Change Pages

for

Uncertainty 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.]

4.3 RESULTS

We present below the results of the alternative C-R function analyses, first for PM and then for ozone.

4.3.1 EFFECTS OF ALTERNATIVE PM CONCENTRATION-RESPONSE FUNCTIONS

Exhibit 4-2 presents the incidence results using the primary C-R function for PM mortality for each target year (2000, 2010, and 2020) as well as the relative changes in mortality incidence associated with using the alternative C-R functions (Pope et al., 2002; Laden et al., 2006; and the EE study results). Exhibit 4-3 compares box plots of the primary and alternative results distributions. These two exhibits show the following:

- The mean benefits estimates generated from the Pope et al. (2002) study are 44 percent lower than the primary estimate, while the Laden et al. (2006) study results are roughly 40 percent higher, due to the difference in the magnitude of the relative risks (RRs) from these two studies.
- The mean estimates of annual avoided deaths due to CAAA generated from the PM EE results vary by expert and range between 83 percent lower than the mean primary estimate up to 76 percent higher at the extremes. The rest of the estimates are within approximately 40 percent or less of the primary estimate.
- As shown in Exhibit 4-3, the spread of the confidence bounds of the alternative C-R function estimates of avoided mortality results vary, with the largest spread found in the distribution provided by Expert A from the EE study and the smallest spread associated with the Pope et al., 2002, which only estimates statistical uncertainty. However, there is some overlap between the confidence bounds of all of the alternate C-R functions, implying that the results are not all statistically significantly different from each other.

4.3.2 EFFECTS OF ALTERNATIVE OZONE CONCENTRATION-RESPONSE FUNCTIONS

Exhibit 4-4 presents changes in mortality incidence based on the primary C-R function for ozone mortality for each target year (2000, 2010, and 2020), as well as the relative changes in mortality incidence associated with using the alternative C-R functions. Exhibit 4-5 is a box plot that illustrates the primary and alternative results distributions. These exhibits show the following:

- The mean benefits estimates generated from the Levy et al. (2005) study are the largest; they are roughly 66 percent higher than the primary estimate, though these are very similar to the Ito et al. estimates. The mean benefits estimates generated from the Bell et al. (2004) study are the lowest, roughly 63 percent lower than the primary estimate.
- In general, the results derived from the three meta-analyses (Ito et al., 2005; Levy et al., 2005; Bell et al., 2005) are greater than the results derived from three NMMAPS-based studies (Schwartz, 2005; Bell et al., 2004; Huang et al., 2005).

[Continued on 4-4a – April 29 revised]

- As shown in Exhibit 4-5, the spread of the confidence bounds of the alternative C-R function estimates incidence results vary, with the largest spread found in the distribution of our primary estimate (the pooling of all six studies) and the

[Continued on 4-5 – April 29 revised]

smallest spread associated with Bell et al. (2004). However, there is some overlap between the confidence bounds of all of the alternate C-R functions, implying that the results are not all statistically significantly different from each other.

EXHIBIT 4-2. ALTERNATIVE C-R FUNCTION MORTALITY INCIDENCE RESULTS FOR $PM_{2.5}$

MORTALITY C-R FUNCTION	PERCENTILE 5	MEAN	PERCENTILE 95
Primary Estimate - 2000	**20,000**	**110,000**	**230,000**
Primary Estimate - 2010	**31,000**	**160,000**	**350,000**
Primary Estimate - 2020	**44,000**	**230,000**	**480,000**
	Percent Change from Mean Primary Estimate		
Pope et al. (2002)	-77%	-44%	-11%
Laden et al. (2006)	-22%	40%	98%
Expert A	-71%	38%	150%
Expert B	-87%	1%	95%
Expert C	-59%	10%	79%
Expert D	-95%	-21%	28%
Expert E	-9%	76%	156%
Expert F	-41%	-9%	24%
Expert G	-100%	-34%	20%
Expert H	-100%	-21%	83%
Expert I	-90%	10%	83%
Expert J	-86%	-11%	83%
Expert K	-100%	-83%	-24%
Expert L	-99%	-28%	24%

Note: All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.

[Continued on 4-6 – April 29 revised]

EXHIBIT 4-3. BOX-PLOT OF 90 PERCENT CONFIDENCE BOUNDS FOR ALTERNATIVE C-R FUNCTION MORTALITY INCIDENCE

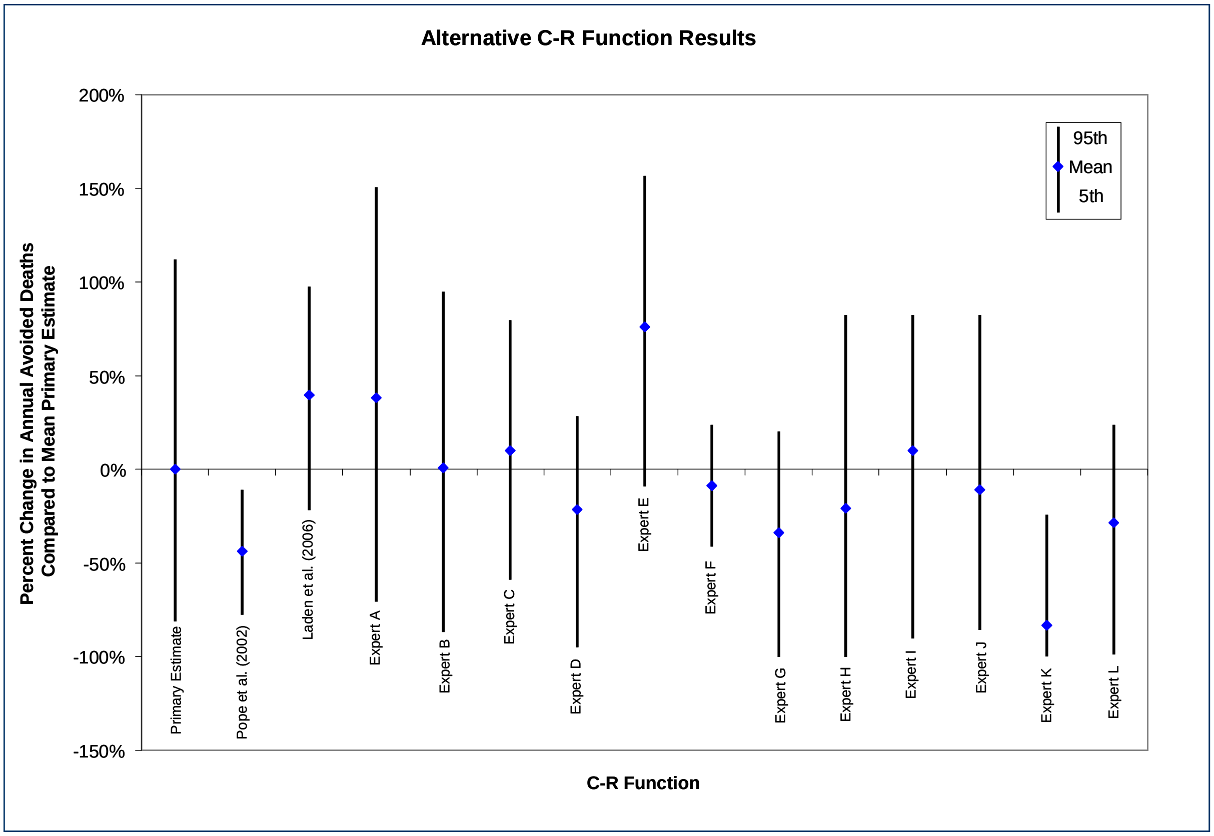


EXHIBIT 4-4. ALTERNATIVE C-R FUNCTION MORTALITY INCIDENCE RESULTS FOR OZONE

MORTALITY C-R FUNCTION	PERCENTILE 5	MEAN	PERCENTILE 95
Primary Estimate - 2000	210	1,400	2,800
Primary Estimate - 2010	790	4,300	8,700
Primary Estimate - 2020	1,200	7,100	15,000
	Percent Change from Mean Primary Estimate		
Meta-Analyses			
Ito et al. (2005)	1%	63%	123%
Levy et al. (2005)	17%	66%	113%
Bell et al. (2005)	-41%	17%	76%
NMMAPS-Based Studies			
Schwartz (2005)	-81%	-45%	-8%
Bell et al. (2004)	-87%	-63%	-41%
Huang et al. (2005)	-75%	-40%	-5%
Note: Incidence results are rounded to two significant figures.			

[Continued on 4-7]

The spreadsheet uses the estimates of avoided deaths from BenMAP generated from the use of the CMAQ exposure model for each target year, along with an estimate of the default Value of a Statistical Life (VSL) of $7.4 million in 1990 (in 2006$), and a five percent discount rate, to calculate the net present economic value of the modeled stream of monetized benefits under each lag assumption.[122]

6.3 EFFECT OF ALTERNATIVE CESSATION LAG STRUCTURES

The exponential decay function that we employed as a new alternative lag structure relies on time constant values derived from combining information from a particular PM cohort and intervention study pair. Therefore, use of this smooth function implies that selecting an alternate C-R function will affect not only the total avoided mortality (as described in Chapter 4) but also the way in which that avoided mortality accrues over time following a change in exposure. We first present the effects of applying the two step functions and the exponential functions derived from the primary C-R function to the mortality incidence results generated with the primary C-R function. We also compare the results of applying the exponential decay function lag based on the smoking literature to the primary C-R function. We next present the relative benefits resulting from applying the two step functions and the exponential decay functions derived from the Pope and Laden studies to the mortality incidence results generated from Pope and Laden C-R functions.

6.3.2 CESSATION LAG RESULTS BASED ON THE PRIMARY C-R FUNCTION ESTIMATE

Exhibits 6-3 and 6-4 show the difference in the timing of avoided deaths due to CAAA-related $PM_{2.5}$ changes in 2020 when applying the various cessation lag structures to the primary mortality incidence results. Exhibit 6-3 shows the number of deaths that would occur in each year and Exhibit 6-4 compares the cumulative number of avoided deaths over time. Exhibit 6-5 displays the mean valuation results using the default 20-year distributed lag and the percent change in valuation that occurs as a result of employing each of the alternative cessation lag structures. We present below a summary of the key impacts of varying the cessation lag model on the primary estimates of mortality reductions due to CAAA programs:

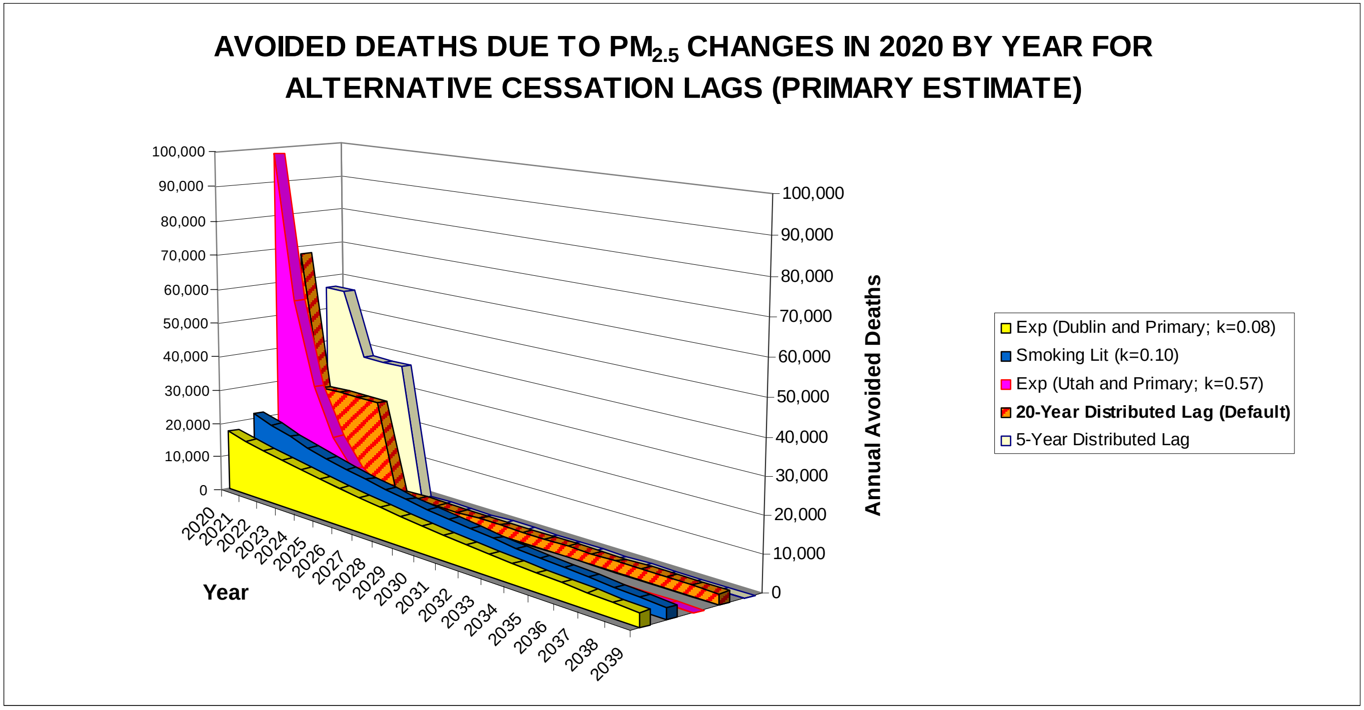
- The five-year distributed lag valuation results are roughly nine percent higher than the 20-year distributed lag assumption. This is due to the fact that the avoided deaths in the 20-year lag assumption are spread over a longer time period and the corresponding VSLs are more heavily discounted, while under the five-year lag assumption, 50 percent of deaths occur within the first two years and all deaths occur within five years.

[122] This approach is equivalent to discounting future VSLs from the years in which mortality reductions are expected to occur and multiplying each discounted VSL times avoided deaths in that year. The approach does not discount future avoided deaths.

[Continued on 6-8]

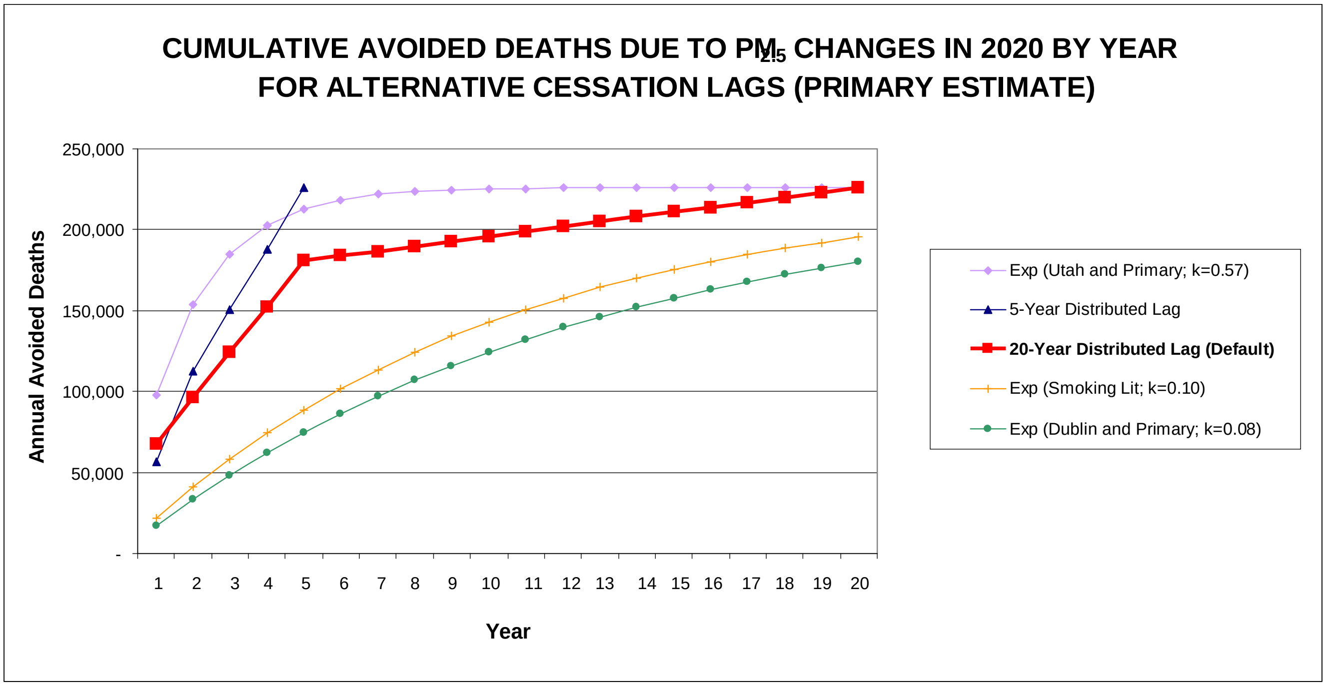
- The results based on the smooth function lag structure vary depending on the time constant selected. When relying on the k value derived from the primary C-R function and the Dublin Coal Ban study (k = 0.08), the economic value decreases 23 percent from the default. This reflects the fact that the avoided deaths are spread over a longer period of time after the exposure change. The benefits that accrue far into the future are assigned less economic value because the VSL is more heavily discounted. Applying the k value derived from primary C-R function and the Utah Valley study (k = 0.57) results in valuation estimates that are 10 percent higher than the default lag assumption. Use of the k value derived from the smoking cessation literature (k = 0.10) results in a monetary benefits estimate that is 18 percent lower than the 20-year distributed lag.
- Assuming no lag, and therefore no discounting of VSL, results in an increase in benefits of approximately 16 percent above the default, 20-year distributed lag.

EXHIBIT 6-3. ALTERNATE CESSATION LAGS - ANNUAL DEATHS (PRIMARY ESTIMATE)



[Continued on 6-9a – April 29 revised]

EXHIBIT 6-4. ALTERNATE CESSATION LAGS – CUMULATIVE DEATHS (PRIMARY ESTIMATE)



6.3.1 CESSATION LAG RESULTS BASED ON POPE ET AL., 2002

Exhibits 6-6 and 6-7 show the difference in the timing of avoided deaths due to CAAA-related $PM_{2.5}$ changes in 2020 when applying the various cessation lag structures to the Pope mortality incidence results. Exhibit 6-6 shows the number of deaths that would occur in each year and Exhibit 6-7 compares the cumulative number of avoided deaths over time. Exhibit 6-8 displays the percent change in valuation results from the primary estimate (i.e., the primary C-R function estimate with the 20-year distributed lag) as a result of employing each of the alternative lag structures to the Pope incidence results. We present below a summary of the key results of varying both the C-R function employed and the cessation lag model on the primary estimates of avoided mortality due to CAAA programs:

- The use of the Pope et al. incidence estimates along with the default 20-year distributed lag result in valuation estimates that are 43 percent lower than the primary estimate. Since we are only varying the incidence estimate and not the lag structure, this difference is solely due to the different magnitudes of the two C-R functions.

[Continued on 6-10 – April 29 revised]

EXHIBIT 6-5. VALUATION RESULTS FOR THE PRIMARY C-R FUNCTION ESTIMATE AND THE EFFECT OF USING ALTERNATIVE LAG STRUCTURES

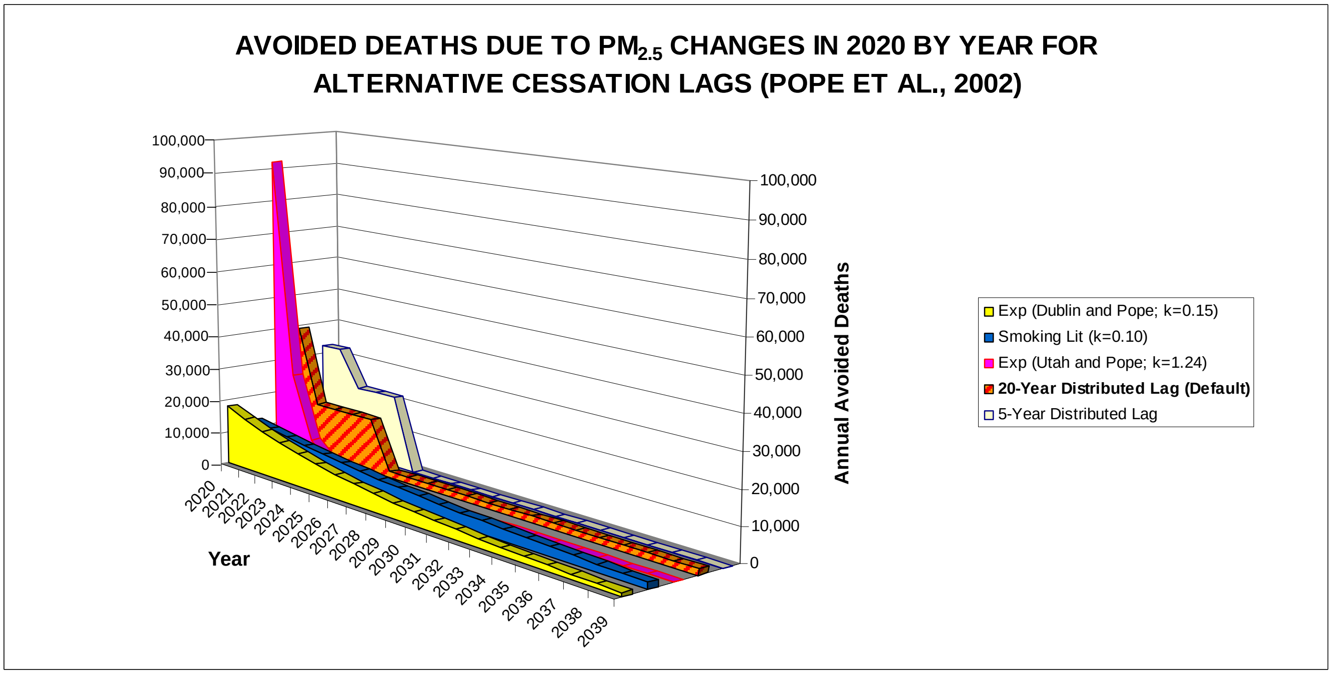
MORTALITY CESSATION LAG	
Primary Estimate with 20-Year Distributed Lag - 2000	**710,000**
Primary Estimate with 20-Year Distributed Lag - 2010	**1,200,000**
Primary Estimate with 20-Year Distributed Lag - 2020	**1,700,000**
	Percent Change from the Primary Estimate with Default Lag*
Primary Estimate with 5-Year Distributed Lag	9%
Primary Estimate with Smooth Function, k = 0.08 (Dublin Intervention Study)	-23%
Primary Estimate with Smooth Function, k = 0.10 (Smoking cessation)	-18%
Primary Estimate with Smooth Function, k = 0.57 (Utah Valley Intervention Study)	10%
No Lag, No Discounting	16%
* All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.	

- Applying the 5-year distributed lag to the Pope incidence results in a benefits estimate that is 42 percent lower than the primary estimate. In this case, the reduction in avoided mortality due to the lower Pope C-R coefficient dominates the effect of shortening the lag period and increasing the percentage of benefits accrued in early years.
- The results based on the smooth function lag structure vary depending on the time constant selected. When relying on the k value derived from Pope and the Dublin Coal Ban study (k = 0.15), the economic value decreases 52 percent from the default. This reflects the fact that the avoided deaths are spread over a longer period of time after the exposure change, but again the bulk of the impact comes from changing the C-R function. Applying the k value derived from Pope and the Utah Valley study (k = 1.24) results in valuation estimates that are similar to assuming no lag, since 92 percent of avoided mortality occurs within the first year. These results are 37 percent lower than the default lag assumption, again

[Continued on 6-11a – April 29 revised]

illustrating that the results are less sensitive to the choice of cessation lag than they are to the choice of C-R coefficient.

EXHIBIT 6-6. ALTERNATE CESSATION LAGS – ANNUAL DEATHS (POPE ET AL., 2002)



[Continued on 6-11a – April 29 revised]

EXHIBIT 6-7. ALTERNATE CESSATION LAGS - CUMULATIVE DEATHS (POPE ET AL., 2002)

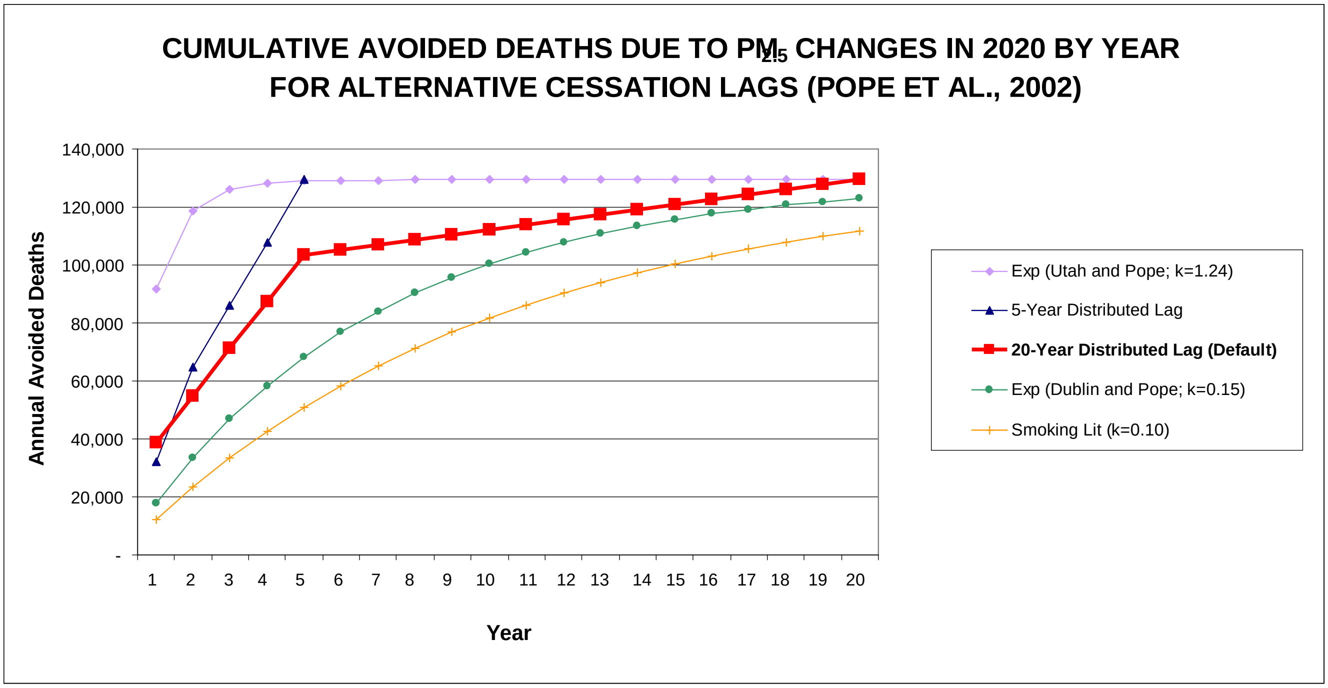


EXHIBIT 6-8. RELATIVE VALUATION RESULTS USING ALTERNATIVE LAG STRUCTURES – POPE ET AL., 2002

MORTALITY CESSATION LAG	PERCENT CHANGE FROM PRIMARY ESTIMATE WITH DEFAULT LAG*
Pope et al. 2002 with 20-Year Distributed Lag	-43%
Pope et al. 2002 with 5-Year Distributed Lag	-42%
Pope et al. 2002 with Smooth Function, k = 0.15 (Dublin Intervention Study)	-52%
Pope et al. 2002 with Smooth Function, k = 1.24 (Utah Valley Intervention Study)	-37%

* All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.

[Continued on 6-11b – April 29 revised]

6.3.3 CESSATION LAG RESULTS BASED ON LADEN ET AL., 2006

Exhibits 6-9 and 6-10 show the difference in the timing of avoided deaths due to CAAA-related $PM_{2.5}$ changes in 2020 when applying the various cessation lag structures to the Laden mortality incidence results. Exhibit 6-9 shows the number of deaths that would occur in each year and Exhibit 6-10 compares the cumulative number of avoided deaths over time. Exhibit 6-11 displays the percent change in valuation results from the primary estimate (i.e., the primary C-R function estimate with the 20-year distributed lag) as a result of employing each of the alternative lag structures to the Laden incidence results. We present below a summary of the key results of varying both the C-R function employed and the cessation lag model on the primary estimates of avoided mortality due to CAAA programs:

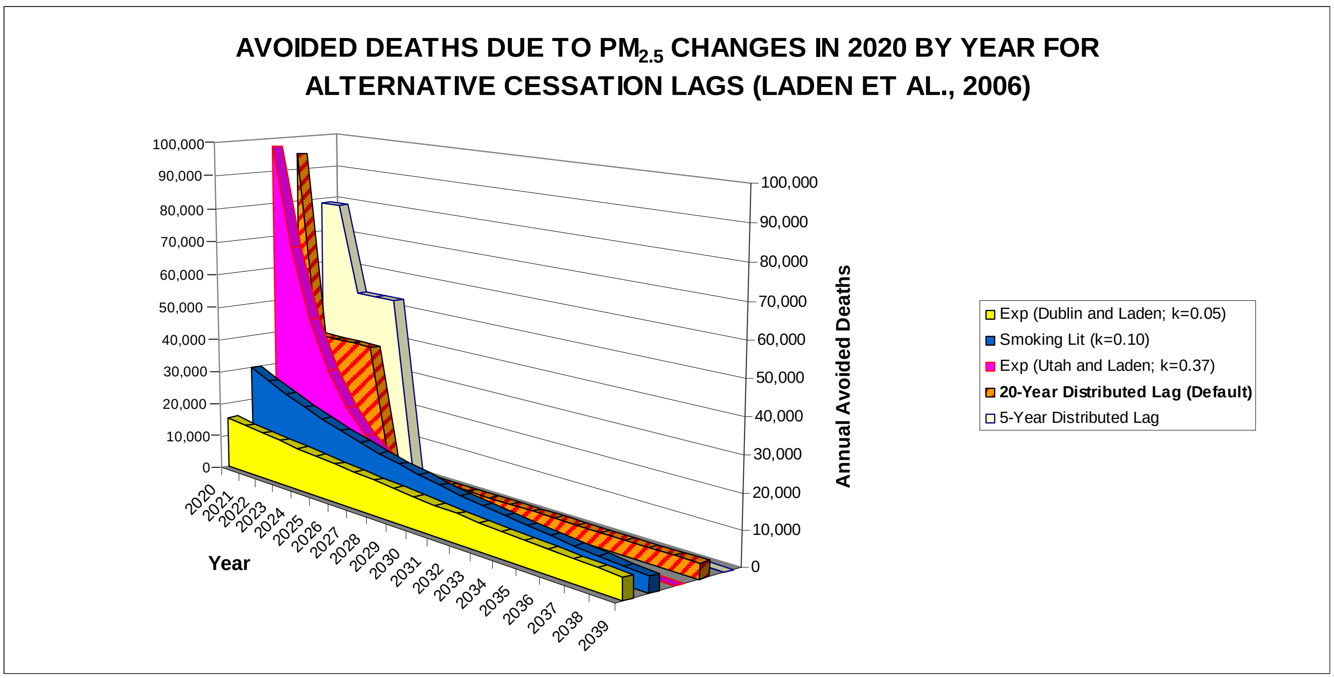
- The use of the Laden incidence results with the 20-year distributed lag result in benefits estimates that are 37 percent higher than the primary estimate, due to the larger RR reported by Laden et al. as compared with the primary C-R function.
- Applying the 5-year distributed lag to the Laden incidence estimates results in benefits that are 47 percent higher than the primary estimate. This is due to both

[Continued on 6-12 – April 29 revised]

the difference in the magnitude of the C-R functions as well as the fact that the avoided deaths in the 20-year lag assumption are spread over a longer time period and the corresponding VSLs are more heavily discounted, while under the five-year lag assumption, 50 percent of deaths occur within the first two years and all deaths occur within five years. In this case, the increase in avoided mortality due to the higher Laden C-R coefficient dominates the effect of shortening the lag period and increasing the percentage of benefits accrued in early years.

- As with the primary C-R function estimate and the Pope results, the results based on the smooth function lag structure vary depending on the intervention study selected. When relying on the k value derived from Laden and the Dublin Coal Ban study (k = 0.05), the economic value is 12 percent lower the primary estimate. Application of this time constant spreads the avoided deaths over a very long time period, causing the economic value to be heavily reduced due to discounting. In this case, the application of the alternative lag dominates over the different C-R function, bringing the benefits estimate relatively close to the primary estimate. Applying the k value derived from Laden and the Utah Valley study (k = 0.37) results in valuation estimates that are 47 percent higher than the default value, a similar estimate to the 5-year lag application.

EXHIBIT 6-9. ALTERNATE CESSATION LAGS - ANNUAL DEATHS (LADEN ET AL., 2006)



[Continued on 6-12a – April 29 revised]

EXHIBIT 6-10. ALTERNATE CESSATION LAGS - CUMULATIVE DEATHS (LADEN ET AL., 2006)

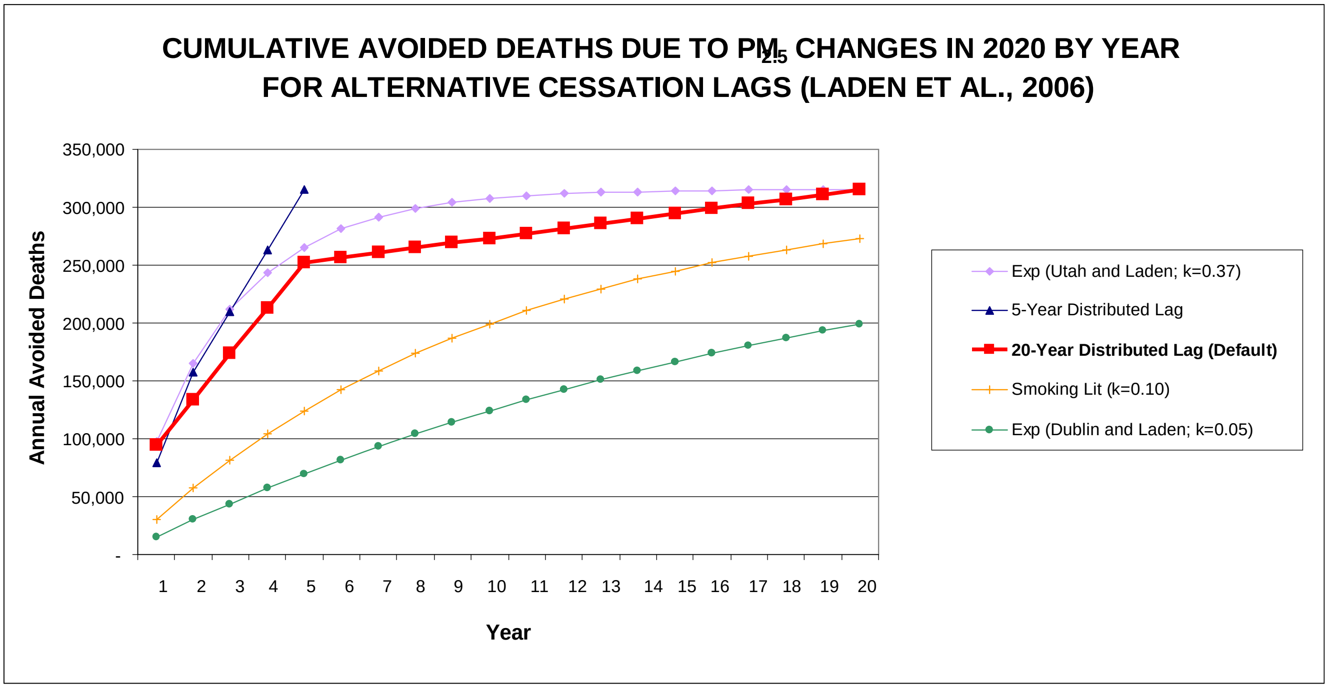


EXHIBIT 6-11. MEAN VALUATION RESULTS USING ALTERNATIVE LAG STRUCTURES – LADEN ET AL., 2006

MORTALITY CESSATION LAG	PERCENT CHANGE FROM PRIMARY ESTIMATE WITH DEFAULT LAG*
Laden et al. 2006 with 20-Year Distributed Lag	38%
Laden et al. 2006 with 5-Year Distributed Lag	50%
Laden et al. 2006 with Smooth Function, k = 0.05 (Dublin Intervention Study)	-13%
Laden et al. 2006 with Smooth Function, k = 0.37 (Utah Valley Intervention Study)	45%

* All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.

target-year specific adjustment factor that accounts for income growth over time,[135] the effect of cessation lag on accrual of the mortality benefits from air pollution changes in the target year, and the effect of discounting VSL values for mortality benefits expected to occur after the target year. The result of this scaling calculation is a distribution of NPVs for avoided mortality benefits, based on an assumed 20-year distributed cessation lag for PM mortality effects and application of a 5 percent discount rate.

We also generated alternative results substituting discount rates of 3 and 7 percent, in addition to the default discount rate of 5 percent.[136]

8.2 RESULTS

8.2.1 ALTERNATE VSLs

Exhibit 8-1 provides a table of valuation results for the three target years using alternative VSL distributions. Exhibit 8-2 presents these same results using box plots that illustrate alternative results distributions.

- Overall, the mean valuation estimates from BenMAP for premature mortality due to CAAA-related changes in $PM_{2.5}$ using the alternative estimates of VSL range from 20 percent lower to equivalent to our primary estimate when applying the Viscusi et al., 2004 and Viscusi and Aldy (2003) Model 5 distributions, respectively.
- The spread of the confidence bounds of the VSL estimates vary, with the distribution of the primary estimate (Weibull) having the largest spread and the Viscusi (2004) results having the smallest spread.

8.2.2 ALTERNATIVE DISCOUNT RATES

Exhibit 8-3 provides the economic valuation results for each target year, applying alternative discount rates to calculate the NPV. Exhibit 8-4 provides a graphical representation of the 90 percent confidence bounds around each of the benefits estimates. Applying alternative discount rates has little effect on the benefits estimates; applying a discount rate of 7 percent results in benefits that are four percent lower than the default and applying a 3 percent discount rate results in a benefits estimate four percent higher than the default.

[135] Income adjustment factors reflecting future income growth projections and the income elasticity of VSL were obtained from BenMAP (Abt Associates, Inc. (2008). BenMAP User's Manual. Prepared for the U.S. EPA's Office of Air Quality Planning and Standards, Research Triangle Park, NC. September.)

[136] Alternative discount rates of three and seven percent are recommended in U.S. EPA (2000). *Guidelines for Preparing Economic Analyses*, EPA 240-R-00-003, September.

[Continued on 8-4 – April 29 revised]

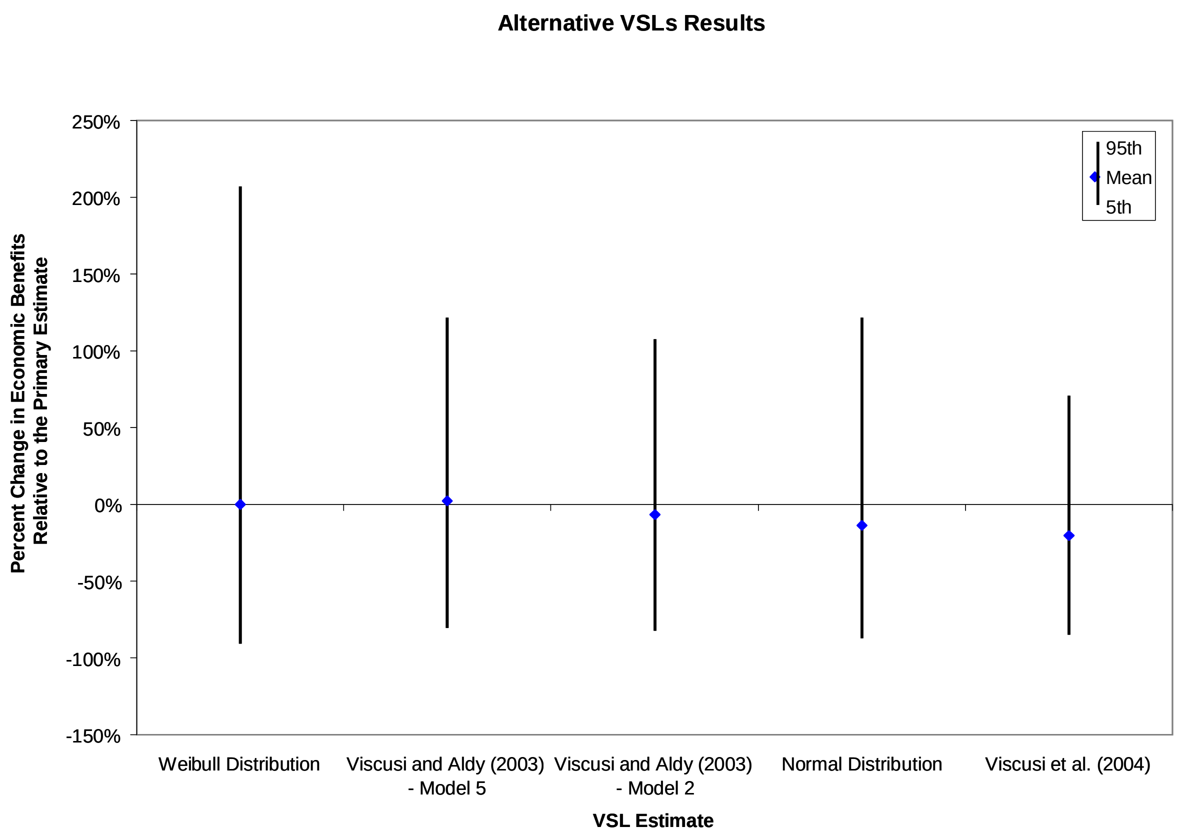
EXHIBIT 8-1. RELATIVE PM/MORTALITY VALUATION RESULTS USING ALTERNATIVE ESTIMATES OF VSL

VSL ESTIMATE	PERCENTILE 5	MEAN	PERCENTILE 95
Weibull Distribution (Primary) - 2000	**$66,000**	**$710,000**	**$2,200,000**
Weibull Distribution (Primary) - 2010	**$110,000**	**$1,200,000**	**$3,600,000**
Weibull Distribution (Primary) - 2020	**$170,000**	**$1,700,000**	**$5,300,000**
	Percent Change from Mean Primary Estimate*		
Viscusi and Aldy (2003) - Model 5	-80%	0%	122%
Viscusi and Aldy (2003) - Model 2	-82%	-7%	108%
Normal Distribution	-87%	-14%	122%
Viscusi et al. (2004)	-85%	-20%	71%

* All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.

[Continued on 8-5 – April 29 revised]

EXHIBIT 8-2. BOX-PLOT OF 90 PERCENT CONFIDENCE BOUNDS FOR ALTERNATIVE VSL RESULTS



[Continued on 8-6 – April 29 revised]

EXHIBIT 8-3. RELATIVE PM/MORTALITY VALUATION RESULTS USING ALTERNATIVE DISCOUNT RATES

VSL ESTIMATE	PERCENTILE 5	MEAN	PERCENTILE 95
Baseline (5 percent) - 2000	**$66,000**	**$710,000**	**$2,200,000**
Baseline (5 percent) - 2010	**$110,000**	**$1,200,000**	**$3,600,000**
Baseline (5 percent) - 2020	**$170,000**	**$1,700,000**	**$5,300,000**
	Percent Change from Mean Primary Estimate*		
High (7 percent)	-91%	-4%	191%
Low (3 percent)	-90%	4%	223%

***** All values in the table represent the percent change from the mean primary estimate. Percent change estimates do not vary by target year.

[Continued on 8-7 – April 29 revised]

EXHIBIT 8-4. BOX-PLOT OF 90 PERCENT CONFIDENCE BOUNDS FOR ALTERNATIVE DICSOUNT RATE RESULTS

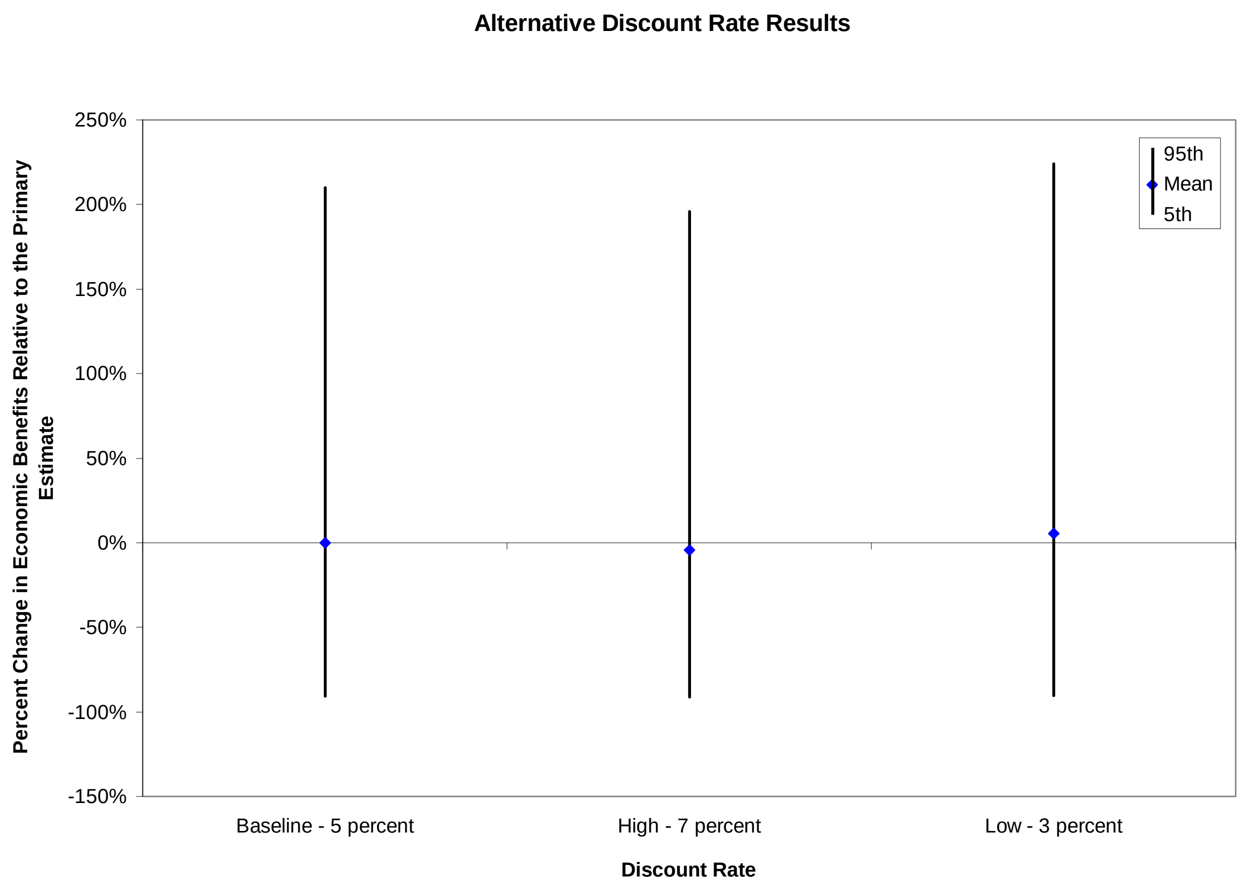


EXHIBIT 9-1. QUANTITATIVE ANALYSES OF UNCERTAINTY IN THE 812 SECOND PROSPECTIVE ANALYSIS

FACTOR	TYPE OF UNCERTAINTY EVALUATED	ALTERNATIVE ASSUMPTIONS	IMPACT OF ALTERNATIVE ASSUMPTIONS ON 2020 PRIMARY ESTIMATE
UNCERTAINTIES RELATED TO COST ESTIMATES			
Unidentified controls (Ch 2)	Parameter	Alternate assumption about the threshold for, and cost of, applying unidentified local controls to achieve NAAQS compliance ($10,000/ton).	-18% of local control costs; **-2.1% of total costs**
I&M program vehicle failure rates(Ch 2)	Parameter	Alternative assumption about failure rates for I&M program testing based on NRC (2001).	-11% to -14% for mobile source costs; **-6% to -7.6% of total costs**
Learning curve assumptions (Ch 2)	Parameter	Alternate assumptions about the learning rate (5 and 20%)	**-6.0% to 3.2% of total costs**
Fleet composition and fuel efficiency (Ch 2)	Scenario	Alternate assumption about future fleet composition and fuel efficiency using AEO 2008.	-0.2% to -3.6% for mobile source costs; **-0.1% to -2.0% of total costs**
UNCERTAINTIES RELATED TO BENEFITS ESTIMATES			
Alternate C-R function for PM (Ch 4)[a]	Parameter	Alternative C-R functions - two from empirical literature (Pope et al., 2002 and Laden et al., 2006) and 12 subjective estimates from the expert elicitation study	-83% to 76%, Based on most extreme estimates from PM EE study. Rest of alternatives range from -44% to 40%
Emissions from EGU sources (Ch 3)	Scenario	Use continuous emissions monitoring (CEM) data in place of Integrated Planning Model (IPM) results, coupled with alternative counterfactual consistent with CEM approach.	+50% in 2000 Due almost entirely to the impact of the alternative *without-CAAA* scenario.
PM/Mortality Cessation lag (Ch 6) [a]	Model and parameter	Alternative lag structures - one step function and a series of smooth functions (based on an exponential decay). Smooth functions in some cases also require change in C-R coefficient.	-23% to 16% when using primary C-R function. -52 to 50% when also changing C-R function.
VSL (Ch 8) [a]	Parameter	Alternative VSL estimates	-20% to 0%
Discount rates (Ch 8) [a]	Parameter	Alternate discount rates (5% and 7%)	-4% to 4%
Alternate C-R function for ozone (Ch 4)	Parameter	Alternative C-R functions - three from NMMAPS-based studies and three meta-analyses	0% for total mortality benefits. -63% to 66% For ozone-related mortality.
Emissions sectors (Ch 3)	Scenario	Altering each sector-specific emissions by 10 percent	[a]

[Continued on 9-4 – April 29 revised]

FACTOR	TYPE OF UNCERTAINTY EVALUATED	ALTERNATIVE ASSUMPTIONS	IMPACT OF ALTERNATIVE ASSUMPTIONS ON 2020 PRIMARY ESTIMATE
Differential toxicity of PM components (Ch 5)	Parameter	Potential alternative estimates of toxicity for specific PM components	N/A. No quantitative sensitivity analysis performed due to significant data gaps.
Dynamic population modeling (Ch 7)	Model	Incorporation of dynamic population estimates to calculate life years gained and changes in life expectancy	N/A. Life years gained and changes in life expectancy are supplemental estimates of PM/mortality effects and cannot be directly compared to the primary estimate.

Notes:
a [Placeholder: Results for this analysis have yet to be updated to current C-R function recommended by SAB HES, and so are not presented in this draft.]

9.2.1 COST UNCERTAINTIES

Exhibit 9-1 shows that the impact of our alternative assumptions about mobile source cost parameters, learning curves, and unidentified local control costs each have relatively modest impacts on total costs, with the I&M failure rate and learning curve assumptions have slightly more of an impact on total costs.[137] In addition, the assumptions underlying our primary cost estimates tend to be conservative; most of the alternatives decrease total compliance costs and none increase costs more than about three percent.

9.2.2 BENEFIT UNCERTAINTIES

On the benefits side, Exhibits 9-1 and 9-2 show that the most influential assumptions affecting benefits are the choice of the C-R function, the cessation lag model for the accrual of benefits, and the VSL distribution. While the two most extreme results from EPA's EE study imply substantial effects of C-R choice (about 80 percent in either direction) most of the alternatives from the EE study and the published epidemiological studies suggest effects on benefits of about 40 percent or less in either direction. By themselves, longer cessation lag alternatives can reduce monetized benefits by as much as a 25 percent and if coupled with a change in the C-R function, by close to half; however, the SAB HES suggested much of the risk reduction benefits from $PM_{2.5}$ controls are more

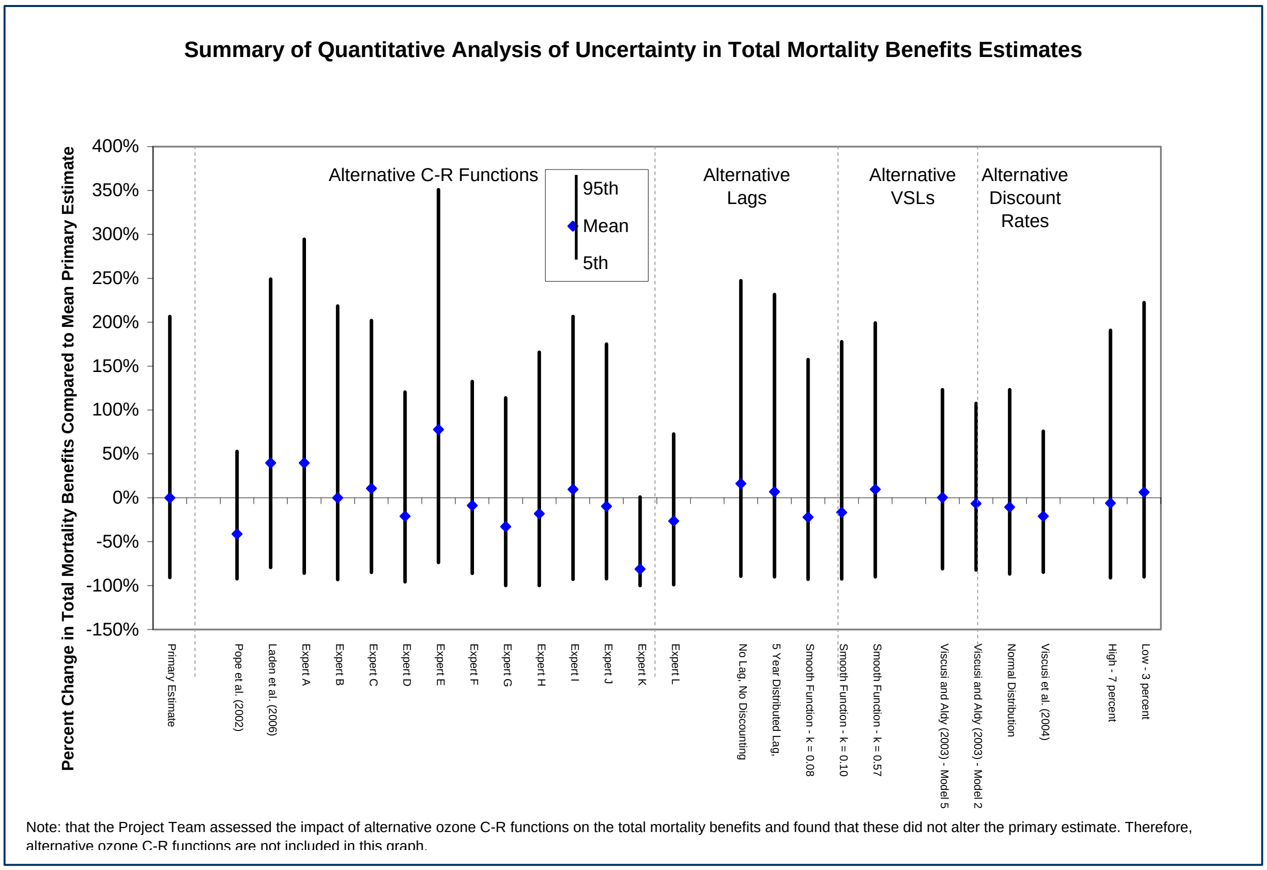
[137] The estimate of the impact on total costs is derived from the relative contribution of the affected cost sector to the overall costs of compliance, assuming all other sectors are unaffected.

[Continued on 9-5 – April 29 revised]

likely to accrue sooner rather than later. Accelerating benefits increases benefits by about 13 percent when maintaining the same C-R function, but could increase them by as much as half when using a smooth function based on the Laden Six Cities follow-up effect estimate. VSL distribution choices in one case produce the same central estimate; in others reduce VSL between 7 and 22 percent.

A review of the box plots in Exhibit 9-2 for the factors that have the greatest potential to change the central estimate shows that most of the alternatives do not have a dramatic effect on the spread of uncertainty. Some alternatives suggest the high end of the distribution could be lower, including all of the alternative VSL distributions, which give less weight to higher VSL values than the 26-study Weibull. On the other hand, only a few alternatives (from the EE study) significantly extend the upper end and hardly any extend the lower end, suggesting our primary estimate is unlikely to understate the uncertainty in avoided mortality benefits.

EXHIBIT 9-2. SUMMARY OF QUANTITATIVE ANALYSIS OF UNCERTAINTY IN MONETIZED MORTALITY BENEFITS ESTIMATES



[Continued on 9-6]

9.2.3 ADDITIONAL OBSERVATIONS

Offline modeling of marginal changes in emissions by sector suggests that the EGU sector yields the most benefits at the margin in 2020 (on a dollar per ton basis), followed by area sources, non-EGU point sources, on-road sources, and non-road sources. The benefit per ton ratio in 2020 is about 3:2 for when comparing EGU emissions to area emissions and to non-EGU emissions; the ratio is 3:1 for EGU emissions to both mobile source categories. **[Placeholder: We will review the results and conclusions of the sector-based emissions analysis once the revisions to primary $PM_{2.5}$ air quality values are complete and will adjust as necessary prior to the next draft of this report.]** These results rank the expected sensitivity of benefit results to uncertainties in emissions inventories for these sectors, and could provide perspective on the ordering of priorities for additional reductions in future air regulations.

Scenario uncertainty related to the details of the *without-CAAA* scenario for EGUs, as discussed in Chapter 3, is another potentially significant uncertainty for benefits; use of the Ellerman-based alternative *without-CAAA* scenario in 2000 coupled with the CEM-based *with-CAAA* scenario produces a central estimate of avoided mortality benefits approximately 50 percent greater than the standard scenarios. **[Placeholder: Result based on use of Pope et al. 2002; not yet updated for Weibull C-R.]** Given that the differences between the alternative *without-CAAA* scenario RSM runs were often much greater than the differences between the CEM- and IPM-based *with-CAAA* RSM runs, the difference in benefits appears to be due predominantly to the changes in the *without-CAAA* scenario. While we are unable to determine which represents the more accurate counterfactual, the *without-CAAA* scenario we apply for the primary results appears to be the more conservative choice.

The 812 Project Team's use of a damage model with dynamic population simulation yielded striking results that demonstrate the substantial effect of the CAAA on population over time and provide useful insights into gains in life expectancy due to the CAAA. Use of a dynamic model showed an approximate doubling of the expected life years saved due to a single year's exposure improvement, suggesting that the static approach to benefits assessment likely underestimates the mortality benefits of improved air quality, possibly by a substantial margin. **[Placeholder: We will review these conclusions once the revisions to primary $PM_{2.5}$ air quality values are complete and will adjust as necessary prior to the next draft of this report.]**

A comparison of the qualitative uncertainty tables from the First and Second Prospective studies indicates that significant advancements over the First Prospective include the use of improved monitoring data for $PM_{2.5}$, an improved understanding and treatment of atmospheric chemistry and the composition of $PM_{2.5}$ emissions, and the use of longer-term simulations with integrated modeling of criteria pollutants using CMAQ rather than a collection of separate air quality models. Other potentially major uncertainties affecting benefits estimates in the Second Prospective not mentioned above include the inclusion in the *with-CAAA* scenario of CAIR and CAMR, both of which are being re-tooled by EPA in the wake of court rulings.

[Continued on 9-7 – April 29 revised]

[Placeholder for additional conclusions regarding effects of uncertainty on comparison of benefit and costs estimates pending revision and finalization of the primary benefit results for the Second Prospective.]