SUMMARY AND CRITIQUE OF THE BENEFITS ESTIMATES IN THE RIA FOR THE OZONE NAAQS RECONSIDERATION

NERA
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Executive Summary

EPA's statements on health benefits from lowering the Ozone NAAQS grossly misrepresent what EPA is actually estimating as the potential benefits of reducing public exposures to ozone. If based on ozone benefits alone, not one of EPA's estimates of the benefits of reducing ozone to a tighter alternative ozone standard is as large as the costs of attaining that respective ozone standard – all cost more than the ozone benefits they might provide.

EPA's estimates of ozone benefits are less than their costs despite the fact that EPA has now escalated those benefits by always including benefits due to ozone-related mortality. EPA's science advisors (CASAC) found no "causal" link established between ozone and mortality during their deliberations, but EPA now presumes, as part of the reconsideration, a causal link between ozone and mortality risk. Despite this change that is unsupported by CASAC, EPA's net benefits estimates for ozone standards tighter than 0.075 ppm are all still deeply negative.

The only way EPA finds benefits greater than costs for a tighter ozone standard is to add in health gains from concomitant reductions in $PM_{2.5}$ that may occur while reducing ozone precursors – "co-benefits" that have nothing to do with ozone exposures. Thus, EPA's claim that tightening the Ozone NAAQS has greater benefits than costs has nothing to do with reducing risks from ozone. EPA also has inflated the magnitude of these co-benefits as part of the reconsideration through several specious assumption changes. The Agency's inflated co-benefits assumptions during this reconsideration represent a change compared to those assumed in the original Ozone NAAQS review ending in 2008. Even with both ozone mortality benefits and $PM_{2.5}$ mortality co-benefits, a large fraction of EPA's net benefits estimates are negative.

Introduction

In 2008, EPA reduced the Ozone National Ambient Air Quality Standard (NAAQS) from 0.08 ppm to 0.075 ppm.[1] At the time of the 2008 NAAQS decision, a final Regulatory Impact Analysis (RIA) was released that estimated costs and benefits of several alternative NAAQS standards relative to the 0.084 ppm standard (USEPA, 2008, hereafter called the "*2008 RIA*"). The *2008 RIA* analyzed alternative ozone standard levels of 0.075, 0.070, and 0.065 ppm. In 2010, EPA announced it would be reconsidering the Administrator's decision to set the standard at 0.075 ppm, and would consider levels in the range of 0.060 to 0.070 ppm. A "*Supplemental RIA*" was released (USEPA, 2010) that provided "updated" benefits estimates for the three alternative standards in the original *2008 RIA*, and supplemented these with benefits estimates for alternative Ozone NAAQS of 0.060 and 0.055 ppm.

This paper explains the changes in the two versions of the ozone RIA, and provides a summary and critique of EPA's benefit estimates for the ozone reconsideration. This paper does not attempt to critique the RIA's cost estimates, recognizing that others have already done so. The primary conclusions of this paper are that none of the alternative ozone standards, including the current one of 0.075 ppm, can be justified on the basis of net benefits (*i.e.*, benefits minus costs) being positive. Using EPA's own estimates in its *Supplemental RIA*, ozone-related net benefits are negative by billions of dollars per year. The only way that EPA manages to report positive net benefits requires reliance on "co-benefits" from fine particulate matter ($PM_{2.5}$) mortality reductions *combined with* a causal ozone-mortality association. Even so, EPA needs to use inflated estimates of both the $PM_{2.5}$ and ozone mortality risks to generate any of its positive net benefits estimates for any of the alternative Ozone NAAQS considered in the RIA. EPA makes "updates" in its *Supplemental RIA* that both inflate and give greater emphasis to the mortality estimates that are essential to producing positive net benefits estimates. EPA describes these updates as "methodological improvements" but the changes that make the key differences have no basis in new or improved techniques.

Overview of Changes in the RIA since the 2008 Ozone NAAQS Decision

The ozone reconsideration is supposed to consider only information in the record at the time of the 2008 NAAQS decision, and hence the *Supplemental RIA* also should not rely on any new information. Ostensibly, the *Supplemental RIA* for the ozone reconsideration was prepared to provide analysis of alternative standards additional to those that were analyzed in the *2008 RIA*. However, EPA did also change several important assumptions when "updating" the RIA for the Ozone NAAQS reconsideration. Although the *Supplemental RIA* has not relied on any new clinical or epidemiological studies, it has

[1] The earlier ozone standard was specified only to the second decimal place, and in practice was implemented as if it had been set at 0.084 ppm. I will refer to it as 0.084 ppm hereafter. In both cases, the precise form of the standard was that the fourth highest maximum daily 8-hour average level of ozone was not to exceed these respective concentration levels, when averaged over 3 years.

changed a number of assumptions that increase the level of the estimated benefits for all of the alternative standards levels, including those that were analyzed in the *2008 RIA*:

> "*These changes reflect the more stringent range of options being proposed by the Administrator. It* [sic] *also reflects some significant methodological improvements to air pollution benefits estimation, which EPA has adopted since the ozone standard was last promulgated.*"[2]

One may first wish to ask the question whether changes in benefits estimation methods should be allowed in the RIA for the reconsideration, as these too may be deemed "new information" relative to that available at the time of the Administrator's original decision. Answering this legal question is outside the scope of this review. But within the scope of this review is whether these methodological changes can be characterized as "improvements," as noted by EPA in the quote above. That they are not improvements is explained below for each of the changes individually.

EPA no longer considers the possibility of no causality for ozone mortality.
EPA cites the recommendations of an NAS committee report (NRC, 2008) as its basis for now assuming that ozone mortality associations are causal, and also for no longer giving any weight to the possibility that such associations may not be. This decision supplants CASAC's views on the matter, based on the evidence they considered during their 2008 review and which they reiterated to EPA as recently as February 2011.[3] The *2008 RIA* did report ozone mortality estimates, using the two studies that provide the lower and upper bound in the range of ozone mortality estimates in the *Supplemental RIA*. However, the *Supplemental RIA* employs a significantly different stance in communicating about the ozone mortality portions of its benefits estimates. In the *2008 RIA*, EPA acknowledged "considerable uncertainty" in the association between ozone and mortality, lack of knowledge of any underlying mechanisms causing mortality, and the possibility that there was no causal relationship at all in its summary of multiple benefit scenarios.[4] In contrast, the *Supplemental RIA*'s summary statements ignore even the *possibility* that there is no causal ozone-mortality relationship. This has the effect of greatly raising the lower bound of EPA's benefit estimates because all of the *Supplemental RIA* benefit summaries treat ozone mortality as certainly causal. The only basis for this substantial shift is the 2008 NAS committee opinion, which was not based on any studies that resolved the critical uncertainties noted in the *2008 RIA*. Also, that 2008 NAS opinion remains unsupported by EPA's CASAC panel today: CASAC re-stated during its 2011 reconsideration deliberations that the presumption of causality for ozone-related mortality was "not ready for prime time."

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[2] *Supplemental RIA*, p. S1-1.

[3] The NAS report was not released at the time of the 2008 NAAQS decision (and was not in the record for that decision) and thus constitutes new information, in addition to being at odds with CASAC's past and current views of the evidence available at the time of the 2008 NAAQS decision.

[4] *2008 RIA*, p. 6-1.

EPA has included two more ozone multi-city studies.

The *Supplemental RIA* also cites the 2008 NAS committee report to justify now including two additional studies in its benefit calculations for ozone mortality. One might ask why were these two studies were not considered important enough to incorporate them into EPA's 2008 Risk Analysis for ozone, which received CASAC's review. Nevertheless, their inclusion makes little difference to the RIA results. The ozone mortality estimates of these two studies (*i.e.*, Schwartz, 2005 and Huang *et al*., 2005) fall between the minimum and maximum of the four studies that were used in the *2008 RIA* and so their inclusion causes no meaningful change in the RIA results summarized below.

EPA has increased the value of a statistical life (VSL).

In the *2008 RIA*, EPA used a VSL of $7.9 million (2006$) for benefits in 2020[5] but uses a 2020 VSL of $8.9 million (2006$) in the *Supplemental RIA*.[6] The higher VSL increases the mortality estimates for both ozone and $PM_{2.5}$ by 17% as compared to what they were in the *2008 RIA*. EPA refers the reader to Section 5.7 of the proposed NO_2 RIA (USEPA, 2009) for its rationale for this change,[7] but the discussion in that 2009 document makes EPA's decision seem purely arbitrary.[8] A non-arbitrary, technical rationale for a change in assumption such as this is especially needed in the present situation involving the *reconsideration* of the ozone standard, given that this change creates inconsistency with the original RIA benefit estimates. But, even if a technical basis for now applying a different VSL could be articulated, one would still have to ask whether it is appropriate to incorporate that altered VSL into documents supporting the reconsideration if that technical information was not available to the Administrator at the time of the initial 2008 decision. A non-arbitrary, technical rationale for this VSL change is warranted as a general matter as well, given that mortality estimates are the largest components of EPA's benefit estimates in this and almost all other of EPA's RIAs. Given the relatively tenuous basis for any choice of VSL, it is difficult to imagine any good reason for making this change at this time. Uncertainties in estimating VSL create a range of uncertainty much wider than this 17% increase – EPA acknowledges a range of a factor of 10 in its evidence supporting a VSL assumption.[9] Uncertainty and continued debate about

[5] *2008 RIA*, p. 6-25.

[6] *Supplemental RIA*, p. S2-20.

[7] *Supplemental RIA*, p. S3-2.

[8] The discussion appears on pp. 5-26 to 5-27 of EPA (2009). In essence, it states that although EPA has used the lower VSL in all of its benefit analyses since 2004, EPA never changed its official guidance on the VSL that it published in 2000, which suggested use of the higher VSL. Therefore, EPA has now decided to revert to the VSL that it was using prior to 2004 supposedly for purposes of consistency (*i.e.*, "Until updated guidance is available, the Agency determined that a single, peer-reviewed estimate applied consistently best reflects the SAB-EEAC advice it has received." p. 5-27, emphasis added). Not only did this decision in 2009 to revert to an earlier VSL actually create *inconsistency* with all of EPA's analyses since 2004, but EPA also states that its use of the VSL from its 2000 guidance document "does not represent final agency policy" (EPA, 2009, footnote 17, p. 5-27).

[9] EPA (2009), p. 5-26.

whether it is more appropriate to assign value to the quantity of life-years lost rather than to "statistical lives" further widens that range of uncertainty, and further weakens any justification for EPA to suddenly increase the VSL it has been using since 2004.[10] Therefore, the change in the VSL assumption cannot be viewed as a necessary "improvement" to the *Supplemental RIA*. It merely adds confusion for readers of the two RIAs. For EPA, it provides additional inflation of the mortality benefit estimates that, as I will show below, are critical for EPA in making its case that a tighter Ozone NAAQS will produce positive net benefits.

EPA has removed thresholds from the concentration-response functions for $PM_{2.5}$. One of the most significant changes in the benefit calculations since the *2008 RIA* is EPA's decision to remove $PM_{2.5}$ thresholds from the calculation of morbidity and mortality benefits. As explained below, this single change nearly doubles EPA's 2008 estimates of $PM_{2.5}$ co-benefits. EPA's stated reason for changing this assumption in the *Supplemental RIA* is consistency with other RIAs since 2009 that also computed $PM_{2.5}$ co-benefits.[11] Review of the discussions cited by EPA as the basis for making that methodological change during 2009 finds merely a re-hash of the pre-existing information that a no-threshold, linear model provides the best fit to the available epidemiological data. These data, *by definition*, extend only as low as the lowest measured level in the epidemiological studies. EPA provides no new evidence to support its new "interpretation" that it should now count benefits for all modeled concentrations, no matter how far they fall below the lowest measured level in any of the statistical analyses.[12] Like the VSL increase, this change also lacks a technical basis and cannot be characterized as a "methodological improvement." But, even if relevant new information providing technical support for this new assumption did exist at the time EPA released the *Supplemental RIA*, one might still question the appropriateness of including such new information in the RIA for the reconsideration of the 2008 Ozone NAAQS decision.

Several other changes from the *2008 RIA* made in the *Supplemental RIA* are not emphasized but listed here for completeness although they have little if any noticeable impact on estimates:[13]

- EPA changes the estimate of $PM_{2.5}$ benefits per ton reduced based on a broader geographic area, which the RIA says produces "more reliable and generally larger PM-related benefits estimates."[14]

[10] See, for example, Sunstein (2004).

[11] *Supplemental RIA*, p. S3-3.

[12] See the American Chemistry Council (2009) for a thorough technical critique of EPA's logic and facts in ACC's comments on the draft Portland Cement RIA.

[13] *Supplemental RIA*, p. S3-2 and S3-3.

[14] *Supplemental RIA*, p. S3-3. This change appears to have had little effect on estimates in the 2008 RIA, but a comment is warranted on problems in EPA's "benefits per ton" method in general, which EPA is

- EPA now bases the range for $PM_{2.5}$ mortality only on papers by Pope *et al*. (2002) and Laden *et al*. (2006) rather than including experts' opinions from the Expert Elicitation as well. This narrows the range of $PM_{2.5}$ mortality co-benefits on both ends of the range with little effect on the overall importance of including $PM_{2.5}$ mortality co-benefits at all.

- EPA uses updated population projections in BenMAP.[15] The effect on estimates is not mentioned but it appears to be minimal.

- EPA uses a different function for asthma emergency room (ER) visits that increases that benefit by a small amount.

The Excessive Role of "Co-Benefits" Compared to Ozone-Related Benefits

In the above discussion of changes in the RIA benefit calculations, one might notice that almost all of the important changes are in the estimate of $PM_{2.5}$ "co-benefits." This begs the question: *Why is EPA including $PM_{2.5}$ benefits in its ozone RIA?* EPA has routinely included $PM_{2.5}$ benefits estimates in its RIAs for almost all air-related regulations since 1997 even when those regulations were not directly related to reducing $PM_{2.5}$, calling them "co-benefits." Once it became clear that EPA could calculate $PM_{2.5}$ mortality benefit estimates vastly larger than any non-PM benefits that it could generate, RIAs no longer calculated benefits just from the pollutant that was the subject of a new regulation, but also benefits from incidental additional reductions in $PM_{2.5}$ resulting from controls on the subject pollutant.[16] This practice has enabled EPA to claim that many new air-related regulations will have benefits greater than costs, but usually solely due to the estimates of $PM_{2.5}$ co-benefits.

Table 1 summarizes monetized benefit estimates from the original *2008 RIA* and the *Supplemental RIA* for several key benefit and co-benefit categories, using the 7% discount rate.[17] Although the *2008 RIA* did provide calculations of ozone mortality

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now using in all of its RIAs to calculate co- benefits of $PM_{2.5}$ reductions. This method does not estimate population-based changes in exposure, and thus is inconsistent with *OMB Circular A-4* which requires risk assessments to estimate how regulations will change population-based exposure, and whose exposure will be reduced.

[15] *Supplemental RIA*, p. S3-2.

[16] The use of $PM_{2.5}$ co-benefits had certainly appeared by the time of the proposed Regional Haze Rule that followed closely on the heels of the first $PM_{2.5}$ NAAQS in 1997. In that Regional Haze Rule RIA, positive net benefits could be calculated only because of the inclusion of mortality co-benefits from further reduction of $PM_{2.5}$ below the level of the then-new $PM_{2.5}$ NAAQS.

[17] The RIA provides benefit estimates (but not cost estimates) using a 3% discount rate as well. I prefer to use consistent discount rates for benefit-cost comparisons, but the conclusions in these comments would be the same using the 3% discount rate estimates. EPA generally references benefits using a 3% rate in its summary statements, which are about 9% higher than those using the 7% rate. Such preferential reliance on the 3%-based benefits in summary statements helps inflate benefits in external communications.

benefits (which are shown in Table 1) it did not present those estimates as necessarily causal. The original RIA also provided benefit totals that excluded ozone mortality altogether due to "considerable uncertainty" about their causality.[18] Also, the "primary" estimate of ozone mortality risk in the *2008 RIA* was based Bell *et al*. (2004), whereas Bell *et al*. (2004) generates the lowest of the ozone mortality risk estimates in the *Supplemental RIA*, and no mention is made of it being "primary."[19] Table 1 shows the estimates from Bell *et al*. (2004) in both of the RIAs, to allow straightforward comparison. However, the original *2008 RIA* communicated that all the estimates of ozone mortality were highly uncertain in regards to their causality, while the *Supplemental RIA* implicitly treats the estimate in Table 1 as a lower bound.

Table 1. Summary of Benefits Estimates in the 2008 and Supplemental Ozone RIAs
(2006$ millions, 7% discount rate; "-Orig" indicates the estimates from the *2008 RIA* and "-Supp" indicates the estimates from the *Supplemental RIA*)

	O_3 morbidity	O_3 mortality (Bell 2004)	$PM_{2.5}$ morbidity	$PM_{2.5}$ mortality (Pope)	$PM_{2.5}$ mortality (Laden)	Source in RIAs
0.075-Orig	73	550	300	3006	6606	Table 6.56
0.075-Supp	71	660	426.5	5022	13022	Table S3.6
0.07 -Orig	230	1900	500	5411	12011	Table 6.56
0.07 -Supp	211	2200	772.5	9044	23044	Table S3.6
0.065-Orig	420	3500	780	8816	20016	Table 6.56
0.065-Supp	378	4000	1250	14073	37073	Table S3.6
0.06 -Supp	737.3	7900	1721.1	22100	57100	Table S2.11
0.055-Supp	1299.4	14000	2455.3	31150	81150	Table S2.13

Table 1 shows that the ozone-related morbidity benefits (in the first column) are miniscule compared to those from the calculated $PM_{2.5}$ co-benefits and the presumed mortality attributed to ozone. This can also be visualized in Figure 1.[20] Figure 1 reveals that the calculated benefits from controlling ozone morbidity under tighter alternative Ozone NAAQS are so small that they are nearly invisible on the scale of the chart. Figure 1 and Table 1 also reveal that the vast majority of the benefits being attributed to a

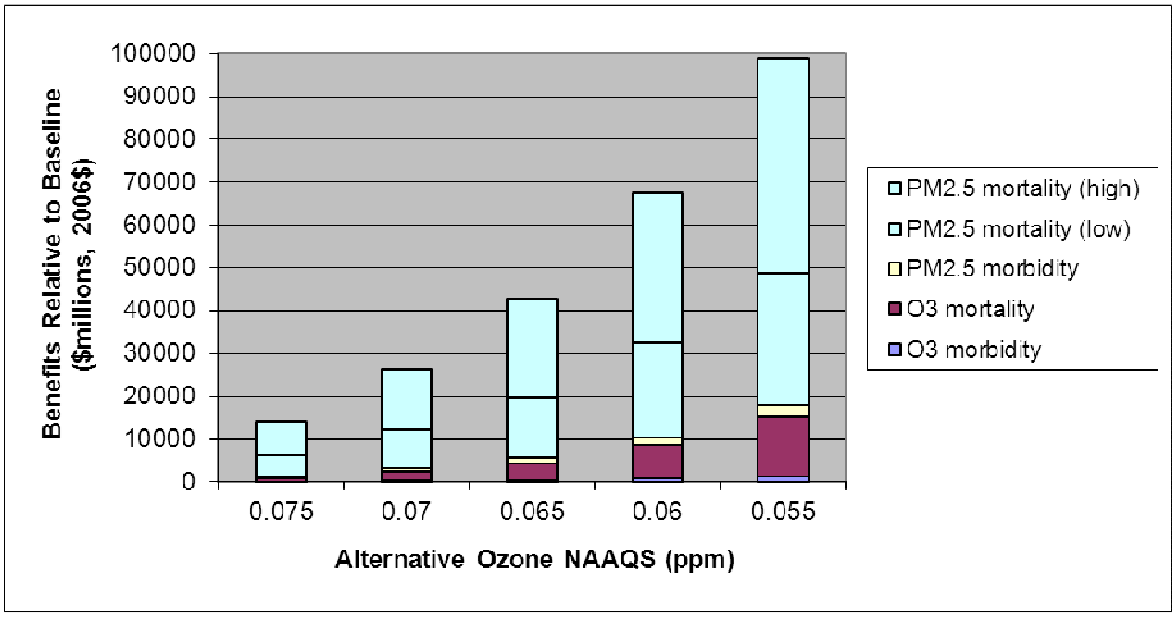
[18] *2008 RIA*, p. 6-1.

[19] Although the *Supplemental RIA* does not state which estimate is its "primary" estimate, it does state that EPA is "placing the greatest emphasis on" the NMMAPS study, of which Bell *et al*. (2004) is the most prominent in that RIA.

[20] The pale blue bars in Figure 1 show the full range of $PM_{2.5}$ mortality from low (Pope-based) to high (Laden-based), with a solid line near their middles identifying where the low estimate ends. Figures S3.5 and S3.6 of the *Supplemental RIA* provide similar types of bar charts, but in a fashion that is more difficult to interpret, and without including the 0.060 and 0.055 alternative standards.

tightening of the Ozone NAAQS are not ozone-related effects at all (*i.e.*, the yellow and pale blue segments of the bars are not ozone-related benefits).

Figure 1. *Supplemental RIA*'s Estimates of Benefits Disaggregated by Type of Benefit and Co-Benefit.



Ozone-Related Benefits Are Far Below Estimated Ozone-Control Costs

The inflating effect of always including $PM_{2.5}$ co-benefits and ozone mortality in the ozone benefits calculation can be observed in another way. A summary figure on benefit uncertainties in EPA's *Supplemental RIA*, Figure S3.7, indicates a lower bound of benefits for the 0.065 ppm alternative standard of $11 billion,[21] but Table 1 above shows that the actual lower bound is only about $0.4 billion when accounting for the possibility that ozone mortality is not causal, consistent with CASAC's stated views.[22] This $0.4 billion lower bound is what EPA reported as its lower bound in its *2008 RIA.*[23] This demonstrates that the much higher range of benefits in the *Supplemental RIA* is not the result of any "improvements" to EPA's benefits calculation methods, but due to EPA's new willingness to ignore the possibility that there is no causal relationship between ozone and mortality risk and to never summarize benefits for ozone-related effects alone

[21] This can be inferred from Figure S3.7 on *Supplemental RIA* p. S3-15 by taking the lowest value shown from the 0.065 ppm case using 3% discounting (i.e., $1200 million) then reducing it by 9% to convert to a 7% discount rate as described in the figure's footnote.

[22] Even if ozone mortality is treated as causal, the lower bound without accounting for $PM_{2.5}$ co-benefits would be about $4.4 billion.

[23] *2008 RIA*, p. 6-2.

(*i.e.*, without co-benefits also added in) as it did on pages 6-1 and 6-2 of its *2008 RIA*. Although EPA does not state it, *the Supplemental RIA's lower bounds for ozone-related benefits when treating the ozone mortality effect as non-causal* are as follows:

- 0.075 ppm alternative standard: $0.07 billion
- 0.070 ppm alternative standard: $0.21 billion
- 0.065 ppm alternative standard: $0.38 billion
- 0.060 ppm alternative standard: $0.74 billion
- 0.055 ppm alternative standard: $1.30 billion.

When rounded to a tenth of a billion, these are identical to the lower bounds reported for ozone-related benefits on pp. 6-1 to 6-2 of the *2008 RIA* (for the three alternative standards analyzed in the *2008 RIA*). The only thing that has changed is how EPA summarizes its estimates, now omitting the true lower bound of its benefit estimates in its summary figures and tables. All of the discussion thus far been about benefit estimates, without reference to the associated costs, which are necessary to calculate *net benefits.* Using only the lower bound of EPA's cost estimates, Table 2 below shows that the *Supplemental RIA* finds that the current ozone standard of 0.075 ppm would have net benefits of -$7.5 billion relative to the pre-2008 ozone standard of 0.084 ppm. The tighter 0.070 to 0.055 ppm alternative standards net benefits range from -$18.8 billion to -$76.7 billion (see Column c of Table 2).[24]

Table 2. Net Benefit Estimates in *Supplemental RIA* for Ozone-Related Effects Only (2006$)

Alternative Standard (ppm)	(a) Lowest Cost Estimate in RIA (*)	(b) Ozone-Related Benefits Estimate if Ozone Mortality is Non-Causal (**)	(c) Net Benefits without Co-Benefits and if Ozone Mortality is Non-Causal *Col (b) – Col (a)*	(d) Highest Ozone-Related Benefits Estimate (***)	(e) Highest Possible Ozone-Related Net Benefits Estimate *Col (d) – Col (a)*
0.075	$ 7.6 billion	$0.07 billion	**-$7.5 billion**	$ 3.1 billion	**-$ 4.5 billion**
0.070	$19.0 billion	$0.21 billion	**-$18.8 billion**	$10.2 billion	**-$ 8.8 billion**
0.065	$32.0 billion	$0.38 billion	**-$31.6 billion**	$18.4 billion	**-$13.6 billion**
0.060	$52.0 billion	$0.74 billion	**-$51.2 billion**	$36.7 billion	**-$15.3 billion**
0.055	$78.0 billion	$1.30 billion	**-$76.7 billion**	$65.3 billion	**-$12.7 billion**

(*): Lower bound of cost range from *Supplemental RIA* Table S1.1.
(**): Sum of all ozone-related morbidity from *Supplemental RIA* tables S3.6, S2.11, and S2.13
(***): Sum of all ozone-related morbidity plus ozone-related mortality based on Levy *et al.* (2005) from *Supplemental RIA* tables S3.6, S2.11, and S2.13.

[24] EPA is computing costs and benefits relative to the 1997 ozone NAAQS of 0.084 ppm (*2008 RIA*, p. 6-3), which is why even the current ozone NAAQS standard has a net cost in this RIA. EPA also states that the $PM_{2.5}$ co-benefits are incremental to an assumption of full attainment of the 2006 $PM_{2.5}$ NAAQS of 15 ug/m3 annual and 35 ug/m3 daily average (*2008 RIA*, p. 6-4).

In fact, even if the very highest of the ozone mortality estimates in the RIA (*i.e*., those based on Levy *et al*. (2005)) are added into the ozone-related morbidity benefits, the total ozone-related benefits in the *Supplemental RIA* remain below the lower bound of EPA's own cost estimates. The net benefits of the 0.075 ppm standard would be about -$4.5 billion (relative to the pre-2008 ozone standard of 0.084 ppm), while the yet-tighter alternative standards (*i.e*., 0.070 through 0.055 ppm) have net benefits ranging from -$8.8 billion to -$12.7 billion (see Column e of Table 2). Use of any of EPA's other, higher cost estimates would only make these net benefits more negative.

Often, EPA reports a "benefit:cost ratio" rather than the dollar value of net benefits. This is just another way of looking at the same information as in Table 2. Positive net benefits require a benefit:cost ratio larger than 1 to 1, and EPA often reports ratios more like 20 to 1. Table 3 below reports the benefit:cost ratios for just ozone-related benefits, based on the results in Table 2. Table 3 shows that if ozone mortality is not causal, the benefit:cost ratio is about 0.01 to 1, meaning that benefit estimates are about 1/100th the level of EPA's cost estimates. Even when including the largest of any of EPA's ozone mortality benefit estimates, Table 3 shows that the benefit:cost ratio never rises as high as 1 to 1. Use of any of EPA's other, higher cost estimates would only make these benefit:cost ratios smaller.

Table 3. Benefit:Cost Ratios in *Supplemental RIA* for Ozone-Related Effects Only

Alternative Standard (ppm)	Benefit:Cost Ratio	
	If Ozone Mortality is Non-Causal *Col (b) ÷ Col (a) from Table 2 above*	**Highest Possible (Using highest ozone mortality estimate)** *Col (d) ÷ Col (a) from Table 2 above*
0.075	0.01 to 1	0.41 to 1
0.070	0.01 to 1	0.54 to 1
0.065	0.01 to 1	0.58 to 1
0.060	0.01 to 1	0.71 to 1
0.055	0.02 to 1	0.84 to 1

Thus, by EPA's own calculations in the *Supplemental RIA*, every one of the alternative Ozone NAAQS standards being analyzed has negative net benefits based on all possible ozone-related effects, including an assumed causal ozone mortality relationship. EPA's cost-benefit methodology in the *Supplemental RIA* cannot produce a single case in which net benefits are positive unless EPA includes $PM_{2.5}$ mortality co-benefits.[25] Even under the best case, which would be the current standard of 0.075 ppm, the ozone-related net benefits imply a loss of more than -$4 billion.

[25] Even adding all the $PM_{2.5}$ *morbidity* co-benefits to the highest of all the ozone-related benefits cannot produce a positive net benefit estimate for any of the alternative standards.

In conclusion, the only way that EPA's *Supplemental RIA* can find that net benefits of a tighter Ozone NAAQS might be positive is to include $PM_{2.5}$ co-benefits – and in particular the $PM_{2.5}$ *mortality* co-benefits. Even then, most of the net benefits estimates remain negative. This can be seen in Table S1.1 of the *Supplemental RIA*, in which the range of net benefits (see last column) is approximately centered around zero, with both negative and positive estimates in all cases, *including the cases in which the highest of the ozone mortality risk estimates is employed* (*i.e.*, the rows labeled "Levy *et al.* 2005"). This tells us that EPA needs to assume not just ozone mortality causality, but also to combine that with its *high-end* estimates of $PM_{2.5}$ mortality risk in order to generate a positive net benefit for any of the alternative Ozone NAAQS.

$PM_{2.5}$ Co-Benefits Are Inflated and Subject to Large Uncertainties

The need to rely on high-end $PM_{2.5}$ mortality risk estimates evident in the *Supplemental RIA* would have been even more pronounced but for two of the changes to its benefits calculations that EPA made when it "updated" the ozone RIA: the estimation of $PM_{2.5}$ risks below the lowest measured level in the PM studies, and the use of a higher VSL. Figure 2 below compares the equivalent set of benefits estimates from the original *2008 RIA* (labeled "-Orig" in the figure) with those from the *Supplemental RIA* (labeled "-Supp" in the figure) that were first shown in Figure 1 above. Figure 2 shows results only for the standards 0.075, 0.070 and 0.065 ppm because the original *2008 RIA* did not analyze 0.060 or 0.055 ppm.

Figure 2. Comparison of Benefits Estimates in 2008 and Supplemental RIAs

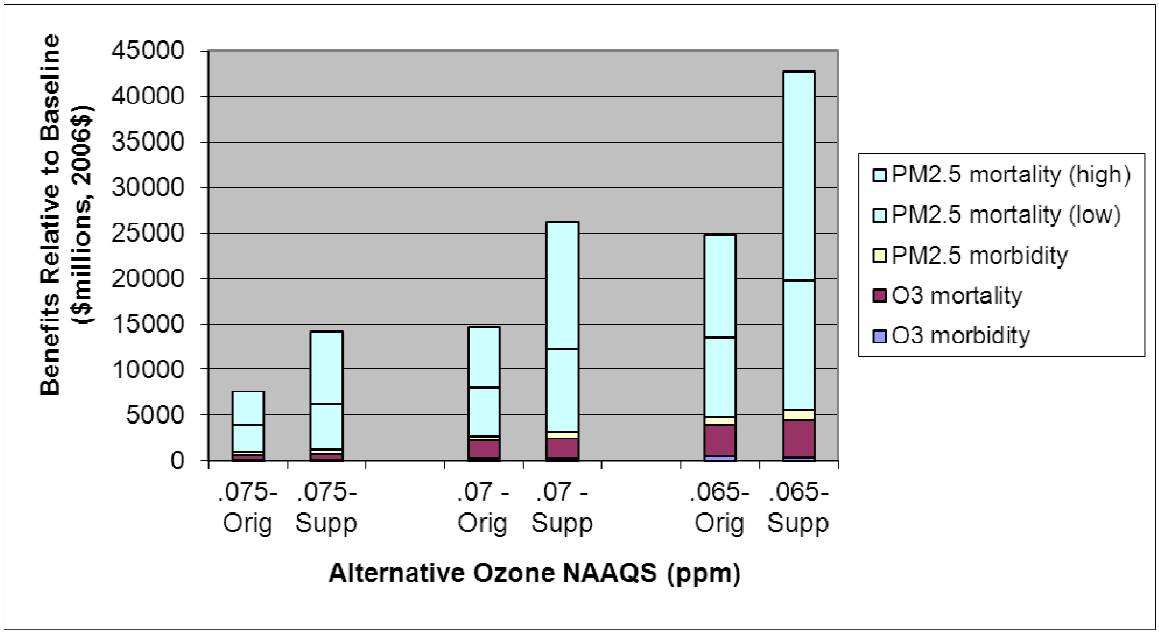


Figure 2 reveals that EPA's "updated" assumptions for the reconsideration reinforced the result that the reported benefits of the ozone standard are almost entirely due to non-ozone related impacts. That is, the largest change in estimated benefits between the *2008 RIA* and the *Supplemental RIA* was an increase in the $PM_{2.5}$ mortality benefit, further increasing the predominance of $PM_{2.5}$ co-benefits over ozone benefits in the analysis. This is consistent with EPA's statement that the removal of the threshold in the $PM_{2.5}$ mortality benefits calculation had by far the largest impact among the changes that it made in the "update."[26] Other changes such as the increased VSL and the use of updated population projections in BenMAP affected the ozone mortality estimate in the same way that they affected the $PM_{2.5}$ mortality estimate, yet the ozone mortality estimates did not increase in the same degree. That is, the heights of the maroon bars for ozone mortality in Figure 2 increase only slightly between the original and supplemental estimates, whereas the heights of the pale blue $PM_{2.5}$ mortality bars double.

EPA increased the VSL in 2020 by 17% from $7.9 million (2006$) in the *2008 RIA*[27] to $8.9 million (2006$) in the *Supplemental RIA.*[28] If nothing else had changed, all the mortality benefits for both ozone and $PM_{2.5}$ should have increased by 17% in the *Supplemental RIA*. The ozone mortality estimates do increase by an average of 17% which suggests that the changed population estimates and revised $/ton benefits estimation method had no significant effect on EPA's benefit estimates overall. In contrast, the low and high $PM_{2.5}$ mortality estimates have increased by 60% and 97%, respectively. By subtracting out the 17% increase due to VSL increase, one can infer that EPA's decision to now count $PM_{2.5}$ benefits down to the lowest measured level increased its low-end (Pope) $PM_{2.5}$ mortality benefit estimates by about 40%, and its high-end (Laden) $PM_{2.5}$ mortality benefit estimates by about 65%. The combined effect of removing the $PM_{2.5}$ threshold and increasing the VSL estimate was to nearly double the high-end estimates of $PM_{2.5}$ mortality from the *2008 RIA* to the current "updated" RIA. EPA takes the position that this doubling of co-benefits is appropriate to incorporate into the RIA used for the ozone reconsideration although the reconsideration supposedly uses information available to the Administrator at the time of the original 2008 decision.

Why tighten an ozone regulation if the benefits are almost entirely attributable to $PM_{2.5,}$ which is itself already subject to regulation that protects the public health with an adequate margin of safety? In pondering that question, one should also be informed that a string of questionable assumptions in the calculations of $PM_{2.5}$ co-benefits exists, including the following:

- The $PM_{2.5}$ benefit estimates are due to small changes in $PM_{2.5}$ starting at very low initial concentrations of $PM_{2.5}$, despite EPA's own statement that "It is important to note that as the stringency of the standards increases, we believe that the uncertainty

[26] *Supplemental RIA*, p. S3-17.

[27] *2008 RIA*, p. 6-25.

[28] *Supplemental RIA*, p. S2-20.

in the estimates of the costs and benefits also increases."[29] EPA states that the $PM_{2.5}$ co-benefits in this RIA are all incremental to exact attainment of the 2006 $PM_{2.5}$ standards,[30] which means that 100% of the $PM_{2.5}$ co-benefits are due to $PM_{2.5}$ changes in areas where exposure levels are already in attainment with the $PM_{2.5}$ NAAQS. Thus, all of the $PM_{2.5}$ co-benefits calculated in the ozone RIA come from changes in $PM_{2.5}$ concentrations that EPA deemed to be too uncertain to consider when setting the $PM_{2.5}$ NAAQS.

- The possibility that $PM_{2.5}$ associations reflect systematic errors rather than a causal relationship (Smith, 2009).

- The assumption that nitrate – which is the only $PM_{2.5}$ constituent appreciably altered in the ozone RIA's co-benefit calculations – is equally as potent as $PM_{2.5}$ constituents generally.[31] This is increasingly unlikely as epidemiological evidence mounts that the culprit surrogate variable in the $PM_{2.5}$ epidemiological literature may rather be vehicle, traffic, or noise-related.

- The failure to use epidemiological relationships for $PM_{2.5}$ that have been estimated with statistical controls for other co-pollutants. For example, the lower benefit bound that is based on the Pope study relies on a single-pollutant model, even though previous studies on that same cohort found that the $PM_{2.5}$ coefficient became insignificant when estimated in a multi-pollutant model with SO_2 (see Krewski *et al.*, 2000). The upper bound benefit is based on Laden *et al.* (2006), which is a single-pollutant analysis that did not even rely on actual $PM_{2.5}$ measurements.

The Ozone-Related Benefits Estimates Are Inflated and Not Credible

The ozone RIA's emphasis on $PM_{2.5}$ co-benefits makes it easy to give minimal scrutiny to the ozone benefit estimates themselves. However, the ozone mortality and morbidity estimates are also problematic.

First, the estimates of ozone-specific benefits are almost entirely based on a *presumption* that the few epidemiological studies of ozone mortality risk demonstrate a causal effect of ozone. This is a leap of faith that CASAC was not prepared to endorse. In their teleconference call of February 18, 2011, CASAC members wondered why there was so much emphasis on ozone mortality in the charge questions EPA had posed. One member stated that CASAC's original recommendation to tighten the ozone standard had not been based on ozone mortality risks and none dissented when another stated that the

[29] *Supplemental RIA*, p. S1-1.

[30] *2008 RIA*, p. 6-4.

[31] The *Supplemental RIA* states "PM co-benefits are derived primarily from reductions in nitrates (associated with NOx controls). As such, these estimates are strongly influenced by the assumption that all PM components are equally toxic" (p. S1 -11).

assumption of ozone mortality was "not ready for prime time." Members noted that this was their view at the time that they performed their original review and it remains their view today of the 2008 body of evidence. The importance of these statements for the RIA cannot be overstated. If $PM_{2.5}$ co-benefits *and* ozone mortality benefit calculations are removed, the total benefits at each standard drop to about $0.2 billion for the 0.070 ppm alternative standard and to $0.7 billion for the 0.060 ppm alternative standard as compared to costs above $19 billion and $56 billion, respectively. Net benefits are solidly in the negative by billions of dollars.

One need not dismiss the causality presumption in order to see such large decreases in the benefits in the RIA, however. As demonstrated in comments during the original 2008 review of the Ozone NAAQS (Smith and Gibbs, 2007), almost all of the benefits being assessed for reductions from the current standard are attributable to exposures on days when peak ozone is very low. This follows from the fact that almost all of the estimated risk at attainment of the current standard comes from days when the *24-hour average ozone* is below 0.04 ppm, as shown in Table 4 on the next page.[32] Table 5, also on the next page, shows that the vast majority of risk estimated for an alternative Ozone NAAQS of 0.064 ppm is associated with 24-hour average ozone below 0.040 ppm. Thus, almost all of the ozone mortality and morbidity benefit calculated by EPA in its *Supplemental RIA* is from small changes in ozone concentrations starting from already-low ozone levels. Again, as EPA itself warns on p. S1-1 of its *Supplemental RIA*, "It is important to note that as the stringency of the standards increases, we believe that the uncertainty in the estimates of the costs and benefits also increases."

The sensitivity shown in Tables 4 and 5 is highly important for another reason as well. The 0.040 ppm cut-off on a 24-hour average basis was selected because it is the level of "policy relevant background" (PRB) that EPA chose to use in its prior 1997 ozone risk analysis. In the current benefits analysis, both for the original 2008 ozone RIA and the *Supplemental RIA*, EPA changed its PRB *assumption* to lower levels ranging from 0.014 to 0.032 ppm (varying by city and month). These values were derived from runs of a model known as GEOS-CHEM. Table 4 above shows that almost all of the increase in ozone morbidity and mortality risk above the previous review cycle is attributable to change in the PRB assumption and *not* to new epidemiological evidence indicating a greater degree of ozone potency than was known in 1997. The above sensitivity analyses are based on EPA's Risk Analysis in support of the 2008 NAAQS decision (EPA, 2007) and not the RIA, but the same computations of benefits are done in the RIA and the same general sensitivity to the PRB assumption must also exist in the RIA benefits estimates. Since the Risk Analysis focuses on cities with generally high ozone levels, one might

[32] The analysis used to produce Tables 4 and 5 uses a 24-hour rather than an 8-hour daily maximum average. Although EPA has claimed in the past that the equivalent 8-hour max is about double the 24-hour average, detailed analysis of the data used by EPA demonstrates that this rule of thumb clearly and consistently overstates the 8-hour maximum for 24-hour averages above about 0.030 ppm. The 8-hour maximum associated with a 24-hour average of 0.040 ppm varies by city but is less than 0.070 ppm and frequently averages closer to 0.060 ppm (Smith, 2008a, 2008b).

expect that an even greater sensitivity than shown in Table 4 pertains to the benefits estimates in the RIA, which account for risks across the entire U.S. with on average lower ozone levels.

Table 4. Sensitivity of Quantitative Risk Estimates PRB Assumption at Exact Attainment of a 0.074 ppm NAAQS (Average of 2002 and 2004 Air Quality Data)

	Numbers of Deaths Estimated Using GEOS-CHEM for PRB Assumptions	Numbers of Deaths Estimated Using PRB = 0.040 ppm Assumption	Percent Reduction in Risk Estimate from Change in PRB Assumption
Atlanta	5.3	0.1	98%
Cleveland	31.7	2.6	92%
Detroit	30.2	0.7	98%
Houston	17.8	0.7	96%
Los Angeles	28.6	0.0	100%
Sacramento	9.5	0.1	99%
St. Louis	3.4	0.2	96%

Source: Smith and Gibbs (2007) Appendix C.

Table 5. Sensitivity of Quantitative Risk Estimates PRB Assumption at Exact Attainment of a 0.064 ppm NAAQS (Average of 2002 and 2004 Air Quality Data)

	Numbers of Deaths Estimated Using GEOS-CHEM for PRB Assumptions	Numbers of Deaths Estimated Using PRB = 0.040 ppm Assumption	Percent Reduction in Risk Estimate from Change in PRB Assumption
Atlanta	4.1	0.0	99%
Cleveland	26.2	1.2	96%
Detroit	23.0	0.2	99%
Houston	12.7	0.2	98%
Los Angeles	15.4	0.0	100%
Sacramento	8.1	0.1	99%
St. Louis	2.5	0.1	98%

Source: Smith and Gibbs (2007) Appendix C.

This is an important issue because the question of what level of ozone is actually background remains open to continuing study and discussion. Monitoring data do not support the GEOS-CHEM results used in the *2008 RIA.* Indeed, monitoring data suggest a trend of rising background ozone levels. Also, new and enhanced GEOS-CHEM

modeling efforts are purported to be predicting higher PRB levels.[33] The evidence above is that even very small increments in the assumed PRB level will greatly reduce both mortality and morbidity benefit estimates for ozone from those that have been reported in the present ozone RIA.

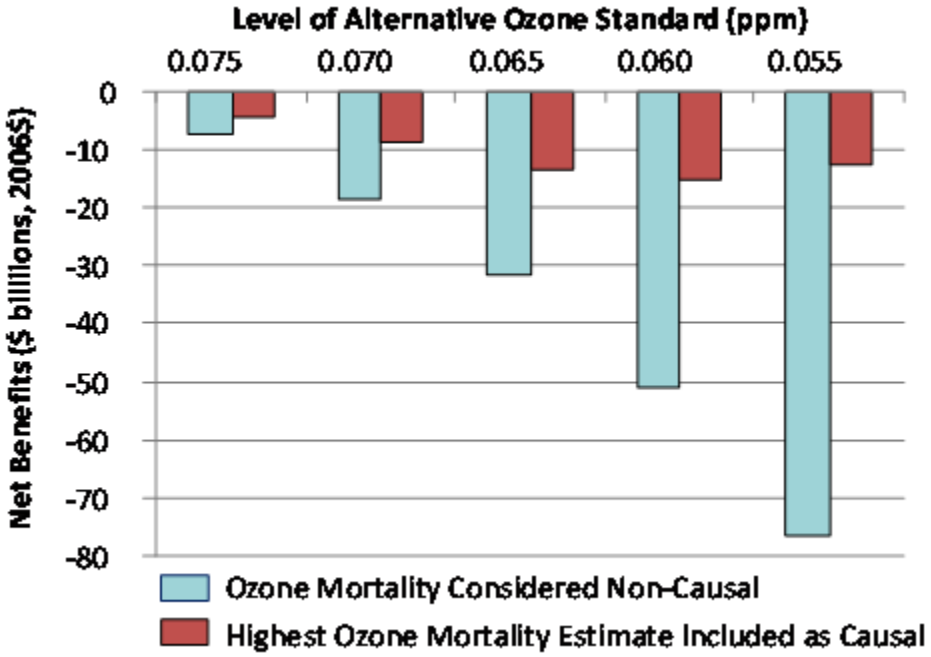
Conclusion

The estimates of benefits in the ozone reconsideration RIA are little different from those in its predecessor, the original *2008 RIA*, despite significant differences in EPA's communication about those estimates. Although EPA represents the *Supplemental RIA* for the ozone reconsideration as an update that has methodological improvements since the *2008 RIA*, the changes that can be called methodological improvements have had no significant effect on the benefits estimates. Rather, the key changes are EPA's unsupported decisions (1) to eliminate all recognition of the uncertainty in a causal relationship between ozone and mortality, and (2) to calculate $PM_{2.5}$ co-benefits down to the lowest predicted $PM_{2.5}$ level rather than to a lowest measured level in the epidemiological studies that serve as the basis for EPA's $PM_{2.5}$ concentration-response relationships. Neither of the latter two changes can be characterized as a methodological "improvement," and neither is based on advice from EPA's CASAC panel overseeing the ozone reconsideration.

Even with EPA's changes, however, the *Supplemental RIA* does not provide a cost-benefit basis for altering the Ozone NAAQS unless one includes estimates of mortality co-benefits from changes in $PM_{2.5}$ levels. That is, not one of EPA's estimates of the benefits of reducing ozone to a tighter alternative ozone standard is as large as the costs of attaining that respective ozone standard – all have <u>negative</u> net benefits if based on ozone benefits alone. Figure 3 on the next page illustrates the data that were presented in Table 2 to summarize the *Supplemental RIA*'s estimates of the net benefits of each of the alternative ozone standards (relative to the standard of 0.084 ppm) when no $PM_{2.5}$ co-benefits are included. Even using the highest estimate of ozone mortality benefit in the RIA combined with the lowest EPA cost estimate, the estimated net benefits of the 0.075 ppm standard are about -$4.5 billion relative to the 0.084 ppm standard while the yet-tighter alternative standards (*i.e.*, 0.070 through 0.055 ppm) have estimated net benefits ranging from -$8.8 billion to -$12.7 billion. If one treats the ozone-mortality association as non-causal, EPA estimates that the current ozone standard of 0.075 ppm would have net benefits of -$7.5 billion and the yet-tighter alternative standards of 0.070 through 0.055 ppm would range from -$18.8 billion to -$76.7 billion. In fact, if there is no causal relationship between ozone and mortality risk, the net benefits estimates for standards tighter than 0.075 ppm remain negative even with the inclusion of the *highest* of EPA's $PM_{2.5}$ mortality and morbidity co-benefits and using the low end of its cost range.

[33] See, for example, Oltmans *et al.* (2008), Wang *et al.* (2009) and Cooper *et al.* (2010).

Figure 3. Summary of Net Benefits of Each Alternative Ozone Standard Relative to Standard of 0.084 ppm for Ozone-Related Benefits Only (All Are Negative).



All of the above net benefits statements are based on EPA's own estimates in the 2010 *Supplemental RIA* for the ozone reconsideration, although EPA does not summarize its results in this manner. However, there are reasons to believe that the net benefits may be much more negative. Sensitivity analyses exist in the original record for the 2008 Ozone NAAQS decision that demonstrate that that almost all of the ozone benefits – both morbidity and mortality – derive from changes in ozone on days when the ozone is already below 0.04 ppm (24-hour average). EPA acknowledges that there is great uncertainty regarding the existence of any adverse effects from ozone exposures in this range. Additionally, ozone background levels may rise as high 0.04 ppm so that much of the change that EPA is assuming in those low ozone concentrations could not even occur. If those assumed changes cannot occur most of the estimated ozone exposure changes could not occur and almost all of EPA's ozone benefits estimates would not occur.

References

American Chemistry Council. 2009. *Comments on EPA's Proposed Rule National Emissions Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry, 74 FR May 6, 2009, Docket EPA-HQ-OAR-2002-0051*. Submitted to Docket as EPA-HQ-2002-0051-2849, September 4. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2002-0051-2849.

Bell, M.L., A. McDermott, S.L. Zeger, J.M. Samet, F. Dominici. 2004. "Ozone and Short-Term Mortality in 95 US Urban Communities, 1987-2000." *JAMA*, 292(19):2372-8.

Bell, M.L., F. Dominici, and J.M. Samet. 2005. "A Meta-analysis of Time-series Studies of Ozone and Mortality with Comparison to the National Morbidity, Mortality, and Air Pollution Study." *Epidemiology*. 16(4): p. 436-45.

Cooper O.R., D.D. Parrish, A. Stohl, M. Trainer, P. Nédélec, V. Thouret, J.P. Cammas, S.J. Oltmans, B.J. Johnson, D. Tarasick, T. Leblanc, I.S. McDermid, D. Jaffe, R. Gao, J. Stith, T. Ryerson, K. Aikin, T. Campos, A. Weinheimer, M.A. Avery. 2010. "Increasing Springtime Ozone Mixing Ratios in the Free Troposphere over Western North America," *Nature* 463:344-348.

Huang Y., F. Dominici, M. Bell. 2005. "Bayesian Hierarchical Distributed Lag Models for Summer Ozone Exposure and Cardio-Respiratory Mortality." *Environmetrics*, 16, 547-562.

Krewski D., R.T. Burnett, M. Goldberg, K. Hoover, J. Siemiatycki, M. Jerrett, M. Abrahamowicz, W.H. White. 2000. *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality.* Special Report, Health Effects Institute, Cambridge, Massachusetts (July).

Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. 2006. "Reduction in Fine Particulate Air Pollution and Mortality." *American Journal of Respiratory and Critical Care Medicine* 173:667-672.

Levy, J.I., S.M. Chemerynski, and J.A. Sarnat. 2005. "Ozone Exposure and Mortality: an Empiric Bayes Metaregression Analysis." *Epidemiology*. 16(4): p. 458-68.

National Research Council. 2008. *Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution*. National Academies Press. Available at: http://books.nap.edu/catalog.php?record_id=12198&utm_medium=etmail&utm_source=National%20Academies%20Press&utm_campaign=New+from+NAP+4.29.08-May-7-2008&utm_content=Downloader&utm_term=

Oltmans S.J., A.S. Lefohn, J.M Harris, D. Shadwick. 2008. "Background Ozone Levels of Air Entering the West Coast of the US and Assessment of Longer-Term Changes," *Atmospheric Environment* 42:6020-6038

Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution." *Journal of the American Medical Association* 287:1132-1141.

Schwartz, J. 2005. How Sensitive is the Association between Ozone and Daily Deaths to Control for Temperature? *Am J Respir Crit Care Med*. 171(6): 627-31.

Smith, A.E. 2009. "Comments on the External Review Draft of EPA's 'Risk Assessment to Support the Review of the PM Primary National Ambient Air Quality Standards'," prepared for Utility Air Regulatory Group, American Petroleum Institute and American Chemistry Council, submitted to PM Docket as part of UARG Comments, November 8.

Smith, A.E. 2008a. Letter to Ms. Lucinda Minton Langworthy (reviewing data in memo dated November 27, 2007 from Abt Associates that was placed in Ozone NAAQS Docket after end of comment period), letter submitted to docket by UARG, Docket # EPA-HQ-OAR-2005-7004, January 9, 2008. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2005-0172-7004.1.

Smith, A.E. 2008b. Supplemental data related to Smith (2008a) added to Docket # EPA-HQ-OAR-2005-7051 on February 4, 2008. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2005-0172-7051.1

Smith, A.E. and B. Gibbs. 2007. "Comments On EPA's Proposed Rule To Revise The National Ambient Air Quality Standards For Ozone (72 Fr 37818)." prepared for Utility Air Regulatory Group, American Petroleum Institute and American Chemistry Council , submitted to Ozone Docket as part of UARG Comments, October 9.

Sunstein, C.R. 2004. "Lives, Life Years, and Willingness to Pay," *Columbia Law Review*, 104(1):205-252.

U.S. Environmental Protection Agency. 2010. *Regulatory Impact Analysis for the Reconsideration of the 2008 Ozone National Ambient Air Quality Standard.* January. Available at: http://www.epa.gov/ttnecas1/ria.html.

U.S. Environmental Protection Agency. 2009. *Proposed NO_2 NAAQS Regulatory Impact Analysis (RIA)*. EPA/OAQPS/HEID/ABCG July 2. Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/proposedno2ria.pdf. -

U.S. Environmental Protection Agency. 2008. *Final Ozone NAAQS Regulatory Impact Analysis*. EPA-452/R-08-003, March. Available at: http://www.epa.gov/ttnecas1/regdata/RIAs/452_R_08_003.pdf.

U.S. Environmental Protection Agency. 2007. *Ozone Health Risk Assessment for Selected Urban Areas*. EPA-452/R-07-009, July. Available at: http://www.epa.gov/ttn/naaqs/standards/ozone/data/ozone_ra_final_tsd_7-2007.pdf.

Wang H., D.J. Jacob, P. Le Sager, D.G. Streets, R.J. Park, A.B. Gilliland, A. van Donkelaar. 2009. "Surface Ozone Background in the US: Canadian and Mexican Pollution Influences," *Atmospheric Environment* 43:1310-1319.