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AN SAB ADVISORY: THE CLEAN AIR ACT SECTION 812 PROSPECTIVE STUDY HEALTH AND ECOLOGICAL INITIAL STUDIES

PREPARED BY THE HEALTH AND ECOLOGICAL EFFECTS SUBCOMMITTEE (HEES) OF THE ADVISORY COUNCIL ON CLEAN AIR COMPLIANCE ANALYSIS

February 10, 1999

EPA-SAB-COUNCIL-ADV-99-005

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Dear Ms. Browner:

Subject: An SAB Advisory on the Health and Ecological Effects Initial Studies of the Section 812 Prospective Study: Report to Congress

The Health and Ecological Effects Subcommittee (HEES) of the Science Advisory Board's (SAB) Advisory Council on Clean Air Compliance Analysis ("the Council") met on January 29-30, 1998 in Washington DC. The Subcommittee reviewed draft materials and received briefings from EPA staff and consultants concerning the development of the first Section 812 Prospective Study. This study, and the SAB review were mandated by the Clean Air Act Amendments of 1990 (CAAA-90). Initial planning for the meeting centered on a three-element charge (see report Section 2.2). The Subcommittee and EPA addressed a series of issues raised during the public meeting. These issues, in brief, were: a) developing a scientifically sound framework for ecological effects valuation; b) economic disaggregation issues; c) air toxics design; d) benefit issues in health valuations; e) economic valuation; f) treatment of uncertainties; g) transboundary effects; and h) other criteria pollutant issues and global issues.

The enclosed advisory is the product of that meeting, and summarizes the HEES' advice to EPA regarding the prospective study design, implementation and future planning. Our detailed comments are included in the report and focus on major recommendations that will assist in achieving appropriate linkages to the economic valuation of the benefits and costs.

Overall, the HEES concludes that the prospective study team had not yet developed a framework for scientifically sound ecological evaluations, nor have they adequately considered the lessons learned from prior EPA studies, such as SAB's 1990 study, *Reducing Risks*. The Agency needs to develop a specific, comprehensive methodology for valuing natural resources and ecological services that incorporates contemporary ecological thinking and findings. It is important that this framework be made explicit and clear to the user in the very near future to support not only the correct tasks, but also decisions for future prospective studies, particularly

with respect to level of detailed service flows, boundary conditions between different ecosystems, and valuation approaches. These approaches also should be coordinated with other Agency efforts, to ensure Agency-wide consistency in assessments. Further, the HEES encourages the Agency to explore valuations at the watershed scale or larger. This approach will assist in avoiding double-counting of pollutant effects and interactions among pollutants, and it will help capture the spirit of viewing ecosystems as functioning "within a framework," rather than "just a sum of the parts." The Subcommittee provided guidelines and proposed a framework for evaluating ecological effects, and provided advice on a number of specific technical issues, such as: a) fish catch relative to population size; b) the interaction between air toxics and acidification; c) lag times in terrestrial and aquatic ecosystems; d) nitrogen saturation in terrestrial ecosystems; e) ozone effects on timber; f) evaluation of simpler estuary models; and g) justification for the target-estuaries approach.

The issue of disaggregation of costs and benefits by pollutant or source categories was discussed in development of the Retrospective Study: Report to Congress (SAB, 1996), and is again highlighted here as a major deficiency as the Agency moves toward development of the Prospective Study: Report to Congress. The proposed effort, as presented to the HEES, needs further development for the selection of scenarios which should reflect realistic conditions for emission reductions. The HEES believes that it would be far more constructive to disaggregate the costs and benefits of existing titles and regulations imposed by the CAAA-90 and that every effort should be made to move toward disaggregation in the prospective studies. This was anticipated by the original intent of evaluating the costs and benefits for industrial sectors by title. We recognize disaggregation by CAAA-90 title is a complex process, but it is important to start developing strategies to address this issue.

With regard to air toxics, the HEES recognizes that the Agency staff cannot realistically evaluate any large fraction of the 189 Hazardous Air Pollutants (HAPS), and that there is no established framework for selecting a relatively small subset of these that are most likely to have the greatest impact. The HEES recommends that the Agency staff focus on selecting the handful of toxic chemicals that may pose the highest risk, and offers a procedure for screening carcinogens among the list of 189 HAPS in order to identify candidate pollutants warranting more in-depth analysis.

Regarding Particulate Matter (PM) mortality response functions, the HEES recommends against using short-term daily mortality studies as an alternative to the cohort studies to derive concentration-response (C-R) functions. Further, the HEES recommends that other cross-sectional epidemiological studies be considered in deriving C-R mortality estimates to be consistent with the retrospective study. The HEES recommends that there should be a more detailed explanation of the approach taken, an explicit acknowledgment of the caveats about PM/mortality causality relationship, and an examination of the sensitivity of the benefits analysis to the C-R uncertainty. In the materials presented to the HEES in the public meetings, the Agency paid only limited attention to uncertainties. However, it is not sufficient to just list

uncertainties. They must be justified by the Agency; furthermore, this issue of the uncertainty of the estimates should be considered for all sections of the Prospective Study.

Our current level of understanding of the relationship between PM and infant mortality does not warrant inclusion of these effects in the Prospective Study. If additional peer-reviewed published reports on PM-related infant mortality are available when the Prospective Study: Report to Congress is being prepared, the HEES recommends that they be evaluated prior to inclusion of PM-related infant mortality in the analysis. With regard to mortality time lags, the HEES agrees with the Agency that current studies on animal mortality do not have an implied time lag, and the inclusion of pollutant-related time lags in mortality at this time is premature.

We appreciate the diligence of the prospective study team on this difficult and timely assessment. We look forward to your response, particularly to the main points outlined in this advisory, and to continued interaction with your professional staff.

Sincerely,

Dr. Maureen L. Cropper, Chair
Advisory Council on Clean Air Compliance Analysis

Dr. Paul Lioy, Chair
Health and Ecological Effects Subcommittee
Advisory Council on Clean Air Compliance Analysis

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ABSTRACT

The Health and Ecological Effects Subcommittee (HEES) of the Advisory Council on Clean Air Compliance Analysis (Council), of the Science Advisory Board, has reviewed precursors to the first Prospective Study: Report to Congress. The HEES concludes that the approach to the health/ecological effects assessment lacks a framework for ecological evaluations. The Agency should develop a comprehensive methodology for valuing natural resources and ecological services, incorporating contemporary ecological thinking and findings. This framework must be made explicit and clear to the user. The HEES encourages the Agency to explore valuations at the watershed level or larger (or other scales of concern) to avoid double-counting of pollutant effects and interactions among pollutants.

The absence of disaggregation of costs and benefits by pollutant or source category was highlighted as a deficiency. The Agency should progress toward disaggregation in the Prospective Studies, in order to evaluate the various parts of the 1990 Clean Air Act Amendments (CAAA-90) (e.g.,industrial sectors by title).

The HEES has provided guidelines and a proposed framework for evaluating ecological effects, provided advice on air toxics, and recommended a procedure for selecting toxic chemicals that might yield quantifiable risks, as well as a procedure for screening the list of 189 hazardous air pollutants (HAPS) for identifying candidate pollutants warranting more in-depth analysis. The HEES has also provided advice on a number of specific technical issues, including particulate matter (PM) mortality response functions and has recommended that PM-related infant mortality data not be included in the current analyses, and that the use of time lags to adjust for downward trends is premature.

Key Words: Clean Air Act, Air Quality Models, Emissions Estimates, Prospective Study

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FIGURE 1. 5

1. EXECUTIVE SUMMARY

Of the issues that the HEES considered necessary for incorporation into the first Prospective Study: Report to Congress and those topics on which we were asked to provide comments by EPA staff, the following were considered to be of the highest priority for resolution:

a) A framework for ecological analyses has not yet been developed for the prospective study. It is not apparent that EPA staff have adequately considered the lessons learned from prior EPA studies, such as Reducing Risks (SAB 1990), wherein ecological issues gained prominence. The Agency needs to develop a position statement on 1) a general framework for ecological valuation and 2) a set of detailed service flows that can be prioritized to commercial/human or general ecological endpoints. Clearly at this point in time the Agency has not achieved the specific charges identified by the HEES.

   Before completing their analyses, however, EPA staff must begin documenting the overall outline for the study, including a decision that justifies selections of ecological endpoints. It is important that this framework be made explicit and clear to the user in the very near future to support not only the current tasks, but also decisions for future prospective studies. It will be necessary to establish the start points and end points for the analyses, the valuation approaches used in the current prospective study, and the degree of significance of each valuation within the constellation of all feasible endpoints, ecological and health, that can be used in the benefit and cost analysis.

b) The issue of disaggregation of costs and benefits was highlighted as a major deficiency in the Retrospective Study: Report to Congress and was not adequately addressed during the review. The proposed effort for development of the first Prospective Study: Report to Congress needs major revisions and further development to select realistic scenarios. In contrast to the hypothetical cases presented, however, they must reflect realistic conditions that establish estimates of potential benefits gained through specific regulations or titles in the CAAA-90.

c) The Air Toxics databases and variables available to complete a benefit and cost analys**es** are inadequate for the task of evaluating all 189 air toxics. A set of criteria must be utilized that can reduce the number of air toxics considered for a national analysis. This approach should focus on selecting those toxic chemicals that might yield a quantifiable risk.

Other issues discussed in the first Prospective Study: Report to Congress should be addressed by EPA staff, including HEES' responses to specific questions or problems raised by the Agency for clarification, or HEES' recommendation of alternative approaches for valuation of

health or ecological endpoints. These will be necessary to achieve a series of defensible variables for linkage to the economic valuation of the benefits and costs. For instance, the HEES recommends that particulate matter (PM)-related infant mortality data not be included in the current analyses, and that the use of time lags to adjust for downward trends is premature.

2. INTRODUCTION AND CHARGE

2.1 Background

At the January 29 and 30, 1998 public meeting, staff of the U.S. Environmental Protection Agency's (EPA's) Office of Air and Radiation (OAR), Office of Policy Analysis and Review (OPAR), and Office of Planning and Evaluation (OPE), the Office of Economy and Environment (OEE) staff provided the HEES Members and Consultants (M/C) with a detailed briefing on the approaches used and/or being considered to complete the first Prospective Study: Report to Congress of the benefits and costs of the 1990 Clean Air Act Amendments (CAAA-90). OAR and OPE staff presented a series of briefings providing an outline and examples of potential analyses for health and ecological valuations. This public meeting was one of three held to comprehensively review the initial studies leading to development of the Agency's first draft Prospective Study: Report to Congress, which will follow this effort. The Air Quality Models Subcommittee (AQMS) had met on January 22 and 23, 1998, and the Council met on February 5 and 6, 1998.

2.2 Charge

Initial planning for the meeting centered on a three-element charge:

a) Are the input data and variables used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

c) If the answers to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the first Prospective Analysis?

The Subcommittee addressed a series of issues during the public meeting. These issues, in brief, were: a) Developing a framework for ecological effects valuation; b) Economic disaggregation Issues; c) Air Toxics design; d) Benefit Issues in health valuations; e) Economic Valuation - linkage to: 1) Human health, and 2) Ecology; f) Treatment of uncertainties; g)Transboundary Effects; and h) Other Criteria Pollutant Issues & Global Issues.

3. SPECIFIC FINDINGS

3.1 Ecological Effects Valuation

As a discipline, ecology provides an understanding of the structure and function of terrestrial and aquatic systems, with an emphasis on the linkages between the abiotic components (e.g., atmosphere, soil, surface waters) and the assemblages of living organisms, including humans. The appropriate context for this understanding is a systems approach rather than one that disaggregates the whole into a few select and isolated processes. Any framework intended to value the economic implications of changes in these linkages must not only recognize, but embrace, this holistic and scientifically defensible systems approach (see Figure 1 for an example addressing forest systems) in order for the analysis to capture the true costs and benefits of (in this application) reducing air pollution.

As presented to the HEES, the current EPA approach is, unfortunately, dated by at least a decade, and is very limited in scope, to the point that it can be considered to be reductionist. Applying this reductionist approach, the investigators have chosen (as the basis for quantifying ecological effects) several important monetizable, human-oriented (anthropocentric) benefits from controlling air pollution and have incorporated them into the analysis -- specifically, forest growth and commercial and recreational fishing. We encourage the Agency to explore valuations at the watershed and landscape scale or larger and to examine a wider range of ecosystem services (see text below, as well as Daily (1997); Daily *et al*. (1997); and Costanza *et al*.[2] (1996 and 1997). Although appropriate analytical methods may not be yet available, this type of approach will help avoid double-counting of pollutant effects and interactions among pollutants; and it will help capture the spirit of viewing ecosystems as functioning "within a framework " rather than just "a sum of the parts."

Several issues are critical in this recasting of the ecological framework. First and foremost, EPA needs to develop a specific, comprehensive methodology for valuing natural resources and ecological services that incorporates contemporary ecological thinking and findings. Relevant references include Daily (1997), Freeman (1997), and Goulder and Kennedy (1997). The framework needs to provide a basis for examining the complexity and interactions among biotic and abiotic components, the dynamics of testing cause-and-effect relationships, and an appreciation of the concept of sustainability, which links the well-being of ecosystems to the well-being of humankind. The framework must also recognize the intrinsic value of ecosystems.

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[2] It should be noted that the Costanza *et al.* studies did not include any new analyses at the watershed or landscape level. Rather, they relied on existing studies at these scales, used a variety of assumptions to extrapolate them to a global level, and summed the extrapolated values. Some economists have expressed important questions about their interpretation and use of some of the data they draw on, the methods for extrapolation, and the usefulness of the summing exercise. Also, they do not avoid double-counting in their calculations. Despite the concerns, Costanza *et al.* demonstrated an important approach to treating such services flows as ecosystem processes. (Figure after Freeman, 1998)

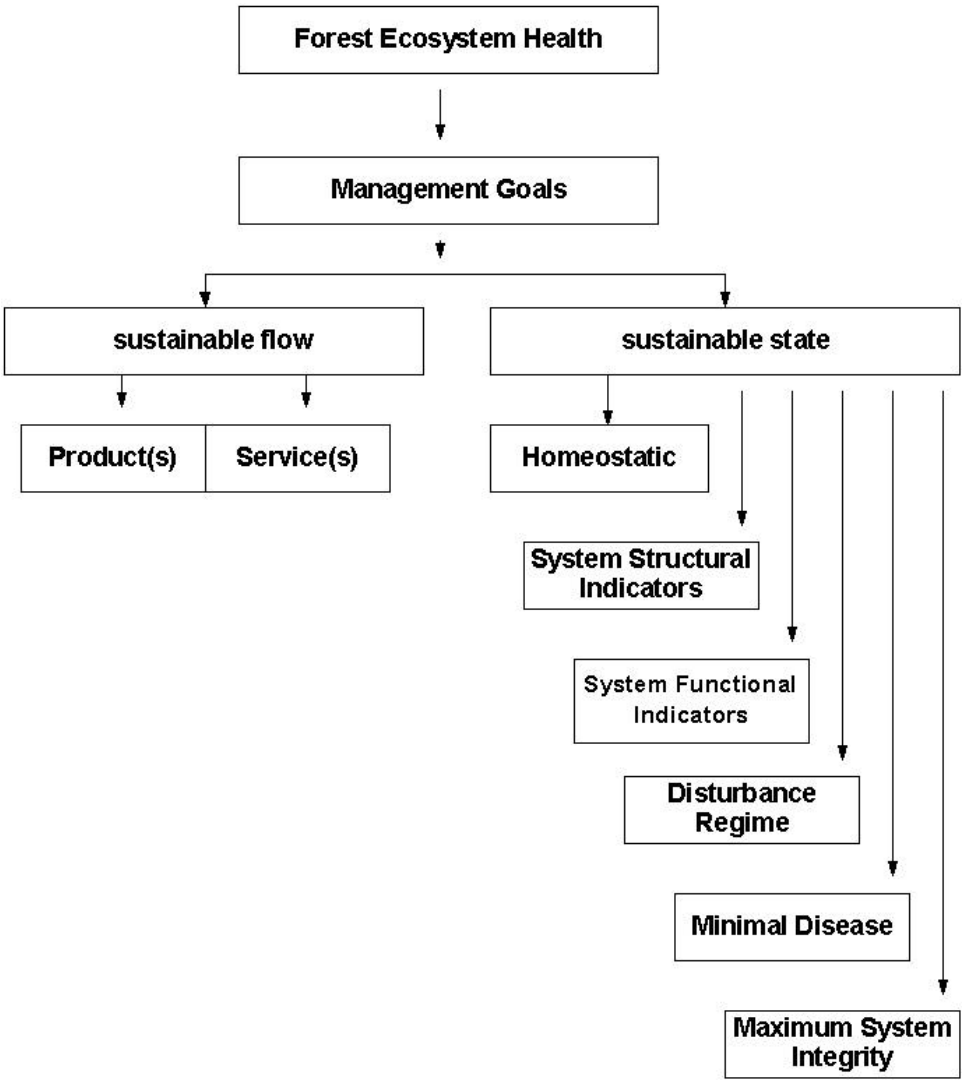

Figure 1: Two world views of forest system health. The "sustainable flow" view has an anthropocentric focus and measures "health" as the ability of forest systems to provide a sustained flow of forest products and/or forest services to human societies. The "sustainable state" view has a biocentric focus and measures "health" as the ability of forest systems to sustain a certain state as defined by one or more of the following metrics: homeostasis; system structural indicators (food web, successional pattern); system functional pattern (nutrient cycling, energy storage); natural disturbance pattern (fire, wind); minimal disease (minimal abnormal physiology as revealed in signs (symptoms)); maximum system integrity (maximum similarity to minimally human disturbed reference system) (W. Smith, personal communication, 1998).

The Subcommittee proposes the following guidelines for developing a framework for evaluating ecological effects:

a) For each major type of ecosystem, identify the major stressors originating from air emissions subject to control under the CAAA-90. Major types of ecosystems considered might include forests subject to commercial harvest; other forest ecosystems; grasslands; managed agriculture; freshwater aquatic systems; marine systems; and wetlands.

b) For each ecosystem type and stressor, identify the possible impacts on such things as community structure, species richness, net primary productivity, other major ecosystem functions, and the flows of ecosystem services to people. This could provide a basis for identifying those impacts for which quantification might be possible.

c) Note that not all ecosystem changes are necessarily adverse. Consider criteria for identifying adverse changes. The criterion that emerges from economics focuses on changes that result in reductions in service flows to people. Which of the stressors and changes identified above are likely to lead to the largest reductions in valued service flows? The answers to this question can be used to: 1) select service flows for valuation; and 2) identify research priorities.

The recasting of the framework for ecology warrants a high priority. Thus, we recommend a) that the description of possible ecological effects should not be limited to those effects for which estimates of monetary value are already available in the literature; and b) an ecologist be more prominently incorporated into the ecological valuation analytical team.

The Agency should also expand its literature review of ecological effects to include the recent flurry of activity related to wetlands. For example, there were no references to the journal *Wetlands* in the EPA's documentation. Furthermore, there were no references to the annual review issue of the journal *Environmental Toxicology and Chemistry*, devoted to wetland ecotoxicology and chemistry. The Agency is directed particularly to the articles related to mercury (Zillioux *et al.*, 1993),on contaminant modeling (Dixon and Florian, 1993), and addressing risk assessment (Pascoe, 1993). Other articles provide good overviews of wetland processes (Rybczyk *et al.*, 1996). The journal *Wetland Biogeochemistry* might also be of interest, especially a review article on wetland mercury research (Rood, 1996).

Finally, we have serious concerns about the following specific technical issues:

a) The EPA staff should recognize that errors in one of the underlying assumptions for the logistic function relating relative catch to relative fish population size in Kahn and Kemp (1985) may vitiate the resultant estimate.[3]

b) The analysis does not incorporate the interaction between air toxics and acidification, which is especially important for bioavailability of metals in aquatic systems.

c) The EPA staff should qualitatively discuss lag times in terrestrial and aquatic systems. For example, even the CO_2 temporarily sequestered in deep ocean waters eventually will reach the ocean surface and either diffuse back into the atmosphere or decrease the amount of CO_2 that can be sequestered for decades or even for centuries.

d) Nitrogen saturation is discussed in terms of aquatic systems (largely in terms of eutrophication). Although the last ten years have seen the development of significant knowledge about nitrogen and nitrogen saturation in terrestrial ecosystems (e.g., Vitousek *et al.*, 1997), the report does not mention terrestrial nitrogen input. In addition, the draft report ignores the measurable and quantifiable effects occurring when nitrogen is well below the saturation level. The HEES recommends that the Agency recognize that nitrogen saturation is at the far end of a continuum of ecological responses, and that the entire continuum needs to be investigated and documented.

e) The deSteiguer study (1990) provides the basis for estimating the service flow from native or human-dominated ecosystems for ozone effects on timber. This study, however, is grounded on "expert opinion." The Subcommittee finds this approach, in lieu of the multi-investigator based data sets incorporating experimentally-derived exposure/response functions recently published, not acceptable. We recommend that the Agency drop its reliance on the deSteiguer study, replacing it with a peer-reviewed data base that can be scaled from seedlings to mature trees.

f) Given the complexity of anthropogenic nitrogen inputs to the Chesapeake Bay, we question why this approach was used as the basis for determining the effects of nitrogen deposition on an estuary. We recommend that the Agency staff evaluate simpler estuary models. Also, the target-estuaries approach ought to be justified in

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[3] The Committee believes that most population biologists would disagree with Equation 2 (and the paragraph preceding it) in Kahn and Kemp (1985). We recommend that the Project Team not adopt Equation 2 in Kahn and Kemp (1985) and, instead, they retain the more traditional form of the density-dependent response shown in Figure 1 of the same paper. The parabola in Figure 1 (not a truncated parabola as in Fig. 5) already accounts for compensatory mortality -- otherwise, the C vs. F plot would be a positively-sloped straight line through the origin.

the prospective study, because any attempt to extrapolate benefits or costs from those non-randomly selected estuaries to all of the estuaries in the U.S. will be suspect.

3.2 Benefits Issues

Specific findings on the relevant issues follow below:

a) Choice of Agricultural Model for Commodity Crops: If resources are available, we recommend that a simple comparative analysis of the two proposed models should be considered: the Agricultural Simulation (AGSIM) model and the Regional Model Farm (RMF) model[4]. Based on that comparison, the Agency could select the model that is most robust in its treatment of agricultural commodities and ozone.

b) Non-commodity Crops: We endorse inclusion of non-commodity crops in California and an expansion to the national scale.

c) Choice of Ozone Averaging Time for Agriculture: We endorse the selection of the SUM06 (the sum of the 6-peak daylight hour concentrations over the growing season) statistic as described by Lefohn *et al*. (1988; 1992).

d) Method of Calculating Ozone Exposure Levels for Agricultural Analysis: We endorse the grid-pattern interpolation method as proposed for assessing the effects of ozone on human health.

e) Ecological Effects of NO_x Deposition: The Agency proposes to assess the effects of reducing NO_x deposition on aquatic ecosystems, fish stocks, and commercial fisheries harvests. There is evidence to suggest that the benefits of improved recreational fishing for some of these species will be at least as large as, and perhaps substantially larger than, those for commercial harvests of these same species. We recommend that the Agency attempt to estimate the effect of increases in fish stocks on recreational angling success and on the economic value of recreational angling.

3.3 Disaggregation

A major shortcoming of the Retrospective Study: Report to Congress was the inability to disaggregate the costs and benefits by the Clean Air Act (CAA) title or by industry sector. Such a

[4] The AGSIM model is an econometric, rather than a mathematical programming model. As a result, it has the potential for better representation of the impacts of small changes in ozone.

disaggregated analysis would provide valuable information on the cost-effectiveness of various parts of the CAA and or controls that target specific industry sectors.

In the present prospective study effort, the Agency acknowledges that such disaggregation will not be perfect because of non-linearities and uncertainties in linking emissions and concentrations. Nevertheless, it is necessary to begin this type of analysis in the present prospective analyses, at least at the industry sector-level. Future prospective studies can be used to refine these estimates.

The Agency identified a key decision, which needs to made now -- whether they should attempt a crude allocation/attribution to derive disaggregated results, or to focus on identifying marginal benefits and costs of discrete increments of additional controls using a limited number of supplemental scenario runs (e.g., analyze the effects of having an additional (speculated) 50% reduction in utility SO_2 emissions). Although the examination of such hypothetical future scenarios is an interesting exercise, the HEES believes that it would be far more constructive to disaggregate the costs and benefits on the basis of the existing titles and regulations imposed by the CAAA of 1990. Further, knowing that benefits exceed costs is only one condition for optimality. The Agency should also estimate the marginal benefits and costs to examine whether the mandated levels of control are approximately correct.[5]

3.4 Toxic Air Pollutants in the Section 812 Prospective Analyses

A major challenge to EPA staff in dealing with the characterization of benefits of emission controls on hazardous air pollutants (HAPS) arises from two major factors:

a) The available modeling approaches and data resources used in the retrospective phase of the CAAA Section 812 led to grossly unrealistic over-estimates of risk for vinyl chloride and asbestos, as well as negligible risks for the other pollutants addressed by the National Emission Standards for Hazardous Air Pollutants (NESHAPS).

b) The prospective analyses must deal with 189 HAPS. The HEES believes that the Agency staff cannot realistically evaluate any large fraction of these, and there is no established approach for selecting a relatively small subset of toxic air pollutants that are likely to have the greatest impact.[6]

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5 Note, however, the Council believed that, although disaggrregation of results by Title would be useful, an alternative approach would be to examine the incremental costs and benefits of extending provisions of the 1990 CAAA.

6 It has been suggested that the calculations used to regulate HAPS need to be adequate for sensible regulation and to provide information on the benefits of abatement. There are three categories of HAPS: a) short-lived which cause a risk only while airborne, b) sufficiently long-lived to enter surface water or become re-intrained (e.g., lead), and c) sufficiently long-lived to become bio-concentrated (e.g., mercury). These three categories need to be modeled very differently. The first category is relatively easy to model and probably the most important group. A simple box model is probably sufficient. For these pollutants, the relative toxicity can be multiplied by its emission, corrected for the number of people with non-trivial exposures. The second category has to deal with the surface-water pathway, to the extent to which these waters are ingested in a condition

One major reason for the exaggeration of the risks of vinyl chloride and asbestos was the reliance on unit risk factors as a basis for the expected number of cases for the estimated level of exposure. It must be recognized that unit risk factors, as well as reference concentrations, were developed to serve a specific purpose -- to be conservative for achieving health protection rather than to be used as a predictive tool. They generally contain large safety factors, and therefore are likely to over-predict population impact for a given level of exposure.

Another major limitation facing the Agency staff in projecting the incidence of disease resulting from exposure to HAPS is the paucity of toxic air pollutant data on population exposures. As with unit risk, the Agency procedures for exposure assessment of toxic air pollutant data are based on conservative estimates, and are typically focused on the most highly exposed individuals in a population. They are not very useful for reliable estimations of average or cumulative population exposure. Furthermore, it is difficult to consider exposures on a regional, national, or broader scale. In situations where the sources are numerous, and the populations at potential risk become large (e.g., mercury, dioxin and related compounds, and combustion-related fine particles), the computational exposure models, whose predictions extend only to 50 km, cannot deal effectively with overall population exposures. The situation is further complicated for pollutants such as mercury and dioxin, where most of the resultant exposure is indirect, being mediated by deposition, accumulation in soil, and eventual movement through food chains.

Based on the presentation at our public meeting on Jan. 29, 1998, it was also apparent that the preliminary exposure analyses made using the Assessment System for Population Exposure Nationwide (ASPEN) approach have little predictive power. The performance evaluation for CO indicates that something in ASPEN's code, boundary conditions, or the quality of selected data must be rectified before it can be relied upon to predict exposure concentrations.

To deal with all the limitations associated with the Agency's ability to perform credible prospective risk assessments for HAPS, we recommend that EPA staff establish a procedure for screening the carcinogens among the list of 189 HAPS for candidate pollutants warranting more in-depth analyses. We recommend the following steps:

a) Apply the admittedly conservative EPA unit risk factors or reference concentrations for carcinogenic pollutants to determine how high average population exposure would have to be to yield a lifetime risk of cancer of 10^{-6}.

b) Examine available records of concentration measurements in urban areas to see if any of the chemicals approach or exceed the concentrations that were calculated in Step a) above.

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where the pollutant risk is unchanged. The third category is the more difficult to model.

c) For any chemicals that are "hits" in Step b), engage in a second level of screening focused on the basis for the unit risk factor and the extent to which it is conservative when used for estimating cancer risks in a population.

d) For chemicals, which do not have highly conservative unit risk factors , conduct a more in-depth review on a case-by-case basis. This review should include not only a further optimization of the risk coefficient, but also a more comprehensive review of air concentration data and the extent of secondary or indirect exposure from food chain accumulation of the toxicant.

3.4.1 Air Toxics

The databases and variables available to complete an air toxics benefits and costs analysis are inadequate for the task of evaluating the prescribed 189 agents. An approach structured to reduce the number of air toxics considered for a national analysis should be developed. This approach should focus on an in-depth cost-benefit analysis of those air toxicants which are most likely to have adverse health effects.

As a matter of organization and presentation of the materials, an effort should be made to distinguish long-lived and persistent substances such as mercury and the dioxins from the volatile and short-lived substances such as benzene and formaldehyde. Source-release-exposure-dose modeling for these two types of substances poses quite different problems. It would be especially helpful to make this distinction in the discussion of the effects of air toxics on aquatic ecosystems, since the harmful effects stem primarily (if not solely?) from the former class of substances.

3.5 Recommendations for Specific Health Valuations Issues

3.5.1 Choice of PM Mortality Response Functions

HEES recommends against using short-term daily mortality studies as an alternative to the cohort mortality studies to derive concentration-response (C-R) functions. Short-term mortality studies may either overestimate or underestimate the C-R coefficient, because these studies do not account for cumulative mortality effects of long-term exposures.

As recommended in the September 26, 1996 letter from the Physical Effects Review Subcommittee (PERS) to the Administrator (SAB, 1996), HEES recommends that other cross-sectional epidemiological studies be considered in deriving C-R mortality estimates, since these studies were used in the retrospective study. Studies of a relatively subtle insult, such as current ambient levels of air pollution, are inherently difficult to perform with precision. The effects of air pollution are greatly exceeded by the effects of other factors, including individual predisposition to disease, occupational and other exposures, and life styles. Estimating air pollution effects requires the use of large samples and controls for factors influencing health that might be correlated with air pollution levels. We stress that air pollution/human health studies should be

carefully peer reviewed and the data should be made available to qualified researchers for independent replication.

In particular, HEES recommends using the revised Pope e*t al.* (1995) results. This is consistent with the retrospective methodology. Caveats concerning the uncertainty of the PM/mortality relationship must be included in the report.

3.5.2 PM Neonatal Mortality

HEES recommends that PM-related infant mortality data not be included in the analysis, without further supporting peer-reviewed published reports. The Agency must have an adequate data base (i.e., at least two or more peer-reviewed published reports) in order to derive a C-R coefficient . The current information does not support use of neonatal mortality. Thus, neonatal mortality should not be included in the Prospective Study .

3.5.3 Ozone-Related Premature Mortality

Some available data suggest a statistical association between ozone and premature mortality. However, it is difficult to separate mortality associated with other pollutants, including PM. Studies by Moolgavkar *et al.* (1995, 1996), Kelsall *et al.* (1997) and Samet *et al.* (1997) did not show an unambiguous relationship between ozone, PM and mortality. Therefore, inclusion of an ozone-specific C-R function would likely result in double-counting. The C-R functions obtained from studies that independently consider ozone may be overestimates (See also U.S. EPA 1995, 1994a and 1994b).

3.5.4 Modeling Time Lags for Cumulative Effects of Long-Term Exposure

HEES agrees that consideration of time lags on annual mortality outcomes might be premature. The current studies on animal mortality do not have an implied time lag, and selection of a value for such a time lag would be arbitrary. The long-term downward trend in pollutant concentrations, especially for PM, presents an important research opportunity for revisiting the issue of time lags using already assembled data bases, and would be a good candidate for sensitivity analysis. An effort of this nature, however, is most likely beyond the scope of the current prospective study.

3.5.5 Valuation of Premature Mortality

Additional methods for expressing the value of the health benefits of the CAA are needed. Although it is appropriate to monetize health benefits, HEES recommends that the prospective study also provide estimates of the ranges of benefits of pollution reductions relative to the total national experience for each health endpoint, and relative to the health impact of one or more common public health risks. These non-monetized benefits can be estimated once a specific damage function is known and used to derive an estimate of the annual incidence of avoided

health effects (as was done in Table ES-1 on page ES-4 of the October 1997 report on the Retrospective Study: Report to Congress (U.S. EPA/OAR, 1997)). For example, the upper estimates of avoided premature deaths associated with PM and lead is approximately 200,000 cases for the 48-state population (Table ES-1). The total number of deaths in the 48 states in 1990 was approximately 2,000,000 cases. Thus, the upper bound mortality effect of PM and lead reductions would appear to be 10% of total deaths.

The range of air pollution avoided health effects can also be compared with EPA's estimates of the health effects of environmental tobacco smoke (ETS). HEES judges that there is reasonable similarity between ambient-air pollution and ETS in terms of individual exposure and volume effects, and that a comparison of ETS and ambient air effects serves the purpose of communicating health benefits to target audiences. These comparisons provide a perspective on health benefits independent of monetary valuations, thereby allowing incorporation of those health benefits that could not be monetized. Likewise, duration of non-monetized valuations are readily understood and easy to communicate.

3.5.6 Inclusion of Ozone-Related Emergency Room Visits for Asthma

Emergency room (ER) visits can be included, provided that double counting is avoided due to overlap between ER visits and resulting admissions (which were separately totaled). It would be useful to survey the literature for additional publications. Further appropriate caveats on causality relationships must be included, since the records are derived from epidemiological investigations (Weisel *et al.*, 1995).

3.5.7 Characterizing the Uncertainty in PM C-R Functions

There is a fundamental issue in that there are regional differences in the C-R functions that may well be due to chemical and/or physical differences in PM, and which may not be simply 'statistical' uncertainty. The Subcommittee suggests that there should be a more detailed explanation of the approach taken and an examination of the sensitivity of the benefits analysis to the C-R uncertainty.

3.5.8 Pollution Level Thresholds for Health Effects

For purposes of analysis, HEES recommends that the annual PM 2.5 level of 15 $\mu g/m^3$ be an assumed threshold for adverse health effects. However, a sensitivity analysis must be performed for assumed thresholds below and above 15 $\mu g/m^3$ (e.g., 0,10, and 20 $\mu g/m^3$). HEES considered using background levels as the assumed threshold, but since background levels differ by region and over long time periods, and since background levels are not a feasible target for standard setting, HEES does not recommend background levels for a threshold analysis. HEES also recommends against using lowest levels, as reported in any individual study, as an annual threshold. HEES also recommends use of the monetized valuation methods from the

Retrospective Study: Report to Congress, including valuation by statistical lives lost and statistical life-years lost.

3.5.9 Estimating Chronic Bronchitis Incidence

HEES endorses the use of the data reported by Schwartz and Abbey (See for instance Abbey *et al.* 1998, 1996, 1995 and 1991; Schwartz 1997, 1996, 1995, 1994a, 1994b, 1989, as well as Schwartz *et al.* 1996, 1995 and 1994). Recent studies from other countries, especially those with higher pollution levels, such as central Europe or some Asian cities, should be considered and might provide data for refining C-R estimates (with appropriate caveats).

3.6 Uncertainties

The Retrospective Study: Report to Congress (U.S. EPA/OAR 1997) provided a series of summary tables on the unquantified uncertainties in the analysis. The tables identify sources of uncertainty, identify the potential direction of bias, if any, and provide comments about the potential significance of the uncertainties. In contrast, the prospective study briefing materials presented to the Subcommittee paid only limited attention to uncertainties. The Subcommittee believes it is not sufficient just to list uncertainties.

The efforts to value ecological services and natural resources provide a good example of the problems arising from the EPA's use of the term “uncertainty.” The draft document commonly refers to the uncertainty of benefits. Given that the draft documents provide an analysis of three (of nearly twenty) ecological service flows, it is inappropriate to state that the analysis of ecological benefits is uncertain. The direction of the estimate of “true” benefits is known; true benefits are certainly underestimated.

The Agency should continue to address the potential direction of bias and significance of uncertainties. Further attention to the potential significance of uncertainties can provide a useful enhancement in the analysis and can be accomplished through more limited quantitative analyses such as screening analyses, case studies, and sensitivity analyses.

Subcommittee Members and Consultants expressed concern that the term “uncertainties” may cause confusion because it is used to cover statistically quantified uncertainty, unquantified uncertainties, variability, and procedures and omissions with known directions of bias. Perhaps the phrase ”...omissions, biases and uncertainties...” would better communicate this aspect of the analysis, once they are identified for specific economic, social, and pollution variables.

3.7 Other Issues

3.7.1 Transboundary Effects

Ozone and particulate matter from sources in the U.S. cross the U.S. boundary, especially into eastern Canada, and may damage exposed populations. To the extent that the air quality models predict changes in concentrations outside of the U.S., the analysis should include the benefits to foreign residents of reductions of emissions in the U. S. attributable to CAAA-90 controls.

Some persistent pollutants such as mercury and polychlorinated biphenyls (PCB's) have residence times in the atmosphere on the order of years rather than hours or a few days. Doses of these pollutants to U.S. residents depend primarily on global emissions and are likely to be little affected by reductions in U.S. emissions. The Agency should address this issue in developing its plan for assessing the effects of controls on the omission and accumulation of persistent pollutants.

3.7.2 Other Criteria Pollutants

The materials presented to the HEES focused on estimating the effects of changes in concentrations of ozone and PM. There was no discussion of additional analyses of changes in emissions of lead or CO. The omission of lead may be appropriate since there were no new controls on lead emissions in the CAAA-90; but this should be made explicit in the Prospective Study: Report to Congress. Title II of the CAAA-90 included additional requirements for controlling CO emissions, and this point should be addressed in the prospective study.

LIST OF ACRONYMS

AGSIM	Agricultural Simulation Model
AQMS	Air Quality Models Subcommittee (U.S. EPA/SAB/COUNCIL/AQMS)
ASPEN	Assessment System for Population Exposure Nationwide
CAA	Clean Air Act
CAAA-90	Clean Air Act Amendments of 1990
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COUNCIL	Advisory Council on Clean Air Compliance Analysis (U.S. EPA/SAB/COUNCIL)
C-R	Concentration-Response Functions
EPA	U.S. Environmental Protection Agency (EPA, or U.S. EPA)
ER	Emergency Room
ES	Executive Summary
ETS	Environmental Tobacco Smoke
HAPS	Hazardous Air Pollutants
HEES	Health and Ecological Effects Subcommittee (of the Council, U.S. EPA/SAB)
km	Kilometer
LTR	Letter
M/C	Members/Consultants
OAR	Office of Air and Radiation (U.S. EPA)
OEE	Office of Economy and Environment (U.S. EPA/OPPE/OEE)
OPAR	Office of Policy Analysis and Review (U.S. EPA/OAR/OPAR)
OPPE	Office of Policy Planning and Evaluation (U.S. EPA)
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NO_x	Nitrogen Oxides
PCBs	Polychlorinated Biphenyls
PERS	Physical Effects Review Subcommittee (The predecessor Subcommittee to the HEES of the Council, U.S. EPA/SAB/ COUNCIL/PERS)
PM	Particulate Matter ($PM_{2.5}$, 2.5 microns; PM_{10}, 10 microns)
RMF	Regional Model Farm
SAB	Science Advisory Board (U.S. EPA/SAB)
SO_2	Sulfur Dioxide
SUM06	Sum of all hourly averages greater than 0.06 ppm.
$\mu g/m^3$	Micrograms per cubic meter
U.S.	United States

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