

# Herramientas para determinar impactos a la salud usando observaciones y modelos

The logo features a stylized globe with a light blue and white color scheme. Overlaid on the globe is the text "BenMAP" in a sans-serif font. "Ben" is in blue and "MAP" is in green. Below the text is the official seal of the United States Environmental Protection Agency (EPA), which includes a green plant, a blue sun, and the text "UNITED STATES ENVIRONMENTAL PROTECTION AGENCY".

BenMAP

Environmental Benefits Mapping and Analysis Program

# En las noticias, el análisis de costo beneficio

“La nueva norma resultará en beneficios a salud valorizados en \$2 a \$19 billones con un costo estimado de \$7.6 a \$8.5 billones, de acuerdo a la USEPA. ”

- Bloomberg.com

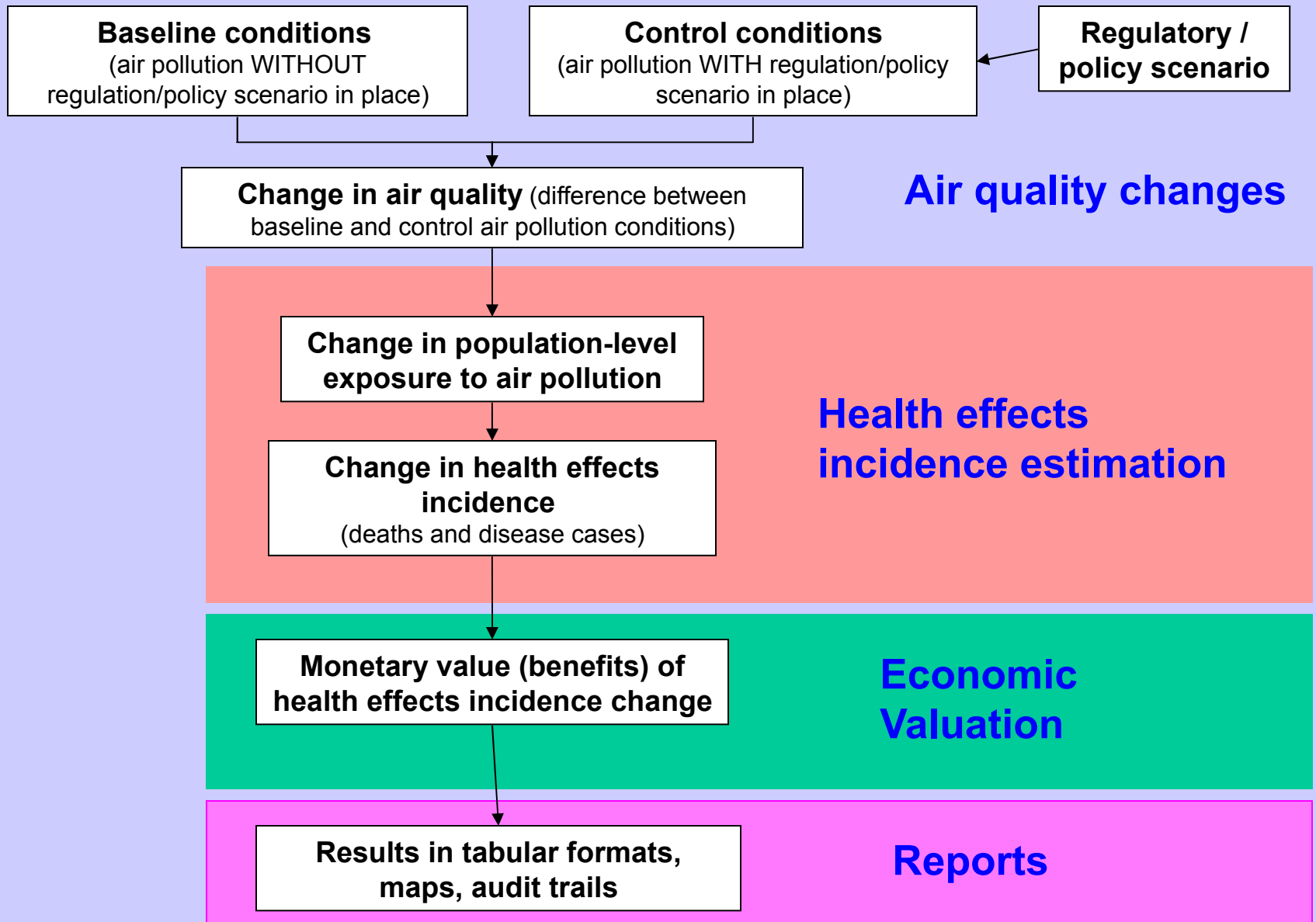
“Los beneficios de la nueva norma de PM2.5 en Chile generará 138.000 menos muertes prematuras en un período de 30 años, además de 30 millones de días de trabajo perdidos evitados .”

- El Mercurio, Santiago

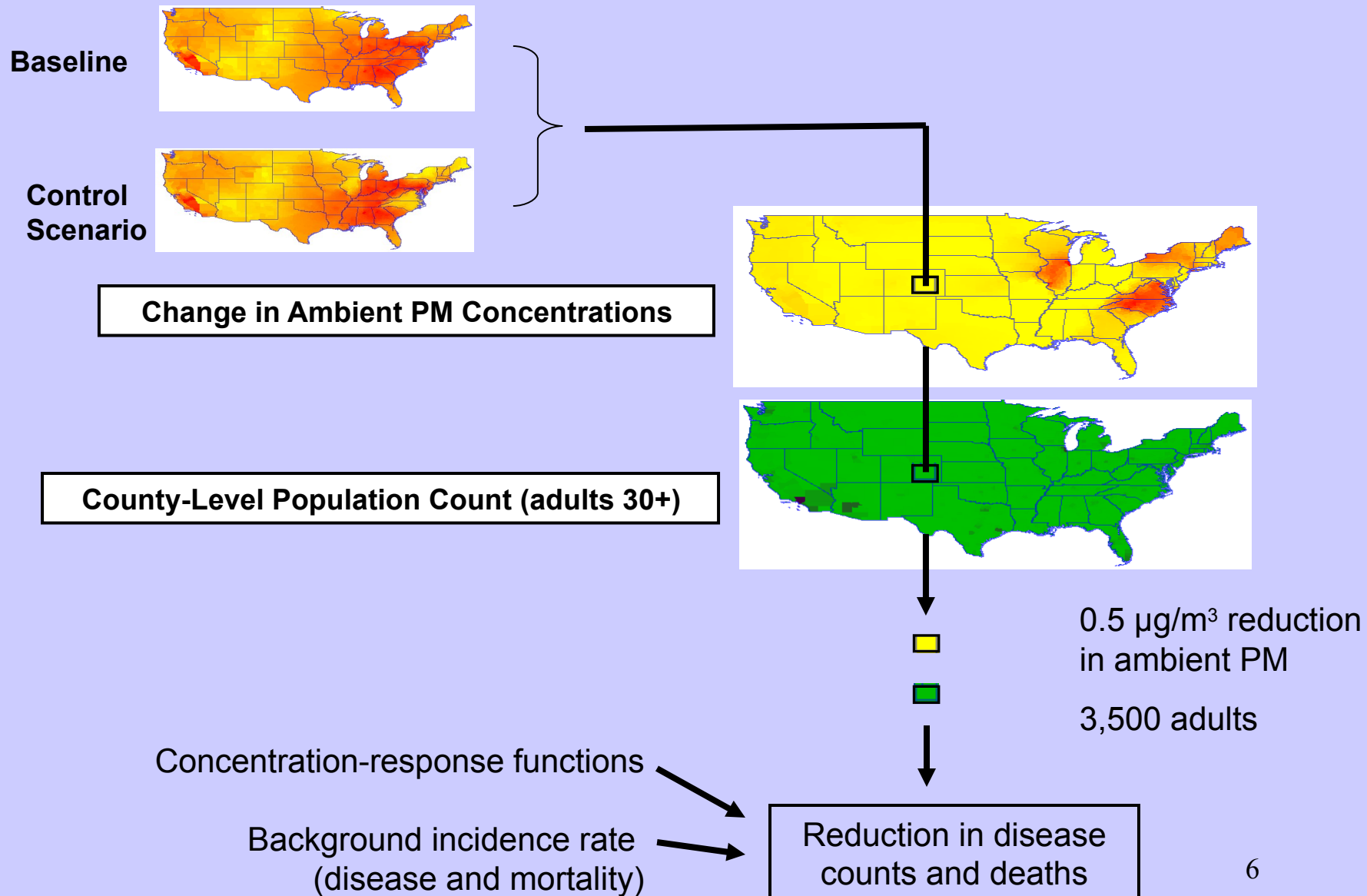
## ¿Qué clase de preguntas puede dar BenMAP?

- ¿Cuáles son los beneficios de los cambios observados o modelados de las concentraciones ambientales de PM u O<sub>3</sub>?
- ¿Qué beneficios se lograrían con escenarios hipotéticos tales como?
  - Si se reducen los niveles de ozono en Texas en 20%
  - ¿Si una ciudad cumpliera una norma diaria de 40 µg/m<sup>3</sup> de PM<sub>2.5</sub> qué cantidad de muertes, ataques de asma u otras enfermedades se evitarían?  
¿Qué valoración económica tendría?
  - ¿Qué escenarios regulatorios modelados presentarían los mayores beneficios?

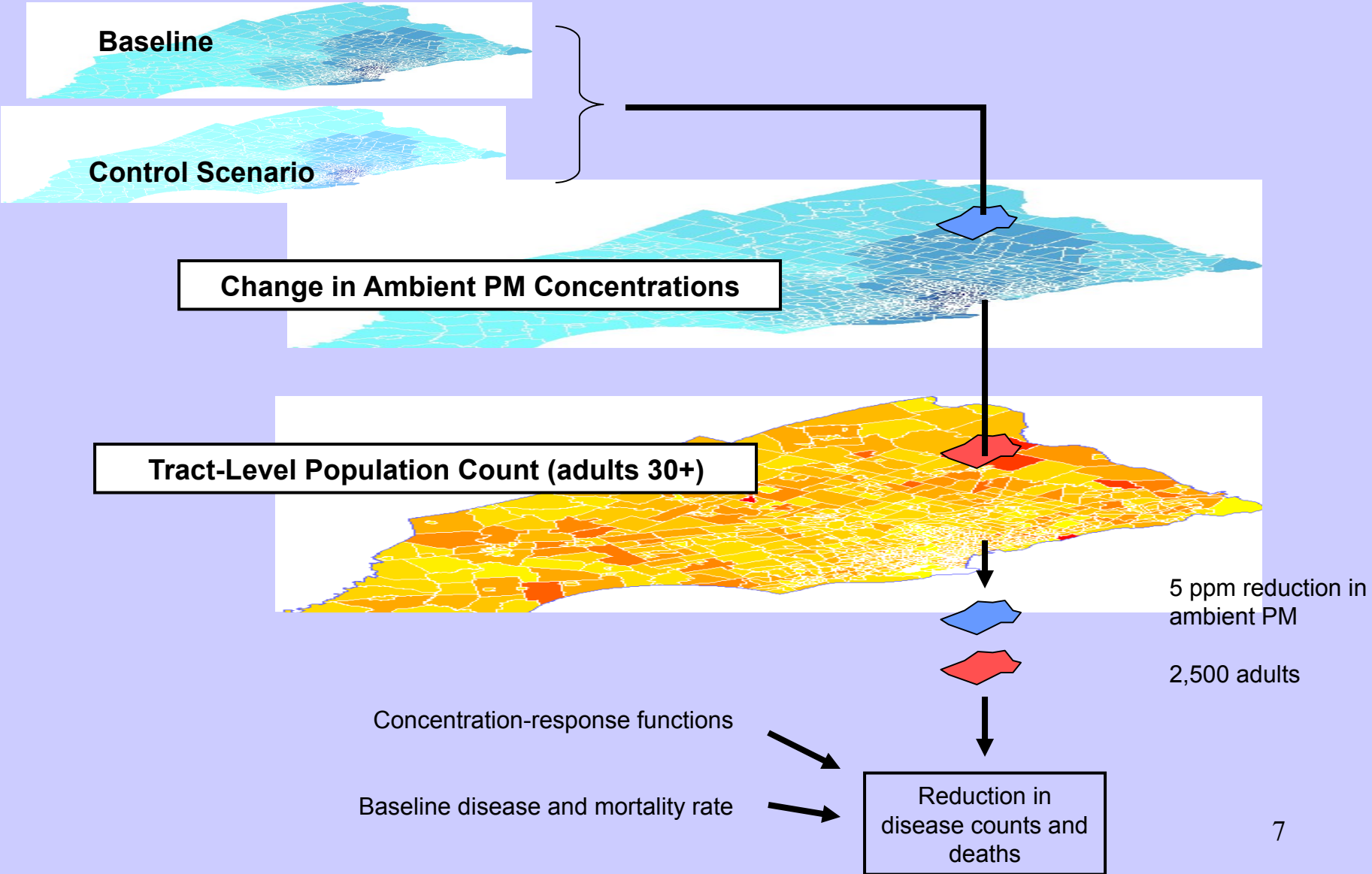
# Steps in BenMAP Analysis



# Benefits Analysis – GIS-based Spatial Context



# Benefits analysis – GIS-based spatial context



# Generation of Benefits Estimates

## Health Incidence Results:

$$\text{Mortality reduction} = \text{Air quality change} \times \text{Effect estimate} \times \text{Incidence rate} \times \text{Population}$$

Change in annual pollution concentration (baseline – control ) ( $\mu\text{g}/\text{m}^3$ )	Percent change in incidence per $\mu\text{g}/\text{m}^3$	Annual mortality rate (deaths/population per year) (background incidence rate)	People within specified age group
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$$\begin{aligned} \text{Mortality reduction} &= 8 \times 0.00402 \times 0.01 \times 3700 \\ &= 1.2 \text{ deaths avoided} \end{aligned}$$

## Valuation Results:

$$\begin{aligned} \text{Monetized Benefit} &= \text{Incidence Result} \times \text{Valuation Function} \\ &= 1.2 \times \$5,000,000 \text{ (VSL)} \\ &= \$6 \text{ million} \end{aligned}$$



# BenMAP User Interface – Main Window

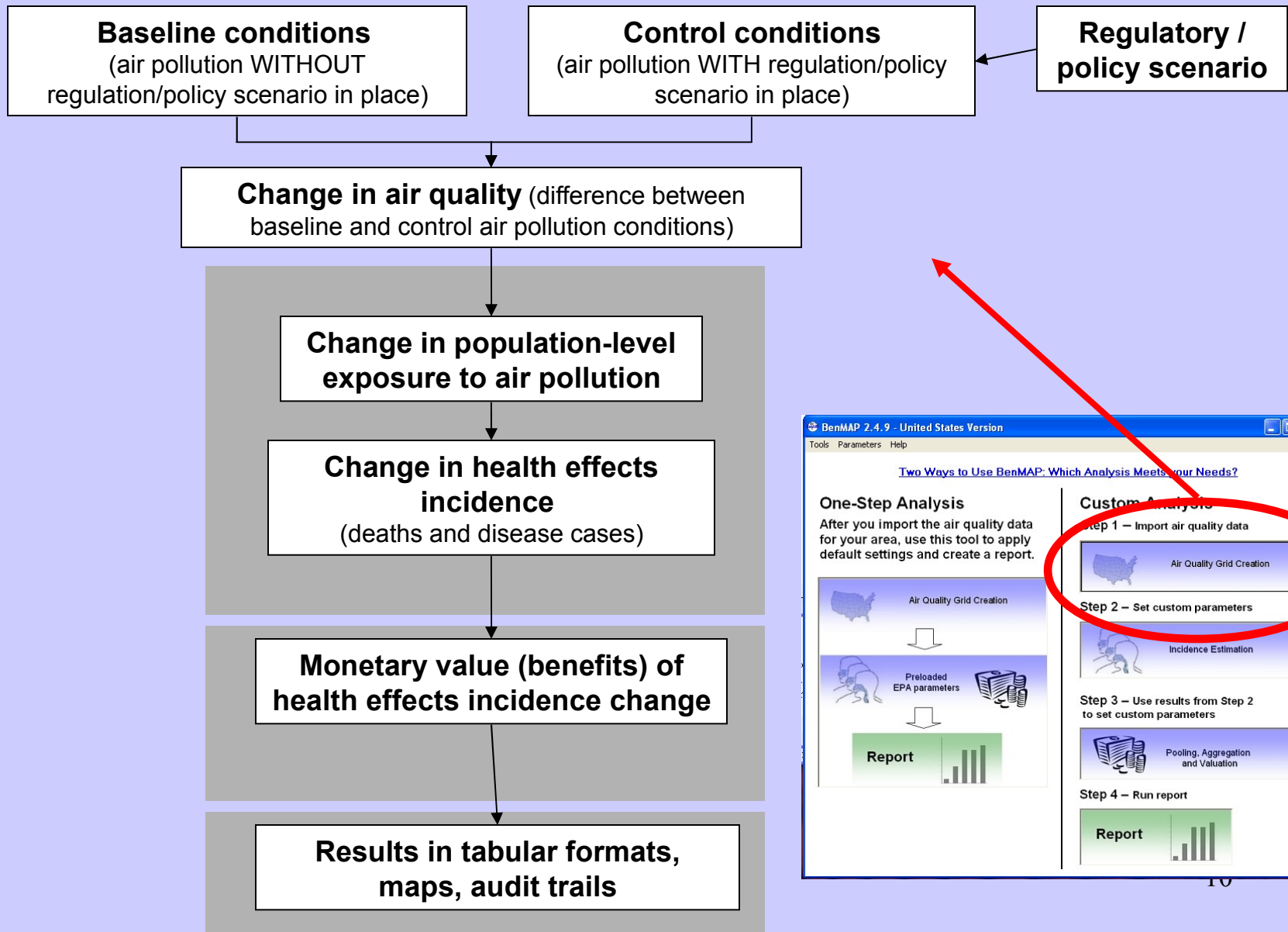
“All-in-one”

Simplified approach

Separate steps

Detailed approach

# Steps in Analysis – 1 of 4 – Creating Air Quality Grids



# Steps in Analysis – 1 of 4 – Creating Air Quality Grids

## Inputs:

### Air Quality Monitoring Data:

- preloaded into BenMAP database
- e.g., PM<sub>2.5</sub> monitoring data for 2000

### Air Quality Modeling Data:

- external files
- e.g., CMAQ, CAMx model runs for 2020

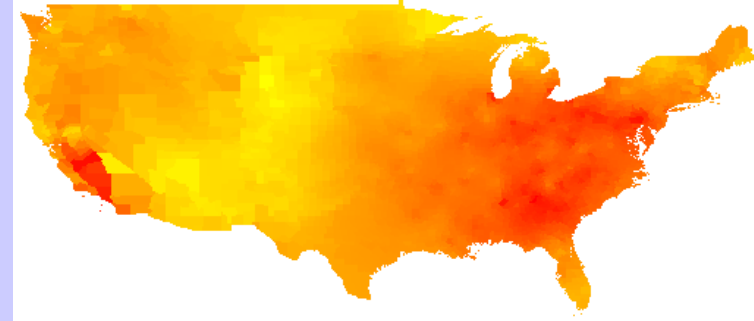
## Outputs:

### Air Quality Grid (aqg):

- BenMAP data format for storing air pollution data
- Baseline and Control aqg

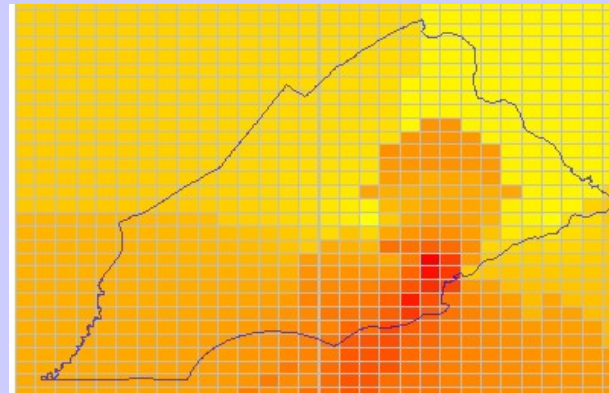
## Key Terms:

- Baseline aqg — this scenario is usually considered the reference scenario, where emissions and air quality are not adjusted or controlled.
- Control aqg — this scenario is a sensitivity scenario, where emissions and air quality are adjusted from the baseline scenario due to pollution controls or other assumptions.



# Air Quality Grid Creation – Model Direct

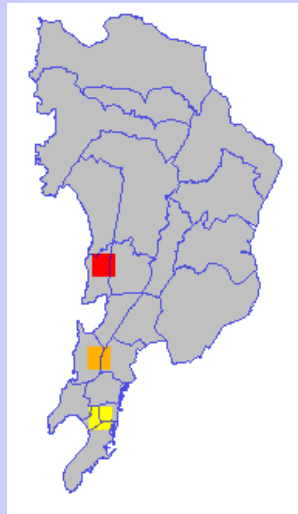
**Model direct:** grid cell pattern reflects model design. Area-weighted averaging is often required.



# Closest Monitor & Voronoi Neighbor Averaging (VNA)

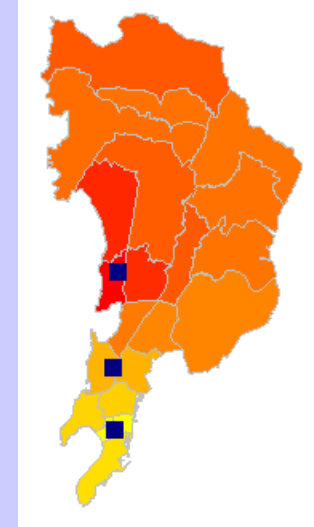
**Monitor direct:** spread (interpolate) monitor data using different approaches

*PM10 Monitors*

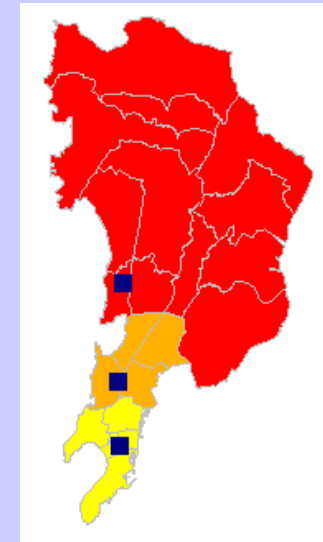


**Interpolation**

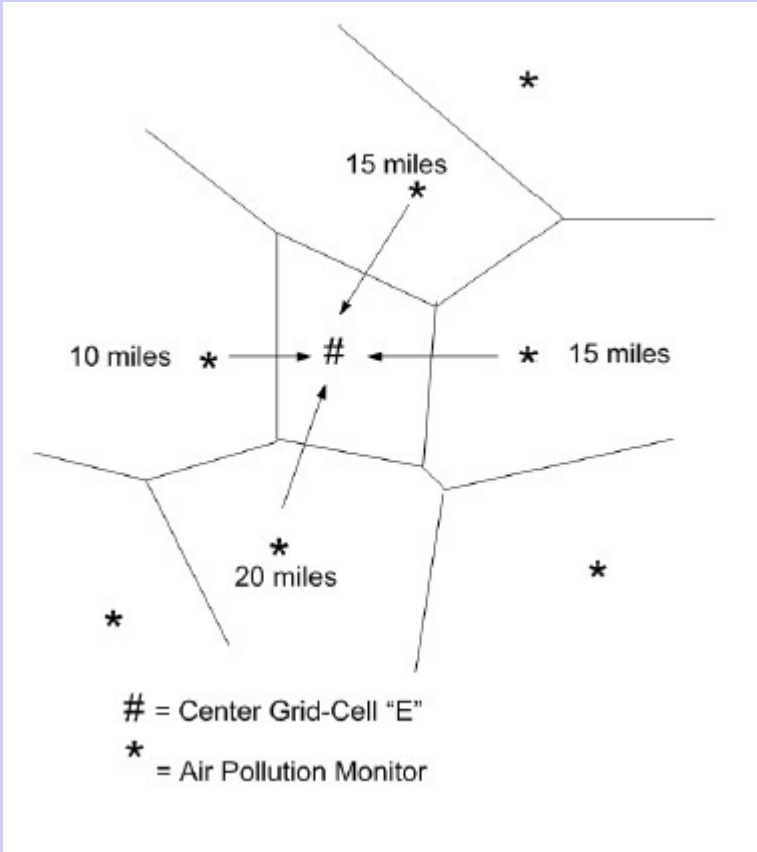
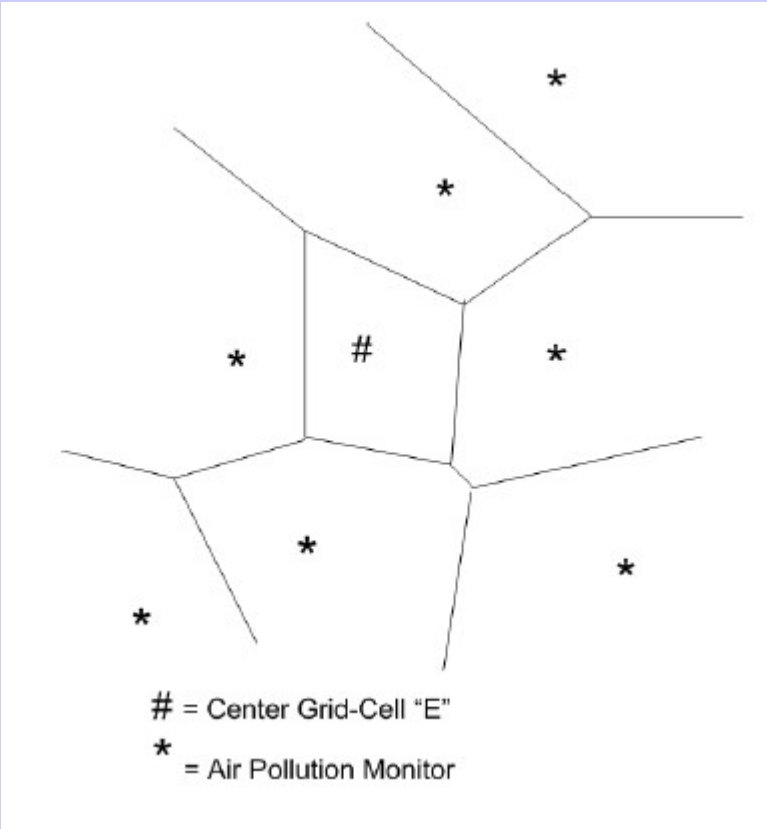
**VNA**



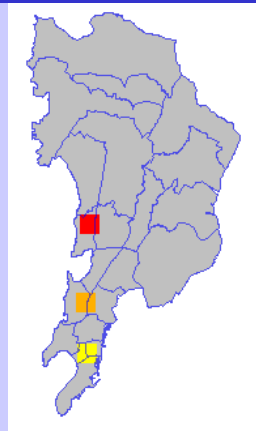
**Closest Neighbor**



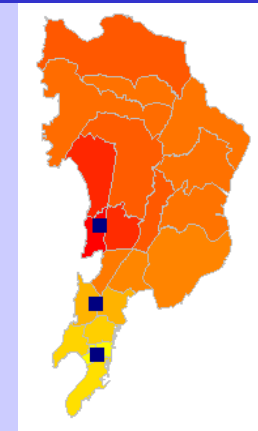
# Voronoi Neighbor Averaging (VNA)



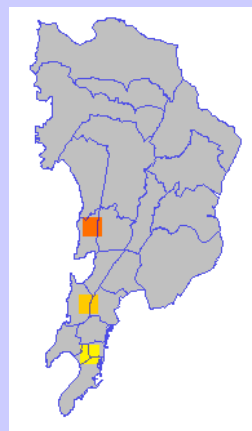
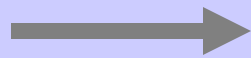
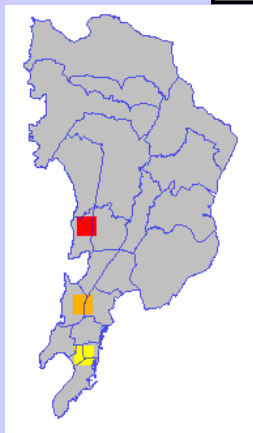
# Monitor Data – Rollback Introduction



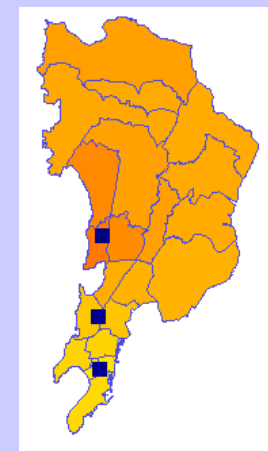
**Baseline Scenario:  
Interpolate 2000 Monitors**



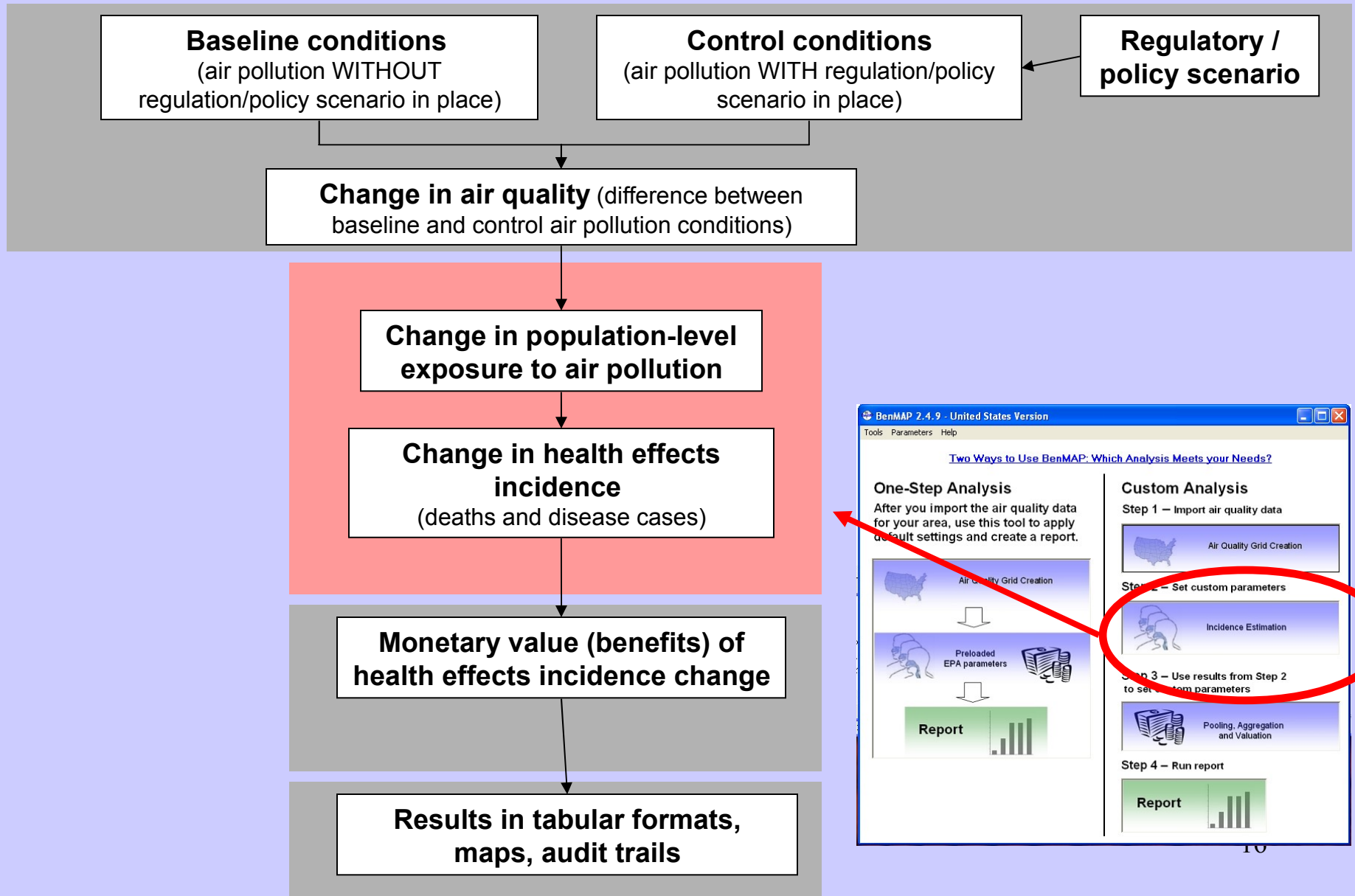
**Control Scenario (Step 1):  
Rollback 2000 Monitors**



**Control Scenario (Step 2):  
Interpolate Reduced Monitors**



# Steps in Analysis – 2 of 4 – Health Incidence Results





# Steps in Analysis – 2 of 4 – Health Incidence Results

## Inputs:

Baseline and Control aqg:

Population Data

- e.g., U.S. Census 2000 interpolated to the CMAQ grid

Background Incidence Rates

- e.g., projections of background mortality rates to 2020

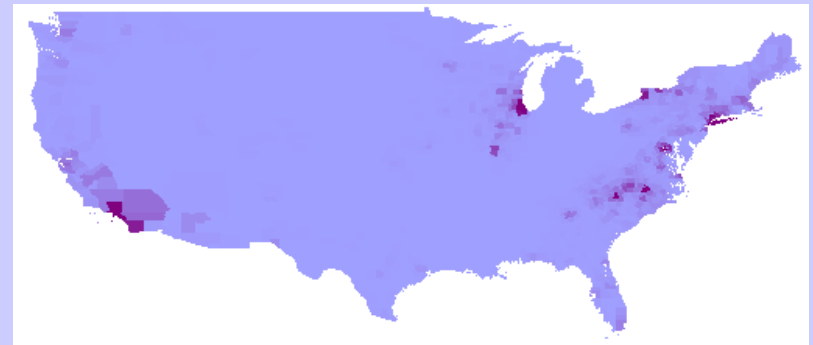
Health Impact Functions

- e.g., specific mortality function based on a study that quantifies the change in mortality due to a change in air quality

## Outputs:

Health Incidence Results (cfgr):

- BenMAP data format for storing health incidence results and related results
- Health incidence results:
  - number of avoided deaths
  - number of avoided asthma attacks
- Air quality delta:
  - **change** in air quality (baseline - control)



# Steps in Analysis – 2 of 4 – Health Incidence Results

## Key Terms:

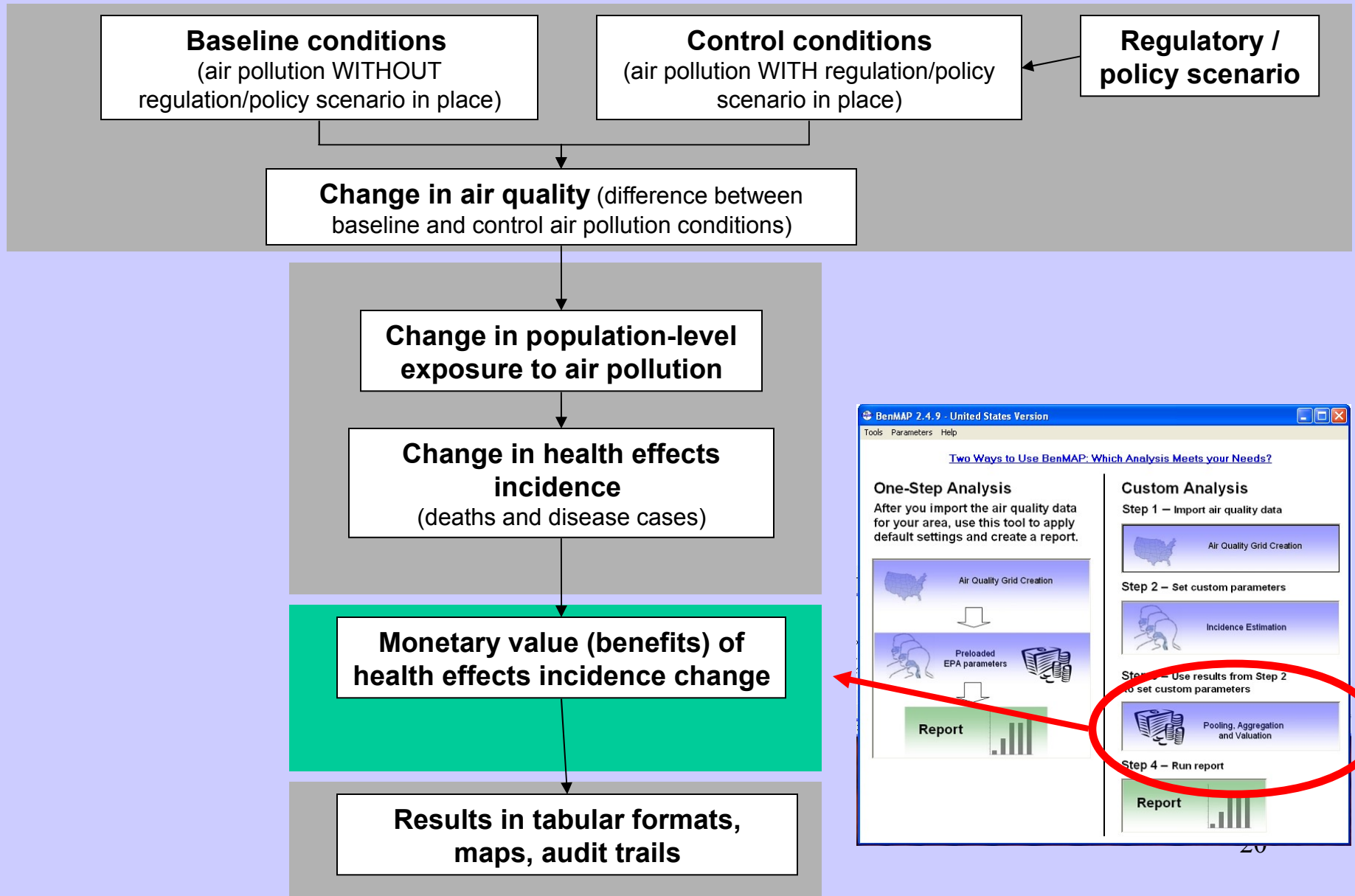
- Background Incidence Rate — the background rate of a health effect per person in a geographic area due to all causes (including air quality)
  - e.g., 1.24 mortalities/(10,000 people per year) for a particular county
- Health Incidence Results — the **change** in total number of adverse health effects due to a **change** in AQ (baseline - control). Typically, this is the result of a BenMAP analysis.

# Steps in Analysis – 2 of 4 – Health Incidence Results

## Health effects currently quantified in BenMAP:

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

# Steps in Analysis – 3 of 4 – Valuation Results



# Steps in Analysis – 3 of 4 – Valuation Results

## Inputs:

Health incidence results (cfgr)

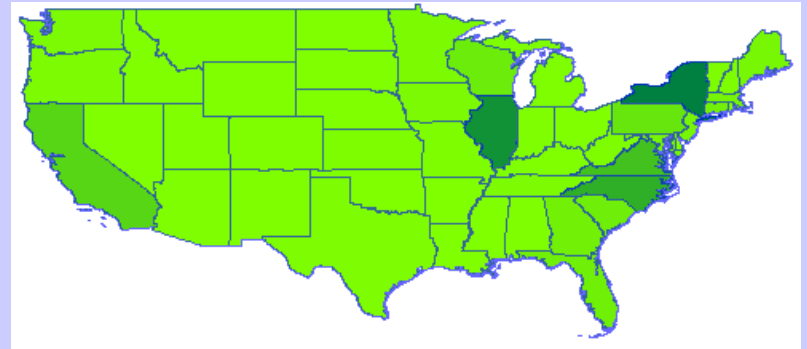
Valuation functions

- e.g., Value of a Statistical Life (VSL)

## Outputs:

Valuation results (apvr):

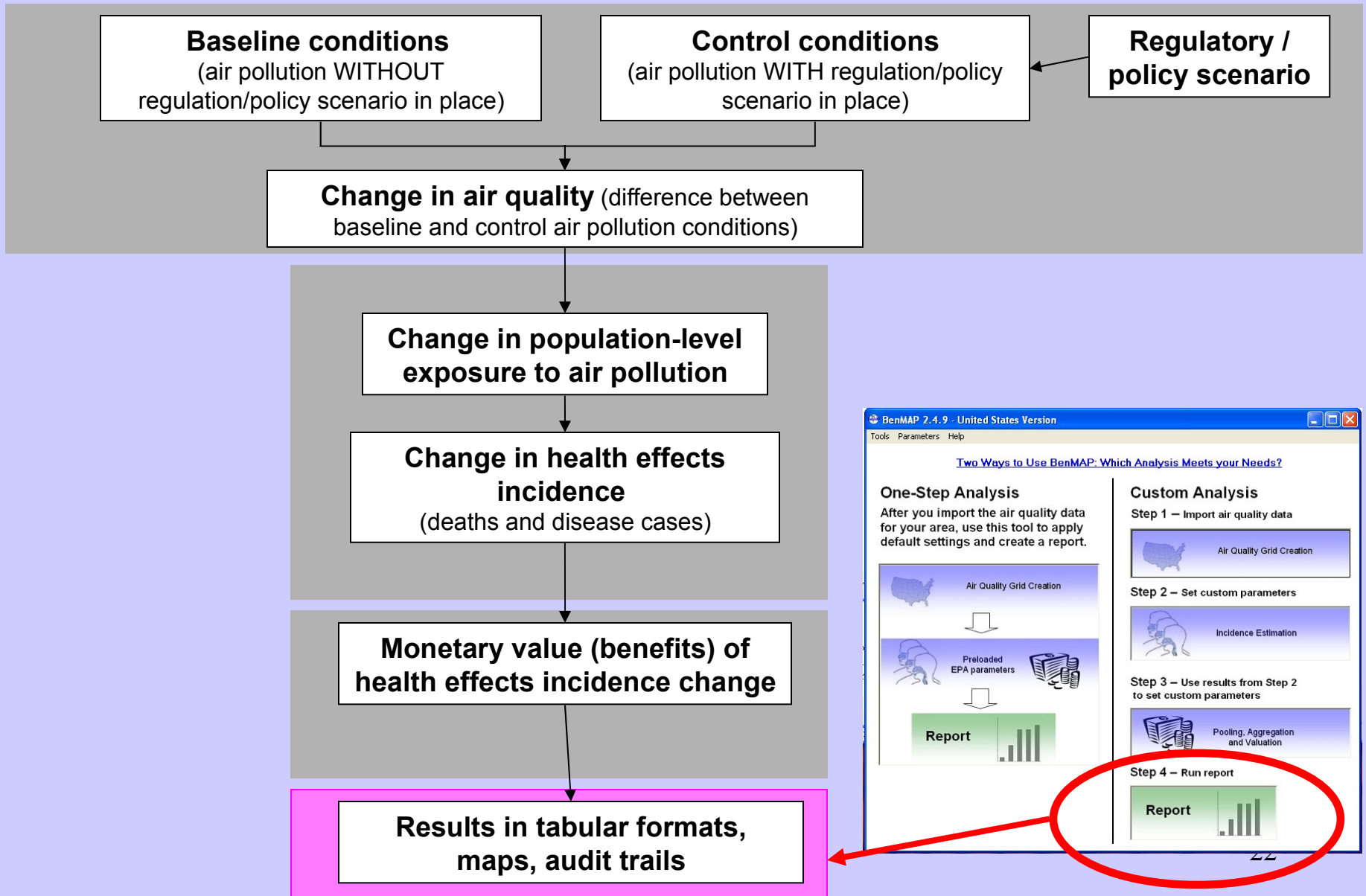
- BenMAP data format for storing valuation results and related results
- Valuation results:
  - Monetized benefits (\$) of the avoided deaths
  - Monetized benefits (\$) of the avoided asthma attacks
- Whole series of related results



## Key Terms:

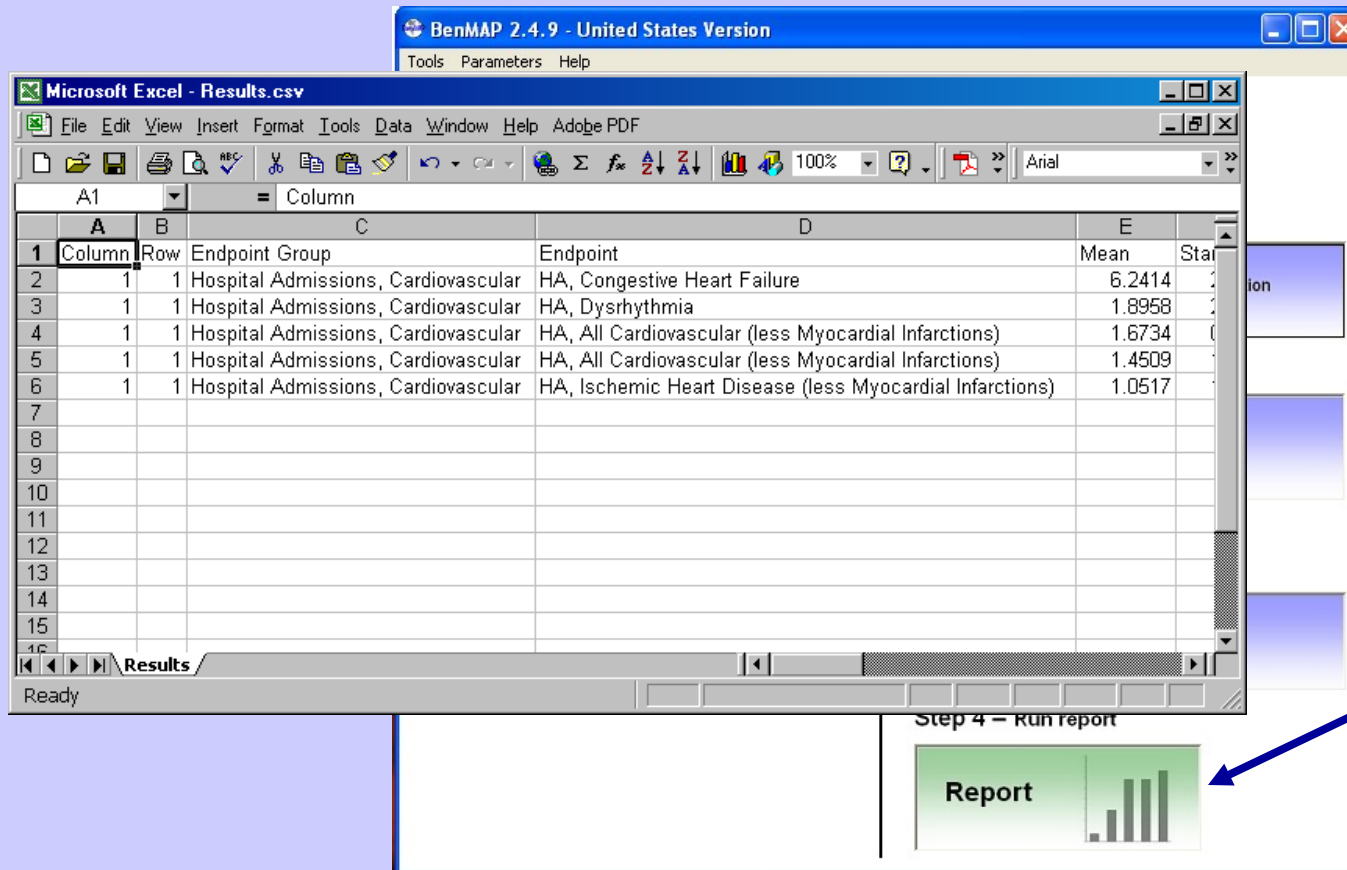
- Monetized — expressing society's preferences for avoiding certain health effects as a dollar value. In BenMAP we estimate monetized benefits by using either Willingness-to-Pay or Cost-of-Illness valuation functions.

# Steps in Analysis – 4 of 4 – Generating Reports



# Steps in Analysis – 4 of 4 – Generating Reports

BenMAP can generate tabular reports (\*.csv files) that can be viewed in various spreadsheet and database applications



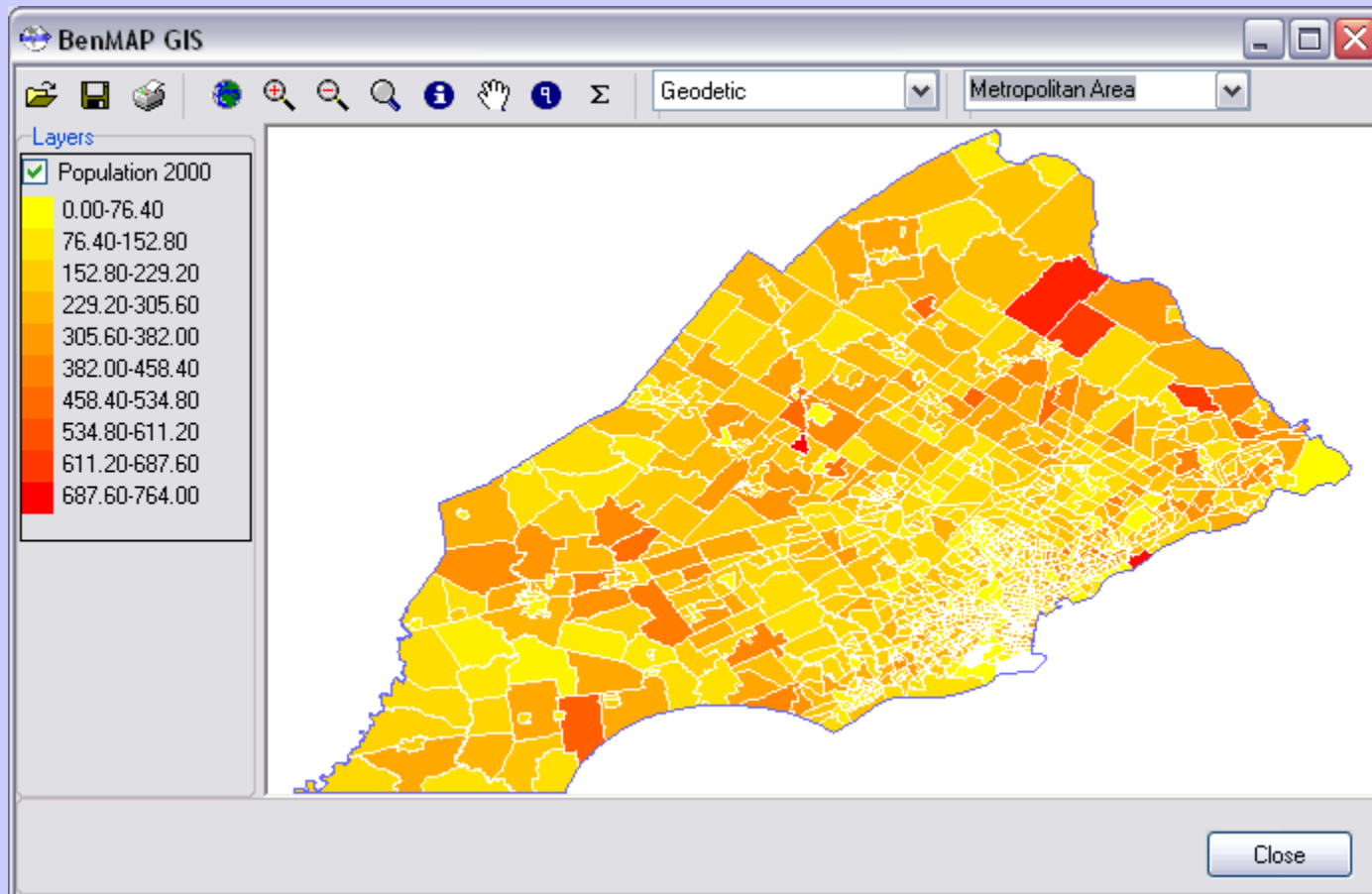
The screenshot displays the BenMAP 2.4.9 - United States Version interface. A Microsoft Excel window titled "Results.csv" is open, showing a table with the following data:

Column	Row	Endpoint Group	Endpoint	Mean	Standard Deviation
1	1	Hospital Admissions, Cardiovascular	HA, Congestive Heart Failure	6.2414	1.8958
2	1	Hospital Admissions, Cardiovascular	HA, Dysrhythmia	1.8958	1.6734
3	1	Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	1.6734	1.4509
4	1	Hospital Admissions, Cardiovascular	HA, All Cardiovascular (less Myocardial Infarctions)	1.4509	1.0517
5	1	Hospital Admissions, Cardiovascular	HA, Ischemic Heart Disease (less Myocardial Infarctions)	1.0517	

Below the Excel window, a "Step 4 – Run report" button is visible, featuring a bar chart icon and the word "Report". A blue arrow points from the "Report" button towards the right side of the slide.

# Steps in Analysis – 4 of 4 – Generating Reports

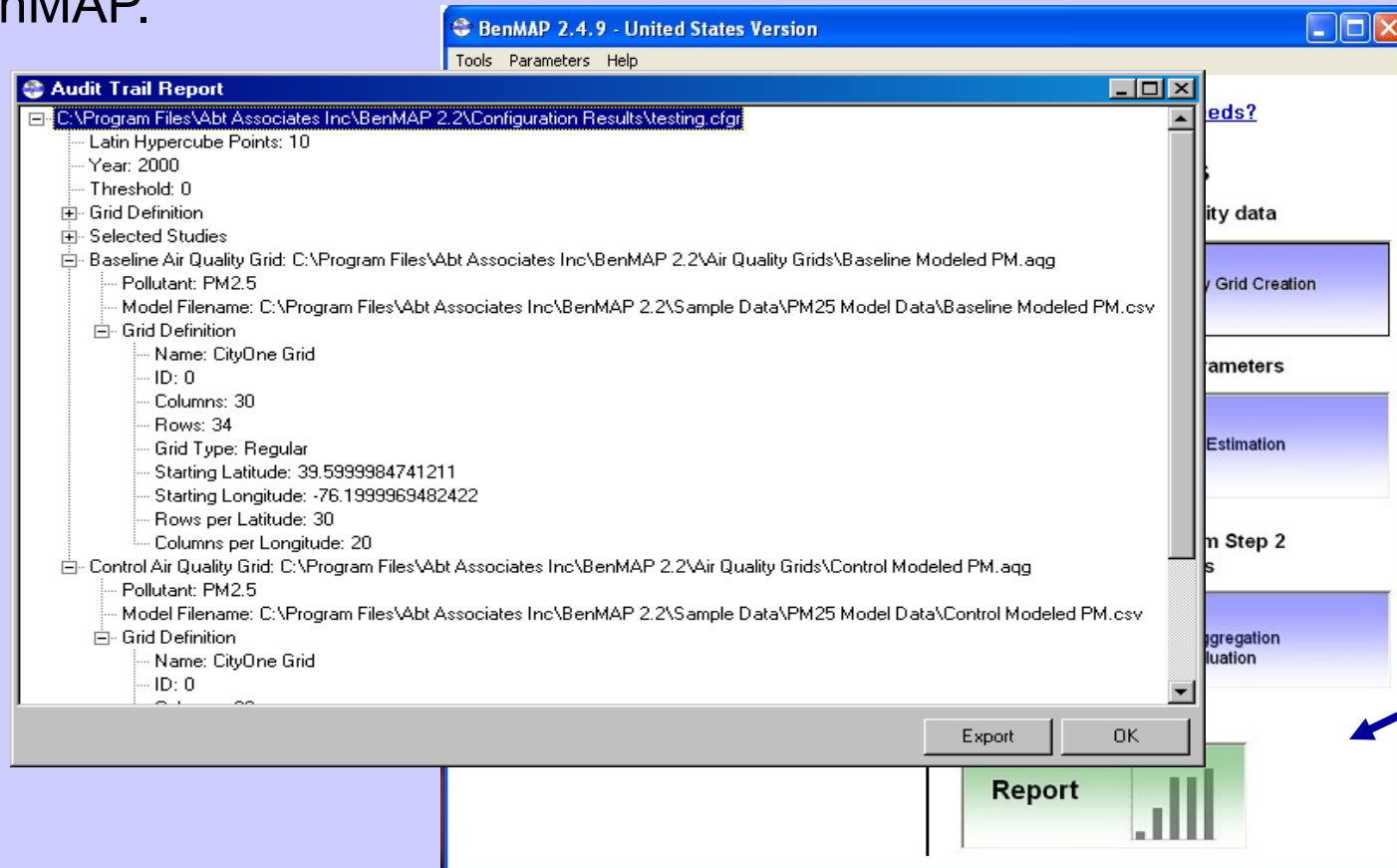
Mapping through BenMAP's GIS tool



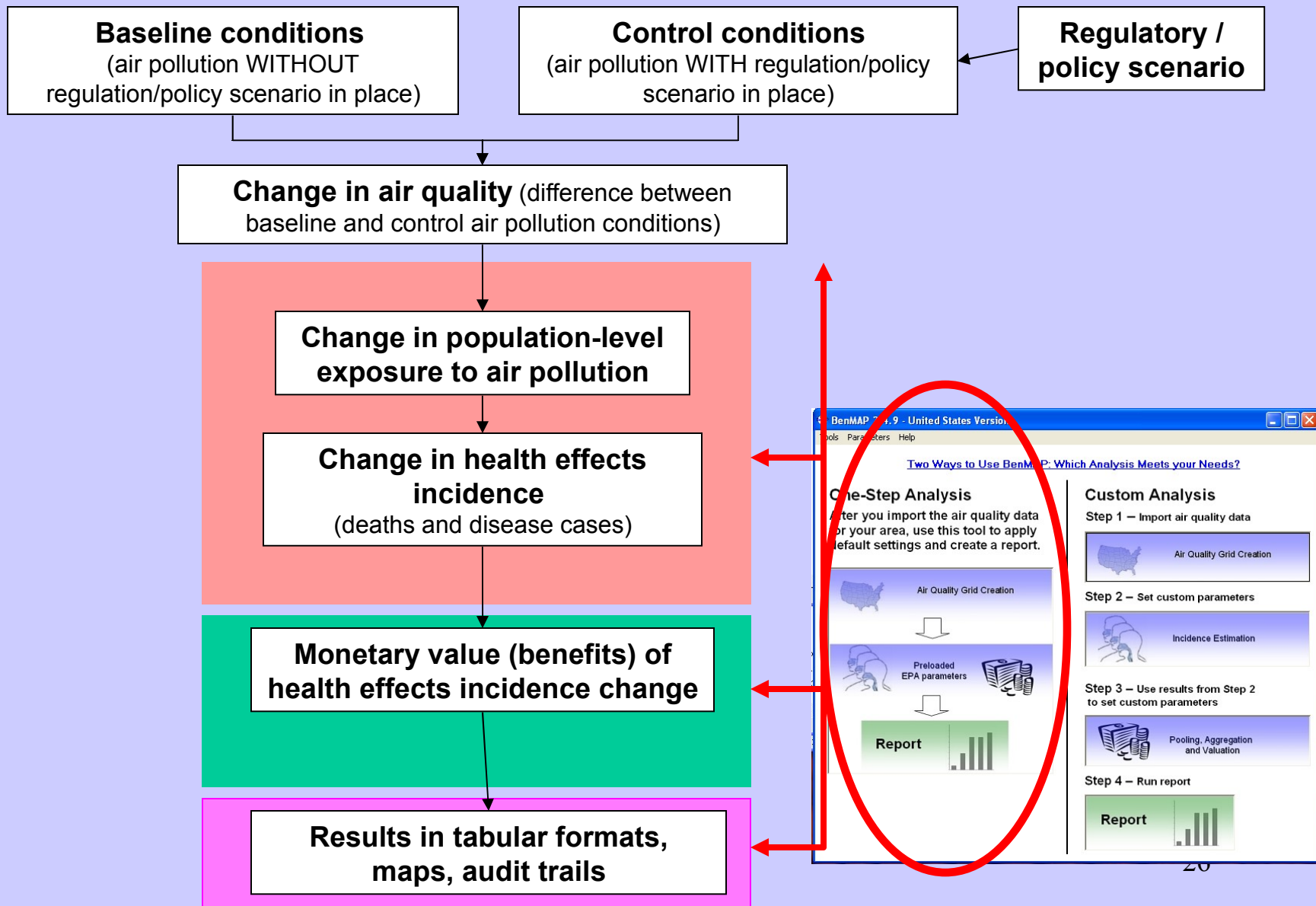


# Steps in Analysis – 4 of 4 – Generating Reports

- BenMAP can generate Audit Trail reports, which contain a record of all the choices involved in the creation of a particular file.
- Audit Trail reports can be generated from any of the files created by BenMAP.



# One-Step Analysis



# BenMAP – Strengths and Limitations (1 of 3)

## STRENGTHS

- **Flexibility** – can use BenMAP anywhere in the world, using own data and map files
- **Data management** – users can easily manage their own data and share with others
- **Speed** – quickly perform analyses, and generate maps & reports
- **Pooling** – several methods for combining health impact & monetary value estimates
- **Transparency** – easy to check assumptions made in analysis
- **Scriptable** – using command-line version
- **Portable** – once a desired set of options has been chosen and configured, one can repeat or share configuration file with others

# BenMAP – Strengths and Limitations (2 of 3)

## STRENGTHS (continued)

- **User-friendly experience** – Windows-based graphical user interface (GUI) for both standardized and highly customized analysis.
- **Preloaded data** – includes substantial population, health, and air quality databases for continental U.S.
- **Benefits transfer** – includes health impact and valuation functions from peer-reviewed sources. As new studies develop new functions, these functions can be added to BenMAP.

# BenMAP – Strengths and Limitations (3 of 3)

## LIMITATIONS

- **No air quality model** – air quality modeling not available in BenMAP
- **Loading data** – identifying and loading data requires careful attention to detail
- **Other pollutants** – ability to use other pollutants dependent on availability of epidemiological data
- **Rollback** – cannot increase the value of monitor values in creating air quality grids through the rollback technique
- **New functions computationally inefficient** – health impact and valuation functions not precompiled into BenMAP can be added, but are inefficient

# Applications in the U.S.

- **National-scale regulatory development (United States)**
  - Cost-benefits analysis (Regulatory Impact Analysis)
    - PM and O<sub>3</sub> regulations including mobile sources and power plants
    - Small Spark Ignition Rule
    - Locomotive and Marine Diesel Rule
    - Clean Air Interstate Rule (CAIR)
    - SO<sub>2</sub> and NO<sub>2</sub> NAAQS review (upcoming)
  - Energy Policy Act (EPAAct) Study (joint between EPA and FAA)
- **Regional/urban analysis (in support of local-scale policy analysis)**
  - Estimate benefits for PM control options (diesel bus retrofit)
  - Include consideration for all diesel sources (on-road and off-road)
  - Oregon woodstove analysis
  - New York City Department of Health borough-level analysis
  - Georgia Department of Natural Resources SIP process
  - Philadelphia diesel PM<sub>2.5</sub> benefits analysis

# International Applications

- **China**

- Benefits analyses of Electric Generating Unit (EGU) control strategy

- **South Korea**

- Health benefits of Seoul air quality management plan

- **Latin America**

- Benefits of air quality improvements in Mexico City, Sao Paulo, Santiago

- **India**

- Benefits analyses in Mumbai

# Uso de herramientas tipo BENMAP en análisis de costo beneficio en Chile

- Plan de prevención y descontaminación de contaminación atmosférica de Santiago de Chile, Trabajo por Dr. Luis Cifuentes, Universidad Católica.



# Resumen Medidas Evaluadas

Sector	Subsector	Medida
Fuentes Móviles	Transporte Público	Normas de emisión para buses nuevos y filtro buses existentes
	Vehículos pesados	Normas de emisión para vehículos nuevos
	Vehículos pesados	Exigencias de Tecnologías de Control de Emisiones y Registro de Flotas de Vehículos de carga y servicio.
	Vehículos livianos y medianos	Normas de emisión para vehículos nuevos
	Vehículos livianos y medianos	Actualización de los estándares de emisión de vehículos controlados en plantas de revisión técnica.
	Vehículos livianos y medianos	Restricción vehicular permanente (4 SSV)
	Motocicletas Nuevas	Normas de emisión para vehículos nuevos
	Calidad de Los Combustibles	Diesel 50 ppm S a 15 ppm S / Gasolina 30 ppm S a 10 ppm S
Fuentes Fijas	Mayores emisores	Norma SO <sub>2</sub> (ng/J) para mayores emisores
	Mayores emisores	Meta 2010 PM (50% de emisiones 1997)
	Mayores y Menores emisores	Meta 2010 NO <sub>x</sub> (50% de emisiones 1997)
	Mayores emisores	Compensación fuentes nuevas
	Fuentes Estacionarias	Norma SO <sub>2</sub> y CO
	Grupos Electrógenos	Control de emisiones grupos electrogénos existentes
	Grupos Electrógenos	Control de emisiones grupos electrogénos nuevos

# Resumen Medidas Evaluadas (Continuación)

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Sector	Subsector	Medida
<b>Otras Fuentes</b>	Off Road	Instalación de filtros en maquinarias fuera de ruta
	Leña	Regulación para el uso de calefactores Gestión de Episodios Críticos (GEC)
	Quemas	Erradicación de quemas agrícolas
	PAC	Programa de aspirado de calles
	Áreas Verdes	Plan Santiago Verde
	Ciclovías	Programa de construcción de ciclovías urbanas

Fuente: Elaboración propia

# Indicadores de Rentabilidad Social por medida (MUS\$)

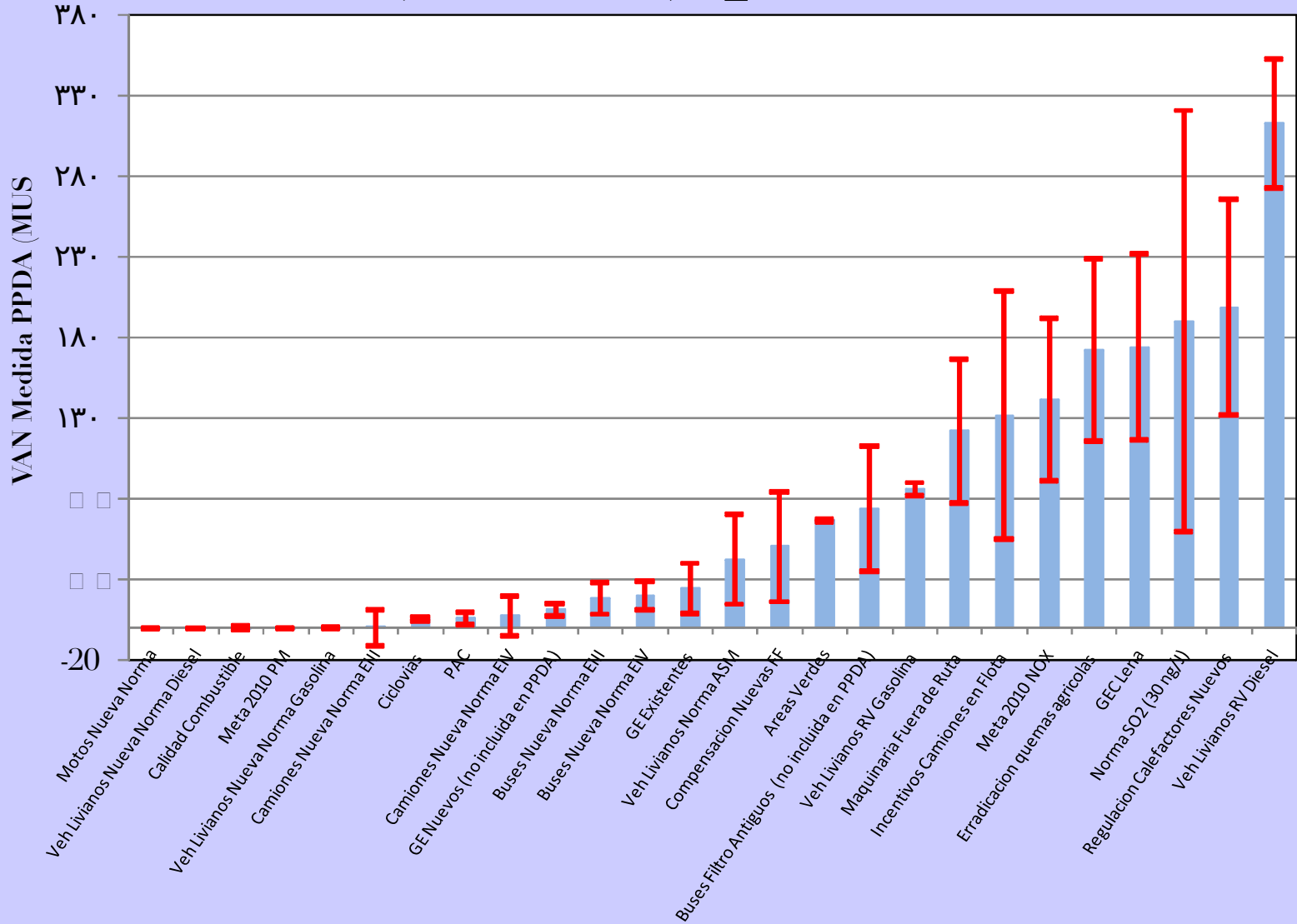
35

Sector	Medida	VP Costos (MUS\$)	VP Ben (MUS\$)	VP Ben Neto (MUS\$) - IC 90%		Razón B/C	Red PM2.5 2015 (ug/m3)
Fuentes Móviles	Buses Nueva Norma EIII	11.4	30.0	18.6	(9 - 28)	2.6	0.10
	Buses Nueva Norma EV	7.5	27.9	20.3	(11 - 29)	3.7	0.17
	Buses Filtro Antiguos (no incluida en PPDA)	46.1	119.7	73.7	(35 - 113)	2.6	0.33
	Camiones Nueva Norma EIII	34.5	34.9	0.4	(-11 - 12)	1.0	0.12
	Camiones Nueva Norma EV	30.6	38.3	7.7	(-5 - 20)	1.3	0.34
	Incentivos Camiones en Flota	105.7	237.3	131.6	(55 - 209)	2.2	0.69
	Veh Livianos Nueva Norma Diesel	1.2	1.2	0.0	(-0.4 - 0.4)	1.0	0.01
	Veh Livianos Nueva Norma Gasolina	0.7	1.0	0.4	(0.0 - 0.7)	1.5	0.01
	Veh Livianos Norma ASM	43.2	85.9	42.7	(15 - 71)	2.0	0.36
	Veh Livianos RV Diesel	39.4	352.2	312.8	(273 - 353)	8.9	0.31
	Veh Livianos RV Gasolina	15.4	101.7	86.3	(82 - 90)	6.6	0.03
	Motos Nueva Norma	0.1	0.0	-0.1	(-0.1 - -0.1)	0.3	0.00
	Calidad Combustible	3.4	3.6	0.2	(-1 - 1)	1.1	0.01
Fuentes Fijas	Norma SO2 (30 ug/J)	212.6	402.4	189.7	(60 - 321)	1.9	1.46
	Meta 2010 PM	0.4	0.6	0.3	(0.1 - 0.5)	1.8	0.00
	Meta 2010 NOX	13.1	154.7	141.5	(92 - 192)	11.8	0.56
	Compensacion Nuevas FF	54.6	105.0	50.4	(17 - 85)	1.9	0.69
	GE Existentes	23.6	48.3	24.7	(9 - 40)	2.0	0.17
	GE Nuevos (no incluida en PPDA)	0.0	11.8	11.8	(8 - 16)	0.0	0.11
Otras fuentes	Maquinaria Fuera de Ruta	15.9	137.9	122.0	(78 - 167)	8.7	0.42
	Regulacion Calefactores Nuevos	8.7	207.6	198.8	(132 - 266)	23.8	1.28
	GEC Iera	3.8	178.0	174.2	(117 - 232)	47.2	0.57
	Eradicacion quemas agricolas	2.3	174.8	172.5	(116 - 229)	74.8	0.54
	PAC	5.5	11.8	6.3	(3 - 10)	2.2	0.04
	Areas Verdes	185.2	252.1	66.8	(66 - 68)	1.4	0.01
	Ciclovia	33.3	39.2	5.9	(5 - 7)	1.2	0.02
<b>Total</b>		<b>898</b>	<b>2,758</b>	<b>1,860</b>	<b>(1,170 - 2,560)</b>	<b>3.1</b>	<b>8.4</b>

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Fuente: DICTUC (2008), AGIES del PPDA

# VAN (MUS\$) por Medida



# Escenarios de Análisis: Eventos Evitados

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## PPDA periodo 2009 - 2015

Tipo de casos Evitados	Normal	Pasivo	Agresivo
Muertes Prematuras (exp aguda)	1,650	1,130	2,910
Muertes Prematuras (Exp crónica)	10,100	6,900	17,800
Admisiones Hospitalarias	6,710	4,600	11,800
Bronquitis Crónica	10,400	7,110	18,300
Bronquitis Aguda	17,400	11,900	30,700
Visitas Sala Emergencia	40,600	27,800	71,600
Ataques de Asma	371,000	254,000	655,000
Días Perdida Trabajo (WLDs)	3,120,000	2,140,000	5,510,000
MRADs & Síntomas Respiratorios	10,700,000	7,320,000	18,800,000

# Norma de Calidad de Aire PM2.5

# Alternativas evaluadas

Las alternativas evaluadas son:

- Norma Anual (promedio tri-anual, ug/m<sup>3</sup>)

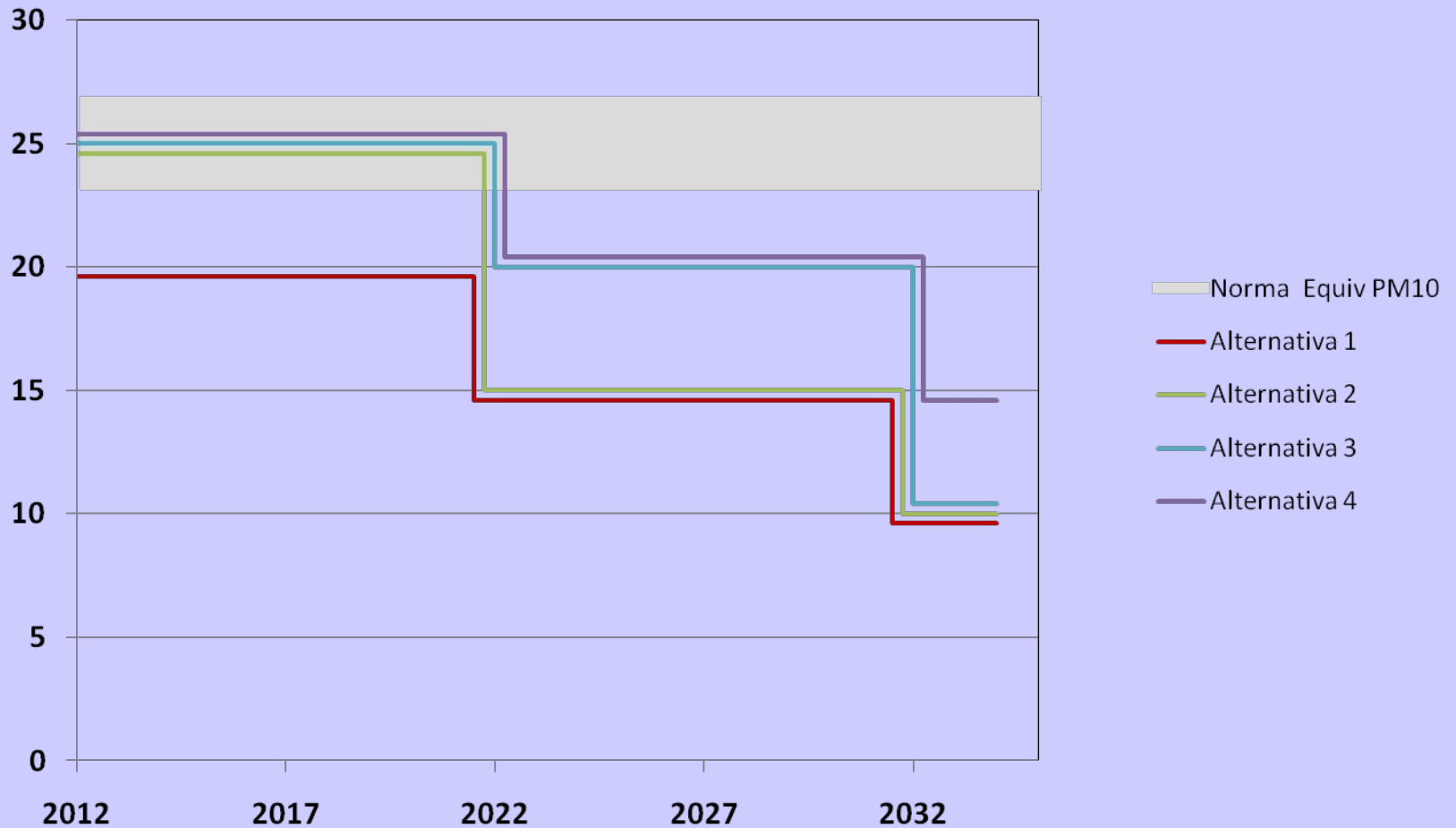
Alternativa	2012	2022	2032
1	20	15	10
2	25	15	10
3	25	20	10
4	25	20	15

- Norma Diaria (percentil 98, ug/m<sup>3</sup>)

Alternativa	D1	D2	D3
Razón Norma Diaria / Norma Anual	2x	2.5x	3x

# Alternativas evaluadas

## Norma Anual



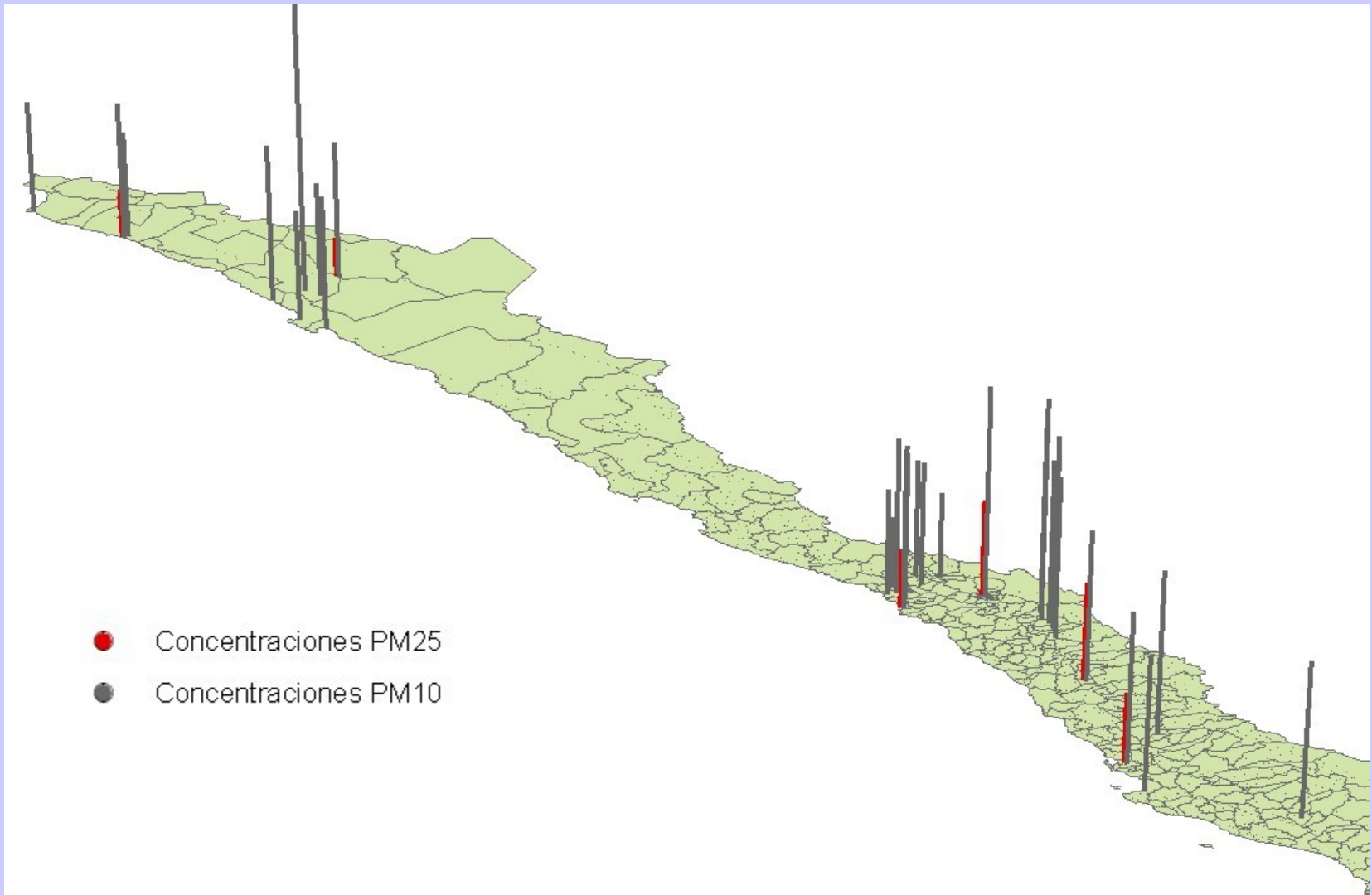


# Alternativas Evaluadas: Norma Diaria

Norma Anual PM2.5	Norma Diaria PM2.5			
	2x	2.5x	3x	3.5x
25	50	63	75	88
20	40	50	60	70
15	30	38	45	53
10	20	25	30	35

Recomendación OMS Norma diaria: 2x

# Concentraciones Ciudades



# Concentraciones Ciudades: Zona Norte

Zona	Area Metropolitana	Población (habitantes)	PM10		PM <sub>2.5</sub>		Razón
			Año	Promedio Anual (ug-m <sup>3</sup> )	Año	Promedio Anual (ug-m <sup>3</sup> )	PM <sub>2.5</sub> -PM10
Norte	Arica	185,268	2008	41.3			
	Alto Hospicio	50,215	2008	50.2	2008	18.2	0.36
	Pozo Almonte	10,830	2007	39.0			
	Antofagasta	296,905	2007	47.3			
	Calama	138,402	2007	49.5	2007	14.5	0.29
	Mejillones	8,418	2006	39.1			
	Sierra Gorda	2,356	2005	41.3			
	Tocopilla	23,986	2006	56.0			

# Concentraciones Ciudades: Zona Centro

Zona	Area Metropolitana	Población (habitantes)	PM10		PM2.5		Razón
			Año	Promedio Anual (ug-m3)	Año	Promedio Anual (ug-m3)	PM2.5-PM10
Centro	Ia Calera	49,503	2007	51.1			
	Cabildo	18,916	2007	23.3			
	Gran Valparaiso	734,452	2007	43.6	2008	19.4	0.45
	Putendo	14,649	2007	38.8			
	Ilaillay	21,644	2007	40.7			
	Puchuncavi	12,954	2007	35.3			
	Quillota	75,916	2007	48.6			
	Catemu	12,112	2007	47.5			
	Los Andes	60,198	2007	28.1			
	Gran Santiago	6,046,430	2007	69.1	2006	31.7	0.46
	Gran Pangua	242,972	2007	72.2			
	Requinoa	22,161	2007	53.0			
	Rengo	50,830	2007	62.8			
	San Fernando	63,732	2007	52.6			

# Concentraciones Ciudades: Zona Sur

Zona	Area Metropolitana	Población (habitantes)	PM10		PM2.5		Razón
			Año	Promedio Anual (ug-m <sup>3</sup> )	Año	Promedio Anual (ug-m <sup>3</sup> )	PM2.5-PM10
Sur	Talca	201,797	2007	48.9	2007	32.1	0.66
	Gran Chillan	184,037	2007	52.1			
	Gran Concepcion	871,231	2008	49.4	2008	24.9	0.50
	Arauco	34,873	2008	42.9			
	Codegua	10,796	2007	60.7			
	Gran Temuco	304,142	2007	48.8			

- Se observa que la concentración anual de PM10 no es cumplida por varias comunas

# Razón PM25/PM10

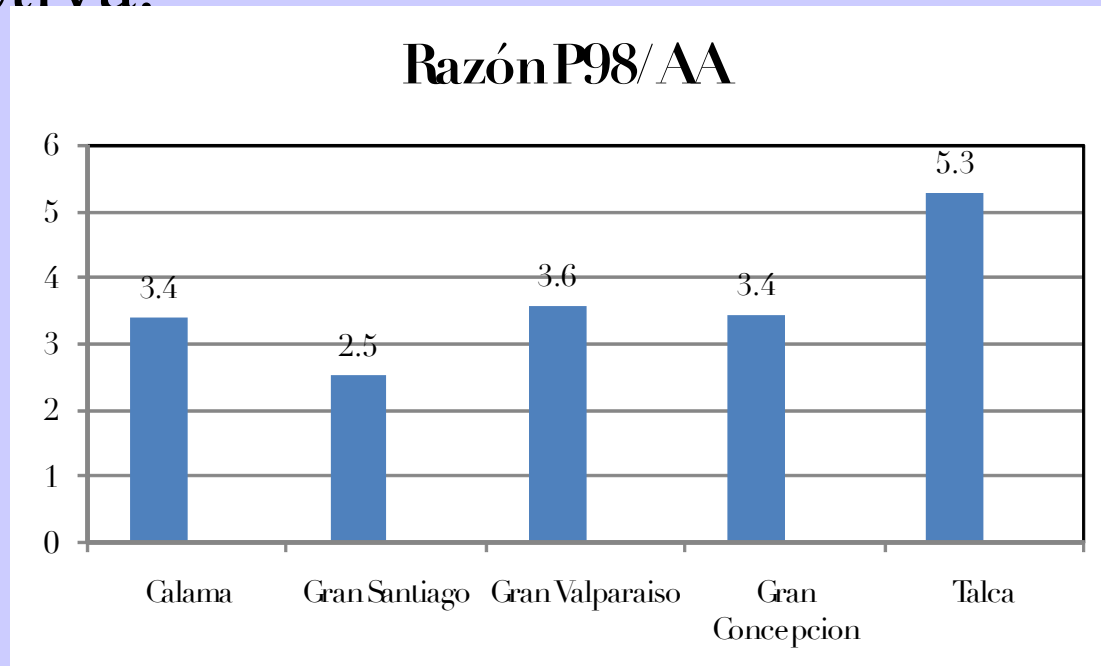
- Para las ciudades sin información de concentraciones de PM2.5 se aplicó el siguiente criterio:
  - Si tiene información de PM10, se estimó la concentración de PM2.5 en función de la razón PM2.5/PM10 de cada zona.

Zona	Media Anual	Percentil 98	Fuente
Norte	0.18	0.18	Monitoreo Calama
Centro - Costa	0.46	0.58	Monitoreo Gran Valparaiso
Centro - Interior	0.50	0.60	Monitoreo Rancagua
Sur	0.50	0.70	Monitoreo Temuco

- Si no hay información de PM10 se asignó la concentración promedio de aquellas ciudades con información de región cuyas condiciones climáticas y/o fuentes industriales son similares.

# Relación Promedio Anual/Percentil 98

- Esta relación determina que norma (anual o diaria) es activa.



- Calculados a partir de mediciones reales de PM10 y PM2.5 para ciudades con datos en el mismo año.

# Impactos en Salud Considerados

Efecto	Causa	Grupo Edad
Mortalidad Prematura	Todas las causas	Todos
	Cardiopulmonares	Todos
Admisiones Hospitalarias	Cardiovasculares	65+
	Disritmia	65+
	Enfermedad isquémica	65+
	Enfermedad Respiratoria crónica	65+
	Pneumonía	65+
	Asma	<65
	Respiratorias	Todos
Visitas Sala Urgencia	Causas Respiratorias	Todos
	Asma	<65



# Efectos Unitarios PM2.5

- Reducción de casos por Millón de personas por ug/m<sup>3</sup>

Efecto	Causa	Grupo Edad	Casos en Excesos Unitarios Casos/Millones personas por ug/m <sup>3</sup>
Mortalidad Prematura	Exp. De largo plazo Todas las causas	Todos	(7 – 40)
	Exp. De largo plazo Cardiopulmonar	65+	(8 – 27)
	Exp. Aguda Todas las causas	65+	(3 – 8)
Admisiones Hospitalarias	Asma	<65	(25 – 97)
	Enfermedades Respiratorias Crónicas	Todos	(20 – 68)
	Enfermedades Cardiovasculares	Todos	(22 – 54)
	Enfermedades Respiratorias	<65	(29 – 85)

# Casos Evitados Norma PM2.5

- Casos evitados período 2012 - 2041

Tipo de Casos Evitados	Alternativa 1	Alternativa 2	Alternativa 3	Alternativa 3
Muertes Prematuras (exp aguda)	21,000	18,000	15,000	11,000
Muertes Prematuras (Exp crónica)	125,000	111,000	90,000	64,000
Admisiones Hospitalarias	84,000	74,000	60,000	43,000
Bronquitis Crónica	129,000	114,000	93,000	66,000
Bronquitis Aguda	216,000	192,000	155,000	111,000
Visitas Sala Emergencia	505,000	448,000	362,000	259,000
Ataques de Asma	4,618,000	4,093,000	3,311,000	2,372,000
Días Perdida Trabajo (WLDs)	38,831,000	34,415,000	27,840,000	19,949,000
MRADs & Síntomas Respiratorios	132,857,000	117,748,000	95,251,000	68,255,000

-Período: 2012 – 2041

-Escenario Caso No Saturado Tendencia

# Valor Presente de Costos (MUS\$)

- Costos agrupados por zona para cuatro alternativas

Ciudad	Alternativa 1	Alternativa 2	Alternativa 3	Alternativa 4
Norte	0	0	0	0
Centro	263	247	170	38
Sur	5 488	4 156	2669	1437
Santiago	2 674	1 911	1231	761
<b>Total Nacional</b>	<b>8 425</b>	<b>6 314</b>	<b>4 070</b>	<b>2 236</b>

-Período: 2012 - 2041

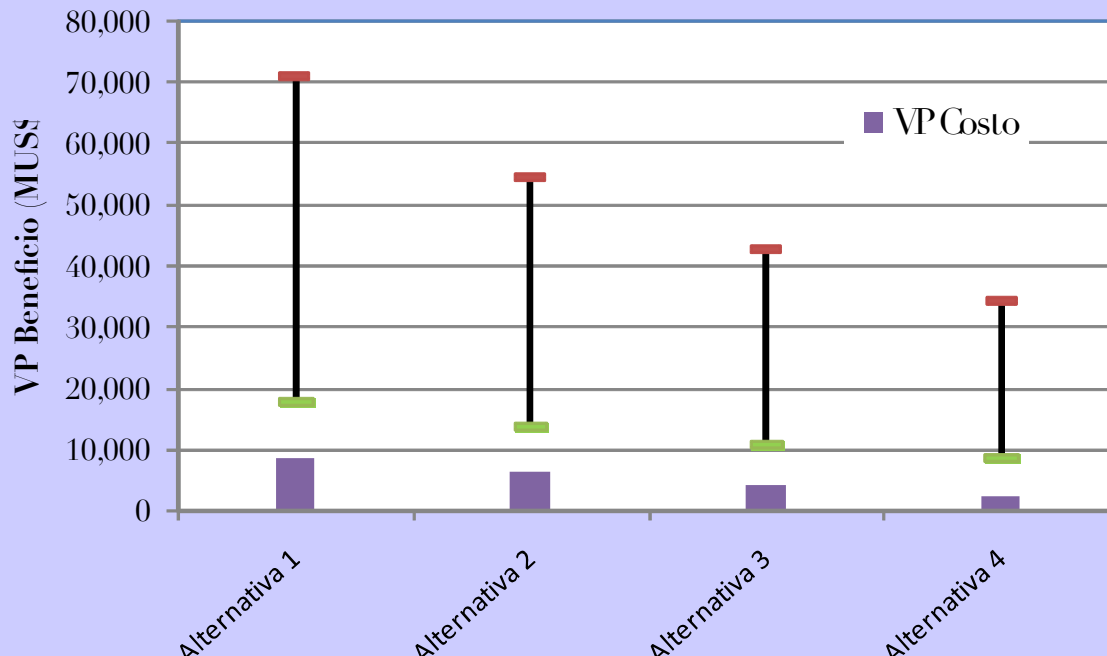
-Tasa de descuento: 8%

-1 US\$ = 640 CLP\$

-Escenario Caso No Saturado Tendencia

# VP Beneficios (MUS\$)

Ciudad	Alternativa 1	Alternativa 2	Alternativa 3	Alternativa 4
Norte	(0 -0)	(0 -0)	(0 -0)	(0 -0)
Centro	(450-880)	(440-860)	(280-540)	(120-240)
Sur	(7,500-15,000)	(5,800-11,000)	(4,500-8,800)	(3,600-7,000)
Santiago	(9,900-47,000)	(7,600-36,000)	(6,000-28,000)	(4,800-23,000)
<b>Total Nacional</b>	<b>(18,000-63,000)</b>	<b>(14,000-48,000)</b>	<b>(11,000-37,000)</b>	<b>(8,500-30,000)</b>



-Período: 2012 - 2041  
 -Tasa de descuento: 8%  
 -1US\$ = 640 CLP\$  
 -Escenario Caso No Saturado  
 Tendencia

# Razón Beneficio Costo por ciudad

Ciudad	Alternativa 1	Alternativa 2	Alternativa 3	Alternativa 4
Alto Hospicio	↗ 1.7	↗ 1.7	↗ 1.3	↖ 8.2
Huasco	↘ 0.1	↘ 0.1	↘ 0.1	↘ 0.2
La Serena-Coquimbo	↖ 26.6	↖ 26.6	↖ 19.6	↖ 162.1
Ovalle	↖ 4.0	↖ 4.0	↖ 3.0	↖ 24.6
La Calera	↗ 0.6	↗ 0.5	↗ 0.6	↗ 1.5
Cabildo	↖ 63.1	↖ 63.1	↖ 63.1	↘ 0.0
Quintero	↗ 0.9	↗ 0.9	↗ 0.6	↖ 5.3
Gran Valparaíso	↖ 21.9	↖ 21.9	↖ 16.5	↖ 75.5
Putendo	↗ 0.6	↗ 0.6	↘ 0.4	↖ 3.2
Ilaillav	↗ 0.7	↗ 0.7	↗ 0.5	↖ 2.7
Puchuncavi	↗ 0.7	↗ 0.7	↗ 0.6	↖ 14.4
Quillota	↗ 1.2	↗ 1.1	↗ 1.1	↖ 3.3
Catemu	↘ 0.2	↘ 0.2	↘ 0.2	↗ 0.6
Los Andes	↖ 6.5	↖ 6.5	↖ 6.5	↘ 0.0
San Antonio	↖ 3.2	↖ 3.2	↖ 2.4	↖ 11.4
San Felipe	↗ 1.8	↗ 1.8	↗ 1.4	↖ 6.6
Gran Santiago	↖ 3.7	↖ 4.0	↖ 4.8	↖ 6.4
Panagua	↘ 0.2	↘ 0.2	↘ 0.3	↘ 0.4
Requinoa	↘ 0.1	↘ 0.1	↘ 0.1	↘ 0.2
Pengo	↘ 0.1	↘ 0.1	↘ 0.2	↘ 0.2
San Fernando	↘ 0.4	↘ 0.4	↘ 0.5	↗ 0.9
San Vicente	↗ 0.6	↗ 0.5	↗ 0.6	↗ 1.7
Cauquenes	↘ 0.5	↘ 0.4	↘ 0.5	↗ 1.1
Constitucion	↗ 0.5	↘ 0.4	↗ 0.5	↗ 1.2
Curico	↗ 0.5	↗ 0.5	↗ 0.5	↗ 0.9
Lirares	↘ 0.4	↘ 0.4	↘ 0.4	↗ 0.6
Talca	↘ 0.4	↘ 0.4	↘ 0.4	↗ 0.6
Chillan	↗ 0.6	↗ 0.6	↗ 0.7	↗ 1.1
Gran Concepcion	↖ 25.1	↖ 21.3	↖ 25.8	↖ 55.8
Arauco	↗ 0.7	↗ 0.6	↗ 0.6	↖ 2.1
Codegua	↘ 0.0	↘ 0.0	↘ 0.0	↘ 0.1
Los Angeles	↘ 0.2	↘ 0.2	↘ 0.2	↘ 0.3
San Carlos	↘ 0.1	↘ 0.1	↘ 0.1	↘ 0.1
Angol	↘ 0.1	↘ 0.1	↘ 0.1	↘ 0.1
Nueva Imperial	↘ 0.0	↘ 0.1	↘ 0.1	↘ 0.1
Gran Temuco	↘ 0.3	↘ 0.3	↘ 0.3	↘ 0.4
Osorno	↘ 0.2	↘ 0.3	↘ 0.3	↘ 0.4
Puerto Montt	↘ 0.3	↘ 0.3	↘ 0.4	↘ 0.5
Valdivia	↘ 0.2	↘ 0.2	↘ 0.3	↘ 0.4
Coihaique	↘ 0.1	↘ 0.1	↘ 0.1	↘ 0.2
Punta Arenas	↗ 1.6	↗ 1.6	↗ 1.6	↖ 4.4

Código	Razón Beneficio - Costo
↖	Mayor que 2
↗	Entre 0.5 y 2
↘	Menor que 0.5

Centro y Sur de Chile:

- Mayor reducción de emisiones
- Mayor Costo
- Menor beneficio unitario por el tamaño de población

# Conclusiones

- BENMAP una gran herramienta de evaluación social y económica de escenarios regulatorios.
- Se pueden lograr resultados estrictamente basado en observaciones.
- Combinado con modelos, se puede completar el mapa de exposición, y evaluar las medidas con mayor precisión.