BenMAP

Environmental Benefits Mapping and Analysis Program

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Overview

- Principles of health benefits analysis
- Running BenMAP
- Interpreting BenMAP results
- Training opportunities
Scientific Foundation for BenMAP: Derivation of Health Impact Functions

\[ \ln(y) = \ln(B) + \beta(PM) \]

\[ \Delta Y = Y_0 (1 - e^{-\beta \Delta PM}) \times \text{Pop} \]

- \( Y_0 \) – Baseline Incidence
- \( \beta \) – Effect estimate
- \( \text{Pop} \) – Exposed population

Epidemiology studies – derivation of concentration-response functions (beta values)
\[ \Delta Y = Y_0 (1 - e^{-\beta \Delta PM}) \times Pop \]
What Health Effects Does EPA Quantify?

<table>
<thead>
<tr>
<th>Health Endpoint</th>
<th>Particulate Matter</th>
<th>Ozone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Nonfatal heart attacks</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hospital admissions</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Asthma ER visits</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Acute respiratory symptoms</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Asthma attacks</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Work loss days</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Worker productivity</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>School absence rates</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Scientific Foundation for BenMAP: Valuing Health Outcomes

• **Cost of Illness (COI)**
  - Medical expenses for treatment of illness
  - Captures the money savings to society of reducing a health effect
  - Ignores the value of reduced pain and suffering

• **Willingness To Pay (WTP)**
  - Lost wages, avoided pain and suffering, loss of satisfaction, loss of leisure time, etc.
  - Measures the complete value of avoiding a health outcome

• **Quality adjusted life years (QALY)** – measured in terms of “healthy” life year equivalents rather than dollars
Scientific Foundation for BenMAP: Valuing Health Outcomes

- Example: Value of a statistical life saved
- 1 μg/m³ reduction in pollutant concentration produces decrease in mortality risk of 1/10,000
- For every 10,000 individuals, one individual would be expected to die in the absence of the reduction in PM concentrations
- WTP for this 1/10,000 decrease in mortality risk is $500
- Value of a statistical life is 10,000 x $500 = $5 million
- Mortality benefits have accounted for about 90% of the total benefits of PM$_{2.5}$ air rules
The Data BenMAP Uses to Perform a Benefits Analysis

- Census Population Data
- Air Quality Monitoring
- Health Functions
- Valuation Functions
- Population Estimates
- Population Exposure
- Adverse Health Effects
- Economic Costs
- Population Projections
- Air Quality Modeling
- Incidence and Prevalence Rates

White text represents user specification or input
Green text represents result from inputs
Step One: Specifying Air Quality Data and Calculating Changes in Exposure

- **Goal:** estimate population exposure to pollutant of interest

- **Option 1:** Apply user-generated modeled data
  - Easy to import CMAQ, CAMx data
  - Minor modifications required to accept other model data such as AERMOD

- **Option 2:** Apply built-in monitor data
  - AIRS data for ozone, PM$_{10}$, and PM$_{2.5}$ for a number of recent years (1996-2004)
  - In process of importing Pb, NOx, SOx and CO monitoring data
Step One: Specifying Air Quality Data and Calculating Changes in Exposure
Step One: Specifying Air Quality Data and Calculating Changes in Exposure

Air Quality Distribution

Population Distribution
Step Two: Specifying the Benefits Analysis Options

- Select health impact and valuation functions
- BenMAP pre-loaded with hundreds of PM$_{2.5}$ and O$_3$ health impact functions
- Users can add import additional functions through equation editor
- Model will “pool” functions and aggregate results
- BenMAP uses Monte Carlo methods to estimate distributions of incidence and valuation results
### Step Two: Specifying the Benefits Analysis Options

#### Configuration Settings

<table>
<thead>
<tr>
<th>Available CF Functions</th>
<th>Data</th>
<th>Function Parameters</th>
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<tbody>
<tr>
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<tr>
<td><strong>Tree</strong></td>
<td><strong>Endpoint Group</strong></td>
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Step Two: Specifying the Benefits Analysis Options
Step Three: Reporting the Results
Step Three: Reporting the Results
(1) Age Group Impacts

Mortality Impacts by Age Group
Step Three: Reporting the Results:
(2) Distributions of Incidence

Cumulative Distribution of Total Change in Mortality from a 30% Reduction in PM$_{2.5}$ Levels

Mean Reduction = 42,366
Step Three: Reporting the Results:
(3) Distributions of Monetized Benefits

Cumulative Distribution of Value of Reductions in Premature Mortality from a 30% Reduction in PM$_{2.5}$ Levels
Use of BenMAP in EPA Analyses

- Past Projects:
  - Non-Road Diesel Rule
  - Clean Air Interstate Rule
  - PM$_{2.5}$ NAAQS
  - Small Spark Ignition Rule
  - Locomotive and Marine Diesel Rule
  - Ozone NAAQS
- Upcoming Projects:
  - SO$_2$ NAAQS
  - NO$_x$ NAAQS
Other BenMAP Projects

• FAA aircraft analysis

• Washington and Oregon woodstove analyses

• New York City Department of Health borough-level analysis

• Georgia Department of Natural Resources SIP planning
BenMAP International Projects

- China: Benefits analysis of EGU control strategy.
- South Korea: Health benefits of Seoul air quality management plan
- Latin America: Benefits of air quality improvements in Mexico City, Saõ Paulo, Santiago
- India: Benefits analysis in Mumbai
BenMAP Training

- Two providers of BenMAP Training:
  - Abt Associates Inc.
  - Community Modeling Analysis System