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for

Health and Welfare Benefits Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act (April 2010 draft)

[Note: these pages substitute for pages in the April 2010 draft document to replace highlighted placeholder text.]

EXHIBIT 1-4. SUMMARY OF MEAN PRIMARY BENEFITS RESULTS

BENEFIT CATEGORY	MONETIZED BENEFITS (MILLION 2006$) BY TARGET YEAR			NOTES
	2000	2010	2020	
Health Effects				
PM Mortality PM Morbidity Ozone Mortality Ozone Morbidity	$710,000 $27,000 $10,000 $420	$1,200,000 $46,000 $33,000 $1,300	$1,700,000 $68,000 $55,000 $2,100	-PM mortality estimates based on a Weibull distribution of C-R coefficients with mean of 1.06 derived from Pope et al. (2002) and Laden et al. (2006). -Ozone mortality estimates based on pooled C-R function
Subtotal Health Effects	$750,000	$1,300,000	$1,900,000	
Visibility*				
Recreational Residential	$4,100 $13,000	$9,000 $27,000	$18,000 $49,000	Recreational visibility only includes benefits in the regions analyzed in Chestnut and Rowe, 1990 (i.e., California, the Southwest, and the Southeast).
Subtotal Visibility	$17,000	$36,000	$67,000	
Agricultural and Forest Productivity	[pending]			
Materials Damage	$58	$93	$110	
Ecological	$6.9	$7.5	$8.2	Reduced lake acidification benefits to recreational fishing assuming effect threshold of 50 microequivalents per liter.
Total: all categories	$770,000	$1,300,000	$2,000,000	

Note: See Chapters 2 through 5 of this report for detailed results summaries. Values presented are means from results reported as distributions. Additional, alternative estimates are provided in the separate companion report on uncertainty. Estimates presented with two significant figures.
*Note that the benefits estimates in this chapter have been reduced by 10 percent to reflect revised primary PM2.5 estimates. The Project Team is in the process of developing a revised visibility estimate to reflect these changes in the emissions data.

The health effects estimates for the second prospective are much larger than the estimates EPA developed for the first prospective. The 2020 estimates are new to the second prospective, but the comparable mean estimate of health benefits in 2000 and 2010 for the first prospective were $71 billion in 2000 and $110 billion in 2010, in 1990$[3] - if updated to 2006$, these estimates would be $110 billion in 2000 and $170 billion in 2010. There are six key reasons we have identified for the increase in benefits:

[3] See The Benefits and Costs of the Clean Air Act 1990 to 2010, USEPA Office of Air and Radiation and Office of Policy, EPA-410-R-99-001, November 1999.

EXHIBIT 2-4. PM RELATED HEALTH ENDPOINTS BASIS FOR THE HEALTH IMPACT FUNCTION ASSOCIATED WITH THAT ENDPOINT, AND SUB-POPULATIONS FOR WHICH THEY WERE COMPUTED

ENDPOINT	POLLUTANT	STUDY	STUDY POPULATION
Premature Mortality			
Premature mortality—all-cause[a]	$PM_{2.5}$ (annual avg)	Weibull distribution of C-R coefficients[a]	>24 years
Infant mortality—all-cause	$PM_{2.5}$ (annual avg)	Woodruff et al. (1997)	Infant (<1 year)
Chronic Illness			
Chronic bronchitis	$PM_{2.5}$ (annual avg)	Abbey et al. (1995)	>26 years
Nonfatal myocardial infarction	$PM_{2.5}$ (24-hour avg)	Peters et al. (2001)	Adults (>18 years)
Hospital Admissions			
Respiratory	$PM_{2.5}$ (24-hour avg)	Pooled estimate: Moolgavkar (2003)—ICD 490-496 (COPD) Ito (2003)—ICD 490-496, 480-487 (COPD, pneumonia)	>64 years
Respiratory	$PM_{2.5}$ (24-hour avg)	Moolgavkar (2000a)—ICD 490-492, 494-496 (COPD, less asthma)	20-64 years
Respiratory	$PM_{2.5}$ (24-hour avg)	Sheppard (2003)—ICD 493 (asthma)	<65 years
Cardiovascular	$PM_{2.5}$ (24-hour avg)	Pooled estimate: Moolgavkar (2003)—ICD 390-429 (all cardiovascular) Ito (2003)—ICD 411-414, 429, 428 (ischemic heart disease, dysrhythmia, heart failure)	>64 years
Cardiovascular	$PM_{2.5}$ (24-hour avg)	Moolgavkar (2000b)—ICD 390-429 (all cardiovascular)	20-64 years
Asthma-related ER visits	$PM_{2.5}$ (24-hour avg)	Norris et al. (1999)	<18 years
Other Health Endpoints			
Acute bronchitis	$PM_{2.5}$ (annual avg)	Dockery et al. (1996)	8-12 years
Lower respiratory symptoms	$PM_{2.5}$ (24-hour avg)	Schwartz and Neas (2000)	7-14 years
Upper respiratory symptoms	$PM_{2.5}$ (24-hour avg)	Pope et al. (1991)	9-11 years

ENDPOINT	POLLUTANT	STUDY	STUDY POPULATION
Asthma exacerbation	$PM_{2.5}$ (24-hour avg)	Pooled estimate: Ostro et al. (2001) (cough, wheeze, shortness of breath) Vedal et al. (1998) (cough)	6-18 years[b]
Minor restricted-activity days	$PM_{2.5}$ (24-hour avg)	Ostro and Rothschild (1989)	18-64 years
Work loss days	$PM_{2.5}$ (24-hour avg)	Ostro (1987)	18-64 years

a This distribution of coefficients for the PM mortality function is based on recommendations made by the HES; it features a Weibull distribution with a mean value of 1.06 that is approximately the average of coefficients derived from Pope et al. (2002) and Laden et al. (2006). The Pope and Laden coefficients fall roughly at the 25th and 75th percentiles of the Weibull distribution.

b The original study populations were 8 to 13 for the Ostro et al. (2001) study and 6 to 13 for the Vedal et al. (1998) study. Based on advice from the HES, we extended the applied population to 6 to 18, reflecting the common biological basis for the effect in children in the broader age group. See: U.S. Science Advisory Board. 2004. Advisory Plans for Health Effects Analysis in the Analytical Plan for EPA's Second Prospective Analysis - Benefits and Costs of the Clean Air Act, 1990—2020. EPA-SAB-COUNCIL-ADV-04-004. See also National Research Council (NRC). 2002. Estimating the Public Health Benefits of Proposed Air Pollution Regulations. Washington, DC: The National Academies Press.

EXHIBIT 2-9. NATIONAL OZONE BENEFITS OF CAAA IN 2000

ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality – All Cause[1]	210	1,400	2,800	$530	$10,000	$32,000
Morbidity						
Hospital Admissions, Respiratory (>64)	100	3,000	5,700	$2.5	$70	$140
Hospital Admissions, Respiratory (<2)	1,400	3,000	4,600	$14	$30	$46
Emergency Room Visits, Respiratory	0	2,200	6,200	$0	$0.81	$2.2
Minor Restricted Activity Days	1,300,000	3,100,000	4,800,000	$70	$180	$330
School Loss Days	480,000	1,200,000	1,900,000	$43	$110	$170
Outdoor Worker Productivity				$30	$30	$30

Results are rounded to two significant figures.
[1]Mortality results from Ito et al. (2005), Schwartz (2005), Bell et al. (2004), Bell et al. (2005), Levy et al. (2005), and Huang et al. (2005) are pooled using equal weights.

EXHIBIT 2-10. NATIONAL OZONE BENEFITS OF CAAA IN 2010

ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality – All Cause[1]	790	4,300	8,700	$2,000	$33,000	$98,000
Morbidity						
Hospital Admissions, Respiratory (>64)	740	9,900	18,000	$17	$230	$440
Hospital Admissions, Respiratory (<2)	4,300	9,000	14,000	$43	$90	$140
Emergency Room Visits, Respiratory	0	6,600	18,000	$0	$2.4	$6.4
Minor Restricted Activity Days	4,400,000	9,500,000	15,000,000	$230	$560	$1,000
School Loss Days	1,400,000	3,200,000	5,100,000	$120	$290	$450
Outdoor Worker Productivity				$100	$100	$100

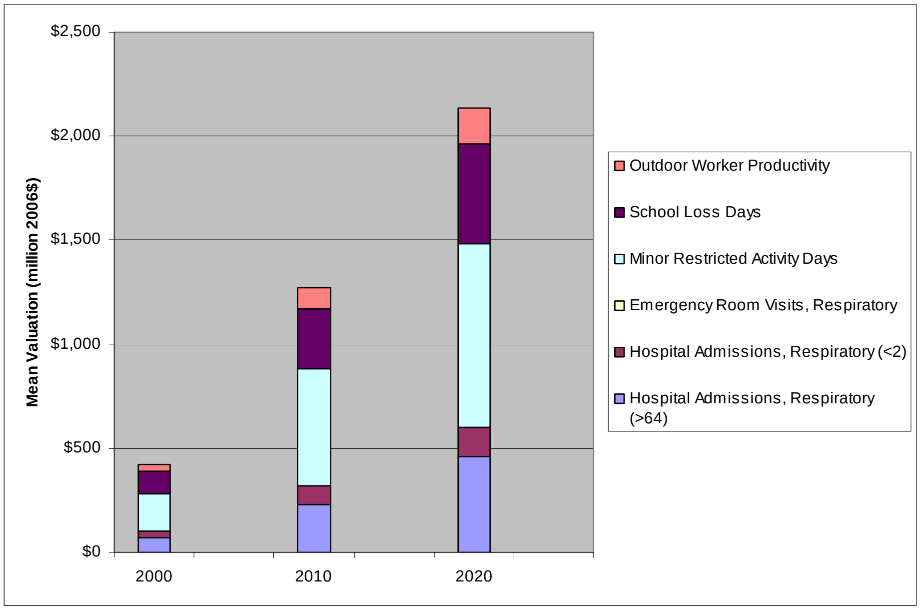
Results are rounded to two significant figures.
[1]Mortality results from Ito et al. (2005), Schwartz (2005), Bell et al. (2004), Bell et al. (2005), Levy et al. (2005), and Huang et al. (2005) are pooled using equal weights.

EXHIBIT 2-11. NATIONAL OZONE BENEFITS OF CAAA IN 2020

ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality – All Cause[1]	1,200	7,100	15,000	$3,200	$55,000	$170,000
Morbidity						
Hospital Admissions, Respiratory (>64)	990	19,000	36,000	$23	$460	$860
Hospital Admissions, Respiratory (<2)	6,600	14,000	22,000	$65	$140	$220
Emergency Room Visits, Respiratory	0	11,000	31,000	$0	$4.1	$11
Minor Restricted Activity Days	6,400,000	15,000,000	23,000,000	$330	$880	$1,600
School Loss Days	2,200,000	5,400,000	8,600,000	$190	$480	$770
Outdoor Worker Productivity				$170	$170	$170

Results are rounded to two significant figures.
[1]Mortality results from Ito et al. (2005), Schwartz (2005), Bell et al. (2004), Bell et al. (2005), Levy et al. (2005), and Huang et al. (2005) are pooled using equal weights.

EXHIBIT 2-12. NATIONAL OZONE MORBIDITY BENEFITS



PM BENEFIT ESTIMATES

PM benefit estimates are calculated at the national level for the contiguous 48 states. Exhibit 2-13 summarizes the valuation of PM benefits. Exhibits 2-14 through 2-16 give detailed PM benefit estimates in each target year. In addition to the mean incidence and valuation estimates, we have included 5th and 95th percentile estimates when available.

Benefits of reduced morbidity account for approximately four percent of the total PM benefits. Exhibit 2-17 presents a more detailed comparison of the PM morbidity estimates. Benefits of reduced mortality make up the remainder of the total PM benefits.

EXHIBIT 2-13. SUMMARY PM VALUATION RESULTS

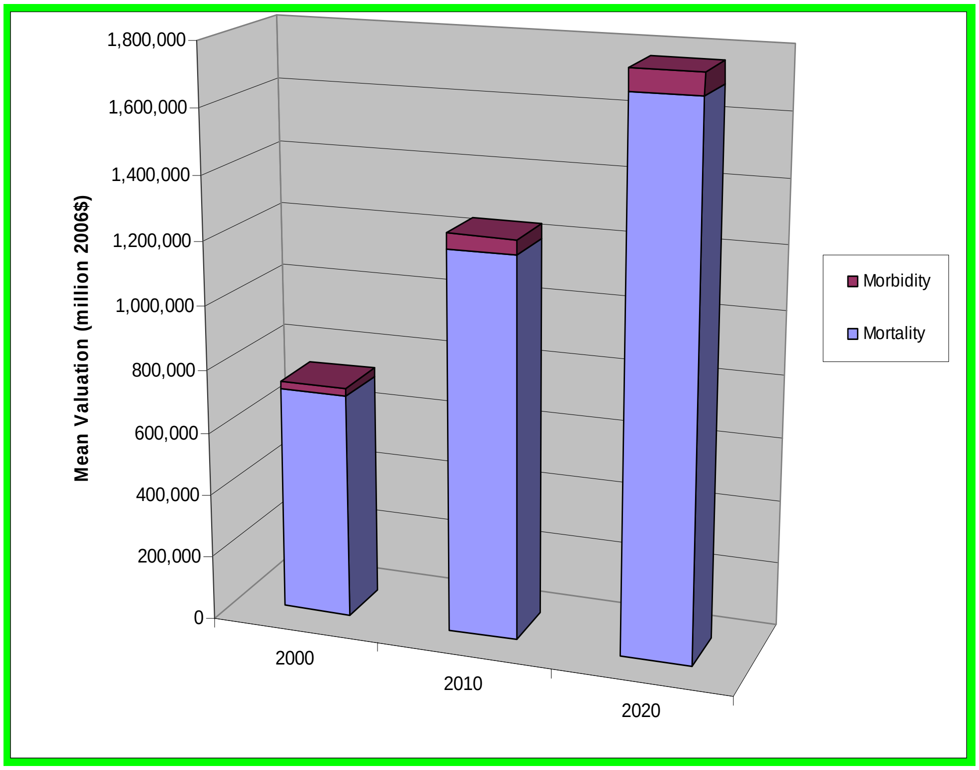


EXHIBIT 2-14. NATIONAL PM BENEFITS OF CAAA IN 2000

ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality - Weibull Distribution	20,000	110,000	230,000	$66,000	$710,000	$2,200,000
Morbidity						
Infant Mortality - Woodruff et al., 1997	81	160	250	$190	$1,300	$3,200
Chronic Bronchitis	5,500	34,000	62,000	$1,200	$14,000	$51,000
Nonfatal Myocardial Infarction	31,000	79,000	120,000	$2,300	$8,100	$20,000
Hospital Admissions, Respiratory	6,800	14,000	21,000	$94	$190	$280
Hospital Admissions, Cardiovascular	20,000	26,000	32,000	$550	$760	$990
Emergency Room Visits, Respiratory	34,000	56,000	77,000	$12.0	$21.0	$31.0
Acute Bronchitis	-4,000	96,000	180,000	-$2.00	$42.0	$100
Lower Respiratory Symptoms	600,000	1,200,000	1,800,000	$9.0	$22.0	$40.0
Upper Respiratory Symptoms	310,000	980,000	1,700,000	$8.40	$30.0	$63.0
Asthma Exacerbation	130,000	1,200,000	3,400,000	$7.10	$61.0	$190
Minor Restricted Activity Days	39,000,000	46,000,000	53,000,000	$1,600	$2,700	$4,000
Work Loss Days	7,000,000	8,000,000	9,100,000	$1,100	$1,300	$1,400
Notes: Results are rounded to two significant figures.						

EXHIBIT 2-15. NATIONAL PM BENEFITS OF CAAA IN 2010

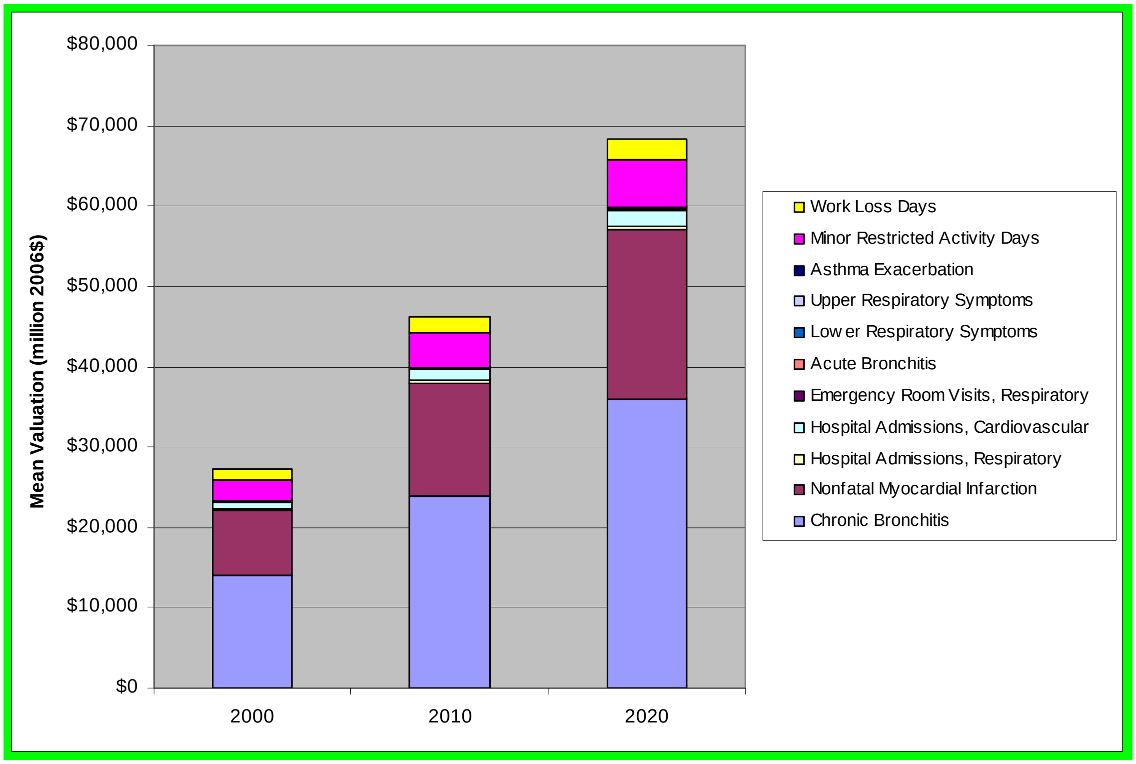
ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality - Weibull distribution	31,000	160,000	350,000	$110,000	$1,200,000	$3,600,000
Morbidity						
Infant Mortality - Woodruff et al., 1997	120	230	350	$280	$1,900	$4,900
Chronic Bronchitis	8,800	54,000	96,000	$2,000	$24,000	$84,000
Nonfatal Myocardial Infarction	53,000	130,000	200,000	$4,100	$14,000	$33,000
Hospital Admissions, Respiratory	11,000	22,000	33,000	$150	$310	$460
Hospital Admissions, Cardiovascular	34,000	45,000	54,000	$930	$1,300	$1,700
Emergency Room Visits, Respiratory	49,000	80,000	110,000	$17.0	$29.0	$44.0
Acute Bronchitis	-5,000	130,000	250,000	-$2.00	$61.0	$150
Lower Respiratory Symptoms	840,000	1,700,000	2,400,000	$13.0	$30.0	$55.0
Upper Respiratory Symptoms	440,000	1,400,000	2,300,000	$12.00	$42.0	$89.0
Asthma Exacerbation	190,000	1,700,000	4,900,000	$11.00	$90.0	$270
Minor Restricted Activity Days	63,000,000	74,000,000	85,000,000	$2,600	$4,400	$6,300
Work Loss Days	11,000,000	13,000,000	14,000,000	$1,700	$2,000	$2,200

Notes: Results are rounded to two significant figures.

EXHIBIT 2-16. NATIONAL PM BENEFITS OF CAAA IN 2020

ENDPOINT GROUP	INCIDENCE			VALUATION (MILLION 2006$)		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Mortality						
Mortality - Weibull distribution	44,000	230,000	480,000	$170,000	$1,700,000	$5,300,000
Morbidity						
Infant Mortality - Woodruff et al., 1997	140	280	420	$370	$2,500	$6,400
Chronic Bronchitis	12,000	75,000	130,000	$3,100	$36,000	$130,000
Nonfatal Myocardial Infarction	80,000	200,000	300,000	$6,200	$21,000	$48,000
Hospital Admissions, Respiratory	16,000	33,000	49,000	$230	$460	$680
Hospital Admissions, Cardiovascular	52,000	69,000	84,000	$1,400	$2,000	$2,600
Emergency Room Visits, Respiratory	66,000	110,000	150,000	$23.0	$39.0	$58.0
Acute Bronchitis	-7,000	180,000	340,000	-$4.00	$94.0	$220
Lower Respiratory Symptoms	1,200,000	2,300,000	3,300,000	$18.0	$42.0	$76.0
Upper Respiratory Symptoms	620,000	2,000,000	3,300,000	$17.00	$60.0	$130.0
Asthma Exacerbation	270,000	2,400,000	6,700,000	$15.00	$130.0	$390
Minor Restricted Activity Days	84,000,000	99,000,000	110,000,000	$3,500	$5,900	$8,500
Work Loss Days	15,000,000	17,000,000	19,000,000	$2,300	$2,700	$3,000
Notes: Results are rounded to two significant figures.						

EXHIBIT 2-17. NATIONAL PM MORBIDITY BENEFITS



accomplish this objective in somewhat different ways.[35] Tolley et al. (1986) specify a hypothetical pollution control program that will only affect visibility: "Suppose a program could be set up to prevent the decline in visibility, realizing that there would be no health effects." In contrast, Brookshire et al. (1979) specify a more general pollution control program, but they ask respondents to focus only on their preferences for visibility improvements: "I am only interested in how you value being able to see long distances." Finally, Loehman et al. (1986) present summary tables to respondents that describe the expected number of days per year at various health and visibility levels for both the baseline and the improved situations. Respondents are asked to provide WTP for air quality improvements with an increased number of good visibility days but with health levels held constant.

The degree to which the three studies were successful in convincing respondents to focus solely on visibility is unclear, as none of the three studies includes follow-up questions necessary to investigate the issue. Furthermore, no other residential visibility CV studies provide evidence regarding the degree to which health effects are embedded in visibility values. Although the McClelland et al. (1991) study has a follow-up question designed to allocate WTP across several categories, the CV question in the McClelland et al. study was focused on air pollution generally rather than visibility. As a result, we do not adjust the results from these studies to account for potentially embedded health effects.

RESULTS

The primary estimate of benefits to recreational and residential visibility is provided in Exhibit 3-7. The primary estimate for recreational visibility only includes benefits in the original study regions (i.e., California, the Southwest, and the Southeast). The primary estimate for residential visibility includes benefits in all MSAs. In general, benefits to visibility increase over time as visibility improves due to the CAAA. Benefits to residential visibility are approximately three times as large as benefits to recreational visibility.

Exhibit 3-8 provides an alternative estimate of benefits to recreational visibility. This alternative estimate includes all Class I areas, not just those that were directly analyzed in the original Chestnut and Rowe study. The alternative recreational visibility benefits estimate is approximately 40 percent greater than the primary estimate.

EXHIBIT 3-7. PRIMARY ESTIMATE OF BENEFITS TO VISIBILITY (BILLION 2006$)

	2000 BENEFITS	2010 BENEFITS	2020 BENEFITS
Recreational Benefits	$4.1	$9	$18
Residential Benefits	$13	$27	$49
Total Benefits	$17	$36	$67

[35] See Leggett et al. (2004) for a more detailed discussion of this issue.

*Note that the benefits estimates in this chapter have been reduced by 10 percent to reflect revised primary $PM_{2.5}$ estimates. The Project Team is in the process of developing a revised visibility estimate to reflect these changes in the emissions data. In this draft, the deciview data and maps in Exhibits 3-1, 3-2, 3-3, 3-9, 3-10, 3-11, and 3-13 have not yet been updated and do not reflect this revision.

EXHIBIT 3-8. ALTERNATIVE ESTIMATE OF BENEFITS TO VISIBILITY (BILLION 2006$)

	2000 BENEFITS	2010 BENEFITS	2020 BENEFITS
Recreational Benefits	$5.8	$13	$24
Residential Benefits	$13	$27	$49
Total Benefits	$19	$40	$73

*Note that the benefits estimates in this chapter have been reduced by 10 percent to reflect revised primary $PM_{2.5}$ estimates. The Project Team is in the process of developing a revised visibility estimate to reflect these changes in the emissions data. In this draft, the deciview data and maps in Exhibits 3-1, 3-2, 3-3, 3-9, 3-10, 3-11, and 3-13 have not yet been updated and do not reflect this revision.

Exhibit Exhibits 3-9 through 3-11 map the primary estimate of benefits to recreational, residential, and total visibility by state in 2020. Exhibit 3-12 ranks states by their level of benefits to recreational, residential and total visibility. Exhibit 3-13 provides a visual comparison of the primary benefits estimate visibility across all years (i.e., 2000, 2010, and 2020). The full set of primary results by State is given in Appendix A. Overall, the spatial pattern of benefits is similar for recreational and residential visibility. Totals benefits are lowest in Wyoming, North Dakota, Vermont, South Dakota, Montana, and Idaho. Total benefits are highest in California, New York, Texas, Pennsylvania, and Florida. Benefits appear to be largely driven by population as these are some of the least and most populous states.

Recreational visibility benefits are driven by population and park location. The primary benefits estimate includes only those Class I areas located within the original study regions of Chestnut and Rowe (1990a). These regions are California, the Southwest (Arizona, Nevada, Utah, Colorado, and New Mexico), and the Southeast (Delaware, Maryland, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Florida, and Mississippi). Households express WTP for visibility improvements in Class I areas located in-region as well as out-of-region. For this reason, there may be high recreational benefits in a state that has no Class I areas. Although household WTP is higher for in-region parks, this effect seems to be dominated by the effect of population. For example, less populated states such as New Mexico and Utah with Class I areas have low benefits to recreational visibility, while more populated states such as New York without Class I areas have high benefits to recreational visibility (see Exhibit 3-12). In some cases, the effect of being an in-region state is evident, for example Florida is ranked second in recreational benefits, but fifth in residential benefits (see Exhibit 3-12).

Residential visibility benefits are driven by population and visibility improvements. Overall, benefits are greater in the East. This is due in part to greater population levels as well as greater visibility improvements (see Exhibit 3-1). Benefits are also very high in California due to the state's large population and visibility improvements, especially in and around Los Angeles and San Francisco. Residential visibility is also dependent upon the WTP value applied. Much of the West uses the WTP value for Denver (see Exhibit 3-6), which is highest WTP value being widely applied. Yet, the West still has lower

CHAPTER 6 | SUMMARY OF PRIMARY BENEFITS

This chapter presents an integrated summary of the quantified and monetized primary benefits estimates described in this report and in the companion Second Prospective Section 812 study report, *Ecological Benefits Analyses to Support the Second Section 812 Prospective Benefit-Cost Analysis of the Clean Air Act.*.

SUMMARY OF ANNUAL BENEFITS

The results of this benefits analysis demonstrate that implementation of the CAAA's programs on air emissions yields substantial human health and welfare benefits across the U.S. over the period from 1990 to 2020. These benefits include reductions in mortality risk, reductions in respiratory and cardiovascular morbidity, improved visibility, improved productivity of agricultural crops and commercial forests, and reduced materials damage to resources as bridges, architectural coatings, and other materials that can be damaged by air pollution. Exhibit 6-1 presents a summary of the mean primary annual economic benefits results from the Second Prospective analysis for 2000, 2010, and 2020. Total annual benefits (in 2006 dollars) range from $770 billion in 2000 to $2 trillion in 2020 across all monetized benefit categories, with increasing benefits for each target year.

The bulk of the economic benefits result from improvements in human health; primarily from the reduction in premature mortality, which constitutes 85 percent of the total monetized benefits value in 2020. As we acknowledge throughout this report, there are numerous effects of improved air quality, including most of the ecological benefits that we currently are unable to quantify and/or monetize. A proper economic accounting of these benefits would likely lead to even greater benefit values and would alter the relative contribution of the different categories of effects. Exhibit 6-2 presents a list of the un-quantified and/or un-monetized benefit associated with CAAA improvements in air quality.

SUMMARY OF CUMULATIVE MONETIZED BENEFITS

Although this analysis focused on estimating annual benefits for each of three target years, benefits of improved air quality due to the CAAA are expected to accrue through the study period. We estimate these cumulative benefits by interpolating between the target years, using information on the expected trend and trajectory of benefits throughout the period, and aggregating the resulting values to produce a discounted present value estimate of the cumulative benefits of Titles I through V of the CAAA.

EXHIBIT 6-1. SUMMARY OF MEAN PRIMARY BENEFITS RESULTS

BENEFIT CATEGORY	MONETIZED BENEFITS (MILLION 2006$) BY TARGET YEAR			NOTES
	2000	2010	2020	
Health Effects				
PM Mortality PM Morbidity Ozone Mortality Ozone Morbidity	$710,000 $27,000 $10,000 $420	$1,200,000 $46,000 $33,000 $1,300	$1,700,000 $68,000 $55,000 $2,100	-PM mortality estimates based on Weibull distribution of C-R coefficients with mean of 1.06 derived from Pope et al. (2002) and Laden et al., (2006). -Ozone mortality estimates based on pooled C-R function
Subtotal Health Effects	$750,000	$1,300,000	$1,900,000	
Visibility*				
Recreational **Residential**	$4,100 $13,000	$9,000 $27,000	$18,000 $49,000	Recreational visibility only includes benefits in the regions analyzed in Chestnut and Rowe, 1990 (i.e., California, the Southwest, and the Southeast).
Subtotal Visibility	$17,000	$36,000	$67,000	
Agricultural and Forest Productivity	[pending]			
Materials Damage	$58	$93	$110	
Ecological	$6.9	$7.5	$8.2	Reduced lake acidification benefits to recreational fishing assuming effect threshold of 50 microequivalents per liter.
Total: all categories	$770,000	$1,300,000	$2,000,000	

Note: See Chapters 2 through 5 of this report for detailed results summaries. Values presented are means from results reported as distributions. Additional, alternative estimates are provided in the separate companion report on uncertainty. Estimates presented with two significant figures.

*Note that the benefits estimates in this chapter have been reduced by 10 percent to reflect revised primary PM2.5 estimates. The Project Team is in the process of developing a revised visibility estimate to reflect these changes in the emissions data.

Air quality modeling was carried out only for the three target years (2000, 2010, and 2020). The resulting annual benefit estimates indicate an increasing temporal trend of monetized benefits across the period resulting from the annual changes in air quality. They do not, however, characterize the uncertainty associated with the yearly estimates for intervening years. In an effort to generate improved estimates of the trajectory of benefits in these years, the 812 Project Team generated emissions reduction trajectories across the study period for seven pollutants in the *with-* and *without-CAAA* scenarios. Appendix O of the Second Section 812 Prospective Emissions Analysis describes the methods used to derive trajectories for each major emitting sector and presents emissions trajectories for VOC, NO_x, CO, SO_2, PM10, $PM_{2.5}$, and NH_3, which we reproduce here as Exhibits 6-3a and 6-3b. In general, these trajectories show flat to slightly increasing reductions in the early 1990s followed by relatively rapid increases in reductions between the mid-1990s and 2000. From 2000 through the end of the study period, the seven pollutants show a steady linear increase in reductions.

Using these emissions reduction trajectories, and average human health benefit-per-ton estimates for each pollutant obtained from the most recent ozone NAAQS RIA, we generated a pollutant-weighted "benefits index" value for each target year and each of the intervening years.[52] This index is the sum of the tons of each pollutant reduced in a given year, weighted by the benefit-per-ton values. We these index values to interpolate benefits between the study years and create a benefits trajectory as follows, using 2007 as an example year:

$$BT_{2007} = BT_{2000} + (BT_{2010} - BT_{2000})\frac{BI_{2007} - BI_{2000}}{BI_{2010} - BI_{2000}}$$

Where: BT_{2007} = Benefits trajectory value in 2007

BT_{2000} = Benefits trajectory value in 2000

BT_{2010} = Benefits trajectory value in 2010

BI_{2007} = Benefits index value in 2007

BI_{2000} = Benefits index value in 2000

BI_{2010} = Benefits index value in 2010

We used this procedure to generate benefits trajectories from 1990 to 2000, from 2000 to 2010, and from 2010 to 2020. Exhibit 6-4 illustrates the benefits trajectory resulting from our interpolation approach.

[52] 2008 National Ambient Air Quality Standards for Ground-Level Ozone. Technical Support Document: Calculating Benefit Per-Ton Estimates. We used benefit-per-ton values that assumed a 50 percent reduction in emissions and employed the Pope et al. (2002) $PM_{2.5}$ mortality function.

EXHIBIT 6-3A. TRAJECTORY OF CAAA-RELATED REDUCTIONS IN VOC, NO_X, AND SO_2 EMISSIONS: 1990 THROUGH 2020 (TONS OF POLLUTANT REDUCED)

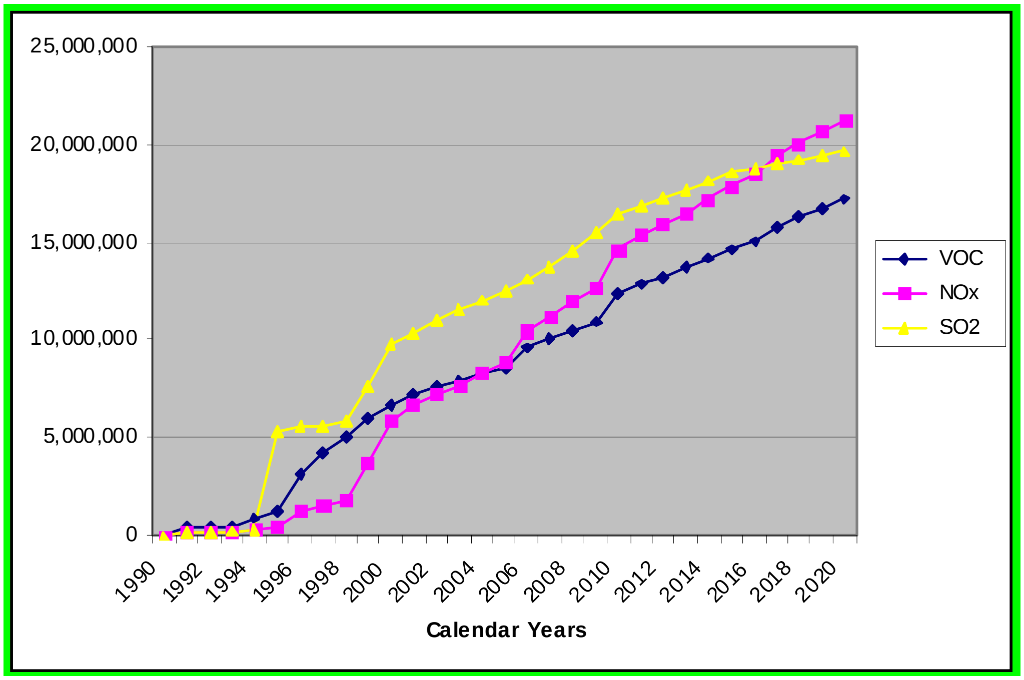


EXHIBIT 6-3B. TRAJECTORY OF CAAA-RELATED REDUCTIONS IN PM_{10} AND $PM_{2.5}$ EMISSIONS: 1990 THROUGH 2020 (TONS OF POLLUTANT REDUCED) [PLACEHOLDER: TO BE REVISED]

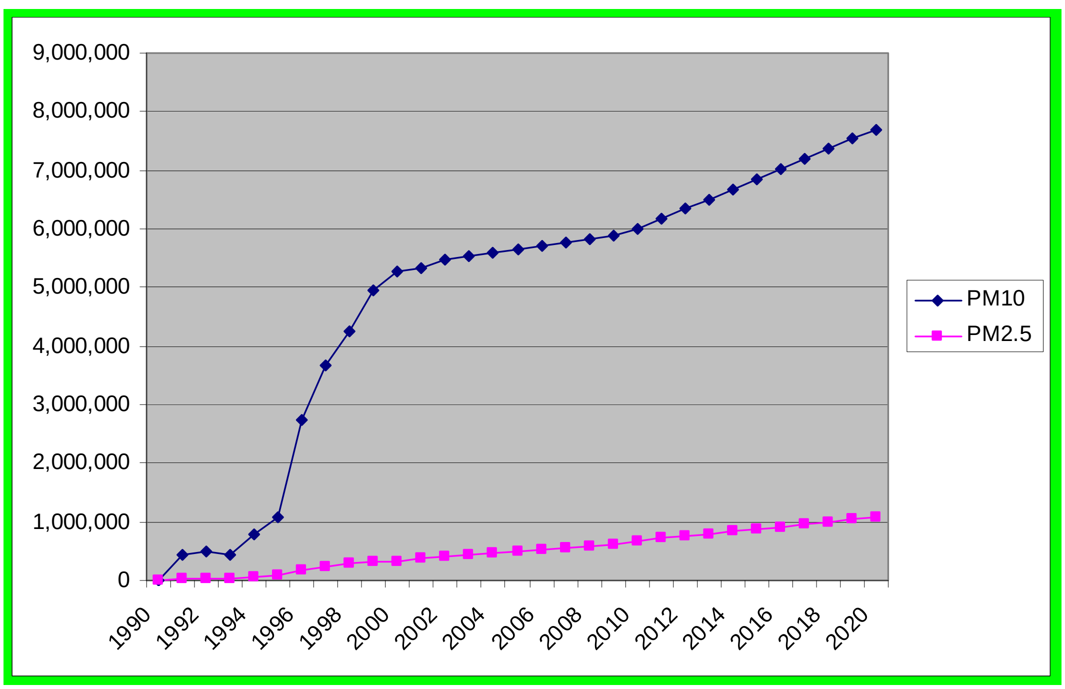
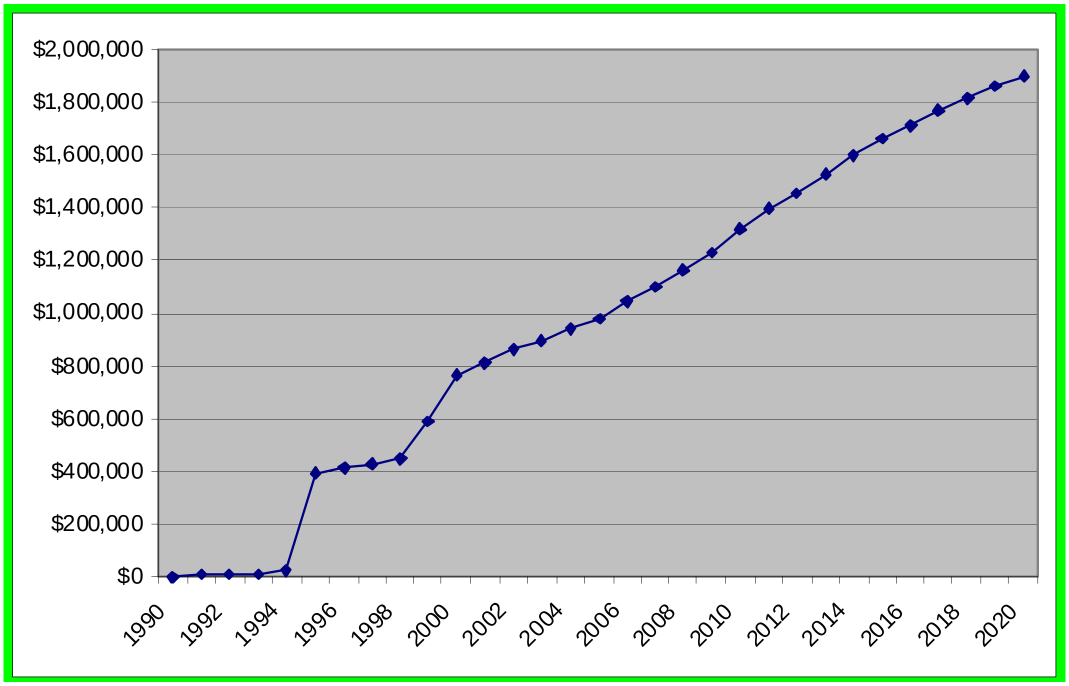


EXHIBIT 6-4 - INTERPOLATION STRATEGY FOR CUMULATIVE BENEFITS (MILLIONS OF 2006$)



In an attempt to represent uncertainty associated with these estimates, we relied on the ratios of the 5th percentile to the mean and the 95th percentile to the mean in the target years. In general, these ratios were fairly constant across the target years, for a given endpoint. The ratios were interpolated between the target years, yielding ratios for the intervening years. Multiplying the ratios for each intervening year by the central estimate generated for that year provided estimates of the 5th and 95th percentiles, which we use to characterize uncertainty about the Primary Central estimate. In Exhibit 6-5 we present the cumulative monetized benefits aggregated from 1990 to 2020. We present the mean estimate from the aggregation procedure, along with the Primary Low (i.e., 5th percentile of the distribution) and Primary High (i.e., 95th percentile of the distribution) estimates, for all provisions of Titles I through V. Aggregating the stream of monetized benefits across years involved discounting the stream of monetized benefits estimated for each year to the 1990 present value (using a five percent discount rate).

EXHIBIT 6-5. CUMULATIVE MONETIZED BENEFITS OF CAAA TITLES I THROUGH V IN THE U.S.

PRESENT VALUE (MILLIONS 2006$, DISCOUNTED TO 1990 AT 5 PERCENT)		
PRIMARY LOW	PRIMARY CENTRAL	PRIMARY HIGH
$1,400,000	$12,000,000	$35,000,000

COMPARISON WITH RESULTS FROM THE FIRST PROSPECTIVE

The health effects estimates for the second prospective are much larger than the estimates EPA developed for the first prospective. The 2020 estimates are new to the second prospective, but the comparable mean estimate of health benefits in 2000 and 2010 for the first prospective were $71 billion in 2000 and $110 billion in 2010, in 1990$[53] - if updated to 2006$, these estimates would be $110 billion in 2000 and $170 billion in 2010. There are six key reasons we have identified for the increase in benefits:

1. ***Scenario differences*:** The *with-CAAA* scenario, especially for the 2010 target year, includes new rules with substantial additional pollutant reductions that were not included in the comparable first prospective scenario, such as the Clean Air Interstate Rule (CAIR).
2. ***Improved air quality models*:** The first prospective relied on the Regional Acid Deposition Model/Regional Particulate Model (RADM/RPM) for PM and deposition estimates in the eastern U.S., the Regulatory Modeling System for Aerosols and Acid

[53] See The Benefits and Costs of the Clean Air Act 1990 to 2010, USEPA Office of Air and Radiation and Office of Policy, EPA-410-R-99-001, November 1999.