

Are we really going to figure out how to do this?

Meeting the policy and science challenges
for a multipollutant approach

Dan Greenbaum, President
Health Effects Institute

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So whose idea was this anyway?

- **“From a Particulate Matter Research Program to a Multipollutant Research Program:** This shift in focus should acknowledge that real-world exposures involve complex mixtures of hundreds of air contaminants of several physical-chemical classes.” (NRC PM Report IV, 2004)
- **“Take an *Integrated Multipollutant Approach* to Mitigating Most Significant Risks”** (NRC Report Air Quality Management in the United States, 2004)



Who's to blame:

PM Committee Membership

- **Jonathan Samet** (*Chair*), Johns Hopkins University, Baltimore, MD
- **Judith Chow**, Desert Research Institute, Reno, NV
- **Bart Croes**, California Air Resources Board, Sacramento
- **Robert Forster**, University of Pennsylvania, Philadelphia
- **Daniel Greenbaum**, Health Effects Institute, Boston, MA
- **Philip Hopke**, Clarkson University, Potsdam, NY
- **Petros Koutrakis**, Harvard University, Boston, MA
- **Daniel Krewski**, University of Ottawa, ON
- **Paul Lioy**, University of Medicine and Dentistry of New Jersey, Piscataway
- **Joe Mauderly**, Lovelace Respiratory Research Institute, Albuquerque, NM
- **Roger McClellan**, Albuquerque, NM
- **Günter Oberdörster**, University of Rochester, NY
- **Rebecca Parkin**, The George Washington University Medical Center, Washington, DC
- **Joyce Penner**, University of Michigan, Ann Arbor
- **Richard Schlesinger**, Pace University, New York, NY
- **Frank Speizer**, Harvard Medical School, Boston, MA
- **Mark Utell**, University of Rochester, NY
- **Ronald White**, Johns Hopkins University, Baltimore, MD
- **Warren White**, University of California, Davis
- **Ronald Wyzga**, Electric Power Research Institute, Palo Alto, CA
- **Terry Yosie**, American Chemistry Council, Arlington, VA



Who's to blame:

AQM Committee Membership

- **William Chameides (Chair), Georgia Institute of Technology.**
- **Daniel Greenbaum (Vice Chair), Health Effects Institute,**
- **Carmen Benkovitz, Brookhaven National Laboratory.**
- **Eula Bingham, College of Medicine at the University of Cincinnati.**
- **Michael Bradley, M.J. Bradley & Associates.**
- **Richard Burnett, Healthy Environments and Consumer Safety Branch of Health Canada**
- **Dallas Burtraw, Resources for the Future.**
- **Laurence Caretto, California State University, Northridge**
- **Costel Denson, University of Delaware.**
- **Charles Driscoll, Syracuse University.**
- **Jane Hall, California State University,**
- **Philip Hopke, Clarkson University**
- **Arnold Howitt, Kennedy School of Government, Harvard University,**
- **C. S. Kiang College of Environmental Sciences at Peking University in China.**
- **Beverly Law, Oregon State University.**
- **James Lents, University of California at Riverside.**
- **Denise Mauzerall, Princeton University.**
- **Thomas McGarity, University of Texas School of Law.**
- **Jana Milford, University of Colorado at Boulder.**
- **Michael Morris, North Central Texas Council of Governments.**
- **Spyros Pandis, Carnegie Mellon University.**
- **P. Barry Ryan, Emory University**
- **Adel Sarofim, University of Utah**
- **Sverre Vedal, National Jewish Medical and Research Center in Denver, Colorado**
- **Lauren Zeise, California Environmental Protection Agency.**



“Multipollutant” vs. “Mixtures”

“Tomahato” or “tomayto”?

- Policy makers say “multipollutant”
- Scientists say “mixtures”
- Both are correct
 - But “multipollutant” suggests a discrete and perhaps manageable set of compounds (i.e. the criteria pollutants and a subset of priority air toxics)
 - “Mixtures” conjures up endless discussions of “bottoms up” and “top down” approaches to thousands of compounds which, frankly, have not gotten us very far
- For policy purposes – and manageable science - the first seems better



Why take a multi-pollutant approach?

- No one is exposed to only one pollutant
- No pollutant comes from only one source
- Sources are asked today to control one pollutant at a time
 - Could be substantially more cost effective to address a set of pollutants simultaneously
- Today's system addresses average exposure to a limited number of pollutants
 - No ability to address simultaneous exposures to both criteria pollutants and air toxics, or hot spots if they exist



The many reasons why we have stuck with one-pollutant-at-a-time

- Federal Government: *“we have always done it that way”*
- Industry: *“tell us the specific thing to cut and we will do that”*
- Environmentalists: *“beware the toxic soot”* or *“smog”* or *“benzene”*
- Lawyers: *“the law does not allow it”*
- Scientists: *“it’s just too difficult”*
- Industry: *“how can we be sure it is pollutant X and not pollutant Y”*
- Scientists: *“the statistics made me do it”*
- Everyone: *“we have always done it that way”*



So when might multipollutant science make a difference to decisions?

- The *NAAQS* process:
 - We all focus on this, but not likely to set multipollutant NAAQS in the near term
- There are at least two other key junctures:
 - Designing *Control Plans* and *Setting Priorities*
 - E.g. State Implementation Plans
 - Designing *Source Control Strategies*

From the NRC Air Quality Management Report

3) Assessing Status and Measuring Progress

- Emissions trends
- Air quality trends
- Health effects trends
- Ecosystem trends
- Institutional accountability

Chapter 6

1) Setting Standards and Objectives

- Emissions standards
- Ambient air quality standards
- Reducing acid deposition
- Reducing regional pollution
- Protecting visibility

Chapter 2

Scientific and Technical Foundation

Monitoring:

- Emissions
- Ambient air quality
- Health and exposure
- Ecosystems
- Meteorology

Analysis:

- Models (e.g., air quality, emissions)
- Economics
- Health and ecological risk assessment

Research:

- Public health and ecosystems studies
- Laboratory studies (e.g. air chemistry, toxicology)

Development:

- Source control technology
- Monitoring technology

2) Designing and Implementing Control Strategies

- Source control technology requirements
- Emissions caps and trading
- Voluntary or incentive -based programs
- Energy efficiency
- Pollution prevention (e.g., product substitution and process alteration)
- Compliance assurance

Chapters 3,4,5



A Simple (Simplistic?) Vision

- All single pollutant NAAQS set at one time
 - With coordinated compliance deadlines
- States/Localities develop integrated “Air Quality Management Plans”
 - Addressing all criteria pollutants and highest priority air toxics; hot spots if appropriate
- Federal and regional source control strategies set to address all priority emissions from each source at one time



Would this be all that hard?

NAAQS*

- We actually set all NAAQS at the same time in the beginning (1970)
- Europe has just completed setting all “limit values” at the same time
 - Clean Air for Europe (CAFÉ)
- Why couldn't we, after this round, review all NAAQS at same time and only proceed with reviews of those where the science has changed significantly?
 - This will be an easy task for Jon Samet as chair of CASAC...
- Might need a law change.....

* With apologies for the *agita* this slide will cause John Vandenberg and Lydia Wegman



Would this be all that hard?
Control Plans and Priority Setting

- South Coast Air Quality Management District already has a multipollutant Air Quality Management Plan (AQMP)
- And EPA has pilots for these underway with three states/localities



Would this be all that hard?

Source control strategies

- We have been doing some multipollutant control of sources for some time:
 - Cars: VOCs, NO_x, CO
 - Trucks/Buses: PM, NO_x
 - Power Plants: (SO_x, NO_x)
- How hard would it be to make these broader based on priority “parts of the mixture”, e.g.
 - Benzene as well as broader VOCs?
 - Ultrafine numbers in addition to PM mass (Europe is already doing this)

Science to Inform Decisions

- So given these substantial opportunities, what can science do to help?
- *Essential Need*: Better understanding of whether certain mixtures of key pollutants have higher or lower effects.
 - *For NAAQS*: At what ambient level?
 - *For Control Plans and Emission Standards*: Are some mixtures of higher priority for control?



What do we need?

- Better data evaluation and synthesis tools
 - Will not get to simultaneous reviews of multiple NAAQS pollutants without these
- Continuously improving statistical methods for dealing with multiple pollutants to:
 - Assess roles of different pollutants within a mixture and
 - Assess and compare the effects of different whole mixtures
 - HEI will have a new RFA on these methods issues in early 2009



What do we need?

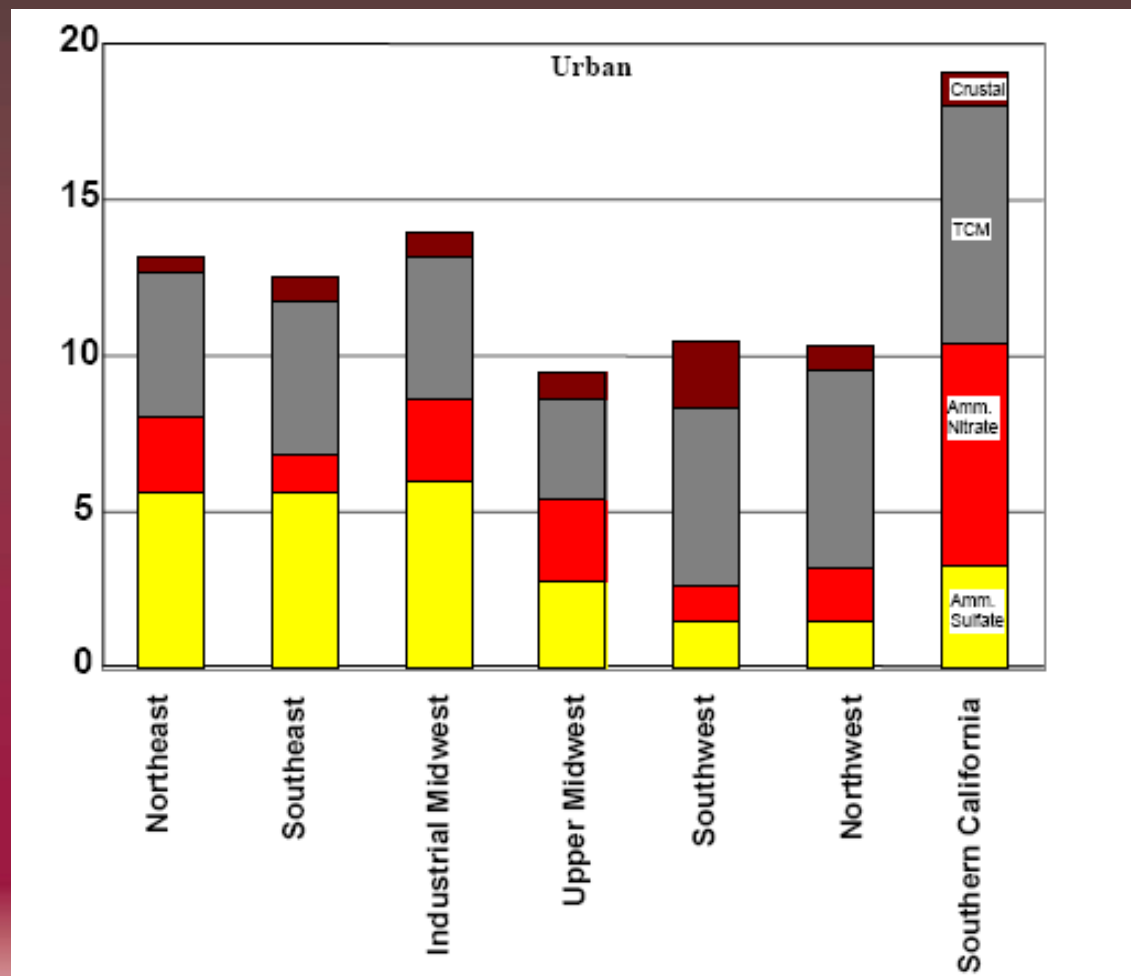
- Continually improving methods for “real world” toxicology
 - E.g. CAPS, source exposures (especially aged source exposures like TERESA)
- A focus in epidemiology on long term (i.e. cohort) studies
- Integrated epidemiology and toxicology

*Integrated epidemiological and toxicological
cardiovascular studies to identify
toxic components and sources of fine PM
(UWash/LRRI NPACT Study)*

Hypothesis 1: PM_{2.5} chemical components in primary motor vehicle exhaust emissions have more long-term cardiovascular toxicity (increases in markers of atherosclerosis, atherosclerosis prevalence and progression, and incident cardiovascular events) than PM composed of either secondary inorganic aerosols or crustal components.



Annual average compositional mass concentrations of urban $PM_{2.5}$ ($\mu\text{g}/\text{m}^3$) in 2003 by region (from EPA Speciation Network; TCM = total carbonaceous mass) (US EPA 2005 [from Schmidt 2005])



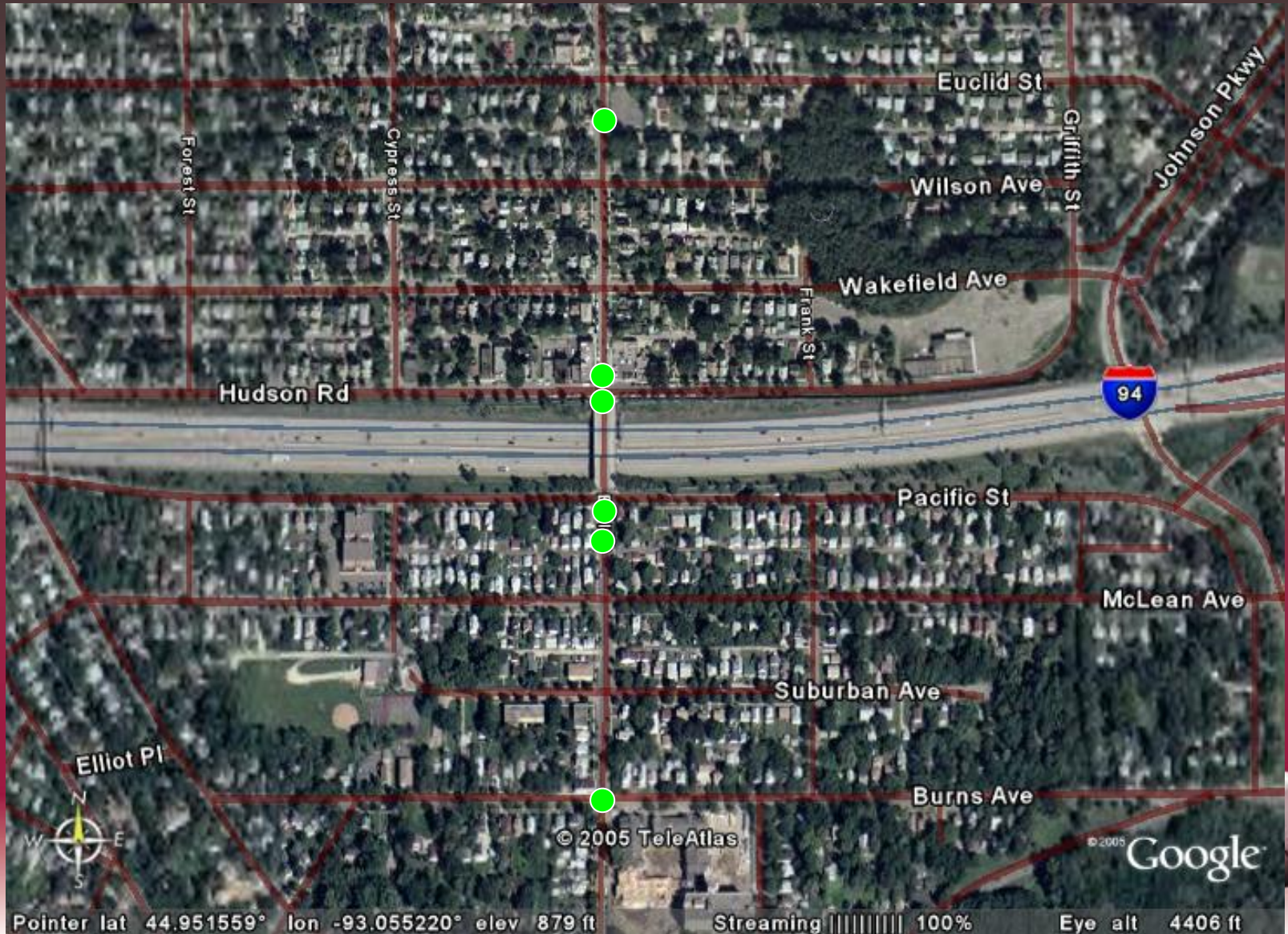
MESA Air 2-week sampling protocol

(HEI project)

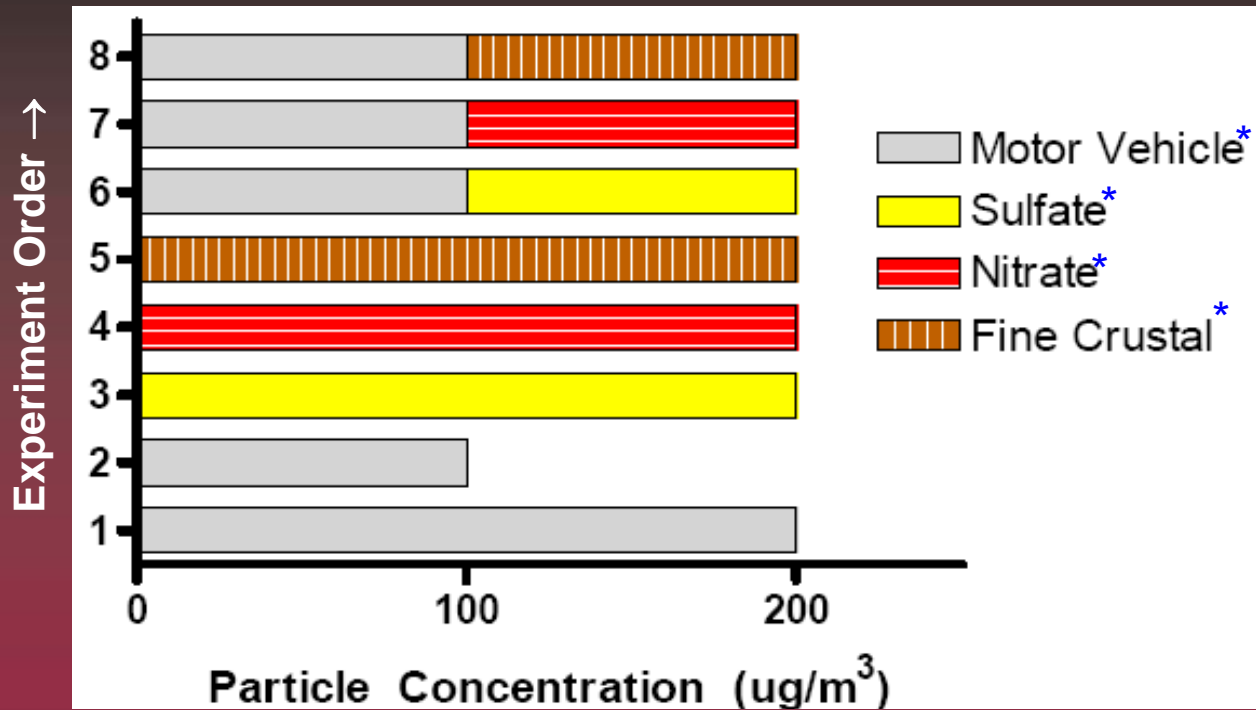
	fixed ¹	home outdoor ²	home indoor ³	personal ⁴	traffic gradient ⁵
mass, BC, elements/metals ^a	✓	✓	✓	✓	
EC, OC, DTT, ESR ^b	✓	✓			
NO _x , NO ₂ , O ₃ , SO ₂ ^c	✓ no O ₃	✓	✓	✓ no O ₃	✓ only NO _x and NO ₂
^a Teflon filter ^b quartz filter ^c Ogawa sampler	¹ regulatory, roadside, household (3-7/city [27 total]) ² rotating every 2 weeks > 50 homes/city in 2 seasons ³ ~50/city in 2 seasons ⁴ ~15/city in 2 seasons ⁵ ~50 sites/city (3-season “snapshot” campaign)				



Traffic gradient site



EXPOSURE ATMOSPHERES



**With and without gas/vapor phase of vehicle emissions*



Common endpoints in the animal studies and MESA Air

	ApoE^{-/-} mouse model	MESA Air
patho-physiological	* MMP regulation, morphology of aortic arch	* ultrasound carotid intima-media thickness (CIMT)
	calcification of aortic arch by Van Kossa's staining	* CT coronary artery calcium (CAC) and abdominal aorta calcium
	* coronary vascular reactivity - ACh, NO, ET-1	ultrasound and pulse wave large and small artery compliance
serum/tissue	cholesterol, triglycerides, Lipogels	cholesterol, HDL, LDL, triglycerides, RBC membrane fatty acids
	glucose	glucose, insulin
	amyloid alpha, ET-1 real time PCR HO-1, ET-1, IKB-e in aorta and heart	acute phase reactants, pro- and anti-inflammatory cytokines, adhesion molecules, markers of infection
	oxLDL, LPO, PGI₂, cardiac troponin	lipid oxidation markers, oxLDL, nitric oxide
	fibrinogen, aPTT	coagulation and fibrinolytic markers, platelet markers
	* real time PCR for MMPs, TIMPs, TF, TF inhibitor in aorta and heart	MMPs, macrophage and lymphocyte activation, tissue factor expression on monocytes
	hematology	hematology

Concluding Thoughts

- A focused set of multipollutant regulatory approaches is not “beyond the pale”
 - E.g. EPA is already working on Air Quality Management Plans
- As to the science:
 - We should not focus only on the NAAQS
 - Are there “priority mixtures” of a set of chemicals from major sources that deserve more regulatory attention?
 - There is much we can do on statistics, toxicology, epidemiology, synthesis



Concluding Thoughts II

- A caution: let's not get too fancy
 - Measuring and trying to tease out the contribution to health effects of every single part of the mixture will likely ensure we never make progress
 - Building science around the major sources - and around mixtures of the major, priority components of the mixture - may be a better place to start
 - e.g. criteria pollutants (including major PM components) and priority toxics (e.g. benzene, aldehydes, metals)

*“The perfect is nearly always the enemy
of the very good”*



Thank You

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