



Environmental Benefits Mapping and Analysis Program

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Air Benefits and Cost Group

Overview

- What is the BenMAP model?
- Data inputs to BenMAP
- Demonstration of model interface and outputs
- Analytical transparency in BenMAP
- Peer review results
- Use of BenMAP in Regulatory Impact Analyses
- Future directions for BenMAP development

The BenMAP Model

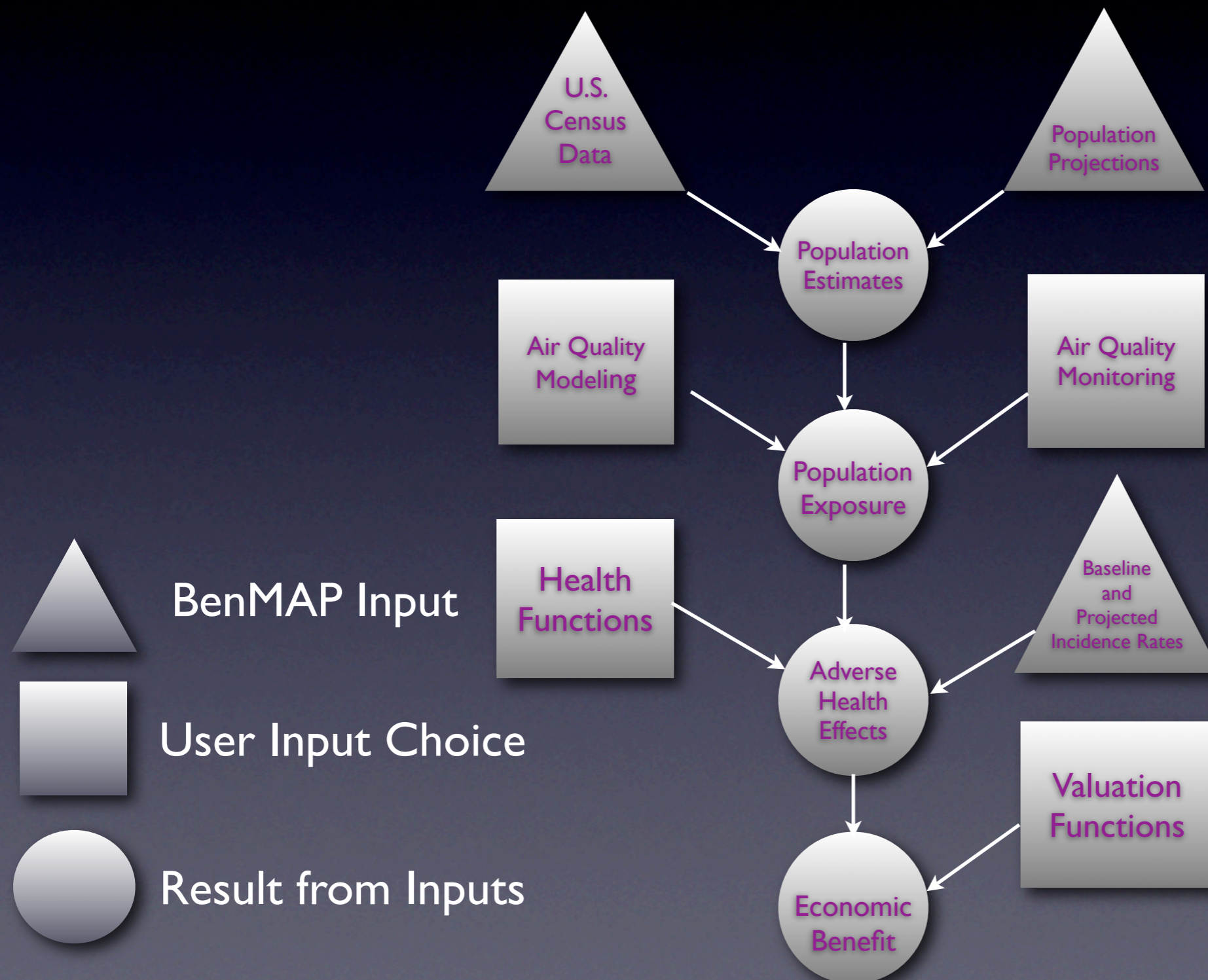
A geographic information system-based program that:

- 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

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

The Elements of a BenMAP Benefits Analysis



Options for Providing BenMAP with Air Quality Data

- Model accepts user-provided air quality data, both monitored and modeled
- Preloaded with:
 - AIRS data for ozone, PM_{10} , and $PM_{2.5}$ for a number of recent years (1996-2004)
 - Grid definitions corresponding to currently used EPA air quality models
- 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

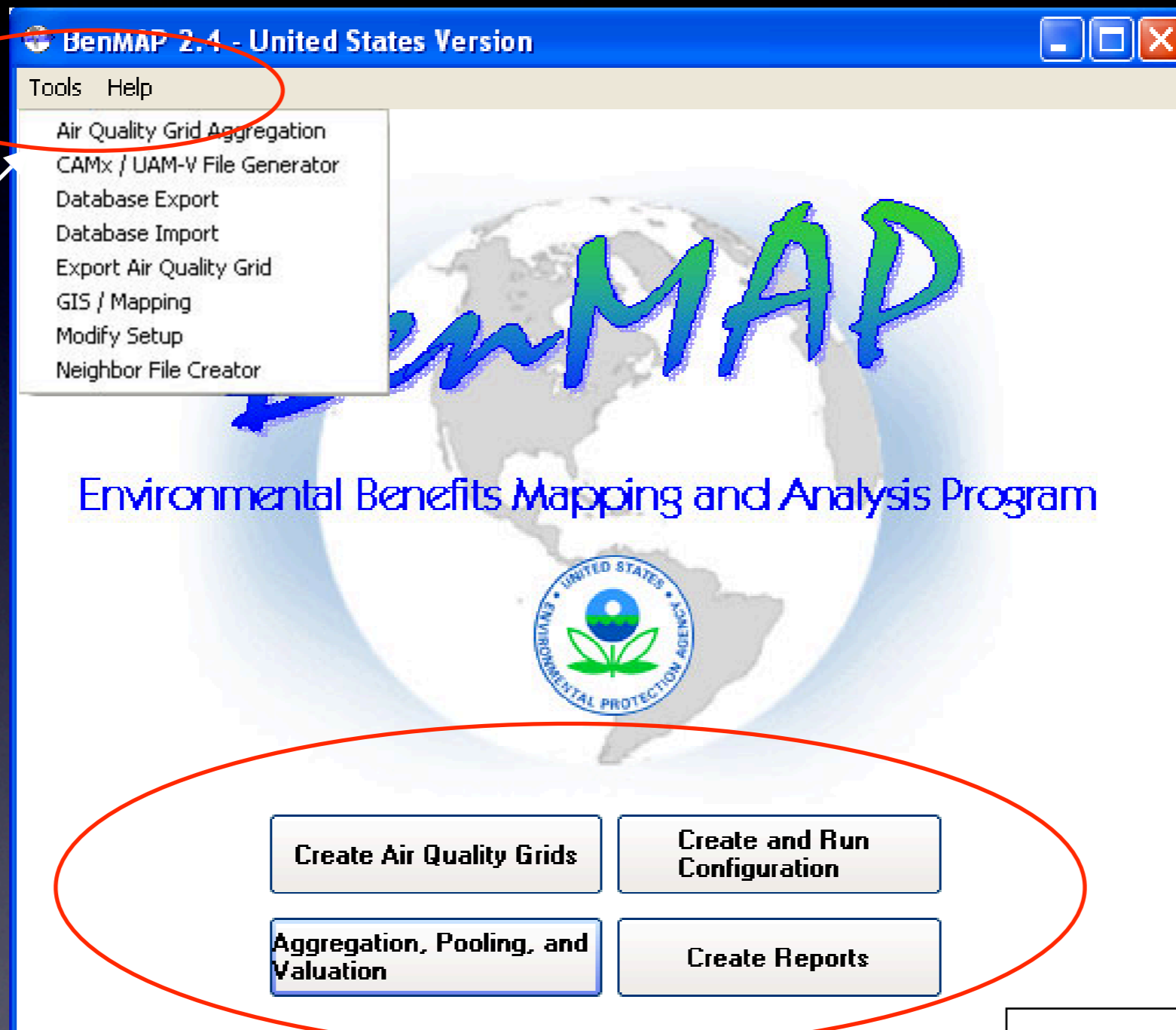
Options for Specifying Benefits Analysis

- Preloaded with hundreds of PM and Ozone concentration-response functions
 - Includes expert-elicitation derived $PM_{2.5}$ functions used in recent $PM_{2.5}$ Regulatory Impact Analysis
 - Users can easily add more C-R functions with the equation editor
- Model enables users to pool and aggregate incidence and valuation results
- Model estimates distributions of incidence and valuation results using Monte Carlo methods

BenMAP Data Libraries

- Incidence rates (spatially variable)
 - A variety of incidence rate data covering numerous health effects
- Affected populations (spatially variable)
 - 2000 Census data and projections to 2025 for 250 age/sex/race population subgroups
- Estimated pollutant effect coefficients (represented by distributions)
 - Hundreds of concentration-response functions from the epidemiology literature
- Estimated/modeled changes in ambient air pollution (spatially variable)
 - BenMAP can estimate population level exposures based on modeled or monitored air quality, or a combination of both
- Estimated dollar values for avoided health effects (represented by distributions)
 - Hundreds of health effect-specific values

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 Ohio?”
 - 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 non-AIRS data into BenMAP

Step Two: Estimating Health Impacts

Configuration Settings

Available CR Functions:

Tree			Data										
DataSet	Endpoint Group	Endpoint	Metric	Seasonal Metric	Metric Statistic	Author	Year	Location	Other Pollutants	Qualifier	Reference	Race	Gender
+	EPA PM2.5 C-R												
-	EPA Standard C												
-		Mortality											
+			Mortality, All Cause										
-		Acute Myocardial In											
-			Acute Myocardial Inf										
			D24HourMean		None	Peters et al.	2001	Boston, MA			Peters, A., D.W. Do		
-		Hospital Admissions											
+			HA, Chronic Lung Di										
-			HA, Chronic Lung Di										
			D24HourMean		None	Moolgavkar	2003	Los Angeles, CA		Los Angeles County	Moolgavkar, S.H. Ai		
			D24HourMean		None	Ito	2003	Detroit, MI		Detroit, MI	Ito, K. Associations c		
+		HA, Pneumonia											
+		HA, Asthma											
+		Chronic Bronchitis											
+		Acute Bronchitis											
+		Hospital Admissions											
+		Emergency Room V											
+		Acute Respiratory S											
+		Lower Respiratory S											
+		Asthma Exacerbatio											
+		Work Loss Days											
+		Upper Respiratory S											

Selected CR Functions:

Function Identification												Function Parameters						
DataSet	Endpoint Group	Endpoint	Metric	Seasonal Metric	Metric Statistic	Author	Year	Location	Other Pollutants	Qualifier	Reference	Race	Gender	Start Age	End Age	Incidence DataSet	Prevalence Data...	Variable DataSet
EPA Standa	Mortality	Mortality, All	D24HourM	QuarterlyMean	Mean	Pope et al.	2002	51 cities		Pollution da	Pope, C.A., 3r			30	99	2010 Mortality Incide		
EPA Standa	Acute Myocardial Ir	Acute Myoc	D24HourM		None	Peters et a	2001	Boston, MA			Peters, A., D.V			18	24	2000 Incidence and		
EPA Standa	Acute Myocardial Ir	Acute Myoc	D24HourM		None	Peters et a	2001	Boston, MA			Peters, A., D.V			25	44	2000 Incidence and		
EPA Standa	Acute Myocardial Ir	Acute Myoc	D24HourM		None	Peters et a	2001	Boston, MA			Peters, A., D.V			45	54	2000 Incidence and		
EPA Standa	Acute Myocardial Ir	Acute Myoc	D24HourM		None	Peters et a	2001	Boston, MA			Peters, A., D.V			55	64	2000 Incidence and		
EPA Standa	Acute Myocardial Ir	Acute Myoc	D24HourM		None	Peters et a	2001	Boston, MA			Peters, A., D.V			65	99	2000 Incidence and		

Cancel Previous Run

Step Three: Pooling, Aggregating, and Valuing Health Impacts

Select Valuation Methods, Pooling, and Aggregation

Variable DataSet: EPA Standard Variables

Valuation Methods

- EPA Standard Valuation Functions
 - Acute Bronchitis
 - Acute Myocardial Infarction
 - Acute Respiratory Symptoms
 - Asthma Exacerbation
 - Chronic Bronchitis
 - Work Loss Days
 - Hospital Admissions, Respiratory
 - Emergency Room Visits, Respiratory
 - Hospital Admissions, Cardiovascular
 - Lower Respiratory Symptoms
 - Mortality
 - Upper Respiratory Symptoms

Pooling Window Name: Basic Functions Basic Functions

Endpoint Group	Endpoint	Author	Qualifier	Location	Start Age	Valuation Method	Pooling Method
Mortality	Mortality, All Cause						None
		Laden et al.			0	VSL, based on rang	
		Pope et al.			0	VSL, based on rang	
		Woodruff et al			0	VSL, based on rang	

Pooling Window Name: Cardio HA over 65 Cardio HA over 65

Endpoint Group	Valuation Method	Pooling Method
Hospital Admissions	COI: med costs + wa	

Pooling Window Name: Resp HA over 65 Resp HA over 65

Endpoint Group	Valuation Method	Pooling Method
Hospital Admissions	COI: med costs + wa	

Advanced Cancel Previous Next

Outputs

- Users can export results to a number of formats:
 - ASCII files
 - Spreadsheets
 - GIS shape files
- Built-in GIS will display:
 - Gridded air quality data
 - Incidence and valuation estimates
- Users can print basic results information

Report Generation

ConfigurationResultsGridReportForm

Column Selection

Grid Fields: Column Row

C-R Function Fields:

- Endpoint Group
- Endpoint
- Pollutant
- Author
- Year
- Qualifier
- Location
- LowAge
- HighAge
- Race
- Gender
- Other Pollutants
- Averaging Time
- Beta
- DistBeta
- P1Beta
- P2Beta
- A
- NameA
- B
- NameB
- C
- NameC
- Function
- Version
- Database
- CompiledFunction
- Incidence
- Incidence2
- Prevalence

Result Fields:

- Point Estimate
- Population
- Delta
- Mean
- Standard Deviation
- Variance
- Latin Hypercube Points

Grouping Options:

- Group by Gridcell, then by C-R function.
- Group by C-R function, then by Gridcell.

Display Options:

Digits After Decimal Point: 0

Elements in Preview: 25

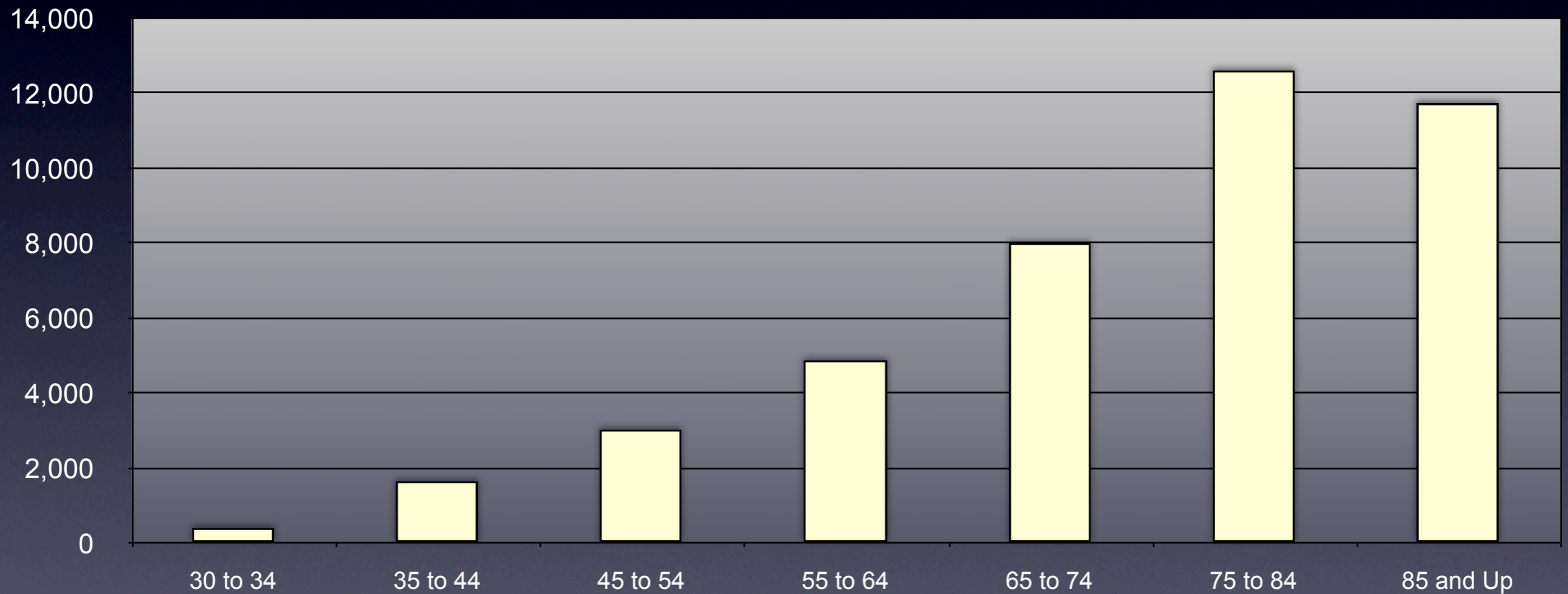
Preview

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
1	1	Hospital Admissions, Cardiovascular	65-74; CO; no ICD410	2	2681	15	2	1

Cancel OK

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

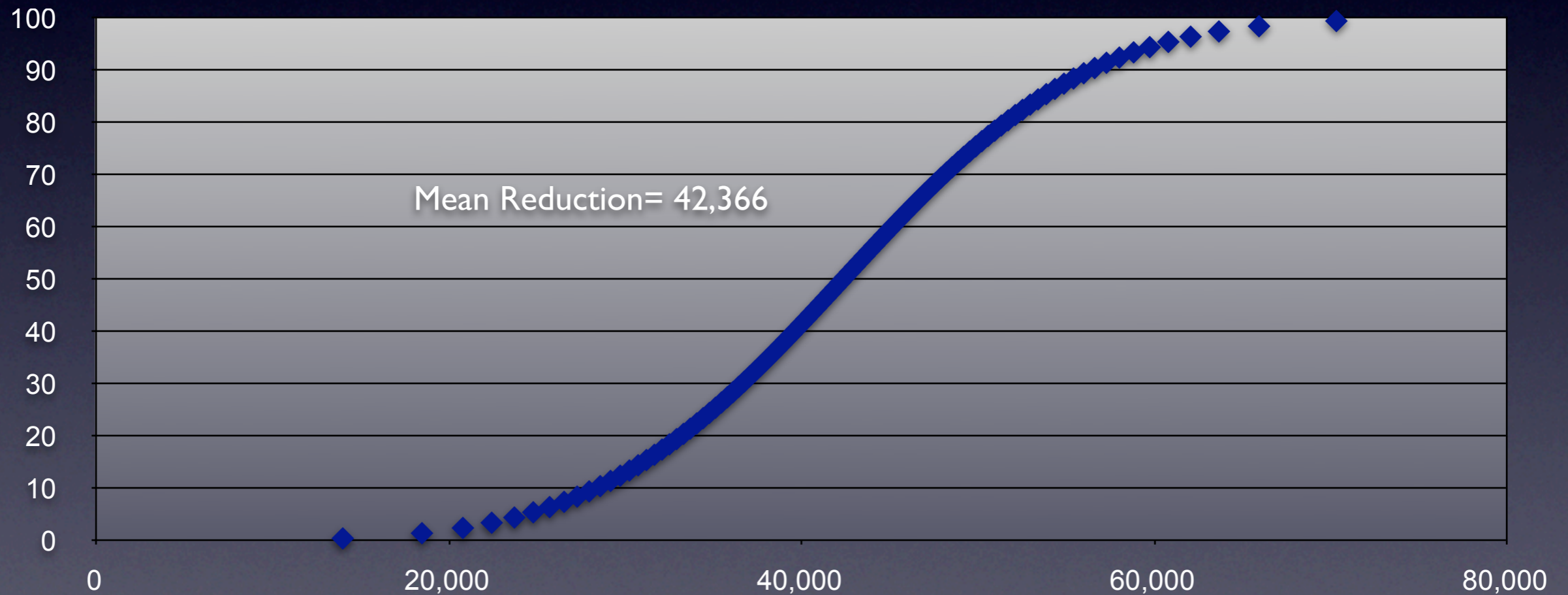
Mortality Impacts by Age Group



Examples of Graphs Produced Using BenMAP Outputs

(2) Distributions of Incidence

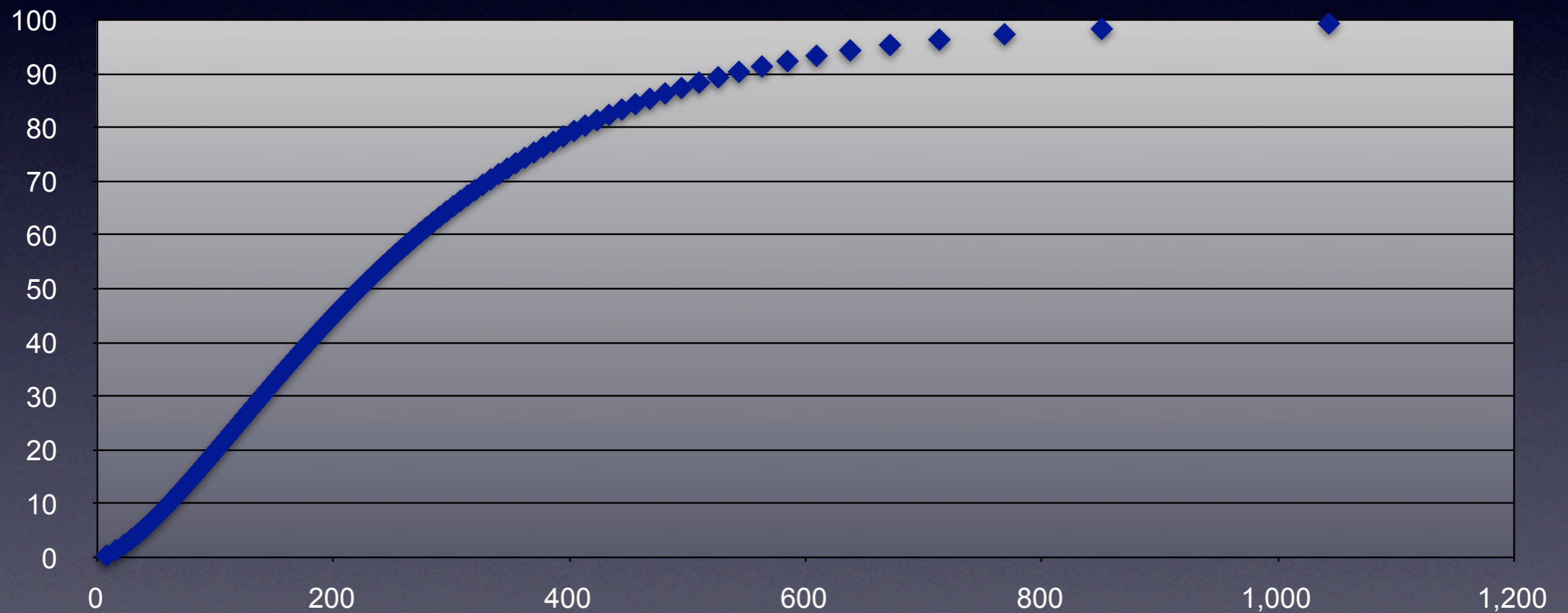
Cumulative Distribution of Total Change in Mortality from a 30% Reduction in PM_{2.5} Levels



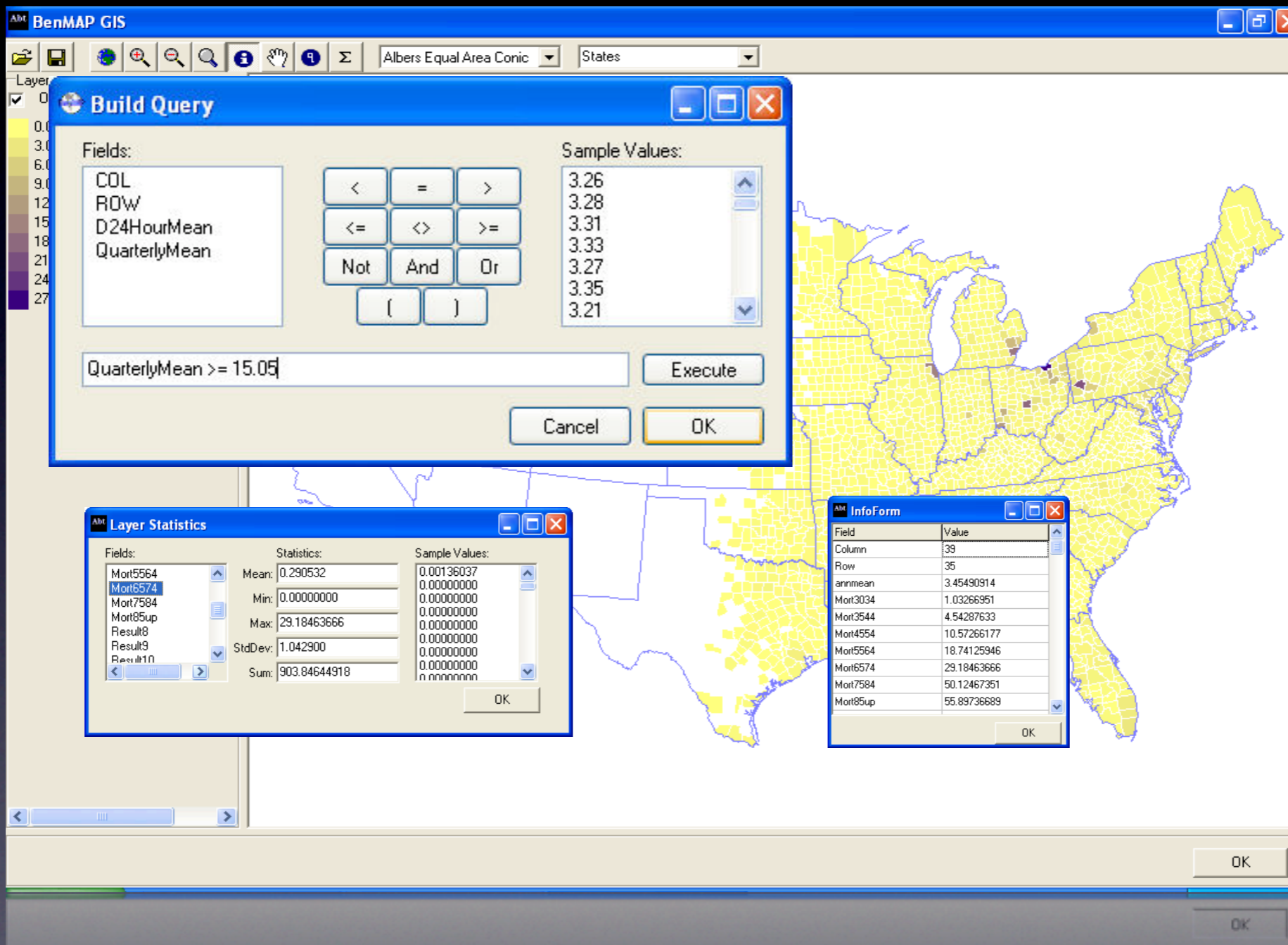
Examples of Graphs Produced Using BenMAP Outputs

(3) Distributions of Monetized Benefits

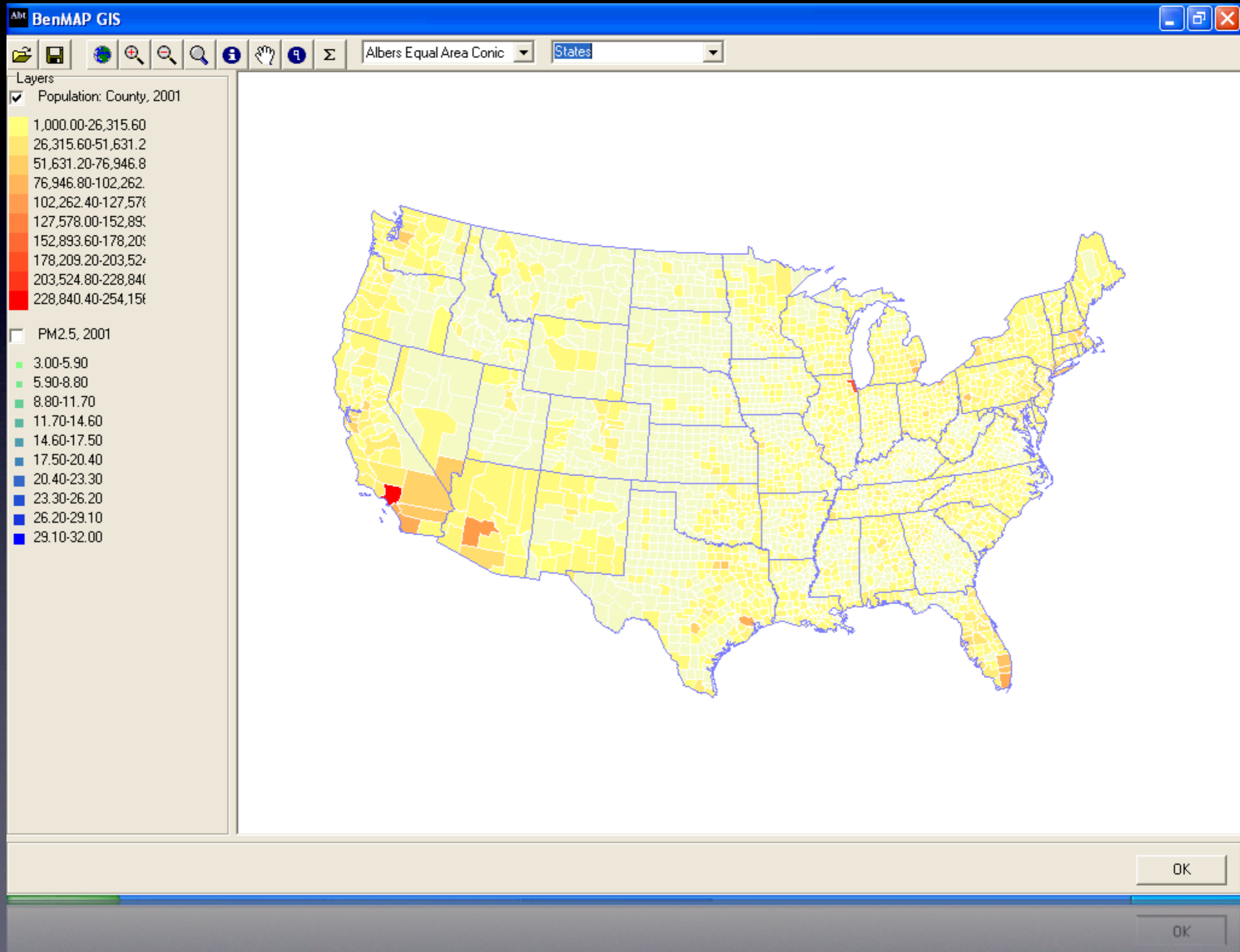
Cumulative Distribution of Value of Reductions in Premature Mortality from a 30% Reduction in PM2.5 Levels



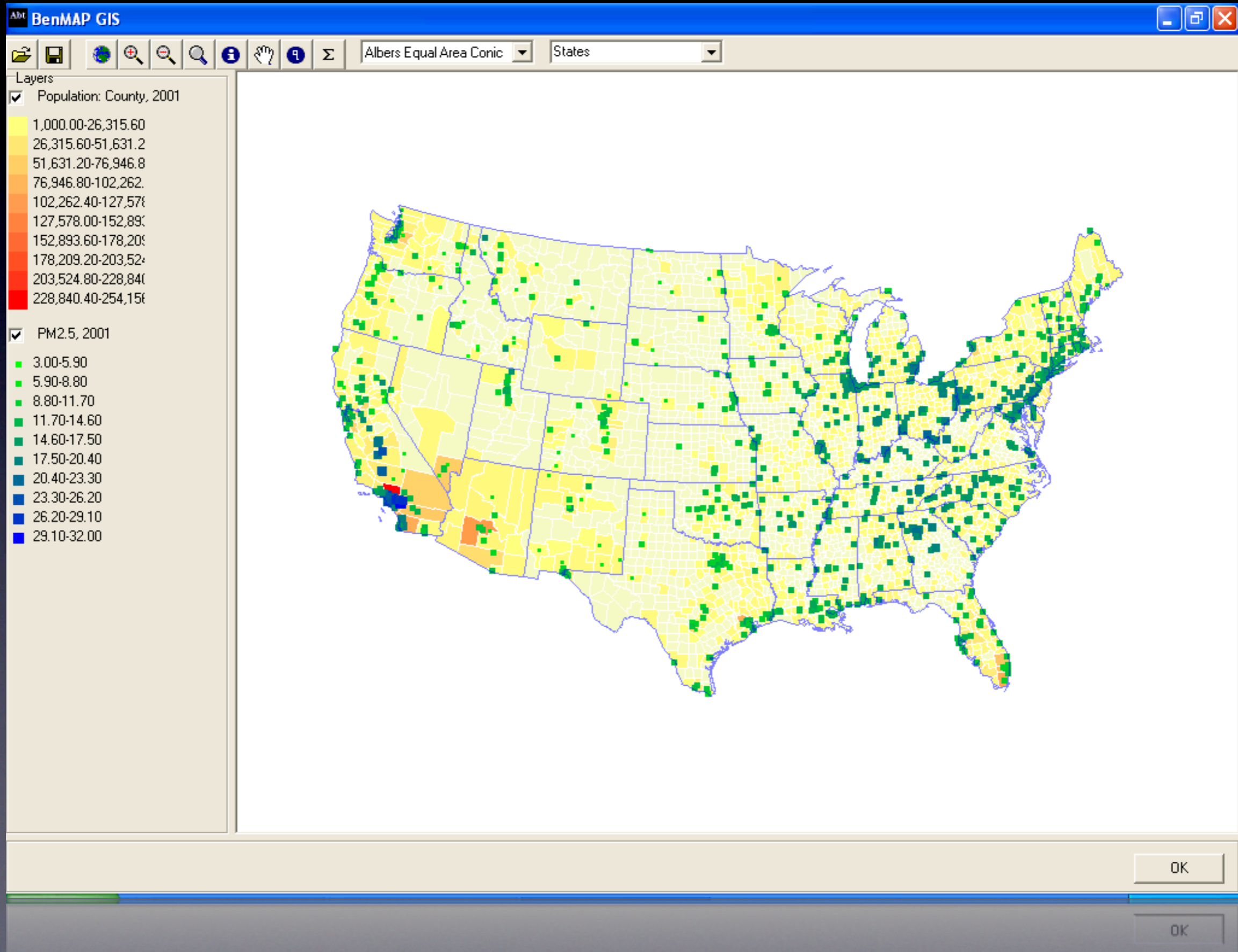
Example of Mapped Mortality Incidence Results



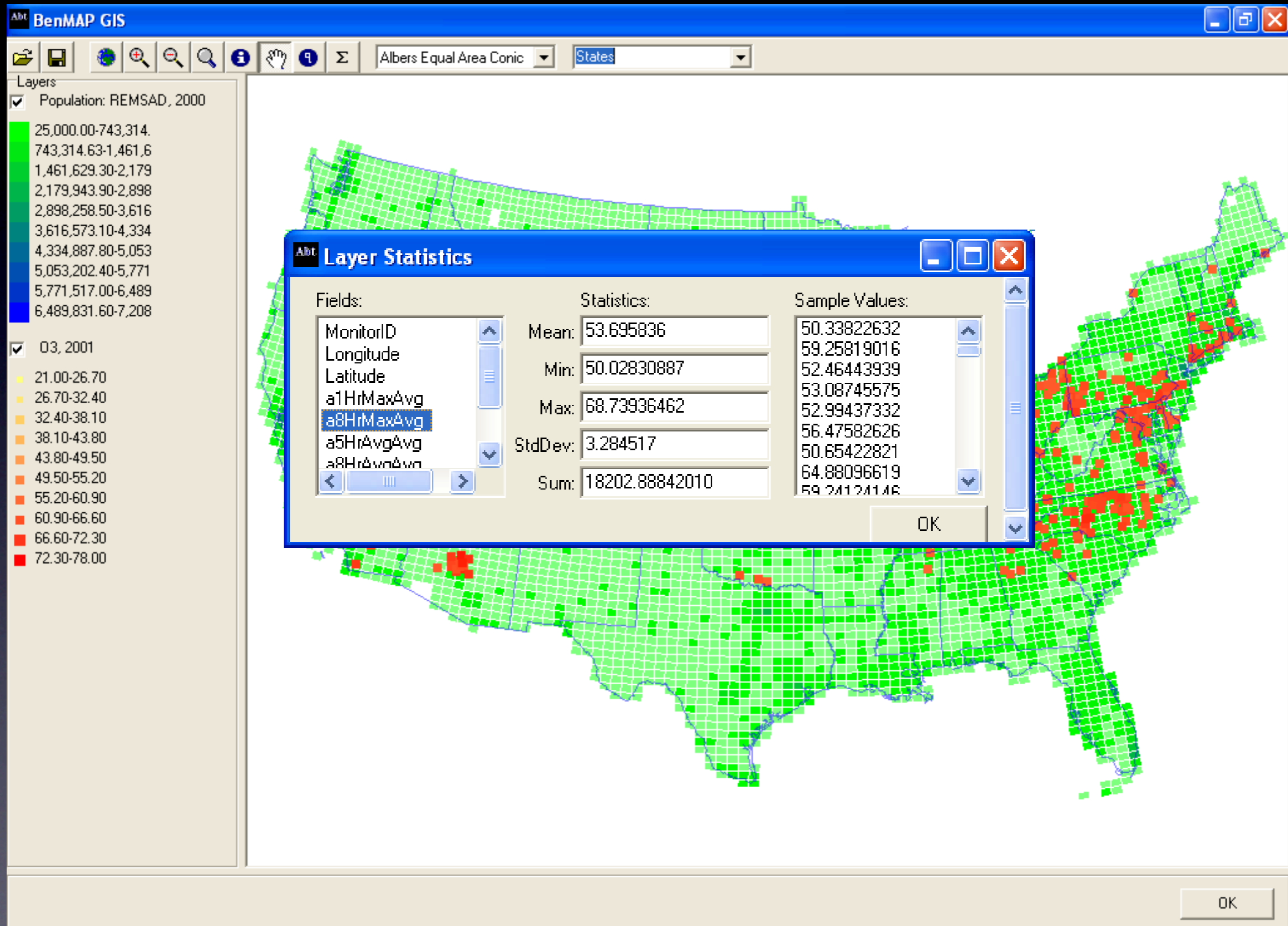
Map underlying population, air quality, and incidence rates



Overlay data from multiple sources



Query data and generate statistics



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.aqq
 - [+] Control Air Quality Grid: C:\Program Files\Abt Associates Inc\Air Quality Grids\Presenation rollback control.aqq
 - 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

Export

OK

Export

OK

[-] Valuation Pooling Trees

Peer Review

- BenMAP was peer reviewed in the Spring of 2004.
- Peer review available on the BenMAP website and included in all distribution CD's.
- Peer review guidance followed to ensure independent, expert review
- Many peer review comments were addressed in version 2.3, released in 2005.

New Features Added in Response to Comments

- Added more C-R and valuation functions
- Added mortality rate projections
- Enhanced documentation
- Enhanced accessibility of underlying databases
- Enhanced flexibility in adding new databases
- Addition of Quality Adjusted Life Years functions
- Addition of income adjustment factors (with uncertainty)

Use of BenMAP in Regulatory Impact Analyses

- Past RIA's:
 - Non-Road Diesel Rule
 - Clean Air Interstate Rule
 - PM_{2.5} NAAQS
 - Small Spark Ignition Rule
 - Locomotive and Marine Diesel Rule
- Upcoming RIA's:
 - Ozone NAAQS
 - SO₂ NAAQS
 - NO_x NAAQS

Example International BenMAP Projects

- South Korea: Health benefits of Seoul air quality management plan
- Latin America: Benefits of air quality improvements in Mexico City, São Paulo, Santiago
- India: Benefits analyses in Mumbai and Pune of alternate air quality policies

Future Directions

- Adding new capabilities:
 - Assessing distributional impacts
 - Valuing reductions in exposures to air toxics
- Improving model interface
 - Creating wizard to enable users to perform a benefits analysis with default options
 - Refreshing user interface
 - Adding context-specific help
- Revising manual