Environmental Analysis:

Summary of NCS Research Day Plenary Session

Howard Andrews, PhD
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New York-Northern New Jersey NCS Consortium
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Columbia University
Mailman School of Public Health

National Children's Study
Federal Advisory Committee Meeting
October 19, 2011

An integrated approach to health system analysis and response

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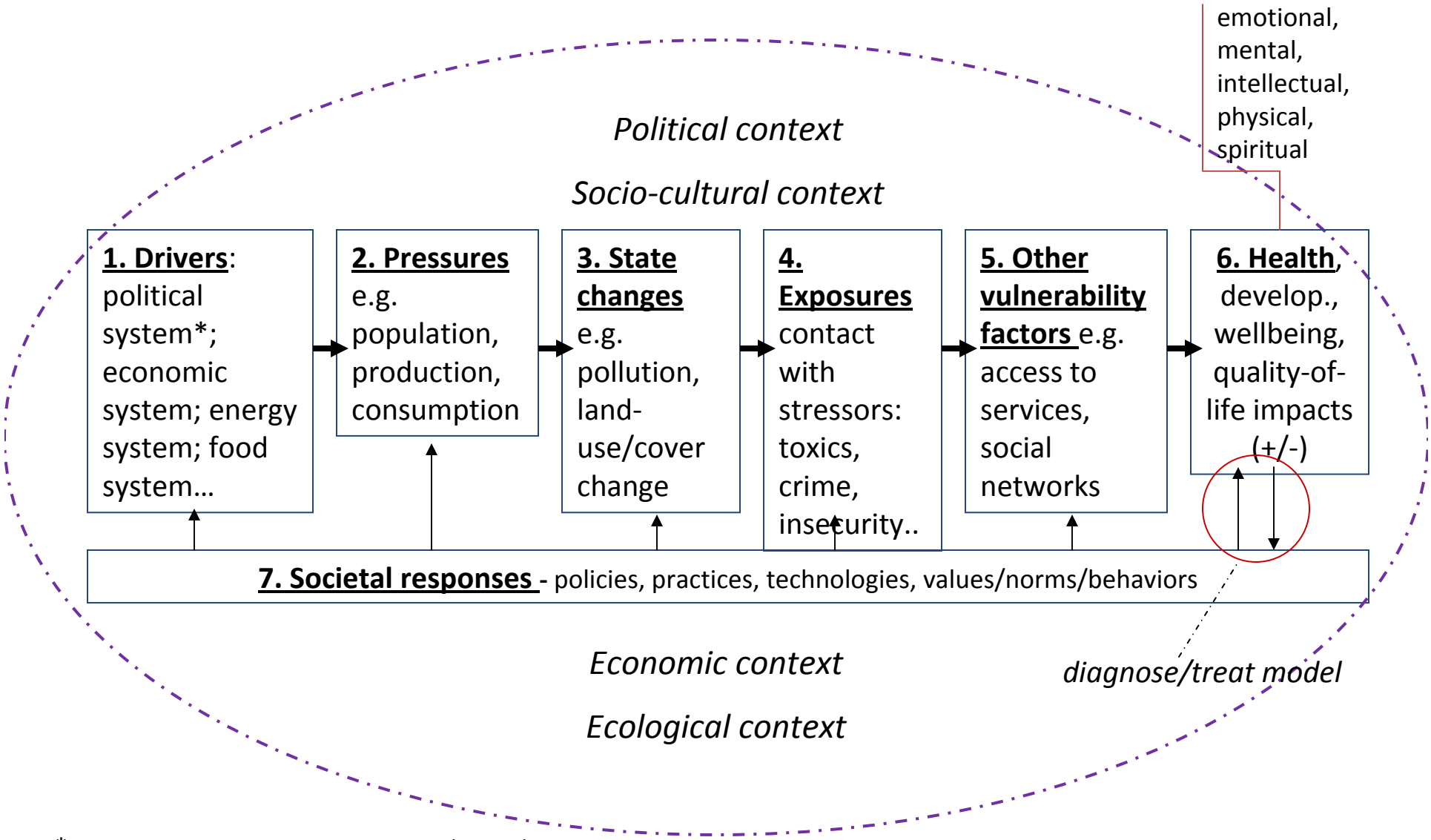
Environmental Science & Policy Program, Clark University
MassCHILD NCS Study Center
Worcester, Mass.

NCS Analysis/Science Goal:

"The National Children's Study will examine the effects of the environment, as broadly defined to include factors such as air, water, diet, sound, family dynamics, community and cultural influences, and genetics on the growth, development, and health of children …"

NCS Website 08/2011

Integrated Health System Frame



*policies, practices, technologies, values/norms/behaviors

Examples of System Indicators

Context: mortality and morbidity associated with coal-fired power plant emissions

Aspect	Examples of aspect	Indicator(s)	Method
1. Drivers	Coal-fired energy system	Coal burned (tons/week)	Extant data
2. Pressures	Energy demand/consumption	Demand vs. Supply (KWh_e)	Extant data
3. State changes	Ambient air quality	Levels of PM, SO_2, Hg, NOx	Air testing
4. Exposures	Air toxicants	PM dose rate (μg/kgBW/day)	Exp. testing
5. Other vulnerability factors	•Poverty – inability to move •Access to quality health care	•Household poverty level •Access level, quality level	•Survey tool •Survey tool
6. Impacts (+/-) on: •Health •Development •Wellness/Wellbeing •Quality of life	•Resp. disease morb./mort. •Edu. access, cognitive ability •Fitness level, ability to work •Happiness level, rec. access	•Asthma, COPD rate, resp. mort. •School attendance, IQ test •Fitness metric, lost workdays, DALYs •Happiness level, green-space access	•Test, records •Survey tool •Fitness test •Survey tool
7. Societal response(s)	Energy policy, pollution policy, cleaner technology	Policy documents/reports incl. USEPA work on acid-aerosol impacts	Lit. review, case studies

Searching for a Common Language among Disciplines and Stakeholders: *Vulnerability Theory*

Aspects	Concept	Relevant indicators/data	Env *	Gen
1. Differential exposure of individuals in a group, or between groups	contacts over time w/risk agents, stressors*	•PM dose rate (inhalation) •Neighborhood crime rate •Unemployment •Health disparities	●	
2. Differential susceptibility	exposure thresholds for negative impact	•Health disparities within and between groups •genetic risk factors	●	●
3. Differential sensitivity	how risk and/or magnitude of impact changes with exposure		●	●
4. Differential preparedness to respond (or coping, or adaptability)	Individual and/or group capacity to reduce, mitigate and/or absorb impacts	Access to health care Access to social networks Individual planning capacity Group planning capacity	●	●
5. Differential resilience	Ability to 'bounce-back' from impacts	Resilience metrics e.g. illness recovery time	●	●

*expansive notion of environment: biophysical, social, political, economic, cultural

Pragmatic knowledge frame: Mixed methods

Discipline/Field	Method(s)	Examples of data types
Clinical Medicine	Clinical testing	Health status, bio-specimens
Epidemiology	Case/control, cohort	Risk factors for diseases
Risk/Vulner. Analysis	QRA, exposure assessment	Dose rates for toxicants
Health Anthropology	Ethnography, listening	Narratives and contexts
Biosocial health science	Biological/sociological	Narrative/quant/qual.
Environmental Science	Air/water/soil testing	Air/water/soil quality
Geographic Info. Science	Computational, spatial stats	Maps, spatial patterns
Sustainability Sci. & Policy	Comparing options	Expected impacts of options

- Worth more attention: understanding a person's life, relationships with others, with nature, rich/nuanced health information and health contexts
- Worth more attention: integrative, can reveal spatial associations among data

REMOTE SENSING TECHNOLOGY FOR INDOOR AIR QUALITY MONITORING

Dorr G. Dearborn, PhD, MD & Ellen M. Wells, Ph.D.
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Dept Environmental Health Sciences
Cleveland, Ohio

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REMOTE SENSING TECHNOLOGY FOR INDOOR AIR QUALITY MONITORING

Goal: To develop new, low cost platform technology for real-time sensing and remote monitoring of air quality.

Purpose: Develop and investigate the feasibility, acceptability and cost of remote sensing technology to monitor residential indoor and outdoor air quality in NCS homes.

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REMOTE SENSING TECHNOLOGY FOR INDOOR AIR QUALITY MONITORING

- **Approach:**
  - real-time sensors with telemetry (3G) data transfer to central server for translation, analysis, and storage
  - Home (indoor and outdoor) air quality parameters-
    - temperature,
    - humidity,
    - particulates ($PM_{>2.5}$ and $PM_{>0.5}$),
    - total volatile organic compounds (VOCs),
    - nitrogen oxides (NO_x)
    - carbon monoxide
    - carbon dioxide

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REMOTE SENSING TECHNOLOGY FOR INDOOR AIR QUALITY MONITORING

- Investigators:
  - Dorr Dearborn, PI
  - Ellen Wells, environmental epidemiologist
  - CC Liu, Chem Engineering, sensor technology
  - Ken Loparo, Elect. Eng, sensor data archiving and analysis
  - Marcia Nishioka, Battelle, air quality/pollution
  - Intwine Connect, Inc-
    - Steve Cloud, electronic engineer

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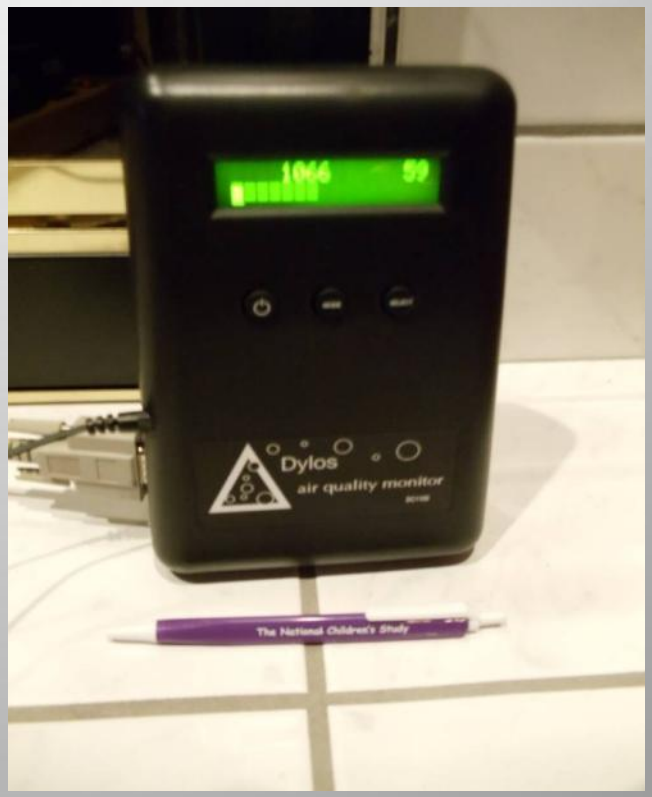
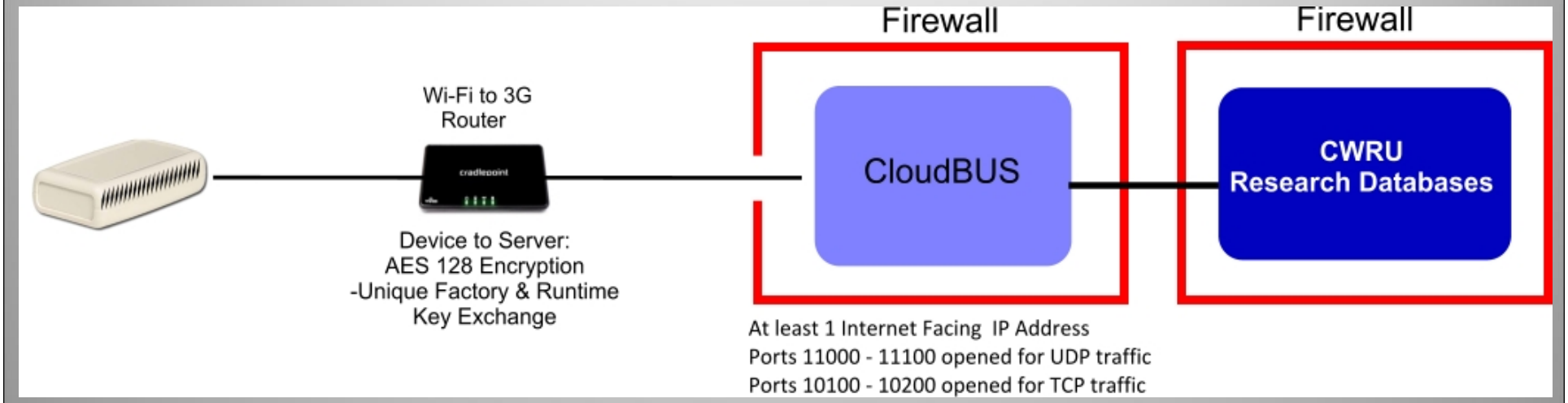
Air Quality Monitoring Units

Sensor platform unit



DYLOS particulates unit

CloudBUS Setup



Particulate Matter Observations (test houses)

- PM >2.5 vs PM >0.5
- Indoor vs Outdoor
- Smoker vs Non-smoker (PM >0.5)
- Other exposures

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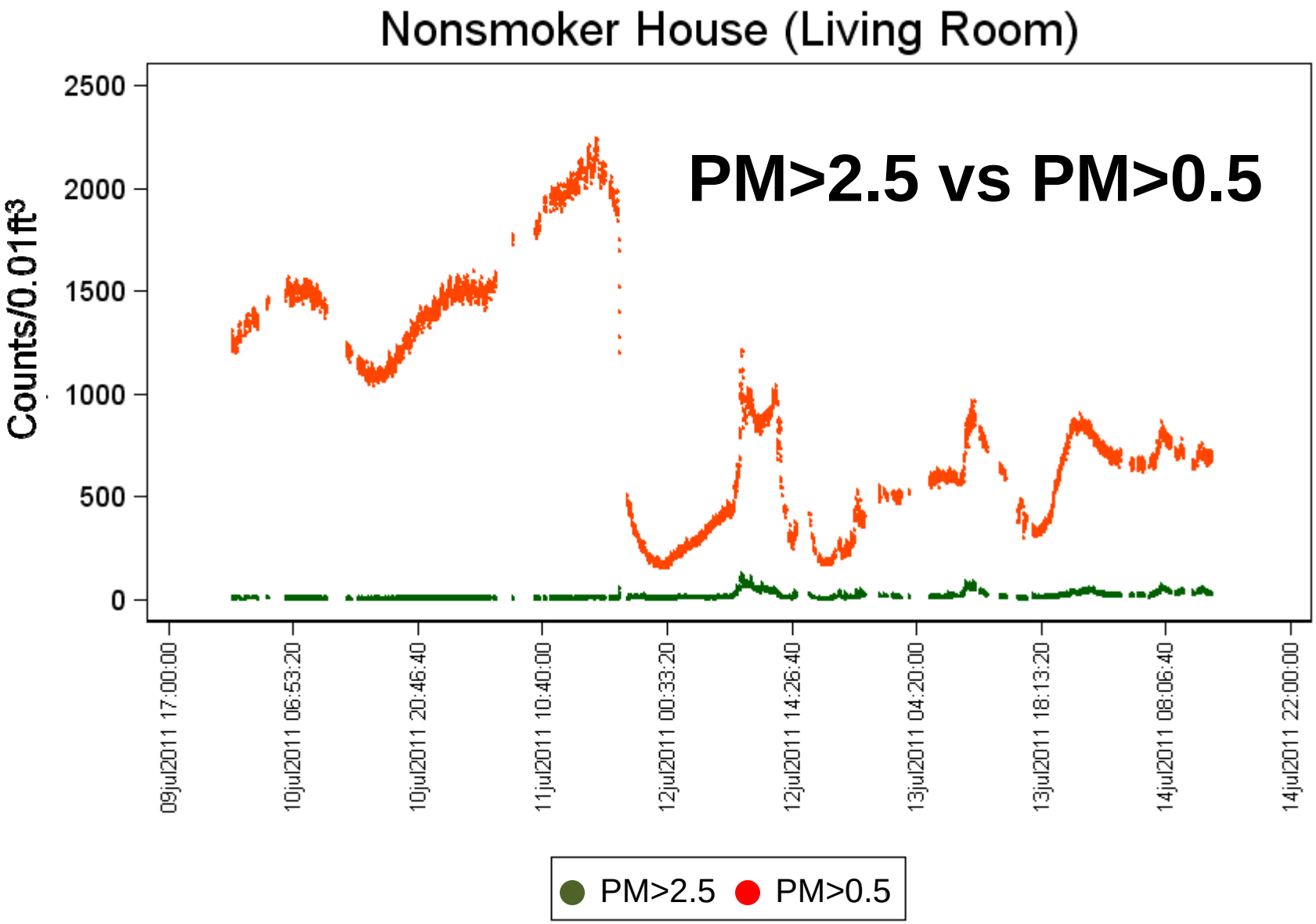
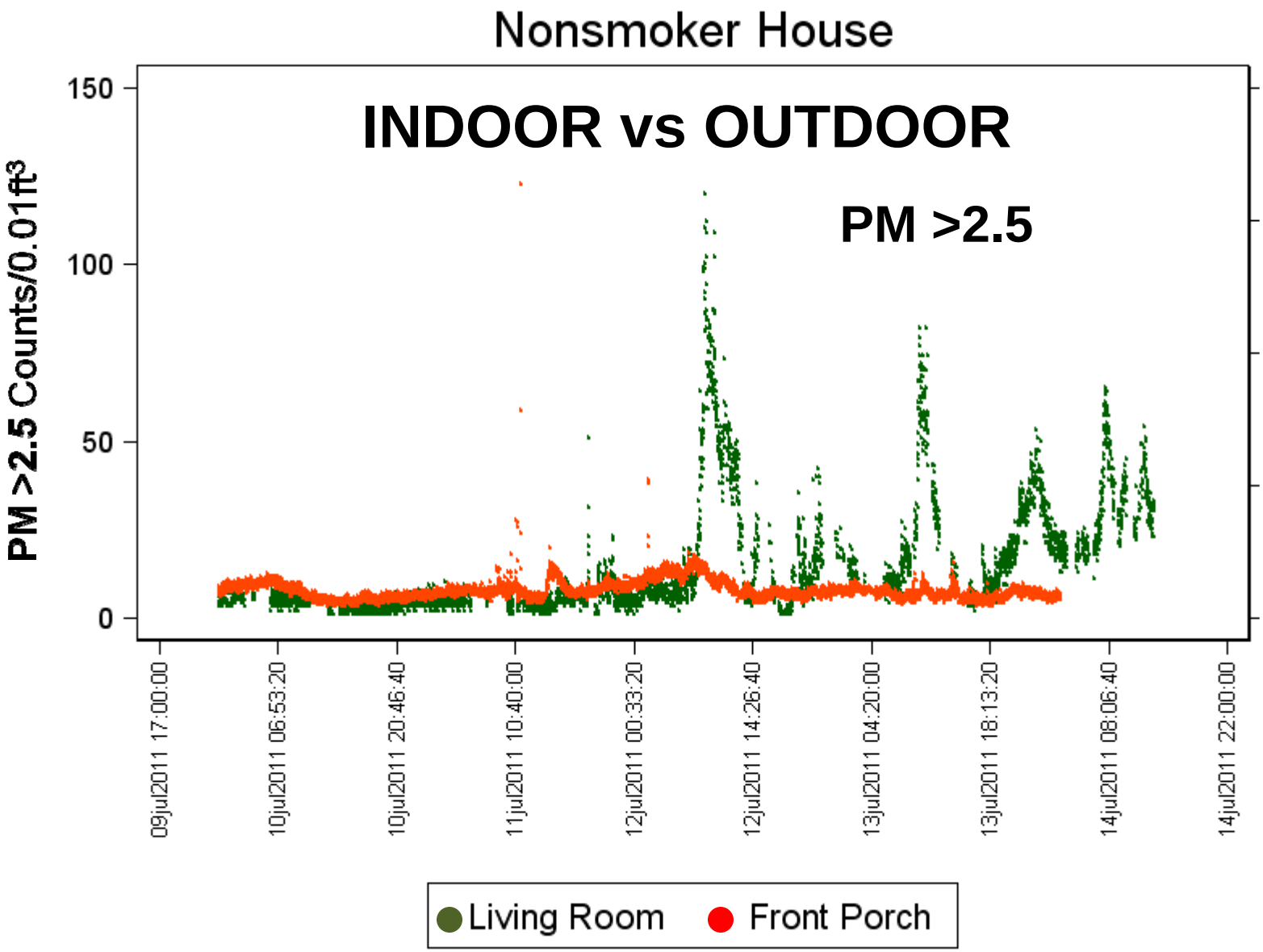
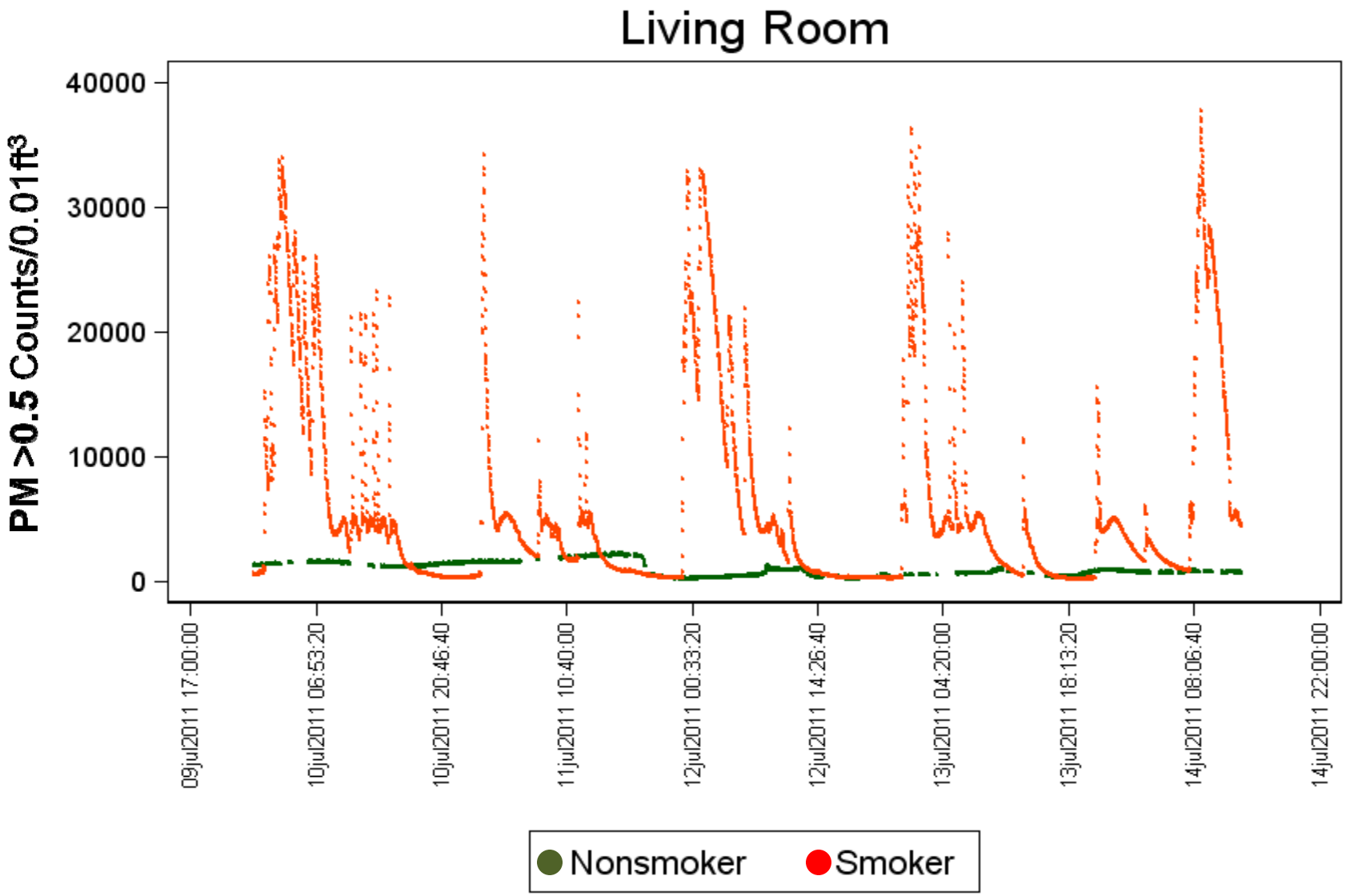
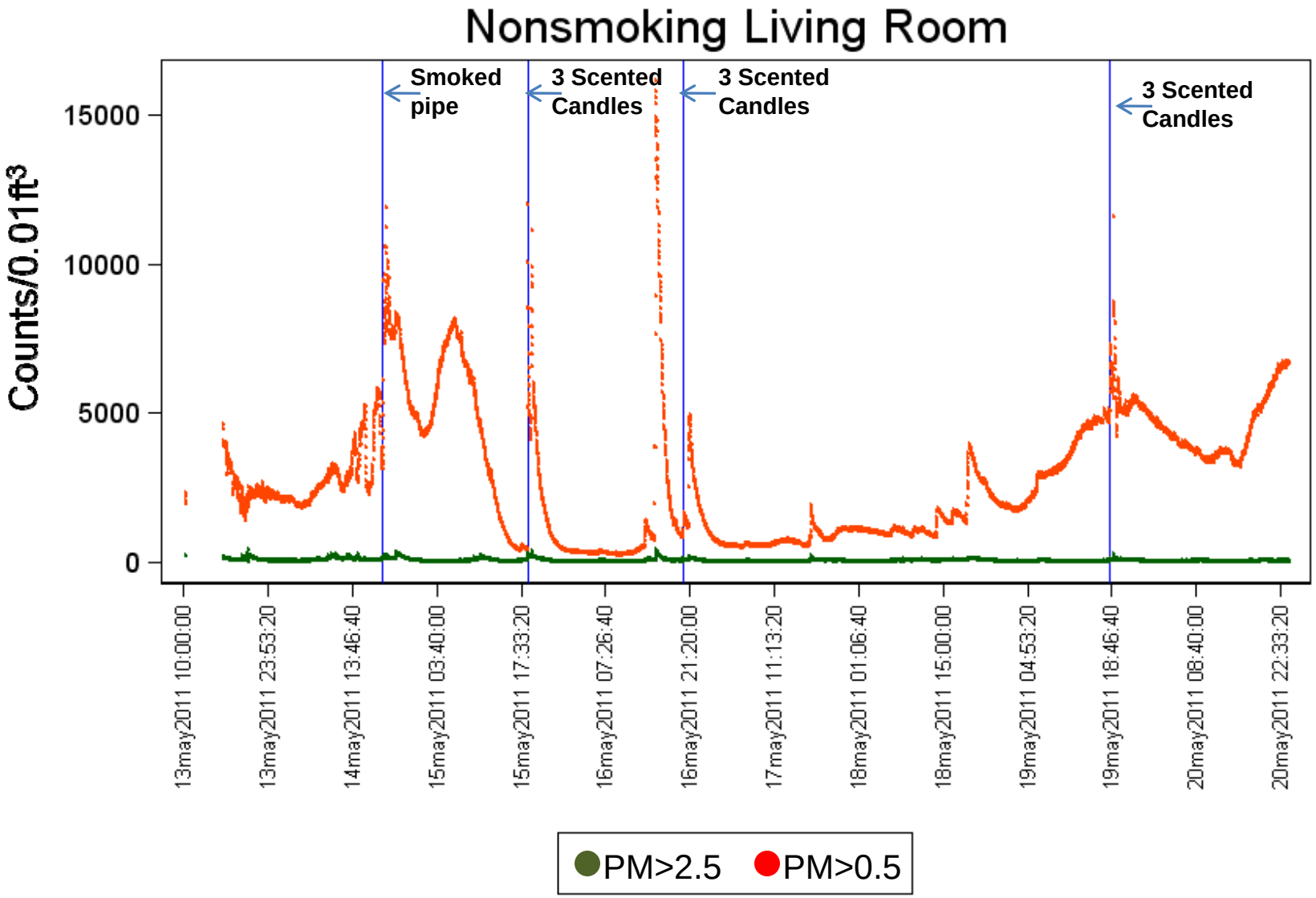

Nonsmoker House (Living Room)
PM>2.5 vs PM>0.5
Counts/0.01ft3
2500
2000
1500
1000
500
0
09jul2011 17:00:00
10jul2011 06:53:20
10jul2011 20:46:40
11jul2011 10:40:00
12jul2011 00:33:20
12jul2011 14:26:40
13jul2011 04:20:00
13jul2011 18:13:20
14jul2011 08:06:40
14jul2011 22:00:00
PM>2.5
PM>0.5


Nonsmoker House
INDOOR vs OUTDOOR
PM >2.5
PM >2.5 Counts/0.01ft3
150
100
50
0
09jul2011 17:00:00
10jul2011 06:53:20
10jul2011 20:46:40
11jul2011 10:40:00
12jul2011 00:33:20
12jul2011 14:26:40
13jul2011 04:20:00
13jul2011 18:13:20
14jul2011 08:06:40
14jul2011 22:00:00
Living Room
Front Porch

SMOKER vs NON-SMOKER



OTHER EXPOSURES



Practical Questions for Field Study

- Frequency of data points (30-60 sec?)
  - How much 'smoothing' for routine analysis?
- Stability? (calibrate before install & at end)
- Memory at unit
  - Need to cover power outages?
  - Need to cover 3G phone network saturations?
- Acceptability to subjects

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Blood Metals in Pregnant Women Enrolled in the Vanguard Study: Comparison with NHANES

Mary Ellen Mortensen MD, MS

Senior Medical Toxicologist
Division of Laboratory Sciences
Centers for Disease Control

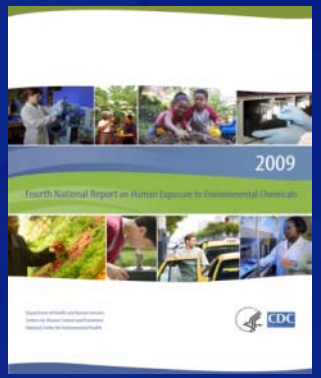
NCS Research Day
August 24, 2011

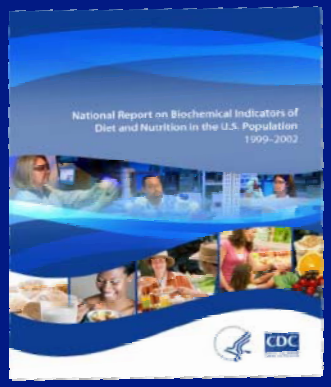
Background

- **Environmental chemical exposure information for pregnant women and young children (< 5 years old) is limited.**
- **Environmental chemicals are usually present at very low levels in human specimens, requiring special consideration and collection and handling procedures.**
- **NCEH/DLS proposed to measure a broad array of environmental chemicals and nutritional biomarkers in Vanguard Study participants**
- **Goals of the NCS-NCEH/DLS collaboration include:**
  - Characterize exposures in pregnant women and infants to aid Main Study planning
  - Evaluate biospecimen collection, processing, and shipping, and Repository retrieval procedures
- **Blood metals in a sample of pregnant women are early available results**

Methodology

- **Convenience sample of about 450 participants at 7 Vanguard Centers**
- **Analyze a broad array of environmental chemicals and nutritional biomarkers using:**
  - Blood /serum and urine (third trimester)
  - Cord blood, and urine (infant)
  - Breast milk
- **Technical assistance and review of biospecimen protocols provided by experienced CDC laboratory scientists**





http://www.cdc.gov/exposurereport/
http://www.cdc.gov/nutritionreport/

NCS Total Blood Lead
Geometric means and selected percentiles (in µg/dL)

Selected Percentiles (95% confidence interval)					
Category	**Geometric Mean (95% CI)**	**50th**	**75th**	**90th**	**95th**
All Women	**0.431** (0.408-0.456)	0.410 (0.390-0.440)	0.580 (0.560-0.640)	0.910 (0.780-1.100)	1.340 (1.030-1.680)
Age Group					
<= 29 years	**0.416** (0.387-0.448)	0.400 (0.370-0.430)	0.550 (0.500-0.610)	0.860 (0.690-1.200)	1.340 (0.970-2.140)
> 29 years	0.451 (0.414-0.491)	0.440 (0.390-0.470)	0.640 (0.580-0.720)	0.940 (0.780-1.290)	1.310 (1.100-2.100)
Race / Ethnicity					
Non-Hispanic black	**0.590** (0.475-0.734)	0.560 (0.460-0.660)	0.860 (0.590-1.340)	1.320 (0.930-1.630)	1.340 (1.320-1.630)
Non-Hispanic white	**0.370** (0.349-0.393)	0.370 (0.350-0.390)	0.500 (0.460-0.520)	0.680 (0.600-0.730)	0.790 (0.720-1.020)
Other	**0.592** (0.527-0.666)	0.565 (0.450-0.630)	0.910 (0.710-1.110)	1.600 (1.110-2.070)	2.070 (1.610-3.090)

Limit of detection = 0.25

NHANES 2007-2008 Blood Lead

Population weighted geometric means and selected percentiles (in µg/dL)

Selected Percentiles (95% confidence interval)						
Category	**Geometric Mean (95% CI)**	**50th**	**75th**	**90th**	**95th**	**Sample Size**
Total	**1.27** (1.21-1.34)	1.22 (1.18-1.30)	1.90 (1.80-2.00)	2.80 (2.67-2.96)	3.70 (3.50-3.90)	8266
Females	**1.11** (1.06-1.16)	1.09 (1.00-1.14)	1.64 (1.54-1.74)	2.41 (2.35-2.50)	3.00 (2.85-3.20)	4119
≥ 20 years	**1.38** (1.31-1.46)	1.34 (1.26-1.42)	2.06 (1.94-2.18)	3.00 (2.80-3.14)	3.90 (3.68-4.23)	5364

Limit of detection = 0.25

NCS sample values were 2 -3 times lower than U.S. reference ranges for all females (ages 1 year and older) and for all adults older than 20 years.

Conclusions

- **In this convenience sample of pregnant women:**
  - Blood lead levels were about 2-3 times lower than reference ranges for U.S. females age 1 year and older
  - Blood total mercury and cadmium levels were generally similar to reference ranges for U.S. females age 1 year and older and also all adults age 20 years and older
  - Blood total mercury levels were about 2 times lower than for U.S. females age 16-49 years*
- **Information on manganese and selenium blood levels in pregnancy are limited, so these results serve as preliminary reference ranges until population-based data are available.**
- **NHANES data may be useful to examine the representativeness of the NCS participants.**

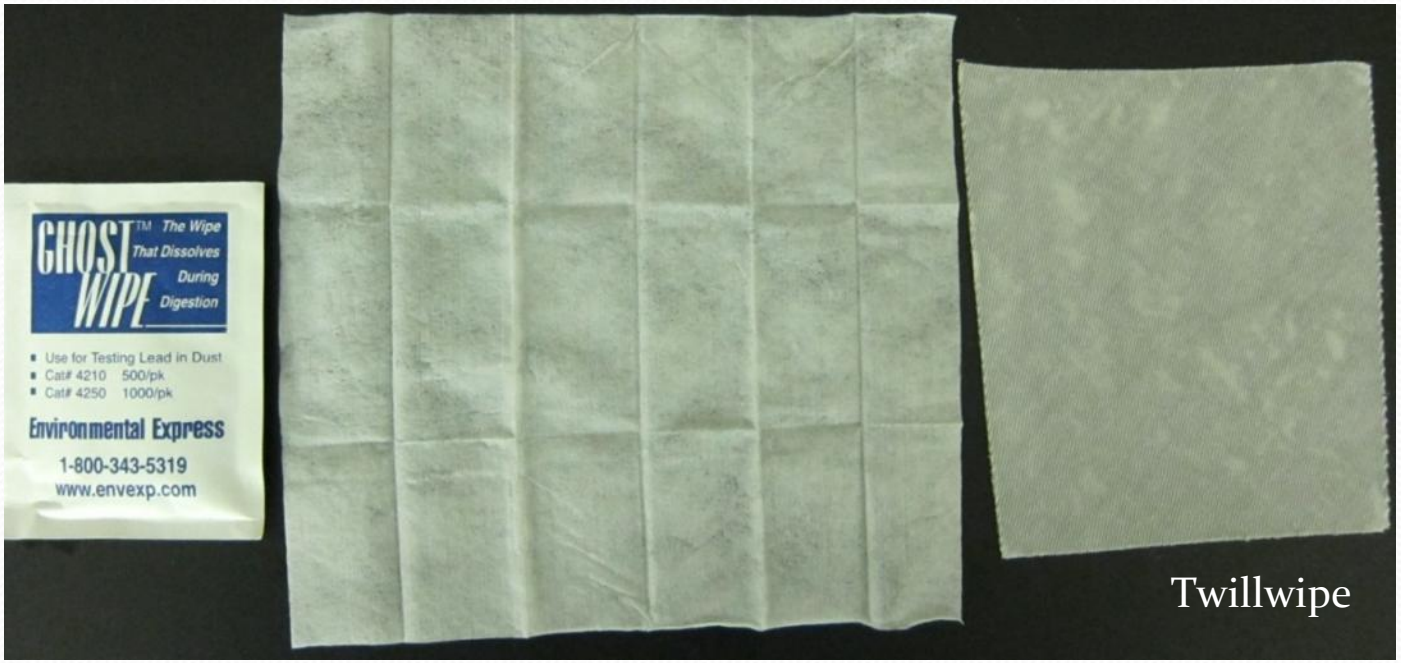
*Caldwell KL,, et al. Total blood mercury concentrations in the U.S. popoulation:1999-2006. Int J Hyg Environ Health 2009;212:588.

Comparison of Wipe Materials and Wetting Agents for Pesticide Residue Collection

David Camann – Southwest Research Institute
Nicole Deziel. Susan Marie Viet, David Marker, John Rogers, Maire Heikkinen - Westat
Daniel Stout II – NERL/U.S. EPA
Alice Yau – Southwest Research Institute
Michael Dellarco – NICHD/The National Children's Study

Study Design

- 3 wipes selected for study:
  - Pre-cleaned Twillwipe (4.5 in x 4.5 in, M. G. Chemicals) wetted with 2 mL of deionized water (TW)
  - Pre-cleaned Twillwipe (4.5 in x 4.5 in), M. G. Chemicals) wetted with 2 mL of isopropanol (TI)
  - Ghost Wipe (pre-packaged, 6 in x 6 in, Environmental Express), wetted with 4 mL deionized water



Study Design - continued

- 3 x 2 factorial design – 3 wipes at high and low pesticide concentrations

- Sample size selected to ensure 80% power to detect a 20% difference in mean collection efficiency and a two-fold difference in CVs between wipes
  - 26 replicates per wipe - 13 replicates at high analyte concentrations and 13 at low analyte concentrations

27 Pesticides Tested

Organochlorines

α-Chlordane
γ-Chlordane
4,4'-DDE
4,4'-DDT
Heptachlor

Organophosphates

Chlorpyrifos
Diazinon
Malathion

Pyrethroids

Allethrin
Bifenthrin
Cyfluthrin
λ-Cyhalothrin
Cypermethrin
Deltamethrin
Esfenvalerate
Fenpropathrin
Imiprothrin
cis-Permethrin
trans-Permethrin
Prallethrin
Pyrethrin I
Pyrethrin II
Resmethrin
Sumithrin
Tetramethrin

Other

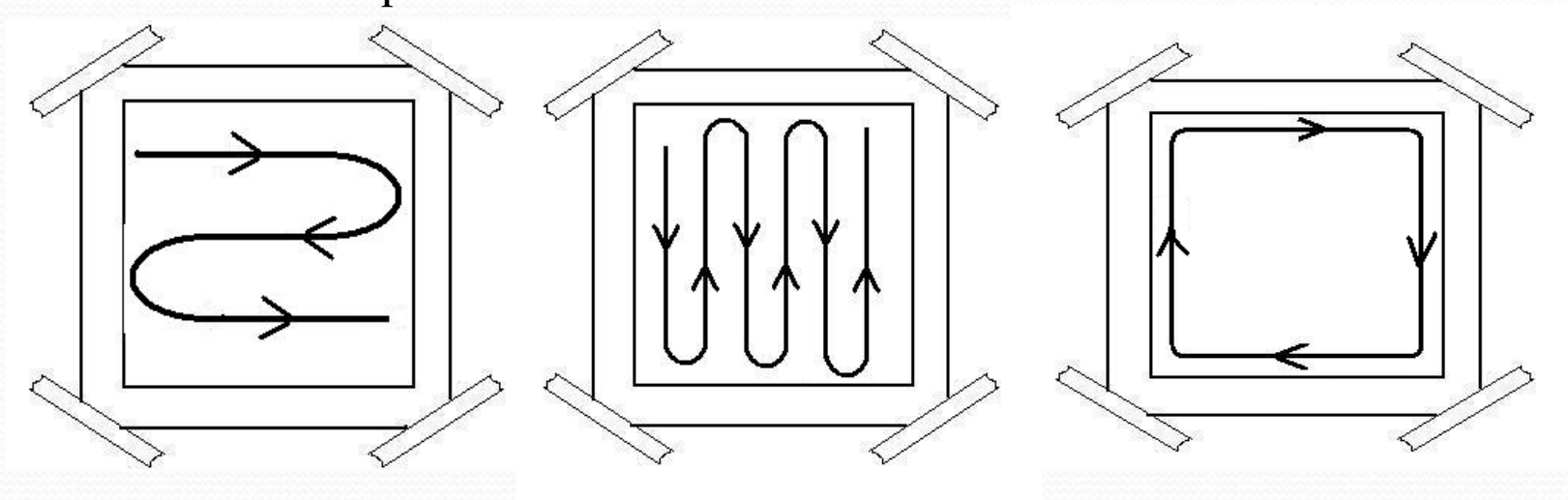
Fipronil
Piperonyl butoxide

Test Surface Preparation

- Stainless steel tool wrap 309SS mounted on plywood with double-sided foam adhesive
- Surface cleaned with acetone and allowed to dry
- 13 disposable sets of triplicate templates (interior sampling area = 1 sq. ft.) secured with masking tape

Wipe Sample Collection

- Each 1 sq ft area wiped according to NCS Pyrethroid Wipe Protocol (parallel to ASTM Wipe Method for Lead)
  - S-shaped wipe from left to right, folded
  - S-shaped wipe up and down, folded
  - Perimeter wipe



- Placed in 60-mL amber glass jar
- Stored at -20°C until extraction

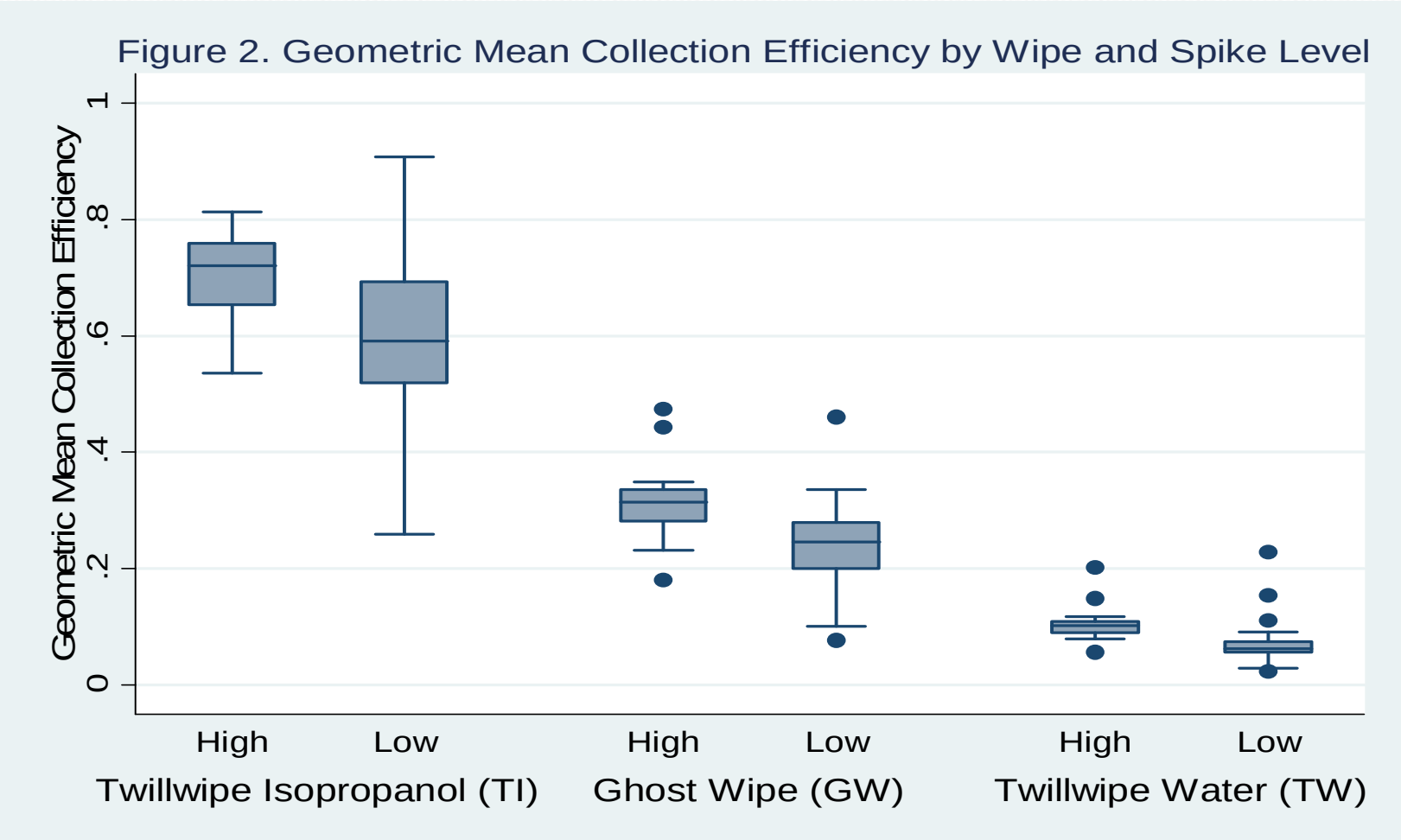
Quality Control

- One sampling blank of each wipe (TW, TI, GW) before collection of low level replicates
- One sampling blank of each wipe (TW, TI, GW) before collection of high level replicates
- One spike of high level spike solution (90 µL) directly onto each wipe (TW, TI, GW) after collection of high level replicates
- One solvent blank with each extraction batch of 21 – 24 samples

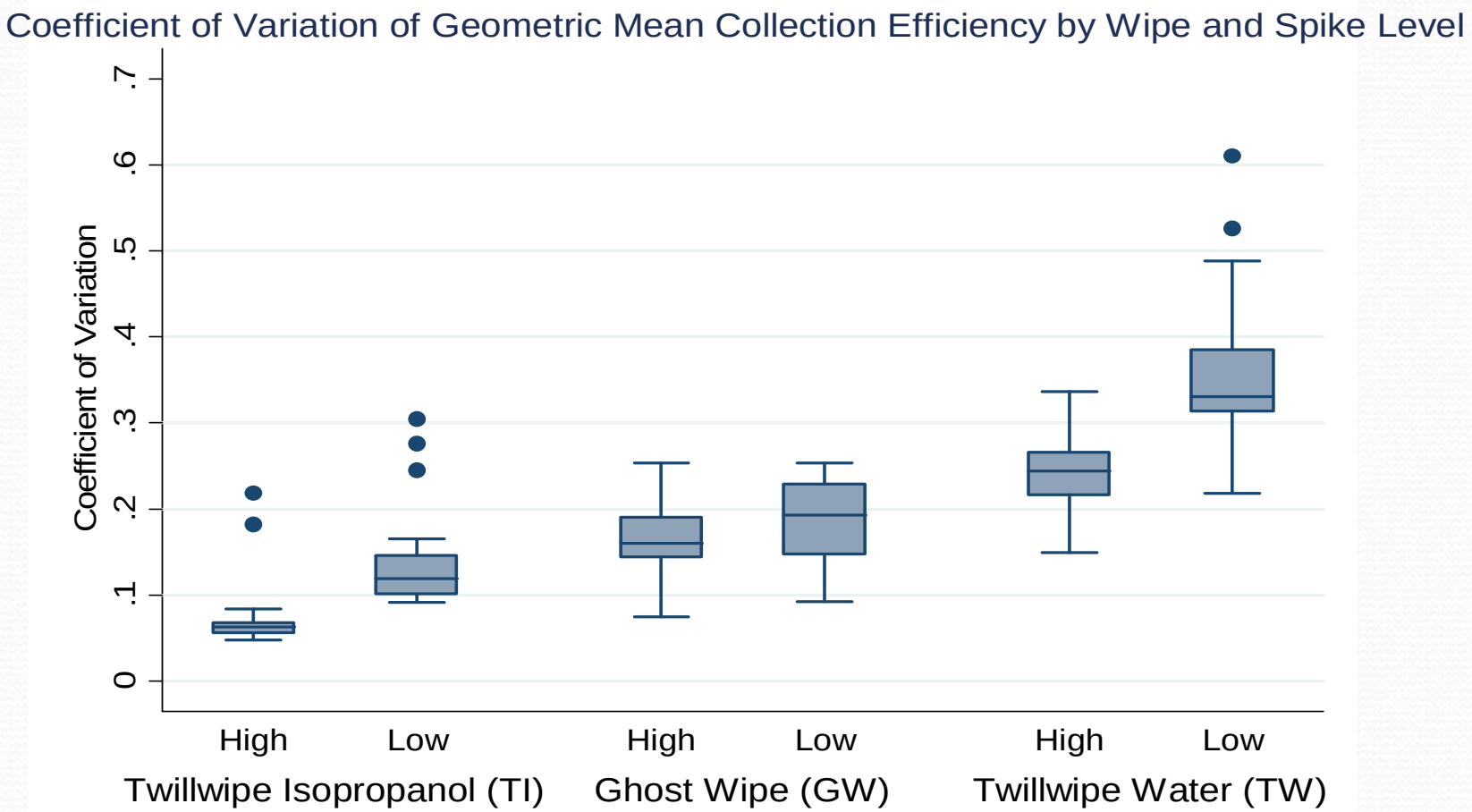
Statistical Analysis

- Collection efficiency = ratio of measured to known spiked amount of each pesticide
- Used measured amount when below DL
- Used log-transformed collection efficiency
- Linear mixed model (SAS MIXED procedure) used to assess differences among wipes
- Precision based on coefficient of variation (CV) of collection efficiency

Results - Collection Efficiency



Results - Precision



Conclusions

- Demonstrated a valid methodology for comparison of wipe methods
- Showed clear and significant differences between collection efficiency and precision of 3 wipes at both concentration levels
- Allows comparison of analytical results across wipe methods

Conclusions - continued

- Allows selection of wipe appropriate to study needs:
  - If low detection limits are required, select wipe with highest collection efficiency – Twillwipe wetted with isopropanol
  - If ease of use in field is desired and participant concerns are issues, e.g., large multi-center epidemiology study like the National Children's Study – consider Ghost Wipe (possibly customized)

Using Community Level Indicators in the National Children's Study:

Assessing segment representativeness, evaluating recruitment performance, and building multi-level analytic models quantifying the impact on developmental outcomes of interactions between individual and community-level risk factors

Howard F. Andrews[1]

James Quinn[2], Suzy Allen[3], Regina Zimmerman[4], Cynthia Lendor[3], Joseph Gilbert[3], Kimberly Mantilla[3], Shahnaz Alimokhtari[6], Leonardo Trasande[5], Perry Sheffield[3], Andrew Rundle[1], Virginia Rauh[1], Ezra Susser[1], Philip Landrigan[3]

[1]Columbia University Mailman School of Public Health [2]Columbia Center for International Earth Science Information Network, [3]Mount Sinai School of Medicine [4]New York City Department of Health & Mental Hygiene, [5]New York University, [6]University of Medicine and Dentistry of NJ—Environmental and Occupational Health Sciences Institute

Queens Vanguard Center

THE NATIONAL CHILDREN'S STUDY

HEALTH GROWTH ENVIRONMENT

MSSM

MOUNT SINAI SCHOOL OF MEDICINE

Community Characterization: Purpose

- Selecting NCS study segments representative of the county
- Informing stake-holders of the nature of the selected communities (segments)
- Developing tailored recruitment and outreach strategies
- Assessing the representativeness of a broad range of community characteristics, beyond those used in segment selection
- Determining predictors of recruitment and retention success
- In terms of the ultimate goal of the NCS: Determining the extent to which community-level risk factors interact with individual exposures to impact developmental outcomes

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HEALTH GROWTH ENVIRONMENT

Assessing Segment Representativeness

- Segment selection was based on limited number of key birth-related and census-based characteristics
- Goal is to define segments that are representative of the study location (PSU) as a whole
- Does planned representativeness with respect to one set of domains reflect representativeness with respect to a larger set of community domains?

Nine Community Domains, 56 Indicators

- **Demographics** (14 indicators)
- **Socio-economics** (5 indicators)
- **Household Composition** (3 indicators)
- **Maternal/ Birth** (7 indicators)
- **Transit-related** (7 indicators)
- **Parks and Greenery** (4 indicators)
- **Safety and Social Disorder** (6 indicators)
- **Pollution Sources (**4 indicators)
- **Land Use** (6 indicators)

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HEALTH GROWTH ENVIRONMENT

Queens Census Tracts with Segments (n=43) vs. Tracts with no Segments (n=597)

- Census tracts containing NCS segments are representative of Queens as a whole with respect to both average values and variability
- Significant differences found in only one of 56 indicators in both parametric and non-parametric tests:
  - % Female* (52% non-NCS vs 51% NCS)
  - % Asian-Pacific Islander only** (16% non-NCS vs 22% NCS)
  - % two or more races listed** (6% non-NCS vs 5% NCS)
  - % births to Women <17* (2% non-NCS vs 2% NCS)
  - Low Birth Weight** (9% non-NCS vs 8% NCS)
  - Bicyclists Injured in Car Accidents*** (1 in non-NCS vs 1 in NCS)
  - % of Tract within ¼ mile of Point Source** (4 in non-NCS vs 1 in NCS)

*p<0.05 by Mann Whitney U; **p<0.05 by t-test; ***p<.05 in both Mann Whitney U and t-test

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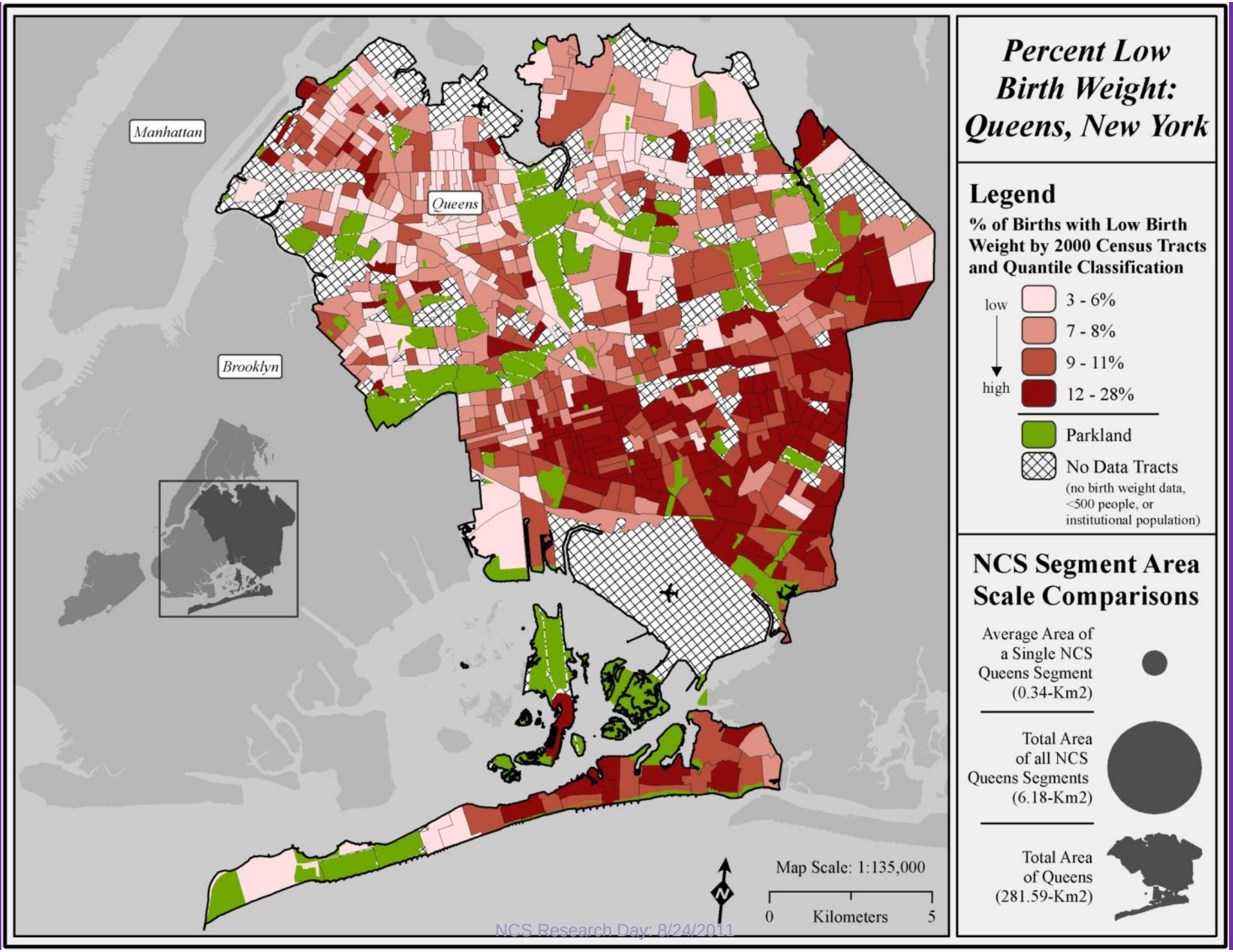
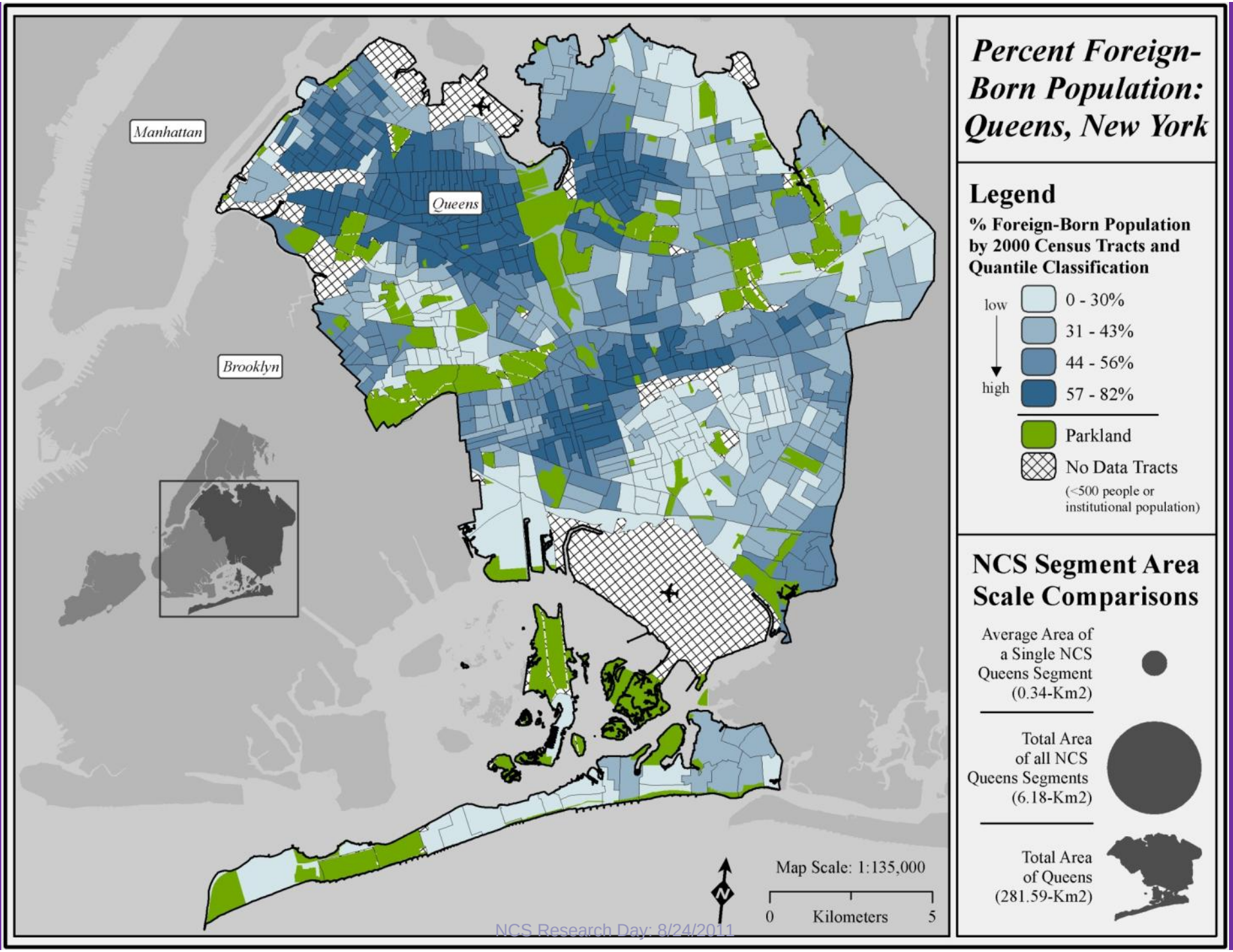
HEALTH GROWTH ENVIRONMENT


Percent Low Birth Weight: Queens, New York
Legend
% of Births with Low Birth Weight by 2000 Census Tracts and Quantile Classification
low
high
3 - 6%
7 - 8%
9 - 11%
12 - 28%
Parkland
No Data Tracts
(no birth weight data, <500 people, or institutional population)
NCS Segment Area Scale Comparisons
Average Area of a Single NCS Queens Segment (0.34-Km2)
Total Area of all NCS Queens Segments (6.18-Km2)
Total Area of Queens (281.59-Km2)
Manhattan
Queens
Brooklyn
Map Scale: 1:135,000
0
Kilometers
5


Percent Foreign-Born Population: Queens, New York
Legend
% Foreign-Born Population by 2000 Census Tracts and Quantile Classification
low
high
0 - 30%
31 - 43%
44 - 56%
57 - 82%
Parkland
No Data Tracts
(<500 people or institutional population)
NCS Segment Area Scale Comparisons
Average Area of a Single NCS Queens Segment (0.34-Km2)
Total Area of all NCS Queens Segments (6.18-Km2)
Total Area of Queens (281.59-Km2)
Manhattan
Queens
Brooklyn
Map Scale: 1:135,000
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Kilometers
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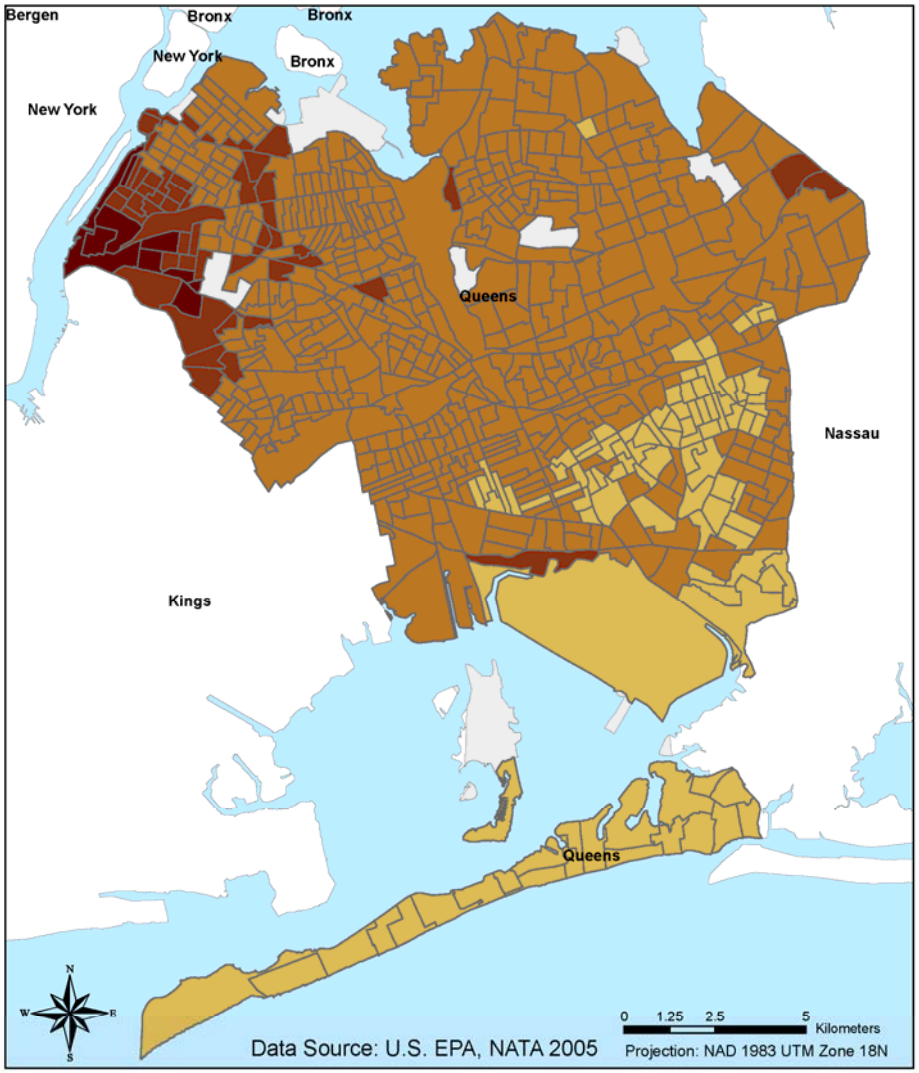
Modeled annual average estimates of ambient air toxics concentrations

(census tract averages calculated for 2005; left: benzene; right: formaldehyde)

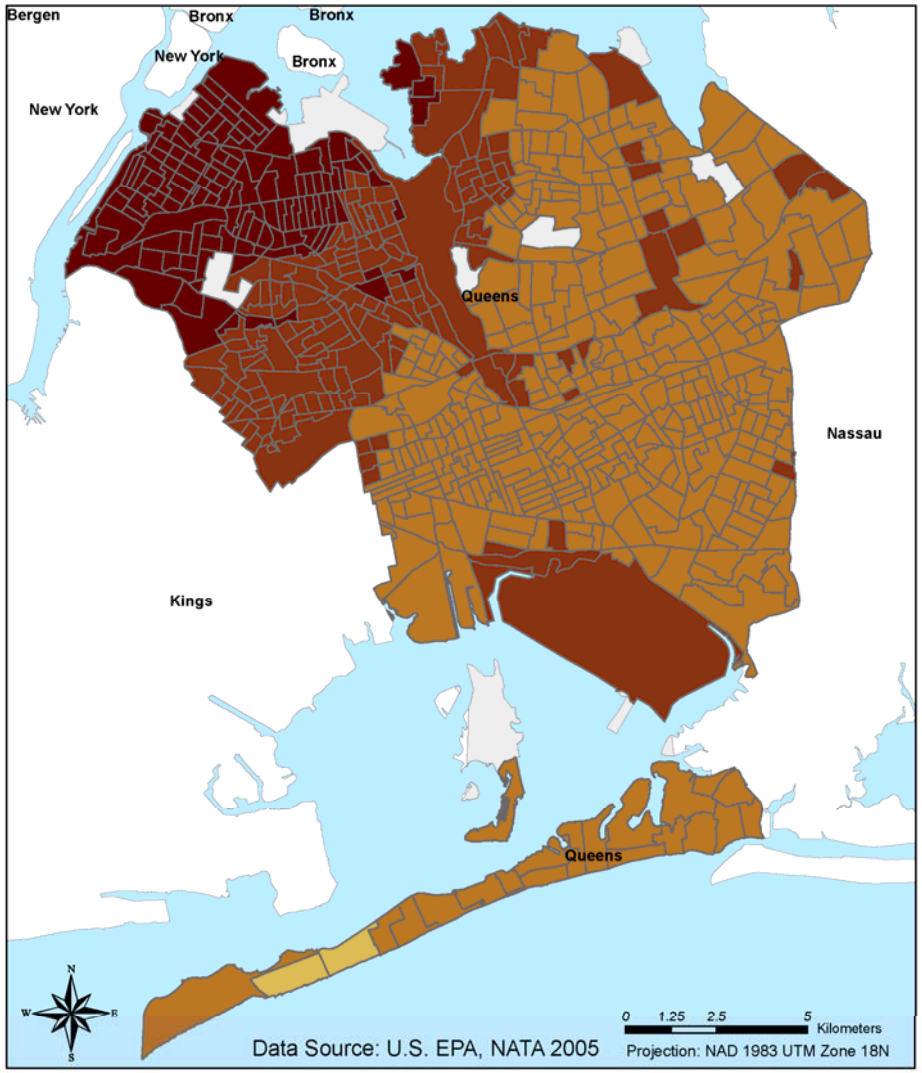


benzene concentrations (maximum: 4194.24 nanogram/m^3)

- 0.00% - 19.99%
- 20.00% - 39.99%
- 40.00% - 59.99%
- 60.00% - 79.99%
- 80.00% - 99.99%
- No Data (pop. = 0)

Shown are the annual average ambient concentrations at the census tract level of air toxics, normalized by the maximum value within Queens county.

CCL Computational Chemodynamics Laboratory



formaldehyde concentrations (maximum: 4325.83 nanogram/m^3)

- 0.00% - 19.99%
- 20.00% - 39.99%
- 40.00% - 59.99%
- 60.00% - 79.99%
- 80.00% - 99.99%
- No Data (pop. = 0)

Shown are the annual average ambient concentrations at the census tract level of air toxics, normalized by the maximum value within Queens county.

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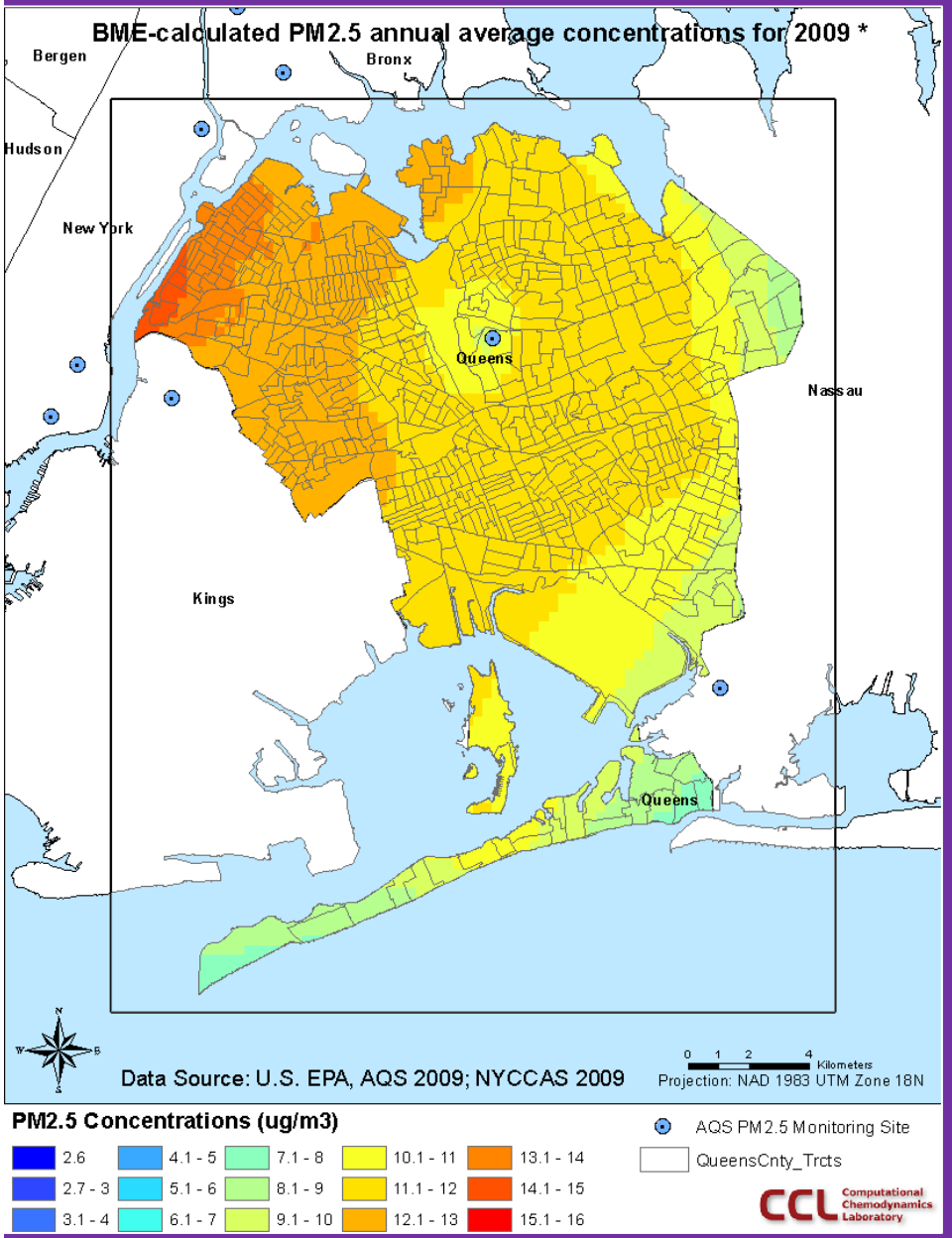
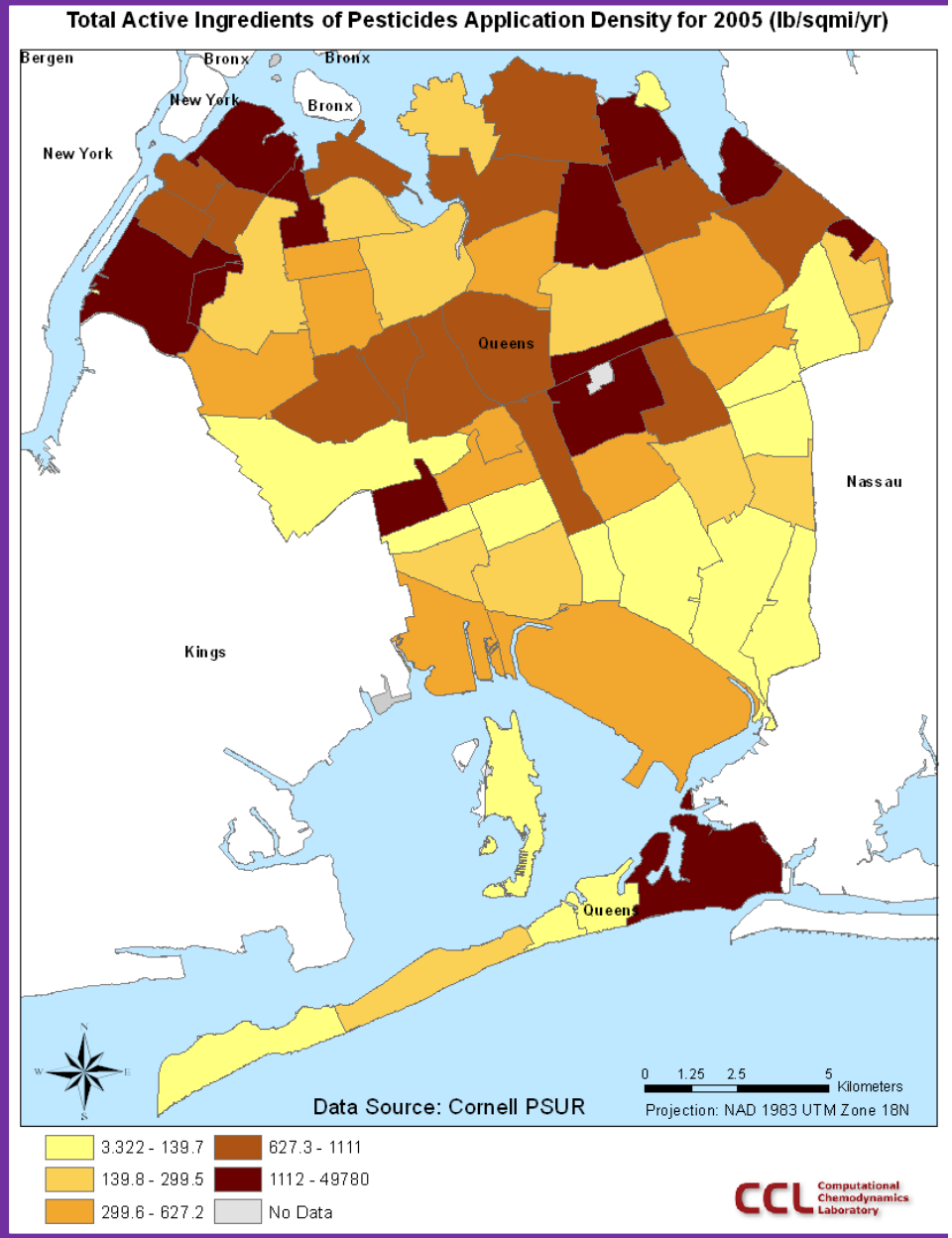
Additional examples of environmental information available for Queens

Left: Ambient PM2.5 estimates from 2009 monitored data; Right: pesticide use for 2005





Descriptive Characteristics and Predictors of Enumeration, Pregnancy Screening and Consent[1]

Sociodemographic Characteristic	Mean (SD)	Enumeration Completion (correlation coefficient)	Pregnancy Screening Completion (correlation coefficient)	Consent (correlation coefficient)
Percent of Births to Mothers with Some College	47.04 (12.89)	.210	-.160	-.320
Percent of Births to Primiparous mothers	34.51 (4.88)	.159	-.224	-.200
Percent of Mothers Receiving Late or No Prenatal Care	8.00 (3.84)	.251	.114	.433
Percent Foreign-born Population	48.57 (15.81)	.244	-.058	-.138
Median Household Income	41,400 (10,200)	.003	-.360	-.463
Percent Population Below Poverty level	15.340 (7.1943)	.275	.394	.158
Gun Arrests Per 10,000 Population, 2001-2004	1.67 (2.06)	.023	.011	.072
Felonies Per 1000 Population, 2001-2004	3.70 (1.20)	.025	.023	.142
Percent Medicaid	55.52 (15.02)	.421	.173	.275
Percent Low Birth Weight	7.29 (1.84)	.648**	.508*	.571*
Percent Preterm Birth	11.33 (3.03)	.325	.349	-.003

*p<.05; **p<.01

[1]Update of table originally published in Trasande L, Andrews HF, Goranson C, Li W, Barrow EC, Vanderbeek SB, McCrary B, Allen SB, Gallagher KD, Rundle A, Quinn J, Brenner B. Early experiences and predictors of recruitment success for the National Children's Study. Pediatrics 2011;127(2):261-8.

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Conclusions

- Communities in which NCS Queens Vanguard Center segments are located are representative of Queens communities as a whole, with respect to more than 50 indicators in 9 domains of interest.
- The NY/NNJ NCS Consortium has established a robust GIS/informational infrastructure for using community-level information in all phases of the NCS Study
- This infrastructure and associated statistical methods could provide a model for other NCS Sites, and could be leveraged to operate at the national level, at relatively low cost

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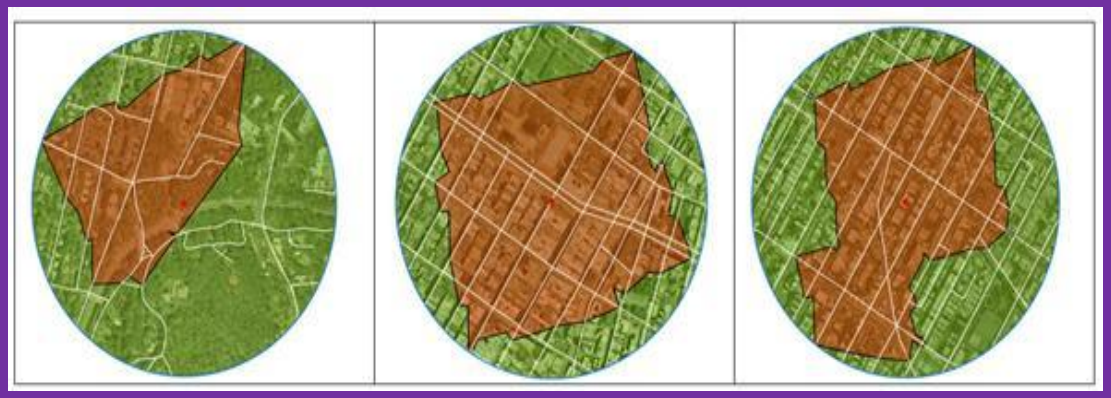
Next Steps: Community Buffers

- Implement *GIS buffering technology*. The brown areas are reachable in a walk of .5 miles or less from the home (red dot) along city streets (Rundle et al, 2009, *Envtl Health Perspectives*)



- Using *irregular buffer shapes* estimate community characteristics for each buffer, and therefore characterize the community experienced by each household