Summary Minutes of the
U.S. Environmental Protection Agency (EPA)
Advisory Council on Clean Air Compliance Analysis (Council)
Health Effects Subcommittee (HES)
Public Meeting of December 15-16, 2009

Committee Members: See roster (Attachment A)

Date and Time: Tuesday, December 15, 2009, 9:00 AM – 5:00 PM
Wednesday, December 16, 2009, 9:00 AM – 2:00 PM

Location: SAB Conference Center
1025 F Street, NW Suite 3705, Washington, DC 20004

Purpose: The purpose of the meeting was to provide advice on health-related chapters in the Agency's draft *Benefits Analysis to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act* and *Uncertainty Analysis to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act*. The Federal Register announcement of the meeting is in Attachment B and the meeting agenda is in Attachment C.

Participants: Dr. John Bailar, Chair
Dr. Michelle Bell
Dr. James Hammitt
Mr. J. Fintan Hurley
Dr. Patrick Kinney
Dr. Michael Kleinman*
Dr. Jonathan Levy*
Dr. Bart Ostro
Dr. Rebecca Parkin
Dr. Arden Pope

Dr. Marc Rigas, Designated Federal Officer (DFO)
Dr. Vanessa Vu, Director, EPA SAB Staff Office
Mr. Jim Democker, EPA Office of Air and Radiation
Mr. Neal Fann, EPA Office of Air and Radiation
Dr. Bryan Hubbell, EPA Office of Air and Radiation
Mr. Jim Neumann, Industrial Economics
Mr. Henry Roman, Industrial Economics
Additional Attendees (See Attachment D)

*Participated by telephone

Dr. Rigas, the DFO, convened the meeting at 9:00 AM. He noted that as required under the Federal Advisory Committee Act (FACA), the Committee's deliberations are held in public with advanced notice given in the Federal Register, and the meeting minutes will be made publicly available after

the meeting. He noted that the HES received no written or public comments. He also noted that Committee Members are all subject to federal ethics regulations and conflict-of-interest laws that pertain to them. He then turned over the meeting to Dr. Vanessa Vu, Director of the EPA SAB Staff Office and to Dr. John Bailar, Chair of the Health Effects Subcommittee.

Dr. Vu offered welcoming remarks, provided some context for the HES and the Council deliberations and thanked the members of the HES for their participation in the meeting and for their service. She then turned the meeting over to Dr. Bailar.

Dr. Bailar initiated a round of introductions among participants and briefly went through the meeting agenda and goals. Agency supplied background and charge questions are in Attachment E. Dr. Bailar then introduced the first of four Agency presentations.

Agency Presentations

Mr. Democker of the Office of Policy Analysis and Review at EPA's Office of Air and Radiation and project team lead presented an overview of the Second Section 812 Prospective Analysis and the health benefits reported. He discussed historical work on a retrospective study, a first prospective analysis of Clean Air Act Benefits, the planning for the current study, and the status of this second prospective analysis of Clean Air Act Benefits and Costs. He noted that the health benefits estimated by the current study are much greater than estimated in previous Section 812 work due, in part to better data, better models, and improved analytical methodology. Slides from Mr. Democker's presentation are in Attachment F.

Committee members commented that the application of better methods leading to larger than previously estimated benefits suggests that previous methods underestimated benefits and that EPA should make this clear. The committee also discussed with EPA, the intended audience and how the results would be presented to different audiences as well as how they will influence methodology for regulatory impact analyses. The committee also noted that this work and methodologies may be adopted internationally.

Mr. Fann of the Office of Air Quality Planning and Standards at EPA's Office of Air and Radiation presented the alternate $PM_{2.5}$ and ozone mortality estimates used by the project team. He also discussed the impact of two studies that were published in 2009 on the Agency's mortality effect estimates. The Agency seeks the HES input on these studies in specific charge question 2a. Slides from Mr. Fann's presentation are in Attachment F.

The committee briefly discussed these studies and the differences between time series studies and cohort studies, with further discussion reserved until the completion of the presentations.

Mr. Roman from Industrial Economics presented an expert elicitation of a range of opinions on particulate matter (PM) mortality effects. He also presented a statistical method to combine the mortality estimates from the 12 experts (twelve probability distributions) into a single distribution using copula functions. Slides from Mr. Roman's presentation are in Attachment F. EPA is seeking guidance from the HES on the applicability of the copula function approach or any other ideas for combining expert elicitation. The committee discussed this briefly and reserved comment for later

discussion. Several people did, however, comment that the method may not be appropriate and that information may be gained from the expert elicitation using a more qualitative or a simpler approach.

Mr. Neuman from Industrial Economics presented on population dynamics simulation methodology and the associated PopSim software. Mr. Neuman notes that this will not be used for valuation, that is, not combined with value of statistical life (VSL) information. It will only be used in the health benefits analyses. Slides from Mr. Neuman's presentation are in Attachment F.

The committee discussed briefly the difficulties in incorporating population dynamics, given that immigration and emigration is not taken into account, noting that the benefit picture will be incomplete.

HES Discussion

Dr. Bailar suggested that the discussion of the general charge (General Charge Questions #1-3) be switched to the end of the meeting as a wrap up. He proposed reordering the agenda and beginning with discussion of Specific Charge Questions 2 a – j. This proposal was unanimously accepted.

The committee began with discussion of charge question 2a on the particulate matter (PM) mortality concentration response function. Committee members note that all the studies under consideration focus on two data sets, the American Cancer Society (ACS) study and the Harvard Six Cities study. It is an important that these are two very well scrutinized data sets.

The committee members discussed possible alternative epidemiological data sets and the advantages and disadvantages of each. The EPA's primary estimate relies on the ACS study, which is representative of the U.S. as a whole, so this is a reasonable choice. However, multiple committee members commented that given the results obtained in the expert elicitation and more recent studies, there is more evidence that the specific study that EPA uses for its primary PM mortality estimate is conservative. Use of newer information would result in greater health benefits from reduction of PM.

Members then discussed different ways to incorporate the new studies and the expert elicitation. Without reaching resolution, the committee recessed for lunch break.

December 15, 2009 afternoon session

Dr. Rigas reconvened the meeting following a lunch recess. The discussion continued on different statistical and qualitative methods for combining PM mortality estimates. The committee determined that the copula function approach was not transparent and that a simpler approach may be possible, because the two studies cited by EPA represent the approximately the 25^{th} and 75^{th} percentile of the expert elicitation, making it possible to easily generate a new distribution based on those studies and a mean value from the expert elicitation.

Regarding the PM mortality lag structure, the committee questioned EPA staff further on the methodology. Dr. Hubbell noted that the results are more sensitive to the chosen discount rate than to the lag structure. Some members asked why only cardiovascular mortality and respiratory mortality

were chosen as health endpoints. Dr. Hubbell commented that these two account for almost all the mortality that can be attributed directly to PM.

Committee members agreed that the 20-year distributed step-wise lag function was recommended by the Council during the planning phase and it still seems reasonable. Newer data might support a different lag structure, but given that the results are more sensitive to discount rate, minor adjustments to lag structure are probably not necessary.

Discussion then moved to questions of estimates of PM-related infant mortality. Committee members discussed challenges with using any of the data sets for quantitative assessments of air pollution effects on infant mortality and also pointed out that a critical age window to be considered is really from 1 month of age to 1 year of age. EPA staff described the rationale for their approach. The committee then discussed possible alternative studies and concluded that all of them have problems, including lack of representativeness for U.S. population. The committee members noted that with the studies that EPA considered, a weight of evidence could be argued for their analytical results. The committee decided that for societal reasons, it is important to show that PM has an impact throughout the lifespan. At the minimum, making that qualitative case is an important outcome of the results.

Regarding the charge question on a mortality effect threshold for PM, committee members briefly discussed the mechanistic, biological plausibility of a threshold. After brief discussion, committee members agreed with the EPA assumption that for PM mortality effects, the assumption of no threshold is reasonable.

The committee discussed the EPA sensitivity analysis of differential toxicity for different composition of PM. Committee members discussed the relative merits of epidemiology and toxicology studies in answering these questions. EPA staff answered questions about their choices. All committee members agreed that better toxicity data is needed for EPA to thoroughly perform a sensitivity analysis of PM composition. While some committee members found that better toxicology data are needed, others pointed out that the health effect is not always caused by toxicity to a component (either chemical component or particle size), but rather by the human body's response to the air pollution insult.

Committee members agreed with the challenging nature of determining the toxicity of different PM components for this policy analysis and determined that EPA's approach is comprehensive in dealing with the issues. The committee does not support including components in the Section 812 analysis. However, the document is weak in terms of support for any future research and analysis that may make study of components possible.

Having now completed the PM-related discussion, Dr. Bailar returned discussion briefly to charge question 2a regarding the mortality effect concentration response function for PM, to summarize and assure that the panel had reached consensus on its recommendation. In brief discussion, committee members summarized their thoughts for the recommendation.

The committee then began a discussion of the health benefits of ozone pollution reduction. Recognizing that air pollution related deaths may affect different people at different ages, the

committee discussed differences in economic valuation methods for all of the mortality estimates, including value per statistical life (VSL) and value per statistical life-year (VSLY).

For the ozone mortality CRF, the panel members agreed that the EPA approach and chosen studies are reasonable.

At this time, the meeting was recessed for the day, to reconvene at 9:00 AM on Wednesday, December 16.

December 16, 2009

Dr. Rigas reconvened the meeting at 9:00 AM EST.

The committee members briefly discussed the use of time-series studies for ozone mortality as was done in the Section 812 studies. The panel members agreed, without a great deal of discussion, that the time series studies are appropriate and that a cessation lag is, therefore, not appropriate.

The use of a no threshold model was discussed. Panel members generally agree that for ozone response a no threshold mortality effect model is appropriate. Several members note the complexity of the problem, because the mortality data for ozone are less clear than for PM. Also, external temperature may affect ozone response in humans. But temperature also affects climatic conditions responsible for producing ozone. An alternative stratified threshold model based on external temperature was proposed, incorporating new data from the Jerrett et al. (2009) paper. Following discussion, committee members concurred with EPA decision to use a no-threshold model for the ozone mortality effects.

Committee members discussed the poor data in the area of baseline incidence and prevalence of certain cardiovascular and respiratory conditions for use in the Section 812 analysis. As an example, the baseline missed school day data are subject to much error and difficult to interpret. Several members commented that the use of this and other data sets require numerous assumptions.

EPA staff explained the importance of considering some of the endpoints from their perspective. The committee members agreed and proposed that the report include better information about data gaps and where more research is needed to obtain better data. Committee members determined that while difficult to use, the incorporation of the baseline incidence/prevalence data will not change the overall 812 study results significantly, so data quality may not be as worrisome from the perspective of the 812 study.

Committee members discussed with EPA staff the population dynamics simulations, including their details and the limitations of the Popsim software, which has limited spatial resolution because of the computationally intensive calculations. After discussion, the committee consensus was that despite some limitations, the dynamic approach offered by Popsim is preferable to a static approach unless greater spatial resolution is needed. Committee members noted that better background on the operation of the Popsim software would be helpful in the report.

After discussion of population dynamics simulation, Dr. Bailar initiated a summary discussion on the general charge to the committee. Committee members generally support the EPA's methodological and data choices, with some caveats. They also discussed some ideas for improvement, to be presented in the general charge section of the report. Dr. Bailar noted that the analysis relies primarily on the use of multiplicative models (e.g., relative risk, odds ratios) and that the difficulties with these in the larger context should be explained. He also suggested EPA describe the differences in outcomes between the 812 analyses and regulatory impact analyses (RIA). If results are significantly different, why? The committee decided that the inclusion of some information on coarse particulate matter health effects may be warranted and decided to include some suggestions of recent studies in their report.

The committee also noted that a Table of Data sources would be useful as would a list of assumptions. The committee then recessed for a lunch break.

December 16, afternoon session

Dr. Rigas reconvened the meeting following a lunch recess. Dr. Bailar discussed next steps, report writing assignments and deadlines for submitting draft material. He then recapitulated the committee's overall thoughts and asked for additional comments.

Some additional discussion ensued on the impacts of premature birth and low birthweight on the benefits estimates. The committee determined that evidence in this area is too limited to include more in the analyses but the committee may make some recommendations about data sources in their written report for EPA to consider.

Dr. Rigas adjourned the meeting at 2:00 PM on December 16, 2009.

Respectfully Submitted:

____/***SIGNED***/_____
Dr. Marc Rigas
Designated Federal Officer

Certified as True:

___/***SIGNED***/_____
Dr. John Bailar, Chair
Health Effects Subcommittee
Advisory Council on Clean Air Compliance Analysis

ATTACHMENT A: ROSTER
U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis
Health Effects Subcommittee
Augmented for the Review of Health Benefits Analyses in the Second Prospective 812 Study

COUNCIL MEMBERS

Dr. John Bailar, Chair of the Health Effects Subcommittee, Scholar in Residence, The National Academies, Washington, DC

Dr. Michelle Bell, Associate Professor, School of Forestry and Environmental Studies, Yale University, New Haven, CT

Dr. James K. Hammitt, Chair of the Council, Professor, Department of Health Policy and Management, Harvard School of Public Health, Boston, MA

Dr. Jonathan Levy, Associate Professor, Department of Environmental Health, Harvard School of Public Health, Landmark Center, Boston, MA

Dr. Arden Pope, Professor, Department of Economics, Brigham Young University , Provo, UT

SUBCOMITTEE MEMBERS

Mr. John Fintan Hurley, Research Director, Institute of Occupational Medicine (IOM), Edinburgh, United Kingdom, UK

Dr. Patrick Kinney, Professor, Department of Environmental Health Sciences, Mailman School of Public Health , Columbia University, New York, NY

Dr. Michael T. Kleinman, Professor, Department of Medicine, Division of Occupational and Environmental Medicine, University of California, Irvine, Irvine, CA

Dr. Morton Lippmann, Professor, Nelson Institute of Environmental Medicine, New York University School of Medicine, Tuxedo, NY

Dr. Bart Ostro, Chief, Air Pollution Epidemiology Unit, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Oakland, CA

Dr. Rebecca Parkin, Professor and Associate Dean, Environmental and Occupational Health, School of Public Health and Health Services, The George Washington University Medical Center, Washington, DC

SCIENCE ADVISORY BOARD STAFF

Dr. Marc Rigas, Designated Federal Officer, 1200 Pennsylvania Avenue, NW, Washington, DC, Phone: 202-343-9978, Fax: 202-233-0643, (rigas.marc@epa.gov)

ATTACHMENT B: FEDERAL REGISTER NOTICE

[Federal Register: November 27, 2009 (Volume 74, Number 227)]
[Notices]
[Page 62307-62308]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr27no09-66]

ENVIRONMENTAL PROTECTION AGENCY

[FRL-8985-8]

EPA Science Advisory Board Staff Office; Notification of a Meeting of the Health Effects Subcommittee of the Advisory Council on Clean Air Compliance Analysis (Council)

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice.

SUMMARY: The EPA Science Advisory Board (SAB) Staff Office announces a public face-to-face meeting of the Health Effects Subcommittee (HES) of the Advisory Council on Clean Air Compliance Analysis (Council). The HES, supplemented with additional members from the Council, will review technical assessments related to health benefits analyses and uncertainty analyses to support of the Office of Air and Radiation's Second Section 812 Benefit-Cost Analysis of the Clean Air Act.

DATES: The meeting dates are Tuesday, December 15, 2009, from 8:30 a.m. to 5 p.m. and Wednesday, December 16, 2009, from 8:30 a.m. to 3 p.m.(Eastern Time).

ADDRESSES: The public meeting will be held at the SAB Conference Center at 1025 F Street, NW., Suite 3700, Washington, DC 20004.

FOR FURTHER INFORMATION CONTACT: Members of the public who wish to obtain further information about this meeting may contact Dr. Marc Rigas, Designated Federal Officer (DFO), EPA Science Advisory Board Staff Office (1400F), U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW., Washington, DC 20460; by telephone/voice mail: (202) 343-9978 or at rigas.marc@epa.gov. General information about the Council may be found on the Council Web site at: http://www.epa.gov/advisorycouncilcaa.

SUPPLEMENTARY INFORMATION: Background: Pursuant to the Federal Advisory Committee Act, 5 U.S.C., App. 2 (FACA), notice is hereby given that the Health Effects Subcommittee (HES) of the Advisory Council on Clean Air Compliance Analysis (Council) will hold a public meeting to evaluate draft documents regarding Human Health Benefits and Uncertainty Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act. The Council was established in 1991 pursuant to the Clean Air Act (CAA) Amendments of 1990 (see 42 U.S.C. 7612) to provide advice, information and recommendations on technical

and economic aspects of analyses and reports EPA prepares on the impacts of the CAA on the public health, economy, and environment of the United States. The Council is a Federal Advisory Committee chartered under FACA. The HES will provide advice through the Council and will comply with the provisions of FACA and all appropriate SAB Staff Office procedural policies.

Pursuant to Section 812 of the 1990 Clean Air Act Amendments, EPA conducts periodic studies to assess benefits and costs of the EPA's regulatory actions under the Clean Air Act. The Council has provided advice on an EPA retrospective study published in 1997 and an EPA prospective study completed in 1999. EPA initiated a second prospective study to evaluate the costs and benefits of EPA Clean Air programs for years 1990-2020. The Council has previously provided advice on analytic blueprints for this study. EPA's Office of Air and Radiation is now nearing completion of the analytical work for the second prospective study. The December 15-16, 2009 meeting will provide the HES the opportunity to review the technical documents pertaining to human health benefits as well as uncertainty in the benefits and costs estimates.

Technical Contacts: The Office of Air and Radiation technical contact for the Second Section 812 Benefit-Cost Analysis of the Clean Air Act is Mr. Jim DeMocker at (202) 564-1673 or democker.jim@epa.gov.

Availability of Meeting Materials: EPA draft documents (Benefits Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act--Draft (Chapter 1: Introduction and Chapter 2: Human Health Benefits) and Uncertainty Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act--Draft)may be found at: http://www.epa.gov/oar/sect812/prospective2.html. The meeting agenda for December 15-16, 2009 and any background materials will be posted on the Council Web site (http://www.epa.gov/advisorycouncilcaa) prior to the meeting.

Procedures for Providing Public Input: Interested members of the public may submit relevant written or oral information for the HES to consider on the topics of this advisory activity and/or the group conducting the activity. Oral Statements: In general, individuals or groups requesting an oral presentation at a public meeting will be limited to five minutes per speaker, with no more than one hour for all speakers. Interested parties should contact Dr. Rigas at the contact information provided above by December 8, 2009, to be placed on the public speaker list for the December 15-16, 2009 meeting.

Written Statements: Written statements should be received in the SAB Staff Office by December 8, 2009, so that the information may be made available to the HES for their consideration prior to this meeting. Written statements should be supplied to Dr. Rigas via e-mail to rigas.marc@epa.gov (acceptable file format: Adobe Acrobat PDF, MS Word, MS PowerPoint, or Rich Text files). Submitters are requested to provide two versions of each document submitted with and without original signatures, because the SAB Staff Office does not publish documents with signatures on its Web sites.

Accessibility: For information on access or services for individuals with disabilities, please contact Dr. Marc Rigas at (202)343-9978, or via e-mail at rigas.marc@epa.gov, preferably at least ten (10) days prior to the meeting, to give EPA as much time as possible to process your request.

Dated: November 19, 2009.
Vanessa T. Vu,
Director, EPA Science Advisory Board Staff Office.

[FR Doc. E9-28407 Filed 11-25-09; 8:45 am]

ATTACHMENT C: AGENDA

U.S. ENVIRONMENTAL PROTECTION AGENCY
ADVISORY COUNCIL ON CLEAN AIR COMPLIANCE ANALYSIS
Health Effects Subcommittee
Augmented for the Review of Health Benefits Analyses in the Second Prospective 812 Study
Public Meeting, December 15-16, 2009
Science Advisory Board (SAB) Conference Center
1025 F St. NW, Suite 3700.,
Washington, D.C. 20004

AGENDA

Tuesday, December 15, 2009

9:00 – 9:10 am	**Meeting Convened by the Designated Federal Officer** Dr. Marc Rigas
	Welcoming Remarks Dr. Vanessa Vu, Director EPA Science Advisory Board Staff Office
9:10 – 9:20 am	**Purpose of the Meeting and Review of Agenda** Dr. John Bailar, Chair
9:20 – 10:30 am	**Introduction and Health Effects Estimation Methodology** Mr. Jim DeMocker, Mr. Neal Fann, and Dr. Bryan Hubbell EPA Office of Air and Radiation
10:30 – 10:40 am	**Public Comments**
10:40 – 11:00 am	**Break**
11:00 am – 12:30 pm	**Discussion of general charge (Questions #1a – c)**
12:30 – 1:30 pm	**Lunch**
1:30 – 3:30 pm	**Specific issues related to particulate matter (Charge questions 2a – d, i)**
3:30 – 3:45 pm	**Break**
3:45 – 5:00 pm	**Specific issues related to ozone (Charge questions 2 e-g)**

Wednesday, December 16, 2009

9:00 am	**Reconvene Meeting** Dr. Marc Rigas, DFO
9:00 – 9:15 am	**Summary of Day 1 Discussion** Dr. John Bailar, Chair
9:15 – 10:00 am	**Baseline incidence / prevalence estimates (Charge question 2h)**
10:00 – 11:00 am	**Dynamic Population modeling (Charge question 2j)**
11:00 – 11:15 am	**Break**
11:15 – 12:00 pm	**Other general comment**
12:00 – 12:30 pm	**Summary of major recommendations and next steps** Dr. John Bailar and committee
12:30 – 2:30 pm	**Working lunch and writing session**
2:30 pm	**Adjourn**

ATTACHMENT D: LIST OF ATTENDEES

List of Attendees
Advisory Council on Clean Air Compliance Analysis
Health Effects Subcommittee Meeting
December 15, 2009

Name	**Affiliation**
Jim Democker	EPA
Neal Fann	EPA
Maria Hegsted	Inside EPA
Brian Heninger	EPA
Bryan Hubbell	EPA
Jim Neuman	Industrial Economics
Henry Roman	Industrial Economics
Stephanie Sanzone	EPA

List of Attendees (cont).
Advisory Council on Clean Air Compliance Analysis
Health Effects Subcommittee Meeting
December 16, 2009

Name	**Affiliation**
Jim Democker	EPA
Neal Fann	EPA
Bryan Hubbell	EPA
Jim Neuman	Industrial Economics
Stuart Parker	Inside Washington Publishers
Henry Roman	Industrial Economics
Stephanie Sanzone	EPA

ATTACHMENT E:
AGENCY- SUPPLIED BACKGROUND AND CHARGE QUESTIONS

ADVISORY COUNCIL ON CLEAN AIR COMPLIANCE ANALYSIS

Health Effects Subcommittee (HES)

Review Background and Charge Questions

December 15-16, 2009 Meeting

Review Background

The section 812 benefit-cost studies of the Clean Air Act are a unique series of EPA analyses. Unlike routine Regulatory Impact Analyses (RIAs) which focus on the incremental effect of proposed new rules relative to a continually changing, prevailing policy baseline, the 812 studies are intended to evaluate the benefits and costs of the Clean Air Act as a whole relative to a consistent baseline, taking account of critical interactions between program elements and outcomes which are not captured by the generally isolated and incremental policy scenarios assessed in RIAs. In addition, Congress expressed their intent that the comprehensiveness of the 812 studies should encourage and enable EPA to develop and continually refine its capabilities in clean air program assessment. Congress' stated objective was to ensure EPA could provide better information on clean air program benefits and costs in support of the next round of Clean Air Act reauthorization, whenever that may occur.

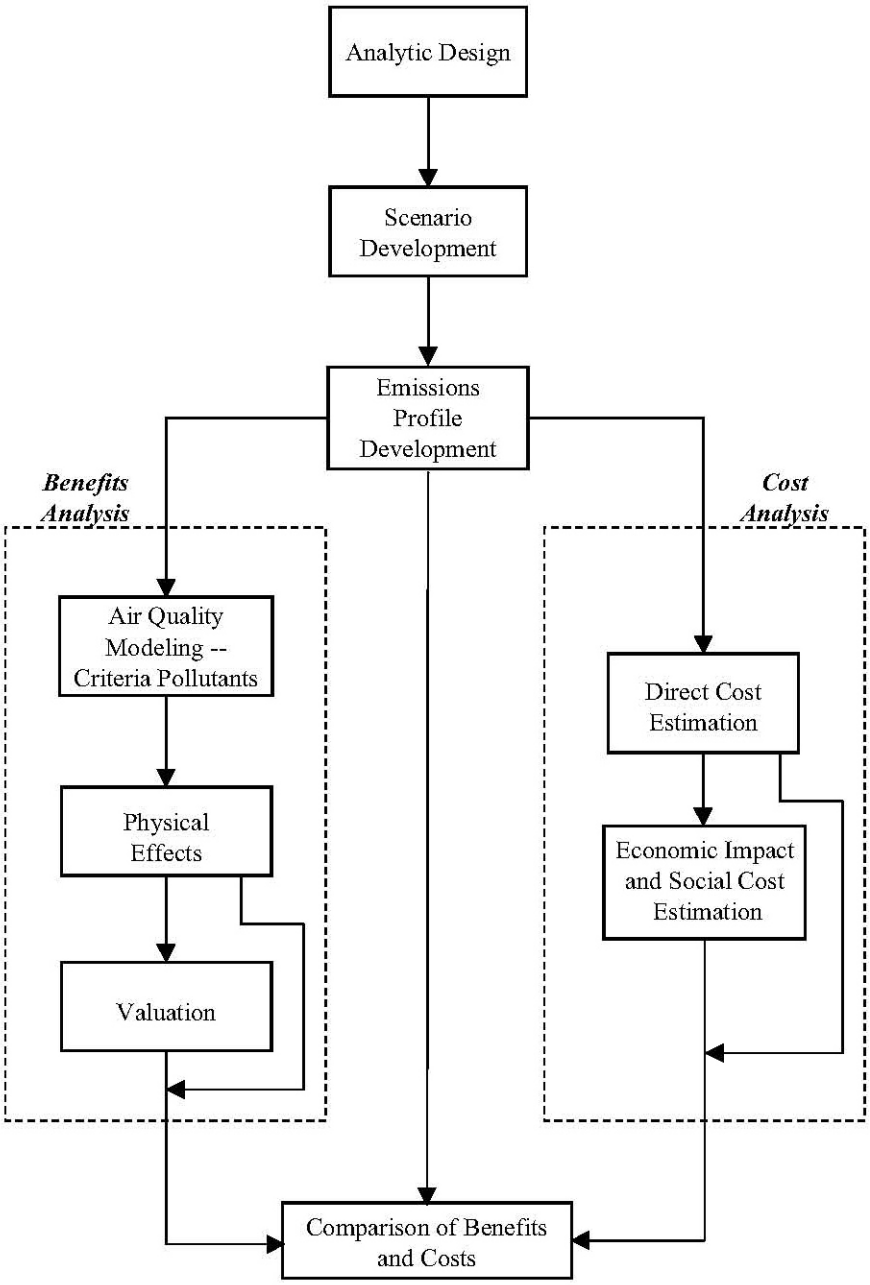
In response to section 812 requirements, EPA has published two studies as Reports to Congress: a Retrospective Study published in November 1997 examining the benefits and costs of the 1970 Clean Air Act and the 1977 Amendments from the period 1970 to 1990, and a First Prospective Study published in October 1999 which evaluated the incremental effects of 1990 Clean Air Act Amendment programs from 1990 to 2010. Currently, EPA's 812 Project Team is nearing completion of the analytical work for a study which updates and extends the First Prospective Study. This new study, commonly referred to as the Second Prospective Study, is similar in scope and design to the First Prospective Study, but incorporates many of the major programs promulgated since the 1999 publication of the First Prospective, applies more up-to-date scientific and economic information, and evaluates effects out to the year 2020.

A particularly important feature of the section 812 studies is the scope, timing, and quality of outside expert review. Section 812 of the Amendments required EPA to convene a panel of outside experts in a range of relevant disciplines to advise the Administrator on the data chosen for the analysis, the selection of models used to conduct the analysis, and the validity and utility of the resulting estimates of Clean Air Act program benefits and costs. EPA is unaware of any similarly comprehensive assessment of government programs which involves such rigorous *ex ante* review of planned methodologies and *ex post* review of analytical results. The quality of the outside expert reviews conducted throughout the series of studies has immensely improved all three studies, enabling EPA to meet the Congressional objectives of improved EPA analytical capabilities and deeper insights into the effects of Clean Air Act programs.

Organized under the auspices of EPA's Science Advisory Board (SAB), the statutorily-prescribed Advisory Council on Clean Air Act Compliance Analysis (Council) was established in 1991 to provide this multi-disciplinary outside expert review. Subsequently, separate subcommittees were established to advise the parent Council on particular technical aspects of the studies. The Air Quality Modeling Subcommittee (AQMS) was formed to advise the Council on issues of emissions estimation, air quality modeling, and some aspects of exposure modeling. Initially, a single subcommittee was formed to advise the Council on issues associated with estimation of physical effects, including those related to both human health and environmental outcomes. This subcommittee was named the Physical Effects Review Subcommittee (PERS). Later, the name of this subcommittee was changed to the Health and Environmental Effects Subcommittee (HEES), though the disciplinary scope of its review responsibilities remained the same. Eventually, this subcommittee was split into the two separate subcommittees in place today: the Health Effects Subcommittee (HES) responsible for advising the Council on human health effects estimation and the Ecological Effects Subcommittee (EES) responsible for advising the Council on issues associated with estimation of ecological consequences.

To facilitate the *ex ante* review of planned methodologies for the Second Prospective Study, the 812 Project Team published an "analytical blueprint." An initial draft blueprint was developed by the 812 Project Team and submitted for Council, AQMS, HES, and EES review in 2001. Pursuant to the Council's advice, significant revisions were made to the analytical blueprint, and a final version was published in 2003. Following the May 2004 publication of the Council's review of the revised analytical blueprint, the Project Team initiated the analysis.

The core analytical sequence for the Second Prospective Study is summarized in the following exhibit adapted with a slight modification from the May 2003 final analytical blueprint:



This sequence of analytical components is used to estimate the differences in economic, health, and environmental outcomes between two "core scenarios." The first core scenario, which serves as the analytical baseline, is the "*without-CAAA90*" case. This scenario freezes Clean Air Act and related State and local programs at the levels of scope and stringency which prevailed in November 1990 when the 1990 Amendments were passed, while allowing the population and economy to grow. The core scenario which is contrasted with this baseline case is the "*with-CAAA90*" scenario. For the historical years of the study's 1990 to 2020 reference period, the *with-CAAA90* case reflects actual CAAA program implementation. For future years,

the *with-CAAA90* reflects the Project Team's judgment at the time the scenarios were locked regarding the future implementation of Clean Air Act programs. It is the estimates for the incremental change in benefits and costs moving from the *without-CAAA90* case to the *with-CAAA90* case during the 2000, 2010, and 2020 target years which represent the principal analytical outputs of the Second Prospective Study.

In addition to the principal results provided by the core scenarios analysis, a number of supplemental analyses were conducted to provide additional information about Clean Air Act program costs and benefits. These supplemental analyses, which are all complete or nearing completion, include:

1. a Hazardous Air Pollutant (HAP) benefits case study, which focused on evaluating the effect of the 1990 Clean Air Act Amendments on benzene emissions and subsequent exposure and risk changes in the Houston MSA,

2. an ecological effects case study, which focused on estimation of changes in Adirondack lake acidification and resulting improvements in ecological service flows, as well as characterizing potential effects on standing timber, and

3. a computerized general equilibrium (CGE) analysis assessing the broader economic consequences of the changes in direct compliance expenditures and, to a limited extent, in population health and productivity resulting from 1990 CAA Amendment programs.

Each major component of the core scenarios analysis and each key supplemental analysis have been, or will soon be, documented in a standalone report. These standalone reports provide detailed descriptions of the methodologies and results for each analytical component, and it is these component-specific reports which have provided the focus for review by the Council and its technical subcommittees. In early 2010, a single integrated report documenting the overall Second Prospective Study will be drafted and submitted to the Council for review.

As of today, the planned methodologies and, in many cases, the results of the core scenario analysis components and the supplemental analyses have been reviewed by the relevant Council panels. Final review meetings for each of the panels are planned for late 2009 and early 2010. Current plans for the timing and key objectives for each of these panel meetings are as follows:

1. **HES.** December 15-16, 2009.

    a. Review the draft human health effect primary estimates incorporated in relevant chapters of the draft standalone benefits report.

    b. Review the human health components of the draft standalone uncertainty analysis report.

c. Provide advice to the Council regarding the validity and utility of the draft human health effects estimates and several final analytical choices pertaining to the health effect analysis and uncertainty analysis.

2. **AQMS.** 2010-Second Quarter.

a. Review the final standalone air quality modeling report.

b. Provide advice to the Council regarding the validity and utility of the final estimates of air quality concentration changes.

3. **EES**. 2010-Second Quarter.

a. Review the final updated ecological effects literature review and the ecological effects case study report.

b. Provide advice to the Council regarding the validity and utility of the literature review and ecological effects case study.

4. **Council**. 2010-Third Quarter.

a. Review the draft integrated report documenting all aspects of the Second Prospective Study, taking account of the final advisory recommendations of the technical subcommittees.

November 2010 is the 20th anniversary of the passage of the 1990 Clean Air Act Amendments. EPA has set a goal to complete the Second Prospective Study in time for its results to inform discussions and other activities associated with the 20th anniversary of the Act's most recent amendments.

The remainder of this document describes key considerations related to Council subcommittee review scope and process, lists the documents being submitted for Council HES review, and presents the review charge questions which EPA respectfully submits to the Council HES for consideration.

Review Scope and Process

Consistent with the statutorily-defined role of the Council and consistent with longstanding precedent in the conduct and review of the 812 studies, EPA proposes two types of charge questions. The first questions are general and conform to the particular requirements for review statutorily prescribed in section 812. Given their wide-ranging scope and generality, Council review panels have traditionally and properly interpreted these general charge questions as an invitation to review and consider rendering advice on any aspect of the analytical design, implementation, and results which may be considered appropriate by the panel chair.

The general charges are usually supplemented with more specific questions from the Project Team. These specific questions are typically motivated by the Project Team's need for advice from a panel on a particularly controversial and/or highly significant methodological choice. For example, the charge questions presented below include a request for advice from the HES regarding the Project Team's current plan to use the Pope et al. 2002 ACS follow-up study as the basis for the Primary Estimate of the change in incidence of PM-related premature mortality.

Both types of charge questions are configured by EPA to be as consistent as possible with the statutorily-defined advisory –as opposed to co-authorship—role of the Council and its technical subcommittees. In particular, charge questions are typically formulated to elicit advice from the Council on analytical choices already adopted, at least tentatively, by the Project Team. In many cases these analytical choices already conform to –or at least take account of—advice rendered by a previous Council panel during review of the analytical blueprint or during one of the interim reviews conducted since the Second Prospective Study began. In other cases, these analytical choices may have changed since the analytical blueprint was published based on emerging literature and/or relevant advice from other qualified panels such as those convened by the National Academy of Sciences. Nevertheless, every analytical choice reflected in the materials submitted for Council and Council subcommittee review is "fair game" for consideration and advice, though EPA by statute and tradition retains ultimate responsibility for all final analytical choices manifest in the section 812 studies.

Another factor which influences how the charge questions are configured is the organizational relationship between the Council and its technical subcommittees. Specifically, as a formal matter the technical subcommittees have all been chartered to provide advice to the Council, which retains exclusive authority and responsibility for rendering formal advice to the Agency. The Council, however, has consistently encouraged direct engagement between the technical subcommittees and the 812 Project Team during public review meetings such as the one scheduled for December 15-16, 2009. This direct engagement is also consistent with the point in the previous paragraph that the responsibility for all analytical choices ultimately resides solely with EPA.

Finally, the chapters and appendices submitted for review to the Council HES incorporate other analytical methods and choices apart from those associated with the HES' responsibilities to provide advice on human health effects estimation. For example, the draft benefits report chapter documenting the human health effects incidence estimates also presents draft results for the economic valuation of those incidence changes. However, review of the analytical choices pertaining to economic valuation of effects is primarily the responsibility of the parent Council. It is likely that the Council would be interested in any advice the HES chooses to convey regarding any analytical issue linked to the human health effects estimates; however, the HES is under no obligation to review elements of the review documents which the HES chair considers more appropriately managed by the Council or one of the other Council subcommittees.

Review Documents

The following documents are submitted for review and consideration by the Council HES during the December 15-16, 2009 meeting.

1. Industrial Economics Incorporated, "Benefits Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act – Draft", prepared for the US EPA Office of Air and Radiation, November 13, 2009.

    a. Chapter 1: Introduction *[7 pages]*

    b. Chapter 2: Estimation of Human Health Effects and Economic Benefits *[46 pages]*

2. Industrial Economics Incorporated, "Uncertainty Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act - Draft", prepared for the US EPA Office of Air and Radiation, November 13, 2009.

    a. Chapter 1: Introduction *[9 pages]*

    b. Chapter 4: Concentration-Response Function Uncertainty *[10 pages]*

    c. Chapter 5: Differential Toxicity of PM Components *[21 pages]*

    d. Chapter 6: Particulate Matter/Mortality Cessation Lag *[12 pages]*

    e. Chapter 7: Dynamic Population Modeling *[10 pages]*

    f. Appendix C: Table C-4. Key Uncertainties Associated with Human Health Effects Modeling, pp. C-8 to C-12 *[5 pages- full appendix is 14 pages]*

In addition to these documents submitted for formal review, the Project Team is providing the following additional materials to facilitate the Council HES review.

1. Abt Associates, 2008. *Environmental Benefits Mapping and Analysis Program (BenMAP) User's Manual Appendices.* Prepared for EPA/OAR/OAQPS, September 2008.

2. Industrial Economics Incorporated, *Alternative Presentation of PM Expert Elicitation Results, Presentation to EPA Science Advisory Board 812 Council Health Effects Subcommittee*, December 15, 2009.

3. Technical Memorandum from Neal Fann, OAR/OAQPS to Jim DeMocker, OAR/OPAR, *Estimating $PM_{2.5}$ and Ozone-related Premature Mortality Based on Risk Estimates from the Jerrett et al. (2009) and Krewski et al. (2009) Studies*, November 15, 2009. *[7 pages]*

4. Industrial Economics Incorporated, *ibid.* Draft Uncertainty Report, Appendix A: Qualitative Uncertainty Analysis Tables From The First Prospective Analysis , Table A-4, pp. A-10 to A-14, November 13, 2009. *[5 pages- full appendix is 19 pages]*

Review Charge Questions

1. General Charge. EPA requests that the Council HES review the human health-related chapters and appendices of the draft Section 812 Second Prospective Study benefits and uncertainty reports. Consistent with the statutory language defining the role of the Council in reviewing the 812 studies—and consistent with the role of the HES as advisor to the Council on human health effect estimation—EPA respectfully submits the following general charge questions to the HES:

    a. Does the Council HES support the data choices made by the 812 Project Team for the development of the human health-related chapters and appendices of the draft benefits and uncertainty reports? If not, are there alternative data sets the Council HES recommends should be applied instead?

    b. Does the Council HES support the methodological choices made for analyzing those data and developing the human health effect estimates for the relevant scenarios, and for characterizing their uncertainty? If not, are there alternative methodologies the Council HES recommends should be applied instead?

    c. What advice does the HES have for the Council regarding the validity and utility of the human health effect analyses incorporated in the draft benefits report and the uncertainty analyses incorporated in the draft uncertainty report? If the validity and/or utility of the reports and their underlying analyses could be improved, what specific improvements does the Council HES recommend that the 812 Project Team consider, either for the present analysis or as part of a longer term research and development program?

2. Specific Charges. The general charge question #1 covers any and all aspects of the draft benefits report which the Council HES might consider appropriate to address in its review. In conducting this review, EPA also respectfully requests that the Council HES consider the following analytical choices made by the 812 Project Team and manifest in the draft reports submitted for review. Consistent with the scope and process for review pursuant to the General Charge, for each of these analytical choices EPA requests that the Council HES consider providing advice regarding the reasonableness of the analytical choice made by the Project Team. If the Council HES does not support the analytical choice made by the Project Team, EPA respectfully requests that the Council HES identify one or more appropriate alternative approaches. In describing such alternatives, EPA requests that the Council HES indicate whether such alternative is likely to be feasible for application in the Second Prospective Study according to its current schedule or whether such potential improvement should be viewed as a subject for longer-term research and potential application in future studies.

    a. PM Mortality Concentration-Response Function (CRF). The current draft benefits report reflects adoption of the Pope et al. 2002 study as the basis for the Primary Estimates of the difference in incidences of PM-related premature mortality. Also within the main benefits report, an Alternative Estimate is presented prominently

which is based on the Laden et al. 2006 study. Furthermore, the Project Team is currently assessing the potential significance of the recent Krewski et al. (2009) publication since it appears to strengthen the evidence for PM-related Ischemic heart disease and lung cancer mortality and could provide the basis for a revised Primary Estimate or an additional Alternative Estimate. Uncertainty in the Primary Estimate is further described in the draft uncertainty report through graphical presentation of results obtained by applying each of the 12 expert elicitation study functions to the differences in PM exposure estimated for the *with-CAAA90* and *without-CAAA90* core scenarios. In addition, the Project Team has recently been considering an approach developed by Industrial Economics which uses a Copula function to generate results representing the 12 expert functions. This approach is summarized in a draft briefing which the Project Team proposes to present to the HES on December 15 for its consideration.

> Does the Council HES support these study selections and the organization and presentation of PM mortality estimates in the draft benefits and uncertainty reports? In addition, a particular question for which the Project Team seeks HES advice is whether the application of mortality risk coefficients drawn from the Krewski et al. (2009) study should be considered for use in generating the Primary Estimate, or at least as the foundation for an Alternative Estimate. If the answer to either, or both, of these two questions is negative, are there alternative study choices and/or methods for generating, organizing, and presenting results which the Council HES recommends EPA consider?

b. <u>PM Mortality Cessation Lag Function</u>. The Primary Estimates for PM mortality reflect an assumed lag between cessation of exposure and realization of the change in health effect incidence. Based in part on prior Council HES advice, the primary estimates in the draft benefits report reflect a 20-year distributed lag. Specifically, 30 percent of the total reduced incidences is assumed to occur in the first year following the exposure change. Another 50 percent of the total incidence changes is assumed to be spread evenly over years two through five. The remaining 20 percent of the incidence change is spread evenly over years six through twenty. The effect of the cessation lag is realized through discounting (at a 5 percent rate) of the monetized value of future-year incidence changes (i.e., there is no need, and no intent, to represent the discounted values as reflecting direct discounting of incidences *per se*). In addition, the draft uncertainty report evaluates the effect of alternative lag structures. These alternatives include the 5-year distributed lag applied in the First Prospective Study and a set of smoothed lag functions derived from consideration of the results of available cohort and intervention studies.

> Does the Council HES support the use of the 20-year distributed lag structure described above for generation of the Primary Estimates of the monetary value of PM mortality incidence reduction and the specific alternative lag functions presented in the draft uncertainty report? If not, are there alternative study choices and/or methods for organizing and presenting results which the Council HES recommends EPA consider?

c. PM Infant Mortality. EPA's current approach to estimating the association between PM exposure and respiratory inflammation and infection leading to premature mortality in children under 5 years of age relies on the cohort study conducted by Woodruff et al. (1997). This is based in part on prior (SAB-HES) advice, which noted several strengths of the study, including the use of a larger cohort drawn from a large number of metropolitan areas and efforts to control for a variety of individual risk factors in infants (e.g., maternal educational level, maternal ethnicity, parental marital status, and maternal smoking status). A more recent study by Woodruff et al. (2006) continues to find associations between $PM_{2.5}$ and infant mortality, and also found the most significant relationships with respiratory-related causes of death.

> Does the Council HES recommend continued reliance on the Woodruff et al. (1997) study to characterize the association between PM exposure and respiratory inflammation and infection leading to premature mortality in children under 5 years of age, or recommend that the relationship be characterized by the more recent Woodruff et al. (2006) study, or recommend some other approach that relies on a third study or some combined consideration of multiple studies? Are there specific reasons to favor the results of one of these studies or of another study?

d. PM Mortality Effect Threshold. Consistent with prior SAB and NAS advice, the Project Team did not attempt to alter the Pope 2002 CRF to reflect an assumed concentration threshold below which PM concentration changes would yield no change in estimated incidences. In addition to the lack of compelling evidence for any particular effects threshold, the Project Team is not aware of any valid procedure for the altering the CRF above an assumed threshold. In other words, the Project Team presumed that imposition of an (arbitrary) threshold would require respecification of the CRF to ensure a "with threshold" CRF slope that would accurately account for the total change in incidence expected based on the epidemiological study from which the CRF was derived. Prior efforts to apply a threshold simply truncated the incidence change estimated from a no-threshold CRF, though prior SAB advice indicates this is improper and the Project Team chose not to apply such an adjustment in the current analysis.

> Does the Council HES support the use of a no-threshold model for generation of the Primary Estimates of PM mortality incidence reduction? If not, are there methods for estimating and applying an effects threshold which the Council HES recommends EPA consider, either for the Primary Estimates or for presentation in the draft uncertainty report?

e. Ozone Mortality CRF. Based in part on prior SAB and NAS advice, EPA has included changes in ozone-related premature mortality as part of the Primary Estimate of benefits in the draft benefits report. Recognizing the ongoing uncertainty regarding the appropriate study or studies from which a quantitative CRF should be derived, the Project Team adopted a placeholder function for the Primary Estimate of changes in ozone mortality which encourages focus on several key factors: study selection, pooling across studies, and pooling methodology. Given the particular uncertainties regarding the reasonableness of pooling across the multi-city NMMAPS

studies and the meta-analyses, the Project Team specified a CRF for the Primary Estimate which reflects inverse variance-weighted pooling of the Bell et al. 2004 and Schwartz 2005 mortality effect estimates, both of which reflect an all-cause mortality endpoint. In addition, the draft uncertainty report presents alternative results obtained by applying CRFs derived from each of the three individual multi-city time-series studies and three meta-analyses. Furthermore, EPA has developed an alternative CRF based on the Jerrett et al. (2009) long-term ozone mortality study. This approach is described in the technical memorandum included in the package of review documents.

Does the Council HES support the use of the ozone mortality CRF derived by pooling the Bell et al. 2004 and Schwartz 2005 studies for the Primary Estimate and the presentation of the six alternative estimates in the draft uncertainty report? A particular question for which the Project Team seeks HES advice is whether application of the respiratory mortality risk estimate drawn from Jerrett et al. (2009) might be suitable for use in generating the Primary Estimate, or at least for generation of an Alternative Estimate. If the answer to either, or both, of these two questions is negative, are there alternative study selection and/or pooling approaches the Council HES recommends EPA consider for the Primary Estimate in the draft main benefits report and/or for the Alternative Estimates presented in the draft uncertainty report?

f. Ozone Mortality Cessation Lag. Based on a perceived lack of empirical data to support specification of a cessation lag structure for ozone-related mortality effects, the Project Team has not attempted to apply a cessation lag structure for the Primary Estimate of ozone mortality reduction benefits in the draft benefits report, nor are alternatives evaluated in the draft uncertainty report.

Does the Council HES support the use of a no-lag assumption for the Primary Estimate of ozone mortality benefits presented in the draft benefits report? If not, are there methods for estimating and applying a cessation lag structure for ozone mortality which the Council HES recommends EPA consider, either for the Primary Estimates or for presentation in the draft uncertainty report?

g. Ozone Mortality Effect Threshold. Based on a perceived lack of empirical data to support application of a concentration threshold for ozone-related premature mortality effects, the Project Team did not attempt to apply an effect threshold for the Primary Estimate of ozone mortality reduction benefits.

Does the Council HES support the use of a no-threshold model for generation of the Primary Estimates of ozone mortality incidence reduction? If not, are there methods for estimating and applying an effects threshold which the Council HES recommends EPA consider, either for the Primary Estimates or for presentation in the draft uncertainty report?

h. Baseline Incidence / Prevalence Estimates. Baseline incidence / prevalence are key determinants of the estimated changes in health effect incidence described in the draft benefits and uncertainty reports.

Does the Council HES support the choices made by the Project Team regarding baseline incidence / prevalence across the various human health endpoints incorporated in the Primary Estimate of benefits? If not, are there alternative baseline incidence / prevalence data which the Council HES recommends EPA consider, either for the Primary Estimates or for presentation in the draft uncertainty report?

i. PM Differential Toxicity Sensitivity Analysis. In its review of the Second Prospective Study analytical blueprint, the Council recognized that the state of the science did not support development and application of assumptions regarding the potential differential toxicity of PM components suitable for informing the present analysis. However, the Council did encourage the Project Team to explore the feasibility of conducting a sensitivity analysis to gauge the potential significance of differential toxicity. After extensive review of the literature and analysis of options, the Project Team concluded that currently available data and methodologies remain insufficient to meet the challenge of developing a reasonably valid and usefully informative sensitivity analysis, even on a notional basis. Indeed, the Project Team concluded that the potential research utility of such a sensitivity analysis in the end did not appear to justify the risks from potential misinterpretation and misapplication of the results of such a sensitivity analysis. The Project Team's evaluation of the issue of differential toxicity is presented in chapter 5 of the draft uncertainty report.

Does the Council HES support the Project Team's decision to defer quantitative sensitivity analysis of potential PM component differential toxicity? If not, are there data or methods for conducting a quantitative analysis of PM component differential toxicity which the HES recommends EPA consider, or are there other aspects of differential PM component toxicity which the HES recommends should be addressed in the draft benefits and/or uncertainty reports?

j. Dynamic Population Modeling. Chapter 7 of the draft uncertainty report describes the results of the Project Team's application of a dynamic population simulation model to the evaluation of changes in pollution-related premature mortality risks. The Project Team continues to consider the potential utility of dynamic population modeling approaches and respectfully requests that the HES review the methodology and results and consider providing advice regarding the potential utility of further development and future application of this approach.

Does the Council HES have recommendations regarding the potential value for future analyses of the dynamic population approach described in chapter 7, or any alternative approaches the HES may suggest for addressing the issue of population changes during a study's reference period?

# # #

ATTACHMENT F:
AGENCY BRIEFING PRESENTATIONS

Section 812 Second Prospective Health Benefits

HES Review
December 15, 2009

Jim DeMocker
Office of Policy Analysis and Review
Office of Air and Radiation

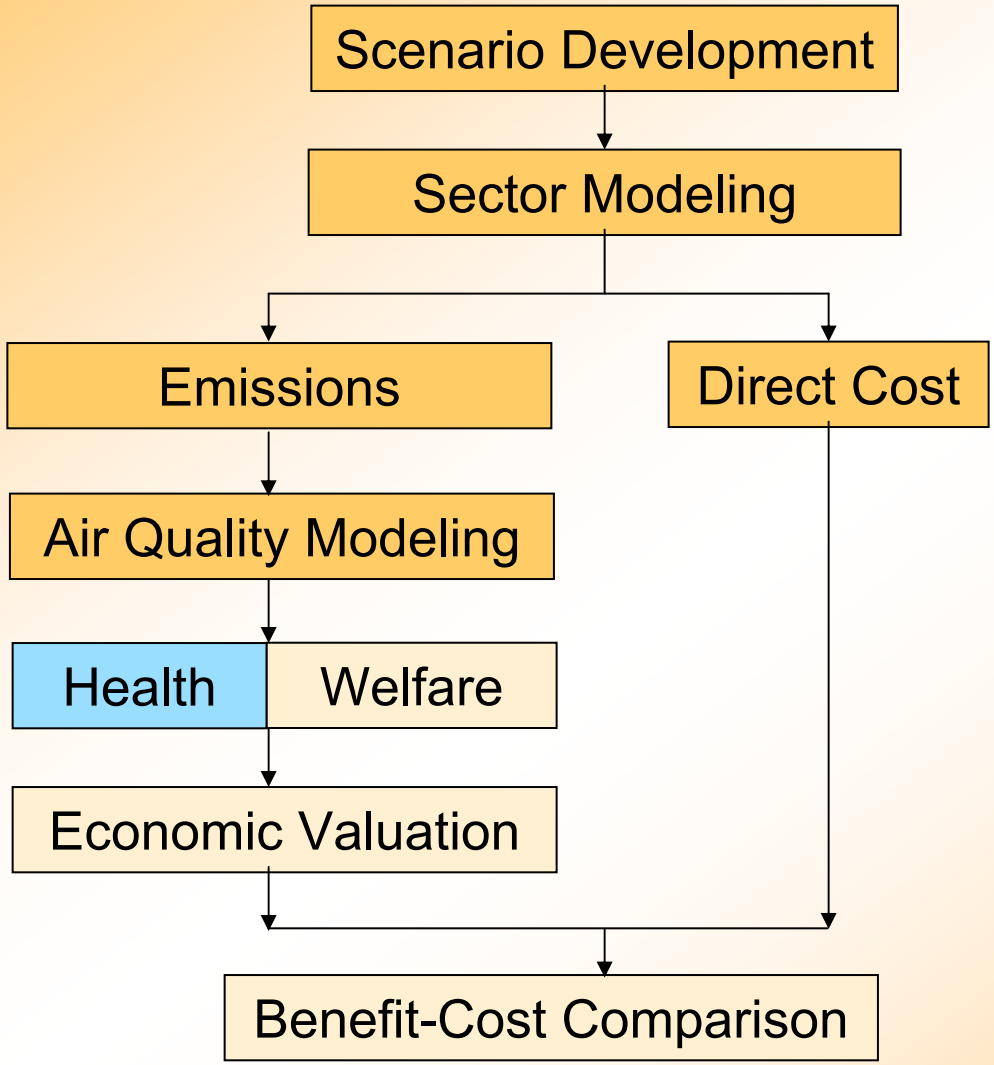
Project Team Presentations

- Jim DeMocker, EPA
  - Overall study goals, status
  - Diagnostics for five-fold increase in health benefits
  - Principle on configuration of 812 primary estimates
  - Merits of combining elicited expert judgments
  - Health effect inputs to macroeconomic modeling
- Neal Fann, EPA
  - Jerrett and Krewski approach for PM, ozone
- Henry Roman, IEc
  - Copula method for combining EE CRFs
- Jim Neumann, IEc
  - Dynamic population approach

Goals and Uses of the 812 Studies

- Stated Goals
  - Support CAA and related legislative efforts
  - Capture interaction effects between programs
  - Improve analytical methodologies for OAR, EPA
  - Help identify program and research priorities

- Anticipated Uses
  - Add refined perspective on value of CAA programs *per se* and co-benefits of GHG control
    - Example: better foundation for energy externalities work
  - Input to EPA strategic planning processes
  - Methods development laboratory
    - Examples: use of EE results, dynamic pop, CGE
  - Data and tools for other researchers, States



Scenarios:
Core
Hi Econ Growth
Lo Econ Growth
Marginal Changes

Supplemental Analyses:

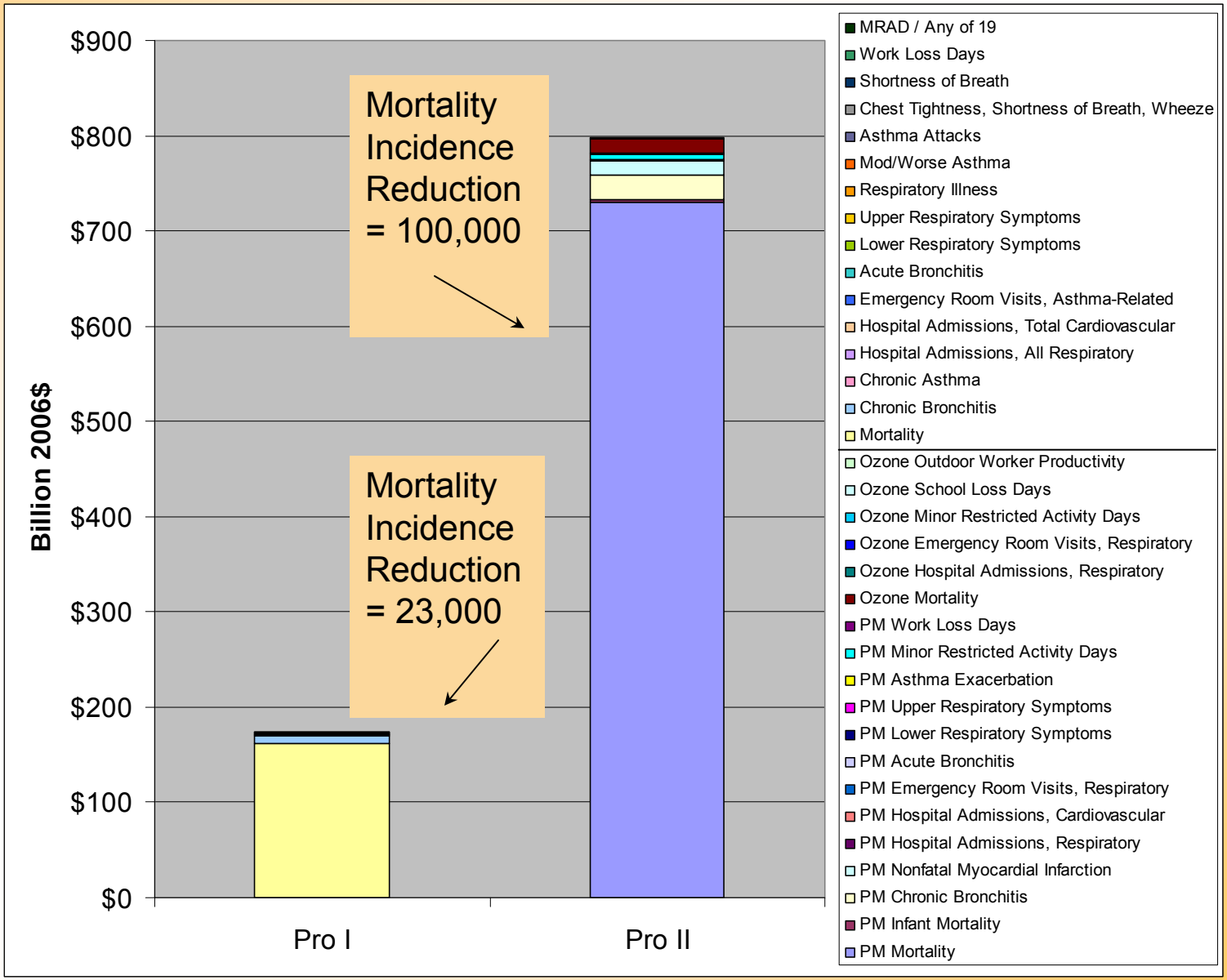
- HAP case study
- Eco lit review
- Eco case study
- ~~Title VI reanalysis~~
- Uncertainty
- CGE modeling

Final

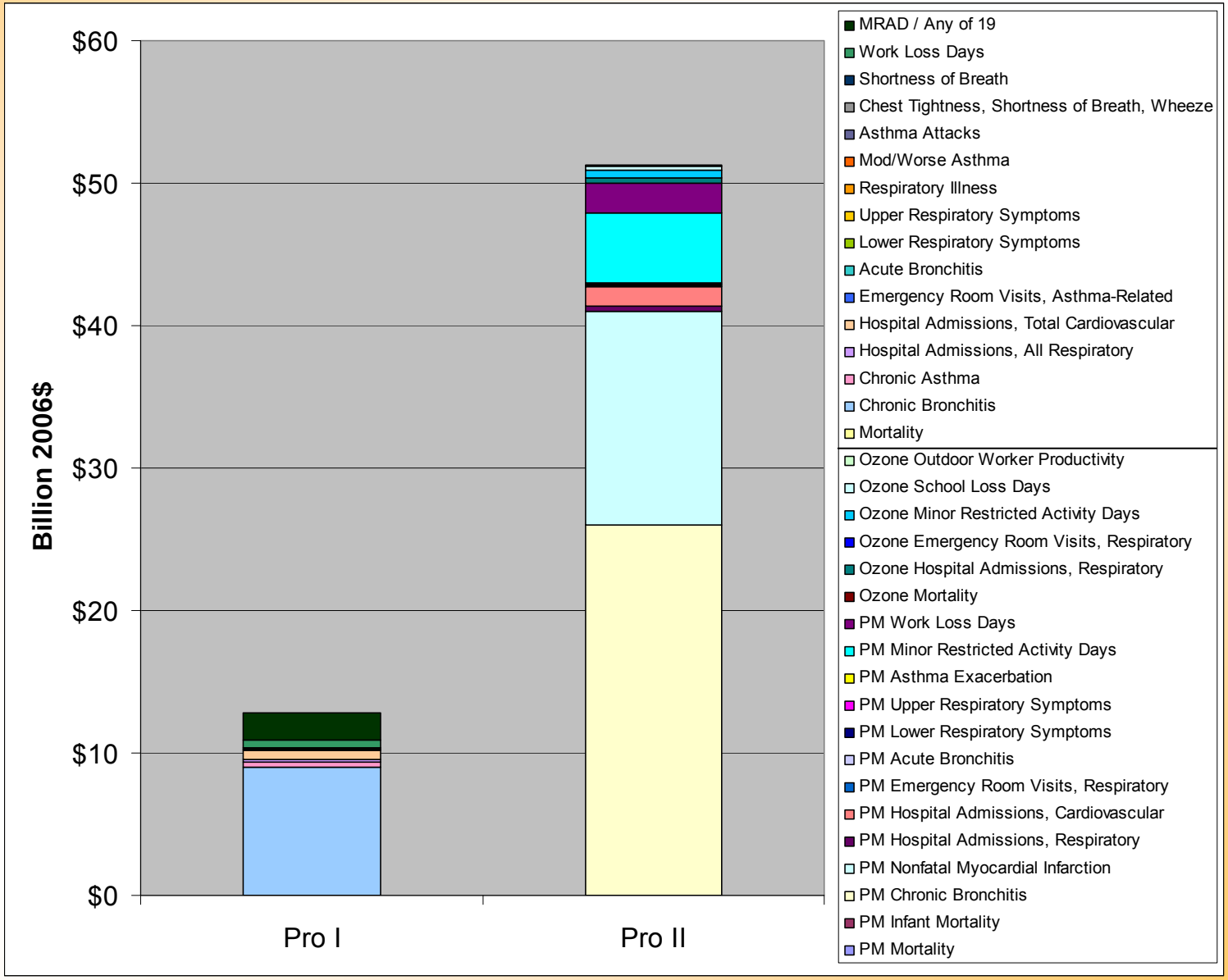
Draft Final

In Progress

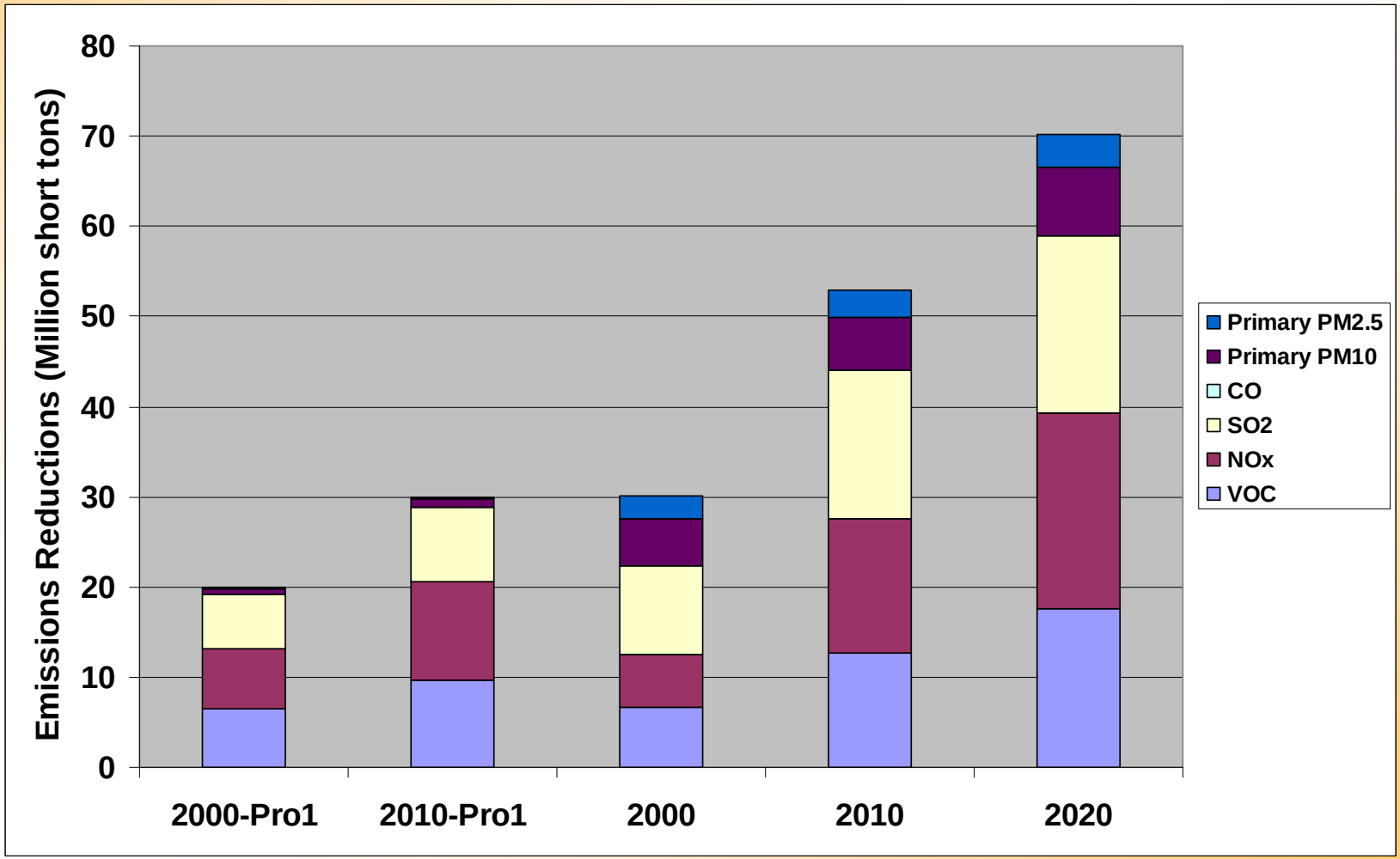
Pro I vs Pro II Monetized 2010 Health Benefits By Health Endpoint – Billions of 2006$



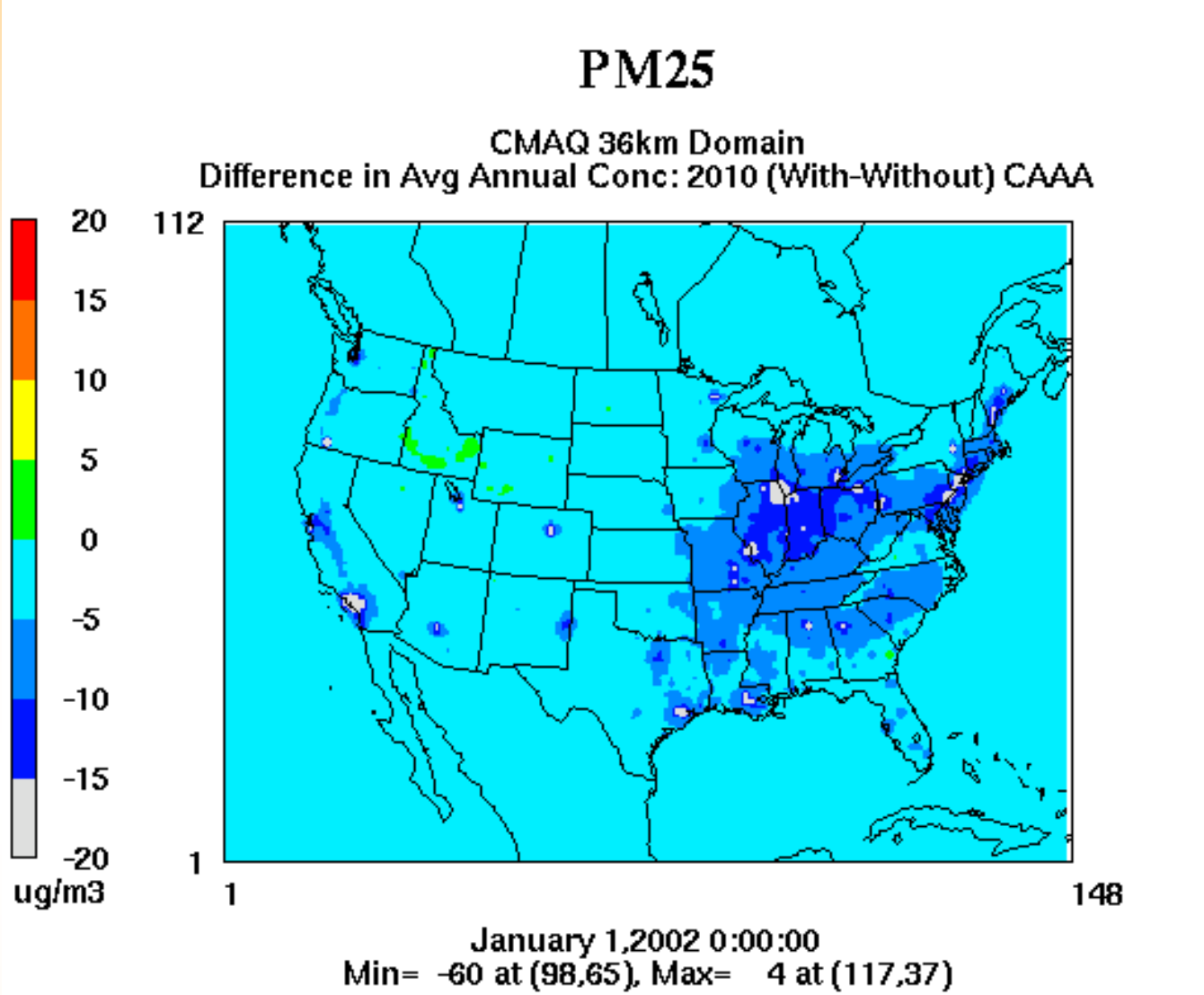
Pro I vs Pro II Monetized 2010 Health Benefits - Morbidity Only By Health Endpoint – Billions of 2006$



Pro I vs Pro II Emissions Reductions [excluding CO]



Pro I vs Pro II Air Quality Modeling
PM2.5 Ambient Concentration Changes 36km CONUS - 2010



Pro I vs Pro II Air Quality Modeling

- Project Team's Assessment
  - Differences in models, model configuration may be factors
    - Grid resolution, simulation period, met data, baseline concentrations
    - More complete coverage of particle species may be key
  - Core model formulation changes probably don't contribute significantly to differences
    - Chemistry, advection schemes
  - Monitor interpolation method to estimate baseline concentrations between monitors is also countervailing
    - Pro II (MATS) narrows modeled concentration changes relative to Pro I method (eVNA)
  - Richness of baseline PM2.5 monitor data may be a major factor
    - Pro I relied on cross estimation from PM10
    - Pro II employed much more extensive and valid PM2.5 monitor data
- Loss of Pro I grid-level data precludes full and effective comparative analysis of Pro I vs Pro II

Pro I vs Pro II Concentration-Response

- Pro I PM Mortality CRF:
  - Pope et al (1995) / 50 U.S. cities / single pollutant model
  - PM2.5 β = 0.006408
  - ΔPM2.5 = change in annual median concentration
    - Across 1979-1983 period
- Pro II PM Mortality CRF:
  - Pope et al (2002) / 51 U.S. cities / single pollutant model
  - PM2.5 β = 0.005827
  - ΔPM2.5 = change in annual mean concentration
    - Averaged across 1979-1983 and 1999-2000
  - Double the follow-up time of Pope et al (1995)
- Contribution of CRF to Pro I vs Pro II differences is small

Key Factors Driving Pro I vs Pro II Differences

- Scenario Changes ↑
  - CAIR, CAVR, CAND, HDDV, Tier II, etc in Pro II
- Emissions ↑
  - Greater reductions in direct PM2.5 and precursor emissions
  - Reductions apparently better targeted to population
- Air Quality Modeling ↑
  - Improved AQM captures previously omitted species
  - PM2.5 monitor data replaced PM10 cross estimation
- Concentration-Response Function for PM Mortality ↔
  - Move from Pope et al (1995) to Pope et al (2002)
- Morbidity Endpoints ↑
  - Addition of AMI

Defining Primary Estimates in 812

- Traditional 812 approach follows BCA principles
  - BCA focus on expected value outcomes + acknowledgement of uncertainties
  - 812 reports have provided "Primary Estimates"
    - Distribution: "Primary Central" with 5% "Primary Low" and 95% "Primary High"
    - Supplemented by "Alternative Estimates" and sensitivity analyses
- Competing trend in some recent RIAs
  - Some recent RIAs have employed multiple "primary estimates"
    - 3% versus 7% discount rate "alternative primaries"
    - Pope et al (2002) plus Laden et al (2006) "alternative primaries"
  - "Proliferation of answers" more problematic in 812 context
    - Large number of benefit and cost endpoints to be addressed
    - Many uncertain or controversial factors are unimportant to bottom line
    - Multiple answers or ranges based on extreme observations arguably not helpful
- Where Project Team has been told studies or estimates cannot be validly combined, single basis for Primary Estimate has been adopted
  - For PM mortality, Primary Estimate based on Pope et al (2002), Laden et al (2006) presented as Alternative Estimate
  - For ozone mortality, Primary Estimate based on pooling of Schwartz (2005) and Bell et al (2004) NMMAPS studies focused on non-accidental death

Combination of Elicited Expert Judgments

- Reasons not to combine
  - PM EE Study not designed to yield expert consensus function
  - Combined function obscures experts' individual judgments
  - Combined function may obscure extent of uncertainty, variability
  - Best use of this "limited poll of experts" is to gauge uncertainty by reporting 12 individual estimates
  - May not be important to combine unless used for primary estimate

- Reasons to combine
  - Presentation of 12 separate estimates is challenging
  - Combination would reflect considerable agreement among interviewed experts
  - SAB said EE range reported in the PM NAAQS was misleading
  - Combining occurs implicitly, at least at the policy step, so better to approach systematically than *ad hoc*

- <u>If</u> combination is reasonable, what are technical options?
  - Technical proposal from IEc based on copula function approach
  - Other options are available, such as simulation approach
    - This is approach applied for other factors such as VSL

CGE "Benefits-Adjusted Run" Inputs for 2010

Endpoint	Change In Incidence	Change in Prevalence[1]	Workdays Gained
PM			
Acute Myocardial Infarction	142,000	581,000	23,029,000
Chronic Bronchitis	59,000	590,000	19,299,000
Hospital Admissions, Cardiovascular	49,000	n/a	351,000
Hospital Admissions, Respiratory	24,000	n/a	219,000
Emergency Room Visits, Respiratory	87,000	n/a	19,000
Work Loss Days	14,104,000	n/a	14,104,000
Ozone			
School Loss Days	3,212,000	n/a	2,340,000
Worker Productivity	n/a	n/a	1,323,000
Hospital Admissions, Respiratory	19,000	n/a	48,000
Emergency Room Visits, Respiratory	7,000	n/a	2,000

Next Up

- Neal Fann, EPA
  - Jerrett and Krewski approach for PM, ozone
- Henry Roman, IEc
  - Copula method for combining EE CRFs
- Jim Neumann, IEc
  - Dynamic population approach

Presentation to the Health Effects Subcommittee

December 15th, 2009

ALTERNATE $PM_{2.5}$ AND OZONE MORTALITY ESTIMATES

Overview

- Approach to presenting mortality incidence estimates
- Presentation of results based on Jerrett et al. (2009) and Krewski et al. (2009)
- Key science policy questions

Current approach to presenting ozone and $PM_{2.5}$-related mortalities

Short-term ozone mortality estimates

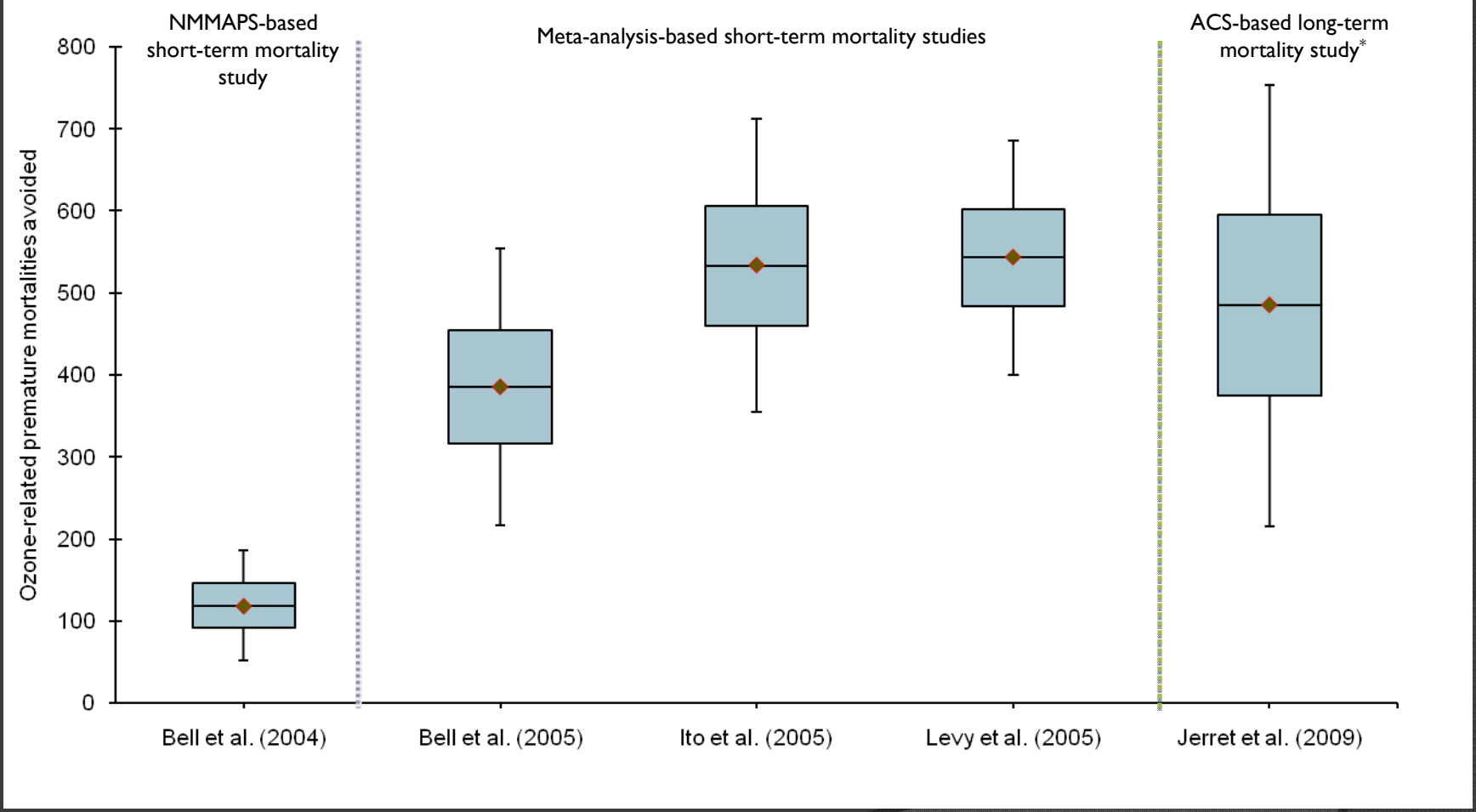
Table 1: Ozone-related premature mortalities of Alternate Ozone NAAQS in 2020 (95% confidence intervals)

Mortality study		0.075 ppm	0.070 ppm	0.065 ppm
Multi-city studies	Bell et al. (2004)	74 (36—120)	250 (130—410)	450 (240—730)
	Schwartz (2005)	110 (54—190)	380 (190—630)	700 (350 1,100)
	Huang et al. (2004)	130 (66—200)	420 (230—670)	770 (420 1,200)
Meta-analyses	Bell et al. (2005)	240 (410—350)	800 (490 1,200)	1,500 (910 2,200)
	Ito et al. (2005)	330 (230—450)	1,100 (790 1,500)	2,000 (1,400 2,800)
	Levy et al. (205)	340 (260—430)	1,100 (870 1,500)	2,100 (1,600 2,600)

Figure 1: Long-Term $PM_{2.5}$ Mortality Estimates

Presentation of results based on Jerrett et al. (2009) and Krewski et al. (2009)

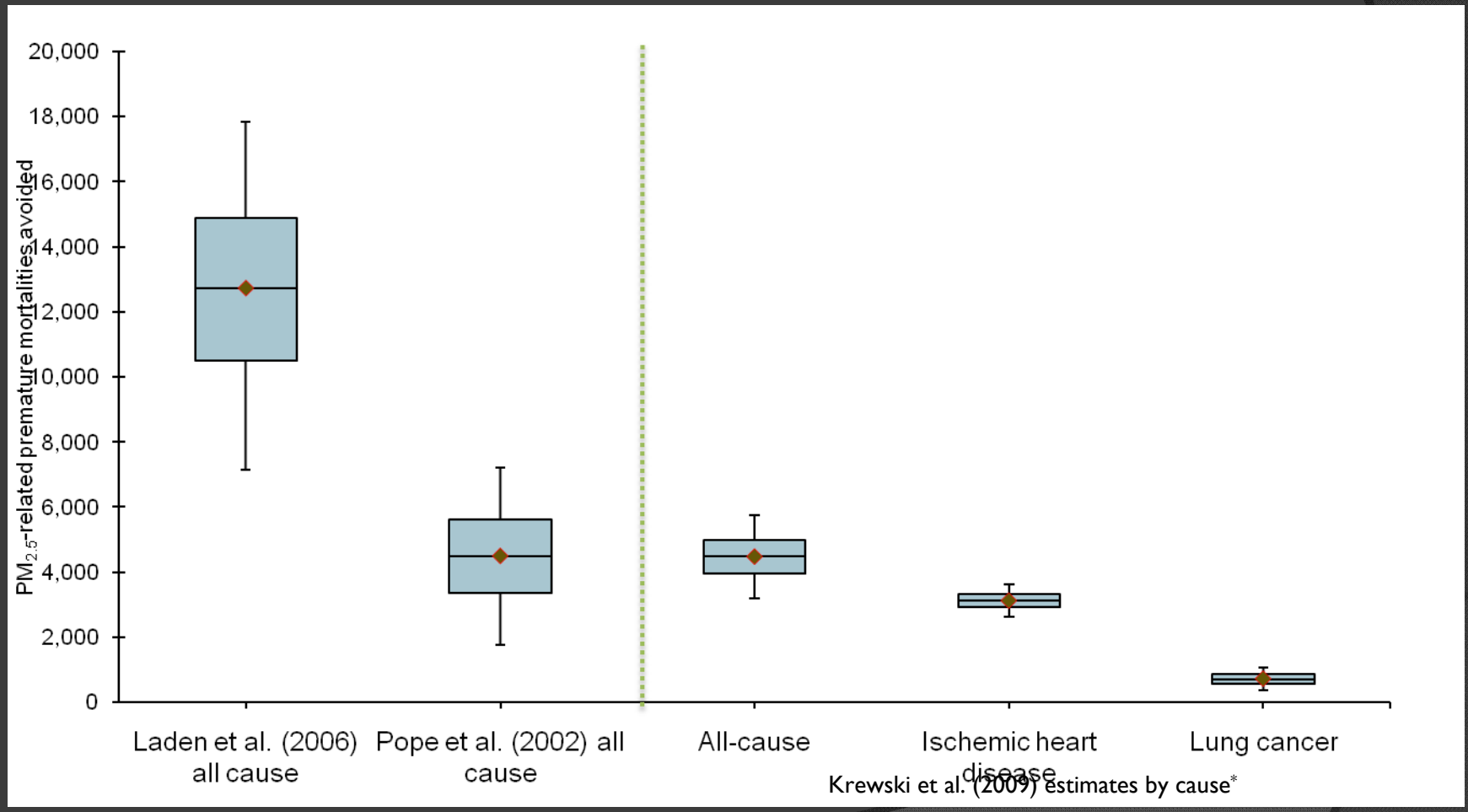
Figure 2: Comparing Alternate Estimates of Ozone-Related Premature Mortality



*Respiratory mortality based on two-pollutant model controlling for $PM_{2.5}$. Exposure metric adjusted from 1hr daily maximum to 8hr daily maximum to maintain consistency with results of short-term studies

Ozone impacts modeled using air quality impacts nationwide from May to September

Figure 3: Comparing Alternate Estimates of $PM_{2.5}$-Related Premature Mortality



*Effect coefficients drawn from table 4 of HEI commentary

Key Science Policy Questions

1. Krewski et al. reports the strongest association between IHD mortality and long-term $PM_{2.5}$ exposure, while Jerrett finds a positive relationship between long-term ozone exposure and respiratory mortality. Krewski also reconfirms previous findings regarding long-term PM exposure and lung cancer. Based on the strength of this evidence, does the SAB agree that EPA should begin to report :
   - IHD- and Lung cancer-related PM mortality and
   - respiratory-related ozone mortality?

Key Science Policy Questions

2. When estimating the monetary value of avoided PM-related mortalities based on long-term PM mortality risk coefficients, EPA discounts the stream of mortality benefits according to an SAB-recommended cessation lag. Should EPA apply such a lag to ozone-related premature mortality based on the risk estimate reported in Jerrett? If so, how should it specify this lag?

Key Science Policy Questions

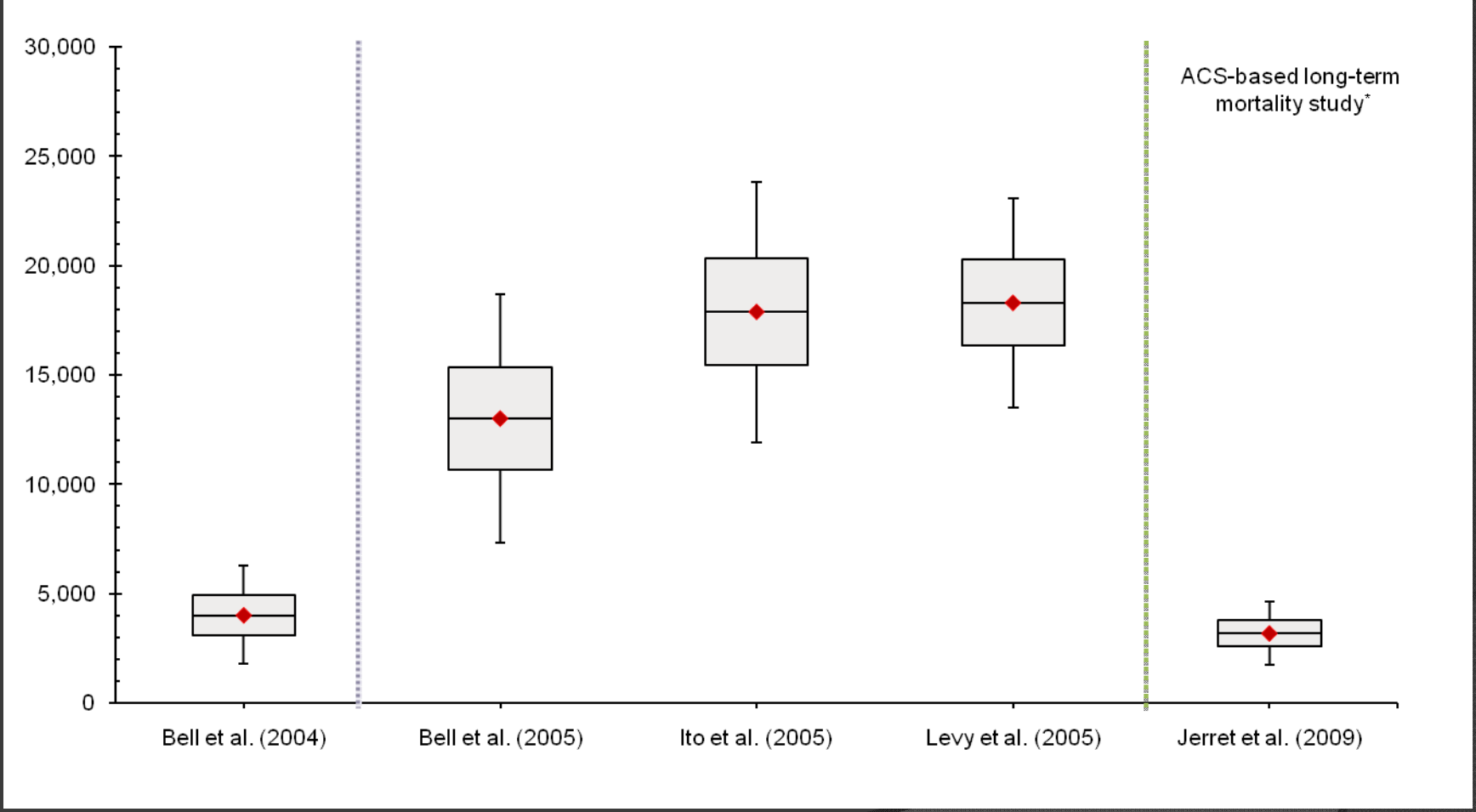
3. The Jerrett et al. study evaluated the evidence for a population-level threshold, finding limited evidence. The authors apply a threshold model, finding that a threshold value of 56 ppb best fits the data. However, this result fails a test of statistical significance ($p = 0.06$) and the authors conclude that the threshold model is "not clearly a better fit." Does this evidence merit:
   - a quantitative sensitivity analysis based on this limited evidence, or instead
   - a qualitative characterization of uncertainty around this parameter?

Key Science Policy Questions

4. Does the SAB agree that EPA should present:
   - the Krewski et al. estimates as a substitute for the Pope et al. (2002) estimate?
   - the Jerrett et al. estimates as a complement to the existing array of short-term mortality estimates?

Appendix

Figure 4: Comparing Alternate Estimates of Ozone-Related Premature Mortality—Jerrett et al. Threshold Estimate



*One-pollutant model incorporating 56ppb

Ozone impacts modeled assuming a 30% reduction in May to September ozone levels nationwide

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Alternative Presentation of PM Expert Elicitation Results

Presentation to EPA Science Advisory Board 812 Council Health Effects Subcommittee

December 15,2009

Henry Roman
Principal

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, MA 02140
617/354-0074

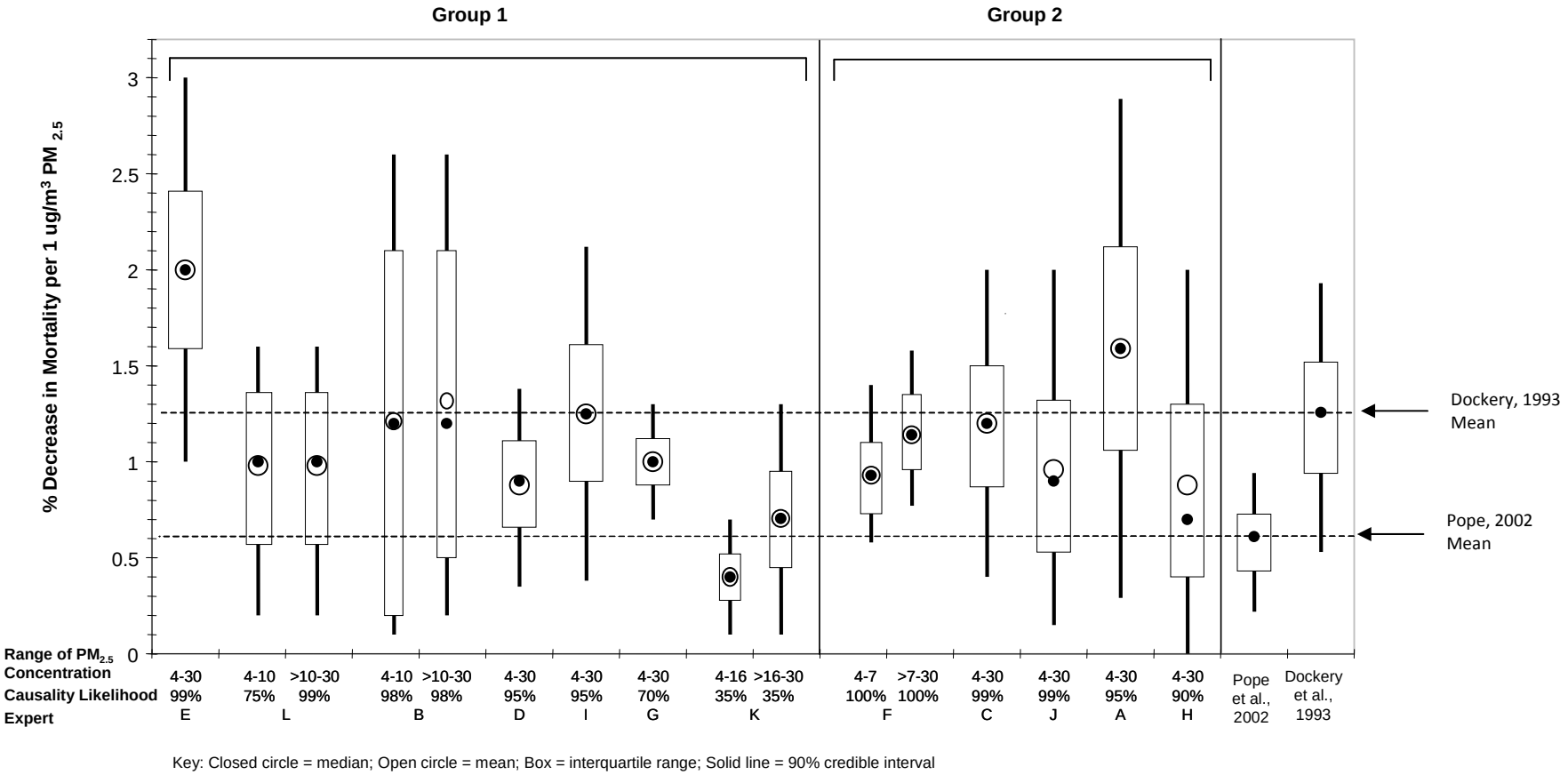
Background

- Major Expert Elicitation (EE) study of the mortality effects of PM2.5 completed by EPA in 2006.
- Elicited subjective probabilistic distributions of uncertainty in PM-mortality concentration response coefficient for use in EPA benefits analyses.
- 12 experts, 12 distributions (A - L)
- Individual expert distributions programmed in BenMAP, applied (unpooled) in subsequent analyses (PM, NAAQS RIA; RSM-based PM co-benefits in other RIAs).
- Lack of combined estimate poses presentation challenges
  - Reporting of 12 distributions can be cumbersome.
  - SAB critiqued EE range reported in PM NAAQS as misleading.

Past SAB Advice

- Excerpt from EPA SAB PM NAAQS RIA consultation in 2008:
  - "Where experts largely agree, it would be appropriate to collapse the various estimates into a single distribution (or point estimate with uncertainty bounds) while still providing the individual estimates elsewhere…In future analyses, the decision about aggregation must be made in the context of each analysis and its purpose."
- Is aggregation a reasonable approach for the 812 analysis? Is there a viable means of combining the PM EE results?

Results of the PM Expert Elicitation (2006)



Key: Closed circle = median; Open circle = mean; Box = interquartile range; Solid line = 90% credible interval

Note: Box plots represent distributions as provided by the experts to the elicitation team. Experts in Group 1 preferred to give conditional distributions and keep their probabilistic judgment about the likelihood of a causal or non-causal relationship separate. Experts in Group 2 preferred to give distributions that incorporate their likelihood that the $PM_{2.5}$ mortality association may be non-causal. Therefore, the expert distributions from these two groups are not directly comparable.

Challenges

- PM EE study not designed to yield "combinable" estimates
  - No test or "seed" questions in protocol
  - No self- or peer-weights
  - Consensus not an objective
  - Allowed for variation in:
    - Shape of C-R function
    - Threshold
    - Treatment of Causal Probability
- Likely significant dependence among expert responses.

Options for Combining Results

- Substantial literature from 80s onward (Genest and Zidek, Clemen and Winkler, Cooke, Jouini and Clemen) but little agreement on whether and how to combine distributions mathematically
- Choices
  - Linear opinion pool
  - Logarithmic opinion pool
  - Cooke's classical method
  - Copula functions

Opinion Pooling

- Linear opinion pool

$$f(\theta) = \sum_{i=1}^{n} w_i f_i(\theta)$$

  - Weighted average of individual distributions using subjective weights (e.g., equal weighting)
  - Useful where other weights are lacking
  - Equal weights potentially appropriate for public policy analysis
  - Can perform as well as more complex methods (Clemen, 1989)
  - Does not account for dependence among experts (may overweight some views)
  - Tends to broaden distributions

Opinion Pooling (cont'd)

- Logarithmic Opinion Pool

$$f(\theta) = k\prod_{i=1}^{n} f_i(\theta)^{w_i}$$

  - Derives a combined distribution by taking a weighted geometric mean of a set of individual distributions
  - Weights can be subjective, including equal weights
  - Not designed to address dependence among experts
  - "Single Expert Veto": any values considered implausible by any one expert are zeroed out in the pooled distribution (O'Hagan et al., 2006)
  - Tends to produce narrower distributions, projecting greater knowledge
  - Rarely used

Other Approaches

- Cooke's method
  - Requires performance measures based on responses to seed questions
- Copula functions
  - First proposed by Jouini and Clemen (1996); Also Hammitt and Shlyakhter, 1999).
  - A copula is "a mathematical function that can be used to represent probabilistic dependence when coupling marginal probability distributions (the experts' judgments) into a multivariate distribution (the joint likelihood of the experts' judgments)." (Hammitt and Shlyakhter, 1999).
  - Flexible; does not restrict the form of the expert distributions
  - Incorporates dependence among experts
  - Can exhibit the single-expert veto

Example Application of Copula Function

- Many copula functions exist. We used same form as Hammitt and Shlyakhter and Jouini and Clemen:

$$f_n(\theta) = kC_{n|\alpha}\,[1 - H_1(\theta), 1 - H_2(\theta), \ldots, 1 - H_n(\theta)]h_1(\theta)h_2(\theta)\ldots h_n(\theta) \quad (1)$$

$$C_{n|\alpha}\,(u_1, u_2, \ldots, u_n) = \log_\alpha \left[1 + \frac{(\alpha^{u_1} - 1)\ldots(\alpha^{u_n} - 1)}{(\alpha - 1)^{n-1}} \right] \quad (2)$$

- Where:
  - $H_i(\theta)$ = expert i's CDF, evaluated at θ
  - $h_i(\theta)$ = expert i's PDF, evaluated at θ
  - α = measure of dependence (0 =complete dependence; 1 = complete independence)
  - n = number of experts
  - k = normalization constant
  - All experts treated as equally dependent or independent

Approach

1. **Derive PDFs/CDFs for C-R coefficients.** Obtain mathematical expression of $h_i(\theta)$ and $H_i(\theta)$ for each expert.
2. **Input PDFs/CDFs into copula.** Evaluate across range of thetas.
3. **Normalize copula.** Set k so area under curve = 1.
4. **Make BenMAP compatible.** Convert function for input into BenMAP.
5. **Repeat for different baseline PM levels**
   - **PM >16 $\mu g/m^3$**
   - **10 <PM $\leq$ 16 $\mu g/m^3$**
   - **7 <PM $\leq$ 10 $\mu g/m^3$**
   - **PM $\leq$ 7 $\mu g/m^3$**
6. **Run BenMAP.** Pool Copula results across baseline PM levels.

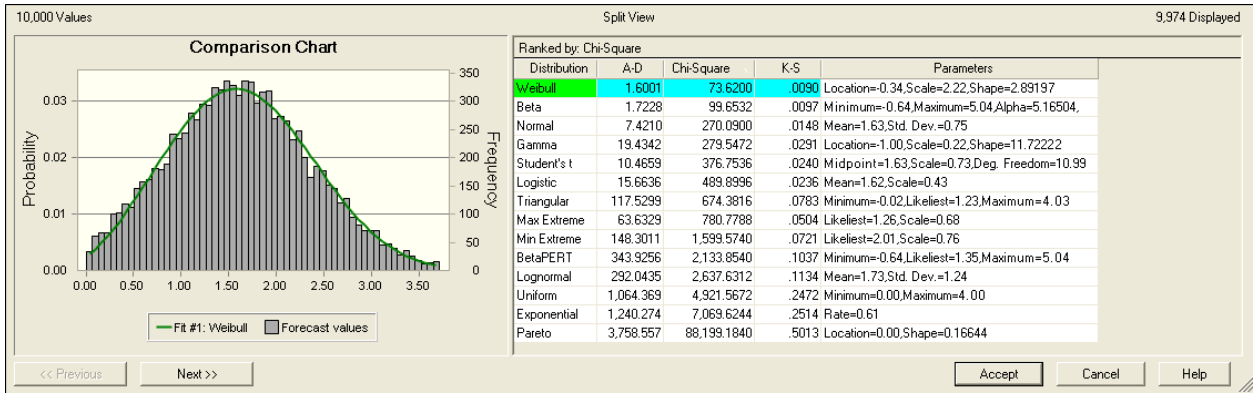
Derivation of PDFs and CDFs

- Challenges
  - Some experts provided fractiles (as requested) of an unspecified distributional form.
  - Even experts who specified parametric distributions modified them in some way.
    - Some are truncated.
    - About half the experts gave distributions conditional on a causal relationship.
    - One expert specified a probabilistic threshold.
- The Good News
  - Re-ran 812 CMAQ core scenario results through BenMAP with no threshold configuration for expert K. *Results differ only minimally from applying threshold.* Can reasonably assume no threshold for this application.

Derivation of PDFs and CDFs (cont'd)

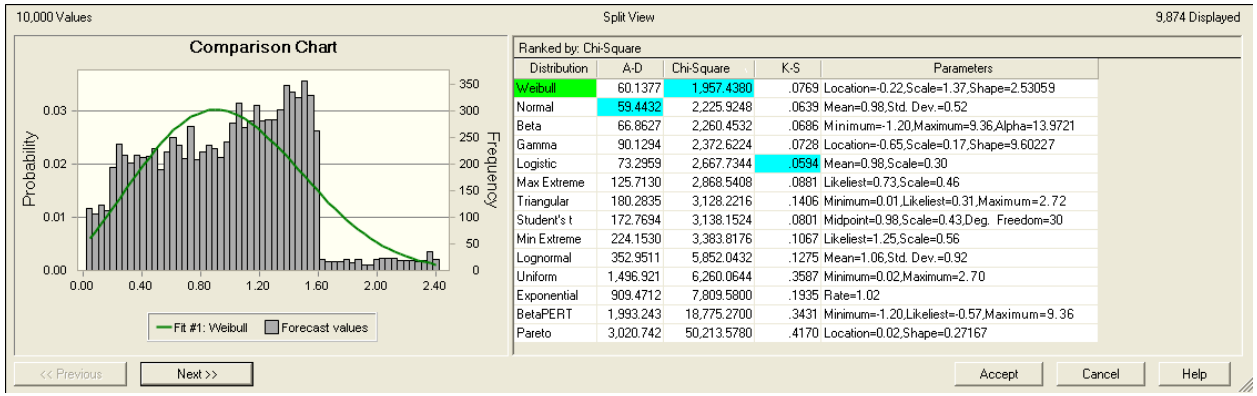
- Used Crystal Ball™ to:
  1. sample from elicited distributions (n = 10,000)
  2. Fit distributions to sample output

A



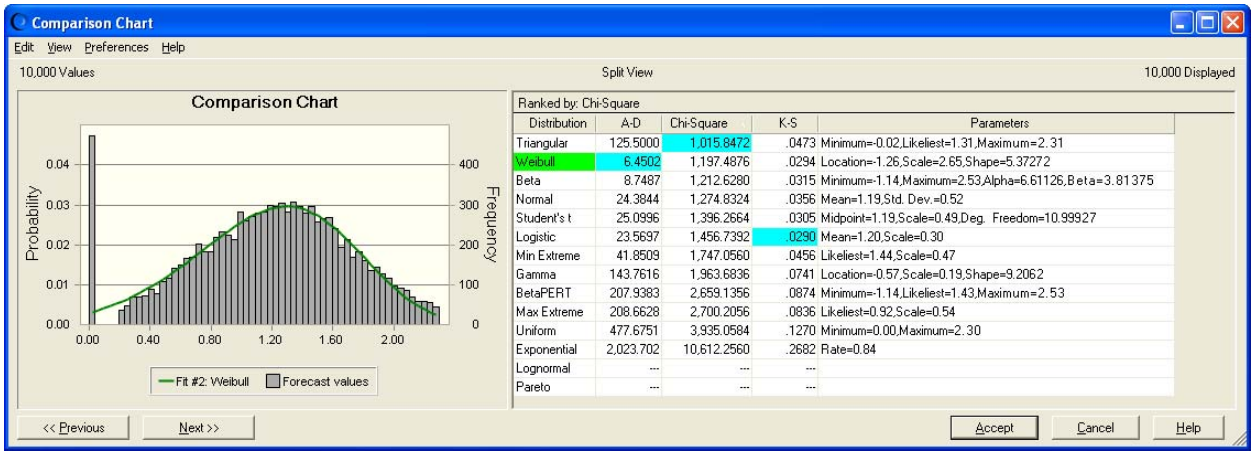
F

(high)



Causality

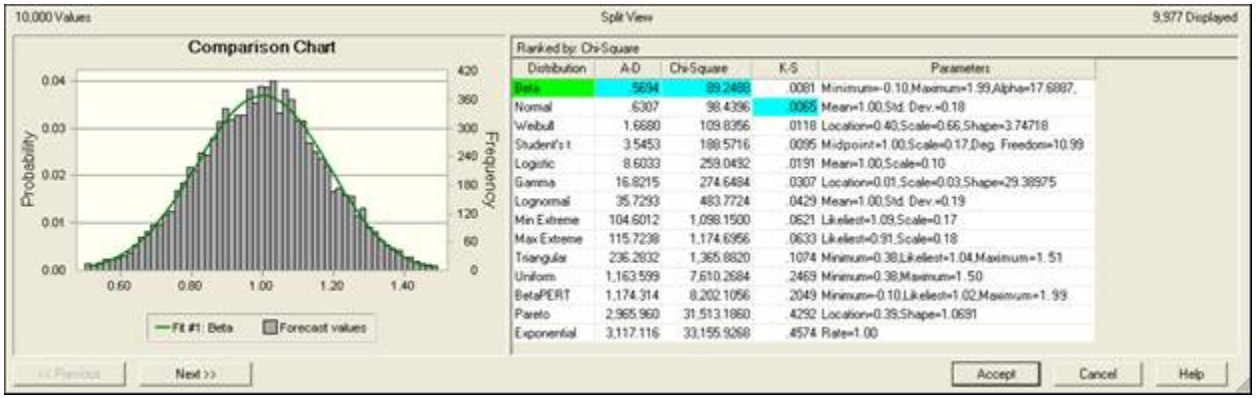
- For conditional distributions, we opted not to incorporate p(causal) before fitting.



- Instead, chose to fit conditional distributions and represent pdf as a combination of a discrete probability at zero and an adjusted pdf for positive values.

Causality Example

- Expert G(Conditional, P(causal) = 0.7); Fit Beta distribution to his conditional sample



- G PDF:
  - If θ = 0, $h_g(\theta)$ based on narrow rectangular slice at zero, such that area = 0.3. Does not overlap rest of pdf.
  - For positive θ within the bounds of the Beta distribution, $h_g(\theta)$ equals 0.7 times the output of the Beta pdf at θ.
- G CDF:
  - If θ = 0, $H_g(\theta) = 0.3$
  - For positive θ within the bounds of the Beta distribution, $H_g(\theta)$ = 0.3 + 0.7 times the output of the Beta cdf at θ.

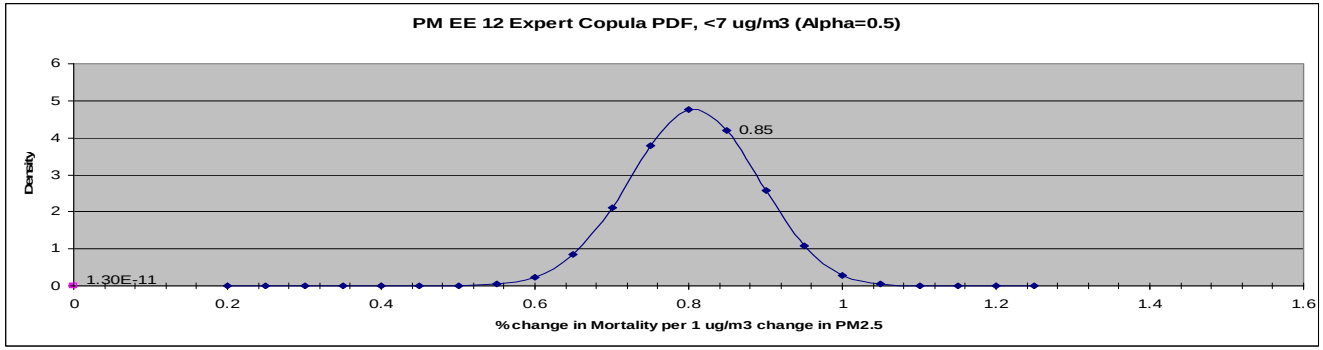
Fitted Expert Distributions

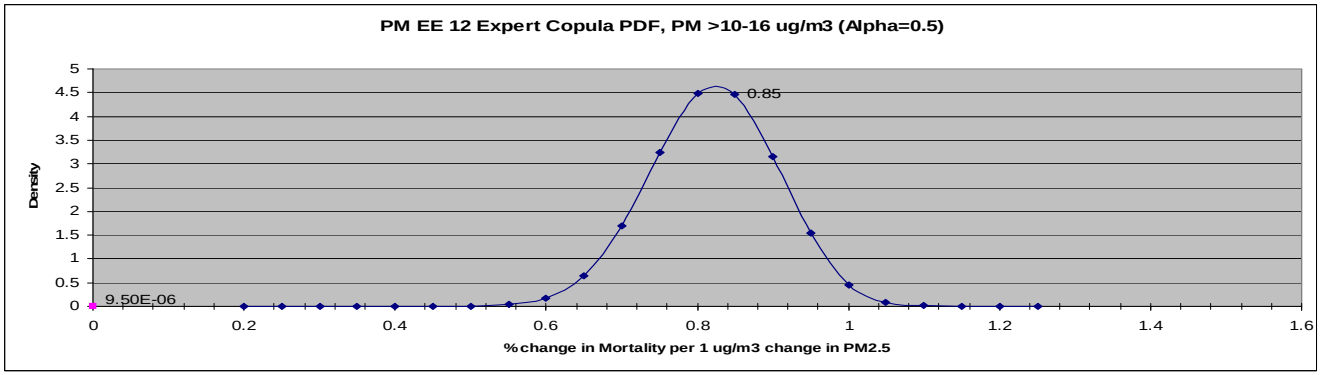
Expert	Distribution	Conditional?	P(θ = 0)	PDF/CDF adjustment
A	Weibull	No	N/A	N/A
B(4-10)	Beta	Yes	0.02	0.98
B(>10-30)	Beta	Yes	0.02	0.98
C	Weibull	No	N/A	N/A
D	Triangular	Yes	0.05	0.95
E	Beta	Yes	0.01	0.99
F(>7-30)	Beta	No	N/A	N/A
F(<7)	Gamma	No	N/A	N/A
G	Beta	Yes	0.3	0.7
H	Beta	No	N/A	N/A
I	Beta	Yes	0.05	0.95
J	Beta	No	N/A	N/A
K(4-16)	Weibull	Yes	0.65	0.35
K(>16-30	Weibull	Yes	0.65	0.35
L(4-10)	Beta	Yes	0.25	0.75
L(<10-30)	Weibull	Yes	0.01	0.99

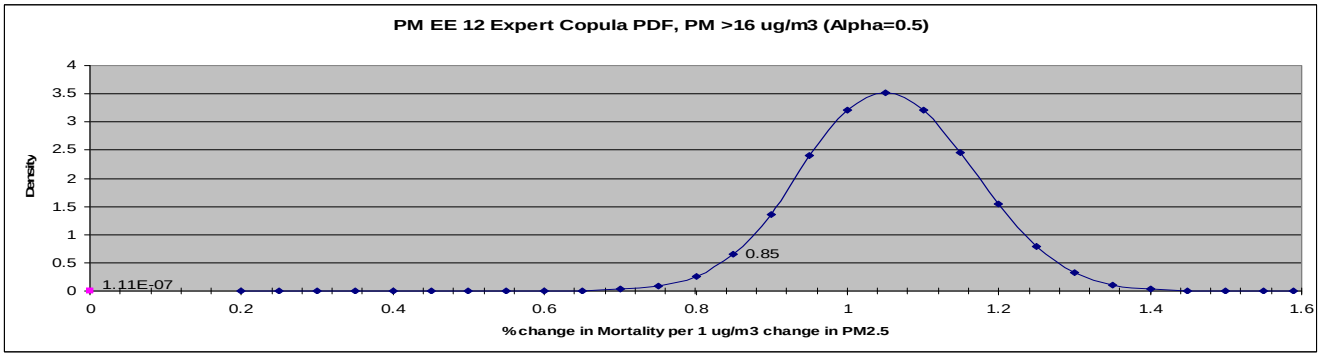
Calculating Fn(θ)

- Developed spreadsheet model to calculate $h_i(\theta)$ and $H_i(\theta)$ for each expert and feed into non-normalized copula function F(θ).
- Identified θ that maximized F(θ)for a given α; used to select range of θs.
- Calculated F(θ) for uniformly spaced range of θs.
- "Integrated" resulting curve using trapezoidal approximation and summing areas of each segment to get AUC.
- Normalized F(θ) by setting k=1/sum of non-normalized AUC.
- Calculated $F_n(\theta)$ for range of θ's. Result is copula PDF.
- Estimated AUC for $F_n(\theta)$; plotted cumulative AUC for copula CDF.

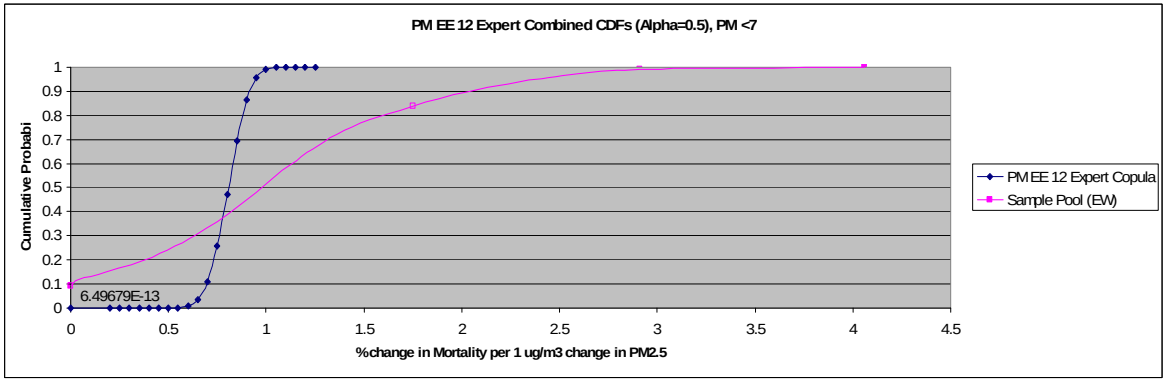
Copula Combined PDFs

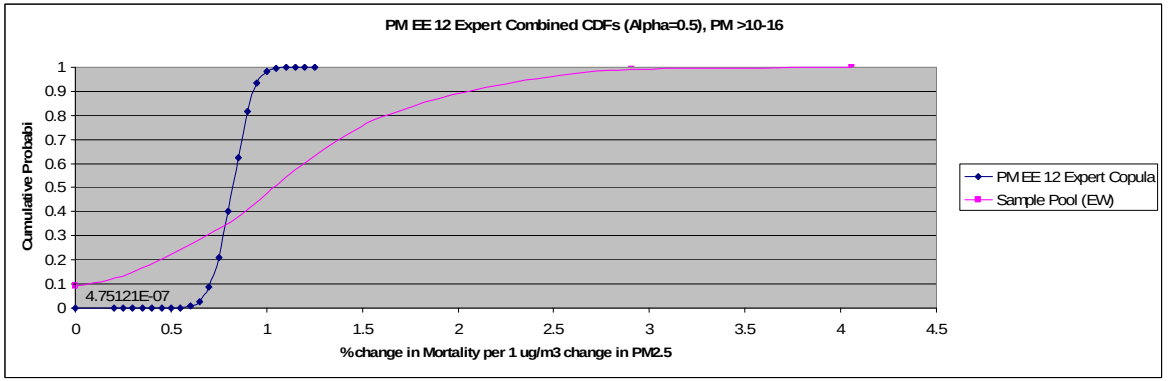


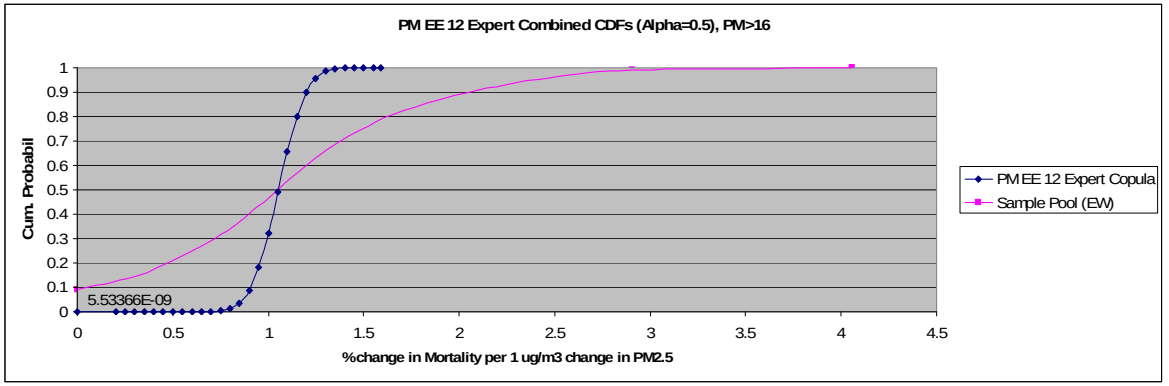




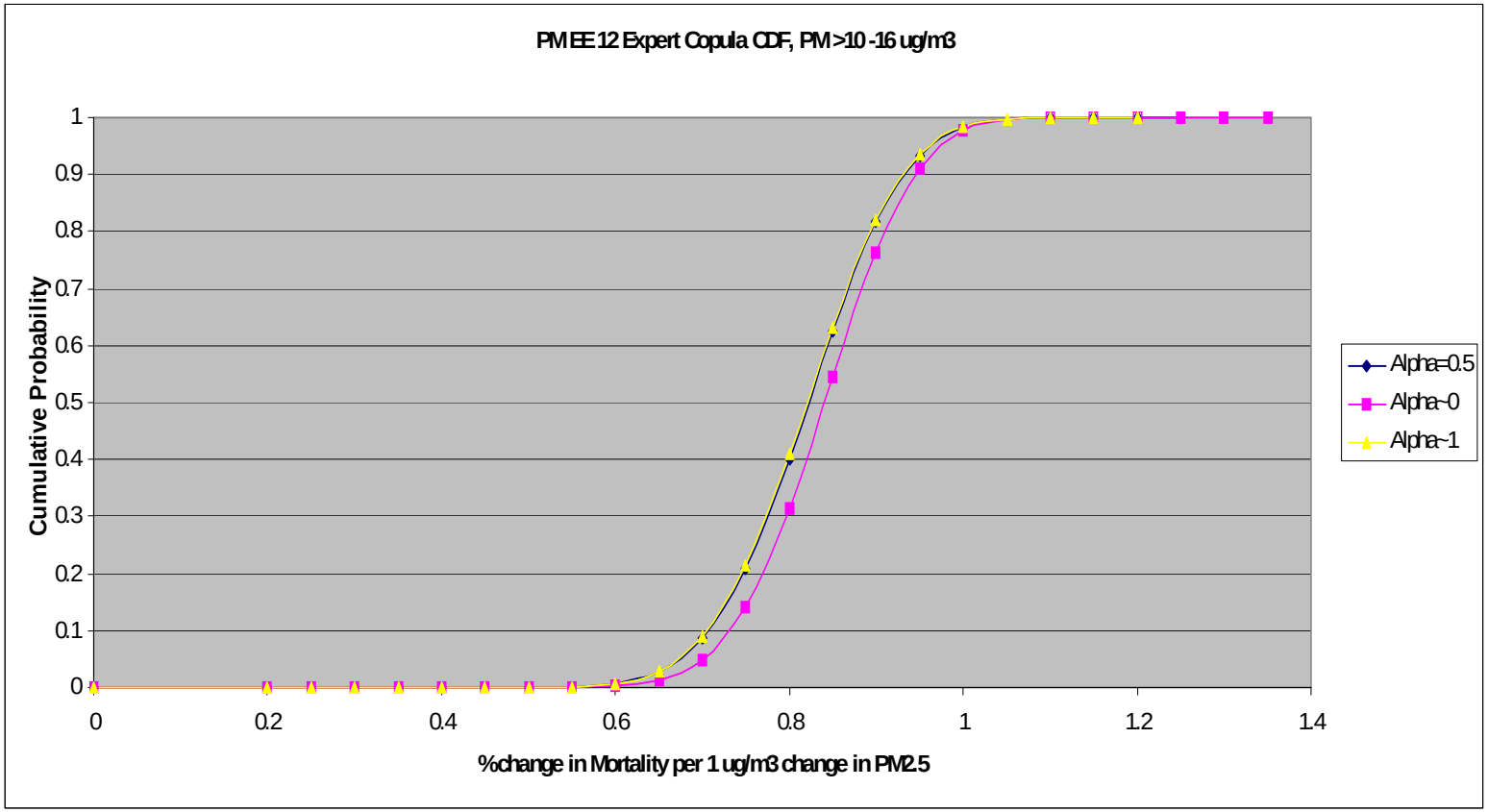
Copula Combined CDFs Compared to Equal Weight (Linear) Pooling







Sensitivity Analysis (alpha)



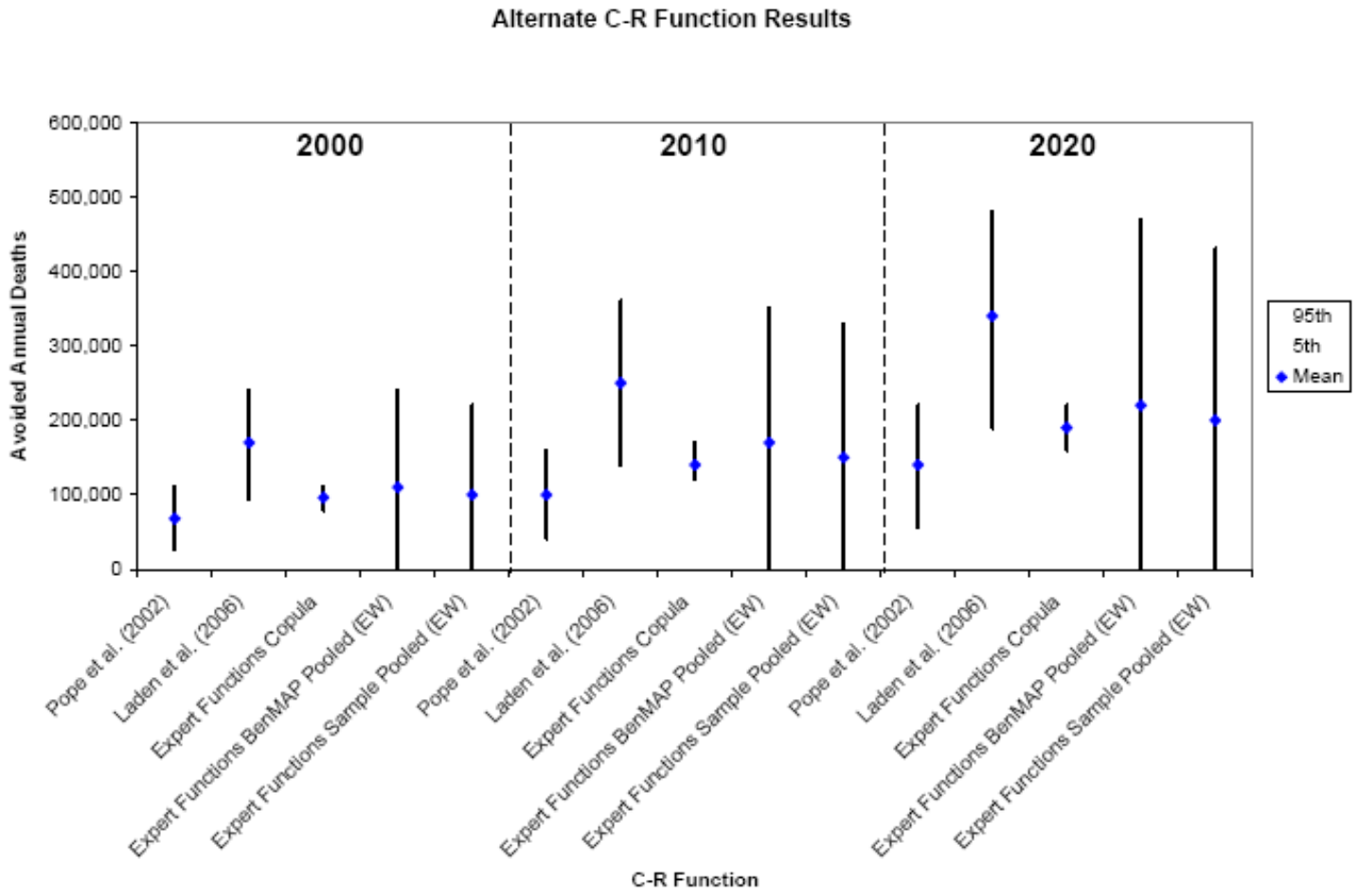
- Results do not appear sensitive to assumptions about dependence.

BenMAP Results

- Copula results for PM C-R coefficient were fed back through Crystal Ball™ to generate a percentile for input into BenMAP.
- Results were pooled across all PM levels in BenMAP.

C-R FUNCTION	2000			2010			2020		
	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95	PERCENTILE 5	MEAN	PERCENTILE 95
Pope et al. (2002)	27,000	68,000	110,000	41,000	100,000	160,000	56,000	140,000	220,000
Laden et al. (2006)	94,000	170,000	240,000	140,000	250,000	360,000	190,000	340,000	480,000
Expert Functions Copula	79,000	96,000	110,000	120,000	140,000	170,000	160,000	190,000	220,000
Expert Functions BenMAP Pooled (EW)	0	110,000	240,000	0	170,000	350,000	0	220,000	470,000
Expert Functions Sample Pooled (EW)	0	100,000	220,000	0	150,000	330,000	0	200,000	430,000

Avoided Mortality Comparison



Summary

- Example Copula application produces central estimate of C-R coefficient consistent with PM EE study results.
- However, produces a dramatically narrower distribution. Different analytical choices may yield alternative results (e.g,. alternative functional forms for the copula, adjustments to tails of distributions to account for potential overconfidence).
- Accounts for dependence, but results evaluated across all 12 experts insensitive to those assumptions. However, some subsets of experts may exhibit greater dependence than the group as a whole.
- Equal weighting dramatically broadens distribution, by comparison
- Seeking guidance on next steps

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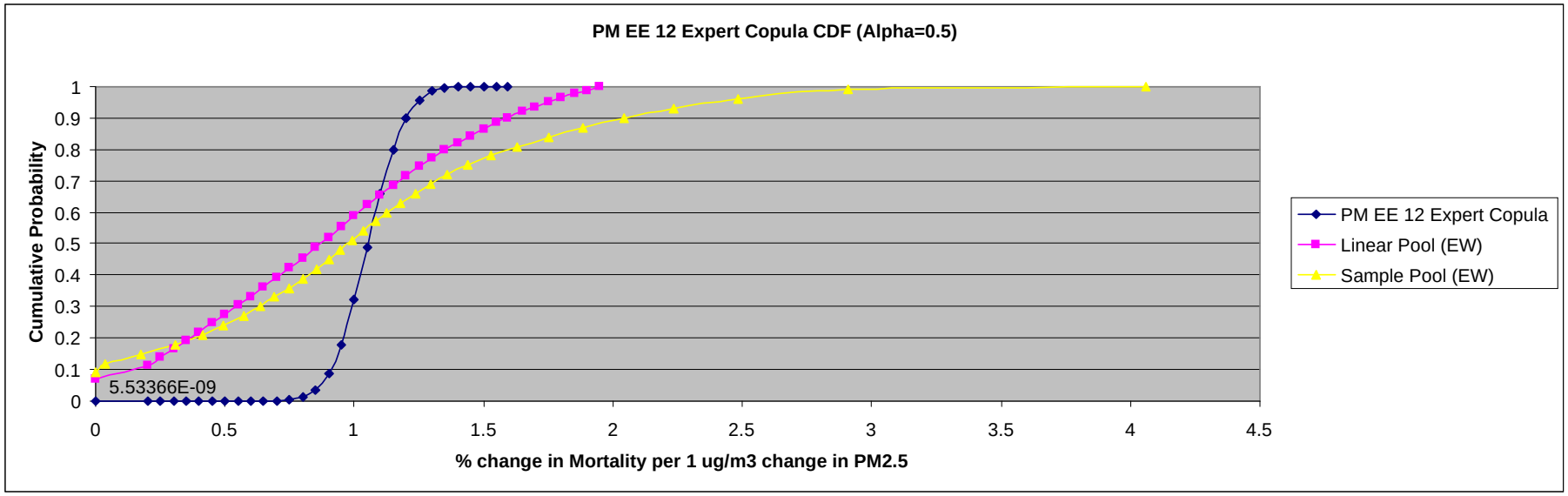
PM EE 12 Expert Copula CDF (Alpha=0.5)
Cumulative Probability
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5.53366E-09
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
% change in Mortality per 1 ug/m3 change in PM2.5
PM EE 12 Expert Copula
Linear Pool (EW)
Sample Pool (EW)

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Overview of Population Simulation Modeling and Results

Presentation to EPA Science Advisory Board 812 Council Health Effects Subcommittee

December 15,2009

Jim Neumann,
Principal

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, MA 02140
617/354-0074

Background and Motivation

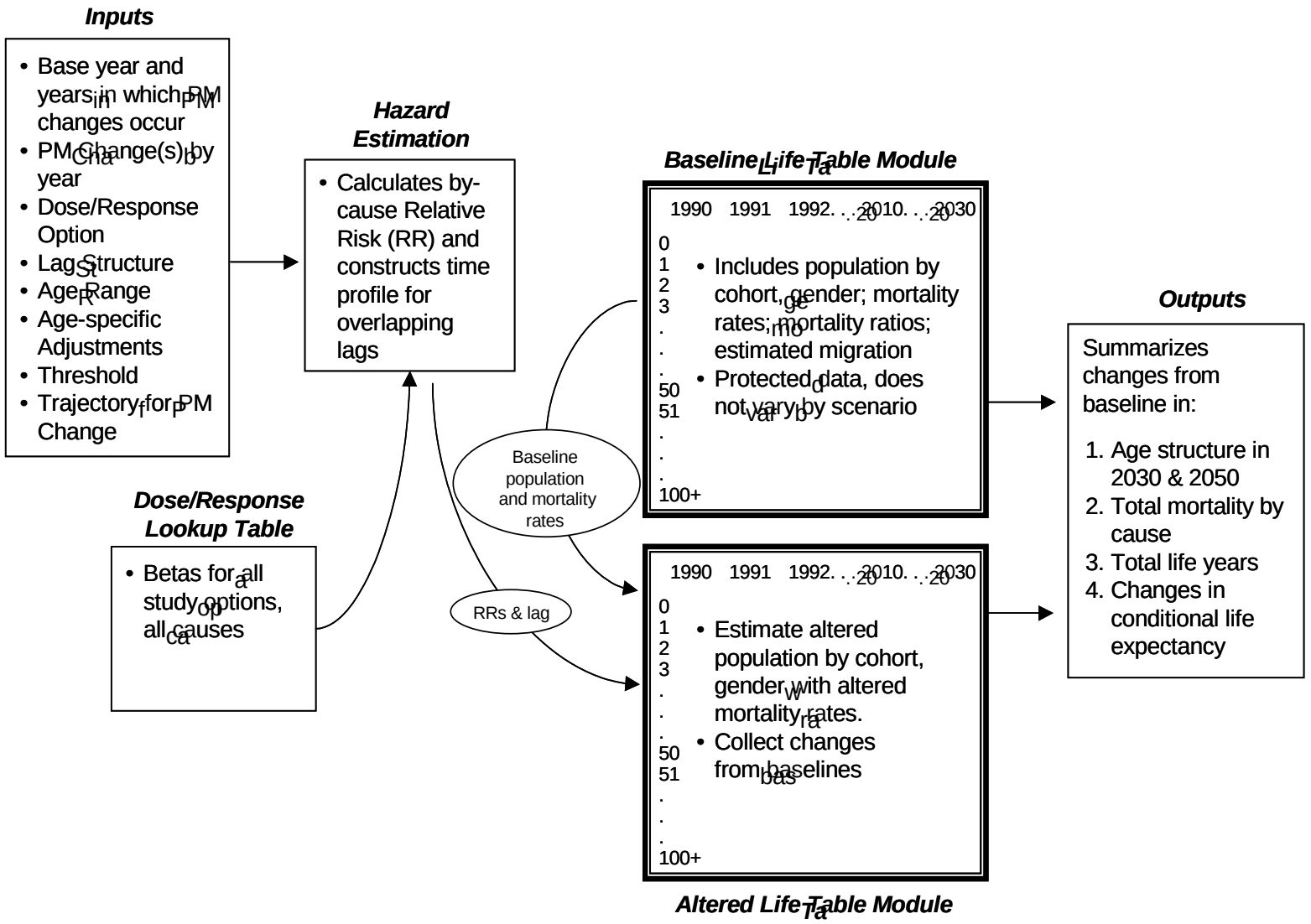
- BenMAP estimates mortality impact over time of a one year change in exposure to air pollution.
- Population basis for BenMAP mortality (and morbidity) estimates incorporates a county-level Census-based forecast, but is static.
- Some observers have asked, "Are we 'saving' the same individual multiple times?"
- Dynamic population simulation incorporates cumulative effect of air pollution hazard on population over time.
- Detailed life-table approach, flexibility in hazard level, concentration-response basis, overlapping cessation lags.
- Does not replace BenMAP, but life-years and life expectancy results complement BenMAP results.

Past SAB Advice

- Excerpt from HES advisory in 2004:

> "The Subcommittee also notes that mortality and morbidity rates may change over time for at least two different reasons: either because of changes in underlying age-specific disease rates or because of changes in the age structure of the population. Therefore, there is a need for the Agency to carefully consider the potential impacts of changing age structure on mortality and morbidity."

Conceptual framework of Popsim model



Key Results

- Age structure by scenario
- Total mortality (all cause deaths by cohort)
- Life-years lost
- Effect of air pollution hazard on period conditional and cohort conditional life expectancy

Estimated Life Years Gained As A Result Of CAAA

AGE COHORT	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045
0 to 4	0	5	74	209	537	636	788	992	1,180	1,308	1,436	1,588
5 to 9	0	0	5	73	208	535	635	786	990	1,178	1,306	1,434
10 to 14	0	0	0	5	73	208	535	634	786	990	1,178	1,305
15 to 19	0	0	0	0	5	73	208	534	633	785	989	1,177
20 to 24	0	0	0	0	0	5	73	207	532	631	783	986
25 to 29	0	0	0	0	0	0	5	73	207	531	629	780
30 to 34	0	296	759	1,248	1,494	1,920	2,165	2,382	2,228	2,360	2,660	2,722
35 to 39	0	570	2,646	4,358	5,677	6,694	8,141	8,961	9,070	8,303	8,478	8,672
40 to 44	0	677	3,847	8,496	10,458	12,437	14,209	16,576	17,445	17,302	15,756	15,910
45 to 49	0	790	4,882	12,362	17,724	20,100	22,562	24,817	27,701	28,468	27,921	25,329
50 to 54	0	922	6,044	15,898	25,954	33,290	35,630	38,125	40,110	43,523	44,044	42,891
55 to 59	0	1,158	7,206	19,890	34,485	49,336	58,902	60,004	61,054	62,295	66,361	66,443
60 to 64	0	1,673	9,026	23,272	44,389	65,605	86,788	98,033	94,901	93,431	93,505	98,375
65 to 69	0	2,520	12,594	28,164	51,534	85,163	115,387	144,165	154,480	144,940	140,056	138,629
70 to 74	0	3,415	17,959	37,078	59,415	93,375	143,030	182,851	217,232	225,959	208,803	199,834
75 to 79	0	3,917	23,165	50,202	72,951	101,435	147,254	213,903	259,913	299,829	306,957	281,588
80 to 84	0	4,218	24,680	60,155	90,034	114,201	147,784	203,774	282,960	334,227	380,073	386,629
85 to 89	0	3,739	22,972	55,562	92,439	122,370	145,677	180,759	239,503	325,735	380,787	431,916
90 to 94	0	2,481	15,562	39,545	67,388	101,559	127,916	147,669	178,136	233,069	316,690	371,797
95 to 99	0	1,041	6,642	17,256	34,015	53,805	78,844	97,987	111,475	134,960	178,484	246,571
100+	0	311	1,788	4,950	11,669	22,832	38,384	59,753	80,526	100,320	127,277	171,954
Total Life Years Gained	0	27,734	159,852	378,724	620,451	885,580	1,174,917	1,482,985	1,781,063	2,060,144	2,304,174	2,496,530

Comparison of Life Years Gained Estimates: BenMAP and Popsim results

AGE COHORT		BENMAP RESULTS		POPULATION SIMULATION MODEL	
START AGE	END AGE	2010	2020	2010	2020
30	34	45,234	59,717	5,267	5,435
35	44	143,633	161,788	51,332	57,714
45	54	248,562	262,899	139,270	146,227
55	64	353,304	478,477	326,448	329,696
65	74	328,485	553,108	660,371	711,835
75	84	297,882	376,579	1,012,853	1,192,017
85	99	134,954	185,015	1,284,263	1,539,837
	Total	1,552,054	2,077,583	3,479,803	3,982,762

Increase In Period Conditional Life Expectancy Attributable To CAAA

AGE COHORT	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045
0	0.00	0.09	0.23	0.33	0.40	0.47	0.53	0.55	0.55	0.55	0.55	0.55
10	0.00	0.09	0.23	0.33	0.40	0.47	0.53	0.55	0.56	0.56	0.55	0.55
20	0.00	0.09	0.23	0.33	0.40	0.47	0.53	0.55	0.56	0.56	0.56	0.55
30	0.00	0.10	0.23	0.33	0.41	0.48	0.54	0.56	0.56	0.56	0.56	0.55
40	0.00	0.09	0.22	0.32	0.39	0.46	0.51	0.54	0.54	0.54	0.54	0.53
50	0.00	0.08	0.21	0.30	0.37	0.43	0.49	0.51	0.51	0.52	0.51	0.51
60	0.00	0.07	0.18	0.27	0.33	0.39	0.44	0.46	0.47	0.47	0.47	0.47
70	0.00	0.06	0.15	0.22	0.27	0.32	0.36	0.38	0.39	0.39	0.39	0.39
80	0.00	0.04	0.11	0.16	0.20	0.24	0.27	0.28	0.29	0.29	0.29	0.29
90	0.00	0.03	0.07	0.10	0.12	0.14	0.15	0.16	0.16	0.16	0.16	0.16
100+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Suggestion for using these results

1. Estimates of deaths are not comparable to those from BenMAP; BenMAP mortality approach better reflects local-scale exposures and data AND is a better technical fit for addressing the key policy questions as currently defined by EPA in the conduct of this type of analysis.

2. Dynamic approach makes a large difference in life-years lost estimates, measuring cumulative effect. Is Popsim approach superior to BenMAP approach for this measure?

3. Life expectancy results provide new, relevant measure that as a technical matter provides an effective supplement to the BenMAP results. EPA has indicated an interest in exploring whether such supplemental results may be useful to a policy-making audience. Does the HES have advice in this regard?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