Approaches to Quantifying Community Exposures to Air Toxics

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Why Do We Want to Study Community Exposure to Air Toxics?

- There are large gaps in understanding community exposure to air toxics and cumulative health risks
  - There are a variety of sources of air toxics, including small point sources in local community.
  - Spatial variation of air toxics can be large in communities with dense sources of air toxics.
  - Communities located in close proximity to sources of air toxics, many are socio-economically disadvantaged groups, may be at a greater health risk but the community-based spatial variation and personal exposure data of air toxics are limited

Why Do We Want to Study Community Exposure to Air Toxics? – cont'

- Exposure to air toxics and health risks for people living in an area with dense sources of air pollution may be under-estimated based on routine ambient air monitoring data.

- Current database may under-represents the time-location pattern for socioeconomically disadvantaged population, who often live in close proximity to air pollution

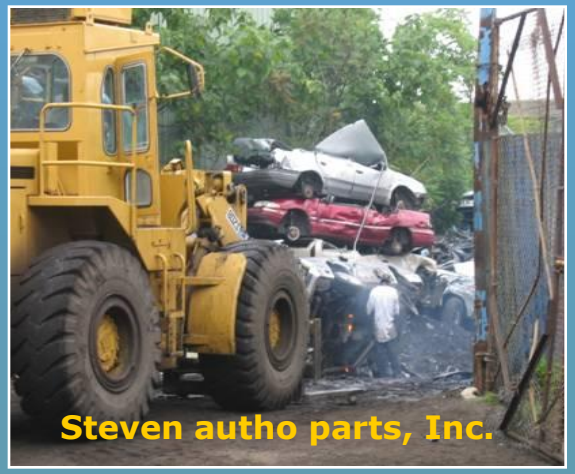
- National Human Activity Pattern Survey (NHAPS) (Klepeis et al. 2001) between 1992 and 1994
  - 24-h time-location-activity data by telephone interview from 9,386 respondents all through the U.S. (except Alaska and Hawaii)

The Village of Waterfront South (WFS) in Camden, NJ

- **Mixed sources of air toxics**
  - Industrial sources (26 industrial and manufacturing facilities)
  - Mobile sources (>100,000 diesel trucks/yr, HYW 676 and other major roads)
  - Urban Sources (Philadelphia ~ 8 miles west of WFS)

Industrial facilities **Subject homes**

Industrial Facilities in WFS


Steven autho parts, Inc.

Industrial facilities in WFS (NJ DEP, 2005)

ID	Facility Name	Type of Operation	Main Pollutants Emitted
PS1	Camden County Municipal Utilities Authority	Sewage Treatment Facility	PM, MTBE, BTEX, chloroform, carbon tetrachloride, Formaldehyde, PAH
PS2	Mafco	Spice and Extract manufacturing	PM, propylene glycol, ammonium
PS3	Art Metalcraft	Electroplating	Hydrogen cyanide, metals
PS4	PSE&G Camden Coal Gas	Other Electric Power Generation	benzene, toluene, formaldehyde
PS5	Georgia Pacific (Domtar Gypsum inc.)	Gypsum Product Manufacturing	hexane, benzene, toluene, formaldehyde, metals
PS6	Container Recyclers of Camden Inc.	Other Metal Container Manufacturing	Xylene, titanium dioxide
PS8	American Minerals, inc.	All other Metal Ore Mining	PM
PS9	Hospital Central Services Inc. Laundry	Laundry Service	PM, metals
PS10	Camden County Resource Recovery Association	Refuse System (Materials Recovery)	PM, formaldehyde, PAH
PS11	St. Lawrence Cement	Cement Plant	PM, metals
PS12	Colonial Processing	Welding & Soldering Equipment manufacturing (Paint appl.)	PM, Xylene, Hexane
PS13	Comarco	Process Pork	PM, lead
PS14	Broadway Finishing	Industrial Paint Shop	Toluene, Xylene, MEK
PS15	SL Surface Technologies	Electroplating	PM, metals

Industrial facilities in WFS (NJ DEP, 2005)-cont'

ID	Facility Name	Type of Operation	Main Pollutants Emitted
PS16	Camdett	Industrial Inorganic Chemicals, NEC (alumina)	Ammonia
PS17	Camden Cogeneration	Fossil Fuel Electric Power Generation	PM, ammonia
PS18	F.W. Winter	Secondary Smelting, Refining & Alloying of Nonferrous metal	PM, metals
PS19	State Metal Industries inc.	Secondary Smelting, Non Ferrous Metals	PM, hexane, toluene, dioxins, metals
PS20	CWS Industries	Electroplating, Plating, Polishing	PM, cadmium
PS21	Duro Plating Co.	Electroplating	Cadmium, hydrogen cyanide
PS22	Camden Iron & Metal (The Pier)	Recyclable Material Wholesaler	toluene, hexane, metals
PS23*	Steve's Auto Parts Inc.	Car scraping facility, automotive body repair, paint	PM, gasoline emissions
PS24	Plastic Consulting & MFG Co.	Coating, Engraving, allied services, NEC (Cos. Jewelry)	PM, metals, and VOCs
PS25	Teideken Bros Auto Body inc.	Automotive body, paint, & interior repair & maintenance	MIBK
PS26	Cam Core	Secondary Aluminum Smelter	PM, toluene, hexane, metals
PS27	Peerless Castings	Aluminum Foundries	PM, toluene, hexane, ethylene

Demographic Information

Geographic Level	Ethnicity			Income	
	Black	Hispanic	Non-White	Median Household Income	Individuals Below Poverty
New Jersey State	13.6%	12.5%	27.4%	$55,136	8.5%
Camden County	18.1%	9.7%	29.1%	$48,097	10.4%
Camden City	53.3%	38.8%	82.5%	$23,421	35.5%
Waterfront South	57.8%	27.2%	85.4%	$22,417[2]	33.8%[2]
Copewood/Davis	69.3%	25.6%	88.2%	NA[3]	NA[3]

[1]US Census 2000. [2] NJDEP, 2005. [3] not available.

Personal Exposure to Air Toxics in Camden, New Jersey

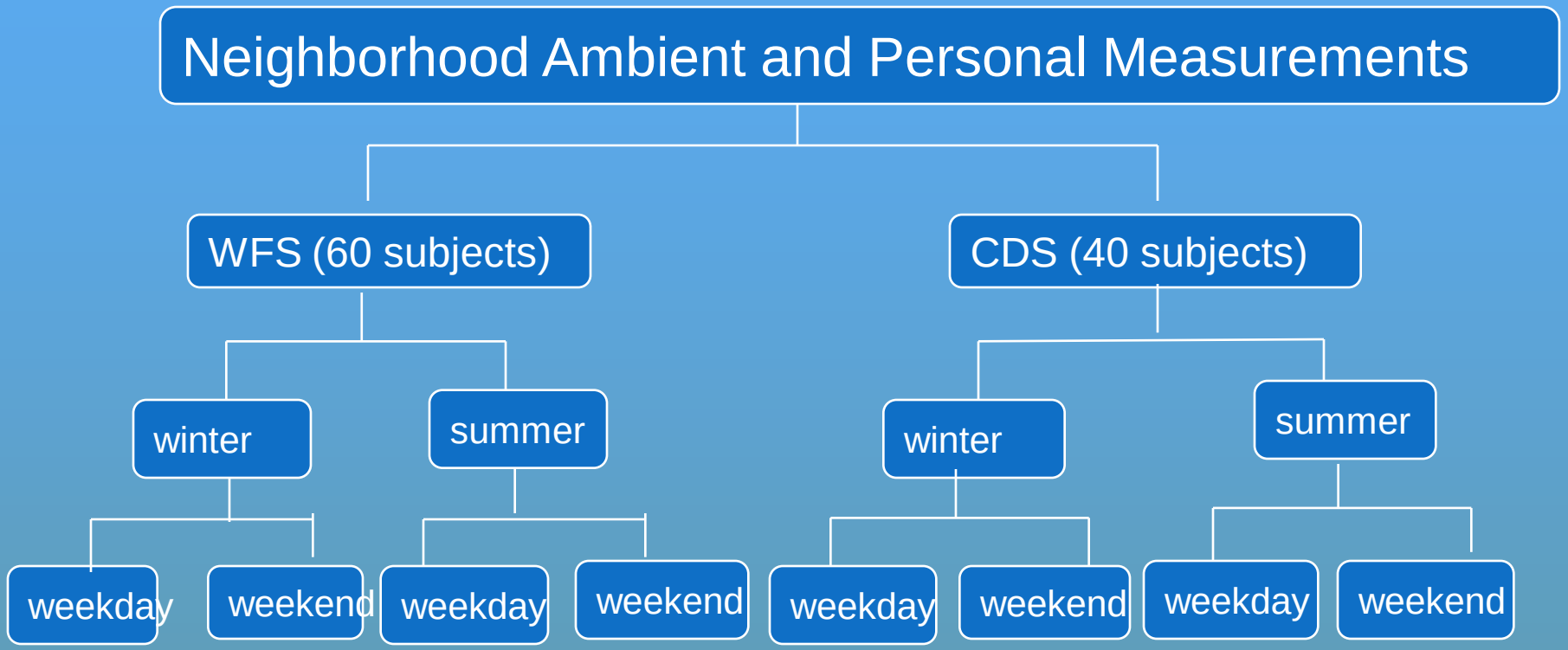
Objectives

- To characterize local ambient and personal concentrations of air toxics using measurements and simulations in Waterfront South (WFS) Camden, NJ.
- To assess the impact of local industrial and mobile sources on measured neighborhood ambient concentrations and personal exposures in WFS and Copewood/Davis (CDS) area, a reference site.
- To identify the sources of concern.

Objectives-cont'

- To characterize the time-location patterns of the population living in areas with elevated air pollution levels.
- To evaluate the factors that may influence the time-location patterns of the people living in those areas.

Study Design



A. 24-h outdoor and personal samples of Fine particles, Volatile Organic Compounds, carbonyls, & Polycyclic Aromatic Hydrocarbons
B. Baseline and Activity questionnaires and Time/Activity Diaries
C. Modeling Exposure

Time-Activity Log

Activity Log							
	Indoors			Outdoors		In Vehicle	
Time (hours)	home	School Or work	Other	In Neighborhood	Out of Neighborhood	With open windows	With closed windows
8 am							
9 am							
10 am							
11 am							
12 pm							
1 pm							
2 pm							
3 pm							
4 pm							
5 pm							
6 pm							
7 pm							
8 pm							
9 pm							
10 pm							
11 pm							
12 am							
1 am							
2 am							
3 am							
4 am							
5 am							
6 am							
7 am							
8 am							
9 am-next day							
10 am-next day							
11 amnext day							
12 pmnext day							
1 pmnext day							

If less than half an hour, please record the time below, eg. School/work: 10:00 amto 10:30am.

Home_____

School/work_____

Other_____

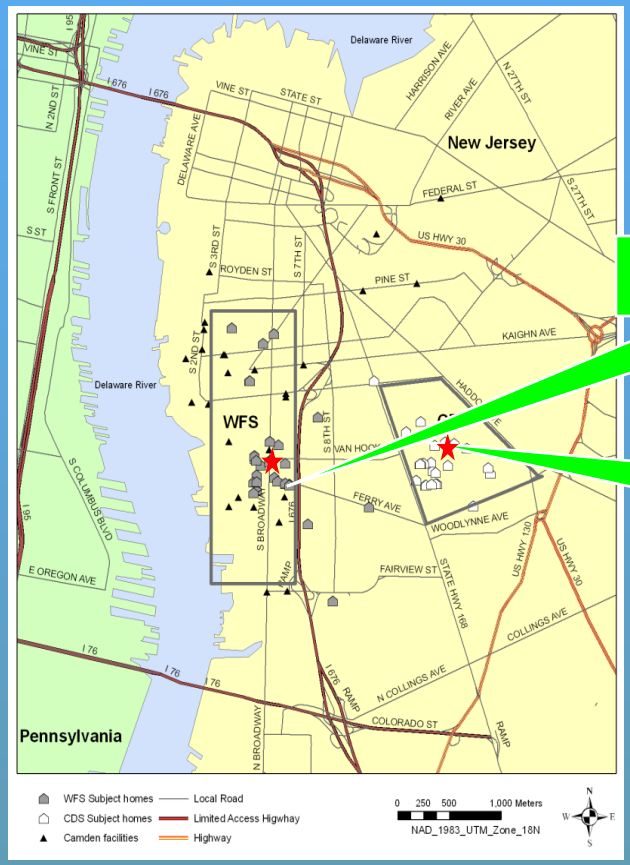
Out of neighborhood_____

In neighborhood_____

With open windows_____

With closed windows_____

Sampling Approaches-Simultaneously Personal and Outdoor Sampling



The fixed site in WFS

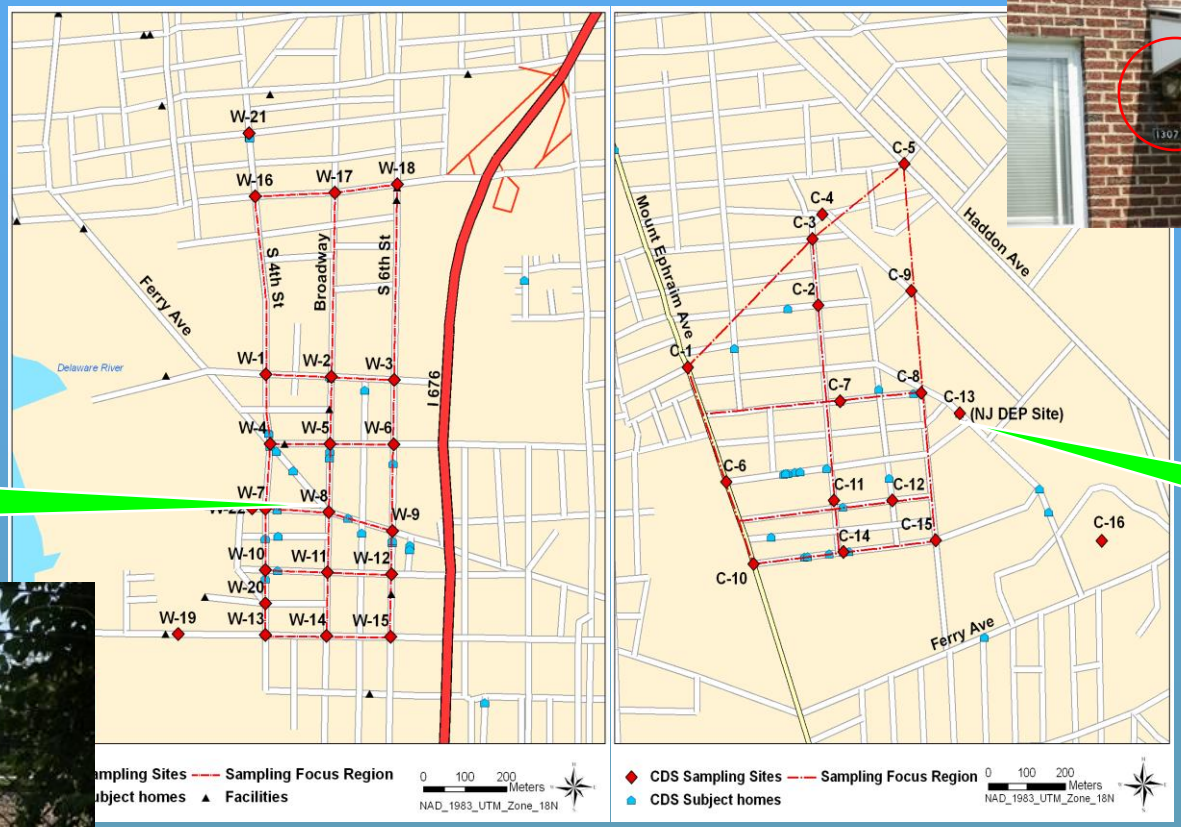
The fixed site in CDS – Ref. area

★ : the fixed sampling sites

Spatial Saturation Sampling

▲Facility

⬟Subject home

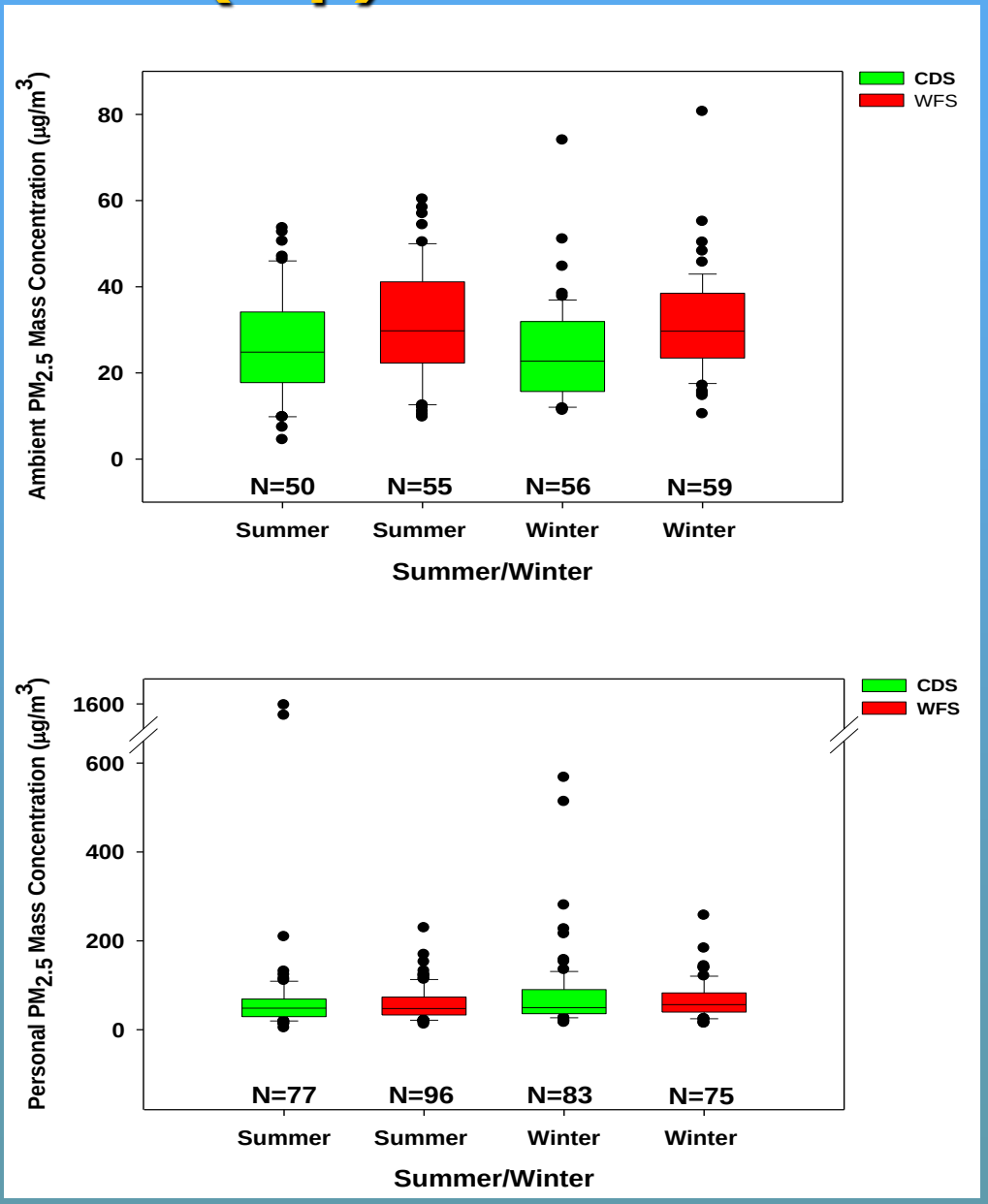


Fixed Site in WFS

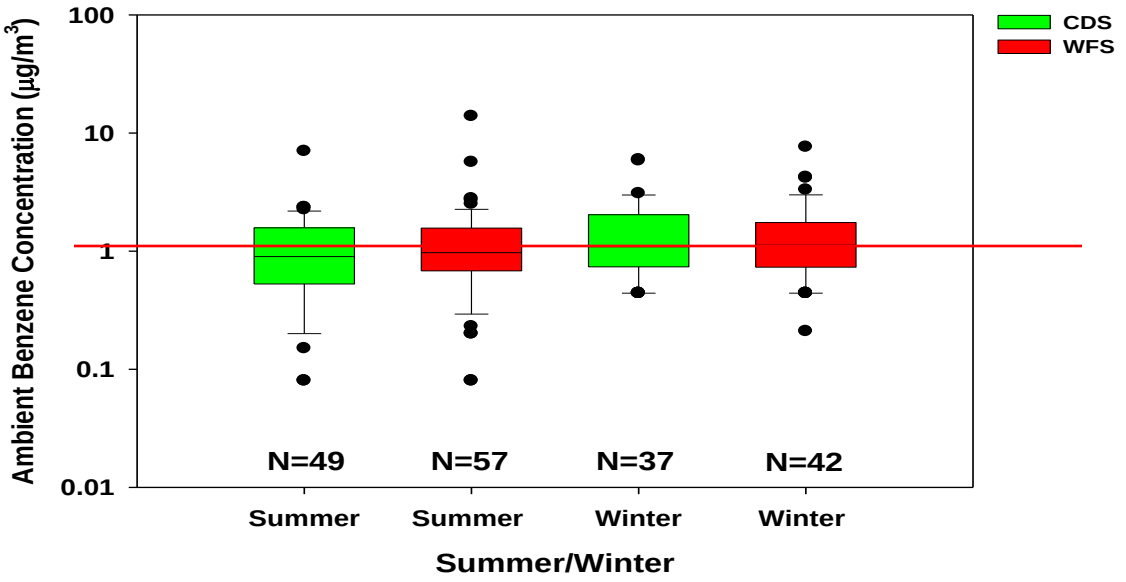
Fixed Site in CDS

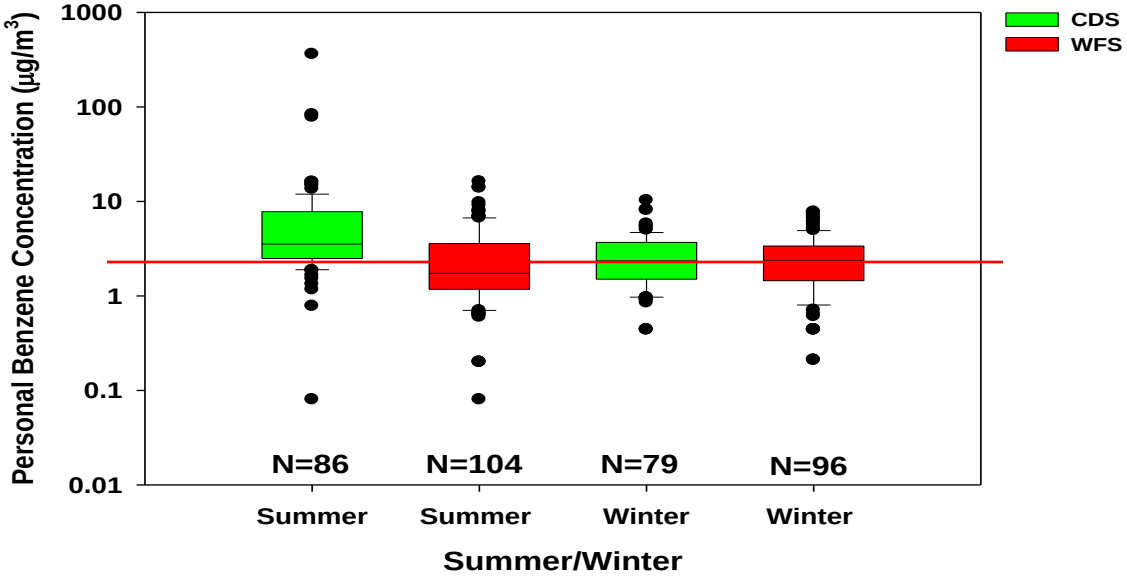
Two summer and one winter sampling campaigns in 2005 (VOCs and aldehydes)

$PM_{2.5}$: Ambient (top) and Personal Levels (bottom)

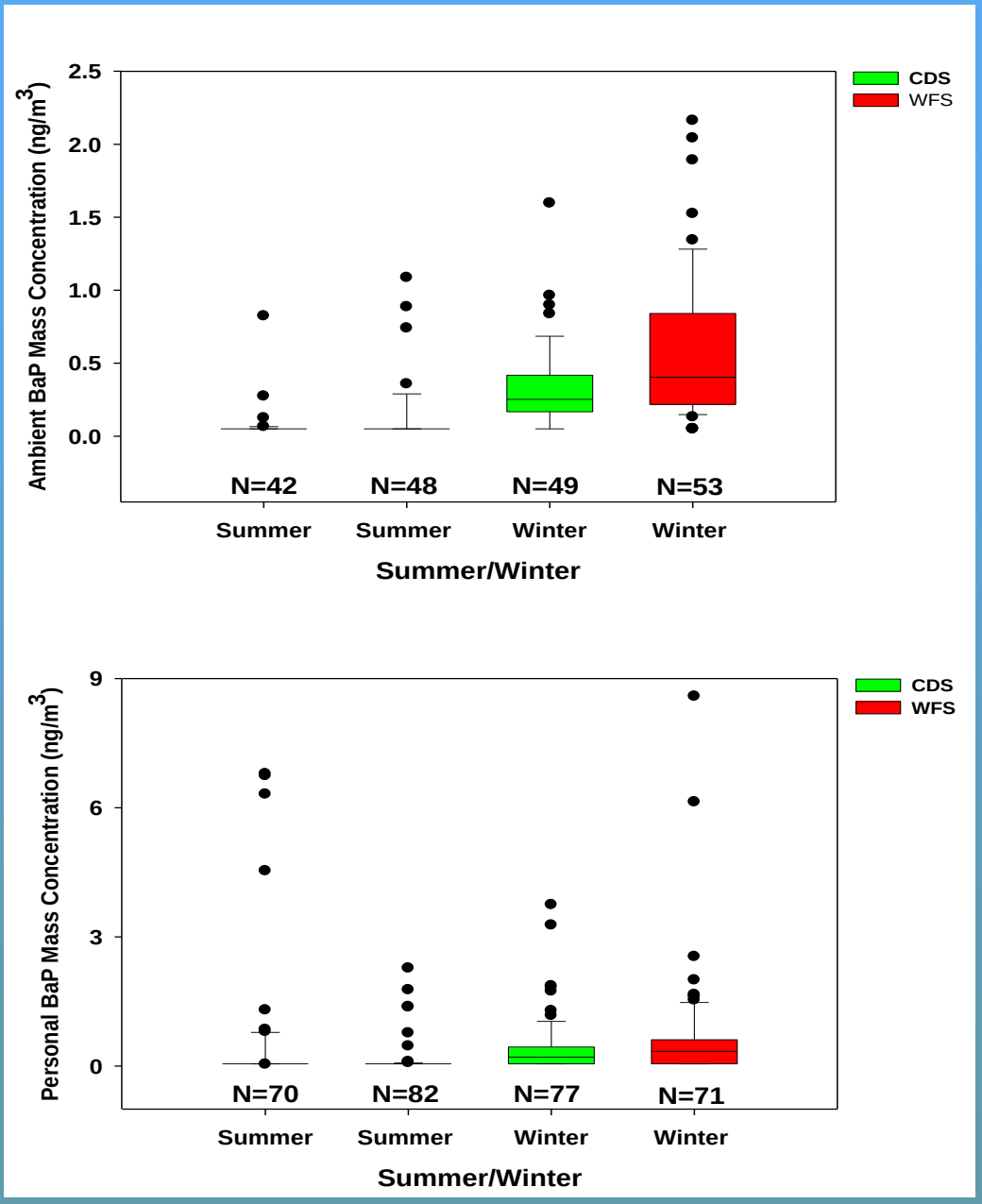


Benzene: Ambient (top) and Personal Levels (bottom)



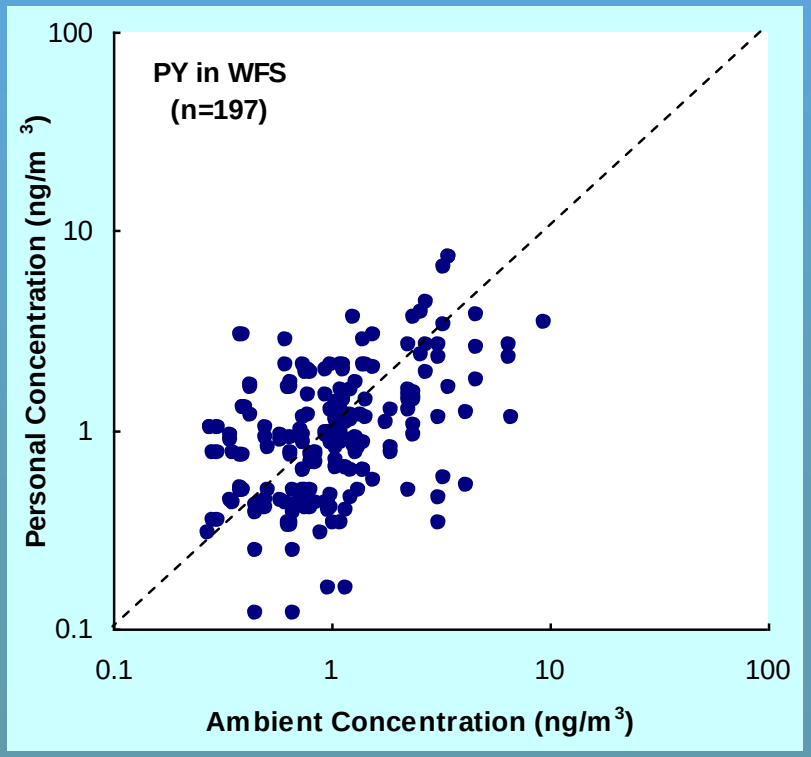


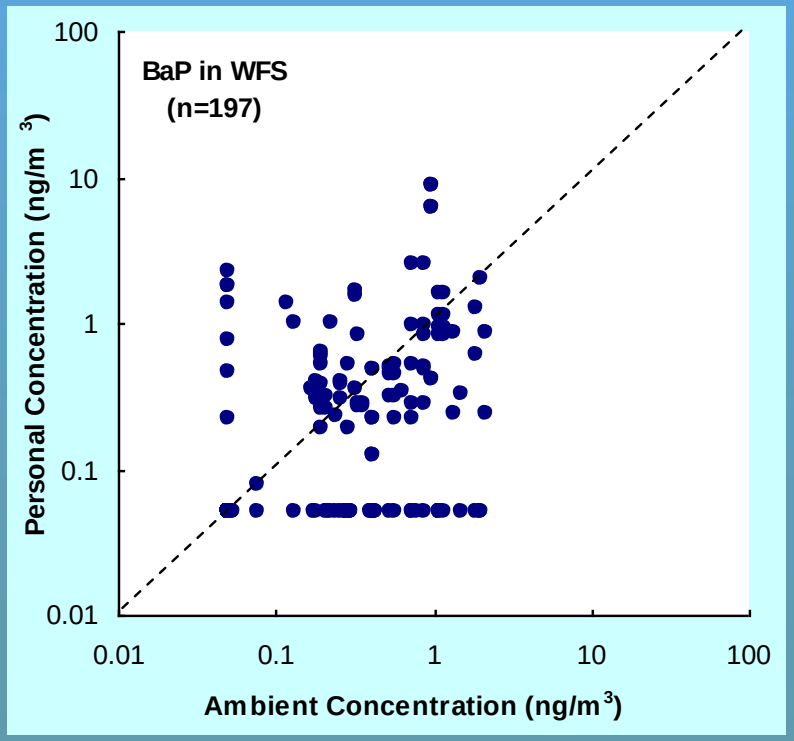
Benzo(a)pyrene: Ambient (top) and Personal levels (bottom)



Prediction of personal exposure based on ambient concentration using a mixed model

	WFS				CDS			
	Slope	Intercept	*p*	R^2	Slope	Intercept	*p*	R^2
NAP	0.28	2.53	0.037	0.96	0.38	2.86	0.056	0.87
PHE	0.51	1.61	0.0002	0.81	0.47	1.78	0.003	0.73
PY	0.46	-0.06	0.001	0.71	0.58	0.37	0.004	0.98
BaP	0.47	-1.25	0.002	0.67	0.73	-0.43	0.002	0.94
Σ16-PAH	0.58	2.37	0.003	0.91	0.61	2.74	0.026	0.95

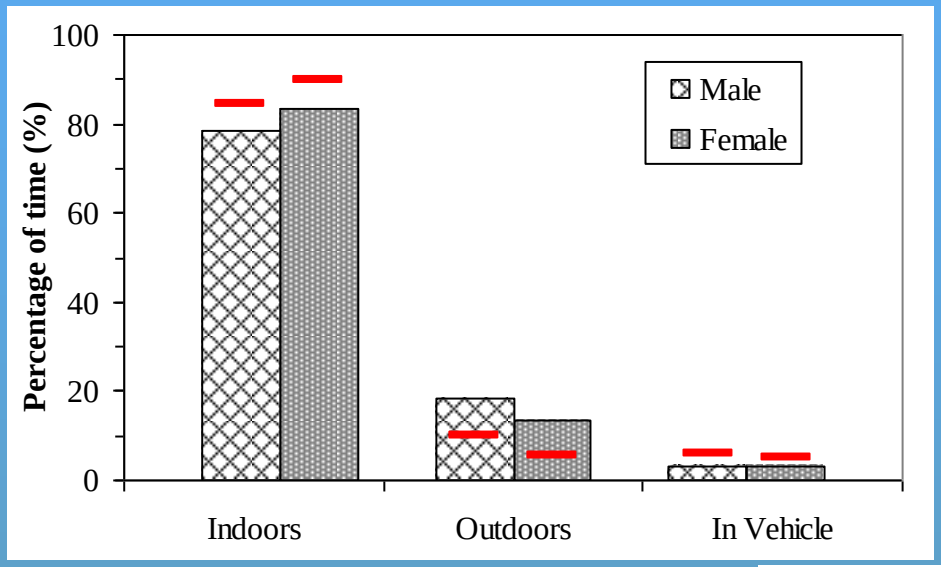




Time–location Pattern
Camden vs. US General Population

Overall Weighted mean percentage (%)	U.S. general population	Camden study cohort
Total Indoors	86.9	81.0
Total Outdoors	7.58	**15.82**
Total in Vehicle	5.52	3.18

%Time Spent in Different Microenvironment

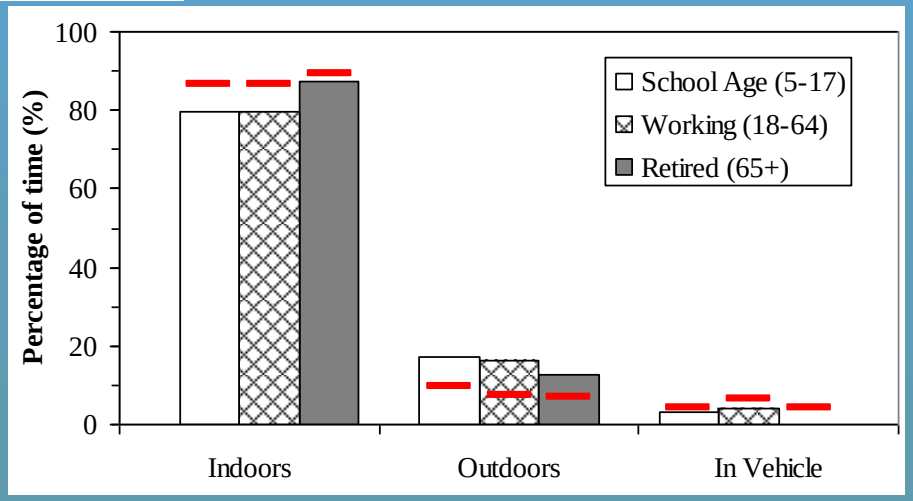


By Gender

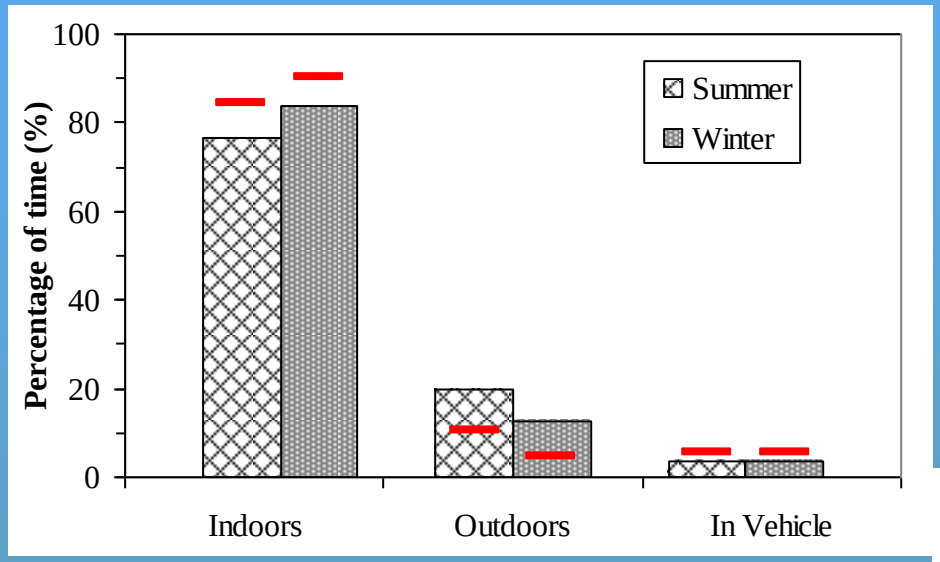
By Subject type

Bars are weighted means of the Camden data. (N=335)

Red lines are weighted means of the NHAPS data. (N=9368) (Klepeis et al., 1996)

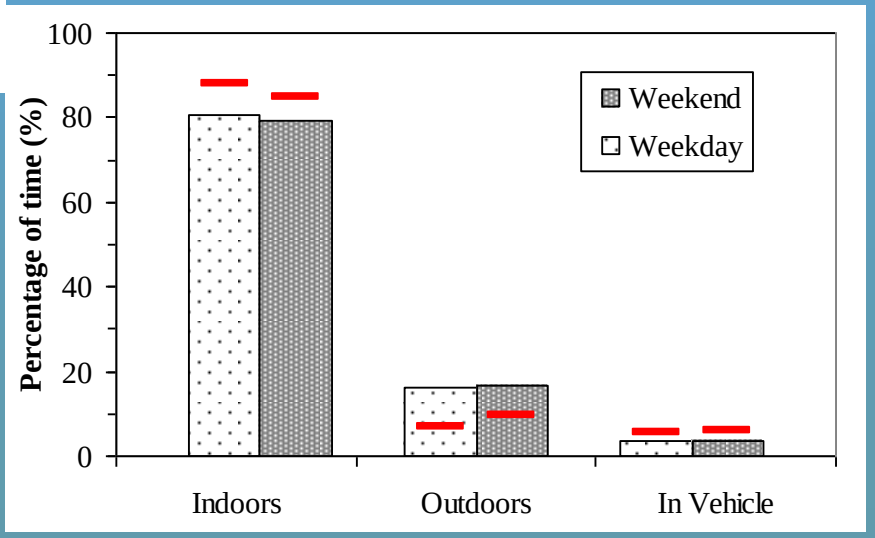


%Time Spent in Different Microenvironment



By Season

By Day-of-the-Week



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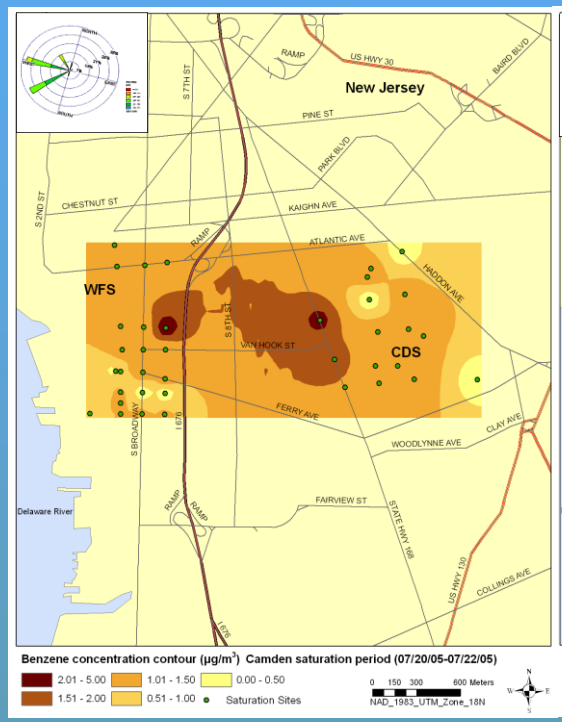
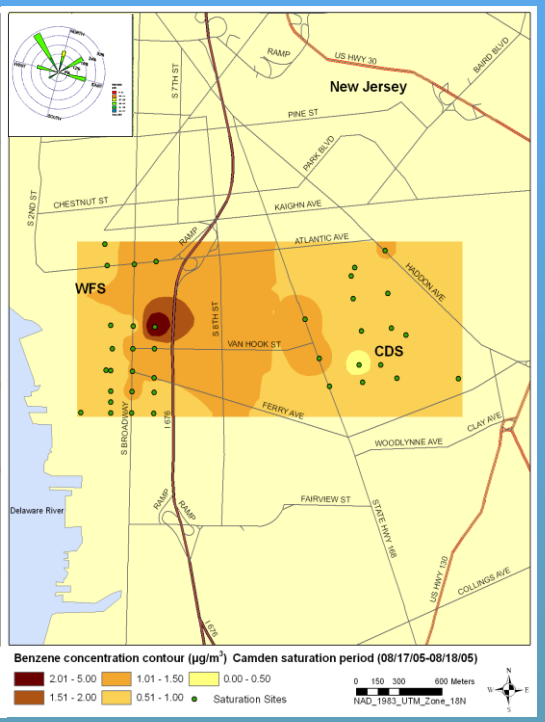
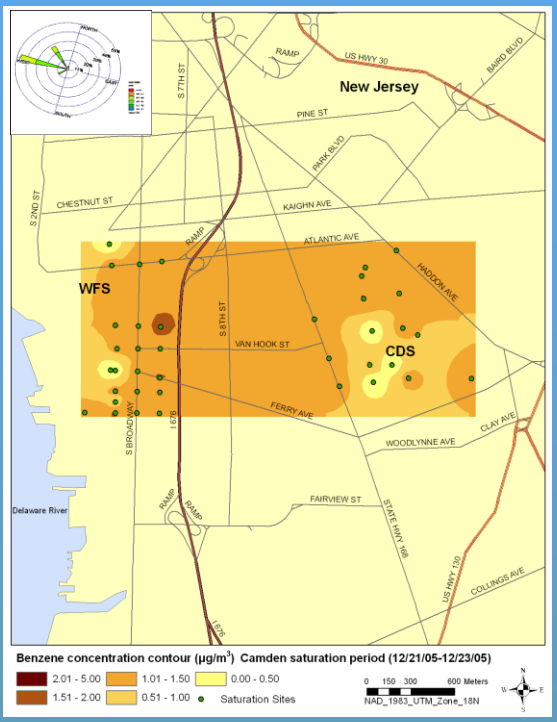
Spatial Distribution of Benzene (WFS: 0.5-3.1 μg/m³ CDS: 0.67-3.5 μg/m³)



July

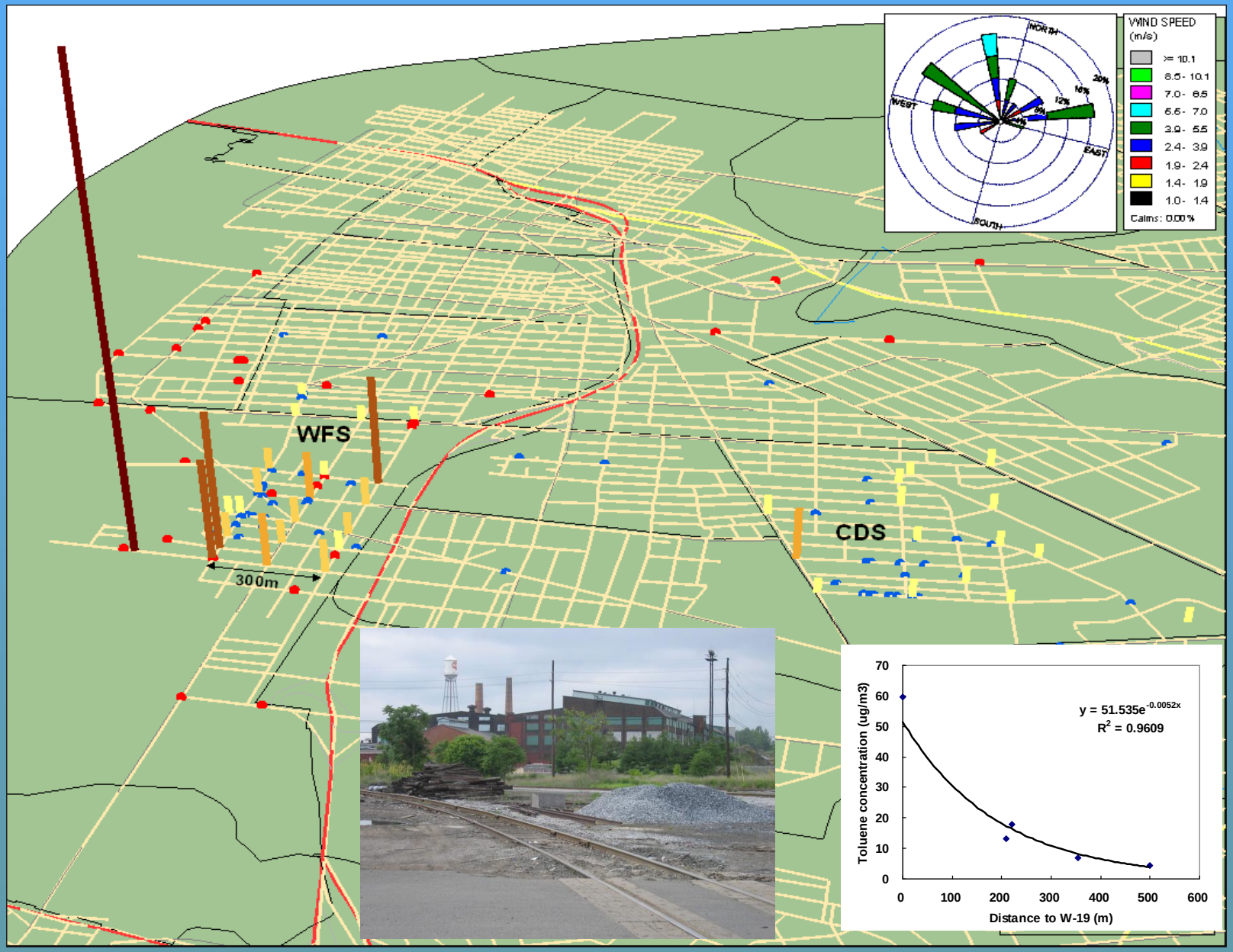


August



December, 2005

Toluene (2-60 µg/m³)



Ratio = $C_{fix\ site}/C_{mean\ of\ each\ area}$

Compound	WFS			CDS		
	7/20-22	8/17-18	12/20-22	7/20-22	8/17-18	12/20-22
MTBE	0.9	0.8	0.7	0.9	0.9	0.7
Chloroform	0.9	0.9	1.0	1.0	0.9	1.0
Carbon Tetrachloride	1.0	1.0	1.0	1.0	1.0	1.0
Benzene	1.2	1.1	1.0	0.8	0.8	0.8
Toluene	0.7	0.5	0.6	0.8	0.8	0.7
Ethylbenzene	0.8	0.5	0.6	0.7	0.8	0.7
m/p-Xylene	0.8	0.5	0.6	0.7	0.8	0.7
o-Xylene	0.8	0.7	0.7	0.7	0.8	0.7
Formaldehyde	1.3	1.0	1.1	1.0	1.3	1.0

Proximity to Sources of Air Toxics and Spatial Variation (WFS, n=61)

		Parameter Estimate						
Compound	R^2(sources only)	$PS1^{-1}$	$PS6^{-1}$	$PS12^{-1}$	$PS14^{-1}$	$PS23^{-1}$	U	T
MTBE	(0.2)					0.192	-0.126	0.605
CHCl3	(0.013)						-0.789	0.047
CCl4	(NA)						-0.051	0.299
Benzene	(0.394)	0.098			0.037	0.259	-0.164	0.038
Toluene	(0.162)		0.092			0.070	-0.058	
Ethylben	(0.418)			0.152	0.052	0.214	-0.152	
m,p-Xyl	(0.435)			0.222	0.048	0.165	-0.159	
o-Xyl	(0.461)	0.042		0.173		0.246	-0.180	

Proximity to Sources of Air Toxics and Spatial Variation (CDS, n = 40)

		Parameter Estimate				
Compound	R^2	Haddon Ave^{-1}	NJ-168^{-1}	PS23^{-1}	U	T
MTBE	(0.007)	0.003	0.004		-0.110	0.823
CHCl3	(NA)				-0.941	0.010
CCl4	(0.031)		0.031		-0.069	0.716
Benzene	(0.239)		0.239			
Toluene	(0.138)		0.138		-0.265	0.191
Ethylbenzene	(0.368)	0.029	0.014	0.285	-0.126	0.302
m,p-Xyl	(0.358)	0.034		0.294	-0.133	0.285
o-Xyl	(0.405)	0.048		0.317	-0.181	0.168

Summary and Implication

- The community air monitoring approach can
  - Better define the population at high exposure risks.
  - Provide accurate data for the estimate of health risks associated exposure to air toxics.
  - Identify the major air toxics sources of concern and aid in developing effective controlling strategies to reduce community exposure to air toxics.
- Personal activity has significant impact on personal exposure to air toxics and associated health risks.

Acknowledgments

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