Summary of the updated Regulatory Impact Analysis (RIA) for the Reconsideration of the 2008 Ozone National Ambient Air Quality Standard (NAAQS)

On September 16, 2009, EPA committed to reconsidering the ozone NAAQS standard promulgated in March 2008. The ozone NAAQS will be selected from the proposed range of 0.060 to 0.070 ppm, based on this reconsideration of the evidence available at the time the last standard was set. Today's proposed rule also includes a separate secondary NAAQS, for which this RIA provides only qualitative analysis due to the limited nature of available EPA guidance for attaining this standard

This supplement to the RIA contains an updated illustrative analysis of the potential costs and human health and welfare benefits of nationally attaining a new primary ozone standard. The basis for this updated economic analysis is the RIA published in March 2008 with a few significant changes. These changes reflect the more stringent range of options being proposed by the Administrator. It also reflects some significant methodological improvements to air pollution benefits estimation, which EPA has adopted since the ozone standard was last promulgated. These significant changes include the following:

- In March 2008, the Administrator lowered the primary ozone NAAQS from 0.084 ppm to 0.075 ppm. The RIA which accompanied that rule analyzed a less stringent alternative standard of 0.079 ppm, and two more stringent standards of 0.065 and 0.070 ppm. This RIA supplement presents an analysis of three alternative standards within the proposed range: 0.060, 0.065 and 0.070 ppm. Because today's proposed rule is a reconsideration, each alternative standard is compared against the prior standard of 0.084 ppm. Per Executive Order 12866 and the guidelines of OMB Circular A-4, this Regulatory Impact Analysis (RIA) also presents analyses of two alternative standards, 0.075 ppm and 0.055 ppm. 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. This is explained in more detail in sections 2 and 3 of this supplement.

- We have adopted several key methodological updates to benefits assessment since the 2008 Ozone NAAQS RIA. These updates have already been incorporated into previous RIAs for the proposed Portland cement NESHAP, proposed NO_2 NAAQS, and Category 3 Marine Diesel Engine Rule, and are therefore now incorporated in this analysis. Significant updates include:

    - We removed the assumption of no causality for ozone mortality, as recommended by the National Academy of Science (NAS).

- We included two more ozone multi-city studies, per NAS recommendation.
- We revised the Value of a Statistical Life (VSL) to be consistent with the value used in current EPA analyses.
- We removed thresholds from the concentration-response functions for $PM_{2.5}$, consistent with EPA's Integrated Science Assessment for Particulate Matter.

Structure of this Updated RIA

As part of the ozone NAAQS reconsideration, this RIA supplement takes as its foundation the 2008 ozone NAAQS RIA. Detailed explanation of the majority of assumptions and methods are contained within that document and should be relied upon, except as noted in this summary.

This supplement itself consists of four parts:

- Section 1 provides an overview of the changes to the analysis and summary tables of the illustrative cost and benefits of obtaining a revised standard and several alternatives.
- Section 2 contains a supplemental benefit and cost analysis for standard alternatives at 0.055 and 0.060 ppm.
- Section 3 contains a supplemental benefits analysis outlining the adopted changes in the methodology, updated results for standard alternatives 0.065, 0.070 and 0.075 ppm using the revised methodology and assumptions.
- Section 4 contains supplemental evaluation of a separate secondary ozone NAAQS in the range of 7 to 15 ppm-hr, as well as a less stringent of 21 ppm-hr. This supplemental provides an explanation of the extreme difficulty of quantifying the costs and benefits of a secondary standard at this time.

S1.1 Results of Benefit-Cost Analysis

This updated RIA consists of multiple analyses, including an assessment of the nature and sources of ambient ozone; estimates of current and future emissions of relevant ozone precursors; air quality analyses of baseline and alternative control strategies; illustrative control strategies to attain the standard alternatives in future years; estimates of the incremental costs and benefits of attaining the alternative standards, together with an examination of key uncertainties and limitations; and a series of conclusions and insights gained from the analysis. It is important to recall that this RIA rests on the analysis done in 2008; no new air quality modeling or other assessments were completed except those outlined above.

The supplement includes a presentation of the benefits and costs of attaining various alternative ozone National Ambient Air Quality Standards in the year 2020. These estimates only include areas assumed to meet the current standard by 2020. They do not include the costs or benefits of attaining the alternate standards in the San Joaquin Valley and South Coast air basins in California, because we expect that nonattainment designations under the Clean Air Act for these areas would place them in categories afforded extra time beyond 2020 to attain the ozone NAAQS.

In Table S1.1below, the individual row estimates reflect the different studies available to describe the relationship of ozone exposure to premature mortality. These monetized benefits include reduced health effects from reduced exposure to ozone, reduced health effects from reduced exposure to $PM_{2.5}$, and improvements in visibility. The ranges within each row reflect two PM mortality studies (i.e. Pope and Laden).

Ranges in the total costs column reflect different assumptions about the extrapolation of costs as discussed in Chapter 5 of the 2008 Ozone NAAQS RIA. The low end of the range of net benefits is constructed by subtracting the highest cost from the lowest benefit, while the high end of the range is constructed by subtracting the lowest cost from the highest benefit. The presentation of the net benefit estimates represents the widest possible range from this analysis.

Table S1.2 presents the estimate of total ozone and $PM_{2.5}$-related premature mortalities and morbidities avoided nationwide in 2020 as a result of this regulation.

Table S1. 1: Total Monetized Costs with Ozone Benefits and $PM_{2.5}$ Co-Benefits in 2020 (in Billions of 2006$)*

	Ozone Mortality Function	Reference	Total Benefits **		Total Costs ***	Net Benefits	
			3%	7%	7%	3%	7%
0.075 ppm	Multi-city	Bell et al. 2004	$6.9 to $15	$6.4 to $13	$7.6 to $8.8	$-1.9 to $7.4	$-2.4 to $5.4
		Schwartz 2005	$7.2 to $16	$6.8 to $13	$7.6 to $8.8	$-1.6 to $8.4	$-2.1 to $5.4
		Huang 2005	$7.3 to $16	$6.9 to $13	$7.6 to $8.8	$-1.5 to $8.4	$-2.0 to $5.4
	Meta-analysis	Bell et al. 2005	$8.3 to $17	$7.9 to $14	$7.6 to $8.8	$-0.50 to $9.4	$-1.0 to $6.4
		Ito et al. 2005	$9.1 to $18	$8.7 to $15	$7.6 to $8.8	$0.30 to $10	$-0.20 to $7.4
		Levy et al. 2005	$9.2 to $18	$8.8 to $15	$7.6 to $8.8	$0.40 to $10	$-0.10 to $7.4
0.070 ppm	Multi-city	Bell et al. 2004	$13 to $29	$11 to $24	$19 to $25	$-12 to $10	$-14 to $5.0
		Schwartz 2005	$15 to $30	$12 to $25	$19 to $25	$-10 to $11	$-13 to $6.0
		Huang 2005	$15 to $30	$13 to $26	$19 to $25	$-10 to $11	$-12 to $7.0
	Meta-analysis	Bell et al. 2005	$18 to $34	$16 to $29	$19 to $25	$-7.0 to $15	$-9.0 to $10
		Ito et al. 2005	$21 to $37	$18 to $31	$19 to $25	$-4.0 to $18	$-6.0 to $12
		Levy et al. 2005	$21 to $37	$18 to $31	$19 to $25	$-4.0 to $18	$-6.0 to $12
0.065 ppm	Multi-city	Bell et al. 2004	$22 to $47	$19 to $40	$32 to $44	$-22 to $15	$-25 to $7.0
		Schwartz 2005	$24 to $49	$21 to $42	$32 to $44	$-20 to $17	$-23 to $9.0
		Huang 2005	$25 to $50	$22 to $42	$32 to $44	$-19 to $18	$-23 to $10
	Meta-analysis	Bell et al. 2005	$31 to $56	$27 to $48	$32 to $44	$-13 to $24	$-17 to $16
		Ito et al. 2005	$36 to $61	$32 to $53	$32 to $44	$-8.0 to $29	$-13 to $20
		Levy et al. 2005	$36 to $61	$32 to $53	$32 to $44	$-7.0 to $29	$-12 to $20
0.060 ppm	Multi-city	Bell et al. 2004	$35 to $73	$30 to $61	$52 to $90	$-55 to $21	$-60 to $9.0
		Schwartz 2005	$39 to $78	$34 to $66	$52 to $90	$-51 to $26	$-56 to $14
		Huang 2005	$41 to $78	$35 to $66	$52 to $90	$-49 to $26	$-55 to $14
	Meta-analysis	Bell et al. 2005	$53 to $91	$46 to $78	$52 to $90	$-37 to $39	$-44 to $26
		Ito et al. 2005	$63 to $100	$55 to $87	$52 to $90	$-27 to $48	$-35 to $35
		Levy et al. 2005	$63 to $100	$56 to $87	$52 to $90	$-27 to $48	$-34 to $35
0.055 ppm	Multi-city	Bell et al. 2004	$53 to $110	$45 to $90	$78 to $130	$-77 to $32	$-85 to $12
		Schwartz 2005	$61 to $120	$52 to $100	$78 to $130	$-69 to $42	$-78 to $22
		Huang 2005	$63 to $120	$54 to $100	$78 to $130	$-67 to $42	$-76 to $22
	Meta-analysis	Bell et al. 2005	$84 to $140	$74 to $120	$78 to $130	$-46 to $62	$-56 to $42
		Ito et al. 2005	$100 to $160	$90 to $140	$78 to $130	$-30 to 82	$-40 to $62
		Levy et al. 2005	$100 to $160	$91 to $140	$78 to $130	$-30 to $82	$-39 to $62

*All estimates rounded to two significant figures. As such, they may not sum across columns. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California.

**Includes ozone benefits, and $PM_{2.5}$ co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to estimates from the $PM_{2.5}$ premature mortality functions from Pope et al. and Laden et al. Tables exclude unquantified and nonmonetized benefits.

***Range reflects lower and upper bound cost estimates. Data for calculating costs at a 3% discount rate was not available for all sectors, and therefore total annualized costs at 3% are not presented here. Additionally, these estimates assume a particular trajectory of aggressive technological change. An alternative storyline might hypothesize a much less optimistic technological trajectory, with increased costs, or with decreased benefits in 2020 due to a later attainment date.

Table S1.2: Summary of Total Number of Annual Ozone and PM$_{2.5}$-Related Premature Mortalities and Premature Morbidity Avoided: 2020 National Benefits [A]

Combined Estimate of Mortality		0.075 ppm	0.070 ppm	0.065 ppm	0.060 ppm	0.055 ppm
NMMAPS	Bell et al. (2004)	760 to 1,900	1,500 to 3,500	2,500 to 5,600	4,000 to 8,700	5,900 to 13,000
	Schwartz	800 to 1,900	1,600 to 3,600	2,700 to 5,800	4,500 to 9,200	6,700 to 13,000
	Huang	820 to 1,900	1,600 to 3,600	2,800 to 5,900	4,600 to 9,300	6,900 to 14,000
Meta-analysis	Bell et al. (2005)	930 to 2,000	2,000 to 4,000	3,500 to 6,600	6,000 to 11,000	9,400 to 16,000
	Ito et al.	1,000 to 2,100	2,300 to 4,300	4,000 to 7,100	7,100 to 12,000	11,000 to 18,000
	Levy et al.	1,000 to 2,100	2,300 to 4,300	4,100 to 7,200	7,100 to 12,000	12,000 to 18,000
Combined Estimate of Morbidity		**0.075 ppm**	**0.070 ppm**	**0.065 ppm**	**0.060 ppm**	**0.055 ppm**
Acute Myocardial Infarction [B]		1,300	2,200	3,500	5,300	7,500
Upper Respiratory Symptoms [B]		9,900	19,000	31,000	48,000	69,000
Lower Respiratory Symptoms [B]		13,000	25,000	41,000	63,000	91,000
Chronic Bronchitis [B]		470	880	1,400	2,200	3,200
Acute Bronchitis [B]		1,100	2,100	3,400	5,300	7,600
Asthma Exacerbation [B]		12,000	23,000	38,000	58,000	83,000
Work Loss Days [B]		88,000	170,000	270,000	420,000	600,000
School Loss Days [C]		190,000	600,000	1,100,000	2,100,000	3,700,000
Hospital and ER Visits		2,600	6,700	11,000	21,000	35,000
Minor Restricted Activity Days		1,000,000	2,600,000	4,500,000	8,100,000	13,000,000

[A] Only includes areas required to meet the current standard by 2020, does not include San Joaquin Valley and South Coast air basins in California. Includes ozone benefits, and PM$_{2.5}$ co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to both the lower and upper ends of the range of the PM$_{2.5}$ premature mortality functions characterized in the expert elicitation described in Chapter 6 of the 2008 RIA.

[B] Estimated reduction in premature mortality due to PM$_{2.5}$ reductions only.

[C] Estimated reduction in premature mortality due to ozone reductions only.

The following set of graphs is included to provide the reader with a richer presentation of the range of costs and benefits of the alternative standards. The graphs supplement the tables by displaying all possible combinations of net benefits, utilizing the six different ozone functions, the fourteen different PM functions, and the two cost methods. Each of the 168 bars in each graph represents a separate point estimate of net benefits under a certain combination of cost and benefit estimation methods. Because it is not a distribution, it is not possible to infer the likelihood of any single net benefit estimate. The blue bars indicate combinations where the net benefits are negative, whereas the green bars indicate combinations where net benefits are positive. Figures S1.1 through S1.5 shows all of these combinations for all standards analyzed. Figure S1.6 shows the comparison of total monetized benefits with costs using the two benefits anchor points based on Pope/Bell 2004 and Laden/Levy.

Figure S1.1:

Net Benefits for an Alternate Standard of 0.075 ppm (7% discount rate)

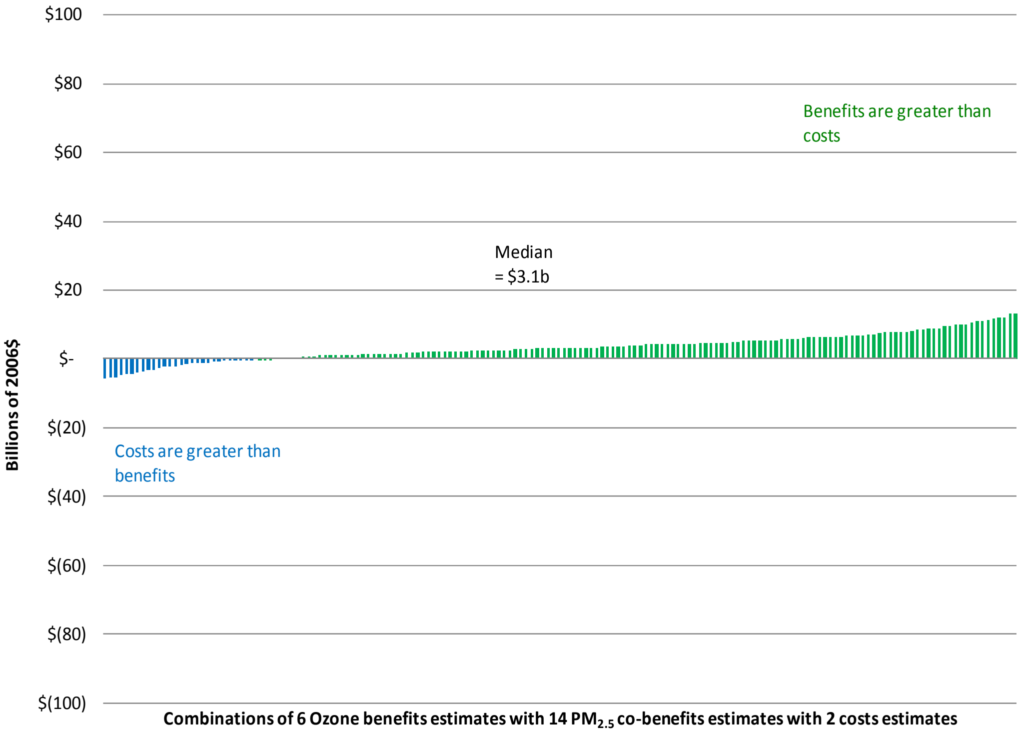
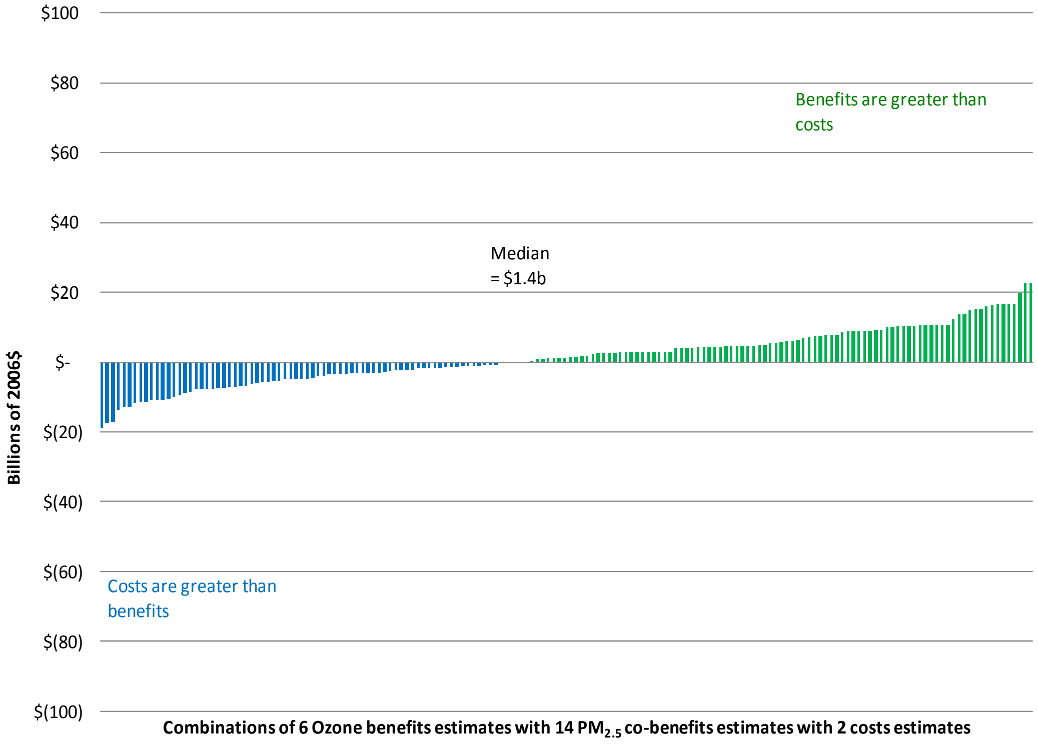


Figure S1.2:

Net Benefits for an Alternate Standard of 0.070 ppm (7% discount rate)



These graphs show all 168 combinations of the 6 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. These combinations do not represent a distribution.

Figure S1.3:

Net Benefits for an Alternate Standard of 0.065 ppm (7% discount rate)

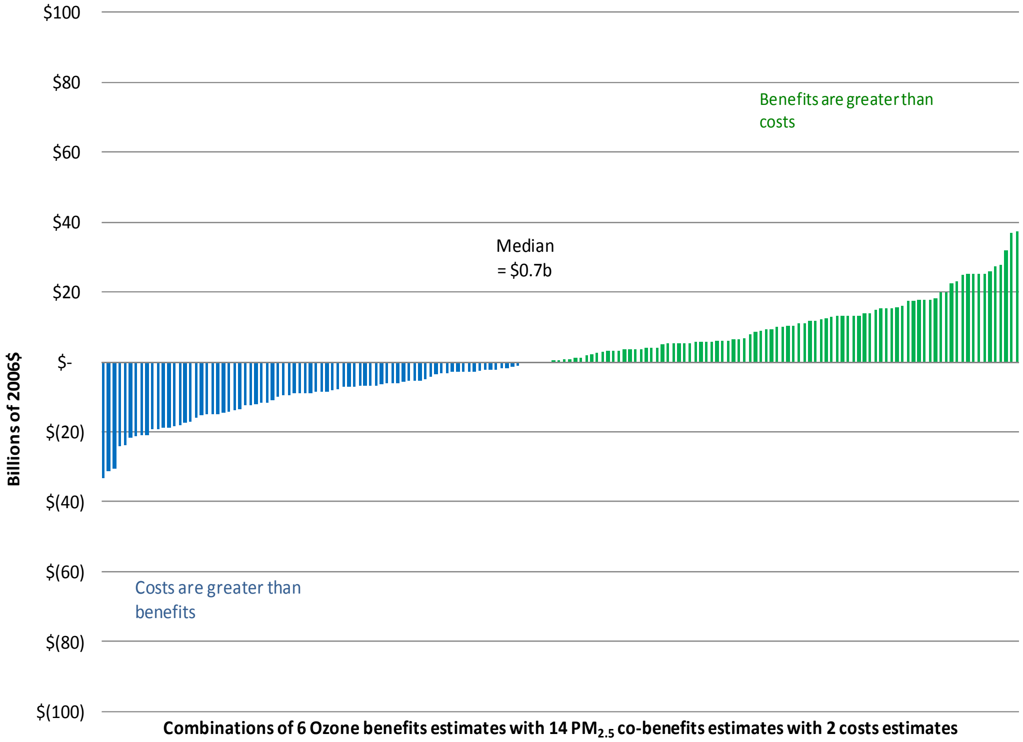
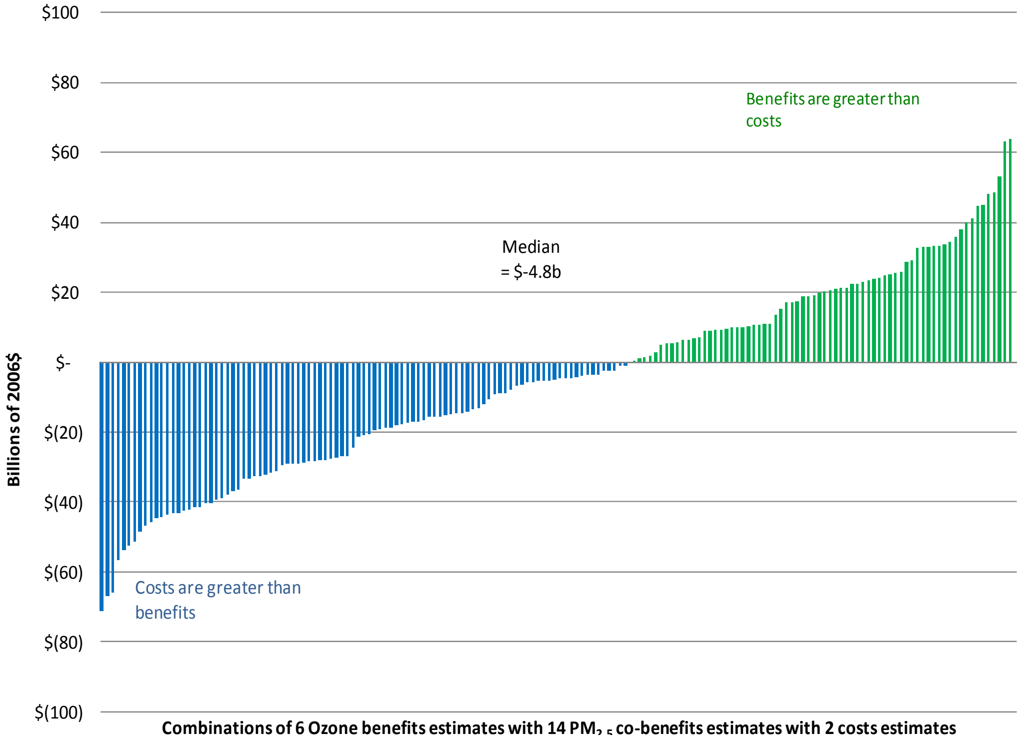


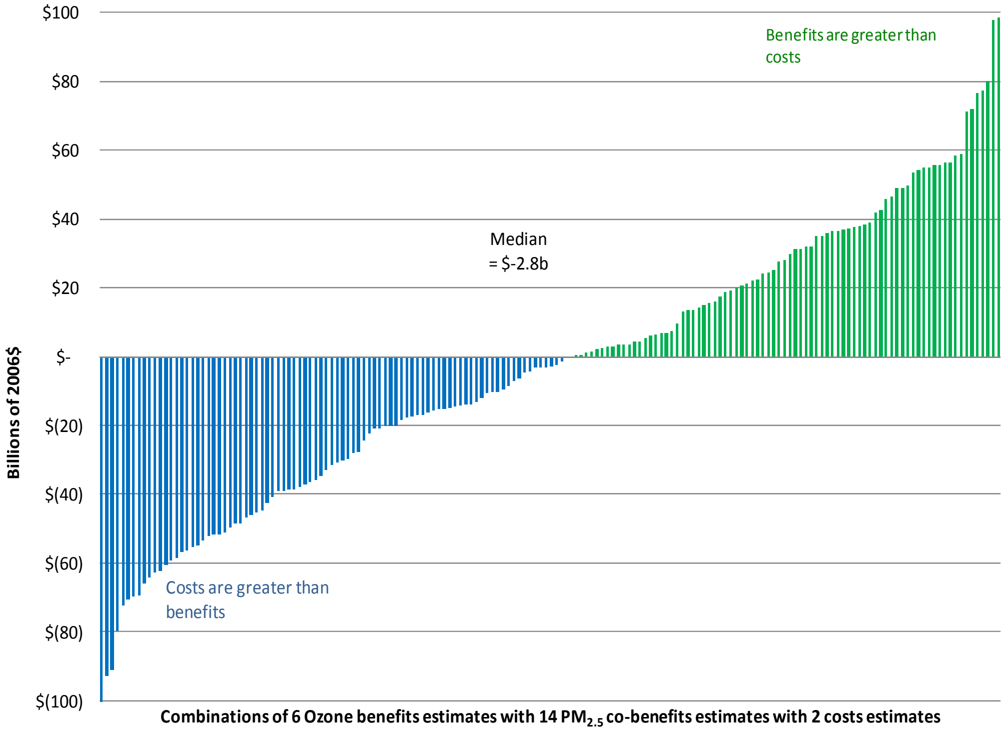
Figure S1.4:

Net Benefits for an Alternate Standard of 0.060 ppm (7% discount rate)



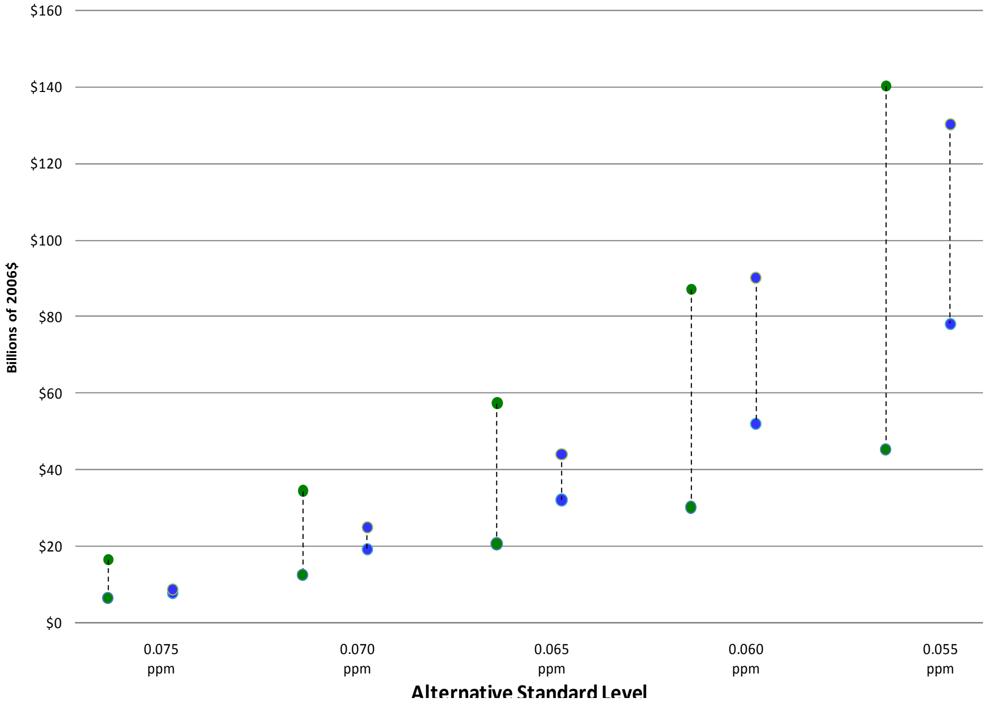
These graphs show all 168 combinations of the 6 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. These combinations do not represent a distribution.

Figure S1.5:
Net Benefits for an Alternate Standard of 0.055 ppm (7% discount rate)



This graph shows all 168 combinations of the 6 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. These combinations do not represent a distribution.

Figure S1.6:
Comparison of Total Monetized Benefits to Costs for Alternative Standard Levels in 2020 (Updated results, 7% discount rate)



The low benefits estimate is based on Pope/Bell 2004 and the high benefits estimate is based on Laden/Levy. The two cost estimates are based on two different extrapolated cost methodologies. These endpoints represent separate estimates based on separate methodologies. The dotted lines are a visual cue only, and these lines do not imply a uniform range between these endpoints.

S1.2 Analysis of the Proposed Secondary NAAQS for Ozone

Exposures to ozone have been associated with a wide array of vegetation and ecosystem effects, including those that damage or impair the intended use of the plant or ecosystem. Such effects are considered adverse to the public welfare.

Today's proposed rule contains a cumulative seasonal secondary standard, expressed as an index of the annual sum of weighted hourly concentrations (using the W126 form), set at a level in the range of 7 to 15 ppm-hours, and requests comment on a level of 21 ppm-hours. The index would be cumulated over the 12-hour daylight window (8:00 a.m. to 8:00 p.m.) during the consecutive 3-month period during the ozone season with the maximum index value (hereafter, referred to as the 12-hour, maximum 3-month W126). For reasons detailed in section 4 of this supplement, we were not able to calculate monetized costs and benefits of attainment of these levels. However, section 4 contains a detailed discussion of the relevant welfare effects, and estimates of the number of counties nationwide which would not attain each alternative secondary NAAQS, both currently and in 2020.

S1.3 Caveats and Conclusions

Of critical importance to understanding these estimates of future costs and benefits is that they are not intended to be forecasts of the actual costs and benefits of implementing revised standards. There are many challenges in estimating the costs and benefits of attaining a tighter ozone standard, which are fully discussed in 2008 Ozone NAAQS RIA and the supplement to this analysis accompanying today's proposed rule.

The estimated costs and benefits of attaining alternate ozone standards of 0.060 ppm or 0.055 ppm are highly speculative and subject to limitations and uncertainties that are unique to this analysis. We first summarize these key uncertainties:

- *The estimated number of potential non-attainment areas is uncertain. Based on present-day ozone concentrations it is clear that many areas currently exceed the ozone targets of 0.055 and 0.060. It is also clear that there will be substantial improvements in ozone air quality between now and 2020 due to existing and recently promulgated emissions reduction rules. We have used an air quality model to project ozone levels in 2020 based on certain estimates of how emissions will increase or decrease over that time period. These assumptions about forecasted emissions growth or reduction are* *highly uncertain and will depend upon economic outcomes and future policy decisions.* Additionally, the methodology for projecting future nonattainment relies upon baseline observations from the existing ozone monitoring network. This network may not include some counties that easily attain higher ozone standards, but may not attain ozone standards so far below the current NAAQS. We estimate human health benefits by adjusting monitored ozone values to just attain alternate standard levels; we can only perform this extrapolation in counties containing an ozone monitor.

- *The predicted emission reductions necessary to attain these two alternative standards are also highly uncertain. Because the hypothetical RIA control scenario left a significant portion of the country exceeding the 0.055 and 0.060 targets, we had to extrapolate the rate of ozone reduction seen in previous air quality modeling exercises to estimate the additional emissions reductions needed to meet the lower targets. The details of the approach are explained below, but for most areas of the analysis we used simple impact ratios to project the ozone improvements as a rate of NOx emissions reduced. Use of non-site-specific, linear impact ratios to determine the non-linear, spatially-varying, ozone response was a necessary limitation which results in considerable uncertainty in the extrapolated air quality targets.*

- *The costs of identified control measures accounts for an increasingly smaller quantity of the total costs of attainment.* This is a major limitation of the cost analysis. We assume a majority of the costs of attaining the tighter alternative standards will be incurred through technologies we do not yet know about. Therefore costing future attainment based upon unspecified emission reductions is inherently difficult and speculative.

The uncertainties and limitations summarized above are generally more extensive than those for the 0.075 ppm, 0.070 ppm, and 0.065 ppm analyses. However, there are significant uncertainties in both cost and benefit estimates for the full range of standard alternatives. Below we summarize some of the more significant sources of uncertainty common to all level analyzed in the 2008 ozone NAAQS RIA and this supplemental analysis:

- Benefits estimates are influenced by our ability to accurately model relationships between ozone and PM and their associated health effects (e.g., premature mortality).

- Benefits estimates are also heavily dependent upon the choice of the statistical model chosen for each health benefit.

- 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. Co-benefit estimates are also influenced by the extent to which a particular area chooses to use NOx controls rather than VOC controls.

- There are several nonquantified benefits (e.g., effects of reduced ozone on forest health and agricultural crop production) and disbenefits (e.g., decreases in tropospheric ozone lead to reduced screening of UV-B rays and reduced nitrogen fertilization of forests and cropland) discussed in this analysis in Chapter 6 of the 2008 Ozone NAAQS RIA.

- Changes in air quality as a result of controls are not expected to be uniform over the country. In our hypothetical control scenario some increases in ozone levels occur in areas already in attainment, though not enough to push the areas into nonattainment

- As explained in Chapter 5 of the 2008 Ozone NAAQS RIA, there are several uncertainties in our cost estimates. For example, the states are likely to use different approaches for reducing NOx and VOCs in their state implementation plans to reach a tighter standard. In addition, since our modeling of known controls does not get all areas into attainment, we needed to make assumptions about the costs of control technologies that might be developed in the future and used to meet the tighter alternative. For example, for the 21 counties (in four geographic areas) that are not expected to attain 0.075 ppm[1] in 2020[2], assumed costs of unspecified controls represent a substantial fraction, of the costs estimated in this analysis ranging from 50% to 89% of total costs depending on the standard being analyzed.

    - As discussed in Chapter 5 of the 2008 Ozone NAAQS RIA, advice from EPA's Science Advisory Board has questioned the appropriateness of an approach similar to one of those used here for estimating extrapolated costs. For balance, EPA also applied a methodology recommended by the Science Advisory Board in an effort to best approximate the costs of control technologies that might be developed in the future.

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[1] Areas that do not meet 0.075 ppm are Chicago, Houston, the Northeastern Corridor, and Sacramento. For more information see chapter 4 section 4.1.1 of the 2008 Ozone NAAQS RIA.

[2] This list of areas does not include the San Joaquin and South Coast air basins who are not expected to attain the current 0.084 ppm standard until 2024.

- Both extrapolated costs and benefits have additional uncertainty relative to modeled costs and benefits. The extrapolated costs and benefits will only be realized to the extent that unknown extrapolated controls are economically feasible and are implemented. Technological advances over time will tend to increase the economic feasibility of reducing emissions, and will tend to reduce the costs of reducing emissions. Our estimates of costs of attainment in 2020 assume a particular trajectory of aggressive technological change. This trajectory leads to a particular level of emissions reductions and costs which we have estimated based on two different approaches, the fixed cost and hybrid approaches. An alternative storyline might hypothesize a much less optimistic technological change path, such that emissions reductions technologies for industrial sources would be more expensive or would be unavailable, so that emissions reductions from many smaller sources might be required for 2020 attainment, at a potentially greater cost per ton. Under this alternative storyline, two outcomes are hypothetically possible: Under one scenario, total costs associated with full attainment might be substantially higher. Under the second scenario, states may choose to take advantage of flexibility in the Clean Air Act to adopt plan with later attainment dates to allow for additional technologies to be developed and for existing programs like EPA's Onroad Diesel, Nonroad Diesel, and Locomotive and Marine rules to be fully implemented. If states were to submit plans with attainment dates beyond our 2020 analysis year, benefits would clearly be lower than we have estimated under our analytical storyline. However, in this case, state decision makers seeking to maximize economic efficiency would not impose costs, including potential opportunity costs of not meeting their attainment date, when they exceed the expected health benefits that states would realize from meeting their modeled 2020 attainment date. In this case, upper bound costs are difficult to estimate because we do not have an estimate of the point where marginal costs are equal to marginal benefits plus the costs of nonattainment. Clearly, the second stage analysis is a highly speculative exercise, because it is based on estimating emission reductions and air quality improvements without any information about the specific controls that would be available to do so.

S2: Supplemental Regulatory Impact Analysis of Alternative Standards 0.055 and 0.060 ppm for the Ozone NAAQS Reconsideration

Synopsis

This supplemental chapter presents the costs and benefits of two additional alternative standards[1], 0.055 ppm and 0.060 ppm.

S2.1 Uncertainties and Limitations

The estimated costs and benefits of attaining alternate ozone standards of 0.060 ppm or 0.055 ppm are highly speculative and subject to limitations and uncertainties that are unique to this analysis. We first summarize these key uncertainties before describing how best to interpret these results.

- *The estimated number of potential non-attainment areas is uncertain. Based on present-day ozone concentrations it is clear that many areas currently exceed the ozone targets of 0.055 and 0.060. It is also clear that there will be substantial improvements in ozone air quality between now and 2020 due to existing and recently promulgated emissions reduction rules.[2] We have used an air quality model to project ozone levels in 2020 based on certain estimates of how emissions will increase or decrease over that time period. These assumptions about forecasted emissions growth or reduction are highly uncertain and will depend upon economic outcomes and future policy decisions.* Additionally, the methodology for projecting future nonattainment relies upon baseline observations from the existing ozone monitoring network. This network may not include some counties that easily attain higher ozone standards, but may not attain ozone standards so far below the current NAAQS. We estimate human health benefits by adjusting monitored ozone values to just attain alternate standard levels; we can only perform this extrapolation in counties containing an ozone monitor.

- *The predicted emission reductions necessary to attain these two alternative standards are also highly uncertain. Because the hypothetical RIA control scenario left a significant portion of the country exceeding the 0.055 and 0.060 targets, we had to extrapolate the*

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[1] For benefits results of the alternative standards analyses for 0.065, 0.070, and 0.075, please see Section 3 of this supplement. For the cost results of the alternative standards analyses for 0.065, 0.070, and 0.075, please see the 2008 Ozone NAAQS RIA, which can be found at < http://www.epa.gov/ttn/ecas/regdata/RIAs>.

[2] This improvement in ozone air quality is anticipated despite other factors that may worsen ozone air quality, such as increased population, increased traffic, or other federal policies.

rate of ozone reduction seen in previous air quality modeling exercises to estimate the additional emissions reductions needed to meet the lower targets. The details of the approach are explained below, but for most areas of the analysis we used simple impact ratios to project the ozone improvements as a rate of NOx emissions reduced. Use of non-site-specific, linear impact ratios to determine the non-linear, spatially-varying, ozone response was a necessary limitation which results in considerable uncertainty in the extrapolated air quality targets.

- *The costs of identified control measures accounts for an increasingly smaller quantity of the total costs of attainment.* This is a major limitation of the cost analysis. We assume a majority of the costs of attaining the tighter alternative standards will be incurred through technologies we do not yet know about. Therefore costing future attainment based upon unspecified emission reductions is inherently difficult and speculative.

The uncertainties and limitations summarized above are generally more extensive than those for the 0.075 ppm, 0.070 ppm, and 0.065 ppm analyses. The table below contrasts our level of confidence in each of the key results.

Table S2.1: Key uncertainties and limitations in the analysis for 0.060 ppm and 0.055 ppm

Analytical question	**Standard Alternatives Analyzed**	
	0.055 ppm & 0.060 ppm	***0.065 ppm, 0.070 ppm & 0.075 ppm***
Air quality estimates		
Number of counties attaining each standard alternative	Medium	Higher
Air quality increment necessary to attain standard	Lower	Medium
Costs		
Total cost estimate	Lower	Medium
Distribution of costs by sector	Lower	Medium
Level of extrapolated costs	Lower	Medium
Benefits		
Size of ozone-related human health benefits	Lower	Higher
Size of $PM_{2.5}$-related human health co-benefits	Lower	Higher
Distribution of benefits across the population	Lower	Higher

Given the pervasive uncertainties in the 55ppb and 60ppb analysis, the types of conclusions that readers may draw is necessarily limited. Conclusions of this supplemental analysis are provided in Section S2.6.

S2.2 Estimating AQ Targets

The methodology used to develop the estimates of additional emissions reductions needed to meet the 0.055 ppm and 0.060 ppm standards is based on estimation techniques previously summarized in the 2008 Ozone NAAQS RIA Section 4.1, including application of the same control measure reductions and costs. The procedures used to extend that original analysis to the two lower ozone targets is explained below.

Of the 659 counties that are part of the analysis, there are 565 and 385 counties that are projected not to meet the 0.055 ppm and 0.060 ppm ozone targets in 2020, even after implementation of the controls in the hypothetical RIA scenario. As described in the earlier documentation, these “extrapolated control areas” were separated into three groups for the purposes of determining what additional emissions reductions would be necessary for projected attainment.

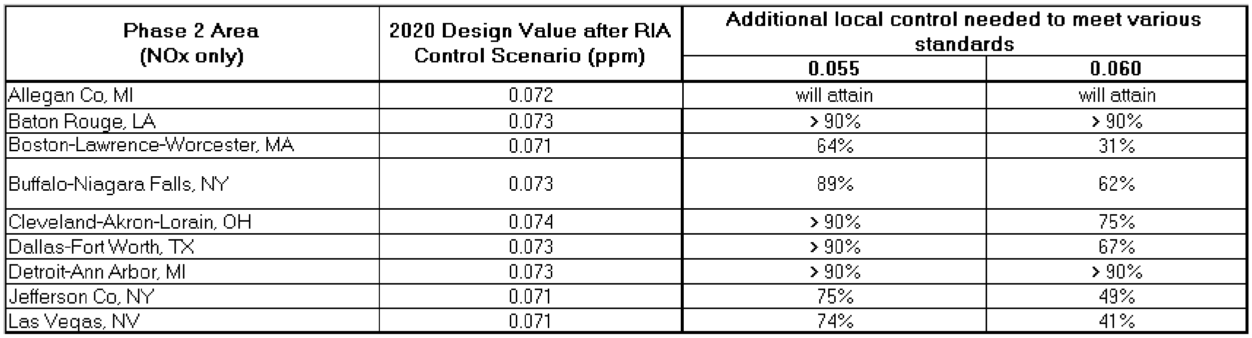
Phase 1 areas were defined as the four areas with the largest expected extrapolated costs: Southern California, western Lake Michigan, Houston, and parts of the Northeast Corridor. For these locations, we have an available set of sensitivity modeling results which allows for an assessment of the impacts of additional NOx and NOx + VOC controls of up to 90 percent beyond the RIA case. Unlike the original analysis, there were no areas for which an equal combination of NOx and VOC controls was determined to be a more cost effective control path to attain the lower ozone targets than NOx control exclusively. Therefore, for this supplemental analysis, we assumed that all additional extrapolated emissions reductions would come from NOx controls. Table S2.2 presents the additional NOx reductions estimated to be needed to meet the 0.055 and 0.060 ppm targets, above and beyond the hypothetical RIA control case. It should be noted that because the sensitivity modeling did not consider controls beyond a 90 percent reduction, it is not possible to estimate the necessary “extrapolated tons” for any area that does not meet the target in the sensitivity modeling even after 90 percent control. The emissions targets for these areas are simply listed as “greater than 90%”.

Table S2.2: Estimated Percentage Reductions of NOx beyond the RIA Control Scenario Necessary to Meet the Supplemental Analysis Targets in the Phase 1 Areas

Phase 1 Area (NOx only)	2020 Design Value after RIA Control Scenario (ppm)	Additional local control needed to meet various standards	
		0.055	0.060
Amador and Calaveras Cos., CA	0.071	65%	47%
Chico, CA	0.068	58%	37%
Imperial Co., CA	0.071	70%	51%
Inyo Co., CA	0.068	87%	56%
Los Angeles South Coast Air Basin, CA	0.122	> 90%	> 90%
Mariposa and Tuolumne Cos., CA	0.072	72%	52%
Nevada Co., CA	0.075	74%	58%
Sacramento Metro, CA	0.080	82%	69%
San Benito Co., CA	0.066	54%	29%
San Diego, CA	0.076	80%	67%
San Francisco Bay Area, CA	0.069	64%	45%
San Joaquin Valley, CA	0.096	> 90%	87%
Santa Barbara Co., CA	0.068	55%	35%
Sutter Co., CA	0.067	56%	35%
Ventura Co, CA	0.077	73%	59%
Northeast Corridor, CT-DE-MD-NJ-NY-PA	0.077	> 90%	70%
Eastern Lake Michigan, IL-IN-WI	0.080	> 90%	> 90%
Houston, TX	0.087	> 90%	> 90%

Phase 2 areas were defined as any area outside a Phase 1 area whose projected 2020 design value exceeded 0.070 ppm in the hypothetical RIA scenario. The impacts of additional hypothetical emissions reductions in upwind Phase 1 areas were accounted for in the calculation of needed extrapolated tons in Phase 2 areas. After those upwind reductions were accounted for, we utilized simple “impact ratios” (ppm improvement / % emissions reduced) to determine the remaining additional reductions needed to meet the 0.055 and 0.060 ppm targets. A site-specific impact ratio was used for each Phase 2 area based on the localized ozone changes in the RIA control scenario modeling. Table S2.3 presents the extrapolated percent reductions estimated for the Phase 2 areas.

Table S2.3: Estimated Percentage Reductions of NOx beyond the RIA Control Scenario Necessary to Meet the Supplemental Analysis Targets in the Phase 2 Areas



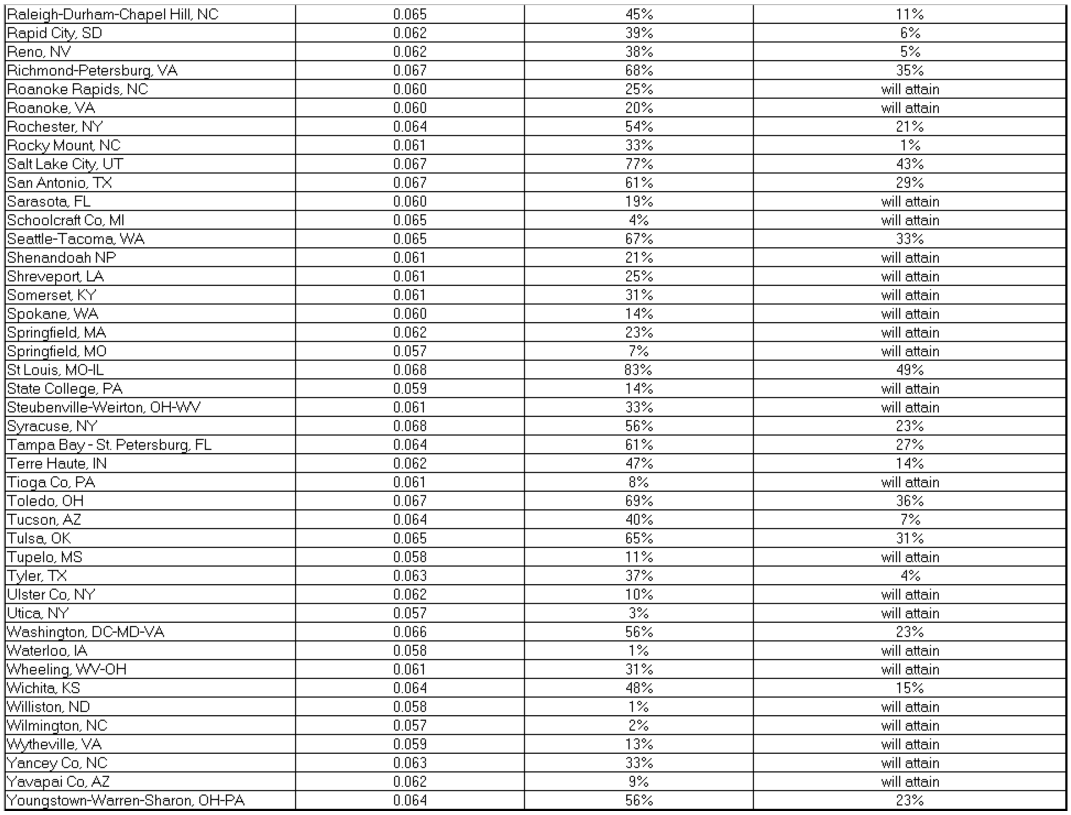
Phase 2 Area (NOx only)	2020 Design Value after RIA Control Scenario (ppm)	Additional local control needed to meet various standards	
		0.055	**0.060**
Allegan Co, MI	0.072	will attain	will attain
Baton Rouge, LA	0.073	> 90%	> 90%
Boston-Lawrence-Worcester, MA	0.071	64%	31%
Buffalo-Niagara Falls, NY	0.073	89%	62%
Cleveland-Akron-Lorain, OH	0.074	> 90%	75%
Dallas-Fort Worth, TX	0.073	> 90%	67%
Detroit-Ann Arbor, MI	0.073	> 90%	> 90%
Jefferson Co, NY	0.071	75%	49%
Las Vegas, NV	0.071	74%	41%

All other locations that did not meet the 0.055 or 0.060 ppm targets after the 2020 RIA control scenario were considered as a Phase 3 area. A highly simplified approach was used to determine the extrapolated tons needed in these areas. First, instead of explicitly accounting for the impacts of the Phase 1 and Phase 2 upwind emissions reductions on Phase 3 areas, we assumed that the design values from the 60% NOx reduction run were the appropriate starting point for estimating the additional emissions reductions in the Phase 3 areas. Since the targets for the Phase 1 areas are generally greater than 60% and since we have not accounted for the Phase 2 reductions, these estimates should provide a conservative estimate of the percentage emissions reductions needed for full attainment. Secondly, we did not develop site-specific impact ratios for the multiple Phase 3 areas. Instead, we used a standard relationship of 0.150 ppb / 1% NOx reduction for calculating the emissions reductions needed to attain 0.055 and 0.060 ppm in these areas. This value was the average site-specific relationship calculated for the Phase 2 areas, as described above. As a result of these assumptions, the estimated emissions reductions needed to attain the supplemental standards in the Phase 3 should be considered to be highly uncertain. The results of the Phase 3 analysis are shown in Table S2.4.

Table S2.4: Estimated Percentage Reductions of NOx beyond the RIA Control Scenario Necessary to Meet the Supplemental Analysis Targets in the Phase 3 Areas

Phase 3 Area (NOx only)	2020 Design Value after RIA Control Scenario (ppm)	Additional local control needed to meet various standards	
		0.055	**0.060**
Albuquerque, NM	0.064	55%	22%
Altoona, PA	0.058	9%	will attain
Appleton-Oshkosh, WI	0.065	25%	will attain
Atlanta, GA	0.068	79%	45%
Augusta, GA-SC	0.063	19%	will attain
Austin, TX	0.062	29%	will attain
Beaumont-Port Arthur, TX	0.066	72%	39%
Benton Harbor, MI	0.069	35%	2%
Benzie Co, MI	0.061	9%	will attain
Berkeley and Jefferson Co, WV	0.060	19%	will attain
Birmingham, AL	0.063	45%	12%
Boise, ID	0.069	87%	54%
Bowling Green, KY	0.058	14%	will attain
Burlington, VT	0.061	27%	will attain
Campbell Co., WY	0.067	75%	42%
Canton-Massillon, OH	0.061	36%	3%
Canyonlands NP	0.063	51%	18%
Carlsbad, NM	0.064	50%	17%
Carson City, NV	0.062	21%	will attain
Cass Co, MI	0.066	14%	will attain
Cedar Co, MO	0.062	43%	10%
Cedar Rapids, IA	0.057	1%	will attain
Charleston, SC	0.057	2%	will attain
Charleston, WV	0.062	33%	will attain
Charlotte-Gastonia-Rock Hill, NC-SC	0.071	90%	62%
Chattanooga, TN-GA	0.064	38%	5%
Chesterfield Co, SC	0.058	3%	will attain
Cincinnati-Hamilton, OH-KY-IN	0.067	71%	38%
Clarksville-Hopkinsville, TN-KY	0.057	6%	will attain
Clearfield and Indiana Cos, PA	0.061	37%	3%
Cleveland, MS	0.057	3%	will attain
Clinton, IA	0.061	24%	will attain
Cochise Co, AZ	0.064	59%	26%
Colorado Springs, CO	0.059	9%	will attain
Columbia, SC	0.064	53%	19%
Columbus, OH	0.066	63%	30%
Cookeville, TN	0.061	30%	will attain
Corpus Christi, TX	0.061	32%	will attain

Davenport, IA	0.060	18%	will attain
Dayton-Springfield, OH	0.062	44%	11%
Denver-Boulder-Greeley-Ft Collins-Love.,	0.067	77%	44%
Duplin Co, NC	0.058	8%	will attain
El Paso Co., TX-NM	0.068	80%	47%
Elmira, NY	0.059	6%	will attain
Erie, PA	0.067	70%	37%
Essex Co (Whiteface Mtn), NY	0.067	60%	27%
Eugene-Springfield, OR	0.059	13%	will attain
Evansville, IN	0.061	32%	will attain
Farmington, NM	0.069	87%	53%
Fayetteville, NC	0.060	21%	will attain
Flint, MI	0.062	39%	6%
Florence, SC	0.060	18%	will attain
Fond du Lac, WI	0.060	2%	will attain
Fort Wayne, IN	0.063	44%	11%
Franklin Co, PA	0.062	38%	5%
Fredricksburg, VA	0.060	9%	will attain
Grand Canyon NP	0.067	36%	3%
Grand Rapids, MI	0.064	18%	will attain
Grayson, KY	0.058	5%	will attain
Great Basin NP	0.065	25%	will attain
Great Smoky Mountains NP	0.063	49%	16%
Green Bay, WI	0.061	16%	will attain
Greene Co, IN	0.061	32%	will attain
Greene Co, PA	0.062	35%	1%
Greensboro-Winston Salem-High Point, NC	0.061	35%	2%
Greenville NC	0.059	9%	will attain
Greenville-Spartanburg-Anderson, SC	0.064	39%	6%
Gulfport-Biloxi, MS	0.065	61%	28%
Hagerstown, MD	0.062	23%	will attain
Hamilton Co, NY	0.061	33%	will attain
Hancock, Knox, Lincoln & Waldo Cos, ME	0.068	56%	22%
Hickory-Morganton-Lenoir, NC	0.062	33%	will attain
Huntington-Ashland, WV-KY	0.069	82%	49%
Huntsville-Decatur, AL	0.061	31%	will attain
Huron Co, MI	0.067	66%	32%
Indianapolis, IN	0.068	60%	26%
Ironton, OH-KY-WV	0.063	45%	12%
Jackson Co, IN	0.061	24%	will attain
Jamestown, NY	0.069	83%	49%
Johnson City-Kingsport-Bristol, TN	0.066	65%	31%
Johnstown, PA	0.062	27%	will attain
Joplin, MO-OK	0.063	38%	5%
Kansas City, MO-KS	0.065	54%	21%
Kinston, NC	0.059	11%	will attain
Knoxville, TN	0.065	57%	24%
La Crosse, WI	0.059	7%	will attain
Lafayette, IN	0.062	9%	will attain
Lafayette, LA	0.061	31%	will attain
Lake Charles, LA	0.063	45%	12%
Lansing-East Lansing, MI	0.064	26%	will attain
Lawrenceburg, TN	0.058	11%	will attain
Lima, OH	0.064	54%	21%
Little Rock, AR	0.062	36%	3%
Longview, TX	0.064	53%	20%
Louisville, KY-IN	0.066	67%	33%
Macon, GA	0.063	47%	14%
McAlester, OK	0.060	19%	will attain
McAllen, TX	0.062	30%	will attain
Medford, OR	0.061	35%	2%
Memphis, TN-AR	0.068	82%	49%
Mesa Verde NP	0.061	36%	3%
Minneapolis, MN	0.059	21%	will attain
Mobile, AL	0.064	54%	21%
Monroe, LA	0.060	25%	will attain
Mount Vernon, IL	0.057	5%	will attain
Muncie, IN	0.062	23%	will attain
Murray Co, GA	0.058	7%	will attain
Muskegon, MI	0.068	17%	will attain
Nashville, TN	0.061	37%	4%
Natchez, MS	0.059	17%	will attain
New Orleans, LA	0.065	67%	33%
Newton Co, AR	0.060	20%	will attain
Norfolk-Virginia Beach-Newport News, VA	0.070	87%	53%
Oklahoma City, OK	0.059	23%	will attain
Omaha, NE-IA	0.062	40%	7%
Orlando, FL	0.058	5%	will attain
Owensboro, KY-IN	0.063	53%	19%
Paducah, KY-IL	0.062	43%	9%
Panama City, FL	0.062	44%	11%
Parkersburg-Marietta, WV-OH	0.061	35%	1%
Pascagoula, MS	0.067	77%	43%
Pensacola, FL	0.065	58%	25%
Phoenix-Mesa, AZ	0.068	74%	40%
Pittsburgh-Beaver Valley, PA	0.069	85%	51%
Pocatello, ID	0.061	21%	will attain
Portland, ME	0.061	39%	6%
Portland, OR-WA	0.063	46%	13%
Providence, RI	0.066	3%	will attain



Raleigh-Durham-Chapel Hill, NC	0.065	45%	11%
Rapid City, SD	0.062	39%	6%
Reno, NV	0.062	38%	5%
Richmond-Petersburg, VA	0.067	68%	35%
Roanoke Rapids, NC	0.060	25%	will attain
Roanoke, VA	0.060	20%	will attain
Rochester, NY	0.064	54%	21%
Rocky Mount, NC	0.061	33%	1%
Salt Lake City, UT	0.067	77%	43%
San Antonio, TX	0.067	61%	29%
Sarasota, FL	0.060	19%	will attain
Schoolcraft Co, MI	0.065	4%	will attain
Seattle-Tacoma, WA	0.065	67%	33%
Shenandoah NP	0.061	21%	will attain
Shreveport, LA	0.061	25%	will attain
Somerset, KY	0.061	31%	will attain
Spokane, WA	0.060	14%	will attain
Springfield, MA	0.062	23%	will attain
Springfield, MO	0.057	7%	will attain
St Louis, MO-IL	0.068	83%	49%
State College, PA	0.059	14%	will attain
Steubenville-Weirton, OH-WV	0.061	33%	will attain
Syracuse, NY	0.068	56%	23%
Tampa Bay - St. Petersburg, FL	0.064	61%	27%
Terre Haute, IN	0.062	47%	14%
Tioga Co, PA	0.061	8%	will attain
Toledo, OH	0.067	69%	36%
Tucson, AZ	0.064	40%	7%
Tulsa, OK	0.065	65%	31%
Tupelo, MS	0.058	11%	will attain
Tyler, TX	0.063	37%	4%
Ulster Co, NY	0.062	10%	will attain
Utica, NY	0.057	3%	will attain
Washington, DC-MD-VA	0.066	56%	23%
Waterloo, IA	0.058	1%	will attain
Wheeling, WV-OH	0.061	31%	will attain
Wichita, KS	0.064	48%	15%
Williston, ND	0.058	1%	will attain
Wilmington, NC	0.057	2%	will attain
Wytheville, VA	0.059	13%	will attain
Yancey Co, NC	0.063	33%	will attain
Yavapai Co, AZ	0.062	9%	will attain
Youngstown-Warren-Sharon, OH-PA	0.064	56%	23%

Figures S2.1 and S2.2 show which counties are part of the extrapolated cost areas as well as the estimated percent reduction needed beyond the RIA control case to meet the alternative standards of 0.055 and 0.060 ppm within each of those areas. The conversion of these additional percentage reductions to actual extrapolated tons is described in Sections S2.3 of this supplement.

Figure S2.1: Map of Extrapolated Cost Counties for the 0.055 ppm Alternate Standard and Estimated Percentage NOx Controls Needed to Meet that Standard in 2020

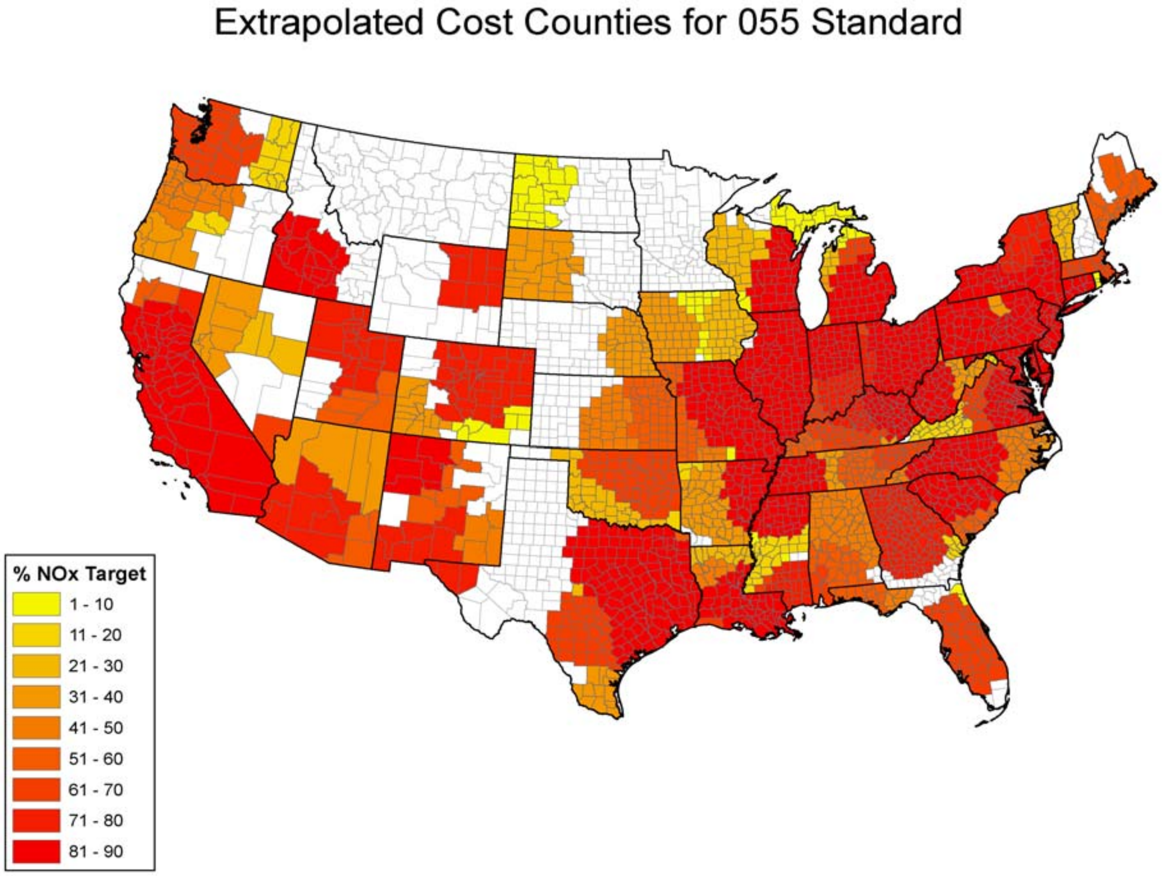
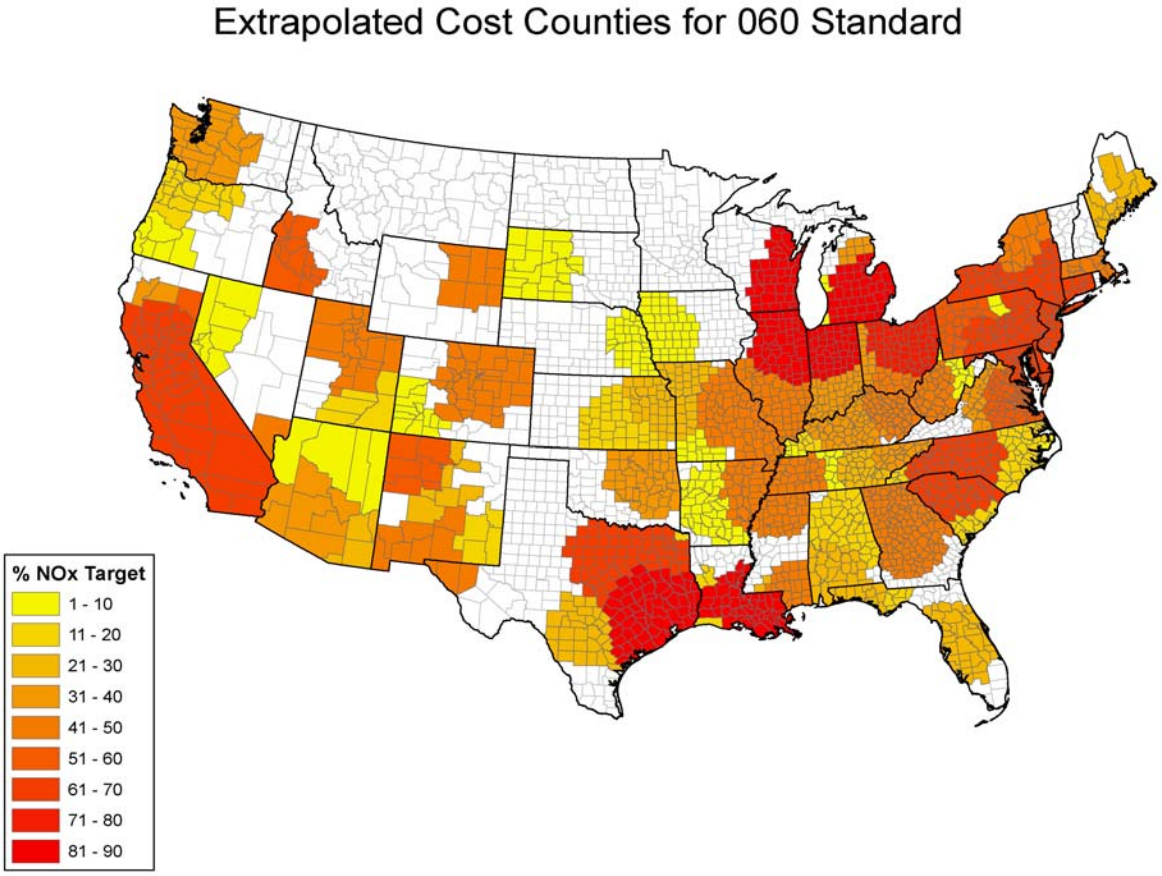


Figure S2.2: Map of Extrapolated Cost Counties for the 0.060 ppm Alternate Standard and Estimated Percentage NOx Controls Needed to Meet that Standard in 2020



S2.3 Estimating Emission Targets

The methodology to develop air quality NOx reduction targets for estimating extrapolated tons reduced for the alternative standards is presented in the 2008 Ozone NAAQS RIA[3] Section 4.1.5. No methodological changes were made to extend the analysis to targets for the 0.055 ppm and 0.060 ppm alternative standards. Discussion on the creation of the NOx targets for the 0.055 ppm and 0.060 ppm standards is in section S1.1. These NOx targets were applied to the remaining emissions from the RIA control scenario by geographic area. Table S2.5 provides the extrapolated reductions by geographic area needed to obtain the two alternative standards post-RIA control scenario emissions. The extrapolated NOx tons are obtained by multiplying the NOx targets in Tables S2.2 through S2.4 by the remaining emissions for each area after the RIA control scenario.

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[3] http://www.epa.gov/ttn/ecas/regdata/RIAs/4-ozoneriachapter4.pdf

It is important to repeat that the extrapolated cost areas are potentially standard-specific because the location of counties in an extrapolated area depends on whether the particular standard is being violated by a greater or lesser number of monitors in the area. For example, as seen in Figures 4.3a and 4.3b of the 2008 Ozone NAAQS RIA[3] the Boise Idaho area extends further east for the 0.055 ppm alternate standard where areas like New Orleans attained the 0.060 standard but not 0.055 ppm alternate standard.

Table S2.5: Extrapolated Emission Reductions (post-RIA control scenario) Needed to Meet the 0.055 ppm and 0.060 ppm Alternate Standards in 2020[a]

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	**0.060 ppm**
Albuquerque, NM	7,800	3,100
Appleton-Oshkosh, WI	3,600	
Atlanta, GA	140,000	80,000
Augusta, GA-SC	4,900	
Austin, TX	41	
Baton Rouge, LA	250,000	250,000
Benton Harbor, MI	3,500	200
Benzie Co, MI	1,800	
Berkeley and Jefferson Counties, WV	1,200	
Birmingham, AL	72,000	17,000
Boise, ID	32,000	17,000
Boston-Lawrence-Worcester, MA	62,000	40,000
Buffalo-Niagara Falls, NY	50,000	35,000
Burlington, VT	3,100	
Campbell Co, WY	26,000	14,000
Canyonlands NP	1,500	530
Carlsbad, NM	20,000	6,800
Cedar Co, MO	1,400	2,200
Cedar Rapids, IA	160	
Charleston, WV	220	
Charlotte-Gastonia-Rock Hill, NC-SC	210,000	150,000
Chattanooga, TN-GA	12,000	1,600
Chico, CA	3,000	1,900
Cincinnati-Hamilton, OH-KY-IN	110,000	59,000
Clearfield and Indiana Cos, PA	410	33
Cleveland, MS	180	
Cleveland-Akron-Lorain, OH	190,000	160,000
Clinton, IA	24,000	
Cochise Co, AZ	4,800	2,100
Colorado Springs, CO	500	
Columbia, SC	24,000	8,700
Corpus Christi, TX	31,000	
Dallas-Fort Worth, TX	220,000	120,000
Davenport, IA	150	
Denver-Boulder-Greeley-Ft Collins-Love.,	80,000	43,000
Detroit-Ann Arbor, MI	180,000	180,000

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	0.060 ppm
El Paso, TX-NM	20,000	12,000
Eugene-Springfield, OR	450	
Farmington, NM	86,000	52,000
Franklin Co, PA	630	100
Grand Canyon NP	22,000	1,800
Grand Rapids, MI	90	
Great Basin NP	470	
Great Smoky Mountains NP	560	180
Green Bay, WI	420	11,000
Gulfport-Biloxi, AL-MS	25,000	6,600
Hancock, Knox, Lincoln & Waldo Co, ME	17,000	
Houston-Galveston-Brazoria, TX	260,000	310,000
Huntington-Ashland, WV-KY	170,000	100,000
Huron Co, MI	15,000	7,500
Jefferson Co, NY	26,000	17,000
Johnson City-Kingsport-Bristol, TN	45,000	21,000
Kansas City, MO-KS	100,000	37,000
Knoxville, TN	22,000	9,200
La Crosse, WI	290	
Lake Charles, LA	6,900	1,100
Lansing-East Lansing, MI	1,900	
Las Vegas, NV	23,000	14,500
Little Rock, AR	18,000	1,500
Longview, TX	950	360
Los Angeles South Coast Air Basin, CA[b]	270,000	230,000
Louisville, KY-IN	59,000	29,000
Macon, GA	7,500	4,200
Madison and Page Cos (Shenandoah NP), VA	350	
McAlester, OK	800	
Medford, OR	5,200	300
Memphis, TN-AR-MS	160,000	98,000
Mesa Verde NP	4,600	390
Minneapolis-St.Paul, MN-WI	6,300	
Mobile, AL	25,000	9,900
Monroe, LA	9,300	
Muskegon, MI	160	
Nashville, TN	1,900	210
Natchez, MS	6,100	960
Nevada Co, CA	1,200	
New Orleans, LA	2,800	
Newton, AR	2,300	
Norfolk-Virginia Beach-Newport News (HR)	130,000	79,000
Northeast Corridor, CT-DE-MD-NJ-NY-PA	550,000	430,000
Oklahoma City, OK	18,600	
Omaha, NE-IA	62,000	11,000
Orlando, FL	1,300	
Owensboro, KY-IN	18,000	5,400

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	**0.060 ppm**
Paducah, KY-IL	590	620
Panama City, FL	3,400	850
Parkersburg-Marietta, WV-OH	13,000	380
Pascagoula, MS	59,000	33,000
Pensacola, FL	24,000	10,000
Phoenix-Mesa, AZ	51,000	28,000
Pittsburgh-Beaver Valley, PA	82,000	49,000
Portland, OR-WA	37,000	11,000
Providence (All RI), RI	310	
Raleigh-Durham-Chapel Hill, NC	25,000	6,200
Rapid City, SD	4,400	700
Reno, NV	9,700	1,300
Richmond-Petersburg, VA	30,000	15,000
Roanoke, VA	7,700	
Rocky Mount, NC	710	20
Sacramento Metro, CA	11,000	8,900
Salt Lake City-Ogden-Provo, UT	43,000	24,000
San Antonio, TX	39,000	19,000
San Joaquin Valley, CA[b]	180,000	150,000
Schoolcraft Co, MI	1,000	
Seattle, WA	98,000	48,000
Somerset, KY	450	
Spokane, WA	2,700	
Springfield, MO	90	
St Louis, MO-IL	230,000	120,000
Steubenville-Weirton, OH-WV	260	
Tampa Bay-St. Petersburg, FL	140,000	52,000
Toledo, OH	2,000	1,000
Tulsa, OK	130,000	55,000
Tupelo, MS	1,600	
Washington, DC-MD-VA	2,500	1,000
Waterloo, IA	19	
Western Lake Michigan, IL-IN-WI	420,000	420,000
Wheeling, WV-OH	130	
Wichita, KS	26,000	11,000
Williston, ND	620	
Wytheville, VA	240	

[a] Estimates are rounded to two significant figures. As such, totals will not sum down columns.

[b] The Los Angeles South Coast Air Basin and San Joaquin Valley areas of CA will be reducing emissions to meet the 0.08 ppm standard in the year 2020. They are included in this analysis due to their influence on the attainment of the Sacramento geographic area.

S2.4 Engineering Costs

The methodology used to develop the extrapolated costs presented in this supplemental analysis is presented in the 2008 Ozone NAAQS RIA[4] Section 5.2.1. To extend the analysis for the 0.055 ppm and the 0.060 ppm alternative standards no methodological changes were made to the estimation techniques for the fixed cost approach or the hybrid approach.

S.2.4.1 Supplemental Controls Analysis

The analysis steps are identical to the extrapolated cost analysis steps presented for the 0.065 ppm supplemental controls analysis in the 2008 Ozone NAAQS RIA[4]. The first step in the estimation process was to identify additional supplemental known control measures that were not included in the modeled control strategy. These controls consisted of additional known measures for the geographic areas that were not included in the modeled control strategy as well as additional controls that are discussed in the 2008 Ozone NAAQS RIA[5] Appendix 3a.1.6. An exception for the 0.055 ppm and 0.060 ppm alternative standard analyses relates to the application of additional VOC controls. We did not apply additional VOC controls for these two alternative standards for the Lake Michigan geographic area. When referring to the Phase 1 air quality modeling, it was deemed that a NOx only extrapolated control strategy would be preferable to a NOx + VOC strategy. The extrapolated emission reductions needed to meet the two alternative standards post the application of supplemental controls is presented in Table S2.6. It is important to note that negative emission reductions needed indicate that there were enough supplemental known control measures for the geographic area to reach attainment without the application of unknown control measures. Detailed results of the supplemental controls analysis are provided in Appendix S2a of this supplement.

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[4] Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs/5-ozoneriachapter5.pdf>.

[5] Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs/3-ozoneriachapter3appendix.pdf>.

Table S2.6: Extrapolated Emission Reductions Needed (Post Application of Supplemental Controls) to Meet the 0.055 ppm and 0.060 ppm Alternative Standards in 2020[a]

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	0.060 ppm
Albuquerque, NM	7,200	2,500
Appleton-Oshkosh, WI	800	
Atlanta, GA	120,000	64,000
Augusta, GA-SC	(6)[b]	
Austin, TX	41	
Baton Rouge, LA	240,000	240,000
Benton Harbor, MI	3,500	180
Benzie Co, MI	(200)[b]	
Berkeley and Jefferson Counties, WV	(200)[b]	
Birmingham, AL	55,000	500
Boise, ID	28,000	14,000
Boston-Lawrence-Worcester, MA	57,000	35,000
Buffalo-Niagara Falls, NY	49,000	34,000
Burlington, VT	2,700	
Campbell Co, WY	22,000	10,000
Canyonlands NP	550	(40)[b]
Carlsbad, NM	(10)[b]	(60)[b]
Cedar Co, MO	1,400	1,900
Cedar Rapids, IA	(500)[b]	
Charleston, WV	(4)[b]	
Charlotte-Gastonia-Rock Hill, NC-SC	200,000	130,000
Chattanooga, TN-GA	7,800	(300)[b]
Chico, CA	2,600	1,500
Cincinnati-Hamilton, OH-KY-IN	98,000	47,000
Clearfield and Indiana Cos, PA	97	(50)[b]
Cleveland, MS	(10)[b]	
Cleveland-Akron-Lorain, OH	180,000	150,000
Clinton, IA	5,600	
Cochise Co, AZ	4,600	1,900
Colorado Springs, CO	(40)[b]	
Columbia, SC	22,000	6,700
Corpus Christi, TX	15,000	
Dallas-Fort Worth, TX	210,000	110,000
Davenport, IA	39	
Denver-Boulder-Greeley-Ft Collins-Love.,	67,000	29,000
Detroit-Ann Arbor, MI	170,000	170,000
El Paso, TX-NM	16,000	8,100
Eugene-Springfield, OR	450	
Farmington, NM	67,000	34,000
Franklin Co, PA	460	(20)[b]
Grand Canyon NP	20,000	520
Grand Rapids, MI	92	
Great Basin NP	470	
Great Smoky Mountains NP	560	180

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	0.060 ppm
Green Bay, WI	(900) [b]	
Gulfport-Biloxi, AL-MS	19,000	5,100
Hancock, Knox, Lincoln & Waldo Co, ME	15,000	5,000
Houston-Galveston-Brazoria, TX	140,000	190,000
Huntington-Ashland, WV-KY	150,000	77,000
Huron Co, MI	5,500	(5) [b]
Jefferson Co, NY	24,000	15,000
Johnson City-Kingsport-Bristol, TN	35,000	12,000
Kansas City, MO-KS	87,000	27,000
Knoxville, TN	16,000	3,500
La Crosse, WI	290	
Lake Charles, LA	810	(100) [b]
Lansing-East Lansing, MI	1,700	
Las Vegas, NV	22,000	13,000
Little Rock, AR	9,900	(2,000) [b]
Longview, TX	830	240
Los Angeles South Coast Air Basin, CA[c]	270,000	220,000
Louisville, KY-IN	57,000	27,000
Macon, GA	7,300	4,100
Madison and Page Cos (Shenandoah NP), VA	330	
McAlester, OK	(70) [b]	
Medford, OR	4,700	(20) [b]
Memphis, TN-AR-MS	140,000	72,000
Mesa Verde NP	830	(700) [b]
Minneapolis-St.Paul, MN-WI	4,900	
Mobile, AL	5,800	(6) [b]
Monroe, LA	(20) [b]	
Muskegon, MI	160	
Nashville, TN	1,900	130
Natchez, MS	(40) [b]	
Nevada Co, CA	1,100	860
New Orleans, LA	700	
Newton, AR	2,100	
Norfolk-Virginia Beach-Newport News (HR)	120,000	70,000
Northeast Corridor, CT-DE-MD-NJ-NY-PA	540,000	420,000
Oklahoma City, OK	360	
Omaha, NE-IA	50,000	(60) [b]
Orlando, FL	170	
Owensboro, KY-IN	17,000	4,900
Paducah, KY-IL	590	500
Panama City, FL	2,400	(10) [b]
Parkersburg-Marietta, WV-OH	7,800	(200) [b]
Pascagoula, MS	37,000	11,000
Pensacola, FL	15,000	1,500
Phoenix-Mesa, AZ	46,000	23,000
Pittsburgh-Beaver Valley, PA	78,000	45,000
Portland, OR-WA	33,000	5,900

Extrapolated Cost Area	Additional NOx Emission Reductions Needed (annual tons/year)	
	0.055 ppm	0.060 ppm
Providence (All RI), RI	240	
Raleigh-Durham-Chapel Hill, NC	20,000	530
Rapid City, SD	1,700	(20) [b]
Reno, NV	9,500	1,100
Richmond-Petersburg, VA	25,000	11,000
Roanoke, VA	5,600	
Rocky Mount, NC	710	20
Sacramento Metro, CA[c]	8,700	7,000
Salt Lake City-Ogden-Provo, UT	38,000	19,000
San Antonio, TX	26,000	5,900
San Joaquin Valley, CA[c]	180,000	150,000
Schoolcraft Co, MI	(4,000) [b]	
Seattle, WA	95,000	46,000
Somerset, KY	380	
Spokane, WA	1,100	
Springfield, MO	76	
St Louis, MO-IL	210,000	100,000
Steubenville-Weirton, OH-WV	190	
Tampa Bay-St. Petersburg, FL	130,000	45,000
Toledo, OH	1,800	850
Tulsa, OK	99,000	32,000
Tupelo, MS	(100) [b]	
Washington, DC-MD-VA	2,500	1,000
Waterloo, IA	(20) [b]	
Western Lake Michigan, IL-IN-WI	390,000	390,000
Wheeling, WV-OH	130	
Wichita, KS	11,000	(5) [b]
Williston, ND	(70) [b]	
Wytheville, VA	56	

[a] Estimates are rounded to two significant figures. As such, totals will not sum down columns.

[b] Negative numbers indicate the supplemental control measures applied yielded greater emission reductions than were needed for the geographic are to attain the alternative standard being analyzed.

[c] The Los Angeles South Coast Air Basin and San Joaquin Valley areas of CA will be reducing emissions to meet the 0.08 ppm standard in the year 2020. They are included in this analysis due to their influence on the attainment of the Sacramento geographic area.

S.2.4.2 Hybrid Approach Extrapolated Costs

A complete discussion of the theoretical model for the Hybrid Approach is provided in the 2008 Ozone NAAQS RIA[4] Section 5.2.1.2 as well as the Appendix[6] 5a.4.4. Consistent with

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[6] Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs/5a-ozoneriachapter5appendixa.pdf>.

the results presented in 2008 Ozone NAAQS RIA the hybrid approach results are shown for the mid range estimate[7] (Table S2.7). Sensitivities are provided in Appendix Sa1 of this supplement.

Table S2.7: Extrapolated Cost by Region to Meet the 0.055 ppm and 0.060 ppm Alternative Standards Using the Hybrid Approach (Mid)[a]

2020 Extrapolated Cost by Region	Hybrid Approach (Mid) - Extrapolated Cost (M 2006$)	
	0.055 ppm	**0.060 ppm**
East	$100,000	$72,000
West	$11,000	$3,900
California	$11,000	$9,000
Total Extrapolated Cost	**$120,000**	**$85,000**

[a] Estimates are rounded to two significant figures. As such, totals will not sum down columns.

S.2.4.3 Fixed Cost Approach Extrapolated Costs.

A complete discussion of the fixed cost approach is provided in the 2008 Ozone NAAQS RIA[4] Section 5.2.1.4. Consistent with the results presented in the 2008 Ozone NAAQS RIA the fixed cost approach results are shown for the $15,000/ton estimate (Table S2.8). Sensitivities are provided in Appendix Sa1 of this supplement.

Table S2.8: Extrapolated Cost by Region to Meet the 0.055 ppm and 0.060 ppm Alternative Standards Using the Fixed Cost Approach ($15,000/ton)[a]

2020 Extrapolated Cost by Region	Fixed Cost Approach ($15,000/ton) - Extrapolated Cost (M 2006$)	
	0.055 ppm	**0.060 ppm**
East	$59,000	$39,000
West	$7,000	$3,000
California	$6,800	$5,700
Total Extrapolated Cost	**$73,000**	**$47,000**

[a] Estimates are rounded to two significant figures. As such, totals will not sum down columns.

S.2.4.4 Summary of Total Costs

Table S2.9 presents a summary of the total national costs of attaining the 0.055 ppm and the 0.060 ppm alternative standards in 2020. This summary includes the engineering costs of the modeled control strategy (presented in the 2008 Ozone NAAQS RIA Chapter 5[4]), the additional supplemental controls, as well as the extrapolated costs. Consistent with OMB Circular A-4, costs are presented at a 7% discount rate.

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[7] The mid range estimate consists of using an M value of 0.24 for the estimation of the average cost per ton of control by geographic area. For a complete listing of average cost per ton by geographic area see Appendix S2a.

Table S2.9: Total Costs of Attainment in 2020 for the 0.055 ppm and 0.060 ppm Alternative Standards in 2020[a]

Cost Type	Region	Engineering Costs in 2020 (M 2006$)			
		0.055 ppm		0.060 ppm	
Known Control Costs	East	$4,600		$4,000	
	West	$400		$330	
	California	$160		$160	
	Known Control Costs[b]	$5,100		$4,500	
Extrapolated Costs	Approach	Fixed	Hybrid	Fixed	Hybrid
	East	$59,000	$100,000	$39,000	$72,000
	West	$7,000	$11,000	$3,000	$3,900
	California[c]	$6,800	$11,000	$5,700	$9,000
	Extrapolated Costs	$73,000	$120,000	$47,000	$85,000
	Total Costs	**$78,000**	**$130,000**	**$52,000**	**$90,000**

[a] Estimates are rounded to two significant figures. As such, totals will not sum down columns.

[b] Known control costs consist of the modeled control strategy costs presented in the RIA Table 5.1, as well as supplemental controls presented in Appendix Sa1.

[C] The extrapolated costs for the South Coast and San Joaquin areas of California only include the costs required to bring Sacramento into attainment.

S2.5 Benefits

This section presents the benefits analysis for ozone standard levels at 0.060 ppm and 0.055 ppm updated to reflect key methodological changes that EPA has implemented since having published the 2008 Ozone NAAQS RIA. In this updated analysis, we re-estimate the human health benefits of reduced exposure to ambient ozone and $PM_{2.5}$ co-benefits from simulated attainment with an alternate daily 8hr maximum standard. These benefits were calculated using exactly the same method as used to calculate the updated benefits at 0.065 ppm, and are incremental to an air quality baseline that reflects attainment with the 1997 ozone and 2006 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS).[8]

For an alternative standard at 0.060 ppm, EPA estimates the total monetized benefits to be $35 to $100 billion (2006$, 3% discount rate) in 2020.[9] For an alternative standard at 0.055 ppm, EPA estimates the total monetized benefits to be $53 to $160 billion (2006$, 3% discount rate) in 2020.[10] These monetized benefits include reduced health effects from reduced exposure to ozone, reduced health effects from reduced exposure to $PM_{2.5}$, and improvements in visibility. Higher or lower estimates of benefits are possible using other assumptions. These

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[8] For more information, please consult Chapter 6 of the 2008 Ozone RIA (U.S. EPA, 2008) and the updated benefits section S3 of this supplemental.

[9] Results are shown as a range from Bell et al. (2004) with Pope et al. (2002) to Levy (2005) with Laden et al. (2006). $PM_{2.5}$ co-benefits using a 7% discount rate would be approximately 9% lower.

[10] Results are shown as a range from Bell et al. (2004) with Pope et al. (2002) to Levy (2005) with Laden et al. (2006). $PM_{2.5}$ co-benefits using a 7% discount rate would be approximately 9% lower.

updated estimates reflect three key methodological changes we have implemented since the publication of the 2008 RIA that reflect EPA's most current interpretation of the scientific literature and include: (1) a no-threshold model for $PM_{2.5}$ that calculates incremental benefits down to the lowest modeled air quality levels; (2) removal of the assumption of no causality for the relationship between ozone exposure and premature mortality; (3) a different Value of Statistical Life (VSL). Methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including ecosystem effects.

These updated estimates reflect three key methodological changes we have implemented since the publication of the 2008 RIA that reflect EPA's most current interpretation of the scientific literature and include: (1) a no-threshold model for PM2.5 that calculates incremental benefits down to the lowest modeled air quality levels; (2) removal of the assumption of no causality for the relationship between ozone exposure and premature mortality; (3) a different Value of Statistical Life (VSL).[11] For more information on these changes, please see Section 3 of this supplemental.

In Table S2.10 and S2.11, we show the ozone benefits with confidence intervals and the ozone benefits compared to $PM_{2.5}$ co-benefits at 0.060 ppm. Tables S2.12 and S2.13, we show the ozone benefits with confidence intervals and the ozone benefits compared to $PM_{2.5}$ co-benefits at 0.055 ppm. In tables S2.14, we show the increase in life years gained as a result of increased life expectancy for 0.060 ppm and 0.055 ppm. In Table S2.15, we show the percentage of total mortality attributable to ozone based on the Bell et al. (2004) and Levy et al. (2005) risk coefficients. In the interest of clarity, we elected to report life years and percentage of total mortality attributable to ozone based on the studies with the smallest and largest effect estimate.

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[11] The current VSL is $6.3 million (2000$). After adjustments for a different currency year (2006$) and income growth to 2020, the VSL is $8.9m.

Table S2.10: Summary of National Ozone Benefits for 0.060 ppm with confidence intervals (in millions of 2006$)[A, B, C]

Endpoint Group	Author	Year	0.060 ppm Valuation	0.060 ppm Incidence
Hospital Admissions, Respiratory			$56 ($30 -- $82)	5,600 (2,700 -- 8,500)
Emergency Room Visits, Respiratory			$1.3 (-$2.6 -- $4.4)	3,600 (-8,200 -- 12,000)
School Loss Days			$190 ($82 -- $260)	2,100,000 (830,000 -- 3,000,000)
Acute Respiratory Symptoms			$330 ($130 -- $610)	5,600,000 (2,600,000 -- 8,600,000)
Hospital Admissions, Respiratory			$160 ($22 -- $270)	6,900 (330 -- 12,000)
Mortality	Bell et al.	2004	$7,900 ($660 -- $24,000)	890 (340 -- 1,400)
Mortality	Schwartz		$12,000 ($990 -- $36,000)	1,400 (500 -- 2,200)
Mortality	Huang		$13,000 ($1,100 -- $39,000)	1,500 (640 -- 2,400)
Mortality	Bell et al.	2005	$30,000 ($2,200 -- $73,000)	2,900 (1,500 -- 4,200)
Mortality	Ito et al.		$35,000 ($3,300 -- $99,000)	4,000 (2,500 -- 5,500)
Mortality	Levy et al.		$36,000 ($3,300 -- $98,000)	4,000 (2,900 -- 5,200)

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Confidence intervals are not available for PM co-benefits because of methodological limitations when using benefit-per-ton.

[C] All estimates rounded to two significant digits

Table S2.11: Summary of National Ozone Benefits and $PM_{2.5}$ Co-Benefits for 0.060 ppm (in millions of 2006$)[A, B, C]

	Endpoint Group	Author	0.060 ppm Valuation (3% discount rate)	0.060 ppm Valuation (7% discount rate)	0.060 ppm Incidence
Ozone	Infant Hospital Admissions, Respiratory		$56	$56	5,600
	Emergency Room Visits, Respiratory		$1.3	$1.3	3,600
	School Loss Days		$190	$190	2,100,000
	Acute Respiratory Symptoms		$330	$330	5,600,000
	Hospital Admissions, Respiratory		$160	$160	6,900
	Mortality	Bell et al. (2004)	$7,900	$7,900	890
	Mortality	Schwartz	$12,000	$12,000	1,400
	Mortality	Huang	$13,000	$13,000	1,500
	Mortality	Bell et al. (2005)	$25,000	$25,000	2,900
	Mortality	Ito et al.	$35,000	$35,000	4,000
	Mortality	Levy et al.	$36,000	$36,000	4,000
$PM_{2.5}$	Chronic Bronchitis		$980	$980	2,200
	Acute Myocardial Infarction		$520	$510	5,300
	Hospital Admissions, Respiratory		$9	$9	740
	Hospital Admissions, Cardiovascular		$39	$39	1,600
	Emergency Room Visits, Respiratory		$0.87	$0.87	2,600
	Acute Bronchitis		$0.36	$0.36	5,300
	Work Loss Days		$47	$47	420,000
	Asthma Exacerbation		$2.8	$2.8	58,000
	Acute Respiratory Symptoms		$130	$130	2,500,000
	Lower Respiratory Symptoms		$1.0	$1.0	63,000
	Upper Respiratory Symptoms		$1.3	$1.3	48,000
	Infant Mortality		$100	$100	13
	Mortality	Pope et al	$25,000	$22,000	3,100
	Mortality	Laden et al	$63,000	$57,000	7,800
	Mortality	Expert K	$8,700	$7,800	1,100
	Mortality	Expert E	$83,000	$75,000	10,000

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Does not include confidence intervals

[C] All estimates rounded to two significant digits

Table S2.12: Summary of National Ozone Benefits for 0.055 ppm with confidence intervals (in millions of 2006$)[A, B, C]

Endpoint Group	Author	Year	0.055 ppm Valuation	0.055 ppm Incidence
Hospital Admissions, Respiratory			$97 ($52 -- $140)	9,800 (4,800 -- 15,000)
Emergency Room Visits, Respiratory			$2.4 (-$4.6 -- $7.8)	6,500 (-15,000 -- 21,000)
School Loss Days			$330 ($150 -- $460)	3,700,000 (1,500,000 -- 5,300,000)
Acute Respiratory Symptoms			$580 ($230 -- $1,100)	9,800,000 (4,500,000 -- 15,000,000)
Hospital Admissions, Respiratory			$290 ($41 -- $490)	12,000 (620 -- 22,000)
Mortality	Bell et al.	2004	$14,000 ($1,200 -- $42,000)	1,600 (620 -- 2,500)
Mortality	Schwartz		$22,000 ($1,700 -- $65,000)	2,400 (890 -- 4,000)
Mortality	Huang		$24,000 ($2,000 -- $70,000)	2,600 (1,100 -- 4,200)
Mortality	Bell et al.	2005	$50,000 ($4,000 -- $130,000)	5,100 (2,600 -- 7,500)
Mortality	Ito et al.		$63,000 ($5,900 -- $180,000)	7,100 (4,500 -- 9,600)
Mortality	Levy et al.		$64,000 ($5,900 -- $170,000)	7,200 (5,100 -- 9,200)

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Confidence intervals are not available for PM co-benefits because of methodological limitations when using benefit-per-ton.

[C] All estimates rounded to two significant digits

Table S2.13: Summary of National Ozone Benefits and PM2.5 Co-Benefits for 0.055 ppm (in millions of 2006$)[A, B, C]

	Endpoint Group	Author	0.055 ppm Valuation (3% discount rate)	0.055 ppm Valuation (7% discount rate)	0.055 ppm Incidence
Ozone	Infant Hospital Admissions, Respiratory		$97	$97	9,800
	Emergency Room Visits, Respiratory		$2.4	$2.4	6,500
	School Loss Days		$330	$330	3,700,000
	Acute Respiratory Symptoms		$580	$580	9,800,000
	Hospital Admissions, Respiratory		$290	$290	12,000
	Mortality	Bell et al. (2004)	$14,000	$14,000	1,600
	Mortality	Schwartz	$22,000	$22,000	2,400
	Mortality	Huang	$24,000	$24,000	2,600
	Mortality	Bell et al. (2005)	$45,000	$45,000	5,100
	Mortality	Ito et al.	$63,000	$63,000	7,100
	Mortality	Levy et al.	$64,000	$64,000	7,200
PM$_{2.5}$	Chronic Bronchitis		$1,400	$1,400	3,200
	Acute Myocardial Infarction		$740	$720	7,500
	Hospital Admissions, Respiratory		$13	$13	1,000
	Hospital Admissions, Cardiovascular		$56	$56	2,200
	Emergency Room Visits, Respiratory		$1.20	$1.20	3,700
	Acute Bronchitis		$0.51	$0.51	7,600
	Work Loss Days		$67	$67	600,000
	Asthma Exacerbation		$4.0	$4.0	83,000
	Acute Respiratory Symptoms		$190	$190	3,600,000
	Lower Respiratory Symptoms		$1.5	$1.5	91,000
	Upper Respiratory Symptoms		$1.8	$1.8	69,000
	Infant Mortality		$150	$150	19
	Mortality	Pope et al	$35,000	$31,000	4,300
	Mortality	Laden et al	$90,000	$81,000	11,000
	Mortality	Expert K	$12,000	$11,000	1,500
	Mortality	Expert E	$120,000	$110,000	15,000

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Does not include confidence intervals

[C] All estimates rounded to two significant digits

Table S2.14: Estimated Reduction in Ozone-Related Premature Mortality in Terms of Life Years Gained from Increases in Life Expectancy

Age Range	*Bell et al. (2004) mortality estimate*		*Levy et al. (2005) mortality estimate*	
	0.060 ppm	0.055 ppm	0.060 ppm	0.055 ppm
25-29	240 (110—380)	400 (180—630)	2,100 (1,600—2,700)	3,600 (2,600—4,500)
30-34	220 (94—340)	360 (160—560)	1,900 (1,400—2,400)	3,200 (2,300—4,000)
35-44	850 (380—1,300)	1,400 (630—2,200)	5,100 (3,800—6,500)	8,700 (6,400—11,000)
45-54	1,700 (740—2,600)	2,900 (1,300—4,500)	8,300 (6,100—10,000)	14,000 (10,000—18,000)
55-64	3,300 (1,500—5,200)	5,700 (2,500—8,900)	15,000 (11,000—19,000)	26,000 (19,000—32,000)
65-74	3,900 (1,700—6,100)	6,700 (3,000—11,000)	17,000 (13,000—22,000)	30,000 (22,000—37,000)
75-84	2,700 (1,200—4,200)	4,600 (2,000—7,200)	12,000 (8,600—15,000)	20,000 (15,000—26,000)
85-99	1,400 (590—2,100)	2,300 (1,000—3,600)	5,600 (4,300—7,400)	10,000 (7,400—13,000)

Table S2.15: Percentage of Total Mortality Attributable to Ozone

Age Range	*Bell et al. (2004) mortality estimate*		*Levy et al. (2005) mortality estimate*	
	0.060 ppm	0.055 ppm	0.060 ppm	0.055 ppm
25-29	0.098%	0.165%	0.409%	0.694%
30-34	0.095%	0.161%	0.398%	0.681%
35-44	0.094%	0.161%	0.399%	0.682%
45-54	0.096%	0.162%	0.408%	0.692%
55-64	0.091%	0.158%	0.391%	0.674%
65-74	0.088%	0.154%	0.375%	0.657%
75-84	0.087%	0.152%	0.370%	0.650%
85-99	0.090%	0.155%	0.384%	0.663%

S2.6 Conclusions

Given the pervasive uncertainties in the 0.055 ppm and 0.060 ppm analysis, the types of conclusions that readers may draw is necessarily limited. One reasonable conclusion is that the magnitude of the costs and benefits of these two alternatives is significantly larger than that of 0.065 ppm, 0.070 ppm or 0.075 ppm. The reasons for these large uncertainties are outlined in section 2.1 above. As we noted in more detail above, our ability to predict the emissions reductions necessary to achieve the two lower standards is quite limited, and as a result, our estimates of costs and benefits of those levels is highly speculative.

S2.7 References

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Section 3: Re-analysis of the Benefits of Attaining Alternative Ozone Standards to Incorporate Current Methods

Synopsis

This chapter presents a benefits analysis of three alternate ozone standards updated to reflect key methodological changes that EPA has implemented since having published the 2008 Ozone NAAQS RIA. In this updated analysis we re-estimate the human health benefits of reduced exposure to ambient ozone and $PM_{2.5}$ co-benefits from simulated attainment with three alternate daily 8hr maximum standards: 0.075 ppm, 0.070 ppm, and 0.065 ppm. For an alternative standard at 0.075 ppm, EPA estimates the monetized benefits to be $6.9 to $18 billion (2006$, 3% discount rate) in 2020.[1] For an alternative standard at 0.070 ppm, EPA estimates the monetized benefits to be $13 to $37 billion (2006$, 3% discount rate) in 2020. For an alternative standard at 0.065 ppm, EPA estimates the monetized benefits to be $22 to $61 billion (2006$, 3% discount rate) in 2020. Higher or lower estimates of benefits are possible using other assumptions. The benefits of attaining an alternate standard of 0.060 ppm and 0.055 ppm may be found in Section 2 of this supplement. These updated estimates reflect three key methodological changes we have implemented since the publication of the 2008 RIA that reflect EPA's most current interpretation of the scientific literature and include: (1) a no-threshold model for $PM_{2.5}$ that calculates incremental benefits down to the lowest modeled air quality levels; (2) removal of the assumption of no causality for the relationship between ozone exposure and premature mortality; (3) a different Value of Statistical Life (VSL). These benefits are incremental to an air quality baseline that reflects attainment with the 1997 ozone and 2006 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). Methodological limitations prevented EPA from monetizing the benefits from several important benefit categories, including ecosystem effects.

S3.1 Background

In response to the recent court vacatur of the 2008 Ozone NAAQS, EPA is reconsidering this rulemaking. Consistent with EPA's decision to, in general, use the "existing record" for this reconsideration, we present a benefits analysis based on the same air quality modeling inputs as the 2008 analysis. However, we update this analysis to make the results consistent with an array of methodological updates that EPA has incorporated since the release of Regulatory Impact Analysis (RIA) for the 2008 Ozone NAAQS (U.S. EPA, 2008). Because the rulemaking period for the reconsideration is condensed, we only provide estimates associated with the

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[1] Results are shown as a range from Bell et al. (2004) with Pope et al. (2002) to Levy (2005) with Laden et al. (2006). $PM_{2.5}$ co-benefits using a 7% discount rate would be approximately 9% lower.

promulgated standard level of 0.075 ppm and the two more stringent standard levels previously analysis (i.e., 0.070 ppm and 0.065 ppm). A separate analysis of the costs and benefits of simulated attainment with 0.060 ppm and 0.055 ppm may be found in Section 2 of this Supplement. All benefits estimates in this analysis are incremental to the 1997 Ozone NAAQS standard at 0.08 ppm and the 2006 $PM_{2.5}$ NAAQS standard at 15/35 $\mu g/m^3$.

S3.2 Key updates to the benefits assessment

In this analysis, we update several aspects of our benefits assessment for the human health benefits of reducing exposure to ozone and $PM_{2.5}$.[2] Both ozone benefits and $PM_{2.5}$ co-benefits incorporate the updated population projections in BenMAP. In addition, both ozone benefits and $PM_{2.5}$ co-benefits reflect EPA's current interpretation of the economic literature on mortality valuation to use the value-of-a statistical life (VSL) based on meta-analysis of 26 studies.[3]

For ozone benefits, these updates are a response to recent recommendations from the National Research Council (NRC, 2008). In this analysis, we have incorporated three of NRC's recommendations:

1) We no longer include estimates of ozone benefits with an assumption of no causal relationship between ozone exposure and premature mortality.
2) We include two additional ozone mortality estimates, one based on the National Morbidity, Mortality and Air Pollution Study (NMMAPS) (Huang, 2005), and one 14-city study (Schwartz, 2005), placing the greatest emphasis on the multi-city studies, such as NMMAPS.
3) We present additional risk metrics, including the change in the percentage of baseline mortality attributable, and the number of life years lost due, to ozone-related premature mortality.

In addition to these recommendations, we modify the health functions used to estimate the number of emergency department visits for asthma avoided by reducing exposure to ozone. Specifically, we removed the Jaffe et al. (2003) function because the age range overlaps partially with Wilson et al. (2005) and Peel et al. (2005) functions. This change results in a

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[2] This analysis does not attempt to describe the overall methodology for estimating the benefits of reducing ozone and $PM_{2.5}$. For more information, please consult Chapter 6 of the 2008 Ozone NAAQS RIA (U.S. EPA, 2008).

[3] For more information regarding mortality valuation, please consult section 5.7 of the proposed NO_2 RIA (U.S. EPA, 2009b).

slightly larger estimate of ozone-related emergency department visits as compared to the 2008 analysis.

For $PM_{2.5}$ co-benefits, this analysis is consistent with proposed Portland Cement NESHAP RIA (U.S. EPA, 2009a) and proposed NO_2 NAAQS RIA (U.S. EPA, 2009b). In this analysis, we incorporate four updates:

1) We removed assumed thresholds from the mortality and morbidity concentration-response functions for $PM_{2.5}$.[4] Removing the assumed 10 $\mu g/m^3$ threshold is a key difference between the method used in this analysis of $PM_{2.5}$-co benefits and the methods used in RIAs prior to Portland Cement, and we now calculate incremental benefits down to the lowest modeled $PM_{2.5}$ air quality levels. This change results in a larger estimate of PM-related premature mortality as compared to the 2008 analysis.
2) We now present the summary of the $PM_{2.5}$ co-benefits results using concentration-response functions for mortality from two cohort studies (Pope et al. (2002) and Laden et al. (2006)) instead of range between the minimum and maximum results from an expert elicitation of the relationship between exposure to $PM_{2.5}$ and premature mortality (Roman et al., 2008). This change produces a slightly narrower range of PM-related mortality estimates as compared to the 2008 analysis. In addition, we provide the full suite of results based on the expert elicitation in the body of the benefits results chapter.
3) When adjusting the benefits of the modeled PM co-benefits for alternate standard levels, we apply $PM_{2.5}$ benefit per ton estimates calculated using a broader geographic area, which, when compared to the 2008 analysis, produces more reliable and generally larger PM-related benefits estimates.
4) We incorporated an updated methodology for quantifying the health incidences associated with the benefit-per-ton estimates. This change should produce more reliable estimates of PM-related health impacts.

In this analysis we estimate ozone-related premature mortality using risk coefficients drawn from short-term mortality studies. Two recent epidemiologic studies assessed the relationship between long-term exposure to ozone and premature mortality. Jerrett et al. (2009) utilized the ACS cohort with air quality data from 1977 through 2000 (April through September). Jarrett et al. reported a positive and statistically significant association between ambient ozone concentration and respiratory causes of death after controlling for $PM_{2.5}$ using

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[4] For more information regarding thresholds in the $PM_{2.5}$ mortality relationship, please consult the proposed Portland Cement NESHAP RIA (U.S. EPA, 2009a).

co-pollutant models. Further examination of the association between ozone exposure and respiratory-related mortality revealed the association was increased by higher temperatures and geographic variation. In single pollutant models, long-term ozone exposure was also associated with cardiopulmonary, cardiovascular, and ischemic heart disease mortality, but the associations were not present in the co-pollutant model. Krewski et al. (2009) also utilized data from the ACS cohort with air quality data from 1980 (April through September) and observed a positive association between ozone exposure and all-cause and cardiopulmonary disease mortality. This association was robust to control for ecologic variables, but no association was observed with ischemic heart disease or lung cancer. In addition, Krewski et al. observed no association with year-round ozone exposure.

EPA anticipates incorporating risk coefficients from one or both of these two long-term cohort studies after consulting with the EPA SAB to resolve key technical questions regarding the specification of the health impact analysis. For example, when estimating long-term $PM_{2.5}$-related mortality we apply an SAB-recommended 20-year distributed cessation lag, over which period we discount monetized benefits. To the extent that there is a lag between the cessation of ozone exposure and the return of population risk to a new steady state risk level, EPA would specify this parameter in the health impact analysis. We also plan to elicit guidance from the SAB regarding the selection of: national versus regional effect coefficients; the use of estimators derived using single versus co-pollutant models; and, the health mortality endpoint to be quantified, among other issues. EPA anticipates consulting with the SAB in late 2009.

S3.3 Presentation of results

Tables S3.1 through S3.6 show the results of this updated analysis. Figures S3.1 and S3.2 show the breakdown of ozone benefits and $PM_{2.5}$ co-benefits by endpoint category using a single mortality study as an example. Figures S3.3 and S3.4 show the ozone benefits and $PM_{2.5}$ co-benefits by mortality study. Figures S3.5 and S3.6 show the breakdown of monetized benefits between ozone, PM, morbidity, mortality, and visibility. Figure S3.7 shows the results of this updated analysis graphically.

Table S3.1: Summary of Total Number of Ozone and $PM_{2.5}$-Related Premature Mortalities and Morbidity Incidences Avoided in 2020 [A, D]

Combined Estimate of Mortality		**0.075 ppm**			**0.070 ppm**			**0.065 ppm**		
Multi-city	Bell et al. (2004)	760	to	1,900	1,500	to	3,500	2,500	to	5,600
	Schwartz	800	to	1,900	1,600	to	3,600	2,700	to	5,800
	Huang	820	to	1,900	1,600	to	3,600	2,800	to	5,900
Meta-analysis	Bell et al. (2005)	930	to	2,000	2,000	to	4,000	3,500	to	6,600
	Ito et al.	1,000	to	2,100	2,300	to	4,300	4,000	to	7,100
	Levy et al.	1,000	to	2,100	2,300	to	4,300	4,100	to	7,200
Combined Estimate of Morbidity		**0.075 ppm**			**0.070 ppm**			**0.065 ppm**		
Acute Myocardial Infarction [B]		1,300			2,200			3,500		
Upper Respiratory Symptoms [B]		9,900			19,000			31,000		
Lower Respiratory Symptoms [B]		13,000			25,000			41,000		
Chronic Bronchitis [B]		470			880			1,400		
Acute Bronchitis [B]		1,100			2,100			3,400		
Asthma Exacerbation [B]		12,000			23,000			38,000		
Work Loss Days [B]		88,000			170,000			270,000		
School Loss Days [C]		190,000			600,000			1,100,000		
Hospital and ER Visits		2,600			6,700			11,000		
Minor Restricted Activity Days		1,000,000			2,600,000			4,500,000		

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] PM-related benefits only

[C] Ozone-related benefits only

[D] All estimates rounded to two significant digits

Table S3.2: Summary of Total Monetized Benefits in 2020 (3% discount rate, in millions of 2006$)[A, B, C]

Combined Estimate of Mortality		0.075 ppm			0.070 ppm			0.065 ppm		
NMMAPS	Bell et al. (2004)	$6,900	to	$15,000	$13,000	to	$29,000	$22,000	to	$47,000
	Schwartz	$7,200	to	$16,000	$15,000	to	$30,000	$24,000	to	$49,000
	Huang	$7,300	to	$16,000	$15,000	to	$30,000	$25,000	to	$50,000
Meta-analysis	Bell et al. (2005)	$8,300	to	$17,000	$18,000	to	$34,000	$31,000	to	$56,000
	Ito et al.	$9,100	to	$18,000	$21,000	to	$37,000	$36,000	to	$61,000
	Levy et al.	$9,200	to	$18,000	$21,000	to	$37,000	$36,000	to	$61,000

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] All estimates rounded to two significant digits

[C] Includes Visibility benefits of $160,000

Table S3.3: Summary of Total Monetized Benefits in 2020 (7% discount rate, in millions of 2006$)[A, B, C]

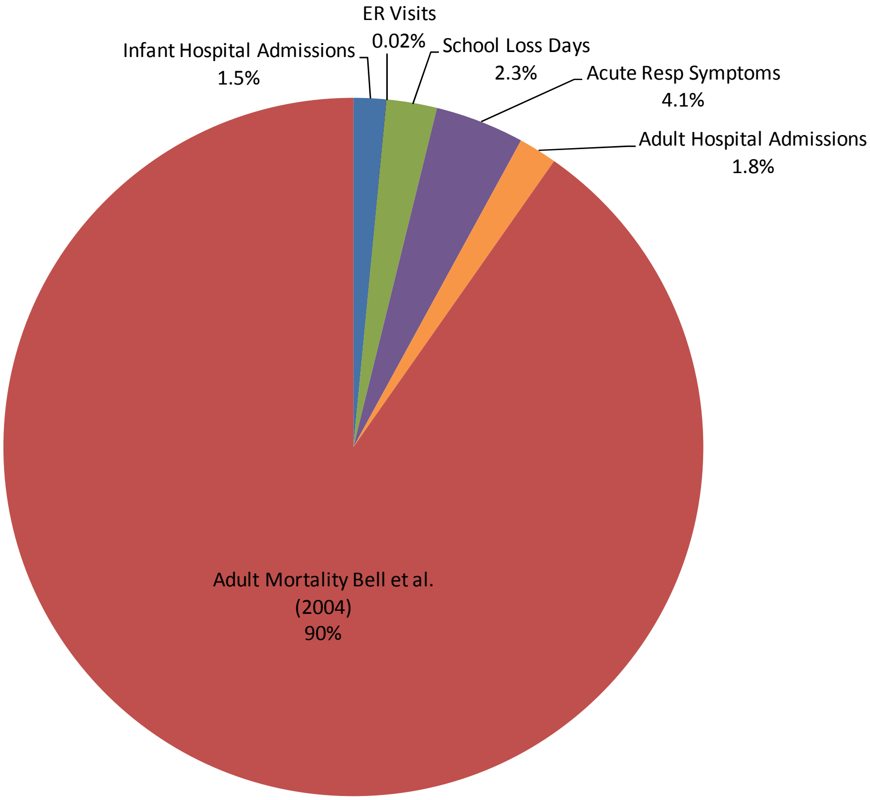
Combined Estimate of Mortality		0.075 ppm			0.070 ppm			0.065 ppm		
NMMAPS	Bell et al. (2004)	$6,400	to	$13,000	$11,000	to	$24,000	$19,000	to	$39,000
	Schwartz	$6,700	to	$13,000	$12,000	to	$25,000	$21,000	to	$41,000
	Huang	$6,800	to	$13,000	$13,000	to	$26,000	$21,000	to	$42,000
Meta-analysis	Bell et al. (2005)	$7,800	to	$14,000	$16,000	to	$29,000	$27,000	to	$48,000
	Ito et al.	$8,600	to	$15,000	$18,000	to	$31,000	$31,000	to	$52,000
	Levy et al.	$8,700	to	$15,000	$18,000	to	$31,000	$32,000	to	$52,000

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] All estimates rounded to two significant digits

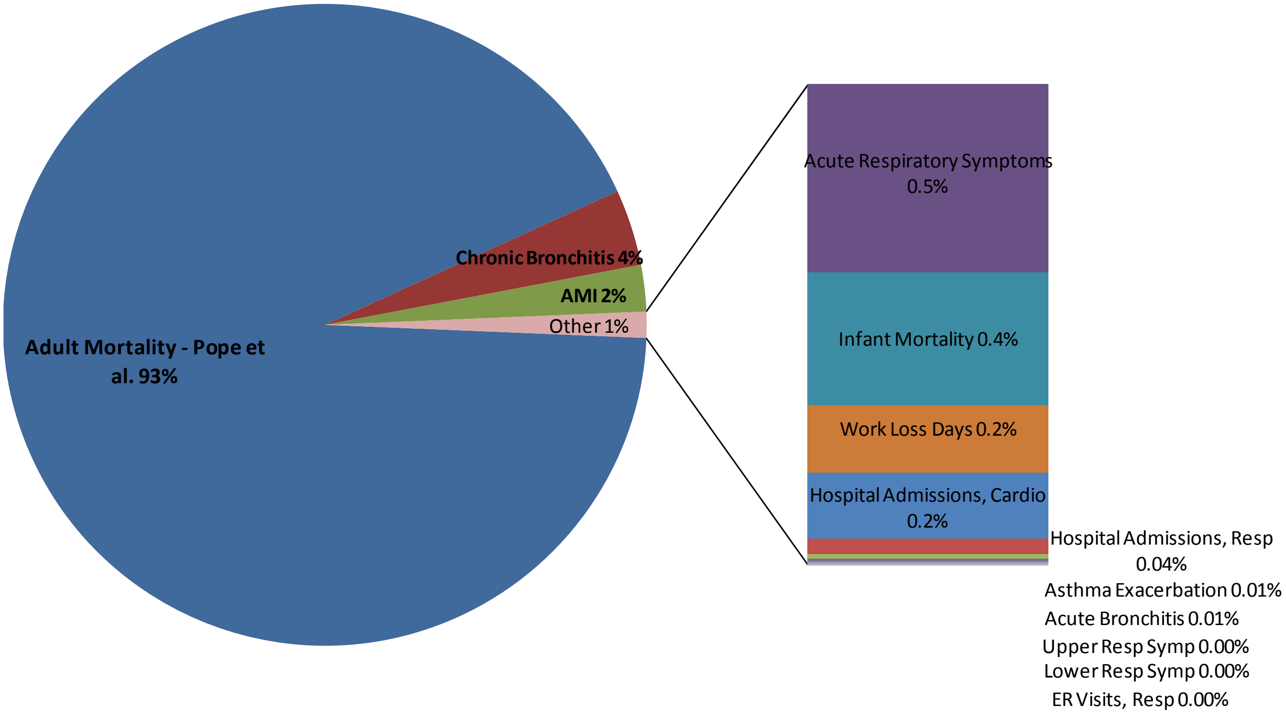
[C] Includes Visibility benefits of $160,000

Figure S3-1: Breakdown of Ozone Health Benefits (using Bell 2004)*



*This pie chart breakdown is illustrative, using the results based on Bell et al. (2004) as an example. Using the Levy et al. (2006) function for premature mortality, the percentage of total monetized benefits due to adult mortality would be 97%.

Figure S3-2: Breakdown of PM$_{2.5}$ Health Benefits (using Pope)*



*This pie chart breakdown is illustrative, using the results based on Pope et al. (2002) as an example. Using the Laden et al. (2006) function for premature mortality, the percentage of total monetized benefits due to adult mortality would be 97%. This chart shows the breakdown using a 3% discount rate, and the results would be similar if a 7% discount rate was used.

Table S3.4: Summary of National Ozone Benefits by Standard Level with 95th percentile confidence intervals (in millions of 2006$)[A, B, C]

Endpoint Group	Author	0.075 ppm Valuation	0.075 ppm Incidence	0.070 ppm Valuation	0.070 ppm Incidence	0.065 ppm Valuation	0.065 ppm Incidence
Infant Hospital Admissions, Respiratory		$11 ($5.7 -- $16)	550 (310 -- 830)	$17 ($8.5 -- $25)	1,700 (960 -- 2,600)	$30 ($15 -- $43)	3,000 (1,700 -- 4,500)
Emergency Room Visits, Respiratory		$0.11 (-$.21 -- $.35)	290 (-310 -- 930)	$0.36 (-$.71 -- $1.2)	990 (-890 -- 3,200)	$0.66 (-$1.3 -- $2.2)	1,800 (-1,600 -- 5,800)
School Loss Days		$17 ($7.5 -- $24)	190,000 (93,000 -- 280,000)	$53 ($23 -- $76)	600,000 (300,000 -- 880,000)	$96 ($42 -- $140)	1,100,000 (550,000 -- 1,600,000)
Acute Respiratory Symptoms		$30 ($12 -- $56)	510,000 (280,000 -- 790,000)	$96 ($37 -- $180)	1,600,000 (910,000 -- 2,500,000)	$170 ($68 -- $320)	2,900,000 (1,700,000 -- 4,500,000)
Hospital Admissions, Respiratory		$13 ($1.7 -- $22)	550 (130 -- 980)	$45 ($5.6 -- $77)	1,900 (550 -- 3,400)	$81 ($11 -- $140)	3,400 (1,000 -- 6,100)
Mortality	Bell et al. 2004	$660 ($54 -- $2,000)	74 (36 -- 120)	$2,200 ($180 -- $6,600)	250 (130 -- 410)	$4,000 ($330 -- $12,000)	450 (240 -- 730)
Mortality	Schwartz	$1,000 ($82 -- $3,000)	110 (54 -- 190)	$3,400 ($270 -- $10,000)	380 (190 -- 630)	$6,200 ($500 -- $19,000)	700 (350 -- 1,100)
Mortality	Huang	$1,100 ($95 -- $3,300)	130 (66 -- 200)	$3,800 ($320 -- $11,000)	420 (230 -- 670)	$6,800 ($580 -- $20,000)	770 (420 -- 1,200)
Mortality	Bell et al. 2005	$2,000 ($190 -- $6,100)	240 (140 -- 350)	$7,000 ($630 -- $21,000)	800 (490 -- 1,200)	$10,000 ($1,100 -- $37,000)	1,500 (910 -- 2,200)
Mortality	Ito et al.	$2,900 ($280 -- $8,200)	330 (230 -- 450)	$9,900 ($930 -- $28,000)	1,100 (790 -- 1,500)	$18,000 ($1,700 -- $50,000)	2,000 (1,400 -- 2,800)
Mortality	Levy et al.	$3,000 ($280 -- $8,200)	340 (260 -- 430)	$10,000 ($930 -- $28,000)	1,100 (870 -- 1,500)	$18,000 ($1,700 -- $50,000)	2,100 (1,600 -- 2,600)

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Confidence intervals are not available for PM co-benefits because of methodological limitations when using benefit-per-ton estimates.

[C] All estimates rounded to two significant digits

Table S3.5: Summary of National Ozone Benefits and $PM_{2.5}$ Co-Benefits by Standard Level (in millions of 2006$ at a 3% discount rate)[A, B, C]

	Endpoint Group	Author	0.075 ppm Valuation	0.075 ppm Incidence	0.070 ppm Valuation	0.070 ppm Incidence	0.065 ppm Valuation	0.065 ppm Incidence
Ozone	Infant Hospital Admissions, Respiratory		$11	550	$17	1,700	$30	3,000
	Emergency Room Visits, Respiratory		$0.11	290	$0.36	990	$0.66	1,800
	School Loss Days		$17	190,000	$53	600,000	$96	1,100,000
	Acute Respiratory Symptoms		$30	510,000	$96	1,600,000	$170	2,900,000
	Hospital Admissions, Respiratory		$13	550	$45	1,900	$81	3,400
	Mortality	Bell et al. (2004)	$660	74	$2,200	250	$4,000	450
	Mortality	Schwartz	$1,000	110	$3,400	380	$6,200	700
	Mortality	Huang	$1,100	130	$3,800	420	$6,800	770
	Mortality	Bell et al. (2005)	$2,100	240	$7,100	800	$13,000	1,500
	Mortality	Ito et al.	$2,900	330	$9,900	1,100	$18,000	2,000
	Mortality	Levy et al.	$3,000	340	$10,000	1,100	$18,000	2,100
$PM_{2.5}$	Chronic Bronchitis		$230	470	$430	880	$700	1,400
	Acute Myocardial Infarction		$140	1,300	$240	2,200	$380	3,500
	Hospital Admissions, Respiratory		$2.5	180	$4.3	310	$6.8	490
	Hospital Admissions, Cardiovascular		$11	390	$18	670	$29	1,000
	Emergency Room Visits, Respiratory		$0.22	590	$0.39	1,100	$0.63	1,700
	Acute Bronchitis		$0.08	1,100	$0.15	2,100	$0.25	3,400
	Work Loss Days		$11	88,000	$20	170,000	$34	270,000
	Asthma Exacerbation		$0.64	12,000	$1.2	23,000	$2.0	38,000
	Acute Respiratory Symptoms		$31	520,000	$58	980,000	$95	1,600,000
	Lower Respiratory Symptoms		$0.24	13,000	$0.45	25,000	$0.75	41,000
	Upper Respiratory Symptoms		$0.29	9,900	$0.54	19,000	$0.89	31,000
	Infant Mortality		$22	3	$44	5	$73	8
	Mortality	Pope et al	$5,500	690	$10,000	1,200	$16,000	2,000
	Mortality	Laden et al	$14,000	1,800	$26,000	3,200	$41,000	5,100
	Mortality	Expert K	$1,900	230	$3,500	430	$5,700	700
	Mortality	Expert E	$19,000	2,300	$34,000	4,200	$55,000	6,800

[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins

[B] Does not include confidence intervals

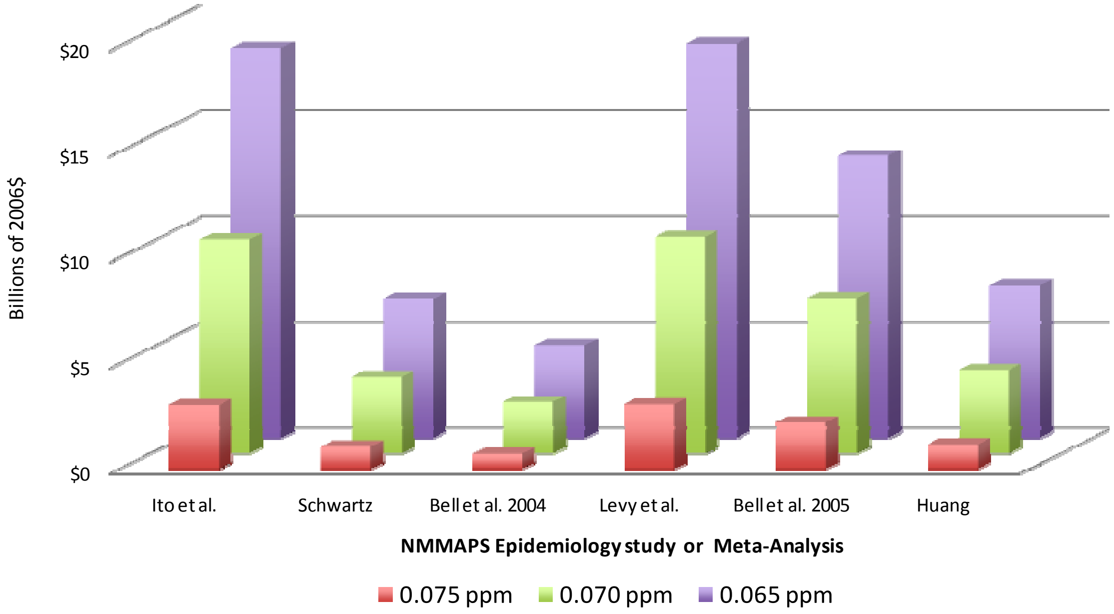
[C] All estimates rounded to two significant digits

Table S3.6: Summary of National Ozone Benefits and $PM_{2.5}$ Co-Benefits by Standard Level (in millions of 2006$ at a 7% discount rate)[A, B, C]

	Endpoint Group	Author	0.075 ppm Valuation	0.075 ppm Incidence	0.070 ppm Valuation	0.070 ppm Incidence	0.065 ppm Valuation	0.065 ppm Incidence
Ozone	Infant Hospital Admissions, Respiratory		$11	550	$17	1,700	$30	3,000
	Emergency Room Visits, Respiratory		$0.11	290	$0.36	990	$0.66	1,800
	School Loss Days		$17	190,000	$53	600,000	$96	1,100,000
	Acute Respiratory Symptoms		$30	510,000	$96	1,600,000	$170	2,900,000
	Hospital Admissions, Respiratory		$13	550	$45	1,900	$81	3,400
	Mortality	Bell et al. (2004)	$660	74	$2,200	250	$4,000	450
	Mortality	Schwartz	$1,000	110	$3,400	380	$6,200	700
	Mortality	Huang	$1,100	130	$3,800	420	$6,800	770
	Mortality	Bell et al. (2005)	$2,100	240	$7,100	800	$13,000	1,500
	Mortality	Ito et al.	$2,900	330	$9,900	1,100	$18,000	2,000
	Mortality	Levy et al.	$3,000	340	$10,000	1,100	$18,000	2,100
$PM_{2.5}$	Chronic Bronchitis		$230	470	$430	880	$700	1,400
	Acute Myocardial Infarction		$140	1,300	$240	2,200	$380	3,500
	Hospital Admissions, Respiratory		$2.5	180	$4.3	310	$6.8	490
	Hospital Admissions, Cardiovascular		$11	390	$18	670	$29	1,000
	Emergency Room Visits, Respiratory		$0.22	590	$0.39	1,100	$0.63	1,700
	Acute Bronchitis		$0.08	1,100	$0.15	2,100	$0.25	3,400
	Work Loss Days		$11	88,000	$20	170,000	$34	270,000
	Asthma Exacerbation		$0.64	12,000	$1.2	23,000	$2.0	38,000
	Acute Respiratory Symptoms		$31	520,000	$58	980,000	$95	1,600,000
	Lower Respiratory Symptoms		$0.24	13,000	$0.45	25,000	$0.75	41,000
	Upper Respiratory Symptoms		$0.29	9,900	$0.54	19,000	$0.89	31,000
	Infant Mortality		$22	3	$44	5	$73	8
	Mortality	Pope et al	$5,000	690	$9,000	1,200	$14,000	2,000
	Mortality	Laden et al	$13,000	1,800	$23,000	3,200	$37,000	5,100
	Mortality	Expert K	$1,700	230	$3,100	430	$5,100	700
	Mortality	Expert E	$17,000	2,300	$31,000	4,200	$49,000	6,800

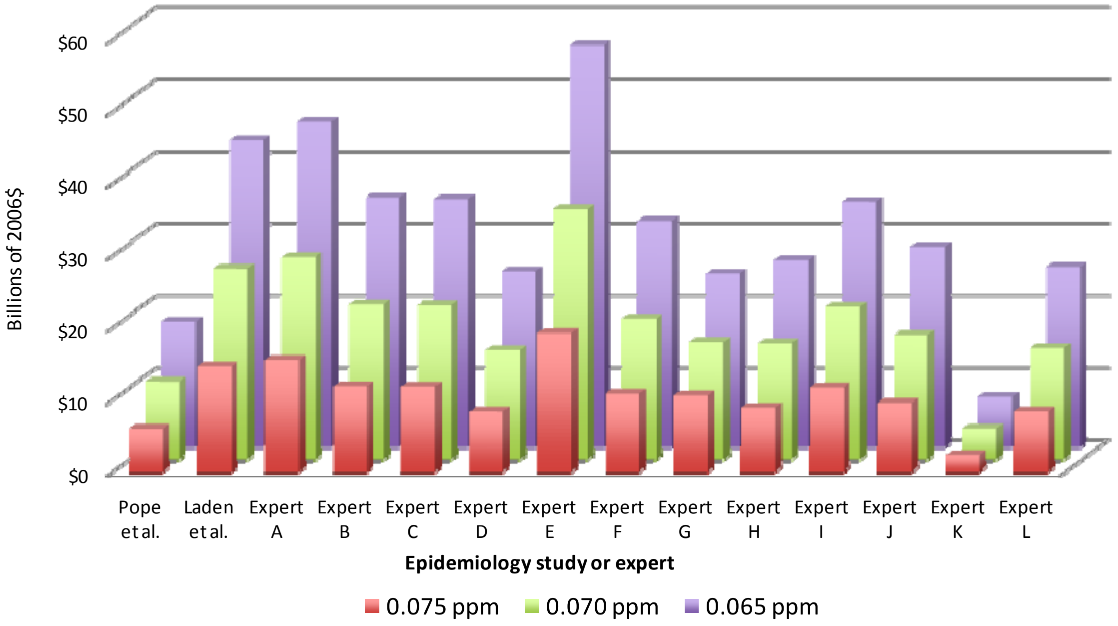
[A] Does not reflect estimates for the San Joaquin and South Coast Air Basins
[B] Does not include confidence intervals
[C] All estimates rounded to two significant digits

Figure S3.3: Ozone benefits for Alternate Standard Levels*



*This graph shows the estimated ozone benefits in 2020 using three NMMAPS-based epidemiology studies and three meta-analyses. The results shown are not the direct results from the studies; rather, the estimates are based in part on the concentration-response function provided in those studies. Because all ozone-related health effects are short-term, the discount rate does not affect the results.

Figure S3.4: $PM_{2.5}$ co-benefits for Alternate Standard Levels*



*This graph shows the estimated $PM_{2.5}$ co-benefits in 2020 using the no-threshold model at discount rates of 3% using effect coefficients using the Pope et al. study and the Laden et al study, as well as 12 effect coefficients derived from EPA's expert elicitation on PM mortality. The results shown are not the direct results from the studies or expert elicitation; rather, the estimates are based in part on the concentration-response function provided in those studies. Results using a 7% discount rate would be similar, but approximately 9% lower.

Figure S3.5: Breakdown of total monetized benefits for Alternate Standard Levels (Low)

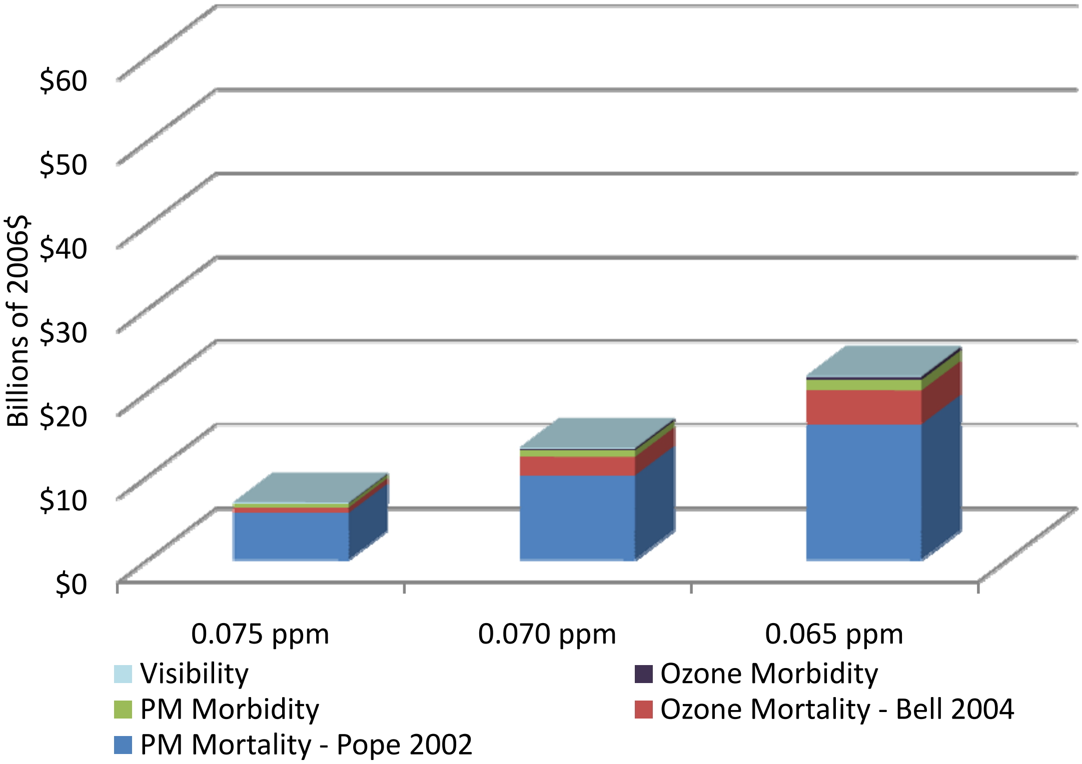


Figure S3.6: Breakdown of total monetized benefits for Alternate Standard Levels (High)

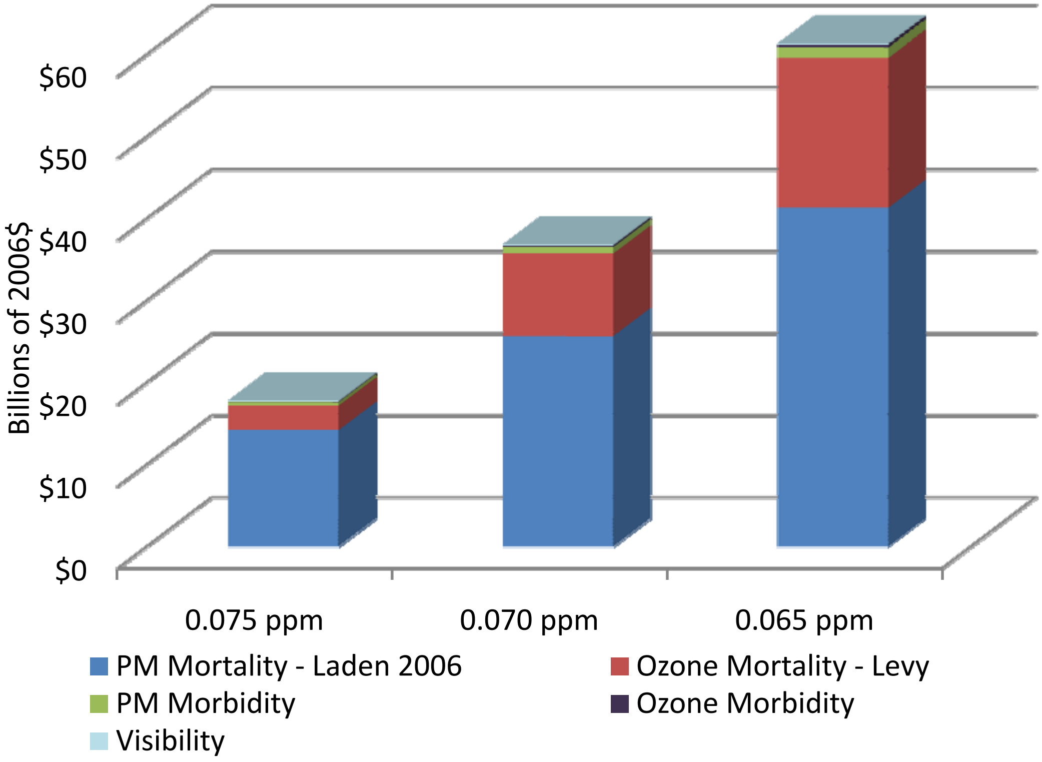
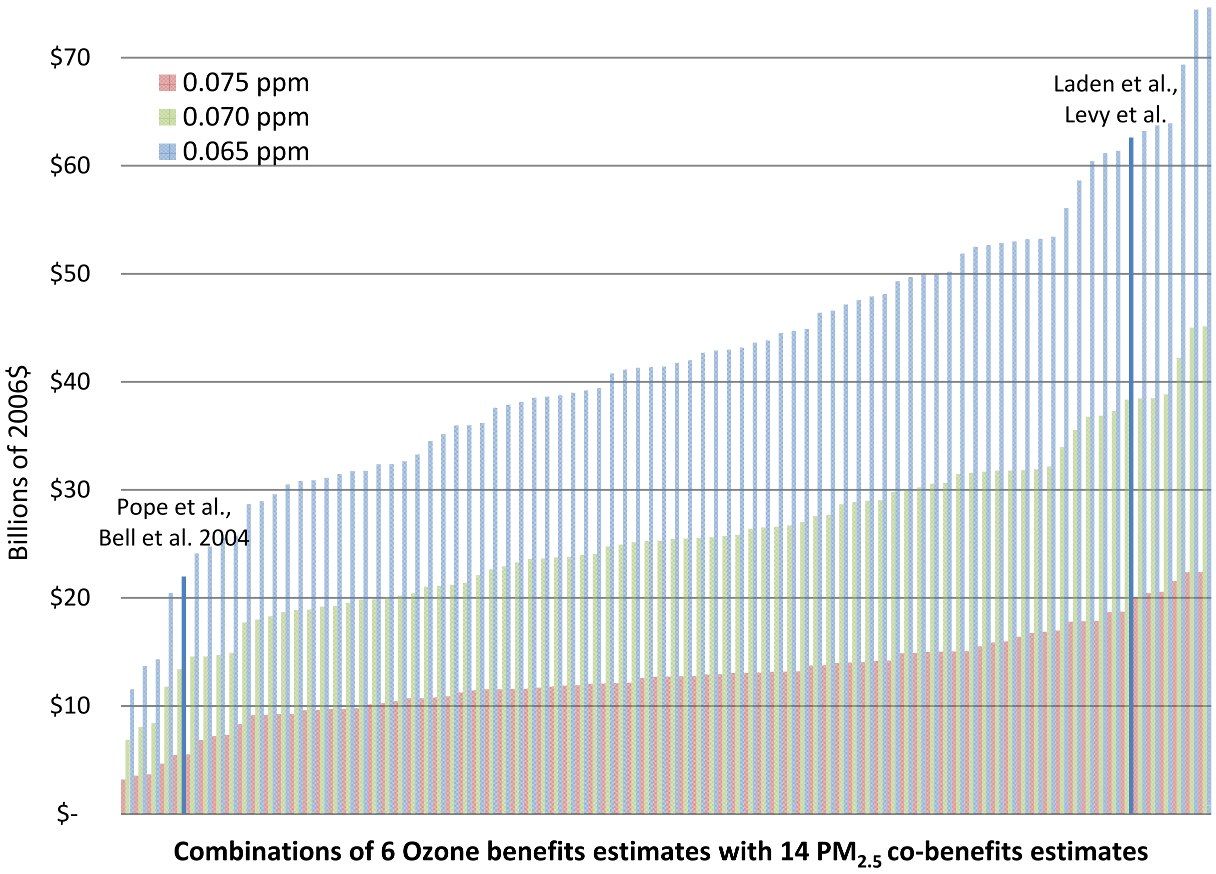


Figure S3.7: Total Monetized Benefits for Alternate Standard Levels*



*This graph shows the estimated total monetized benefits in 2020 using the no-threshold model at discount rates of 3% using effect coefficients derived from the 6 ozone mortality studies and PM co-benefits estimates using the Pope et al. study and the Laden et al study, as well as 12 effect coefficients derived from EPA's expert elicitation on PM mortality. The highlighted results represent the combined estimates from Bell et al. (2004) with Pope et al. (2002) and Levy (2005) with Laden et al. (2006). The results shown are not the direct results from the studies or expert elicitation; rather, the estimates are based in part on the concentration-response function provided in those studies. PM co-benefit results using a 7% discount rate would be similar, but approximately 9% lower.

In 2008, the National Research Council (NRC) evaluated the EPA's approach to estimating ozone-related mortality benefits. Among other recommendation, in its report the NRC indicated that "EPA should consider placing greater emphasis on reporting decrease in age-specific death rates and increases in life expectancy…" (NRC, 2008). As a first step in implementing this recommendation, below for two of the three scenarios, we present changes in the percentage of total cause-specific mortality attributable to ozone and the change in the number of life years.[5] Table 7 summarizes the estimated number of life years gained resulting from simulated attainment with the 0.065 ppm and 0.070 ppm standard alternatives. To

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[5] Here we omit the results for the 0.075 ppm alternative. We estimated the benefits of attaining this alternative through an interpolation approach that made subsequent estimation of life years and changes in death rates technically challenging.

simplify this presentation we include results based on the estimates of ozone mortality reported in Levy et al. (2005) and Bell et al. (2004), which provide upper and lower-bound estimates, respectively.

Table S3.7: Estimated Reduction in Ozone-Related Premature Mortality in Terms of Life Years Gained from Increases in Life Expectancy

	Bell et al. (2004) mortality estimate		*Levy et al. (2005) mortality estimate*	
Age Range	0.070 ppm	0.065 ppm	0.070 ppm	0.065 ppm
25-29	75 (32—120)	130 (58—210)	660 (780—830)	1,200 (850—1,500)
30-34	66 (28—100)	120 (51—180)	580 (420—740)	1,000 (750—1,300)
35-44	260 (110—410)	460 (200—730)	1,600 (1,200—2,000)	2,800 (2,000—3,500)
45-54	520 (220—830)	930 (400—1,500)	2,600 (1,900—3,300)	4,500 (3,300—5,700)
55-64	1,000 (440—1,600)	1,800 (780—2,800)	4,600 (3,400—5,900)	8,100 (5,900—10,000)
65-74	1,200 (500—1,900)	2,100 (900—3,300)	5,200 (3,800—6,600)	9,100 (6,700—12,000)
75-84	810 (340—1,300)	1,400 (620—2,200)	3,500 (2,600—4,500)	6,200 (4,600—7,900)
85-99	400 (170—630)	720 (310—1,100)	1,800 (1,300—2,200)	3,100 (2,300—4,000)

Table S3.8 summarizes the percentage of total mortality attributable to ozone. As above, we include estimates based on the Bell et al. (2004) and Levy et al. (2005) risk coefficients.

Table S3.8: Percentage of Total Mortality Attributable to Ozone

	Bell et al. (2004) mortality estimate		*Levy et al. (2005) mortality estimate*	
Age Range	0.070 ppm	0.065 ppm	0.070 ppm	0.065 ppm
25-29	0.030%	0.054%	0.126%	0.224%
30-34	0.029%	0.052%	0.123%	0.217%
35-44	0.029%	0.051%	0.123%	0.217%
45-54	0.030%	0.052%	0.127%	0.224%
55-64	0.028%	0.050%	0.122%	0.212%
65-74	0.027%	0.047%	0.114%	0.200%
75-84	0.026%	0.046%	0.112%	0.197%
85-99	0.027%	0.048%	0.115%	0.206%

S3.4 Comparison of results to previous results in 2008 Ozone NAAQS RIA

The overall effect of incorporating the array of methodological changes was to increase the estimated benefits of attaining alternate ozone standards estimates presented in the 2008 Ozone NAAQS RIA. In general, the key update that had the largest effect on the valuation and the incidence results is removing the threshold from the PM concentration-response functions. Tables 9 and 10 show the total monetized benefits, costs, and net benefits for the 2008 Ozone RIA analysis and this updated analysis, respectively. Figure 6 shows a comparison of the range of net benefits estimates in this updated analysis compared to the net benefits presented in the 2008 Ozone NAAQS RIA.[6]

Table S3.9: Total Monetized Costs with Ozone Benefits and $PM_{2.5}$ Co-Benefits in 2020 (in Billions of 2006$) * 2008 RIA

	Ozone Mortality Function	Reference	Total Benefits **		Total Costs ***	Net Benefits	
			3%	7%	7%	3%	7%
0.075 ppm	NMMAPS and Multi-city	Bell et al. 2004	$4.4 to $8.5	$4.1 to $7.7	$7.6 to $8.8	$-4.4 to $0.9	$-4.7 to $0.1
		Schwartz 2005	N/A	N/A	N/A	N/A	N/A
		Huang 2005	N/A	N/A	N/A	N/A	N/A
	Meta-analysis	Bell et al. 2005	$5.6 to $9.7	$5.3 to $9.0	$7.6 to $8.8	$-3.2 to $2.1	$-3.5 to $1.4
		Ito et al. 2005	$6.3 to $10	$5.9 to $9.6	$7.6 to $8.8	$-2.5 to $2.7	$-2.9 to $2.0
		Levy et al. 2005	$6.3 to $10	$6.0 to $9.7	$7.6 to $8.8	$-2.5 to $2.8	$-2.8 to $2.1
0.070 ppm	NMMAPS and multi-city	Bell et al. 2004	$8.8 to $16	$8.2 to $15	$19 to $25	$-16 to $-2.8	$-17 to $4.1
		Schwartz 2005	N/A	N/A	N/A	N/A	N/A
		Huang 2005	N/A	N/A	N/A	N/A	N/A
	Meta-analysis	Bell et al. 2005	$13 to $21	$13 to $19	$19 to $25	$-12 to $1.5	$-12 to $0.2
		Ito et al. 2005	$15 to $23	$15 to $21	$19 to $25	$-9.6 to $3.8	$-10 to $2.5
		Levy et al. 2005	$16 to $23	$15 to $22	$19 to $25	$-9.3 to 4.1	$9.9 to $2.7
0.065 ppm	NMMAPS and multi-city	Bell et al. 2004	$15 to $27	$14 to $24	$32 to $44	$-29 to $-5.4	$-30 to $-7.5
		Schwartz 2005	N/A	N/A	N/A	N/A	N/A
		Huang 2005	N/A	N/A	N/A	N/A	N/A
	Meta-analysis	Bell et al. 2005	$22 to $34	$21 to $32	$32 to $44	$-22 to $2.4	$-23 to $0.3
		Ito et al. 2005	$27 to $39	$26 to $36	$32 to $44	$-17 to $6.6	$-18 to $4.4
		Levy et al. 2005	$27 to $39	$26 to $37	$32 to $44	$-17 to $7.0	$-18 to $4.9

*All estimates rounded to two significant figures. As such, they may not sum across columns. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California.

**Includes ozone benefits, and $PM_{2.5}$ co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to estimates from the $PM_{2.5}$ premature mortality functions from Pope et al. and Laden et al. Tables exclude unquantified and nonmonetized benefits.

***Range reflects lower and upper bound cost estimates. Data for calculating costs at a 3% discount rate was not available for all sectors, and therefore total annualized costs at 3% are not presented here. Additionally, these estimates assume a particular trajectory of aggressive technological change. An alternative storyline might hypothesize a much less optimistic technological trajectory, with increased costs, or with decreased benefits in 2020 due to a later attainment date.

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[6] Net benefits are total monetized benefits minus total monetized costs. Total monetized benefits include ozone health benefits, $PM_{2.5}$ health co-benefits, visibility benefits, but not other unquantified benefit categories.

Table S3.10: Total Monetized Costs with Ozone Benefits and $PM_{2.5}$ Co-Benefits in 2020 (in Billions of 2006$) * Updated Analysis

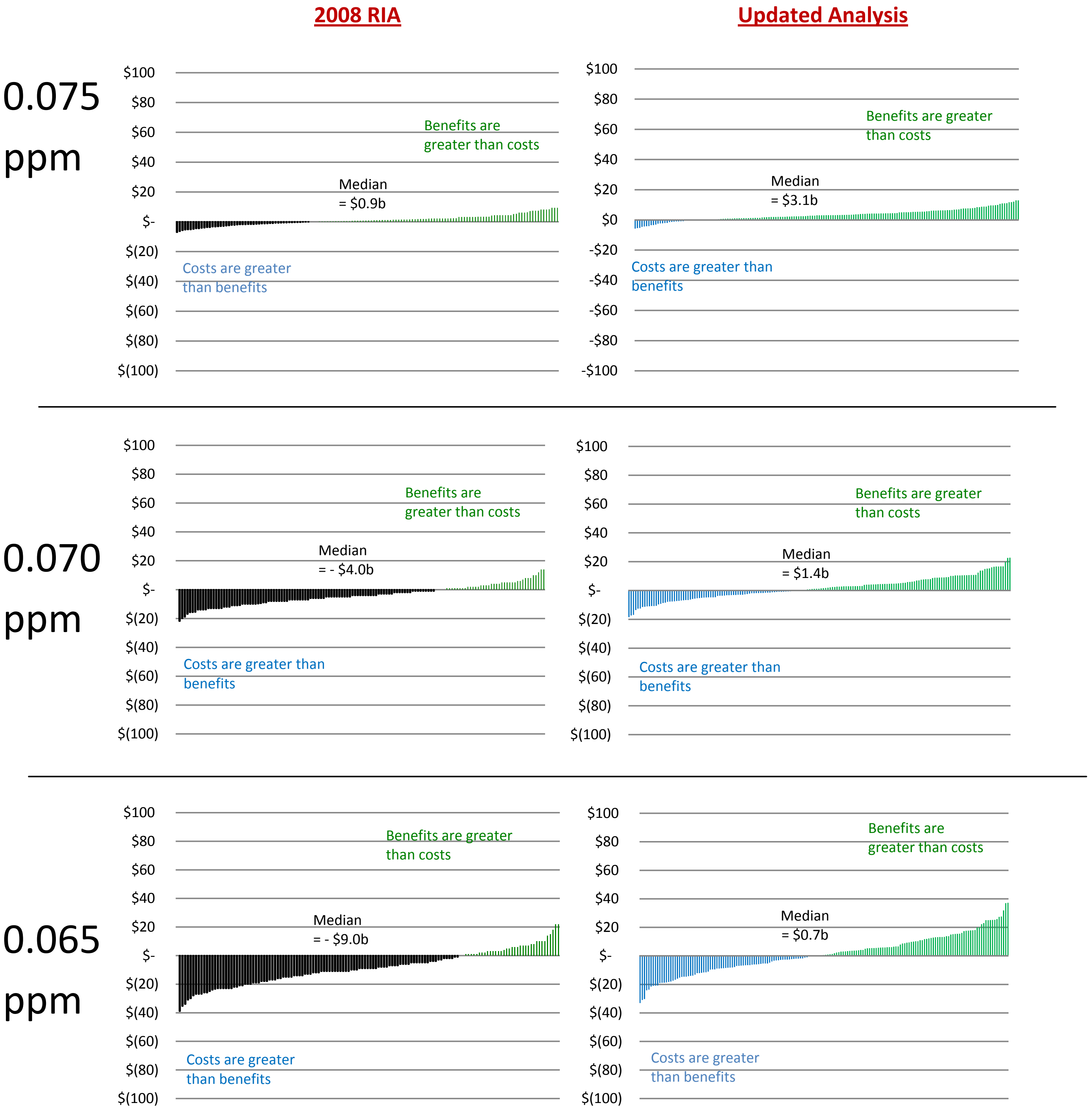
Ozone Mortality Function		Reference	Total Benefits **		Total Costs ***	Net Benefits	
			3%	7%	7%	3%	7%
0.075 ppm	NMMAPS and multi-city	Bell et al. 2004	$6.9 to $15	$6.4 to $13	$7.6 to $8.8	$-1.9 to $7.4	$-2.4 to $5.4
		Schwartz 2005	$7.2 to $16	$6.8 to $13	$7.6 to $8.8	$-1.6 to $8.4	$-2.1 to $5.4
		Huang 2005	$7.3 to $16	$6.9 to $13	$7.6 to $8.8	$-1.5 to $8.4	$-2.0 to $5.4
	Meta-analysis	Bell et al. 2005	$8.3 to $17	$7.9 to $14	$7.6 to $8.8	$-0.50 to $9.4	$-1.0 to $6.4
		Ito et al. 2005	$9.1 to $18	$8.7 to $15	$7.6 to $8.8	$0.30 to $10	$-0.20 to $7.4
		Levy et al. 2005	$9.2 to $18	$8.8 to $15	$7.6 to $8.8	$0.40 to $10	$-0.10 to $7.4
0.070 ppm	NMMAPS and multi-city	Bell et al. 2004	$13 to $29	$11 to $24	$19 to $25	$-12 to $10	$-14 to $5.0
		Schwartz 2005	$15 to $30	$12 to $25	$19 to $25	$-10 to $11	$-13 to $6.0
		Huang 2005	$15 to $30	$13 to $26	$19 to $25	$-10 to $11	$-12 to $7.0
	Meta-analysis	Bell et al. 2005	$18 to $34	$16 to $29	$19 to $25	$-7.0 to $15	$-9.0 to $10
		Ito et al. 2005	$21 to $37	$18 to $31	$19 to $25	$-4.0 to $18	$-6.0 to $12
		Levy et al. 2005	$21 to $37	$18 to $31	$19 to $25	$-4.0 to $18	$-6.0 to $12
0.065 ppm	NMMAPS and multi-city	Bell et al. 2004	$22 to $47	$19 to $40	$32 to $44	$-22 to $15	$-25 to $7.0
		Schwartz 2005	$24 to $49	$21 to $42	$32 to $44	$-20 to $17	$-23 to $9.0
		Huang 2005	$25 to $50	$22 to $42	$32 to $44	$-19 to $18	$-23 to $10
	Meta-analysis	Bell et al. 2005	$31 to $56	$27 to $48	$32 to $44	$-13 to $24	$-17 to $16
		Ito et al. 2005	$36 to $61	$32 to $53	$32 to $44	$-8.0 to $29	$-13 to $20
		Levy et al. 2005	$36 to $61	$32 to $53	$32 to $44	$-7.0 to $29	$-12 to $20

*All estimates rounded to two significant figures. As such, they may not sum across columns. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California.

**Includes ozone benefits, and $PM_{2.5}$ co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to estimates from the $PM_{2.5}$ premature mortality functions from Pope et al. and Laden et al. Tables exclude unquantified and nonmonetized benefits.

***Range reflects lower and upper bound cost estimates. Data for calculating costs at a 3% discount rate was not available for all sectors, and therefore total annualized costs at 3% are not presented here. Additionally, these estimates assume a particular trajectory of aggressive technological change. An alternative storyline might hypothesize a much less optimistic technological trajectory, with increased costs, or with decreased benefits in 2020 due to a later attainment date.

Figure S3.6: Comparison of Net Benefits in Updated Analysis to 2008 Ozone NAAQS RIA*



These graphs shows all combinations of the 6 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. These combinations do not represent a distribution.

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Section 4: Secondary Ozone NAAQS Evaluation

Synopsis

Exposure to ozone has been associated with a wide array of vegetation and ecosystem effects, including those that damage or impair the intended use of the plant or ecosystem. Such effects are considered adverse to the public welfare. Using a cumulative seasonal secondary standard (i.e., W126), we evaluated alternate standard levels at 7, 15, and 21 ppm-hours. EPA has not promulgated a distinct secondary NAAQS that is not identical to the primary NAAQS since the original SO_2 regulation in 1970. Therefore, EPA has not previously conducted an analysis of the costs and benefits of attaining a secondary NAAQS, which is an exceptionally complex task. Complexities include determining which attainment year to analyze, whether to include emission reductions that occur as a result of implementing the primary NAAQS in the baseline for the secondary analysis, whether it is feasible to extrapolate beyond currently monitored counties, how to determine the amount of additional reductions needed to attain a secondary standard, whether nonattainment areas would include only areas that violate an air quality standard or also nearby areas that contribute to a violation, whether secondary standard nonattainment would require classification (as marginal, moderate, serious, etc), and whether the traditional nonattainment-area planning perspective would be successful for a secondary ozone standard. Because of these complexities as well as limited time and resources within the expedited schedule, we are limited in our ability to quantify the costs and benefits of attaining a separate secondary NAAQS for ozone for this proposal. However, we have incorporated a limited, qualitative assessment in this evaluation, including indicating which counties would have an additional burden to meet a secondary standard beyond the primary standard, and the qualitative benefits of reducing ozone exposure on forests, crops, and urban ornamentals.

S4.1 Background

Exposure to ozone has been associated with a wide array of vegetation and ecosystem effects in the published literature (U.S. EPA, 2006). These effects include those that damage or impair the intended use of the plant or ecosystem. Such effects are considered adverse to the public welfare and can include reduced growth and/or biomass production in sensitive plant species, including forest trees, reduced crop yields, visible foliar injury, reduced plant vigor (e.g., increased susceptibility to harsh weather, disease, insect pest infestation, and competition), species composition shift, and changes in ecosystems and associated ecosystem services.

Vegetation effects research has shown that seasonal air quality indices that cumulate peak-weighted hourly ozone concentrations are the best candidates for relating exposure to plant growth effects (U.S. EPA, 2006). Based on this research, the Ozone Staff Paper (hereafter, "the Staff Paper") concluded that the cumulative, seasonal index referred to as "W126" is the most appropriate index for relating vegetation response to ambient ozone exposures (U.S. EPA, 2007). Based on additional conclusions regarding appropriate diurnal and seasonal exposure windows, the Staff Paper recommended a cumulative seasonal secondary standard, expressed as an index of the annual sum of weighted hourly concentrations (using the W126 form), set at a level in the range of 7 to 21 ppm-hours. The index would be cumulated over the 12-hour daylight window (8:00 a.m. to 8:00 p.m.) during the consecutive 3-month period during the ozone season with the maximum index value (hereafter, referred to as the 12-hour, maximum 3-month W126). After reviewing the recommendations in the Staff Paper, EPA's Clean Air Scientific Advisory committee (CASAC) agreed with the form of the secondary standard, but instead recommended a range of 7 to 15 ppm-hours (U.S. EPA-SAB, 2007).

S4.2 Air Quality Analysis

In this analysis, we considered the extent to which there is overlap between county-level air quality measured in terms of the 8-hour average form of the current secondary standard and that measured in terms of the 12-hour W126, alternative cumulative, seasonal form. These comparisons used 3-year averages, as well as using the 3-year average current 8-hour form and the annual W126 county-level air quality values using monitoring data collected from 2006 to 2008. These results are listed in Table S4-1, and the counties are mapped in Figures S4-1 through S4-3. When individual years are compared (e.g., using the annual W126 level) significant variability occurs between years in the degree of overlap between the numbers of counties meeting various levels of the 8-hour and W126 forms. Therefore, the degree of protection for vegetation provided by an 8-hour average form in terms of cumulative, seasonal exposures would not be expected to be consistent on a year-to-year basis.

Table S4-1: Number of Counties Exceeding Various W126 Levels When Meeting Various Levels of the 8-Hr Standard in 2006 to 2008*

	Levels of 12-hr W126 (ppm-hrs)		
8-Hour Level Met	**>21**	**>15**	**>7**
0.075 ppm	3	27	250
	(3 - 16)	(21 - 76)	(180 - 272)
0.070 ppm	1	9	84
	(1 - 5)	(7 - 24)	(54 - 114)
0.065 ppm	1	4	29
	(1 - 2)	(3 - 10)	(21 - 50)
0.060 ppm/0.055 ppm	1	4	25
	(1 - 2)	(3 - 10)	(18 - 34)

* The top value in each box represents the number of counties meeting the 8-hour level based on 2006-2008 data but exceeding the W126 level based on a 3-year W126 average for the 2006-2008 period. The numbers in parentheses indicate the range in the number of counties that exceed the W126 level on an annual basis in one of the three years—2006, 2007, 2008– based on 1-year W126 values. This range indicates significant interannual variability.

Figure S4-1: Counties exceeding a W126 Level of 21ppm-hrs (based on 2006-2008 monitoring data)

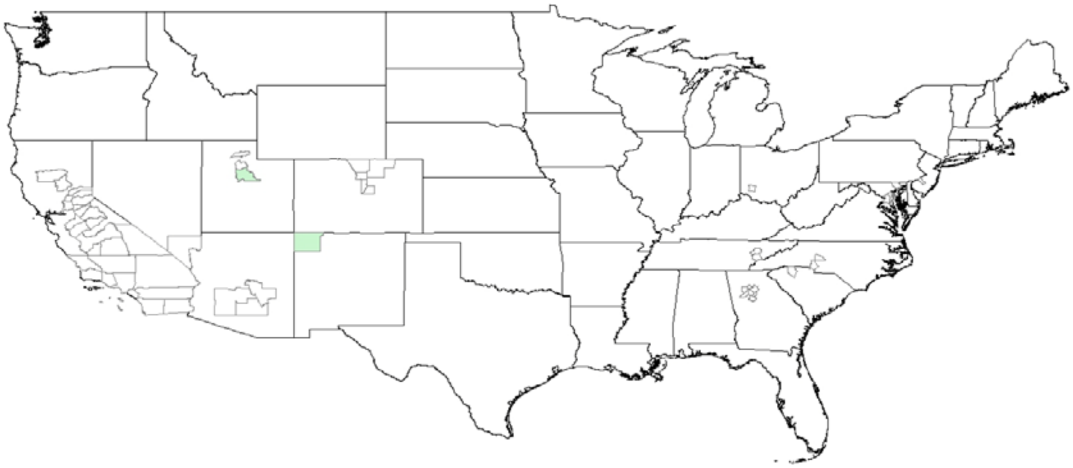


Figure S4-2: Counties exceeding a W126 Level of 15ppm-hrs (based on 2006-2008 monitoring data)

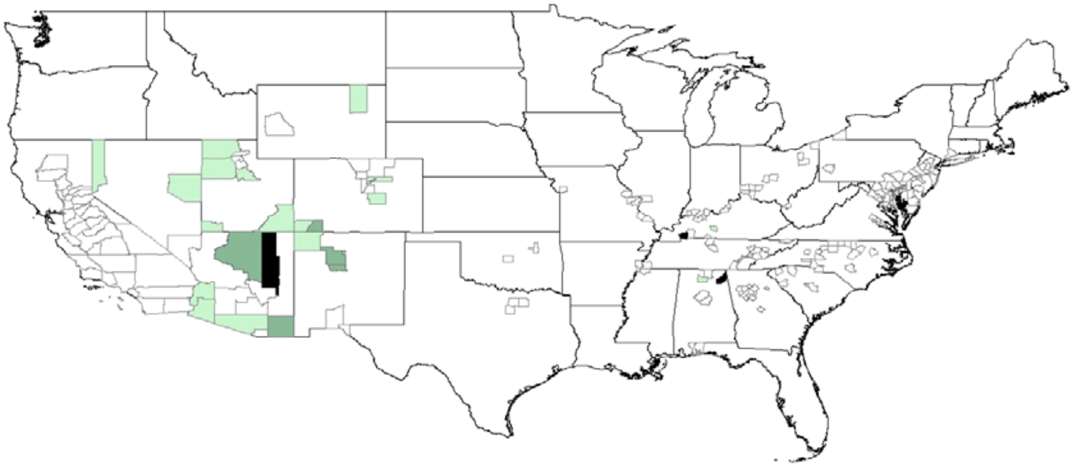
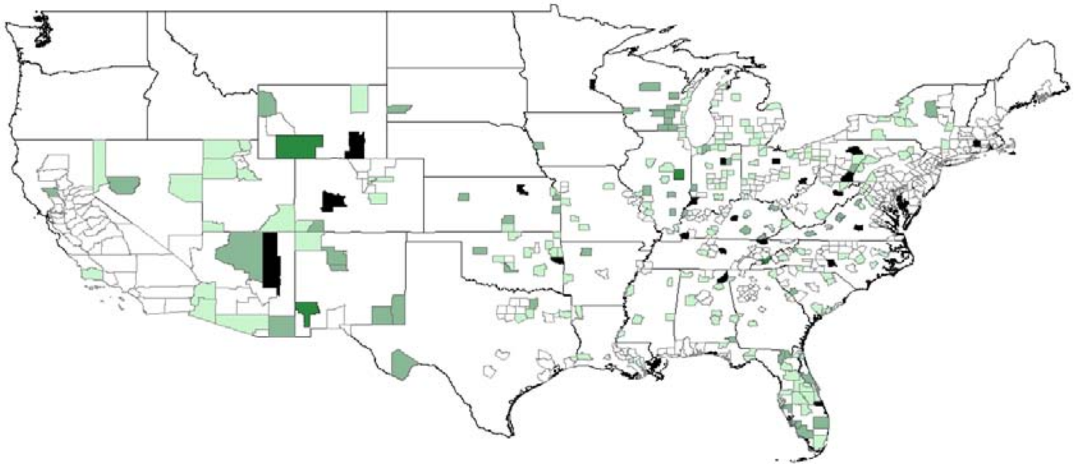


Figure S4-3: Counties exceeding a W126 Level of 7ppm-hrs (based on 2006-2008 monitoring data)



	Meets 0.055 ppm	Meets 0.060 ppm	Meets 0.065 ppm	Meets 0.070 ppm	Meets 0.075 ppm	Exceeds 0.075 ppm
Exceeds 21 ppm-hrs (Figure 1)	1 county (1 total)	-- (1 total)	-- (1 total)	-- (1 total)	+2 counties (3 total)	
Exceeds 15 ppm-hrs (Figure 2)	4 counties (4 total)	-- (4 total)	-- (4 total)	+5 counties (9 total)	+22 counties (27 total)	
Exceeds 7 ppm-hrs (Figure 3)	25 counties (25 total)	-- (25 total)	+4 counties (29 total)	+55 counties (84 total)	+166 counties (250 total)	

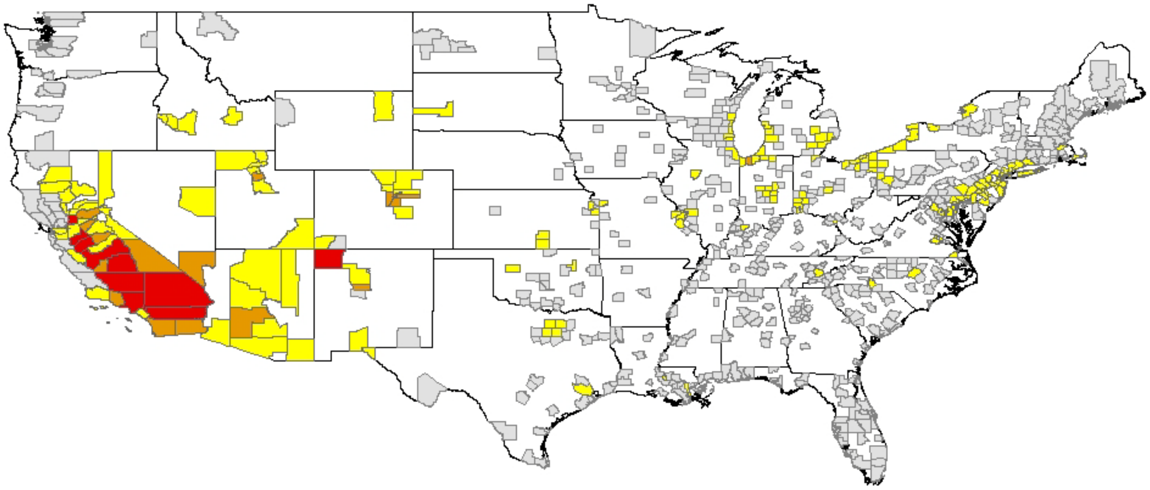
In this analysis, we also projected the W126 levels in 2020 that would result from the modeled control strategy developed as part of the analysis of the primary standard, shown in Figure S4-4. The modeling methodology used to project W126 levels into the future utilizes the same approach as used to project design values of the primary standard, as described in EPA modeling guidance (U.S. EPA, 2007). Essentially, the relative response of the model between the 2020 modeled control strategy and a 2002 base case simulation was paired with ambient values of W126 consistent with the 2002 base. Additionally, EPA assessed the number of counties that are projected to attain the various primary standards in 2020 but would still exceed the various threshold W126 levels. These data are listed in Table S4- 2, and mapped in Figures S4-5 through S4-7. Because this projection approach is prefaced on ambient data, projections can only be made for counties with ozone monitoring data for the base period. As a result, Table S4-2 and the associated figures may not capture other, currently unmonitored, locations. Based on the current analysis, at all alternate standard levels evaluated in 2020, only one county would meet the primary standards but exceed 21 ppm-hours.

Table S4-2: Number of Counties Projected to Exceed Various W126 Levels While Meeting Various Levels of the Primary Standard in the Control Strategy in 2020 [a]

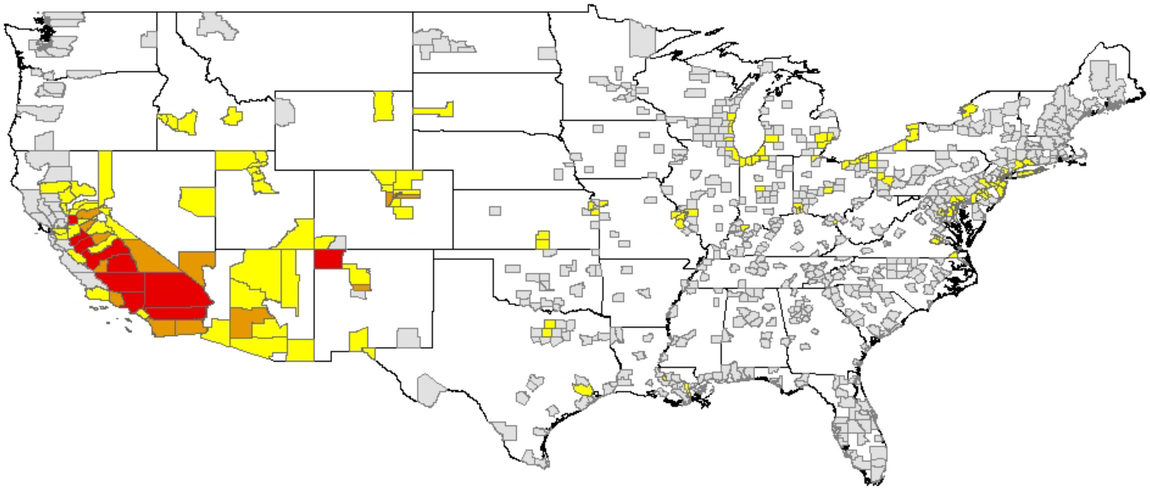
	Levels of 12-hr W126 (ppm-hrs)		
8-Hour Level Met	**> 21**	**> 15**	**> 7**
0.075 ppm	1	11	125
0.070 ppm	1	7	93
0.065 ppm	0	3	43
0.060 ppm	0	1	10
0.055 ppm	0	0	2

[a] Does not include counties that do not meet the various standard alternatives in the modeled control strategy. As these projections are limited to with existing ozone monitoring data, there might be other non-monitored areas that would exceed the secondary standard while attaining the primary standard.

Figure S4-4: Number of Counties Projected to Exceed [21/15/7] ppm-hrs in the Baseline and Modeled Control Strategy in 2020*



🟥	> 21 ppm-hrs	**10** counties that exceed 21 ppm-hrs in the baseline in 2020
🟧	15 - 21 ppm-hrs	**17** additional counties that exceed 15 ppm-hrs for a total of 27
🟨	7 - 15 ppm-hrs	**167** additional counties that exceed 7 ppm-hrs for a total of 194
⬜	< 7 ppm-hrs	**509** counties that meet 7 ppm-hrs



🟥	> 21 ppm-hrs	**10** counties that exceed 21 ppm-hrs after the modeled control strategy in 2020
🟧	15 - 21 ppm-hrs	**14** additional counties that exceed 15 ppm-hrs for a total of 24
🟨	7 - 15 ppm-hrs	**128** additional counties that exceed 7 ppm-hrs for a total of 152
⬜	< 7 ppm-hrs	**551** counties that meet 7 ppm-hrs

* These maps include additional counties beyond those shown in Table S4-2 or Figures S4-5 through S4-7 for two reasons. First, these maps include 45 counties that did not have complete monitoring data for the primary standard, which did not allow for a comparison with the secondary standard. Second, these maps include 21 counties that exceed a primary standard of 0.075 ppm after the modeled control strategy. Many of the counties projected to exceed a W126 level of 21 ppm-hrs are in the South Coast and San Joaquin areas of California, which are not required to attain the primary standards by 2020.

Figure S4-5: Counties exceeding a W126 Level of 21ppm-hrs while meeting various levels of the Primary Standard in the Control Strategy in 2020

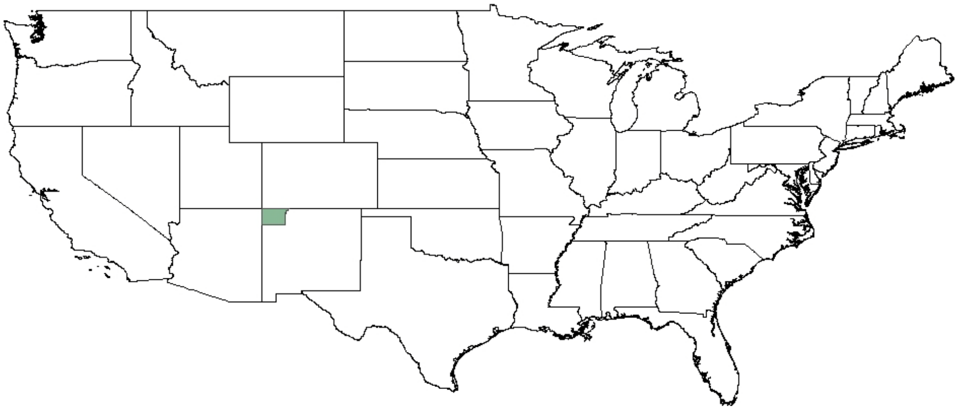


Figure S4-6: Counties exceeding a W126 Level of 15ppm-hrs while meeting various levels of the Primary Standard in the Control Strategy in 2020

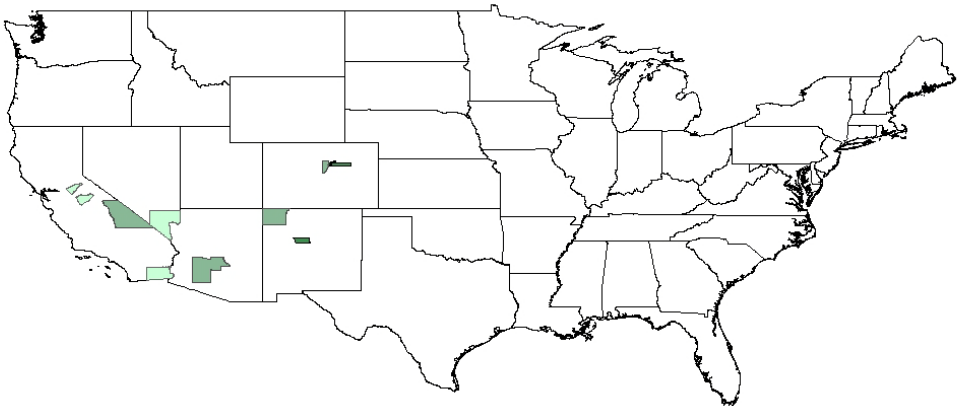
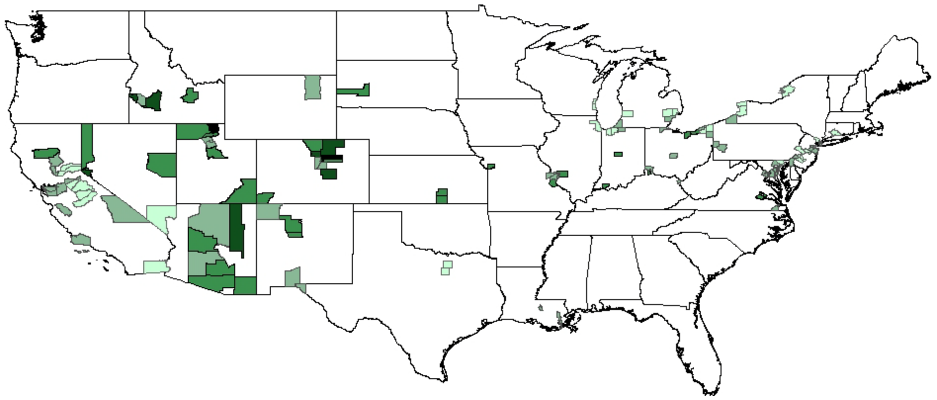


Figure S4-7: Counties exceeding a W126 Level of 7ppm-hrs while meeting various levels of the Primary Standard in the Control Strategy in 2020



	Meets 0.055 ppm	Meets 0.060 ppm	Meets 0.065 ppm	Meets 0.070 ppm	Meets 0.075 ppm
Exceeds 21 ppm-hrs (Figure S4-5)	--	--	--	1 (1 total)	-- (1 total)
Exceeds 15 ppm-hrs (Figure S4-6)	--	1 county (1 total)	+2 counties (3 total)	+4 counties (7 total)	+4 counties (11 total)
Exceeds 7 ppm-hrs (Figure S4-7)	2 counties (2 total)	+8 counties (10 total)	+33 counties (43 total)	+50 counties (93 total)	+32 counties (125 total)

As noted above, this analysis only projected W126 levels in 2020 where there are current ozone monitors. Due to the lack of more complete monitor coverage in many rural areas, this analysis might not be an accurate reflection of the situation in non-monitored, rural counties where important vegetation and ecosystems are located as well as areas of national public interest. This is an important consideration because: (1) the biological database stresses the importance of cumulative, seasonal exposures in determining plant response; (2) plants have not been specifically tested for the importance of daily maximum 8-hour ozone concentrations in relation to plant response; and (3) the effects of attainment of a 8-hour standard in upwind urban areas on rural air quality distributions cannot be characterized with confidence due to the lack of monitoring data in rural and remote areas (U.S. EPA, 2007). Many counties contain high elevation, rural or remote sites where ozone concentration distributions tend to be flatter. These areas may not reflect the typical urban and near-urban pattern of low morning and evening ozone concentrations with a high mid-day peak, but instead maintain relatively flat patterns with many concentrations in the mid-range (e.g., 0.05-0.09 ppm) for extended periods. Therefore, the potential for disconnect between 8-hour average and cumulative, seasonal forms is greater. Additional rural high elevation areas important for vegetation that are not currently monitored would likely experience similar ozone exposure patterns (U.S. EPA, 2007).

S4.3 Evaluation of Costs and Benefits of Attaining a Secondary Ozone NAAQS

The purpose of a secondary NAAQS is to protect the public welfare against the negative effects of criteria air pollutants from decreased visibility, damage to animals, crops, vegetation, and buildings. EPA has not promulgated a distinct secondary NAAQS that is not identical to the primary NAAQS since the original SO_2 regulation in 1970. Therefore, EPA has not previously conducted an analysis of the costs and benefits of attaining a secondary NAAQS, which is an exceptionally complex task. First, it is unclear when an area would need to attain a secondary standard, which makes choosing an analysis year difficult. Whereas attainment dates for the primary NAAQS are explicitly designated in the CAA, the attainment dates for the secondary NAAQS are required “as expeditiously as practicable” after the nonattainment designation (42 USC §7502(a)(2)). As air quality improves over time, an area would not need as many emission reductions for a later analysis year as the area would need for a sooner analysis year. Therefore, the choice of an analysis year has a significant effect on the magnitude of the costs and benefits of attaining a secondary standard.

Second, it is unclear whether it is appropriate to include emission reductions that occur as a result of implementing the primary NAAQS in the baseline for the secondary analysis. This is a critical decision, as it would either improperly ascribe the costs and benefits of the primary NAAQS to the secondary NAAQS or it would violate the requirements of OMB’s Circular A-4 to only include promulgated rules in the regulatory baseline.

Third, the current monitoring network was not designed to adequately reflect W126 levels in many areas of the county, especially the rural west. Therefore, it is difficult to extrapolate the concentrations beyond the currently monitored counties, and we would be unable to quantify the degree of nonattainment in many areas of the country that would be affected by the standard. Earlier this year, EPA proposed an expansion of the non-urban ozone monitoring network (74 FR 34525). If the regulation is finalized, three required non-urban monitors would be required in each State, beginning in 2012. Of those required monitors, at least one monitor was proposed to be located in areas of ecological value, such as National Parks, wilderness areas, or areas of sensitive national vegetation and ecosystems. We note, however, that even after the initial deployment of these additional monitors, it may prove challenging to completely characterize ozone concentrations in some locations that have not traditionally been areas of focus for ozone network deployment.

Fourth, as shown in Figure S4-4, a large number of counties are projected to not to meet the various potential secondary standards in 2020 even after the substantial controls in the hypothetical RIA control scenario. Estimating the amount of additional reductions (extrapolated tons) needed to attain a secondary standard would require a better understanding of the relationship between emissions reductions and the W126 metric. Our long experience with the primary standard allows us to use simple impact ratios with some confidence in the extrapolated cost analysis for the primary standard. At present, it is not possible to reproduce a similar analysis for the secondary standard.

Fifth, EPA has not yet developed draft guidance for States to recommend boundaries of nonattainment areas for a secondary ozone nonattainment area. The Clean Air Act (CAA) requires that nonattainment areas include not only areas that violate an air quality standard but also nearby areas that contribute to a violation. Many of the areas that would violate a secondary ozone standard without violating the primary ozone standard appear to be located in rural areas. Many of these areas lack significant sources of emissions of ozone precursors within the potential nonattainment area, so the cause of the violation is likely due to longer-range transport of ozone and precursors. Analyses of the origin of the contributing emissions in such areas is still incomplete, so it is unclear how large to make these nonattainment areas to afford the kind of protection to the sensitive species of vegetation that the standard is designed to protect while including the nearby sources that may be contributing to the violation and excluding contributing sources that are not “nearby.”

Sixth, EPA has not yet developed draft guidance to States on how they should develop their secondary standard SIPs and anticipate for the implementation proposal setting forth an open-ended solicitation of comments on how that should be done, rather than propose specific guidance. One issue that must be addressed from a legal stand point is whether planning for nonattainment areas must be done under the more prescriptive subpart 2 requirements of the CAA, which would require classification (as marginal, moderate, serious, etc). The CAA language is unclear as to whether subpart 2 applies to nonattainment areas under a secondary standard (although it appears to be clear that the maximum statutory attainment dates in the classification table only apply to the "primary" standard). The agency has never faced this issue in the past for ozone, so there is no precedent and would have to be addressed in rulemaking.

Seventh, it does not appear that the traditional nonattainment-area planning perspective would be very successful for addressing the violations based on the areas that currently violate the various options for a secondary ozone standard. Many of the potential nonattainment areas are in rural areas, many without significant sources of emissions of ozone precursors within the potential nonattainment area, and likely due to longer-range transport of ozone and precursors. An analysis of the origin of the contributing emissions in such areas is still incomplete, so it is unclear from a practical standpoint how SIPs would be developed. In some cases, multi-state plans might need to be developed to address the violations. This may even possibly entail EPA establishment under CAA section 176A of an interstate transport commission to address the problem.

Because of these complexities as well as limited time and resources within the expedited schedule, we are limited in our ability to quantify the costs and benefits of attaining a separate secondary NAAQS for ozone for this proposal. However, we have incorporated a limited, qualitative assessment in this analysis, including indicating which counties would have an additional burden to meet a secondary standard beyond the primary standard, and the qualitative benefits of reducing ozone exposure on forests, crops, and urban ornamentals.

S4.4 Benefits of Reducing Ozone Effects on Vegetation and Ecosystems[1]

Ozone causes discernible injury to a wide array of vegetation (U.S. EPA, 2006; Fox and Mickler, 1996). In terms of forest productivity and ecosystem diversity, ozone may be the pollutant with the greatest potential for regional-scale forest impacts (U.S. EPA, 2006). Studies have demonstrated repeatedly that ozone concentrations commonly observed in polluted areas can have substantial impacts on plant function (De Steiguer et al., 1990; Pye, 1988).

When ozone is present in the air, it can enter the leaves of plants, where it can cause significant cellular damage. Like carbon dioxide (CO_2) and other gaseous substances, ozone enters plant tissues primarily through the stomata in leaves in a process called "uptake" (Winner and

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[1] It is important to note that these vegetation benefits are contingent upon the secondary standard being the controlling standard. In other words, if the primary standard is controlling in all areas, there would not be any additional vegetation benefits beyond those due to the primary standard.

Atkinson, 1986). Once sufficient levels of ozone (a highly reactive substance), or its reaction products, reaches the interior of plant cells, it can inhibit or damage essential cellular components and functions, including enzyme activities, lipids, and cellular membranes, disrupting the plant's osmotic (i.e., water) balance and energy utilization patterns (U.S. EPA, 2006; Tingey and Taylor, 1982). With fewer resources available, the plant reallocates existing resources away from root growth and storage, above ground growth or yield, and reproductive processes, toward leaf repair and maintenance, leading to reduced growth and/or reproduction. Studies have shown that plants stressed in these ways may exhibit a general loss of vigor, which can lead to secondary impacts that modify plants' responses to other environmental factors. Specifically, plants may become more sensitive to other air pollutants, or more susceptible to disease, pest infestation, harsh weather (e.g., drought, frost) and other environmental stresses, which can all produce a loss in plant vigor in ozone-sensitive species that over time may lead to premature plant death. Furthermore, there is evidence that ozone can interfere with the formation of mycorrhiza, essential symbiotic fungi associated with the roots of most terrestrial plants, by reducing the amount of carbon available for transfer from the host to the symbiont (U.S. EPA, 2006).

This ozone damage may or may not be accompanied by visible injury on leaves, and likewise, visible foliar injury may or may not be a symptom of the other types of plant damage described above. Foliar injury is usually the first visible sign of injury to plants from ozone exposure and indicates impaired physiological processes in the leaves (Grulke, 2003). When visible injury is present, it is commonly manifested as chlorotic or necrotic spots, and/or increased leaf senescence (accelerated leaf aging). Because ozone damage can consist of visible injury to leaves, it can also reduce the aesthetic value of ornamental vegetation and trees in urban landscapes, and negatively affects scenic vistas in protected natural areas.

Ozone can produce both acute and chronic injury in sensitive species depending on the concentration level and the duration of the exposure. Ozone effects also tend to accumulate over the growing season of the plant, so that even lower concentrations experienced for a longer duration have the potential to create chronic stress on sensitive vegetation. Not all plants, however, are equally sensitive to ozone. Much of the variation in sensitivity between individual plants or whole species is related to the plant’s ability to regulate the extent of gas exchange via leaf stomata (e.g., avoidance of ozone uptake through closure of stomata) (U.S. EPA, 2006; Winner, 1994). After injuries have occurred, plants may be capable of repairing the damage to a limited extent (U.S. EPA, 2006). Because of the differing sensitivities among plants to ozone, ozone pollution can also exert a selective pressure that leads to changes in plant community composition. Given the range of plant sensitivities and the fact that numerous other environmental factors modify plant uptake and response to ozone, it is not possible to identify threshold values above which ozone is consistently toxic for all plants.

Because plants are at the base of the food web in many ecosystems, changes to the plant community can affect associated organisms and ecosystems (including the suitability of habitats that support threatened or endangered species and below ground organisms living in the root zone). Ozone impacts at the community and ecosystem level vary widely depending upon numerous factors, including concentration and temporal variation of tropospheric ozone, species composition, soil properties and climatic factors (U.S. EPA, 2006). In most instances, responses to chronic or recurrent exposure in forested ecosystems are subtle and not observable for many years. These injuries can cause stand-level forest decline in sensitive ecosystems (U.S. EPA, 2006, McBride et al., 1985; Miller et al., 1982). It is not yet possible to predict ecosystem responses to ozone with much certainty; however, considerable knowledge of potential ecosystem responses has been acquired through long-term observations in highly damaged forests in the United States (U.S EPA, 2006).

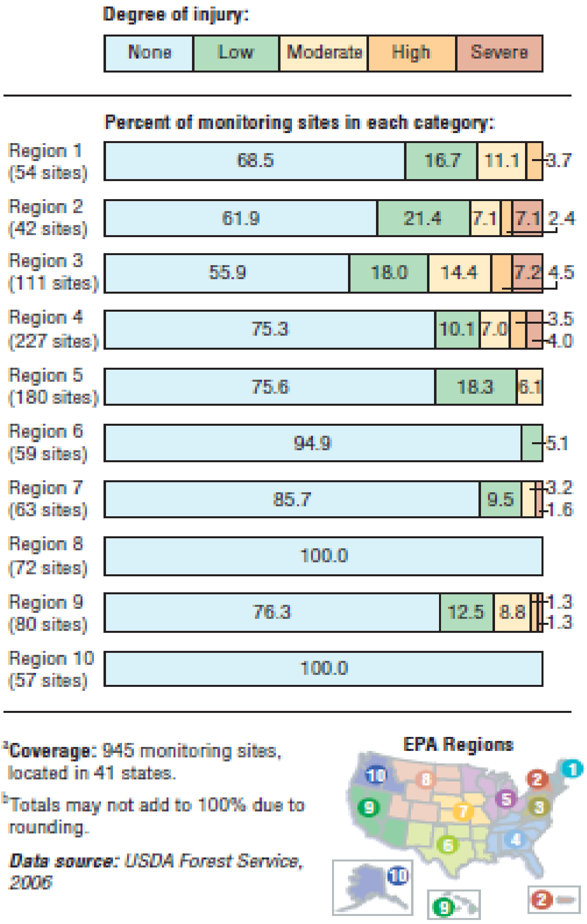
Ozone Effects on Forests

Air pollution can affect the environment and affect ecological systems, leading to changes in the ecological community and influencing the diversity, health, and vigor of individual species (U.S. EPA, 2006). Ozone has been shown in numerous studies to have a strong effect on the health of many plants, including a variety of commercial and ecologically important forest tree species throughout the United States (U.S. EPA, 2007).

In the U.S., this data comes from the U.S. Department of Agriculture (USDA) Forest Service Forest Inventory and Analysis (FIA) program. As part of its Phase 3 program, formerly known as Forest Health Monitoring, FIA examines ozone injury to ozone-sensitive plant species at ground monitoring sites in forestland across the country (excluding woodlots and urban trees). FIA looks for damage on the foliage of ozone-sensitive forest plant species at each site that meets certain minimum criteria. Because ozone injury is cumulative over the course of the growing season, examinations are conducted in July and August, when ozone injury is typically highest.

Monitoring of ozone injury to plants by the USDA Forest Service has expanded over the last 10 years from monitoring sites in 10 states in 1994 to nearly 1,000 monitoring sites in 41 states in 2002. The data underlying the indictor in Figure S4-2 are based on averages of all observations collected in 2002, the latest year for which data are publicly available at the time the study was conducted, and are broken down by U.S. EPA Regions. Ozone damage to forest plants is classified using a subjective five-category biosite index based on expert opinion, but designed to be equivalent from site to site. Ranges of biosite values translate to no injury, low or moderate foliar injury (visible foliar injury to highly sensitive or moderately sensitive plants, respectively), and high or severe foliar injury, which would be expected to result in tree-level or ecosystem-level responses, respectively (U.S. EPA, 2006; Coulston, 2004). The highest percentages of observed high and severe foliar injury, which are most likely to be associated with tree or ecosystem-level responses, are primarily found in the Mid-Atlantic and Southeast regions.

Figure S4-2: Ozone Injury to Forest Plants in U.S. by EPA Regions, 2002[a, b]



[a]**Coverage:** 945 monitoring sites, located in 41 states.

[b]Totals may not add to 100% due to rounding.

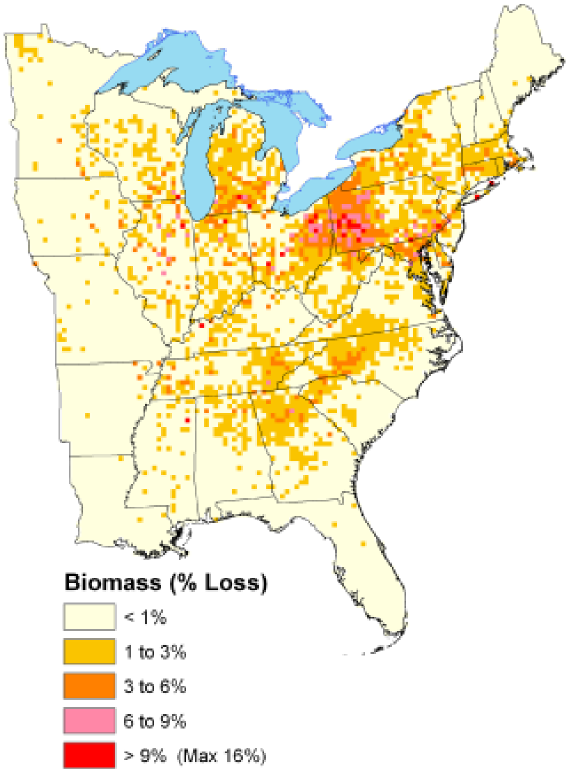
***Data source:** USDA Forest Service, 2006*

Assessing the impact of ground-level ozone on forests in the eastern United States involves understanding the risks to sensitive tree species from ambient ozone concentrations and accounting for the prevalence of those species within the forest. As a way to quantify the risks to particular plants from ground-level ozone, scientists have developed ozone-exposure/tree-response functions by exposing tree seedlings to different ozone levels and measuring reductions in growth as “biomass loss.” Typically, seedlings are used because they are easy to manipulate and measure their growth loss from ozone pollution. The mechanisms of susceptibility to ozone within the leaves of seedlings and mature trees are identical, and the decreases predicted using the seedlings should be related to the decrease in overall plant fitness for mature trees, but the magnitude of the effect may be higher or lower depending on the tree species (Chappelka and Samuelson, 1998). In areas where certain ozone-sensitive species dominate the forest community, the biomass loss from ozone can be significant. Significant biomass loss can be defined as a more than 2% annual biomass loss, which would cause long term ecological harm as the short-term negative effects on seedlings compound to affect long-term forest health (Heck, 1997).

Some of the common tree species in the United States that are sensitive to ozone are black cherry (*Prunus serotina*), tulip-poplar (*Liriodendron tulipifera)*, and eastern white pine (*Pinus strobus)*. Ozone-exposure/tree-response functions have been developed for each of these tree species, as well as for aspen (*Populus tremuliodes*), and ponderosa pine (*Pinus ponderosa*) (U.S. EPA, 2007). Other common tree species, such as oak (*Quercus* spp*.)* and hickory (*Carya* spp.), are not nearly as sensitive to ozone. Consequently, with knowledge of the distribution of sensitive species and the level of ozone at particular locations, it is possible to estimate a "biomass loss" for each species across their range. As shown in Figure S4-3, current ambient levels of ozone are associated with significant biomass loss across large geographic areas (U.S. EPA, 2009b). However, this information is unavailable for a future analysis year or incremental to a specified control strategy.

To estimate the biomass loss for forest ecosystems across the eastern United States, the biomass loss for each of the seven tree species was calculated using the three-month, 12-hour W126 exposure metric at each location, along with each tree's individual C-R functions. The W126 exposure metric was calculated using monitored ozone data from CASTNET and AQS sites, and a three-year average was used to mitigate the effect of variations in meteorological and soil moisture conditions. The biomass loss estimate for each species was then multiplied by its prevalence in the forest community using the U.S. Department of Agriculture (USDA) Forest Service IV index of tree abundance calculated from Forest Inventory and Analysis (FIA) measurements (Prasad, 2003). Sources of uncertainty include the ozone-exposure/plant-response functions, the tree abundance index, and other factors (e.g., soil moisture). Although these factors were not considered, they can affect ozone damage (Chappelka, 1998).

Figure S4-3: Estimated Black Cherry, Yellow Poplar, Sugar Maple, Eastern White Pine, Virginia Pine, Red Maple, and Quaking Aspen Biomass Loss due to Current Ozone Exposure, 2006-2008 (U.S. EPA, 2009b)



Ozone damage to the plants including the trees and understory in a forest can affect the ability of the forest to sustain suitable habitat for associated species particularly threatened and endangered species that have existence value – a nonuse ecosystem service - for the public. Similarly, damage to trees and the loss of biomass can affect the forest's provisioning services in the form of timber for various commercial uses. In addition, ozone can cause discoloration of leaves and more rapid senescence (early shedding of leaves), which could negatively affect fall-color tourism because the fall foliage would be less available or less attractive. Beyond the aesthetic damage to fall color vistas, forests provide the public with many other recreational and educational services that may be impacted by reduced forest health including hiking, wildlife viewing (including bird watching), camping, picnicking, and hunting. Another potential effect of biomass loss in forests is the subsequent loss of climate regulation service in the form of reduced ability to sequester carbon.

Ozone Effects on Crops and Urban Ornamentals

Laboratory and field experiments have also shown reductions in yields for agronomic crops exposed to ozone, including vegetables (e.g., lettuce) and field crops (e.g., cotton and wheat).

Damage to crops from ozone exposures includes yield losses (i.e., in terms of weight, number, or size of the plant part that is harvested), as well as changes in crop quality (i.e., physical appearance, chemical composition, or the ability to withstand storage) (U.S. EPA, 2007). The most extensive field experiments, conducted under the National Crop Loss Assessment Network (NCLAN) examined 15 species and numerous cultivars. The NCLAN results show that "several economically important crop species are sensitive to ozone levels typical of those found in the United States" (U.S. EPA, 2006). In addition, economic studies have shown reduced economic benefits as a result of predicted reductions in crop yields, directly affecting the amount and quality of the provisioning service provided by the crops in question, associated with observed ozone levels (Kopp et al, 1985; Adams et al., 1986; Adams et al., 1989). According to the Ozone Staff Paper, there has been no evidence that crops are becoming more tolerant of ozone (U.S. EPA, 2007). Using the Agriculture Simulation Model (AGSIM) (Taylor, 1994) to calculate the agricultural benefits of reductions in ozone exposure, U.S. EPA estimated that meeting a W126 standard of 21 ppm-hr would produce monetized benefits of approximately $160 million to $300 million (inflated to 2006 dollars) (U.S. EPA, 2007).

Urban ornamentals are an additional vegetation category likely to experience some degree of negative effects associated with exposure to ambient ozone levels. Because ozone causes visible foliar injury, the aesthetic value of ornamentals (such as petunia, geranium, and poinsettia) in urban landscapes would be reduced (U.S. EPA, 2007). Sensitive ornamental species would require more frequent replacement and/or increased maintenance (fertilizer or pesticide application) to maintain the desired appearance because of exposure to ambient ozone (U.S. EPA, 2007). In addition, many businesses rely on healthy-looking vegetation for their livelihoods (e.g., horticulturalists, landscapers, Christmas tree growers, farmers of leafy crops, etc.) and a variety of ornamental species have been listed as sensitive to ozone (Abt Associates, 1995). The ornamental landscaping industry is valued at more than $30 billion (inflated to 2006 dollars) annually, by both private property owners/tenants and by governmental units responsible for public areas (Abt Associates, 1995). Therefore, urban ornamentals represent a potentially large unquantified benefit category. This aesthetic damage may affect the enjoyment of urban parks by the public and homeowners' enjoyment of their landscaping and gardening activities. In addition, homeowners may experience a reduction in home value or a home may linger on the market longer due to decreased aesthetic appeal. In the absence of adequate exposure-response functions and economic damage functions for the potential range of effects relevant to these types of vegetation, we cannot conduct a quantitative analysis to estimate these effects.

Other ozone co-benefits

In addition to the direct benefits on vegetation that the secondary ozone NAAQS is intended to produce, there are many other benefits from reducing ambient ozone concentrations.[2] Controlling ozone concentrations is associated with significant human health benefits, including mortality and respiratory morbidity. [3] In addition, controlling ozone precursor pollutants (i.e., NO_X) would reduce respiratory effects, reduce aquatic and terrestrial acidification, reduce excess aquatic and terrestrial nutrient enrichment, and improve visibility.[4] Furthermore, NO_X and VOCs are also precursors to $PM_{2.5}$, which would lead to reductions in human health effects including mortality, respiratory morbidity, and cardiovascular morbidity.[5]

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[2] It is important to note that these health benefits are contingent upon the secondary standard being the controlling standard. In other words, if the primary standard is controlling in all areas, there would not be any additional health benefits beyond those due to the primary standard.

[3] See the Chapter 6 of the 2008 RIA, the updated benefits analysis in Section 3 of this supplemental, and the Ozone Staff Paper (U.S. EPA, 2007) for additional information on the health effects of ozone.

[4] See the Integrated Science Assessment for Oxides of Nitrogen: Health Criteria (U.S. EPA, 2008a) for more information on the health effects of NO_2 and the Integrated Science Assessment for Oxides of Nitrogen and Sulfur - Ecological Criteria (U.S. EPA, 2008b) for more information on the ecological effects of NO_2.

[5] See Chapter 6 of the 2008 RIA, the updated benefits analysis in Section 3 of this supplemental, and the PM Integrated Science Assessment (U.S. EPA, 2009) for additional information on the health effects of fine particles.

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Section 5: Appendix: Examples of cost of attaining standard alternatives for selected non-attainment areas.

As seen in the analysis presented in the 2008 ozone NAAQS RIA and the supplemental analysis presented in the body of the current update to that RIA, several areas cannot reach attainment by use of only known controls for our selected illustrative control strategy. Our approach for estimating the total cost for attainment is detailed in Chapter 5 of the 2008 Ozone NAAQS RIA. In section 5.2, Extrapolated Engineering Costs, beginning on page 5-10, we discuss our approach for estimating the cost of attainment when additional reductions are needed beyond those which are attainable from known controls. We presented two methods for estimating these costs. The following descriptions are from page 5-12 of the 2008 Ozone NAAQS RIA:

> EPA used two methodologies for estimating the costs of unspecified future controls: a new hybrid methodology and a fixed-cost methodology. Both approaches assume that innovative strategies and new control options make possible the emissions reductions needed for attainment by 2020. The fixed cost methodology was preferred by EPA's Science Advisory Board over two other options, including a marginal-cost-based approach. The hybrid approach has not yet been reviewed by the SAB.
>
> The hybrid approach creates a marginal cost curve and an average cost curve representing the cost of unknown future controls needed for 2020 attainment. This approach explicitly estimates the average per-ton cost of unspecified emissions reductions assumed for each area, with a higher average cost-per-ton in areas needing a higher proportion of unknown controls relative to known modeled controls. This requires assumptions about the average cost of the least expensive unspecified future controls, and the rate at which the average cost of these controls rises as more extrapolated tons are needed for attainment (relative to the amount of reductions from known, modeled controls). These factors in turn depend on implicit assumptions about future technological progress and innovation in emission reduction strategies.
>
> The fixed cost methodology utilizes a national average cost per ton of future unspecified controls needed for attainment, as well as two sensitivity values (presented in Appendix 5a.4.3). The range of estimates reflects different assumptions about the cost of additional emissions reductions beyond those in the modeled control strategy. The alternative estimates implicitly reflect different assumptions about the amount of technological progress and innovation in emission reduction strategies.

> The hybrid methodology has the advantage of using the information about how significant the needed reductions from unspecified control technology are relative to the known control measures and matching that with expected increasing per unit cost for going beyond the modeled technology. Under this approach, the relative costs of unspecified controls in different geographic areas reflect the expectation that average per-ton control costs are likely to be higher in areas needing a higher ratio of emission reductions from unspecified and known controls. The fixed cost methodology reflects a view that because no cost data exists for unspecified future strategies, it is unclear whether approaches using hypothetical cost curves will be more accurate or less accurate in forecasting total national costs of unspecified controls than a fixed-cost approach that uses a range of national cost per ton values.

The following graphs are examples of marginal extrapolated cost curves for several areas that are unable to attain the various levels of the standard using known controls. These areas vary in the amount of extrapolated controls required to meet various levels of the standard, and should provide some insight as to how the curves differ between areas. Unfortunately, we are unable to provide a marginal extrapolated cost curve for Los Angeles-South Coast-San Joaquin, CA, one of the most challenging areas, because this area is not required to attain the standard by 2020. This is the first attempt to create such graphics, and is a work in progress. However, this preliminary analysis is intended to provide the public with a more transparent representation of how extrapolated costs were calculated using both the fixed cost and hybrid approach.

It should be noted, however, that the hybrid approach was designed to be a national strategy. It is difficult to present the results at the extrapolated cost area geographic level, because the size of the area itself changes between standard levels. Due to the manner in which extrapolated cost areas are created, there are changes in the assignment of counties to areas between levels of the standard. As a result, there may be more identified controls within an area at more stringent levels of the standard, which would affect both the starting point of the marginal extrapolated cost curve as well as the slope of the curve. If each curve for an area started from the same level of known controls, the slope would not be affected. In this case, there would be a single marginal cost curve for each area, and you would move farther along the curve for more stringent levels of the standard. The slope does vary significantly between extrapolated costs areas, but does not vary greatly between standards within each extrapolated cost area.

The goal of the hybrid approach was to calculate an increasing marginal cost curve rather than a fixed cost curve. That is, each additional ton of reduction should cost more than its predecessor. While this is the case for each marginal cost curve separately, there are instances in which some controls may appear to be cheaper at tighter standards. This is due to the manner in which the cost is calculated. For each level of the standard, extrapolated cost areas are determined by creating 200 km buffers around counties that are projected to not reach attainment and any other counties in existing non-attainment areas that these projected non-attainment counties intersect. As a result, at more stringent levels of the standard an individual extrapolated cost area may encompass more counties, thereby allowing the identification of supplementary known controls that may exist in these additional counties. The marginal extrapolated cost is a function of a fixed national cost per ton (*N*), a fixed multiplier that reflects technological change (*M*)[1], and the ratio of unknown emissions to known emissions within an extrapolated cost area (*R*). Between levels of the standard within an area, the additional of supplementary known controls affects both the starting point on the X-axis (i.e., the point at which controls move from known to extrapolated) as well as the slope of the curve (through the effect on the ratio of unknown to known controls). As a result, the curves are not directly comparable between standards in cases where there are different starting points. Additionally, while the price of the first ton of extrapolated control is $15,000 within each area, the interaction of the technological change variable *M* and ratio of unknown to unknown controls *R* variables determines the price of additional tons of controls as well as the maximum price within an area. In the graphs that follow, Baton Rouge, LA, has the lowest ratio of unknown to known controls, and faces a maximum extrapolated cost of just under $25,000/ton. The Northeast Corridor has a higher ratio of unknown to known controls, and as a result faces the higher maximum extrapolated cost of just under $40,000/ton. For additional details about the derivation of the hybrid approach as well as the determination of the extrapolated cost areas, the reader is referred to Chapters 4 and 5 of the 2008 Ozone NAAQS RIA[2]. The creation of extrapolated cost areas is discussed in Chapter 4 (p. 4-1), while the derivation of the hybrid approach is discussed in Chapter 5 (p. 5-10).

Presentation of the marginal extrapolated cost curves at this level of disaggregation leads to some anomalous results. For example, in the case of Baton Rouge, LA, reductions from known controls as well as the required reductions are the same for both the .060 and .055 standard. This is due to reductions coming from other nearby areas that are not represented in this graph. Because of the way the extrapolated cost areas are created and the resulting shifting of counties between areas at more stringent levels of the standard, Houston-Galveston-Brazoria, TX, appears to have fewer reductions from known controls as well as lower required reductions at the .055 level of the standard than at higher levels of the standard. Again, these costs would be assigned to other areas. While these costs are not represented in the graph, they are part of the national level estimates provided in the RIA.

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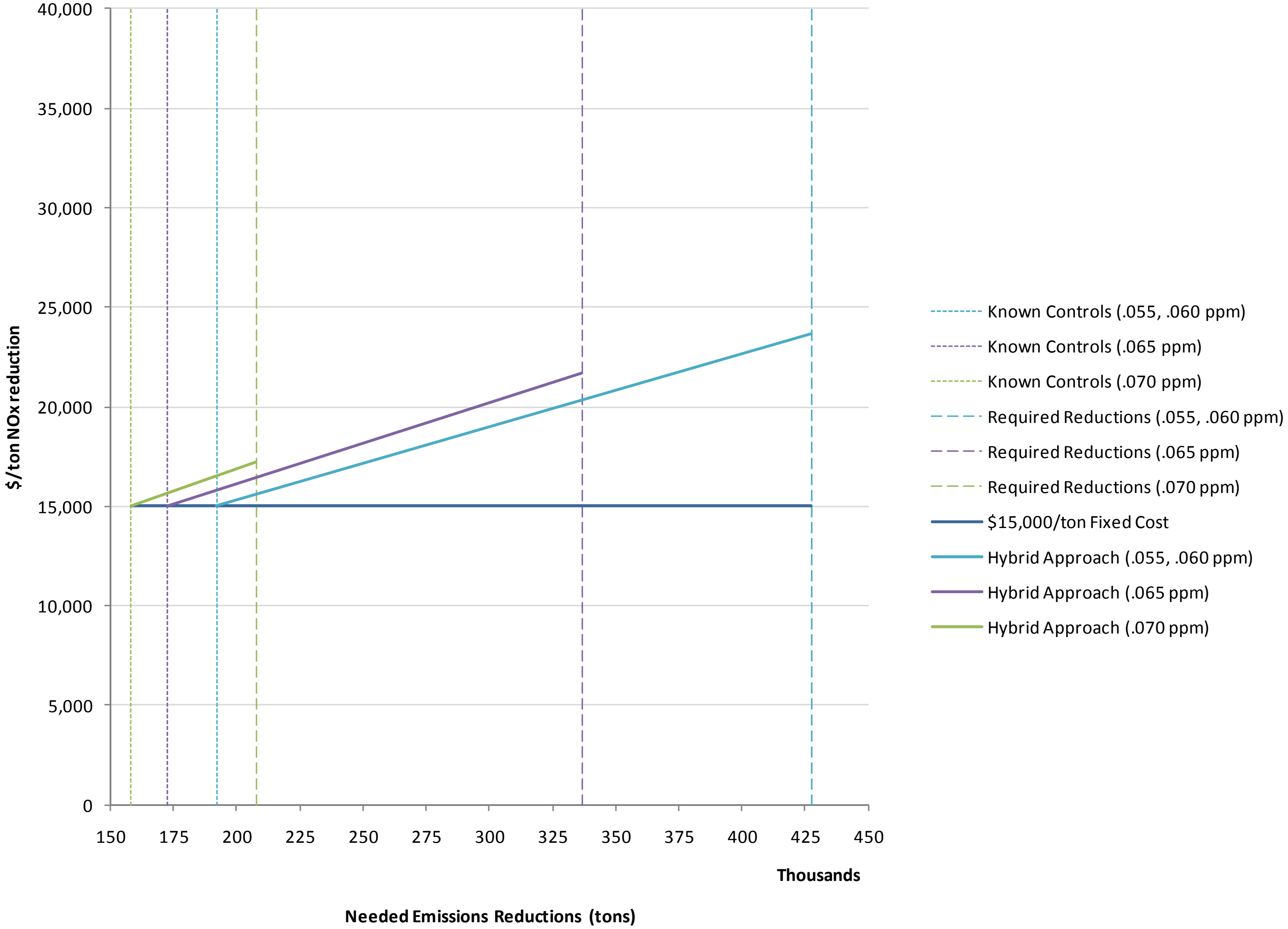
[1] While *M* is described here as a technological change parameter, it actually incorporates many different influences on the unit costs of control, such as technological change in control technology, change in energy technology, learning by doing, relative price changes, and the distribution of sources with uncontrolled emissions.

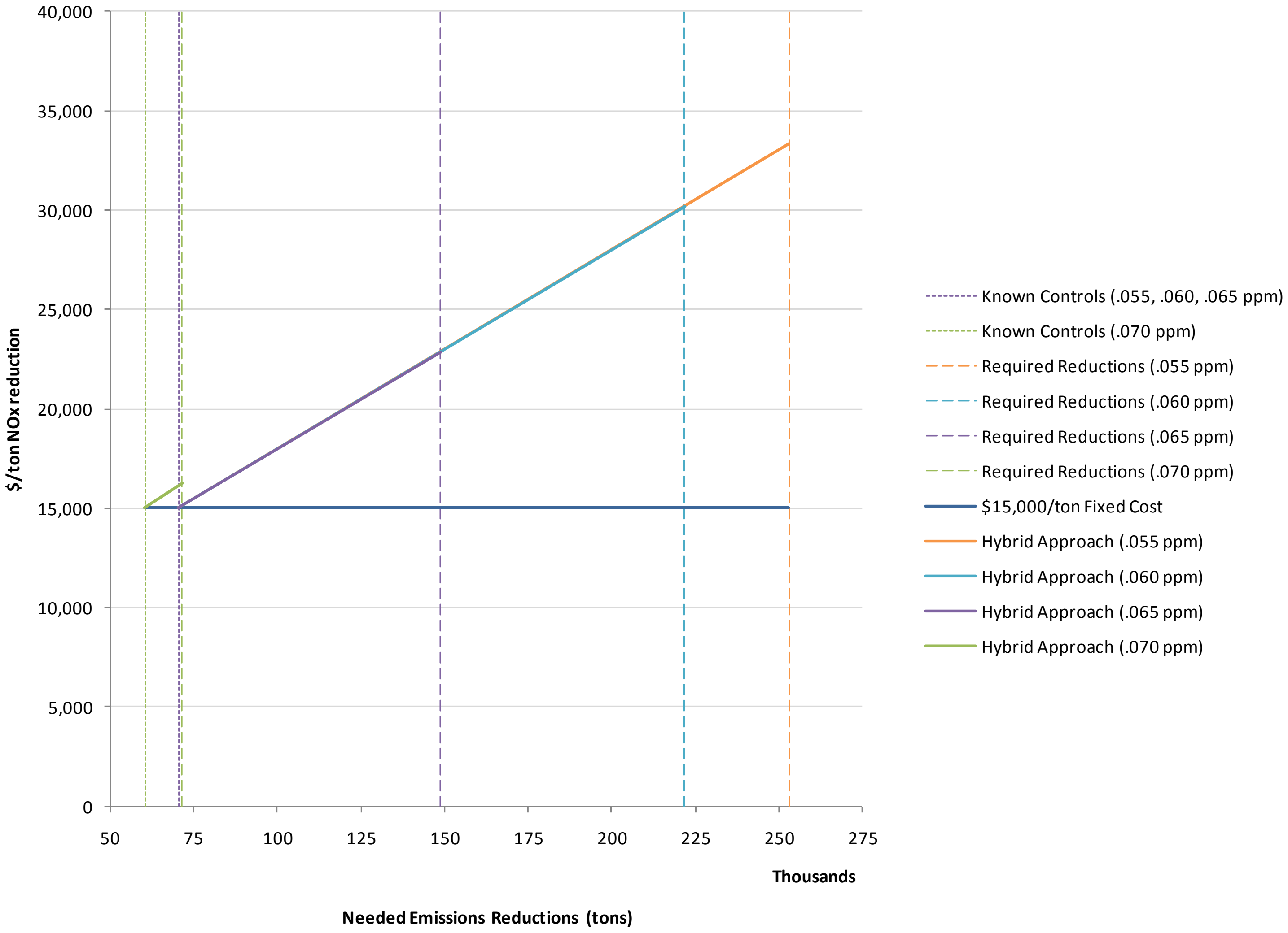
[2] Available on the Internet at <http://www.epa.gov/ttn/ecas/regdata/RIAs>.

Figure S5.1: Marginal Extrapolated Cost Curves – Baton Rouge, LA



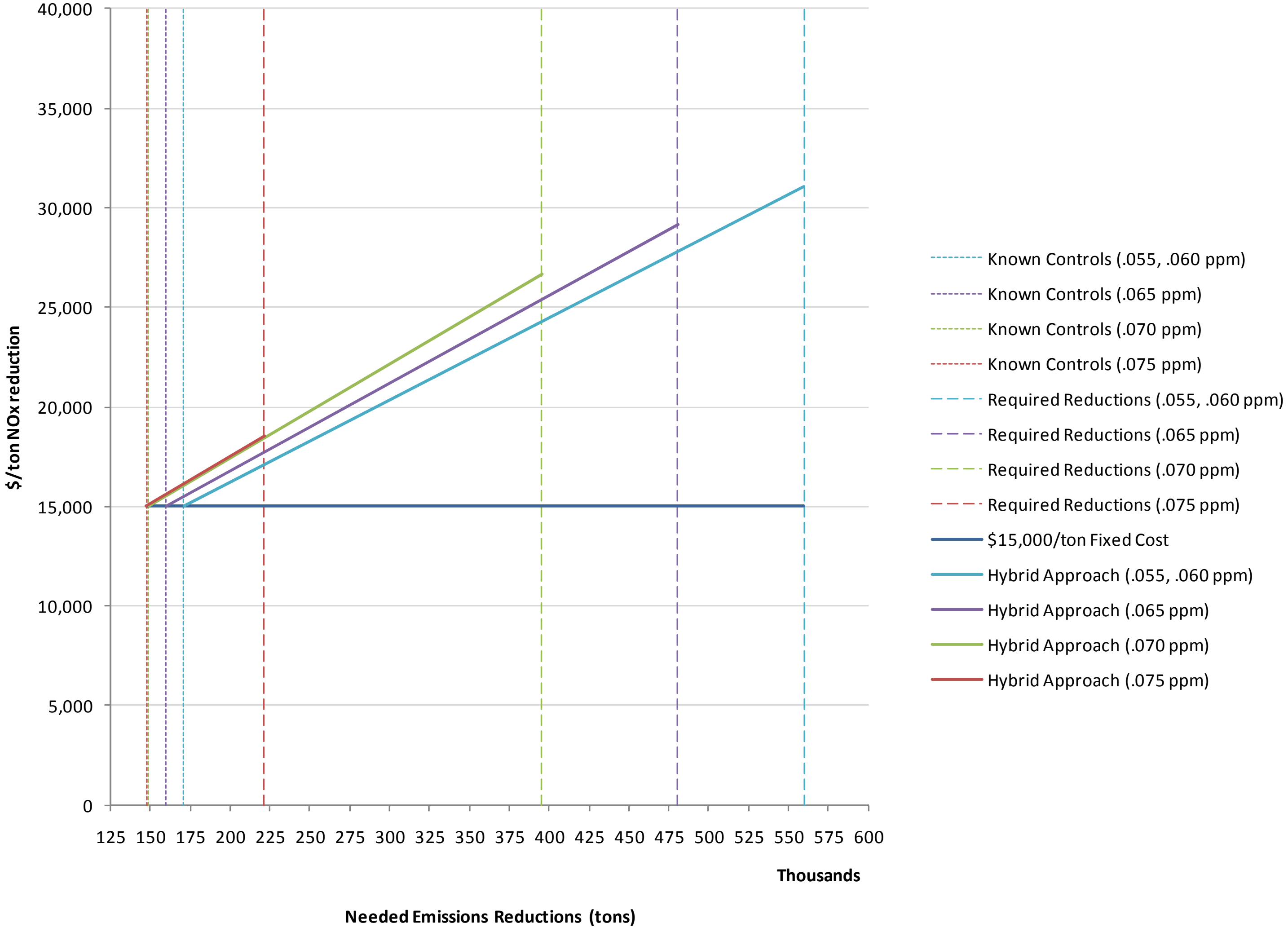
NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.

Figure S5.2: Marginal Extrapolated Cost Curves – Cleveland-Akron-Lorain, OH



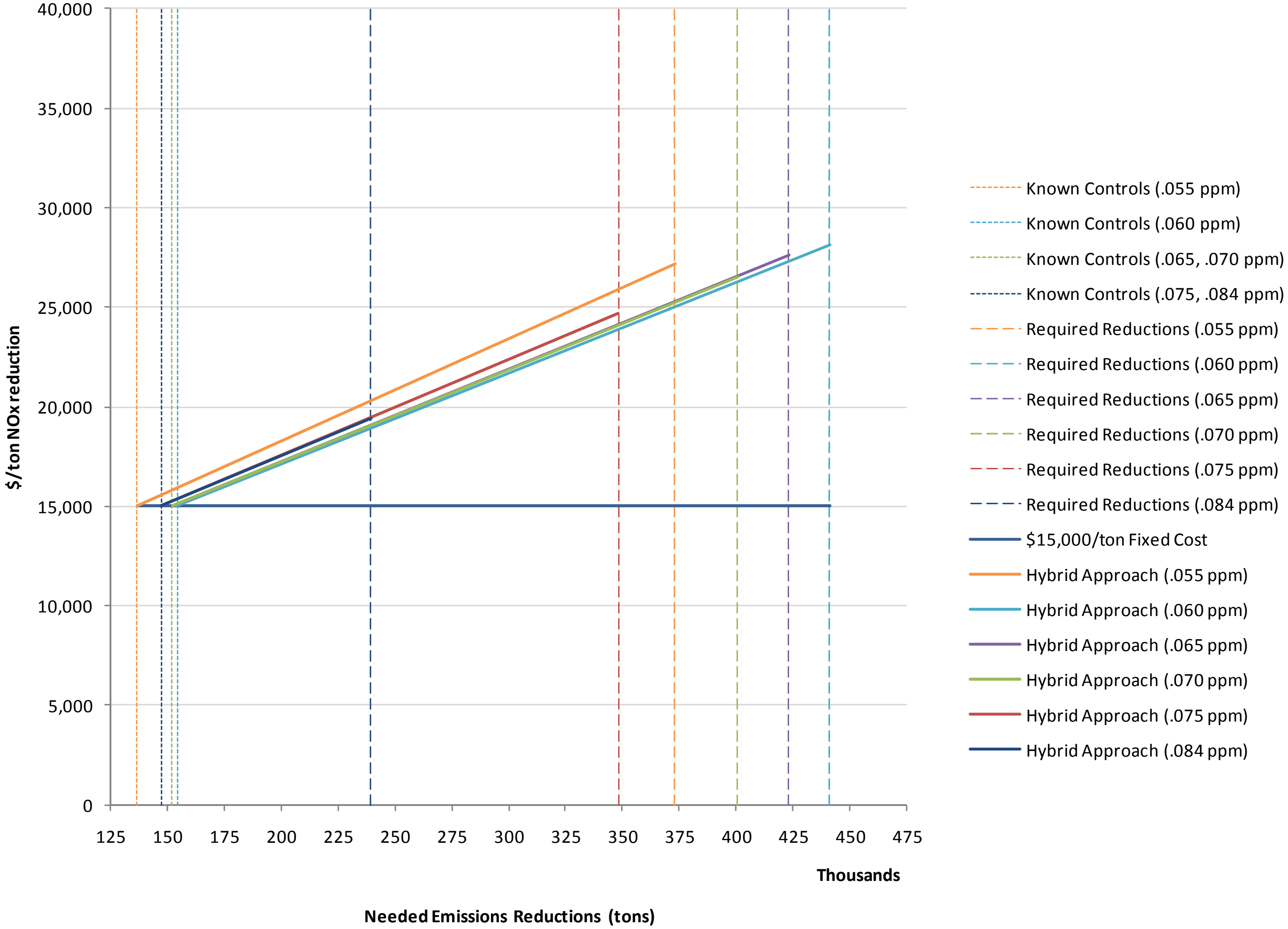
NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.

Figure S5.3: Marginal Extrapolated Cost Curves – Western Lake Michigan, IL-IN-WI



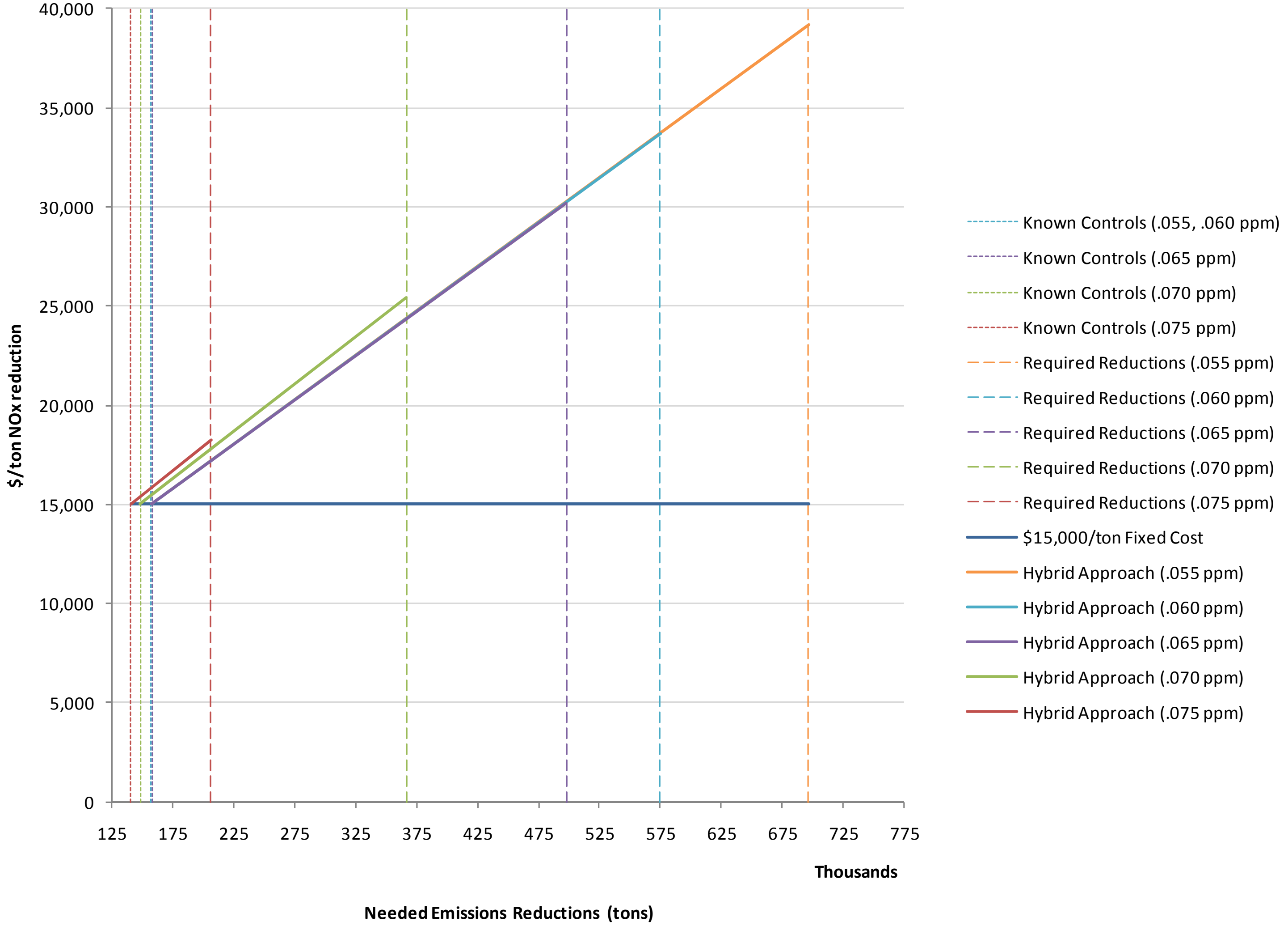
NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.

Figure S5.4: Marginal Extrapolated Cost Curves – Houston-Galveston-Brazoria, TX



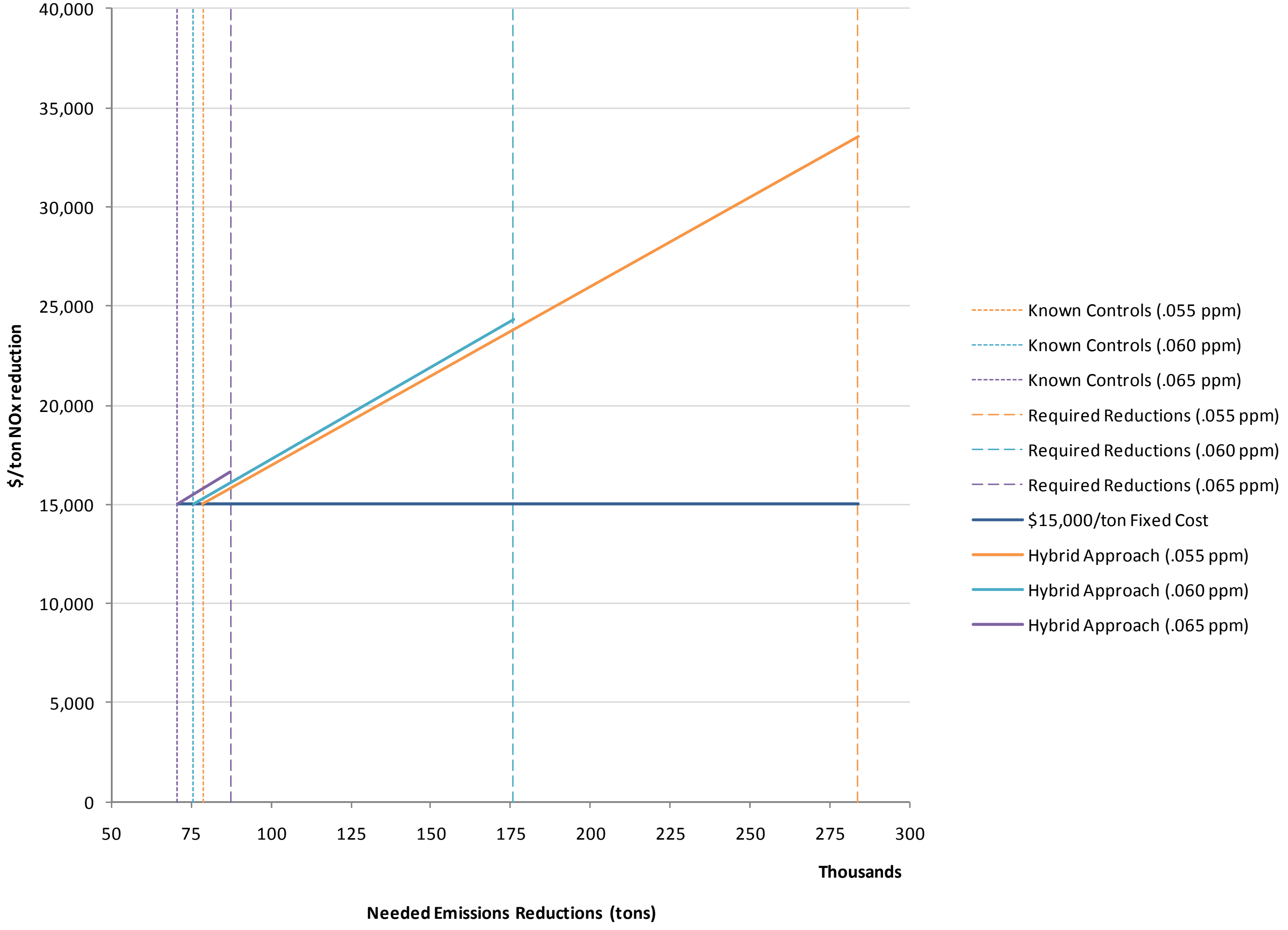
NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve. In the case of the .055 level of the standard, some counties included in the Houston area at the .060 level of the standard were reassigned to the Dallas area. While this affects the amount of control required in the Houston area, this does not affect the overall national estimate.

Figure S5.5: Marginal Extrapolated Cost Curves – Northeast Corridor, CT-DE-MD-NJ-NY-PA



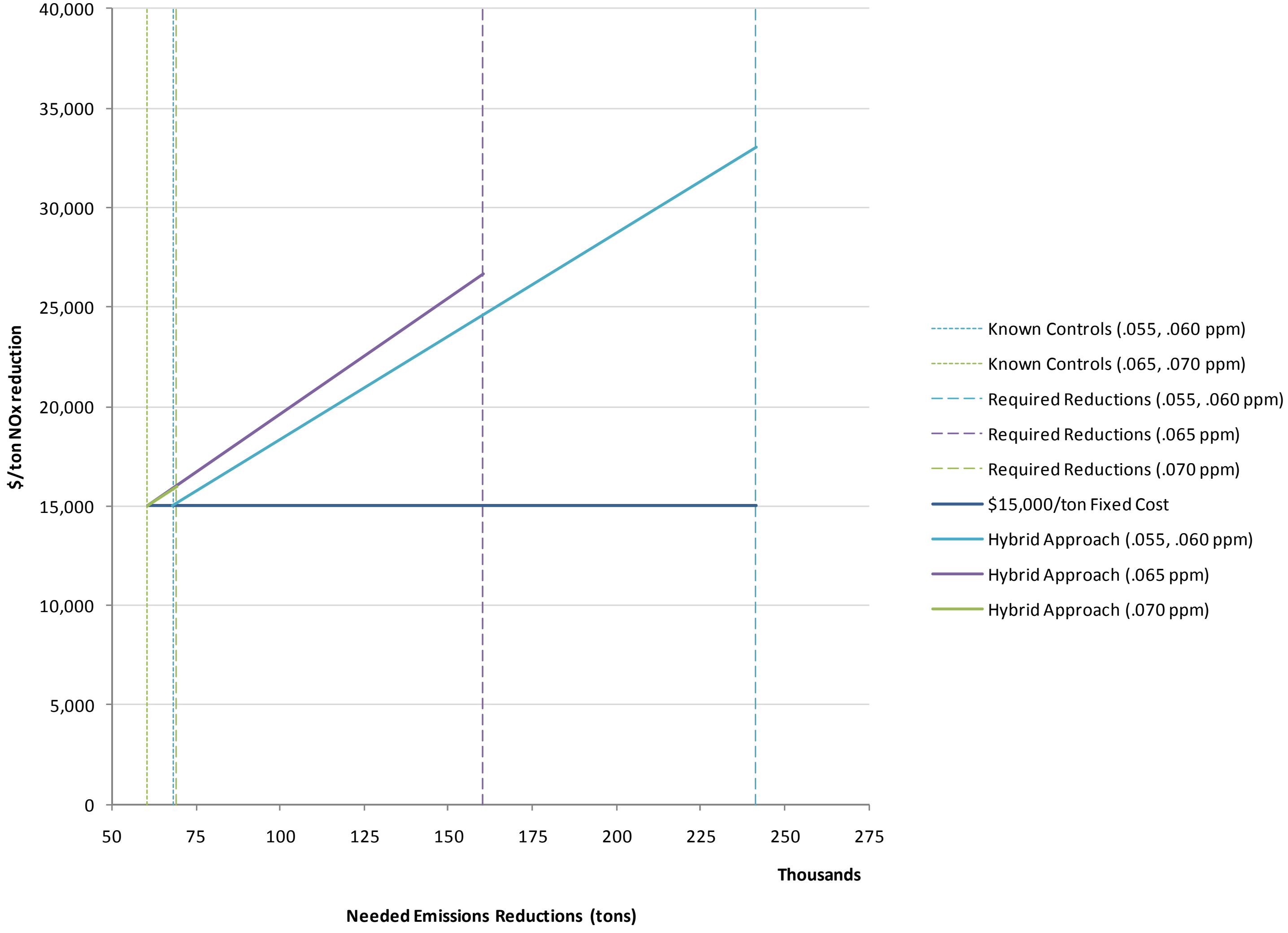
NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.

Figure S5.6: Marginal Extrapolated Cost Curves – St Louis, MO-IL



NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.

Figure S5.7: Marginal Extrapolated Cost Curves – Detroit-Ann Arbor, MI



NOTE: The size of the geographic area for extrapolated cost areas varies between levels of the standard. Typically, more counties are included at more stringent levels of the standard, increasing the quantity of known controls available, affecting both the starting point and slope of the marginal extrapolated cost curve.