BenMAP

Environmental Benefits Mapping and Analysis Program

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Air Benefits and Cost Group

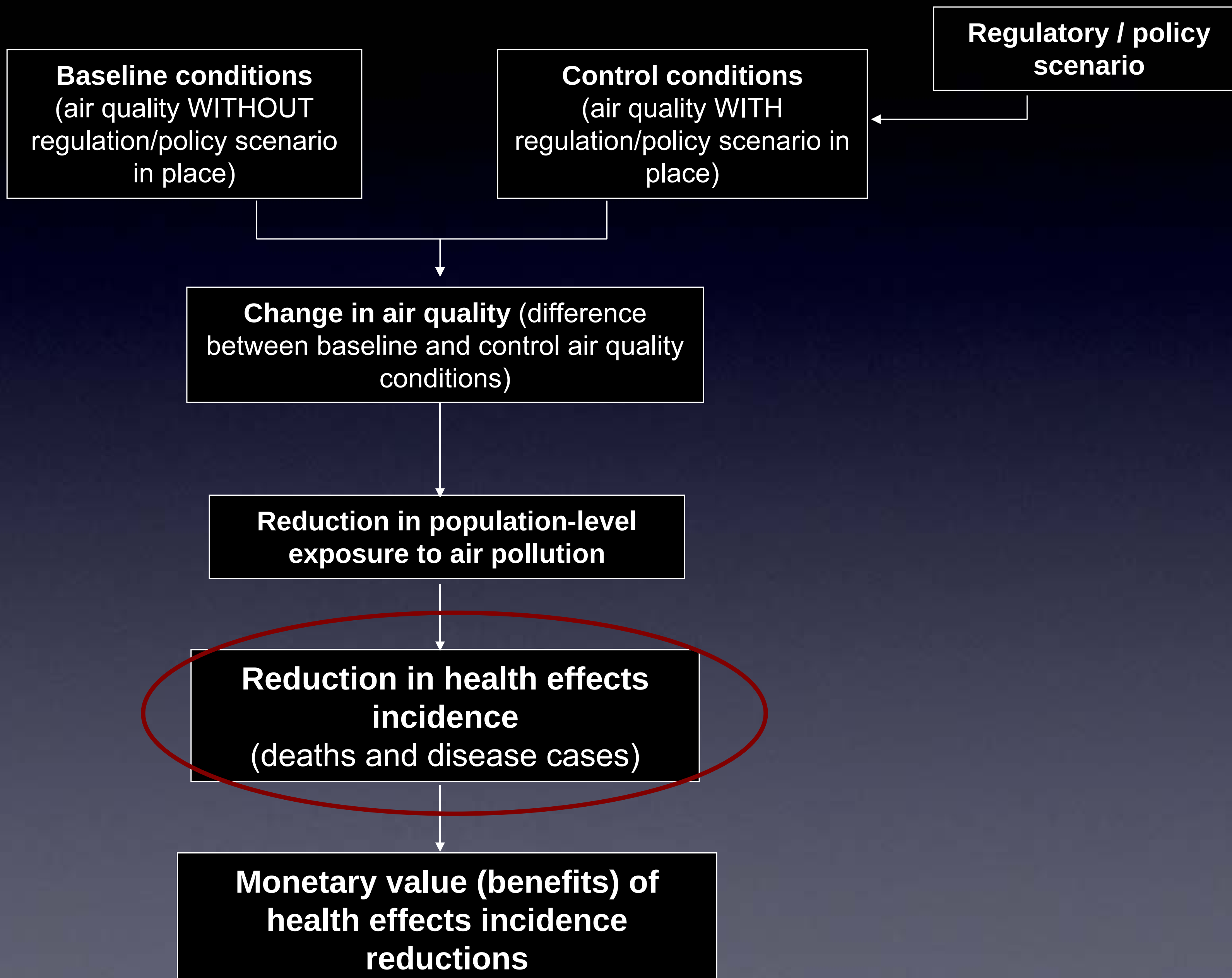
Overview

- What is a human health benefits analysis and what purpose does it serve?
- How can BenMAP help perform a benefits analysis?
- Data inputs to BenMAP
- Demonstration of model interface and outputs
- Analytical transparency in BenMAP
- Use of BenMAP in non-US projects

What is a Human Health Benefits Analysis?

- The process of:
  - estimating of improvements in health outcomes that result from improvements in air quality
  - applying a monetary value to those improvements in health outcomes
- Benefits information can help inform the selection of optimal air regulations

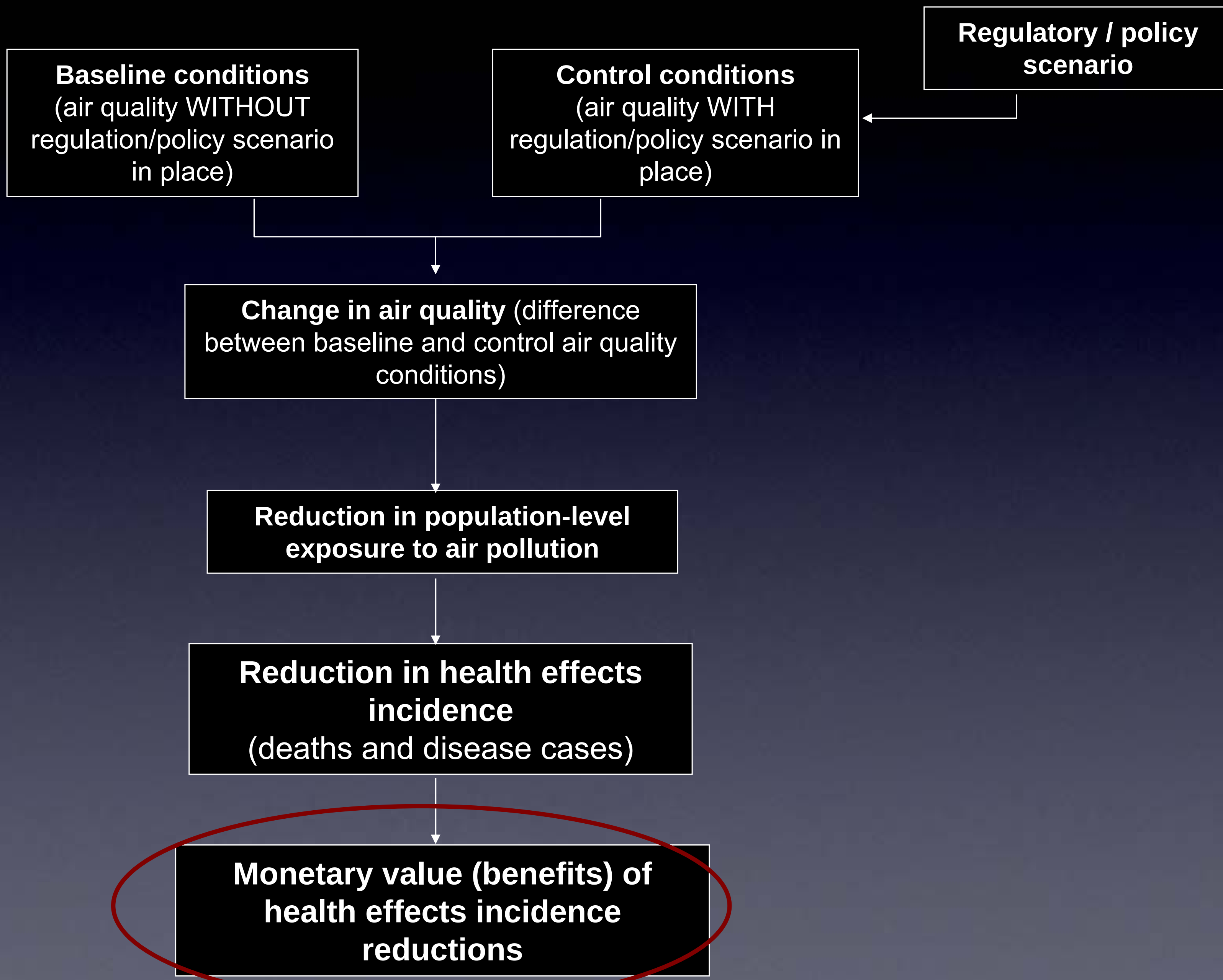
Benefits Analysis



What Health Effects Does EPA Quantify?

	Particulate Matter	**Ozone**
Current		
Mortality	✓	(✓)
Chronic bronchitis	✓	
Nonfatal heart attacks	✓	
Hospital admissions	✓	✓
Asthma ER visits	✓	✓
Acute respiratory symptoms	✓	✓
Asthma attacks	✓	✓
Work loss days	✓	
Worker productivity		✓
School absence rates		✓

Benefits Analysis



How Do You "Value" Changes in Health Outcomes?

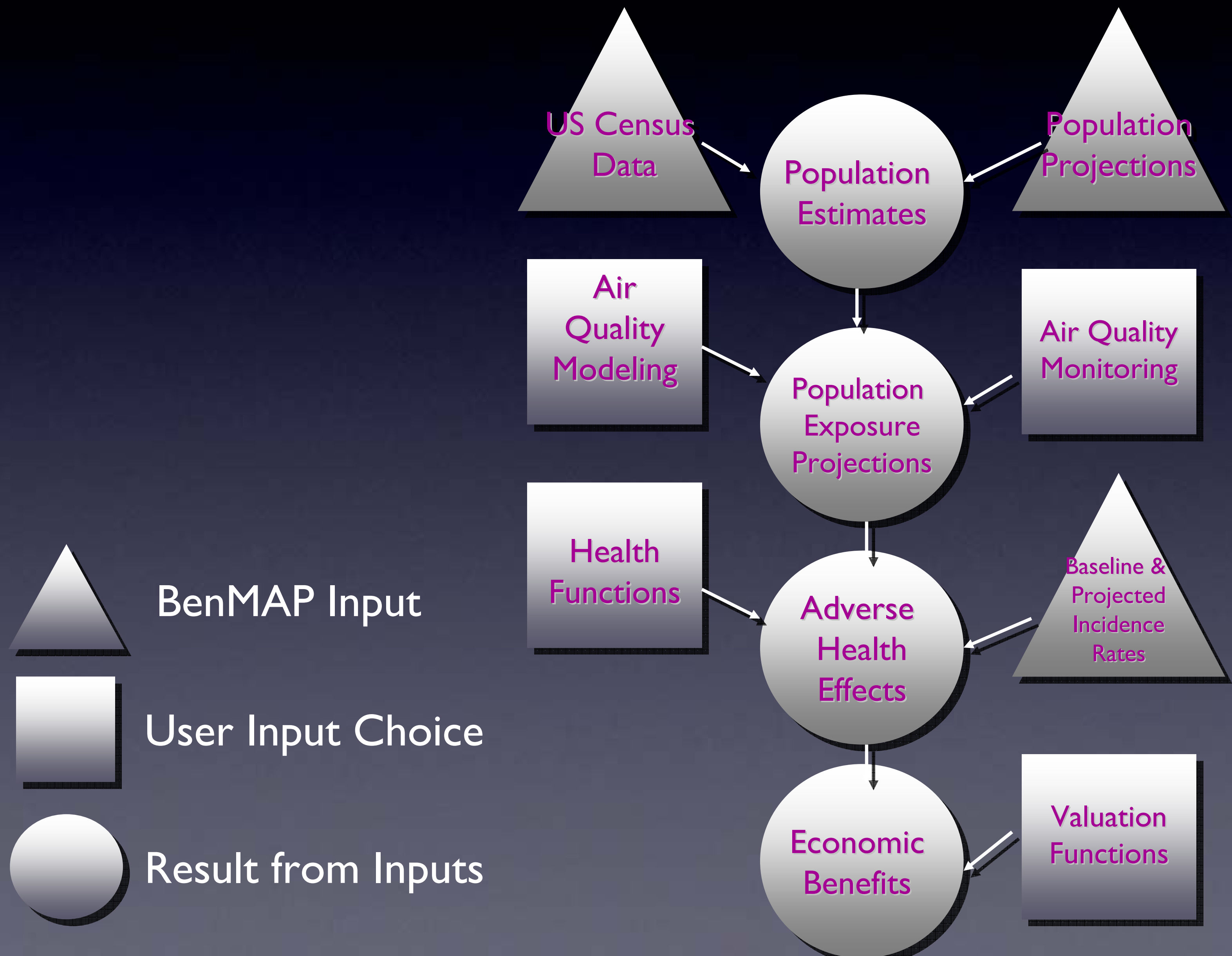
- Cost of Illness (COI)
  - Medical expenses for treatment of illness
  - Captures the money savings to society of reducing a health effect
  - Ignores the value of reduced pain and suffering
- Willingness To Pay (WTP)
  - Lost wages, avoided pain and suffering, loss of satisfaction, loss of leisure time, etc.
  - Measures the complete value of avoiding a health outcome

The BenMAP Model

A geographic information system-based program that:

- creates population level exposure surfaces
- estimates changes in incidence of a variety of health outcomes associated with changes in certain ambient air pollutants
- places a dollar value on changes in incidence of health outcomes

The Data BenMAP Uses to Perform a Benefits Analysis



Key Features of BenMAP

- User-friendly experience
  - Driven by windows-based graphical user interface
  - Results (exposure, incidence, and valuation) available in a variety of formats including ASCII, .dbf, and shape files
- Comprehensiveness
  - Model includes a substantial population, health and air quality databases
  - Model incorporates an integrated GIS mapping, query, and statistics tool
- Flexibility
  - Enables users to perform a standardized or highly customized analysis
  - Users can add their own population, air quality, and health databases

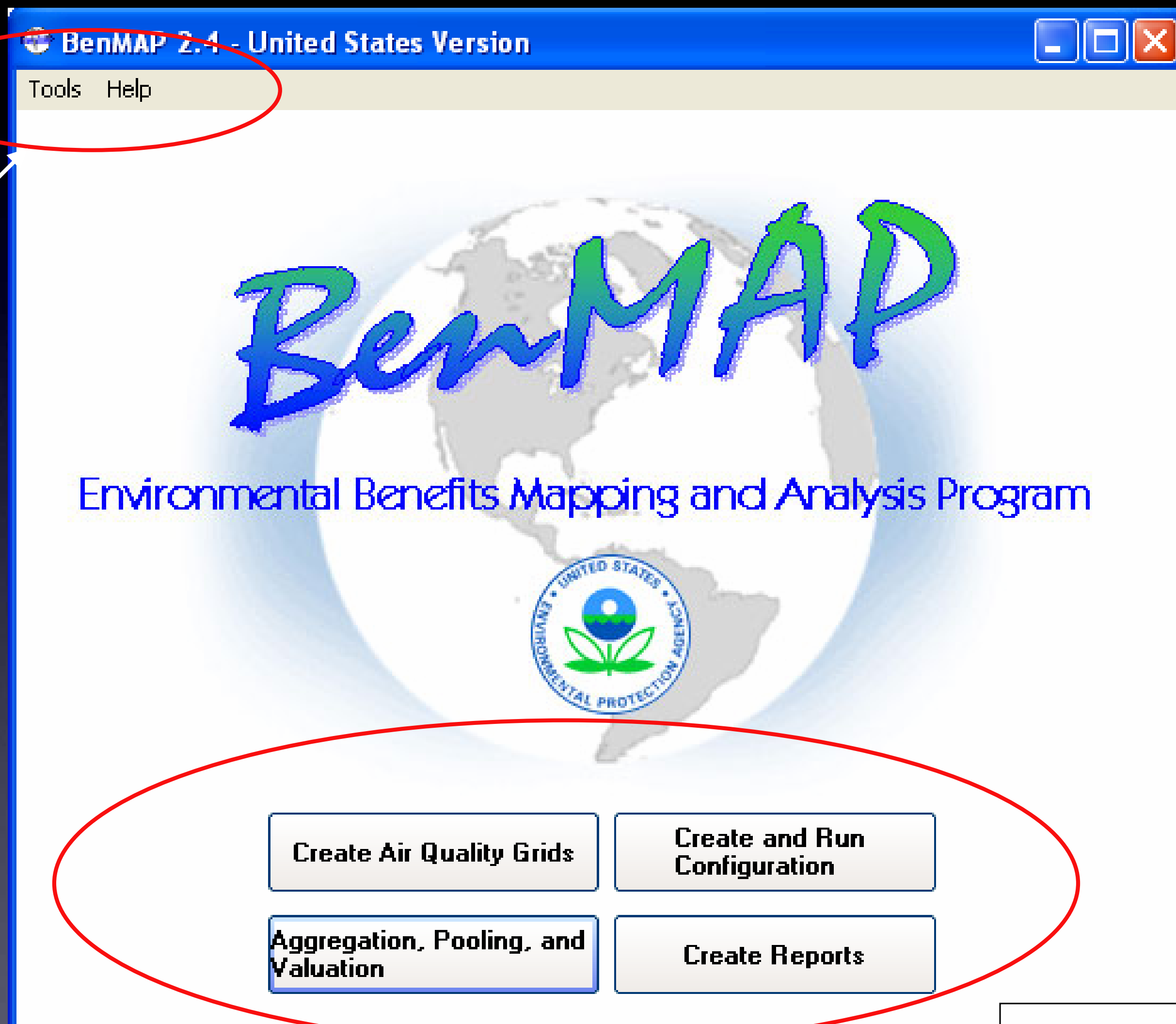
Options for Providing BenMAP with Air Quality Data

- Model accepts user-provided air quality data, both monitored and modeled
- Provides several options for creating population exposure maps:
  - direct use of monitor or model data
  - use of model data with monitor data in a relative sense

Options for Specifying Benefits Analysis

- Preloaded with hundreds of PM and Ozone concentration-response functions from US and Canadian studies
  - Users can easily add more C-R functions with the equation editor
  - Users can add region-specific baseline incidence rates
- Model enables users to pool and aggregate incidence and valuation results
- Model estimates distributions of incidence and valuation results using Monte Carlo methods

The BenMAP Interface



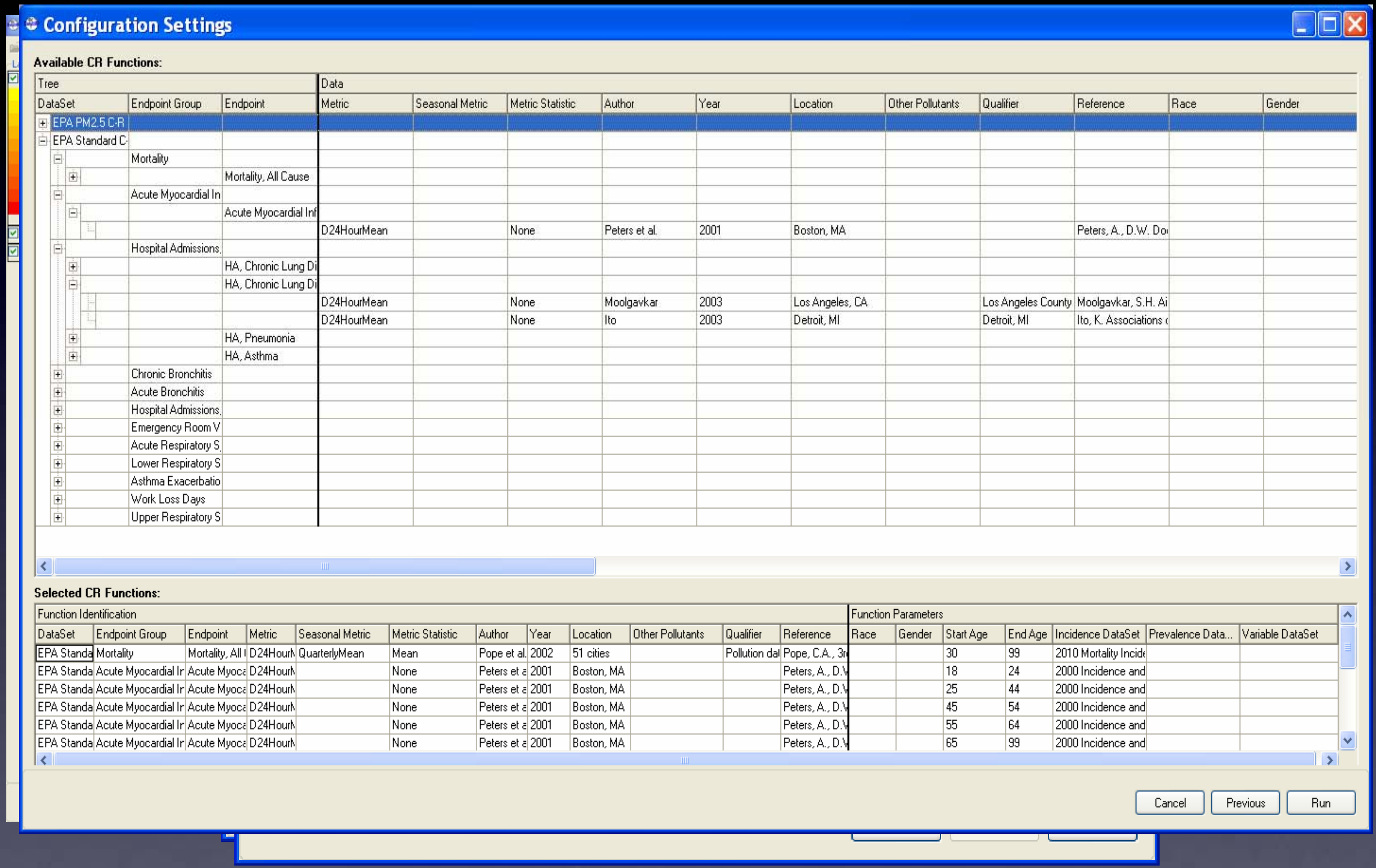
Data Entry and Utilities

Program Function Buttons

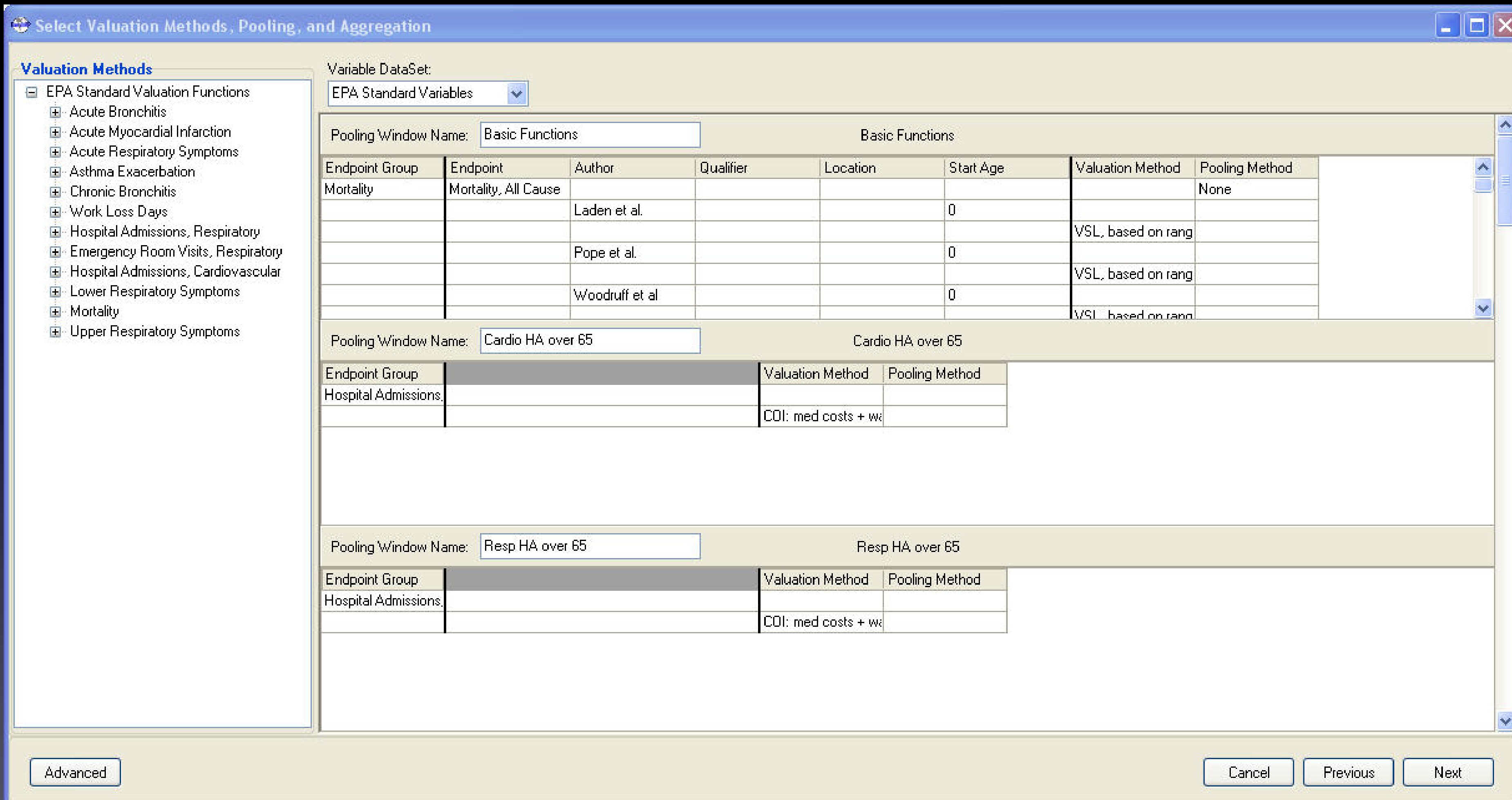
Alternative Ways to Analyze Air Quality Data

- Monitor Rollbacks
  - Useful for answering hypothetical questions like: "What if PM2.5 levels were reduced by 20 percent in Mexico City?"
  - Available options include percentage reduction, absolute reduction, and rollback to standard
- Spatial and Temporal Scaling
  - Use a combination of modeling and monitoring data to project future air quality
- Monitor Direct
  - Import monitoring data into BenMAP

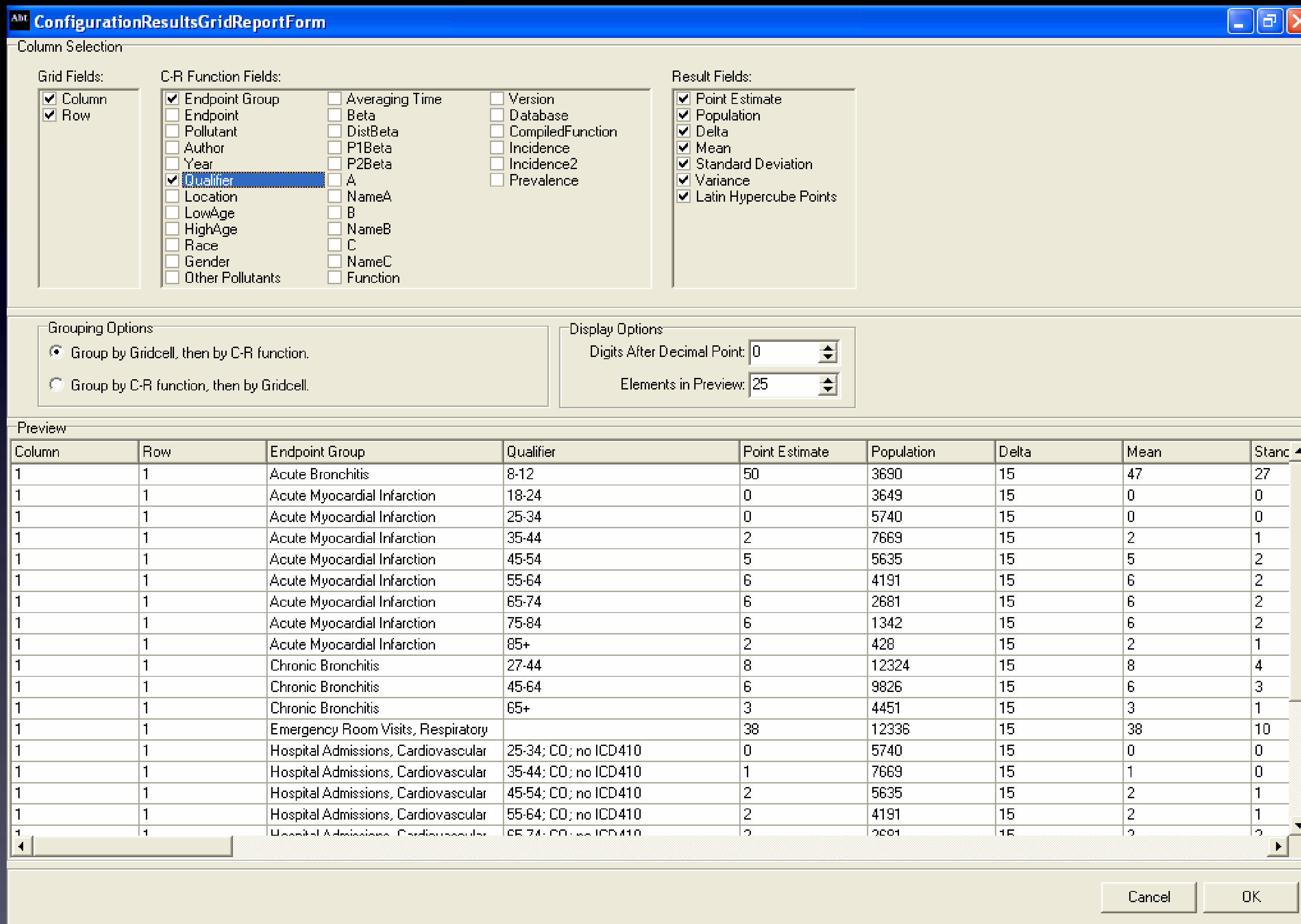
Step Two: Estimating Health Impacts



Step Three: Pooling, Aggregating, and Valuing Health Impacts



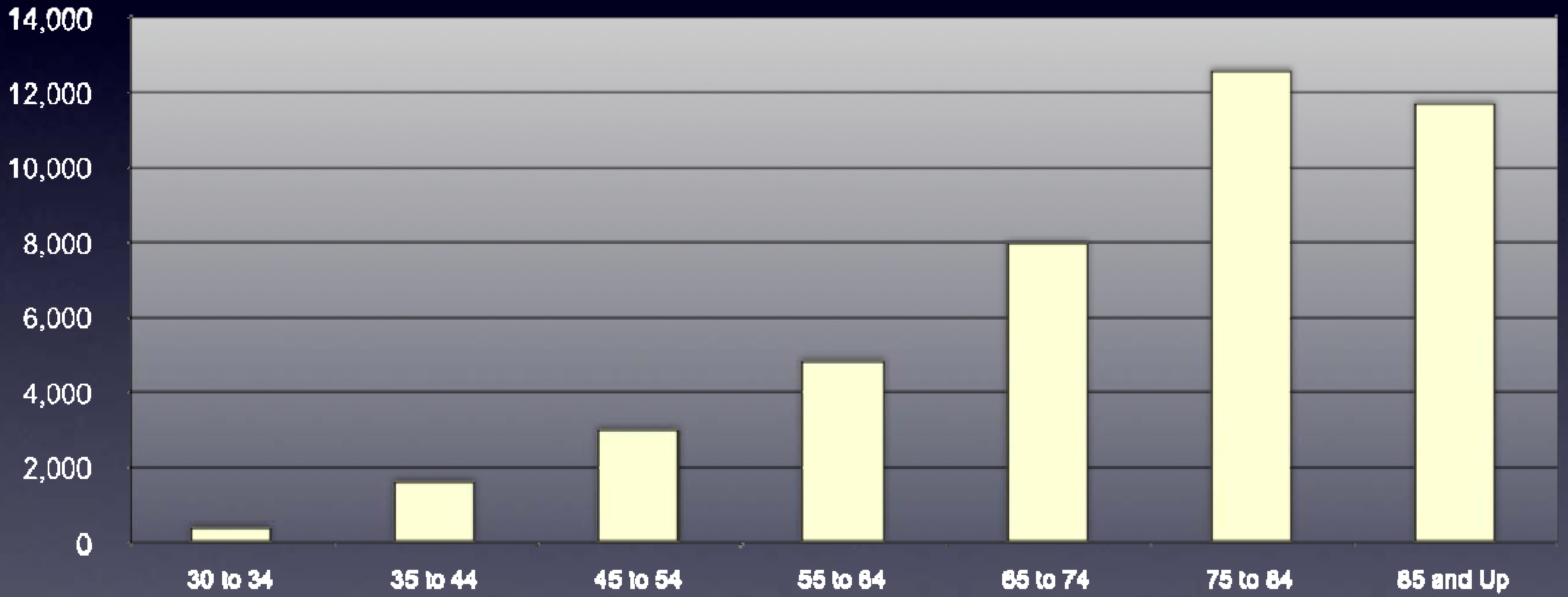
Step Four: Reporting Results



Column	Row	Endpoint Group	Qualifier	Point Estimate	Population	Delta	Mean	Stanc
1	1	Acute Bronchitis	8-12	50	3690	15	47	27
1	1	Acute Myocardial Infarction	18-24	0	3649	15	0	0
1	1	Acute Myocardial Infarction	25-34	0	5740	15	0	0
1	1	Acute Myocardial Infarction	35-44	2	7669	15	2	1
1	1	Acute Myocardial Infarction	45-54	5	5635	15	5	2
1	1	Acute Myocardial Infarction	55-64	6	4191	15	6	2
1	1	Acute Myocardial Infarction	65-74	6	2681	15	6	2
1	1	Acute Myocardial Infarction	75-84	6	1342	15	6	2
1	1	Acute Myocardial Infarction	85+	2	428	15	2	1
1	1	Chronic Bronchitis	27-44	8	12324	15	8	4
1	1	Chronic Bronchitis	45-64	6	9826	15	6	3
1	1	Chronic Bronchitis	65+	3	4451	15	3	1
1	1	Emergency Room Visits, Respiratory		38	12336	15	38	10
1	1	Hospital Admissions, Cardiovascular	25-34; CO; no ICD410	0	5740	15	0	0
1	1	Hospital Admissions, Cardiovascular	35-44; CO; no ICD410	1	7669	15	1	0
1	1	Hospital Admissions, Cardiovascular	45-54; CO; no ICD410	2	5635	15	2	1
1	1	Hospital Admissions, Cardiovascular	55-64; CO; no ICD410	2	4191	15	2	1

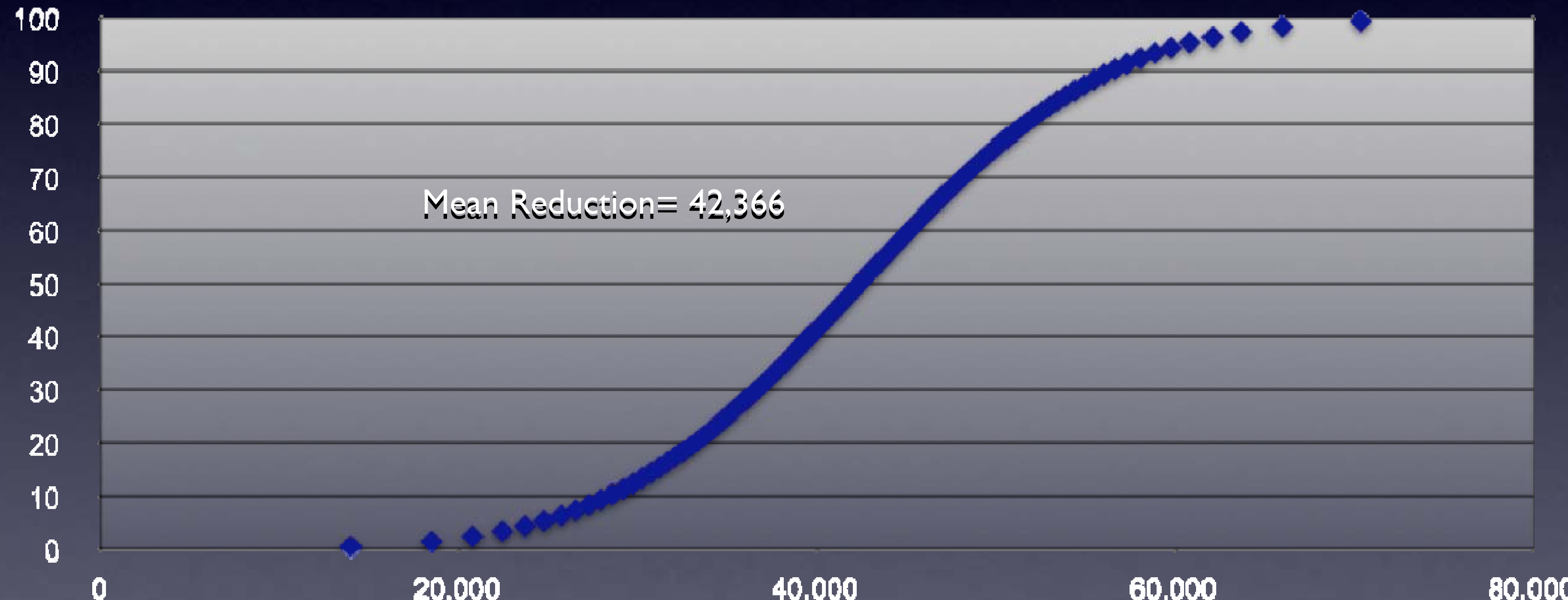
Examples of Graphs Produced Using BenMAP Outputs (1) Age Group Impacts

Mortality Impacts by Age Group



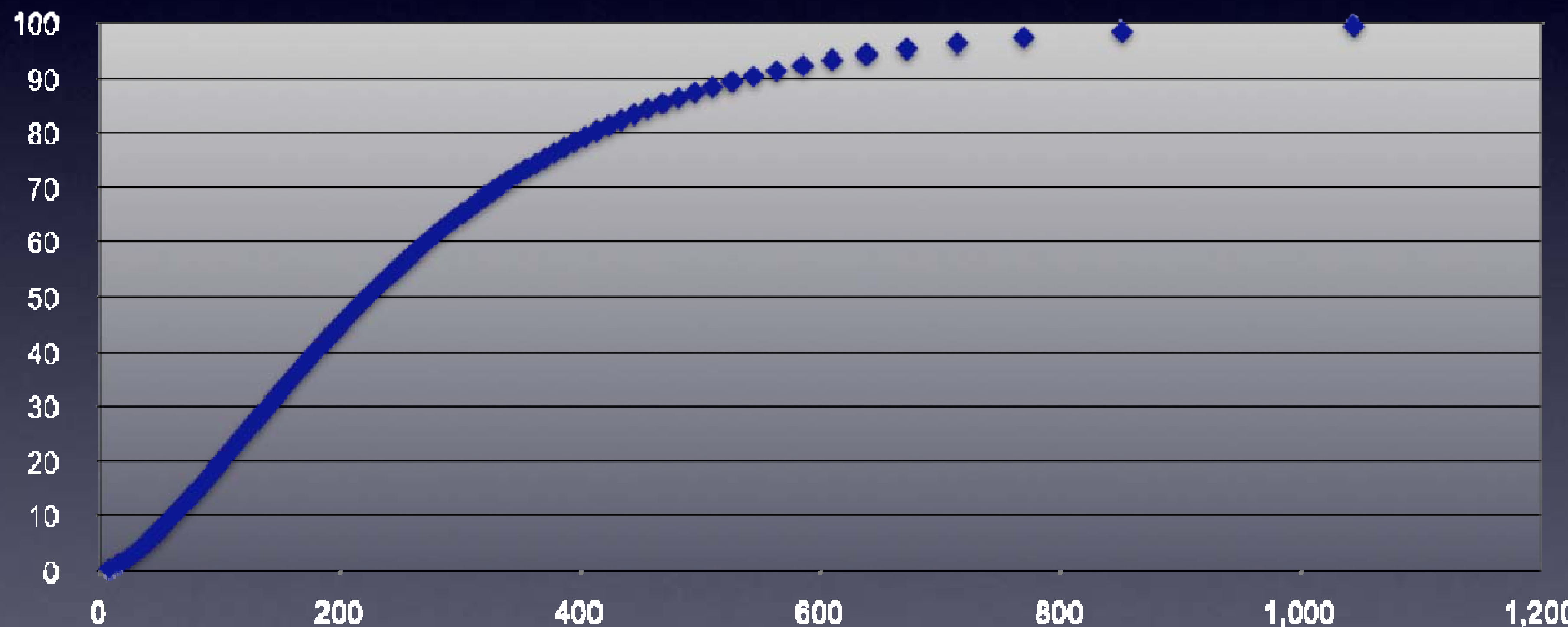
Examples of Graphs Produced Using BenMAP Outputs
(2) Distributions of Incidence

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

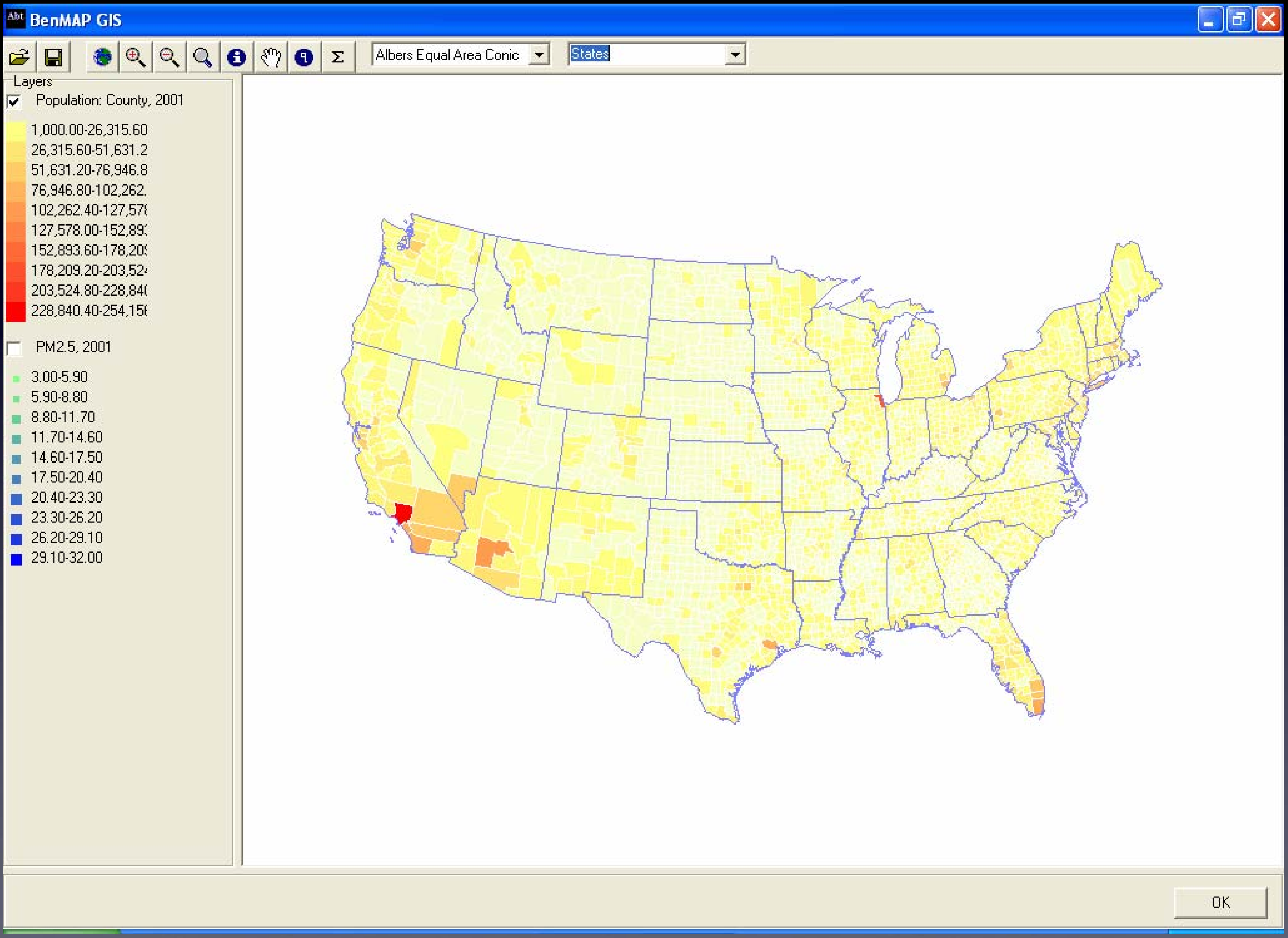


Examples of Graphs Produced Using BenMAP Outputs
(3) Distributions of Monetized Benefits

Cumulative Distribution of Value of Reductions in Premature Mortality from a 30% Reduction in PM2.5 Levels



Map underlying population, air quality, and incidence rates



Analytical Transparency and Reproducibility

- BenMAP designed for public use and public scrutiny
- Published a detailed User's Guide with extensive appendices documenting model algorithms and data sources
- With each run, the user can generate an "audit trail" listing details of the run for QA and comparison with other analyses
- Consistent with Data Quality Guidelines, this "audit trail" can and should be shared with reviewers

Audit Trail Report

- Aggregation, Pooling, and Valuation Configuration Result: C:\Program Files\Abt Associates Inc\Configuration Results\presentation pooling example.apvr
  - Configuration Results: C:\Program Files\Abt Associates Inc\Configuration Results\presentation pooling example.cfgr
    - Baseline Air Quality Grid: C:\Program Files\Abt Associates Inc\Air Quality Grids\Presenation rollback base.aqg
    - Control Air Quality Grid: C:\Program Files\Abt Associates Inc\Air Quality Grids\Presenation rollback control.aqg
    - Latin Hypercube Points: 10
    - Pollutant: PM2.5
    - Year: 2000
    - Threshold: 0.000000
    - Selected Studies
      - Moolgavkar, 2000 | 65-74; CO; no ICD410
      - Moolgavkar, 2000 | 75-84; CO; no ICD410
      - Moolgavkar, 2000 | 85+; CO; no ICD410
      - Lippmann et al., 2000 | 65-74; O3
      - Lippmann et al., 2000 | 75-84; O3
      - Lippmann et al., 2000 | 85+; O3
      - Lippmann et al., 2000 | 65-74; O3
      - Lippmann et al., 2000 | 75-84; O3
      - Lippmann et al., 2000 | 85+; O3
      - Lippmann et al., 2000 | 65-74; O3; no ICD410
      - Lippmann et al., 2000 | 75-84; O3; no ICD410
      - Lippmann et al., 2000 | 85+; O3; no ICD410
  - Advanced
    - Incidence Aggregation Level: State
    - Valuation Aggregation Level: None
    - Default Advanced Pooling Method: Round Weights to Two Digits
    - Default Monte Carlo Iterations: 5000
    - Random Seed: 378245560
    - Dollar Year: 2000
  - Incidence Pooling Trees
    - Pooling Tree 1
      - Hospital Admissions, Cardiovascular [Pooling Method: Random / Fixed Effects] [Advanced Pooling Method: Round Weights to Two Digits]
        - [Weight: 0.76, Mean: 3,067.60, StdDev: 3,196.05] Moolgavkar, HA, All Cardiovascular, 2000, Los Angeles, CA [Pooling Method: Sum (Dependent)]
          - 65, 74, 65-74; CO; no ICD410, All, All, CO, TwentyFourHourDailyAverage, (exp(Beta*DELTAQ)-1)*(Incidence-Incidence2)*POP, 1
          - 75, 84, 75-84; CO; no ICD410, All, All, CO, TwentyFourHourDailyAverage, (exp(Beta*DELTAQ)-1)*(Incidence-Incidence2)*POP, 1
          - 85, Max, 85+; CO; no ICD410, All, All, CO, TwentyFourHourDailyAverage, (exp(Beta*DELTAQ)-1)*(Incidence-Incidence2)*POP, 1
        - [Weight: 0.24, Mean: 9,084.97, StdDev: 5,747.26] Lippmann et al. [Pooling Method: Sum (Dependent)]
          - HA, Congestive Heart Failure, 2000, Detroit, MI [Pooling Method: Sum (Dependent)]
          - HA, Dysrhythmia, 2000, Detroit, MI [Pooling Method: Sum (Dependent)]
          - HA, Ischemic Heart Disease, 2000, Detroit, MI [Pooling Method: Sum (Dependent)]
  - Valuation Pooling Trees

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Example International BenMAP Projects

- 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 analyses in Mumbai and Pune of alternate air quality policies

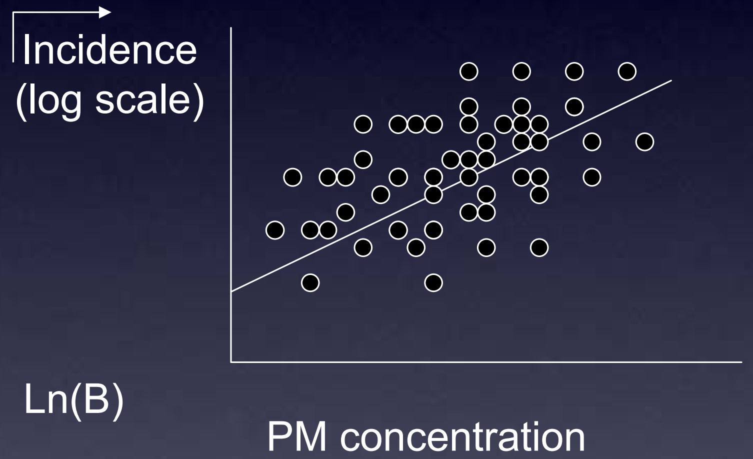
Using BenMAP International

- Program components users must modify:
  - Baseline and projected population data
  - Monitoring data (if applicable)
  - Valuation function library
- BenMAP components users should consider modifying:
  - Concentration-response function library
  - Baseline and projected incidence rates
  - Income growth adjustment functions

Appendix

Derivation of Effects Estimates

$$\ln(y) = \ln(B) + \beta(PM)$$



ß - Effect estimate

$$\Delta Y = Y_o\,(1 - e^{-\beta \Delta PM})$$

Yo – Baseline Incidence

Epidemiology studies – derivation of concentration-response functions (beta values)

Valuation Procedures (I)

- WTP reflects individuals' preferences
  - Market goods - e.g., buying a new automobile
  - Non-market goods - e.g., health-related improvements in environmental quality
- WTP for a non-market good difficult to estimate
  - Decrease the risk of a day of coughing
  - Decrease the risk of admission to the hospital for respiratory illness
- Benefits analysis estimates the value of a *statistical* health problem avoided
- Reduction in air pollutant concentrations results in a reduction in mortality risk

Valuation Procedures (II)

- EXAMPLE: Value of a *statistical* life saved
  - 1 $\mu g/m^3$ 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
- International benefits transfer between countries