Creation of built environment indices

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Outline

- Definition of built environment indices
- Previous applications
- Suggested alternative/complementary approach
  - Data
  - Methods
  - Comparison of methods
  - Comparison to established standard
- Conclusions

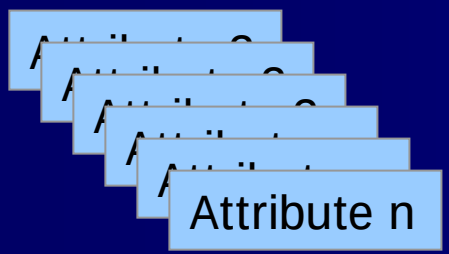
Objectives

- Identify data requirements
- Understand development of indices
- Assess strengths/weakness of various approaches –with example
- Develop or propose
  - Refinements to indices
  - New uses for indices

Definition

- Score or scores qualifying environment
  - Sprawl index
  - Pedestrian environment index
  - Transit serviceability index
  - 3 Ds: diversity, design, density

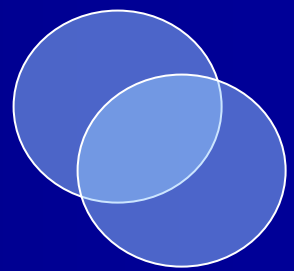
Characteristics of the urban environment



Analytical tools

Cluster analysis
Delphi methods
Principal components analysis
Factor analysis

Index or indices



Motivation

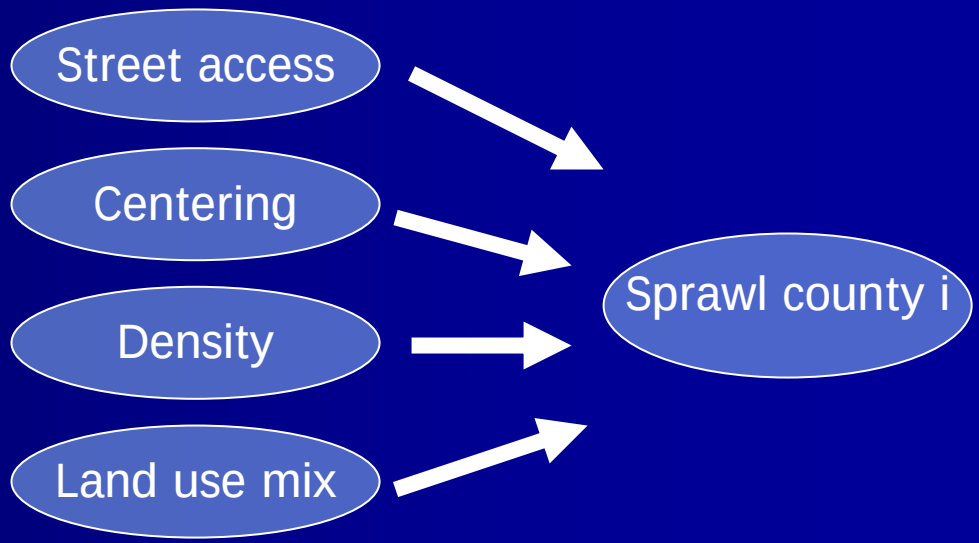
- Usefulness of built environment indices
  - Research
    - Data reduction technique (spatial co-variation)
    - Input to sampling frame
  - Identify priority areas
    - Funding
      - Transportation improvements (roads, transit)
      - Safety interventions
      - Water/sewer/school investments
    - Areas of change, areas of stability
  - Benchmark for measuring community goals

Selected previous examples

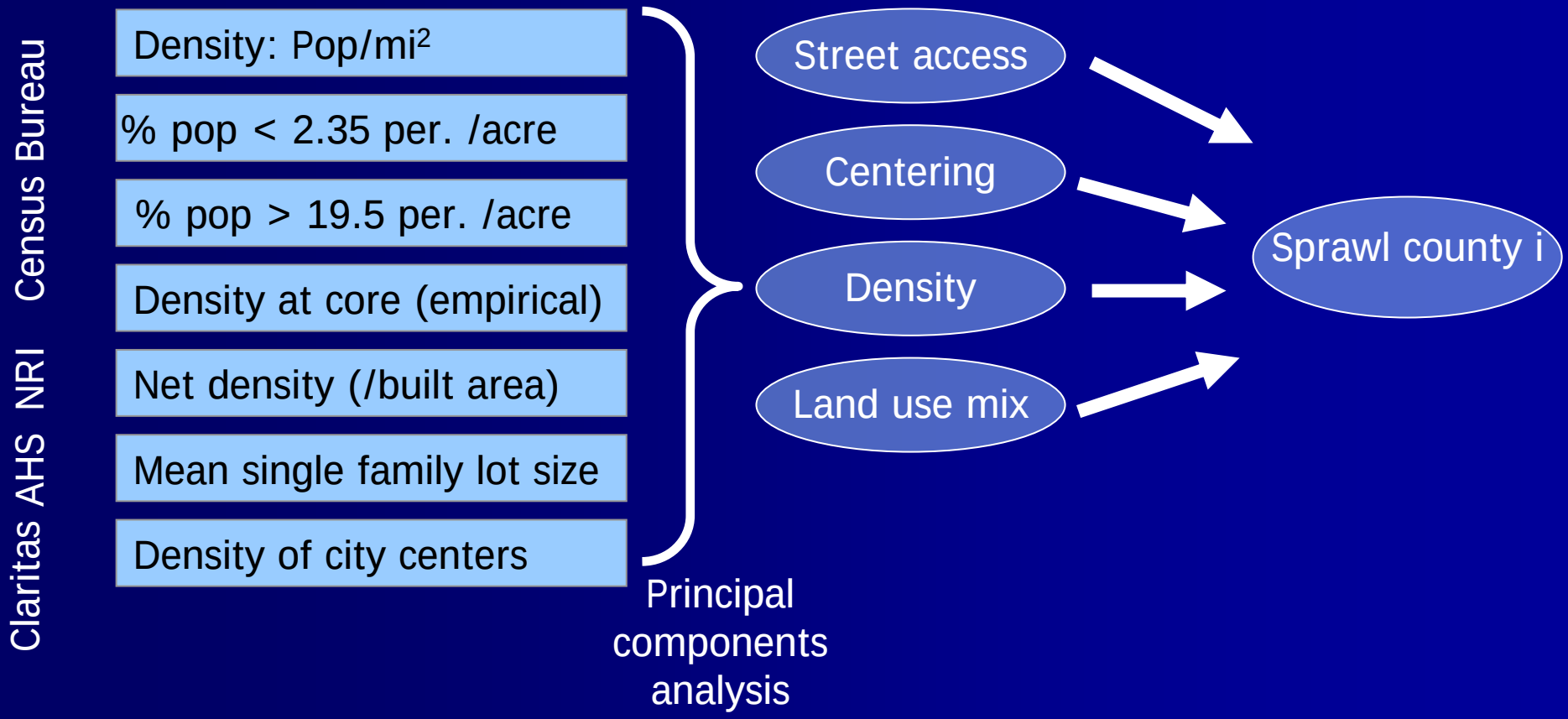
- Metropolitan-level –compare across areas
- Intra-metropolitan
  - County-level sprawl index
  - Pedestrian Friendliness Index (PFI)
  - Pedestrian Environment Factor (PEF)

County-level sprawl

- A priori factors



County-level sprawl



PFI

- Montgomery County, MD
  - Analysis unit: Traffic analysis zones
  - Range: 0-1, 1 = very friendly
  - Method: Delphi-like
  - Data elements
    - Land use mix (0-0.25) Setbacks (0-0.1)
    - Transit stops (0-0.1), Bicycle integration (0-0.1), Sidewalks (0-0.45)
  - Data sources: GIS, expert knowledge, site visits

PEF

- Portland metro (LUTRAQ)
  - Analysis unit: Traffic analysis zone
  - Range: 4-12, 12 = supportive environment
  - Method: Delphi-like
  - Data elements
    - Ease of street crossing –width, volumes, signals (1-3) Sidewalk continuity on arterials (1-3) Street connectivity (1-3), Topography (1-3)
  - Data sources: GIS, expert knowledge, site visits

Srinivasan (2002)

- Boston metro
  - Analysis unit: Traffic Analysis Zone
  - Range: unclear
  - Method: Factor analysis
  - Data elements
    - % roads with no urbanization, % roads with no sidewalk, % roads with level terrain, average road width
  - Data sources: GIS, expert knowledge, site visits

Observations

- Limited ability to generalize
- Reliability of methods
  - PCA vs. factor analysis?
  - Delphi-method vs. PCA?
- Validity of GIS data?
- Clear urban-suburban focus
  - Rural areas?
- Use of surrogates (e.g., population density, street density)

A suggested approach

- Relies mostly on Census Bureau data
  - Available throughout most of the U.S.
  - Varying quality
- Robust analysis tool
  - High inter-tool reliability
    - Applied in Portland & Montgomery Cty, MD
    - Following are Portland's results
- Comparison with established index
  - Portland's PEF

Data –Portland example

Development intensity factors	
Population density	Census 1990
Housing unit density	Census 1990
Employment density	CTPP, 1990
Park density	RLIS
Motorized transportation factors	
Roadway density	RLIS (Census)
Bus route density	RLIS
Transit commuting	Census 1990
Proximity to subway station	RLIS
Pedestrian and bicycle infrastructure factors	
Sidewalk density	RLIS
Sidewalk coverage	RLIS
Ped & bicycle commuting	Census 1990

Methods

- Tested 3 approaches to calculating BEI
  - Principal components analysis
    - Output: formula to score each TAZ
    - Range of score: -2.9-9
  - Non-hierarchical cluster analysis
    - Output: cluster membership (urban, suburban, exurban)
    - Range of score: 1-3
  - Naïve ranking method (16% increments)
    - Output: formula to score for each TAZ
    - Range of score: 0.01-1.3

Reliability part 1

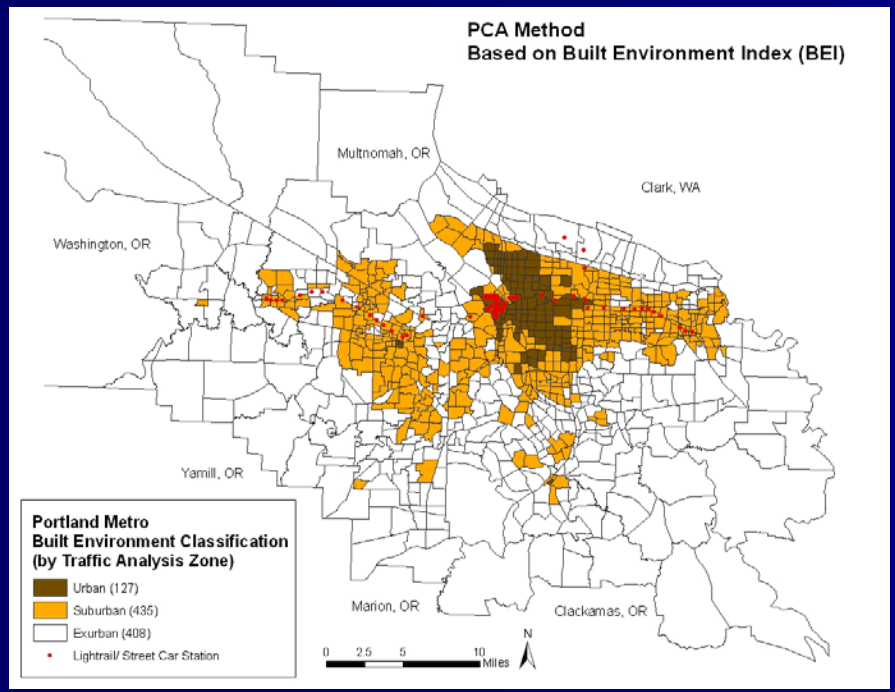
- Pearson correlations of raw score from each method

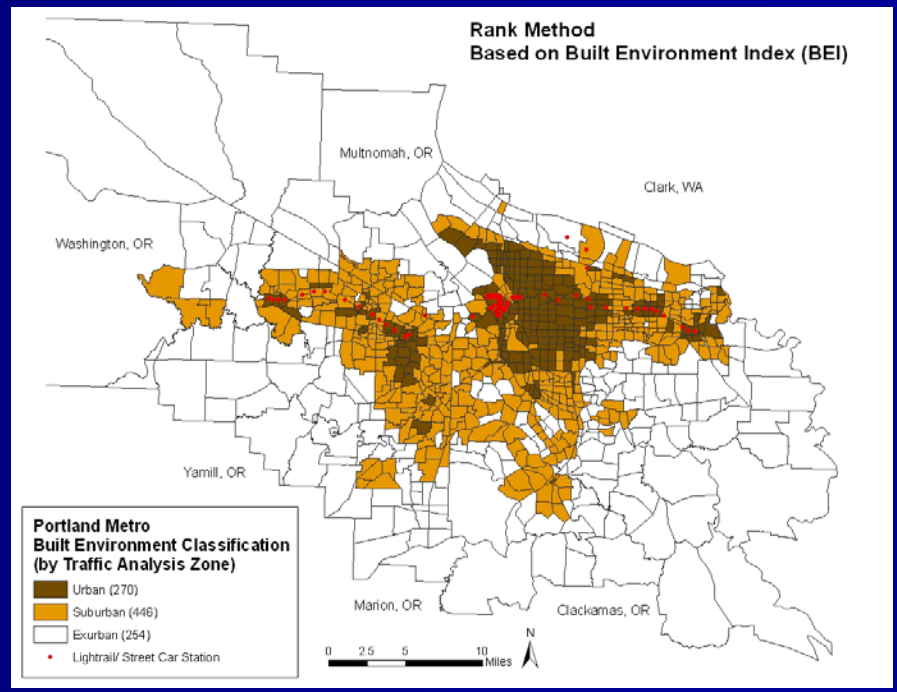
	Cluster	PCA
PCA	0.86	
Naïve	0.84	0.90

P < 0.00 in all cases

Classification into three categories

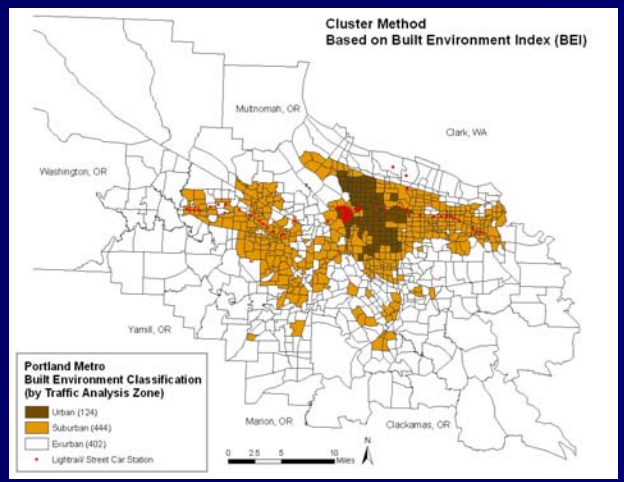
- For continuous scores (PCA, naïve)
  - Minimize within category variation

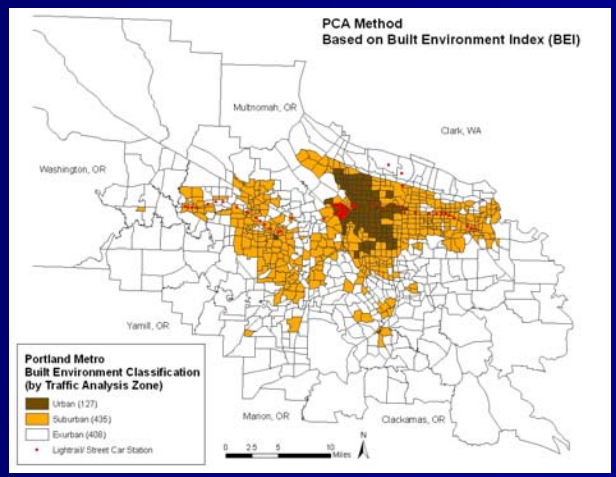


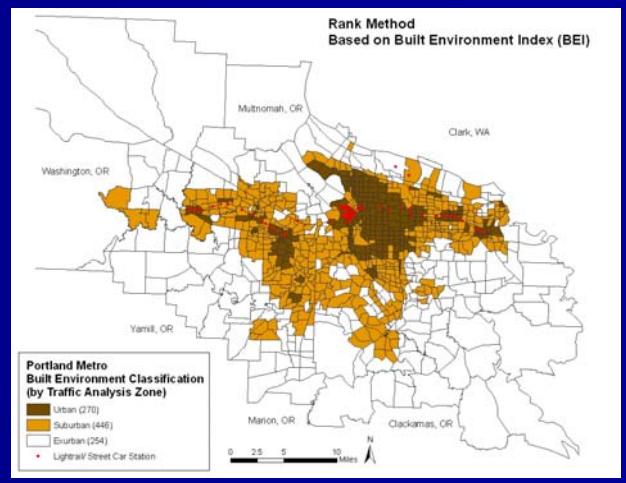


Classification into three categories

- Naïve classifies more areas as urban
- Cluster classifies most number as exurban







Reliability part 2

- Agreement of classification into three groups from each method
  - % agreement

	Cluster	PCA
PCA	96.9%	
Naïve	69.1%	68.9%

  - Kappa coefficient

	Cluster	PCA
PCA	0.94*	
Naïve	0.52*	0.52*

*$P < 0.00$

Comparison to PEF?

- PEF is quasi-‘gold’ standard
  - Predictive & face validity
  - Widely used in planning practice and research about Portland
- Compare three approaches to PEF
  - Pearson correlation of raw scores and Kappa for three categories

Comparison to PEF?

	Pearson correlation	% agreement	Kappa
Cluster method	0.68*	64.1	0.44*
PCA method	0.71*	65.6	0.46*
Naïve method	0.67*	62.6	0.43*

* $P < 0.00$

Conclusions

- Not all indices are created equal
- Use of BEI instead of PEF not justified
  - Measuring same construct, just differently?
  - Measuring different constructs?
    - PEF: Ease of street crossing, sidewalk continuity on arterials, connectivity & topography
    - Can they complement each other?
  - Predictive validity of BEI?

Acknowledgments

- Part of this work was funded by RWJF's ALR program
- Robert Schneider, Toole Design Group
- Hannah Young, MRP Candidate @ UNC

MEASURING THE ENVIRONMENT

Methods for "Macro-Level" Measures

- Proximity
  - Compactness
  - Heterogeneity
  - Floor Area Ration
- Connectivity
  - Intersection Density
- Micro Level Measures
  - Pedestrian Environment
    - Not shown Here

Figure 4-2: Comparative Analysis of neighborhood street patterns in California suburbs

	Gridiron (c. 1900)	Fragmented Parallel (c. 1950)	Warped Parallel (c. 1960)	Loops and Lollipops (c. 1970)	Lollipops on a Stick (c. 1980)
Street patterns					
Intersections					
Linear feet of streets	20,800	19,000	16,500	15,300	15,600
# Blocks	28	19	14	12	8
# of Intersections	26	22	14	12	8
# of Access points	19	10	7	6	4
# of Loops & Cul-de-Sacs	0	1	2	8	24

Source: Southworth, M. and P. Owens. 1993. The Evolving Metropolis: Studies of Community, Neighborhood, and Street Form at the Urban Edge. *Journal of the American Planning Association* 59(3): 271-87, Figure 13.

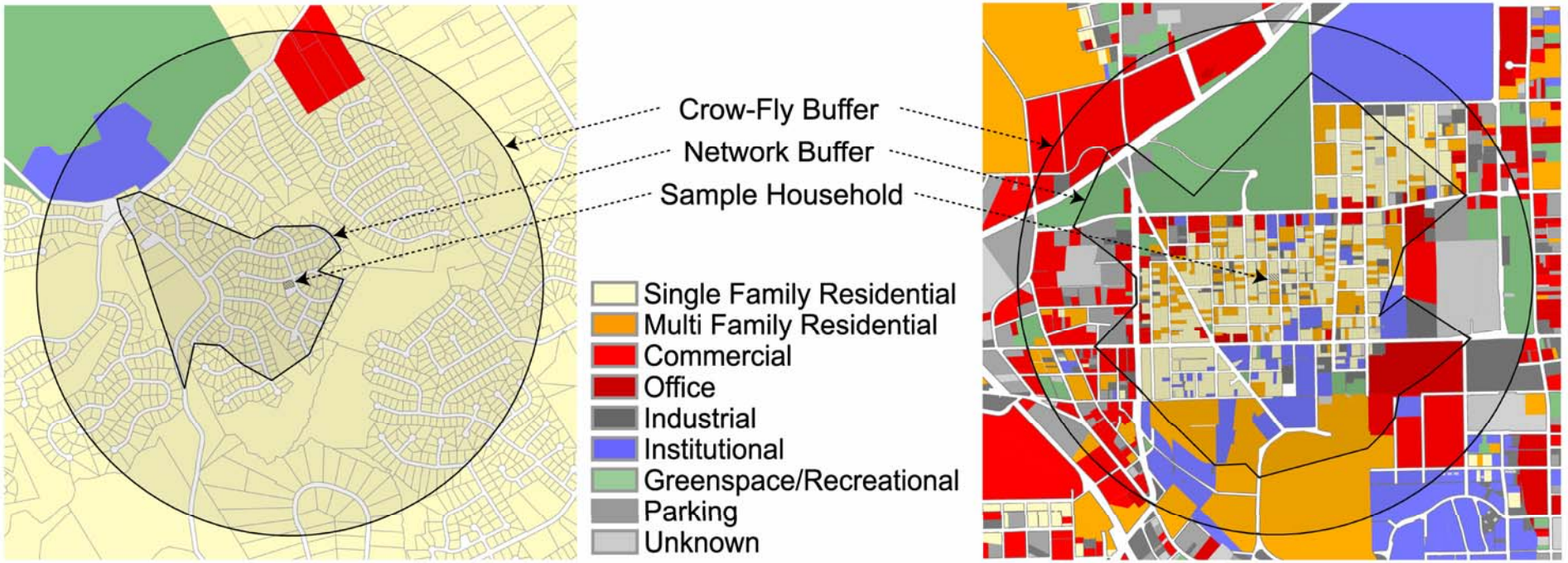
ROUTE DIRECTNESS

1.3 miles *vs.* *0.5 miles*

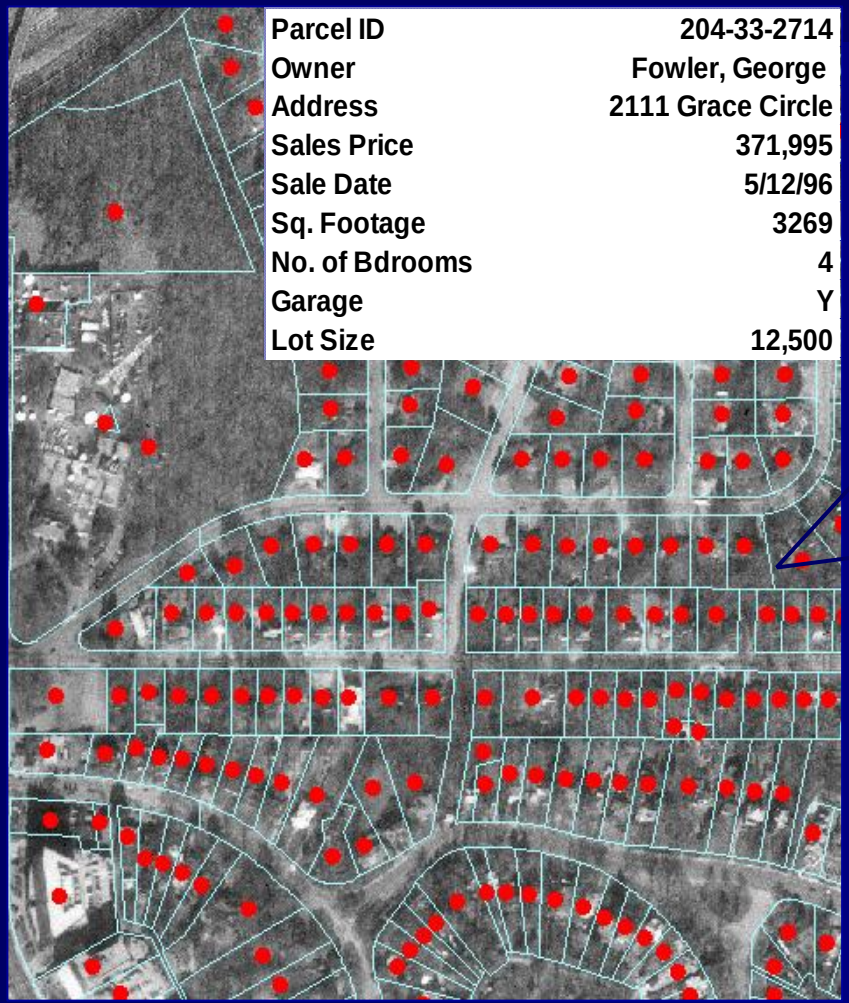
Images are same scale, approximately 1 sq mi.

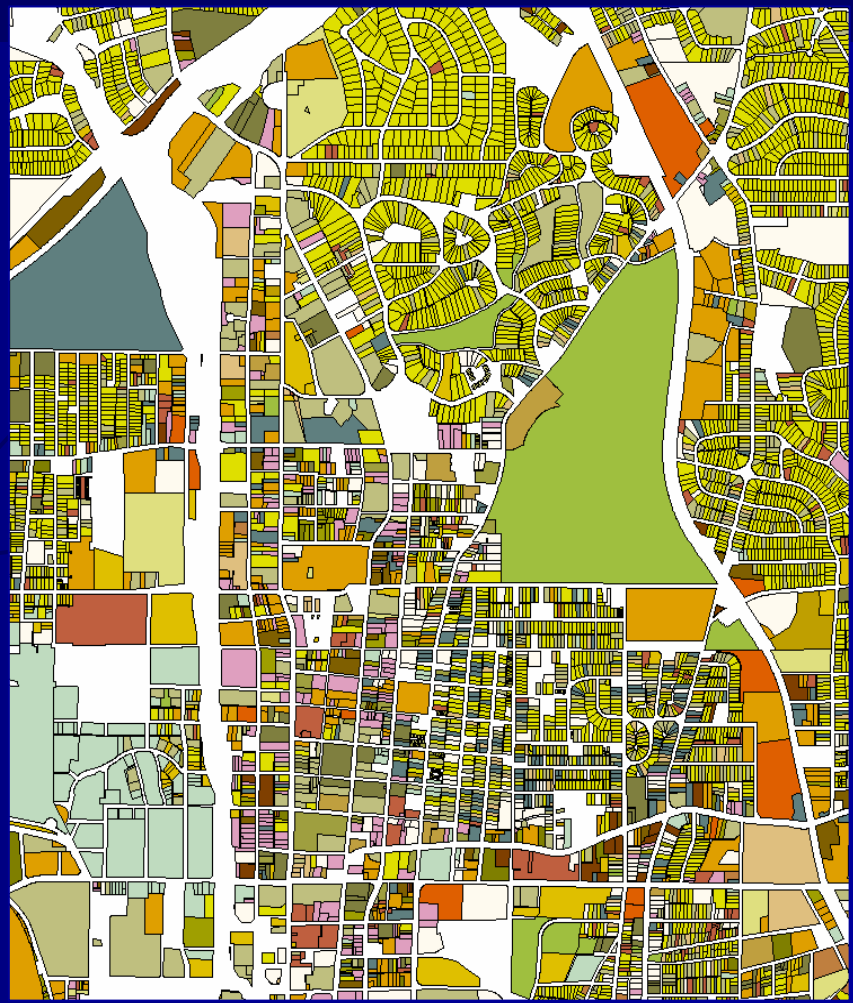
Disconnected

Connected



Parcel Level Land Use Database

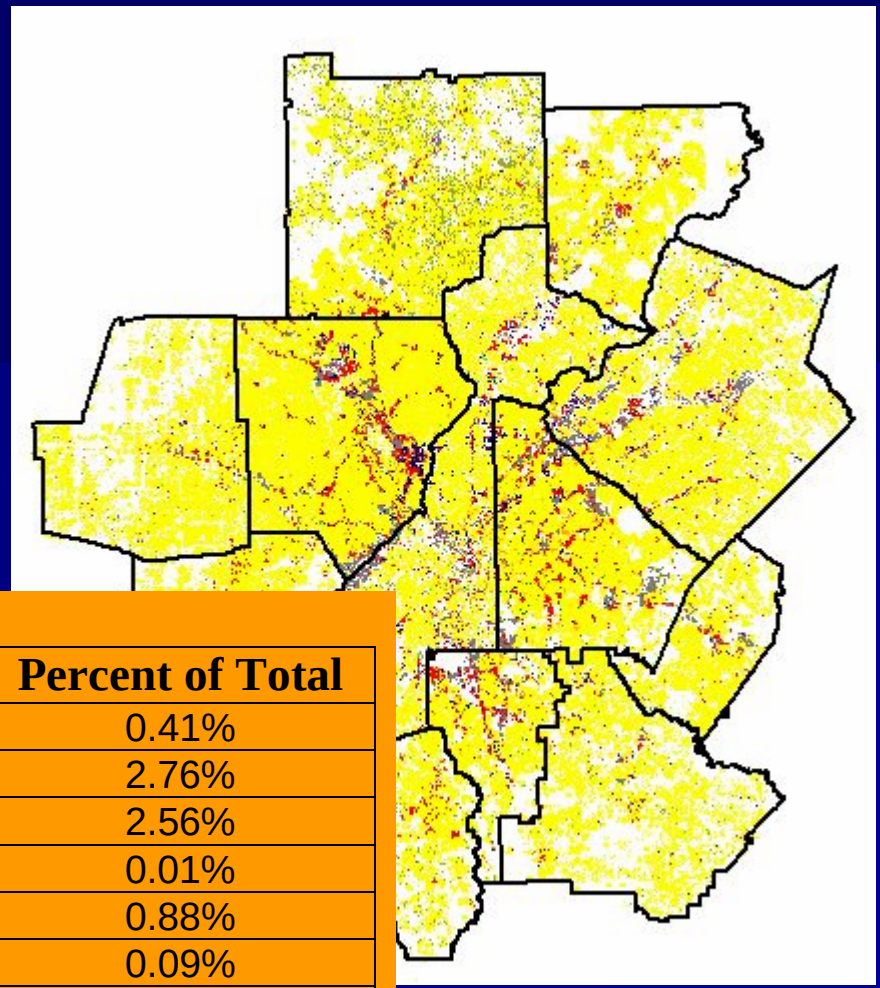




Levels of Aggregation

Dr. Lawrence Frank

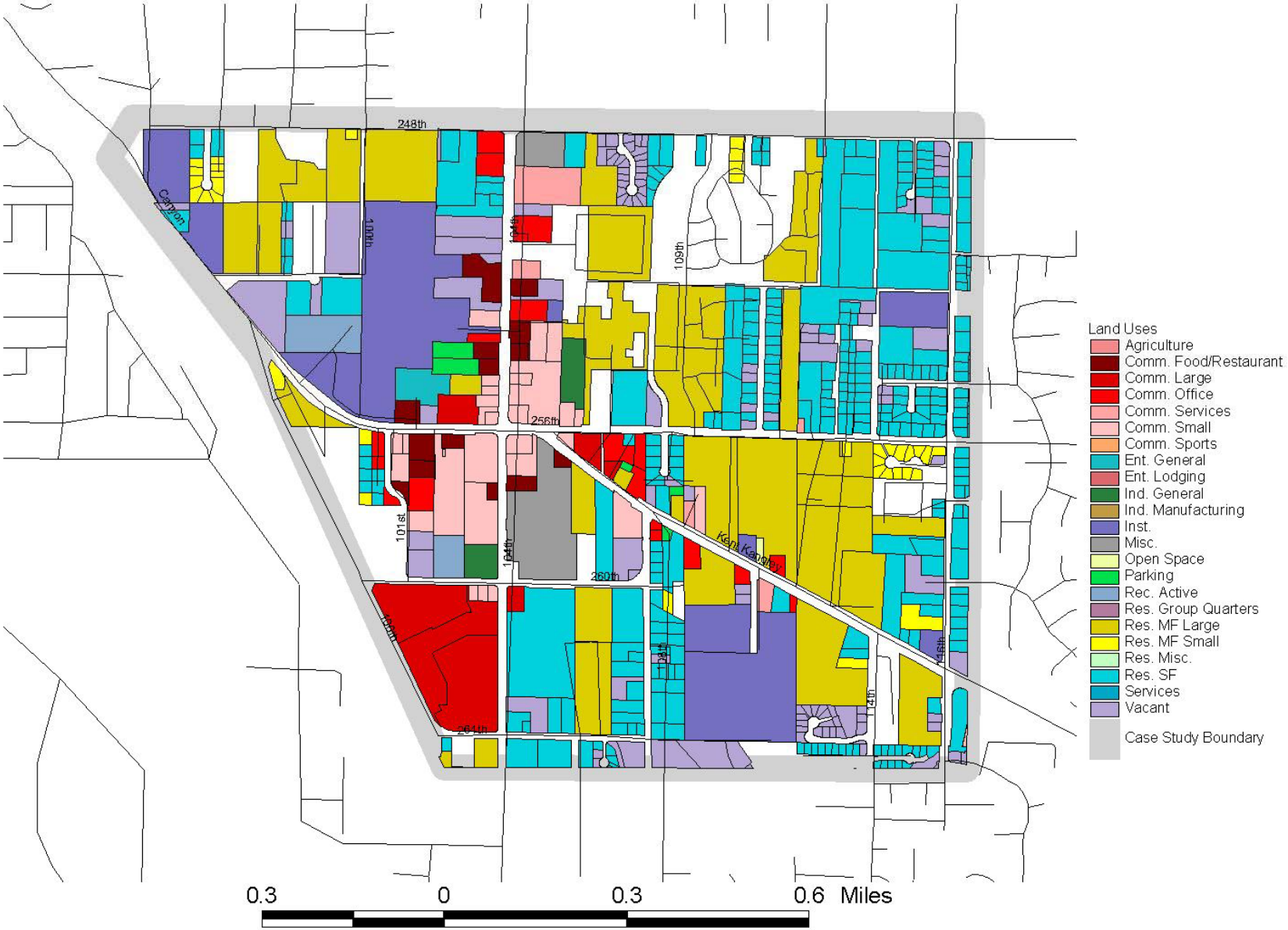
Distribution of Parcels by Land Use Category



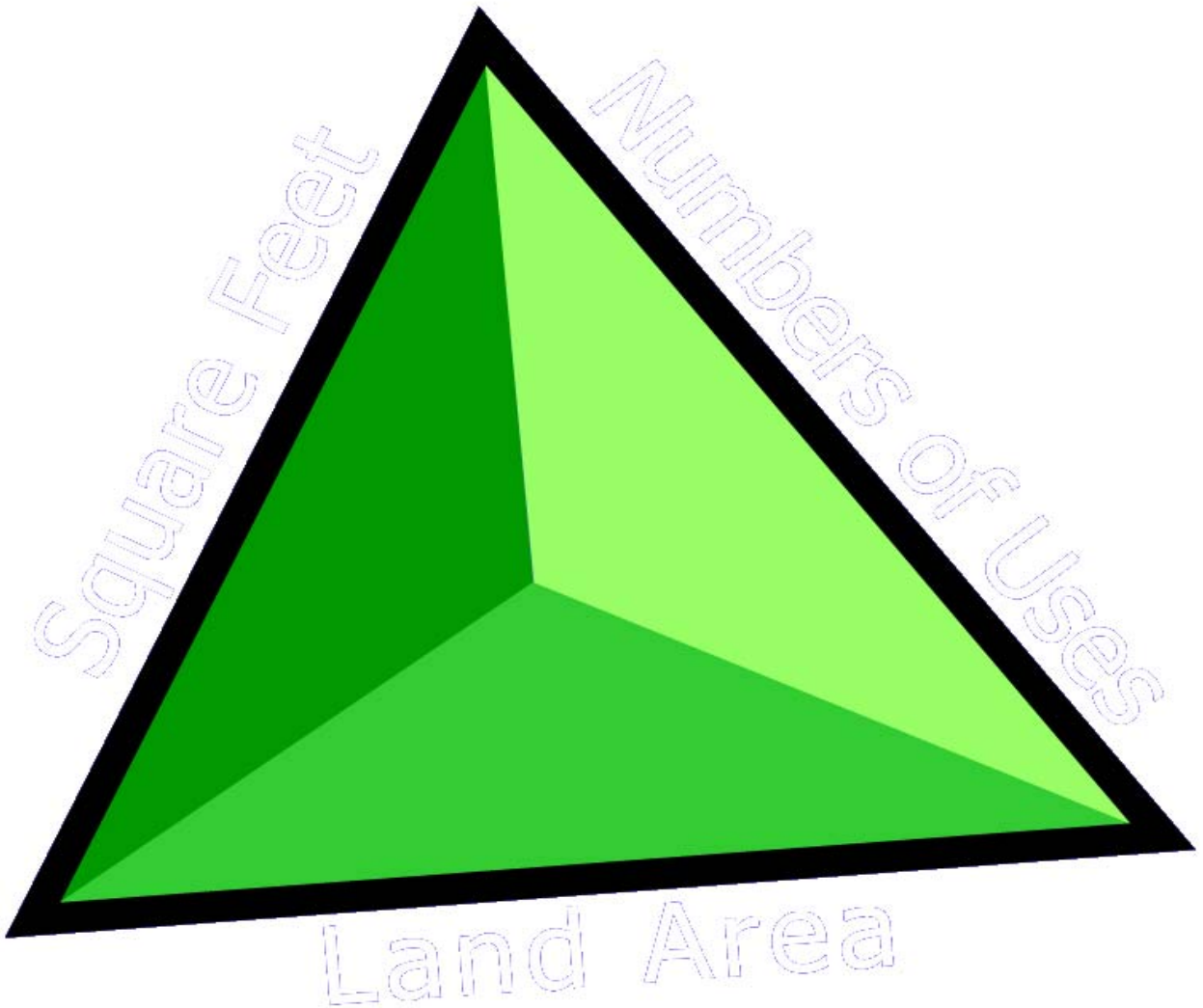
Land Use	Number of Parcels	Percent of Total
Agriculture	4733	0.41%
Commercial	31504	2.76%
Multifamily Residential	29286	2.56%
Mixed Use	73	0.01%
Office	10002	0.88%
Open Space	1003	0.09%
Public	3544	0.31%
Recreation	786	0.07%
Single Family Residential	982653	86.03%
Unknown	25266	2.21%
Vacant	53432	4.68%
Total	**1142282**	**100 %**

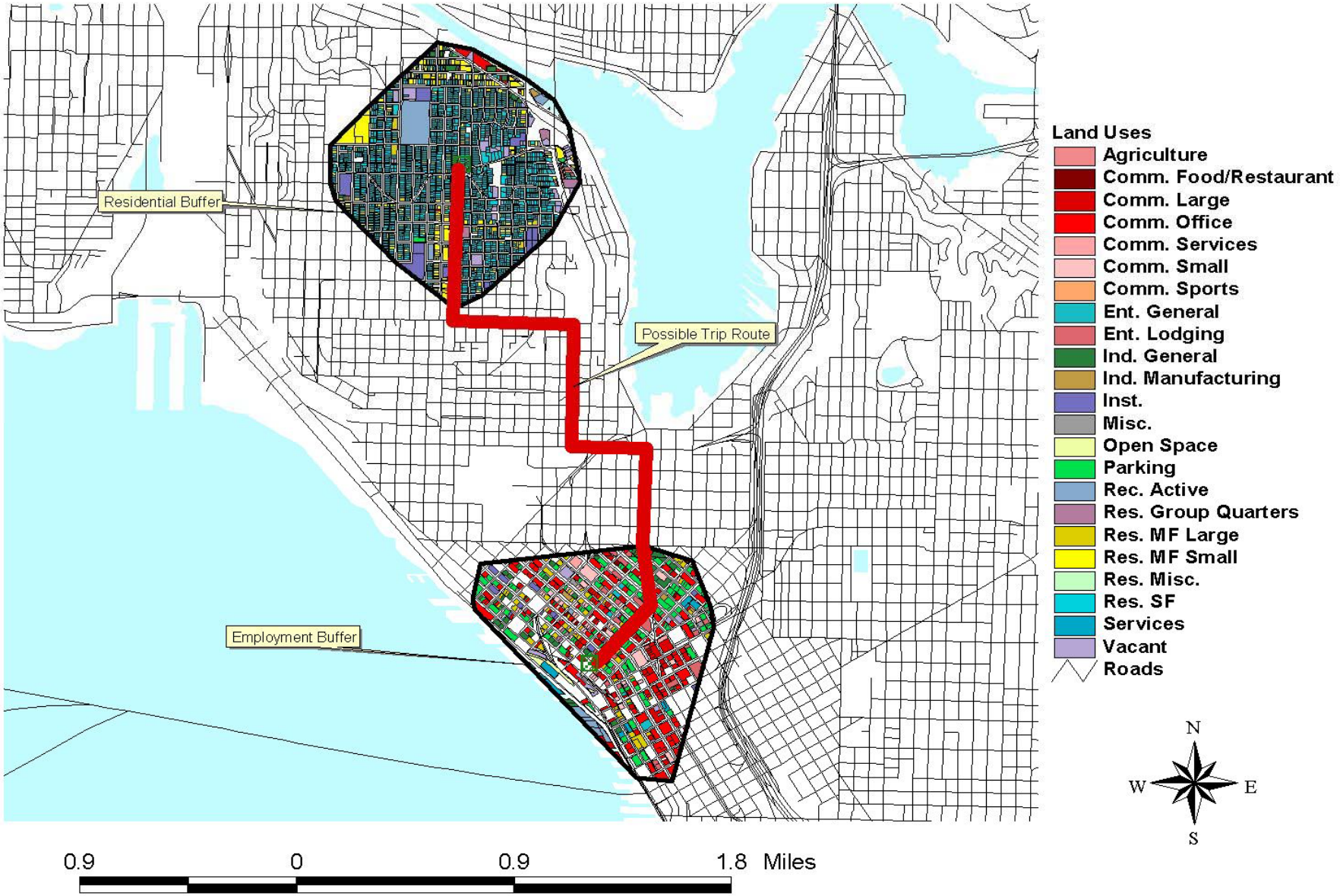
Source: French, Frank, and Bachman, 2000

Kent East Hill

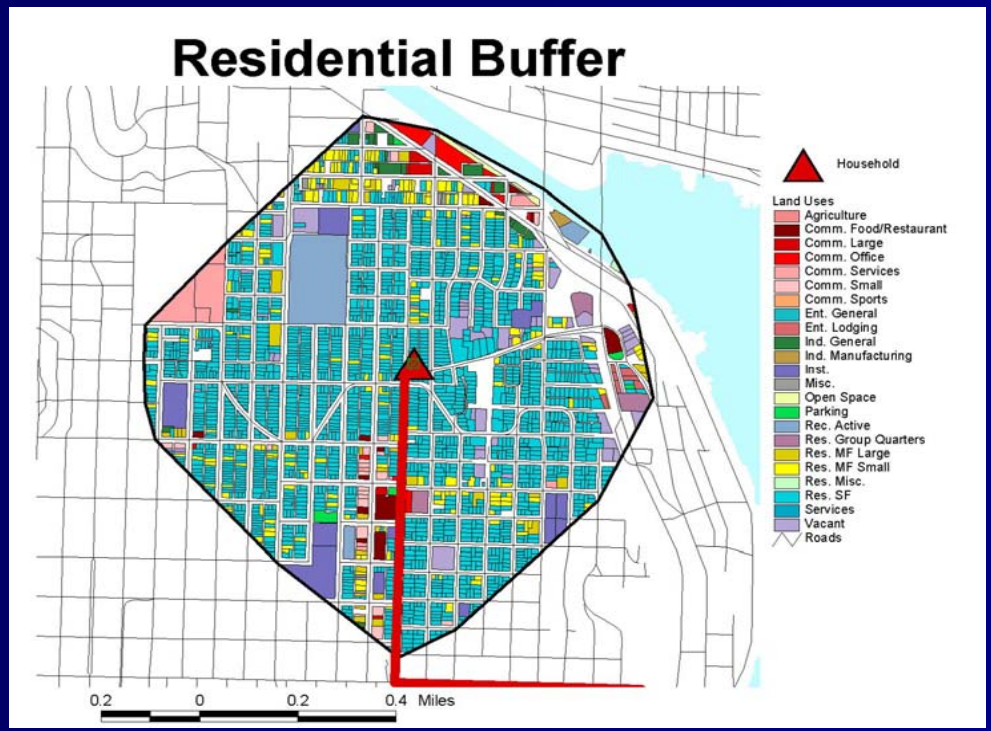


Land Use Triangle




Residential Buffer
Possible Trip Route
Employment Buffer
Land Uses
Agriculture
Comm. Food/Restaurant
Comm. Large
Comm. Office
Comm. Services
Comm. Small
Comm. Sports
Ent. General
Ent. Lodging
Ind. General
Ind. Manufacturing
Inst.
Misc.
Open Space
Parking
Rec. Active
Res. Group Quarters
Res. MF Large
Res. MF Small
Res. Misc.
Res. SF
Services
Vacant
Roads
N
W
E
S
0.9
0
0.9
1.8 Miles

Residential Buffer



	Square Footage	# of Land Uses	Land Area
Residential	4,306,770	2243	232.95 acres
Retail	18,849	33	0.27 acres
Entertainment	94,374	14	17.96 acres
Office	194,336	17	5.17 acres
Institutional	390,092	17	48.10 acres

The Choice to Walk

Larger Numbers = Stronger Relationship

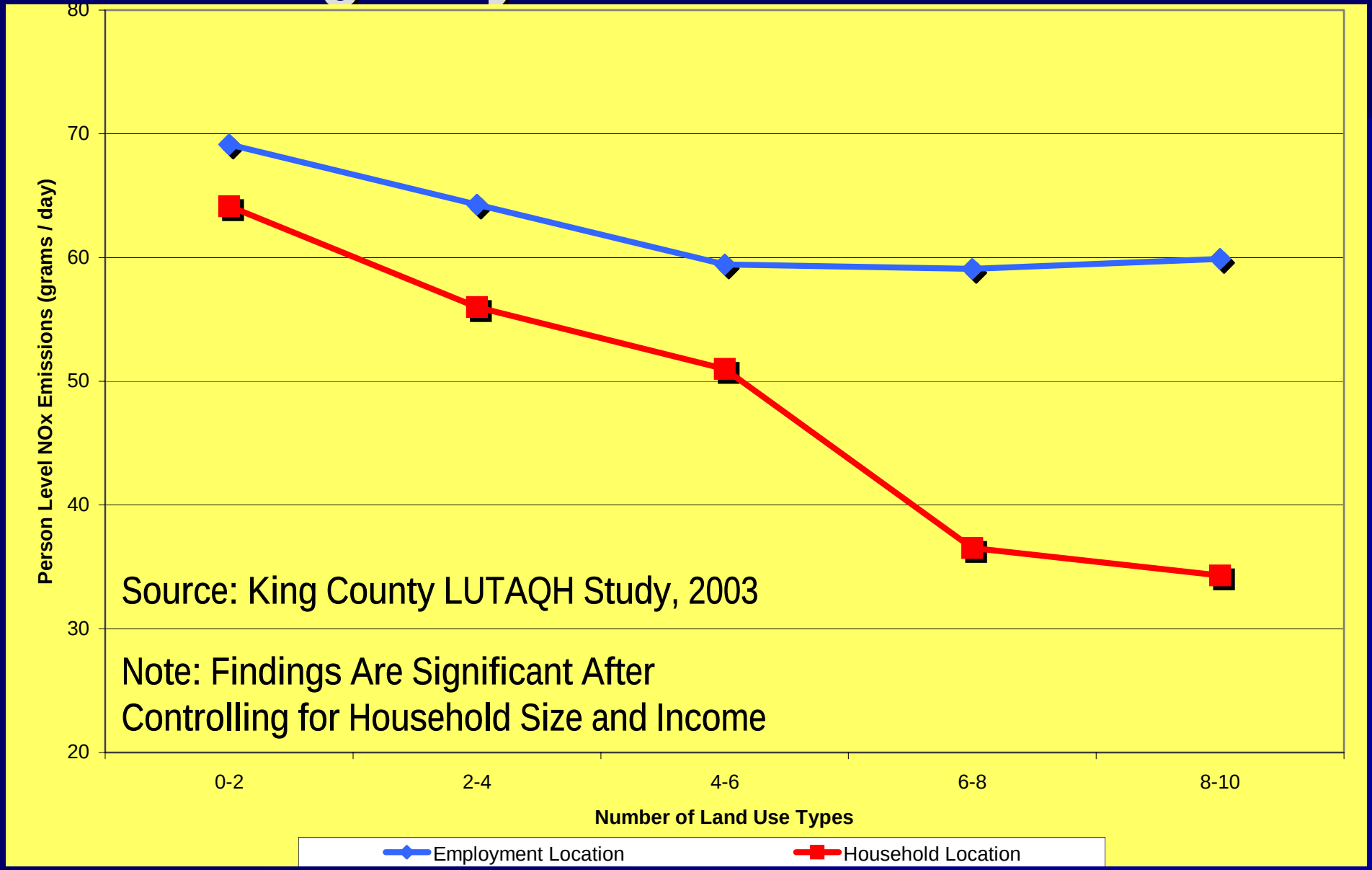
Correlations Between Land Use and % Household Walk Trips

(Controlling for Household Size and Income, Street Connectivity and Sidewalk Density)

Land Use Type	Number of Attractions	Rentable Building Area	Total Parcel Area
Civic	**0.2073 (P=0.000)**	0.1683 (P=0.000)	0.0806 (P=0.000)
Educational	**0.2594 (P=0.000)**	0.1427 (P=0.000)	0.1421 (P=0.000)
Retail - Neighborhood	**0.2965 (P=0.000)**	**0.2920 (P=0.000)**	0.1456 (P=0.000)
Restuarants and Taverns	**0.2757 (P=0.000)**	**0.2432 (P=0.000)**	0.1423 (P=0.000)
Office Buildings	**0.2557 (P=0.000)**	**0.2280 (P=0.000)**	0.1615 (P=0.000)
Grocery Stores	**0.2174 (P=0.000)**	0.1717 (P=0.000)	0.1194 (P=0.000)

Assessed at Place of Residence

Oxides of Nitrogen and Land Use Heterogenity at Home and Work

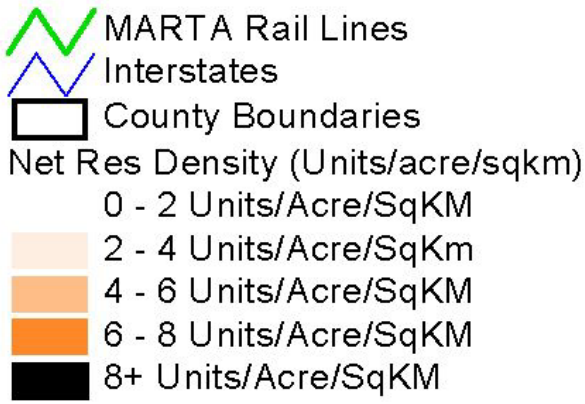


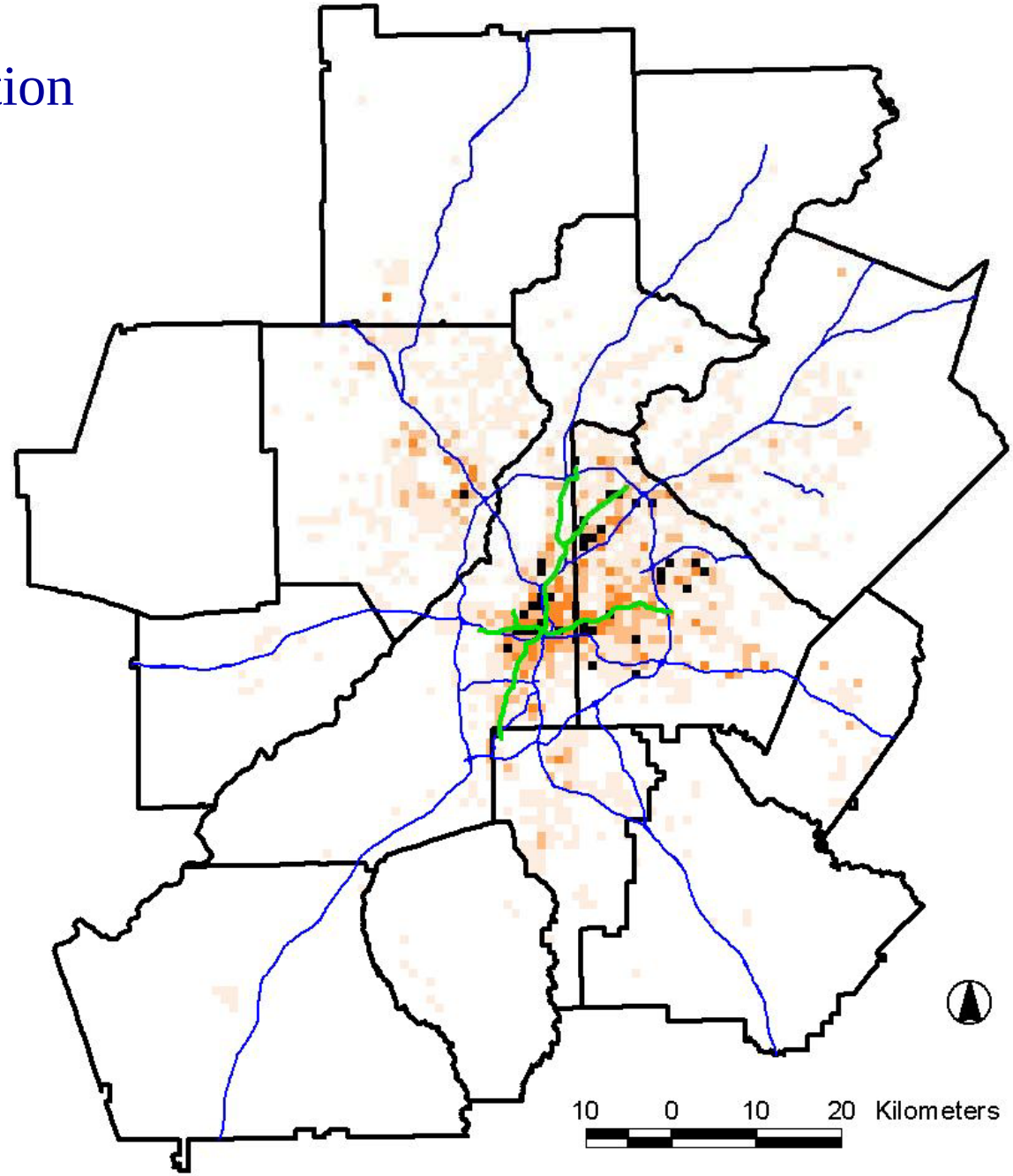
Net Residential Stratification

SMARTRAQ 2/8/2001
GT GIS Center

OPTION TWO:

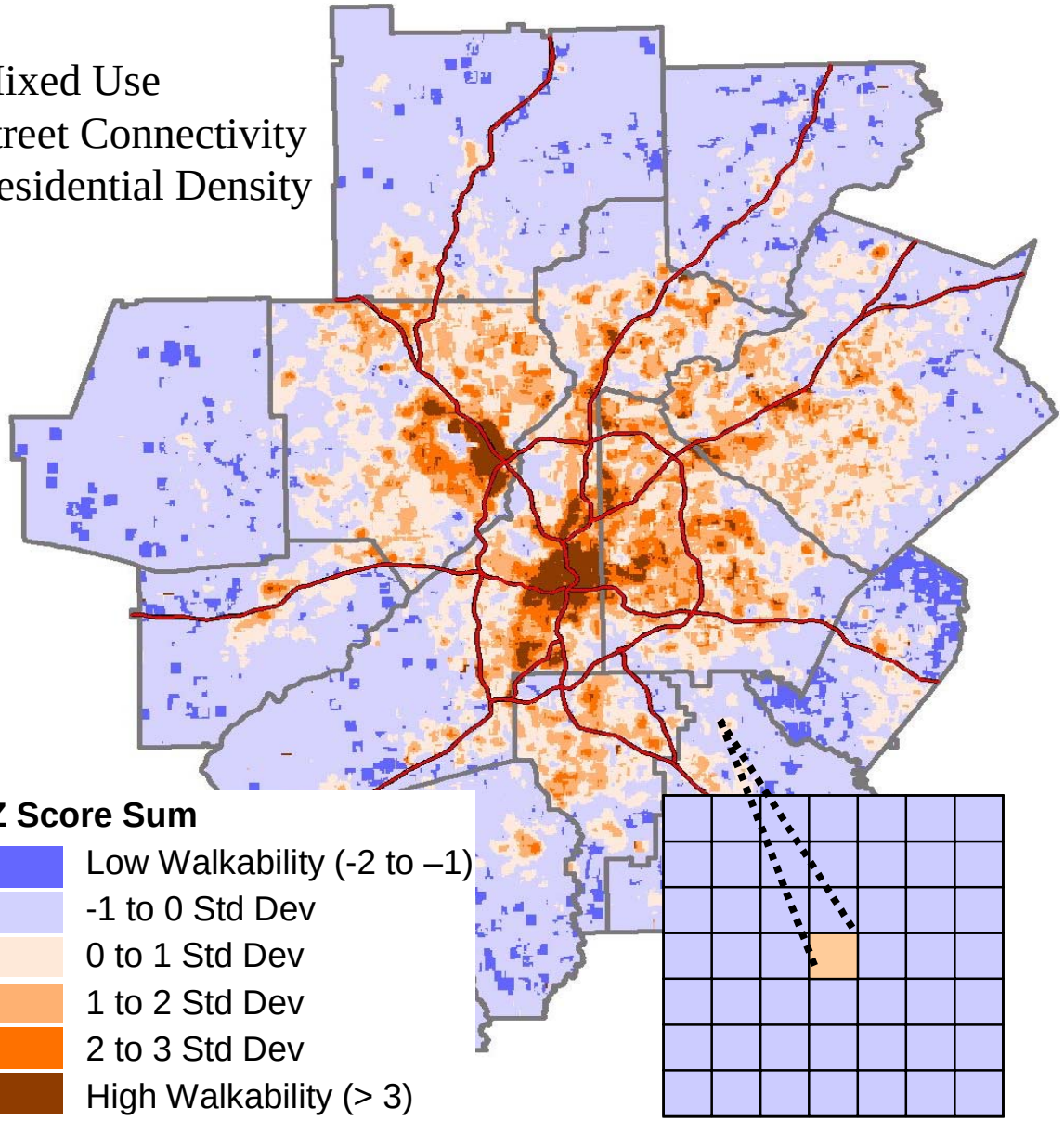
Units / Acre	Res. Units	Sq. KM
0-2	591552	9557
2-4	344500	920
4-6	110117	191
6-8	54589	68
8+	46319	43





200 Meter Walkability Surface

- Mixed Use
- Street Connectivity
- Residential Density
- (



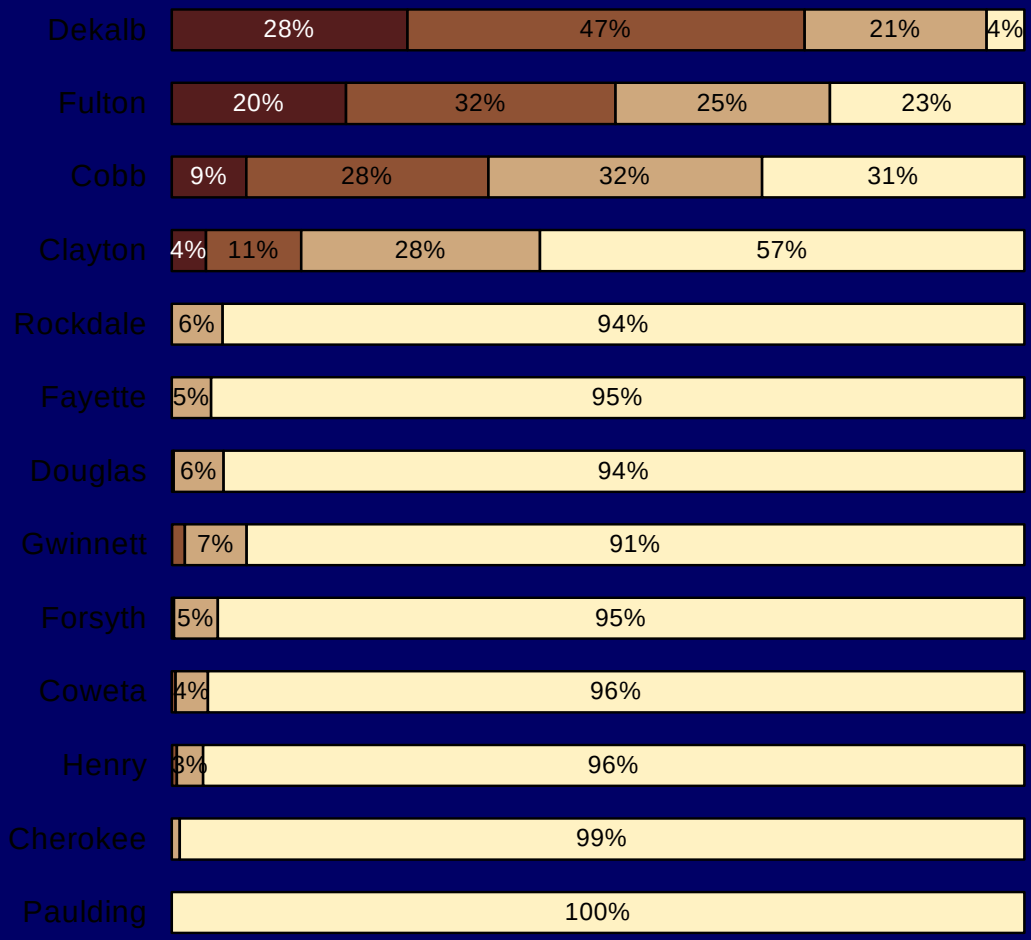
Built Environment

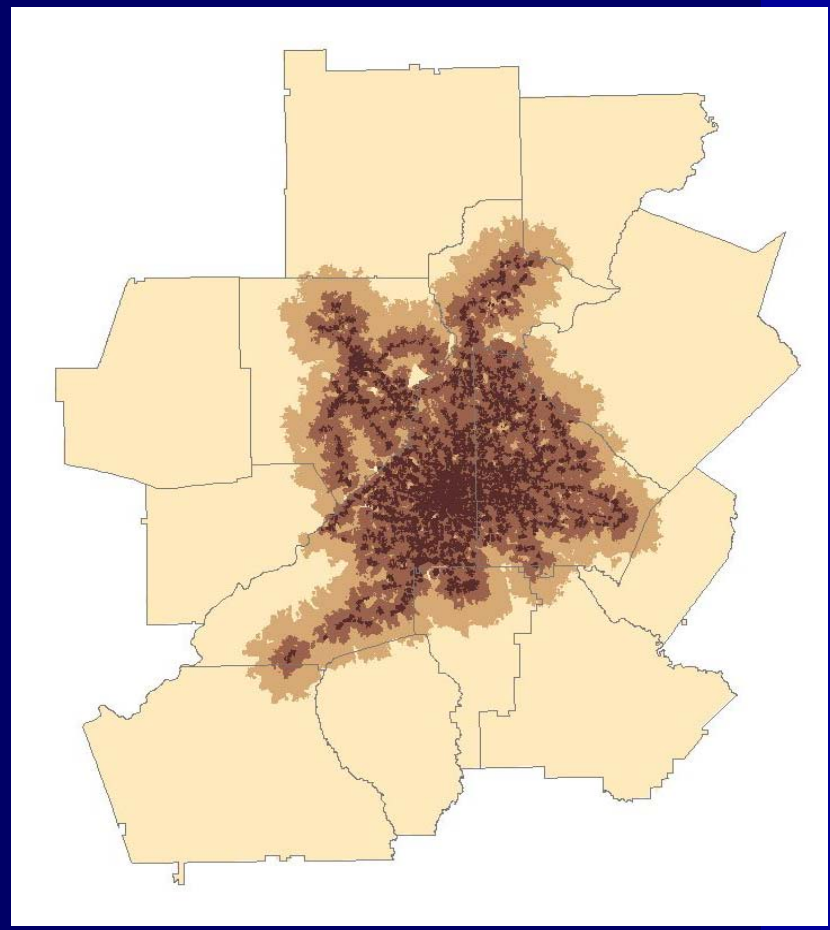
Goal: Improve Mobility, Accessibility and the Coordination of Land Use and Transportation Decisions (GRTA 2001 Annual Report)

Objective: Improve accessibility to jobs and essential activities and services
(GRTA 2001 Annual Report)

Measure: Transit Accessibility – Distance (Miles) to Transit Stop

Proportion of county within certain distance to transit

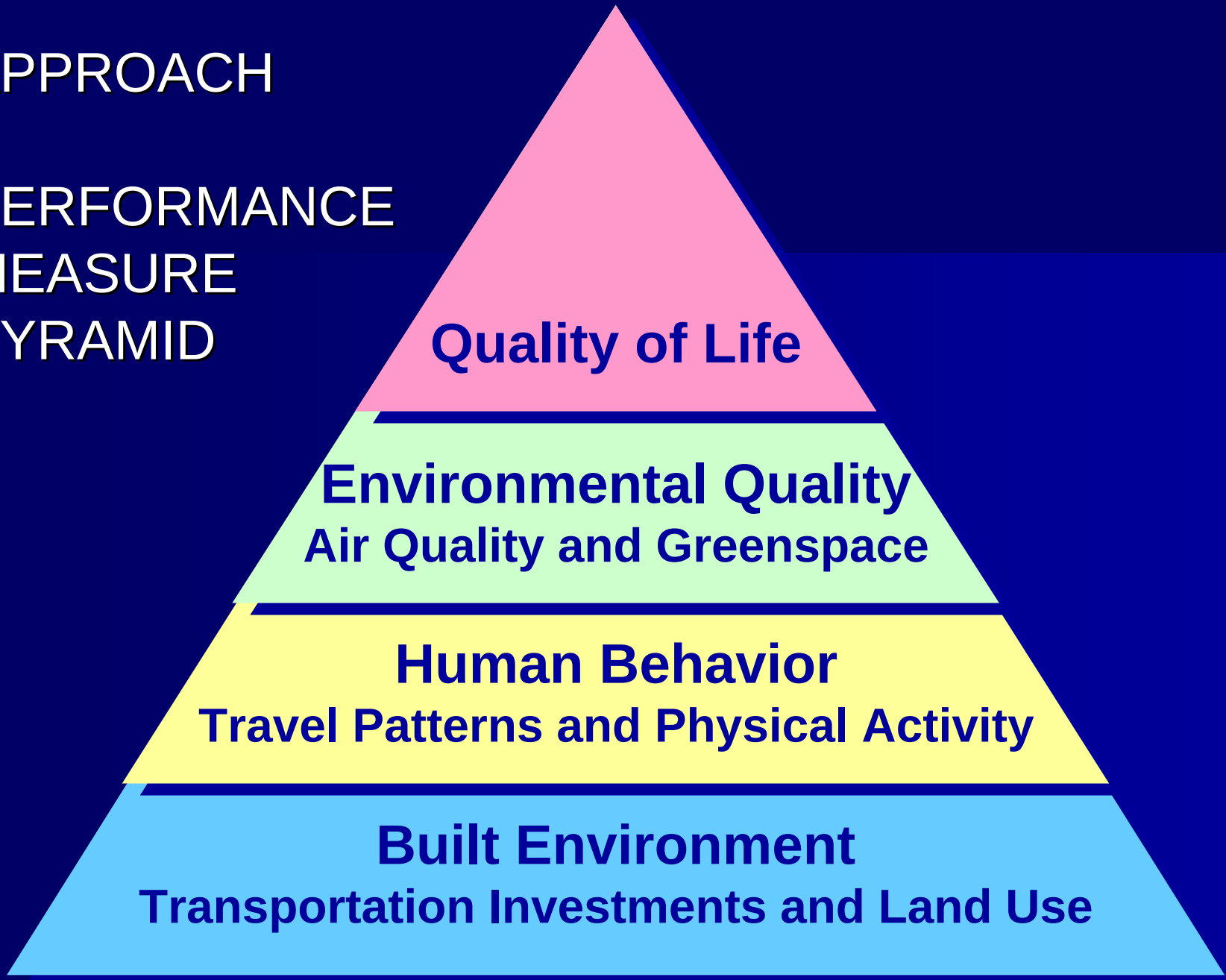




Source: SMARTRAQ, UBC Research Group

APPROACH

PERFORMANCE MEASURE PYRAMID



Neighborhood Quality of Life Study: Results from King County, Washington

James F. Sallis, Ph.D.
Brian E. Saelens, Ph.D.
Lawrence D. Frank, Ph.D.
Kelli L. Cain, M.A.
Terry L. Conway, Ph.D.
Lauren Leary, M.A.

Neighborhood Quality of Life Study: Results from King County, Washington

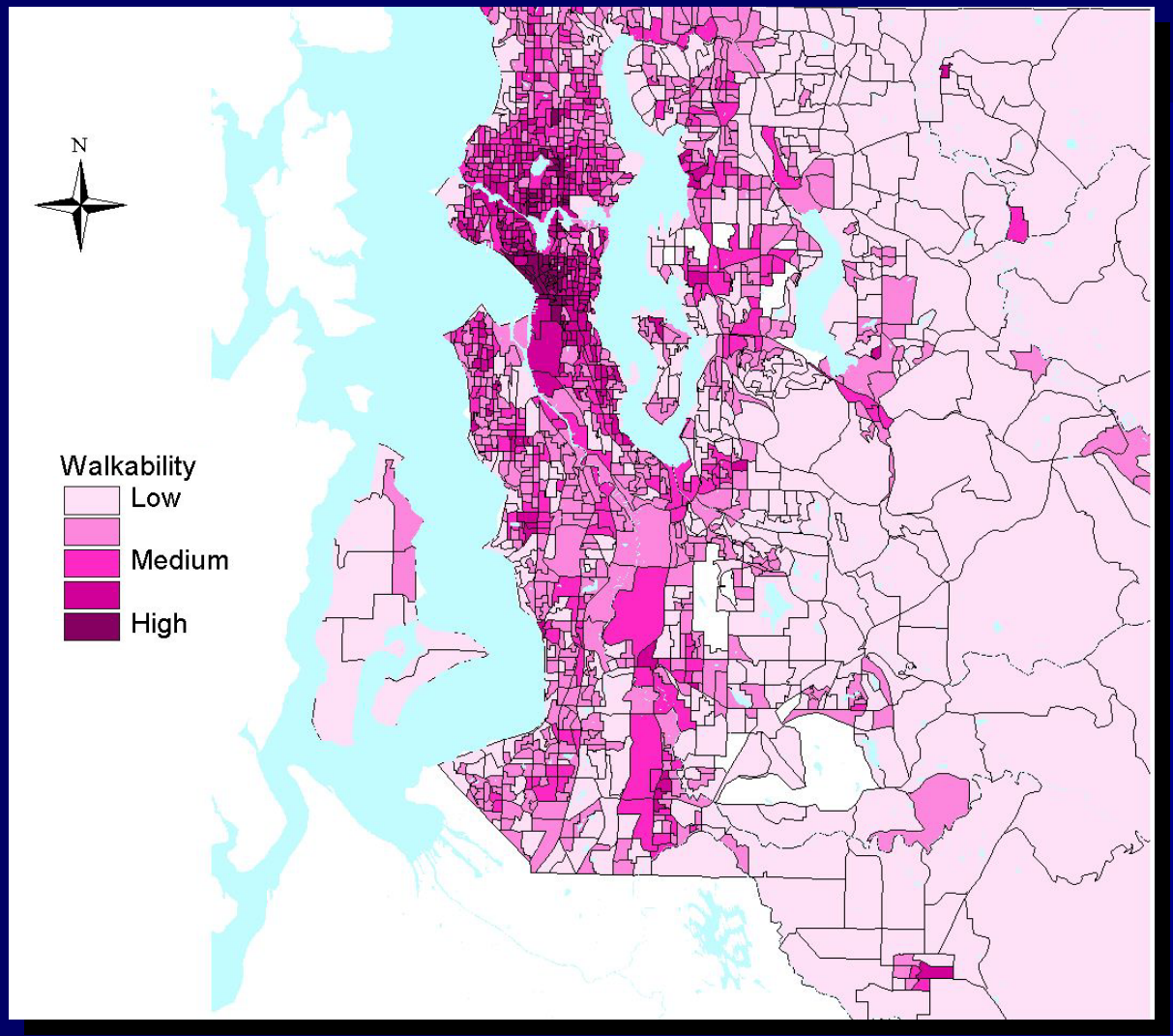
Primary Aim

- Investigate whether people who live in "walkable" communities are more active and less likely to be obese, after adjusting for SES, than people who live in less walkable communities.

"Walkability" means high density, high street connectivity, and mixed land use.

James Sallis, Ph.D. (PI), Lawrence Frank, Ph.D. (CO-PI) Brian Saelens, Ph.D. (CO-PI) Kelli L. Cain, M.A., Terry L. Conway, Ph.D. Lauren Leary, M.A.

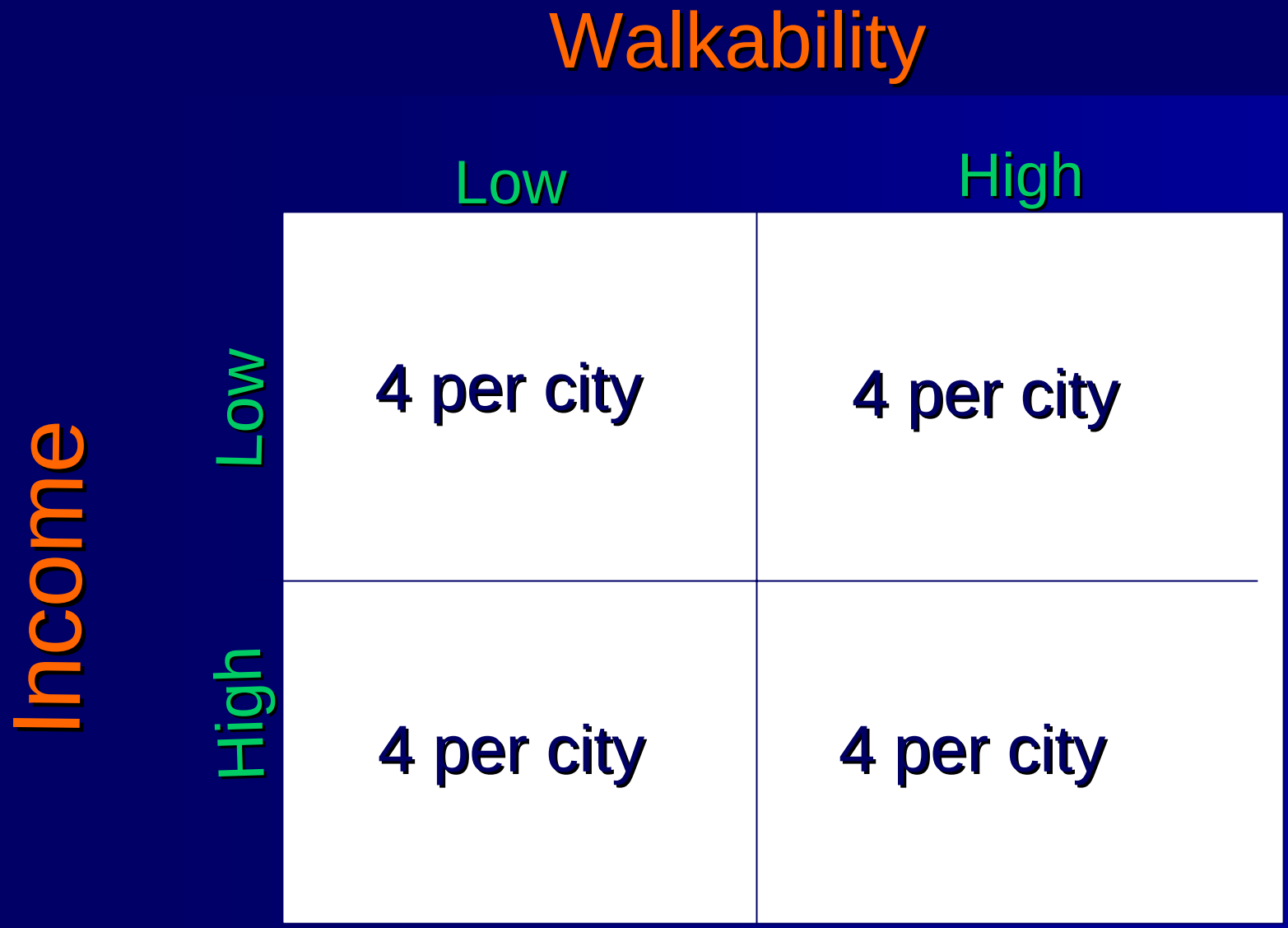
Walkability



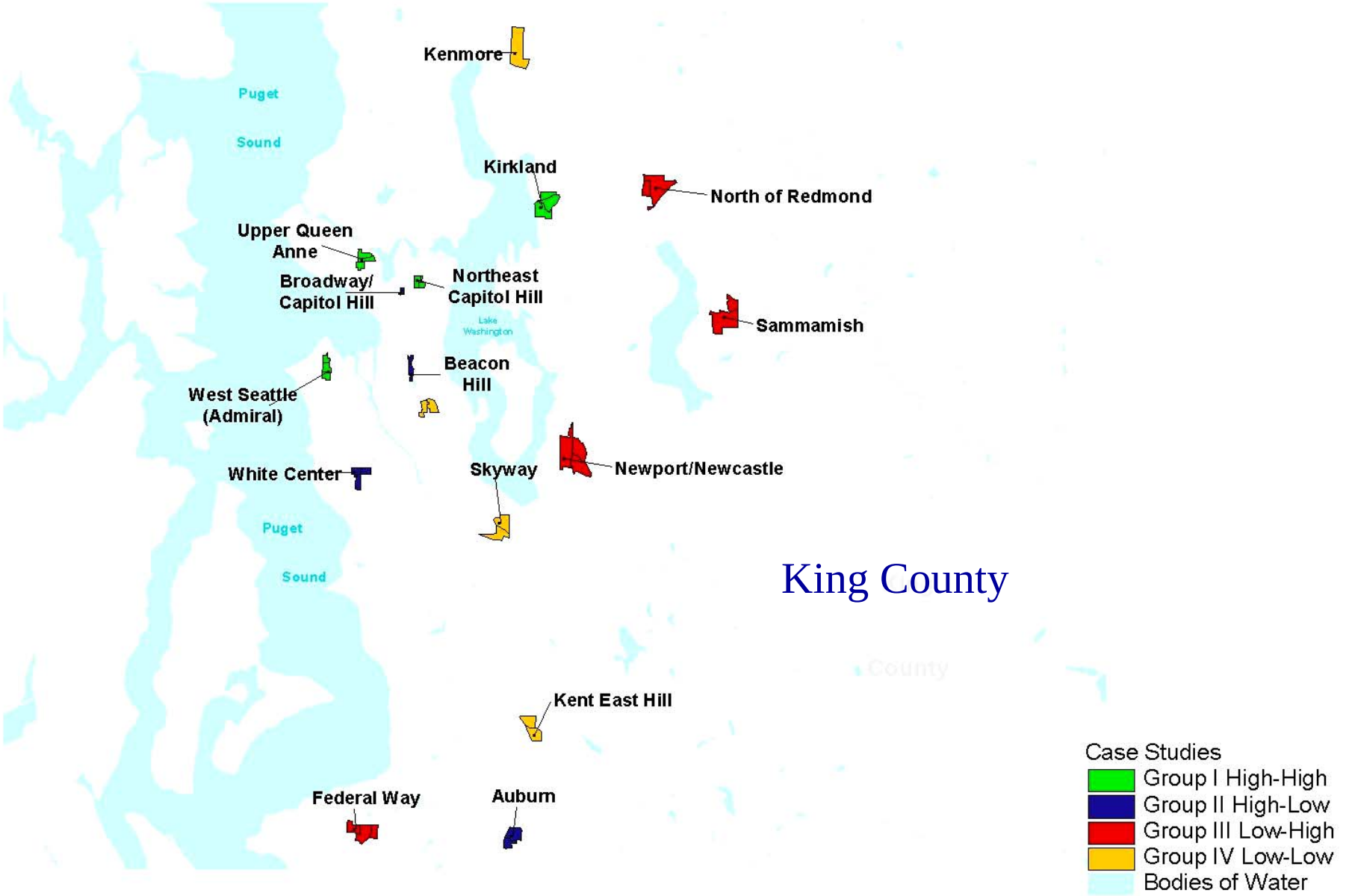
- Mixed Use
- Density
- Street Connectivity
- Amount of Retail

Census Block Groups

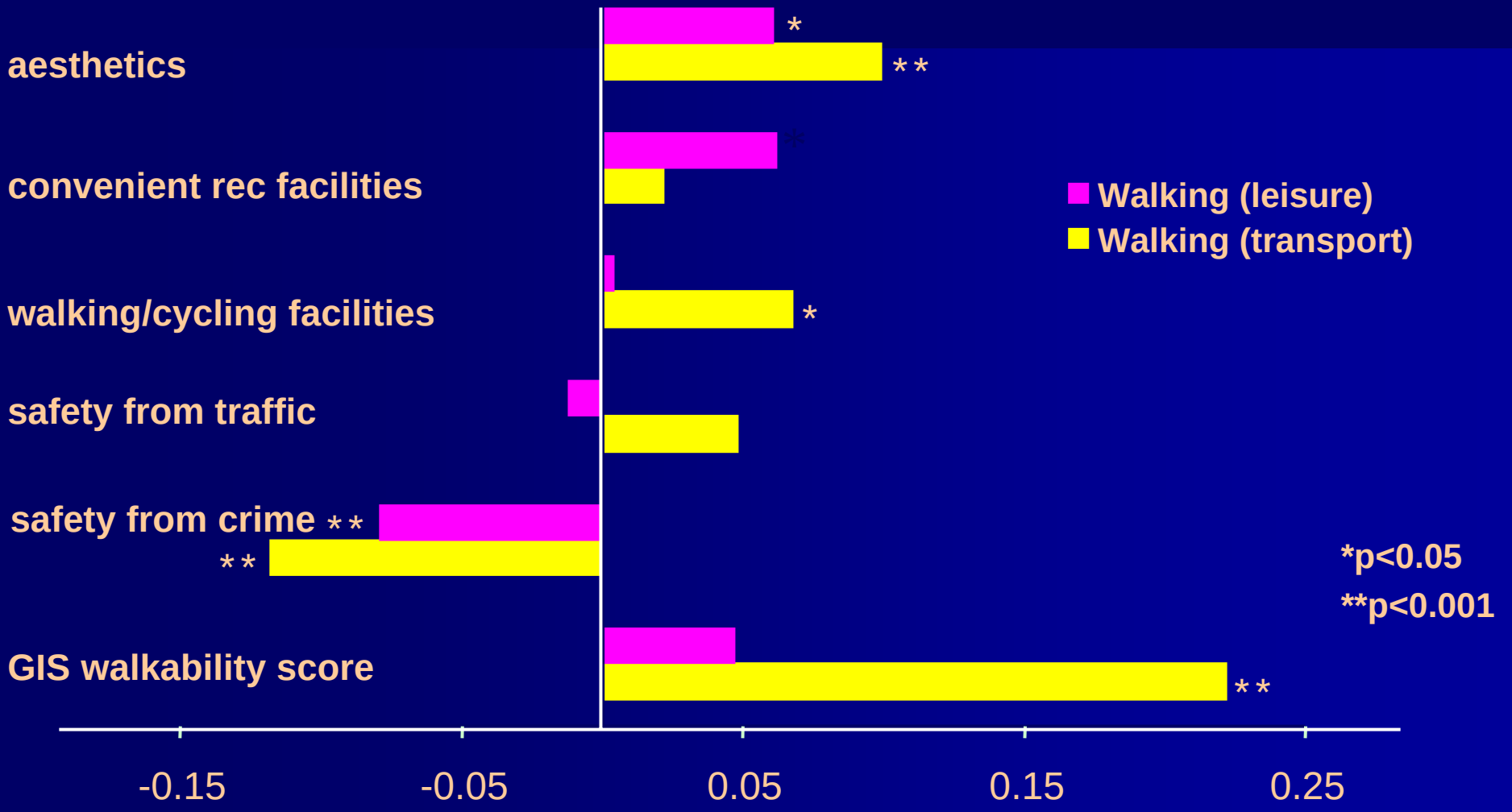
NQLS Neighborhood Categories



NIH/NQLS Case Studies

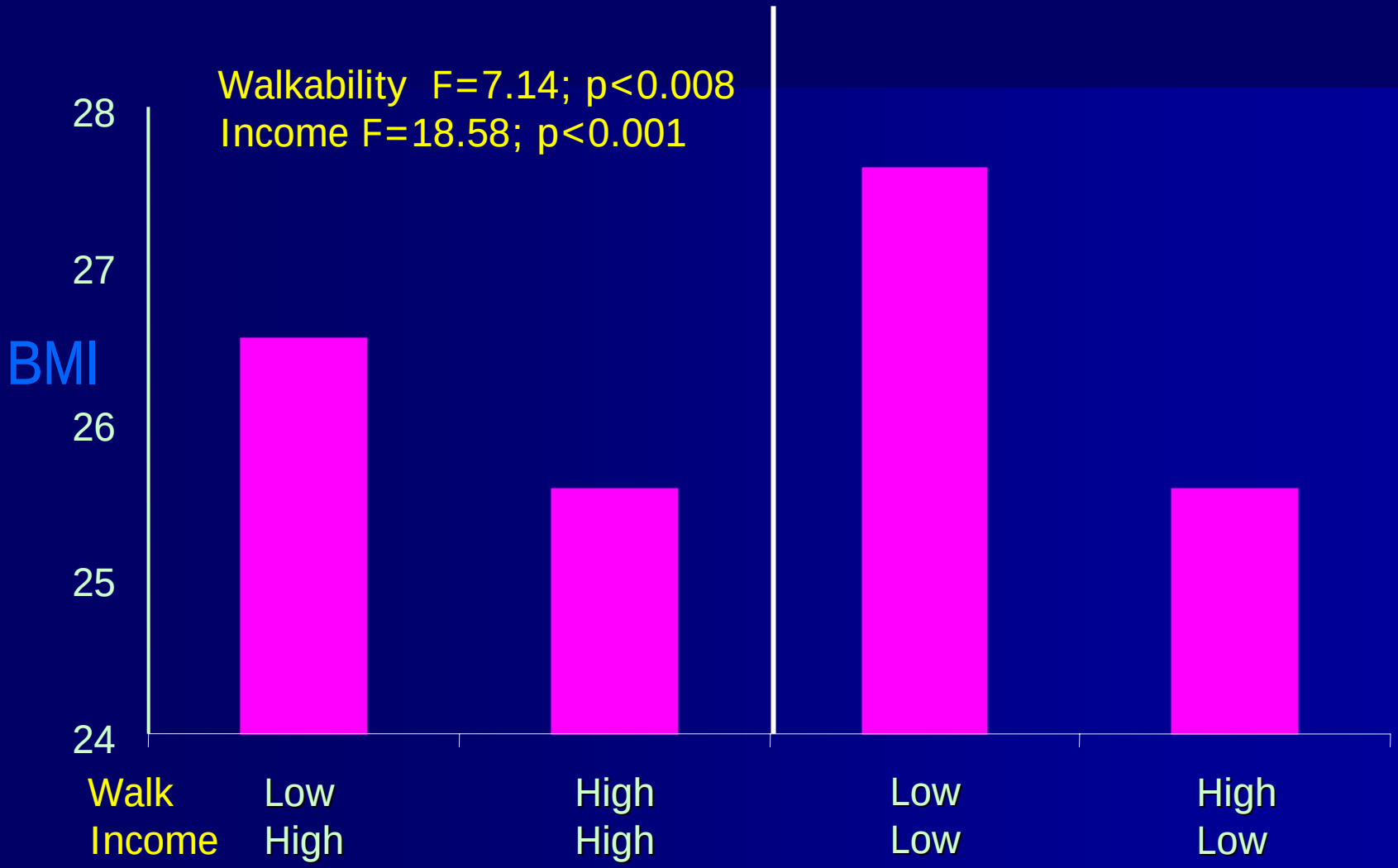


Environmental variables and PA



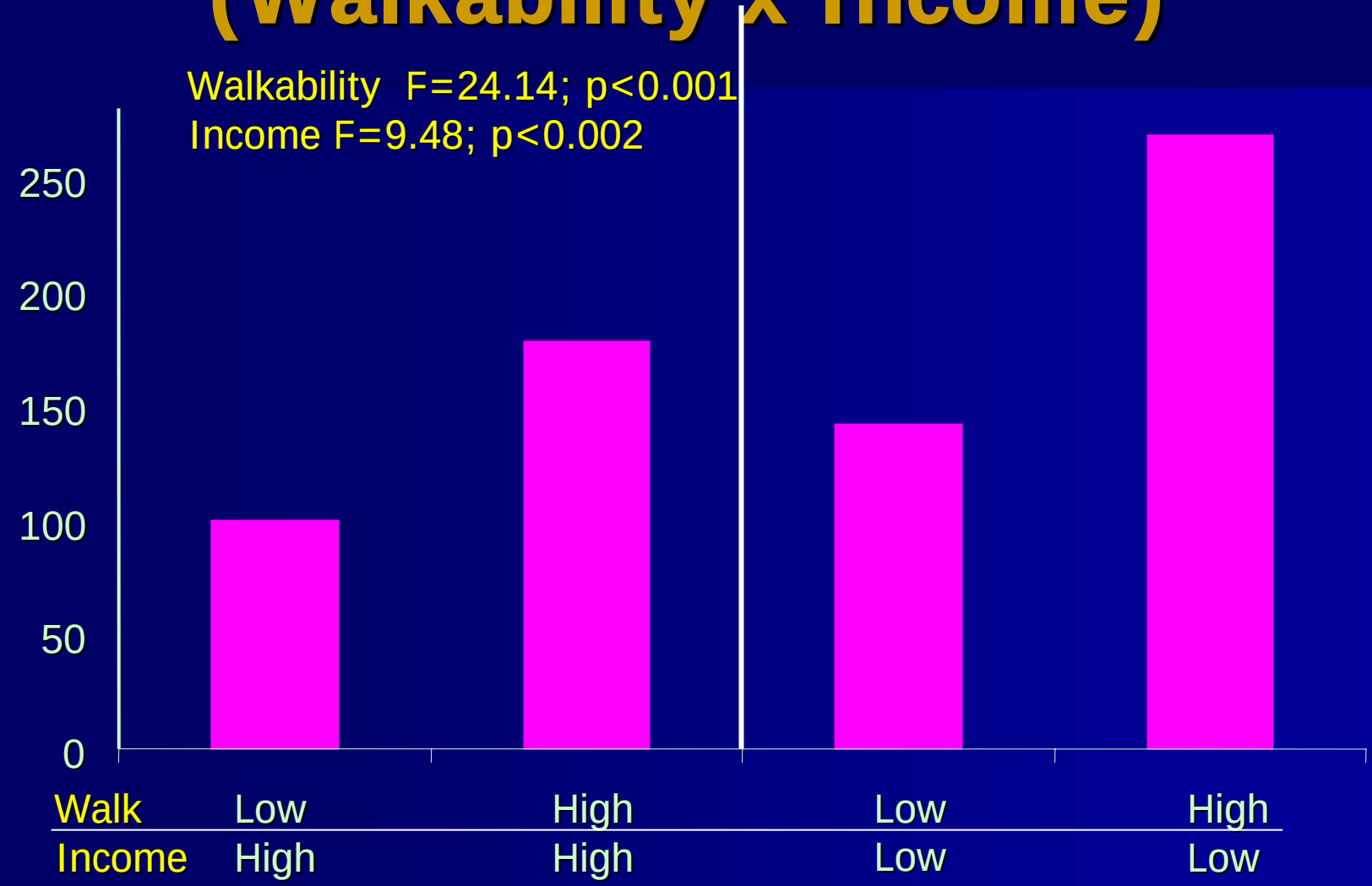
NQLS

Body Mass Index (BMI) (Walkability x Income)



NQLS

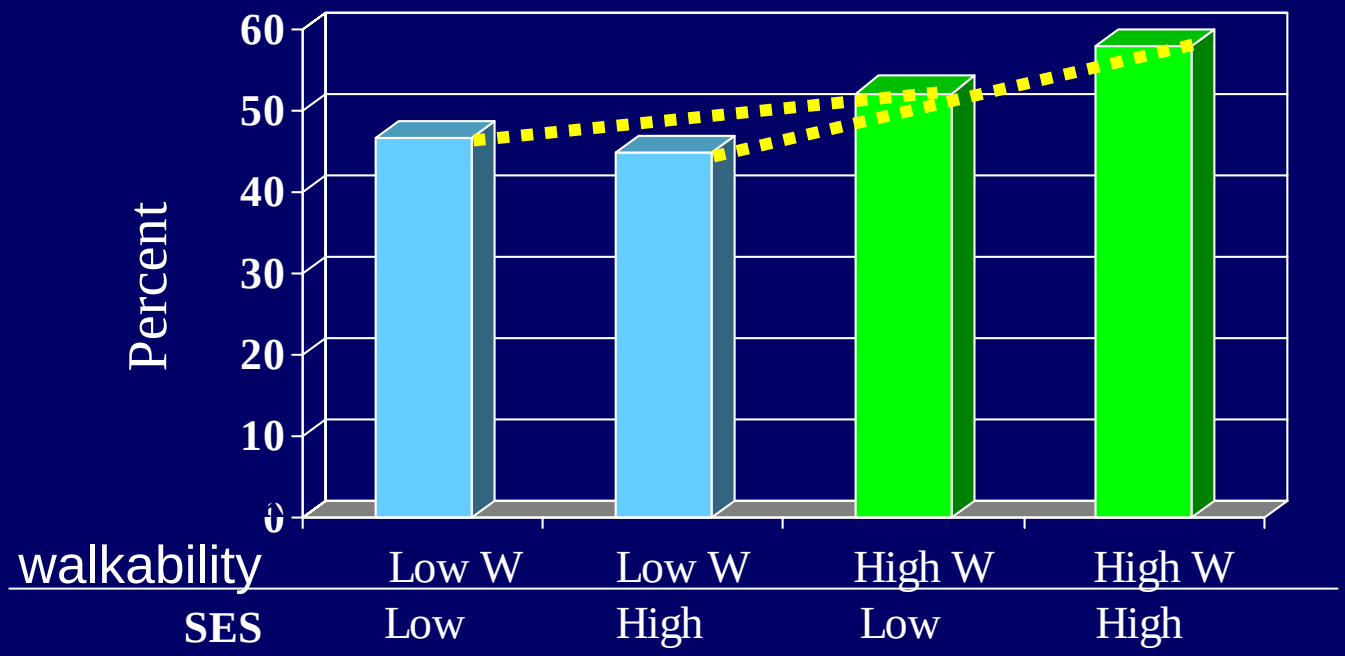
Walking for Transportation (min/week) (Walkability x Income)



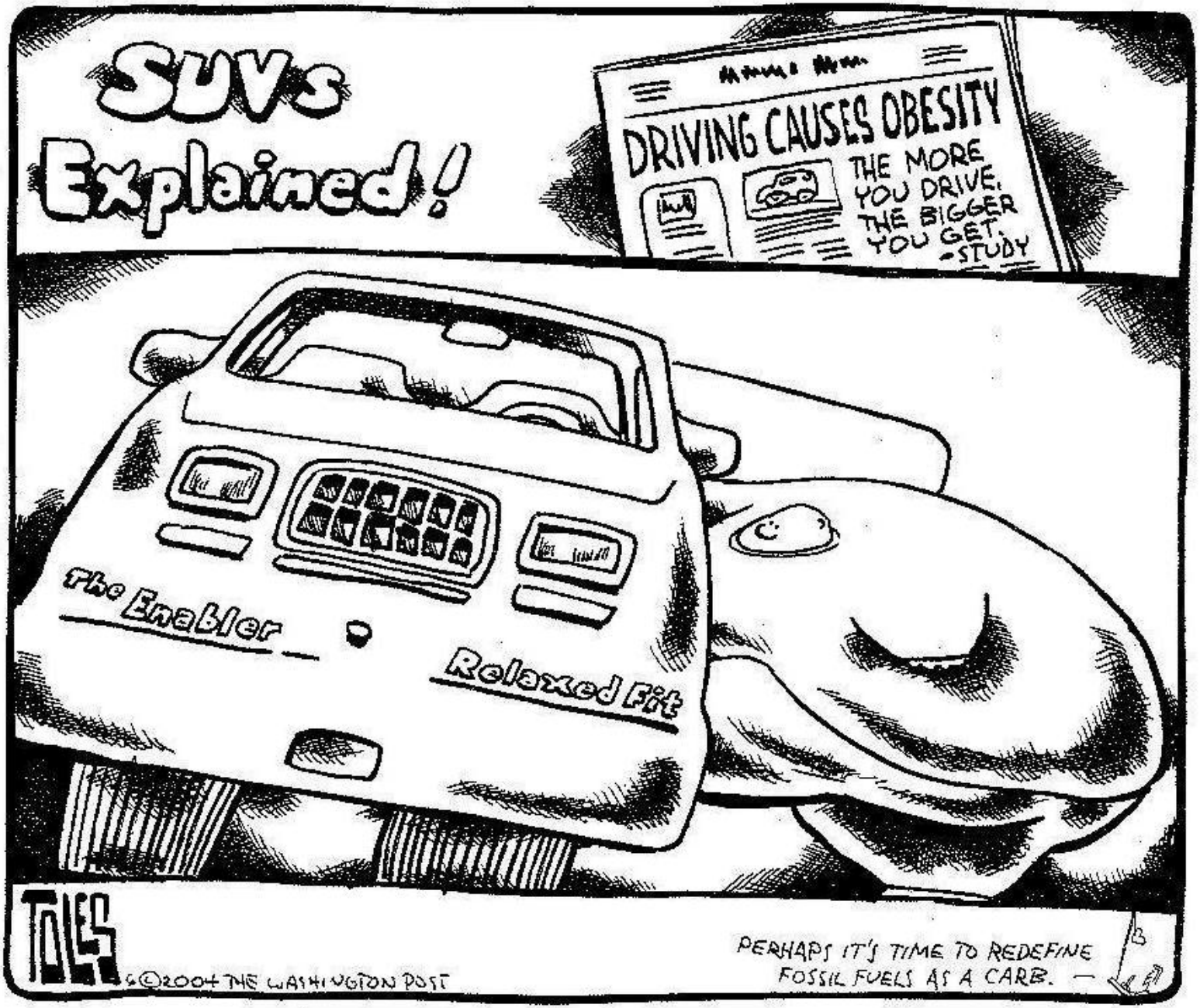
OBJECTIVELY MEASURED PHYSICAL ACTIVITY

% meeting 30 min per day guideline of moderate + vigorous

Walkability: F=4.71 *p=.030* *
Income: F=1.1 *p=.295*
Walkability x Income: F=3.18 *p=.075*



Adjusted for age and sex; * $p < .05$


SUVs Explained!
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THE MORE YOU DRIVE, THE BIGGER YOU GET. -STUDY
The Enabler
Relaxed Fit
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