Environmental Benefits Mapping and Analysis Program – Community Edition

User's Manual

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CHAPTER 1

Welcome to BenMAP-CE

In this chapter, find…

- **An overview of the tool.**
- **Installation instructions.**
- **Contacts, sources for more information, and answers to frequently asked general questions.**

The environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) is a powerful, yet easy-to-use program that helps you estimate the number and economic value of health impacts resulting from changes in air pollution concentrations. The open-source BenMAP-CE tool replaces the proprietary version of the program (BenMAP) that the U.S. Environmental Protection Agency (U.S. EPA) first developed in 2003 to analyze national-scale air quality regulations. These analyses include health benefits assessments for the National Ambient Air Quality Standards (NAAQs) for Particulate Matter (2006, 2012) and Ozone (2008, 2010) as well as the Locomotive Marine Engine Rule (2008).

U.S. EPA and its partners designed BenMAP-CE to serve the analytical needs of a range of users, including scientists, policy analysts, and decision makers. Most users apply the BenMAP-CE tool to answer one of two types of questions:

1. What are the human health and economic benefits associated with a policy improving air quality?

2. What is the human health burden attributable to total air pollution levels?

While the BenMAP-CE development team designed the program to be accessible to novice users, the tool includes a number of features that will appeal to advanced analysts as well. For example, analysts can add their own health impact and valuation functions, map results, and perform a suite of sensitivity analyses. Beginning users can take advantage of U.S. EPA's pre-programmed settings and reports in the core program.

1.1 Overview of BenMAP-CE & Benefits Assessment

The BenMAP-CE program estimates the human health impacts and economic value of air quality changes. That is — BenMAP-CE relates air quality changes to human health benefits. Such analyses are a critical component of air quality policy assessments. As such, a variety of Federal, State and Local air pollution officials have used BenMAP-CE to inform air quality management decisions.[1]

BenMAP-CE estimates benefits from improvements in human health, such as reductions in the risk of premature death, heart attacks, and other adverse health effects. Other benefits of reducing air pollution (i.e., visibility and ecosystem effects) are not quantified in the current version of BenMAP-CE. After estimating the reductions in the incidence of adverse health effects, BenMAP-CE calculates the monetary benefits associated with those reductions.

How does BenMAP-CE estimate human health effects?

First, BenMAP-CE determines the change in ambient air pollution using user-specified air quality data. Because BenMAP-CE does not model air quality changes, these data

[1] For a list of peer-reviewed articles that used the BenMAP and BenMAP-CE tools, see: www.epa.gov/air/benmap

must be input into BenMAP-CE as modeling data or generated from air pollution monitoring data (some monitoring data is pre-loaded in BenMAP-CE). Next, BenMAP-CE applies the relationship between the pollution and certain health effects (also known as health endpoints). This relationship is often referred to as the health impact function or the concentration-response (C-R) function, which is derived from epidemiology studies as shown in Figure 1-1. BenMAP-CE applies that relationship to the exposed population to calculate health impacts.

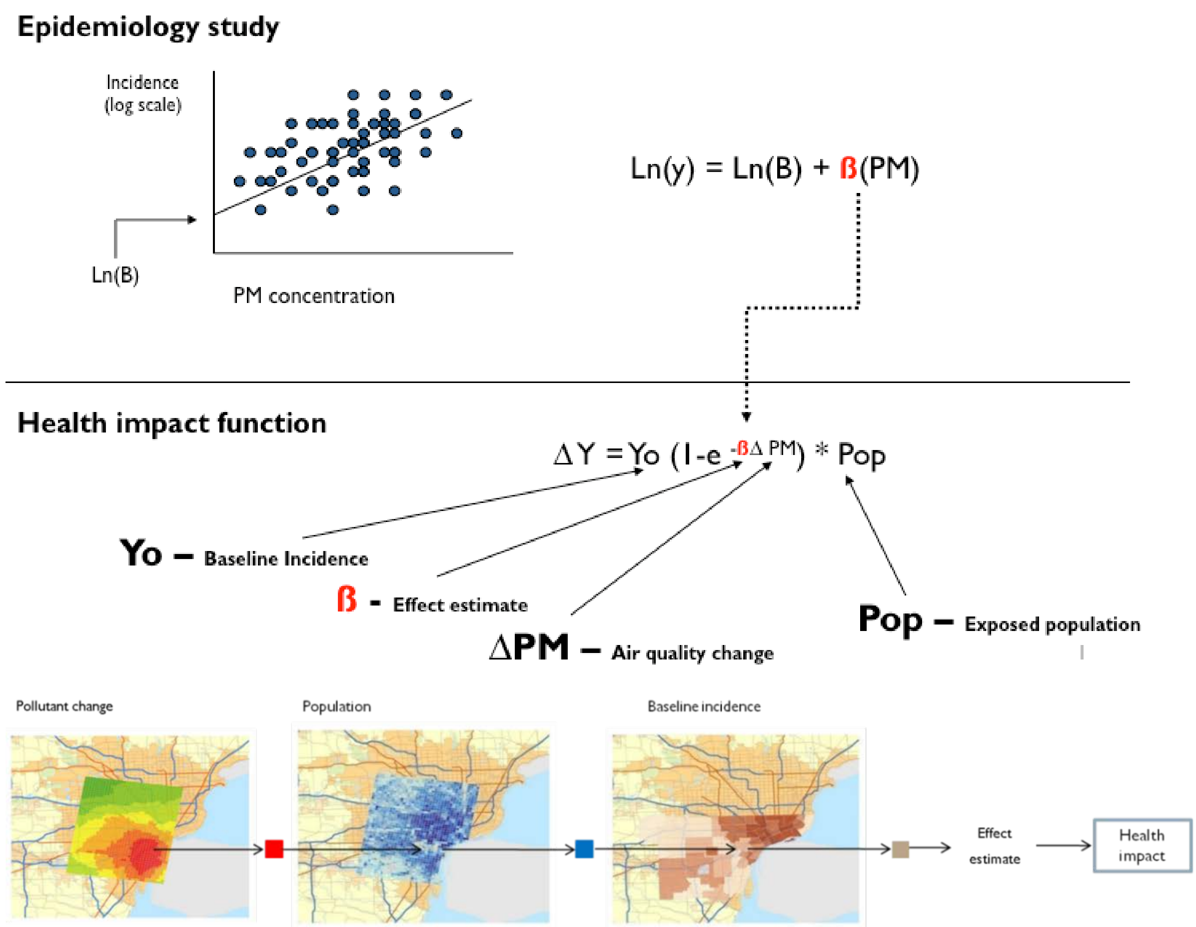


Figure 1-1. Deriving a Health Impact Function from the Epidemiology Literature

A simplified example is shown below.

Health Effect = Air Quality Change * Health Effect Estimate * Exposed Population * Health Baseline Incidence

- **Air Quality Change**. The air quality change is the difference between the starting air pollution level (i.e., the baseline) and the air pollution level after some change, such as a new regulation (i.e., the control).
- **Health Effect Estimate**. The health effect estimate is an estimate of the percentage change in the risk of an adverse health effect due to a one unit change in ambient air pollution. Epidemiological studies are a good source for effect estimates.
- **Exposed Population**. The exposed population is the number of people affected by the air pollution reduction. The government Census office is a good source for this information. In addition, private companies may collect this information and offer it for sale.
- **Health Baseline Incidence**. The health incidence rate is an estimate of the average number of people who die (or suffer from some adverse health effect) in a given population over a given period of time. For example, the health incidence rate might be the probability that a person will die in a given year. Health incidence rates and other health data are typically collected by the government. In addition the World Health Organization is a good source for this.[2]

How does BenMAP-CE estimate the economic value of human health effects?

BenMAP-CE also calculates the economic value of avoided health effects (see Section 7 for details). After calculating the health changes, you can estimate the economic value by multiplying the reduction of the health effect by an estimate of the economic value per case (see Figure 1-2):

Economic Value = Health Effect * Value of Health Effect

[2] The World Health Organization is a good source for international health data, see: http://www.who.int.

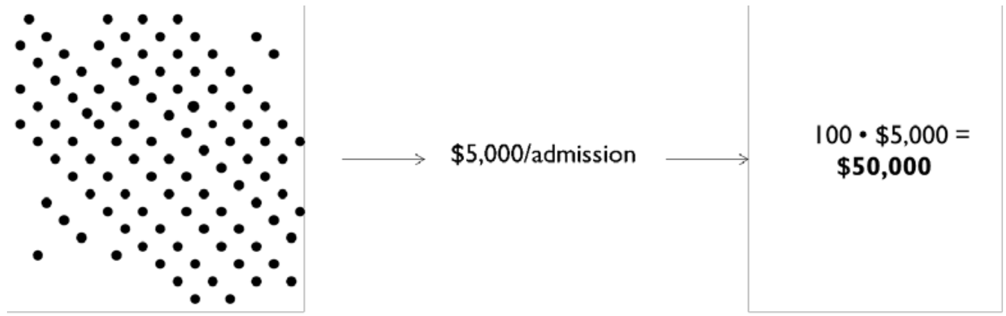


Figure 1-2. Estimating the Economic Value of Human Health Effects

There are several different ways of calculating the value of the health effect. For example, the value of an avoided premature mortality is generally calculated using the Value of Statistical Life (VSL). The value of a statistical life is the monetary value that a group of people are willing to pay to slightly reduce the risk of premature death in the population. For other health effects, the medical costs of the illness may be the only valuation data available. The BenMAP-CE database includes several different functions for VSL and valuation functions for other health effects for you to choose, or you can rely on U.S. EPA's preloaded selections.

Figure 1-3 summarizes the basic steps in BenMAP-CE. This figure shows the types of choices that you make regarding the modeling of population exposure, the types of health effects to model, and how to place an economic value on these health effects. Please note that BenMAP-CE does not have air quality modeling capabilities, and instead relies on externally created air quality modeling and monitoring data.

What else can BenMAP-CE do?

BenMAP-CE incorporates a geographic information system (GIS), allowing users to create, utilize, visualize, and export maps of air pollution, population, incidence rates, incidence rate changes, economic valuations, and other types of data.

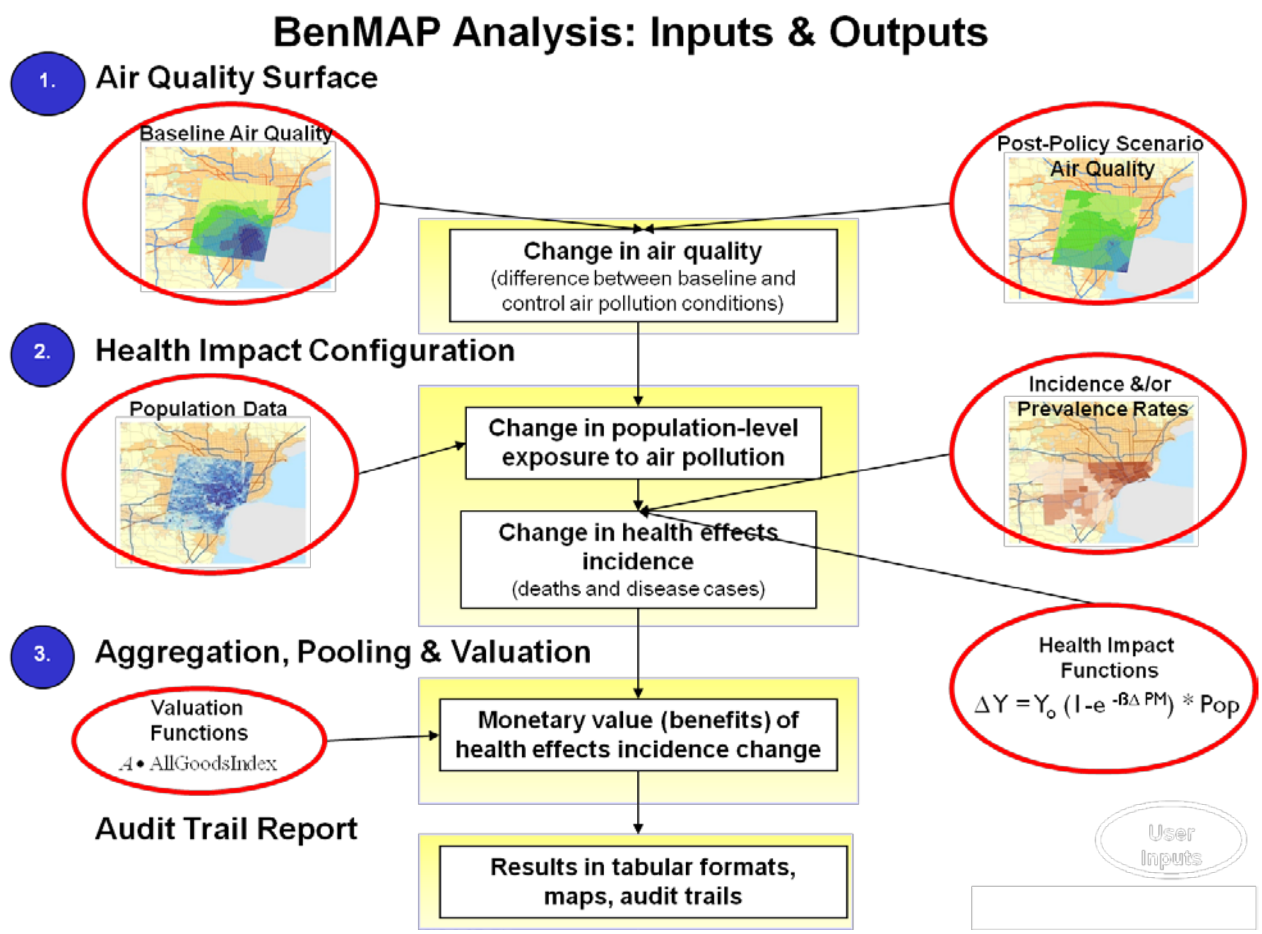


Figure 1-3. BenMAP-CE Flow Diagram

Analysts can use BenMAP-CE to:

- Create maps illustrating the population/community level ambient pollution levels;
- Compare benefits associated with various regulatory programs;
- Characterize the distribution of health impacts among population sub-groups;
- Estimate health impacts and economic values of existing air pollution concentrations;
- Estimate the health benefits of alternative ambient air quality standards; and
- Perform sensitivity analyses of health or valuation functions, or of other inputs.

1.2 How to Use this Manual

Chapters 2 through 9 of this manual provide step-by-step instructions on how to use BenMAP-CE. New users should start with Chapters 2 and 3, which are both very short. These chapters provide a basic overview of the tool and how it works, and they explain some potentially confusing terminology.[3] Use the rest of the manual to answer any specific questions you may have, or to walk you step-by-step through the various components. Chapter 4 discusses how to enter data into BenMAP-CE, Chapters 5 through 7 cover each of the main steps in the Core Program, and Chapters 8 and 9 cover mapping, report options, and additional tools.

Each chapter is introduced by a short section that describes what you can find within the chapter and provides an outline of the chapter's contents. This is a good place to go if the Table of Contents does not provide enough detail for you to find the section you need. The end of most chapters has a series of "Frequently Asked Questions," which may also be helpful in answering specific questions. In chapters that provide instructions on navigating the tool, the following conventions are observed: tree menu items, buttons, tabs and selection box labels are in bold type; prompts and messages are enclosed in quotation marks; and drop-down menu items, options to click or check, and items that need to be filled in or selected by the user are italicized. Throughout the chapters you will also see boxes presenting common mistakes and important things to remember when working with BenMAP-CE.

There is also a set of Technical Appendices to provide more detailed information on model functions, data, and underlying assumptions.

Appendix A: Monitor Rollback Algorithms

Appendix B: Air Pollution Exposure Estimation Algorithms

Appendix C: Deriving Health Impact Functions

Appendix D: Health Incidence & Prevalence Data in U.S. Setup

Appendix E: Particulate Matter Health Impact Functions in U.S. Setup

Appendix F: Ozone Health Impact Functions in U.S. Setup

Appendix G: Nitrogen Dioxide Health Impact Functions in U.S. Setup

Appendix H: Sulfur Dioxide Health Impact Functions in U.S. Setup

Appendix I: Health Valuation Functions in U.S. Setup

Appendix J: Population & Other Data in U.S. Setup

Appendix K: Uncertainty & Pooling

Appendix L: Command Line BenMAP-CE

Appendix M: Function Editor

References

[3] Another good reference is the BenMAP-CE Quick Start Guide, see: http://www.epa.gov/air/benmap.

1.3 Computer Requirements

The computer hardware requirements for BenMAP-CE are typically modest, though this will vary depending on the complexity of the analysis. BenMAP-CE requires a Windows platform and can be used on machines running Windows 7 or Windows 8. In particular, BenMAP-CE requires a computer with:

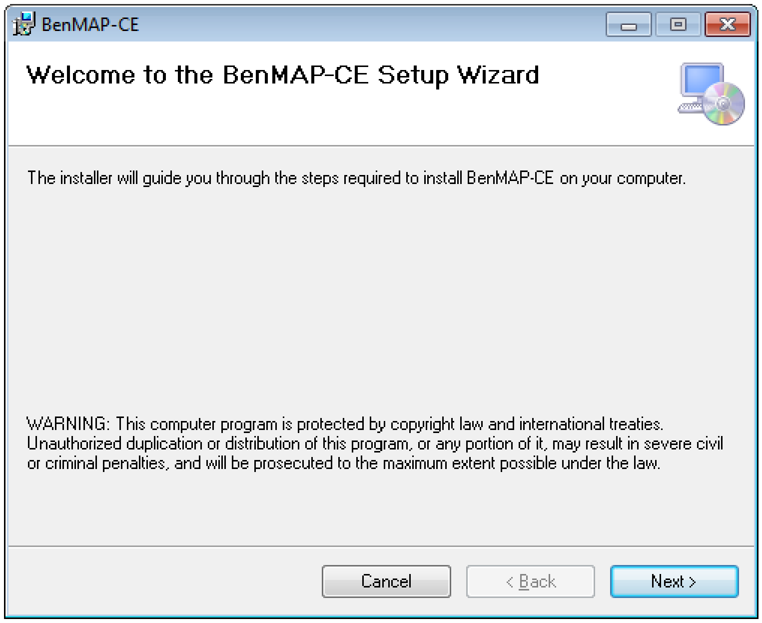
- Windows 7 or Windows 8 (64-bit operating system recommended)
- Adobe Acrobat Reader
- Microsoft Excel or other spreadsheet program (in order to read exported .xlsx files)[4]
- Microsoft .NET Framework 4 (or 4.5)[5]
- 4 Gigabytes of RAM or greater
- Intel or compatible processor, Core i5 (or better)
- At least 10 GB free disk space is recommended for the installation of the BenMAP-CE database and ancillary files.

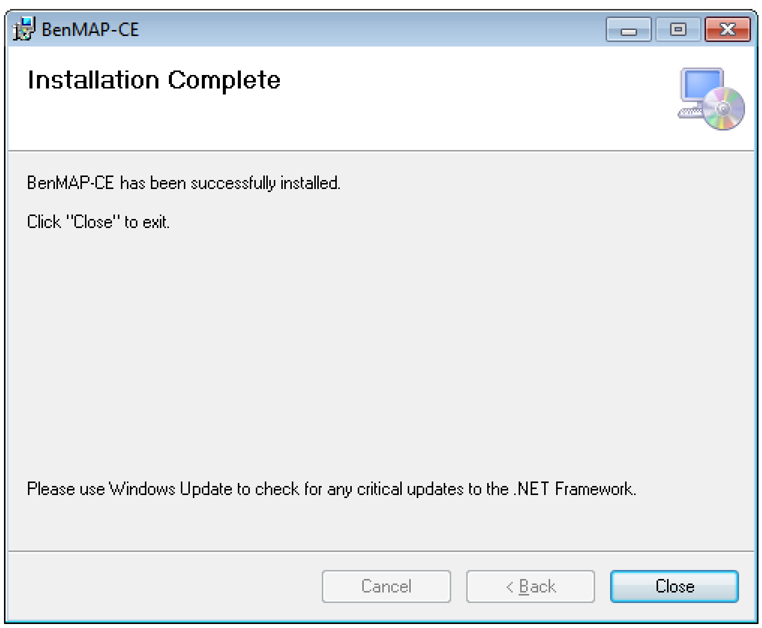
BenMAP-CE works best in a 64-bit Windows environment. With a 32-bit installation there are limits on the memory available to the software application; it can utilize no more than 2 GB of RAM. This will impact performance when processing large spatial datasets or numerous health impact/valuation functions.[6] A solid state drive (SSD) has also shown improved performance over hard disk drives (HDD).

[4] OpenOffice and LibreOffice are two open-source options for spreadsheet tools.
[5] If .NET is not pre-installed, BenMAP-CE will provide a message advising you to install .NET. A standalone installer is available on the Microsoft website (URL: http://www.microsoft.com/en-us/download/details.aspx?id=17718). Install the runtime version and associated files (e.g., dotnetfx40_full_x86_x64.exe).
[6] To determine whether your computer is running a 32-bit or 64-bit version of Windows, refer to this article from Microsoft: http://support.microsoft.com/kb/827218.Installation Paths.

1.4 Installing BenMAP-CE

The installation of BenMAP-CE is very simple. Double click **Setup.exe** in your installation directory to bring up the setup wizard. Then follow the setup wizard by clicking 'Next' or 'OK' to complete the installation.





Upgrading to a new version of BenMAP-CE

Periodically, new versions of BenMAP-CE will be made available and posted to the BenMAP-CE website: http://www.epa.gov/air/benmap/. The upgrade just requires replacing the executable ("*BenMAP-CE.exe*") located in the BenMAP-CE directory, which is typically located at C:\Program Files\BenMAP-CE. The executable is a relatively small file, about 8 megabytes, so the upgrade process is generally very fast.

For upgrades that require replacing or otherwise updating the underlying BenMAP-CE databases, it might be necessary to completely uninstall BenMAP-CE and then reinstall BenMAP-CE with a new installer package. A new installer package can be relatively large, about 400 megabytes for the U.S. version. Luckily a complete reinstallation is often not necessary. Simply replacing the executable or importing new databases (discussed here in the installation section) is usually all that is necessary.

Installation instructions are typically provided with each software release. Refer to these supplemental instructions for important additional information.

1.5 Uninstalling BenMAP-CE

To uninstall BenMAP-CE, go to **Control Panel, Programs and Features** and remove **BenMAP-CE.** Note that uninstalling BenMAP-CE does not also remove any results files that you have created with BenMAP-CE.

1.6 Contacts for Comments, Questions & Bug Reporting

For comments and questions, please contact Neal Fann at the U.S. EPA.

Address: C539-07, U.S. EPA Mailroom, Research Triangle Park, NC 27711

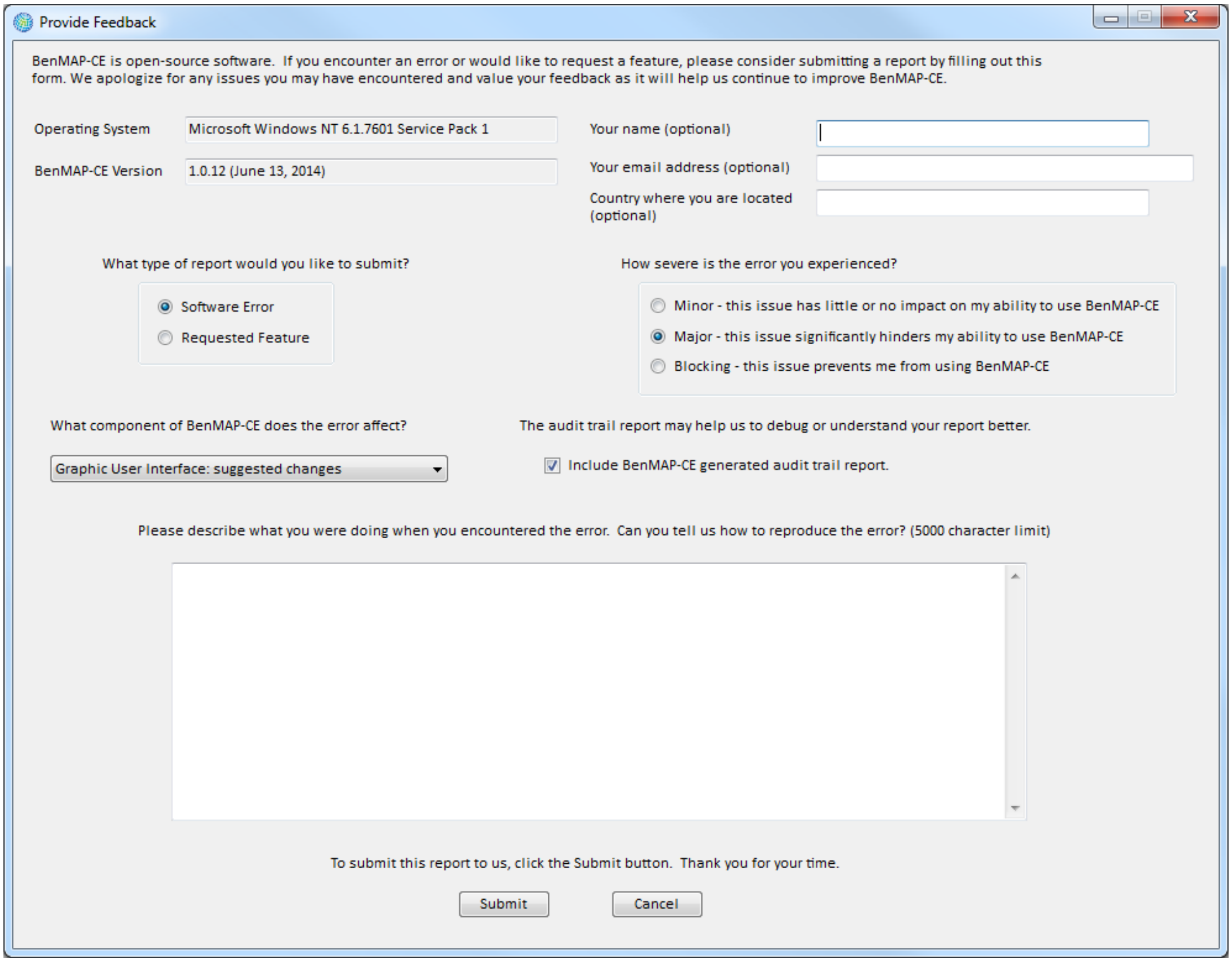
Email: fann.neal@epa.gov

Telephone: 919-541-0209

Alternatively, you can send a message at the BenMAP-CE website: http://www.epa.gov/air/benmap/contact.html, or by simply emailing benmap@epa.gov.

To report programming bugs or suggest additions to the software in BenMAP-CE:

- Select the **Help** menu in the main window;
- Open the **Provide Feedback** form;
- Complete the form and submit the report.



1.7 Sources for More Information

For files that you can use in BenMAP-CE:

- U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (OAQPS), BenMAP-CE website. Available at: http://www.epa.gov/air/benmap/.

For more information on conducting benefit analysis, see the following documents:

- U.S. EPA (various years). Costs and Benefits of the Clean Air Act. Available at: http://www.epa.gov/oar/sect812/
- U.S. EPA (2006). Final Regulatory Impact Analysis: 2006 National Ambient Air Quality Standards for Particulate Matter. Office of Air Quality Planning and Standards. *See*: Chapter 5. Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/Chapter%205--Benefits.pdf

- U.S. EPA (2008). Final Ozone NAAQS Regulatory Impact Analysis. Office of Air Quality Planning and Standards. March. *See:* Chapter 6. Available at: http://www.epa.gov/ttn/ecas/ regdata/RIAs/6-ozoneriachapter6.pdf

- U.S. EPA (2008). Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder. Office of Transportation and Air Quality. EPA420-R-08-001a. May. *See*: Chapter 6. Available at: http://www.epa.gov/otaq/regs/nonroad/420r08001a.pdfU.S. EPA (2010). Final Regulatory Impact Analysis (RIA) for the SO2 National Ambient Air Quality Standards (NAAQS). Office of Air Quality Planning and Standards. June. *See:* Chapter 5. Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/fso2ria100602ch5.pdf

- U.S. EPA (2010). Final Regulatory Impact Analysis (RIA) for the NO2 National Ambient Air Quality Standards (NAAQS). Office of Air Quality Planning and Standards. June. *See:* Chapter 4. Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/FinalNO2RIACh41-20- 10.pdf

- U.S. EPA (2010). Guidelines for Preparing Economic Analyses. Office of the Administrator, National Center for Environmental Economics. EPA 240-R-10-001. December. Available at: http://yosemite.epa.gov/ee/epa/eed.nsf/pages/Guidelines.html

- U.S. EPA (2011). Regulatory Impact Analysis (RIA) for the Final Transport Rule. Office of Air and Radiation. June. See: Chapter 5. Available at: http://www.epa.gov/airtransport/pdfs/FinalRIA.pdf

- U.S. EPA (2011). Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards. Office of Air Quality Planning and Standards. December. See: Chapter 5. Available at: http://www.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf

- U.S. EPA (2012). Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter. *See*: Chapter 5. Available at: http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf

To get email updates about BenMAP-CE:

- U.S. EPA, Office of Air Quality Planning and Standards, BenMAP-CE website - Get Email Updates. Available at http://www.epa.gov/air/benmap/regis.html

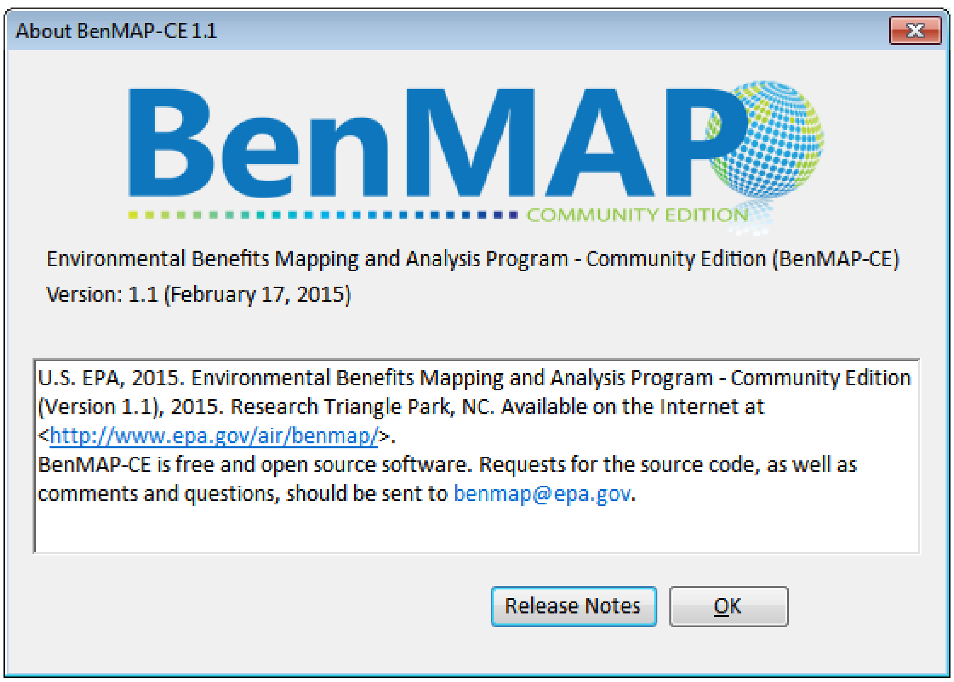
1.8 Frequently Asked Questions (General)

Is BenMAP-CE free? Is there a Terms of Use agreement? Are there any restrictions on using BenMAP-CE?

BenMAP-CE is free. There is no Terms of Use agreement and there are no restrictions on using BenMAP-CE. Feel free to share it with others.

How do I know which version of BenMAP-CE I am using? How do I know if I have the most current version of BenMAP-CE? How do I get the most current version?

You can identify the version of BenMAP-CE you are using by going to the Help menu and choosing **About**. Here you will see the version number and contact information. To determine whether you have the most recent version of BenMAP-CE, you can check the BenMAP-CE website (http://www.epa.gov/air/benmap/), which will have the latest version that is publicly available. Alternatively, you can use the contact information to inquire about any upcoming versions of the model.

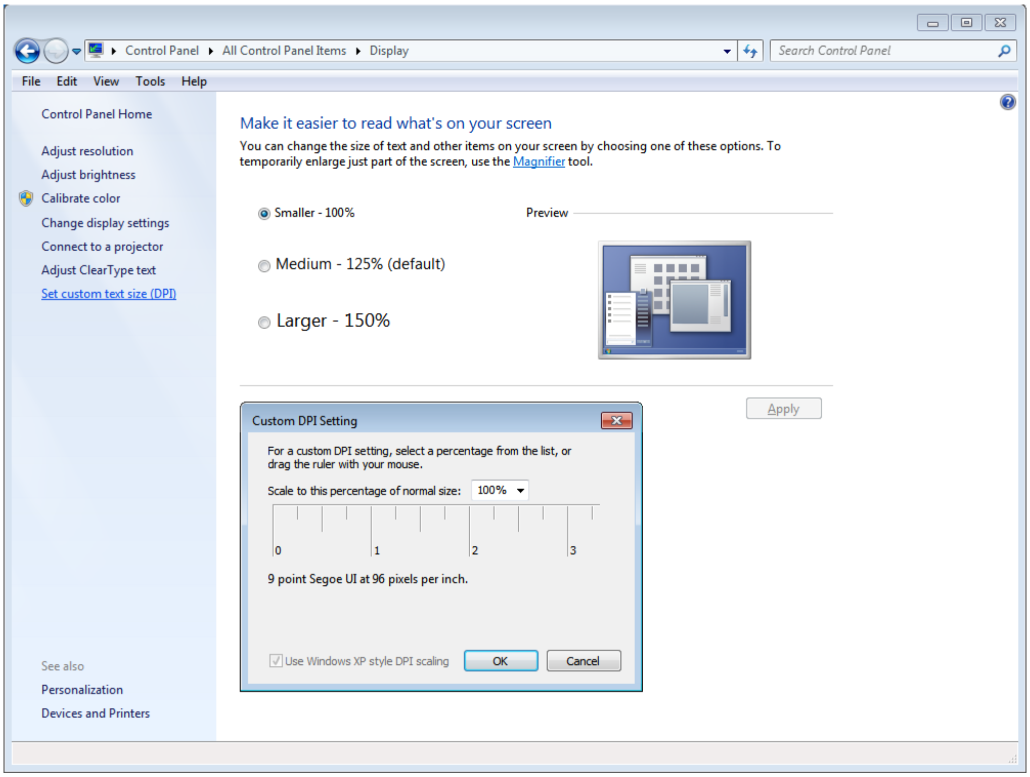


Why don't my files created with an older version of BenMAP work with BenMAP-CE?

Files created with an older version of BenMAP will not, in most cases, work with BenMAP-CE because of changes to the program. For example, later versions of BenMAP-CE have the capability to handle population data differentiated by ethnicity. For this reason, after completing an analysis with BenMAP-CE, it is always good to archive the BenMAP-CE installer along with the files used in your analysis, so that you will always be able to reproduce your work in the future.

Why are my pop-up windows too small? Why are buttons missing?

If the BenMAP-CE pop-up windows do not show the entire content (display seems cut off or buttons are missing), please check the display properties for your computer. Locate your **Control Panel**, then your **Display** settings, and choose the screen resolution associated with **96 DPI** (display pixels per inch). Here is what the screen looks like for Windows 7 Professional operating system.



Why do I get different results than someone else?

There are many possible reasons why your results might differ from someone else's results. One good place to start is the Audit Trail Reporting option. With the Audit Trail you can examine the assumptions and selections that you have made to generate your results and compare your selections with those made in another analysis.

What do I need to be aware of if I use BenMAP-CE for a local scale analysis?

Perhaps the most important issue is to make sure that you have identified the resolution of your analysis and have the appropriate grid definitions loaded into BenMAP-CE. See Chapter 4 (Section 4.1.1) to read about grid definitions. The next key step, which is closely connected to the grid definitions, is to determine the data that you want to use. Data such as air quality modeling, incidence data, and population data need to match the grid definitions that you are using. You also need to be careful about the formatting of your data when loading it into BenMAP-CE. Chapter 4 also provides information on loading data into BenMAP-CE.

Does BenMAP-CE estimate effects of air pollution that are not related to human health (i.e., ecological effects)?

No. BenMAP-CE does not currently have impact functions to estimate other than human health effects. In principle, it would be possible to estimate ecological effects, as BenMAP-CE is designed to combine different types of geographically variable data. To do so, you would need to develop and load data and impact functions appropriate to estimating ecological effects of interest.

How can I get training for BenMAP-CE?

Contact benmap@epa.gov for the latest information on training options.

Where can I find the source code for BenMAP-CE?

BenMAP-CE is an open source program and the development team welcomes contributions and scrutiny from the user community. If you are interested in receiving a current copy of the source code, please contact U.S. EPA at benmap@epa.gov.

CHAPTER 2

Terminology

In this chapter…

- **Find definitions for common terms used in the BenMAP-CE tool and in this manual.**

Active Layer. In the GIS window, the active layer is the top-most data layer. All queries or statistical analysis of the map will act upon this top-most layer.

Aggregation. The summing of grid cell level results to the county, state, and national levels.

Aggregation, Pooling, and Valuation (APV) Configuration. APV configurations store your preferences regarding how to aggregate your results, whether and how to pool your results, and any economic valuation functions you have applied. For example, an APV file might aggregate your estimated change in incidence to the U.S. county level, it might pool across multiple hospital admission health impact functions and it could include an economic valuation function. APV configurations are stored in files with an *.apvx* file extension. The results derived from an APV configuration have an *.apv**r**x* file extension. APV files are by default stored in the *APV* folder, and APV results files are by default stored in the *CFGR* folder.

Air Quality Surface. An air quality surface contains modeled or monitored air pollution data in a series of cells; these cells may be a regular shape (like a 12km by 12km grid) or an irregular shape (like a county or census tract). These surfaces are also referred to as air quality grids. BenMAP-CE uses one air quality grid to represent the baseline scenario and a second grid to represent the control scenario. These baseline and control grids must share the same geographic structure. The program calculates the difference between baseline and control grids as an input to the health impact function. Air Quality Grids are stored in files with an *.aqgx* file extension.

Air Quality Metric. The metric expresses the time period over which air quality values are modeled or observed and whether that modeled or observed air quality value is an average, maximum or minimum. For example, the metric DailyMean represents the average concentration for the sampling day. This could be taken directly from a single 24-hour observation or from an average of hourly (or more frequent) observations. In addition to the time period, some metrics also specify the method used for averaging or aggregation. For example, a typical ozone metric D8HourMax represents the highest of the 8-hour moving averages during the day.

Air Quality Model. Air quality models are valuable air quality management tools. Models are mathematical descriptions of pollution transport, dispersion, and related physical and chemical processes in the atmosphere. Air quality models (like CMAQ[1] and CAMx[2]) are used to estimate the air pollutant concentration at specific locations, which are referred to as receptors, or over a spatial area that has been divided into uniform grid squares. The number of receptors or grid-cells in a model far exceeds the number of monitors one could typically afford to deploy in a monitoring study. Therefore, models provide a cost-effective way to analyze pollutant impacts over a wide spatial

[1] Community Multi-scale Air Quality (CMAQ) Model is available at: http://www.epa.gov/amad/Research/RIA/cmaq.html or https://www.cmascenter.org/cmaq/.
[2] Comprehensive Air Quality Model with Extensions (CAMx) is available at: http://www.camx.com/.

area where factors such as meteorology, topography, and emissions from both local and remote sources could be important. BenMAP-CE does not contain an air quality model.

Attainment. The state of meeting the National Ambient Air Quality Standard (NAAQS) for a pollutant. A geographical area that meets the NAAQS is called an "attainment area."

Audit Trail. This is a report that contains a record of all the choices involved in creating a particular file. Audit trails can be created for any file that BenMAP-CE creates.

Background Concentration. The concentration of a pollutant, generally in the absence of human sources.

Background Incidence. The incidence of a given adverse effect due to all causes including air pollution. Also called baseline incidence rates.

Baseline Scenario. The air quality levels prior to whatever policy change you are evaluating. The baseline is sometimes referred to as “Business as Usual.” The baseline scenario is usually considered to be the reference scenario against which to compare a potential “control scenario”, in which air quality levels are changed from the baseline levels.

Beta. The coefficient for the health impact function. The value of beta (ß) typically represents the percent change in a given adverse health impact per unit of pollution.

Closest Monitor. The procedure by which data from the closest monitor is used to represent air pollutant levels in a population grid cell. BenMAP-CE can also scale the data from the closest monitor with air pollution modeling data. BenMAP-CE includes two types of scaling - “temporal” and “spatial”. See “Scaling” for additional information.

Community Multi-scale Air Quality (CMAQ) Model. An open-source photochemical grid air quality model that the U.S. EPA and others rely upon to predict levels and changes in pollutant concentrations.

Concentration-Response (C-R) Function. A C-R function estimates the relationship between adverse health effects and ambient air pollution, and is used to derive health impact functions (defined below). You will often see that the term C-R function and health impact function are used interchangeably.

Configuration. A Configuration stores the health impact functions and model options used to estimate adverse health effects. Configurations are stored in files with a *.cfgx* file extension. CFGX files are by default stored in the *CFG* folder. The results derived from a Configuration have a *.cfgrx* file extension. CFGR files are by default stored in the *CFGR* folder.

Contingent Valuation. A survey-based economic technique for the valuation of non-market resources, such as environmental preservation or avoidance of air pollution health risk.

Control Scenario. In a modeling study, this is a sensitivity scenario in which emissions from one or more source sectors are changed (increased or decreased) from a given "baseline scenario". The control scenario generally represents air quality levels after a new policy has been implemented.

Core BenMAP-CE. The fully-featured benefits analysis program that accepts user-defined air quality data, quantifies health impacts, aggregates, values and pools results.

Cost of Illness (COI). The cost of illness includes the direct medical costs and lost earnings associated with illness. These estimates generally understate the true economic value of reductions in risk of a health effect, as they include just the direct expenditures related to treatment and lost earnings but not the value of avoided pain and suffering.

Currency Year. The value of the currency based on the year specified. Valuation estimates should use a consistent currency year to account for inflation. For example, you might want to report the valuation estimate in 2000 dollars to make it easier to compare with your cost analysis, which uses that same currency year.

Deltas. The difference between two data points. As used in BenMAP-CE, mapping the air quality deltas shows the change in air pollution between the baseline air quality grid and the control air quality grid.

Discount Rate. In a cost-benefit analysis, the discount rate is a quantitative method to account for the fact that people generally value future benefits and costs less than current costs and benefits. Typically, if a benefit occurs over multiple years, the economic benefit would be discounted.

Endpoint. An endpoint is a subset of an endpoint group, and represents a more specific class of adverse health effects. For example, within the endpoint group *Mortality*, there might be the endpoints *Mortality, Long Term, All Cause* and *Mortality, Long Term, Cardiopulmonary*.

Endpoint Group. An endpoint group represents a broad class of adverse health effects, such as premature mortality or hospital admissions. BenMAP-CE only allows pooling of adverse health effects to occur within a given endpoint group, as it generally does not make sense to sum the number of cases of disparate health effects, such as premature mortality and hospital admissions.

Epidemiology. The study of factors affecting the health and illness of populations. Epidemiological studies cannot prove that a specific risk factor actually causes the disease being studied but can only show that a risk factor is associated (correlated) with a higher incidence of disease in the population exposed to that risk factor.

FIPS Code. Federal Information Processing Standard codes. Each state in the United States is assigned a 2-digit code. For example, "01" refers to Alaska, "37" refers to North Carolina, and "56" refers to Wyoming.

Fixed Effect Pooling. Fixed effect pooling is one method to combine two or more distributions of health impact or economic value estimates into a single new distribution. Fixed effect pooling assumes that there is a single true underlying relationship between these component distributions, and that differences among estimated parameters are the result of sampling error. Weights for the pooling are generated via inverse variance weighting, thus giving more weight to the studies that exhibit lower variance and less weight to the input distributions with higher variance. See Random Effects Pooling below for additional information regarding pooling techniques.

Fixed Radius. An option to interpolate air quality data points that uses all monitors within a fixed radius (or distance) of a given point of interest. All monitors are used and weighted by their relative distance.

GIS. Geographic Information System. A GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data.

Global Burden of Disease. The World Health Organization global burden of disease (GBD) study measures burden of disease using the disability-adjusted-life-year (DALY). This time-based measure combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health. The DALY metric was developed in the original GBD 1990 study to assess the burden of disease consistently across diseases, risk factors and regions.[3]

Grid Cell. One of the many geographic, or spatial, components within a Grid Definition. These can be regularly or irregularly shaped.

Grid Definition. A BenMAP-CE Grid Definition provides a method of breaking a geographic region into areas of interest (Grid Cells) in conducting an analysis. This can be done in two ways - by loading a Shapefile (a particular type of GIS file) or by specifying a regularly shaped grid pattern. These are referred to as Shapefile Grid Definitions and Regular Grid Definitions, respectively. Typically a Shapefile Grid Definition is used when the areas of interest are political boundaries with irregularly shaped borders, while a Regular Grid Definition is used when the areas of interest are uniformly shaped grids (e.g., rectangles). All grid definitions must have a unique (i.e., non-repeating) column and row index.

Health Impact Function. A health impact function calculates the change in adverse health effects associated with a change in exposure to air pollution. Based on a C-R function, a typical health impact function has inputs specifying the air quality metric and pollutant; the age, race and ethnicity of the population affected; and the incidence rate of the adverse health effect.

[3] For more information on the GBD, see: http://www.who.int/topics/global_burden_of_disease.

Incidence. The total number of adverse health effects in a geographic region in a given unit time. In BenMAP-CE, this is the total number of adverse health effects avoided due to a change in air pollution levels.

Incidence Rate. The background rate of a health effect per person in a given geographic region. The average number of adverse health effects per person per unit of time, typically a day or a year. The incidence rate must be expressed at the same time scale as the remainder of the health impact function. For example, a health impact function quantifying day-to-day changes in premature death must specify a daily death rate.

Income Growth Adjustment. Adjusting certain valuation functions to reflect increases in real income over time. Generally, an increase in real income implies an increase in the willingness to pay (WTP).

Interpolation. The process of estimating the air quality level in an unmonitored area by using one or more nearby air quality monitors. BenMAP-CE uses two types of interpolation procedures: one is to simply choose the closest monitor, the other is to use a technique called Voronoi Neighbor Averaging. These interpolation methods are discussed in more detail in Appendix B.

Lat/Long. Latitude and longitude information to specify the geographic coordinates of a spatial location. The CMAQ model data are usually provided for each grid cell identified by the latitude and longitude of the grid cell's center point. Latitude identifies the north-to-south location of a point on the Earth. Longitude identifies the east to west location of a point on the Earth.

Layer. In GIS, a layer represents a logical separation of mapped data usually representing a theme, such as political boundaries, roads, ozone data, number of mortalities avoided, etc.

Layer Statistics. The summary statistics that correspond to the active layer in BenMAP-CE. For example, “mean”, “standard deviation” or “max” of PM2.5 air quality grid.

Metadata. Data that serves to provide context or additional information about other data. BenMAP-CE stores a minimum set of standardized metadata fields for imported data files (e.g., file name, file date, reference, import date, and description). For certain data types, additional metadata are recorded. For example, GIS metadata will include information about datum, geographic coordinate system, resolution, and units.

Micrograms per Cubic Meter ($\mu g/m^3$). The unit of measure for particulate matter in the NAAQS. This unit represents the mass of PM and other particle pollutants found in a cubic meter of air.

Model Data. Pollutant concentration data that are generated by running an air quality model such as CMAQ. This is different from "monitor data," which are based upon observed concentrations.

Monetize. In the context of human health benefits assessment, this is the practice of expressing society's preferences for avoiding certain health effects as an economic value (e.g., in U.S. dollars). In BenMAP-CE we estimate monetized benefits by using either Willingness to Pay or Cost of Illness valuation functions (see above and below).

Monitor Data. Pollutant concentration data that are based upon measurements from an air quality monitor. "Raw" monitor data usually refers to data that are taken directly from measurement networks, with no additional processing of the data. Monitor data are different from "model data," which are based upon numerical predictions from an air quality model.

Monitoring. Actual measurements of air pollution concentrations. The U.S. EPA has monitoring data, as well as other information related to monitoring, available through its Air Quality System (AQS): http://www.epa.gov/air/data/aqsdb.html

Monte Carlo Simulation. A technique used in BenMAP-CE to quantify the confidence intervals around mean incidence and economic value estimate by randomly sampling an uncertainty distribution around the effect coefficients or willingness to pay estimates.

Morbidity. A measure of being diseased or afflicted by an illness (generally non-fatal).

Mortality. A measure of the number of deaths in a given population.

National Ambient Air Quality Standards (NAAQS). The U.S. EPA establishes levels for pollutants that are considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and against damage to animals, crops, vegetation, and buildings. The U.S. EPA has set NAAQS for six principal pollutants, which are called "criteria" pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter ($PM_{2.5}$, PM_{10}), and sulfur dioxide.

Odds Ratio. A quantitative measure reported in epidemiology studies of the relationship between exposure to air pollution and a health outcome. Odds Ratios must be converted to beta coefficients to be used in BenMAP-CE

Ordinality. In relation to air quality monitors, ordinality refers to the number of monitor values in the season that can exceed your standard. For example, if we had set the ordinality to four, then a monitor can have as many as three daily averages (assuming that we are using the daily average metric to define our standard) greater than your standard without violating the standard. In terms of rollback, if it has more than three daily averages in exceedance of the standard, then the rollback technique will be applied to that monitor.

Ozone (O_3). BenMAP-CE focuses on ground level or "bad" ozone, which is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC. Breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

Particulate Matter. Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. Includes $PM_{2.5}$ (particles less than 2.5 microns in aerodynamic diameter), PM_{10} (particles less than 10 microns in aerodynamic diameter), and $PM_{10-2.5}$ (particles between 2.5 and 10 microns in aerodynamic diameter).

Parts per Million (ppm). This unit represents the concentration of the pollutant in a million parts of air. Carbon monoxide is often measured in units of ppm.

Parts per Billion (ppb). This unit represents the concentration of the pollutant in a billion parts of air. Ozone concentrations in BenMAP-CE are reported in units of ppb.

POC (Parameter Occurrence Code). An identifier used by U.S. EPA to distinguish between multiple monitors at the same site that are measuring the same parameter. For criteria pollutants, multiple monitors may be collocated to check precision. For combining data at the site level, the POC identifies the primary monitor (most frequent sampling). (POC appears in BenMAP-CE's advanced filtering options for monitor data.)

Pooling. The combining of different sets of data. BenMAP-CE has several pooling methods, including fixed effects, fixed/random effects, and subjective weighting. Appendix K discusses the pooling approaches available in BenMAP-CE.

Point Mode. When defining the configuration, you may choose to either estimate adverse health effects in point mode or using percentiles. The point mode simply means that BenMAP-CE will use the mean value of the coefficient in the health impact function.

Population Exposure versus Personal Exposure. Population (or ambient) exposure refers to the average air pollution level measured in a grid cell. In contrast, personal exposure keeps track over the course of a day the exposure individuals encounter in different micro-environments, such as the freeway, outdoors and indoors. BenMAP-CE only represents population exposure.

Population-weighted Air Quality. Modeled or monitored ambient concentrations that have been weighted according to the number of people exposed.

Prevalence Rate. The percentage of individuals in a given population who already have a given adverse health condition. Used to calculate changes in health conditions among those who already have a health condition, such as asthmatics.

Random Effect Pooling. Random effect pooling is one method to combine two or more distributions of health impact or economic value estimates into a single new distribution. This approach allows the possibility that the estimated parameter from different studies may in fact be estimates of different parameters, rather than just different estimates of a single underlying parameter.

Regulatory Impact Analysis (RIA). A policy tool used to assess the likely effects of a proposed regulation or regulatory change. It usually involves detailed analyses to quantify the costs and benefits of the regulation.

Relative Risk. Relative risk typically is used as a measure of the change in risk of an adverse health effect associated with an increase in air pollution levels in an epidemiology study. More specifically, it is the ratio of the risk of illness with a higher pollution level to the risk of illness with a lower pollution level, where the "risk" is defined as the probability that an individual will become ill.

Rollback. The process by which monitor data are reduced to a different level. BenMAP-CE rolls back monitor data in three ways. Percentage rollback reduces all monitor observations by the same percentage. Incremental rollback reduces all observations by the same increment. Rollback to a standard reduces monitor observations so that they just meet a specified standard.

Setup. A BenMAP-CE setup encapsulates all of the data needed to run analyses for a particular geographic area—a city, an entire country, etc. These data consist of grid definitions, pollutants, monitor data, incidence and prevalence rates, population data, health impact functions, variables, inflation rates, and valuation functions.

Shapefile. A shapefile is a particular type of GIS file, and has a *.shp* extension. These files are accompanied by companion files with *.shx* and *.dbf* extensions, and can be used to create Shapefile Grid Definitions. See http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf for more information.

Sum Dependent Pooling. Summing two or more incidence or valuation results, assuming the underlying functions are correlated. For example, summing the incidence of respiratory hospital admissions for two different age groups quantified using C-R functions from the same study.

Sum Independent Pooling. Summing two or more incidence or valuation results, assuming the underlying functions are independent (uncorrelated). For example, summing the incidence of respiratory hospital admissions quantified using C-R functions from different studies using different methods.

Threshold. BenMAP-CE's advanced settings for health impact functions allows you to specify an air quality threshold; this is an air quality level below which benefits are not calculated. For example, if the threshold is 5 μg/m^3, then only areas with $PM_{2.5}$ concentrations equal to or greater than 5 μg/m3 will be included in estimating health incidence results. Specifying a threshold does not affect the shape of the C-R function used to quantify impacts.

Unit Value. A unit value is the estimated mean economic value of avoiding a single case of a particular health effect.

User-defined Weights Pooling. User-defined weights let you specify the weights that you want to use when combining two or more distributions of results. The weights should sum to one. If not, BenMAP-CE normalizes the weights so that they do.

Valuation Function. Valuation functions are used by BenMAP-CE to estimate the economic values of changes in the incidence of health effects. These are selected within an Aggregation, Pooling, and Valuation Configuration (APV Configuration).

Variable Datasets. Health Impact functions and valuation functions may sometimes refer to variables other than those for which BenMAP-CE automatically calculates values. For example, some valuation functions reference the median income within each area of analysis. To facilitate this, BenMAP-CE allows you to load datasets of variables for use in functions, which may be used globally or may vary geographically (meaning they are associated with a particular Grid Definition).

VNA (Voronoi Neighbor Averaging). An algorithm used by BenMAP-CE to interpolate air quality monitoring data to an unmonitored location. BenMAP-CE first identifies the set of monitors that best "surround" the center of the population grid cell, and then takes an inverse-distance weighted average of the monitoring values. This is discussed in detail in Appendix B.

WTP (Willingness to Pay). The willingness of individuals to pay for a good or service, such as a reduction in the risk of illness. In general, economists tend to view an individual's WTP for an improvement in environmental quality as the appropriate measure of the value of a risk reduction. An individual's willingness to accept (WTA) compensation for not receiving an improvement is also a valid measure. However, WTP is generally considered to be a more readily available and conservative measure of benefits.

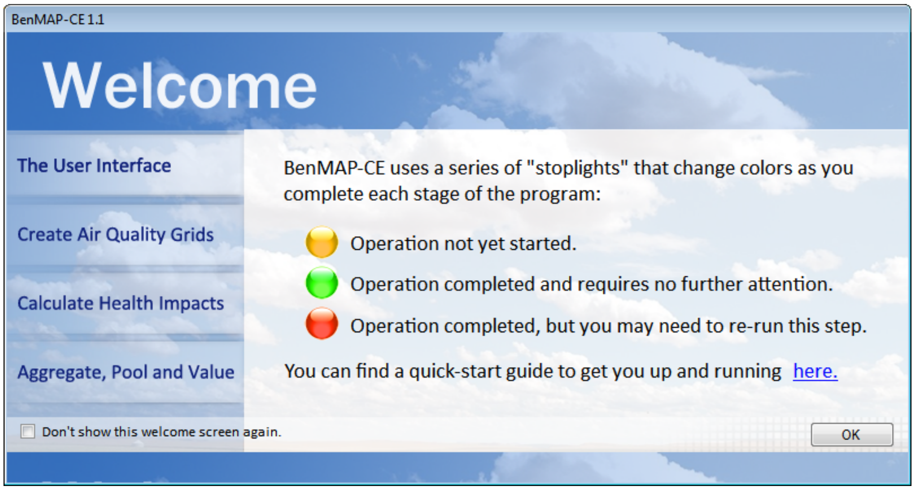
CHAPTER 3

Overview of BenMAP-CE Features

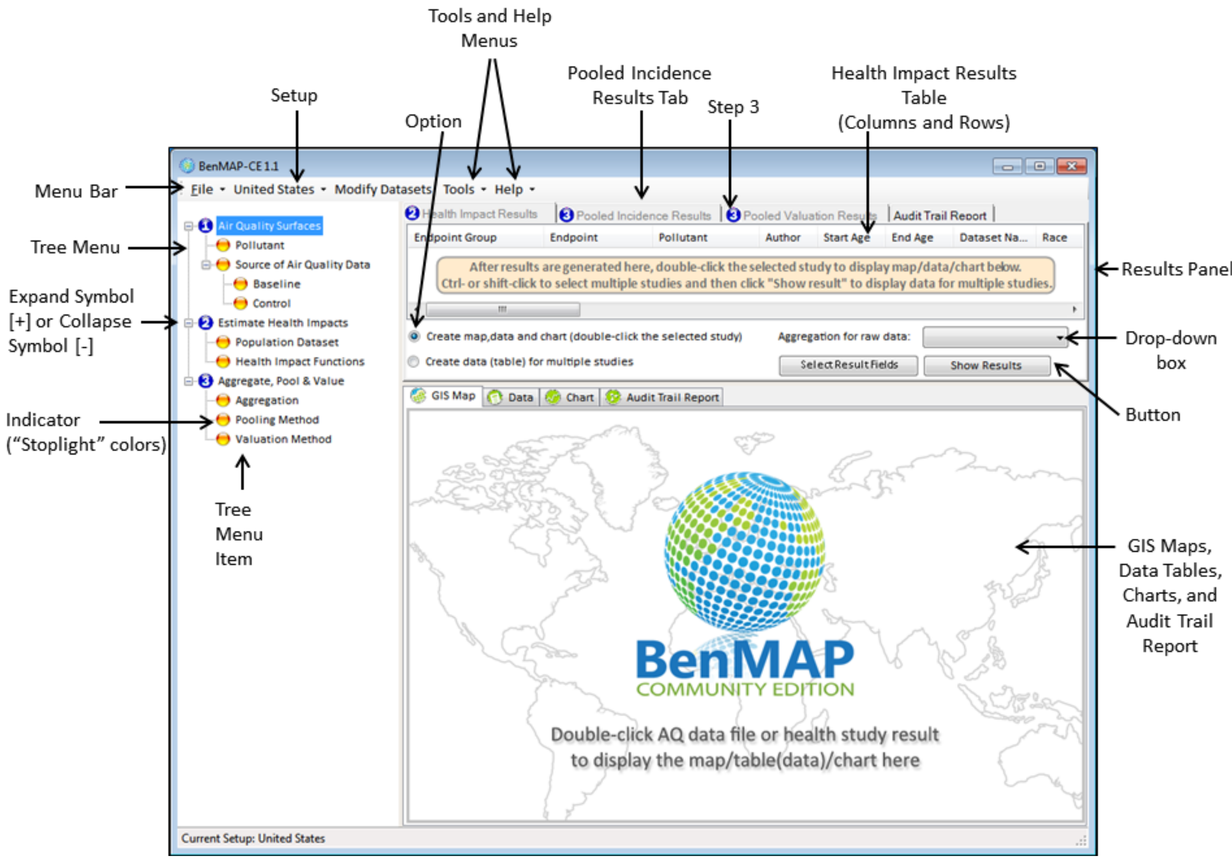
In this chapter…

- Get an overview of the features available with the Core Program.
- Learn about additional BenMAP-CE modules.
- Learn about the Tools and Help menu options.
- Find descriptions of the various outputs including types of files, results, maps and reports available from BenMAP-CE.

Upon starting BenMAP-CE for the first time, you will see the following **Welcome** screen.



The **Welcome** screen gives a brief description of the user interface and highlights the "stoplight" metaphor used in BenMAP-CE to indicate the status of analytical steps performed using the tree menu on the left side of the main window. Clicking the links on the left side of the **Welcome** screen (e.g., **Create Air Quality Grids**) will provide information about each feature. You will also find a link to the BenMAP-CE website for downloading the most current BenMAP-CE software and other reference information. If you do not wish to see the **Welcome** screen at program start-up, check the option '*Don't show this window screen again'* in the lower left-hand corner of the screen. To re-enable the **Welcome** screen, go to **Tools** menu on the main BenMAP-CE window, select **Options,** and check the option for *Show Start Window*. Press **OK** on the **Welcome** screen to close this window and display the BenMAP-CE main window.

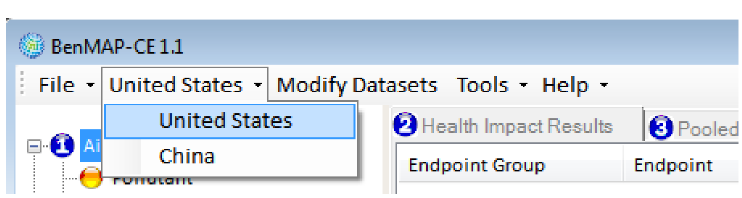


The tree menu on the left-hand window pane lists the analytical steps used in the Core Program. The tree menu items allow you to perform a highly customized health impact analysis. The **Tools** menu at the top of the screen is for less frequently used functions, such as importing and exporting data and special modules described in later sections.

The first section in this Chapter describes the Core Program features. The second section describes the additional functions found in the **Tools** and **Help** menus. The next section covers BenMAP-CE output options. Lastly, we answer some frequently asked questions. Note that this chapter provides an overview of functionality, not keystroke by keystroke instructions. Those may be found in Chapters 4 through 9.

3.1 Core Program

Beginning at the main BenMAP-CE window, you can choose the **Setup** you want to use for an analysis by selecting it from the **Setup** drop-down list. You are then ready to begin using the features available through the tree menu.



The tree menu takes you through the steps of an analysis. The first step, **Air Quality Surfaces**, allows you to select the pollutant of interest, and then specify the baseline and control air quality surfaces. The second step, **Estimate Health Impacts**, lets you choose the population dataset for a particular analysis, and then specify the health impact functions to estimate the incidence of adverse health effects. The last step, **Aggregate, Pool & Value**, gives you different options for combining the health effects estimates and choosing economic valuation functions.

3.1.1 Create Air Quality Surfaces

BenMAP-CE is not an air quality model, nor can it generate air quality data independently. Instead it relies on the air quality inputs given to it. To estimate population exposure to air pollution, BenMAP-CE combines population data with air quality surfaces, which it generates using some combination of air quality modeling and/or monitoring data. In BenMAP-CE, air quality surfaces can be described as air quality grids (the structure) that have been populated with air pollution values (the data). The following is a brief description of each step. For detailed instructions, see Chapter 4: Loading Data and Chapter 5: Creating Air Quality Surfaces.

Pollutant

The **Pollutants** section of a setup specifies the pollutants that BenMAP-CE will analyze and defines the air quality metrics to be used by BenMAP-CE. You are not importing air pollution data, but rather naming your pollutants and defining the measures or metrics BenMAP-CE will use when performing an analysis for each pollutant.

Grid Definition

Air quality surfaces contain air pollution exposure estimates for a particular **Grid Definition**, as defined in the **Modify Datasets** window. **Grid Definitions** are typically comprised of either regularly shaped rectangles covering the region of analysis, or irregularly shaped polygons corresponding to political boundaries.

Modeling and Monitoring Data

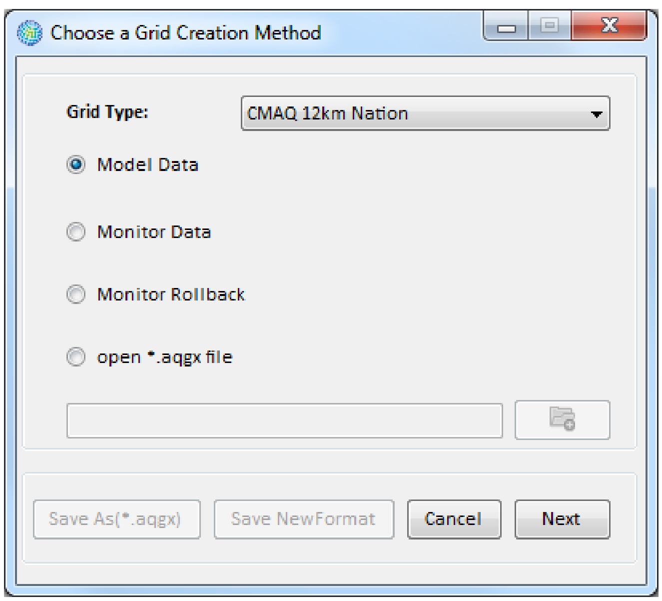
To generate air quality grids, you can use air quality modeling data and air quality monitoring data in three different ways, as discussed below. However, once generated, all air quality grids have the same structure, and have the same *.aqgx extension that BenMAP-CE uses to designate these file types.

- **Model Data.** *Model Data* grid creation simply takes raw model data and converts it into a file that BenMAP-CE recognizes as an air quality grid. This type of grid definition allows you to directly specify the air pollution values for each grid cell in a Grid Definition.

- **Monitor Data.** *Monitor Data* grid creation uses air pollution monitoring data to estimate air pollution levels for each grid cell in the selected Grid Definition. This may be done using one of three interpolation procedures - *Closest Monitor*, *Voronoi Neighborhood Averaging* (VNA), or *Fixed Radius*. With closest monitor, BenMAP-CE simply uses the data of the monitor closest to each grid cell's centroid. With VNA, BenMAP-CE first identifies the set of monitors that most closely "surround" each grid cell, and then calculates an inverse-distance weighted average of the data from these neighboring monitors. With fixed radius, BenMAP-CE constrains the VNA interpolation to a user-specified distance around each monitor.

- **Monitor Rollback.** *Monitor Rollback* grid creation allows you to reduce, or roll back, monitor data using three methods: *Percentage Rollback*, *Incremental Rollback*, or *Rollback to a Standard*. Percentage rollback reduces all monitor observations by the same percentage. Incremental rollback reduces all observations by the same increment. Rollback to a standard reduces monitor observations so that they just meet a specified standard. After the monitor data is rolled back, it may be directly interpolated (as in *Monitor Data* grid creation) or combined with modeling data. This approach is described in more detail in Chapter 5: Creating Air Quality Grids, as well as in the Appendix A: Monitor Rollback Algorithms.

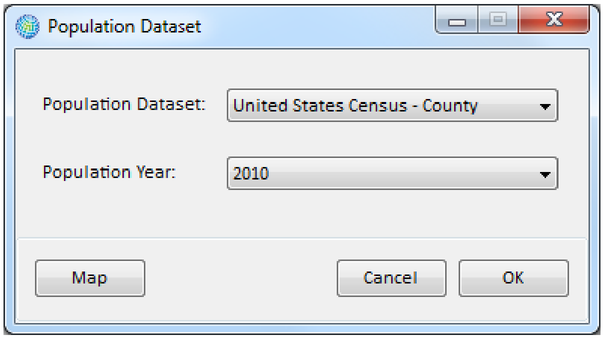
- **Open *.aqgx file.** *Open *.aqgx file* allows you to load a previously created or saved air quality surface.



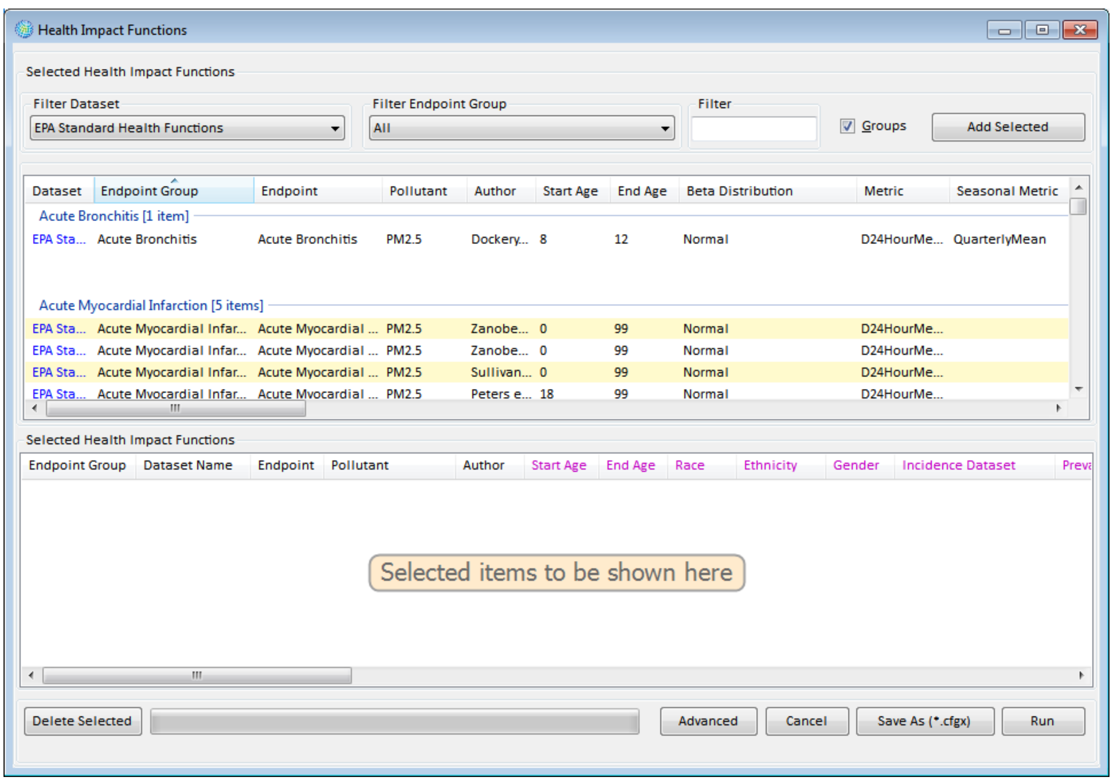
3.1.2 Estimate Health Impacts

The **Estimate Health Impacts** section allows you to calculate the change in the incidence of adverse health effects associated with changes in air quality. There are three steps in the process. The following is a brief description of each step. For detailed instructions, see Chapter 6: Estimating Incidence.

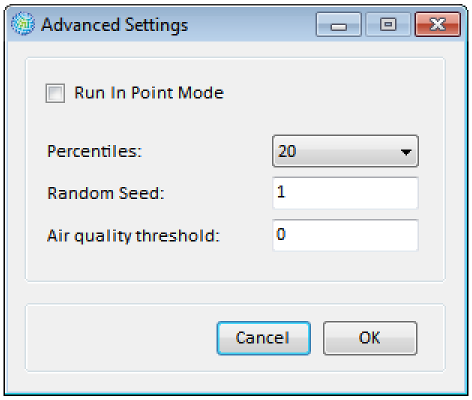
- **Step 1.** Specify the *Population Dataset* and *Population Year*.



- **Step 2.** Choose the *Health Impact Functions* that will be used to estimate the incidence of adverse health effects.



Step 3. BenMAP-CE performs a full Monte-Carlo analysis to quantify the confidence intervals around mean incidence and economic value estimates by randomly sampling an uncertainty distribution around the effect coefficients or willingness to pay estimates. In general, the computation time increases as you specify additional percentiles to report from the Monte-Carlo generated distribution. If you want to replicate the Monte-Carlo distribution from another analysis, then you may also specify the *Random Seed*.) Specify the *Air Quality Threshold*, or a lowest value for air quality data. Any observations which fall below this threshold will be replaced with the threshold value in all calculations.

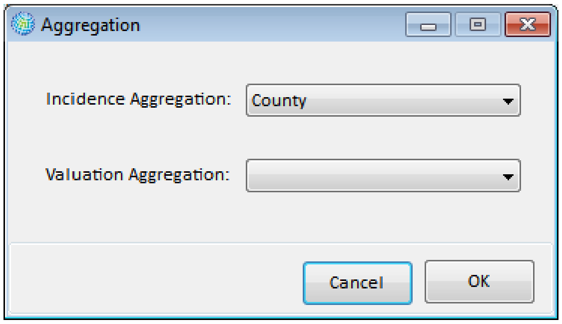


BenMAP-CE can store configuration choices in a user-named file with a *.cfgx* extension, and can store incidence change estimates in a user-named file with a *.cfgrx* extension.

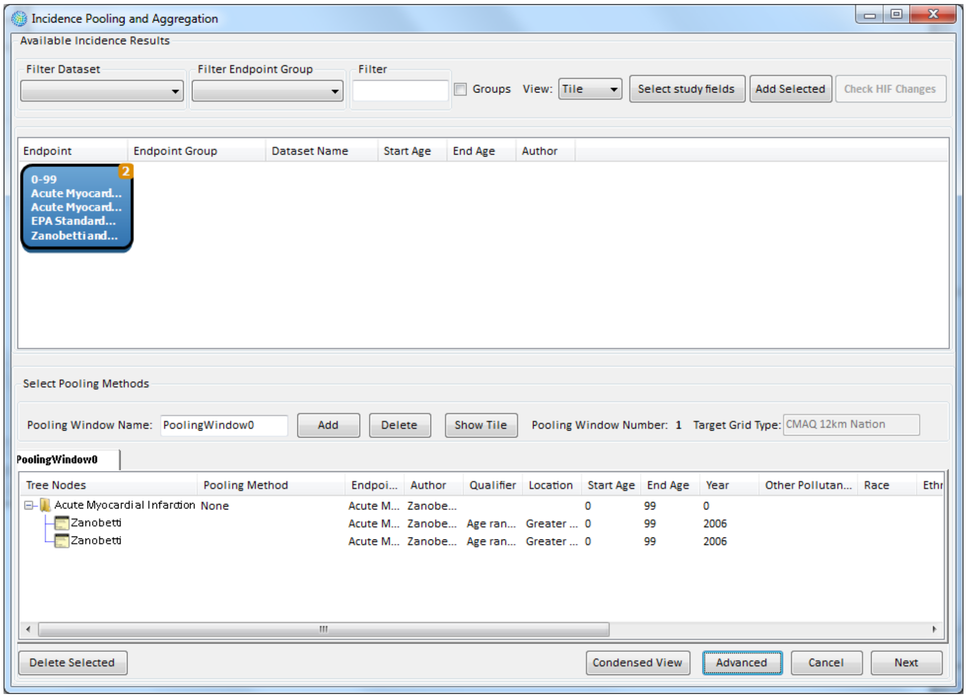
3.1.3 Aggregate, Pool, and Value

The **Aggregate, Pool, & Value** feature on the BenMAP-CE tree menu allows you to aggregate and pool previously calculated incidence estimates and place an economic value on these pooled and aggregated incidence estimates. You can also aggregate the economic values, and finally pool the aggregated economic values. There are several steps in this process. The following is a brief description of each step. For detailed instructions, see Chapter 7: Aggregating, Pooling, and Valuing.

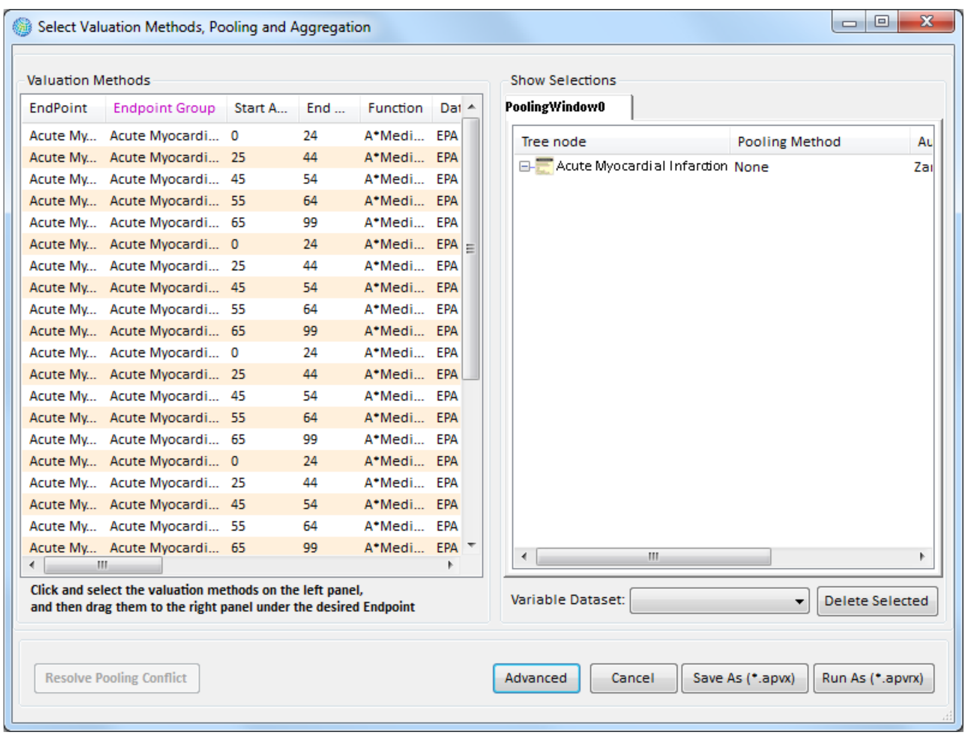
- **Step 1.** Choose the desired aggregation levels.



- **Step 2.** Choose the desired pooling and aggregation options for the incidence results.



- **Step 3.** Choose the economic valuation functions to apply to the pooled and aggregated incidence results.



BenMAP-CE can store APV configuration choices in a user-named file with an *.apvx* extension, and can store APV configuration results in a user-named file with an *.apvrx* extension. As needed, you can access both files for later use.

3.2 Menus

There are five menu options found at the top of the main window: **File**, **Setup**, **Modify Datasets**, **Tools** and **Help**.

- **File.** This menu provides options for selecting saved project files (*.projx*) to open, starting a new project file, saving your work in a project file, and exiting the program.
- **Setup.** BenMAP-CE comes pre-loaded with datasets for the *United States* and *China* setups. The selected setup will be displayed in the menu bar. To learn more about modifying setups, see Chapter 4: Loading Data.
- **Modify Datasets.** BenMAP-CE stores the information needed to run analyses for a particular geographic area, such as a city, region, or nation in a single dataset called a setup. Many users will never need to modify the preloaded setups. However, the **Modify Datasets** menu provides tools to add, modify (load additional datasets), or delete these setups if needed. This is discussed in detail in Chapter 4: Loading Data.
- **Tools.** This menu provides access to data import and export functionality in addition to a number of other features. An overview is provided below.
- **Help.** This menu provides access to a *Quick Start Guide* (available on EPA's website), information *About* BenMAP-CE, and a form to *Provide Feedback* about software errors or requested features. An overview is provided below.

3.2.1 Tools Menu

The **Tools** menu has several options: *Air Quality Surface Aggregation, Database Export, Database Import, Export Air Quality Surface, GBD Rollback, Neighbor File Creator, and Options menu*. A brief description is given below, but further information can be found in Chapter 9: Tools Menu.

- *Air Quality Surface Aggregation*. Create a new air quality surface for a specified grid definition (e.g., County) from an existing air quality surface created with a different (and generally finer) grid definition (e.g., 12km CMAQ).
- *Database Export.* Export all or part of BenMAP-CE's internal database to a file which can later be used on another computer or by another user. Manually loading data into BenMAP-CE can be time and labor intensive, so this tool can be quite useful in sharing data with other users or computers.

- *Database Import.* Import data created using the *Database Export* tool.

- *Export Air Quality Surface*. Generate a text file (*.csv*) with all of the data in air quality surface, including summary statistics such as mean, median, minimum, and maximum.

- *GBD Rollback Tool*. The *GBD Rollback* tool allows you to select a country, region, or group of countries and see the impact of lowering $PM_{2.5}$ emissions based on the data from the 2010 GBD study[1]. The outputs include the baseline and policy case $PM_{2.5}$ concentrations as well as the population-weighted air quality change.

- *Neighbor File Creator*. Create a text file (*.txt*) identifying "neighbor" monitors and associated interpolation weights for each grid cell in an air quality grid.

- *Options.* Select options for start-up and exit screens, validation logs and default set-ups.

3.2.2 Help Menu

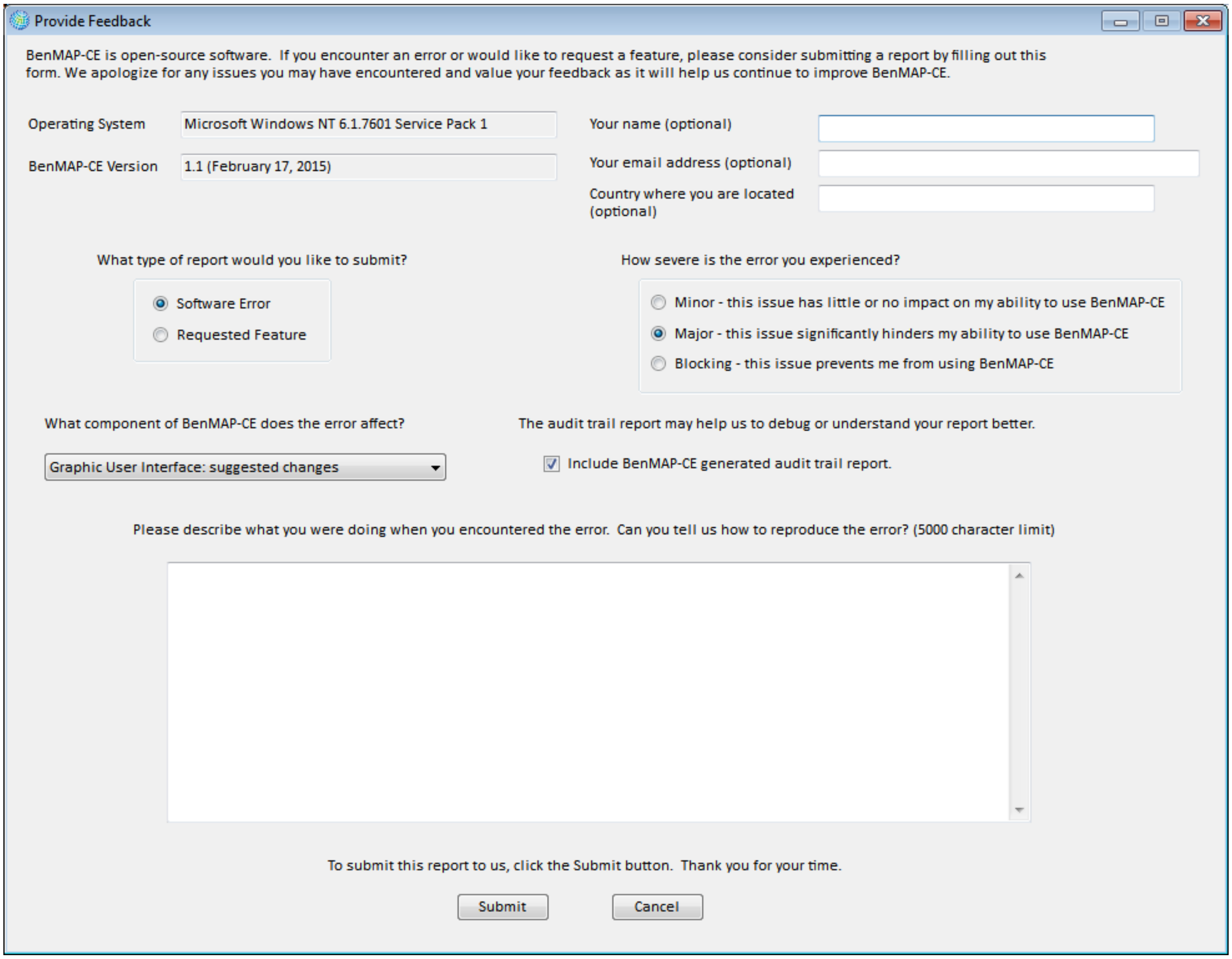
The **Help** menu has a few options to choose from: *Quick Start Guide link*, *Information About BenMAP-CE*, and a form to *Provide Feedback*.

- *Quick Start Guide*. A link will open a webpage to the U.S. EPA site for BenMAP-CE information. On the webpage, the Quick Start Guide can be found under *Training Materials*. Click on the link for *The BenMAP-CE Quick Start Guide*, to begin download of the guide. Files that the Quick Start Guide refers to can be found in the same bullet, but under the *BenMAP-CE Quick Start Data Files (zip)* link. The Quick Start Guide will take you through the basic operations of the BenMAP-CE imports and decision-making.

- *About*. Opens a window that displays information about the program (e.g., software version, contact information, and a suggested citation). You can click on **Release Notes** to read about software modifications and any known issues.

- *Provide Feedback*. This feature allows you to submit any problems that you may encounter while running BenMAP-CE or requested features to the BenMAP-CE development team. There are fields to provide your contact information (optional) and information about the error or requested feature. Your feedback will be logged into an issue tracking system for U.S. EPA to evaluate.

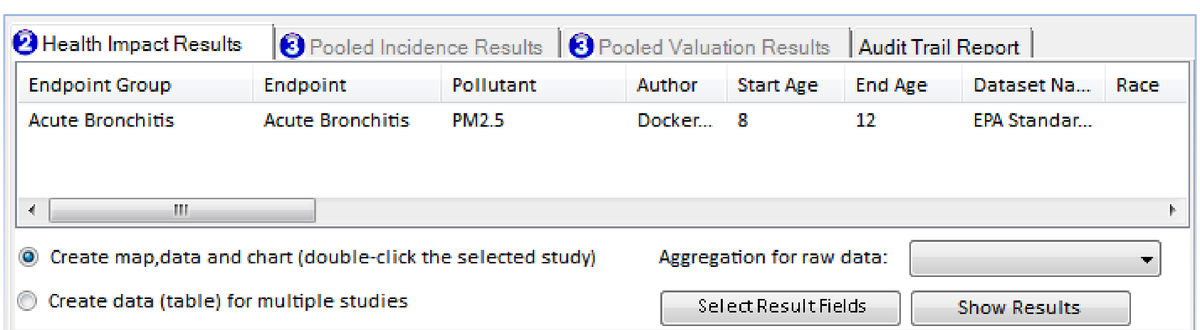
[1] Exposure Assessment for Estimation of the Global Burden of Disease Attributable to Outdoor Air Pollution. Michael Brauer, Markus Amann, Rick T. Burnett, Aaron Cohen, Frank Dentener, Majid Ezzati, Sarah B. Henderson, Michal Krzyzanowski, Randall V. Martin, Rita Van Dingenen, Aaron van Donkelaar, and George D. Thurston. *Environmental Science & Technology* **2012** *46* (2), 652-660



3.3 Outputs

3.3.1 Results

If you are interested in viewing or exporting the results of an analysis, these reports can be accessed by clicking on the appropriate **Results** tabs from the upper portion of the main BenMAP-CE window. The number next to the tab description indicates the associated "step" of the BenMAP-CE analysis (from the tree menu).



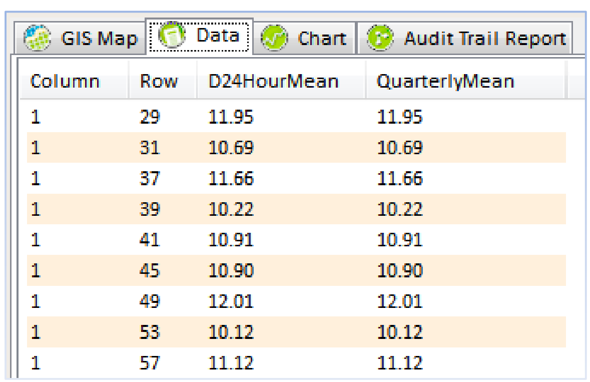
Select the appropriate tab for the type of results you wish to create:

- **Health Impact Results** uses a *Configuration Results* file (with the *.cfgrx* extension) to create a map, data table and bar chart for incidence results based on the selected health impact studies. “Raw” incidence estimates are those that have not been aggregated, pooled or valued. See Chapter 6: Estimating Incidence, for detailed instructions for creating health impact results.

- **Pooled Incidence Results** uses an *Aggregation, Pooling, and Valuation Results* file (with the *.apvrx* extension) to create maps, data tables and bar charts for incidence, aggregated incidence and pooled incidence results. See Chapter 7: Aggregation, Pooling, and Valuation, for detailed instructions for creating pooled incidence results.

- **Pooled Valuation Results** also uses an *Aggregation, Pooling, and Valuation Results* file (with the *.apvrx* extension) to create maps, data tables and bar charts for valuation, aggregated valuation and pooled valuation. See Chapter 7: Aggregate, Pool, and Value, for detailed instructions for creating pooled incidence results.

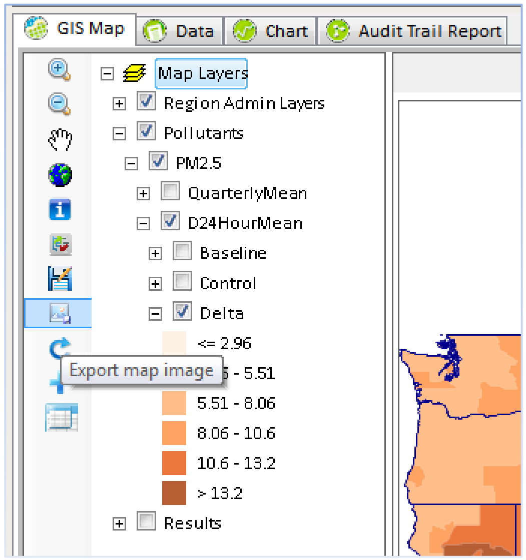
The results data are viewable on the **Data** tab in the lower right frame of the BenMAP-CE main window (see below). You can also view the results in a **GIS Map** (described in the following section), or simple **Chart** format. All results can be output as comma-separated value files (*.csv*), which can be read into spreadsheet and database programs.



Column	Row	D24HourMean	QuarterlyMean
1	29	11.95	11.95
1	31	10.69	10.69
1	37	11.66	11.66
1	39	10.22	10.22
1	41	10.91	10.91
1	45	10.90	10.90
1	49	12.01	12.01
1	53	10.12	10.12
1	57	11.12	11.12

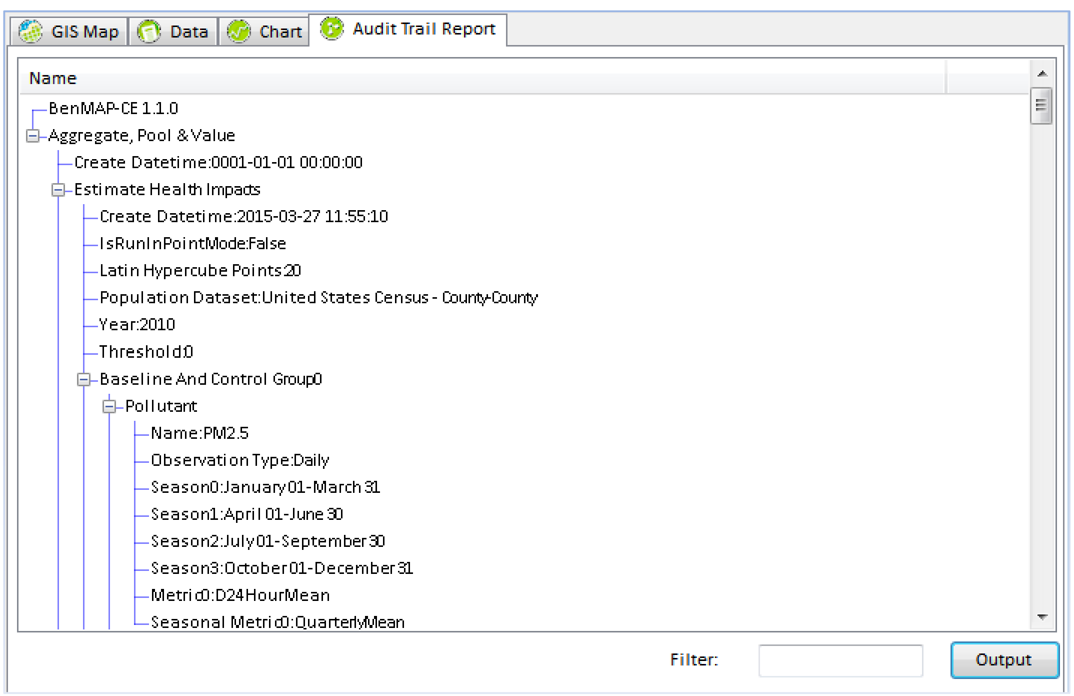
3.3.2 Maps

GIS Maps can be viewed in the lower right frame of the BenMAP-CE main window (see below). Once an air quality surface is displayed, you can choose which layers to view by selecting or deselecting items in the GIS table of contents. Spatial layers (except regional administrative layers) are semi-transparent so that overlapping layers are viewable. You can export a formatted graphics file (e.g., *.png* format) with the map legend and title. For detailed instructions on **GIS Maps**, see Chapter 8: GIS/Mapping.



3.3.3 Audit Trail Report

The **Audit Trail Report** provides a summary of the options selected in the various parts of the analysis. You may generate an audit trail with any of the file types used in BenMAP-CE: Air Quality Grids (with the *.aqgx* extension), Configurations (with the *.cfgx* extension), Configuration Results (with the *.cfgrx* extension), Aggregation, Pooling, and Valuation Configurations (with the *.apvx* extension), and Aggregation, Pooling, and Valuation Configuration Results (with the *.apvrx* extension). The report itself has a tree structure that lets you easily find the information that you are seeking. Below is an example of an Audit Trail Report.



Note that each successive step in an analysis contains a summary of its inputs and attributes, and those of each previous step in the analysis. For example, in the above report the attributes of the *Health Impact Function* file used to generate the APV Results are present in the *Estimate Health Impacts* node. Similarly, the metadata for both the baseline and control air quality grids are present under the *Estimate Health Impacts* node. For more information on audit trails, see Chapter 8: GIS/Mapping.

3.3.4 Dataset Validation Reports

You may load data to BenMAP-CE to tailor the analysis to your specific needs (click **Modify Datasets** from the main menu). Loading data requires specific formatting. BenMAP-CE offers a validation option to confirm that the proper headings and data types are present in the selected file. The validation routines also check that values are within reasonable ranges for certain types of data. If the file does not meet the validation requirements, error and/or warning messages will be reported. For more information about loading and validating data, see Chapter 4: Loading Data.

3.3.5 File Types

BenMAP-CE has a number of file types that you can use to store the settings used in a BenMAP-CE analysis, the results of an analysis, as well as maps and reports. Table 3-1 presents the names of the different file types, their functions, and their default folder locations.

Table 3-1. File Types Generated by BenMAP-CE

File Extension	Description	Default Folder Location[1]
*.aqgx	Air quality grid.	Result\AQG
*.apvx	Aggregation, Pooling, and Valuation configuration specifying the aggregation levels, pooling options, and valuation methods used to generate aggregated incidence estimates, pooled incidence estimates, valuation estimates, aggregated valuation estimates, and pooled valuation estimates.	Result\APV
*.apvrx	Aggregation, Pooling, and Valuation configuration results, containing incidence results at the grid cell level, aggregated incidence results, valuation results, aggregated valuation results, and pooled valuation results.	Result\APVRX
*.bdbx	BenMAP-CE Database Export tool creates files which can contain individual datasets or entire setups. These are saved in a specific format for importing to BenMAP-CE.	User-specified
*.cfgx	Configuration specifying the health impact functions and other options used to generate incidence estimates.	Result\CFG

File Extension	Description	Default Folder Location[1]
*.cfgrx	Configuration results, containing incidence results at the grid cell level.	Result\CFGR
*.csv	Reports (Results Tables) are exported as *.csv files, which may be viewed in a text editor, or in programs such as Excel.	Result\CFGRX or Result\APVRX
*.rtf	Validation results from data imports	ValidationResults
*.shp	Shape files generated by BenMAP-CE's geographic information maps system. These files can be viewed within BenMAP-CE or within shape file viewers, such as ArcView.	AppData\... \Shapefiles[2]
*.xlsx	GBD Rollback Tool results are exported as .xlsx files, which may be viewed in a spreadsheet tool such as Excel (there is also a .csv option).	GBD

[1] Most files generated by BenMAP-CE are stored within the User's directory under C:\Users\<user name>\Documents\My BenMAP-CE Files\.

[2] Shape files (*.shp) are stored at C:\Users\<user name>\AppData\Local\BenMAP-CE\Data\Shapefiles\<setup name>\.

3.4 Frequently Asked Questions

When creating reports from *.cfgrx and *.apvrx files, why do some of the variables that I have checked appear as blanks?

When results are pooled, some of the identifying information for individual health impact functions gets lost. For example, when pooling endpoints within the same endpoint group, such as "HA, Pneumonia" and "HA, Chronic Lung Disease" (both within "Hospital Admissions, Respiratory"), there is no longer a unique endpoint name for the pooled result. So, BenMAP-CE would leave the endpoint name blank.

How do I export my results?

Identify the type of report that you want to create, then refer to the Section 3.3.1 in this chapter on exporting reports.

How do I determine what the Column and Row refer to?

The Column and Row are variables designed to uniquely identify each grid cell in the grid definition. In the case of the County grid definition, the Column refers to the state FIPS code and the row refers to the county FIPS code. One way to get a good sense of the Column and Row variables is to create a map and then view where particular Column and Row variables occur in the map.

CHAPTER 4

Loading Data

In this chapter…

- **Learn how to create a new setup for your project.**
- **Learn more about the file structure for data inputs.**
- **Learn how to export and import a setup.**

BenMAP-CE can store the information needed to run analyses for a particular geographic area, such as a city, region, or nation, in a single dataset. This dataset is called a "Setup" and consists of 10 categories of data:

- Grid definitions
- Pollutants
- Monitor data
- Incidence and prevalence rates
- Population data

- Health impact functions
- Variable data (socioeconomic variables)
- Inflation rates
- Valuation functions
- Income growth data.

Grouping the data in this way has a number of advantages. It makes it easy to organize and view the data, export the data (either a whole setup or a portion of a setup), and import setups generated by others.

In this chapter we discuss how to add, modify, and delete a setup. It is important to keep in mind that if you delete one part of a setup, you may be affecting other parts of the setup. We discuss this further below.

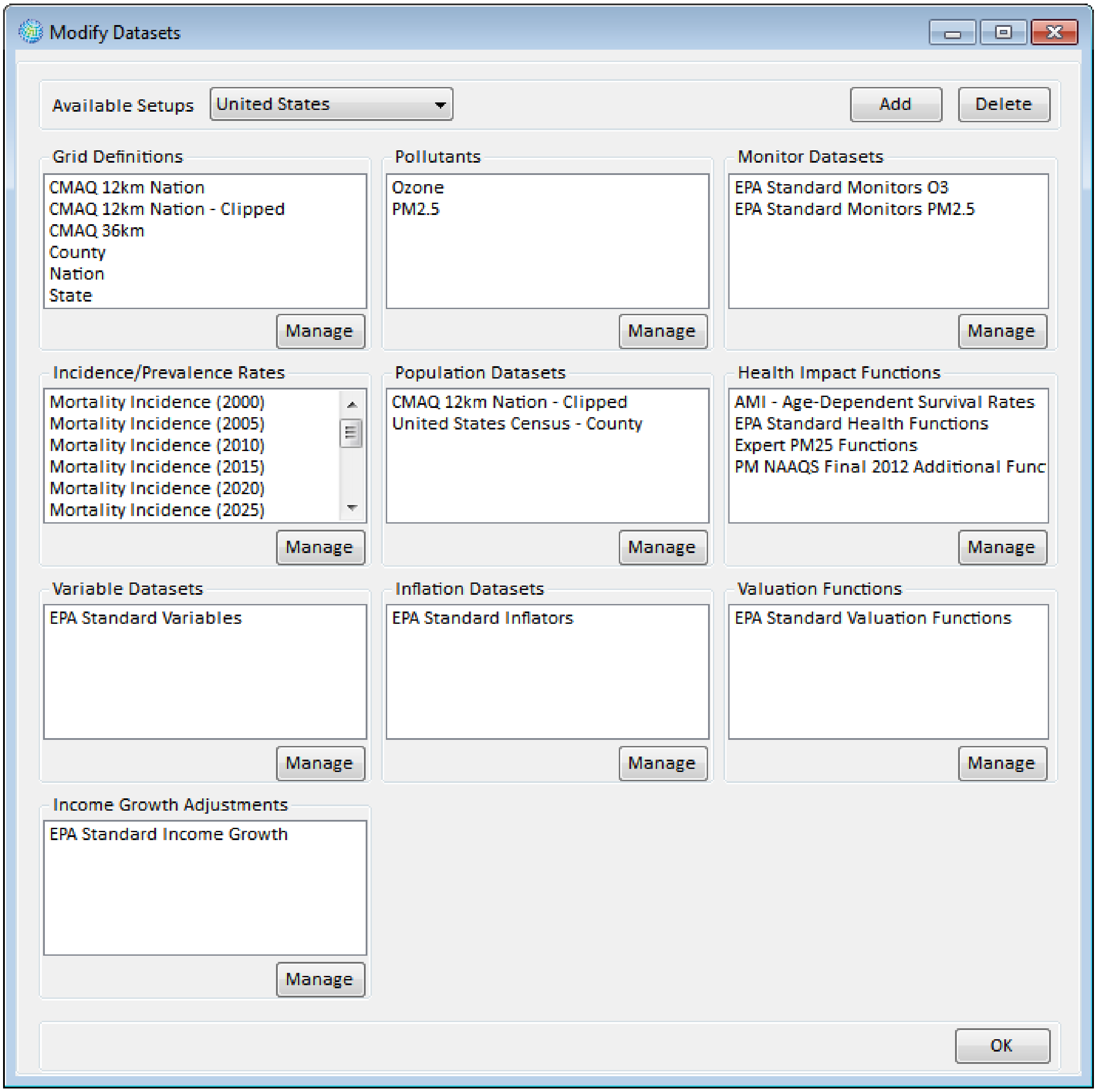
M**any users will never need to modify the setup**. If you are performing an analysis with the pre-loaded *United States* or *China* setups, you may find that BenMAP-CE contains all of the data you need to perform your analysis, and no additional modifications are necessary.

We will also discuss how to load (import) data into an existing setup. There are a number of steps involved in formatting and loading these data, so it is important to carefully review the steps in this chapter. For most dataset types, BenMAP-CE provides a validation tool to help you check your data file format (column names, required columns, and data types) before import. Validation reports are provided which describe any errors or warnings with the associated row number and column name.[1]

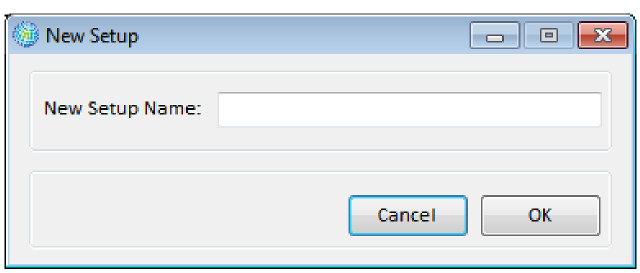
4.1 Add, Modify, and Delete a Setup

To add a new setup, modify an existing setup, or delete a setup, choose **Modify Datasets** from the menu bar. This will bring up the **Modify Datasets** window. The United States setup, which comes preinstalled with BenMAP-CE, includes a variety of datasets and looks like this:

[1] Validation reports are saved to C:\Users\<user name>\Documents\My BenMAP-CE Files\ValidationResults.



<u>Add a Setup</u>. To add a setup (e.g., to add a new country that was not pre-loaded with BenMAP-CE), click the **Add** button. The **New Setup** window will appear where you can type a name for the new setup.



After naming the new setup, you can define the elements that comprise a setup. Table 4-1 lists the 10 dataset types within BenMAP-CE and indicates which types of data are needed to perform certain analyses.

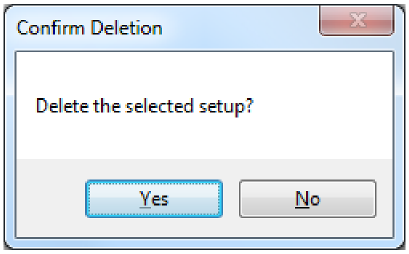
Table 4-1. BenMAP-CE Data Elements

Dataset Type	Required to Estimate Health Impacts	Required to Quantify Economic Values
Grid Definitions	✓	✓
Pollutants	✓	✓
Monitor Datasets (or Modeled Data)	✓	✓
Incidence/Prevalence Rates	✓	✓
Population Datasets	✓	✓
Health Impact Functions	✓	✓
Variable Datasets		
Inflation Datasets		✓
Valuation Functions		✓
Income Growth Adjustments		✓

Some of the elements of a setup are fundamental and should be entered before the others, namely, **Grid Definitions** and **Pollutants**. The **Incidence/Prevalence Rates, Population**, and **Variable** datasets depend on the **Grid Definitions**, and the **Monitor** and **Health Impact Functions** datasets depend on the **Pollutants** that you have defined. Therefore, it is best to start by defining your **Grid Definitions** and **Pollutants**, and then define the other elements of the setup.

Modify a Setup. To modify a setup, click **Modify Datasets** on the menu bar. Choose the setup for modification from the drop-down list of **Available Setups** (the default value is *United States*). Then, click on the **Manage** button under one of the ten components comprising a setup. The sections below provide more information for each of these components.

Delete a Setup. To delete a setup, click **Modify Datasets** on the menu bar. Choose the setup for deletion from the drop-down list of **Available Setups**. Click the **Delete** button. You will then be asked to confirm your decision.



4.1.1 Grid Definitions

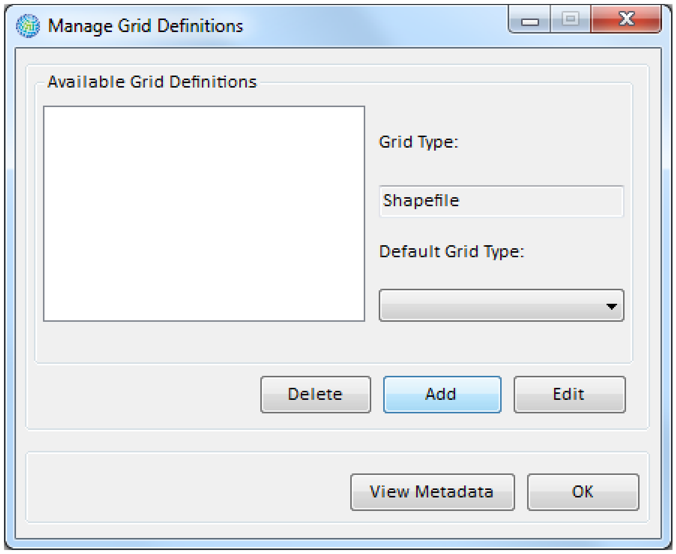
A BenMAP-CE **Grid Definition** specifies geographic units (i.e., grid cells) that serve two purposes: (1) the program assigns air quality, population, and baseline incidence rates to these grids when calculating impacts; and (2) you can use these grids to report results in the GIS. You can define a grid in one of two ways: by loading a Shapefile (a particular type of GIS file) or by specifying a regularly shaped grid pattern. These are referred to as **Shapefile Grid Definitions** and **Regular Grid Definitions**, respectively. A **Regular Grid Definition** is used when you want to specify a grid that is regularly shaped (e.g., 12 x 12 km squares). A **Shapefile Grid Definition** can be used to create either grids that are regularly shaped or grids that match an irregular shape, like a political boundary. All **Shapefile Grid Definitions** must contain an attribute table with a unique (i.e., non-repeating) column and row index.

At least one **Grid Definition** should be created to outline the area of interest for the BenMAP-CE analysis (a city boundary, for example). Additional grid definitions can also be created for subdivisions of that area for which (a) data is available (see the Air Monitoring, Population, Incidence and Prevalence, and Variables sections below), or (b) reports or maps are desired.

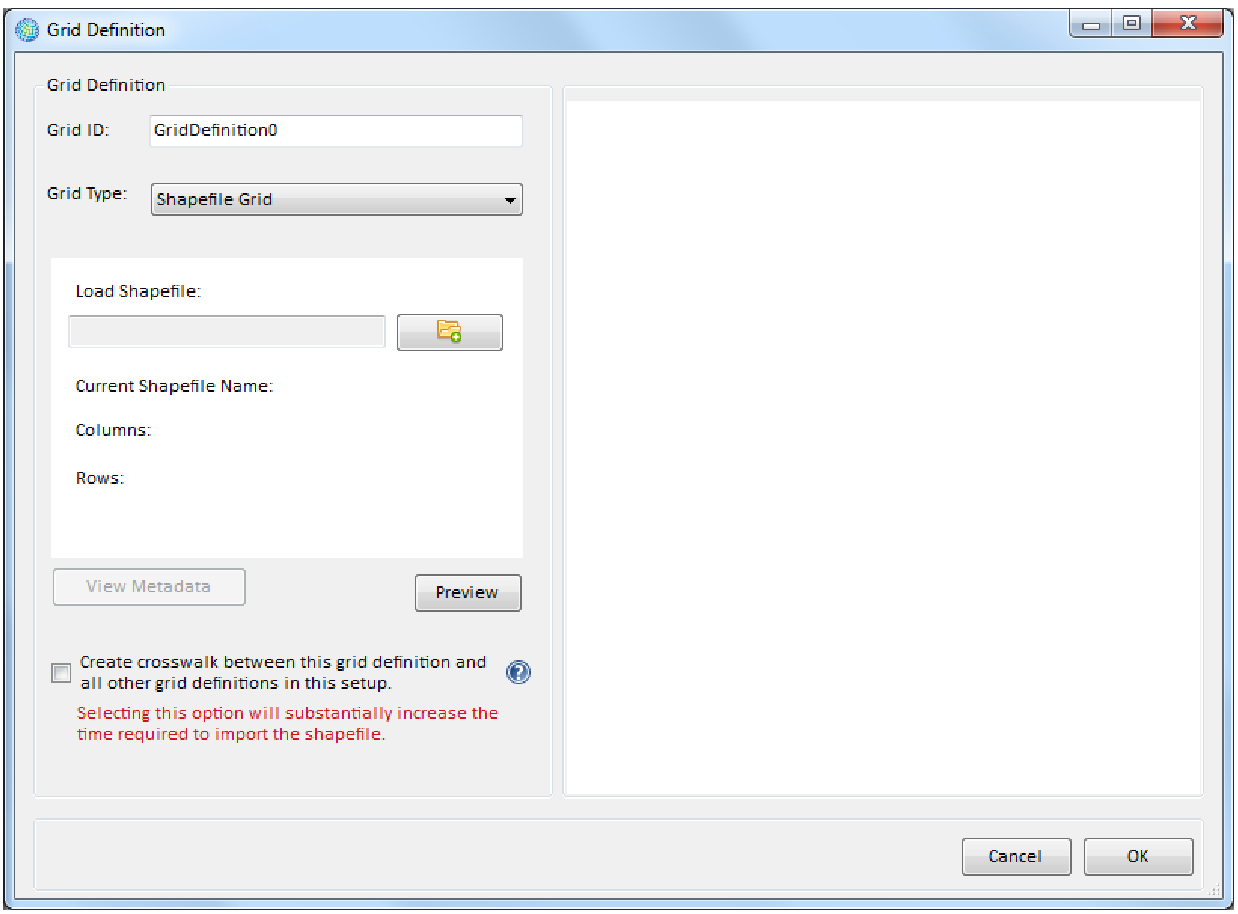
For example, an analysis for the United States might use one or more of the following grid definitions:

- **Nation –** this Shapefile Grid Definition contains an outline of the United States (just the lower forty-eight states), defining an overall area of interest.
- **State –** this Shapefile Grid Definition contains state borders, for use in generating reports and maps with results aggregated to the state level.
- **County –** this Shapefile Grid Definition contains county borders, for use with county-based population and incidence rate data.
- **CMAQ 12km Nation –** this Shapefile Grid Definition contains grid cells that are roughly 12 kilometers on each side, for use with air quality modeling data.

To start adding or modifying grid definitions, click **Modify Datasets** on the menu bar. Click on the **Manage** button below the **Grid Definitions** box. The **Manage Grid Definitions** window will appear.



Click on the **Add** button to display the **Grid Definition** window. Provide a name for the Grid Definition in the **Grid ID** field and specify the **Grid Type**: *Shapefile Grid* or *Regular Grid***.**



4.1.1.1 Regular Grid

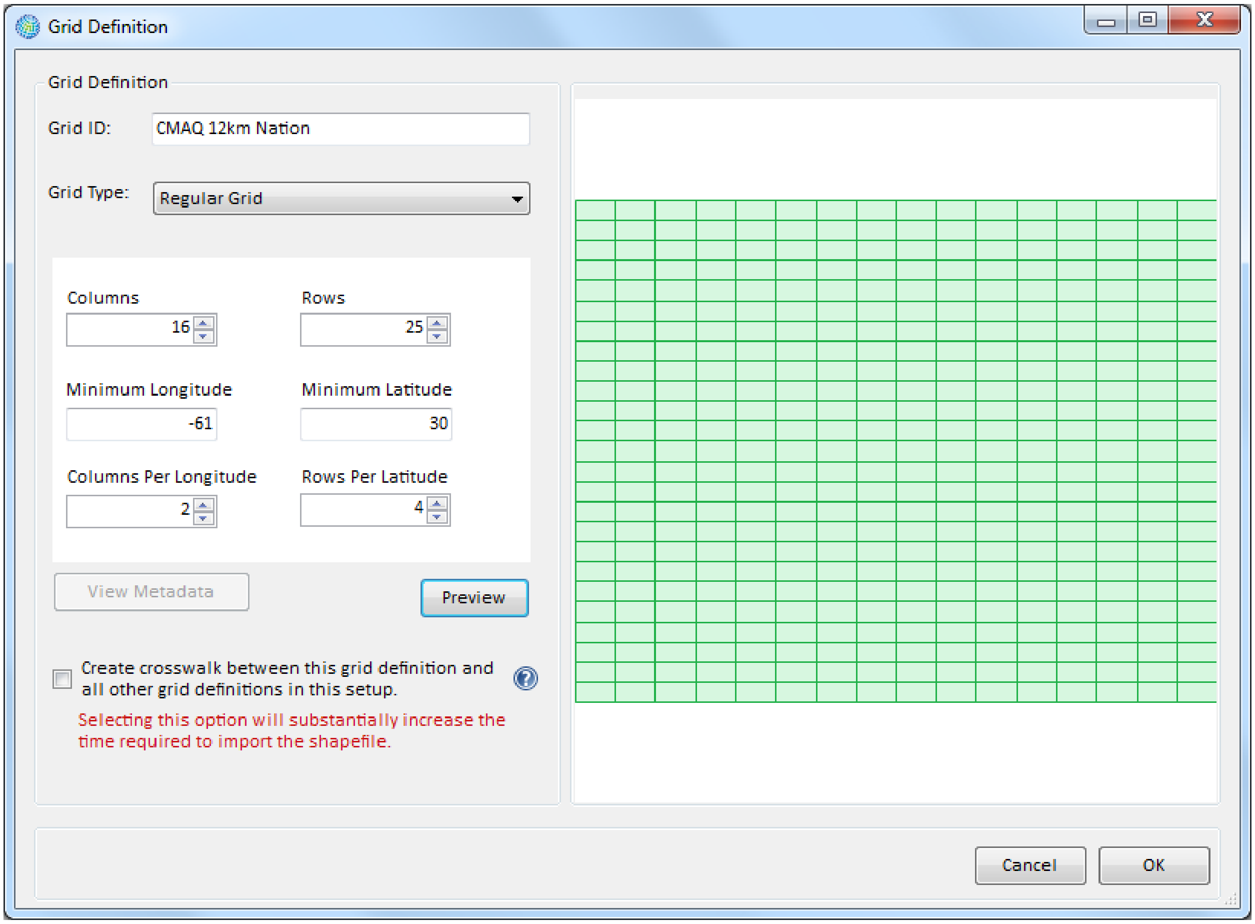
Regular Grid Definitions are defined by a lower left corner (specified as decimal degree latitude and longitude, with West and South having negative values and East and North having positive values), a total number of columns and rows, a number of columns per degree longitude, and a number of rows per degree latitude. Individual cells within the resultant grid are numbered in sequential order (columns from left to right, rows from bottom to top) starting at (1, 1). These field values will be used to link the **Regular Grid Definition** with other sources of data, as discussed in more detail below.

To define a **Regular Grid**, start by selecting *Regular Grid* from the **Grid Type** drop-down menu. Type the name of the grid definition in the **Grid ID** box, and then define the number of **Columns** and **Rows** in the grid. To locate this grid geographically, provide the decimal degree coordinates for the lower left-hand corner of the grid in the **Minimum Longitude** and **Minimum Latitude** boxes.

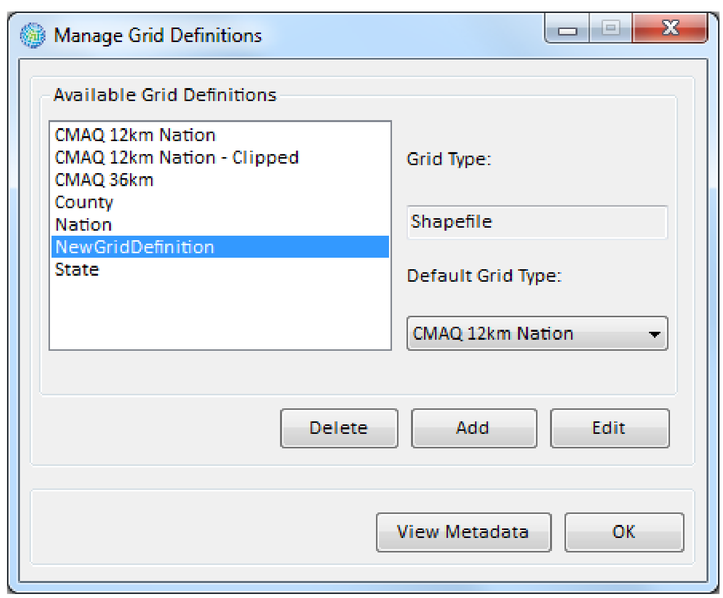
To give the overall geographic size of the grid, provide the number of **Columns Per Longitude** and **Rows Per Latitude**. For example, if you specify 16 columns and 2 columns per degree longitude, then the grid will span 8 degrees of longitude. And if you specify 25 rows and 4 rows per degree latitude, then the grid will span 6.25 degrees of latitude.

Combining the numbers in this example, if the minimum longitude and latitude are -81 and 38 and the grid spans 8 degrees longitude and 6 degrees latitude, then the grid will run between -81 and -73 degrees longitude and between 38 and 44.25 degrees latitude.

After defining the grid, click the **Preview** button to see what the grid looks like. You may change the parameters and click the **Preview** again to see how the grid changes. When you are satisfied with the grid definition, click the **OK** button.



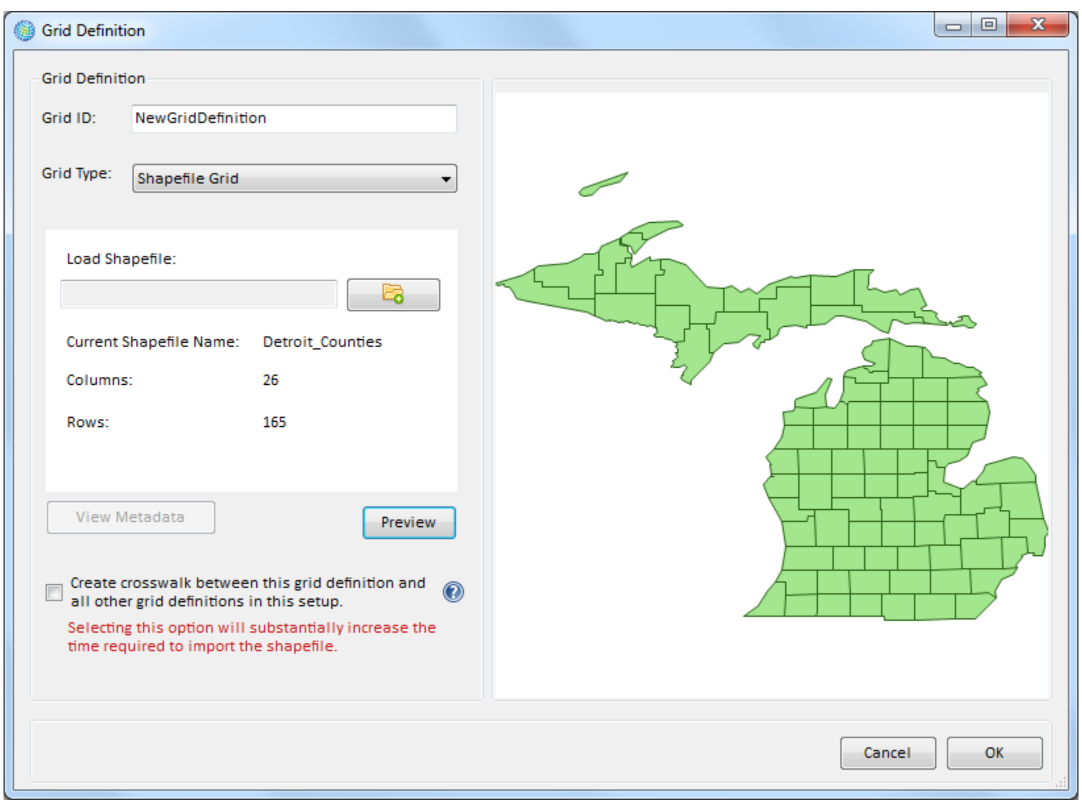
The name of your newly defined grid will then appear in the **Manage Grid Definitions** window. You may click **Edit** to change the grid definition, **Delete** to permanently remove the grid that you just defined, or **Add** to define a new grid definition. **View Metadata** is not applicable for Regular Grid Definitions. Click **OK** to return to the **Modify Datasets** window.



4.1.1.2 Shapefile Grid

Shapefiles used to create **Shapefile Grid Definitions** should be of the ESRI Shapefile format. Details on this format can be found at http://downloads.esri.com/support/whitepapers/other/shapefile.pdf. When a shapefile is being used to create a new grid, BenMAP-CE will: (1) check to see if the file is projected to GCS NAD 83; and (2) if necessary, re-project the file (with notification) from the native projection to GCS NAD 83. Any shapefiles used must contain integer fields named Column (or Col) and Row, and each shape within the shapefile must contain a unique combination of values for these two fields. These column and row values are used, just as the Column and Row field values in Regular Grid Definitions, to link the Shapefile Grid Definition with other sources of data, as discussed in more detail below.

To add a **Shapefile Grid**, click on the **Add** button in the **Manage Grid Definitions** window, choose *Shapefile Grid* from the **Grid Type** dropdown menu, name the grid in the **Grid ID**, and browse for the correct shapefile by clicking on the small open-file icon just to the right of the **Load Shapefile** input box. After locating the file, click **Open**. This will choose the file, and bring you back to the **Grid Definition** window. To view the shapefile, click **Preview**. You can add metadata using the **View Metadata** button. Adding metadata allows you to supply a file **Reference** (e.g., person, organization, publication, or model that produced or supplied the values in the electronic file) and **Description** (or any relevant notes about the use or limitations of the data). Other minimal file attributes are pre-populated automatically during import.



When you are satisfied that the shapefile looks correct, click **OK.** This will save the shapefile and bring you back to **Manage Grid Definitions** window.[2] Note that the **Grid Type** box displays the type of grid for each of your grid definitions. The **View Metadata** button will allow you to see and edit any comments that were previously entered.

Click **OK** when you are finished loading grid definitions. The **Modify Datasets** screen will now list the **Grid Definitions** that you have just created. At any time, you may click the **Manage** button to add, modify, or delete grid definitions.

WARNING! If you delete a **Grid Definition,** you will permanently delete any gridded data that is dependent on it, such as any **Incidence/Prevalence, Population**, and **Variable** datasets that use this particular **Grid Definition**. As we discuss each of these other setup elements below, we will describe how this might happen.

4.1.2 Pollutants

The **Pollutants** section of a setup specifies the pollutants that BenMAP-CE will analyze and defines the air quality metrics to be used by BenMAP-CE. You are not importing air pollution data, but rather naming your pollutants and defining the measures or metrics BenMAP-CE will use when performing an analysis for each pollutant. You may include any pollutant, though typically air pollutants such as particulate matter, ozone, sulfur dioxide, and carbon monoxide are used in a BenMAP-CE analysis.

A key concept for pollutants is the **Metric**. Air quality metric describes the period of the day over which the pollutant observations are averaged. For example, a metric of *D24HourMean* is a daily average of hourly measurements. A metric of *D8HourMax* is the average of the 8-hour period during the day when pollutant levels are the highest (see Table 4-2 below). The air quality change must be expressed in a metric that matches the metric used by the health impact function; this concept is discussed further below.

In general, air pollution data in BenMAP-CE is hierarchical – a pollutant can have multiple **Metrics**, each of which has multiple **Statistics** (these are automatically calculated by BenMAP-CE) and which can have multiple **Seasonal Metrics**. Similarly, **Seasonal Metrics** have multiple **Statistics**. Furthermore, air pollution data can be provided to BenMAP-CE at any of these levels, in addition to the daily and hourly observation level, as described in more detail in Section 4.3.

[2] Shapefiles are saved to C:\Users\<user name>\AppData\Local\BenMAP-CE\Data\Shapefiles\<setup name>\.

Table 4-2. Example Calculation of D8HourMax

Hourly Period[1]	Hourly average O_3 concentration[2] (ppm)	Moving 8-hour average[3]	D8HourMax[4]
07:00	0.000	---	
08:00	0.005	---	
09:00	0.010	---	
10:00	0.015	---	
11:00	0.020	---	
12:00	0.025	---	
13:00	0.030	---	
14:00	0.035	---	
15:00	0.040	0.020	
16:00	0.045	0.025	
17:00	0.050	0.030	
18:00	0.055	0.035	
19:00	0.060	0.040	
20:00	0.055	0.044	
21:00	0.050	0.047	
22:00	0.045	0.048	
23:00	0.040	**0.049**	**← 0.049**
00:00	0.035	0.048	
01:00	0.030	0.047	
02:00	0.025	0.044	
03:00	0.020	0.040	
04:00	0.015	0.035	
05:00	0.010	0.030	
06:00	0.000	0.024	

[1] Days for measuring ozone start and end at 7:00 AM local standard time.
[2] Hourly average is the average of individual measurements taken during the hour.
[3] Moving 8-hour average is the average of the hour and the proceeding 7 hours.
[4] *D8HourMax* is the maximum of the moving 8-hour averages.
Reference: Federal Register 79 FR 75233, Dec. 17, 2004. https://www.federalregister.gov/articles/2014/12/17/2014-28674/national-ambient-air-quality-standards-for-ozone#h-193

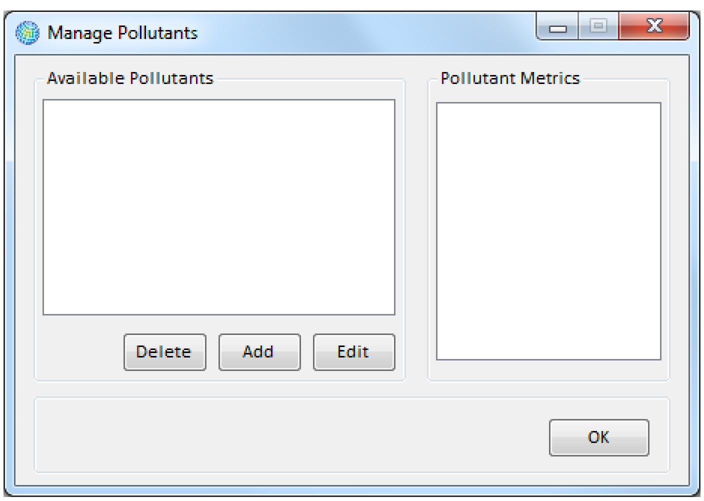
Add a Pollutant

Air pollution data in BenMAP-CE is of two types: (1) point source monitoring data and (2) **Grid Definition**-based modeling data. For both types, the data must be associated with a particular pollutant. Table 4-3 describes these variables used to define a pollutant in BenMAP-CE.

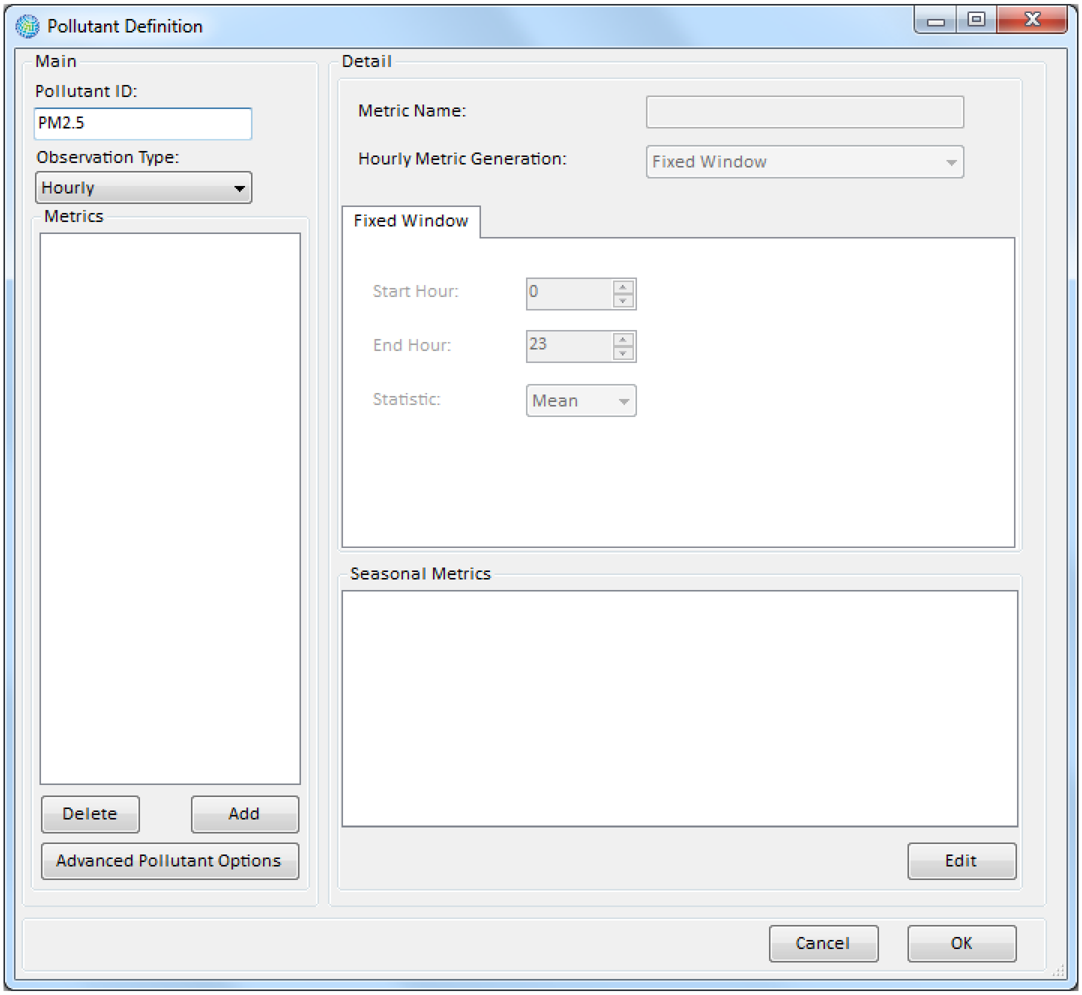
Table 4-3. BenMAP-CE Pollutant Definitions

Pollutant Field Name	Notes
Pollutant ID	Unique name for the pollutant which will be referenced in health impact functions, associated with monitoring and modeling data, etc.
Observation Type	Pollutants may have hourly observations or daily observations. In the United States, Ozone has hourly observations, while PM_{10} and $PM_{2.5}$ have daily observations.
Metrics	Daily values calculated directly from daily observations, or through various mathematical manipulations of hourly observations. Typical ozone metrics include the highest hourly observations during the course of each day, the mean of all twenty four hourly observations, etc.
Seasonal Metrics	Seasonal values calculated from metric values. In the United States, for example, quarterly means are calculated for $PM_{2.5}$ from daily means.

To add pollutant definitions to BenMAP-CE, click **Modify Datasets** on the menu bar. Then click on the **Manage** button below the **Pollutants** group. The **Manage Pollutants** window will appear. Here you may click **Add** to add a new **Pollutant**, **Delete** to remove a previously defined pollutant, or **Edit** to modify an existing pollutant.



To start defining a pollutant, click the **Add** button and the **Pollutant Definition** window will appear. In the **Pollutant ID** box, you give a unique name for the pollutant (e.g., $PM_{2.5}$), and then define the characteristics of this pollutant – the **Observation Type** and **Metrics**.



The **Observation Type** identifies whether a pollutant is measured *Hourly* or *Daily*. In the United States, ozone, sulfur dioxide, carbon monoxide, and others have hourly observations, while particulate matter has daily observations.

Next you need to define a pollutant's **Metrics**. A pollutant has to have one or more metrics, which are daily values calculated directly from daily observations, or through various mathematical manipulations of hourly observations.

To add a **Metric**, click on the **Add** button below the **Metrics** box in the **Pollutant Definition** window. A default name 'Metric 0' will appear in the box. Since the default name is not very descriptive of a metric, it is best to change the name. Typical names used for metrics given in Table 4-4. These are provided just as an example, you may use any names that you like. However, keep in mind that the names that you use for your metrics need to be consistent with the metric names that you include in your air pollution monitoring and modeling data, as well as your health impact functions. (We will discuss this further below.) Additionally, metric names are used to display pollutant concentrations in BenMAP-CE's mapping window. As such, they must be consistent with GIS naming conventions, meaning they must begin with a letter, and may only contain letters, numbers, and underscores.

Table 4-4. Examples of Metric Names

Name	Description
D1HourMax	Highest hourly value from 12:00 A.M. through 11:59 P.M.
D8HourMax	Highest eight-hour average calculated between 12:00 A.M. and 11:59 P.M.
D24HourMean	Average of hours from 12:00 A.M. through 11:59 P.M.

4.1.2.1 Hourly Metrics

Pollutants that are measured hourly (**Observation Type** = *Hourly*), such as ozone, sulfur dioxide, carbon monoxide, and others, must be characterized by a daily metric, which mathematically summarizes the hourly observations.

Table 4-4 lists some of the ways that metrics can be generated from hourly values. Note that these metrics are not arbitrarily chosen, and instead match the metrics used in epidemiological studies.

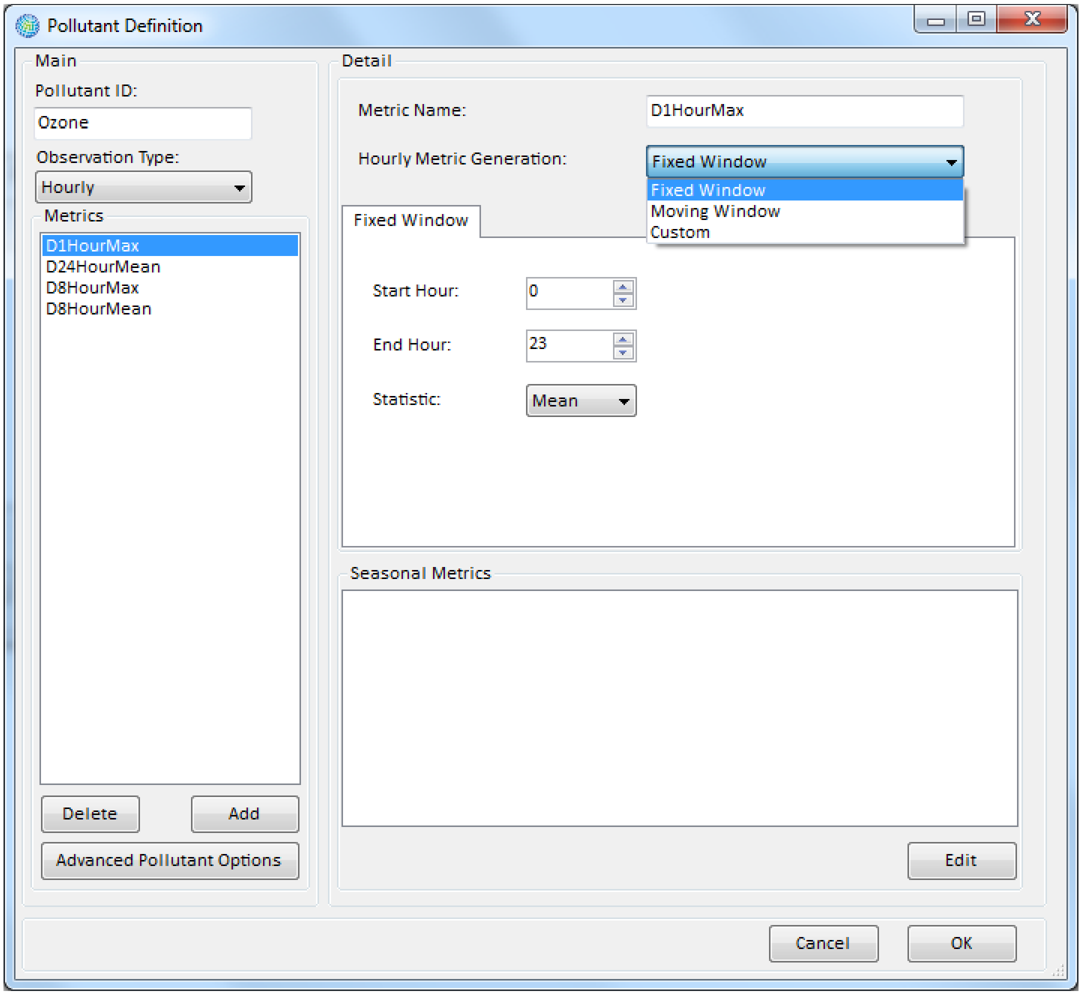
The **Detail** section of the **Pollutant Definition** window lets you define the metrics that you want to use. There are three options that you may choose using the **Hourly Metric Generation** drop-down list: *Fixed Window*, *Moving Window*, and *Custom*.

The **Fixed Window** option lets you define simple metrics which are calculated as statistics over a fixed window of hours (**Start Hour** and **End Hour**) within each day. The **Start Hour** should be less than or equal to the **End Hour**, and both can range from 0 to 23, where 0 stands for the period 12:00 am to 12:59 am, and 23 stands for 11:00 pm to 11:59 pm. The **Statistic** includes the *Mean*, *Median*, *Max*, *Min*, and *Sum.* Some examples follow:

- **D24HourMean**: The mean of the observations from 12:00 am through 11:59 pm. **Start Hour** = *0*. **End Hour** = *23*. **Statistic** = *Mean*.

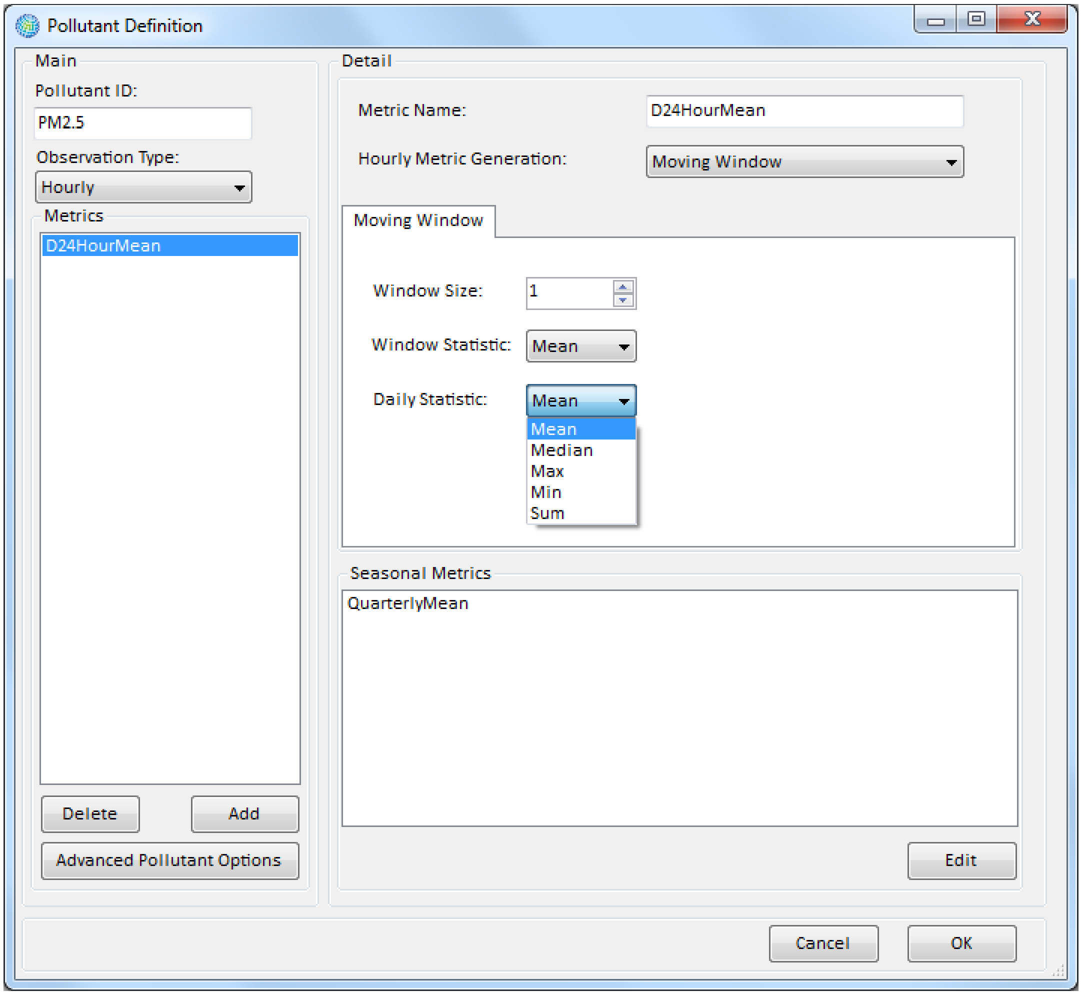
- **D1HourMax**: The highest hourly value of the observations from 12:00 am through 11:59 pm. **Start Hour** = *0*. **End Hour** = *23*. **Statistic** = *Max*.

- **D12HourMean**: The mean of the daylight observations, defined as the period from 8:00 am through 7:59 pm. **Start Hour** = *8*. **End Hour** = *19*. **Statistic** = *Mean*.



The **Moving Window** option lets you consider metrics that are not based on the same set of hours each day. The **Window Size** defines the number of hours that will be considered together. The **Window Statistic** defines how the hours in the **Window Size** will be characterized. And the **Daily Statistic** defines how BenMAP-CE will use the statistics generated for each window.

For example, consider the highest eight-hour mean (*D8HourMax*) over the course of a day. You would have the following settings: **Window Size** = *8*. **Window Statistic** = *Mean*. **Daily Statistic** = *Max*. BenMAP-CE would calculate every possible eight-hour mean, starting with the eight-hour mean from 12:00 am through 7:59 am, and ending with the eight-hour mean from 4:00 pm through 11:59 pm. This would generate 17 possible eight-hour means. BenMAP-CE would then choose the eight-hour mean that has the highest value (see Table 4-2 above for an example).


Pollutant Definition
Main
Pollutant ID:
PM2.5
Observation Type:
Hourly
Metrics
D24HourMean
Delete
Add
Advanced Pollutant Options
Detail
Metric Name:
D24HourMean
Hourly Metric Generation:
Moving Window
Moving Window
Window Size:
1
Window Statistic:
Mean
Daily Statistic:
Mean
Mean
Median
Max
Min
Sum
Seasonal Metrics
QuarterlyMean
Edit
Cancel
OK

The **Custom** tab lets you define **Metrics** using a mathematical function that you specify. These functions can include measures such as the sum of the number of hours of ozone exposure above 60 ppb. The possibilities are quite diverse, as evidenced by the range of functions and variables available for use as shown in Table 4-5. However, the syntax for using these functions is somewhat involved, so we have reserved discussion of this for the Appendix M: Function Editor.

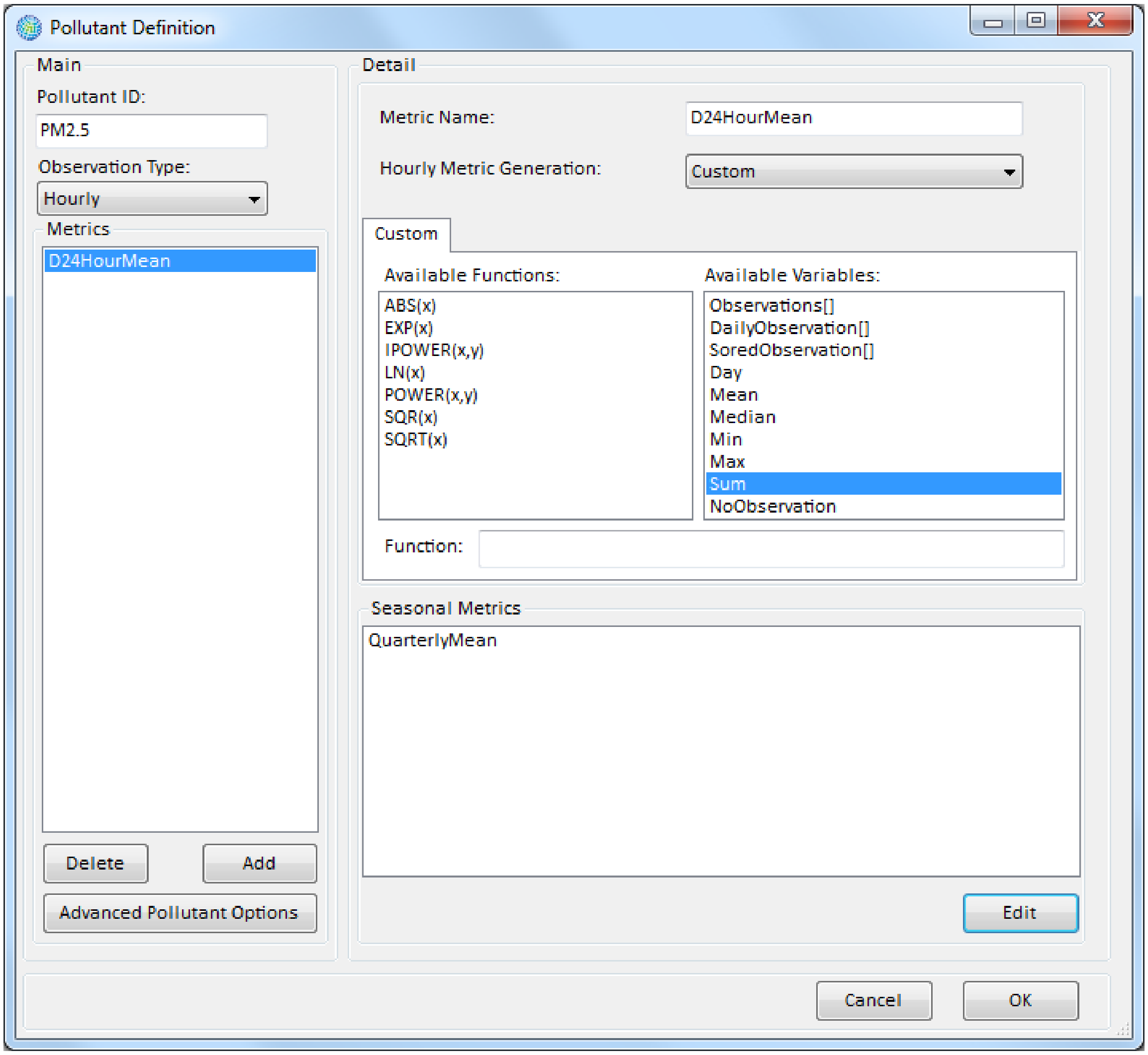


Table 4-5. Available Functions and Variables for Custom Metrics

Name	Description
Functions	
ABS(x)	Returns the absolute value of *x.*
EXP(x)	Returns *e* the power *x*, where *e* is the base of the natural logarithm.
IPOWER(x,y)	Returns *x* to the power *y* (*y* an integer value).
LN(x)	Returns the natural logarithm of *x.*
POWER(x,y)	Returns *x* to the power *y* (*y* a floating point value).
SQR(x)	Returns the square of *x*.
SQRT(x)	Returns the positive square root of *x*.
Variables	
Observations[i]	All hourly observations for the year (index begins at zero, typically ranging to 8,760).
DailyObservations[i]	All hourly observations for the day (indexed zero to twenty-three).
SortedObservations[i]	All hourly observations for the day, sorted from low to high (indexed zero to twenty-three).
Day	Index of the day whose metric value is being generated (index begins at zero).
Mean	Mean of the daily observations.
Median	Median of the daily observations
Min	Minimum of the daily observations.
Max	Maximum of the daily observations.
Sum	Sum of the daily observations.
NoObservation	Flag value indicating a missing observation (-345)

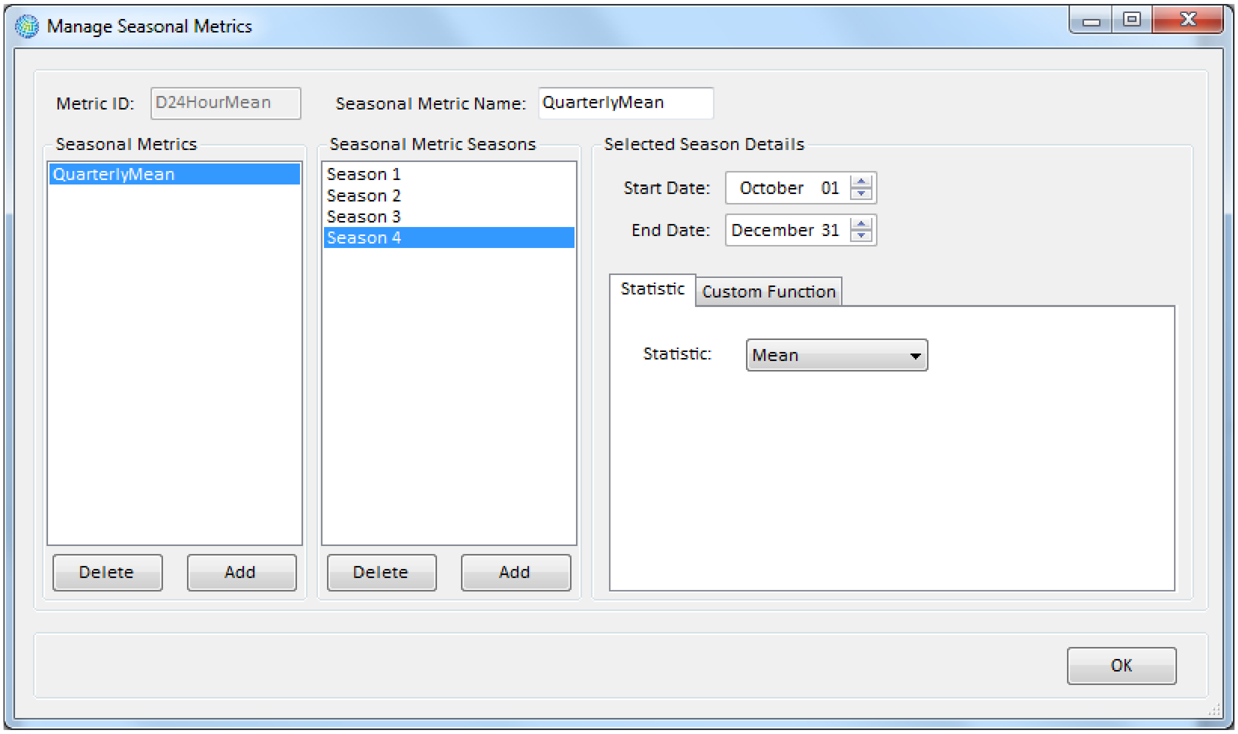
4.1.2.2 Seasonal Metrics

Seasonal Metrics allow you to aggregate daily **Metric** values over a portion of the year that you define. This has a number of uses. For example, if pollutant values vary greatly by season of the year, you can calculate separate pollutant measures for each season of interest. You might be interested in *Dry Season* versus *Wet Season*, or differences between *Winter*, *Spring*, *Summer*, and *Fall*.

To add seasonal metrics, click on the **Edit** button below the **Seasonal Metrics** box. The **Manage Seasonal Metrics** window will appear.

To add a **Seasonal Metric**, click on the **Add** button below the **Seasonal Metrics** box. A default name *Seasonal Metric 0* will appear in the box. Since the default name is not very descriptive, it is best to change the name to something more informative such as the *QuarterlyMean*. As with the **Metric** names, keep in mind that the **Seasonal Metric** names need to be consistent with the metric names that you include in your air pollution monitoring and modeling data, as well as your health impact functions.

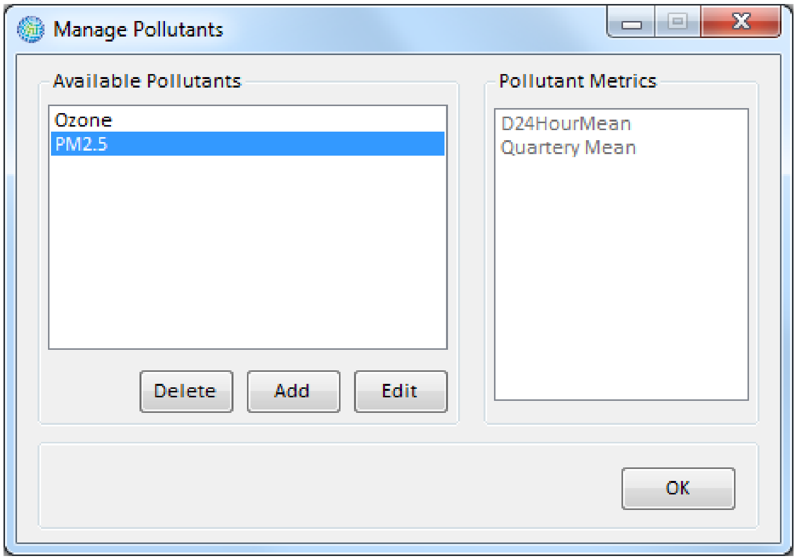
The next step is to define the seasons that you want associated with your **Seasonal Metric** name. For example, in the case of a *Quarterly Mean*, you would want to define four seasons. To start this process, click on the **Add** button below the **Seasonal Metric Seasons** box. Then, in the far right side of the window under **Selected Season Details**, give the **Start Date** and **End Date** for each season. To change the date, click on the month or day, and use the arrows to change the month or day accordingly.



Next, you need to choose the **Statistic** tab or the **Custom Function** tab to determine how the daily **Metrics** will be combined in each season. For example, you might choose the *Mean* from the drop-down list on the **Statistics** tab. This would calculate the mean of the daily metrics in each season. The **Custom** tab allows seasonal metric values to be calculated using customized functions, similar to those used to calculate daily metric values from hourly observations. See Appendix M: Function Editor for more detail on this topic.

Once you have finished defining the **Seasonal Metrics**, click **OK** to return to the **Pollutant Definition** window.

Click **OK** after defining each **Pollutant**. This will return you to the **Manage Pollutants** window.



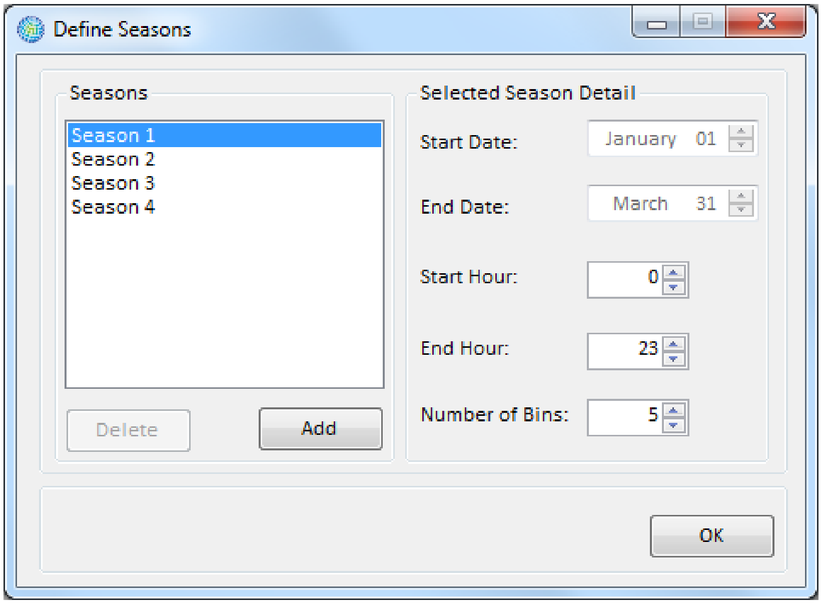
4.1.2.3 Advanced Pollutant Options

The **Advanced Pollutant Options** button on the **Pollutant Definition** window allows you to associate **Seasons** with a **Pollutant**. These seasons differ somewhat from the **Seasonal Metrics** discussed above. They are used to define:

- The portion of the year for which benefits are calculated for a **Pollutant**. You can think of **Seasons** as defining this period of the year "globally" for the pollutant, as it affects the portion of the year over which both **Metrics** and **Seasonal Metrics** are calculated. For example, in the United States ozone benefits are often only calculated for the ozone season, from May 1 through September 30.

- The portion(s) of the year for which missing pollutant concentrations are filled in by BenMAP-CE. That is, in order to calculate benefits, BenMAP-CE in certain cases needs to generate complete sets of metric values by estimating concentrations for those days which have missing observations. This can be important if certain seasons tend to have more missing values than others.

To define **Seasons** for a **Pollutant**, click the **Advanced Pollutant Options** button. This will bring up the **Define Seasons** window. For each season desired, click the **Add** button, select the appropriate **Start Date** and **End Date**, which define the days included in the season; the appropriate **Start Hour** and **End Hour**, which define the hours included in monitoring period; and the appropriate **Number of Bins**, which define the number of bins used in scaling monitor values. The advanced options for $PM_{2.5}$ look like the following:



Once you have finished defining the **Seasons**, click **OK** to return to the **Pollutant Definition** window.

If you later wish to View or Edit a particular **Pollutant** definition, simply select the appropriate **Pollutant** within the **Available Pollutants** box and click the **Edit** button. When you are done, click **OK** to return to the **Modify Datasets** window.

After defining all of the pollutants that you want, click **OK**. This will return you to the **Modify Datasets** window.

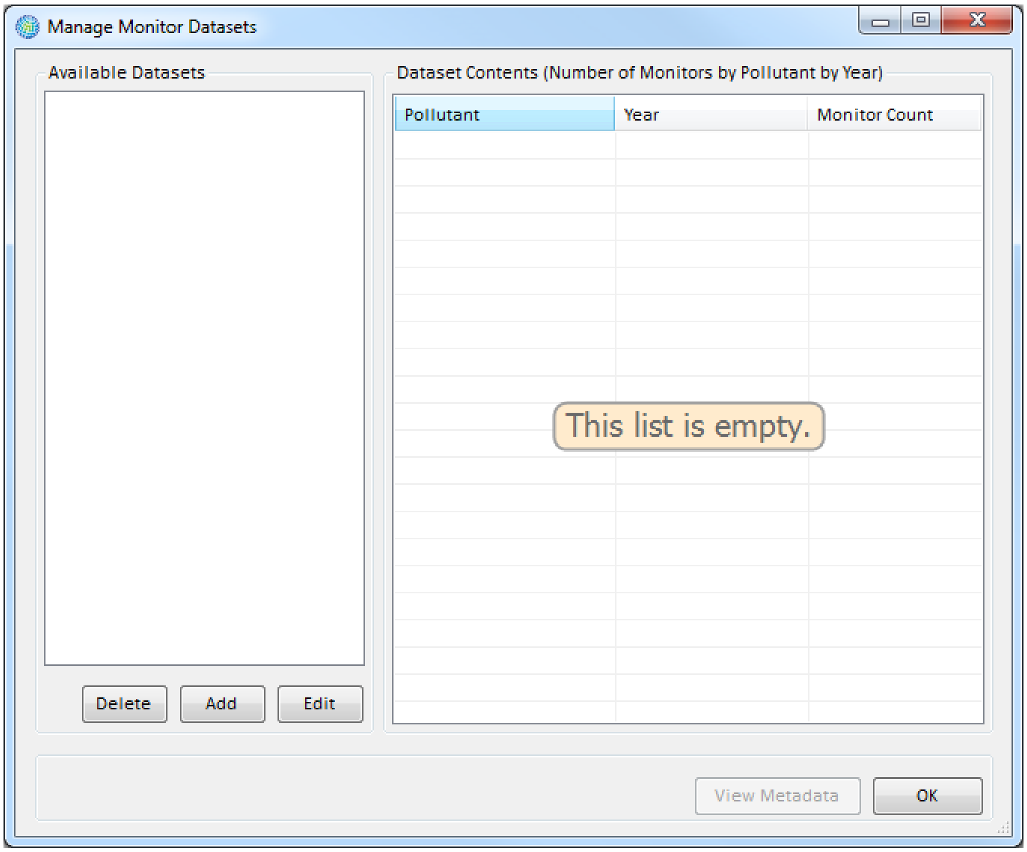
4.1.3 Monitor Datasets

The **Monitor Datasets** section of the **Modify Datasets** window allows you to add air pollution monitoring data to your setup. Air pollution monitoring data may be used to estimate ambient pollution levels in each grid cell defined by a **Grid Definition**. BenMAP-CE uses a variety of procedures (such as *Voronoi Neighbor Averaging*, discussed later) to interpolate the monitor data points across the area of interest.

NOTE: Air pollution data in BenMAP-CE is of two types: (1) point source monitoring data and (2) **Grid Definition**-based modeling data. Both types of data must be associated with a particular pollutant that you have already defined. Only the point source monitoring data is stored in the setup database. The modeling data are loaded into BenMAP-CE as you need them for a particular analysis.

4.1.3.1 Add Monitor Datasets

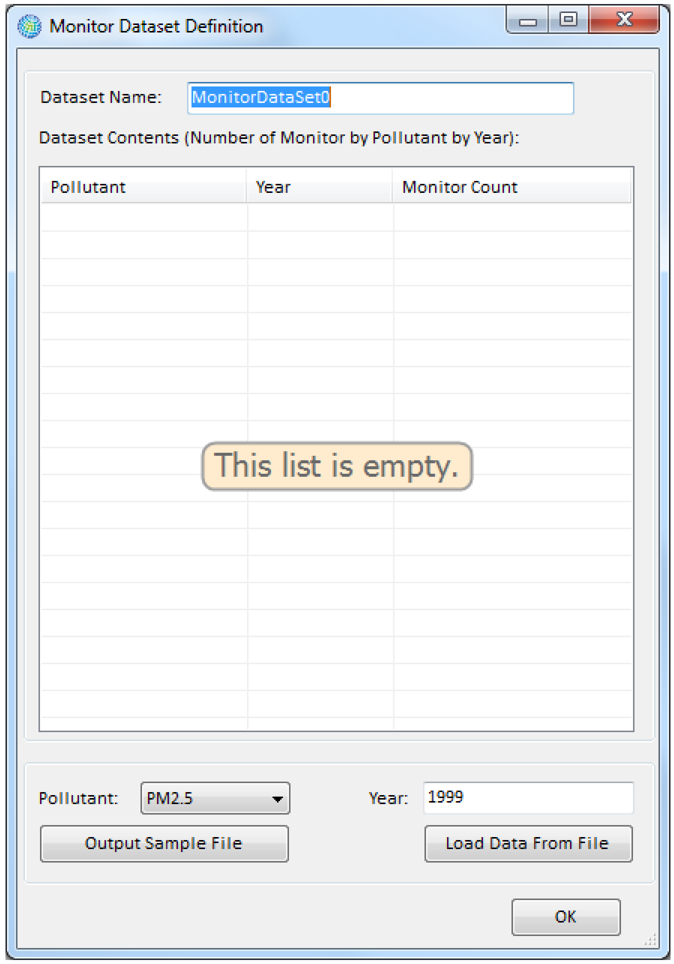
To start, click on the **Manage** button below the **Monitor Datasets** box. The **Manage Monitor Datasets** window will appear. From this window you may **Add** monitoring data, view and **Edit** existing datasets, as well as **Delete** them. The section on the left under **Available Datasets** lists the monitor datasets that are currently in the setup. The section on the right under the **Dataset Contents** identifies the number of monitors in each dataset by *Pollutant* and by *Year*. To view the metadata of a particular monitor, select an **Available Dataset** and click on a row from the **Dataset Contents**, then click the **View Metadata** button. This allows you to view further information about references or descriptions of the file.



To start adding data, click the **Add** button. This will bring up the **Monitor Dataset Definition** window. Give the dataset a name in the **Dataset Name** box, choose the appropriate pollutant from the **Pollutant**[3] drop-down menu, and then type the 4-digit *Year* of the data in the **Year** box.

NOTE: The **Dataset** that you define can have one or more pollutants and multiple years of data (e.g., representing a particular monitoring network). However the data must be imported one pollutant and one year at a time.

[3] The pollutants in the **Pollutant** drop-down menu have been defined under the **Pollutants** box on the **Modify Datasets** window.



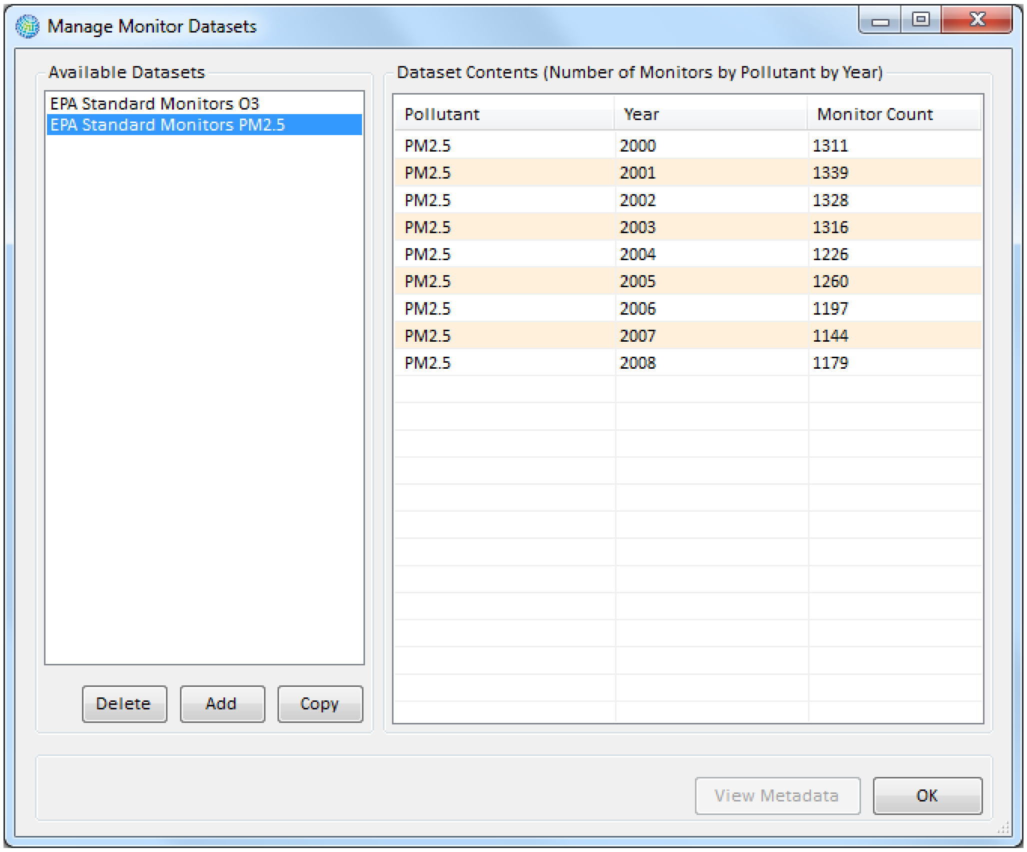
Monitor data must be formatted in a database file, with monitor definition information and monitor values in a single line.

After specifying the **Pollutant** and **Year**, click on the **Load Data From File** button to bring up a window from which you can **Browse** the BenMAP-CE Data directory to find the desired data file. Click **Open,** to choose the file.

Users are advised to click the **Validate** button before loading the monitor dataset. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings.[4] The user also has the option of adding metadata to the file to save references and comments about that specific file. To add metadata, click the **View Metadata** button. After passing validation (and adding metadata if desired) click the **OK** button to bring you back to the **Monitor Dataset Definition** window.

[4] Validation reports are saved to C:\Users\<user name>\Documents\My BenMAP-CE Files\ValidationResults.

Repeat this procedure to load all of your monitoring data. If you try to load the data for the same pollutant/year combination, BenMAP-CE will warn you of the duplication.



To see the years of data and the number of monitors each year, use the scrollbars on the bottom and on the right of the **Dataset Contents** box. To view the metadata for a particular entry in the dataset, choose an **Available Dataset** and row in the **Dataset Contents** and click the **View Metadata** button.

To delete existing datasets, select the dataset in the **Available Datasets** list and click the **Delete** button. To edit an existing dataset, select the dataset in the **Available Datasets** list and click the **Edit** button. (Note: Certain pre-loaded datasets cannot be edited. Instead if you select one of these, you will have the option to **Copy** the locked dataset and then you can edit the copied dataset.)

When you have finished loading your monitor data, click **OK** in the **Manage Monitor Datasets** window. This will take you back to the **Modify Datasets** window, which will show the name of the **Dataset**(s) that you just entered.

4.1.3.2 Format for Monitor Data

Monitor data is required to be formatted in a single database file, with monitor definition information and monitor values in a single line. Tables 4-6a and 4-6b list the variables in the monitor dataset and provide a sample of what a data file might look like.

NOTE: The monitor data files do not specify the pollutant with which the data is associated—this is specified by the user when loading the monitor data into BenMAP-CE.

Table 4-6a. Required Format, Air Monitoring Data File Variables

Variable	Type	Required	Notes
Monitor Name	Text	Yes	Unique name for each monitor in a particular location.
Description	Text	No	Description of the Monitor.
Longitude	Numeric (double)	Yes	Values should be in decimal degree format. Values in the eastern hemisphere are positive, and those in the western hemisphere are negative.
Latitude	Numeric (double)	Yes	Values should be in decimal degree format. Values in the northern hemisphere are positive, and those in the southern hemisphere are negative.
Metric	Text	No	This variable is either blank (signifying that the Values are Observations, rather than Metric values), or must reference an already defined Metric (e.g., 1-hour daily maximum) for the appropriate Pollutant.
Seasonal Metric	Text	No	This variable is either blank (signifying that the Values are not Seasonal Metric values) or must reference an already defined Seasonal Metric for the Metric (e.g., mean of the 1-hour maximum values for the months of June through August).
Statistic	Text	No	This is an annual metric, which is either blank (signifying that the values are not annual statistics) or must be one of: None, Mean, Median, Max, Min, Sum. (e.g., mean of the 1-hour maximum for the year)
Values	Text	Yes	If Metric is blank, values are supplied as a comma-delimited string of values for the year [e.g., 365 or 366 (leap year) values for daily data, 8760 or 8784 (leap year) values for hourly data]. If Metric is defined, but Seasonal Metric and Statistic are blank, 365 or 366 metric values. If Seasonal Metric is defined, but Statistic is blank, n seasonal metric values. If Statistic is defined, one annual statistic value for either the Metric (if Seasonal Metric is blank) or the Seasonal Metric. Missing values are signified with a period ('.').

Table 4-6b. Required Format, Sample Air Monitoring Data File

Monitor Name	Monitor Description	Latitude	Longitude	Metric	Seasonal Metric	Statistic	Values
260050003881011	'RESIDENTIAL, SUBURBAN'	42.7678	-86.1486	D24HourMean	QuarterlyMean	Mean	11.67
260170014881011	'RESIDENTIAL, URBAN AND CENTER CITY'	43.5714	-83.8907	D24HourMean	QuarterlyMean	Mean	11.62
260210014881011	'COMMERCIAL, RURAL'	42.1978	-86.3097	D24HourMean	QuarterlyMean	Mean	11.58
260490021881011	'RESIDENTIAL, URBAN AND CENTER CITY'	43.0472	-83.6702	D24HourMean	QuarterlyMean	Mean	11.56
260650012881011	'RESIDENTIAL, URBAN AND CENTER CITY'	42.7386	-84.5346	D24HourMean	QuarterlyMean	Mean	11.49
260770008881011	'COMMERCIAL, URBAN AND CENTER CITY'	42.2781	-85.5419	D24HourMean	QuarterlyMean	Mean	11.44
260810007881011	'INDUSTRIAL, URBAN AND CENTER CITY'	42.9561	-85.6791	D24HourMean	QuarterlyMean	Mean	11.4
260810020881011	'INDUSTRIAL, URBAN AND CENTER CITY'	42.9842	-85.6713	D24HourMean	QuarterlyMean	Mean	11.36
260990009881011	'COMMERCIAL, SUBURBAN'	42.7314	-82.7935	D24HourMean	QuarterlyMean	Mean	11.43
261010922881011	'RESIDENTIAL, URBAN AND CENTER CITY'	44.3070	-86.2426	D24HourMean	QuarterlyMean		11.43,11.07,10.98,10.90
261130001881011	'FOREST, RURAL'	44.3106	-84.8919	D24HourMean	QuarterlyMean		11.44,14.23,11.20,9.30
261150005881011	'AGRICULTURAL, RURAL'	41.7639	-83.4719	D24HourMean	QuarterlyMean		11.39,13.71,10.04,11.24
261210040881011	'COMMERCIAL, URBAN AND CENTER CITY'	43.2331	-86.2386	D24HourMean	QuarterlyMean		11.28,9.23,15.03,11.10
261250001881011	'RESIDENTIAL, SUBURBAN'	42.4631	-83.1832	D24HourMean	QuarterlyMean		11.27,11.12,13.15,12.03
261390005881011	'RESIDENTIAL, SUBURBAN'	42.8945	-85.8527	D24HourMean	QuarterlyMean		11.27,10.05,10.9,12.13
261470005881011	'RESIDENTIAL, SUBURBAN'	42.9533	-82.4562	D24HourMean	QuarterlyMean		11.26,12.13,15.00,10.01
261610008881011	'COMMERCIAL, URBAN AND CENTER CITY'	42.2406	-83.5996	D24HourMean	QuarterlyMean		11.24,14.05,11.03,10.10
261630001881011	'COMMERCIAL, SUBURBAN'	42.2286	-83.2082	D24HourMean	QuarterlyMean		11.23,9.23,13.04,10.09
261630015881011	'COMMERCIAL, URBAN AND CENTER CITY'	42.3028	-83.1065	D24HourMean	QuarterlyMean		11.23,11.24,10.45,10.04
261630016881011	'RESIDENTIAL, URBAN AND CENTER CITY'	42.3578	-83.0960	D24HourMean	QuarterlyMean		11.2,10.73,11.23,10.45
261630019881011	'RESIDENTIAL, SUBURBAN'	42.4308	-83.0001	D24HourMean			.,.,13.01,.,.,17.19,.,.,3.89,.,.,13.86,.,.,5.9
261630025881011	'COMMERCIAL, SUBURBAN'	42.4231	-83.4263	D24HourMean			.,.,13.48,.,.,8.73,.,.,6.079,.,.,14.534,.,.,3.
261630033881011	'INDUSTRIAL, SUBURBAN'	42.3067	-83.1488	D24HourMean			.,.,15.675,.,.,12.72,.,.,6.46,.,.,16.24,.,.,6.
261630036881011	'COMMERCIAL, SUBURBAN'	42.1873	-83.1539	D24HourMean			.,.,16.52,.,.,15.01,.,.,5.41,.,.,15.39,.,.,5.0
261630038881011	'RESIDENTIAL, URBAN AND CENTER CITY'	42.3350	-83.1096	D24HourMean			.,.,20.52,.,.,21.85,.,.,5.88,.,.,19.28,.,.,5.1
261630039881011	'RESIDENTIAL, URBAN AND CENTER CITY'	42.3233	-83.0685	D24HourMean			.,.,20.14,.,.,7.59,.,.,8.17,.,.,13.11,.,.,7.59

4.1.4 Incidence and Prevalence Rates Data

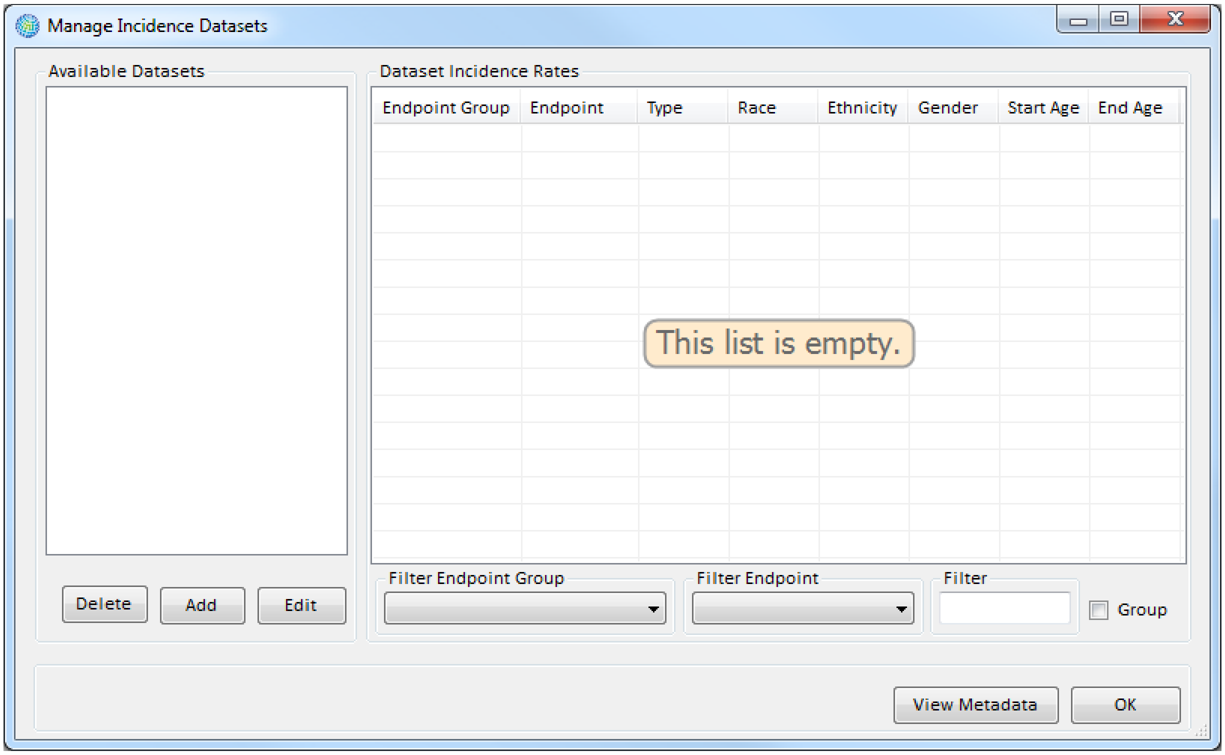
Most health impact functions, such as those developed from log-linear or logistic health impact functions, estimate the percent change in a health effect associated with a pollutant change. In order to estimate the absolute change in incidence using these functions, the baseline incidence rates (and in some cases the prevalence rate) of the adverse health effect are needed.

The incidence rate is the number of health effects per person in the population per unit of time, and the prevalence rate is the percentage of people that suffer from a particular chronic illness. For example, the incidence rate for asthma attacks may be 25 cases per asthmatic individual per year, and the prevalence rate (measuring the percentage of the population that is asthmatic) might be six percent of the total population.

NOTE: For both incidence and prevalence rates, BenMAP-CE allows the user to have rates that vary by race, ethnicity, gender, and age group. BenMAP-CE can support multiple sets of incidence and prevalence rates, if the rates differ by year or by grid definition.

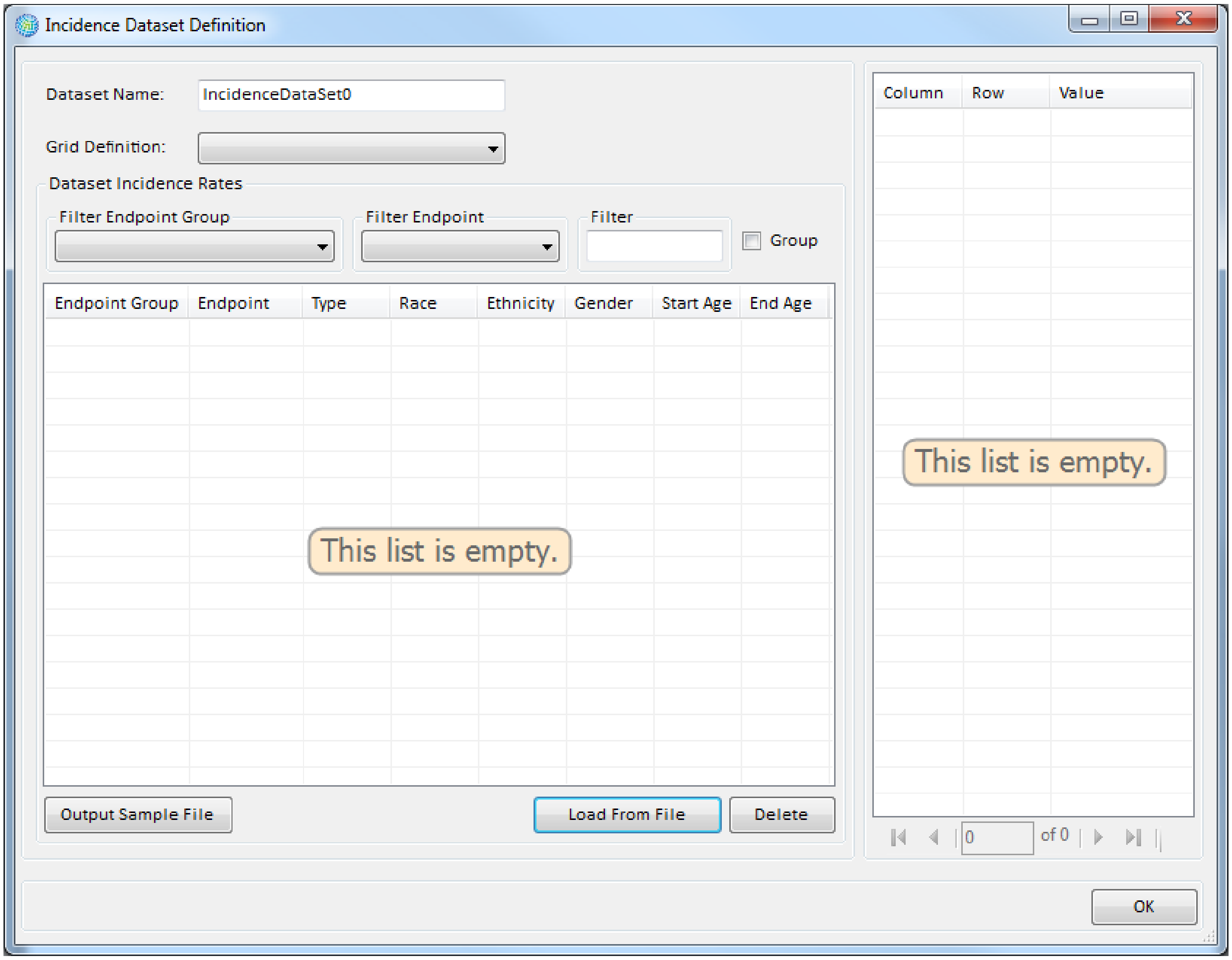
4.1.4.1 Add Incidence/Prevalence Rates

To start adding incidence and prevalence data files, click on the **Manage** button below the **Incidence/Prevalence Rates** box. The **Manage Incidence Datasets** window will appear.



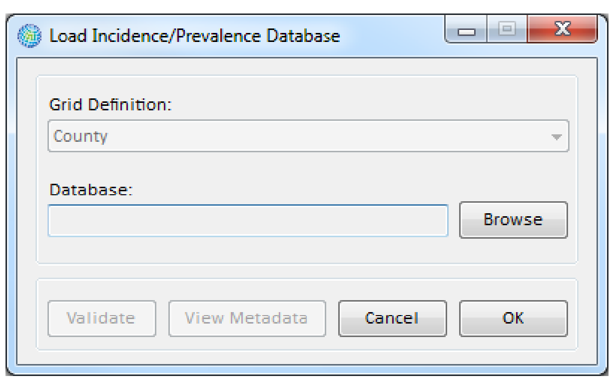
In this window you may **Add**, **Edit**, and **Delete** datasets. The section on the left under **Available Datasets** lists the incidence/prevalence datasets that are currently in the setup. The section on the right under the **Dataset Incidence Rates** identifies the rates in the selected dataset.

To add a dataset, click the **Add** button. This will bring up the **Incidence Dataset Definition** window. Give a name to the dataset that you are creating by typing a name in **Dataset Name** box.

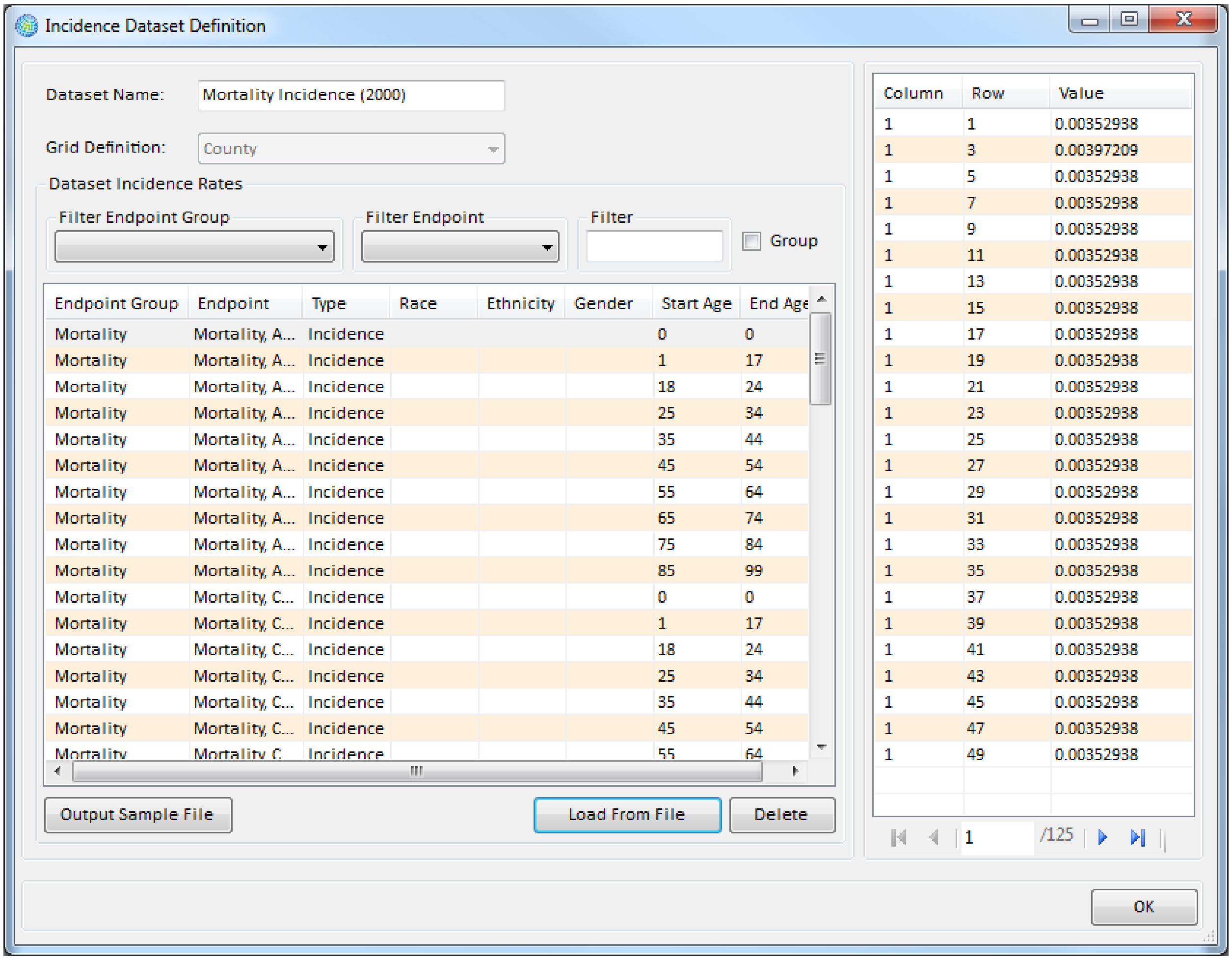


NOTE: If you have multiple incidence or prevalence datasets that vary, for example, by year and grid definition, then use the name to provide a reference to the year and grid definition.

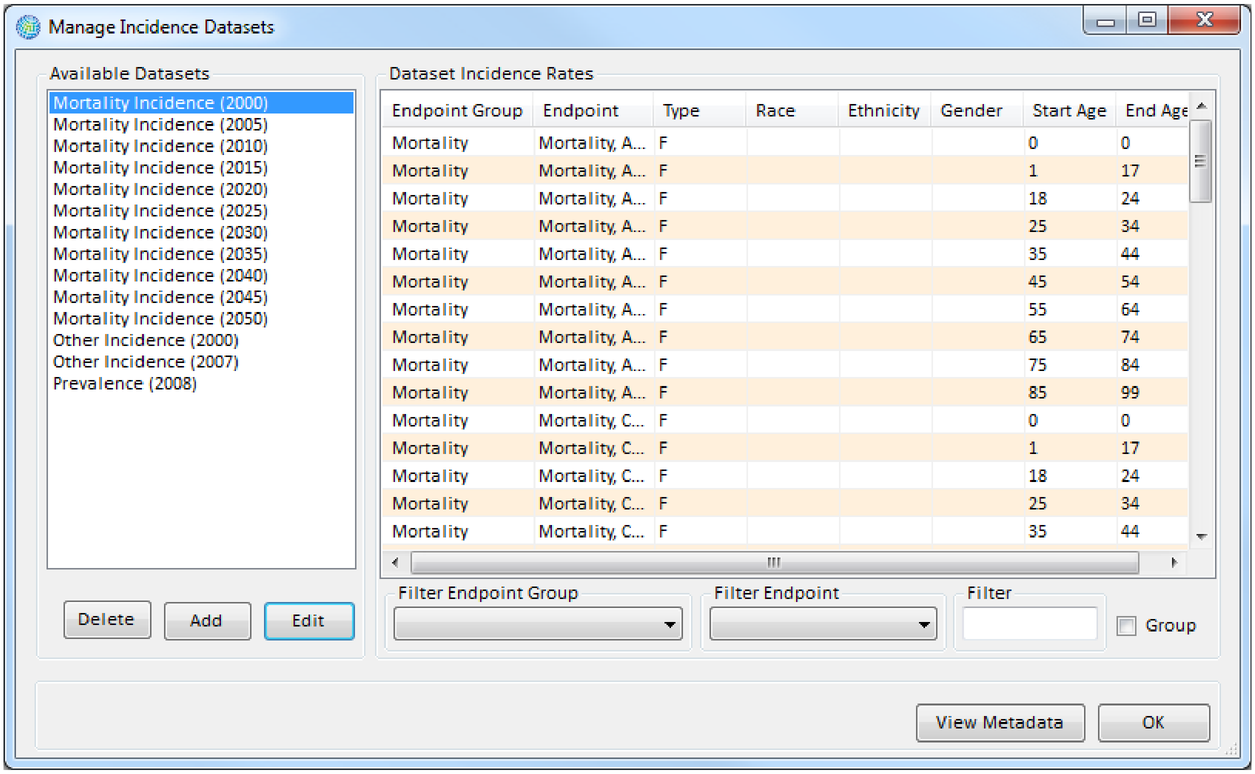
In the **Grid Definition** drop-down list choose the item that matches the grid definition used to develop the incidence/prevalence dataset. Note: The incidence and prevalence rate data must use the same column/row information as the matching grid definition. Click the **Load From File** button. Then click on the **Browse** button, to browse for the dataset file. (The format for the dataset is detailed in the next sub-section.)



After locating the file, click **Open**. Click the **Validate** button before loading the data. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings. You also have the option of adding metadata to the dataset. This is done by clicking the **View Metadata** button and adding any references or descriptions that you see fit. Click **OK** on the **Load Incidence/Prevalence Database** window to load the selected file. The **Incidence Dataset Definition** window will appear, displaying the rates in the data file that you just loaded.



If the data look correct, click **OK.** This will return you to the **Manage Incidence Datasets** window. To view any metadata that was added, select an **Available Dataset** and a **Rate**, and click the **View Metadata** button. The user can view or edit the metadata of the imported files.



Follow the same procedure for any additional incidence/prevalence datasets that you want to add to the setup database. When you have finished adding data, click **OK** in the **Manage Incidence Datasets** window. The **Incidence/Prevalence Rates** box in the **Modify Datasets** window will show the datasets that you have entered.

4.1.4.2 Format for Incidence/Prevalence Data

Table 4-7a presents the variables that can be used in incidence and prevalence datasets, and Table 4-7b presents a sample dataset that follows this format.

Table 4-7a. Health Incidence and Prevalence Dataset Variables

Field Name	Type	Required	Notes
Endpoint Group	Text	Yes	If this does not reference an already defined Endpoint Group, one will be added.
Endpoint	Text	Yes	If this does not reference an already defined Endpoint for the Endpoint Group, one will be added.
Race	Text	No	Should either be blank (signifying All Races) or reference a defined Race, such as "Black" (from one or more Population Configurations).

Field Name	Type	Required	Notes
Ethnicity	Text	No	Should either be blank (signifying All Ethnicities) or reference a defined Ethnicity, such as "Hispanic" (from one or more Population Configurations).
Gender	Text	No	Should either be blank (signifying All Genders) or reference a defined Gender (from one or more Population Configurations).
Start Age	Integer	Yes	Specifies the low and high ages, inclusive. For example, Start Age of "0" and End Age of "1" include infants through the first 12 months of life and all one-year old infants.
End Age	Integer	Yes	
Column	Integer	Yes	The Column and the Row link the incidence/prevalence data with cells from a Grid Definition.
Row	Integer	Yes	
Value	Numeric (double)	Yes	The incidence/prevalence rate for the specified demographic group for this location.
Type	Text	No	If value is a prevalence rate, then "Prevalence" should be specified. Otherwise BenMAP-CE assumes that the value is an incidence rate.

Table 4-7b. Sample Health Incidence Dataset

Endpoint Group	Endpoint	Year	Race	Gender	Ethnicity	Start Age	End Age	Column	Row	Type	Value
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	2	Incidence	2.62E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	3	Incidence	7.73E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	4	Incidence	1.68E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	5	Incidence	5.45E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	6	Incidence	1.02E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	7	Incidence	2.72E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	8	Incidence	5.05E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	9	Incidence	3.03E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	10	Incidence	5.89E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	11	Incidence	3.11E-06
Hospital Admissions, Respiratory	HA, Asthma	2002				0	99	1	12	Incidence	3.30E-06

4.1.5 Population Data

The population data is used to estimate population exposure and in turn any adverse health effects associated with a change in air pollution. BenMAP-CE allows you to specify race, ethnicity, gender, and age of the population, as well as the year of the population estimate.

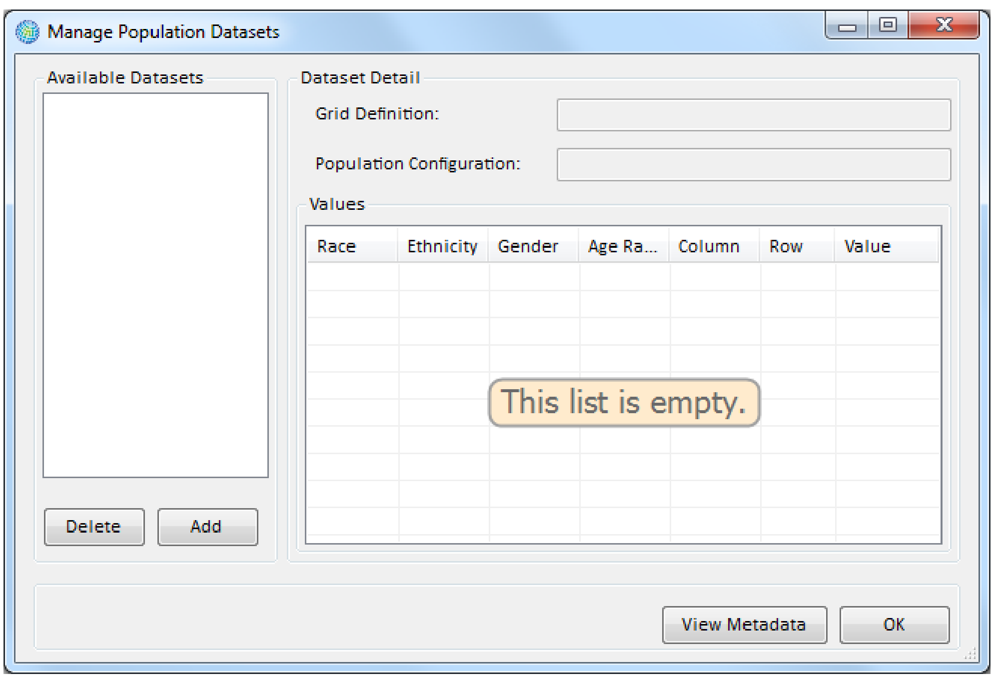
Population data loaded into BenMAP-CE must be associated with a **Population Configuration**, which defines the races, ethnicities, genders, and age ranges present in the data. Race, ethnicity, and gender are unique text values representing population subgroups. Age ranges are defined by integer values for starting age and ending age (inclusive), and a unique text value representing the name of the age range. For example, '0TO1' might be used as a name for the age range defined by a start age of zero and an end age of one, thus consisting of infants through the first twelve months of life and all one-year old infants. The population data provided to BenMAP-CE should then contain population values for all combinations of race, ethnicity, gender, and age range. The population values may be non-integer values.

Population data must also be associated with a **Grid Definition** which specifies the geographic areas for which the data is available (see for more details the section on Grid Definitions). If population data is available for multiple grid definitions (cities and neighborhoods, for example), you can have the option of using different sets of population data for different analyses.

BenMAP-CE can also estimate populations for Grid Definitions for which no population data is available by calculating spatial overlap percentages with Grid Definitions for which data is available.

4.1.5.1 Add Population Data

To add population data to BenMAP-CE, click on the **Manage** button below the **Population Datasets** box in the **Modify Datasets** window. The **Manage Population Datasets** window will appear.

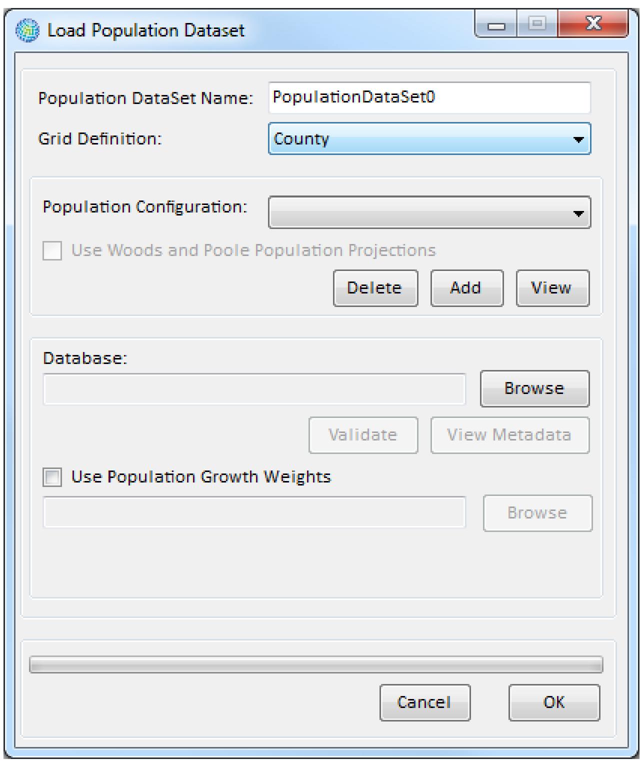


Click on the **Add** button to display the **Load Population Dataset** window. Name the dataset using the **Population Dataset Name** box.

The **Grid Definition** drop-down list provides the list of existing grid definitions. Choose a grid definition that matches your population dataset.

The **Population Configuration** section allows you to define the variables that are in the population data file to be loaded into BenMAP-CE. Use the drop-down list to choose an existing population configuration and then view it by clicking the **View** button, or you may click the **Add** button and define a new population configuration. Clicking the **Add** button will open a **Population Configuration Definition** window where you can enter the fields that appear in the file that will be later uploaded (discussed in more detail below).

The **Browse** button to the right of the Database box allows you to find the data file that you want to load into BenMAP-CE. Once you click **Open** and load the file, the **Validate** and **View Metadata** buttons become active. You can click the **Validate** button before the file is loaded into the **Manage Population Datasets** form. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings. You can also add metadata, which includes references and descriptions, by clicking the **View Metadata** button.



If you wish to run an analysis based on an air quality grid not already defined in BenMAP-CE, you may need to import a new population file matched to that grid definition. The PopGrid program allocates the 2010 block-level U.S. Census population to a user-defined grid, creating a population file ready for importation to BenMAP-CE.[5]

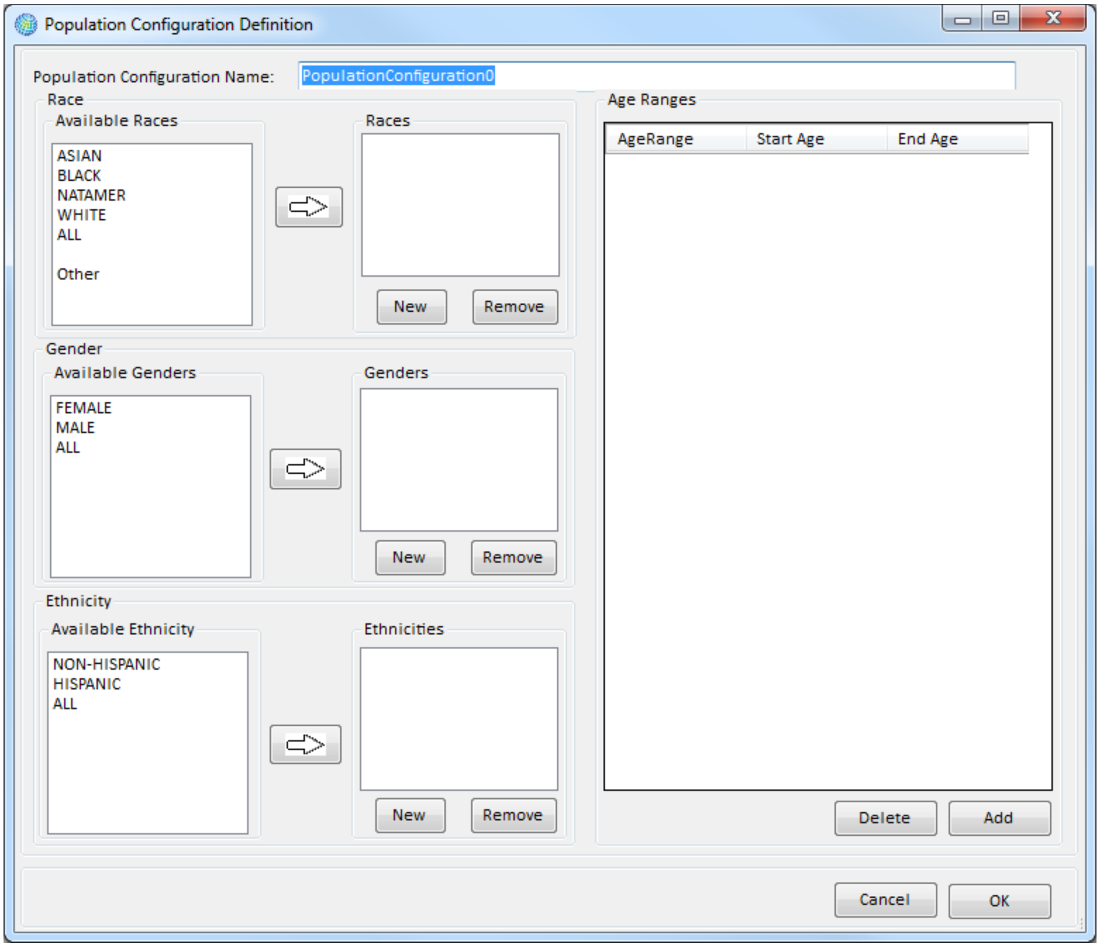
The *Use Population Growth Weights* checkbox should be checked when using population data generated by the PopGrid software application. The population weights file assists in forecasting population levels. See Appendix J for a more detailed discussion of population growth weights in the *United States* setup.

Defining a Population Configuration

If you are performing an analysis outside of the U.S. and are loading your own population data, you will need to first create a new **Population Configuration**. The Population Configuration defines the age range (**Start Age** and **End Age**), **Race**, **Ethnicity**, and **Gender** variables in your population database. It is critical that the age, race, ethnicity, and gender variables in the configuration match your population input data exactly, otherwise BenMAP-CE will fail to load the population data. (If this occurs, you need to go back and either develop a new population configuration to match your data, or you need to revise your population database so that it matches the population configuration.)

To add a population configuration, click the **Add** button in the **Load Population Dataset** window.

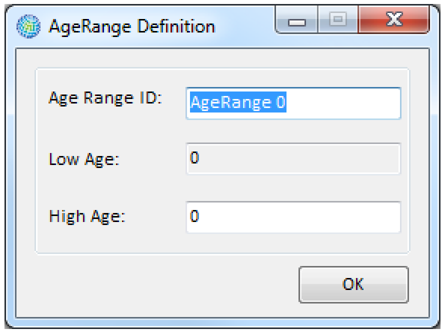
[5] The PopGrid program may be downloaded from EPA's website. See: http://www2.epa.gov/benmap/benmap-community-edition.



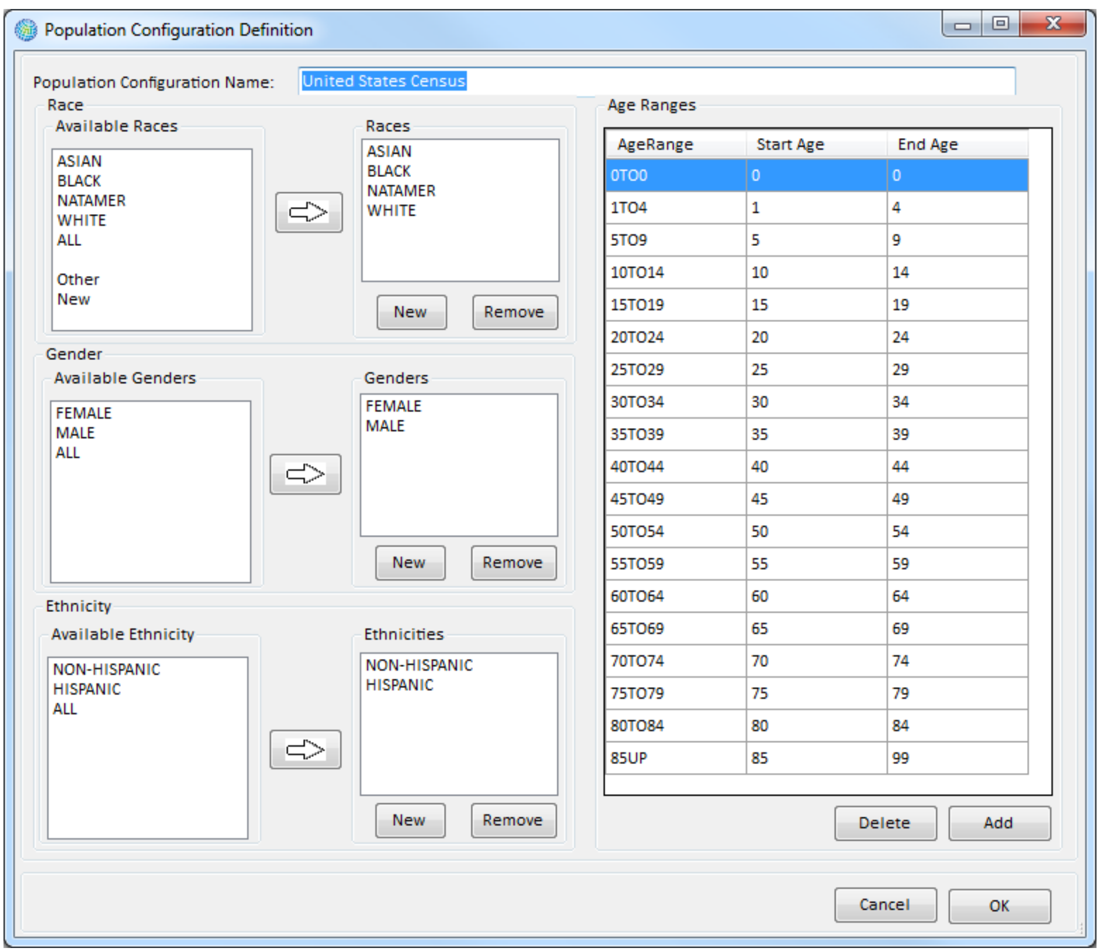
In the **Population Configuration Name** box, replace '*PopulationConfiguration0'* with a name of your choosing. Under the **Races** box click on **New** and type in the name for any races present in your population data. The names appear in both the **Races** list box and the **Available Races** list box. (If you later create alternative population configurations, you can simply drag the relevant names from the **Available Races** list box into the **Races** list box.) Similarly, under the **Available Genders** and **Available Ethnicity** list boxes, click on **New** and type in the name for any ethnicity and gender identifiers present in your population data.

If you want to remove a category in **Races**, **Genders**, or **Ethnicity** list boxes, then highlight the entry that you want to remove and click the **Remove** button. (It is not possible to remove entries from the **Available Races**, **Available Genders**, or **Available Ethnicity** list boxes.)

The next step is to create the age ranges that match the age ranges in your population file. To start click on the **Add** button below the **Age Ranges** list box. The **AgeRange Definition** window will appear. Type in the name of the age variable in the **Age Range ID** box and the upper bound of the age range in the **High Age** box. (BenMAP-CE automatically fills in the value for the **Low Age** box.) For example, the age range names (with corresponding low and high ages) might include the following: *0to0*, *1to4*, *5to9*, *10to14*, *15to19*, *20to24*, *25to29*, *30to34*, *35to39*, *40to44*, *45to49*, *50to54*, *55to59*, *60to64*, *65to69*, *70to74*, *75to79*, *80to84*, and *85up*. The choice of the names is up to you. However, you must be sure that the names exactly match those in your population input file.

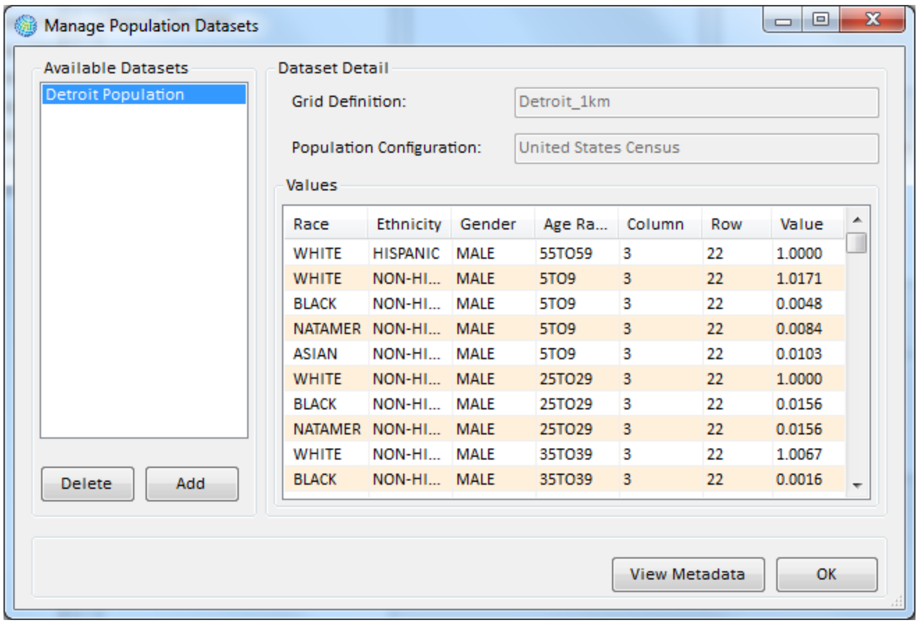


Click **OK** when you have defined the age range. If you make a mistake and want to delete an age definition after you have entered it, click on the **Delete** button. This will remove the last age range that you have entered. (Click on it twice if you want to remove the last two age groups that you entered.) The population configurations can be quite detailed, as in the case of the *United States Census* population configuration that comes loaded with BenMAP-CE.



Click **OK** on the **Population Configuration Definition** window to return to the **Load Population Dataset** window.

Click **OK** on the **Load Population Dataset** window to return to the **Manage Population Datasets** window. To view or edit any metadata that was previously added, click the **View Metadata** button. Click **OK** on the **Manage Population Datasets** window. In the **Population Datasets** box of the **Modify Datasets** window you should see an entry for the population dataset that you just loaded.



4.1.5.2 Format for Population Data

Table 4-8 presents the variables that can be used in population datasets. Note that the names you define for age ranges do not need to follow the same pattern used in this manual; the age ranges should be based on what seems most appropriate for you. However, it is critical that the age, race, ethnicity, and gender variables in your population input data exactly match those defined for the population configuration, otherwise BenMAP CE will fail to load the population data

Table 4-8. Population Dataset Variables

Variable	Type	Required	Notes
Age Range	Text	Yes	References a defined age range in the associated Population Configuration.
Column	Integer	Yes	The column and the row link the population data with cells in a Grid Definition.
Row	Integer	Yes	

Variable	Type	Required	Notes
Year	Integer	Yes	The year of the data. Note that this may include historical population estimates (such as from a census), as well as population forecasts.
Population	Numeric (double)	Yes	Population estimate. Note that the estimate is not restricted to integers.
Race	Text	Yes	References a defined race in the associated Population Configuration.
Ethnicity	Text	No	References a defined ethnicity in the associated Population Configuration.
Gender	Text	Yes	References a defined gender in the associated Population Configuration.

4.1.6 Health Impact Functions

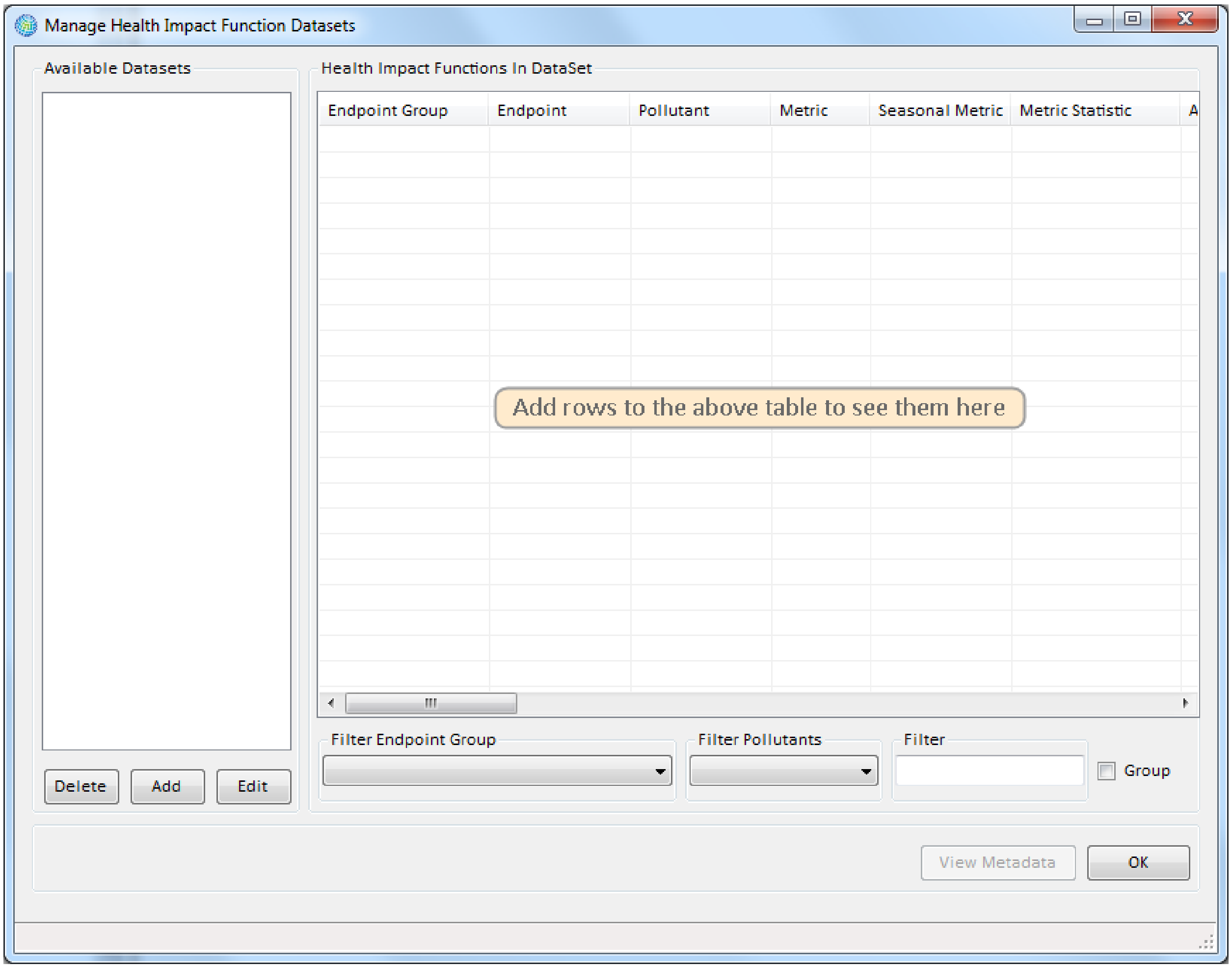
Health impact functions calculate the change in the number of adverse health effects among a certain population associated with a change in exposure to air pollution. A typical health impact function has inputs specifying the pollutant; the metric (daily, seasonal, and/or annual); the age, race, ethnicity, and gender of the population affected; and the incidence rate of the adverse health effect.

Health impact functions are subdivided by user-specified types of adverse health effects. The broadest category is the **Endpoint Group**, which represents a broad class of adverse health effects, such as premature mortality, cardiovascular-related hospital admissions, and respiratory- related hospital admissions, among other categories. (BenMAP-CE only allows pooling of adverse health effects to occur within a given endpoint group, as it generally does not make sense to sum or average together the number of cases of disparate health effects, such as premature mortality and chronic bronchitis.) The **Endpoint Group** may then be subdivided by user-specified **Endpoints**. For example, the respiratory-related hospital admission **Endpoint Group**, may have separate **Endpoints** for asthma-related hospital admissions and chronic bronchitis-related hospital admissions.

There are a wide range of variables that can be included in a health impact function, to specify the parameters of the function and to identify its source, such as the **Author**, **Year**, and **Location** of the study, as well as other **Pollutants** used in the study. The bibliographic **Reference** for the study may be included, as well as any additional information needed to identify a particular impact function. (The **Reference** variables are useful for this.) A number of health impact functions have been developed based on epidemiological studies in the United States and Europe. However, researchers have conducted an increasing number of epidemiological studies in Asia and Latin America that can be used to develop more location-specific impact functions. There are a number of issues that arise when deriving and choosing between health impact functions that go well beyond this user manual. *Hence, it is important to have a trained health researcher assist in developing the impact function data file.* [6]

4.1.6.1 Add Health Impact Functions

To add health impact functions to BenMAP-CE, click on the **Manage** button below the **Health Impact Functions** box in the **Modify Datasets** window. The **Manage Health Impact Functions Datasets** window will appear.



In this window you may **Add**, **Edit**, and **Delete** datasets. The section on the left under **Available Datasets** lists the health impact function datasets that are currently in the setup database. (See Appendix C for more information about the pre-loaded health impact functions.) The section on the right under the **Health Impact Functions in Dataset** lets you view the functions in a selected dataset.

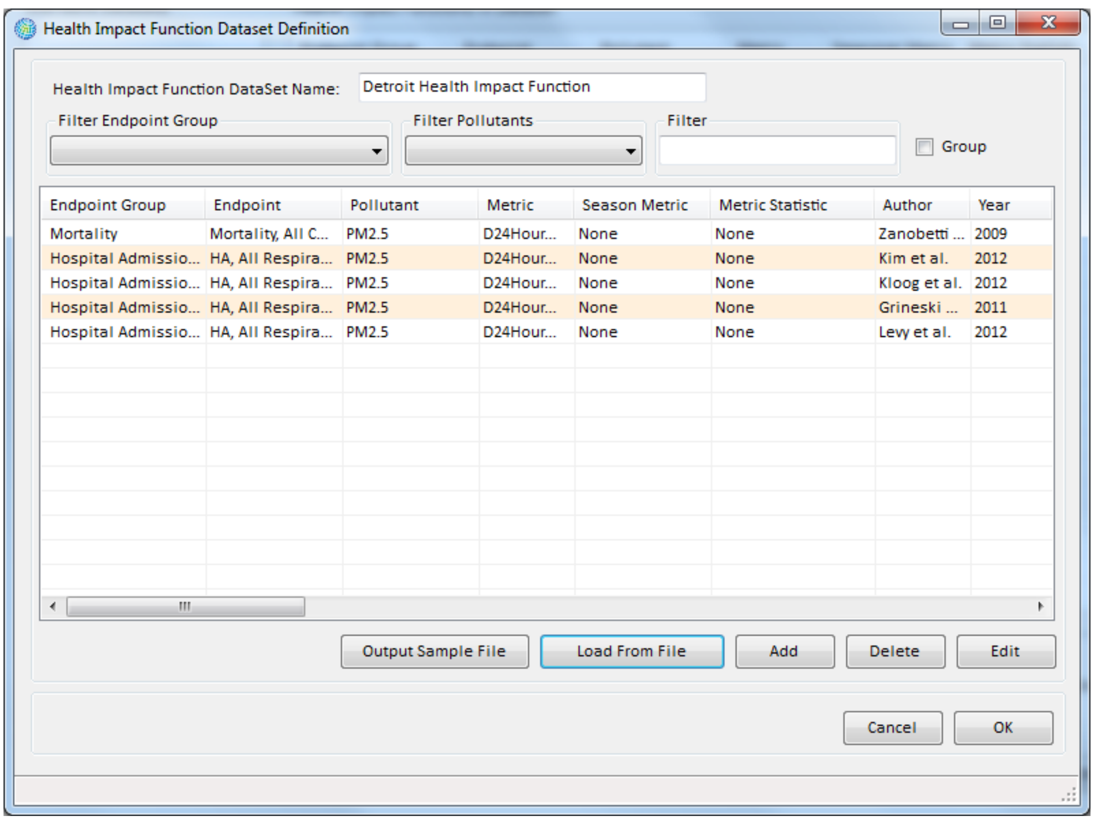
[6] U.S. EPA-default configuration and pooling setup files for ozone and $PM_{2.5}$ health impact assessments are available on the BenMAP-CE website. See: http://www2.epa.gov/benmap/benmap-community-edition.

To add a new dataset, click the **Add** button. The **Health Impact Function Dataset Definition** window will appear. Type the name that you want to use for the dataset in the **Health Impact Function Dataset Name** box.

You may then enter functions into this dataset through an externally created database by clicking the **Load From File** button. Alternatively, you may **Add**, **Delete**, and **Edit** individual functions within BenMAP-CE.

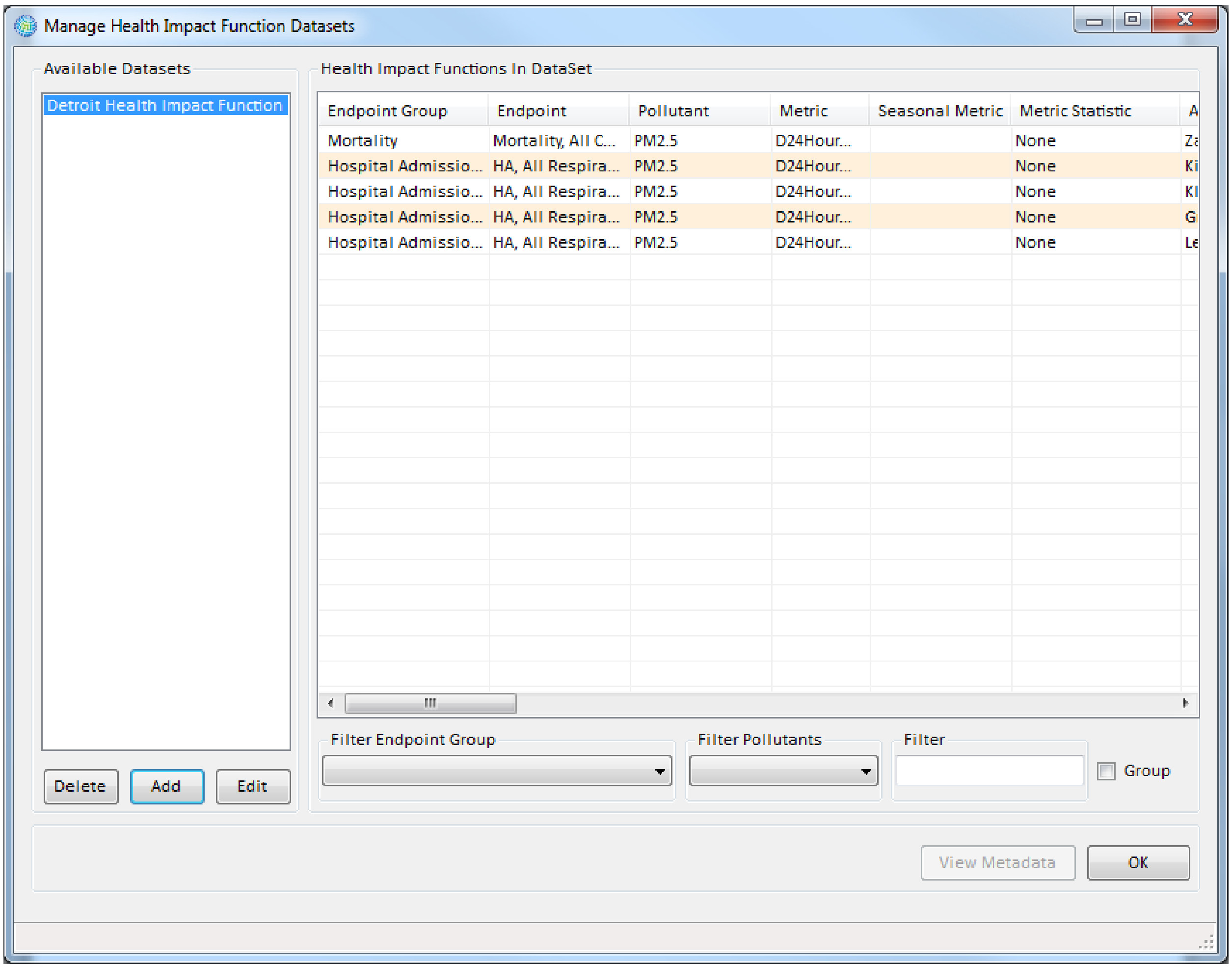
To add a database, click the **Load From File** button. In the **Load Health Impact Dataset** window, click the **Browse** button and then find and select the health impact function database that you want to load into your setup. Click **Open**. If validation is required, then you will have to click the **Validation** button before the file can be imported. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings. You can also add metadata (references and descriptions) to the file that is about to be imported by clicking the **View Metadata** button. Click the **OK** button on the **Load Health Impact Dataset** window to load the dataset.

The **Health Impact Function Dataset Definition** window will reappear, and you can then view the health impact functions that you have loaded into your dataset.

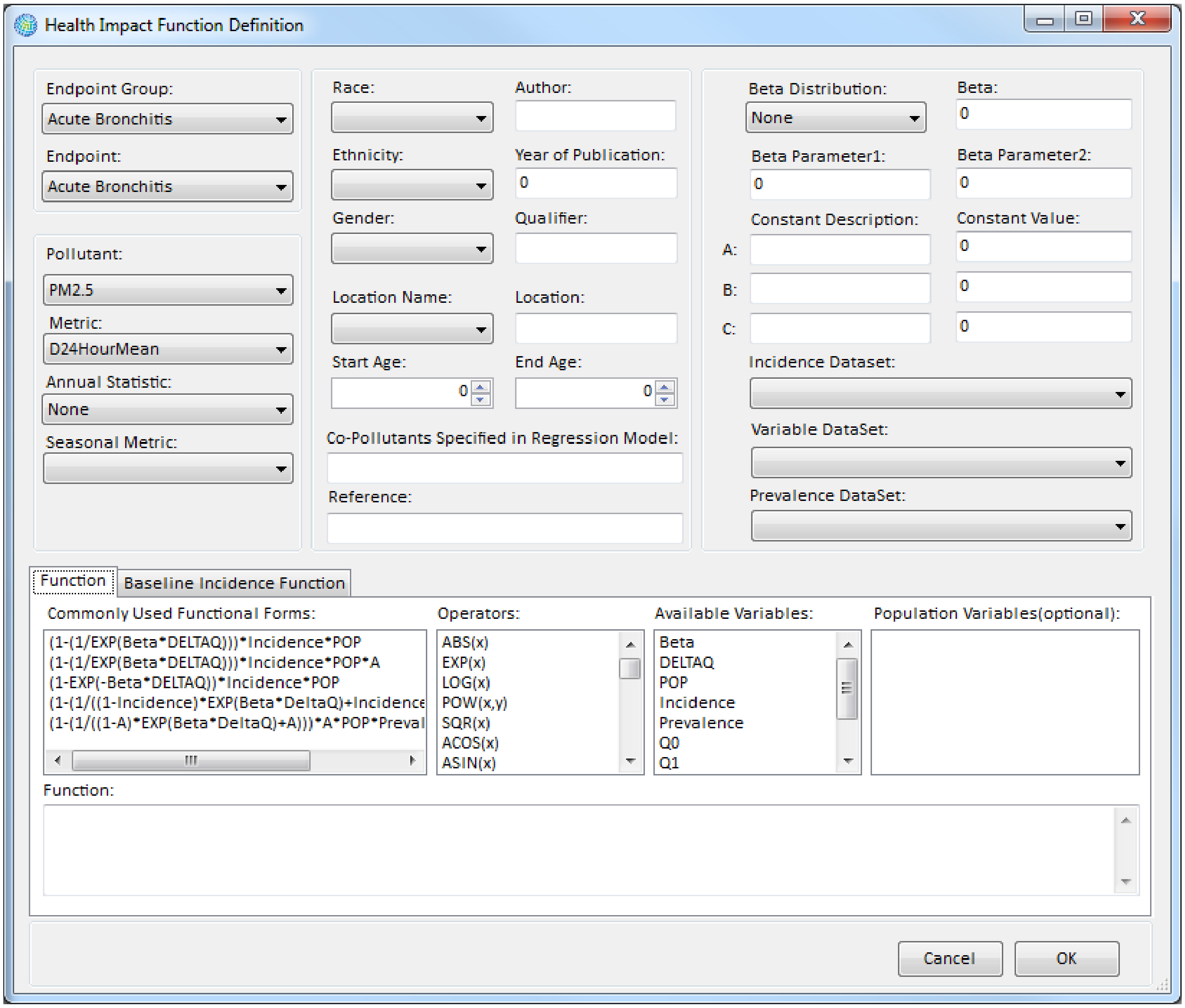


By clicking and holding the cursor on a column header, you may move it to provide the most useful display. For example, by clicking and holding on the **Pollutant** column header and then dragging it to the far left of the window, you can sort all of the health impact functions by **Pollutant**. (Note rearranging the columns is only for display and has no effect on the underlying health impact functions in the database.)

Clicking **OK** brings you back to the **Manage Health Impact Function Datasets** window. The new dataset you just loaded will be displayed in the list of **Available Datasets** and the associated functions will be displayed in the **Health Impact Functions In Dataset** grid to the right. If you have more than one dataset, you can select the dataset by clicking on it.



To edit an existing function, first click to select the dataset in the list of **Available Datasets**. Next, select a particular function in the data grid under **Health Impact Functions in Dataset**. Then, click the **Edit** button. The **Health Impact Function Dataset Definition** window appears, and you may change any of the values in the boxes and the drop-down lists. When you are finished, click **OK**.



From the **Health Impact Function Dataset Definition** window you can also add health impact functions to the ones that are already in your dataset. Click the **Add** button and a blank **Health Impact Function Definition** window will appear and you can then create new health impact functions. (See Appendix M: Function Editor for additional information about the syntax for developing functions with this editor.)

After defining the new health impact function, click **OK**. This will take you back to the **Health Impact Function Dataset Definition** window. When you are finished with any editing or adding of health impact functions, click **OK**. From the **Manage Health Impact Function Datasets** window, you can also select an **Available Dataset** and **Data row** and view the Metadata. To view the Metadata associated with the data file, click the **View Metadata** button to view and edit existing references and descriptions. Click **OK** on the **Manage Health Impact Function Datasets** window when you are satisfied with all your inputs. The **Modify Datasets** window will appear. Here in the **Health Impact Functions** box you should see an entry for any health impact function datasets that you have loaded.

4.1.6.2 Format for Health Impact Functions

Table 4-9 presents the variables that can be used in health impact function datasets.

Table 4-9. Health Impact Function Dataset Variables

Variable	Type	Required	Notes
Endpoint Group	Text	Yes	If this does not reference an already defined Endpoint Group, one will be added.
Endpoint	Text	Yes	If this does not reference an already defined Endpoint for the Endpoint Group, one will be added.
Pollutant	Text	Yes	Should reference an already defined Pollutant.
Metric	Text	Yes	Should reference an already defined Metric for the Pollutant.
Seasonal Metric	Text	No	Should either be blank (signifying no Seasonal Metric value) or reference an already defined Seasonal Metric for the Metric.
Metric Statistic	Text	No	Should either be blank (signifying no annual metric value) or be one of: None, Mean, Median, Min, Max, Sum.
Race		No	Should either be blank (signifying All Races) or reference a defined Race.
Ethnicity		No	Should either be blank (signifying All Ethnicities) or reference a defined Ethnicity.
Gender		No	Should either be blank (signifying All Genders) or reference a defined Gender.
Start Age	Integer	Yes	Specifies the low and high ages, inclusive. For example, Start Age of '*0*' and End Age of '*1*' includes infants through the first 12 months of life and all one-year old infants.
End Age	Integer	Yes	
Study Author	Text	No	The author(s) of the study from which the function is derived.
Study Year	Integer	Yes	The year of publication of the study.
Study Location	Text	No	The location of the study.
Qualifier	Text	No	Provides additional information to identify a particular health impact function, such as when a particular study has multiple functions.
Other Pollutants	Text	No	Identifies other pollutants that were included simultaneously in the estimation equation for the pollutant of interest.
Reference	Text	No	Bibliographic reference, included to identify the source in the health literature.

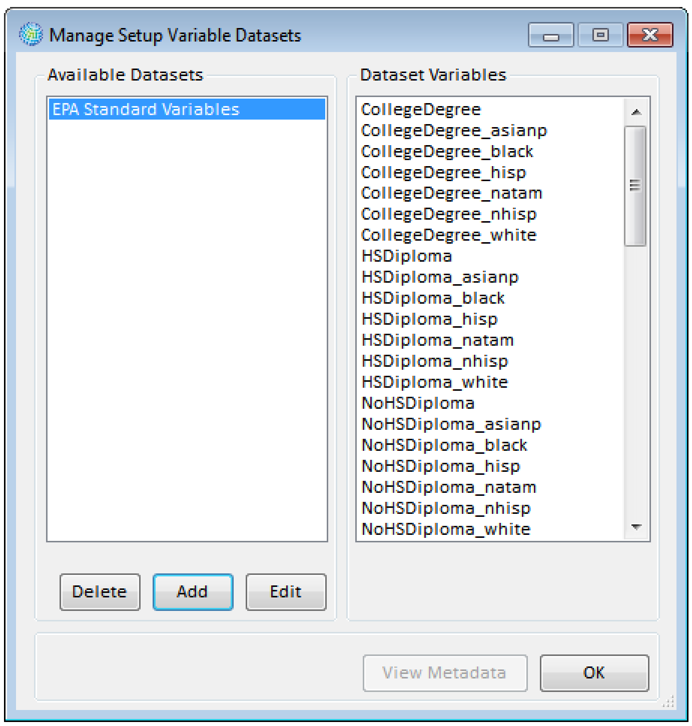
Variable	Type	Required	Notes
Function	Text	Yes	The functional form, interpreted (executed) by BenMAP-CE when running an analysis to estimate air pollution-related health impacts. For example, the log-linear form is as follows: '*(1-(1/ EXP(Beta*DELTAQ)))*Incidence*POP*'.
Baseline Function	Text	No	The functional form, interpreted (executed) by BenMAP-CE to estimate health impacts due to all causes. This typically has the form: '*Incidence*POP*'.
Beta	Numeric (double)	No	Mean value of the Beta distribution.
Distribution Beta	Text	No	If the Beta has no distribution, any value is acceptable. Otherwise, should be one of: *Normal*, *Triangular*, *Poisson*, *Binomial*, *LogNormal*, *Uniform*, *Exponential*, *Geometric*, *Weibull*, *Gamma*, *Logistic*, *Beta*, *Pareto*, *Cauchy*, *Custom*.
Parameter 1 Beta	Numeric (double)	No	Parameter 1 of the Beta distribution (meaning depends on the distribution - for Normal distributions this represents the standard deviation).
Parameter 2 Beta	Numeric (double	No	Parameter 2 of the Beta distribution (meaning depends on the distribution - for Normal distributions this is not required).
Name A	Text	No	Description of variable A.
A	Numeric (double)	No	A constant value which can be referenced by the Function (see below).
Name B	Text	No	Description of variable B.
B	Numeric (double)	No	A constant value which can be referenced by the Function (see below).
Name C	Text	No	Description of variable C.
C	Numeric (double)	No	A constant value which can be referenced by the Function.
Incidence Dataset	Text	No	Specifies the dataset from which incidence data will be derived. The user may choose from multiple datasets. (Initially this field may be left blank.)
Prevalence Dataset	Text	No	Specifies the dataset from which prevalence data will be derived. The user may choose from multiple datasets. (Initially this field may be left blank.)
Variable Dataset	Text	No	Specifies the dataset from which "variable" data (e.g., income data) will be derived. The user may choose from multiple datasets. (Initially this field may be left blank.)

4.1.7 Variable Data

Health Impact Functions and **Valuation Functions** may sometimes refer to socioeconomic variables for which BenMAP-CE does not automatically calculate values. For example, some valuation functions reference the median income within each area of analysis. Other functions apply to populations living below the poverty line in a given country. To facilitate this type of analysis, BenMAP-CE allows you to load datasets of socioeconomic **Variables**, which apply either globally or to a specific geographic area (i.e., they are associated with a **Grid Definition**).

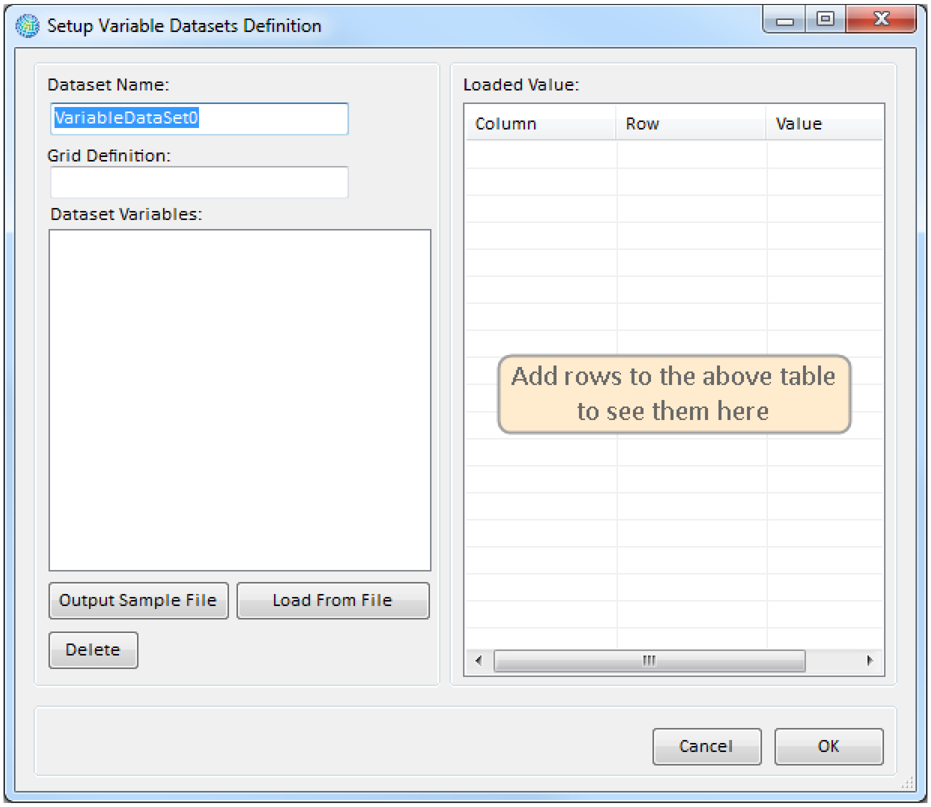
4.1.7.1 Add Variable Data

To add **Dataset Variables** to BenMAP-CE (such as income and other miscellaneous variables that might be needed in the analysis), click on the **Manage** button below the **Variables Datasets** box in the **Modify Datasets** window. The **Manage Setup Variable Datasets** window will appear.



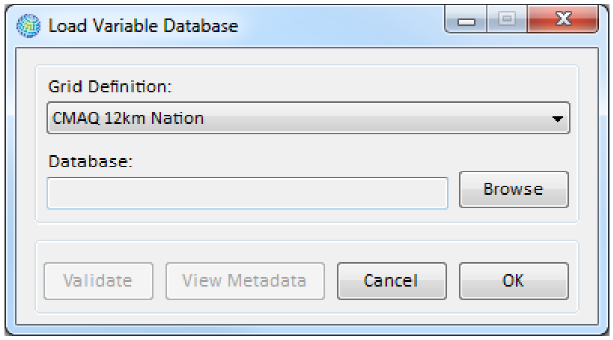
In this window you may **Add**, **Edit**, and **Delete** datasets. The section on the left under **Available Datasets** lists the variables datasets that are currently in the setup database. The section on the right under the **Dataset Variables** lets you view the variables in a selected dataset.

To add a **Variable** dataset click the **Add** button. This will take you to the **Setup Variable Dataset Definition** window. In this window you may add externally created variables through the **Load From File** button for any of your predefined **Grid Definitions**.

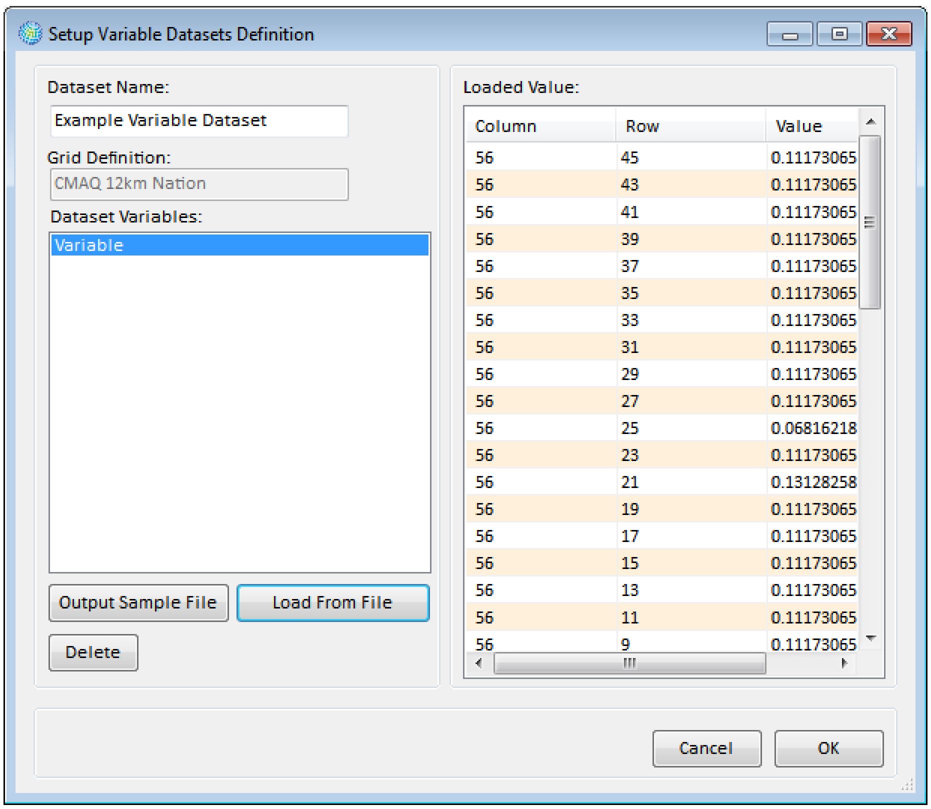


To start, type the name that you want to use for the **Variable Dataset** in the **Dataset Name** box. (This is a name that is internal to BenMAP-CE and used just for identification.)

To add an externally created **Variable Dataset**, click the **Load From File** button. This will bring up the **Load Variable Database** window. Here you need to choose the grid definition from the **Grid Definition** drop-down list that matches the level of aggregation in your variable data file. Remember that the **Variable Dataset** you import must use the same column/row index as the **Grid Definition**. Next, you may use the **Browse** button to find and select the desired **Database** (i.e., input file) and click **Open**. You can click the **Validate** button to ensure the file is properly formatted before importing. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings. You can also add metadata to the imported data (reference and description of the data file) by clicking the **View Metadata** button.

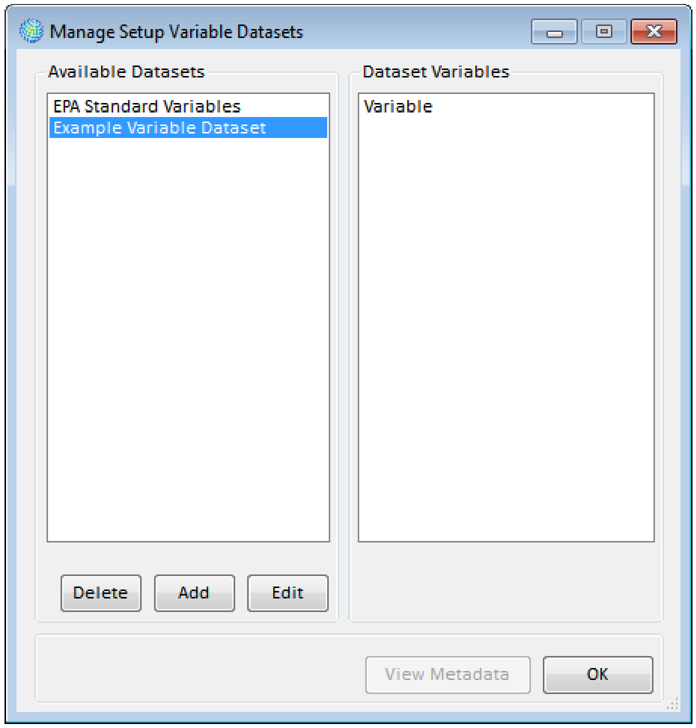


After choosing (and validating) the input file, click **OK**. This takes you back to the **Setup Variable Datasets Definition** window. This window displays the variables in the dataset and their values.



When finished adding variables, click **OK.** This will take you to the **Manage Setup Variable Datasets** window.

In the **Available Datasets** list box there is an entry for the dataset that you just added. And in the **Dataset Variables** list box are the variables in the highlighted dataset.



At this point you may click **Add** to load an additional dataset, click **Edit** to edit the selected dataset, click **Delete** to delete the selected dataset, or complete this variable management step by clicking **OK**.

Clicking **OK** returns you to the **Modify Datasets** window, where the entry for the variable dataset that you just entered should be visible under the **Variable Datasets** box.

4.1.7.2 Format for Variable Data

Table 4-10a presents the variables that can be used in variable datasets, and Table 4-10b presents a sample of what a dataset might look like. Note that if you are loading your own variable data, you can choose your own variable names.

Table 4-10a. Variable Dataset Variables

Variable	Type	Required	Notes
Column	Integer	Yes	The column and the row link the population data with cells in a Grid Definition.
Row	Integer	Yes	
Median_Income	Numeric (double)	Yes	Example: Median income value.
<Variable Name>	Numeric (double)	No	Additional variables may be specified.

Table 4-9b. Sample Variable Dataset

COL	ROW	median_income
42	17	39871.19
42	29	43760.31
42	45	38186.77
42	91	42298.49
42	101	31261.07

4.1.8 Inflation Data

It may be desirable for the economic values generated by **Valuation Functions** to account for inflation and generate economic benefits using currency for years other than the year initially specified by your valuation data. To do this, you can load **Inflation Datasets** into BenMAP-CE, and then include a reference to your inflation data when developing valuation functions. (We give an example of this below.)

The **Valuation Functions** should have a consistent currency year, and this currency year has to be kept in mind when developing the inflation datasets. That is, whichever currency year is used for your valuation functions, then the inflation values for that year should be set to 1. For example, in the *United States* setup, the valuation functions have a dollar year of 2000, so the inflation datasets have a value of 1 for the year 2000. (Values for years earlier than 2000 are less than 1, and values for years after 2000 are greater than 1, because inflation has increased from one year to the next.) The *United States* setup in BenMAP-CE provides inflation factors for three different types of values:

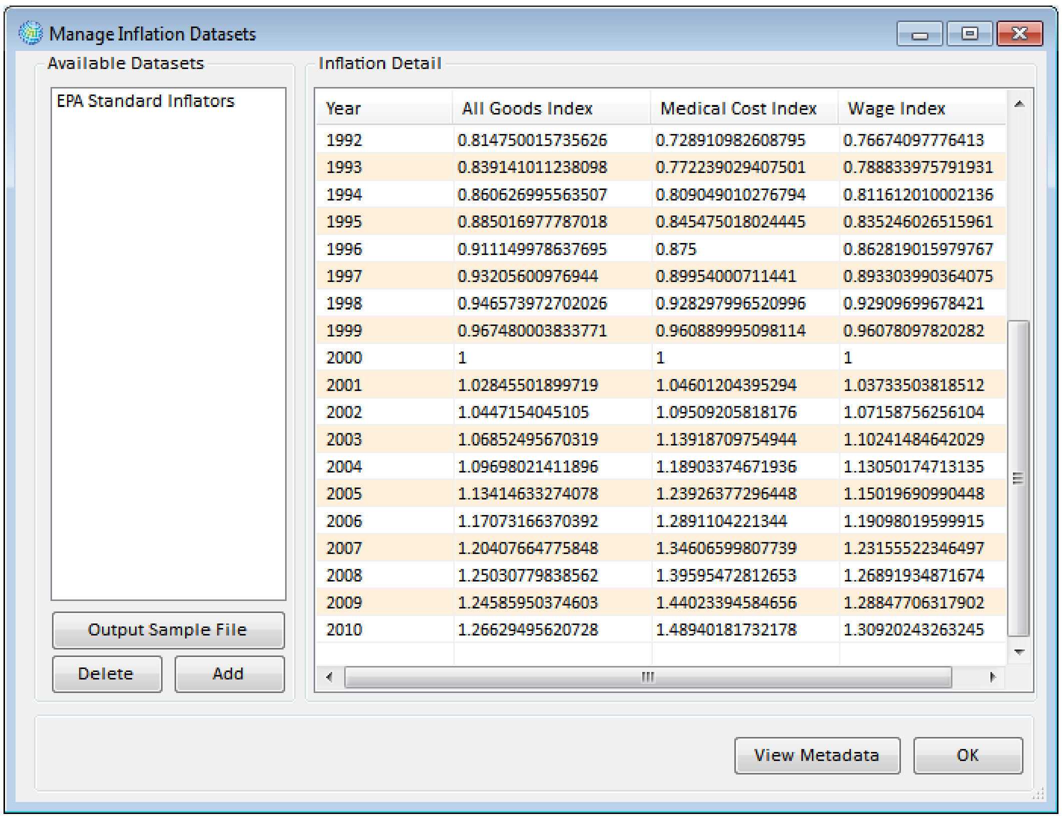
- **All Goods Index** can be used to adjust the value of generic goods.
- **Medical Cost Index** can be used to adjust the value of medical expenses.
- **Wage Index** can be used to adjust the value of wages.

If a **Valuation Function** includes an estimate of wage income, for example, this value could be multiplied by the **Wage Index** adjustment factor to get the specified currency year. For example, in valuing work loss days, the *United States* setup uses a function like the following: *DailyWage*WageIndex*, where the *DailyWage* is specified in year 2000 dollars. In the **Inflation Dataset**, the **WageIndex** scales this **DailyWage** value up or down depending on the currency **Year** you have chosen. If the currency **Year** is 2000, then the **WageIndex** has a value of 1 and no change is made to the **DailyWage**. If the currency **Year** is specified to, say, 2005, then the **WageIndex** will have a value greater than 1 because of the inflation that has occurred between 2000 and 2005.

4.1.8.1. Add Inflation Data

To add inflation data to BenMAP-CE, click on the **Manage** button below the **Inflation Datasets** box in the **Modify Datasets** window. The **Manage Inflation Datasets** window will appear. In this window you may **Add**, **Edit**, and **Delete** datasets. The section on the left under **Available Datasets** lists the **Inflation Datasets** that are currently in the setup database. The section on the right under **Inflation Detail** presents the inflation factors in a selected dataset.

Click on the **Add** button. In **the Load Inflation Dataset** window, type in the name of the dataset in the **Inflation Dataset Name** box, and then click on the **Browse** button to the right of the **Database** box to choose the dataset that you want to import and click **Open**. You can click the **Validate** button to ensure the file is properly formatted before importing. BenMAP-CE's validation tool will review the file format (column names, required columns, and data types) and provide a report with any errors or warnings. In addition, you can add metadata to the file, to include references and descriptions, by clicking the **View Metadata** button. Click **OK**. The **Manage Inflation Datasets** window will appear. Here you may view the data that you just loaded.



Year	All Goods Index	Medical Cost Index	Wage Index
1992	0.814750015735626	0.728910982608795	0.76674097776413
1993	0.839141011238098	0.772239029407501	0.788833975791931
1994	0.860626995563507	0.809049010276794	0.811612010002136
1995	0.885016977787018	0.845475018024445	0.835246026515961
1996	0.911149978637695	0.875	0.862819015979767
1997	0.93205600976944	0.89954000711441	0.893303990364075
1998	0.946573972702026	0.928297996520996	0.92909699678421
1999	0.967480003833771	0.960889995098114	0.96078097820282
2000	1	1	1
2001	1.02845501899719	1.04601204395294	1.03733503818512
2002	1.0447154045105	1.09509205818176	1.07158756256104
2003	1.06852495670319	1.13918709754944	1.10241484642029
2004	1.09698021411896	1.18903374671936	1.13050174713135
2005	1.13414633274078	1.23926377296448	1.15019690990448
2006	1.17073166370392	1.2891104221344	1.19098019599915
2007	1.20407664775848	1.34606599807739	1.23155522346497
2008	1.25030779838562	1.39595472812653	1.26891934871674
2009	1.24585950374603	1.44023394584656	1.28847706317902
2010	1.26629495620728	1.48940181732178	1.30920243263245

At this point you may add more data by clicking **Add**, or you may view and edit the Metadata for a specific dataset. This is done by selecting an **Available Dataset** and an entry in the **Inflation Detail** box and then clicking the **View Metadata** button. If you are satisfied with all import data, you can complete this step by clicking **OK**. Clicking **OK** takes you to the **Modify Datasets** window, where you should see an entry for the inflation dataset that you just loaded under the **Inflation Datasets** box.

4.1.8.2 Format for Inflation Data

Table 4-11a presents the variables that can be used in **Inflation Datasets**, and Table 4-11b presents a sample of what a dataset might look like. Note that if you are loading your own inflation data, you can use different names than the ones specified below. Instead of specifying '*AllGoodsIndex*' you could have a variable called '*General Index*' — this is fine as long as you make sure that your valuation functions properly reference these inflation variables.

Table 4-11a. Inflation Dataset Variables in U.S. Setup

Variable	Type	Required	Notes
Year	Integer	Yes	The year of the data. Note that this will typically only include historical estimates.
AllGoodsIndex	Integer	No	Example: All goods inflation index value.
MedicalCostIndex	Integer	No	Example: Medical cost inflation index value.
WageIndex	Integer	No	Example: Wage inflation index value.
<Variable Name>	Integer	No	Additional indices can be specified.

Table 4-11b. Sample Inflation Dataset

YEAR	AllGoodsIndex	MedicalCostIndex	WageIndex
1995	0.75	0.62	0.71
1996	0.79	0.67	0.74
1997	0.81	0.72	0.76
1998	0.83	0.77	0.78
1999	0.86	0.8	0.81
2000	0.88	0.84	0.83
2001	0.91	0.87	0.86
2002	0.93	0.89	0.89
2003	0.94	0.92	0.92
2004	0.96	0.96	0.96
2005	1	1	1
2006	1.02	1.04	1.03

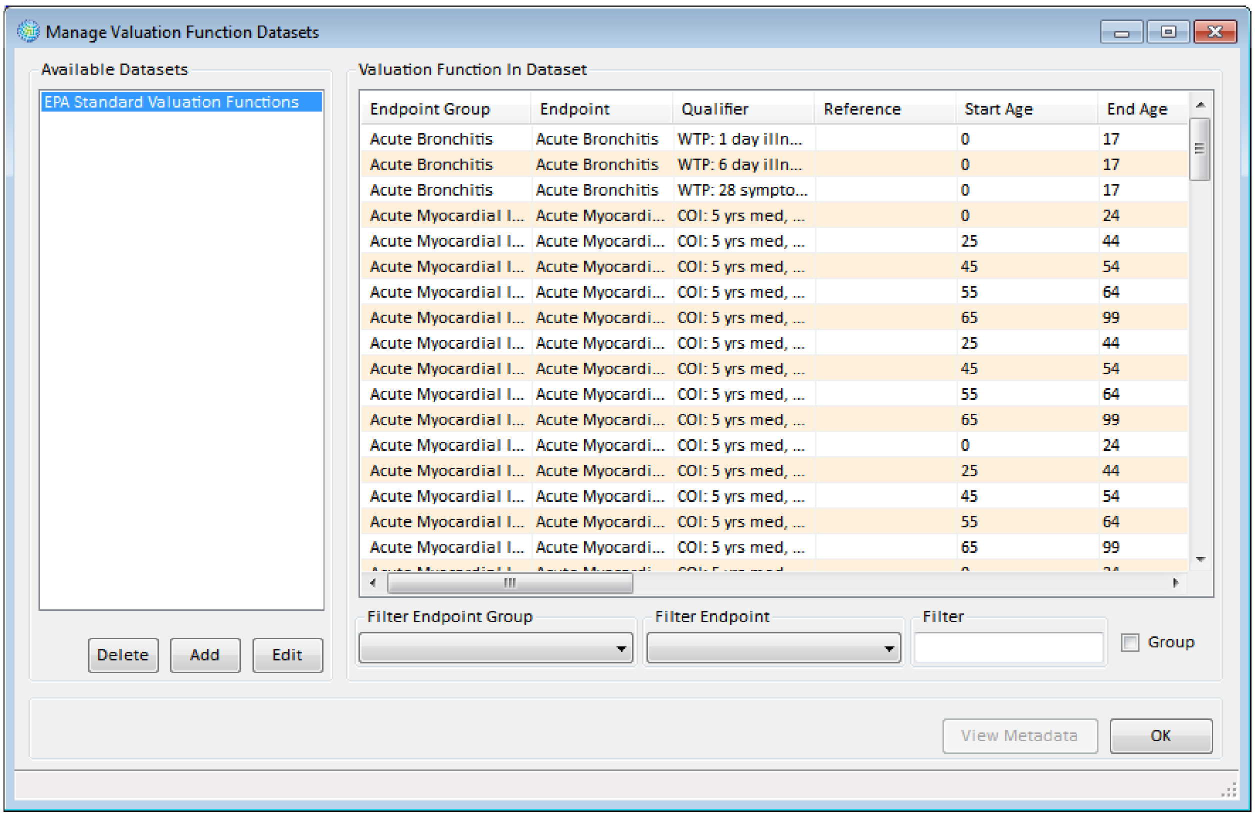
4.1.9 Valuation Data

BenMAP-CE allows the valuation estimates to vary by **Endpoint Group**, **Endpoint**, and **Age** (note that multiple estimates may be provided for a particular combination). BenMAP-CE allows the valuation function to be quite detailed, and allows an uncertain parameter (A) with a user-specified distribution. You can modify the valuation function with a number of constant values (B, C, and D) that might represent an adjustment for inflation, income growth, income elasticity, or, say, purchasing power parity. Finally, BenMAP-CE has two fields to more clearly identify the valuation function (i.e., **Qualifier** and **Reference**).

When reviewing the economic literature to develop a valuation database or to simply add valuation functions to an existing database, it is important to have an economist assist. For an overview of valuation, see the Overview of Valuation section in Chapter 7: Aggregating, Pooling, and Valuing.

4.1.9.1 Add Valuation Data

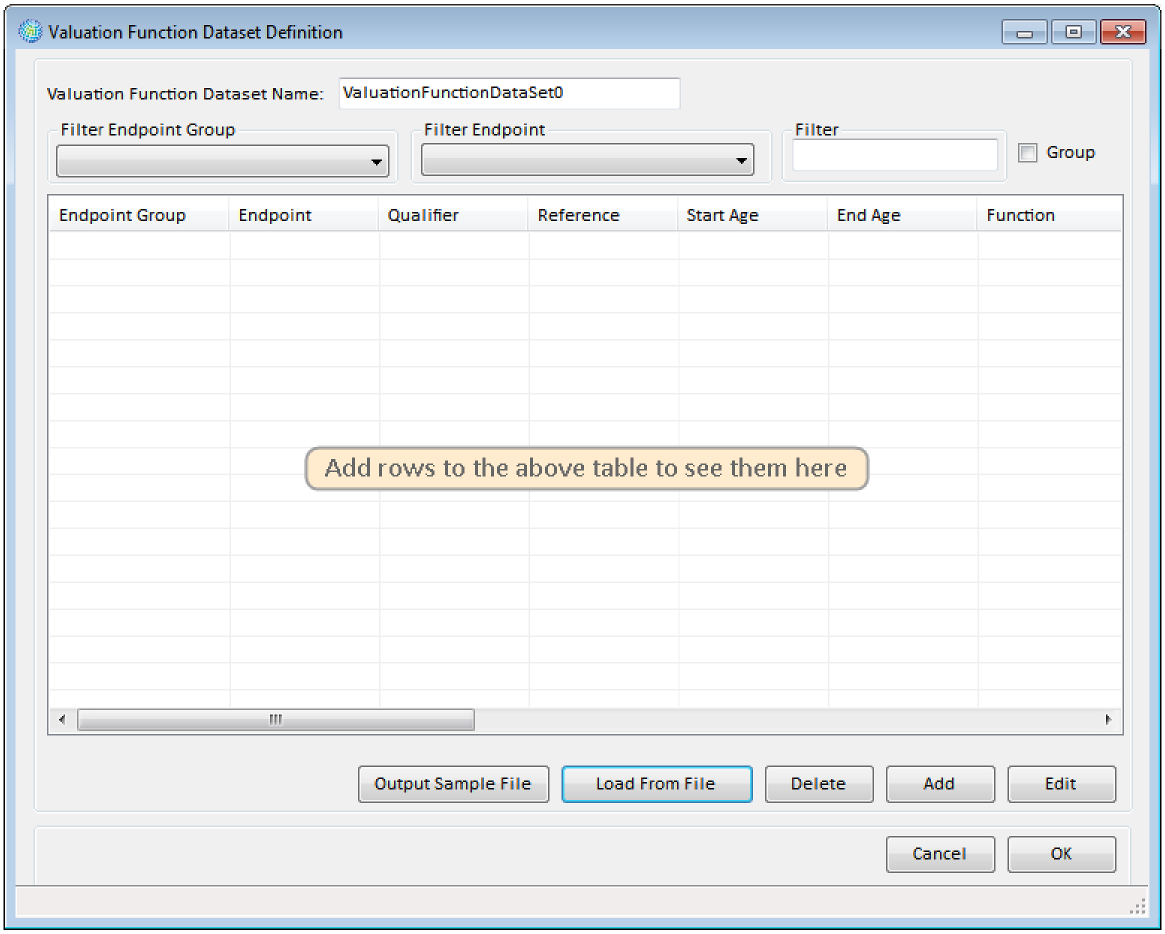
To add valuation functions to BenMAP-CE, click on the **Manage** button below the **Valuation Datasets** box in the **Modify Datasets** window. The **Manage Valuation Function Datasets** window will appear.



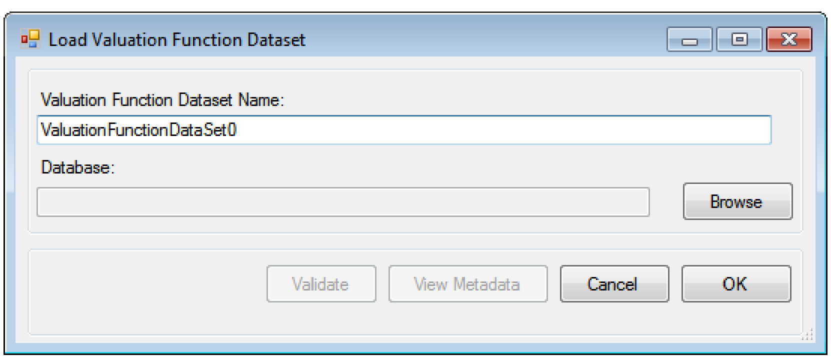
In this window you may **Add**, **Edit**, and **Delete** datasets. The section on the left under **Available Datasets** lists the valuation datasets that are currently in the setup database. The section on the right under the **Valuation Function In Dataset** lets you view the valuation factors in a selected dataset.

If the dataset is large, there are filters available to view a subset of the list by selecting a value from the **Filter Endpoint Group** and/or **Filter Endpoint** drop-down lists. Or, you can type a value in the **Filter** box to search for a particular word or phrase. You can also group data by **Endpoint Group** by selecting the *Group* option.

To add a dataset, click on **Add**. This will display the **Valuation Function Dataset Definition** window.



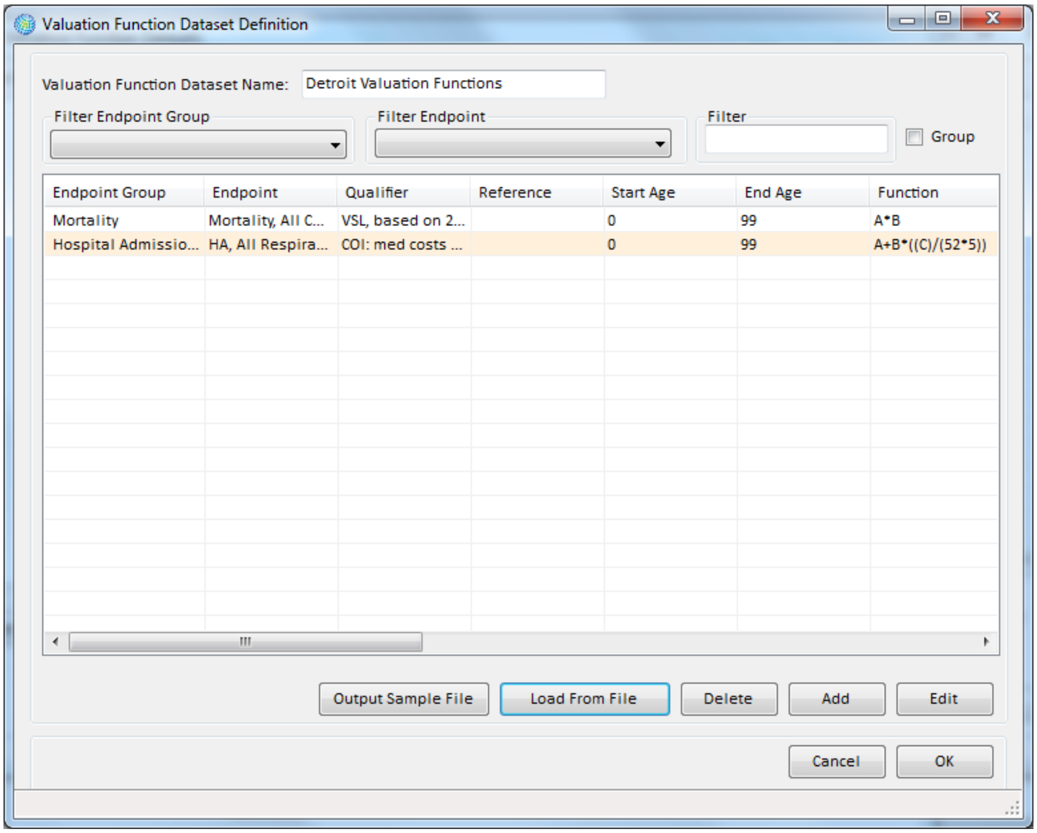
You may load valuation data with an externally-created data file, or you may add individual valuation functions from within BenMAP-CE. To import valuation functions, click on the **Load From File** button. This will bring you to the **Load Valuation Function Dataset** window.



In the **Load Valuation Function Dataset** window provide a name for the valuation function dataset. Use the **Browse** button to choose the valuation database and click **Open**. Once again, you can click the **Validate** button before the file is imported. In addition, you can create metadata, which includes references and descriptions of the file, by clicking on the **View Metadata** button. Click **OK** on the **Load Valuation**

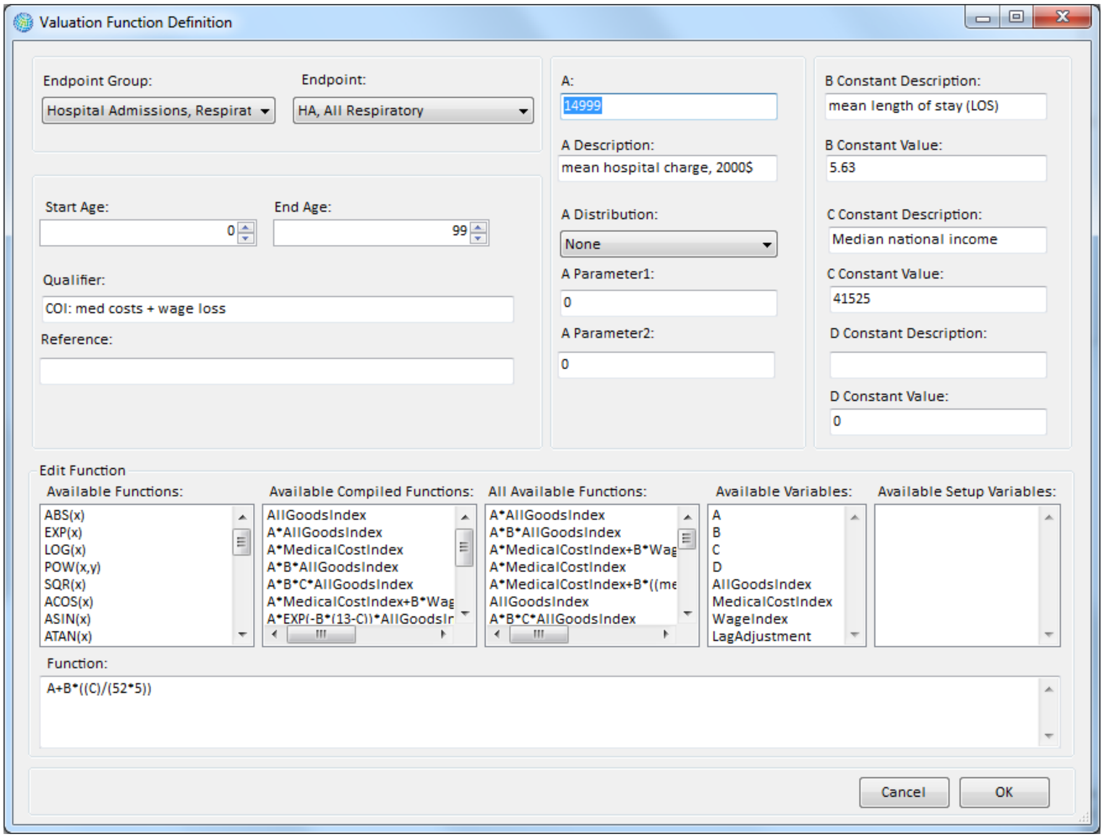
Function Dataset window. This will bring you back to the **Valuation Function Dataset Definition** window. Here you can view the valuation functions that you have in your database.

The columns within each of the list boxes can be rearranged in order to provide the most useful display. (Note that rearranging the columns is only for display and has no effect on the underlying Valuation Function dataset.)



In the **Valuation Function Dataset Definition** window, you can also edit the functions already existing in your dataset by highlighting a particular **Valuation Function** and then clicking the **Edit** button.

If the dataset is large, there are filters available to view a subset of the list by selecting a value from the **Filter Endpoint Group** and/or **Filter Endpoint** drop-down lists. When you are finished, click **OK**.



From the **Valuation Function Dataset Definition** window you can also manually define a new **Valuation Function**. Click the **Add** button to open the **Valuation Function Definition** window where you can then create a new **Valuation Function**. (See Appendix M: Function Editor for additional information about the syntax for developing functions with this editor.)

After defining the new **Valuation Function**, click **OK**. This will take you back to the **Valuation Function Dataset Definition** window. When you are finished, click **OK**.

This will return you to the **Manage Valuation Function Datasets** window. From this form you can **Add**, **Delete**, or **Edit** the available datasets. In addition, you can view or edit the previously created metadata for a file by selecting an **Available Dataset** and **Valuation Function** and then click the **View Metadata** button. When you are satisfied with the inputs, click **OK**. The **Modify Datasets** window will appear. Here in the **Valuation Function** datasets box you should see any updates to the **Valuation Function** dataset that you just made.

4.1.9.2 Format for Valuation Data

Table 4-12 presents the variables that can be used in **Valuation Datasets**.

Table 4-12. Valuation Dataset Variables

Field Name	Type	Required	Notes
Endpoint Group	Text	Yes	If this doesn't reference an already-defined Endpoint Group, one will be added.
Endpoint	Text	Yes	If this doesn't reference an already-defined Endpoint for the Endpoint Group, one will be added.
Qualifier	Text	No	Provides additional information to identify a particular valuation function.
Reference	Text	No	Bibliographic reference, included to identify the source in the economic literature.
Start Age	Integer	No	Specifies the low and high ages, inclusive. For example, Start Age of '*0*' and End Age of '*1*' includes infants through the first 12 months of life and all one-year old infants.
End Age	Integer	No	
Point Estimate	Numeric (double)	Yes	Central estimate of the unit value.
Function	Text	Yes	The functional form, interpreted (executed) by BenMAP-CE when running an analysis.
A Description	Text	No	Description of variable A.
A	Numeric (double)	No	Mean of the A distribution.
A Distribution	Text	No	If A has no distribution, any value is acceptable. Otherwise, should be one of: *Normal*, *Triangular*, *Poisson*, *Binomial*, *LogNormal*, *Uniform*, *Exponential*, *Geometric*, *Weibull*, *Gamma*, *Logistic*, *Beta*, *Pareto*, *Cauchy*, *Custom*.
A Parameter 1	Numeric (double)	No	Parameter 1 of the A distribution (meaning depends on the distribution - for *Normal* distributions this represents the standard deviation).
A Parameter 2	Numeric (double)	No	Parameter 2 of the A distribution (meaning depends on the distribution - for *Normal* distributions this is not required).
Constant Description	Text	No	Description of variables, B, C, and D.
Constant Value	Numeric (double)	No	A constant value (denoted by B, C, and/or D) which can be referenced by the Function.

4.1.10 Income Growth Data

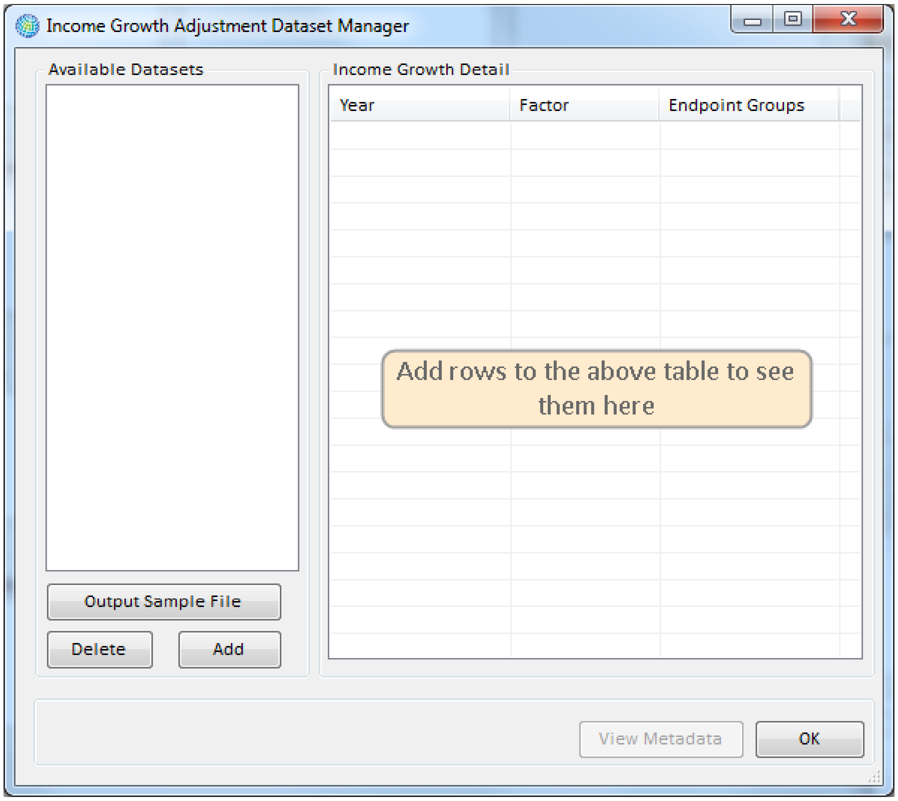
According to economic theory, willingness-to-pay (WTP) to avoid air-pollution related morbidity effects and premature mortality should grow as real income increases. BenMAP-CE allows users to adjust the WTP estimates to account for the growth in income over time. This adjustment is a combination of data on income growth and estimated income elasticity of demand, which measures the responsiveness of the quantity demanded of a good to the change in the income of the people demanding the good; this is distinct from elasticity of demand, which quantifies the change in demand for goods and services as a result of changes in price for those goods and services. This section describes how to load the data adjusting for income growth and how EPA developed these adjustment factors.

Note that the WTP estimates in the default valuation functions in the *United States* setup are assumed to be based on 1990 income, so the income growth adjustments are all relative to 1990. That is, the income growth data has a value of 1 in 1990, and because income has generally increased over time in the U.S., the income growth values are typically greater than 1 after 1990. (An exception is 1991, when incomes declined slightly in the U.S.)

If you load in your own valuation functions and/or income growth adjustment factors, be sure that you have carefully considered the income year. For example, if your valuation functions are based on income in the year 2005, then the income growth adjustment should have a value of 1.0 in 2005, because no adjustment is necessary. As you forecast into the future, under the assumption that incomes go up over time, then your income growth adjustment factors would have values greater than 1.0 for years past 2005, and would have values less than 1.0 for years prior to 2005.

4.1.10.1 Add Income Growth Data

To add income growth data to BenMAP-CE, click on the **Manage** button below the **Income Growth Adjustments** box in the **Modify Datasets** window. The **Income Growth Adjustment Dataset Manager** window will appear.



In this window you may **Add** and **Delete** datasets. The section on the left under **Available Datasets** lists the **Income Growth Adjustments Datasets** that are currently in the setup database. The section on the right under **Income Growth Detail** presents the income growth adjustment factors in a selected dataset.

Click on the **Add** button. In the **Load Income Growth Adjustment Factors Dataset** window, type in the name of the dataset in the **Income Growth Adjustment Dataset Name** box, and then click on the **Browse** button to the right of the **Database** box to choose the dataset that you want to import and click **Open**. To confirm the file has proper formatting, click the **Validation** button before importing the file. In addition, you can edit the metadata for the imported file, to include references and descriptions, by clicking the **View Metadata** button.

Click **OK**. The **Income Growth Adjustment Dataset Manager** window will appear. Here you may view the data that you just loaded. From this window, you can also view or edit metadata by selecting an **Available Dataset** and **Income Growth Detail** and then clicking the **View Metadata** button.

4.1.10.2 Developing Income Growth Adjustment Factors

When reviewing the economic literature to develop income growth adjustment factors, it is important to have an economist assist. For an overview of valuation, see the Overview of Valuation section in Chapter 7: Aggregating, Pooling, and Valuing.

Adjusting WTP to reflect growth in real income requires three steps:

1. *Identify relevant income elasticity estimates from the peer-reviewed literature.*
2. *Calculate changes in future income.*
3. *Calculate adjustments to WTP based on changes in future income and income elasticity estimates.*

<u>1. Identifying income elasticity estimates</u>

Income elasticity estimates relate changes in demand for goods to changes in income. Positive income elasticity suggests that as income rises, demand for the good also rises. Negative income elasticity suggests that as income rises, demand for the good falls. BenMAP-CE does not adjust Cost-of-Illness (COI) estimates according to changes in income elasticity due to the fact that COI estimates the direct cost of a health outcome; instead we adjust this metric using inflation factors described above. BenMAP-CE includes income elasticity estimates specific to the type of health endpoint associated with the WTP estimate. BenMAP-CE contains elasticity estimates for three types of health effects: minor, severe and premature mortality. Minor health effects are those of short duration. Severe, or chronic, health effects are of longer duration. Consistent with economic theory, the peer reviewed literature indicates that income elasticity varies according to the severity of the health effect. Below we summarize the health endpoints considered minor and severe within the default *United States* setup in BenMAP-CE.

Minor

- Asthma exacerbation
- Acute bronchitis
- Acute respiratory symptoms (minor restricted activity days)
- Lower respiratory symptoms
- Upper respiratory symptoms

Severe

- Chronic bronchitis
- Chronic asthma

A review of the literature revealed a range of income elasticity estimates that varied across the studies and according to the severity of health endpoint. Table 4-13 summarizes the income elasticity estimates found in BenMAP-CE to adjust minor health effects, severe health effects and premature mortality. Here we have provided a lower-, upper- and central-estimate for each type of health endpoint.

Table 4-13. Income Elasticity Estimates

Health Endpoint	Lower Bound	Central Estimate	Upper Bound
Minor Health Effect	0.04	0.15	0.30
Severe and Chronic Health Effects	0.25	0.45	0.60
Premature Mortality	0.08	0.40	1.00

2. Calculating changes in future income

The next input to the WTP adjustment is annual changes in future income. To estimate changes in future income, EPA used the Standard & Poor's projections of future changes in Gross Domestic Product (GDP) occurring after the year 2010. EPA then divided the projected change in GDP by the Woods & Poole projected change in total US population to produce an estimate of the future GDP per capita.

3. Calculating changes in WTP

The income elasticity estimates from Table 4-13 and the estimated changes in future income may then be used to estimate changes in future WTP for each health endpoint. The adjustment formula follows four steps:

$$\varepsilon = \frac{\frac{\Delta WTP}{WTP}}{\frac{\Delta I}{I}} = \frac{(WTP_2 - WTP_1)*(I_2 + I_1)}{(I_2 - I_1)*(WTP_2 + WTP_1)}$$

$$\varepsilon I_2 WTP_2 + \varepsilon I_2 WTP_1 - \varepsilon I_1 WTP_2 - \varepsilon I_1 WTP_1 = I_2 WTP_2 + I_1 WTP_2 - I_2 WTP_1 - I_1 WTP_1$$

$$WTP_2 * (\varepsilon I_2 - \varepsilon I_1 - I_2 - I_1) = WTP_1 * (\varepsilon I_1 - \varepsilon I_2 - I_1 - I_2)$$

$$WTP_2 = WTP_1 * \frac{\varepsilon I_1 - \varepsilon I_2 - I_2 - I_1}{\varepsilon I_2 - \varepsilon I_1 - I_2 - I_1}$$

Table 4-14 below summarizes the income-based WTP adjustments used within BenMAP-CE for minor health endpoints, severe health endpoints, and premature mortality.

Table 4-14. Income-Based WTP Adjustments by Health Effect and Year

	Minor Health Endpoint			*Severe Health Endpoint*			*Mortality*		
Year	Low	Mid	Upper	Low	Mid	Upper	Low	Mid	Upper
1990	1	1	1	1	1	1	1	1	1
1991	0.9992	0.997201	0.994013	0.995008	0.991033	0.988061	0.9984	0.992025	0.980181
1992	0.999818	0.999363	0.998636	0.998863	0.997955	0.997274	0.999636	0.998182	0.99546
1993	1.000308	1.001079	1.002314	1.001928	1.003474	1.004634	1.000617	1.003087	1.007736
1994	1.001277	1.004476	1.009617	1.008008	1.01446	1.019327	1.002556	1.012843	1.03242
1995	1.001686	1.005913	1.012715	1.010584	1.019133	1.025592	1.003375	1.016989	1.04302
1996	1.00241	1.00846	1.018216	1.015157	1.027449	1.036768	1.004825	1.024362	1.06204
1997	1.003365	1.011828	1.025519	1.021221	1.038525	1.051698	1.006742	1.034171	1.087674
1998	1.003817	1.013425	1.028991	1.024101	1.043803	1.058834	1.007649	1.038842	1.100018
1999	1.0042	1.014776	1.031932	1.02654	1.048284	1.064901	1.008417	1.042804	1.11056
2000	1.003788	1.013323	1.028768	1.023916	1.043465	1.058376	1.007591	1.038542	1.099223
2001	1.004299	1.015126	1.032696	1.027173	1.049448	1.066479	1.008616	1.043834	1.113309
2002	1.004889	1.017218	1.037261	1.030955	1.056418	1.075937	1.009802	1.049992	1.129849
2003	1.005484	1.019328	1.04188	1.034778	1.063484	1.08555	1.010999	1.056232	1.14677
2004	1.006086	1.021464	1.046565	1.038654	1.07067	1.09535	1.012209	1.062572	1.164134
2005	1.006653	1.023482	1.051003	1.042323	1.077493	1.104675	1.013351	1.068587	1.180766
2006	1.007225	1.025519	1.055492	1.046031	1.08441	1.114152	1.014503	1.074681	1.197779
2007	1.0078	1.027571	1.060025	1.049772	1.09141	1.123765	1.015662	1.080843	1.215152
2008	1.008379	1.029635	1.064598	1.053544	1.098488	1.133508	1.016828	1.087068	1.232878
2009	1.008959	1.03171	1.069205	1.05734	1.105635	1.14337	1.017998	1.09335	1.250943
2010	1.009541	1.033796	1.073846	1.061162	1.112853	1.153355	1.019173	1.099688	1.26936
2011	1.010619	1.037665	1.082486	1.068269	1.126335	1.17207	1.021351	1.111515	1.304233
2012	1.011646	1.041361	1.090777	1.07508	1.139328	1.190187	1.023427	1.122896	1.338433
2013	1.012625	1.044897	1.09874	1.081612	1.151859	1.207737	1.025411	1.133857	1.371986
2014	1.013561	1.048282	1.106398	1.087886	1.163958	1.224753	1.027307	1.144425	1.404924
2015	1.014457	1.05153	1.113771	1.093919	1.175653	1.241267	1.029124	1.154627	1.437278
2016	1.015315	1.054647	1.120876	1.099725	1.186964	1.257303	1.030866	1.164482	1.469069
2017	1.016137	1.057644	1.127729	1.10532	1.197914	1.272886	1.032537	1.17401	1.50032
2018	1.016928	1.060527	1.134347	1.110717	1.208525	1.288044	1.034144	1.183233	1.531063
2019	1.017687	1.063305	1.140745	1.115928	1.218817	1.3028	1.03569	1.192168	1.561322
2020	1.018419	1.065985	1.146937	1.120966	1.22881	1.317176	1.03718	1.200834	1.591123
2021	1.019122	1.068567	1.15292	1.12583	1.238497	1.33116	1.038614	1.209226	1.62042
2022	1.019798	1.071051	1.158694	1.130519	1.247875	1.344743	1.039991	1.217341	1.64917
2023	1.020447	1.073442	1.164269	1.135042	1.256956	1.357937	1.041316	1.225191	1.677381
2024	1.021072	1.075746	1.169656	1.139409	1.265756	1.370763	1.042592	1.23279	1.705078

4.1.10.3 Format for Income Growth Adjustment Data

Table 4-15a presents the variables that can be used in **Income Growth Adjustment Datasets** and Table 4-15b presents a sample of what a dataset might look like.

Table 4-15a. Income Growth Adjustment Dataset Variables

Variable	Type	Required	Notes
Year	Integer	Yes	The year of the data. Note that this will include historical estimates as well as forecasts.
Mean	Numeric (double)	Yes	Mean income growth adjustment factor.
EndPointGroup	Text	Yes	Endpoint group (e.g., *Chronic Asthma*).

Table 4-15b. Sample Income Growth Adjustment Dataset

Year	Mean	EndpointGroup
1990	1.0000	Acute Bronchitis
1991	0.9910	Acute Bronchitis
1992	0.9980	Acute Bronchitis
1993	1.0035	Acute Bronchitis
1994	1.0145	Acute Bronchitis
1995	1.0191	Acute Bronchitis
1996	1.0274	Acute Bronchitis
1997	1.0385	Acute Bronchitis
1998	1.0438	Acute Bronchitis
1999	1.0483	Acute Bronchitis
2000	1.0435	Acute Bronchitis
2001	1.0494	Acute Bronchitis
2002	1.0564	Acute Bronchitis
2003	1.0635	Acute Bronchitis
2004	1.0707	Acute Bronchitis
2005	1.0775	Acute Bronchitis

4.2 Export and Import Setups

BenMAP-CE allows you to export and import entire databases (all **Available Setups**), individual setups (e.g., *United States, China*), and parts of individual setups (e.g. all **Grid Definitions**, or individual **Health Impact Function** datasets). This functionality can be used to archive data, share data with other BenMAP-CE users, as well as to allow you to move databases between computers. In particular, all of the steps involved in creating a setup can be done just once, after which the data can be exported and then imported on other computers. See Chapter 9: Tools Menu for more information about the *Database Export* and *Database Import* tools.

4.3 Frequently Asked Questions

I've loaded new baseline incidence data, but BenMAP-CE won't let me select it in the configuration stage.

When formatting these data for importing to BenMAP-CE, take special care to ensure that you have specified the health endpoints correctly. The baseline incidence rate must be associated with a specific health endpoint and endpoint group in BenMAP-CE. Be sure that you have recorded the endpoint group and endpoint exactly as it is recorded in BenMAP-CE. For example, if the baseline incidence rate is for asthma-related hospital admissions, be sure you have recorded the endpoint group as '*Hospital Admissions, Respiratory*' and the endpoint as '*HA, Asthma*'.

I've loaded a new grid and new population data into BenMAP-CE but I can't seem to use these new data.

Be sure to load the new grid definition first. Next, load the population dataset and be sure to select your new grid definition.

How do I generate a population dataset for a new grid definition?

You can generate a population dataset using a variety of approaches. The key is that you need to have a shapefile of your area of interest (e.g., Census tracts in a city) and you need to have census data matching your area of interest. One source for both a shapefile and the associated population data is the U.S. Census Bureau. (A variety of other agencies have census data, and you need to check around for your area of interest.) Another option for U.S. population data is to use the PopGrid software application, mentioned in Section 4.1.5 and described in Appendix J on Population Data for the U.S. Setup. Using PopGrid, you still need to have a shapefile for your area of interest.

Can I edit a population configuration?

No, you cannot edit a population configuration. You can only view a population configuration. If the population configuration does not match your data, you need to either create a new population configuration to match your data, or reshape your data so that it matches the population configuration.

CHAPTER 5

Creating Air Quality Surfaces

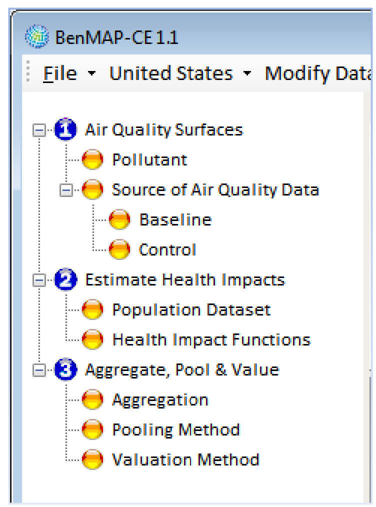
In this chapter…

- **Define air quality grids**
- **Create air quality surfaces using different methods.**
- **Learn how to structure input files.**
- **Learn how to interpolate monitoring data with Closest Monitor, Voronoi Neighborhood Averaging, or Fixed Radius.**
- **Learn about the Monitor Rollback feature.**

BenMAP-CE is not an air quality model and it cannot generate air quality data independently. Instead it relies on the air quality inputs given to it. To estimate population exposure to air pollution, BenMAP-CE uses air quality surfaces that it generates from input air quality data (modeling or monitoring data). Essentially, the air quality surfaces can be described as air quality grids (the structure) that have been populated with air pollution values (the data).

BenMAP-CE creates air quality surfaces to estimate the average exposure to ambient air pollution of people living in a "grid." These grids are either regularly shaped areas like those used by air quality models, or irregular shapes, like provinces, local government areas, cities, or nations. BenMAP-CE does not estimate personal exposure. Instead, the program calculates average pollutant concentration to which people are exposed in each grid cell. BenMAP-CE then uses these average values to calculate health impact functions.

To create air quality surfaces, BenMAP-CE uses a number of inputs, including modeling data or monitoring data. You may enter your own modeling and monitoring data, provided that the data are in a format recognized by BenMAP-CE.



To start the grid creation process, locate **Air Quality Surfaces** on the BenMAP-CE tree menu. Under this header, double-click **Pollutant**. On the selection window, click, hold and drag the pollutant of choice from the left side to the right side. Click **OK**.

Next, double-click **Baseline** on the BenMAP-CE tree menu to open the **Grid Creation Method** window.

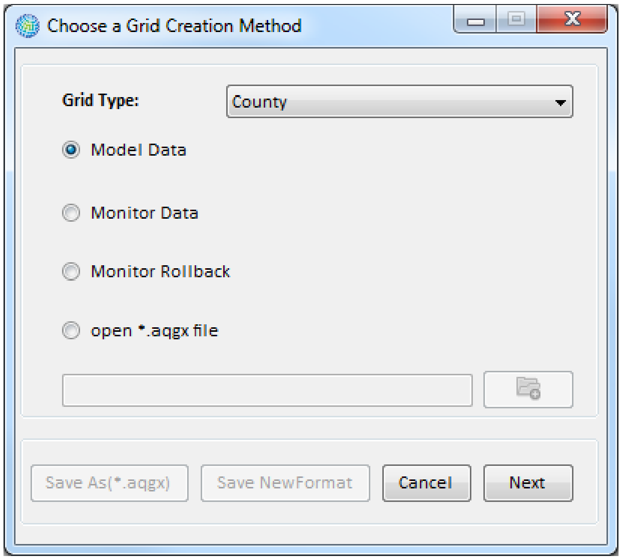
BenMAP-CE will then ask which **Grid Type** (previously loaded shapefile) to use and which of the following types of air quality data you wish to use:

- *Model Data*. Choose this option if you have air quality modeling data that you wish to use directly. Table 5-1 below describes the input format for modeling data.

- *Monitor Data*. Choose this option if you wish to use point source monitoring data (measured observations).

- *Monitor Rollback*. Choose this option if you want to reduce monitor levels by a specified amount.

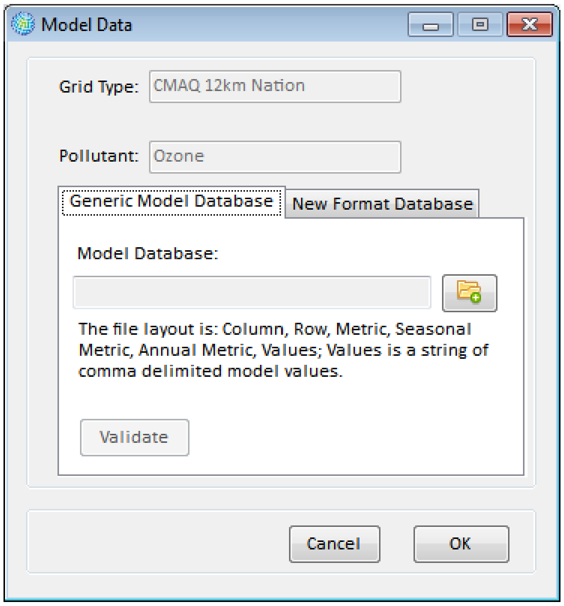
- *Open *.aqgx file.* Choose this option to import a file that has already been created.



Select your **Grid Type** and then click **Next.** BenMAP-CE will direct you through the necessary steps for each option (described below).

5.1 Model Data

After choosing the *Model Data* option, use the **Generic Model Database** tab to load grid-definition-based modeling data (e.g., CMAQ or CAMx).[1] *Note: The **New Format Database** is designed to support a new format model (under development).*



[1] Community Multi-scale Air Quality (CMAQ) Model is available at: http://www.epa.gov/amad/Research/RIA/cmaq.html or https://www.cmascenter.org/cmaq/. Comprehensive Air Quality Model with Extensions (CAMx) is available at: http://www.camx.com/.

The **Model Database** specifies the location of the air quality model results that you want to import. Table 5-1 presents the structure that these files must have, and Table 5-2 presents a sample data file with a variety of metrics. (For more information on air quality models, the EPA website has detailed descriptions of a variety of models at http://www.epa.gov/ttn/scram/.)

Table 5-1. Air Modeling Data File Variables

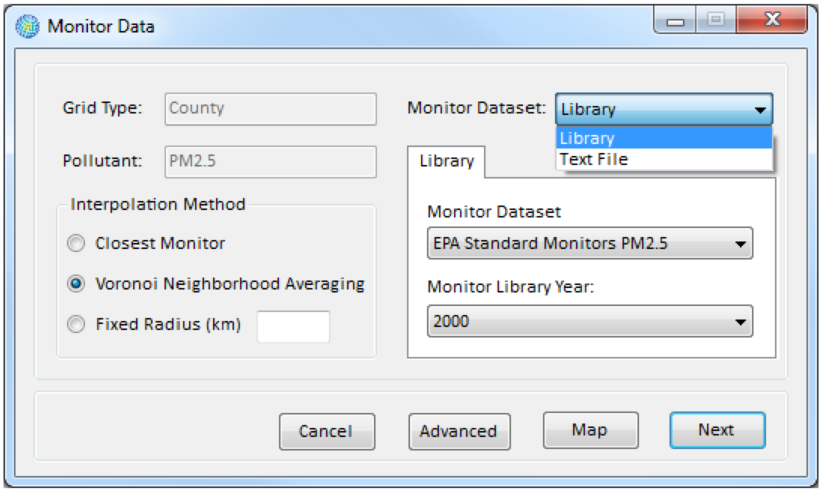
Variable	Type	Required	Notes
Column	Integer	Yes	The column and the row uniquely identify each set of modeling values, and link the modeling data with cells in a Grid Definition.
Row	Integer	Yes	
Metric	Text	No	This variable is either blank (signifying that the Values are Observations, rather than Metric values), or must reference an already defined Metric (e.g., 1-hour daily maximum) for the appropriate Pollutant.
Seasonal Metric	Text	No	This variable is either blank (signifying that the Values are not Seasonal Metric values) or must reference an already defined Seasonal Metric for the Metric (e.g., mean of the 1-hour maximum values for the months of June through August).
Annual Metric	Text	No	This variable is either blank (signifying that the values are not an annual metric) or must be one of: *None*, *Mean*, *Median*, *Max*, *Min*, *Sum* (e.g., mean of the 1-hour maximum values for the year)
Values	Comma Separated Values (Text)	Yes	If Metric is blank, values are supplied as a comma-delimited string of values for the year [e.g., 365 or 366 (leap year) values for daily data, 8760 or 8784 (leap year) values for hourly data]. If Metric is defined, but Seasonal Metric and Annual Metric are blank, 365 or 366 metric values. If Seasonal Metric is defined, but Statistic is blank, *n* seasonal metric values. If Annual Metric is defined, one annual statistic value for either the Metric (if Seasonal Metric is blank) or the Seasonal Metric. Missing values are signified with a period (‘.’).

Table 5-2. Sample Air Modeling Data File

Column	Row	Metric	Seasonal Metric	Annual Metric	Values
24	101				.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,5.90,.,.,11,.,.
24	102				19.80,.,.,3.5,.,.,14.70,.,.,.,.,.,.,4.9(
24	103				11.5,.,.,1.5,.,.,10.20,.,.,2.5,.,.,2.6
24	104				12.60,.,.,4.60,.,.,7.30,.,.,.,.,.,.,9.2(
24	105	DailyAverage			.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,.,5.90,.,.,11,.,.
24	106	DailyAverage			19.80,.,.,3.5,.,.,14.70,.,.,.,.,.,.,4.9(
24	107	DailyAverage			11.5,.,.,1.5,.,.,10.20,.,.,2.5,.,.,2.6
24	108	DailyAverage			12.60,.,.,4.60,.,.,7.30,.,.,.,.,.,.,9.2(
24	109	DailyAverage	QuarterlyAverage		11.82,13.24,18.79,14.25
24	110	DailyAverage	QuarterlyAverage		12.31,13.89,18.27,21.19
25	101	DailyAverage	QuarterlyAverage		12.33,15.68,18.49,15.96
25	102	DailyAverage	QuarterlyAverage		13.52,13.69,19.04,22.43
25	103	DailyAverage		Mean	14.52
25	104	DailyAverage		Mean	16.41
25	105	DailyAverage		Mean	15.62
25	106	DailyAverage		Mean	17.17
25	107	DailyAverage	QuarterlyAverage	Mean	14.29
25	108	DailyAverage	QuarterlyAverage	Mean	18.97
25	109	DailyAverage	QuarterlyAverage	Mean	20.14
25	110	DailyAverage	QuarterlyAverage	Mean	16.46

5.2 Monitor Data

Using the *Monitor Data* grid creation option, you create an air quality grid directly from air pollution monitoring data. At the top left of the **Monitor Data** window, you will see the previously selected grid definition in the **Grid Type** field, and the previously selected pollutant in the **Pollutant** field. Below the **Pollutant** field of the **Monitor Data** window, you are asked to select an **Interpolation Method**. The interpolation method is used to move from point-based monitor data to grid cell based air quality data. That is, some grid cells will have many monitors in them, some will have just one, and some will have none. BenMAP-CE uses the interpolation methods to generate representative air quality metric values for each grid cell from monitor data for all of these cases.



BenMAP-CE includes three **Interpolation Methods**. The *Closest Monitor* method simply uses the monitor closest to a grid cell's center as its representative value. The *Voronoi Neighborhood Averaging* method takes an inverse-distance weighted average of a set of the monitors surrounding a grid cell's center as its representative value. The *Fixed Radius* method averages all of the monitors within a fixed (user-specified) radius measured from the center of the grid cell. Each method is described below. For more detail, also see Appendix B on Air Pollution Exposure Estimation Algorithms.

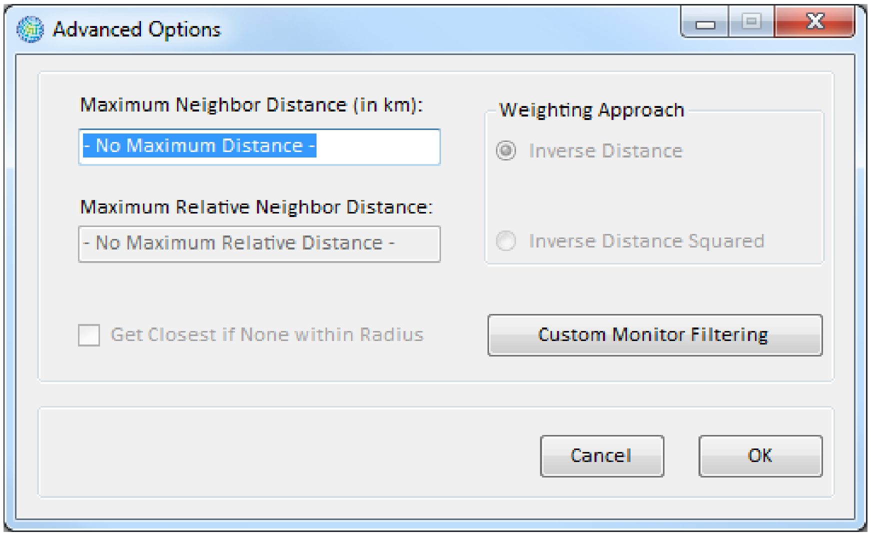
On the right side of the **Monitor Data** window, you can specify a source for your monitor data. Using the **Library** tab, you may select from data that you have already loaded into BenMAP-CE. Choose the **Monitor Dataset** and **Monitor Library Year** from the drop-down lists.

If you want to load your own monitor data, choose *Text File* from the **Monitor Dataset** drop-down list. You can then browse to locate the data file you want to load. See Chapter 4 for more information about formatting monitor datasets.

At the bottom of the **Monitor Data** window, there is a **Map** button. The **Map** button opens the **Monitor Map** window, allowing you to preview the map that you are about to load.

5.2.1 Closest Monitor for Monitor Data

If you choose the *Closest Monitor* option, BenMAP-CE identifies the monitor closest to each grid cell's center, and then assigns that monitor's data to the grid cell. *Closest Monitor* interpolation can be modified by clicking on the **Advanced** button at the bottom of the window and typing in a **Maximum Neighbor Distance (in km)**.



The **Maximum Neighbor Distance** specifies the maximum distance (measured in kilometers) that a monitor may be from the center of a grid cell. Cells without any monitors within this distance will not be included in the resultant air quality grid. The default setting is infinite (i.e., no limit to the monitor's distance from the center of the grid cell).

Note: The **Maximum Relative Neighbor Distance** and the **Weighting Approach** options are irrelevant (and are therefore disabled) when using the *Closest Monitor* method, since BenMAP-CE is only choosing a single monitor to assign to any given grid cell.

5.2.2 Voronoi Neighborhood Averaging (VNA) for Monitor Data

If you choose the *Voronoi Neighborhood Averaging* option, BenMAP-CE first identifies the set of monitors that "surround" each grid cell's center (these monitors are referred to as the grid cell's neighbors), and then BenMAP-CE calculates an inverse-distance weighted average of these neighboring monitors. In this section, we provide some examples of the different ways that BenMAP-CE calculates the average of the neighboring monitors. See Appendix B on Air Pollution Exposure Estimation Algorithms for an expanded discussion of VNA, including how the VNA algorithm actually chooses the neighbor monitors, as well as the different ways that it may be used.

VNA interpolation has three advanced interpolation options, which can be modified by clicking on the **Advanced** button at the bottom of the window:

- **Maximum Neighbor Distance (in km)** specifies the maximum distance that a monitor may be from the center of a grid cell, and still be included in the set of neighbor monitors used to calculate air pollution exposure at a particular grid cell. The default setting is infinite (i.e., no limit to the monitor's distance to the center of the grid cell).

- **Maximum Relative Neighbor Distance** specifies the maximum ratio for the distance of each included monitor to the distance of the closest monitor. The default setting is infinite.

- **Weighting Approach** specifies whether BenMAP-CE should use inverse-distance weighting for the monitors, or inverse-distance-squared weighting of the monitors. The default setting is inverse-distance weighting.

The following examples illustrate how varying these options affects the final average concentration estimate.

Example 1: Monitor Data VNA method

Default options

Consider the following example at a hypothetical rural grid cell, where there are relatively few monitors, and where the distance from a monitor to the center of a grid cell can be fairly large. With *VNA*, BenMAP-CE first identifies the set of "neighbor" monitors for each grid cell. The number of neighbors is usually in the range of about three to eight. In this case, assume that there are five monitors at distances of 25, 50, 100, 200, and 400 km from the grid cell, with annual $PM_{2.5}$ levels of 8, 13, 12, 18, and 15 $\mu g/m^3$, respectively. BenMAP-CE would calculate an inverse-distance weighted average of the monitor values as follows:

$$PM_{2.5}\ average = \frac{\frac{1}{25}\bullet 8+\frac{1}{50}\bullet 13+\frac{1}{100}\bullet 12+\frac{1}{200}\bullet 18+\frac{1}{400}\bullet 15}{\frac{1}{25}+\frac{1}{50}+\frac{1}{100}+\frac{1}{200}+\frac{1}{400}} = 10.68$$

Example 2: Monitor Data VNA method

Maximum Neighbor Distance = 75

Using the same example that we used above, let us say you have specified a **Maximum Neighbor Distance** of 75 km, and left unchanged the default options (infinite value) for **Maximum Relative Neighbor Distance**. BenMAP-CE would only consider the first two monitors, and would calculate an inverse-distance weighted average of the monitor values as follows:

$$PM_{2.5}\ average = \frac{\frac{1}{25}\bullet 8+\frac{1}{50}\bullet 13}{\frac{1}{25}+\frac{1}{50}} = 9.67$$

Example 3: Monitor Data VNA method

Maximum Relative Neighbor Distance = 10

Alternatively, if you left the **Maximum Neighbor Distance** at the default (infinite), but have set the **Maximum Relative Neighbor Distance** to 10, then BenMAP-CE would calculate the ratio of the distance for each monitor to distance of the closest monitor. In this case, the ratios would be 1 (=25/25), 2 (=50/25), 4 (=100/25), 8 (=200/25), and 16 (=400/25), and BenMAP-CE would drop the monitor with a ratio of 16. BenMAP-CE would then calculate an inverse- distance weighted average of the monitor values as follows:

$$PM_{2.5}\,average = \frac{\frac{1}{25}\bullet 8+\frac{1}{50}\bullet 13+\frac{1}{100}\bullet 12+\frac{1}{200}\bullet 18}{\frac{1}{25}+\frac{1}{50}+\frac{1}{100}+\frac{1}{200}} = 10.53$$

Example 4: Monitor Data VNA method

Inverse-distance squared neighbor scaling

In addition, you can specify an inverse-distance-squared weighting of the monitors. Let us say that you have left unchanged the defaults (infinite values) for **Maximum Neighbor Distance** and **Maximum Relative Neighbor Distance**, and specified that the **Weighting Approach** is *Inverse Distance Squared*. BenMAP-CE would then calculate an inverse-distance-squared weighted average of the monitor values as follows:

$$PM_{2.5}\,average = \frac{\frac{1}{625}\bullet 8+\frac{1}{2{,}500}\bullet 13+\frac{1}{10{,}000}\bullet 12+\frac{1}{40{,}000}\bullet 18+\frac{1}{160{,}000}\bullet 15}{\frac{1}{625}+\frac{1}{2{,}500}+\frac{1}{10{,}000}+\frac{1}{40{,}000}+\frac{1}{160{,}000}} = 9.26$$

Example 5: Monitor Data VNA method

Maximum Neighbor Distance = 75
Maximum Relative Neighbor Distance = 10
Inverse-distance squared Weighting Approach

Finally, you could specify changes to all three options: a **Maximum Neighbor Distance** of 75 km, a **Maximum Relative Neighbor Distance** of 10, and a **Weighting Approach** of *Inverse Distance Squared* weighting. BenMAP-CE would then calculate the following average:

$$PM_{2.5}\,average = \frac{\frac{1}{625}\bullet 8+\frac{1}{2{,}500}\bullet 13}{\frac{1}{625}+\frac{1}{2{,}500}} = 9.00$$

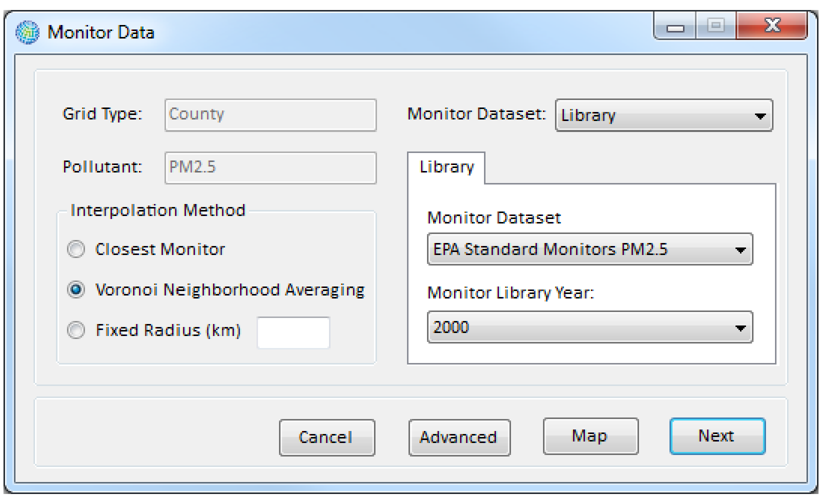
5.2.3 Fixed Radius for Monitor Data

If you choose the *Fixed Radius (km)* option, BenMAP-CE averages all of the monitor values within a fixed radius (measured in kilometers) that you specify. The way that the monitor values are averaged depends on the **Weighting Approach** that you choose after clicking the **Advanced** button. You can choose either *Inverse Distance* or *Inverse Distance Squared* weighting.

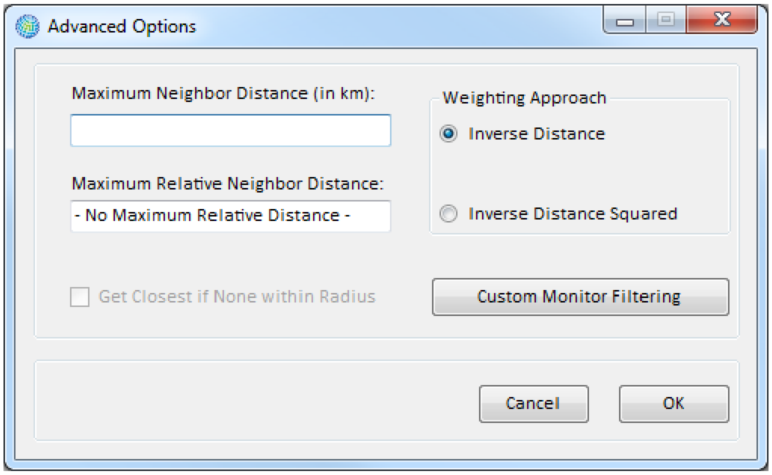
Note that the default option with the *Fixed Radius* approach is that BenMAP-CE will not calculate an average for a grid cell if there are no monitors within the fixed radius (distance) that you specify. In the **Advanced Options** window, if you select *Get Closest if None within Radius*, then for those grid cells without any monitors within the fixed radius, BenMAP-CE will choose the nearest monitor (regardless of distance) and apply that value as the "average".

5.2.4 Custom Monitor Filtering for EPA Standard Monitors

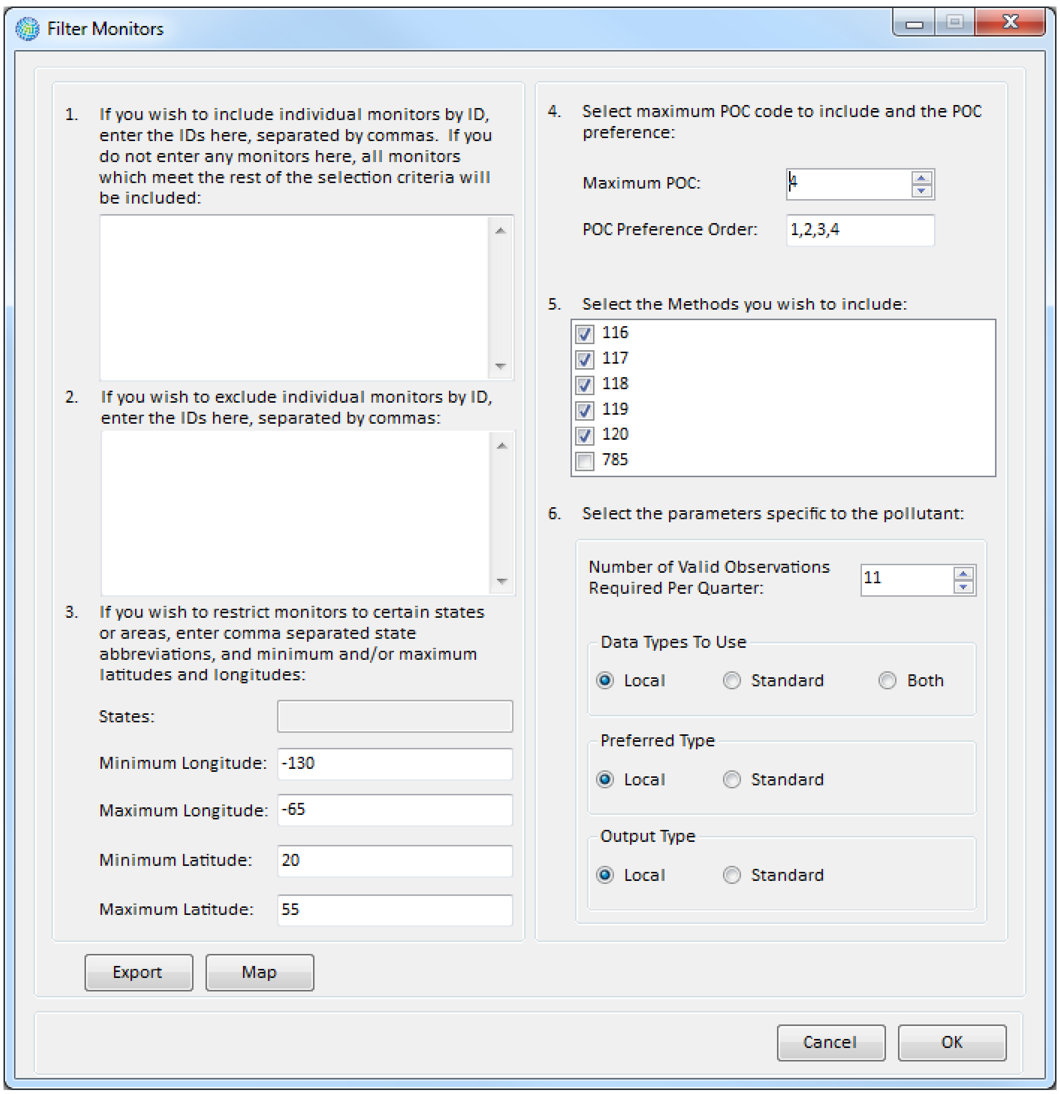
Custom Monitoring Filtering options apply only to the *EPA Standard Monitors* library in the *United States* setup; these are the only monitoring values that include all of the variables that BenMAP-CE needs in order to filter the data properly. This tool allows you to filter, map, and export your monitor data. You can reach the **Custom Monitor Filtering** tool by first choosing your pollutant, data source (e.g., monitor library) and year on the **Monitor Data** window.



Click the **Advanced** button. This will take you to the **Advanced Options** window.



Click the **Custom Monitor Filtering** button. This will take you to the **Filter Monitors** window.



Note that the first five options are essentially the same for each pollutant, and the sixth option depends on the pollutant. The example above shows what the form looks like with *PM2.5* as the selected **Pollutant**.

1. Include specific monitors. Here you can specify particular monitor IDs that you want to include in your analysis. If this is left blank, then BenMAP-CE will include all monitors that meet the rest of the selection criteria.

2. Exclude specific monitors. Here you can exclude any particular monitor IDs from your analysis. Here again, if this option is left blank then BenMAP-CE will include all monitors that meet the rest of the selection criteria.

3. Restrict to particular states and/or latitude/longitude. You can choose monitors to include from particular states, by listing the two-character state abbreviation (e.g., CA = California). You can also choose monitors within particular latitude and longitude ranges. The default values for latitude (20 to 50) and longitude (-130 to -65) completely include the continental U.S. Here again, if this option is left blank then BenMAP-CE will include all monitors that meet the rest of the selection criteria.

4. Parameter Occurrence Code (POC)[2]. Sometimes, multiple monitors are collocated at the same site measuring the same parameter (e.g., to check precision). The **Maximum POC** specifies the highest POC value allowed in the data. The default is a value of 4. And to choose one monitor when more than one monitor is in the same location, the POC Preference Order specifies the preferred ordering of POC codes.

5. Methods.[3] The Method codes listed indicate U.S. EPA-defined methods for collecting and analyzing samples; these codes depend on the pollutant. In the case of $PM_{2.5}$, only federal-reference methods (FRM) are chosen by default -- specifically numbers 116 through 120. In the case of Ozone (O_3), all methods are checked by default.

6. Parameters Specific to the Pollutant. The default options vary by pollutant. Below, we have described the options that appear with *$PM_{2.5}$* and *ozone*.

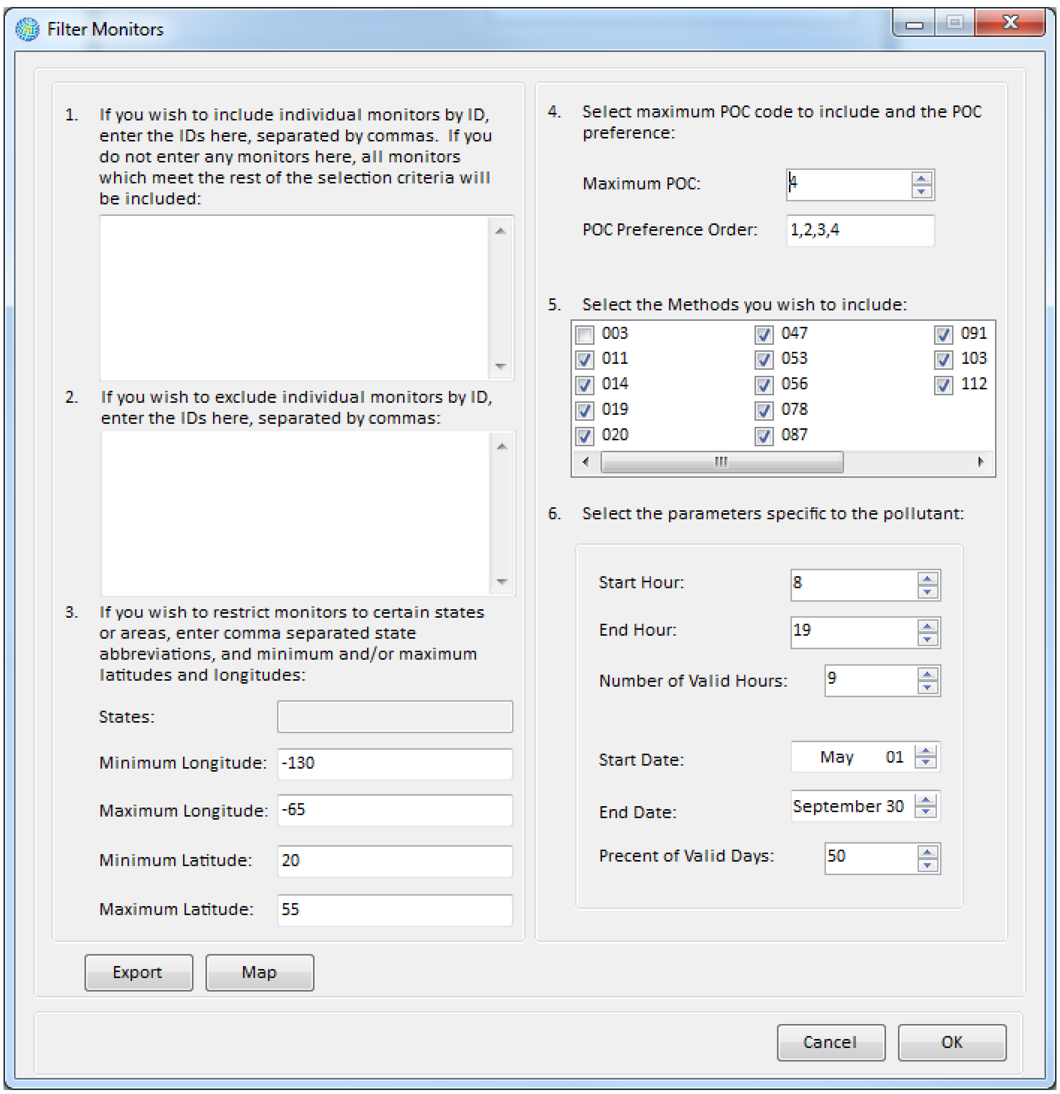
- **$PM_{2.5}$ Monitor Filter:** The **Number of Valid Observations Required per Quarter** specifies the number of days of data needed. The default is to require 11 observations per quarter. The **Data Types to Use** options specify whether to use data at *Local* conditions (parameter code 88101), *Standard* conditions (parameter code 81104), or *Both*.[4] The default for PM2.5 is to use data at *Local* conditions. When data at standard and local conditions are both available at the same monitor location, the **Preferred Type** allows you to choose which to use – the default is

[2] For information about data codes used in U.S. EPA's Air Quality System, refer to the *AQS Data Coding Manual*. http://www.epa.gov/ttn/airs/airsaqs/manuals/AQS%20Data%20Coding%20Manual.pdf
[3] For more information, refer to U.S. EPA's *List of Designated Reference and Equivalent Methods*: http://www.epa.gov/ttn/amtic/files/ambient/criteria/reference-equivalent-methods-list.pdf
[4] Particulate concentrations are expressed in either local conditions (volume is at temperature and pressure of the ambient sample) or at standard conditions (where the volume has been converted to standard conditions, typically 20° C at 760 mm Hg).

Local. The **Output Type** option is designed to allow you to make the data reasonably consistent when both local and standard condition data are used. The default is to use the *Local* output type, so *Standard* condition data will be converted to *Local*.

- **Ozone Monitor Filter:** The *ozone* specific options differ from *$PM_{2.5}$* in large part because ozone is monitored hourly in the United States. The **Number of Valid Hours** specifies the number of hours needed for a particular day of monitoring to be considered "valid." BenMAP-CE counts the number of non-missing hourly values from the **Start Hour** through the **End Hour** and compares this number with that specified in the **Number of Valid Hours**.

The **Percent of Valid Days** specifies the percent of days between the **Start Date** and the **End Date** that need to be valid for the monitor itself to be considered valid. The default is 50 percent of the days between May 1 and September 30. The example below shows what the form looks like with *Ozone* as the selected **Pollutant**.



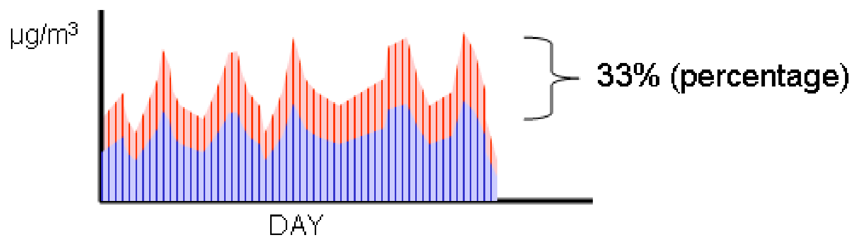
You can view a map of your data with the specified filter options by clicking the **Map** button on the bottom left side of the **Filter Monitors** window. This provides a brief preview of what will be shown once the data are loaded.

You can also export your data by clicking the **Export** button, which is found in the bottom left side of the **Filter Monitors** window. A **Save As** window will appear, allowing you to save the data as a CSV file.

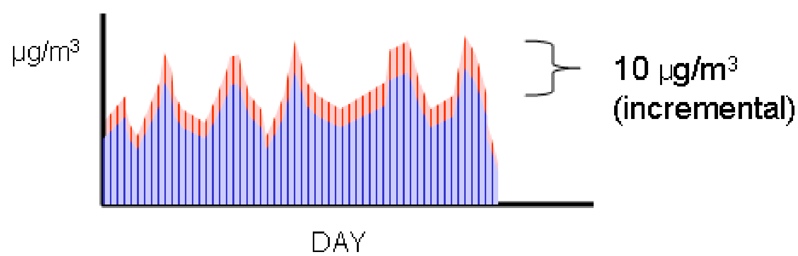
5.3 Monitor Rollback

The *Monitor Rollback* option allows you to quickly test what the benefits would be from reducing historical monitor levels. BenMAP-CE has three methods to reduce, or "roll back," monitor data: *Percentage Rollback*, *Incremental Rollback*, or *Rollback to a Standard*. Each of these methods is depicted below. Note that with each of these methods you can use the same two interpolation algorithms (*Closest Monitor* or *VNA*) as you can use with *Monitor Data*.

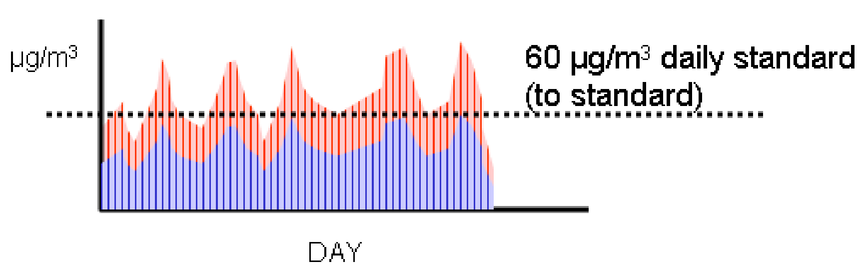
Percentage Rollback reduces all monitor observations by the same percentage.



Incremental Rollback reduces all observations by the same increment.

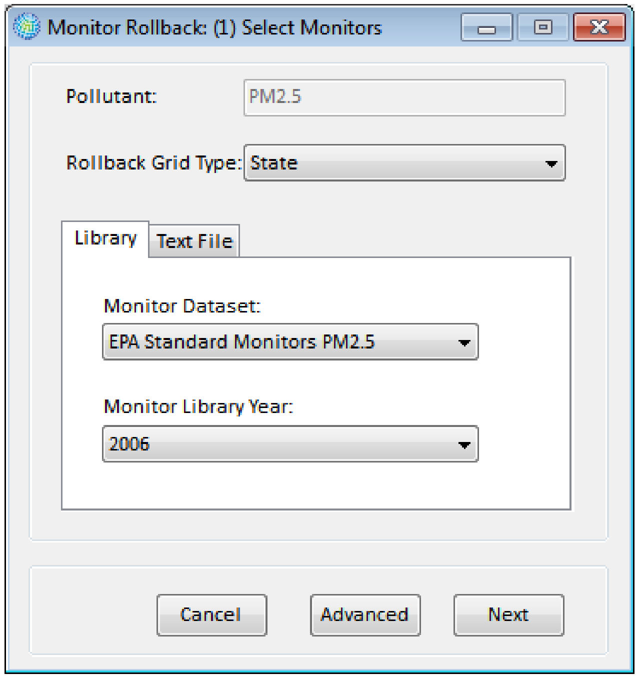


Rollback to a Standard lets you choose a standard, and then reduces any monitor observations exceeding the standard to the level of the standard.



5.3.1 Example: A Single Rollback in One Region

To apply a monitor rollback, first click the **Create Air Quality Grids** button. On the **Air Quality Grid Creation Method** window, choose *Monitor Rollback*. Click **Next**.

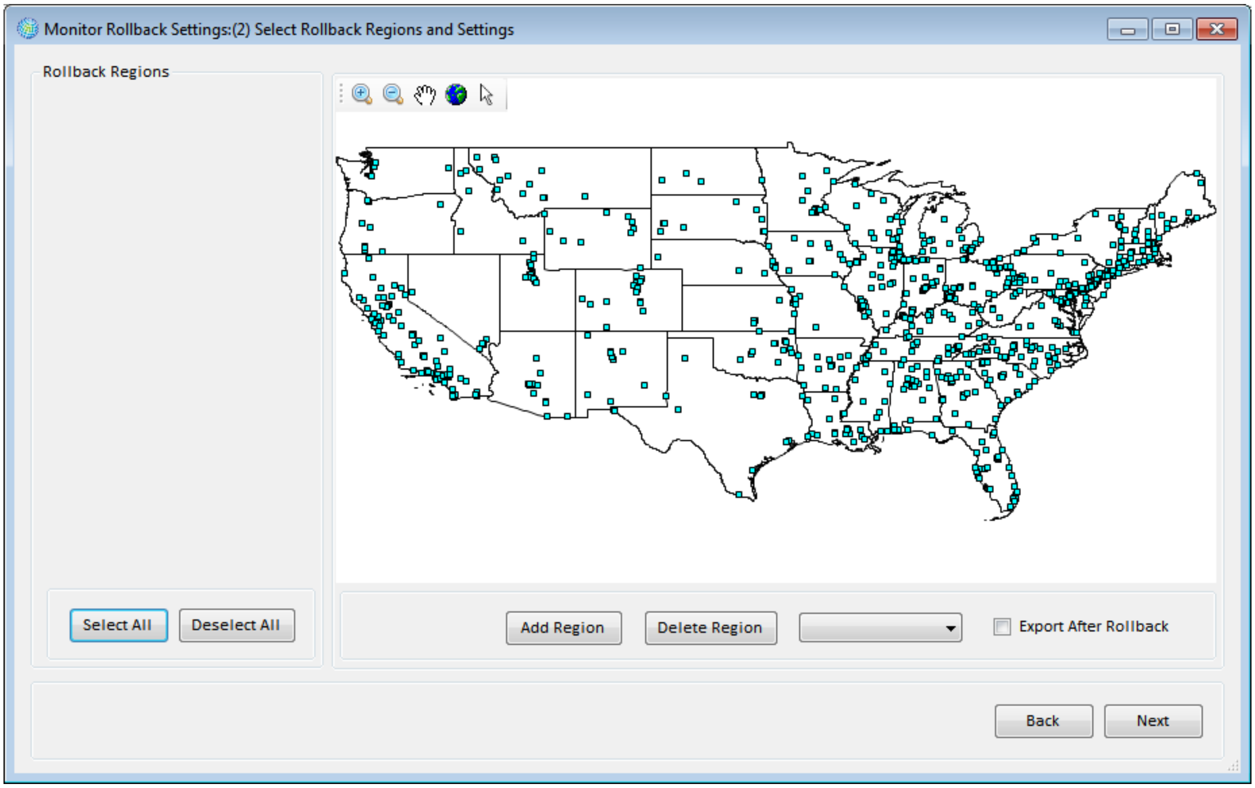


There are three steps to the *Monitor Rollback* method.

1. Select Monitors. Choose the **Rollback Grid Type** from the drop-down list. This allows you to determine how detailed the rollback scenario may be. If the whole region (e.g., United States) will have the same type of rollback then you may simply choose a grid outlining the area of interest. If you are interested in different rollbacks within a region, then you should choose a more finely detailed grid definition (e.g., states).

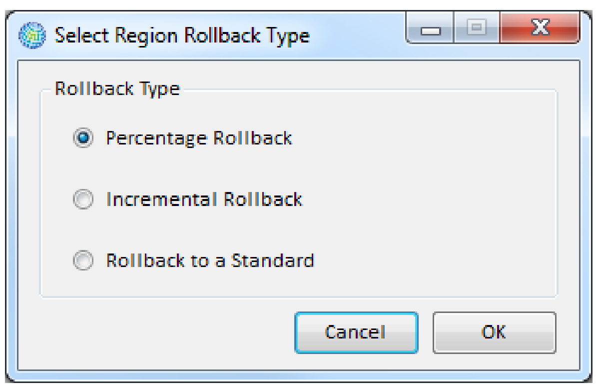
If you use data from an existing dataset, then choose the **Library** tab, and from the drop-down list choose the **Monitor Dataset** and the **Monitor Library Year**. If you want to use your own data, then choose the **Text File** tab. The file should have the monitor data format specified in Chapter 4: Loading Data.

When you have finished making your choices, click **Next**.



2. **Select Rollback Regions and Settings.** In this section, you can specify the type of the rollback method(s) that you would like to use, as well as the location of the monitors that you want to roll back.

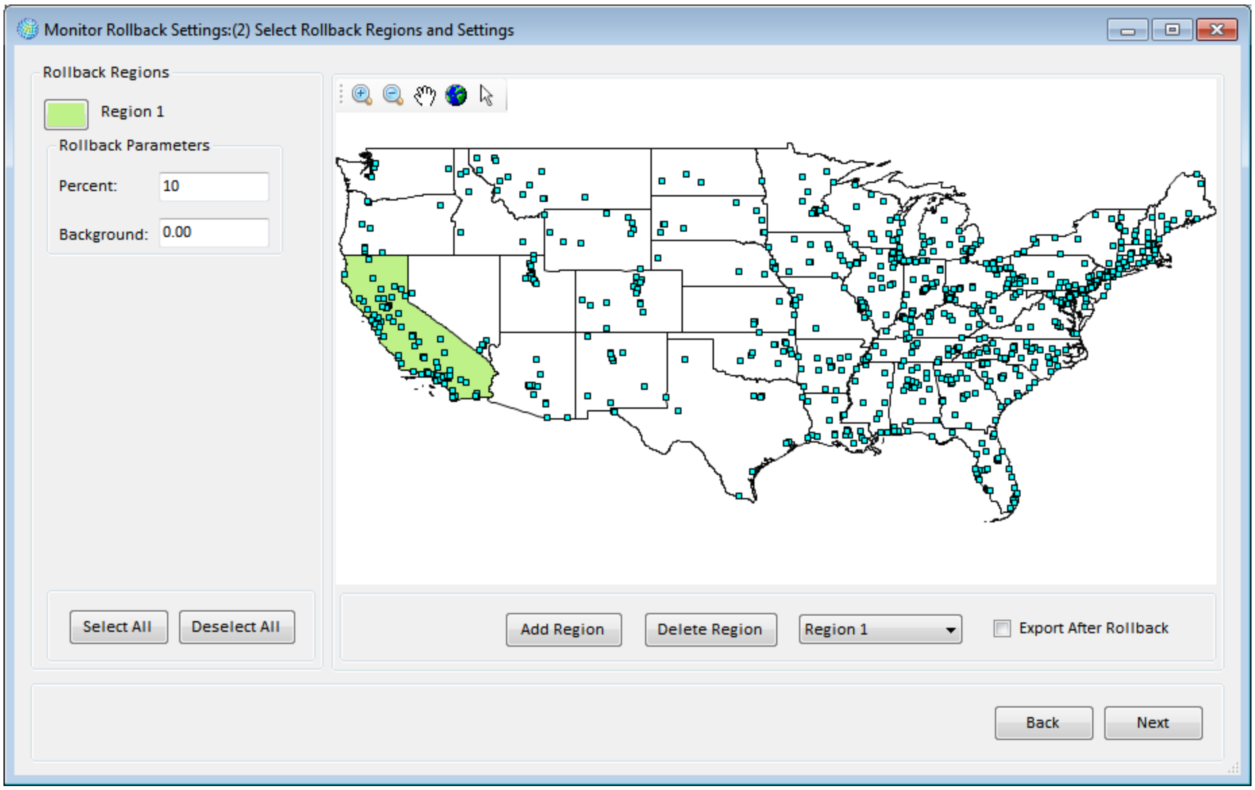
Click the **Add Region** button to display the three rollback options: *Percentage Rollback*, *Incremental Rollback*, and *Rollback to a Standard*.



Choosing the **Rollback Type** and click **OK.** Then, specify the amount of the rollback and the region to which you want to apply it. You can click on the map to select and deselect the states (or other defined areas depending on your rollback grid type) to add to the region.

At the top of the map are five GIS toolbar icons, typically seen in mapping programs, which allow you to zoom in and zoom out, and to focus on the particular groups of grid cells that interest you.

In this example, we specified a 10 percent reduction, a background of 0 ppb, and applied it to all monitors in the state of California (by clicking on the particular state in the GIS window).



To apply the rollback to all the states, you can simply click on the **Select All** button. To clear the selections, click the **Deselect All** button. At any time, you can change the grid cells that you have selected. This particular example is quite simple, so we will use a more complicated example below.

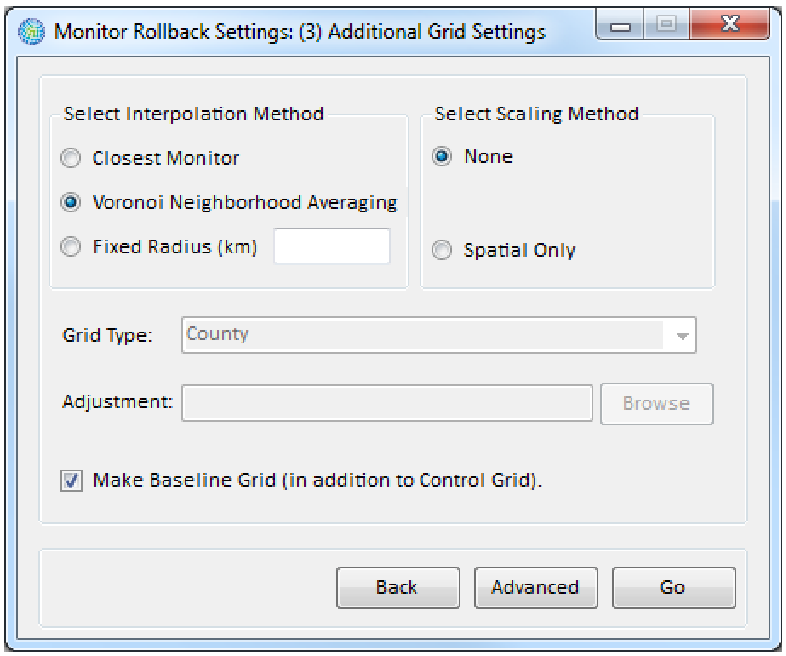
If you want to export your monitor data to a CSV file, click the option for *Export After Rollback*. The exported data will be formatted in the same specific format required of BenMAP-CE **Monitor Data** import files discussed in Chapter 4.

After defining the **Rollback Regions** and setting the **Rollback Parameters**, click on the **Next** button. BenMAP-CE will then perform the rollback you specified on the monitors in the grid cells that you have chosen.

3. Additional Grid Settings.

The third stage is similar to the *Monitor Data* grid creation method. As with monitor data, you need to specify the **Interpolation Method** (*Closest Monitor*, *VNA,* or *Fixed Radius*) and the **Grid Type**.

You may select a **Scaling Method** (*None* or *Spatial Only*). The concept of scaling is to use modeled data to improve interpolation of the actual monitor observations. If you choose spatial scaling, the modeled data are used to provide information in those areas where monitoring data are unavailable. Specify the **Grid Type** and then the location of your modeled data using the **Adjustment** box.



By checking the option for *Make Baseline Grid (in addition to Control Grid)* you tell BenMAP-CE to create a baseline grid at the same time as the control grid. The baseline grid uses the same parameters as the control grid, with the exception of the rollback. That is, the baseline uses the same monitor data, interpolation method, scaling (if any), and the same grid type. The two resultant grids will serve as both baseline and control scenarios and are automatically selected in the "Air Quality Surfaces" stage of the analysis.

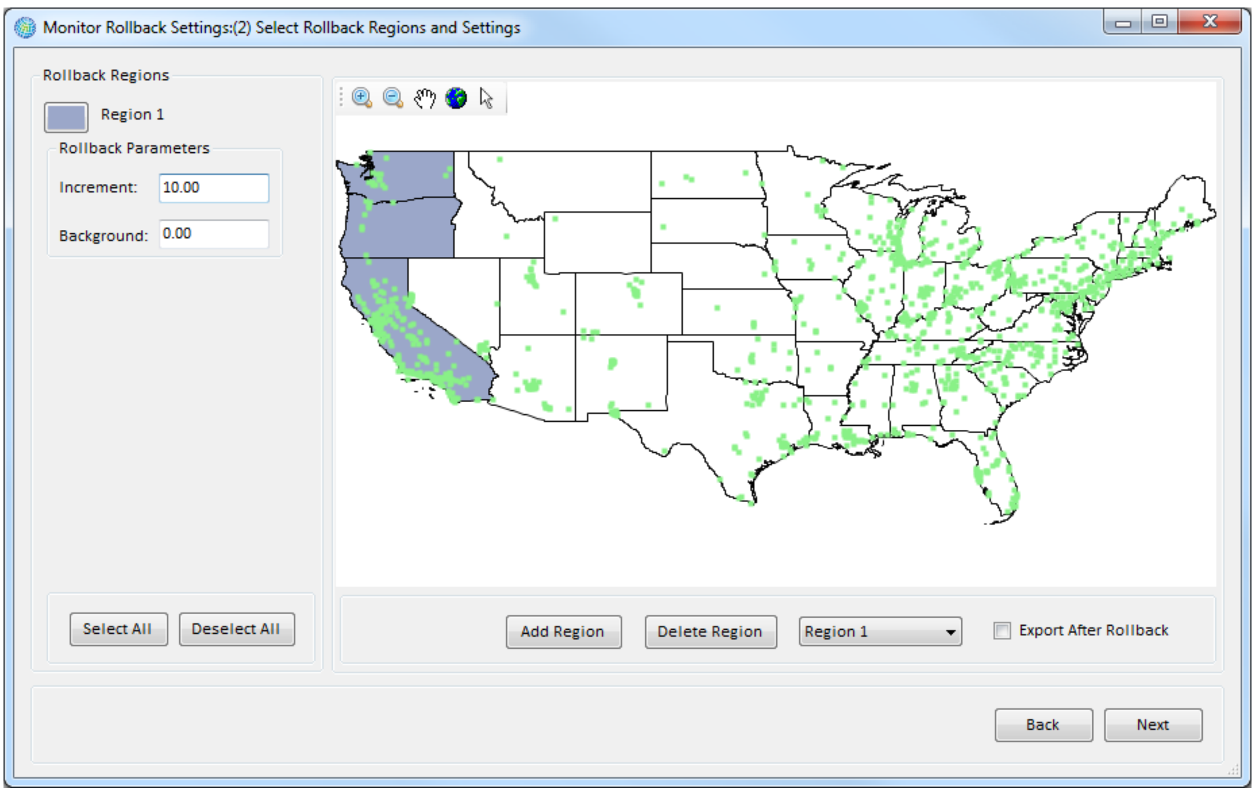
Note that there is an **Advanced** button that lets you select the **Maximum Neighbor Distance (in km)**, **Maximum Relative Neighbor Distance**, and **Weighting Approach**. The specific availability of advanced features depends on the interpolation method that you choose. The **Advanced Options** window is described in more detail in Section 5.2.4. You can view a map of the inputs to the rollback grids that you are creating, as well as the grids themselves by accessing the **Monitor Map.** To do this, click on the **Advanced** button, then the **Custom Monitor Filtering** button, and then the **Map** button (on the **Filter Monitors** window).

5.3.2 Example: Combining Three Rollback Approaches in Different Regions

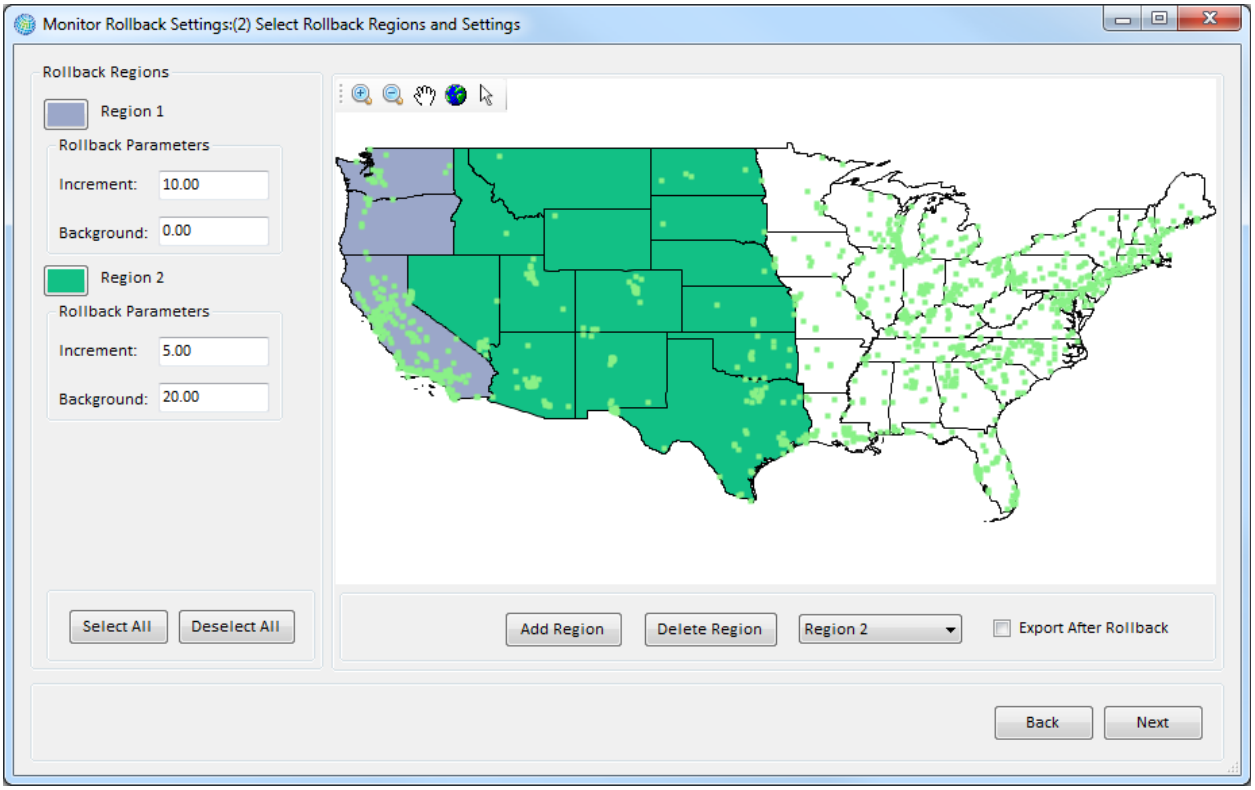
BenMAP-CE allows you to have different rollback approaches in different regions. In this example, we'll use the *United States* setup to combine the three rollback types: *Percentage Rollback*, *Incremental Rollback*, and *Rollback to a Standard*.

Start by clicking on the **Pollutant** button in the left-hand pane of the main screen, and choosing *Ozone*. Next, click **Baseline** under **Source of Air Quality Data**. Select *Monitor Rollback* as the **Grid Creation Method**. On the **Monitor Rollback: (1) Select Monitors** window, select the **Rollback Grid Type** (*State*), **Monitor Dataset** (*EPA Standard Monitors O3)* and **Monitor Library Year** (*2000*), and click **Next**.

On the **Monitor Rollback Settings: (2) Select Rollback Regions and Settings** window, click the **Add Region** button and select the *Percentage Rollback* method. Click **OK**. Enter *10* for the **Percent**. In the previous example, we included only one state in the rollback region. In this example we want to create three regions. Click on the three western-most states to add them to the first region. The states you have added to the region will fill in, as in the picture below.



To add states with a second type of rollback, click on the **Add Region** button, choose the rollback type, and then click on the states to include in this second region, which BenMAP-CE denotes as Region 2. In this example, we have chosen an *Incremental Rollback* with an **Increment** of *5* and a **Background** of *20*, and applied it to the 14 next western-most states.



The map now depicts two rollback regions. We can toggle back and forth between each region by clicking on the legend on the left side of the map. Any states that have not yet been included in a region may be added to an existing region, or we may create one or more regions for these remaining states. Note that once states have been included in a rollback region, they cannot be included in a different rollback region. In our example, the three western-most states are highlighted in gray.

If you want to add or remove states from a defined region, make sure you select the appropriate region from the drop-down list (below the map) before clicking on the map to select or deselect the state(s).

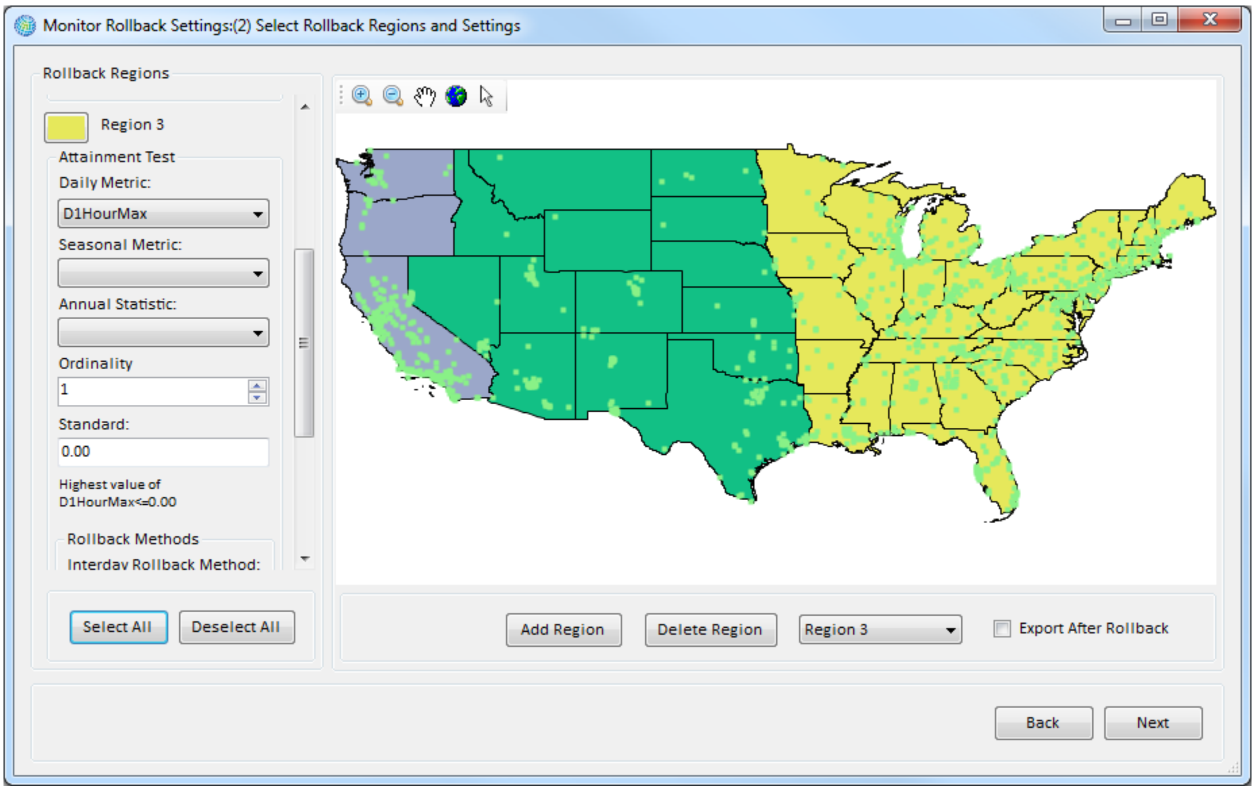
To add a third rollback type covering the rest of the states, click again on the **Add Region** button, and then choose the rollback type. However, instead of individually choosing the states, simply click the **Select All** button. This will select all of the states that are not yet included in a region, and these remaining states will now become Region 3.

In this third region, we have chosen a *Rollback to a Standard*, which involves two groups of parameters - those associated with the **Attainment Test**, which determines whether a monitor is in attainment (meets the standard), and those associated with the **Rollback Methods**, which are used to bring out-of-attainment monitors into attainment.

The **Attainment Test** parameters are **Daily Metric**, **Seasonal Metric**, **Annual Statistic**, **Ordinality**, and **Standard**. (Note: You will need to use the scroll bar to view more detail on the left side of the screen.)

In this step BenMAP-CE calculates the metric to be used to determine whether a monitor's values must be rolled back and, if so, how much (e.g., if **Metric** is *D8HourMax*, BenMAP-CE calculates the 8-hour daily maximum for each day at each monitor).

A monitor is considered in attainment if the n^{th} highest value of a daily metric specified by **Metric** is at or below the value specified by **Standard**, where *n* is the value specified by **Ordinality**. For example, if **Metric** is *D8HourMax*, **Ordinality** is *4*, and **Standard** is *85*, a monitor will be considered in attainment if the fourth highest value of the eight-hour daily maximum is at or below 85 ppb.



The **Attainment Test** can also be used for seasonal metrics (by choosing previously defined seasonal metrics from the drop-down list below **Seasonal Metric**), as well as for annual metrics (by using the drop-down list below **Annual Statistic**). For example, if you want the annual mean ozone level to stay below 60 ppb, then you would choose the daily 24 hour mean (*D24HourMean*) from the drop-down list below **Daily Metric**, choose *Mean* from the drop-down list below **Annual Statistic**, and set the **Standard** to *60*. (Note that in this case **Ordinality** cannot be chosen because there is only a single annual value.)

The **Rollback Methods** parameters determine the rollback procedures used to simulate out-of-attainment monitors coming into attainment:

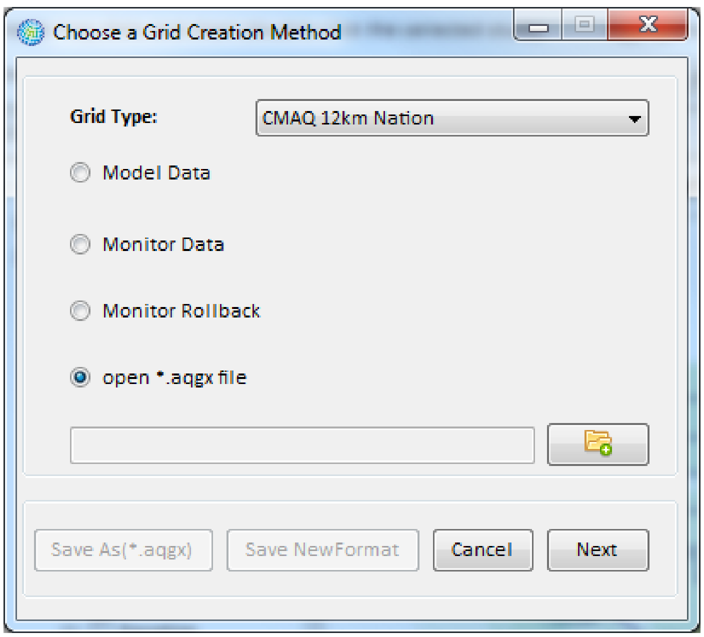
- **Interday Rollback Method** (with associated **Background** level) – These are used to generate target values for the metric specified by the **Attainment Test**. Method types include *Percentage*, *Incremental*, and *Peak Shaving.*

- **Intraday Rollback Method** (with associated **Background** level) **–** These are used to adjust hourly observations to meet the target metric values generated in the previous step. Method types include *Percentage* and *Incremental.*

The methods involved for each can be somewhat complicated, so we have included a section in Appendix A: Monitor Rollback Algorithms which goes through several examples.

5.4 Open *.aqgx File

The final option for uploading an **Air Quality Grid** is to select the *Open *.aqgx File* option from the **Choose a Grid Creation Method** window.



Choosing this option will activate the **Open File Browser** button located directly below this option. Click the **Open File Browser** button. This will cause an **Open** window to appear, allowing you to search for an **Air Quality Grid** (*.aqgx file) that has already been created. Select a file and click **Open**. The file path and name should appear in the box beside the **Open File Browser** button. Click **Next** to close the window and begin to create the map layer.

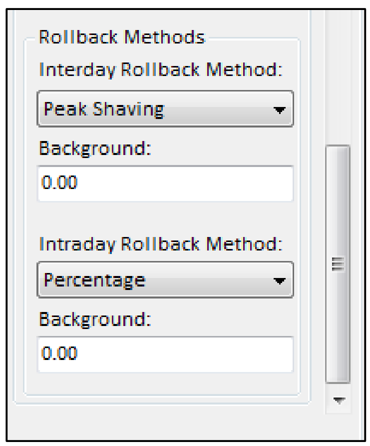
5.5 Frequently Asked Questions

How can I generate a map of an air quality grid and export it?

When viewing any of the displayed maps n the **GIS Map** tab (lower right frame of the main window), click on the GIS toolbar icon for **Save Shapefile** (looks like a 3.5-inch diskette). Follow the prompts to provide a name and location for the file. BenMAP-CE will export a set of files (.dbf, .prj, .shp, .shx) associated with the shapefile that you can use with any GIS viewer. To export the map as an image, click the **Export map image** icon (immediately below the **Save Shapefile** icon). This will use built-in DotSpatial GIS tools to allow you to save the map as a formatted image (.png) file.

For the Rollback to a Standard option, why are there Interday and Intraday rollback options?

The **Interday Rollback Method** option identifies the approach (e.g., *Percentage*) to reduce daily air pollution levels, in order to meet the specified standard. (In other words, there is more than one way to reduce daily pollution levels so as to meet the standard you have chosen, and BenMAP-CE lets you choose from among those approaches.) The **Background** level associated with the **Interday Rollback Method** specifies the bound, below which, BenMAP-CE will not make adjustments to daily levels.



The **Intraday Rollback Method** option is only relevant for hourly air pollution data, like ozone measurements. This option specifies the approach (e.g., *Percentage*) used by BenMAP-CE to reduce hourly air pollution levels to reach the target metric values. That is, once you have chosen the approach to reduce daily air pollution levels, on any given day there is more than one way to reduce the hourly air pollution values to meet the targeted pollution level for that day. The **Background** level associated with the **Intraday Rollback Method** specifies the bound, below which, BenMAP-CE will not make adjustments to hourly levels.

The **Interday** and **Intraday** options are complicated. Appendix A on Monitor Rollback Algorithms explains these options in more detail and gives some numerical examples.

Can I use air quality grids based on different Grid Types in the baseline and control scenarios?

No. In any given analysis, you need to use the same Grid Type in the baseline and control scenarios.

Can I use air quality grids of the same Grid Type but based on different Grid Creation Methods?

Yes. In any given analysis, you may use air quality grids made with different methods. Air quality grids made with Model Data and Monitor Data may be used interchangeably, if desired. Similarly, air quality grids made with different interpolation methods may be compared. However, it generally is not recommended to create grids with different methods and use them in the same analysis.

Can I do an analysis with multiple pollutants?

You can currently only estimate impacts one pollutant at a time; however, BenMAP-CE allows you to aggregate the results of more than one pollutant. This is discussed in Chapter 7: Aggregating, Pooling, and Valuing.

Why does it take so long to generate an Ozone Air Quality grid if there are a lot of grid cells?

It can take a long time to create an air quality grid because the file being generated can be quite large. In some cases, air quality grids can be several hundred megabytes in size. (One reason the ozone files are large is that the definition of ozone has, by default, four metrics. If you do not need all of the default metrics for the health impact functions in your database, then delete the unneeded metrics and BenMAP-CE will run faster and generate smaller air quality grids. This is an advanced step, so do not do it if you are unsure.) The type of computer you use can also affect processing speeds. Refer to Chapter 1, Section 1.3 for recommended hardware specifications.

How do I access data in an Air Quality Surface?

You can access the data in an air quality grid by going to the **Tools** menu and choosing the **Export Air Quality Surface** option. (The **Tools** menu is available on the toolbar of the main BenMAP-CE window.) Locate the air quality grid from which you want to export air quality data and then give a name to your exported file. BenMAP-CE will generate a text file that you can then examine. This is discussed in detail in Chapter 3, Section 3.2.1 (Tools).

- **How do I perform a rollback to simulate attainment with an annual *and* daily PM2.5 standard?**

Unfortunately, BenMAP-CE will roll back to either an annual standard or a daily standard—but not both. If this feature is of interest to you, please contact the BenMAP-CE developers at benmap@epa.gov.

CHAPTER 6

Estimating Incidence

In this chapter…

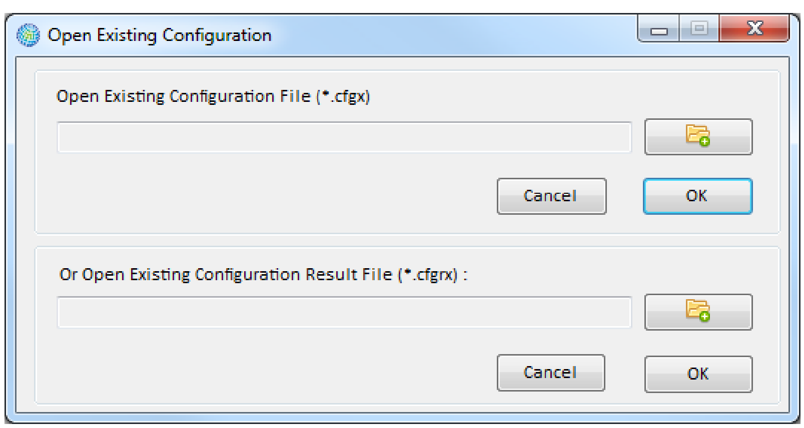
- **Get an overview of how BenMAP-CE estimates the incidence of health outcomes.**
- **Learn to create a health impact configuration.**
- **Learn about baseline and control scenarios.**
- Learn the difference between Point Mode and the **Monte Carlo analysis** option**s**.
- **Learn how to run, save, and re-open a configuration.**
- **Learn how to view and export Incidence Results.**

To estimate changes in the incidence of adverse health effects from air pollution, you will need to create and run a BenMAP-CE configuration file (*.cfgx). A configuration is a reusable file that specifies the air quality grids, health impact functions, population data, and other parameters necessary for an analysis. It is a record of the choices you make in estimating the change in adverse health effects between a baseline and control scenario. The choices include the following:

- The pollutant and air quality grids for the baseline and control scenarios;
- The year for the analysis;
- The population dataset for the analysis;
- The health impact functions to be used in estimating adverse health effects; and
- Whether the analysis will focus on a single "point" estimate (Point Mode), or a range of results that mirror the variability in the inputs to the health impact functions (Monte Carlo-generated percentiles).

BenMAP-CE gives you flexibility in creating, editing, and saving configuration files. You can open an already existing configuration and proceed directly to estimate incidence. Or, you can create a new file, and then estimate incidence. In addition, you may save any edits made to existing configuration files. After calculating the change in adverse health effects, BenMAP-CE saves the results in a "configuration results" file with a *.cfgrx* extension. The results obtained from running a configuration are sometimes referred to as “raw” results because they represent the estimated change in incidence for each air quality grid cell in a given scenario; they have not been aggregated, pooled, or valued (see Chapter 7).

To load a previously saved configuration, click **Estimate Health Impacts**, which is beside **Step 2** in the BenMAP-CE tree menu (on the left side of the main window). An **Open Existing Configuration** window will appear, as shown below:



To open an existing Configuration file, click the top file browser button. To open an existing Configuration Result file, click the bottom file browser button. After selecting either of these options, search and select a file to load in the **Open** window. The file path and name should appear in the box next to the file browser button. Once you have selected the desired option, and are satisfied with the file selection, click **OK**.

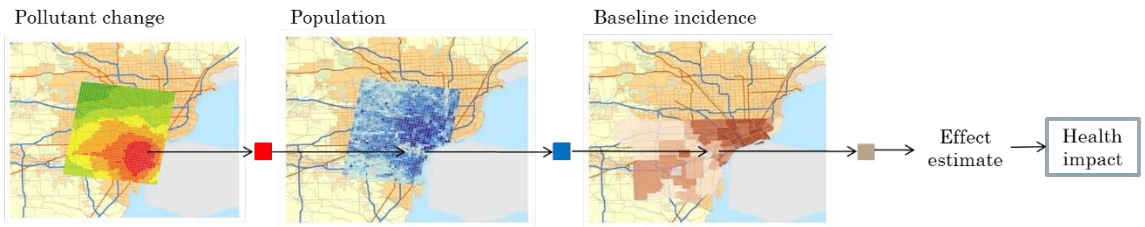
6.1 Introduction to Estimating Health Incidence

Health impact functions relate a change in the concentration of a pollutant to a change in the incidence of a health endpoint (i.e., premature mortality or work-loss days). It is typically derived from the estimated relationship between the concentration of a pollutant and the adverse health effects suffered by a given population in an epidemiology study. For example, the pollutant concentration being measured may be particulate matter ($PM_{2.5}$), and the population response may be daily premature deaths. For the purposes of estimating benefits, we are not interested in the health impact function itself, but rather the relationship between the change in concentration of the pollutant, and the corresponding change in the population-health response. We may want to know, for example, if the concentration of $PM_{2.5}$ is reduced by 10μg/m^3, how many premature deaths will be avoided?

To estimate changes in health incidence, the first step is to calculate the change in pollution concentrations for a particular policy scenario, such as an air quality improvement produced by a set of emissions controls. The concentration change in a pollutant is the increment between the baseline scenario and the control scenario. This increment and a gridded population dataset are then used in health impact functions to calculate the change in health incidence that would result from this change in pollution. These functions are based on epidemiological studies and can be selected by the user. Typically, these health incidence results show the decrease in health incidence (e.g., the decrease in asthma, bronchitis, mortality) due to a decrease in pollution. In BenMAP-CE, the selected health impact functions are stored in configurations, which can be re-used over and over again.

Steps to Calculating Health Impacts

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



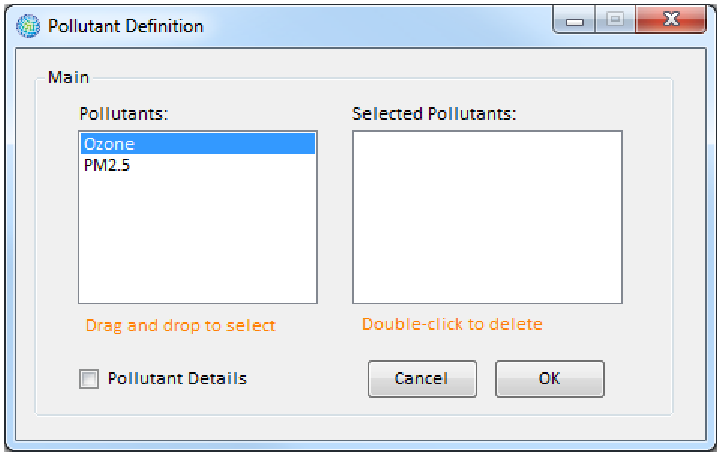
6.2 Create a Health Impact Configuration

There are three major steps to creating a new configuration. First, select a **Pollutant** and specify the **Source of Air Quality Data** for the **Baseline** and the **Control** layers using the BenMAP-CE tree menu on the left side of the main window. Next, choose the **Population Dataset** and **Health Impact Functions** that you want to use in your analysis. Finally, using the **Advanced** button on the **Health Impact Functions** window, specify whether BenMAP-CE will run in **Point Mode** or perform a Monte-Carlo analysis (default setting).

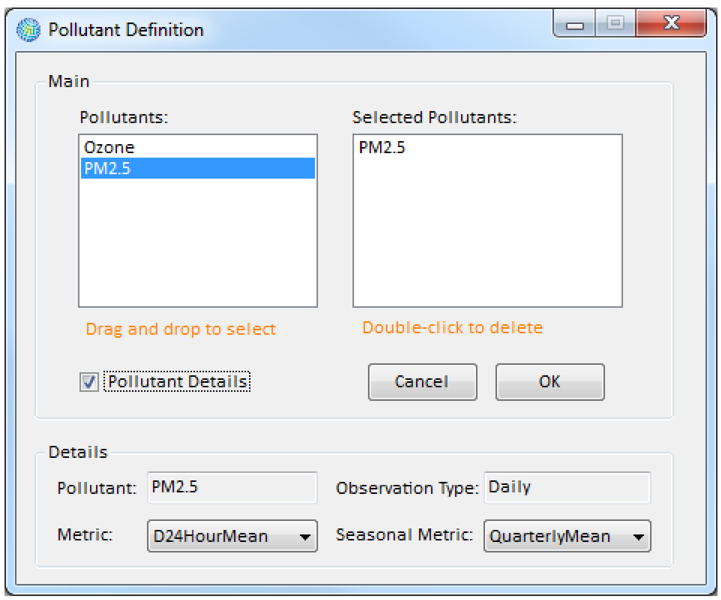
Note: As you move through the analysis steps, the BenMAP-CE tree menu will update its "**stoplight**" colors to reflect progress. **Yellow** indicates an operation has not yet started. **Green** indicates that an operation has been successfully completed. **Red** indicates that an operation completed, but you may need to re-run this step.

6.2.1 Air Quality Surfaces – Pollutants and Air Quality Grids

Using the BenMAP-CE tree menu, specify the pollutant(s) of interest. Click the **Pollutant** tree menu item to open the **Pollutant Definition** window. Select the pollutant(s) of interest by clicking on an item in the **Pollutants** box (left side) and then drag-and-drop the item into the **Selected Pollutants** box (right side). To deselect a pollutant, double-click on the item in the **Selected Pollutants** box.

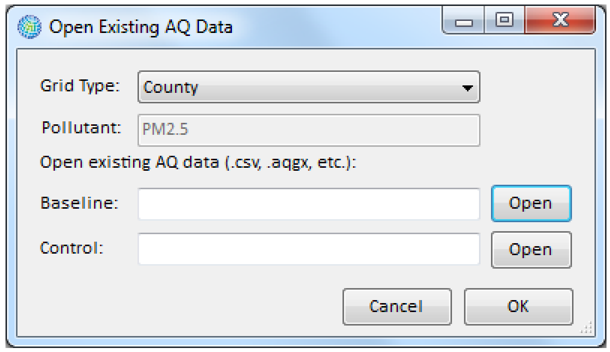


If you want to view or modify any pollutant details, click the box next to *Pollutant Details* and the window will expand to display details and options for the highlighted **Pollutant** (left box). Note that the details are based on the defined **Pollutant Definitions** (see Chapter 4: Loading Data).



Once your pollutant is selected, click **OK** to close the form. The stoplight for **Pollutant** will change from yellow to green when the operation is successfully completed.

Next, select air quality grids for the **Baseline** file and **Control** file. You may choose existing air quality grids by double-clicking the **Source of Air Quality Data** from the tree menu. The **Open Existing AQ Data** window will be displayed. Select air quality grids, designated with an '.aqgx' extension, for **Baseline** and **Control**. To create a new air quality grid, follow the steps outlined in Chapter 5: Creating Air Quality Grids.



The **Baseline** file contains the air quality metrics for the scenario assumed to occur without any change in policy. The **Control** file specifies the air quality metrics assuming that some type of policy or change has been implemented. The air quality grids should be for the same pollutant, and should also be based on the same **Grid Type**.

If you choose a particular **Grid Type** (e.g., *County*) for the **Baseline** file, then the same grid type must be used in the **Control** file. Conversely, it would not be possible to use *County* grid-type in the **Baseline** and a *Tract* grid-type in the **Control** file.

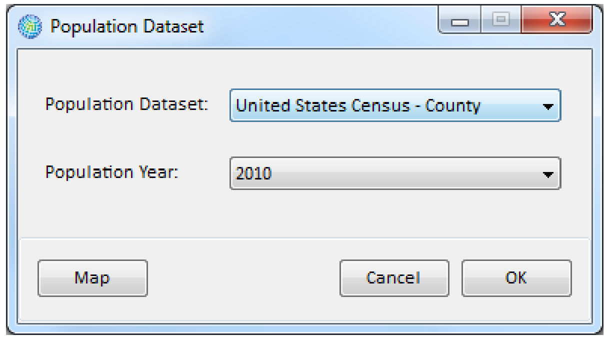
The **Pollutant** specified in the air quality grids determines the suite of **Health Impact Functions** available for the configuration. Only functions associated with the specified **Pollutant** will be available for the configuration. Furthermore, if only certain **Metrics** associated with the pollutant are present in one (or both) of the air quality grids (see the information in Chapter 3 on monitor and model data formats for more information on how this can occur) only those **Health Impact Functions** associated with those **Metrics** will be available.

Once the **Baseline** and **Control** files are selected, click **OK** to close the form. The stoplights for each of these under **Source of Air Quality Data** will change from yellow to green when the operation is successfully completed.

6.2.2 Estimate Health Impacts – Population and Health Impact Functions

The second step in creating a health impact configuration is to select the **Population Dataset**, **Population Year** and **Health Impact Functions**. If you want to open an existing configuration, double-click the **Estimate Health Impacts** tree menu item and select the file to open. Follow instructions from Chapter 3: Overview of BenMAP-CE.

To continue creating a new configuration, double-click **Population Dataset** in the tree menu. Here, you can choose the **Population Dataset** and **Population Year** that will be used in the analysis. The values in the drop-down list for **Population Year** depend on the range of values in your **Population Dataset**. (See Chapter 4: Loading Data.)



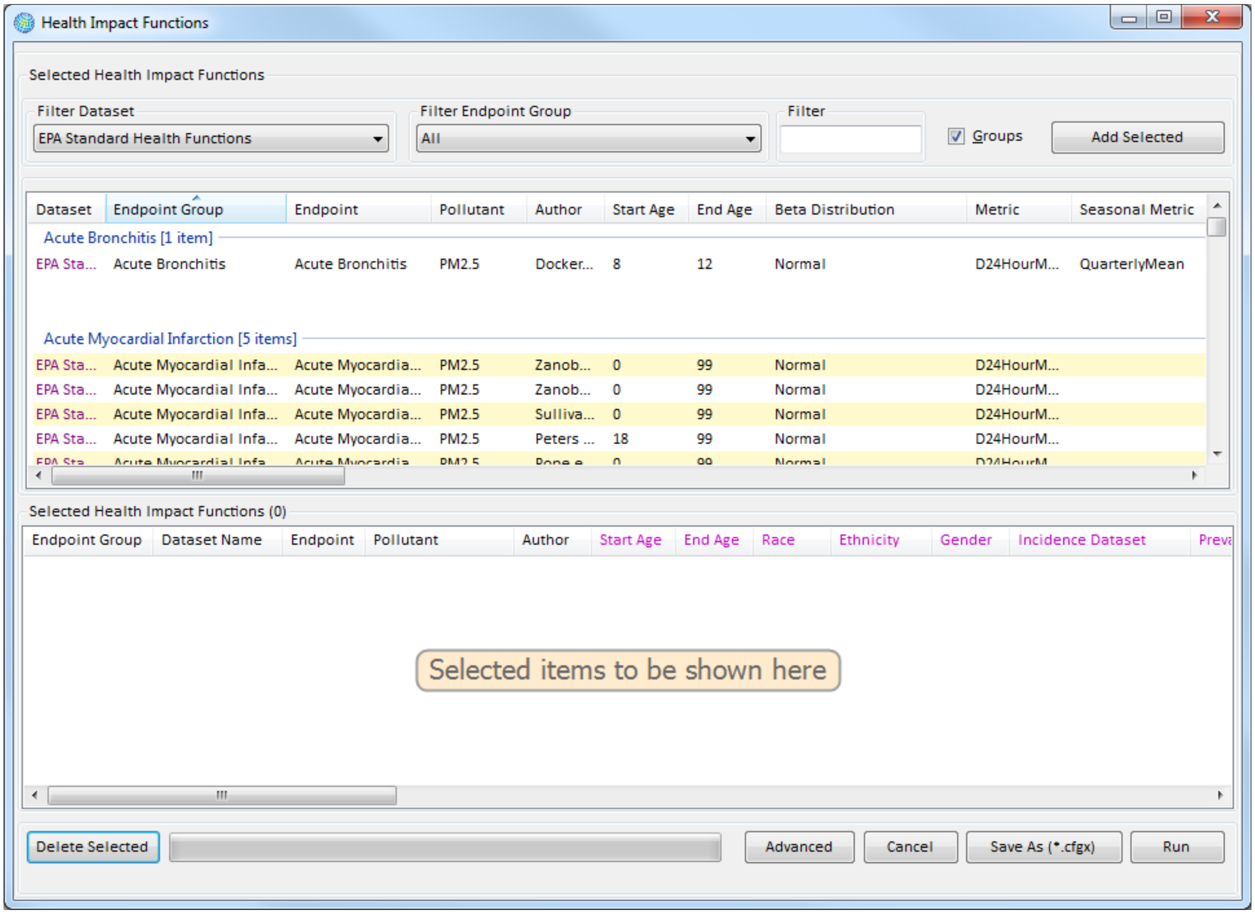
Clicking the **Map** option in the bottom left hand corner will open a separate **Population Map** window. (Warning: this procedure can require a significant amount of time to complete as it creates the population grid and loads the population growth weights). This provides a map of your selected population. If you want to view a different population subgroup based on race, gender, ethnicity, or age range, choose from the available drop-down list (this runs fairly quickly as it uses the same population grid already loaded). The map will refresh automatically.

To change the **Population Dataset** or **Population Year**, click on their respective drop-down list and click **Draw** to update the map and display new results. Warning: This requires BenMAP-CE to recalculate the grid.

Click the close ('×') button at the top of the **Population Map** window to close it.

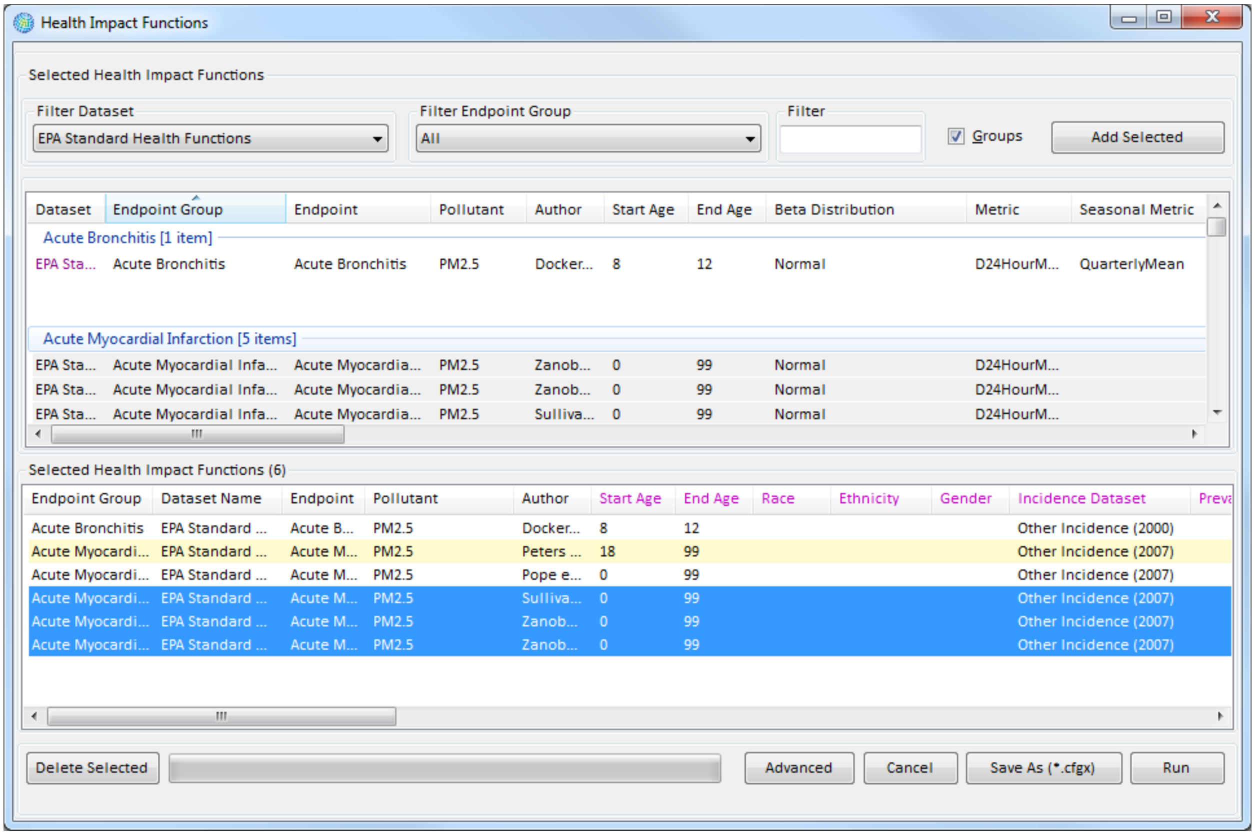
Clicking **OK** on the **Population Dataset** window will close the window and change the stoplight color to green in the tree menu.

Next, double-click **Health Impact Functions** on the tree menu to display the **Health Impact Functions** window.



The **Health Impact Functions** window is split into two display frames. The upper frame presents the **Available Health Impact Functions**, which you may select, and the lower frame shows the **Selected Health Impact Functions** that you have already selected. Both frames have a tree structure and the ability to change the order of the fields for easy viewing of the functions. Above the **Available Health Impact Functions** frame, there are a series of buttons that give you the option to select different datasets and filter options for each one.

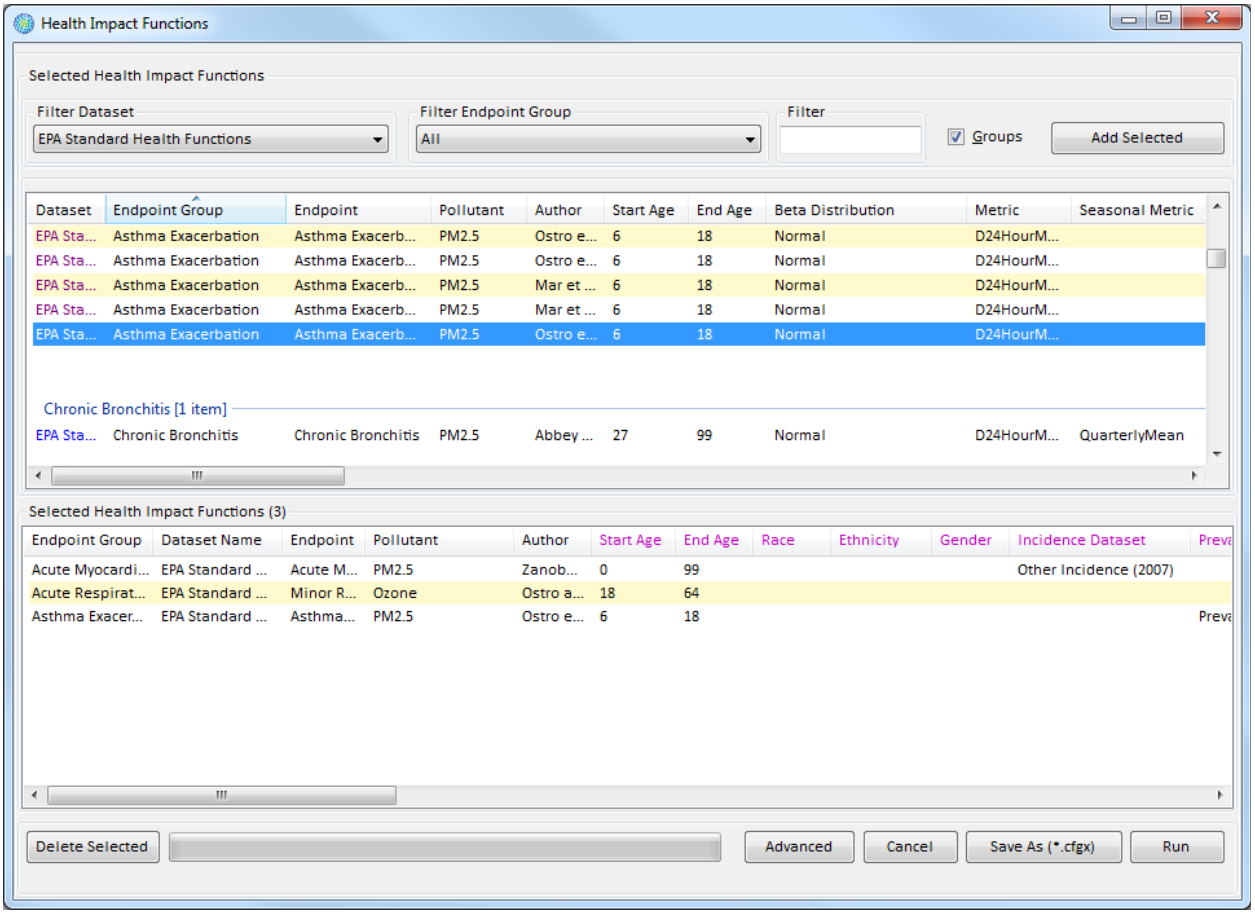
To add studies to your configuration, simply click to select the health impact functions of interest in the top frame and drag them down to the lower frame. You can do this for blocks of health impact functions by selecting the *Groups* option, clicking on the header of an endpoint group, and dragging the entire endpoint group into the lower frame. And, you can use the options to **Filter Dataset**, **Filter Endpoint Group**, and **Filter** (by keyword) to filter the list according to your preference. Once you are satisfied with the filter, click the **Add Selected** button to apply the selection to the list of selected functions.



If you want to delete some of the health impact functions that you added to your configuration, just highlight the studies of interest and hit the **Delete** key on your keyboard (or click the **Delete Selected** button on the form).

BenMAP-CE displays information for selected studies in two broad categories: **Function Identification** (column headings in black text) and **Function Parameters** (column headings in pink text). The **Function Identification** includes information such as the **Endpoint Group**, **Endpoint**, **Metric**, **Location**, and other variables. This identification information is useful when distinguishing between multiple health impact functions. The **Function Parameters** include those variables that you may directly edit: **Race**, **Ethnicity**, **Gender**, **Start Age**, **End Age**, **Incidence Dataset**, **Prevalence Dataset**, and **Variable Dataset**.

Clicking on a column header will sort the health impact functions according to that variable. For example, clicking the **Start Age** column will sort the functions by youngest to oldest **Start Age**. You can add the same study to the selection multiple times, and then make edits, in order to be able to calculate the impact of changes in these variables of the function. For example, you can perform an analysis using multiple versions of the same function with different age ranges. To edit the default **Start Age** and **End Age**, just highlight the appropriate cell and type in the desired age values. Keep in mind that these ages represent inclusive age bounds, so if you type in '*10*' and '*12*' this will include all children ages ten, eleven, and twelve years old. If you want to apply a single age year (e.g., only children who are eleven years old), then type the same year (e.g., '*11*') in both the **Start Age** and the **End Age**. Note that the accuracy of the populations calculated for these age ranges will depend on the specificity of the population data present in your selected population dataset.



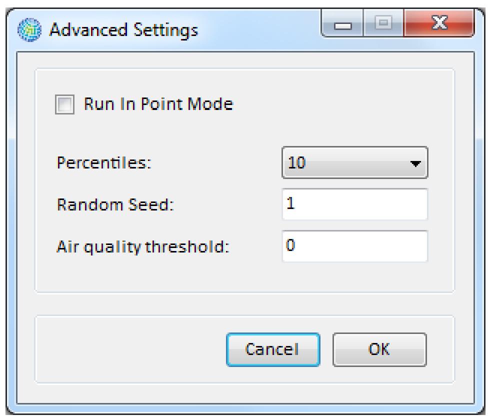
You can also edit the **Race**, **Ethnicity**, and **Gender** variables in the function, by clicking on the appropriate cell, and then scrolling through the drop-down menu. Similarly, if you have multiple datasets to choose from, you can change the source of the incidence and prevalence data that is used for each function. Finally, if you would like to change the default age range, simply select the **Start Age** and **End Age** and enter your preferred values. Use the drop-down lists in the **Incidence Dataset**, **Prevalence Dataset**, and **Variable Dataset** fields.

6.2.3 Advanced Configuration Settings

The last step in creating the health impact configuration is to specify whether BenMAP-CE will calculate incidence using Point Mode or the Monte Carlo method (percentiles) and whether you want to designate an air quality threshold. Click the **Advanced** button at the bottom of the **Health Impact Functions** window to make these selections.

The Point Mode and Monte Carlo options allow you to generate an average incidence estimate, or a range of results that mirror the variability in the inputs to the health impact functions. If you select the option for *Run in Point Mode*, BenMAP-CE uses the mean values of the inputs to the health impact functions, and generates a single "point estimate" of the change in adverse health effects.

With the Monte Carlo (default) option, you can generate a number of estimates that mirror the variability in the inputs to the health impact functions. The Monte Carlo option allows you to generate specific percentiles along the estimated incidence distribution. For example, if you specify 20 **Percentiles** (default value), then BenMAP-CE will generate incidence estimates of the 2.5th percentile, 7.5th percentile, and so on, up through the 97.5th percentile. The number of points suggested in the drop down menu for **Percentiles** varies between 10 and 100. The greater the number of chosen points, the greater the amount of time BenMAP-CE will need to process the results. The relationship between the number of points and time to process is essentially linear, so a doubling of the number of points would double the processing time.



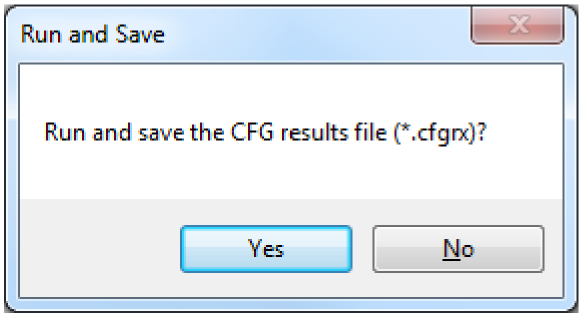
If you choose to *Run in Point Mode*, the field for **Percentile** points for Monte Carlo sampling is disabled and will be ignored (treated as zero). However, with the default Monte Carlo option, the program will still report a point estimate. As discussed in Chapter 7 on Aggregation, Pooling, and Valuation, by choosing the Point Mode, you limit your ability to pool the results. You cannot conduct fixed effect/random effects pooling, or any other procedure that depends on knowing the distribution, or the range of variability of the incidence estimates.

The **Air Quality Threshold** indicates the minimum air quality value that BenMAP-CE will use to quantify health impacts. That is, air quality metrics below the threshold will be replaced with the threshold value. With a threshold of zero, there is no impact on the estimates generated by the health impact functions. However, as the threshold increases, then it will have a progressively larger impact on the incidence estimate. The **Air Quality Threshold** option allows you to explore the impact of any given threshold on the incidence estimate. This can also be useful for scenarios where you might want to know the incidence associated with changes in air quality occurring only above a standard.

After making selections for calculating impact functions, BenMAP-CE allows you to save the configuration for future use. Click the **Save As (*.cfgx)** button and specify a file with a *.cfgx* extension.

6.3 Run Health Impact Configuration

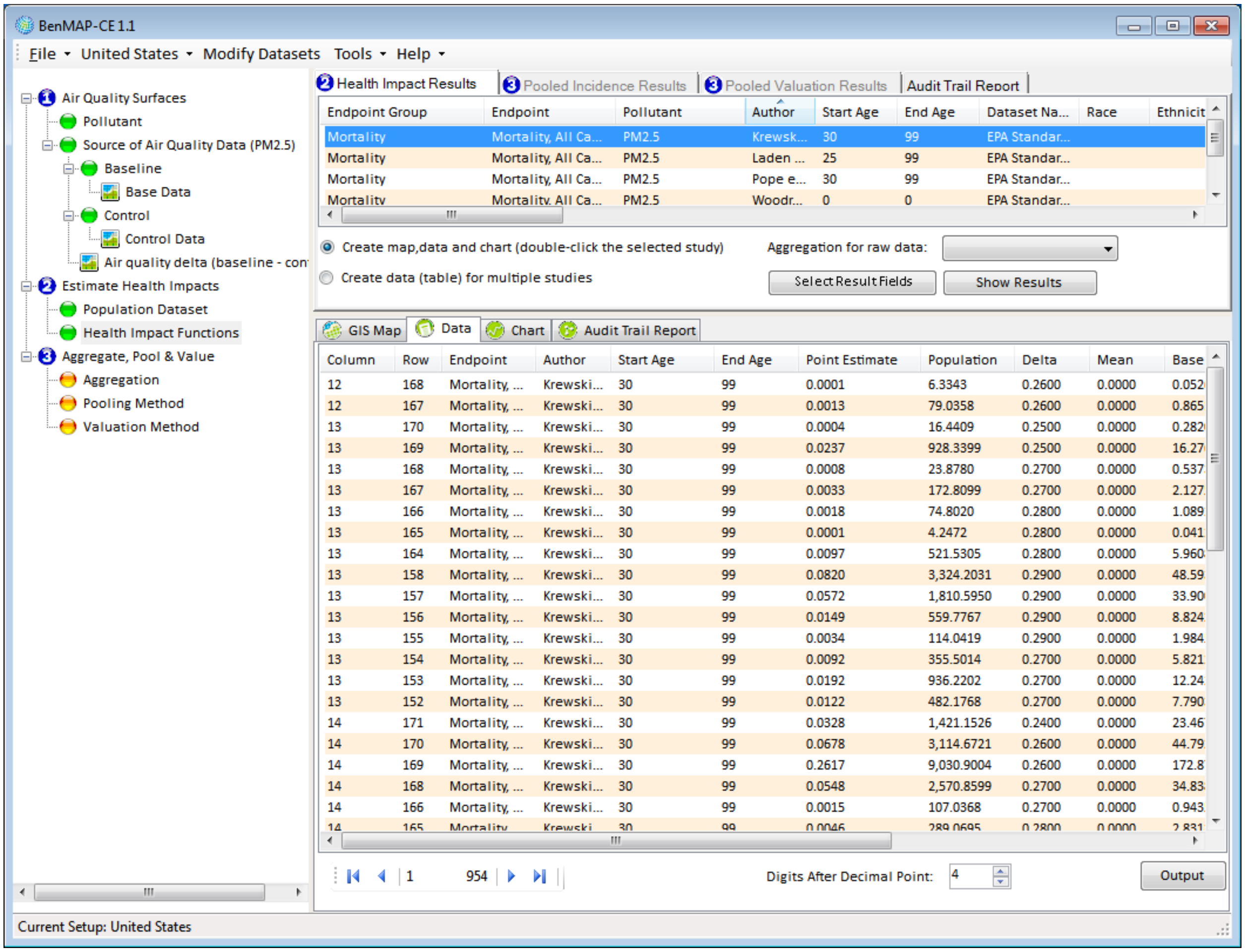
To execute the calculation of incidence for the health impact functions in the configuration, click the **Run** button on the bottom right-hand corner of the **Health Impact Functions** window. BenMAP-CE will require that you specify a file in which to save the results, with a *.cfgrx* extension.



6.4 View and Export Health Impact Results

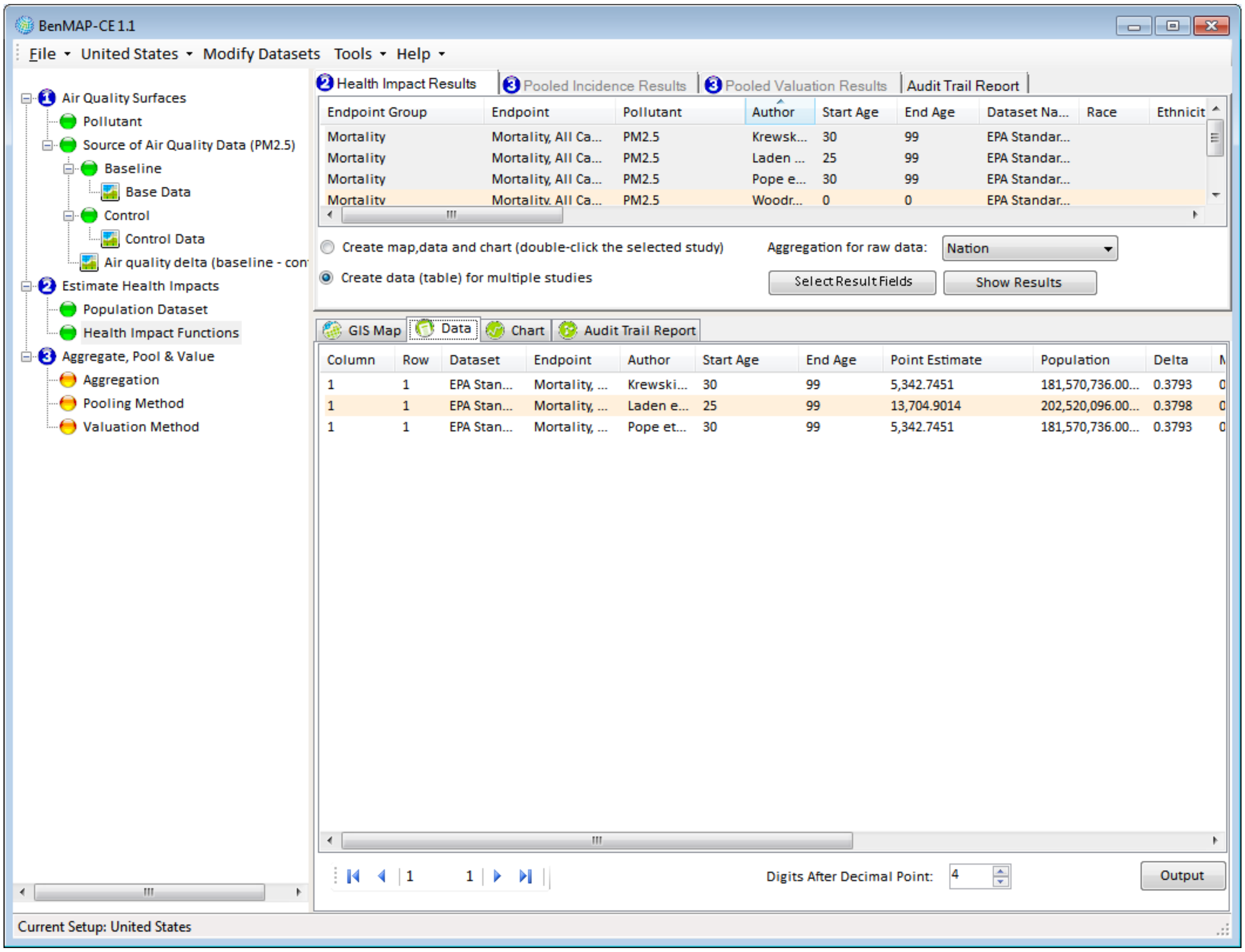
The **Health Impact Results** report gives you the opportunity to examine the incidence results of each health impact function applied at the grid-cell level, or temporarily aggregate them to, say, the state or national level. The configuration results files (*.cfgrx*) contain "raw" health impact estimates that you have not yet aggregated, pooled, or valued.

To begin, click the **Health Impact Results** tab in the upper portion of the main window. To display incidence results for a single study (i.e., health impact function), double-click on the study of interest (or select the study and click the **Show Results** button). Your results will be generated and displayed in a results table (on the **Data** tab). If you choose a single study, you will also have options to view results on the **GIS Map** tab and in a simple bar chart (view in **Chart** tab.) To change the selected study, double-click on a different study choice or select the study and click the **Show Results** button to refresh the display.



The Health Impact Results tab provides a simple tool to aggregate the raw incidence results. You may select an aggregation level from the **Aggregation for raw data** drop-down list. If you do so, the **Data** table will refresh to display the incidence results aggregated to the selected level.

If you check the option to *Create data (table) for multiple studies,* results will only be available in the **Data** tab. For example, you might want to select three different studies and view aggregated results at the national level. As you modify your choices, the display will be updated accordingly.

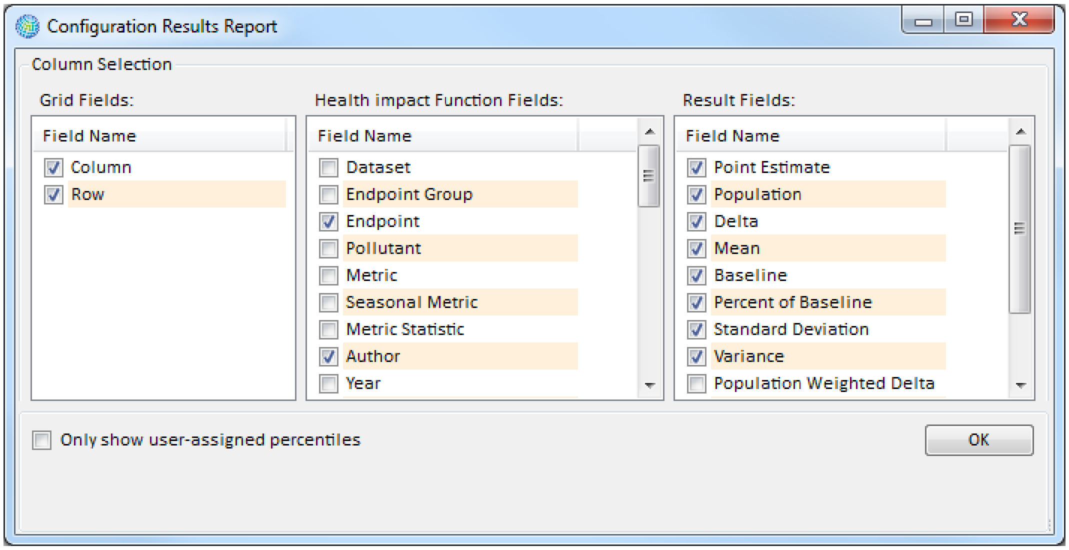


On the **Data** tab, clicking the **Select Result Fields** button opens a **Configuration Results Report** window that allows you to choose the columns that will appear in the results table.

- **Grid Fields** permit the inclusion of *Column* and *Row* fields, which can be helpful in identifying the grid-cell of a particular line in the report. For example, when results have been temporarily aggregated to the national level.

- **Health Impact Function Fields** permit the inclusion of various fields which describe or define a function (e.g., *Endpoint Group*, *Endpoint*, *Pollutant*, *Metric*, *Author*, *Year, Start Age, End Age, Gender, Race, Ethnicity, Beta, Beta Distribution*). These fields can be helpful in identifying the health impact function associated with a particular line in the report.

- **Result Fields** permit the inclusion of fields associated with results of this analysis (e.g., *Point Estimate*, *Population*, *Delta*, *Mean*, *Percentiles*).



At the bottom of the **Data** tab, there is also an option to specify the number of digits that appear after the decimal point (click the up or down arrows to edit the number beside the **Digits After Decimal Point** field, or type a number directly in the box).

Table 6-1 provides a summary of the fields that are new to this report format (as compared to previously-described input data). Essentially, these are the calculated results of the BenMAP-CE health impact analysis. See the section on Health Impact Functions data format in Chapter 4 for a description of the *Health Impact Function Fields.*

Table 6-1. Selected Variables in the Reports Based on the APVR file

Variable	Description
Column	The column of the grid cell of the result. For grid cell level results, this is the column of the grid cell. For county and state level results, this is the state FIPS code. For national results, this is always 1.
Row	The row of the grid cell of the result. For grid cell level results, this is the row of the grid cell. For U.S. county results, this is the county FIPS code. For U.S. state and national results, this is always 1.
Dataset	Specifies the dataset from which a health impact function was chosen.
Population	Population provides the number of persons used in the health impact function calculation.
Delta	The difference between the baseline and control scenarios for the metric used in the health impact function. Calculated by subtracting the metric value in the control scenario from the metric value in the baseline scenario.
Point Estimate	The point estimate for the result from the health impact function. The point estimate is generally based on the mean estimate of the "Beta" from the health impact function.

Variable	Description
Mean	Mean of the points in the Monte Carlo-generated distribution for this result. The mean is set to missing if the Point Mode option is chosen.
Baseline	Estimate based on the baseline function, which typically estimates health impacts due to all causes (not just air pollution-related causes).
Percent of Baseline	Estimates the percentage change in health impacts (e.g., hospital admissions) due to the change in air quality from the baseline to the control scenario. Calculated by dividing the Point Estimate by the Baseline.
Standard Deviation	Standard deviation calculated based on the points in the Monte Carlo-generated percentiles for this result.
Variance	Variance calculated based on the points in the Monte Carlo-generated percentiles for this result.
Percentiles	The number of percentiles depends on the number of points in Monte Carlo-generated percentiles for this result.

Once all of the options have been selected for your report, you can export the **Health Impact Results** data. First select the **Data** tab then click the **Output** button. This will bring up a window allowing you to name the file you want to save. Note that by default BenMAP-CE will export the file to the CFGR folder. Carefully name the file that you are generating so that you will recognize it in the future!

6.5 Frequently Asked Questions

How do I know which health impact functions to use? Which functions does EPA use?

One option regarding the choice of health impact functions is to work with someone, say another BenMAP-CE user, who is familiar with the epidemiological literature and develop your own set of health impact functions. Reviewing the epidemiological literature can be time consuming, though in some situations, this might be the best option. For example, it would be worthwhile to develop health impact functions to estimate the impacts of carbon monoxide exposure, for which BenMAP-CE does not have pre-installed functions.

Another option is to use the ozone and $PM_{2.5}$ configurations used by EPA. These are available on the BenMAP-CE website (http://www2.epa.gov/benmap/benmap-community-edition). These functions are derived from the epidemiology literature described in the appendices to this user manual. If desired you can edit this configuration and then save it under a different file name—it is always a good idea to keep the original version, so you can go back to it if needed!

How do I edit or add other health impact functions?

To edit or add health impact functions you need to go to **Modify Datasets** window available from the BenMAP-CE main menu. See the health impact function section in Chapter 4: Loading Data for details on how to do this.

How do I learn more about the population data in BenMAP-CE?

Appendix J describes the population data for the *United States* setup in detail.

Why did I not get results for a given geographic area that I wanted in my analysis?

Check to see if your air quality grids mapped properly.

How do I determine what the Column and Row refer to in the result table?

The **Column** and **Row** are variables designed to uniquely identify each grid cell in the grid definition. In the case of the *U.S. County* grid definition, the **Column** refers to the *state FIPS code* and the **Row** refers to the *county FIPS code*. One way to get a good sense of the **Column** and **Row** variables is to create a map (discussed in the next chapter) and then view where particular **Column** and **Row** variables occur in the map.

CHAPTER 7

Aggregating, Pooling, and Valuing

In this chapter…

- Get an overview of valuation, discounting, and pooling.
- Configure an Aggregation, Pooling, and Valuation (APV) file.
- Sort and pool incidence results.
- Learn the differences between the pooling methods.
- Assign economic values to incidence results.
- Aggregate incidence results and valuations.
- Run, save, and re-open an APV configuration.
- View and export APV results.

This section presents an introduction to valuation, discounting, and pooling. Most BenMAP-CE users find this portion of the program the most complex to understand and use. You may find yourself referring to this chapter frequently.

Once you have created a configuration results file with incidence results based on your two air quality grids (refer to Chapter 6), you can use the Aggregate, Pool, and Value feature to combine the incidence results and place an economic value on the combined results. You have two options.

- **Create a New Configuration to Aggregate, Pool, and Value results.** You can create a new type of configuration, termed an Aggregation, Pooling, and Valuation (APV) Configuration. This allows you to (1) specify the geographic level at which you want to report your results, (2) specify how you might want to combine or "pool" the incidence results, and (3) specify how to assign an economic value to the health incidence results. These selections can be saved in an APV Configuration file (*.apvx*) and used to calculate results, which are stored in an APV Results file (*.apvrx*).

- **Open Existing Configuration for Aggregation, Pooling, and Valuation.** You can load an existing APV Configuration file, edit the configuration, save it with the same or a different name, and then proceed to calculating the results.

7.1 Introduction to Valuation, Discounting, and Pooling

Valuation generally refers to placing a monetary value on estimated health incidence. In the example below, we discuss U.S. dollar values and provide a brief introduction to discounting, which has to do with placing less weight on things occurring in the future than on things occurring today. Finally, we discuss pooling, which has to do with combining comparable results.

7.1.1 Overview of Economic Valuation

Improvements in ambient air quality generally lower the risk of developing an adverse health effect by a fairly small amount across a large population. A lower risk for everyone means that fewer cases of the adverse health effect are expected, although we cannot predict which people would be spared. Therefore, the health benefits conferred on individuals by a reduction in pollution are actually reductions in the risk of having to endure certain health problems. Monetizing the benefits of a reduction in air pollution involves estimating society's willingness to pay (WTP) for these reductions in risk, or the observed Cost of Illness (COI) for an effect, and is typically referred to as valuation. BenMAP-CE uses valuation functions to estimate the monetized benefits of reducing air pollution.

These benefits (reductions in risk) may vary across the population (and could be zero for some individuals). Likewise, the WTP for a given benefit is likely to vary from one individual to another. In theory, the total social value associated with the decrease in risk of a given health problem resulting from a given reduction in pollution concentrations is generally taken to be the sum of everyone's WTP for the benefits they receive.

7.1.1.1 Monetizing Benefits

Epidemiological studies allow us to estimate the number of cases of an adverse health effect that would be avoided by a given reduction in pollutant concentrations. If we have an estimate of the average individual's WTP for the risk reduction conferred upon him, we can derive from that an estimate of the value of a statistical case avoided. Suppose, for example, that a given reduction in pollutant concentrations results in a decrease in mortality risk of 1/10,000. Then for every 10,000 individuals, one individual would be expected to die in the absence of the reduction in pollutant concentrations (who would not be expected to die in the presence of the reduction in pollutant concentrations). If the average individual's WTP for this 1/10,000 decrease in mortality risk is $100, then the value of a statistical life is 10,000 × $100, or $1 million. In general, the ex-ante WTP for a risk reduction of x can be converted into an ex-post value of a statistical case avoided by dividing the average individual's WTP for the risk reduction of x by x (e.g. $100/0.0001 = $1,000,000). The same type of calculation can produce values for statistical incidences of other health endpoints.

Sometimes those economic values come from contingent valuation studies, in which study participants are queried about their WTP to avoid a specific adverse health effect. When estimates of WTP are not available, it can be approximated by other measures, most notably COI measures.

An individual's WTP to avoid an adverse health effect will include, at a minimum, the amount of money he or she would have to pay for medical expenses associated with the illness. Because medical expenditures are to a significant extent shared by society, via medical insurance, Medicare, etc., the medical expenditures actually incurred by the individual are likely to be less than the total medical cost to society. The total value to society of an individual's avoidance of an adverse health effect, then, might be thought of as having two components: (1) the COI to society, including the total value of the medical resources used (some portion of which will be paid by the individual), plus the value of the lost productivity, as well as (2) the WTP of the individual, as well as that of others, to avoid the pain and suffering resulting from the illness.

The COI approach attempts to estimate the total value of the medical resources used up as well as the value of the individual's time lost as a result of the illness. Because this method does not include the value of avoiding the pain and suffering resulting from the illness (a potentially large component), it is generally believed to underestimate the total economic value of avoiding the illness, perhaps substantially.

The contingent valuation method (and conjoint analysis) attempts to elicit from people what they would be willing to pay (WTP) to avoid the illness. Because of the distortion in the market for medical goods and services, whereby individuals generally do not pay the full value of the medical care, this method too is likely to understate the total economic value of avoiding the illness.

Although the COI and WTP are the two most common methods, other methods have been used in certain circumstances. The method the benefit analyst chooses to value a particular health endpoint will depend in part on what data are available. The unit values currently available for use in BenMAP-CE are data or estimates that have been collected or generated by researchers and can be readily obtained in publicly available databases or in the open literature. When reviewing the economic literature to determine the appropriate valuation functions to use, it is important to have an economist assist.

7.1.1.2 Valuing Reductions in Premature Mortality

The economics literature discussing the value of changes in fatality risks is extensive and provides a basis for monetizing benefits when the number of deaths avoided as a result of an air quality improvement can be calculated, but the literature on certain issues regarding the appropriate method for valuing reductions in premature mortality risk is still developing. Issues such as the appropriate discount rate and whether there are factors, such as age or the quality of life, that should be taken into consideration when estimating the value of avoided premature mortality are still under discussion. BenMAP-CE currently offers a variety of options reflecting the uncertainty surrounding the unit value for premature mortality. See the Appendix I for more detail on the valuation functions available in BenMAP-CE.

Monetary estimates of changes in premature mortality risk are often expressed in terms of the Value of a Statistical Life (VSL). This term is easily misinterpreted and should be carefully described when used in benefit analysis. In particular, VSL refers to the WTP for reductions in the risk of premature death aggregated over the population experiencing the risk reduction; that is, VSL refers to the sum of many small reductions in fatality risks. The basic assumption underlying the VSL approach is that equal increments in fatality risks are valued equally. For similar reasons, the VSL approach is only appropriate for marginal changes in the risk of death and should not be used to value more significant changes. Because changes in individual fatality risks resulting from environmental regulation are typically very small, the VSL approach is usually acceptable for these types of benefit analyses.

The U.S. EPA National Center for Environmental Economics provides answers to frequently asked questions regarding the economic value of mortality risk on its website: http://yosemite.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html. You may wish to consult this site as you have questions regarding how U.S. EPA derives VSL and applies it in an environmental benefits analysis.

7.1.2 Overview of Discounting

What is discounting?

In general, people prefer current consumption to future consumption. In other words, a $1 today is worth more today than a $1 tomorrow is worth today, and that dollar continues to decrease in value as you go further out into the future. (This concept is also referred to as the social rate of time preference or the time value of money. This is a different concept than inflation, which is a general increase in the price level of goods and services.) Discounting is the process of converting that future dollar into a value that can be compared to the value of a dollar today. The discount rate expresses this process in quantitative terms. The higher the discount rate, the faster value decreases over time. For example, $1 twenty years from now is worth $0.55 today at a 3% annual discount rate, but worth only $0.26 at a 7% annual discount rate.

A basic discounting function is as follows:

Present Value = Future Value / $(1+r)^t$

where r is the discount rate and t is the time period (usually years).

Example: $1 twenty years from now at a 3% annual discount rate is worth $0.55 today

Present Value = \$1.00 / $(1 + 0.03)^{20}$ = 1 / $(1.03)^{20}$ = 1 / 1.806111 = 0.553676 = \$0.55

Why do we discount benefits?

The benefits of reductions in air pollution may need to be discounted for three key reasons:

1. Today's society values benefits that occur today more highly than benefits that will occur in the future. Therefore, we must discount in order to compare those future benefits with current benefits.

2. For a cost-benefit analysis, benefits estimates in a future year need to be comparable to the cost estimates for that same year (which are also discounted).

3. Discounting can be used to compare the future *streams* of benefits and costs. The core BenMAP-CE program estimates changes in adverse health effects based on changes in air quality for one specified analysis year, even though certain health benefits may occur after the analysis year.[1] Discounting can be used to compare the future benefits with benefits occurring during the analysis year.

[1] The PopSim tool estimates the change in population mortality risk over a multi-year period, but it is not yet possible to estimate the economic value of these impacts in BenMAP-CE.

Under which scenarios would I need to discount benefits?

Health benefits may occur three different ways after the analysis year specified in BenMAP-CE.

1. Certain health endpoints accrue medical expenses or lost earnings for multiple years. The future medical expenses would need to be discounted to compare with expenses occurring in the analysis year.

2. Pollution exposure and the resulting health effects do not occur within the same year (a.k.a. a cession lag). The monetized benefits of future health effects would need to be discounted to compare with the benefits of health effects that occur during the analysis year.

3. In some analyses, you may want to estimate a stream of benefits occurring over multiple analysis years instead of just one analysis year. In this scenario, you would need to discount the future benefits occurring in each year analyzed back to the present year in order to present the cumulative total estimate of benefits (i.e., the net present value of a stream of benefits).

When would we not discount benefits?

In many instances, it is not necessary to discount the benefits estimates generated by BenMAP-CE. If the health effect and the monetized value of all the medical expenses, lost earnings, and suffering occur entirely in the analysis year, then you may not need to discount your benefits. For example, school loss days occur within the analysis year, and all monetized expenses occur within the analysis year. It is important that you understand the assumptions within the health and valuation functions before you decide whether you need to discount. (If your analysis year for your benefits estimates does not match the analysis year for your costs estimates, you may need to discount in order to compare your benefits with your costs even if you meet the criteria listed above.)

Which discount rate should I choose?

Selecting a discount rate is challenging and is one of the most contentious methodological issues encountered in economic analyses of environmental policies. Because environmental regulations frequently have differing streams of costs and benefits over time, the selected discount rate may determine whether the benefits of a regulatory action exceed the costs. In addition, selecting a higher discount rate may result in a smaller benefits estimate because the future benefits are worth much less than they would be if a lower discount rate was selected. For benefits that occur well into the future, the issue of intergenerational equity further complicates the selection of the discount rate. (In the context of environmental policy, intergenerational equity refers to the fairness of the distribution of the costs and benefits of a long-lived policy when those costs and benefits are borne by different generations. Most criteria pollutants are not considered to have intergenerational equity issues, but the issue frequently arises in analyses of climate and mercury.)

There are various economic arguments in support of and in opposition to various discount rates. To comply with OMB and EPA's recommendations, EPA currently uses discount rates of 3% and 7% for benefit analyses. For more details, see EPA [1999; 2000] listed in Chapter 1, Section 1.7 (Sources for More Information).

Which health endpoints accrue medical expenses or lost earnings for multiple years, and how do I discount them?

BenMAP-CE includes health and valuation functions for several chronic health effects, including $PM_{2.5}$-related chronic bronchitis and non-fatal acute myocardial infarctions (AMIs, or heart attacks).

- Chronic bronchitis is assumed to last from the initial onset of the illness throughout the rest of the individual's life. BenMAP-CE currently includes one WTP function as well as two COI functions representing the two discount rates for chronic bronchitis.
- Technically, AMIs are discrete, acute events, not chronic conditions. However, heart attacks cause chronic follow-up health effects that accrue medical expenses over time, similar to chronic conditions. You can discount the economic value of these chronic effects through the valuation function in BenMAP-CE. AMIs are assumed to accrue costs over five years. Although WTP functions for AMIs are not available, BenMAP-CE currently includes several COI functions that incorporate the direct medical costs and the opportunity cost (lost earnings) for specific age groups at two discount rates.

See Appendix I for details on the discounting assumptions within the valuation functions.

Should I discount the health incidence as well as the valuation?

You should not discount the health incidence for any of the scenarios mentioned above. Changes in the lag assumptions do not change the total number of estimated deaths, for example, but rather the timing of those deaths. If you discounted the health incidence along with valuation, you would essentially be discounting twice.

Which health endpoints do not occur in the same year as exposure?

In many cases, the health effect from exposure to air pollution occurs shortly after exposure, but there can be a significant lag between exposure and the health effect. The cession lag can be a matter of hours or days, but some health effects may lag exposure by much longer. If exposure and the health effect do not occur within the same year, it is necessary to discount those benefits back to the analysis year. The only health function currently in BenMAP-CE that falls into this category is $PM_{2.5}$-related premature mortality. Discounting PM-related premature mortality is controversial because the lag structure is unknown, but scientific literature on similar adverse health effects and new intervention studies suggest that premature mortality probably would not occur in the same year as the exposure. (See: Roosli M, Kunzli N, Braun-Fahrlander C, Egger M. 2005. "Years of life lost attributable to air pollution in Switzerland: dynamic exposure-response model." International Journal of Epidemiology 34[5]:1029-35.)

EPA's Science Advisory Board recommends future research to support the development of defensible lag structures and provided a lag structure that could be assumed until additional research has been completed. See Chapter 5 of the PM Regulatory Impact Analysis for more detail on assumed lag structures for PM2.5-related premature mortality (http://www.epa.gov/ttn/ecas/regdata/RIAs/finalria.pdf). Some example lag structures from the PM RIA are shown in Figures 7-1 and 7-2 below. Currently, BenMAP-CE does not have the capability to do this type of discounting, so you must discount outside of BenMAP-CE.

Note: Discounting is not necessary for ozone-related premature mortality because it occurs within the analysis year.

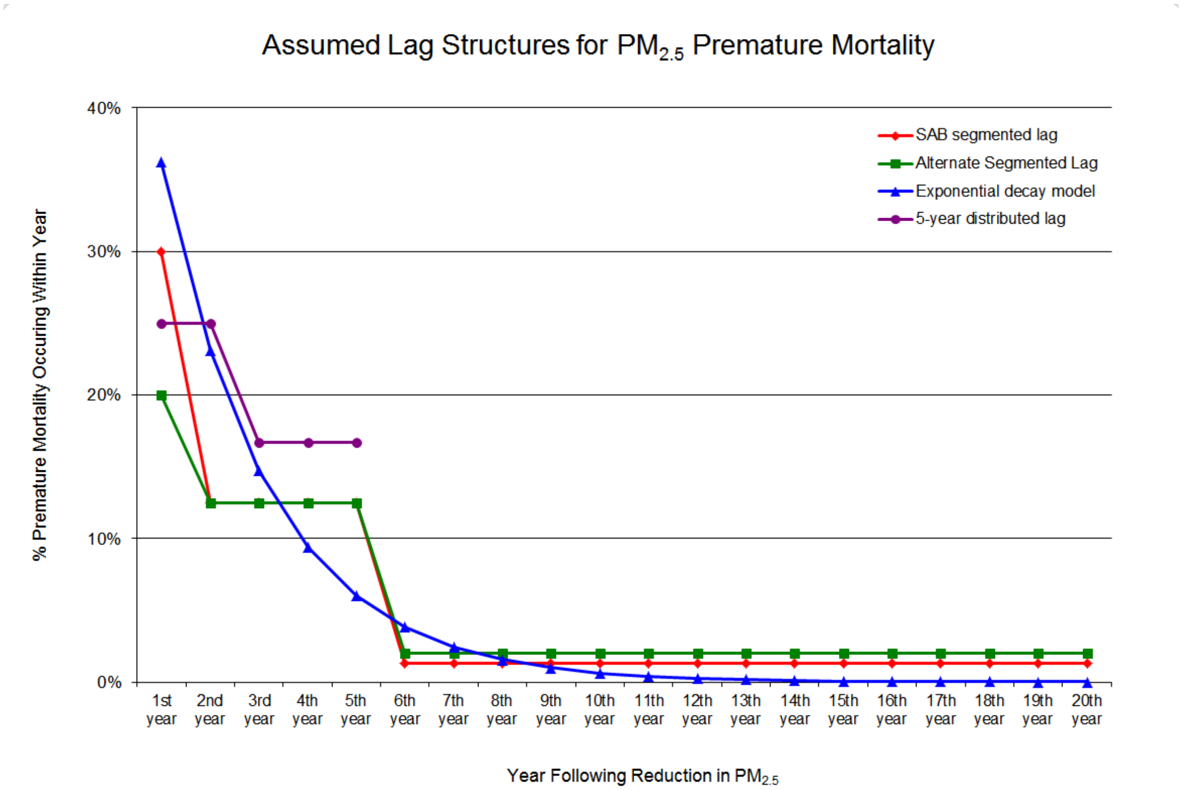


Figure 7-1. Graphical representation of assumed lag structures analyzed in EPA's PM RIA as sensitivity analyses

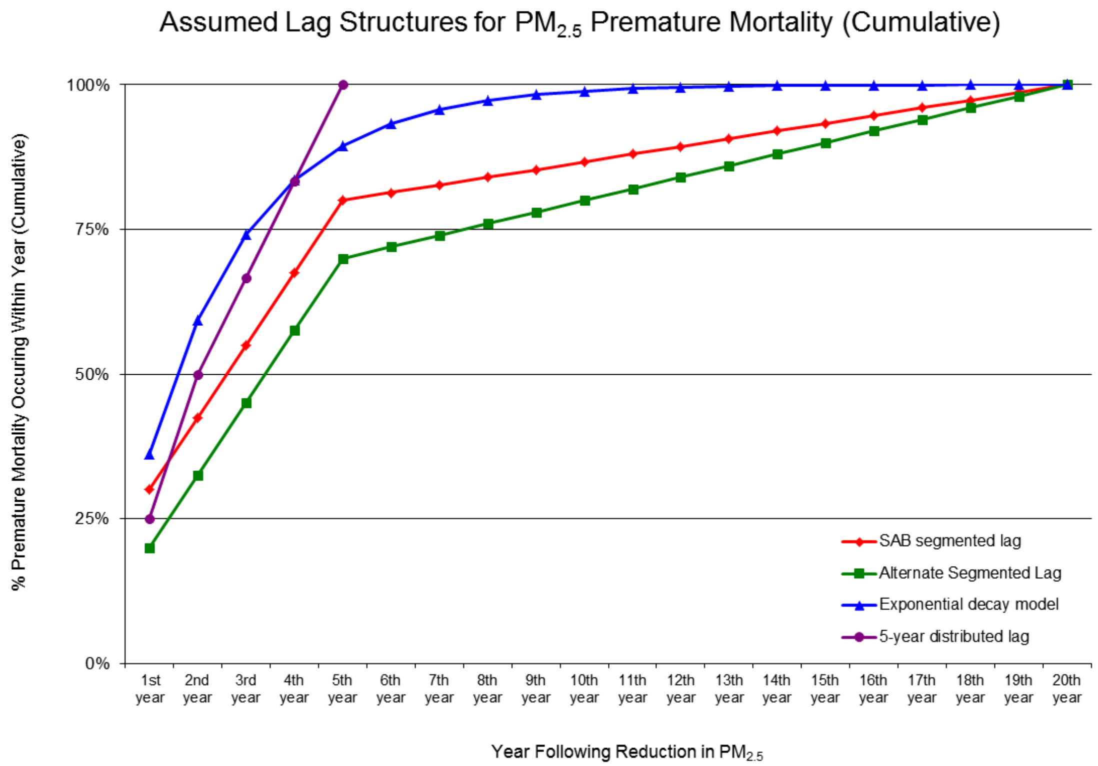


Figure 7-2. Graphical representation of cumulative assumed lag structures analyzed in EPA's PM RIA as sensitivity analyses

7.1.3 Overview of Pooling

For many of the health endpoints (e.g., respiratory hospital admissions), BenMAP-CE contains many different functions from different studies that you could choose to include in your configuration. Combining data from several comparable studies in order to analyze them together is often referred to as meta-analysis. For a number of reasons, it is often impractical or impossible to combine the original data sets. Combining the results of studies provides a second-best way to synthesize information. This is referred to as pooling.

BenMAP-CE allows users to pool the estimated incidence changes predicted by several studies for the same pollutant-health endpoint group combination (e.g., $PM_{2.5}$-related cardiovascular hospital admissions). It also allows the pooling of the corresponding study-specific estimates of monetary benefits.

Why would you want to pool results?

There are two good reasons to pool across study results, one practical and one methodological. Pooling allows you to

- Combine or aggregate multiple study estimates into a single estimate. This combined estimate is easier to report.
- Certain types of pooling—including random effects techniques—account for heterogeneity in the risk estimates reported in the epidemiological literature used to construct the health impact functions you used to calculate incidence.

However, as we discuss below, pooling may not be such a good option if

- You don't know a great deal about the studies used to quantify health impacts; you'll need to know a lot about epidemiological studies used to construct the health impact functions in order to pool properly.
- You think it is important to convey the variability across incidence estimates for a given health endpoint.

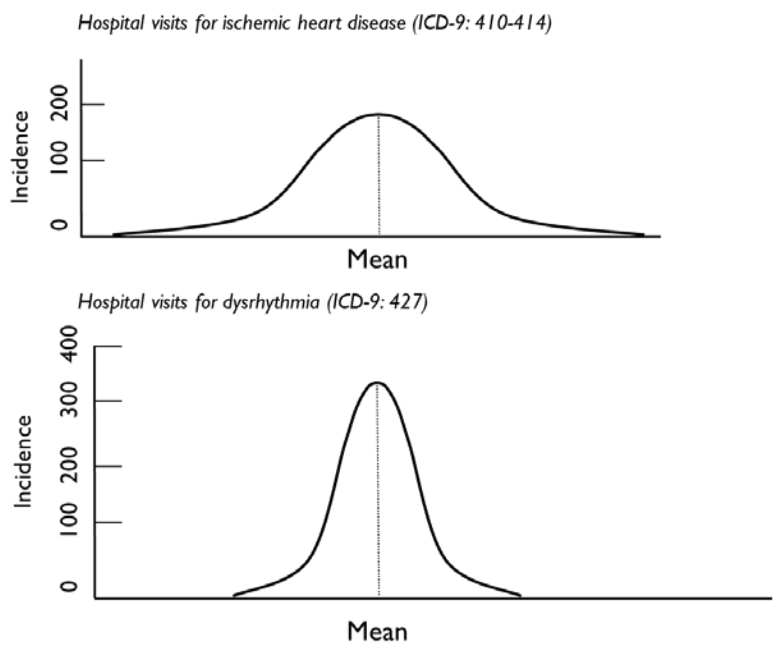
BenMAP-CE allows you to pool in five different ways:

- Addition
- Subtraction
- User-assigned weights
- Random Effects
- Fixed Effect.

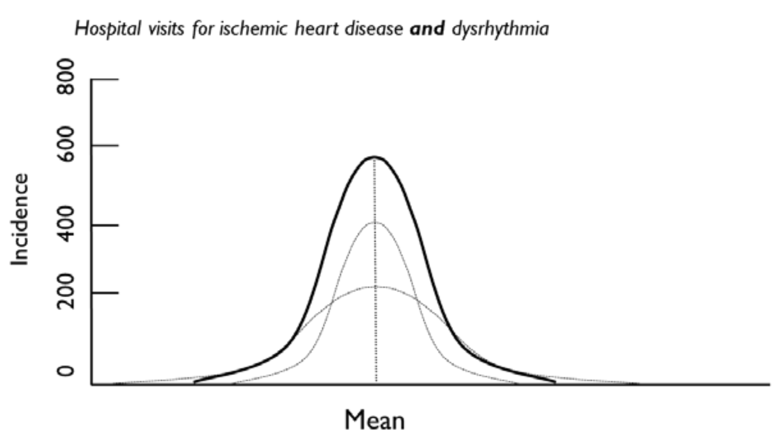
The examples that follow demonstrate each of these methods (Fixed and Random Effects are combined in one example.) In each of the examples below, the distribution of estimated health impacts are represented by a normally distributed probability density function (PDF) shaped as a bell curve. In each PDF, the mean health impact estimate is represented by a dashed line. While we illustrate these examples using a normally distributed PDF for ease of presentation, BenMAP-CE can accommodate several other types of distributions (e.g. Weibull, Triangular).

Example 1: Pooling by Addition

You might want to use the *Pooling by Addition* option if you would like to aggregate two outcomes that are non-overlapping. In the example below, we have estimated ischemic heart disease hospital admissions and dysrhythmia hospital admissions. You'll see that each endpoint is associated with unique, and non-overlapping, International Classification of Disease 9th edition (ICD-9) code (Slee 1978). Therefore, it's ok to add the two estimates, because doing so would not double-count impacts.



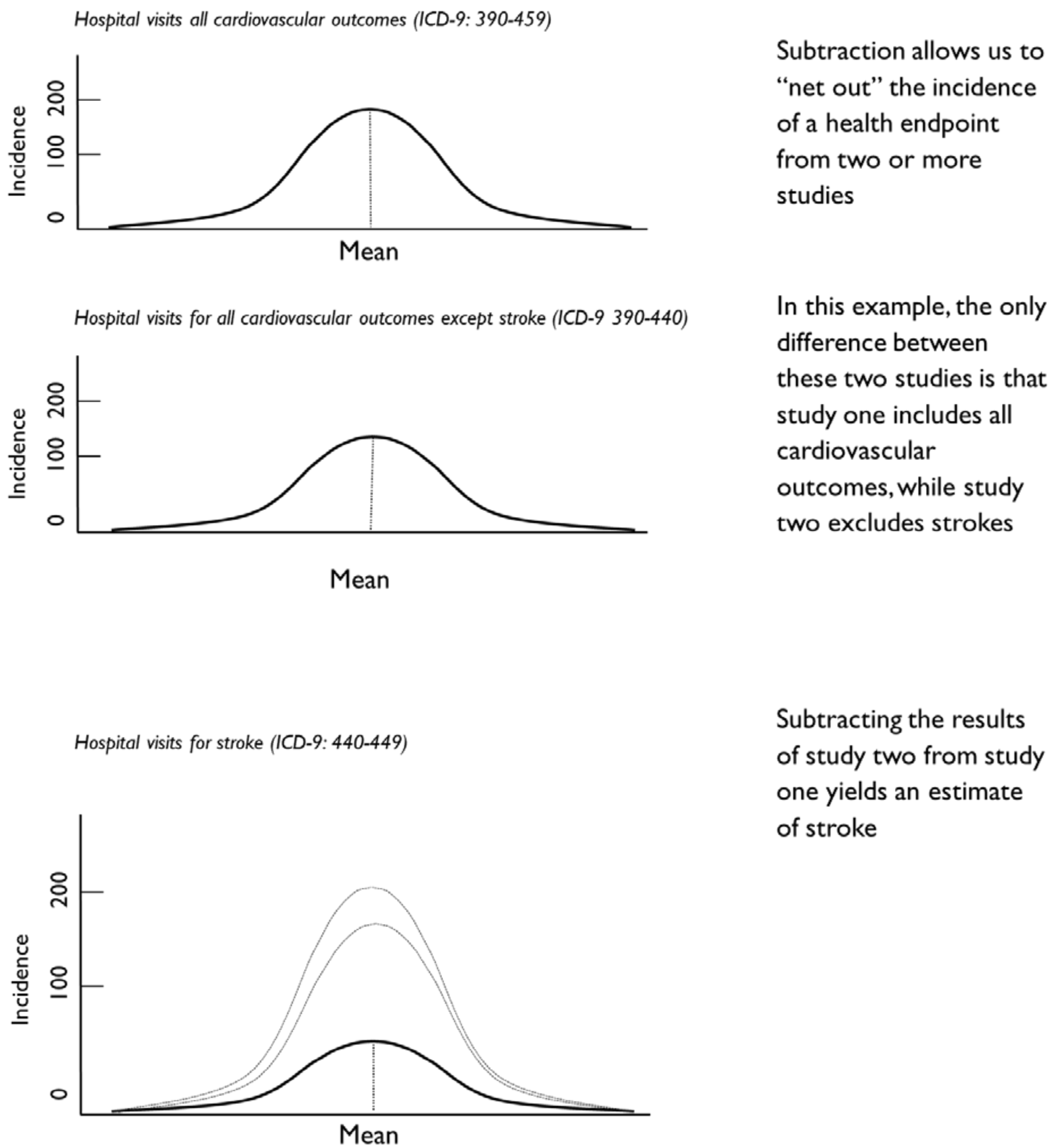
Addition allows us to combine non-overlapping estimates of a common health endpoint



The sum of ischemic heart disease and dysrhythmia is provides a better overall characterization of the effects of air pollution on cardiovascular outcomes than either endpoint alone.

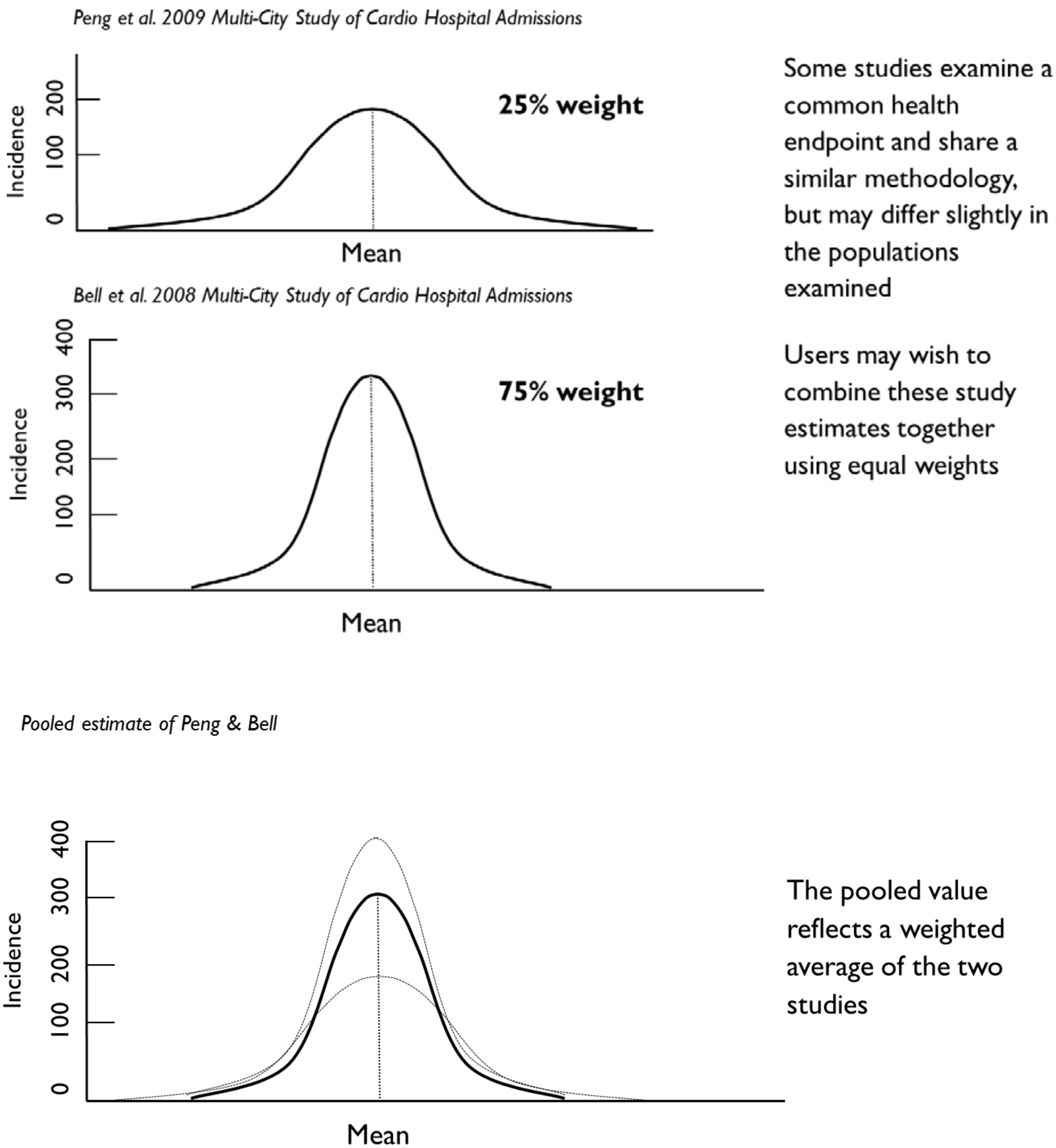
Example 2: Pooling by Subtraction

In this example, suppose that you have estimated the incidence of total cardiovascular hospital admissions using one health impact function. Suppose also that you estimated the incidence of total cardiovascular hospital admissions, *less stroke*. In this instance, you could subtract the second incidence estimate from the first incidence estimate to yield the number of stroke hospital admissions.



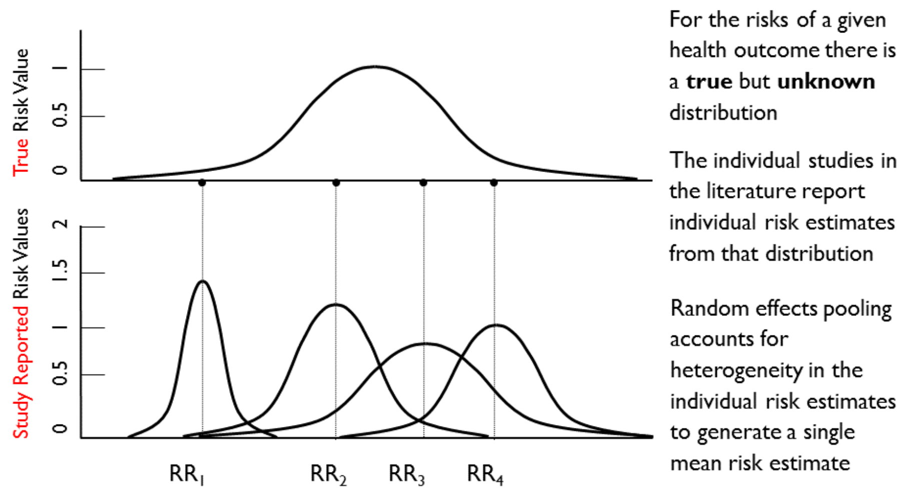
Example 3: Pooling with User-Assigned Weights

In this case, you might have estimated the change in incidence using two different health impact functions for the same health endpoint and would like to combine them using weights that you specify.

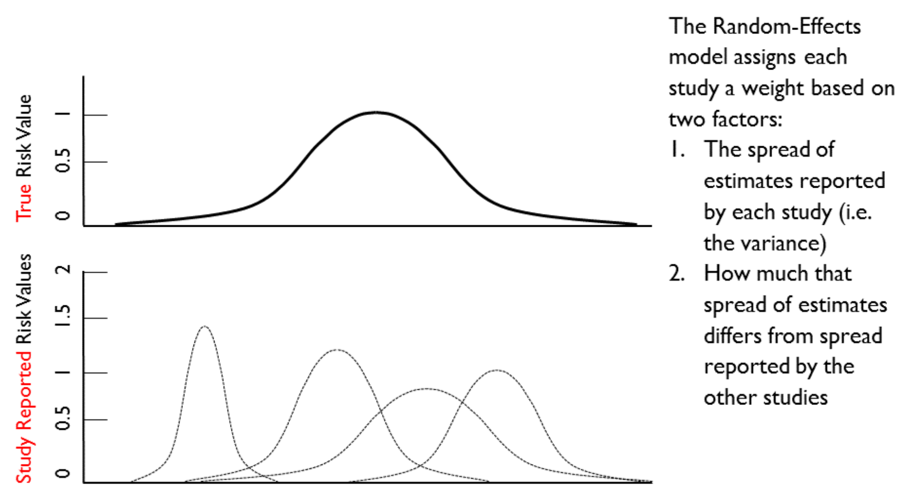


Example 4: Pooling Using the Fixed Effect and Random Effects

The Fixed Effect and Random Effects pooling techniques are among the most complicated and are best applied only when you understand clearly the assumptions inherent in the method and its suitability to the incidence estimates. The example below describes the procedure for performing this technique.



Adapted from: Mosteller and Colditz (1996); Charles Poole EPID 731



Adapted from: Mosteller and Colditz (1996); Charles Poole EPID 731

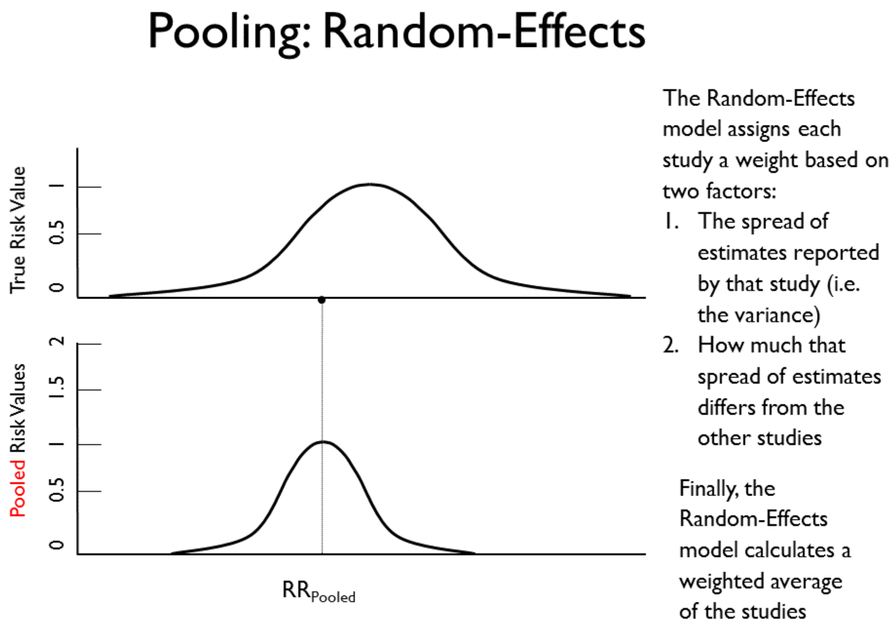


Table 7-1 summarizes the different types of pooling approaches, and Appendix K provides a detailed discussion of the approaches. Note that some pooling methods are only available in Monte Carlo mode. This is because these pooling methods attempt to combine distributions of results into new distributions, and no distributional information is available in Point Mode. The Pooling Method column will thus have different values in its drop-down list depending on the mode used to generate the incidence results being pooled.

Table 7-1. Pooling Approaches for Incidence and Valuation Results

Pooling Approach	Description of Pooling Approach	Availability	
		Point Mode	Monte Carlo
None	No pooling performed.	Yes	Yes
Sum (Dependent)	Results are summed assuming they are perfectly correlated. In Point Mode, this is just a simple sum. In Monte Carlo mode, BenMAP-CE chooses the first point from each result in the pooling and does a simple sum to generate the first point in the pooled result, and so on for all of the points in the distribution of results.	Yes	Yes
Sum (Independent)	Results are summed assuming that they are independent. A Monte Carlo simulation is used. At each iteration, a random point is chosen from the distribution for each result, and the sum of these values is put in a holding container. After some number of iterations, the holding container is sorted low to high and binned down to the appropriate number of percentile points.	No	Yes

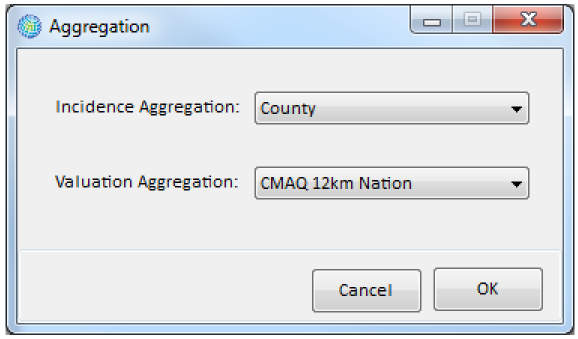
Pooling Approach	Description of Pooling Approach	Availability	
		Point Mode	**Monte Carlo**
Subtraction (Dependent)	Results are subtracted assuming they are perfectly correlated. All subsequent results are subtracted from the first result (the highest result in the display - to reorder results, simply click and hold a result and then drag it to its new position). In Point Mode, this is a simple subtraction. In Monte Carlo mode, BenMAP-CE chooses the first point from each result in the pooling and does a simple subtraction to generate the first point in the pooled result, and so on for all of the points in the distribution of results.	Yes	Yes
Subtraction (Independent)	Results are subtracted assuming that they are independent. A Monte Carlo simulation is used. At each iteration, a random point is chosen from the distribution for the first result, and then random points are chosen from the distribution for each subsequent result and subtracted from the first. The result is put into a holding container. After some number of iterations, the holding container is sorted low to high and binned down to the appropriate number of percentile points.	No	Yes
User defined Weights	Weights are specified by the user. In Point Mode, the new result is generated by a simple weighted sum of the input results. In Monte Carlo mode, the results are combined using the user specified weights with the '*Round Weights to Two Digits*' Advanced Pooling Method. Note that the weights you enter need not add up to one - BenMAP-CE will normalize them internally. Also note that BenMAP-CE initializes all the weights to 1/n, where n is the number of results being pooled.	Yes	Yes

7.2 Create Aggregation, Pooling, and Valuation (APV) Configuration

Once you have run a configuration result file (see Chapter 6), you can begin creating your APV configuration. You will start with selecting the aggregation levels for incidence and valuation results, then move on to pooling and valuation. These processes are described in detail below.

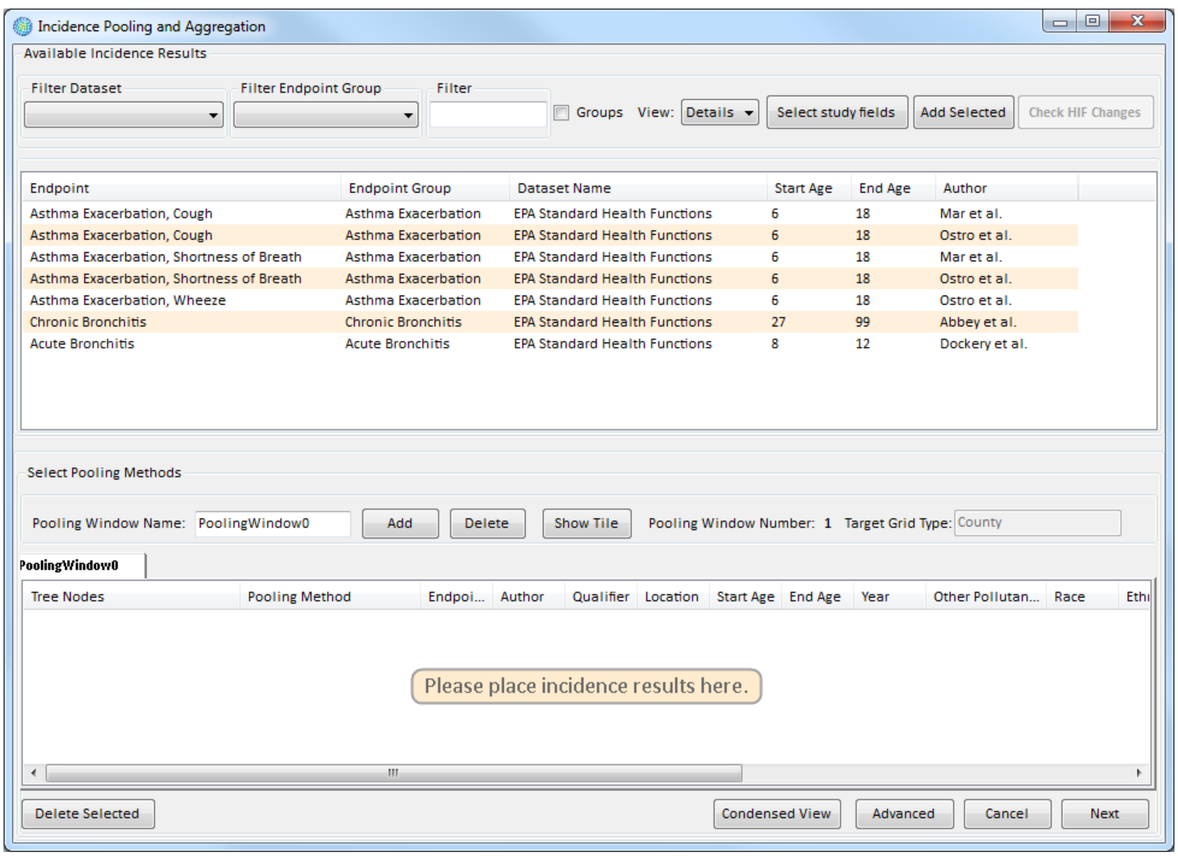
7.2.1 Selecting Aggregation Levels

Double-clicking **Aggregation** from the BenMAP-CE tree menu item opens the window which lets you choose the level of aggregation for the incidence and valuation results.



7.2.2 Pooling Incidence Results

To begin pooling incidence results, double-click **Pooling Method** from the BenMAP-CE tree menu. In the top half of the **Incidence Pooling and Aggregation** window, you will find a list of **Available Incidence Results**. The results are represented by the health impact functions from which they were created.

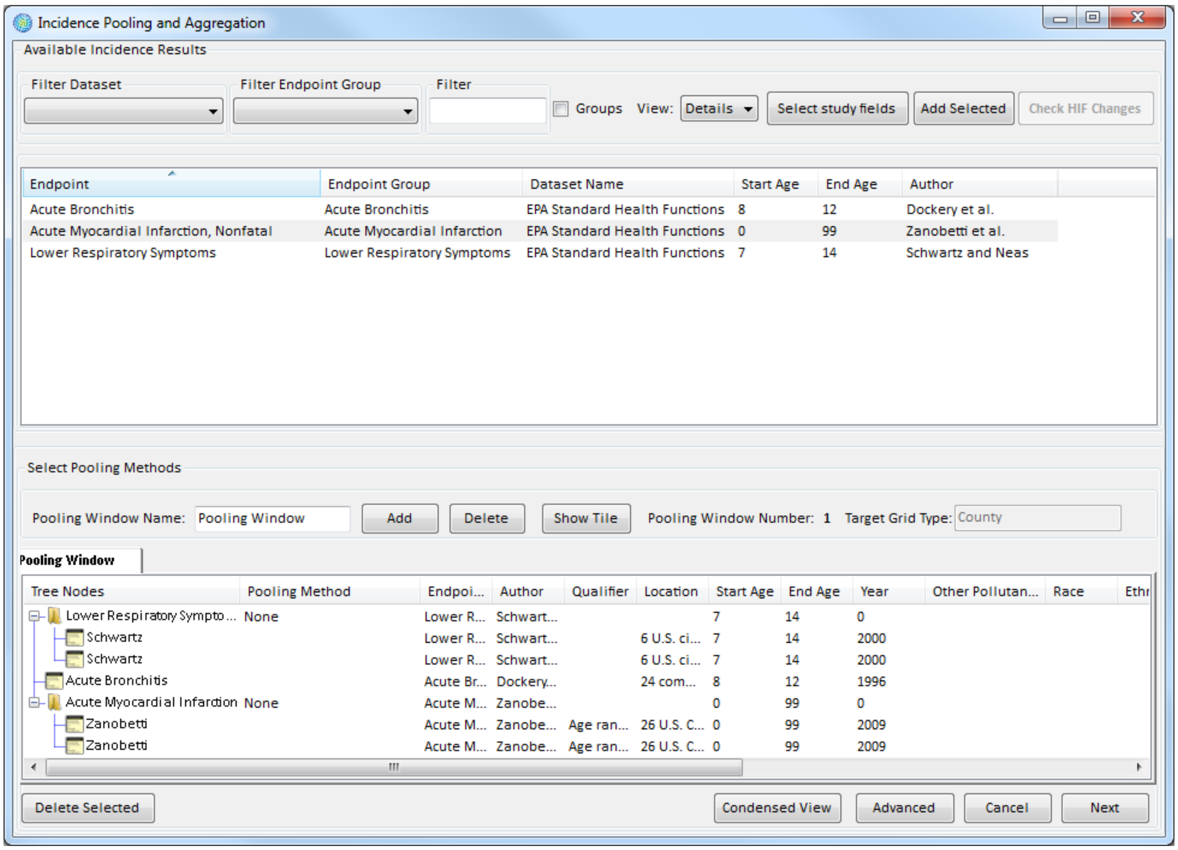


There are several steps to pooling your incidence results:

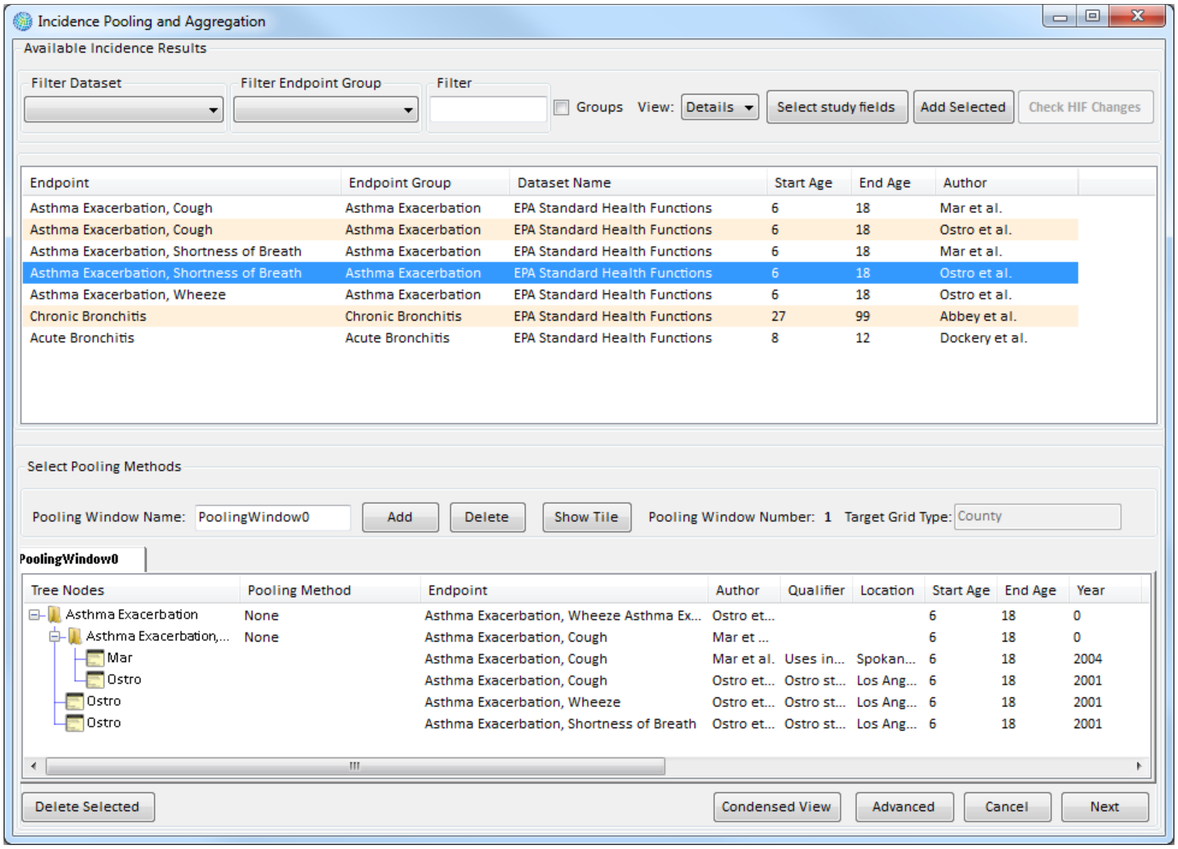
Step 1. Add incidence results to the pooling window

Using the available incidence results, you can drag individual incidence results, or groups of results down to the pooling window. You do not have to drag all of your incidence results over into the pooling window, but note that only those results showing in the pooling window will be included in the pooled incidence or valuation results. As with health impact functions, in Chapter 6, there is a filter method above the **Available Incidences Results** for your convenience.

Incidence results are displayed in the pooling window in a tree structure determined by (1) the order of the columns, and (2) the values of the identifying variables of the **Health Impact Functions** from which the incidence results were generated (**Endpoint Group**, **Endpoint**, etc.).



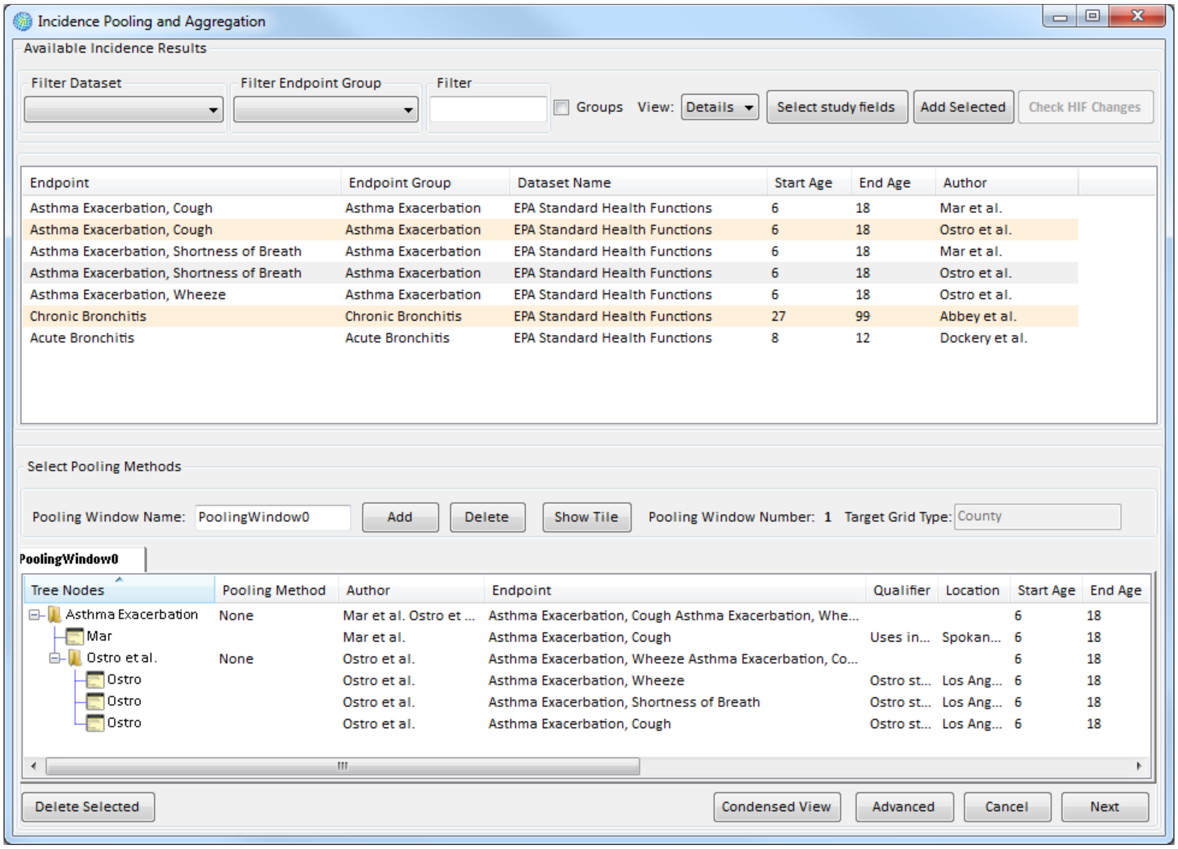
Each line in the pooling window represents a node in the tree structure, with each node representing either an individual incidence result or a collection of incidence results which have common values for their leftmost identifying variables. The tree structure is generated by comparing the leftmost values of the incidence result's identifying variables. High level nodes in the tree are formed when results have common values for identifying variables, and branches in the tree occur when the values differ.



In the above example, four incidence results have been dragged into the pooling window. Each of the four health impact functions has **Endpoint Group** '*Asthma Exacerbation*'. Thus, the top line, or root of the tree structure, represents all four incidence results. A branch then occurs in the tree structure, because two studies have **Endpoint** '*Asthma Exacerbation, Cough*', while two others have **Endpoint** '*Asthma Exacerbation, Wheeze*' and '*Endpoint Asthma Exacerbation, Shortness of Breath*'. A further branch occurs within **Endpoint** '*Asthma Exacerbation, Cough*' when **Author** of the two incidence results differs. Once a node has only a single incidence result, no further branching can occur.

Step 2. Sort results

After dragging incidence results into the pooling window, you can rearrange the order of the columns (variables), and thus change the tree structure. To do this, click on a column and hold the button down as you drag it to its new location. Note that the **Pooling Method** is always the first column after the tree nodes. All the other columns can be moved. To see how the order of the columns in the pooling window affects the tree structure, consider the following example:



This example uses exactly the same incidence results as the previous example, but with the **Author** column (variable) immediately after the **Pooling Method** column.

Step 3. Select pooling methods

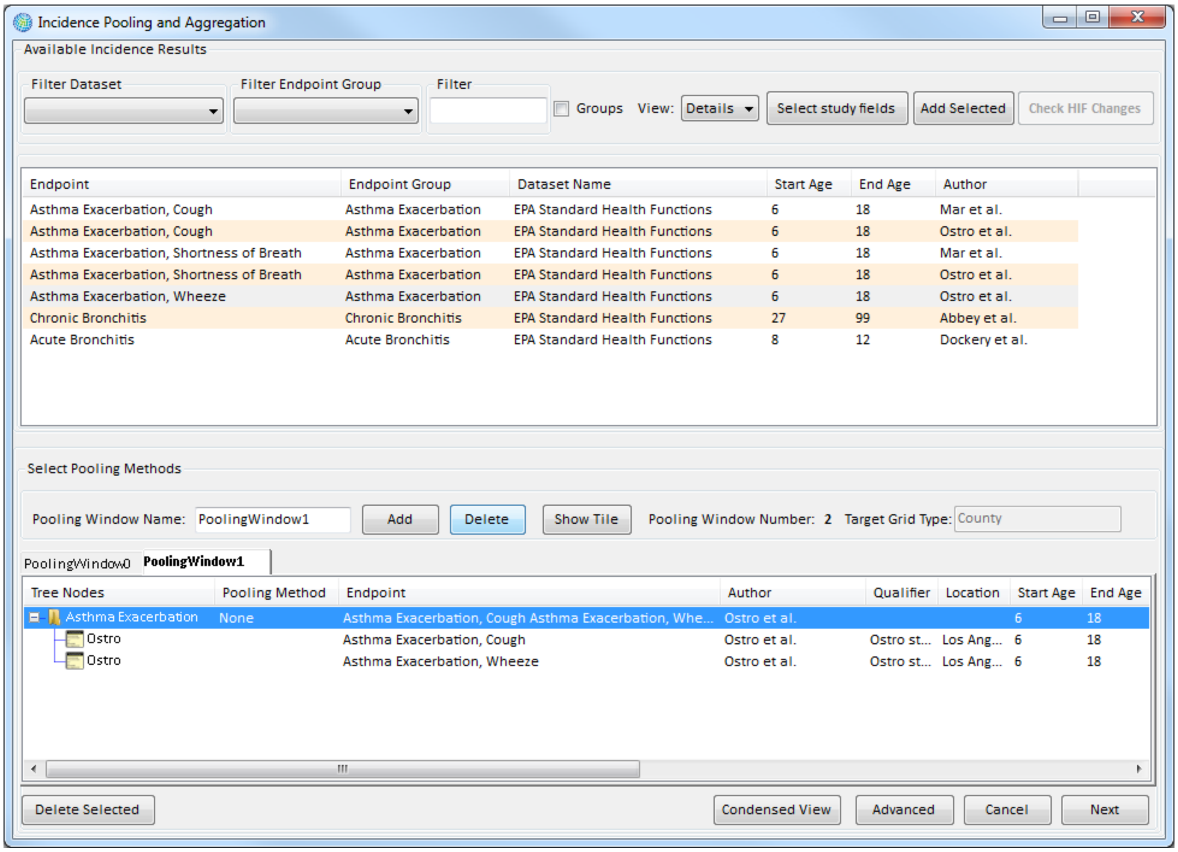
Once the tree structure is set up in the pooling window, you are ready to select your pooling methods. Essentially each **Pooling Method** involves a different method of combining input incidence results to generate new incidence results. Results can be pooled any time a branch occurs in the tree structure — that is, any time two or more results share common values for their leftmost variables. BenMAP-CE helps you to identify these spots by inserting a value of *None* in the **Pooling Method** column at each spot where pooling is possible.

Step 4. Create additional pooling windows if needed

Within a given pooling window, you can have only one ordering of the columns (variables). As we have seen, however, the ordering of the columns determines the structure of the tree used to pool results. It may thus sometimes be necessary for analyses to have multiple tree structures to handle the various pooling trees they require. To facilitate this, BenMAP allows additional pooling windows to be added and deleted. The pooling windows are displayed in a tabbed format.

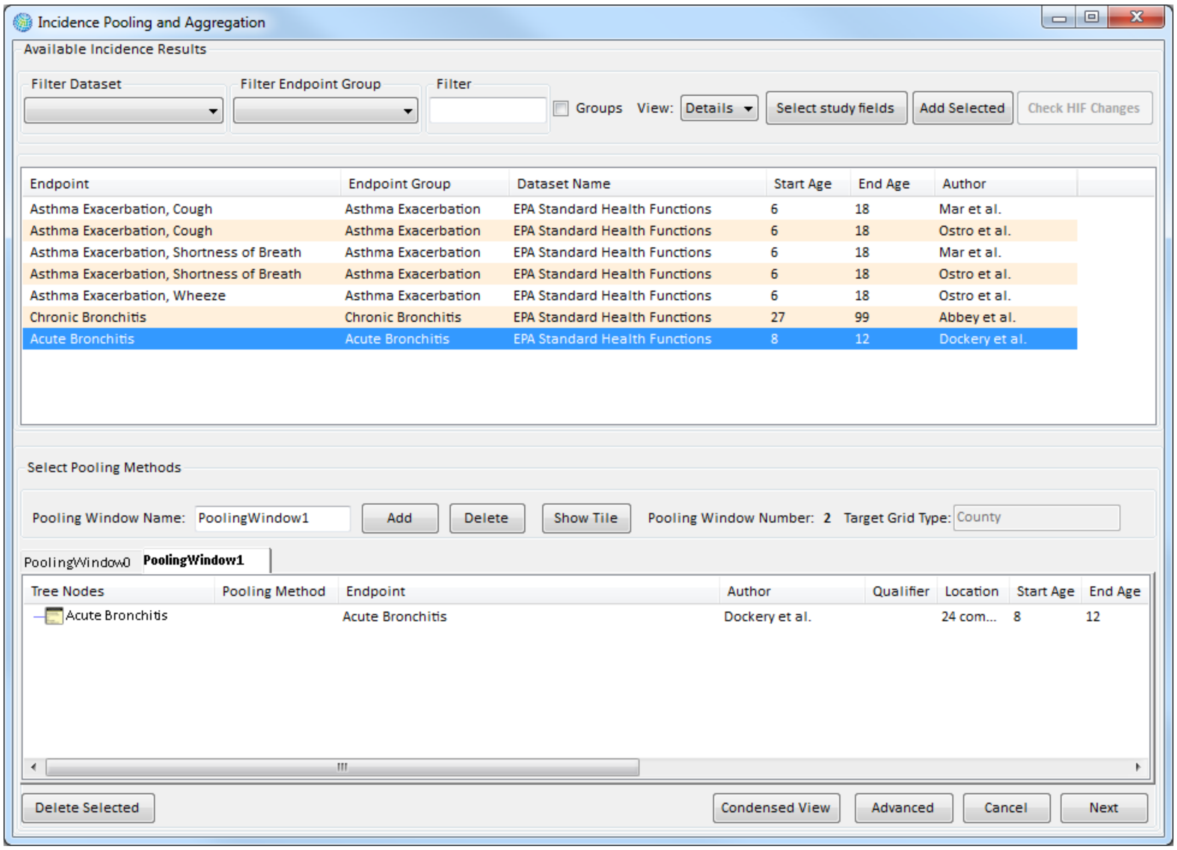
To open a new pooling window, simply click on the **Add** button next to the **Pooling Window Name**. You may do this as many times as needed to accommodate different sort orders. You can add the same incidence results to as many different pooling windows as you like.

As needed, you can also delete a pooling window by clicking on the window you wish to delete and clicking the **Delete** button.

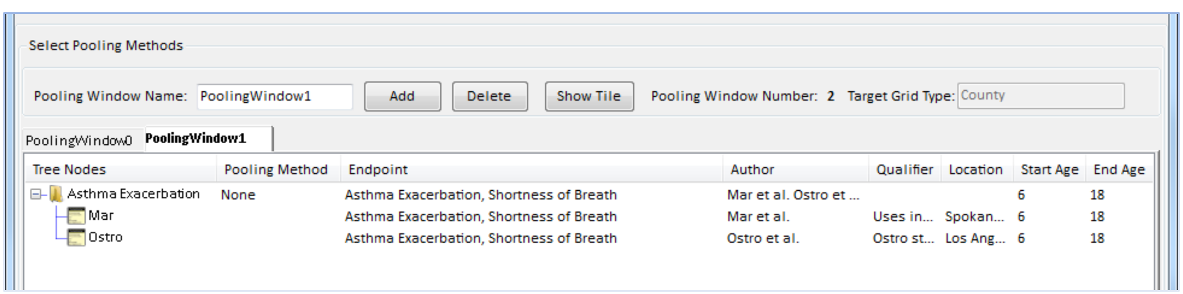


Example: Simple Sorting & Pooling

If you add a single incidence result to the pooling window, you will see just one line, and therefore no opportunities to pool. This is shown in the example below:

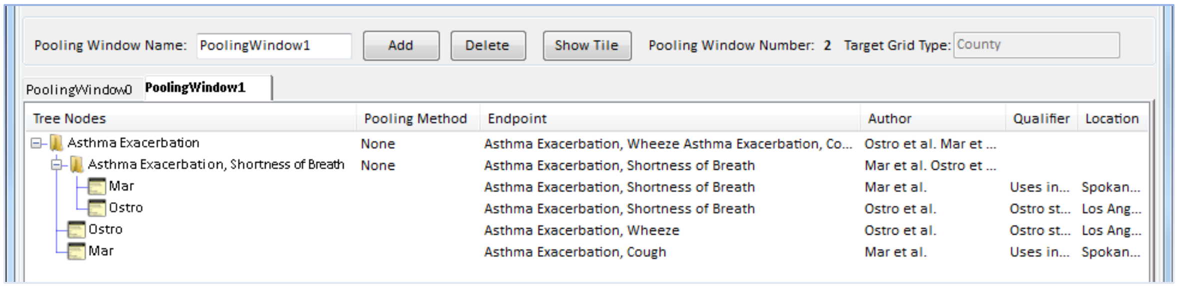


If you add a second incidence result to the window whose health impact function has the same **Endpoint Group**, but a different **Author**, you will then have a tree with two items in it. The tree branches at the point where the two health impact functions vary - at the **Author** column.



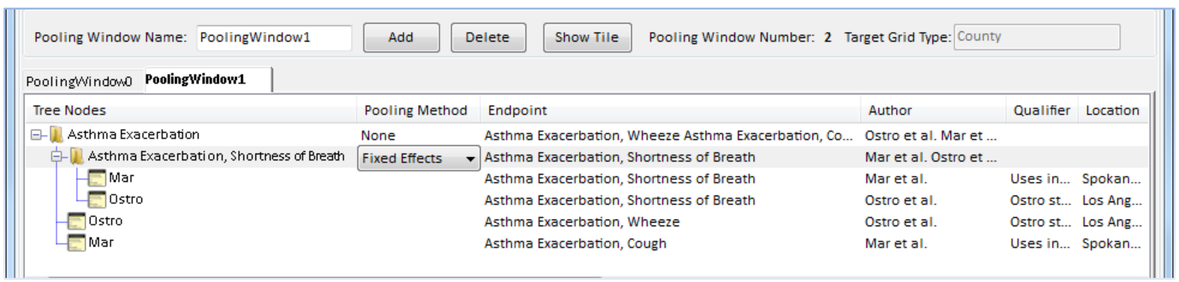
Note that a pooling method can now be selected for the two incidence results, since a branch has appeared. If we desired to pool these two incidence results, we would end up with a pooled result representing two '*Asthma Exacerbation, Shortness of Breath*' incidence results.

If you now add two more incidence results to the window whose health impact functions have the same **Endpoint Group** but different **Endpoints**, you will see the following:

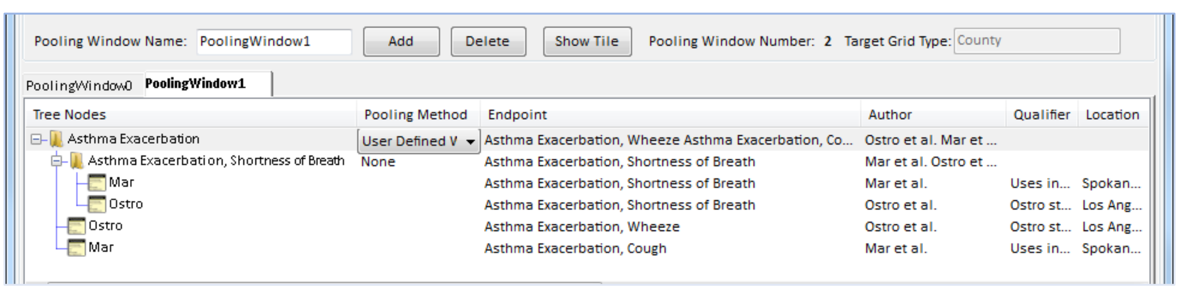


Now you have many pooling options. Setting aside the issue of which pooling method to choose, there are four different pooling options at this point (including doing nothing), since we have two places where we can choose to pool or not to pool.

If you choose to pool at the tree node corresponding to **Endpoint** '*Asthma Exacerbation, Shortness of Breath*' you would end up with three results (one pooled and two unpooled) instead of four individual incidence results.

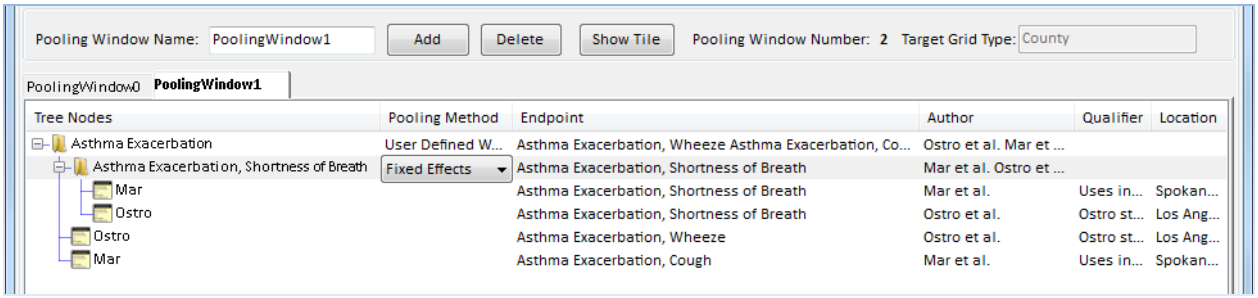


If you choose to pool at the tree node for the **Endpoint Group** '*Asthma Exacerbation*' (where the **Pooling Method** field says '*None'* in the above image*)*, you will end up with a single result representing all four of the original incidence results.



If you pool at both spots:

- First, the '*Asthma Exacerbation, Shortness of Breath*' results are pooled to a give a single '*Asthma Exacerbation, Shortness of Breath*' result.
- Next, the three separate **Endpoint** results are pooled to give a single '*Asthma Exacerbation*' result.



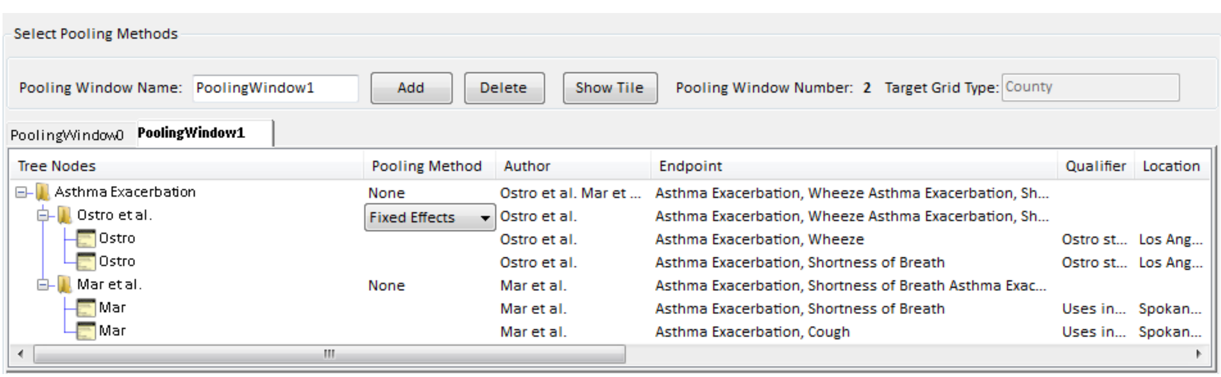
These same principles apply no matter how many incidence results are being pooled, and regardless of which pooling methods are selected.

Example: Multiple Pooling Windows

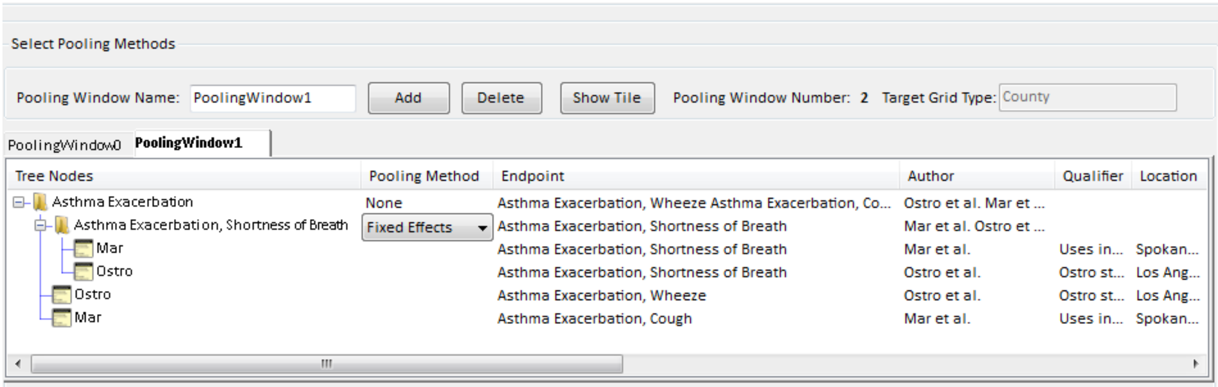
There are many different ways to pool your incidence results. Sometimes you may want to look at the same results in different ways, or you may just have many results that need to be sorted by different variables. In these cases, you can open up multiple pooling windows by clicking on the **Add** button.

For example, you might want to pool all results of health impact functions by a particular **Author**, rather than pooling all results of health impact functions of a particular **Endpoint**. The examples below show the same set of incidence results, first sorted by **Author**, then sorted by **Endpoint**. As you can see, the pooling options are very different.

Sorted by Author:



Sorted by Endpoint:



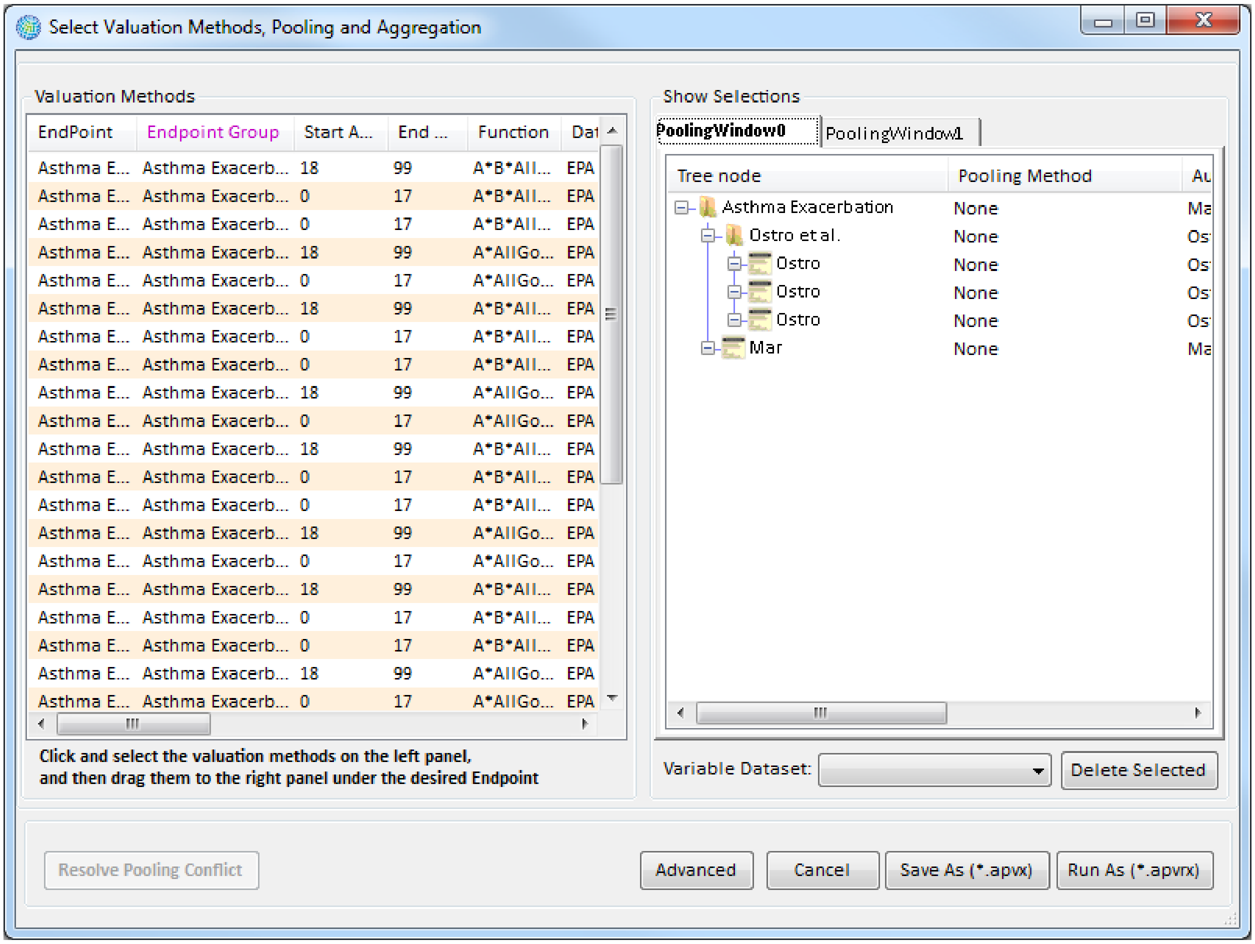
If you use two different pooling windows, each sorted as shown above, you can create results pooled by **Author**, and results pooled by **Endpoint**.

7.2.3 Valuing Pooled Incidence Results

After you have specified your incidence pooling options, click on the **Next** button and select valuations and valuation pooling options from the **Select Valuation Methods, Pooling and Aggregation** window. This window should look quite similar to the **Incidence Pooling and Aggregation** window, with tree views on the left side representing the valuation methods available, and various pooling windows on the right side representing the selected valuations and pooling options.

For each pooling window you created on the **Incidence Pooling and Aggregation** window, there is a corresponding pooling window in the **Select Valuation Methods, Pooling, and Aggregation** window. You will notice that the number of incidence estimates available in the valuation pooling window will reflect any pooling choices you made in the **Incidence Pooling and Aggregation** window. For example, if in the **Incidence Pooling and Aggregation** window you pooled 5 incidence estimates into a single incidence estimate, you will see a single incidence estimate in the **Valuation Methods Pooling and Aggregation** window.

The columns present in the **Select Valuation Methods, Pooling, and Aggregation** window are determined by the incidence results left after all incidence pooling has occurred. There will be exactly enough columns in each pooling window to represent the "least" pooled incidence result. That is, the columns will be in the same order they were in the **Incidence Pooling and Aggregation** window, but the only columns present will be those up to the level of the pooled incidence result with the most columns left over after all pooling has occurred. Here is an example:

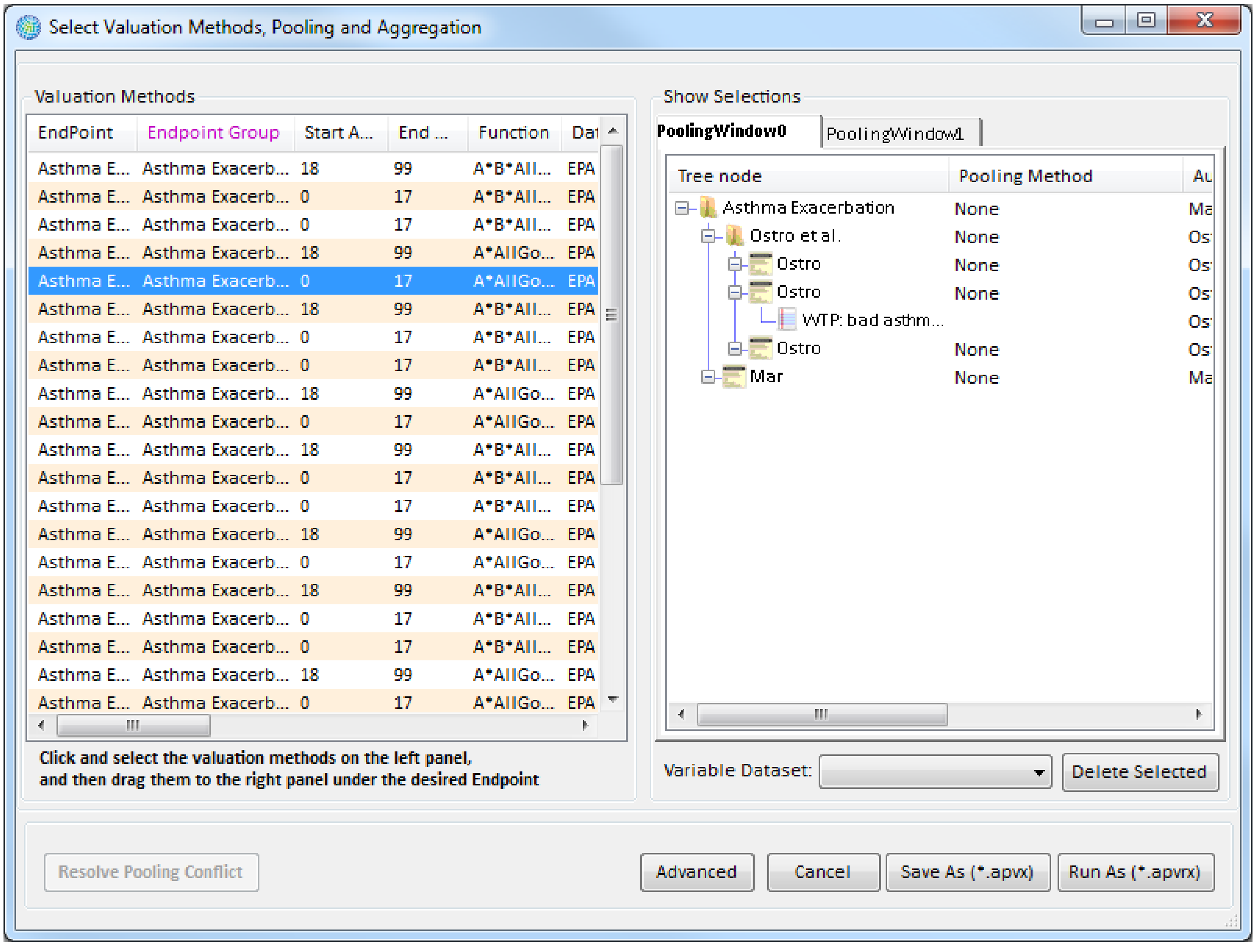


There are several steps to take in the **Select Valuation Methods, Pooling, and Aggregation** window:

Step 1. Select your valuation methods

Valuation Methods are specific to **Endpoint Groups**, and sometimes to **Endpoints** as well. The only **Valuation Methods** which appear on the left-side of the window are those which have the same **Endpoint Group** values as the pooled incidence results which are available to be valued. To select a **Valuation Method**, select it from the table and drag-and-drop it onto the appropriate incidence result in the pooling window. Note that BenMAP-CE will only allow you to drop **Valuation Methods** onto incidence results which have the same **Endpoint Group** value. For example, BenMAP-CE will not allow you to drop a '*Mortality*' valuation on a '*Hospital Admissions*' incidence result. Note also that you can only drag-and-drop individual **Valuation Methods**, not entire groups of them. For explanations of the various valuation methods, see Appendix I.

If you have added any of your own valuation methods, as described in the Valuation Data section of Chapter 4: Loading Data, you can drag-and-drop them in the same way as the *EPA Standard Valuation Functions* shown in these examples.



When BenMAP-CE runs the APV Configuration, it will generate a valuation result for each **Valuation Method** you select by running the method's **Function** on the selected incidence results. You do not need to select a **Valuation Method** for every incidence result—incidence results without any **Valuation Methods** will simply be ignored when valuation results are generated, aggregated, and pooled.

Because valuation functions include an uncertainty distribution around them, generating valuation results is fairly complicated. The procedure depends on whether the incidence results being used were generated in Point Mode or with the default Monte Carlo method. See Chapter 6: Incidence Estimation (Section 6.2.3) for details on these advanced configuration settings.

In Point Mode, BenMAP-CE simply runs the valuation functions once using the point estimate of the incidence result and the mean of the valuation function as inputs.

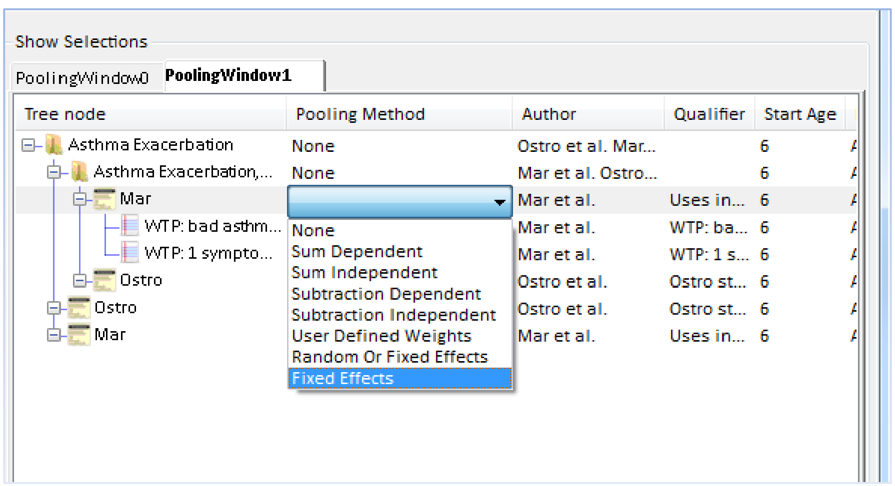
With the Monte Carlo feature, on the other hand, BenMAP-CE generates one hundred percentile points (from the 0.5th percentile to the 99.5th percentile) to represent the distribution of the inputs to the valuation function. To get the value of the health incidence, BenMAP-CE multiplies each combination of values from the incidence result with each of the hundred valuation points, and puts the results into a holding container. (For example, if the incidence result has 10 percentile points and there are 100 valuation points, then the holding container will have 1,000 values.) Finally, the holding container is sorted low to high and binned back down to 100 percentile points (representing the 0.5th percentile to the 99.5th percentile of the economic value of the incidence).

Step 2. Sort results

Depending on how your incidence results were pooled, the columns in the valuation pooling windows can be resorted in the same way as the incidence pooling window columns. This resorting will have the same sort of impact on the tree structure of valuation results that it had on the tree structure of incidence results. (See Step 2 in the section on Pooling Incidence Results.)

Step 3. Select pooling methods

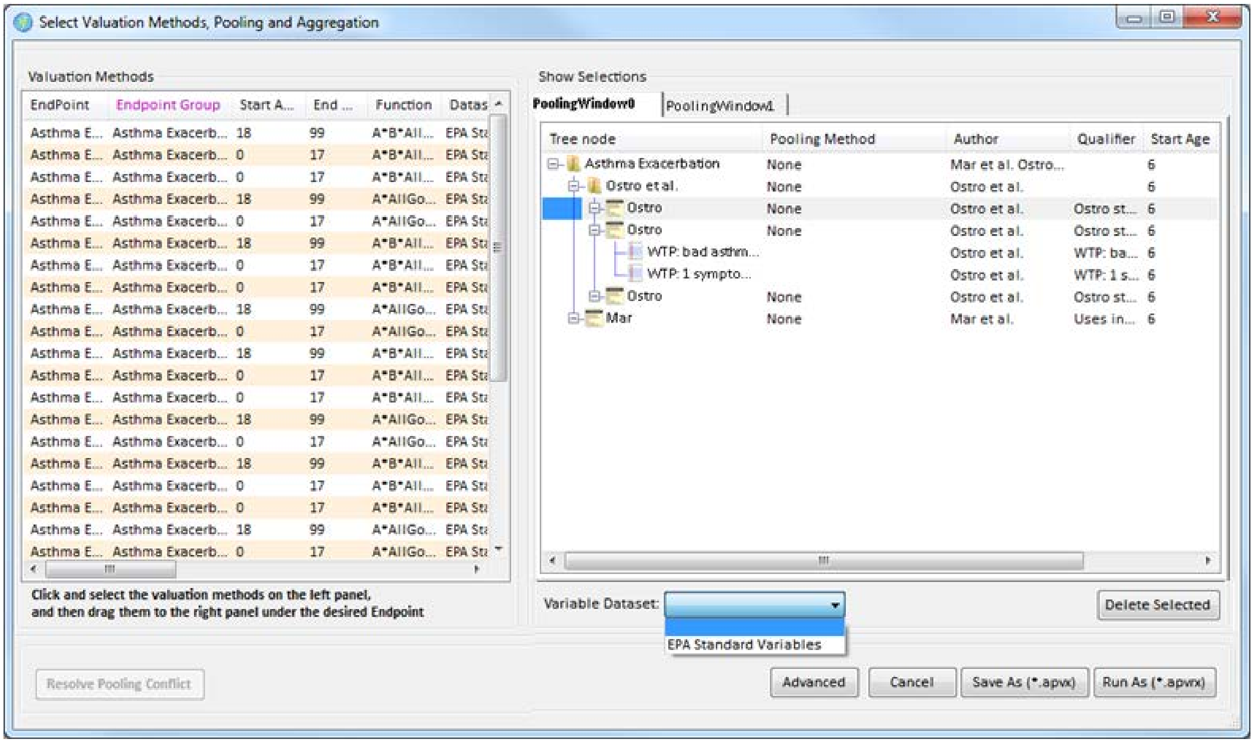
The same pooling methods are available for valuation results which were available for incidence results. (See Step 2 in the section on Pooling Incidence Results.) You should note that when more than one valuation method is selected for a particular pooled incidence result, it is possible to pool the generated valuation results.



Step 4. Select Variable Dataset

In order to proceed to the next step, you must select a **Variable Dataset** from the drop-down menu beneath the pooling window. The **Variable Dataset** can include a variety of data, such as income and poverty data that might be used in health or valuation functions. For the default EPA health and valuation functions, you just need to select the *EPA Standard Variables*.

If you have developed your own setup, then you need to make sure that you also load a **Variable Dataset**. This is necessary even if you do not need the extra variables that can be included in this dataset.

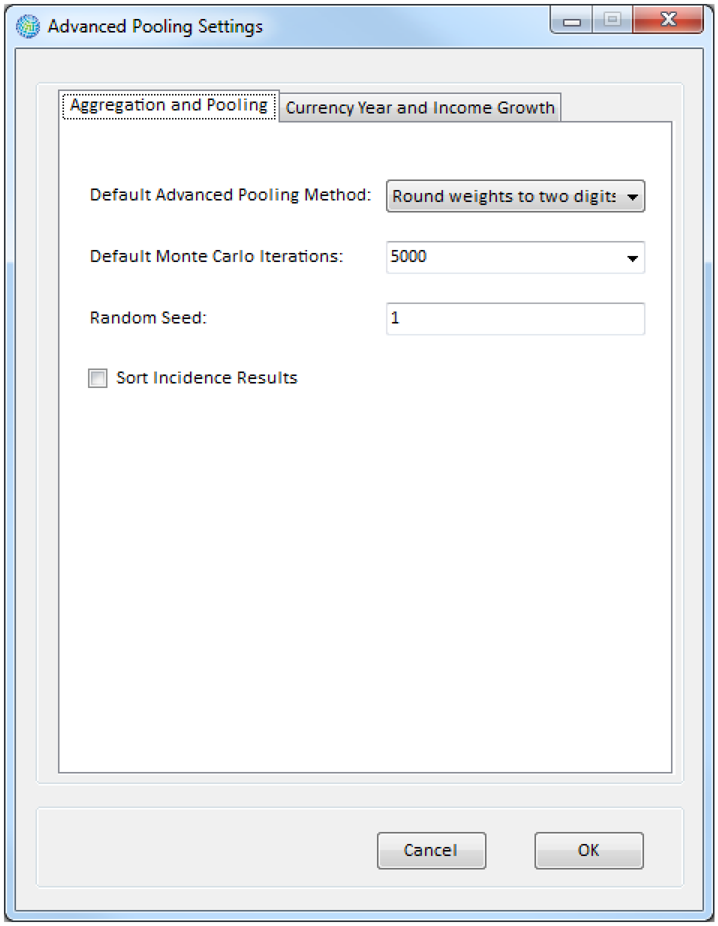


7.2.4 APV Configuration Advanced Settings

At any point when specifying the incidence and valuation pooling options, you may click on the **Advanced** button on the bottom of either the window for **Incidence Pooling and Aggregation** or **Select Valuation Methods, Pooling and Aggregation**. This button will open the **Advanced Pooling Settings** window.

The **Advanced Pooling Settings** window has two tabs:

- **Aggregation & Pooling.** Specify details on the pooling procedure, such as whether to use a Point Mode or Monte Carlo approach.
- **Currency Year and Income Growth.** Choose the currency year, how to adjust for inflation, and how to adjust for income growth.



7.2.4.1 Aggregation and Pooling

Default Advanced Pooling Method

The relative contribution of any one study in the pooling process depends on the weight assigned to that study. A key component of the pooling process, then, is the determination of the weight given to each study. BenMAP-CE lets users assign "subjective" weights and it assigns weights using a fixed effects or a random effects approach. There are three options for using weights available in the **Default Advanced Pooling Method** drop-down list:

Round weights to two digits. BenMAP-CE rounds each weight to two digits (e.g. 0.73), and then multiplies these weights by 100 to get two-digit integers. Each entire distribution (set of percentile points) is then put into a holding container an integral number of times, according to its integral weight. This holding container is then sorted low to high and binned down to the appropriate number of percentile points.

Round weights to three digits. BenMAP-CE rounds each weight to three digits (e.g. 0.732), and then multiplies these weights by 1,000 to get three-digit integers. Each distribution (set of percentile points) is then put into a holding container for an integral number of times, according to its integral weight. This holding container is then sorted low to high and binned down to the appropriate number of percentile points.

Use exact weights for Monte Carlo. BenMAP-CE uses exact weights and a Monte Carlo simulation. During each iteration of the procedure, a particular result is selected with a probability equal to its weight. Once a result is selected, one of its percentile points is chosen at random and put into a holding container. This is done some number of times (see *Monte Carlo Iterations*, below), and the holding container is then sorted low to high and binned down to the appropriate number of percentile points.

Default Monte Carlo Iterations

This drop-down list is only enabled when *Use exact weights for Monte Carlo* is selected as the **Default Advanced Pooling Method**. It specifies the number of iterations the Monte Carlo simulation should be run (see above). Its initial value is set by the **Default Monte Carlo Iterations** value from the **Advanced Pooling Settings** window (see Step 1, above).

Random Seed

The **Advanced Pooling Settings** window allows the specification of a **Random Seed**. Many of the pooling methods require the generation of sequences of random numbers, e.g. choosing a random percentile point during a Monte Carlo simulation. Providing a specific **Random Seed** value allows you to ensure that the same sequence of random numbers is generated as in a previous analysis, thus allowing exact results to be reproduced.

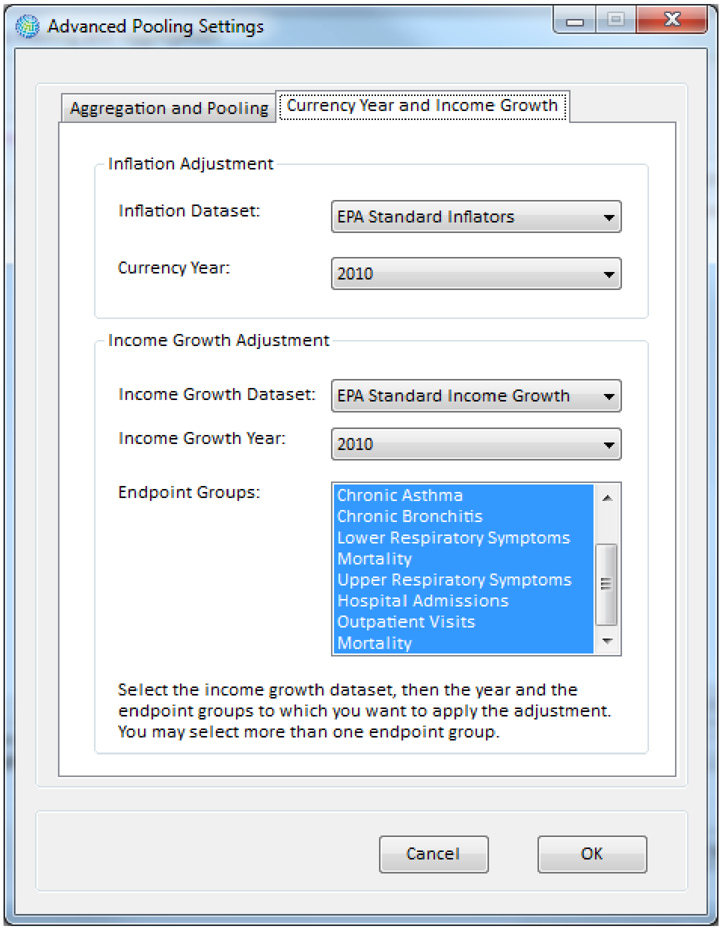
If you do not set the **Random Seed** for a particular run, one will be generated automatically from the system clock (the number generated will depend on the date and time, and should change every minute). Normally, you should not set the **Random Seed** value. If you need to reproduce a specific set of results, however, the random seed used to generate previous APV Configuration Results can be determined from an APV Configuration Result file (*.apvrx*) Audit Trail Report.

Sort Incidence Results

The *Sort Incidence Results* should generally be always checked. This setting ensures that the incidence percentile-point results are sorted low to high.

7.2.4.2 Currency Year and Income Growth

The **Currency Year and Income Growth** tab allows you to specify an **Inflation Dataset** and a **Currency Year**, which in combination allow you to change the currency year to account for inflation. The **Income Growth Adjustment** panel allows you to adjust the valuation estimates to account for the growth in income over time for WTP functions.



Inflation Adjustment

The **Inflation Adjustment** needs to be carefully considered in relation to the valuation dataset that you are using. (This is discussed in detail in the section on loading inflation data in Chapter 4.) The default valuation database in the *United States* setup has a currency year of *2000*, so the inflation dataset has a value of *1* for the year *2000*.

Income Growth Adjustment

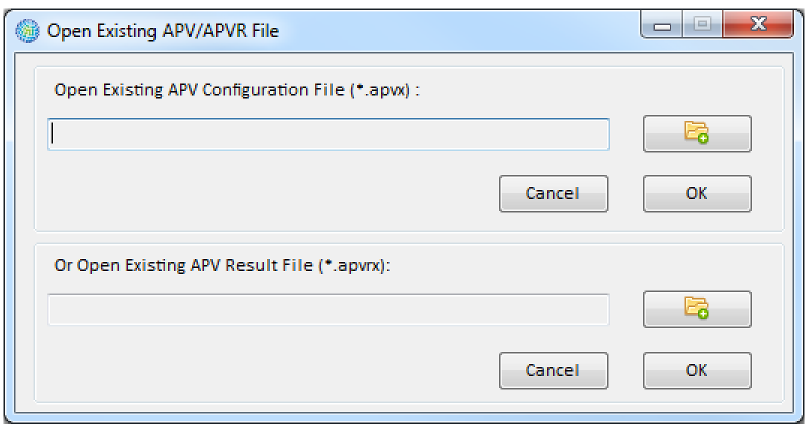
Willingness to pay (WTP) estimates are believed to be tied to the income of individuals. As income rises over time, WTP estimates are likely to increase as well. The **Income Growth Adjustment** is designed to take this phenomenon into account, allowing you to account for income growth between the time when WTP estimates were calculated and the year of your analysis.

As with the **Inflation Adjustment**, the **Income Growth Adjustment** has a close connection to the valuation estimates. For example, the valuation estimates in the *United States* setup are assumed to be based on income levels from 1990, so the income growth adjustment database has a value of 1 for the year 1990. (This is discussed in detail in the section on loading income growth data in Chapter 4.)

To use the **Income Growth Adjustment**, you need to choose a dataset and then choose the income year that you want to use. It is common to set the **Year** variable to the year of the population forecast in your analysis. Of course, you can only choose from the available data. If the income growth adjustment data only goes to 2024 and the population data in your analysis are for 2030, then there will be some, unavoidable mismatch.

7.3 Open & Modify Existing APV Configuration

If you have an existing APV configuration (*.apvx) file or APV result file (*.apvrx), you can open, and edit it. Double click **Aggregate, Pool & Value** from the main tree menu to load the APV Configuration or APV Result file.



If you have only a few changes to make to an existing configuration, it is typically much quicker to open the previous configuration, rather than entering all of your choices again. Note that the various parts of an APV Configuration are quite interdependent, so modifying part of the configuration may cause other parts to be reset. For example, modifying the tree structure for incidence pooling will cause the valuation method selection and valuation pooling tree structure to be cleared and reset. Changing the **Configuration Results Filename** in the **Incidence Pooling and Aggregation** window will not reset the incidence or valuation pooling trees as long as the new file contains incidence results generated from the same health impact functions as the old file. This can be quite helpful for generating new APV Configuration Results from several different Configuration Results files which were generated from different baseline/control scenarios, but with the same set of health impact functions.

7.4 Run APV Configuration

After having specified the various aggregation, pooling, and valuation options, you can save your APV Configuration for future use. The file that you save has an ".apvx" extension. The configuration that you have specified for APV is similar to the configuration that you developed for choosing health impact functions. (That configuration has a ".cfgx" extension.) Both files allow you to save choices that you have made, and re-run them at a later time.

To save your APV configuration with your valuation pooling choices, click the **Save As (*.apvx)** button, and name your configuration file. We suggest that you save this in the Configurations folder. When ready to generate APV Configuration results, click the **Run As (*.apvrx)** button. BenMAP-CE then requires that you specify a file in which to save the results, with an ".apvrx" extension.

7.5 View and Export Pooled Incidence and Valuation Results

Using the results from the APV Results file (".apvrx" extension), you can create, view and export reports that reflect the choices you made about how to aggregate, pool and value your results.

7.5.1 Pooled Incidence Results

The **Pooled Incidence Results** report provides results aggregated and pooled to the level that you previously specified in the Aggregation, Pooling, and Valuation Configuration file. This report has fewer Health Impact Function fields than the **Aggregated Incidence Results Report**, and values for others will be blank. This is because after pooling, only enough fields are retained to uniquely identify individual results.

To generate pooled incidence results, click the **Pooled Incidence** tab in the upper portion of the main window. Double-click to select the study results you would like to view. The selected results should show up in the **Data** tab below, if not, click the **Show Results** button. Notice that you cannot re-aggregate the results in this stage, because you have already defined how to aggregate the results. You may also view the results on a map using the **GIS Map** tab and on a bar chart using the **Chart** tab.

7.5.2 Pooled Valuation Results

The **Pooled Valuation Results** report presents valuation results aggregated and pooled to the level you specified using the **Advanced** button when creating the APV configuration file. As with the **Pooled Incidence Results Report**, fewer Pooled Valuation Method fields are available, because only enough fields are retained to uniquely identify individual results.

Click the **Pooled Valuation Results** tab to begin viewing these results. Similar to the Pooled Incidence Results, you can double-click the study of interest and view the results table in the **Data** tab. Similarly, you may view the results on a map using the **GIS Map** tab and on a bar chart using the **Chart** tab.

7.6 Frequently Asked Questions

I am at the BenMAP-CE valuation window and cannot proceed. What should I do?

In order to proceed to the next step, you must select a Variable Dataset from the drop-down menu in the Select Valuation Methods, Pooling, and Aggregation window. The files in the Variable Dataset can include a variety of data, such as income and poverty data that might be used in health or valuation functions. For the default EPA health and valuation functions, you just need to select the EPA Standard Variables.

If you have developed your own setup, then you need to make sure that you also load a Variable Dataset. This is necessary even if you do not need the extra variables that can be included in this dataset.

How do I edit or add other valuation functions?

To edit or add valuation functions you need to go to Modify Setup option in the Tools drop- down menu available in the upper left-hand corner of the main BenMAP-CE window. See the valuation function section in the chapter on Loading Data for details on how to do this.

How do I know what year dollars (currency year) were used?

You can find the answer in the Audit trail for the APVR file that you generated.

Do the currency year and year of the population data have to match?

No. The currency year and the year of the population data do not need to match. Currency years are always historical because we do not forecast inflation.

CHAPTER 8

GIS/Mapping

In this chapter…

- **Learn about BenMAP-CE's mapping functions.**
- **Map different variables and modify the map display.**

The BenMAP-CE Geographic Information System (GIS) will display maps of air quality, health and economic data. These maps can help answer a number of questions:

- *Quality assurance*: Do your air quality changes seem to be distributed correctly? Are your air quality changes and health impacts occurring in approximately the same location?
- *Presentations*: In what states or provinces are most of the benefits/disbenefits of your policy scenario concentrated?
- *Analysis*: Which air quality grid cells contain the highest ozone values?

The main **GIS Map** tool will be available once you have successfully completed the first stage of the BenMAP-CE analysis (**Air Quality Surfaces** in the main BenMAP-CE tree menu).

8.1 Overview of Mapping

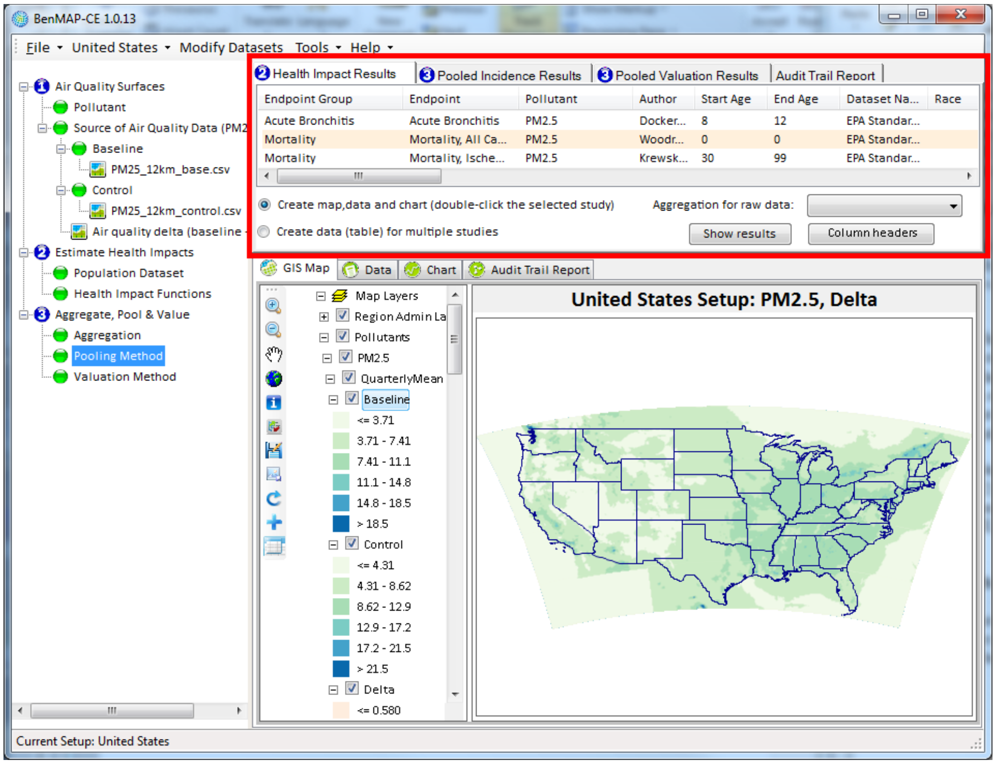
The GIS will map three categories of data:

1. *Air quality (.aqgx)*. Air quality grid maps represent summary air quality metrics (e.g., daily average, daily maximum, or other metric where available) within each grid cell. Air Quality Grids can be added to the **GIS Map** by following the steps in Chapter 5: Creating Air Quality Grids.
2. *Incidence (.cfgrx)*. A configuration results file contains the results of your analysis reported at each air quality grid cell. These results have not been aggregated, pooled or valued. For more information on choosing configuration settings, see Chapter 6: Estimating Incidence.
3. *Aggregated, pooled and valued results (.apvrx).* These are results that have been aggregated to a coarser spatial scale, see Chapter 7: Aggregation, Pooling, and Valuation.

When mapping APV Configuration results, you can generate six different types of maps: (1) *Incidence*, (2) *Aggregated Incidence*, (3) *Pooled Incidence*, (4) *Valuation*, (5) *Aggregated Valuation*, and (6) *Pooled Valuation.* For more information on how to load these files into BenMAP-CE, see Chapters 6 and 7 (Estimating Incidence, and Aggregation, Pooling, and Valuation).

8.2 Results Panel

Once you have gone through all the steps outlined in the previous chapters to import data and files, you are ready to begin exploring the visual results. Each of your selected endpoint groups will be displayed in the results panel (upper right portion of the main BenMAP-CE window).

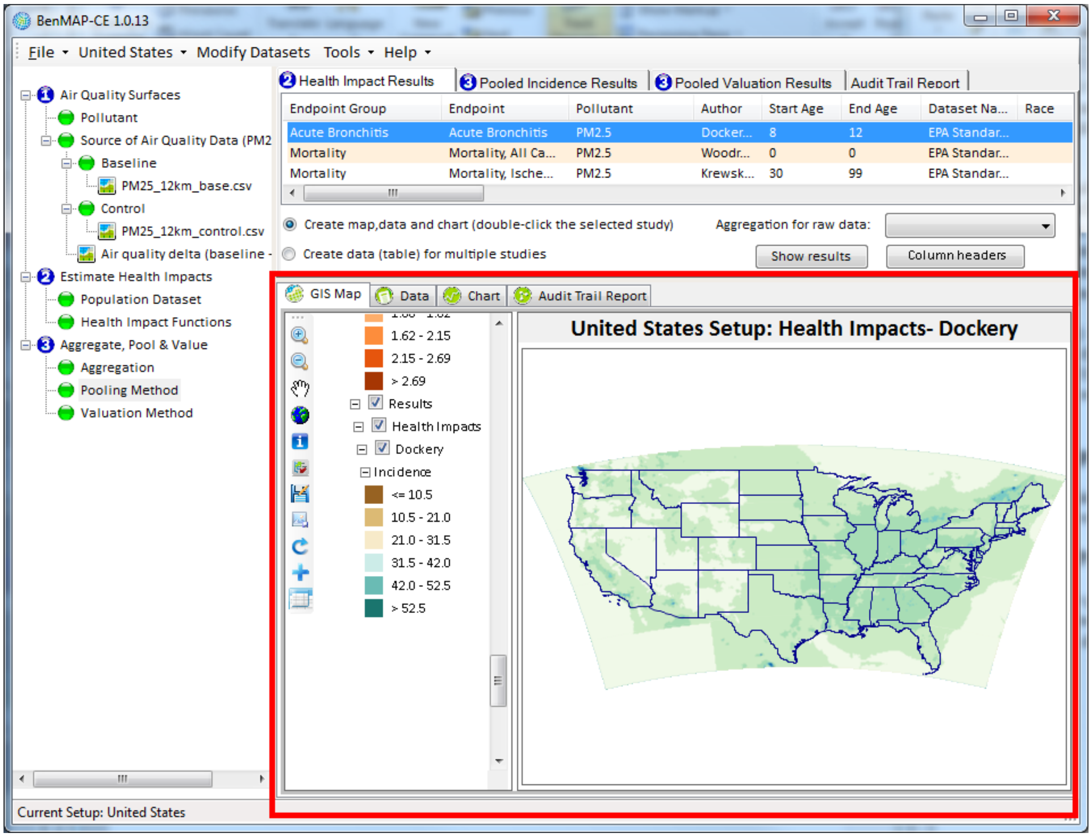


There are four tabs within the results panel, **Health Impact Results**, **Pooled Incidence Results**, **Pooled Valuation Results**, and **Audit Trail Report.** To create a results map layer for an endpoint group, select an entry, or entries, from the list and drag it down onto the GIS Mapping panel. BenMAP-CE will create the map and place an entry into the GIS table of contents below the newly created results group. The layer will most likely be listed under the author's name as subgroup of the main results group. This process of dragging-and-dropping can be done with as many entries as you like, on any of the first three tabs.

Audit Trail Reports facilitate transparency and reproducibility by reporting a summary of your assumptions underlying each step of the analysis. This is described in more detail below.

8.3 GIS Mapping Panel

The GIS Mapping panel is the centerpiece of this tool. Here is where you can view, edit, add, and remove layers from the table of contents and GIS map viewer.

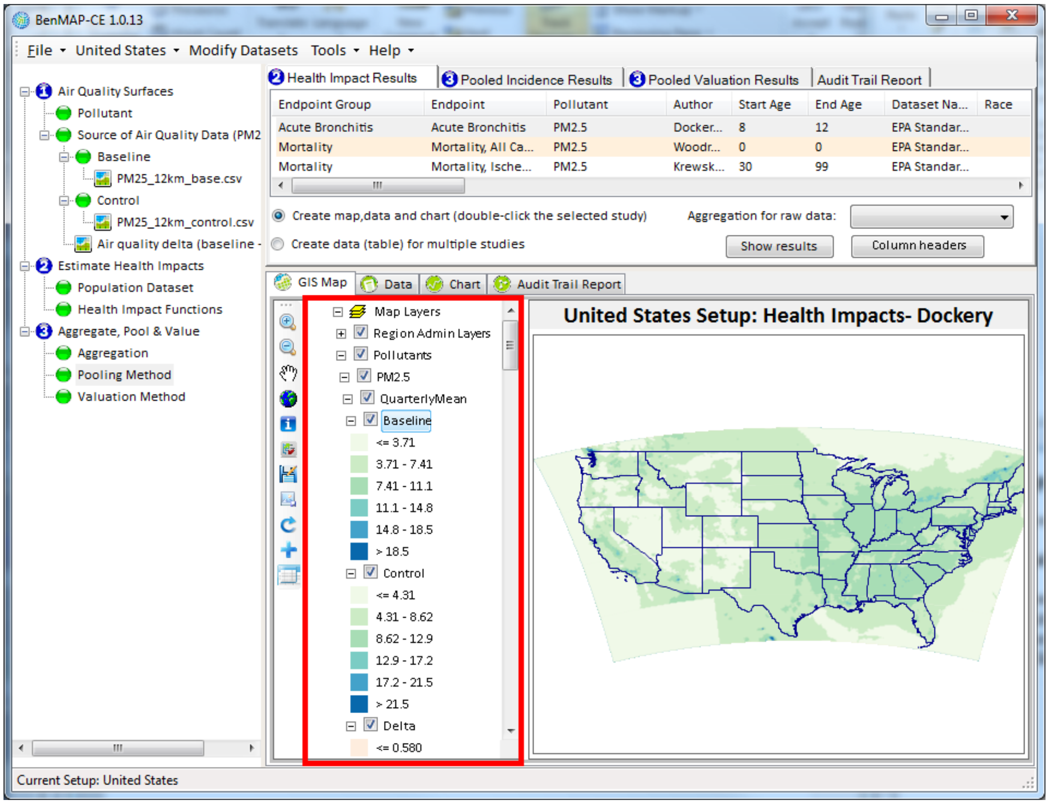


8.3.1 GIS Map Tab

After creating an air quality surface, the **GIS Map** tab is used to view the air quality data (double-click on an available air quality surface to display it). Here you will find a GIS table of contents, toolbar, and interactive map.

8.3.1.1 GIS Table of Contents

The GIS table of contents is where you will find all your loaded map layers. The layers are sorted in groups, with subgroups below them. The general setup will include *Region Admin Layers* group, *Pollutants* group, and *Results* group. You can select or deselect as many layers or groups as you like, for viewing on the map to the right.



- **Region Admin Layers**: This is where the administrative grids can be found for country, state, and county boundaries. For preloaded data, regional administrative layers have been defined. For example, in the *United States* setup, the *State* layer will be automatically selected. You can change the selection to country or county layers by expanding the group.

- **Pollutants**: This is where all the available pollutant data (from the tree menu) will be visible. Under this main group, there will be a group for each pollutant that was selected (e.g., *$PM_{2.5}$*). Below the individual pollutant, there will be metrics that were defined earlier during import and loading (e.g., *Quarterly Mean*, *D24HourMean*). Below each metric, there will be entries for each Air Quality Grid that was loaded (e.g., *Baseline*, *Control*, and *Delta*).

- **Results**: This is where the layers for Health Impact Results, Pooled Incidence Results, and Pooled Validation Results will be listed. Under the results group, there will be a subgroup labeled for each set of results. Usually, these entries will be labeled by the study author's name.

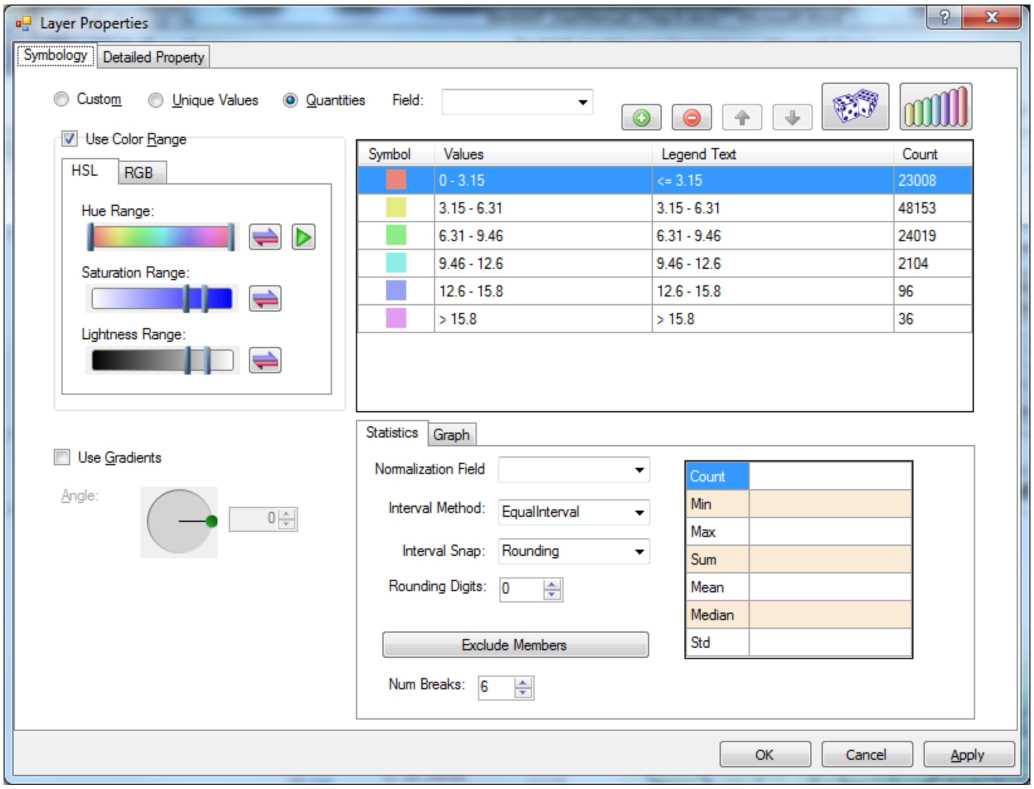
Color Ramps

The color ramps are standard for the imported files. The default color ramp for the **Baseline** and **Control** Air Quality Grids goes from light green to dark blue. The default color ramp for the **Delta** Air Quality Grid goes from light yellow to dark red.

Finally, the default color ramp for the **Results** group entries will be different from each other and any other color ramps that are already in the table of contents.

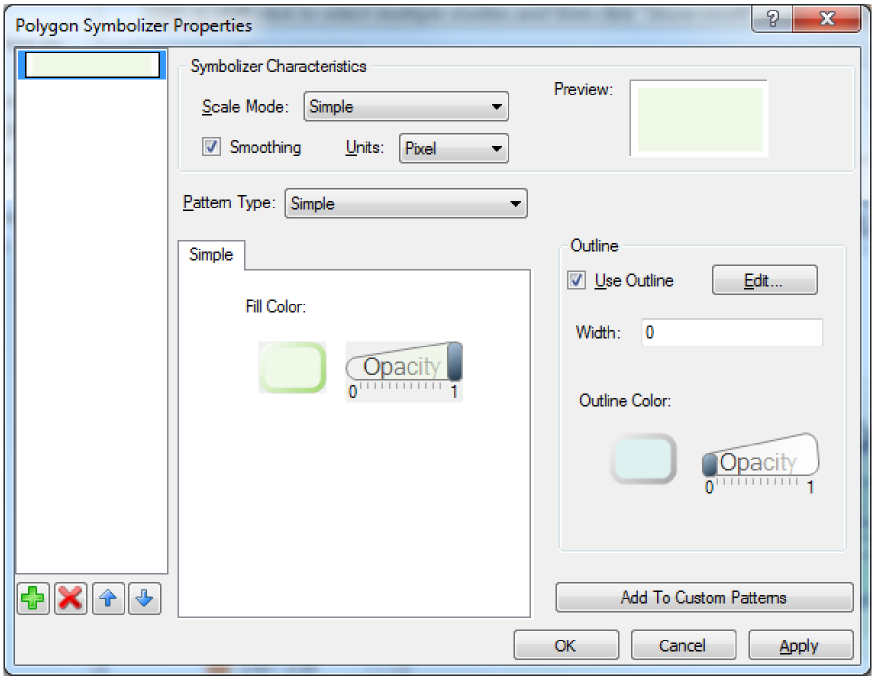
These color ramps can be changed by the user, if desired. There are two possible ways to change the colors:[1]

1) To change the whole color scheme: Right click on a layer and select the **Properties** option. This will open a **Layer Properties** window, where you can change the color ramps and other properties.



2) To change one index within a color ramp: Click on the color box or number range that you wish to change. This opens the **Polygon Symbolizer Properties** window.

[1] BenMAP-CE uses DotSpatial to incorporate, analyze, and map spatial data. The editing tools for layer properties are those included in the DotSpatial libraries and have not been customized for BenMAP-CE. For more information, see: http://dotspatial.codeplex.com/.



Add/Remove a Group

To add a group to the GIS table of contents, right-click on a group, and click **Create New Group** from the pop-up menu. This will add the new group below the group that was right-clicked on.

To remove a group from the GIS table of contents, right-click on the group you wish to remove, and then click **Remove Group** from the pop-up menu. This will remove the entire group from the table of contents.

Remove a Layer

To remove a spatial layer from the GIS table of contents, right-click on the layer you wish to remove, and then choose **Remove Layer** from the pop-up menu. This will remove the layer from the table of contents.

Note: Adding a layer will be discussed in the GIS Toolbar section (Section 8.3.1.2).

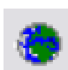
8.3.1.2 GIS Toolbar

There are a number of standard buttons used in most map viewing programs which you can use to navigate and customize the map view. To see the name of each button in the toolbar (to the left of the GIS table of contents), simply hold the cursor over it.

Increase zoom. Allows you to zoom in.

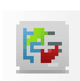
Decrease zoom. Allows you to zoom out.

Drag mode. Allows you to manually move the map by clicking and dragging.



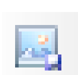
Zoom to full extent. Allows you to view the whole map that you are viewing.

Click to display info for the cell in popup window. Allows you to display information (all the variable values) for individual cells or points by clicking on them.



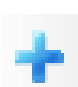
Show Table of Contents. Allows you to show/hide the GIS table of contents to view a larger map.

Save Shapefile. Opens a Save As window to all you to save the map (layer) as a *.shp file.



Export Map Image. Opens a DotSpatial Print Layout window where you can edit/save the data map layer.

Change Projection to *projection type*. Allows you to change/toggle the type of map projections between the following types: GCS/NAD 83 (standard), Albers.

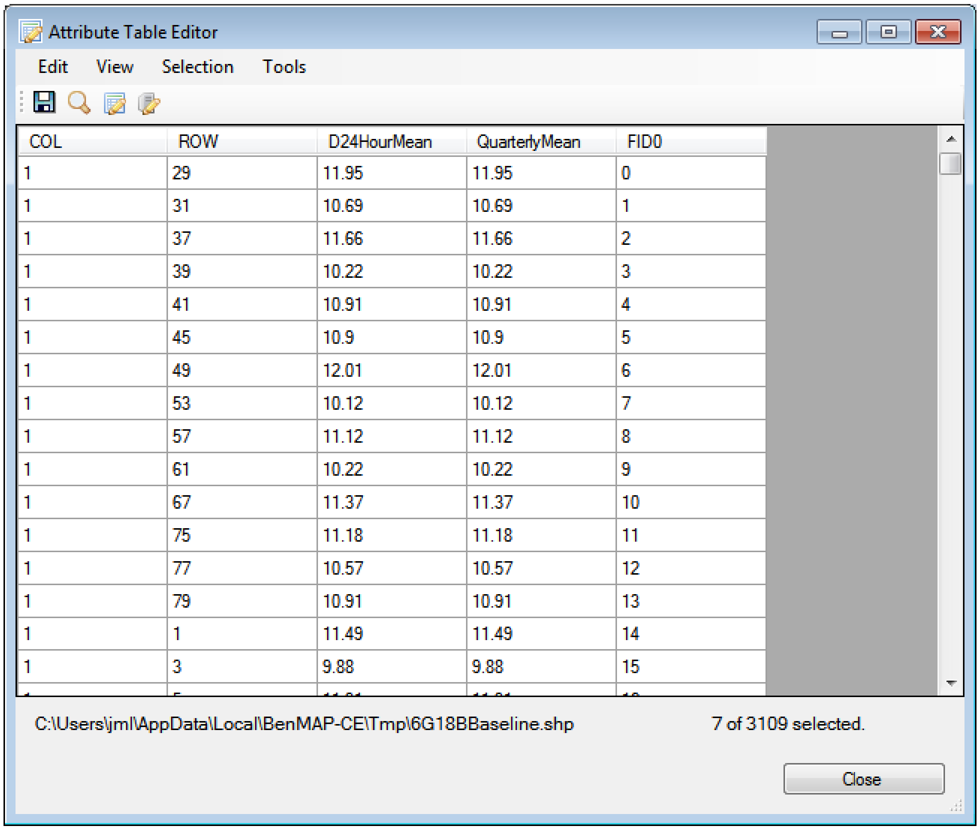


Add Layer. Allows you to add a new layer to the table of contents and map. Typically the new layer is added near the top of the table of contents.

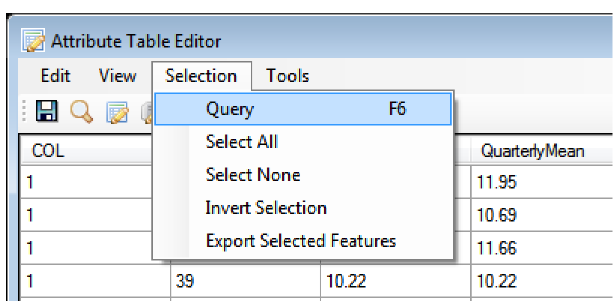
Attribute Table. Opens an Attribute Table Editor Window where the user can view, edit, or filter the data for a specific layer.

Creating a Query

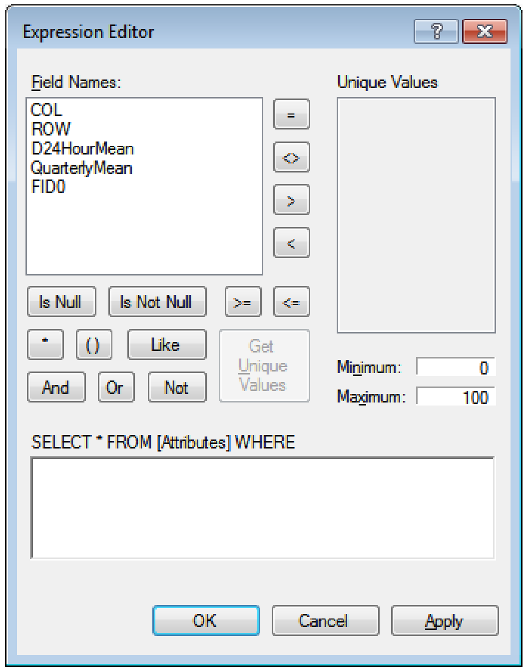
You can create a query on any map layer that shows up in the GIS table of contents. After importing a file (such as **Baseline** or **Control**) you can begin a query by selecting a layer. The selected layer will become highlighted with a light blue bubble around it. Next, click the **Attribute Table button** in the GIS toolbar. This will open the **Attribute Table Editor** window, shown below:



From the window above, click **Selection** from the top menu bar. This will open a drop-down menu where you can select the **Query** option.

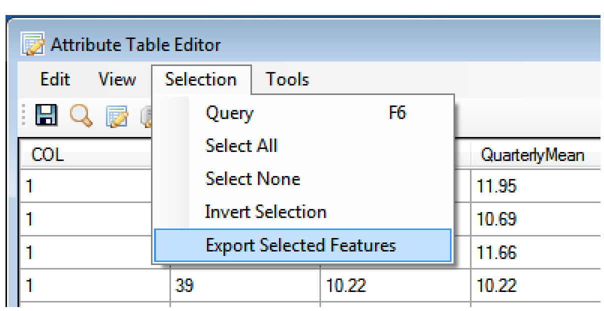


This will open **Expression Editor** window (shown below):



The **Expression Editor** is used to query your data. First, select a **Field Name** to query, by double-clicking on a desired entry. The **Field Name** should show up in brackets in the bottom text box. Next, select an operator from the panel of buttons. The selected operator symbol should show up in the bottom text box next to the field name. Finally, to complete the first query entry, click in the bottom text box (after the operator symbol) and enter a value that you would like to compare against (e.g., *[D24HourMean] >= 15)*. More attributes can be added to the query by clicking the **And**, **Or**, or **Not** buttons. Once you are satisfied with the query statement, click **OK** on the **Expression Editor** window. It may take a few minutes to find all the results. The **Attributes Table Editor** should appear, with the requested selections highlighted. The map on the GIS portion of the main BenMAP-CE home screen should show the query results.

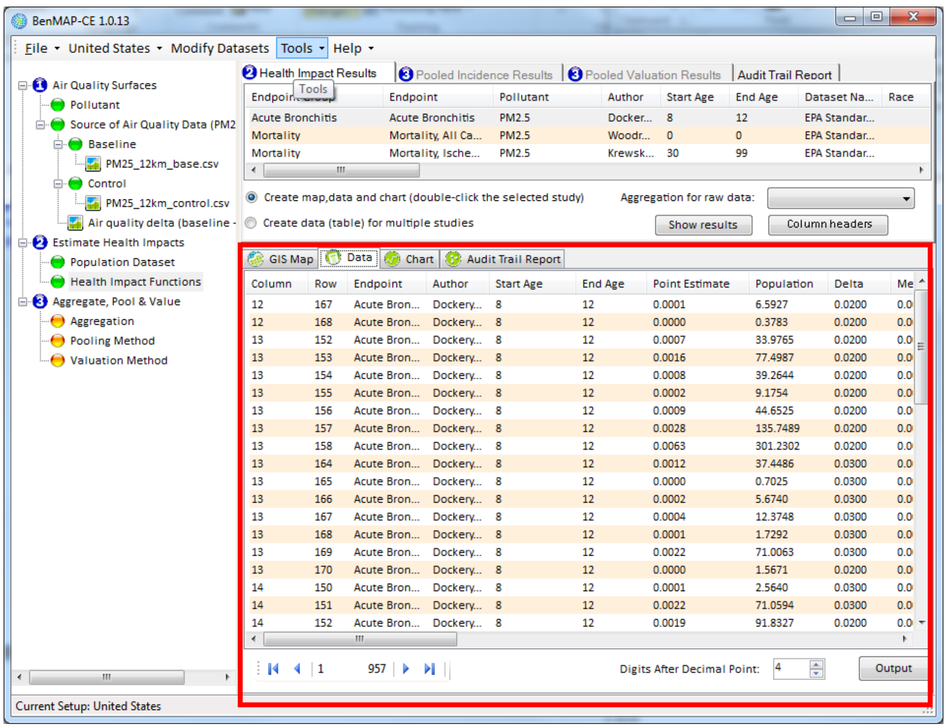
To save these results, click the **Selection** button from the top menu bar of the **Attribute Table Editor** window. From the dropdown menu, select the **Export Selected Features** entry. This will open a **Save As** window, where you can save the query into a shapefile (*.shp*). Click the **Close** button on the **Attribute Table Editor**.



To add the query as a new layer, click the '**+**' button located in the GIS toolbar (located next to the GIS table of contents). An **Open** window will be displayed, where you can select your recently saved shapefile. Select the file and click **Open**. The new layer should appear near the top of the GIS table of contents. The layer can be dragged-and-dropped into any map group you would like within the GIS table of contents.

8.3.2 Data Tab

The **Data** tab allows you to view all the data that is being presented in the map.

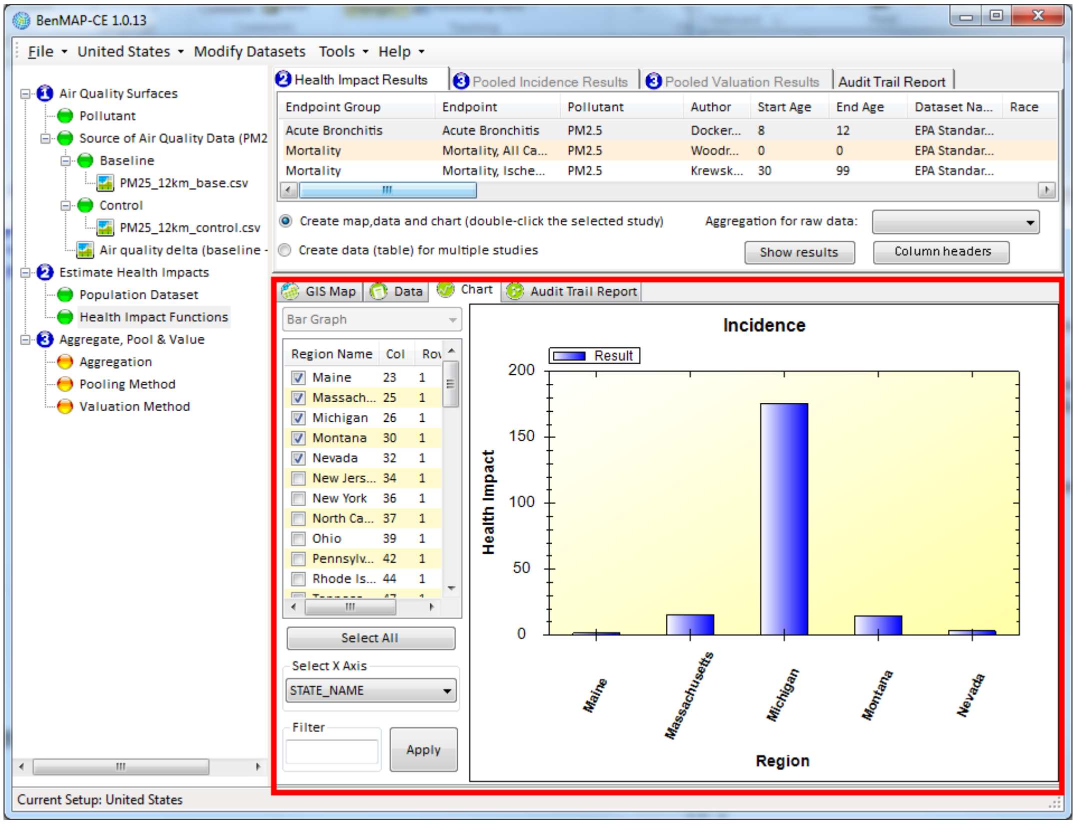


At the bottom of this tab, there are a few options:

- The left-most set of buttons allows you to toggle between pages of data.
- The middle option allows you to change the number of digits that appear after the decimal point.
- The far right entry allows you to export the data table. Clicking the **Output** button opens a **Save As** window, allowing you to save the data as a .csv file.

8.3.3 Chart Tab

The **Chart** tab allows you to select certain regions of data within the main layer to compare localized results more easily.

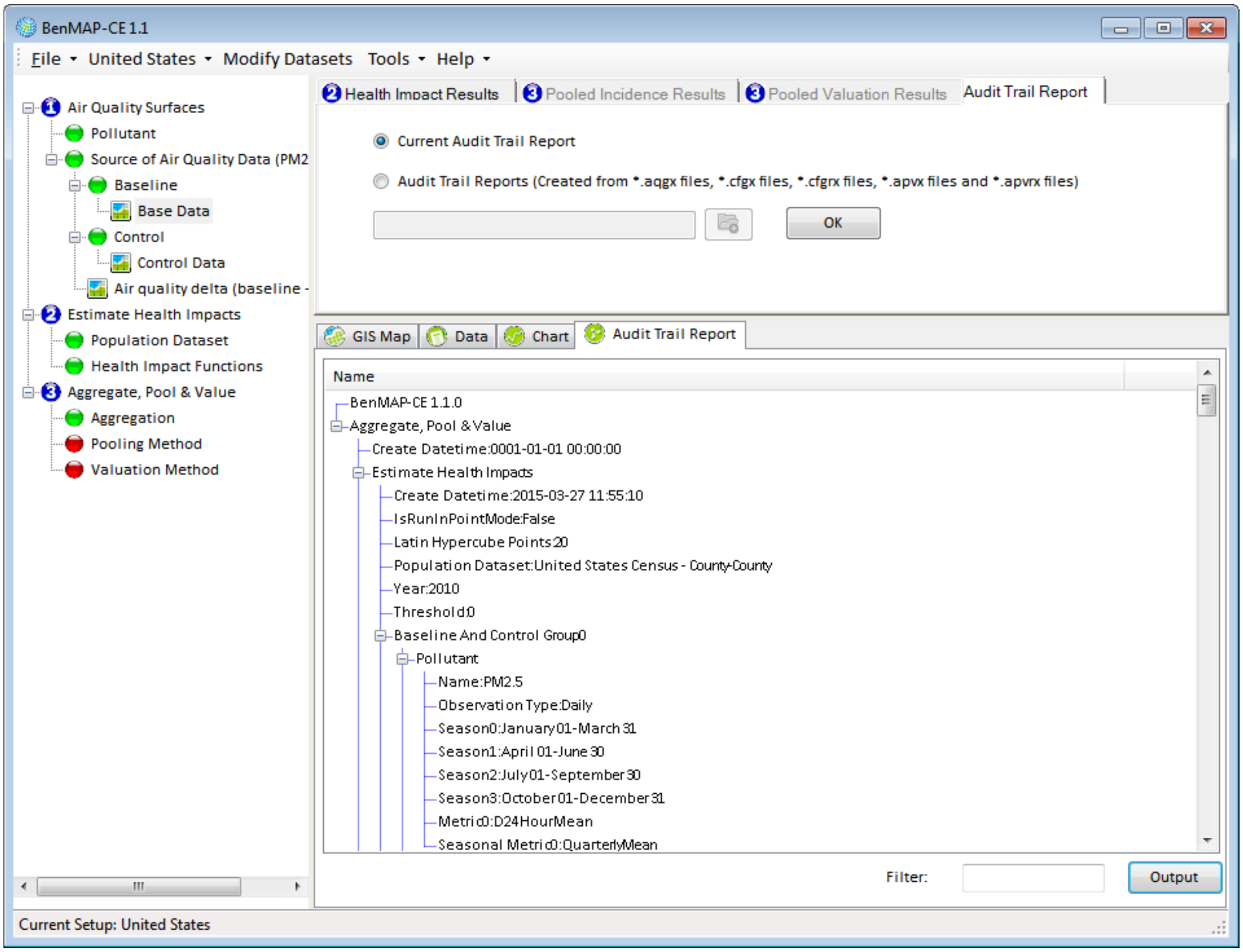


You have the option of selecting the regions that you would like to compare using the list to the left of the chart by checking and unchecking certain regions. The chart automatically updates with each new selection.[2]

8.3.4 Audit Trail Report

Audit Trail Reports facilitate transparency and reproducibility by reporting a summary of your assumptions underlying each of five types of files generated by BenMAP-CE: Air Quality Grids (with the *.aqgx* extension), Incidence Configurations (with the *.cfgx* extension), Configuration Results (with the *.cfgrx* extension), Aggregation, Pooling, and Valuation Configurations (with the *.apvx* extension), and Aggregation, Pooling, and Valuation Results (with the *.apvrx* extension).

[2] The data charts were originally developed using ZedGraph software, which is no longer supported. The BenMAP-CE development team is considering options to update and improve this feature.



Note that each successive step in an analysis contains a summary of its inputs and attributes, and those of each previous step in the analysis. For example, in the above report the attributes of the *Health Impact Function* file used to generate the APV Results are present in the *Estimate Health Impacts* node. Similarly, the metadata for both the baseline and control air quality grids are present under the *Estimate Health Impacts* node.

The process of creating an Audit Trail is described below:

- Click the **Audit Trail Report** tab in the results window. Select *Current Audit Trail Report* (this is the default setting). Click **OK**.
- Carefully review the report, ensuring that the air quality grids, population data, health incidence data, health impact functions and economic value estimates appear as you expected.
- Click the **Output** button to save the audit trail report. The default location for saving audit trail outputs (*.txt*, *.ctlx*, or *.xml*) files will be the location you chose earlier for saving your shape files.

Audit Trail Reports have three output options: *.txt*, *.ctlx*, and *.xml*. These file types can all be viewed using a standard text editor. The *.txt* and *.xml* files will contain the same information displayed in the **Audit Trail Report** window (however, the *.xml* file contains tags to retain the tree structure). If you are familiar with the command line feature, you may use the audit trail report to produce a control (*.ctlx*) file using an existing analysis, rather than creating one from scratch. The control file documents variables and configurations (file paths) associated with an analysis. For more information about the command line tool see Appendix L.

8.4 Frequently Asked Questions

Can I reorder the data layers?

Yes, data layers may be dragged within the GIS table of contents to reorder them within a group.

How do I export shapefiles?

When viewing any of the displayed maps n the **GIS Map** tab (lower right frame of the main window), click on the GIS toolbar icon for *Save Shapefile* (looks like a 3.5-inch diskette). Follow the prompts to provide a name and location for the file. BenMAP-CE will export a set of files (*.dbf*, *.prj*, *.shp*, *.shx*) associated with the shapefile that you can use with any GIS viewer.

How do I save a GIS map as an image?

To export the map as an image, click the *Export map* image icon (immediately below the *Save Shapefile* icon). This will use built-in DotSpatial GIS tools to allow you to save the map as a formatted image (*.png*) file. Alternately, use the *Print Screen* (PrtScn) button on your keyboard to create an image (saved in memory) which you can then paste into a graphics editor or document.

Can I display my map using a projection other than GCS-NAD 83 or Albers?

Yes, click the GIS toolbar icon for "**change projection to…**"; this feature will allow you to alternate between GCS-NAD83 and Albers projections. For more options, right-click on the **Map Layers** feature in the GIS table of contents and select **Projection** from the pop-up menu. This will display information about the current projection. Click the **Change Projection** button to view and apply other available projections.

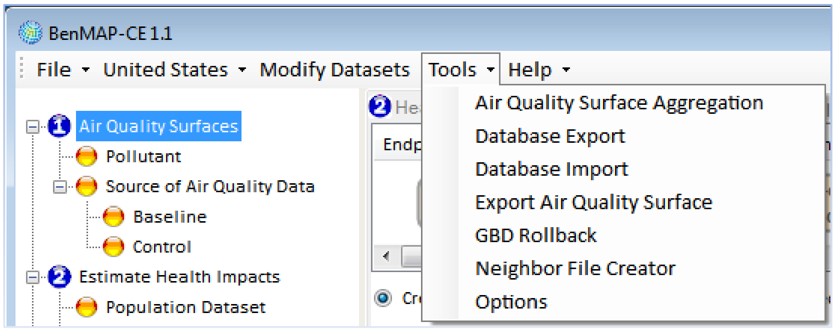
CHAPTER 9

Tools Menu

In this chapter…

- **Learn about the options in the Tools menu.**

The **Tools** menu, available on the main BenMAP-CE screen, provides access to six special add-on tools and an **Options** menu. Below we summarize the purpose of each tool. Note that other sections of the manual have already covered several of these items, so we merely list them here and point you to the appropriate section.



- **Air Quality Surface Aggregation.** Use this tool to change an air quality grid based on one grid definition to a coarser grid definition, using a simple spatially weighted average approach. For example—you could aggregate your air quality surface from 12km × 12km grids to U.S. Counties.

- **Database Export.** Export your entire database (every item in your setup) or parts of your setup (e.g. all GridDefinitions, or individual Health Impact Function Datasets).

- **Database Import.** Import an entire setup or parts of an individual setup.

- **Export Air Quality Surface.** Generate a data file that contains all of the air quality values saved within an air quality surface (.aqgx) file.

- **GBD Rollback.** This application estimates the air pollution-attributable health burden, and the benefits of improved air quality, in each country using data from the 2010 Global Burden of Disease (GBD) study.

- **Neighbor File Creator.** Identify the monitors and weights used in the interpolation process when creating air quality grids.

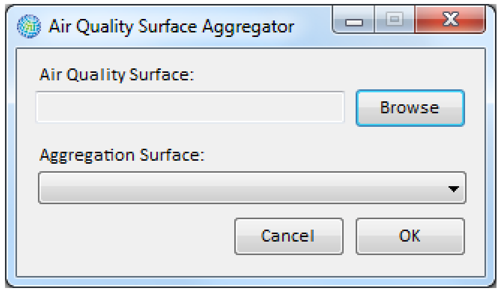
- **Options.** View and edit the general options for BenMAP-CE.

9.1 Air Quality Surface Aggregation

Using the **Air Quality Surface Aggregation** tool, you can change an air quality grid based on one grid definition to another (coarser) grid definition, using a simple spatially weighted average approach.

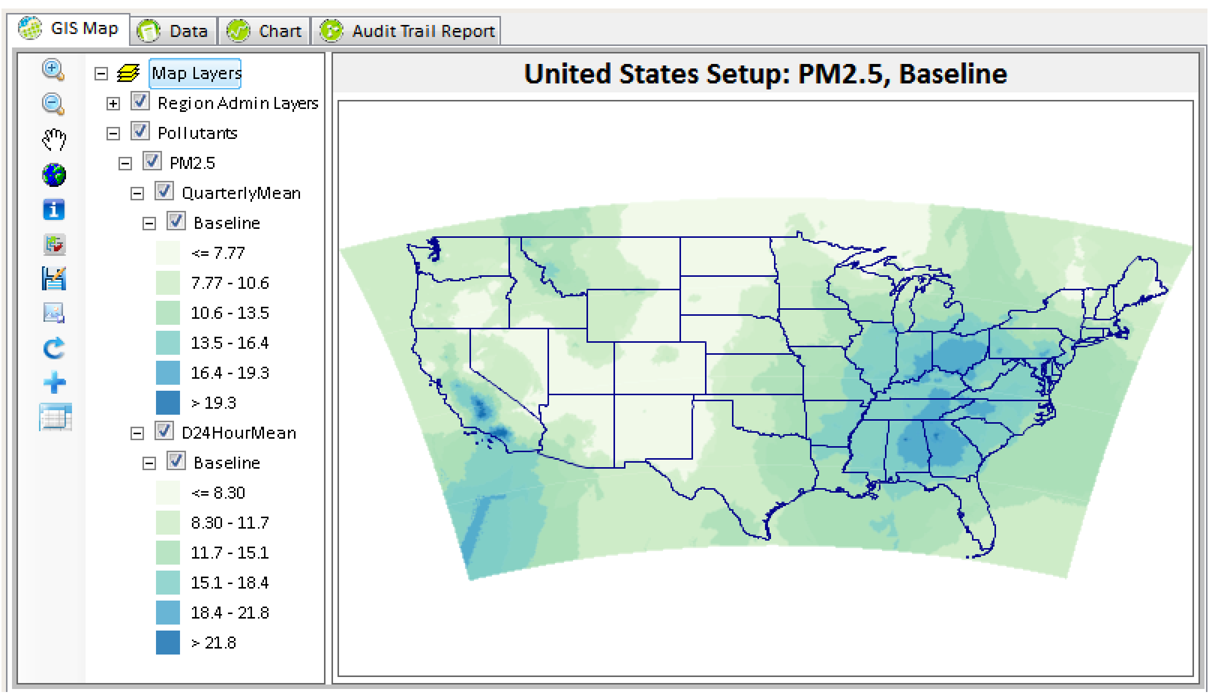
To start, choose *Air Quality Surface Aggregation* from the **Tools** drop-down menu. This will bring up the **Air Quality Surface Aggregator** window. Click the **Browse** button to find the air quality grid (.aqgx file) that you want to change and then use the

Aggregation Surface drop-down list to select the new grid definition that you want to use. For example, you might want to aggregate a 12km model grid to the county-level. Click **OK** when done.

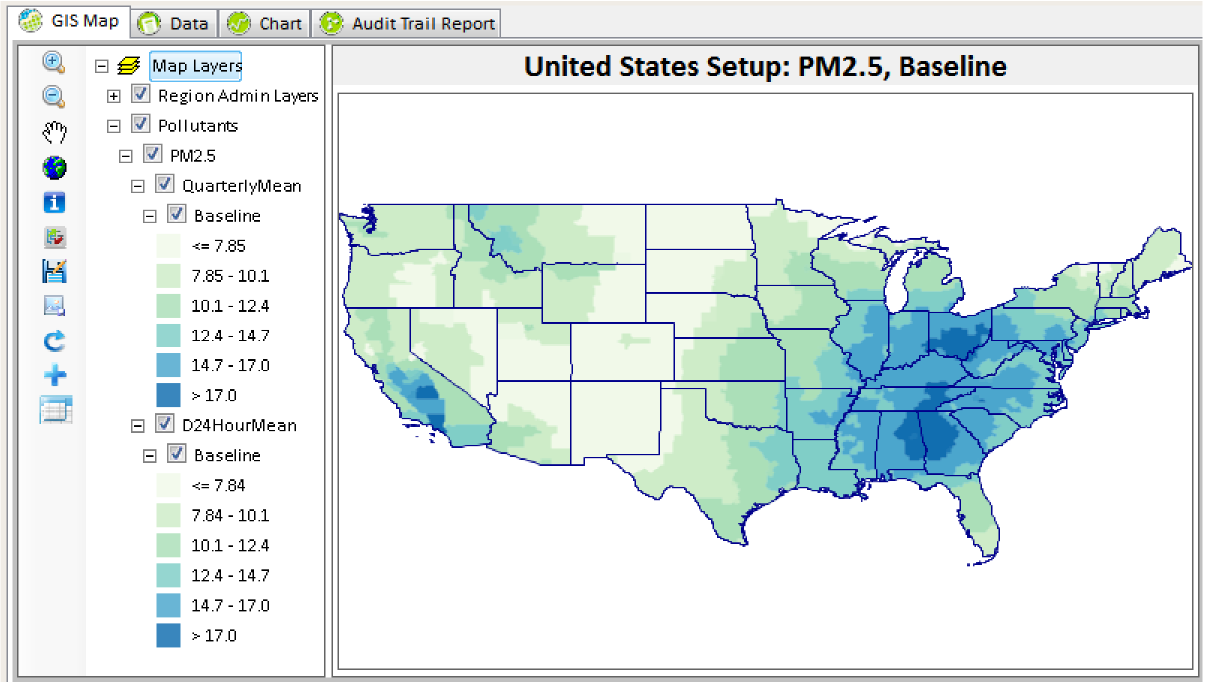


This will bring up the **Save Aggregated Air Quality Grid** window, where you specify the name of the newly aggregated air quality surface (.aqgx file) you are creating and its location. After the file is created, BenMAP-CE will return you to the main BenMAP-CE screen. You can then use the new file just as you would any other air quality surface.

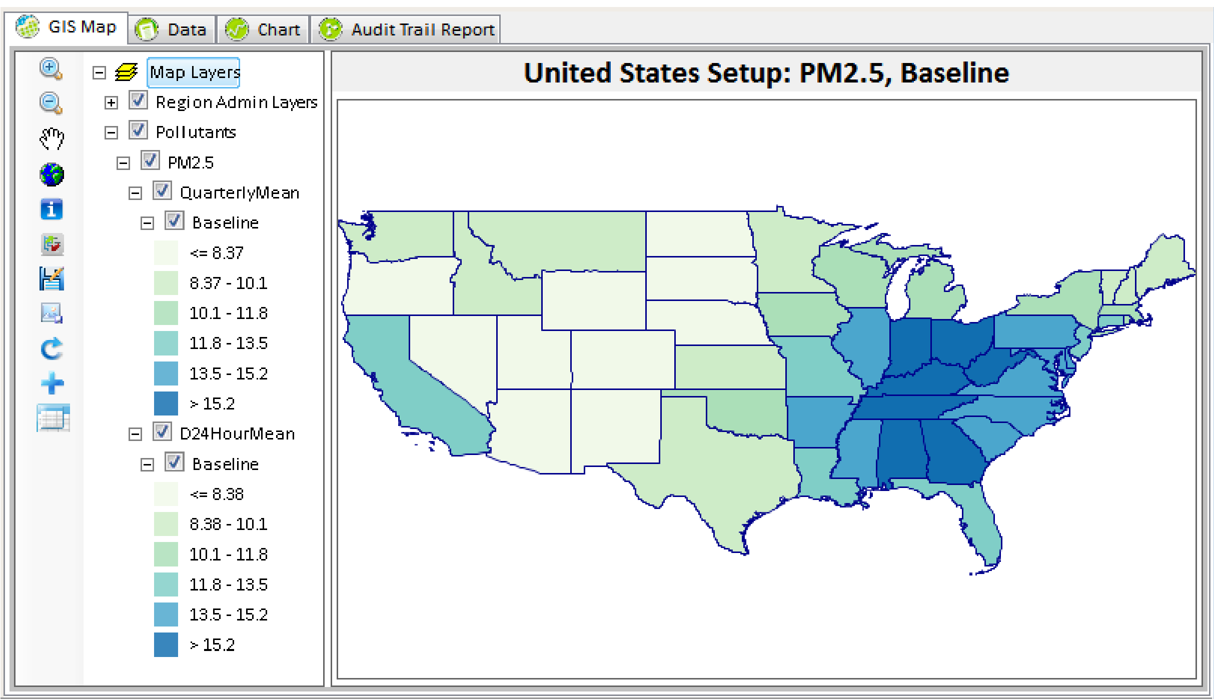
Below is an example of an air quality surface for $PM_{2.5}$ created by the CMAQ model using a 12km grid. (The following images are cropped from the main BenMAP-CE window to focus on the GIS panel.)



Here is an example of the above 12km air quality surface aggregated to the county level.



And, here is an example of the 12km air quality surface aggregated to the state level.



Observe that there is more variation in the county-level file than the state-level file. This is expected, because BenMAP-CE is just using a simple spatially weighted average of the data.

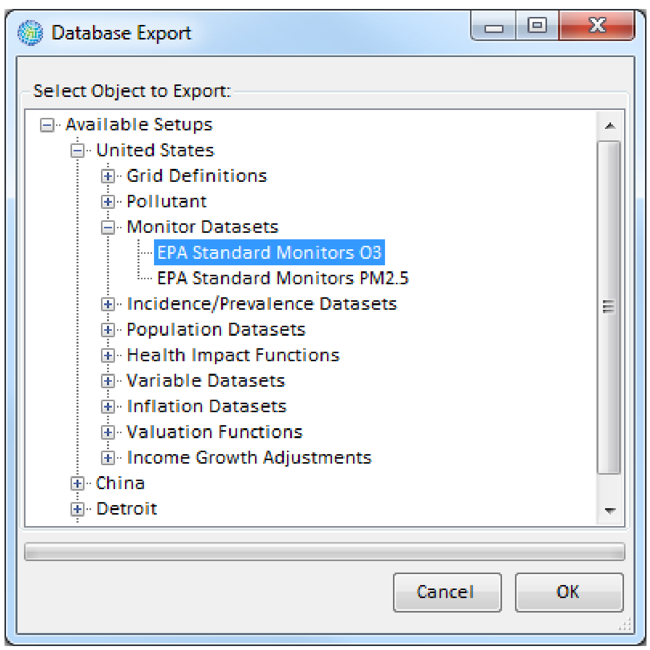
9.2 Database Export

BenMAP-CE allows you to export and import entire databases (all **Available Setups**), individual setups (e.g., *United States, China*), and parts of individual setups (e.g. all **Grid Definitions**, or individual **Health Impact Function** datasets). This functionality can be used to archive data, share data with other BenMAP-CE users, as well as to allow you to move databases between computers. In particular, all of the steps involved in creating a setup can be done just once, after which the data can be exported and then imported on other computers.

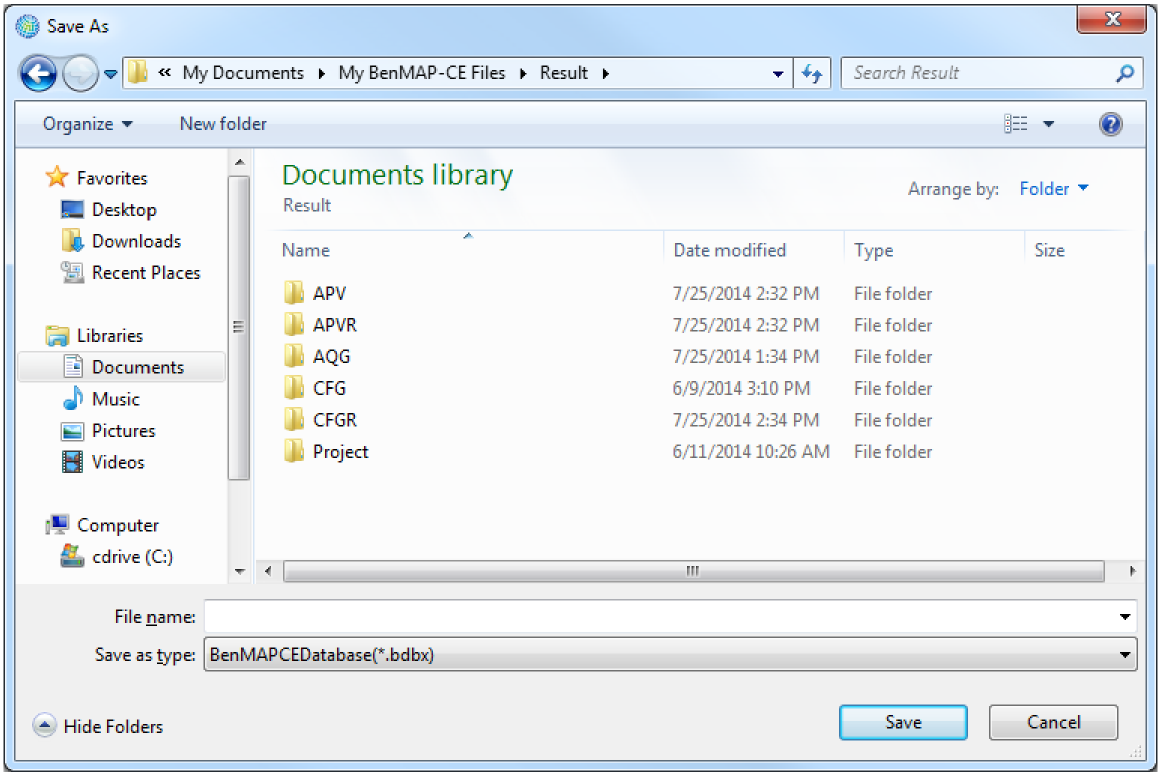
To export part or all of an existing setup, go to the **Tools** menu, and choose the *Database Export* option.

This will bring up the **Database Export** window. Initially, all of the setups are listed in a tree menu, which is initially in a collapsed view. To expand any of the menu items, click on the '+' sign to the left of menu item. This will expand the tree menu to show additional listings for the expanded item. To collapse the tree menu, simply click on the '-' sign.

Choose a dataset to export by selecting it from the tree menu, and then press **OK**. In the screenshot below, we have chosen to export *EPA Standard Monitors O3*.



This will bring up the **Save As** window. From here you may name the export file and choose the save location.

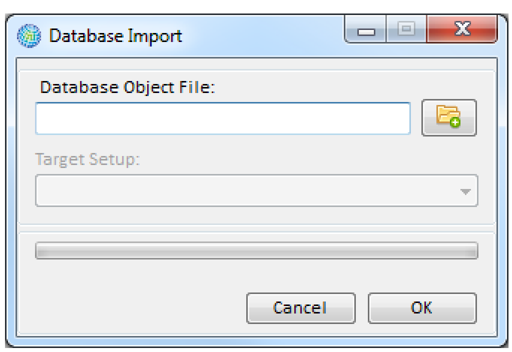


NOTE: Exported BenMAP-CE database files have a *.bdbx* extension, and are a binary format not suitable for viewing in external applications.

9.3 Database Import

Import entire setups or parts of individual setups. This option is described in the Import Setups section of Chapter 4: Loading Data.

To import part or all of an existing setup, go to the **Tools** menu, and choose the *Database Import* option. This will bring up the **Database Import** window.



The **Database Object File** identifies the file that you want to import. Click on the **Browse** icon to locate the file. This will display the **Open** window.

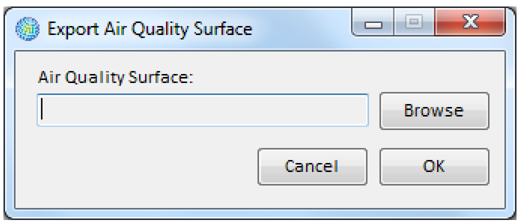
Find and select the *.bdbx* file that you want to import, and then click **Open**. This will return you to the **Database Import** window. Click **OK** to finish the import process.

If the import file contains a subset of a setup, such as a collection (e.g., a set of Grid Definitions) or an individual dataset (e.g., a single grid definition from among many available), select the **Setup** into which it should be imported from the **Target Setup** drop-down list. Click **OK** to finish.

NOTE: Duplicates of datasets (typically identified by their names, e.g., '*Detroit Population*') will overwrite existing data in a setup. New datasets (i.e., non-duplicated) will be added to the setup.

9.4 Export Air Quality Surface

The **Export Air Quality Surface** tool generates a data file (*.csv*) reporting all of the data contained in the air quality grid. After choosing *Export Air Quality Surface* from the **Tools** menu, the **Export Air Quality Surface** window will appear. Click the **Browse** button to choose the air quality grid that you want to examine.



Click **OK** after you have selected your file. Use the **Save As** window to choose the directory where you want to save your file. And in the **File name** box, type in the name of the file.

To help keep track of what you are doing, you might want to use the same file name as your air quality grid, or something very similar. (If you use the same name, you can always distinguish the two files by the extension. An air quality grid has an *.aqgx* extension and the file you are generating here has a *.csv* extension.)

When done, click the **Save** button. You can view the files you have created with any database viewer. For each **Metric** and **Seasonal Metric**, you can see the actual values. In addition, you can see the **Statistics** calculated for each. In the example below for a 12km $PM_{2.5}$ air quality surface, you can see in the first grid cell (Column = 1, Row = 246) that the mean of the *D24HourMean* values is 9.15 and the mean of the *QuarterlyMean* values is 9.2.

Col	Row	D24HourMean	QuarterlyMean
1	246	9.15	9.2
2	246	9.16	9.2
3	246	9.16	9.21
4	246	9.17	9.21
5	246	9.17	9.22
6	246	9.54	9.65

Note that the exported files may be very large (tens to hundreds of megabytes in file size and with row counts exceeding typical spreadsheet applications). With large files, you might need to use a database program to work with the files. Alternatively, these files can also be read by simple text editors.

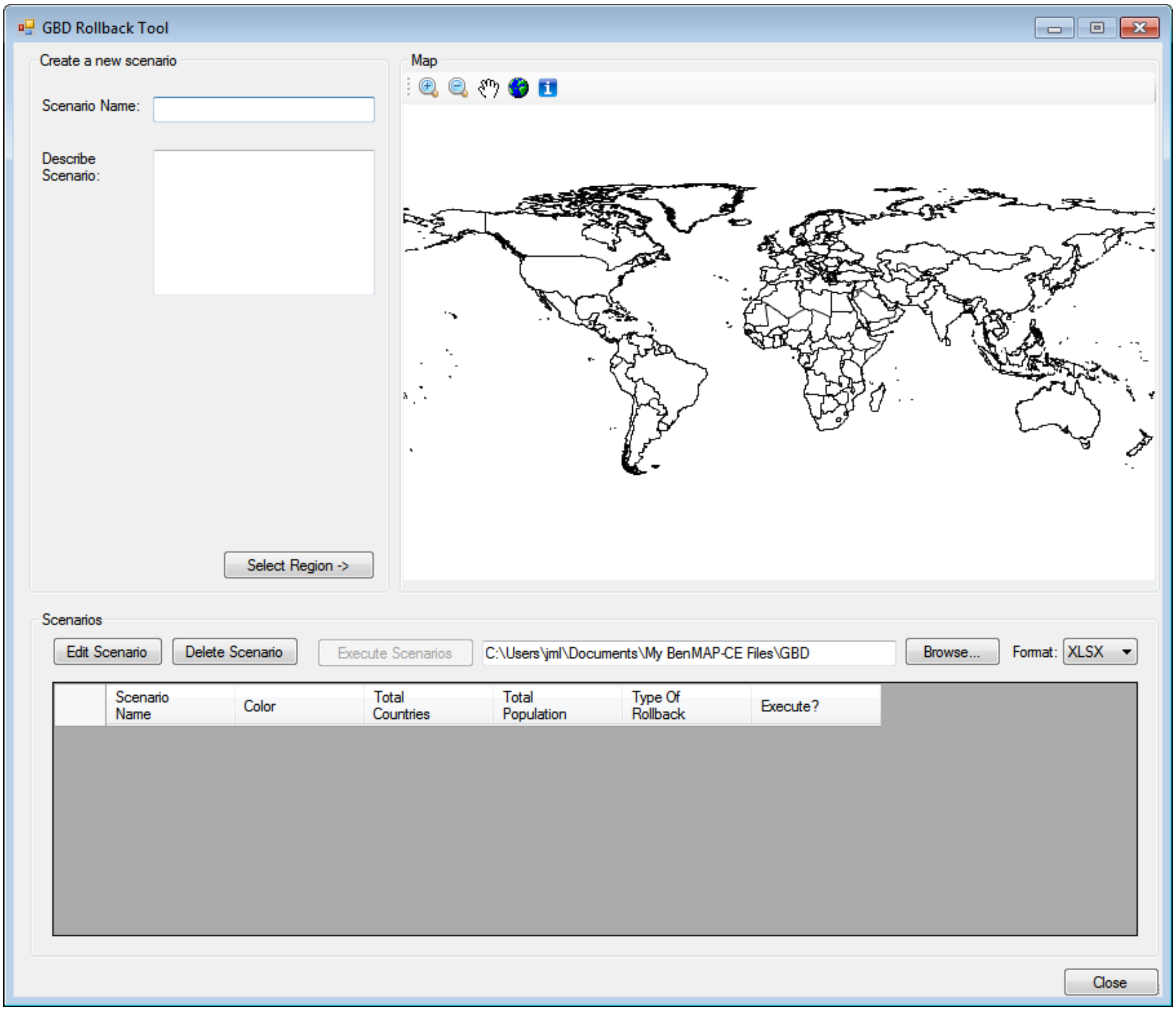
9.5 GBD Rollback

The World Health Organization global burden of disease (GBD) study measures burden of disease using the disability-adjusted-life-year (DALY). This time-based measure combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health. The DALY metric was developed in the original GBD 1990 study to assess the burden of disease consistently across diseases, risk factors and regions.[1]

The **GBD Rollback** tool uses data from the 2010 GBD study to allow users to estimate the human health burden of $PM_{2.5}$ levels in each country as well as the benefits of reducing these air pollution levels. Users can "roll back," or adjust ambient $PM_{2.5}$ levels in one or more countries or regions and calculate the total burden, or avoided deaths, in that region. This new feature is analogous to the monitor roll-back tool already available in core BenMAP-CE (discussed in Chapter 5); that tool allows users to adjust downward (or upward) air quality monitoring data in specified locations according to various algorithms (including proportional, quadratic and incremental rollbacks).

To begin, select *GBD Rollback* from the **Tools** menu. The **GBD Rollback Tool** window will be displayed.

[1] For more information on the GBD, see: http://www.who.int/topics/global_burden_of_disease.



9.5.1 Create New Scenario

To create a new scenario, first provide a **Scenario Name** (required) and description for the scenario (optional). Then, click the **Select Region** button.

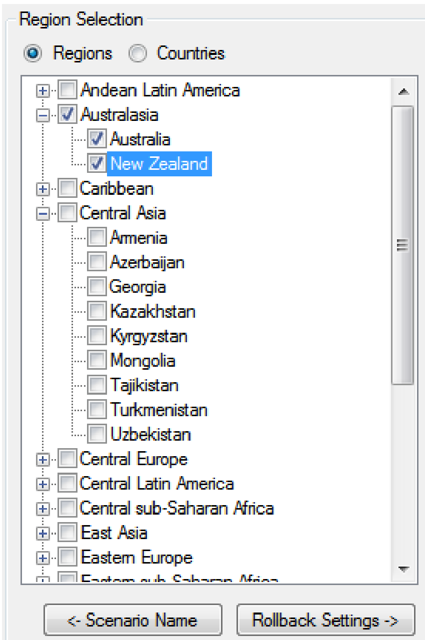
9.5.2 Select Regions or Countries

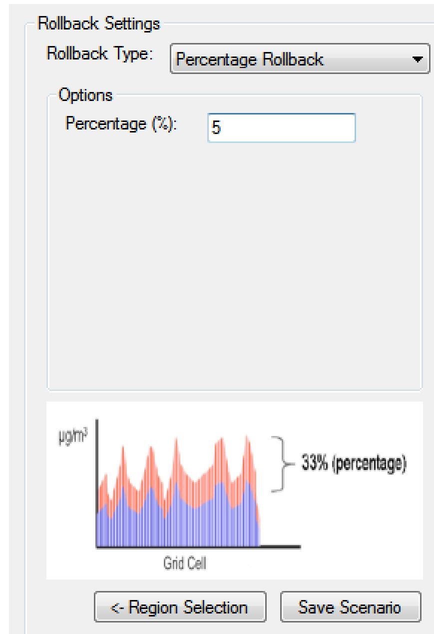
The **Region Selection** box provides options to view *Regions* (as defined in the GBD study) with the associated countries listed beneath, or to view *Countries*. Multiple selections are possible with either selection method and you can toggle between the two.

If you view *Regions*, you can select an entire region (all countries within this region) by checking the box next to the desired region. To view the individual countries for a region, click on the '+' sign to the left of the region. This will expand the tree menu. To collapse the tree menu, simply click on the '-' sign.

If you do not know the name of the region which contains the country you want to select, click the option to view *Countries*. You can search the alphabetically-sorted list to find countries.

As you make selections, the map will highlight them in a bright blue color. Note that the map is not interactive (i.e., you cannot click on the map to make selections). The toolbar located above the map allows you to zoom in and out, pan, view full extent, and identify countries.





9.5.3 Choose Rollback Settings

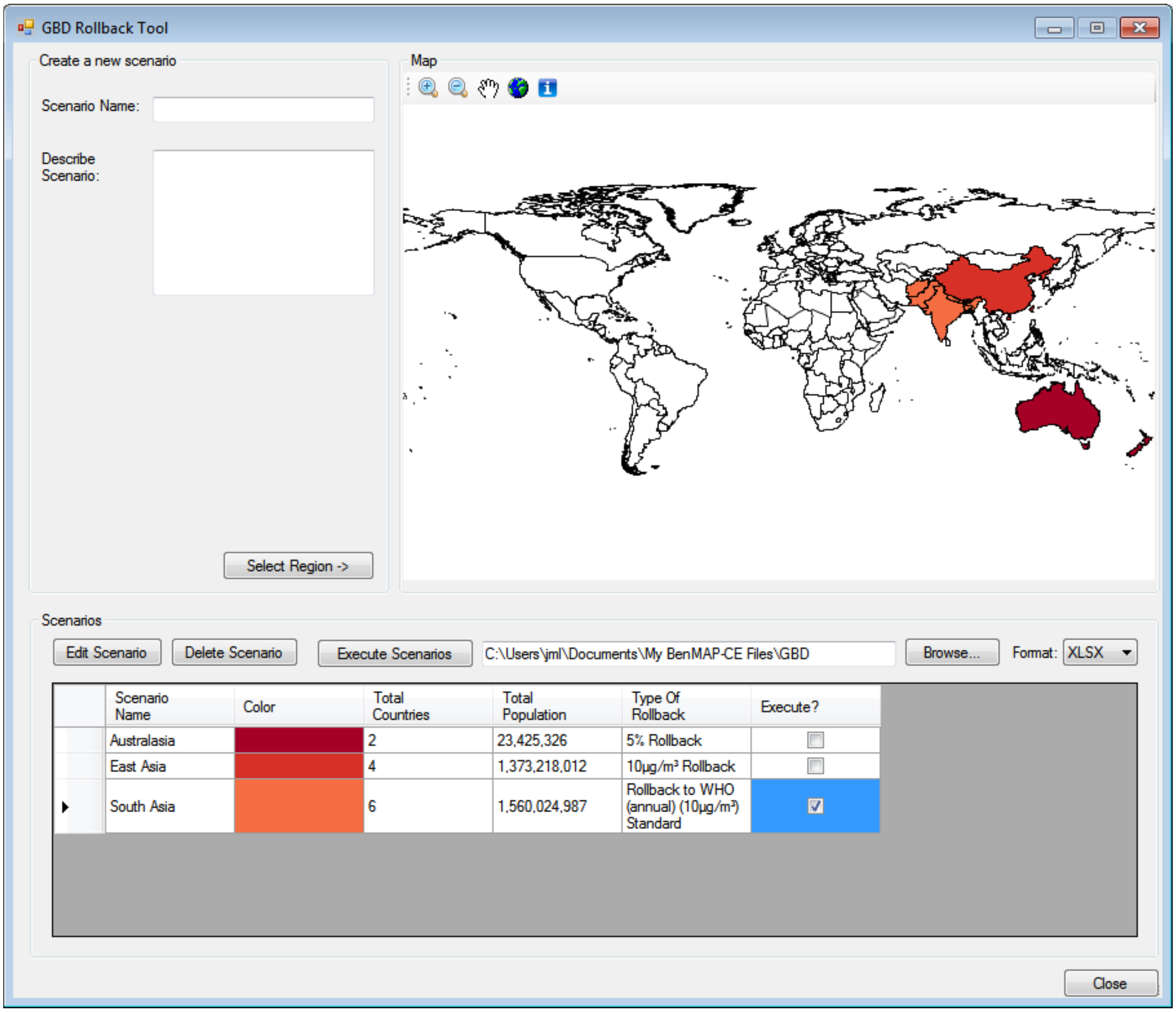
After selecting the countries or regions to analyze, click the **Rollback Settings** button. The **Rollback Settings** pane allows you to choose the **Rollback Type** (*Percentage Rollback*, *Incremental Rollback*, or *Rollback to a Standard*) and configuration options.[2] (An illustrative example for the selected **Rollback Type** will be displayed below the *Options* box.)

For *Percentage* and *Incremental Rollback* types, you must enter a percent value or whole number by which to reduce the pollutant concentration in all grid cells in the selected countries. If you select *Rollback to a Standard*, you may select from a number of national pollutant standards enforced by various countries in different years.

Click the **Save Scenario** button to save your rollback configuration. The map will update the color of the selected countries so that each saved scenario is uniquely different.

[2] The tool uses a background $PM_{2.5}$ concentration = 5.8 $\mu g/m^3$ (lowest measured level in epidemiological literature).

The table at the bottom of the window will update to display the attributes for the saved scenario (*Scenario Name*, *Color*, *Total Countries*, *Total Population*, *Type of Rollback)*, along with an *Execute?* option for you to indicate whether the tool should execute or ignore the scenario.



9.5.4 Execute Scenarios and Save Results

Click the **Execute Scenarios** button to generate results for saved scenarios.

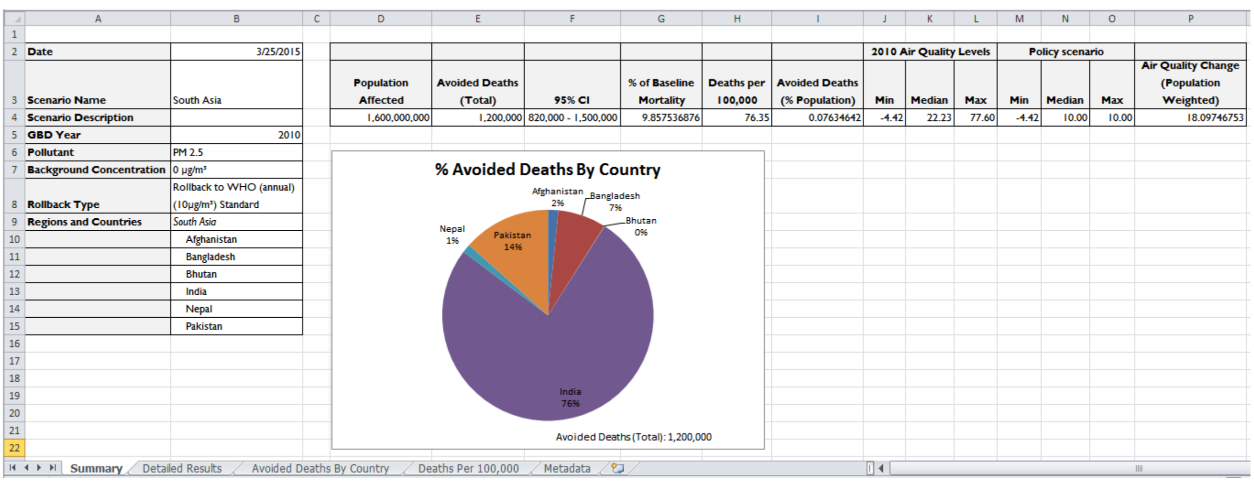
If you are adding to a list of saved scenarios and do not want to re-run the previously executed ones, uncheck *Execute?* in the summary table so that only the new scenario is checked.

Upon execution, the **GBD Rollback** tool will export results in (*.xlsx* format) to a default file location.[3] You can change the file location by clicking the **Browse** button. You can also change the export file format to *CSV* by clicking on the **Format** drop-down list. The results file is named using the *Scenario Name* followed by the time stamp of scenario execution.

- The *XLSX* option provides a formatted summary table, detailed results, charts, and metadata about the supporting datasets used in this analysis.
- The *CSV* option will only create two files: one containing the summary data and one with detailed results.

If you want to edit or delete saved scenarios, select one record at a time from the scenario table (use the record selector on the left side of the grid) and click the **Edit Scenario** or **Delete Scenario** button. If a scenario is edited and re-executed, the timestamp in the filename will help the user identify the new version.

Once you close the **GBD Rollback** tool, the scenarios are cleared from memory; scenarios are not saved in the BenMAP-CE database. Information about the scenario configurations are saved in the results file to help you document the analysis and re-create it if necessary.



The GBD results file (*.xlsx* format) contains 5 worksheet tabs, described as follows:

- **Summary**: Gives a basic background on the scenario chosen, including name, description, pollutants, rollback type, and countries. It also provides a quick overview of total and affected population results.

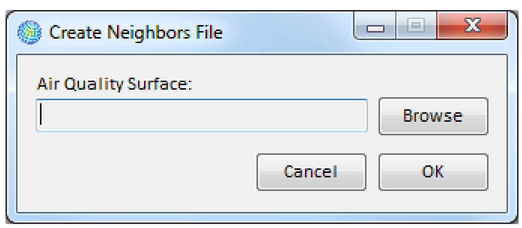
[3] The files are stored by default at the following location: C:\Users\<User Name>\Documents\My BenMAP-CE Files\GBD.

- **Detailed Results**: Gives in-depth breakdown of population and results for each selected country. Important fields on this tab include *Population Affected*, *Avoided Deaths (Total)*, and *Avoided Deaths (%Population)*.
- **Avoided Deaths by Country**: Displays the number of avoided deaths for the region and by country in a bar graph. This graph was generated from the data on the **Detailed Results** tab.
- **Deaths Per 100,000**: Displays the number of deaths for each country (with a population multiplier of 100,000) in a bar graph. This graph was generated from the data on the **Detailed Results** tab.
- **Metadata:** Provides supplementary information about the underlying data and functions used by the **GBD Rollback** tool.

9.6 Neighbor File Creator

The **Neighbor File Creator** tool generates a file containing gridded monitor data created by BenMAP-CE for *Monitor Data* or *Monitor Rollback* air quality surfaces.

To start, choose *Neighbor File Creator* from the **Tools** drop-down menu. This will bring up the **Create Neighbors File** window. Click on the **Browse** button, and find the air quality surface you want to analyze.



After locating the file, click the **OK** button. The file path for the selected file will be displayed in the **Air Quality Surface** box. Click **OK**. A **Save As** window will open. Provide a file name for the **Neighbors file (.csv)** you want to create and click **Save**. An example Neighbors File is shown below.

Col	Row	MonitorName	Weight	Distance
1	246	410030013881011	0.215167	627.5258
1	246	530410006881011	0.253047	533.5881
1	246	530090009881011	0.286508	471.2713
2	246	410030013881011	0.213318	620.813
2	246	530410006881011	0.252881	523.688
2	246	530090009881011	0.287978	459.8632
3	246	410030013881011	0.211387	614.2613
3	246	530410006881011	0.252682	513.8765
3	246	530090009881011	0.289525	448.4836

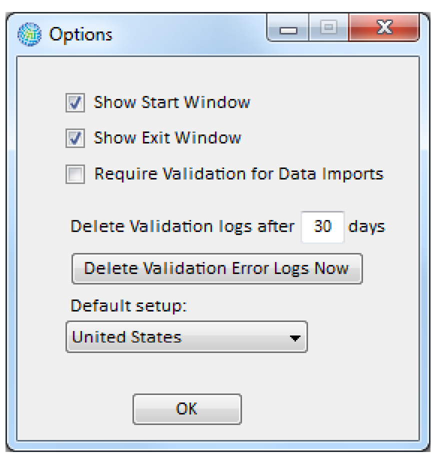
The first two columns specify the *Column* and *Row* variables for each grid cell. In the example above, you will see that Column = 1 and Row = 246 are repeated three times, indicating that three different monitors were used to estimate air quality at this grid cell. The *MonitorName* column provides the monitor identifier. The *Weight* column specifies the weight used in the air quality calculation (e.g., *Voronoi Neighbor Averaging*). And the *Distance* column gives the distance (in kilometers) from the monitor location to the center of the grid cell.

Note that if an air quality grid was created using the *Closest Monitor* option (see Chapter 5 under the Monitor Data section), then only a single monitor is used for any given grid cell. As a result, the neighbor file will contain the same 5 fields, but the *Weight* column will contain a value of "1" all the way down. In addition, there will only be one entry for each grid cell.

Col	Row	MonitorName	Weight	Distance
1	246	410030013881011	1	627.5258
2	246	410030013881011	1	620.813
3	246	410030013881011	1	614.2613
4	246	410030013881011	1	607.8755
5	246	410030013881011	1	601.661
6	246	410671003881011	1	548.5376
7	246	410671003881011	1	541.038
8	246	410671003881011	1	533.702

9.7 Options

You can customize some of the generic options for BenMAP-CE using the *Options* window available from the **Tools** menu.



- **Show Start Window**: If unchecked, the **Welcome** window will not appear during subsequent start-ups. You can update your choice at any time.

- **Show Exit Window:** If unchecked, the window confirming you would like to exit will not appear during subsequent shut-downs. You can update your choice at any time.

- **Require Validation for Data Imports:** If checked, you will be required to validate their input files prior to importing datasets. If unchecked, validation will be an available option but it will not be required.

- **Delete Validation logs after __ days:** You can specify the number of days BenMAP-CE will retain the validation logs (the default value is 30 days). If the number of days is left blank, BenMAP-CE will not automatically delete any validation logs.[4]

- **Delete Validation Error Logs Now:** Select this button if you want to immediately clear all validation logs*. Note: There is no confirmation option here – once the button is clicked, all logs will be deleted.*

- **Default setup:** Select the preferred setup to appear by default in the main BenMAP-CE window.

[4] Validation logs are saved at C:\Users\<User Name>\Documents\My BenMAP-CE Files\ValidationResults.