identical use of NHEERL and NCLAN C-R functions into separate sections of the document. Perhaps the C-R and total productivity risks for crops and trees can be consolidated, followed by use of AGSIM, TREGRO/ZELIG or FASOM in the later analysis of Ecosystem Services. For the NCLAN C-R functions an uncertainty term related to decreasing ozone sensitivity of current cultivars relative to NCLAN era cultivars should be added.

Use of visible injury should be limited to aesthetic values and associated monetization based on willingness to pay. It is increasingly clear that visible injury and other metrics of injury do not correlate well. The National Park study areas are quite appropriate, and represent the best data available.

The ecological metrics to be considered are appropriate, but relatively standard. In the ISA a great deal is made of the potential increase in mean stomatal conductance in forest species and reduced watershed runoff. In some areas, this may have ecological implications to wetlands, riparian species, etc. Furthermore, there may be monetary implications, through irrigation costs (including avoided ground water pumping costs) and lost hydroelectric generation. It should be noted that the increase in mean

conductance is probably due reduced stomatal reactivity to closing stimuli, from a partially closed state, rather than actual stomatal opening.

Ecosystem Services

The planning document could evaluate the trade-offs involved in using FASOM versus other approaches to crop and forest impacts. This possibility and its likelihood of implementation come up several times. Provided that updated economic data are utilized, the modeling approaches are appropriate.

The ecosystem services concept is very appropriate to this analysis. The list of candidate services is quite complete, and represents a nice target which may or may not be achieved. When monetary values can be assigned this will be useful, but lack of valuation or willingness to pay should not prevent risk analysis. For example, the degraded ability of bees to find flowers of agricultural species for pollination will have monetary consequences that might be possible to estimate. This could be a useful exercise, despite being largely qualitiative at this stage.

Continued evaluation of the form of the standard is very important. Repeated assessments have concluded that cumulative ozone exposure is important and high concentrations are particularly significant. Yet it has remained unclear whether the increased complexity of forms such as W126 are sufficiently better at predicting impacts to be worth the increased difficulty of communication to regulated communities.

Dr. Howard S. Neufeld

Comments on Ozone National Ambient Air Quality Standards: Scope and Methods Plan for Welfare Risk and Exposure Assessment

The REA seems quite reasonable, if not ambitious, given the amount of variability and uncertainty in the data with which the EPA has to work. I had no major comments on the goals or the structure of the approach for calculating the risk assessment.

One comment concerns the use of FASOM to assess the economic impacts of ozone on natural ecosystems (Section 1.3, page 1-11). A following statement by Staff alludes to using this same model to assess how ozone affects ecosystem services, such as carbon sequestration. Dr. Han Tian, at Auburn University, School of Forestry and Wildlife Sciences, has developed a very sophisticated model called the Dynamic Land Ecosystem Model (DLEM) for determining major biogeochemical cycles as affected by a suite of environmental variables. As stated by Ren et al. (2011): "*DLEM is a process-based model that couples major biogeochemical cycles, hydrological processes and vegetation dynamics to generate daily, spatially explicit estimates of water, carbon (CO_2, CH_4) and nitrogen fluxes (N_2O, NH_3, NH_4, NO_x) and pool sizes (C and N) in terrestrial ecosystems (Tian et al., 2005, 2010a,c; Ren et al., 2007a,b; Liu et al., 2008; see Fig. 1). The DLEM includes five core components: (1) biophysics, (2) plant physiology, (3) soil biogeochemistry, (4) dynamic vegetation, and (5) disturbances, land use and management*."

This appears to be a potentially useful model for EPA use, especially since it has been used previously to estimate ozone effects, both in the Smokies and in China. Here is the citation for the model:

Tian, H.Q., Liu,M.L., Zhang, C., Ren,W., Chen, G.S., Xu, X.F. & Lu, C.Q. (2005) *DLEM – the Dynamic land ecosystem model, user manual*. Ecosystem Science and Regional Analysis Lab,
Auburn University, Auburn, AL.

If TREGRO and/or ZELIG are used to model tree and forest responses to ozone, will there be any inputs for rising CO_2 and/or elevated temperatures and precipitation? Seeing how rising CO_2 moderates ozone responses in the Aspen FACE system it would seem to suggest that some sort of accommodation should be made for this. As for temperature and precipitation, I do not think there are sufficient data at this point in time for the former factor, but there does seem plenty of information that could be used with the latter factor. We still need considerable research on how climate change can alter potential ozone responses. Since rising CO_2 generally ameliorates ozone responses, the risk assessments could overestimate future responses to ozone if they ignore this factor.

On page 3-2, in section 3.2.1, Staff list as one goal to estimate the "Percent of trails affected by ozone injury." What exactly does Staff mean by this? Is this simply the relative number of trails where foliar injury was observed? If so, I don't see how relevant that is, and it seems especially trivial when compared to the previous item, which estimates the percent of the vegetation with foliar injury.

In Figure 4.1, what is meant by "Habitat Loss"? Is Staff implying that ozone causes habitat loss? I would not agree with that statement. Perhaps they can clear this up.

Recent papers have documented that farmers are extending their planting seasons in the Midwest due to climate change. When building the estimates for crop losses in section 4.1.3.1, I think Staff needs to take into account the extension of the potential growing season due to climate change now, and it's potential extension in the near future due to rising temperatures. That is, if the growing season is longer, will that raise yields that partially counteract the negative effects of ozone? This may be particularly important if the extended portions of the growing season lie outside the main ozone season.

The rest of the document seems well written, and the risk assessments proposed reasonable.

Below, I document the few typos I found:
Section 1.3, line 26 – the entire "O3" is subscripted, when only the "3" should be.
Section 4.1.2, line 15 – change "is" to "are" since data are plural.
Section 4.1.3.1, line 2 – change "this" to "these" since again, data are plural.

Dr. Kathleen Weathers

The approach offered in Scope and Methods Plan for Welfare Risk and Exposure Assessment makes logical sense to me, but, as I've noted in past comments, the devil's in the details. In fact, I think much can be learned from experience and feedback from other panels, for example the NOx SOx secondary effects reviews. The details of that PA, including linking atmospheric inputs (in the absence of direct measures) to multiple process models to estimate welfare effects, appear to be quite similar to what is proposed here. I think that many of the stumbling blocks and challenges will be parallel.

I encourage EPA to take on the task of evaluating and discussing the myriad spatial scales of analysis and mapping that will be used, how they do, or do not match up, and what will be done to resolve critical differences. For example, if the CMAQ model's output (or any other modeling exercise that is used to generate a national ozone surface) is at 12kmx12km spatial resolution, how does that align with vegetation data from National Parks? What kind of spatial variability in exposure can be estimated over the area of, say, Great Smoky Mountain National Park? And, how will recently collected data across elevational gradients and complex terrain be used to verify or extend the models? I applaud the idea and look forward to the rigorous and creative analysis that will underpin the process.

All of the ecological effects analyses require linking models (whether spatial or process) together. It is useful that these models and functions have been vetted, but the challenge of linking them together in credible as well as informative (for standard setting) ways is large, especially given the paucity of data. In fact, model linking is a frontier in earth system science research; the envelope is being pushed in this standard setting process, which can be a good thing for research as well as for policy.

I've listed below a couple of references that may be of interest in regard to approaches (they do not address ozone, perse) for using FIA data, especially, and examining tree species' responses to both pollution and climate (Canham and Thomas and Thomas et al. papers) as well as comparisons of CMAQ output with ground based measurements (e.g., CASTNET; within Pardo et al. paper).

While I think it is interesting to consider the potential effects of ozone on watershed scale hydrology, teasing apart all of the other confounding and controlling variables, especially with so little data available, will be difficult at best.

Canham, C.D. and R.Q. Thomas. 2010. Frequency, not relative abundance, of temperate tree species varies along climate gradients in eastern North America. Ecology 91:3433-3440.
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 U.S. *Nature Geoscience* 3:13-17.
Pardo, L. H., Fenn, M. E., Goodale, C.L., Geiser, L. H., Driscoll, C.T., Allen E.B., Baron, J., Bobbink, R, Bowman, W.D., Clark, C, Emmett, B., Gilliam, F.S., Greaver, T., Hall, S.J., Lilleskov, E.A., Liu, L., Lynch, J., Nadelhoffer, K., Perakis, S.S., Robin-Abbott, M. J., Stoddard, J., Weathers, K., Dennis, R. L. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. *In press. Ecological Applications.*

Some specific questions/comments:
Why isn't the national ozone surface modeling included explicitly in the table of uncertainty and variability analyses listed on page 5-1?
What is meant by a non-linear *programming* model?
Acadia National Park might be included as a case study.
I don't understand how trail data could be used.

Dr. Peter B. Woodbury

Overall, this is a very good plan -- it is appropriately ambitious in building upon the analyses used in previous staff papers and addressing a wider range of ozone impacts both quantitatively and qualitatively given the available data. The comments below are intended to contribute to further development of this plan.

Section-page, line numbers

2-2. Which alternative definitions of the PRB? How will the PRB be estimated? Can a range of plausible PRB surfaces be developed rather than a single one?

2-3, 6. While consistency with the health RA is desirable, there are several reasons why exposure modeling should differ between health and welfare assessments. For vegetation, the exposure metric should be a cumulative one, such as 3-month W126, rather than an 8-h standard. Also, sensitive vegetation occurs in locations with very low human population density, such as Class 1 wilderness areas, and often these locations are far from ozone monitors, requiring a different approach from that used for areas with dense human populations.

2-3, 10. As discussed above, modeling the current standard is not adequate. The metric for vegetation exposure must be cumulative over many months, as discussed in the ISA.

2-3, 19-21. Will analyses include both high and low ozone years? If such variability would affect the results of rollback methods, staff should consider using multiple climate years.

3-1, 11-13. This is an important improvement to use FIA data to quantify the location of different species. However, it should be noted that ozone may be having an impact on the frequency of sensitive populations of some species, even if such effects cannot be modeled quantitatively based on available data.

3-2,13-16. Staff may wish to consider using Acadia National Park, although ozone exposure values are not as high there as some other locations in the USA, there have been exceedences of current standards and there is a body of site-specific data on ozone sensitivity based on open-top chamber experiments and surveys both using native vegetation.

3-3, 9-14. Since urban ozone concentrations may be quite variable over short distances, and be affected by local sources and air flows, it will be important to assure that interpolated ozone surfaces adequately reflect ozone exposures for the urban study areas. It will also be important to consider interacting effects of temperature, drought, and artificial watering on ozone effects on urban vegetation.

4-2. This figure (4.1) is a good start at listing potential ecosystem service impacts, but as mentioned in the draft, a more comprehensive list is needed, for example including climate regulation effects discussed in Chapter 10 of the draft ISA.

4-3. The suggestion to include human recreation frequency data is useful. However, it is also important to assess whether damage is occurring, whether or not a lot of people see it. For damage such as visible symptoms on leaves, this can be viewed as affecting the quality of recreational experiences, but it is also a direct indication of damage to trees. Other effects of ozone on vegetation may not be visible, but may also be important, such as changes in competitive relationships between species with different sensitivity to ozone.

4-3, 9-16. As mentioned above, it is important to include climate change and climate regulation impacts of ozone (Chapter 10 of the draft ISA). As noted, secondary or "cascading" effects and interactions, such as effects on hydrologic cycles, fire frequency, or pest attacks on vegetation are likely to be more important than direct effects of ozone on vegetation, but are very difficult to measure or to model accurately. I commend the staff for considering such interactions despite the challenges in quantifying effects.

4-3 and 4-4. For cropping seasons, staff should be sure to account for double cropping and winter cropping patterns in different regions.

4-4, 10-18. For economic impacts, it is important to quantify not just global or national impacts on, for example, crop yield, supply and price, but also local impacts on yield. This has not been done adequately in the peer-reviewed literature that I have seen. For example, if soybean yield is decreased in an area of the country with higher ozone exposure, this represents an economic loss to farmers in that region, even if there are economic gains to farmers in other regions that result in only small effects on price or total returns to farmers at the national scale. In such a situation, ozone-induced yield decreases can be viewed as shifting income from high-ozone areas to low-ozone areas, including areas outside of the USA, since agricultural commodities like soybean have global markets. I strongly encourage staff to consider the sum of such local negative impacts (not just net changes in farm income) in addition to impacts on price at the national scale.

4-4, 22-28. The following reports should be useful for assessing impacts of ozone on forests throughout the Southern Appalachian Forest region. A peer-review process was included in the report process. These may be useful for the ISA as well as the welfare and risk assessment. They were previously publically available on the internet, but may not be at this time. I can provide PDF copies of these reports if they might be useful.

Weinstein DA, Woodbury PB, Gollands B, King P, Lepak L, Pendleton D. 2002. Assessment of Effects of Ozone on Forest Resources in the Southern Appalachian Mountains. Report to Southern Appalachian Mountain Initiative.

Southern Appalachian Mountain Initiative. 2002. Chapter 5: Ozone Effects to Forests. In: Southern Appalachian Mountain Initiative Final Report. August, 2002.

4-5, 1-3. Can FASOM really model ozone impacts on different species of trees, and the effects of ozone on mixed stands of trees? Can FASOM model the ecosystem services that are most likely to be affected by ozone? For mixed-species forests, I expect that total biomass growth will not be the most sensitive impact from ozone exposure.

4-6, line 6-15. It would certainly be useful to model effects of ozone on urban trees, and on the services which they provide. However, I have some questions about the capabilities of this model. Can the i-TREE model adequately represent the effects of ozone on specific tree species? Can it adequately account for interactions of temperature and moisture status with ozone that may occur with urban trees? Is decreased growth rate the most important impact of ozone on urban trees?

5-1, Table 5-1. Sensitivity analyses are useful, but quantitative uncertainty analyses are more useful, because they quantify the range of possible effects that may be expected due to the uncertainty in model inputs. Sensitivity analysis, in contrast, examines the sensitive of model results to variation in the inputs, typically increased or decreased by some fixed percentage. Quantitative uncertainty analysis develops probability density functions to represent current knowledge of the input values, and then propagates these functions through the model with appropriate consideration of interactions among variables, to produce probabilistic estimates of impacts. Such probabilistic results can directly indicate the likelihood of much more severe or less severe impacts than suggested by single value estimate. I encourage the staff to consider using quantitative uncertainty analysis in place of sensitivity analysis to address the topics listed in the table, and discussed on later pages. I also encourage staff to use quantitative uncertainty analysis approaches rather than qualitative approaches whenever feasible.

5-2 and subsequent pages. The discussion demonstrates that staff are considering the important distinctions between uncertainty and variability. It is indeed important to try to separate these concepts, and I commend the staff for doing so. However, in practice it is not always feasible to separate them. Additional careful consideration to identifying key sources of variability and uncertainty is warranted (see below). Another important concept is to search for sources of bias in estimating ozone impacts. There will always be uncertainty in modeling impacts of stressors over large regions of space and over long time periods. However, careful quantitative uncertainty analysis can help to reveal potential biases that may occur with single point estimates.

5-4. The list of sources of uncertainty is useful, but it’s not clear whether it includes some important gaps in scientific knowledge, including lack of any data on effects of ozone on many plant species, inadequate data on the sensitivity of mature trees compared to seedlings, etc. The list indicates that there is uncertainty about the policy-relevant background level for individual locations, there is also uncertainty about the level at regional to continental scales, since it can only be estimated using air quality models. Consideration of such issues, particularly if they may cause bias in point estimates is warranted.