

# Current Knowledge on Adverse Effects of Low-Level Air Pollution: Have We Filled the Gap?

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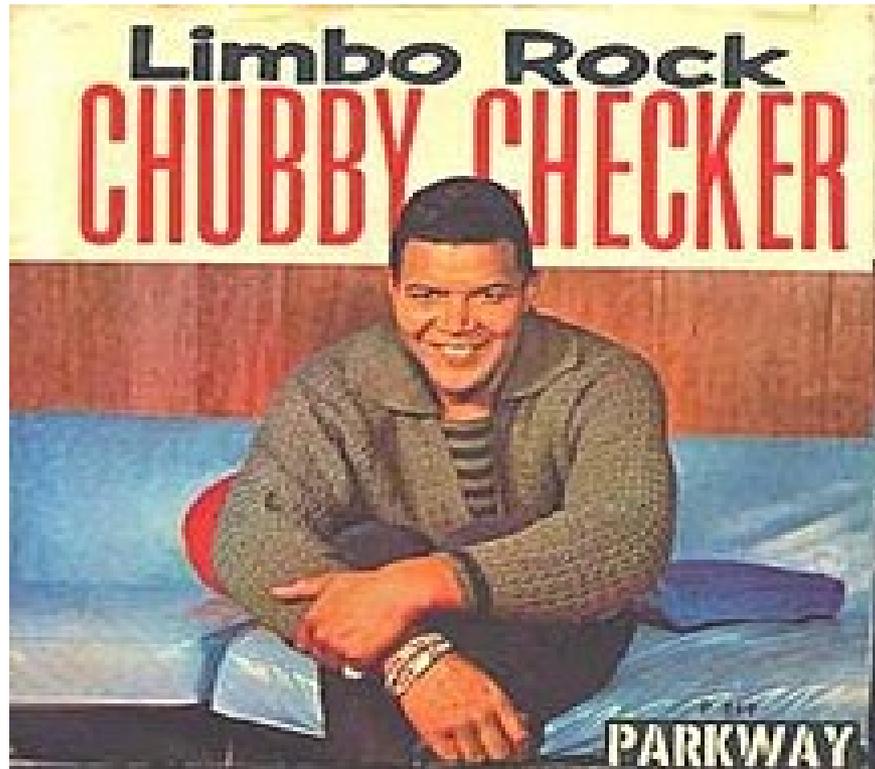
***Health Effects Institute Annual Meeting Session***

**“How Low? Testing Health Effects at the Lowest Levels of Air Pollution”**

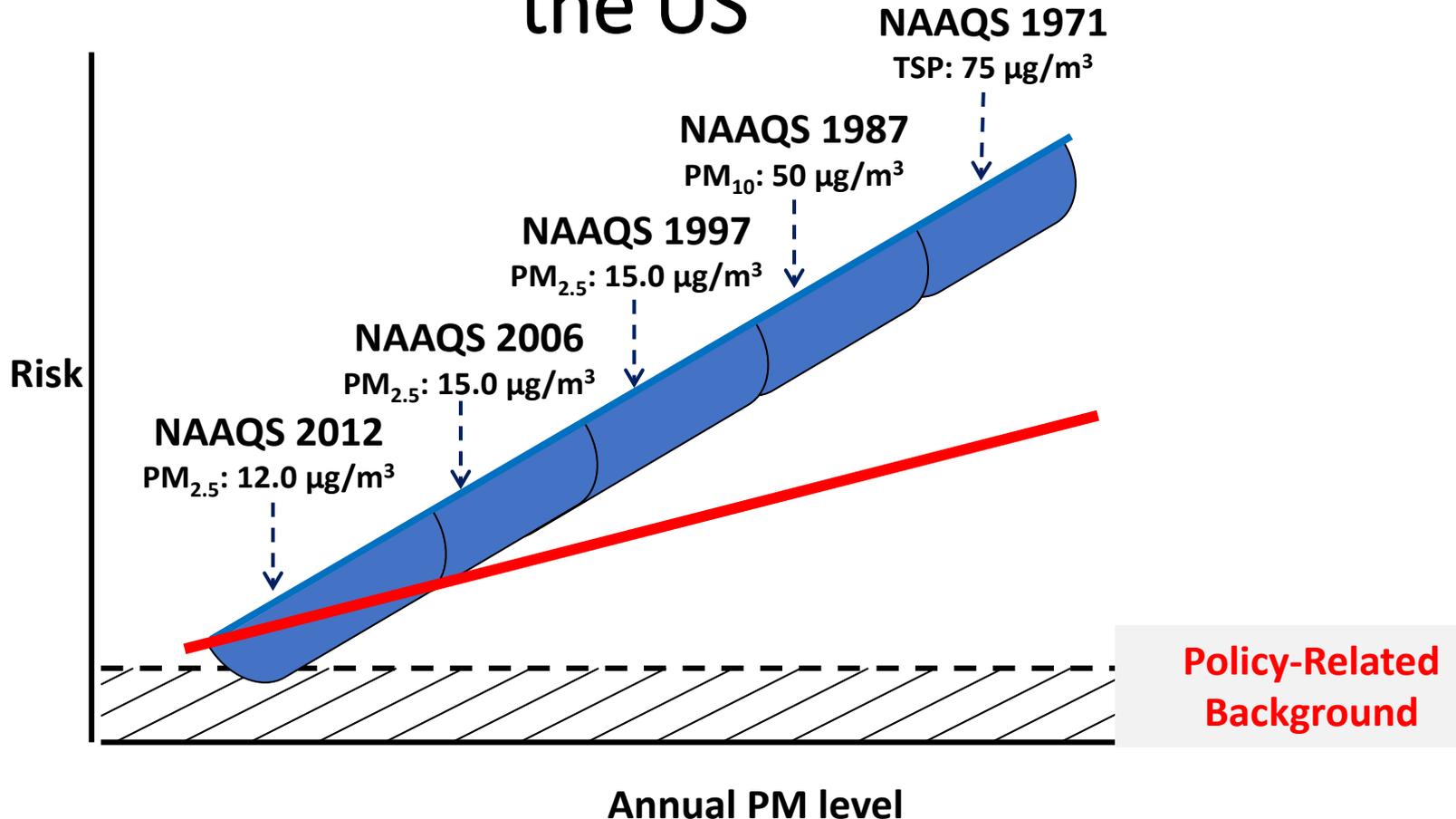
**Seattle, WA**  
**May 7, 2019**

# Unexpected Quiz

**Who Wrote *Limbo Rock*?**



# The Narrowing Range of Exposure: Declining Particulate Matter (PM) Levels in the US



National Ambient Air Quality Standards (NAAQS)

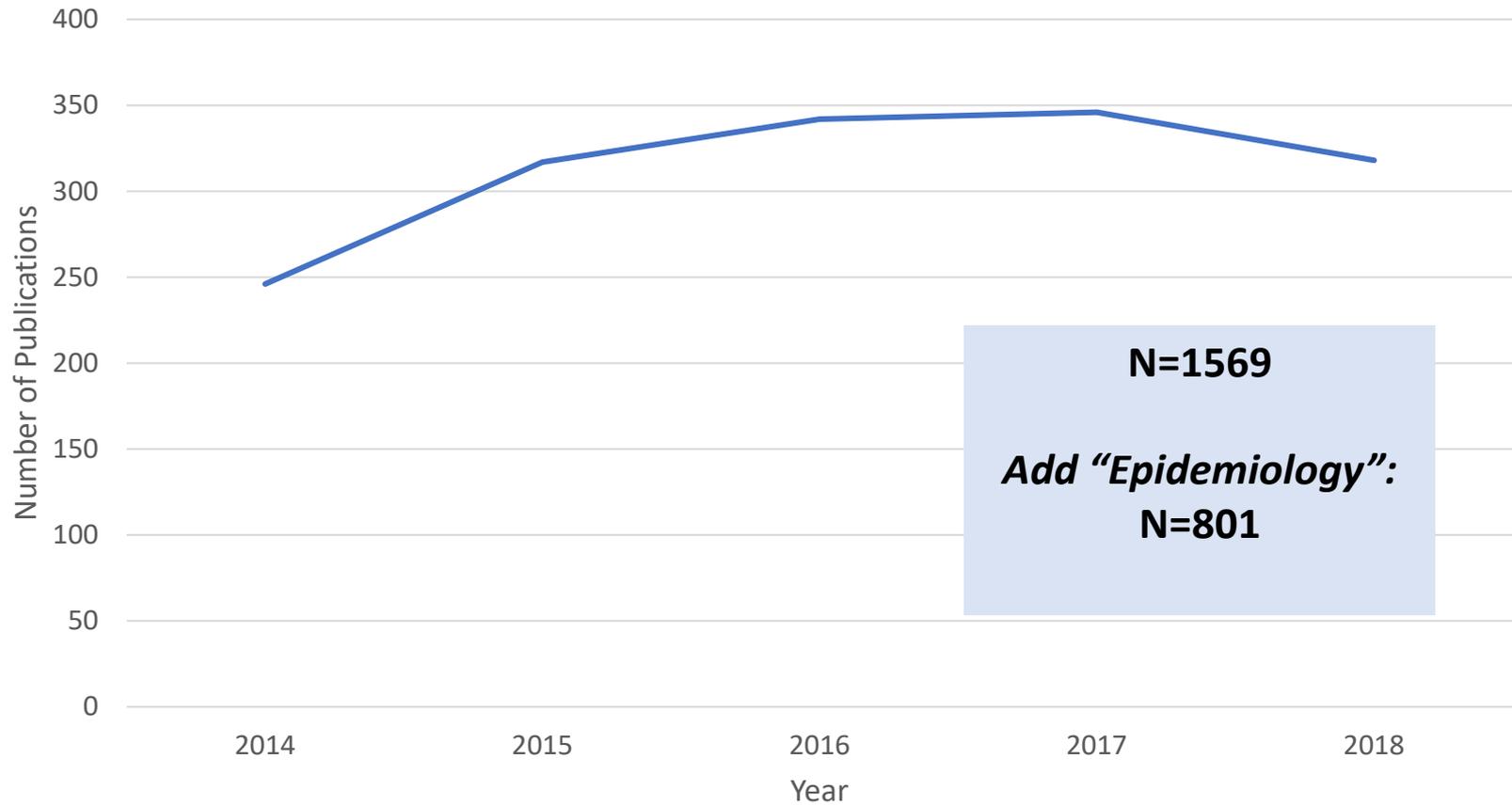
[http://www.epa.gov/ttn/naaqs/standards/pm/s\\_pm\\_index.html](http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html)

# Parsing the Question

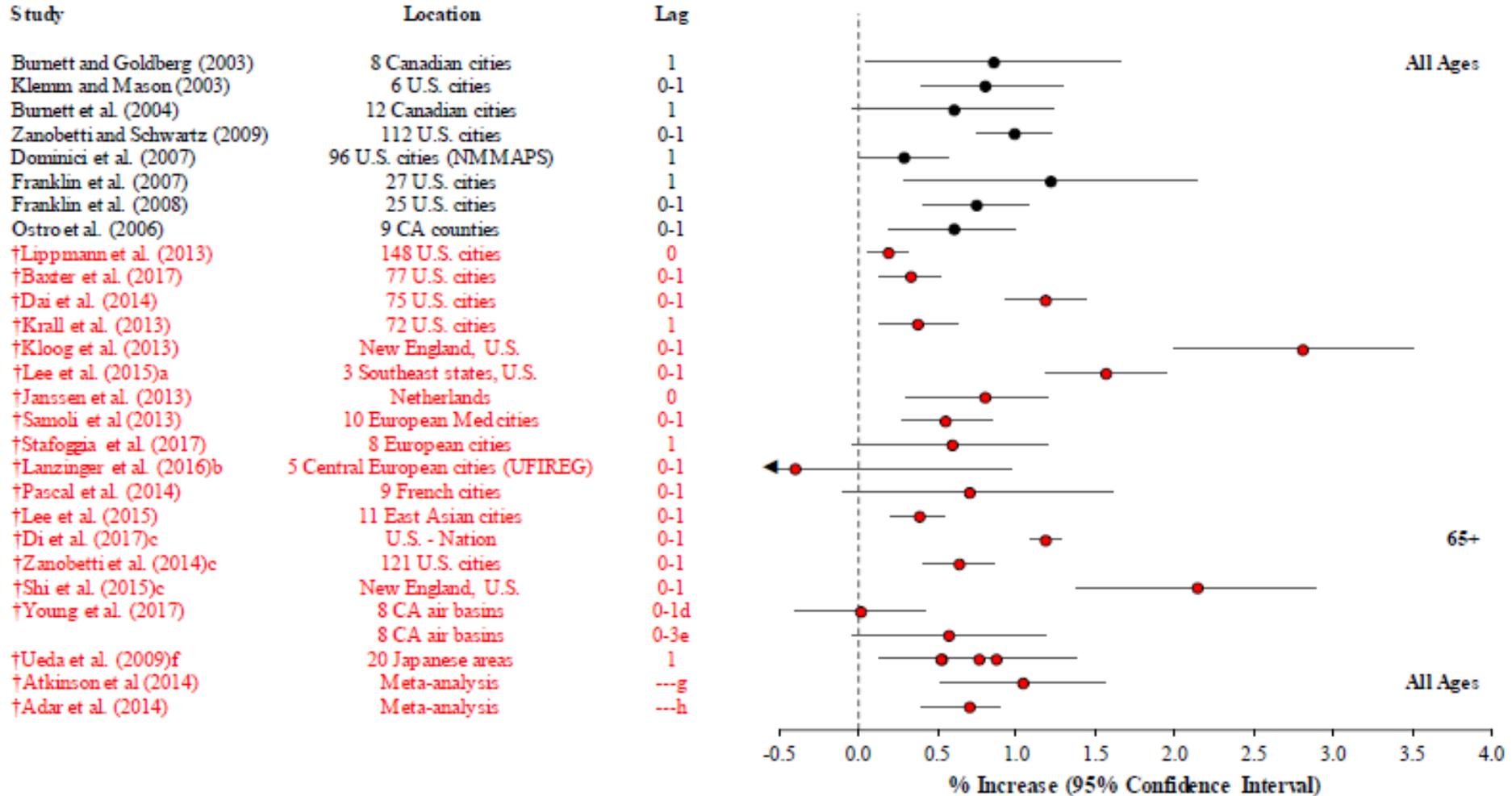
**Current Knowledge on Adverse  
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**Current Knowledge** Continues to Increase

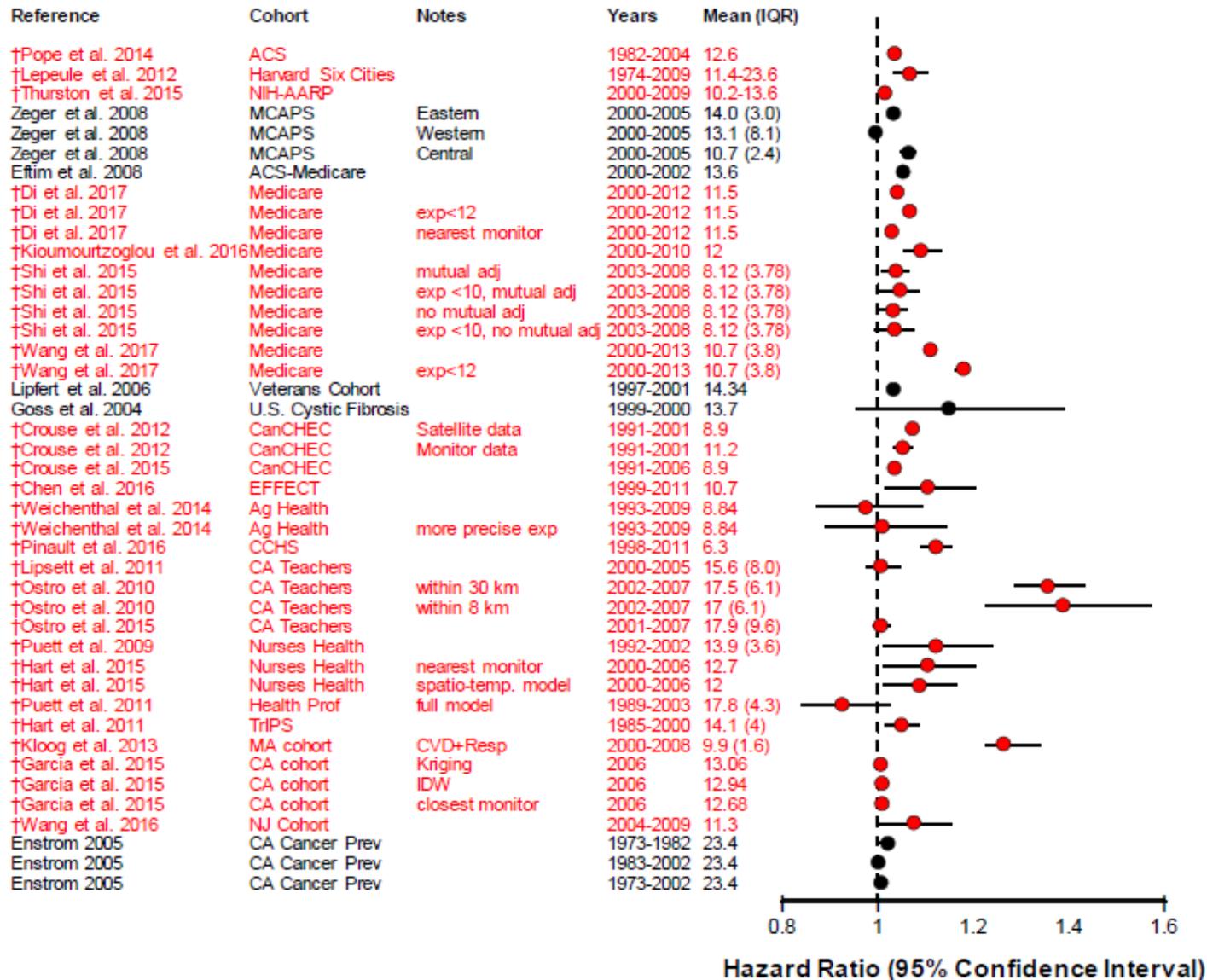
# PubMed Results for “Particulate Matter and Mortality,” 2014-2018



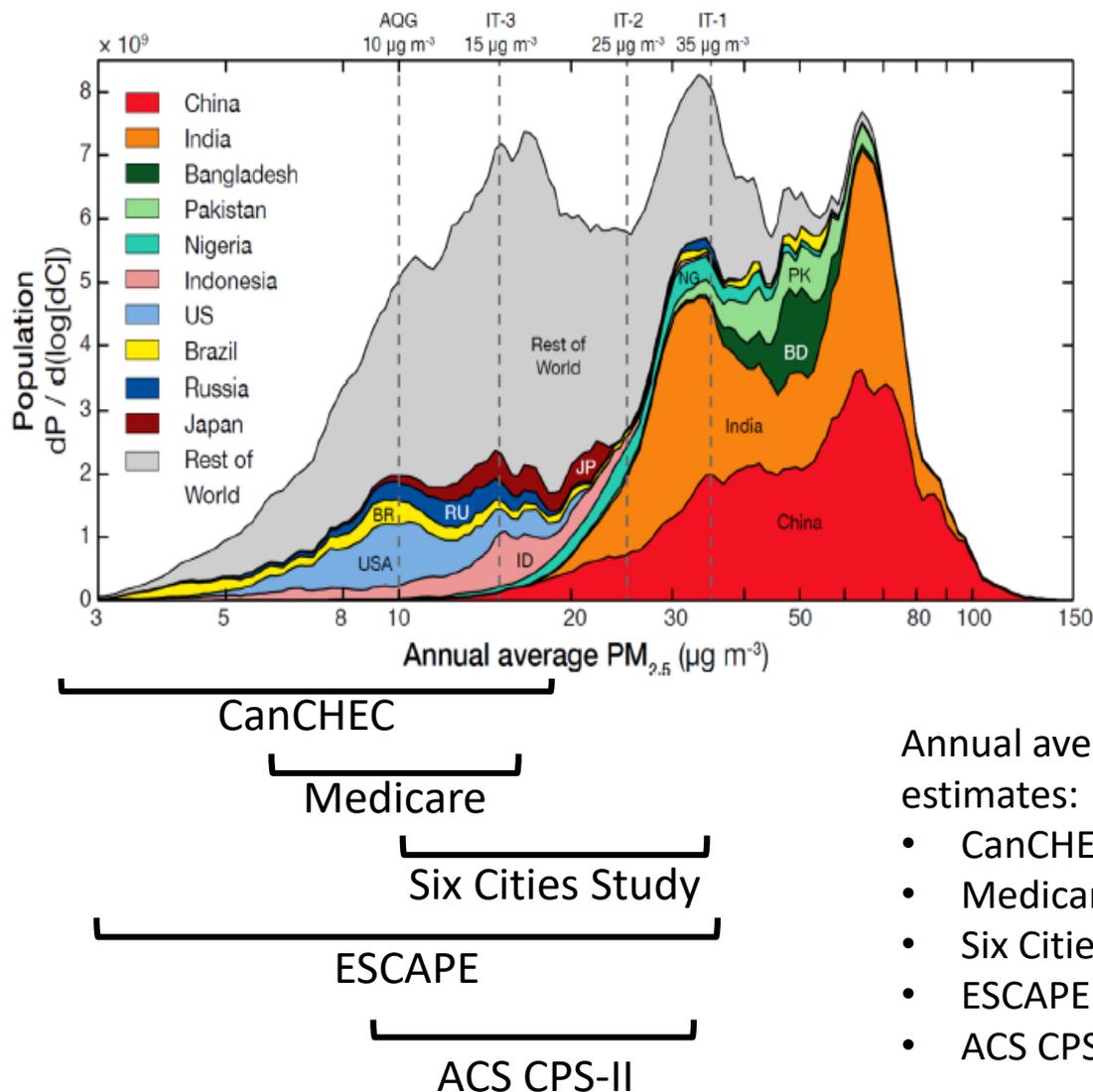
# Summary of associations between short-term PM<sub>2.5</sub> exposure and total (non-accidental) mortality in multicity studies per 10 μg/m<sup>3</sup> increase in 24-hour average concentration



# Associations between long-term exposure to PM<sub>2.5</sub> and total (non-accidental) mortality in recent North American cohorts



# Global PM<sub>2.5</sub> Exposure and Study Ranges



Annual average PM<sub>2.5</sub> concentration estimates:

- CanCHEC: 0-18  $\mu\text{g m}^{-3}$
- Medicare: 6-16  $\mu\text{g m}^{-3}$
- Six Cities Study: 10-35  $\mu\text{g m}^{-3}$
- ESCAPE: 3-37  $\mu\text{g m}^{-3}$
- ACS CPS-II: 9-34  $\mu\text{g m}^{-3}$

Figure 3. Global and regional distributions of population as a function of annual (2013) average ambient PM<sub>2.5</sub> concentration for the world's 10 most populous countries. Plotted data reflect local smoothing of bin-width normalized distributions computed over 400 logarithmically spaced bins; equal-sized plotted areas would reflect equal populations. Dashed vertical lines indicate World Health Organization Interim Targets (IT) and the Air Quality Guideline (AQG).

# Parsing the Question

**Current Knowledge on Adverse Effects of Low-Level Air Pollution: Have We Filled the Gap?**

The range of **Adverse Effects** continues to widen

# What Is An “Adverse Effect”

## 2017 statement of the American Thoracic Society

*“A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework”*

TABLE 1 Considerations for assessing adversity of clinical or pathological effects

Consideration	Pertinent questions
<b>1. Fatality</b>	Does air pollution exposure lead to an increase of short-term or long-term mortality?
<b>2. Persistence of effect</b>	How persistent over time is the effect? (Generally, chronic effects such as the induction of new disease are given greater weight, although short-term exposures may lead to changes that increase risk for triggering acute adverse events, such as myocardial infarction)
<b>3. Population risk</b>	Is there a shift in the population risk distribution of an adverse event?
<b>4. Susceptibility</b>	Are the very young, older adults or individuals with pre-existing health conditions or specific genetic characteristics more likely to be affected?
<b>5. Medical/functional significance</b>	Is there evidence of one or more of the following? 1) severe interference with a normal activity of the affected person or persons; 2) incapacitating illness; 3) permanent injury; 4) progressive dysfunction; 5) reduced quality of life

# Adverse Effects



# Parsing the Question

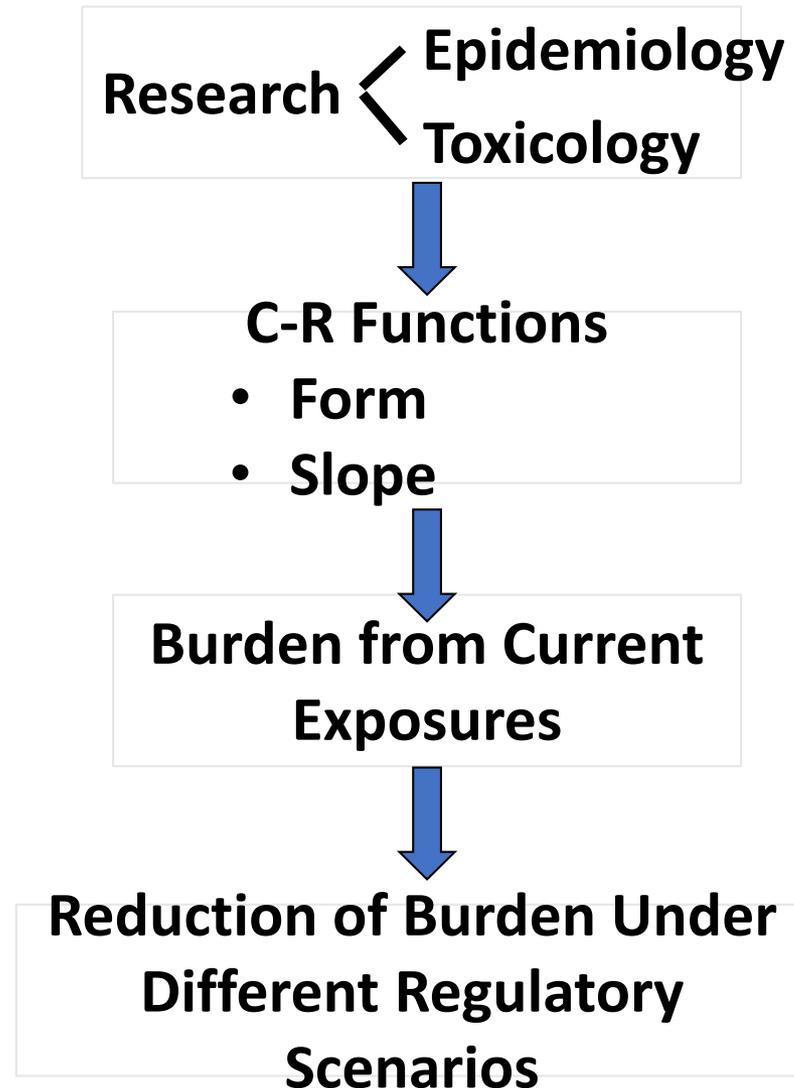
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**What is the Gap**

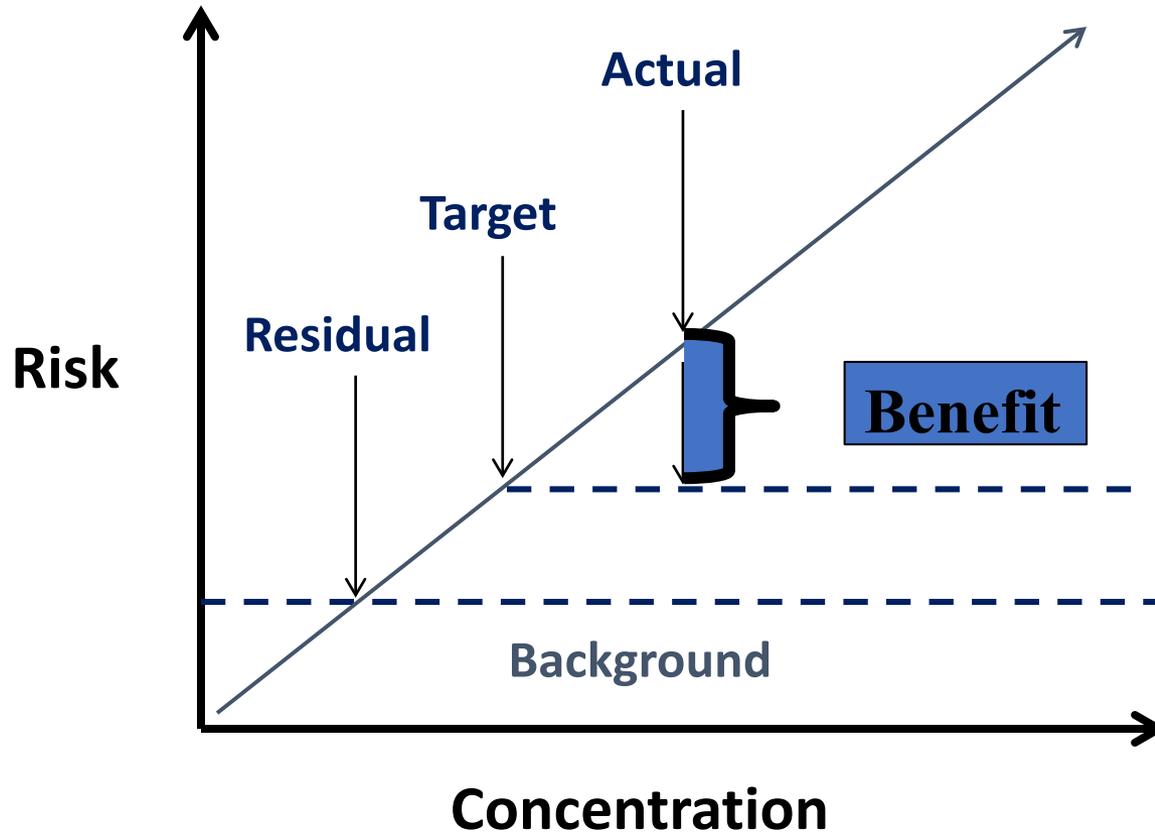
# The Gap: Contexts

- For methods for improved estimation
- For reducing scientific uncertainty?
- For risk assessment and burden estimation?
- For setting standards that provide public health protection?
- For carrying out cost-benefit analyses?
- For directing further research?

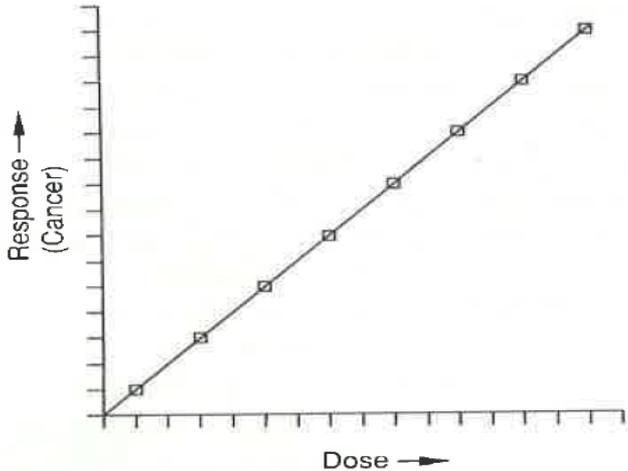
# Using Concentration-Response (C-R) Functions to Guide Standards



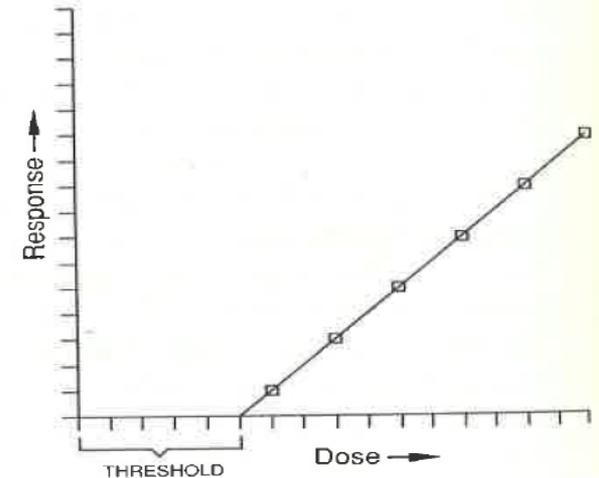
# Using Concentration-Response



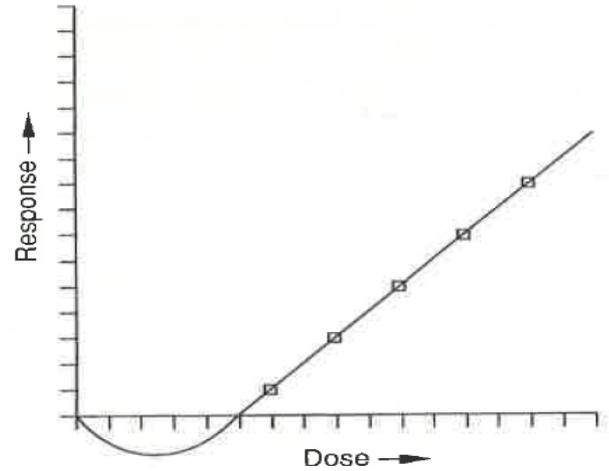
# Form Matters: The Political Morphology of Dose-Response Curves



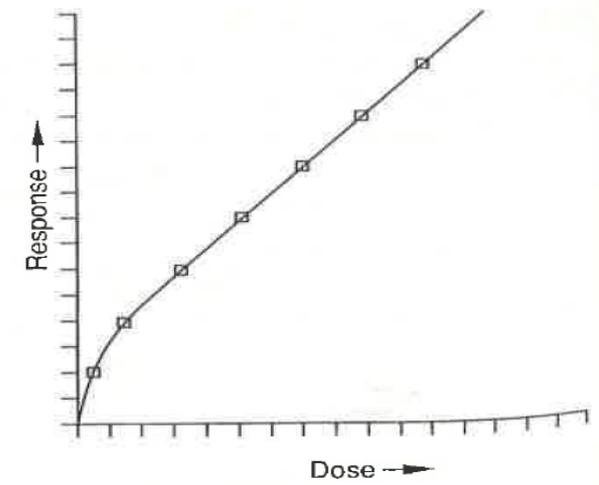
**Environmental / Bureaucratic**  
(linear, no threshold)



**Industrial / Apologetic**  
(linear with threshold)



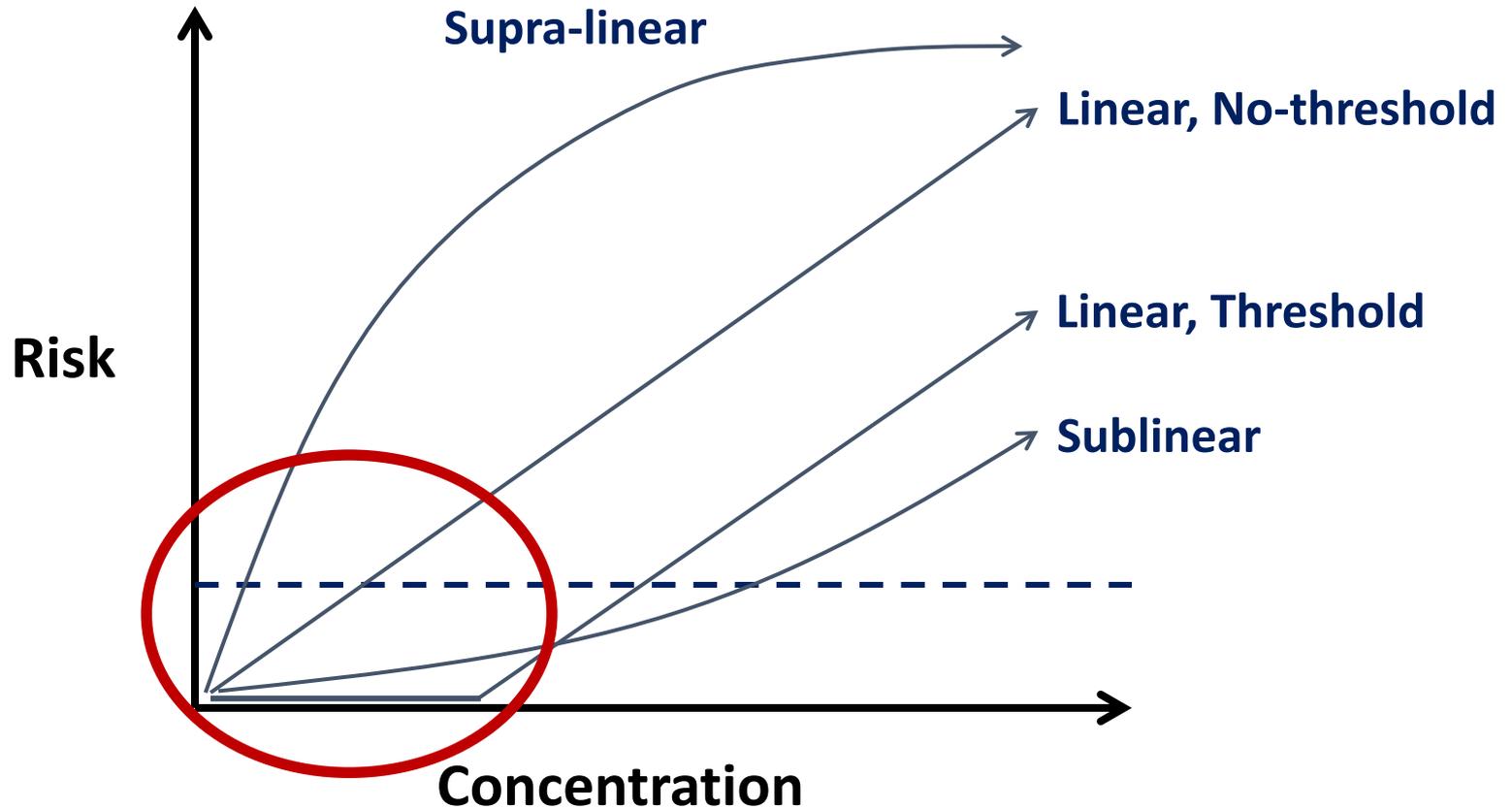
**Hormetic**  
(beneficial at low doses)



**Environmental / Activist**  
(supralinear)

**Proctor (1995)**  
*Cancer Wars*

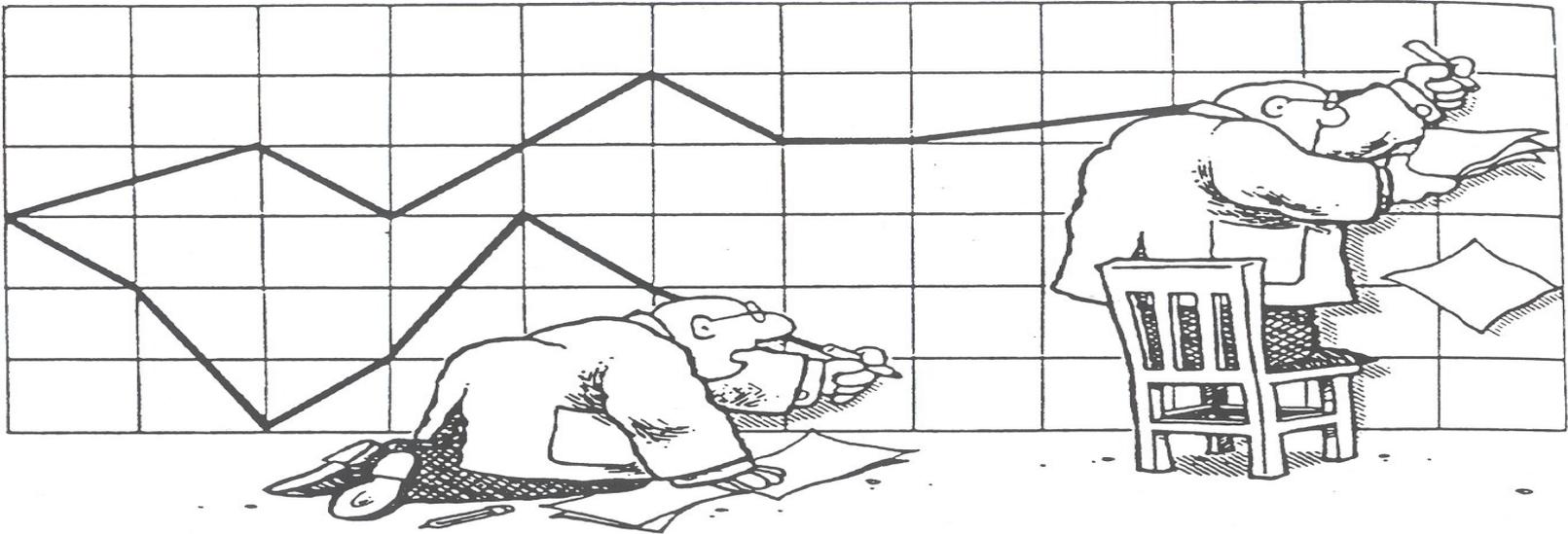
# What is the Form of the Relationship and what is the Slope?



# Is the model the message?

George Box

All models are wrong, but some models are useful. So the question you need to ask is not "Is the model true?" (it never is) but "Is the model good enough for this particular application.?"



"HEY, I THOUGHT WE WERE WORKING WITH THE SAME DATA..."

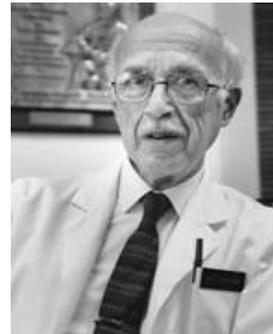
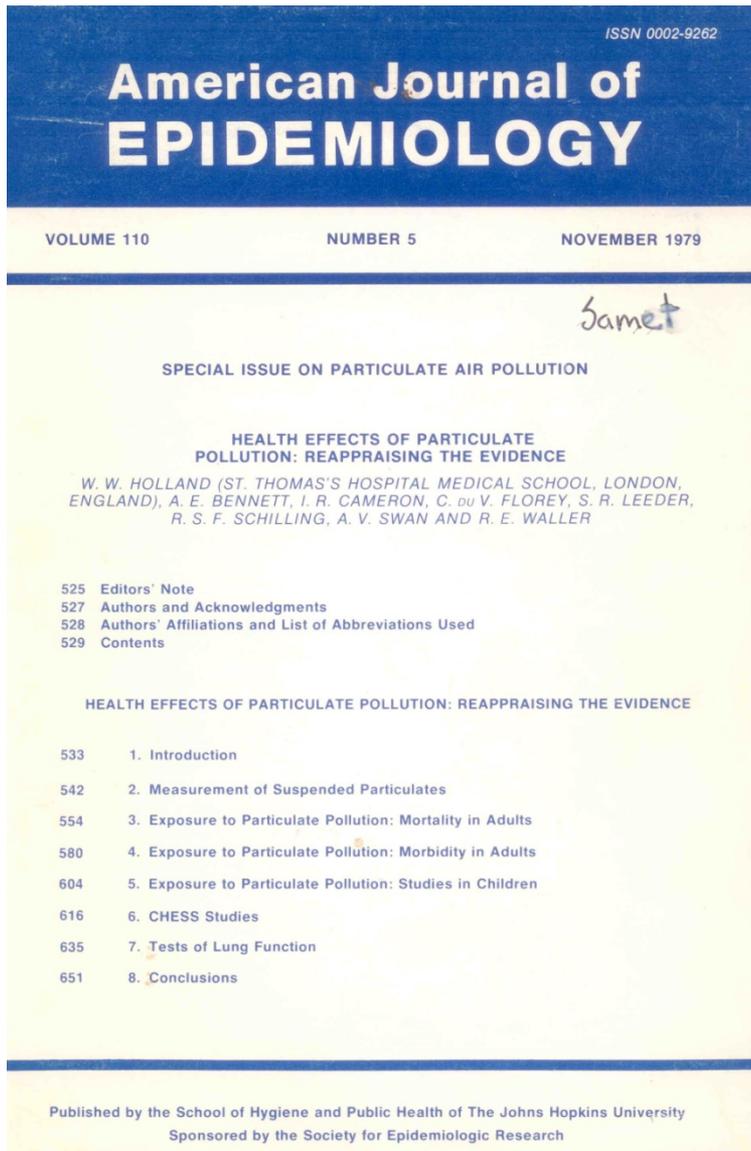
FIGURE 2.3 SOURCE: *National Wildlife Magazine*, August–September, 1984. Copyright © 1984 Mark Taylor. Reprinted with permission of Mark Taylor.

# Back to **the Gap**

- What level of certainty is needed (what level of uncertainty is tolerable) around:
  - The form of the concentration-response relationship
  - The slope of the concentration-response relationship at different concentrations
- How does uncertainty/certainty affect decision-making in different contexts: regulatory, costing and burden estimation, and setting scientific agendas.

# Some Bottom Lines

- We are close to filling “**the Gap**” for some outcomes with observational evidence
  - Methods have been refined
  - For many adverse effects the observations are in the range of regulatory interest
  - Mechanistic uncertainties persist
  - Emerging evidence points to some **Adverse Effects** for which further research is warranted
- Some empiric work might be useful to assess potential sensitivity of decision-making to various scenarios of exposure and risk



## Editor's Note (George Comstock)

Epidemiologic science can give only general guidance to those who must decide upon acceptable limits of air pollutants. Judgment in this area depends much more on the art of epidemiology, the drawing of reasonable conclusions from imperfect data.