Using Satellite Data to Evaluate Linkages Between Land Cover/Land Use and Hypertension in a National Cohort

Background:
Coincident with global expansion of urban areas has been an increase in hypertension. It is unclear how much the urban environment contributes as a risk factor for blood pressure differences, and how much is due to a variety of environmental, lifestyle, and demographic correlates of urbanization.

Objectives/Purpose:
The purpose of this study is to examine the relationship between living environment (defined as urban, suburban, or rural) and hypertension in selected regions from the REasons for Geographic And Racial Differences in Stroke (REGARDS) cohort.

Methods: REGARDS is a national cohort of 30,228 participants from the 48 contiguous United States. We used data from 4 metropolitan regions (Philadelphia, Atlanta, Minneapolis and Chicago) for this study (n=3928). We used Land Cover/Land Use (LCLU) information from the 30-meter National Land Cover Data.

Results: Overall, 1996 (61%) of the participants were hypertensive. We characterized participants into urban, suburban or rural living environments using the LCLU data. In univariate models, we found that living environment is associated with hypertension, but that after adjustment for known hypertension risk factors, the relationship was no longer present at the 95% confidence level.

Conclusions: LCLU data can be utilized to characterize the living environment, which in turn can be applied to studies of public health outcomes. Further study regarding the relationship between hypertension and living environment should focus on additional characteristics of the associated environment.

Learning Objectives: By the end of the session, participants should be able to:

(1) Describe the methodology by which the Land Cover/Land use data were processed;
(2) Evaluate the relationship between LC/LU and blood pressure; and
(3) Articulate the utility of using LC/LU data to characterize the living environment.

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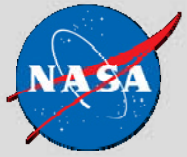
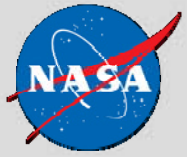


Objective and Hypothesis

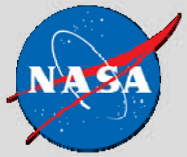
- Objective: Examine the relationship between living environment (urban, suburban, and rural) and blood pressure (Systolic and Diastolic Blood Pressure, hypertension) for four U.S. cities using data from the REGARDS national cohort study.

- Hypothesis: Residents living in urban environments have higher blood pressure and a higher incidence of hypertension than do residents living in suburban and rural environments.



Background

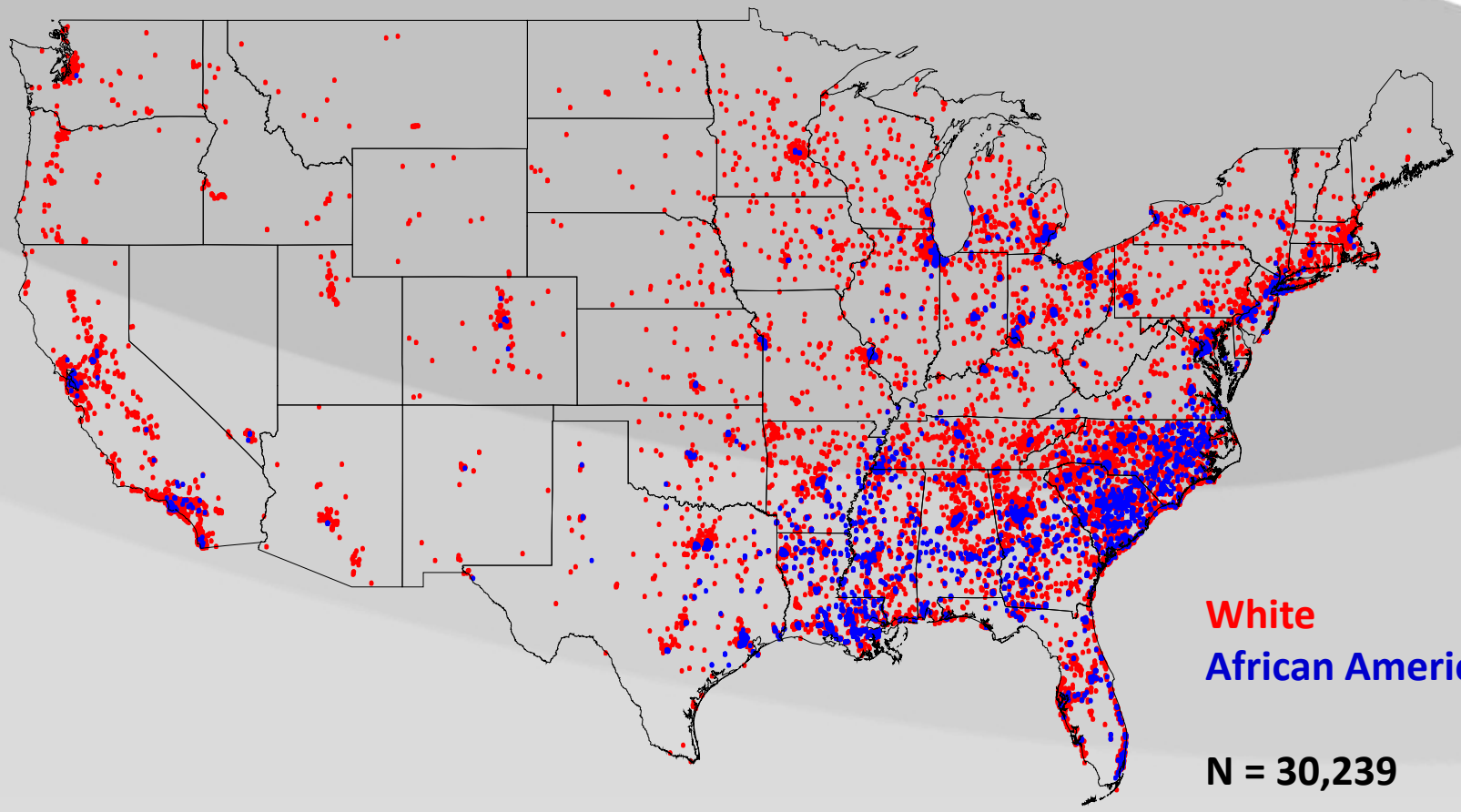
- Hypertension is a risk factor for heart disease, stroke, other cardiovascular diseases and renal disease.
- Hypertension is the second leading cause of disease worldwide.
- Urbanization in increasing, with more than half of the world's population living in cities.
- Studies have correlated hypertension with urbanization in developing countries.
- Urban influence on blood pressure/hypertension is not well documented in the U.S.
- Many urban factors could affect blood pressure/hypertension:
  - Temperature
  - Crowds/noise
  - Air quality
  - Financial pressures



REasons for Geographic And Racial Differences in Stroke (REGARDS)

- Longitudinal population-based cohort of over 30,000 volunteers age 45 and older
- Goal – determine the causes for the excess stroke mortality in the Southeastern US and among African-Americans
- Completed in-home participants in October 2007
- Racial representation
  - 42% African American, 58% white
- Gender representation
  - 45% male, 55% female
- Geographic representation
  - 21% from the 'buckle' of the stroke belt (coastal plain region of NC, SC and GA)
  - 56% from the stroke belt (including buckle; NC, SC, GA, AL, MS, TN, AR, LA)
  - 44% from the rest of the contiguous US

REGARDS Participants



White
African American

N = 30,239

National Land Cover Data (NLCD-2001)

NLCD-2001 is a data set describing land cover over the conterminous U.S., derived from Landsat data obtained between 1999 and 2003.

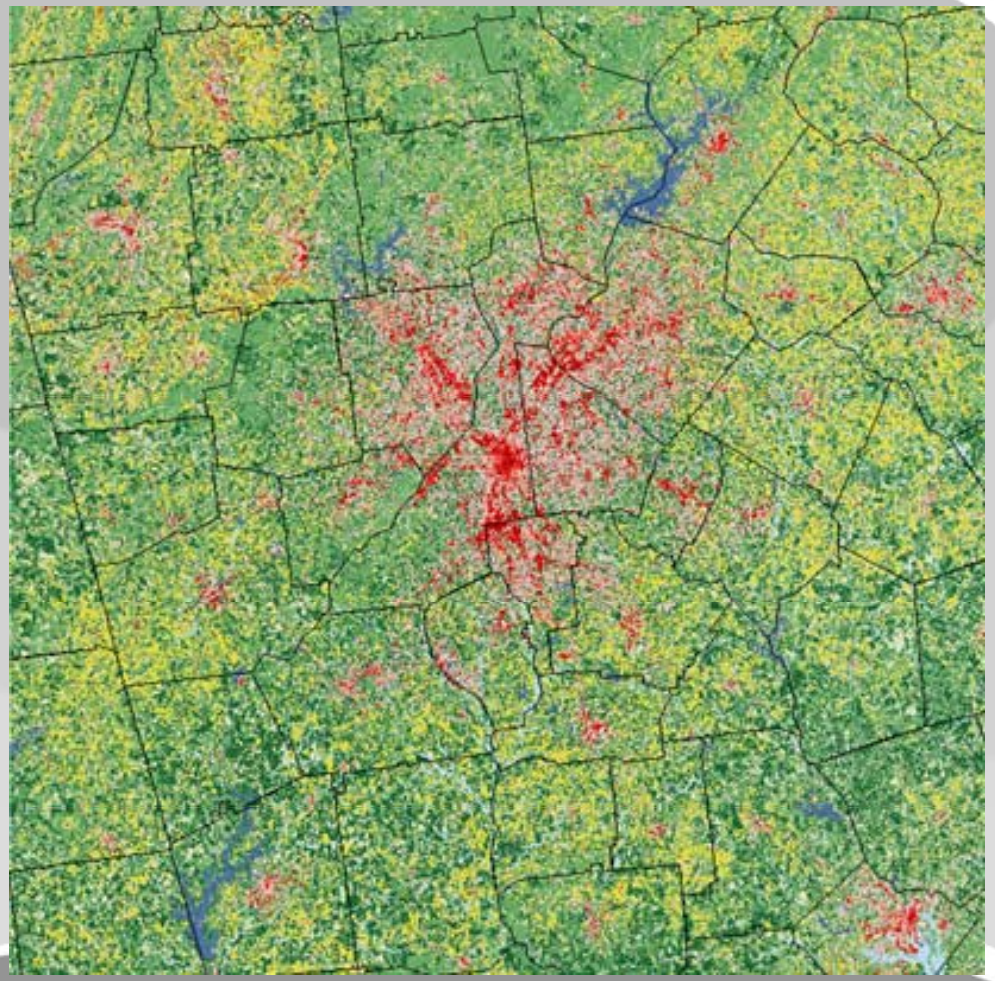
The spatial resolution is 30 m.

There are 16 land use classes relevant to our study areas.

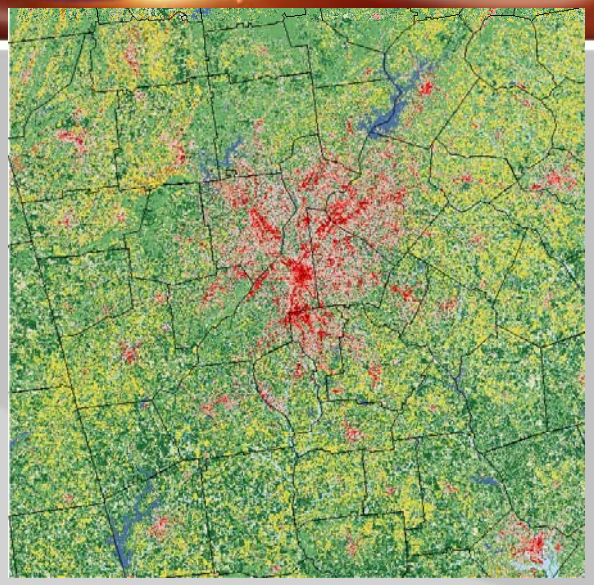
Landsat-derived NLCD 2001

- Open Water
- Perennial Ice/Snow
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Atlanta, GA



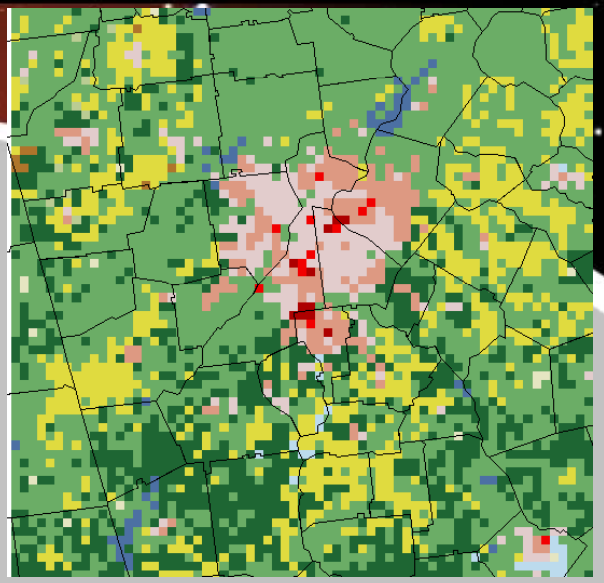
NLCD re-sampling methodology



30-m NLCD

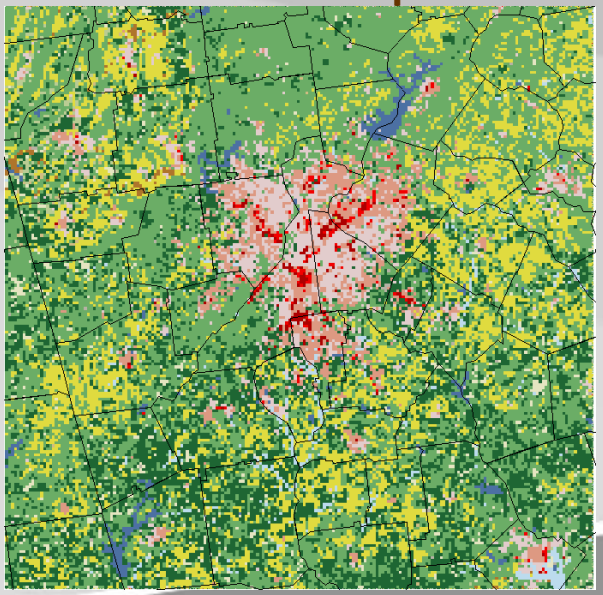
Atlanta, GA

Re-sampling performed by determining the dominant NLCD land cover class within each larger grid cell (1 km, 3 km).



3 km resampled NLCD

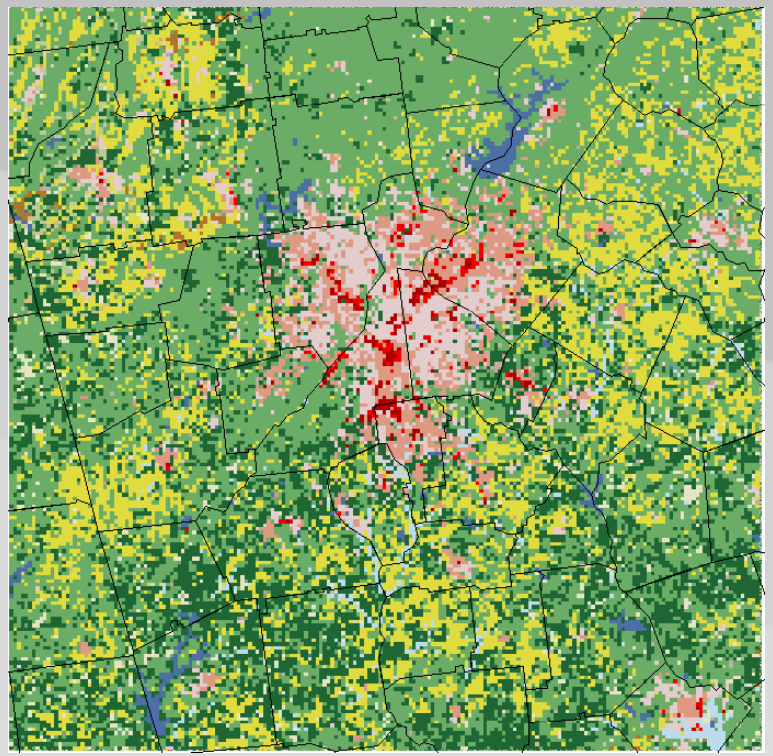
1 km resampled NLCD



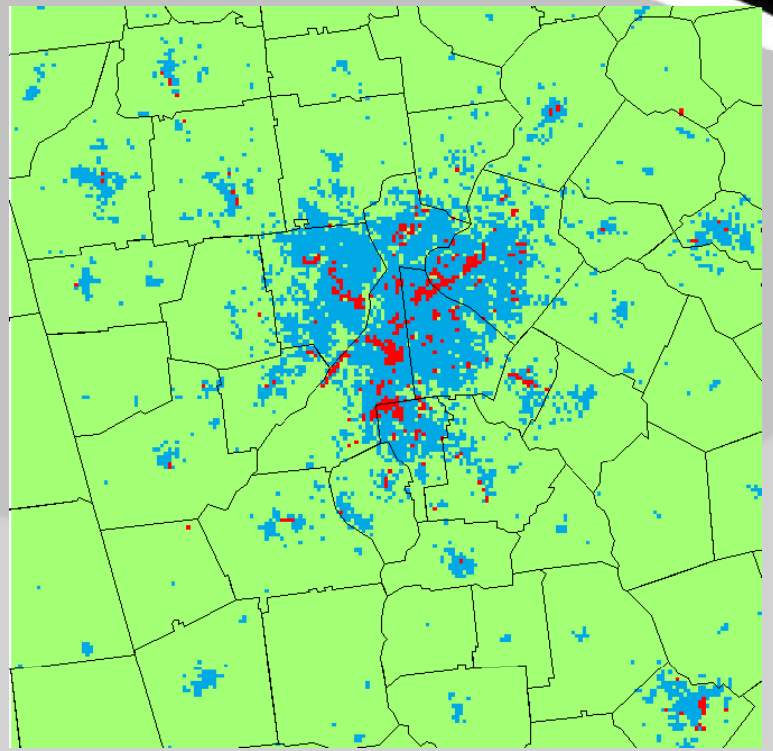
NLCD-derived living environment categories at 1 km

We define three 'living environments' – urban, suburban and rural, based on the dominant NLCD class within 1 km of a person's residence.

1 km NLCD



1 km Living Environment

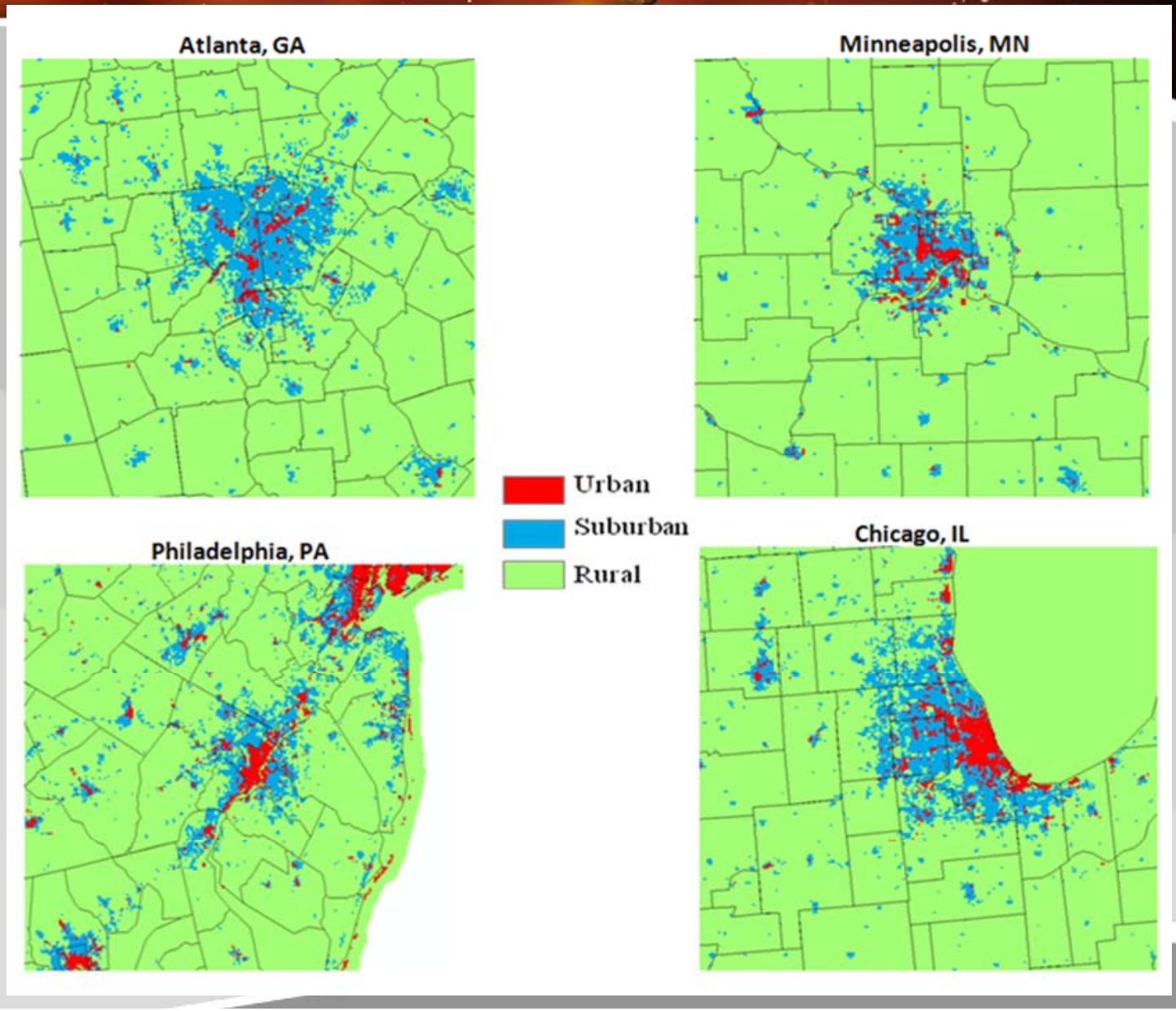


Urban - Developed High Intensity or Developed Medium Intensity

Suburban - Developed Low Intensity or Developed Open Space

Rural - Others

Landsat-derived living environment categories at 1 km



Living environment for four cities

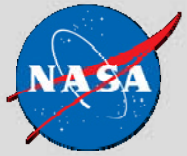
Number of REGARDS participants in each city, by living environment.
Bold font indicates dominant living environment for each city's region.

City	Overall (n=3298)	Urban (n=1058, 32%)	Suburban **(n=1715, 52%)**	Rural (n=525, 16%)
Atlanta	1298	34 (3%)	**934 (72%)**	330 (24%)
Philadelphia	1050	**609 (58%)**	326 (31%)	115 (11%)
Minneapolis	156	19 (12%)	**100 (64%)**	37 (24%)
Chicago	794	**396 (50%)**	355 (45%)	42 (5%)

Blood pressure statistics by living environment

Blood pressure statistics by living environment – four cities combined.
Key: Mean (Std. Dev.) or n (%)
All differences between the living environments are significant at p<0.0001.

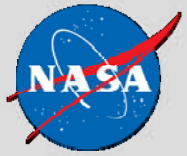
	Overall (n=3298)	Urban (n=1058, 32%)	Suburban (n=1715, 52%)	Rural (n=525, 16%)
SBP	128 (17)	131 (19)	127 (17)	127 (18)
DBP	77 (10)	78 (10)	77 (10)	76 (10)
Hypertensive	1996 (61%)	700 (66%)	1016 (59%)	280 (53%)
Hypertension Risk Ratio		1.7 (1.4, 2.1)	1.3 (1.1, 1.6)	Reference



Living environment by race

Number of REGARDS participants in each living environment, by race. Bold font indicates majority race within each living environment.

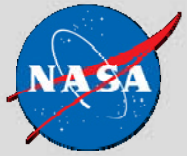
	Overall (n=3298)	Urban (n=1058, 32%)	Suburban (n=1715, 52%)	Rural (n=525, 16%)
African-American	1878 (57%)	**871 (82%)**	860 (50%)	147 (28%)
White	1419 (43%)	187 (18%)	854 (50%)	**378 (72%)**



Blood pressure statistics by race

Blood pressure statistics by race
Key: n (%) or Mean (Std. Dev.)
All differences between the races are significant at p<0.0001.

	Overall (n=3298)	African-American (n=1855)	White (n=1398)
SBP	128 (17)	131 (19)	125 (17)
DBP	77 (10)	78 (10)	76 (9)
Hypertensive	1996 (61%)	1284 (69%)	712 (51%)



Blood pressure statistics by living environment Adjusted for race

Blood pressure statistics by race

Key: Risk Ratio (95% CI) or Mean (Std. Error)

There is no significant relationship between blood pressure and living environment when race is adjusted for.

	Urban (n=1058, 32%)	Suburban (n=1715, 52%)	Rural (n=525, 16%)
SBP	130 (0.58)	127 (0.42)	128 (0.77)
DBP	77 (0.33)	77 (0.24)	76 (0.45)
Hypertensive	1.2 (0.92, 1.5)	1.1 (0.89, 1.3)	Reference

Biostatistical Analysis

Relationships between living environment and SBP, DBP, and hypertension

Living Environment	Model 0[a]	Model 1[b]	Model 2[c]
Mean SBP			
Urban	131 (0.54)	130 (0.58)	128 (0.81)
Suburban	127 (0.42)	127 (0.42)	127 (0.61)
Rural	127 (0.76)	128 (0.77)	127 (0.99)
p-value	<0.0001	0.0021	0.2
Mean DBP			
Urban	78 (0.31)	77 (0.33)	77 (0.47)
Suburban	77 (0.24)	77 (0.24)	77 (0.35)
Rural	76 (0.44)	76 (0.45)	76 (0.57)
p-value	<0.0001	0.28	0.71
Hypertension			
Urban	1.7 (1.4, 2.1)	1.2 (0.92, 1.5)	1.2 (0.85, 1.6)
Suburban	1.3 (1.1, 1.6)	1.1 (0.89, 1.3)	1.1 (0.84, 1.4)
Rural	REF	REF	REF
p-value	<0.0001	0.47	0.62

SBP=systolic blood pressure, DBP=diastolic blood pressure

Hypertension defined by SBP > 140, DBP > 90 or self-reported anti-hypertensive medication

[a] Univariate model

[b] Adjusted for race

[c] Adjusted for race, gender, age, body mass index, income, education, and city of residence

Conclusions

- Remotely-sensed land cover/land use data can be used to characterize living environment for public health applications.
- Such remote sensing and GIS methods have the potential to facilitate additional research linking environmental variables to public health concerns.
- Living environment is associated with hypertension in univariate models, with urban areas having the greatest incidence, but that relationship is no longer present after adjustment for cardiovascular risk factors.

Further Study

- The REGARDS data set, along with the related environmental data generate through this and related projects, affords great opportunity to test hypotheses regarding relationships between environmental conditions, hypertension and strokes.
- Further study regarding living environment and hypertension will focus on additional environmental characteristics such as air temperature, heat stress and air quality.