Urban Atmospheric Environments

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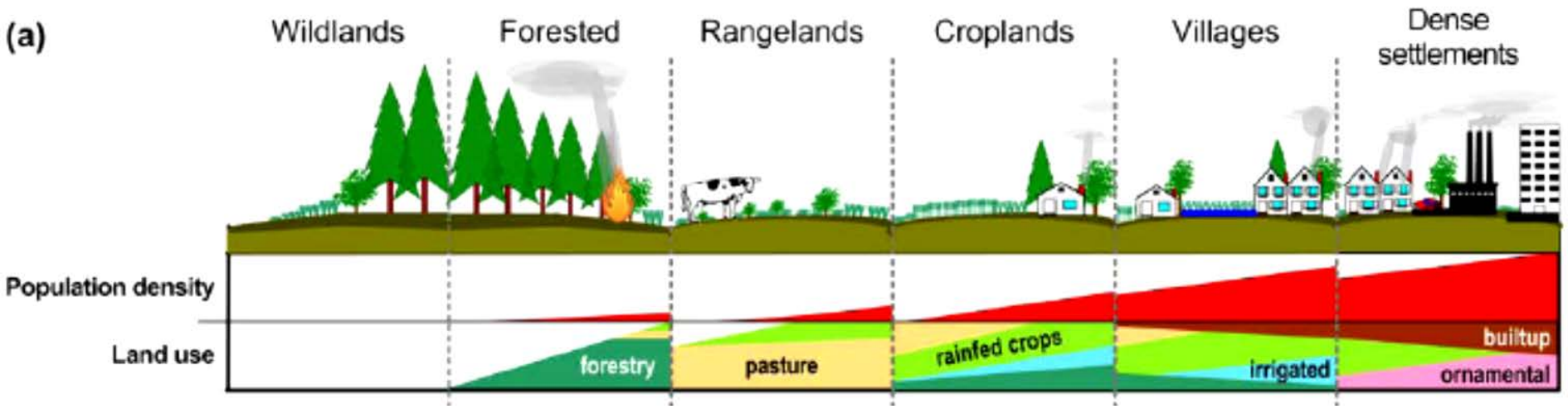
Urban atmospheric pollution?

1. Unique environments (analogue to climate change?)
2. Unique source-sink relationships
3. Implications to human health (where people live!)
4. Regional importance (underestimating load?)
5. Impassioned pitch to incorporate urban areas into deposition networks

Ubiquitous Anthropy?
(Ludwig 1989)



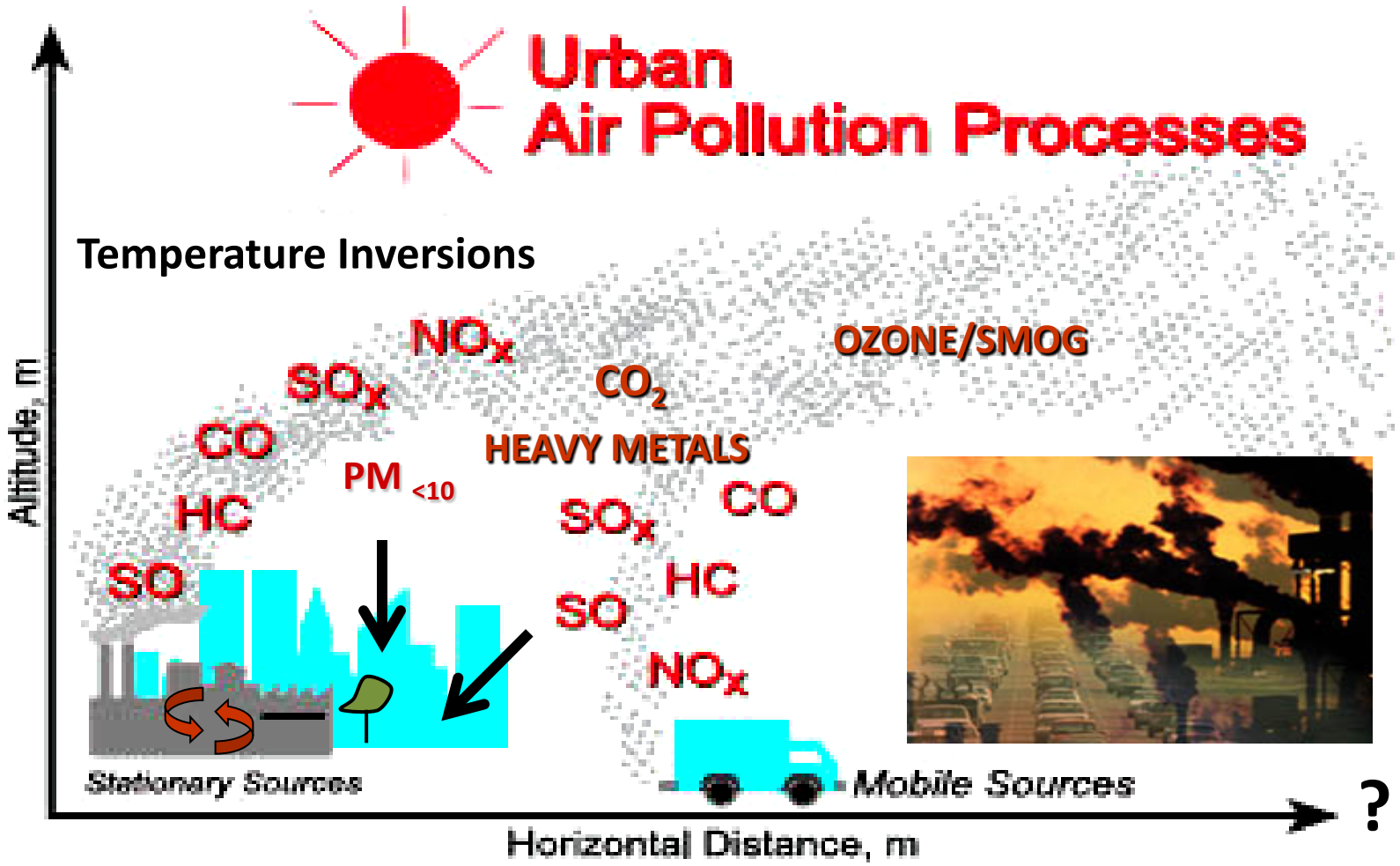
80% of 6.4 billion persons live in dense settlement or village biomes

45% of NPP in cultivated & substantially populated biomes

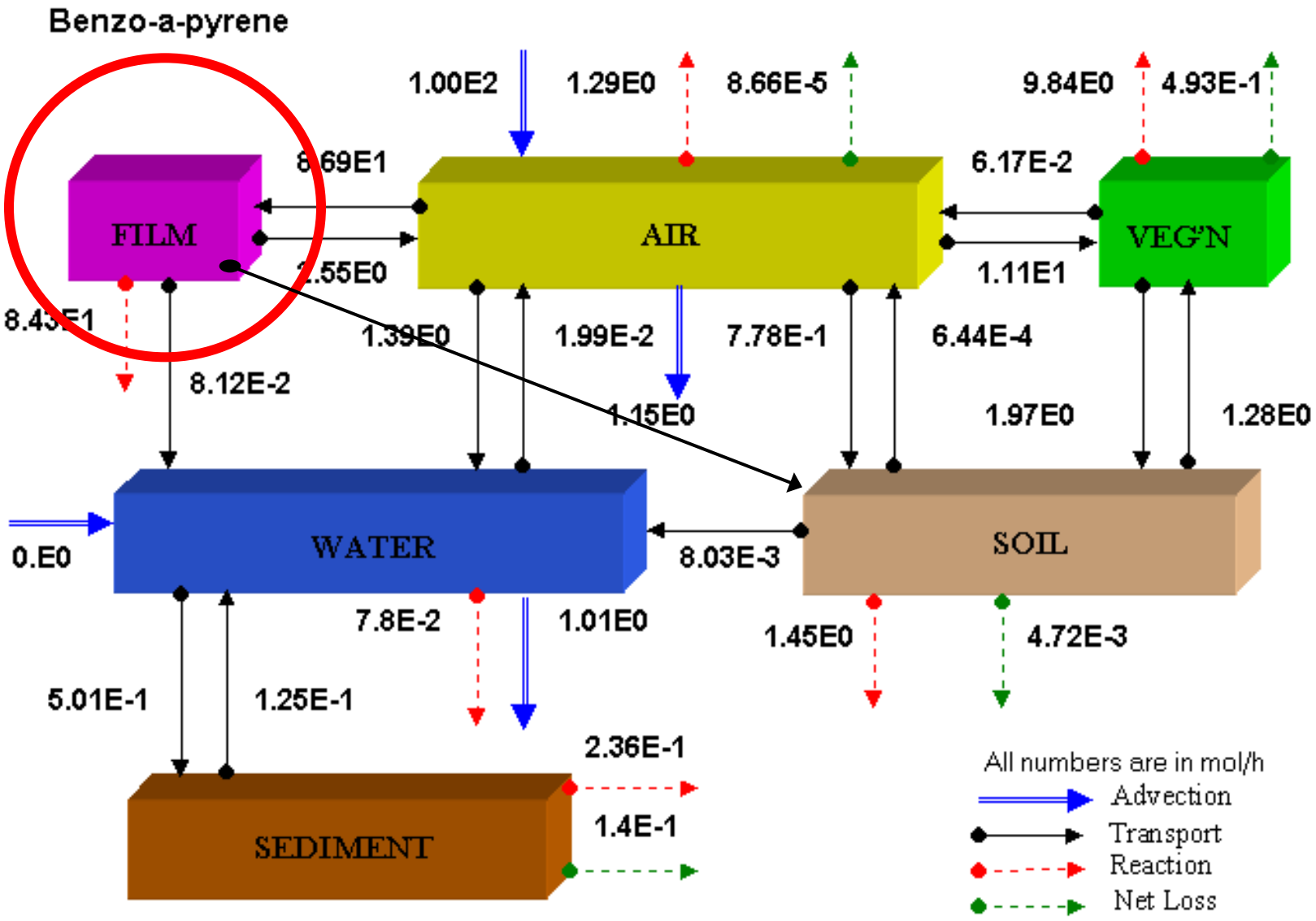
>50% of Nr in biosphere fixed by humans

Ellis et al. 2008, Vitousek et al. 1998

Sources and Reactions Occur at Various Scales



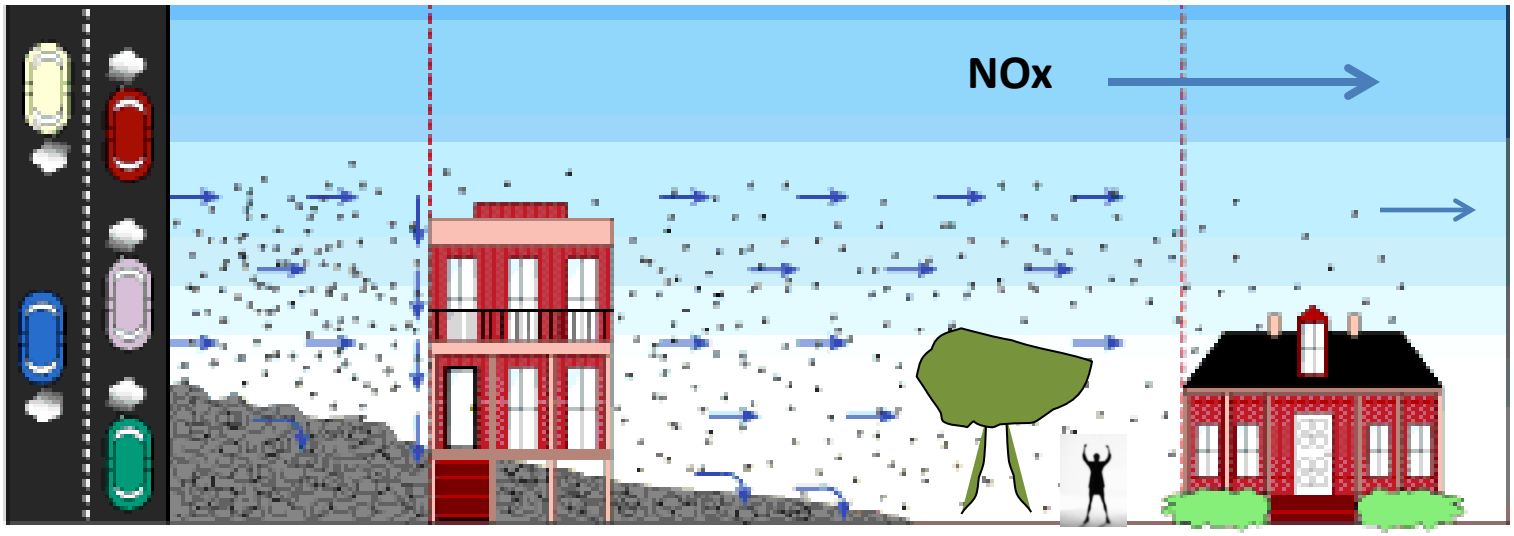
Sinks Occur in Various Media

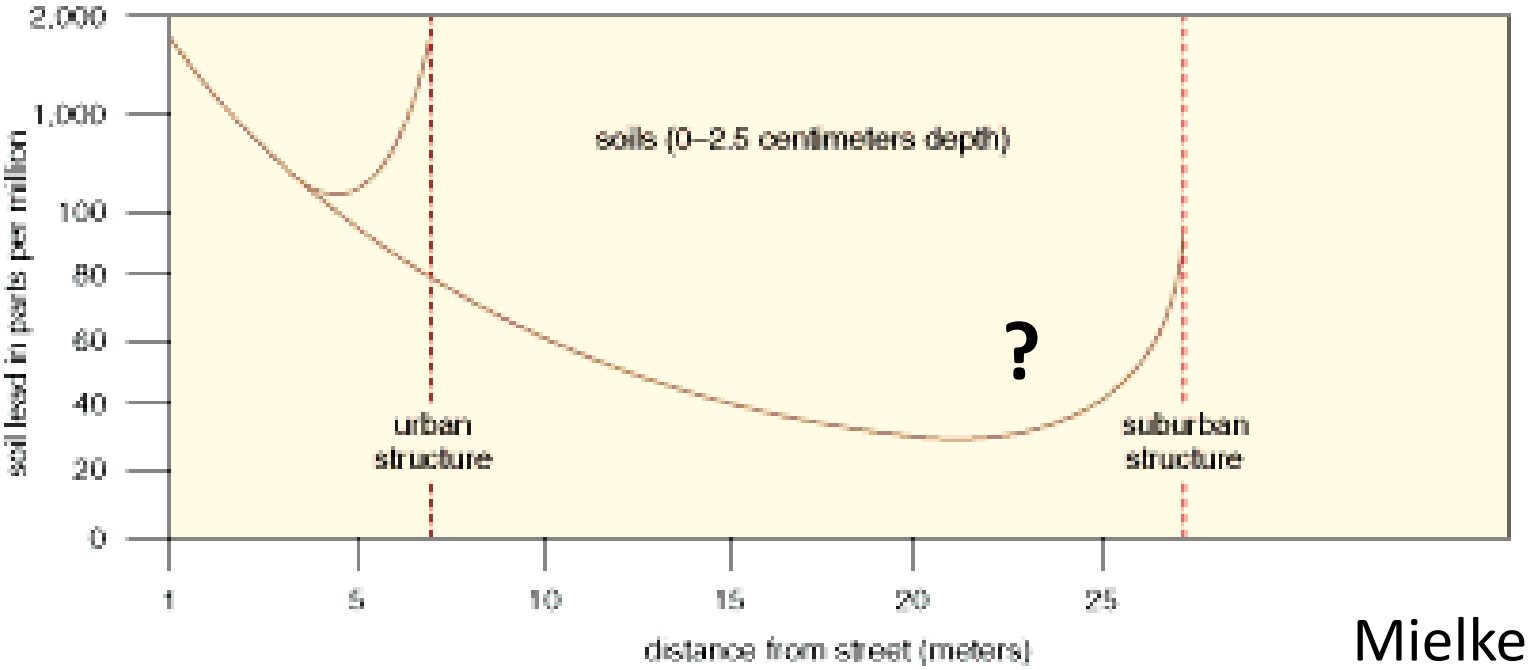


100 mol/h emission into air

M. Diamond et al. 2001

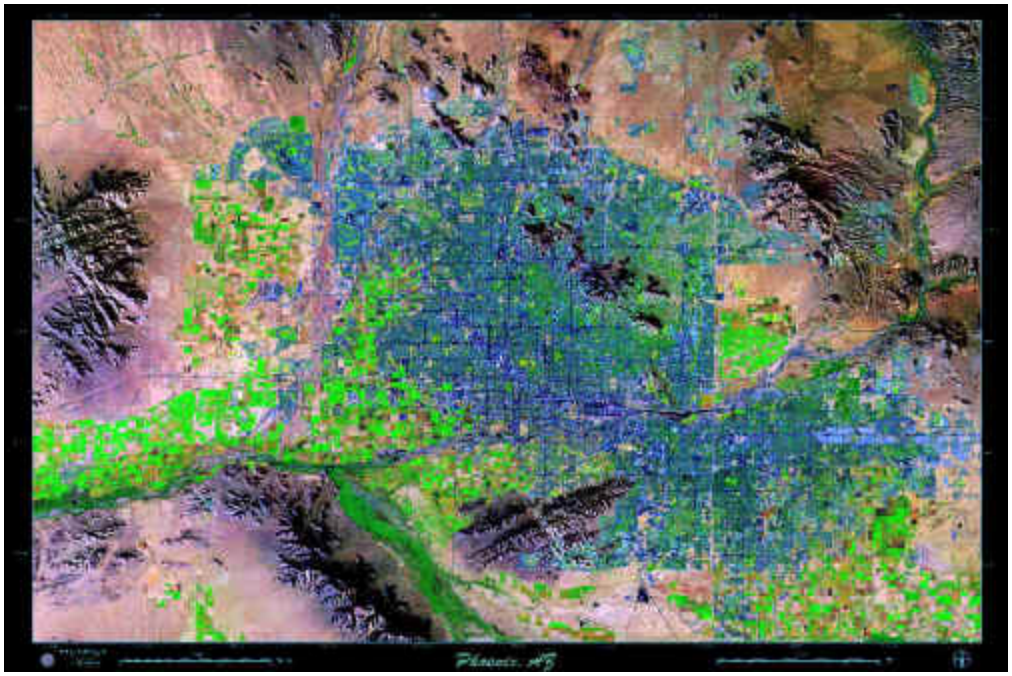
Local Dispersion/Deposition Patterns



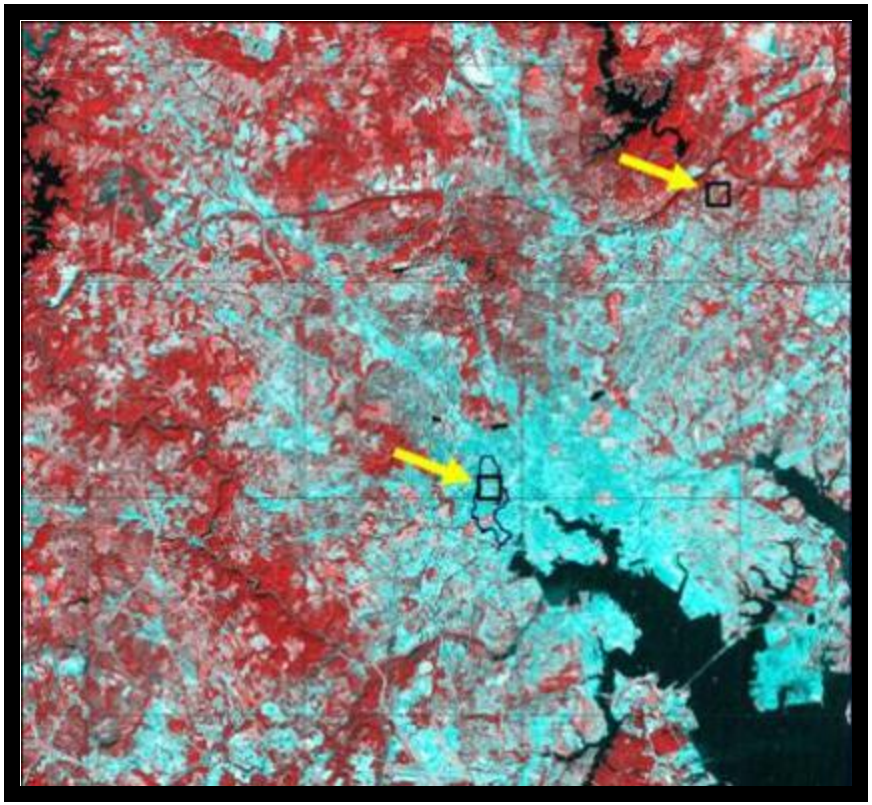


Mielke 1999

Regional Dispersion/Deposition Patterns?



Well defined/Infrastructure

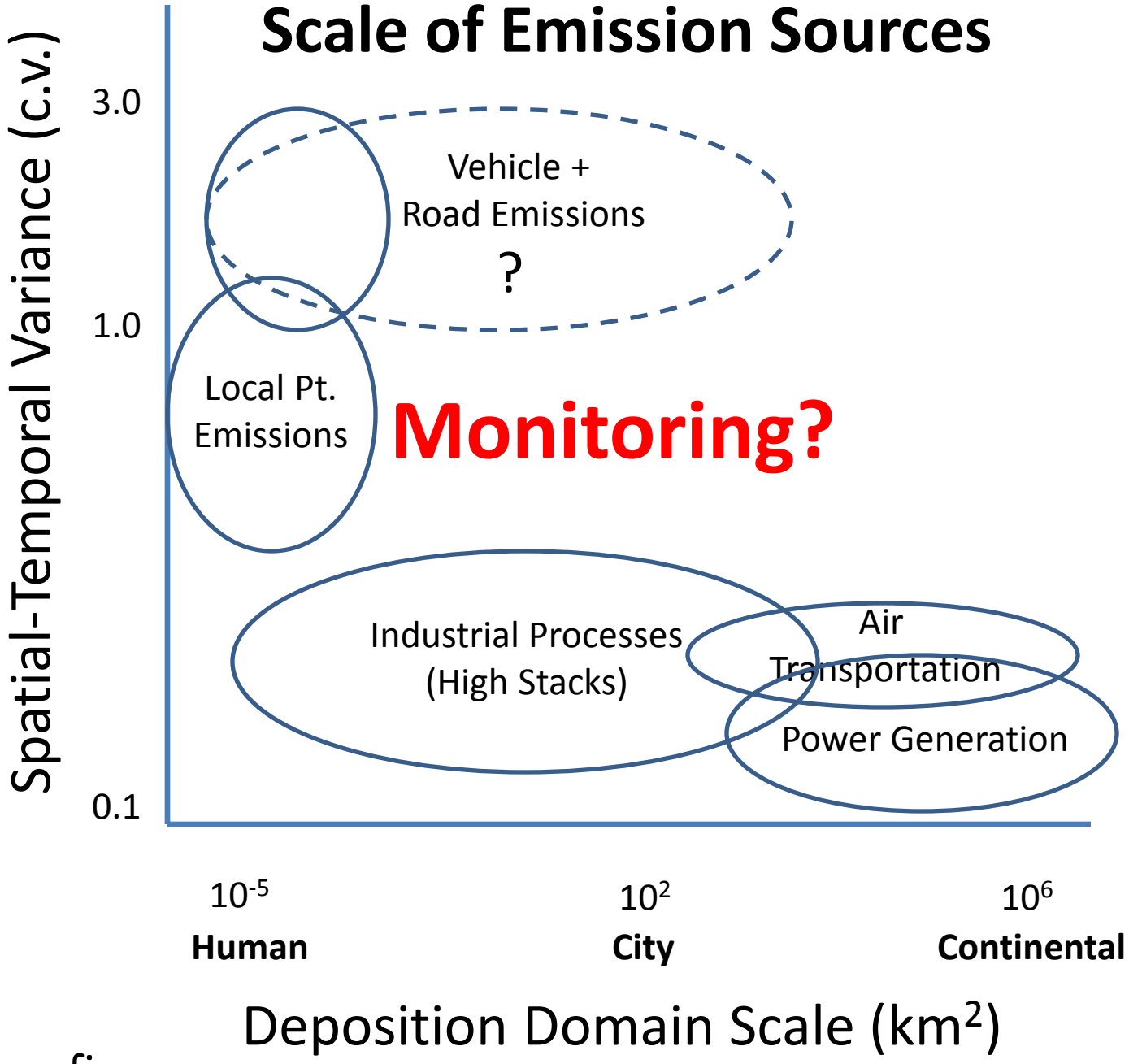


Diffuse/Transportation

Development pattern:

- Geophysical constraints
- Infrastructure
- Transportation network

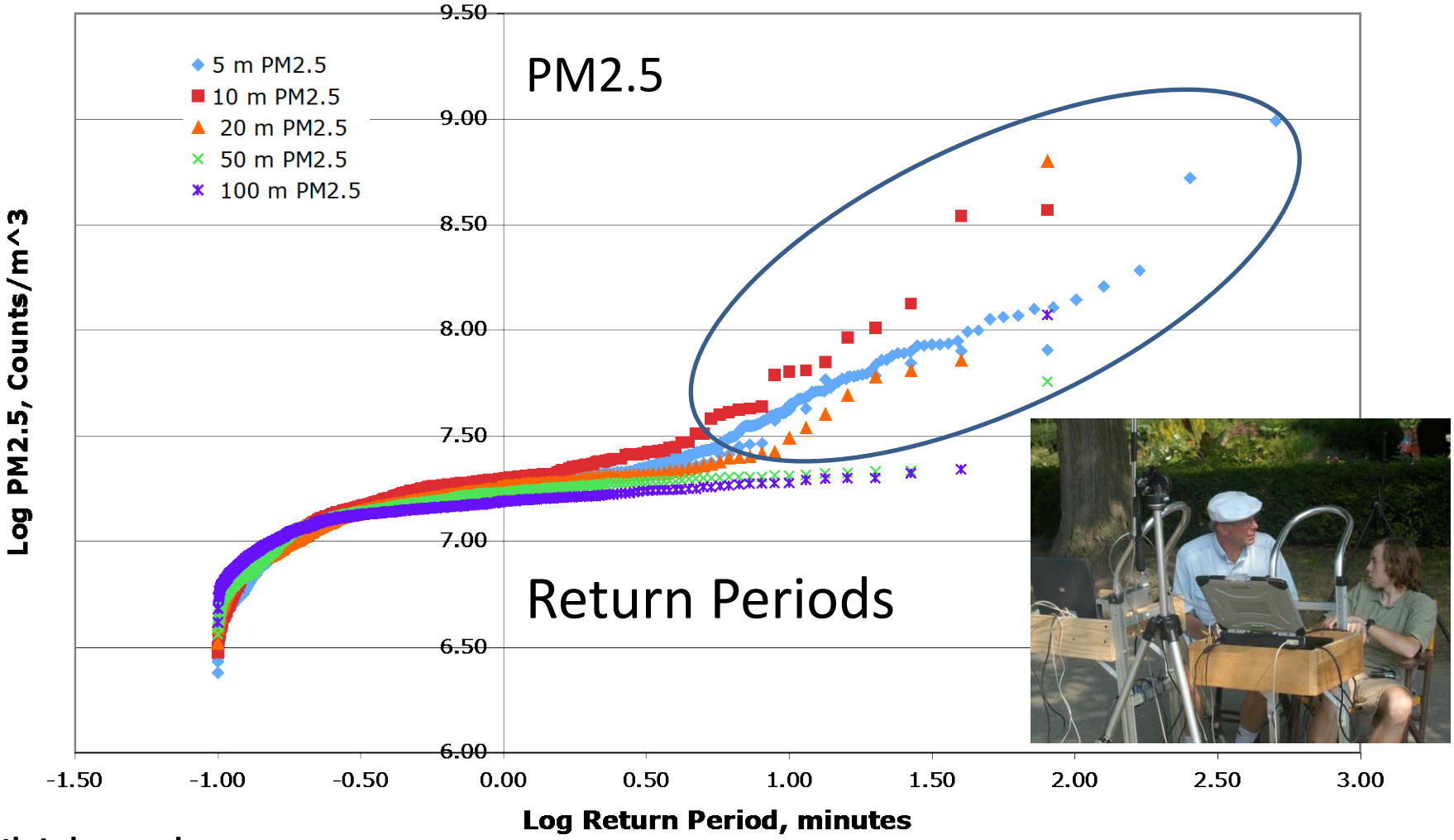
Point sources?
Line sources?
Urban centers as regional source?



T. Whitlow figure

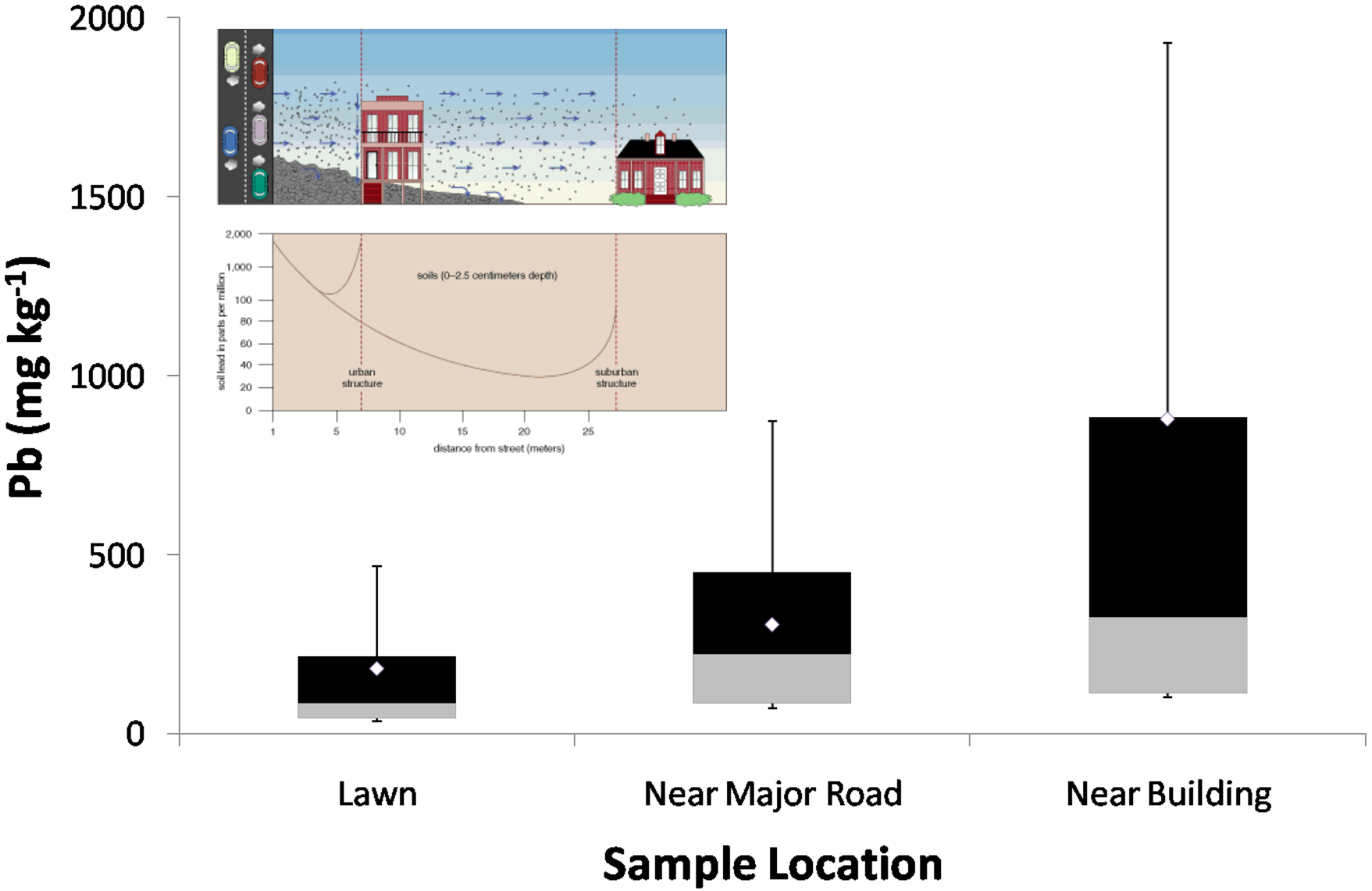
Line Source with “Pulses”

Extreme events decrease in frequency and magnitude
With distance from curb (>50 m “decoupled”)



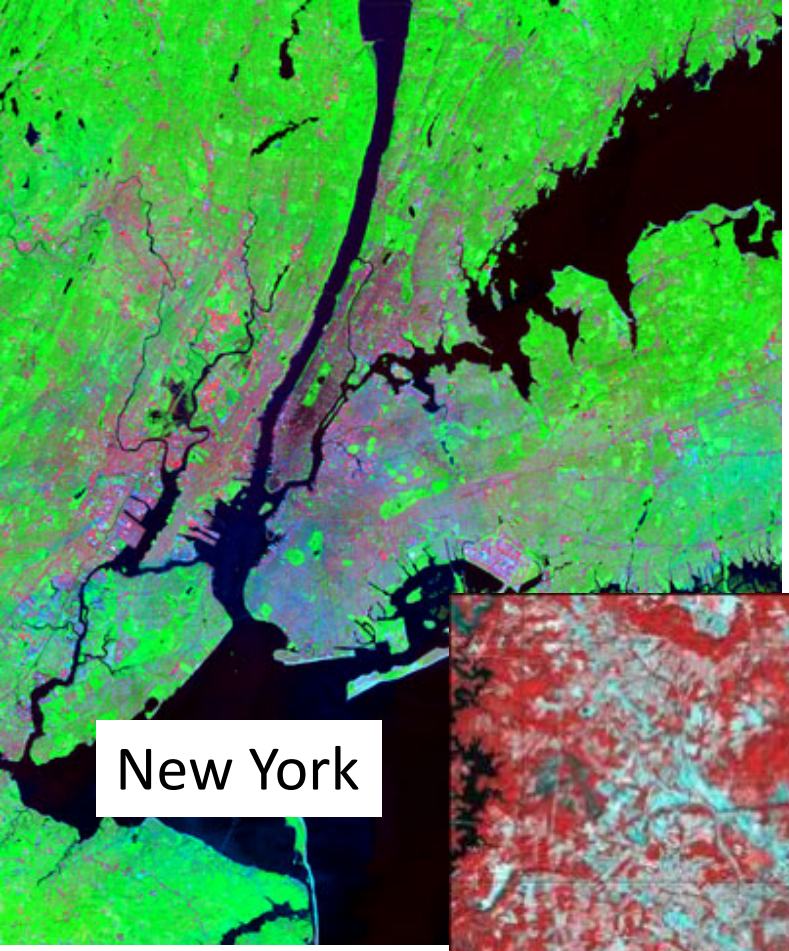
T. Whitlow data

Lead and Sampling Location



Schwarz 2010

Metropolitan Area
(development pattern)



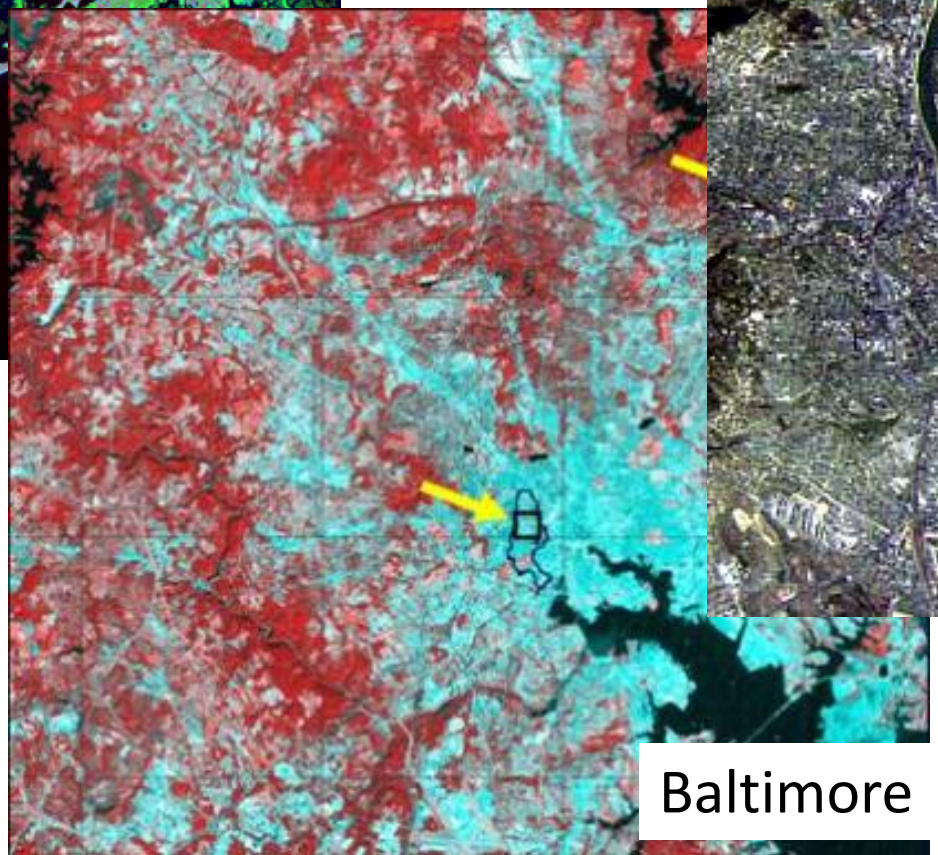
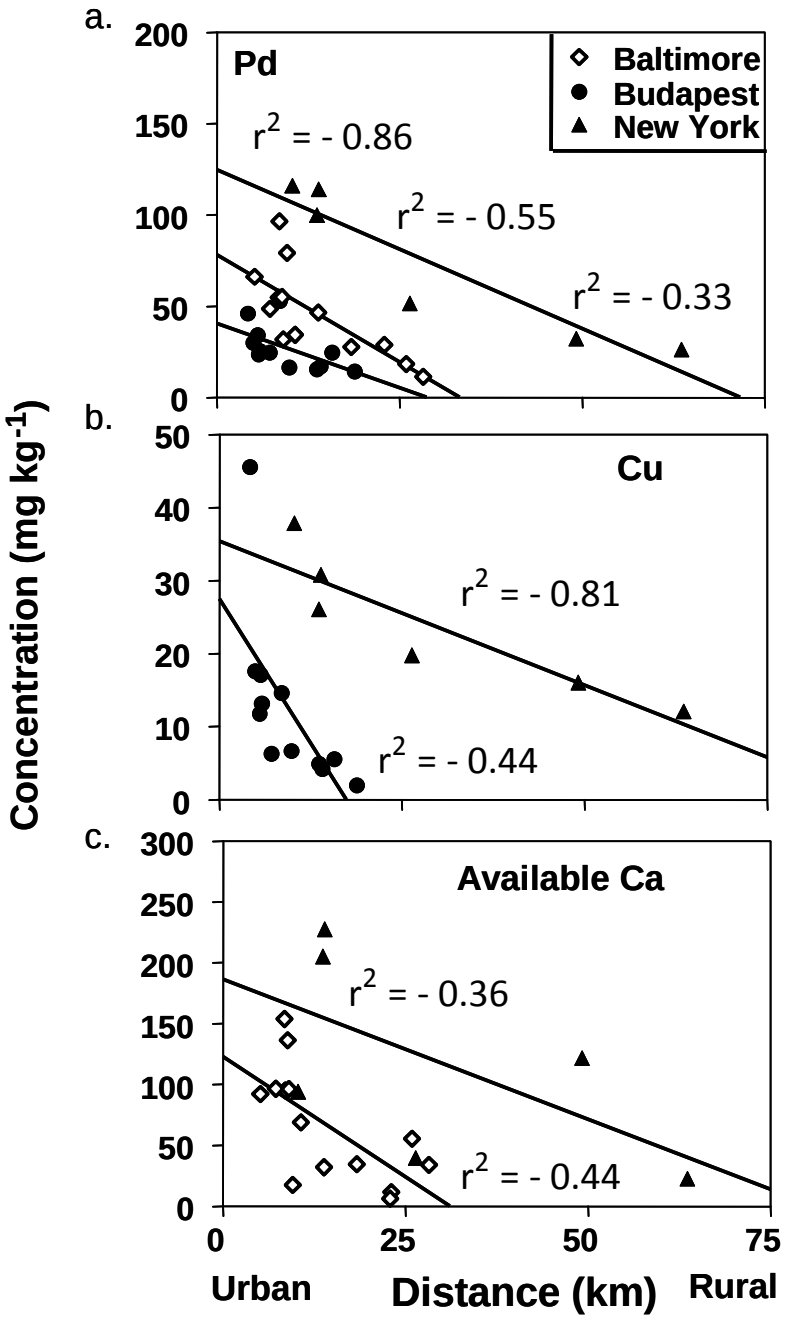


Figure 4.



Forest Patches

City comparisons:

Used distance as surrogate

NYC > Baltimore > Budapest

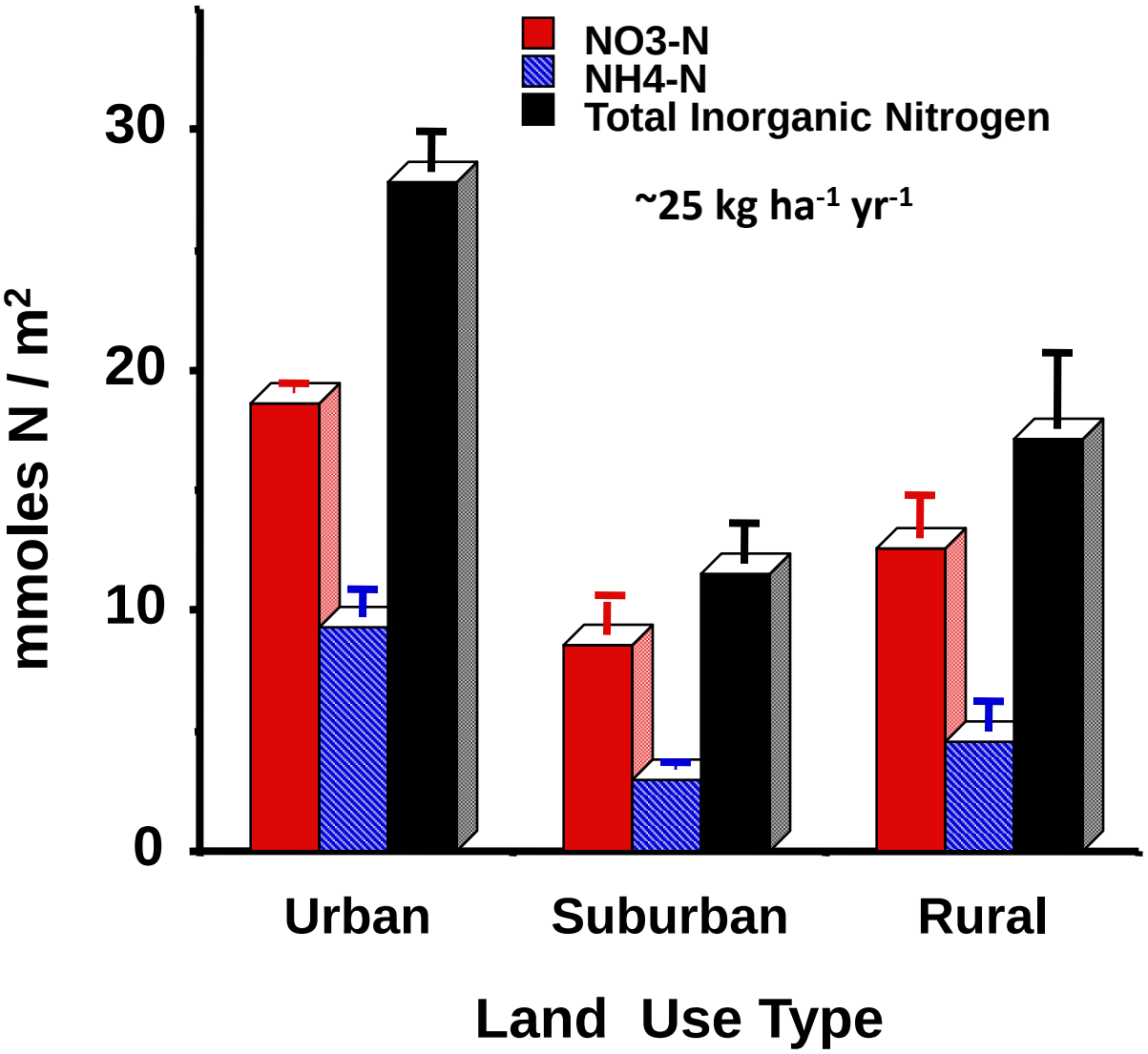
Slope/intercept differed (Pb, Cu, & Ca)

NYC more expansive area & higher levels in urban

Beyond roadside environment

Pouyat et al. 2008

FOREST THROUGHFALL NITROGEN



Lovett et al. (2000)

Urban Scrubber?

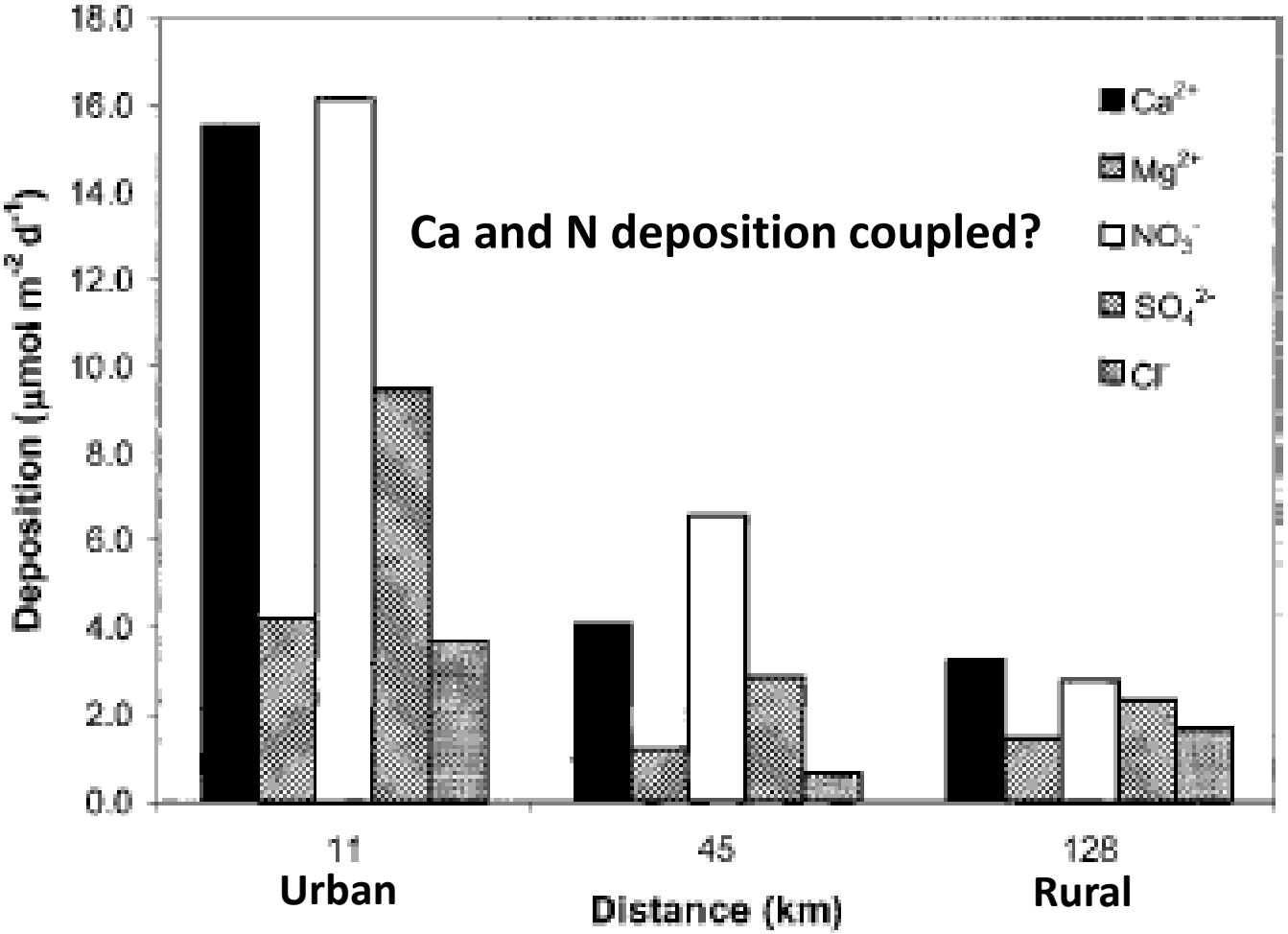
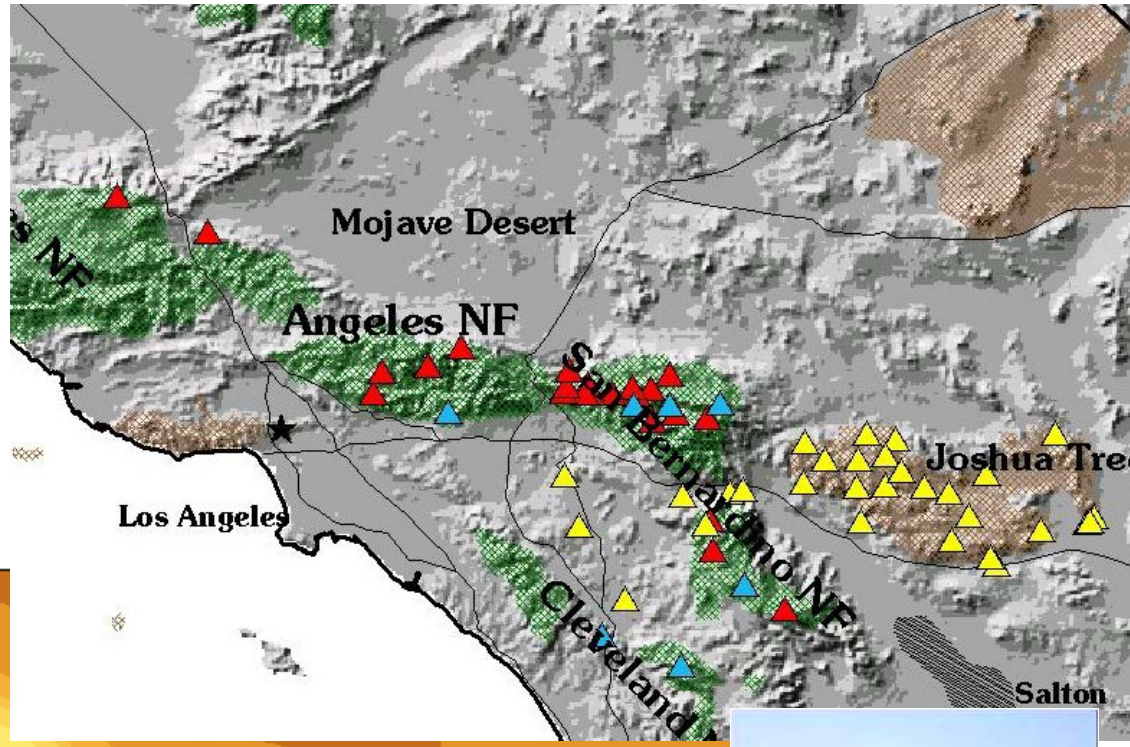


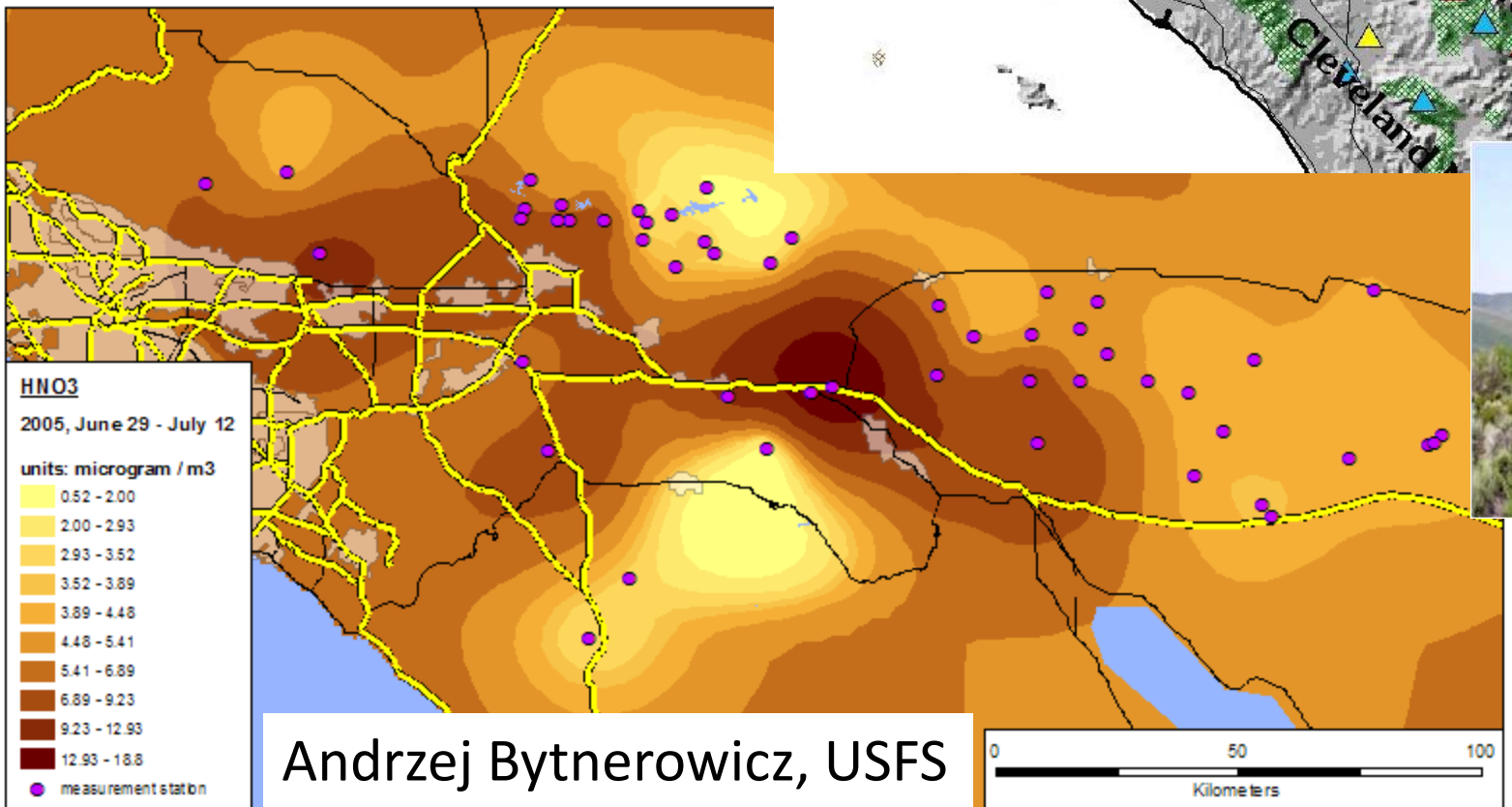
FIGURE 6. Deposition to dust collection plates for urban, suburban, and rural sites in 1997.

N emissions highways?

Extensive Sampling using passive samplers

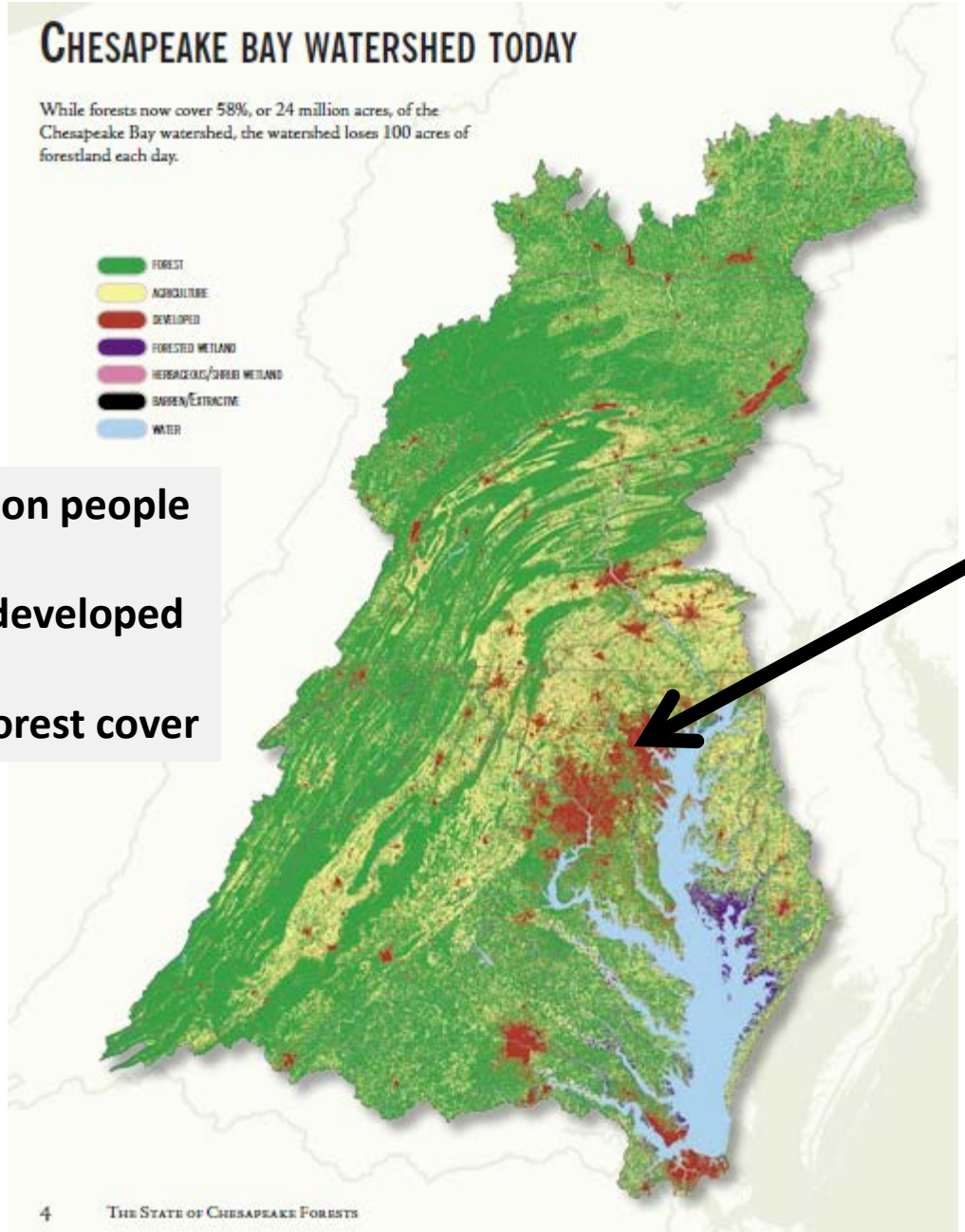
Nitric Acid Vapor: Summer (Passive Samplers)





Andrzej Bytnerowicz, USFS

Why need to account for urban emissions?



19 million people

~11 % developed

~58% forest cover

Urban areas

Total N load?

Proportion from N deposition?

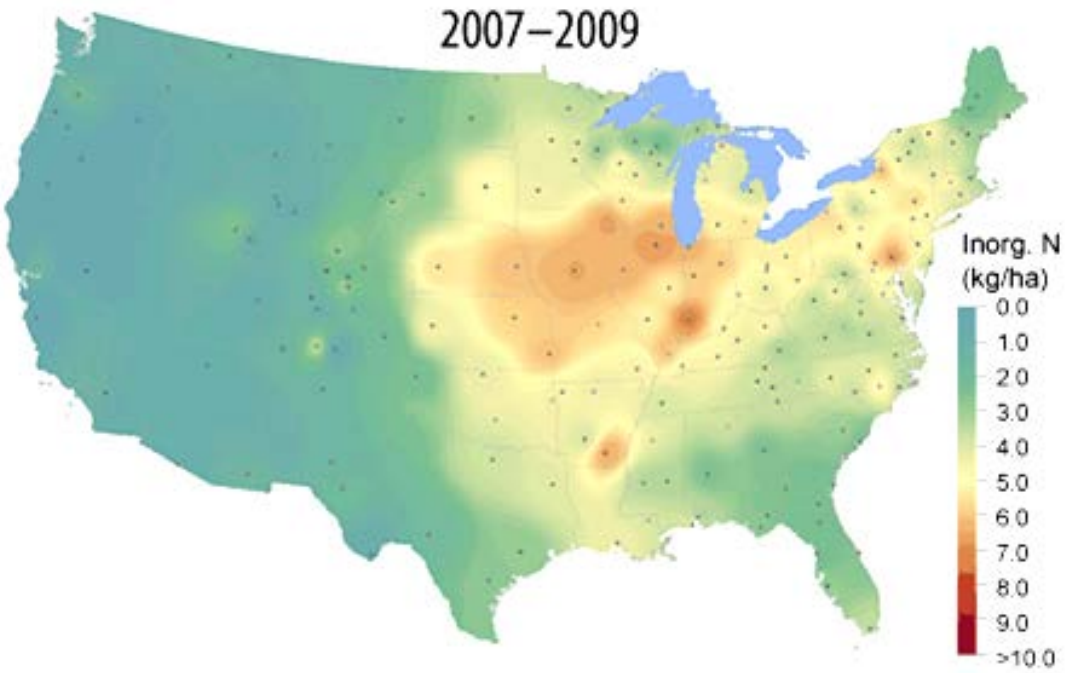
Estimate of total N Deposition: Chesapeake Bay

- Chesapeake Bay Model = 1,210 kg N km^{-2} yr^{-1} (extrapolated from NTN)
- Howarth (2006) = 1,550 kg N km^{-2} yr^{-1}

	Total Load to Bay	Input to Bay from Direct Deposition onto Bay Water Surface	Input to Bay from Deposition onto Watersheds	Total Input to Bay from Deposition
Chesapeake Bay model (2000 conditions)	130*	9 (7%)	25 (19%)	34 (26%)
Deposition increased to 1,550 kg N km^{-2} yr^{-1}; no change in retention assumptions	140	12 (9%)	32 (23%)	44 (32%)
Chesapeake Bay model assumptions on deposition rate; assume 70% retention in landscape	168	9 (5%)	63 (38%)	72 (43%)
Deposition increased to 1,550 kg N km^{-2} yr^{-1}; assume 70% retention in landscape	188	12 (6%)	80 (43%)	92 (49%)

*** Thousands of metric tons of N yr^{-1}**

Percentage values in parentheses (percentage of total N load)



Sub-network of urban influenced sites?

- Comparison with non-urban sites (land use change effects)
- Comparison with other urban areas
- More complete estimates of regional loads
- Situated to account for complexity of urban landscapes
- Need for urban data is high (NADP mission)

Conclusions:

1. Urban > rural environments (concentrations and depositional fluxes of atmospheric chemicals)
2. Urban landscapes: unique source-sink relationships at various scales
3. Urban related emissions affect ecosystems beyond urban boundaries
4. Need for an urban/exurban sub-network (mass-balance analyses, land-use change effects, human health, “natural experiments”)

Calcium deposition similar to S and N

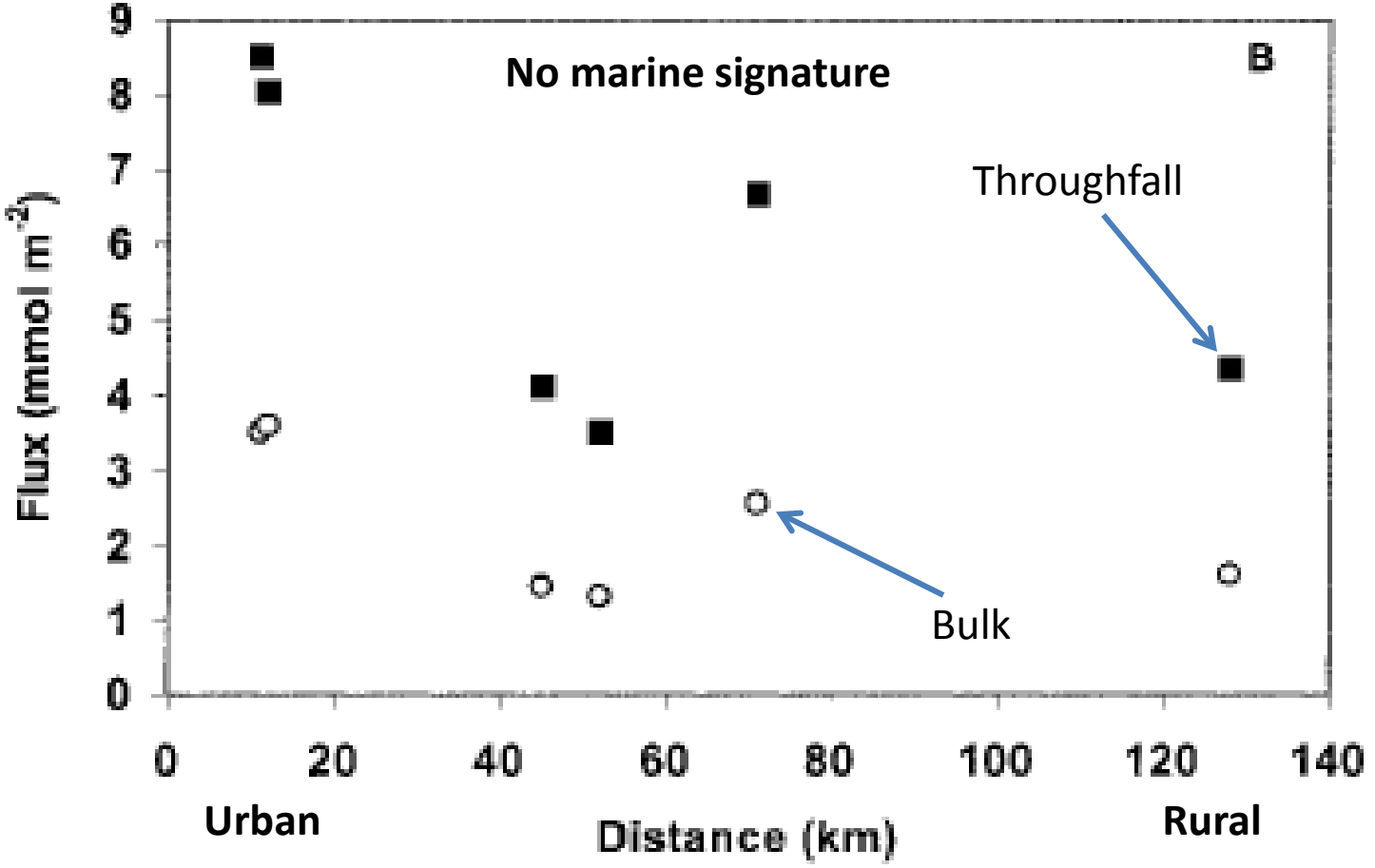
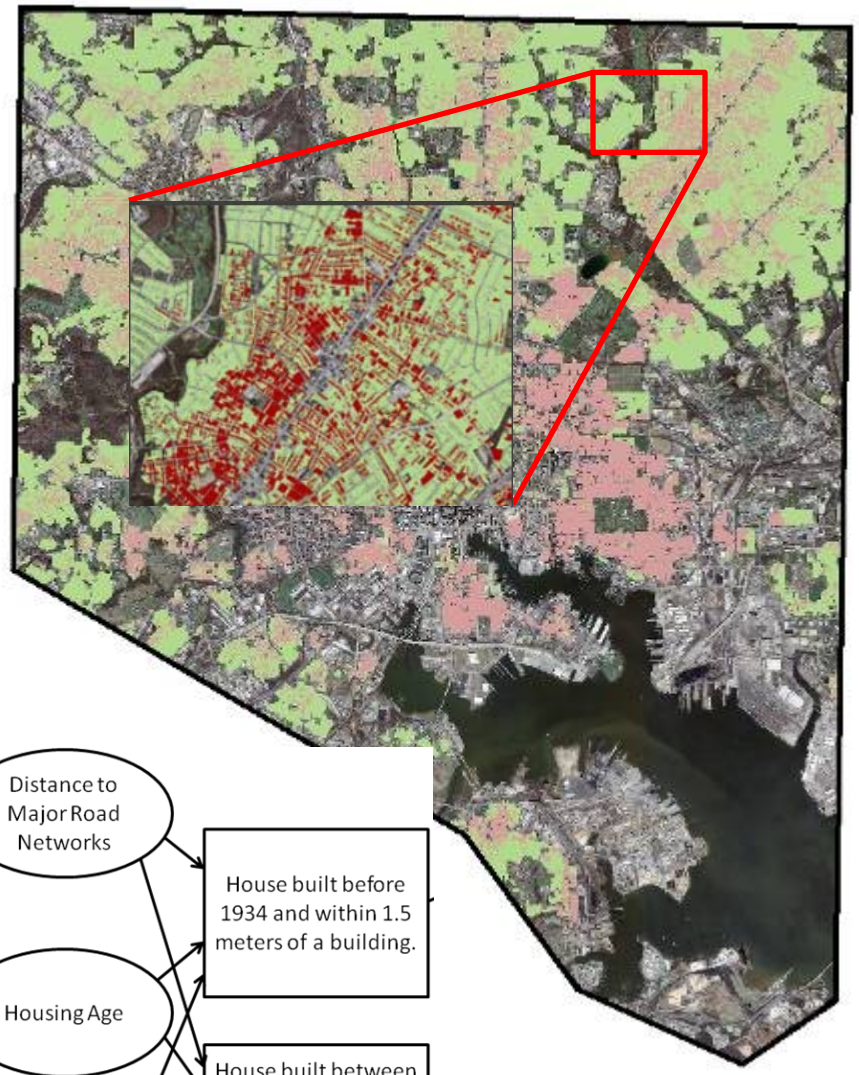
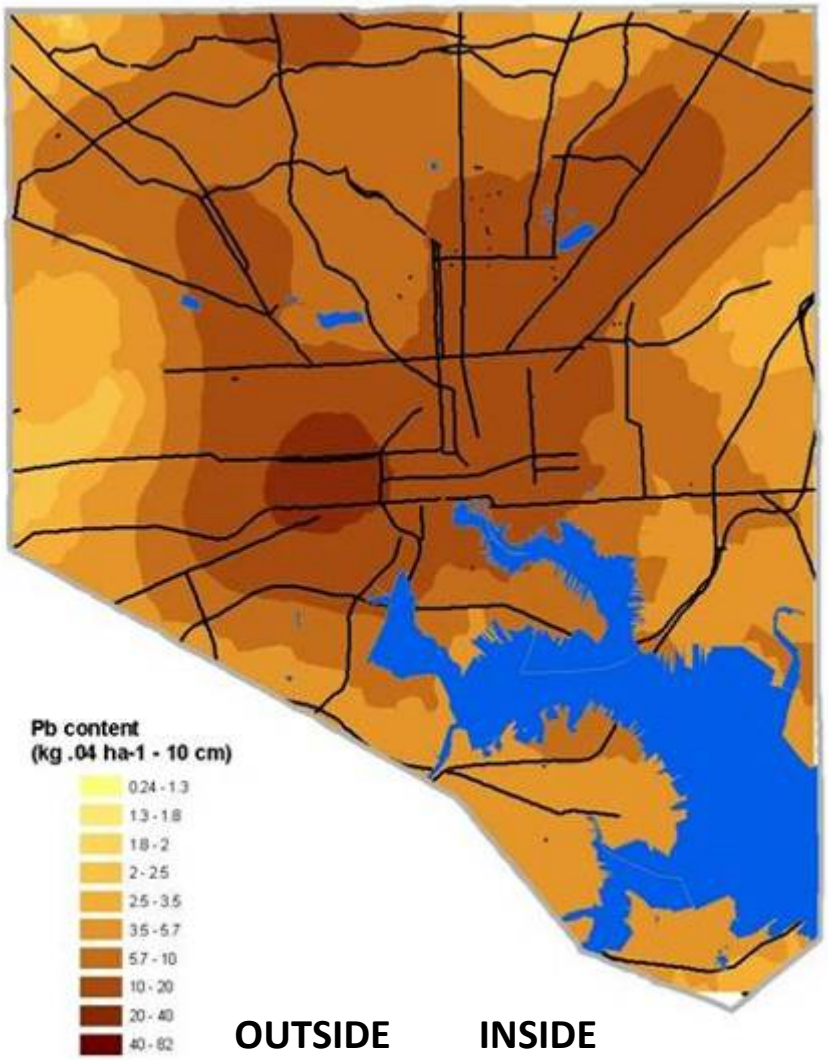


FIGURE 4. Concentration (A) and deposition (B) of Ca^{2+} in bulk deposition and throughfall vs distance from Central Park, NYC. Collection period from June 25 to September 10, 1996. Filled squares are throughfall and open circles are bulk deposition.



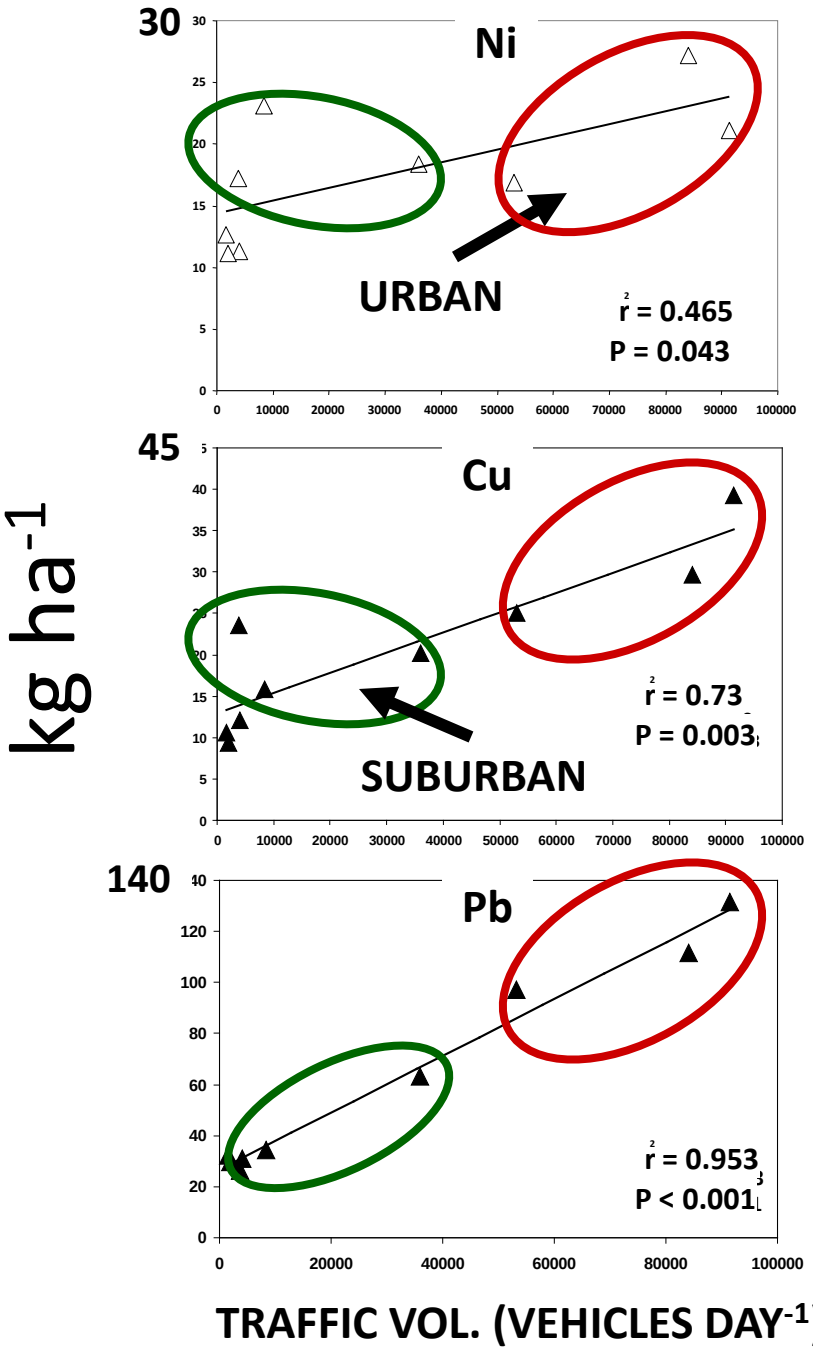
CART Regression Tree

K. Schwarz (2010)



	OUTSIDE	INSIDE	
Cu	2.50654	15.53780	0.0152
Zn	4.32923	65.36054	0.0002
Pb	12.31628	117.54626	<0.0001

Yesilonis et al. (2008)



Ni, Cu, Pb varied along urban-rural gradient

Strongest correlation: traffic volume within 1 km² of forest patch

Beyond "splash zone" (> 30 m)

Pouyat et al. (1995), Pouyat et al. (2008)

CITY/METRO COMPARISONS:

Baltimore, USA (Yesilonis et al. 2008):
Cu, Pb, and Zn

Zagreb, Croatia (Romic and Romic, 2002)
Cu, Pb, and Zn highly related, Ni partially

Polermo, Italy (Angelone et al., 2002)
Cu, Pb, Zn, Sb, and Hg

Seville, Spain (Madrid et al., 2002)
Cu, Pb, and Zn

Hong Kong, China (Xiangdong et al., 2003)
Cu, Ni, Pb, and Zn

Piemonte region, Italy (Facchinelli et al., 2001)
Cu, Pb, and Zn

New York City region, USA (Pouyat et al., 1995) Cu, Ni, Pb

HEAVY METALS & AUTOMOBILES

Metal	Exhaust	Oil leaks	Tires	Brakes	Radiator	Total
Cd	1.2*	< 1.0	< 1.0			1.9
Cr	1.7	< 1.0	2.6	< 1.0		4.8
Cu	< 1.0	< 1.0	3.7	9.1	50.9	63.9
Pb	240	2.0		< 1.0	< 1.0	242
Ni	1.7	< 1.0	2.5	< 1.0	< 1.0	4.7
Zn	2.3	1.5	175	< 1.0	< 1.0	179

*tons per year in Netherlands, based on 6 million automobiles

From H.D. van Bohemen and W.H. Janssen van de Laak, 2003