The European Colloquium on Theoretical and Quantitative Geography
7-11 September 2017
York, UK

Built Environment and Health in the Age of Big Data

Anne Vernez Moudon, Dr es Sc
Urban Form Lab
University of Washington, Seattle, WA, USA
http://depts.washington.edu/ufl/

Presentation

1. City and transport planning can/should support better health
   - obesity and energy balance
2. Behavior- built environment: data and research
3. BE's influences behavior through walkability: Causal path to obesity
4. Exposure to BE: Theory and measures
   - Example of FFRs
5. Spatial modeling of BE and walking/transit use behavior

The Lancet Series September 2016

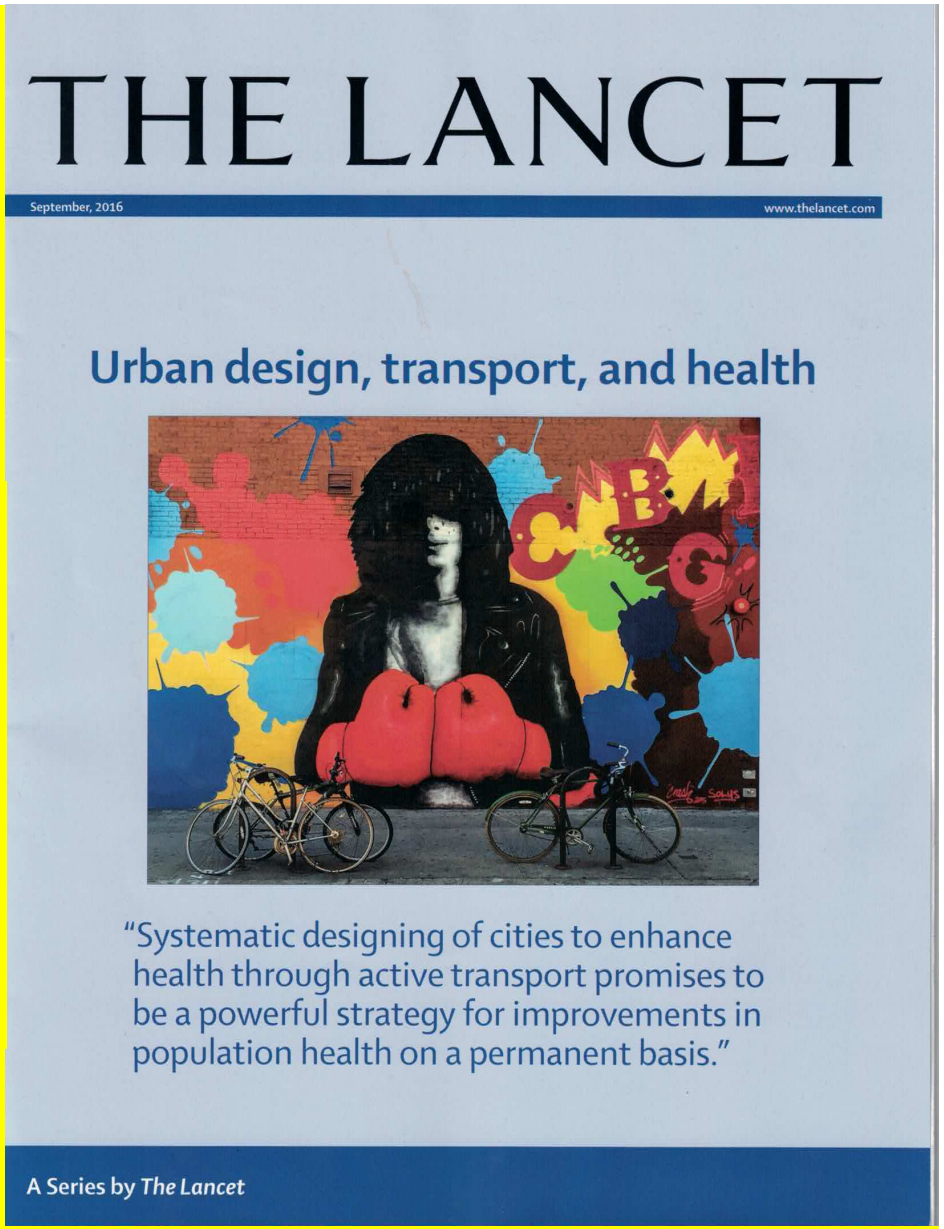
HOW CITY DESIGN AND TRANSPORT PLANNING CAN IMPROVE HEALTH

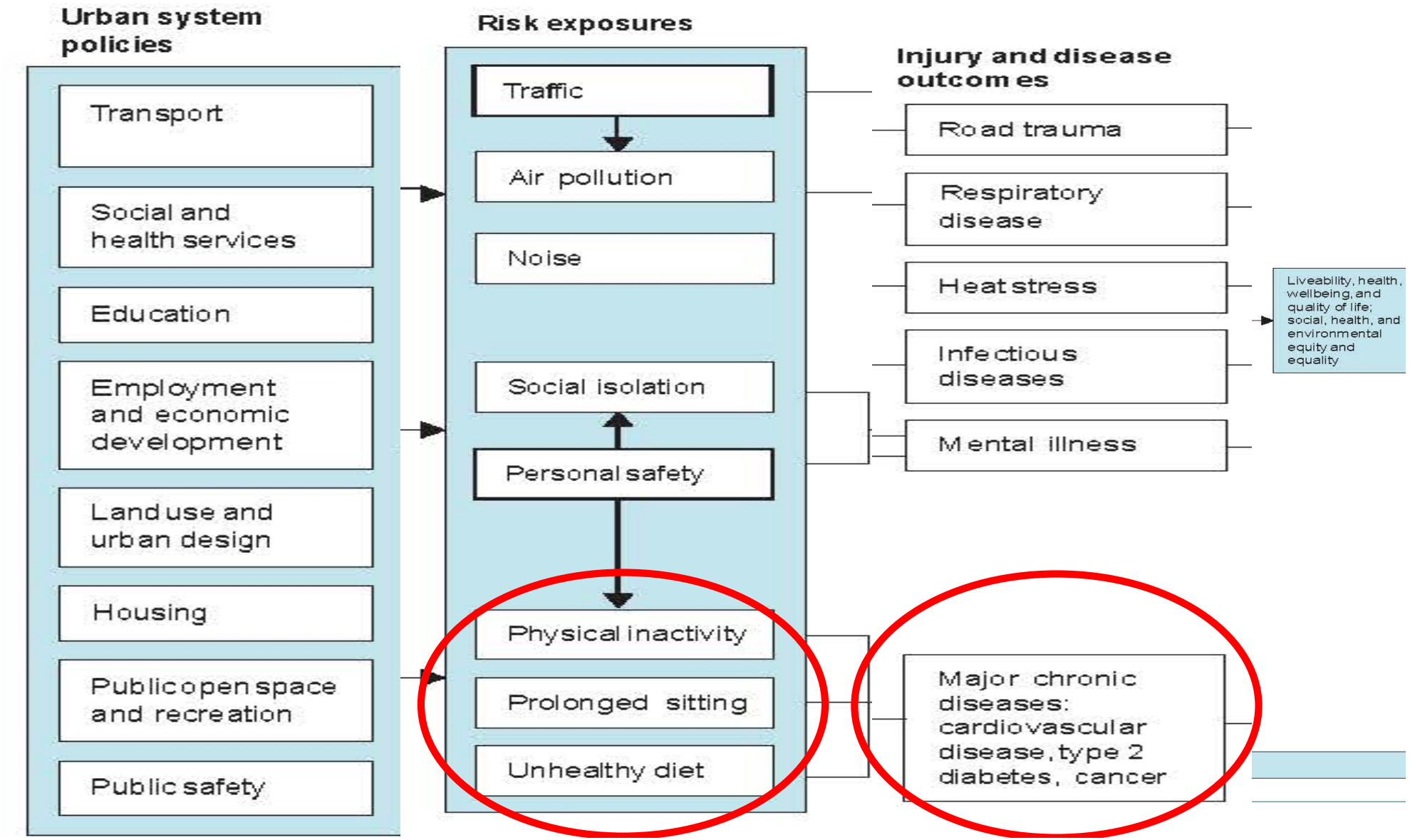
City planning can help reduce air pollution, road trauma, non-communicable diseases (cardiovascular disease and diabetes), and physical inactivity.

For better health, cities need to

- incentivize a shift from private car use to cycling and walking
- adopt a compact city model where distances to shops and facilities, including public transport, are shorter and within walking distance.

http://www.thelancet.com/series/urban-design




Urban system policies
Transport
Social and health services
Education
Employment and economic development
Land use and urban design
Housing
Public open space and recreation
Public safety
Risk exposures
Traffic
Air pollution
Noise
Social isolation
Personal safety
Physical inactivity
Prolonged sitting
Unhealthy diet
Injury and disease outcomes
Road trauma
Respiratory disease
Heat stress
Infectious diseases
Mental illness
Major chronic diseases: cardiovascular disease, type 2 diabetes, cancer
Liveability, health, wellbeing, and quality of life; social, health, and environmental equity and equality

Behavior – built environment

Data and research

Behavior data collection: Four instruments

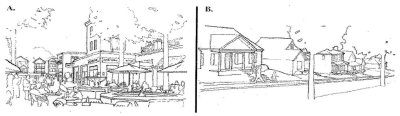
Data 7 days/ 3 times in 5 years

GPS **Accelerometer**

TRAC Survey 1

J. Neighborhood Preference

We'd like you to imagine moving to a different neighborhood. We'd like you to think about the kind of neighborhood you'd hope to find. Please read the following neighborhood descriptions, then circle the appropriate number to indicate your preference. *Keep in mind that anything that we do not refer to in a question - such as school quality, public safety, or house cost - is exactly the same between the two choices presented.*



If I were to move, I'd like to find a neighborhood ...

A. that is a lively and active place, even if this means it has a mixture of single family houses, townhouses, and small apartment buildings that are close together on various sized lots.

Or

B. with single family houses farther apart on lots 1/2 acre or more, even if this means that it is not an especially lively or active place.

Your neighborhood preference is:

1. 0 1 2 3 4 5 6 7 8 9 10 (value (1-11))

strongly prefer **A** | somewhat prefer **A** | neutral | somewhat prefer **B** | strongly prefer **B**

If I were to move, I'd like to find a neighborhood . . .

A. where I can walk to stores, libraries or restaurants, even if this means that the houses and commercial areas are within a few blocks (1/3 mile) of each other.

Or

B. where the commercial areas are kept separate (over a mile; 10 blocks or more) from the houses, even if this means that I can't walk to stores, libraries or restaurants.

Your neighborhood preference is (circle one number):

2. 0 1 2 3 4 5 6 7 8 9 10 (value (1-11))

strongly prefer **A** | somewhat prefer **A** | neutral | somewhat prefer **B** | strongly prefer **B**

Survey

Example: ☐ Mon ☐ Tues ☐ Wed ☒ Thurs ☐ Fri ☐ Sat ☐ Sun Date 6/5/08

Time you put the meter & GPS on: 7:34 (am) pm

Start of Day ☒ Home ☐ Work ☐ Other: ☐ School	Place Name: Home					Activity Code: 1		
	Number or Nearest Intersection	Street	City	Zip	Time Left: 8:15 (am)/pm			
Place #1 ☐ Home ☐ Work ☒ School ☐ Other:	Place Name: School					Activity Code: 3	Travel Mode: 8 ▶	If '1' or '2', # of people in vehicle:
Time Arrived: 9:06 (am)/pm	Number or Nearest Intersection	Street	City	Zip	Time Left: 3:05 am/(pm)			
Place #2 ☐ Home ☐ Work ☐ School ☐ Other:	Place Name: Trader Joes 4555 Roosevelt Way NE Seattle, 98105					Activity Code: 3	Travel Mode: 12 ▶	If '1' or '2', # of people in vehicle:
Time Arrived: 3:23 am/(pm)	Number or Nearest Intersection	Street	City	Zip	Time Left: 3:48 am/(pm)			
Place #3 ☒ Home ☐ Work ☐ School ☐ Other:	Place Name: Home					Activity Code: 3	Travel Mode: 4 ▶	If '1' or '2', # of people in vehicle:
Time Arrived: 4:15 am/(pm)	Number or Nearest Intersection	Street	City	Zip	Time Left: 7:15 am/(pm)			
Place #4 ☐ Home ☐ Work ☐ School ☐ Other:	Place Name: Tour					Activity Code: 13	Travel Mode: 100 ▶	If '1' or '2', # of people in vehicle:
Time Arrived: 7:15 am/(pm)	Number or Nearest Intersection	Street	City	Zip	Time Left: 8:00 am/(pm)			

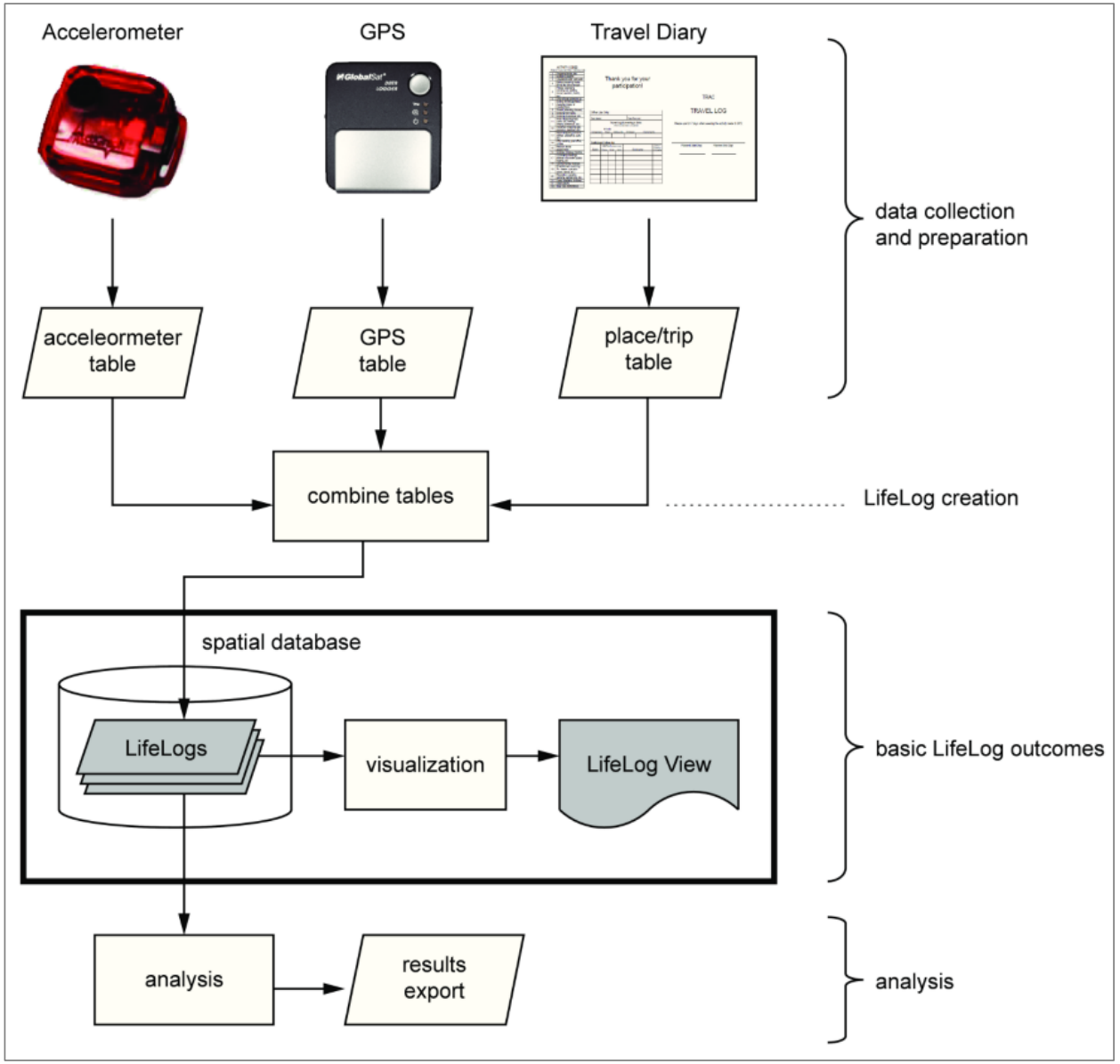
Time you took the meter & GPS off: 11:00 am/(pm)	**BE SURE TO PLUG IN YOUR GPS TO CHARGE!!!**		
Time removed meter or GPS and reason:	8:15-8:30 pm Shower		

Travel Log

Behavior data integration

- Collation of multiple data streams into single “LiifeLog” table containing all source data
- Data joined by common time stamps across table types

Hurvitz *et al.*, 2014



LIFELOG “Big Data” on activity and mobility patterns

- Number of records per subject per week
  - GPS: ~33,000 x, y points
  - Accelerometry: ~51,000 count measures
  - Travel diary: ~43 places and trips

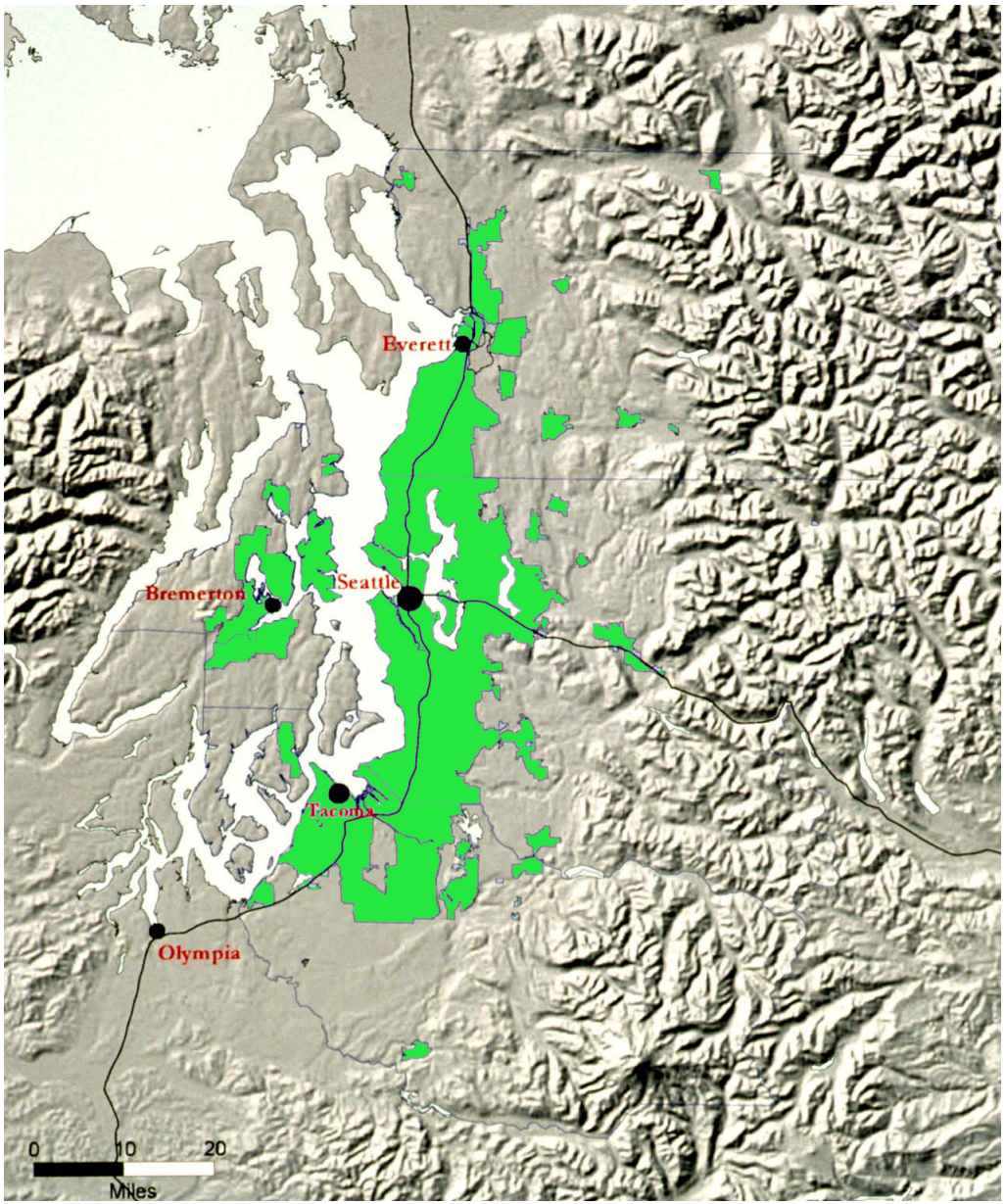
Built environment data

Spatial Extent and data unit

Puget Sound Region

1,000 mi^2 (2500 $km^{2)}$

1,200,000 parcels



Built environment data

by domain and variable of interest

Domains	Variables*	Number of discrete observations in King Co
Neighborhood environment	residential units (houses, apartments, condos, mobile homes)	489k parcels
	employment/jobs	21k parcels
	residential wealth (property values)	489k parcels
	vacant lands	51k parcels
Routine destinations	food facilities	1,500 food stores 6,500 restaurants
	physical activity and fitness facilities	880 parcels
	retail services	5652 parcels
	schools and educational facilities	737 parcels
	offices	4393 parcels
	medical offices	769 parcels
	public services (libraries, etc)	
	open space and parks	1541 parks
	facilities in parks	103 types of facilities per park

* measures typically include counts, densities, and distances between features of interest. Both airline and network measures are calculated; UFL = data already has been collected by the UW Urban Form Lab

Built environment data

by domain and variable of interest

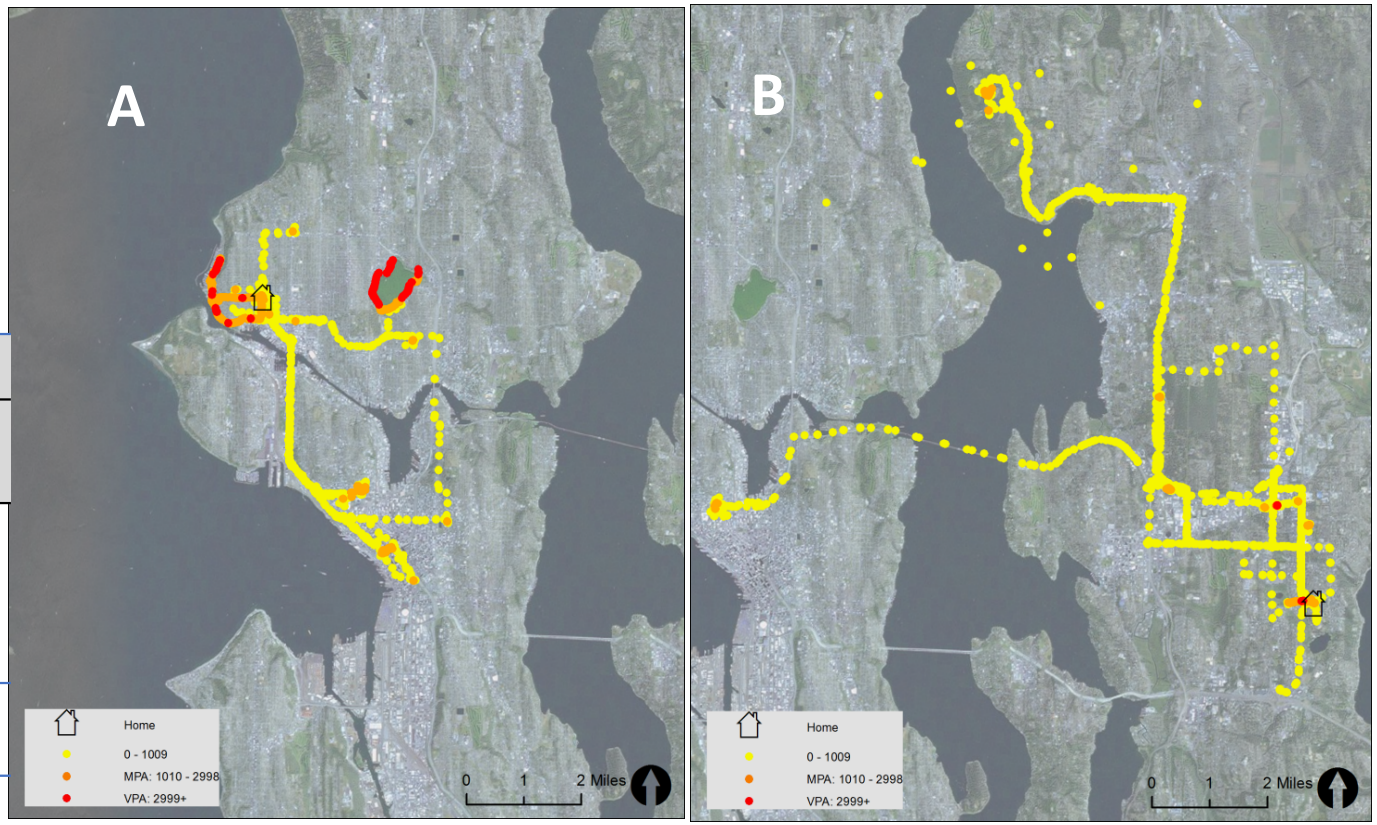
Domains	Variables*	Number of discrete observations in King Co
Transportation infrastructure	street (freeways and expressways, arterials, collector and local streets)	14k linear miles
	intersection density	64k intersections
	trails	829 linear miles
	sidewalks	1708 linear miles
	traffic signals	2000 signals
	parking	2.3 million stalls
	passenger rail stations	17 stations
	bus stops	8635 stops
Traffic conditions	vehicular volumes	86 million daily vehicle-miles
	bus ridership	364k daily trips
	pedestrian/bike collisions	1150 annual collisions

* measures typically include counts, densities, and distances between features of interest. Both airline and network measures are calculated; UFL = data already has been collected by the UW Urban Form Lab

Behavior – built environment data

GPS + accelerometer monitoring
7 consecutive days

Minutes per day	A		B	
	Accelero-meter	GPS	Accelero-meter	GPS
Total observed	1234	262	1260	741
Total MPA	38	14	24	16
Total VPA	5	4	2	2
Total driving (travel diary)	27		70	



From Troiano et al.(2008). Physical activity in the United States measured by accelerometer. Med & Sci in Sports & Exercise. MPA : accelerometer count >= 1010 per 30-sec epoch; VPA: accelerometer count >= 2999 per 30-sec epoch

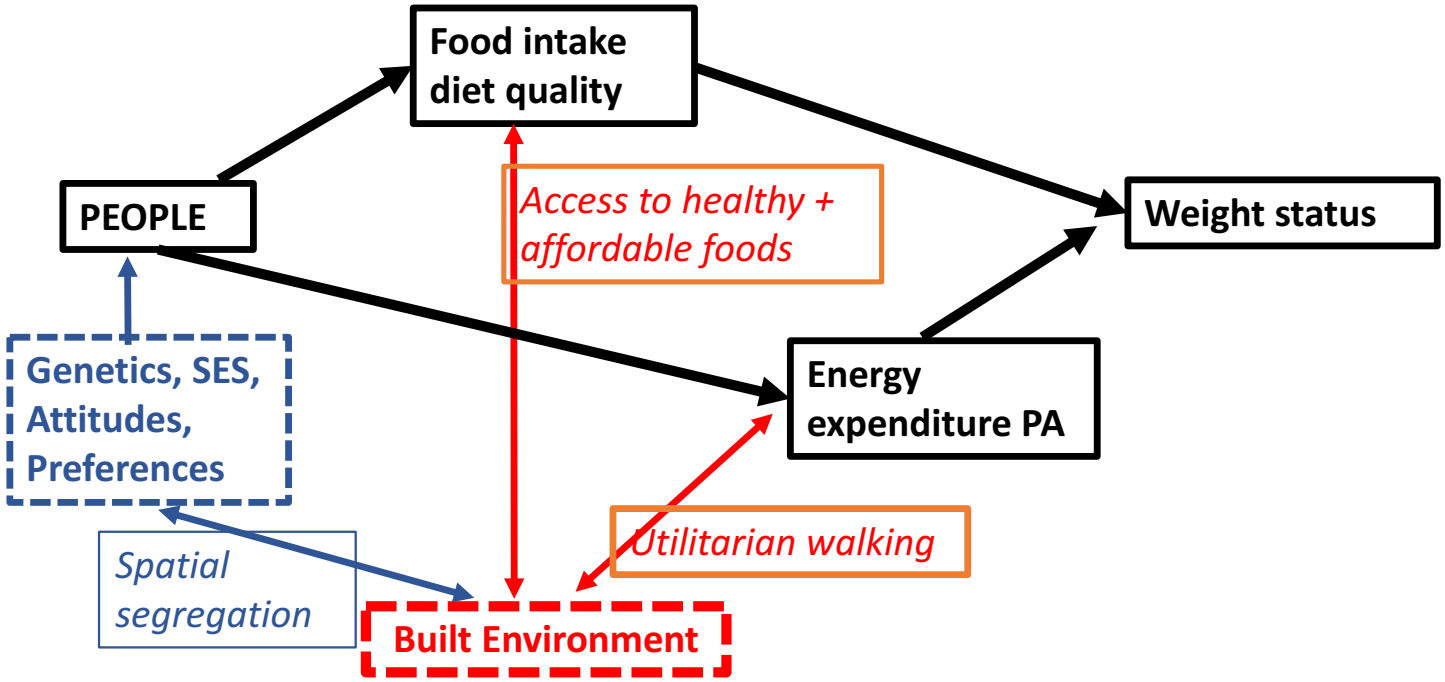
Energy intake

Energy expenditure

Built environment influence on behavior

Causal paths to energy balance

BE and causal paths to energy balance



Horn EE, Turkheimer E, Strachan E, Duncan GE. Behavioral and Environmental Modification of the Genetic Influence on Body Mass Index: A Twin Study. Behav Genet. 2015. doi: 10.1007/s10519-015-9718-6. PubMed PMID: 25894925.

Duncan GE, Cash SW, Horn EE, Turkheimer E. Quasi-causal associations of physical activity and neighborhood walkability with body mass index: A twin study. Prev Med. 2015;70C:90-5. doi: 10.1016/j.ypmed.2014.11.024. PubMed PMID: 25482422.

MVPA, walking, walkability, and BMI

Results from twin studies

Duncan GE, et al. 2014

6376 same-sex adult twin pairs within pair analyses

- Walking and MVPA associated with BMI in phenotypic analyses; associations attenuated but significant in biometric analyses (*Ps* < 0.05).
- Walkability associated with walking (but not with MVPA or with BMI) in both phenotypic and biometric analyses (*Ps* < 0.05), with no attenuation accounting for shared genetic and environmental background.
- *Higher neighborhood walkability is (quasi) causally associated with increased neighborhood walking levels, and, in turn, higher neighborhood walking levels are (quasi) causally associated with reduced BMI*.

MVPA, walkability and BMI

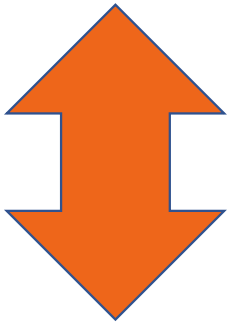
Results from twin studies

Horn EE et al. 2015

5079 same-sex adult twin pairs

- High levels of MVPA suppressed genetic risk for high BMI, controlling for underlying genetic etiology shared between PA and BMI.
- Neighborhood walkability also had moderating effects on genetic variance in BMI; however, these effects were mediated by MVPA.
- *Interventions focusing on PA, including those that improve aspects of the BE that in turn promote more PA, could help reduce obesity*.

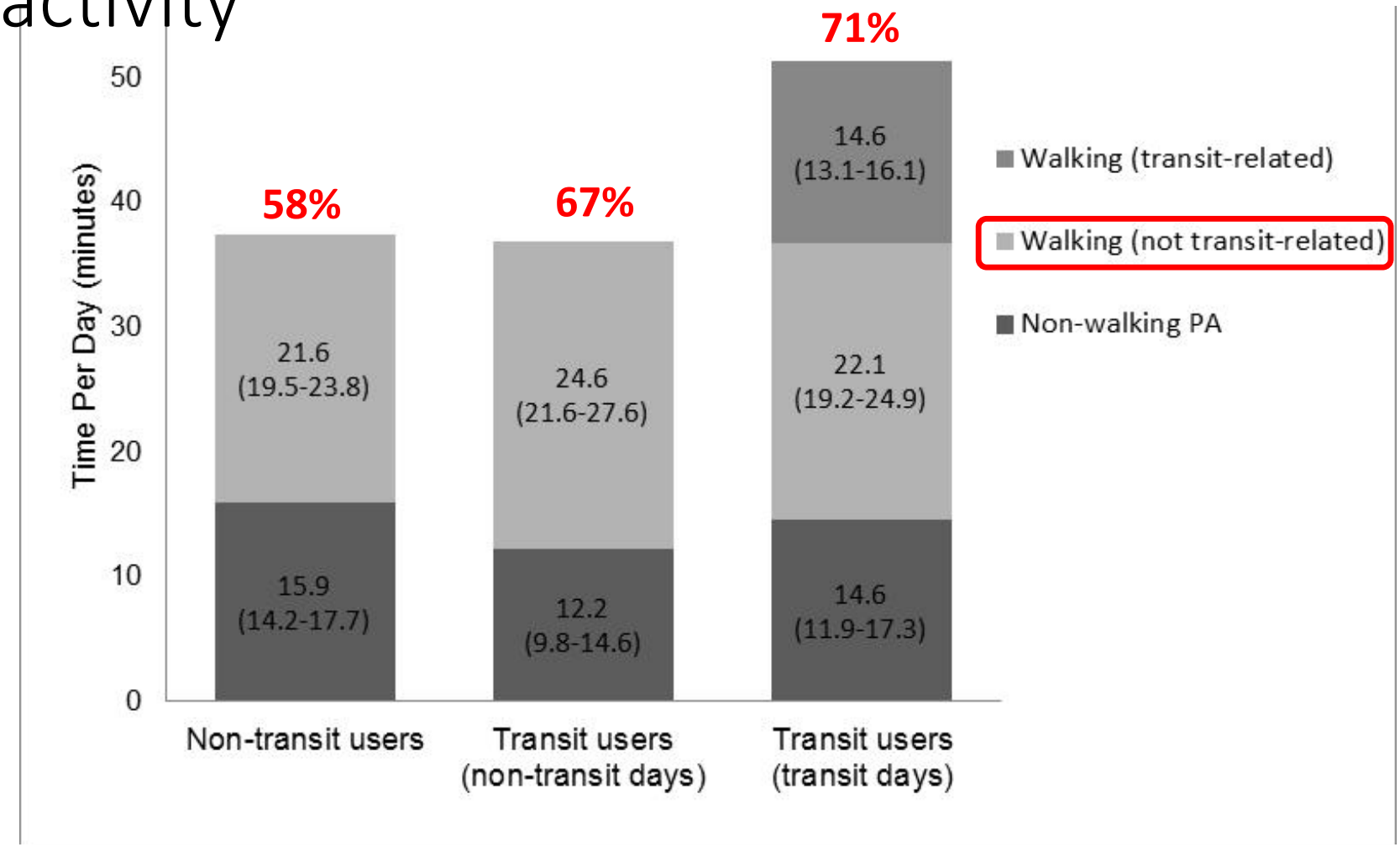
Walking - **physical activity**



Transit use - **built environment**

Effect of transit use on walking share of physical activity

- N = 693 participants
- 4432 person-day
- PA = >1000 cpm



Source: Saelens, BE, Moudon, AV, Kang, B, Hurvitz, PM, Zhou, C. Higher Physical Activity Is Directly Related to Public Transit Use. American Journal of Public Health in press (AJPH 2013-6916)

Walking - **physical activity**

Transit use - **built environment**

- Walking = population-wide preferred mode of physical activity or exercise
- Transit use leads to more walking
- Transit systems coexist with higher development densities, higher mix of uses (routine trips between origins and destinations)

Built environment and energy balance

- **THREE VECTORS TO ENERGY BALANCE**
- SES and spatial segregation
- Walkability and walking
- Access to healthy and affordable foods

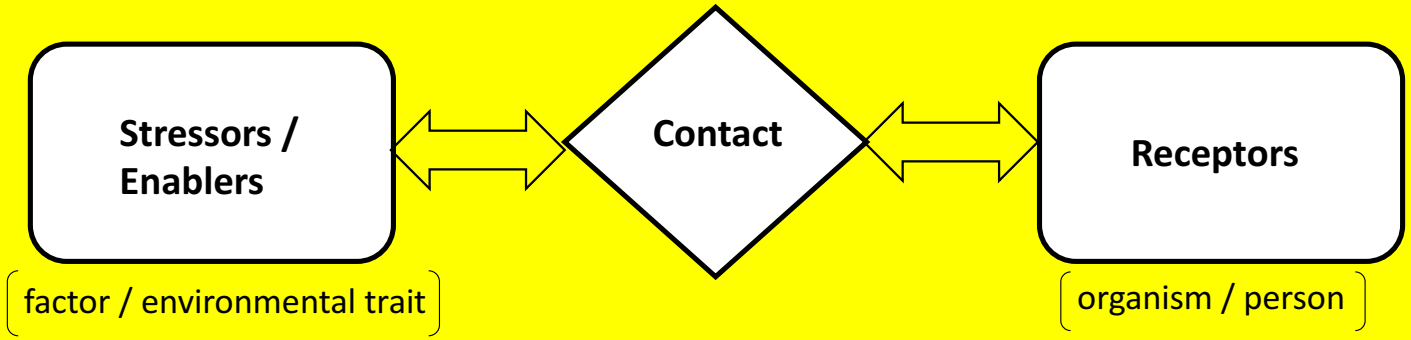
Methodological challenges
Untangling the effects of BE on health

- Direction of causality in behavior - BE
- Self-selection (spatial segregation by socioeconomic status; selective daily mobility bias)
- No random assignment
  - Longitudinal studies
  - Natural experiments
  - Twin studies
- Poor measures of health behaviors (esp. food intake) and BE
- Poor theory of exposure to BE

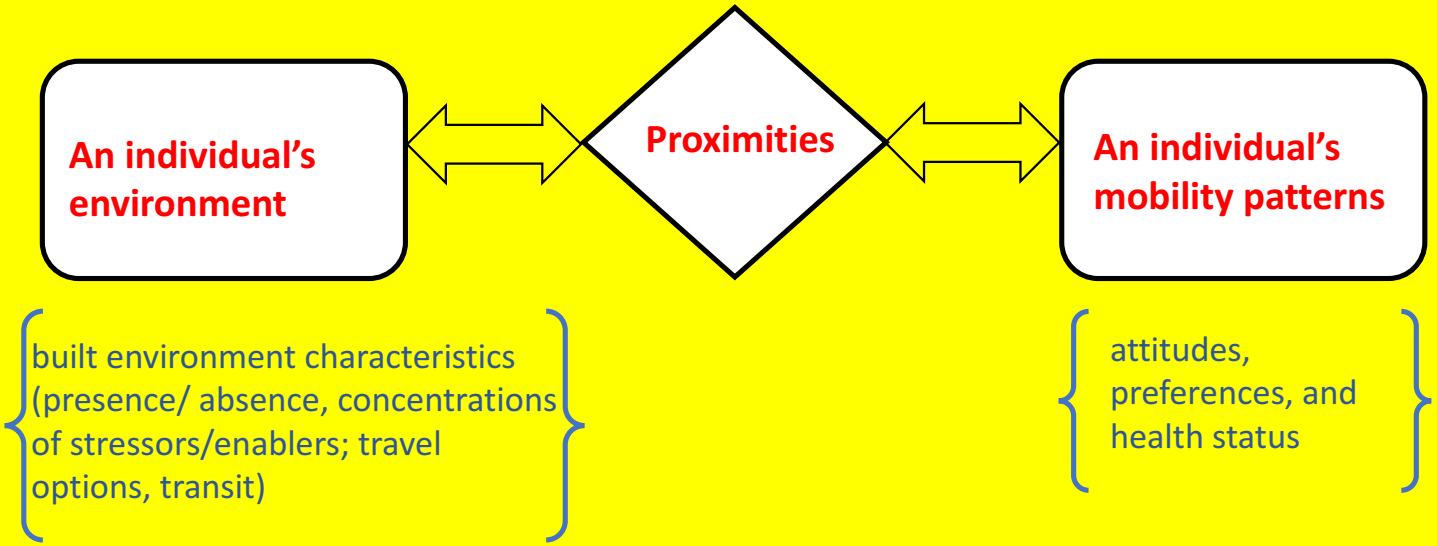
Exposure science

Lioy and Smith, 2013 + Chaix et al. 2012

Classic Lioy and Smith, 2013



Applied to BE Chaix et al. 2012



Environment affecting energy intake

Environment affecting energy expenditure

Stressors/enablers

An individual's environment characteristics

Attributes of BE stressors/enablers

- **ENERGY EXPENDITURE**

- **Walking (utilitarian and recreation) environment**
  - Development density
  - Nearby destinations for daily living
  - Short street-blocks
  - Sidewalks/ crosswalks
  - Public transport
  - Parks and recreation areas (waterways)
  - Trails

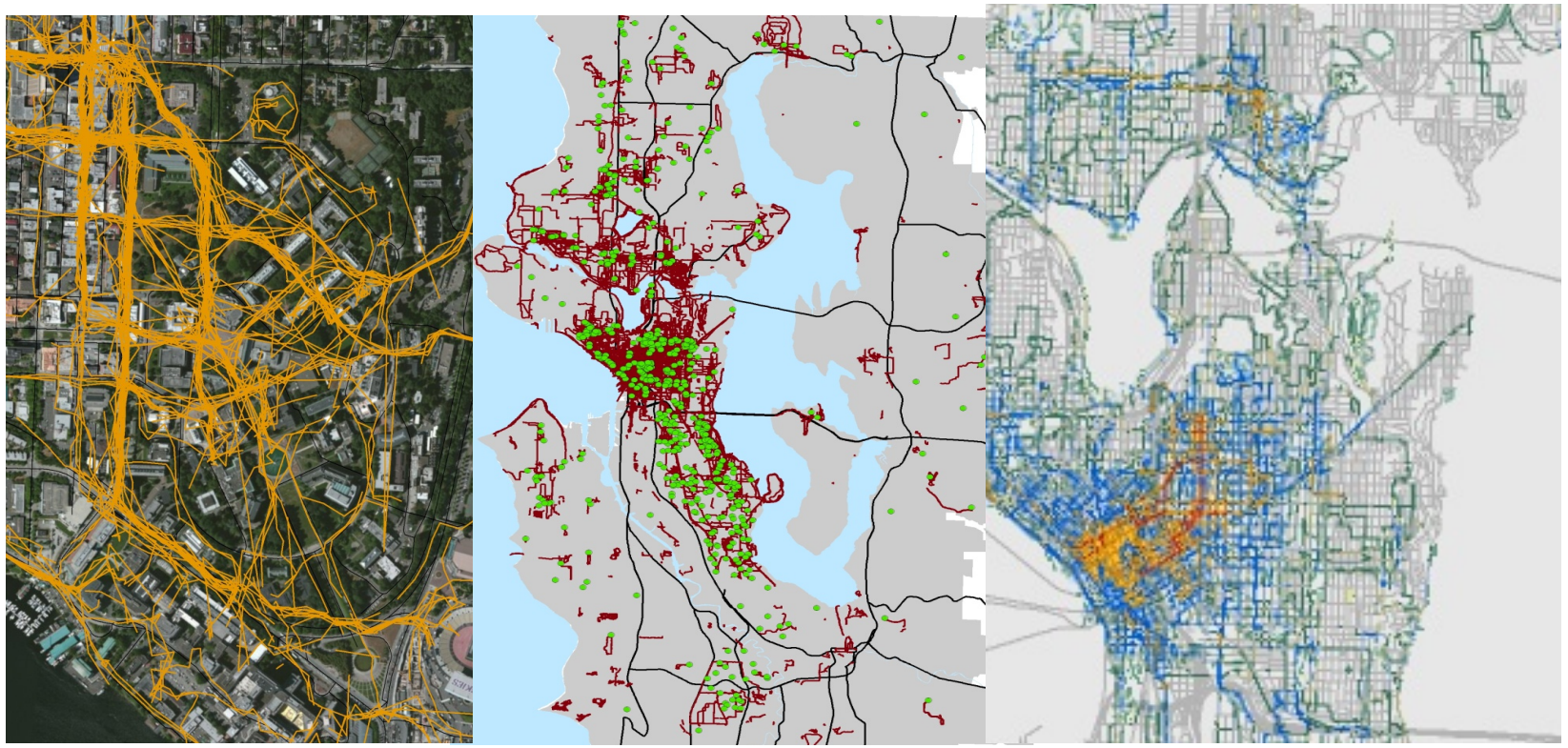
- **ENERGY INTAKE**

- **Food environment**
  - Healthy and unhealthy food venues
    - Calories versus nutrients
    - Affordability

Geographic context of BE stressors/ enablers

- The spatial distribution/concentration of food establishments is based on market place assumptions of the potential **influence of exposure on use**
  - Numerous convenience stores and FFRs (low-cost, impulse buying),
  - Fewer supermarkets (more medium costs SM than low or high cost SM) (purpose/considered buying)
  - Few trails, sports fields, short street-blocks, etc.

- GLOBAL TREND since 1960s, most BEs contain MORE stressors and FEWER enablers of PA and healthy diet



Receptors

Mobility patterns, neighborhood, places visited

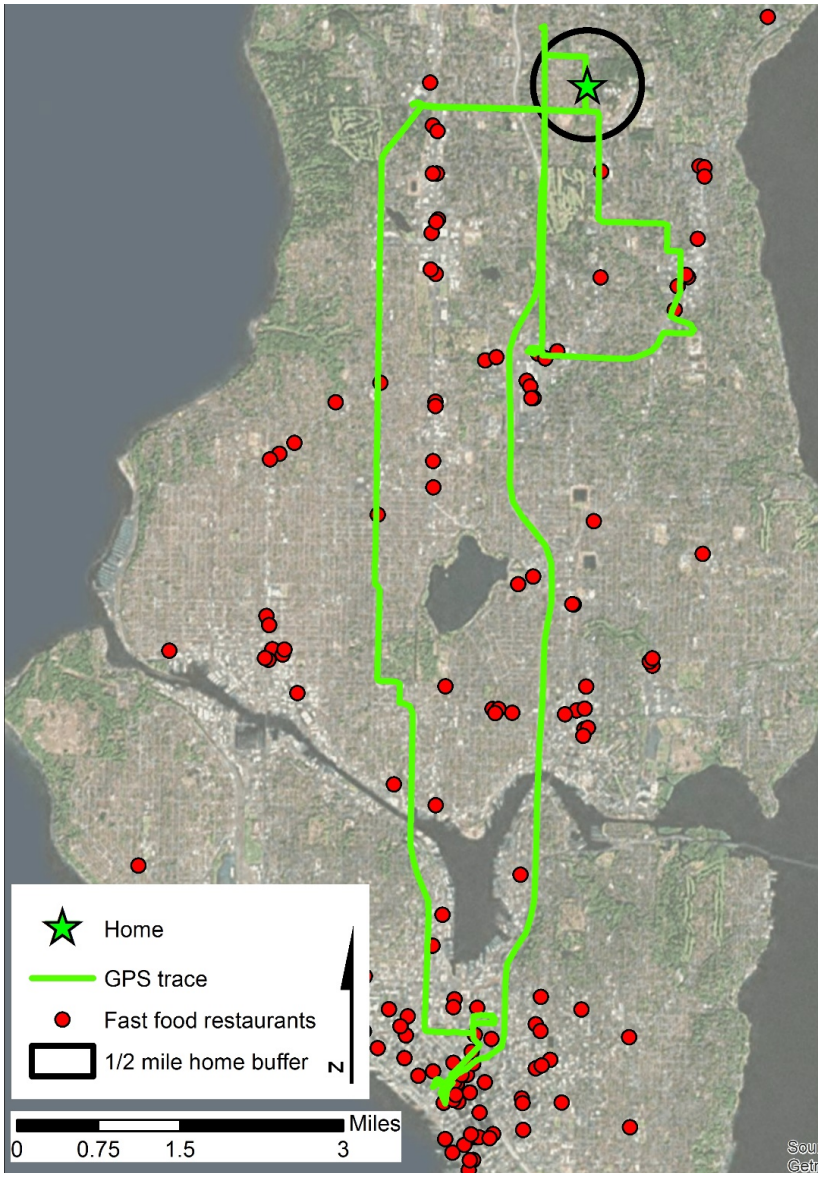
Geographic context of BE receptors

- **Static/dwell areas and places**
  - Residential or work neighborhood
  - Other non-residential and/or non-work
- **Dynamic/move locations**
  - Places visited
  - Along travel route (from travel diaries or GPS traces)

- Uncertain geographical context
  - James et al. in Effects of buffer size and shape on associations between the built environment and energy balance (2014)
- Spatial polygamy
  - Matthews S et al
- Moving away from place-based to people-based measures of exposure
  - Kestens et al. 2010

Example:
Exposure to fast food restaurants

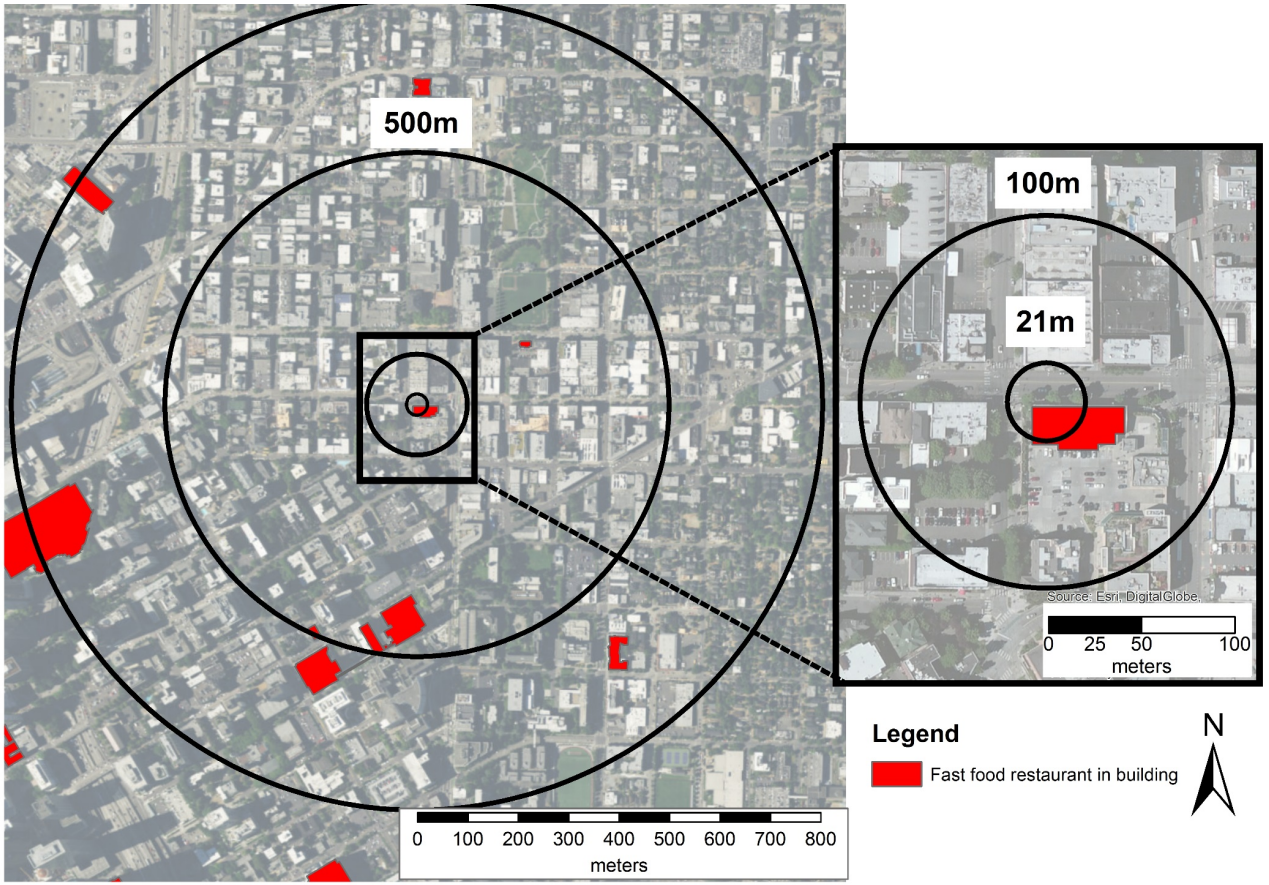
- Stressor:
  - Measuring fast food restaurant counts, densities, percentages, etc., *within proximity* of participant
- Receptor:
  - Measuring participant's dwells and moves



References:
- Self-reported activity locations: VERITAS, Chaix et al. 2012
- Work commute path: Burgoine et al. 2013, & Burgoine et al. 2014
- GPS: Zenk et al. 2011, Christian 2012

At what proximity may contact occur?

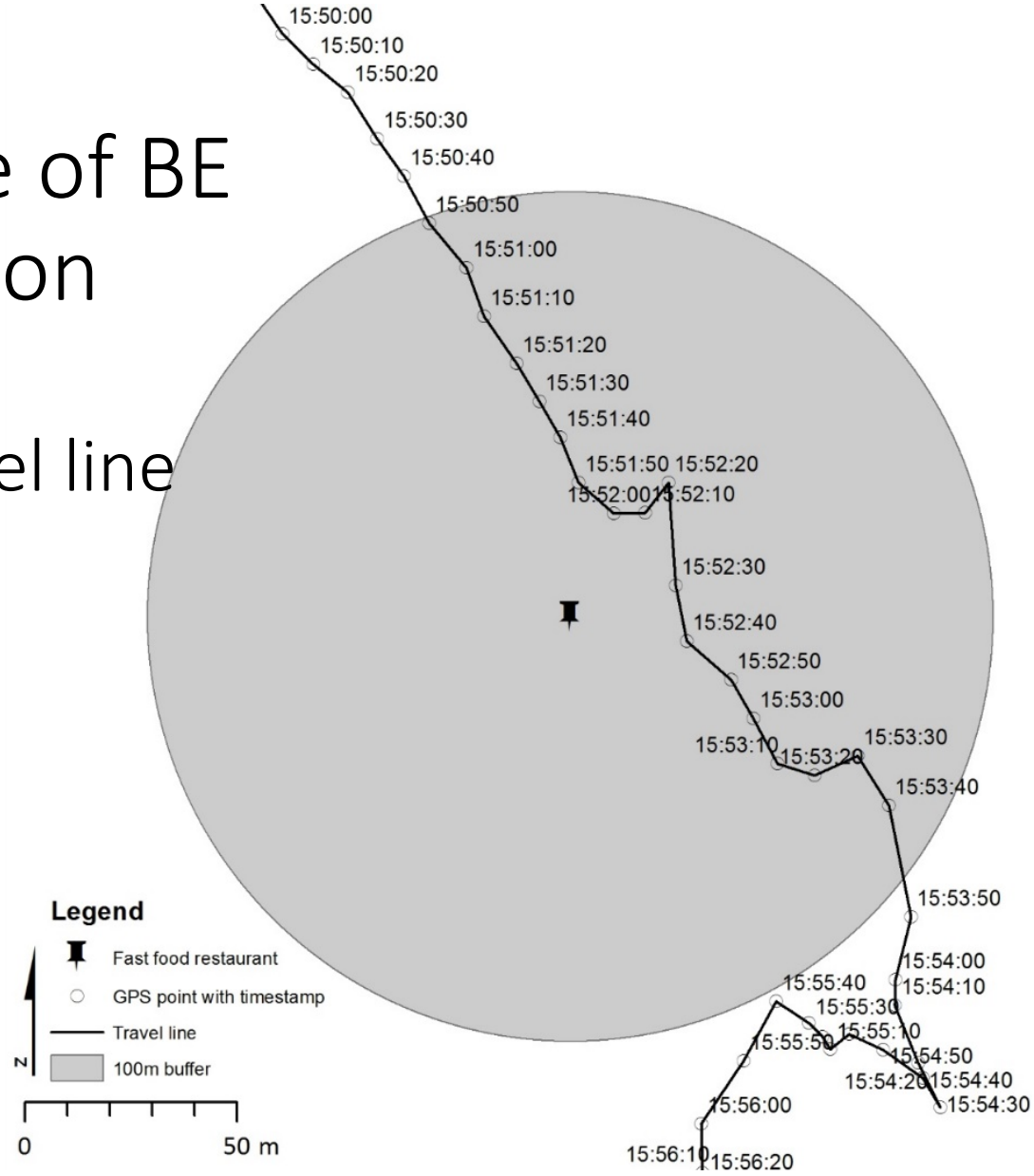
- **21 m**
  - Width of a street
  - Farthest distance at which a human face is recognized
- **100 m**
  - Length of a city block
  - Pedestrian travel
- **500 m**
  - What is accessible by car
- **Half-mile**
  - A 10-minute walk



A novel measure of BE exposure: duration

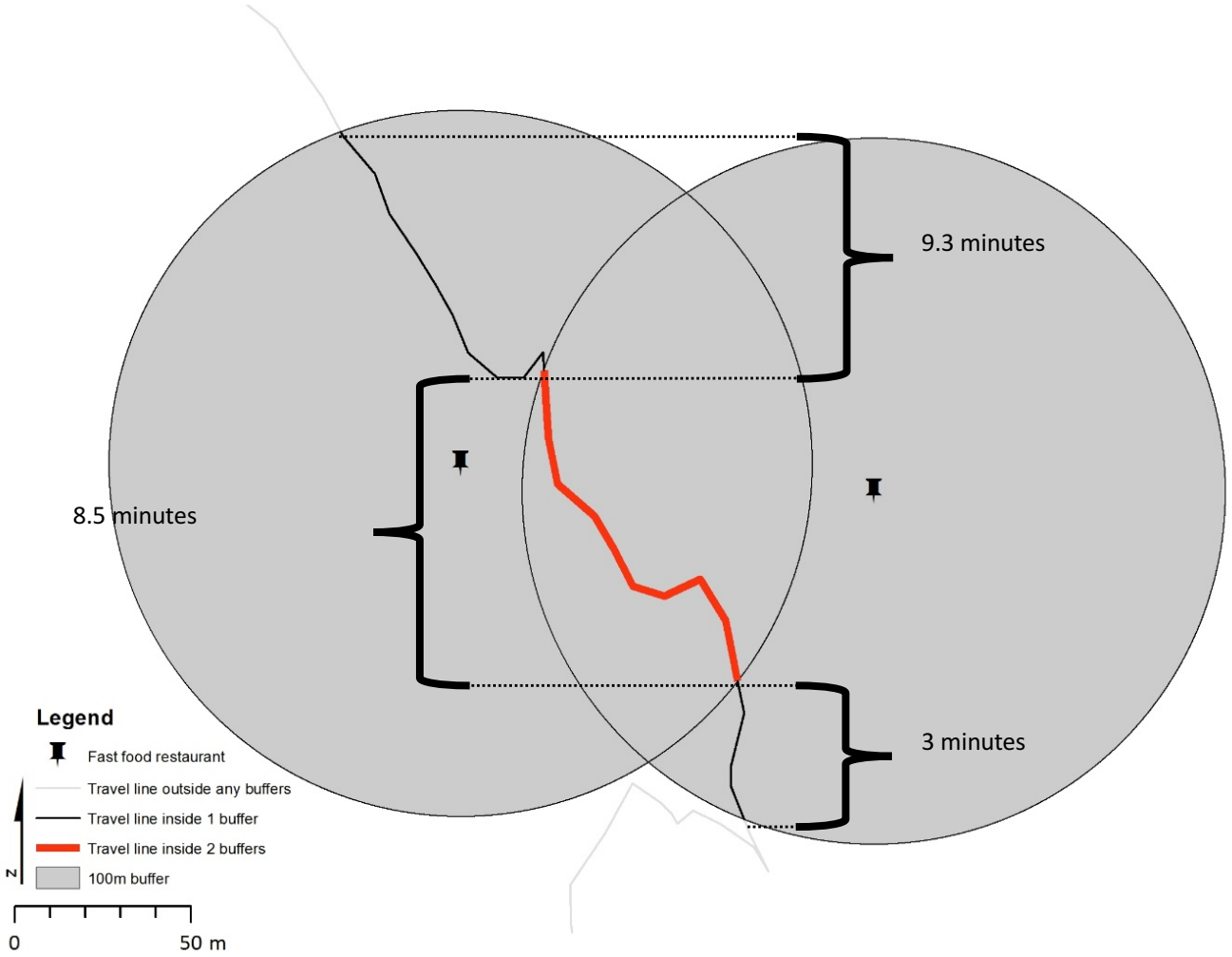
Measuring GPS travel line through FFR buffer

Scully J Y et al. in progress



Exposure duration weighted by the number of proximate fast food restaurants

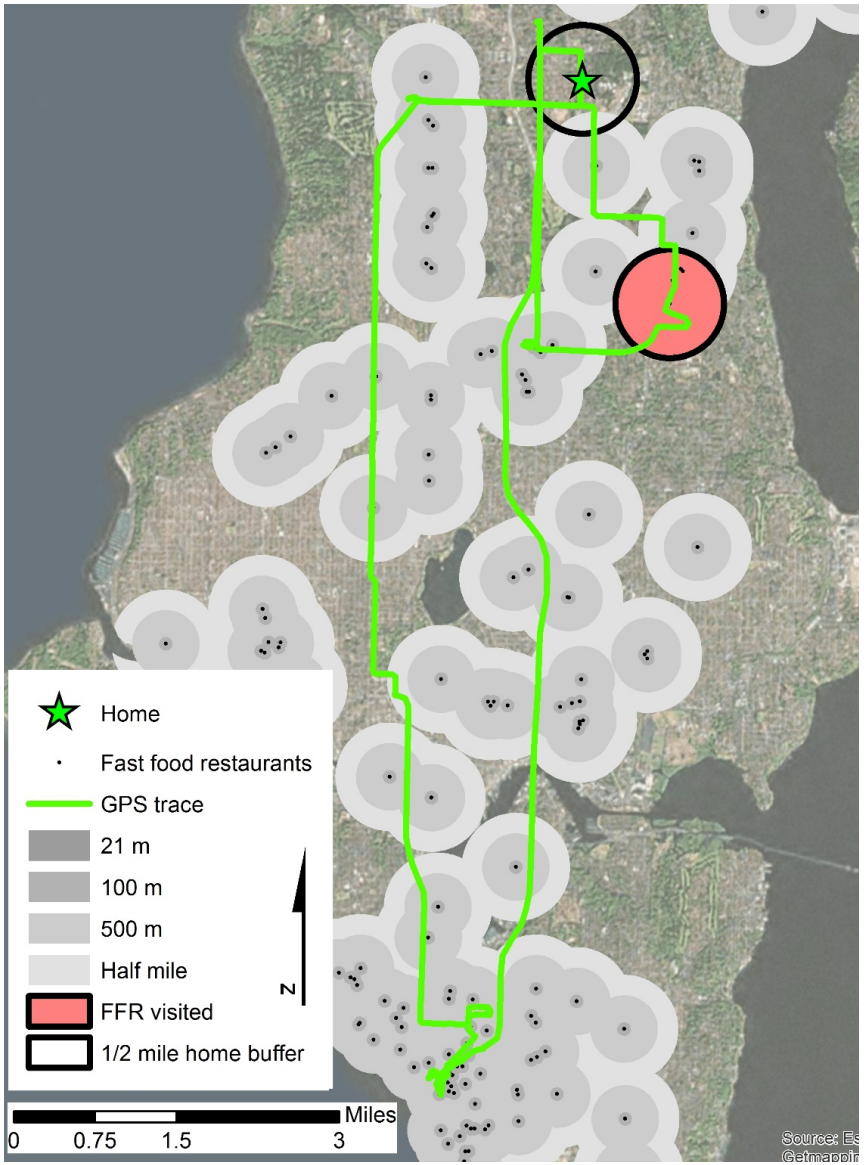
GPS travel line intersecting two or more overlapping buffers = time inside overlapping buffers * the number of buffers



Duration of exposure = 9.3 + 8.5 + 3
Weighted duration of exposure = 9.3*1 + 8.5*2 + 3*1

Results

Proximity	FFR Mean count/day (SD)	Exposure duration Mean minutes/day (SD)
21 m	1.5 (1.1)	1.0 (1.8)
100 m	8.1 (4.5)	17.0 (16.6)
500 m	24.34 (13.2)	84.8 (56.7)
Half mile	34.1 (18.9)	117.7 (69.2)



Results: Odds of visiting > one FFR

Scully J Y et al. In progress

	21 meters			100 meters			500 meters			Half mile		
	Odds	95% CI	p-value	Odds	95% CI	p-value	Odds	95% CI	p-value	Odds	95% CI	p-value
A: By duration of exposure*												
(Intercept)	0.53	0.22-1.27	0.147	0.47	0.19-1.2	0.109	0.7	0.29-1.69	0.426	0.55	0.23-1.36	0.191
Tertile 1	Ref			Ref			Ref			Ref		
Tertile 2	**2.06**	**1.17-3.65**	**0.011**	1.24	0.7-2.18	0.456	1.06	0.61-1.83	0.844	**1.93**	**1.1-3.39**	**0.021**
Tertile 3	**2.8**	**1.58-4.96**	**0.000**	**2.89**	1.65-5.07	**0.000**	**1.72**	**1-2.94**	**0.046**	**2.16**	1.22-3.83	**0.008**
B: By count of FFRs*												
(Intercept)	0.78	0.34-1.83	0.570	0.74	0.31-1.8	0.507	0.77	0.33-1.81	0.541	0.86	0.37-2	0.720
Tertile 1	Ref			Ref			Ref			Ref		
Tertile 2	1.26	0.73-2.18	0.408	1.16	0.66-2.04	0.601	1.32	0.76-2.3	0.323	1.06	0.6-1.86	0.849
Tertile 3	1.41	0.8-2.47	0.229	1.68	0.96-2.93	0.066	1.38	0.76-2.51	0.289	1.49	0.83-2.68	0.175
C: By weighted duration of exposure*												
(Intercept)	0.56	0.23-1.33	0.182	0.49	0.2-1.21	0.117	0.72	0.3-1.75	0.462	0.8	0.34-1.92	0.616
Tertile 1	Ref			Ref			Ref			Ref		
Tertile 2	1.62	0.92-2.85	0.092	1.4	0.79-2.47	0.248	1.15	0.67-1.99	0.606	1.25	0.72-2.17	0.423
Tertile 3	**2.69**	**1.53-4.73**	**0.001**	**3.07**	**1.76-5.36**	**0.000**	1.47	0.86-2.52	0.158	1.15	0.67-1.99	0.600

*** Adjusting for age, gender, race, education, income, number of cars in household, household size, commute distance, and residential density.**

Results: Tertile values

0.148 min = 8.9 sec
0.649 min = 38-9 sec
0.678 min = 40.7 sec

		21 m	100 m	500 m	half mile
A: By duration of exposure (minutes per day)					
	Tertile 1	0-0.148	0-8.96	0-57.1	6.99-81.3
	Tertile 2	**0.148-0.649**	8.96-17.1	57.1-92.2	**81.3-128**
	Tertile 3	**0.649-12.9**	**17.1-190**	**92.2-500**	**128-545**
B: By count of FFRs					
	Tertile 1	0-0.857	0-5.82	0-17	1 to 23
	Tertile 2	0.857-1.71	5.82-9.14	17-28.4	23-40.5
	Tertile 3	1.71-8	9.14-27.2	28.4-78.6	40.5-115
C: By weighted duration of exposure					
	Tertile 1	0-0.155	0-11.4	0-179	6.99-349
	Tertile 2	0.155-0.678	11.4-23.1	179-302	349-626
	Tertile 3	**0.678-12.9**	**23.1-194**	302-1920	626-4420

SmartMaps

Spatial modeling and mapping of BE and behavior at the micro-level

Example: Locating Transportation-Efficient Areas

Transportation-Efficient Land Use Mapping Index
TELUMI

A tool that identifies locations with demand for alternative travel modes (walking, biking, transit) using land use measures

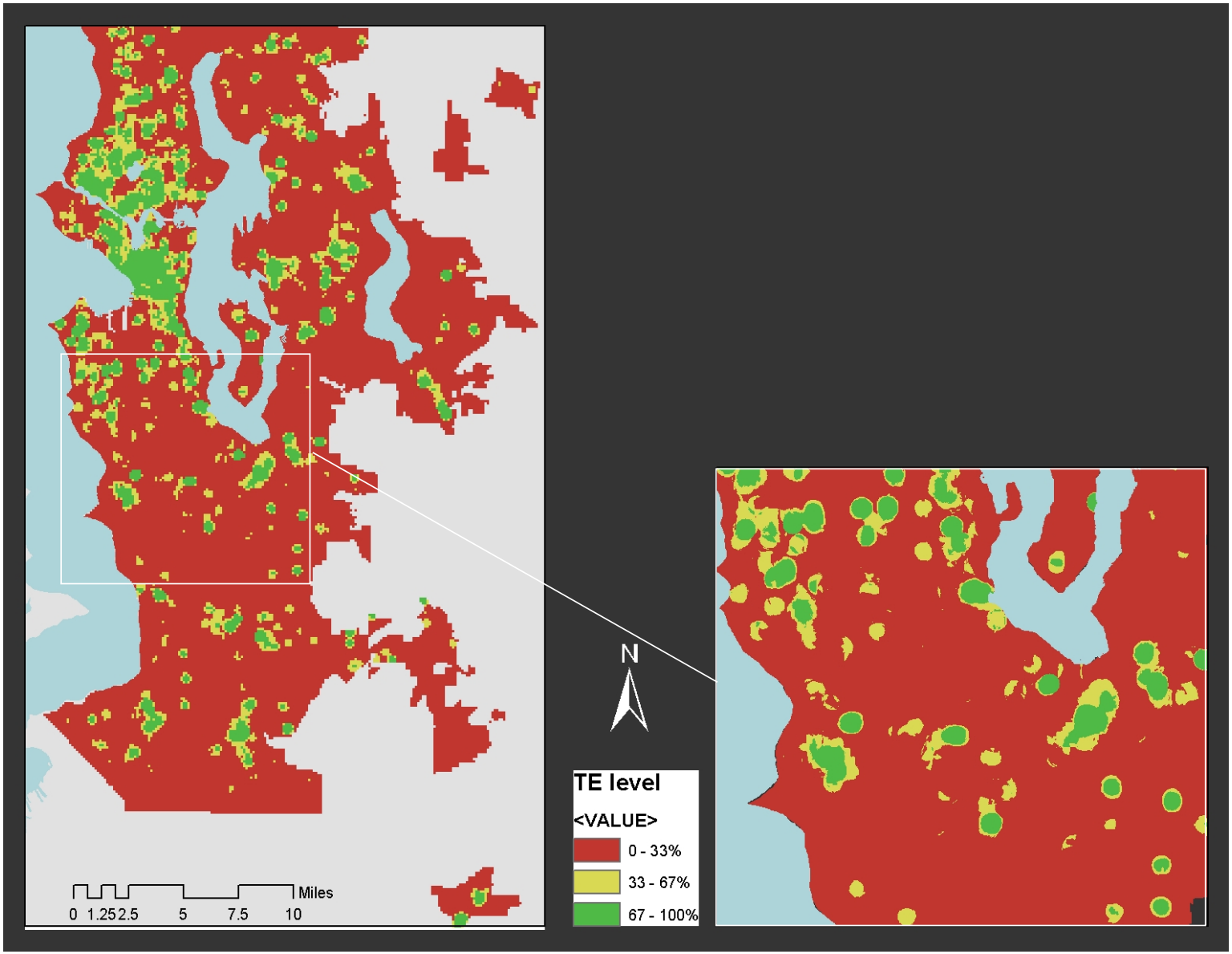
Objective: to help local jurisdictions make decisions on where to target infrastructure and land use investments to support alternative travel modes

Moudon et al. International Journal of Sustainable Transportation, 5:111–133, 2011
DOI: 10.1080/15568311003624262

TELUMI

Transportation-
Efficient **L**and
Use **M**apping
Index

	HIGH EFFICIENCY
	LATENT EFFICIENCY
	LOW EFFICIENCY



TELUMI as a multi-functional tool

Interdisciplinary and interpersonal

to visually display land-use conditions associated with different modes of travel,

to perform advanced quantitative analyses of land-use attributes.

to effectively help bridge common communication gaps between lay and professional audiences.

Interactive —use concrete, readily identifiable individual land-use variables

to facilitate scenario building

to target intervention strategies or investment decisions, such as augmenting residential or employment density or building sidewalks, by evaluating their effectiveness in improving transportation efficiency.

Multi-scaled —

to analyze land use at the regional level (macro scale),

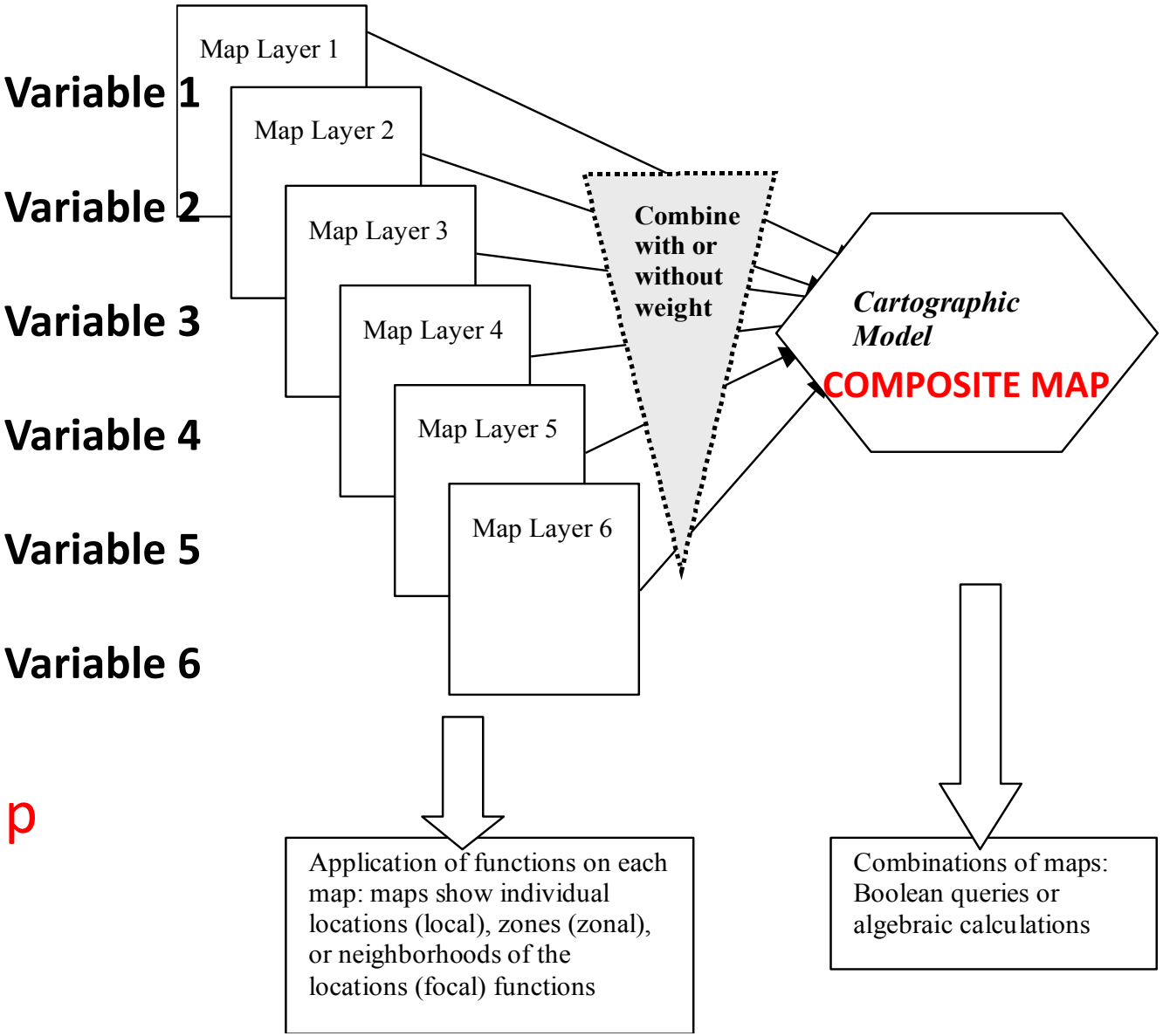
with land-use characteristics captured via fine-grained data (micro scale)

TELUMI

Cartographic Model

Simplified Diagram

Tomlin CD 1970



One land use attribute/variable per map

Six land use domains

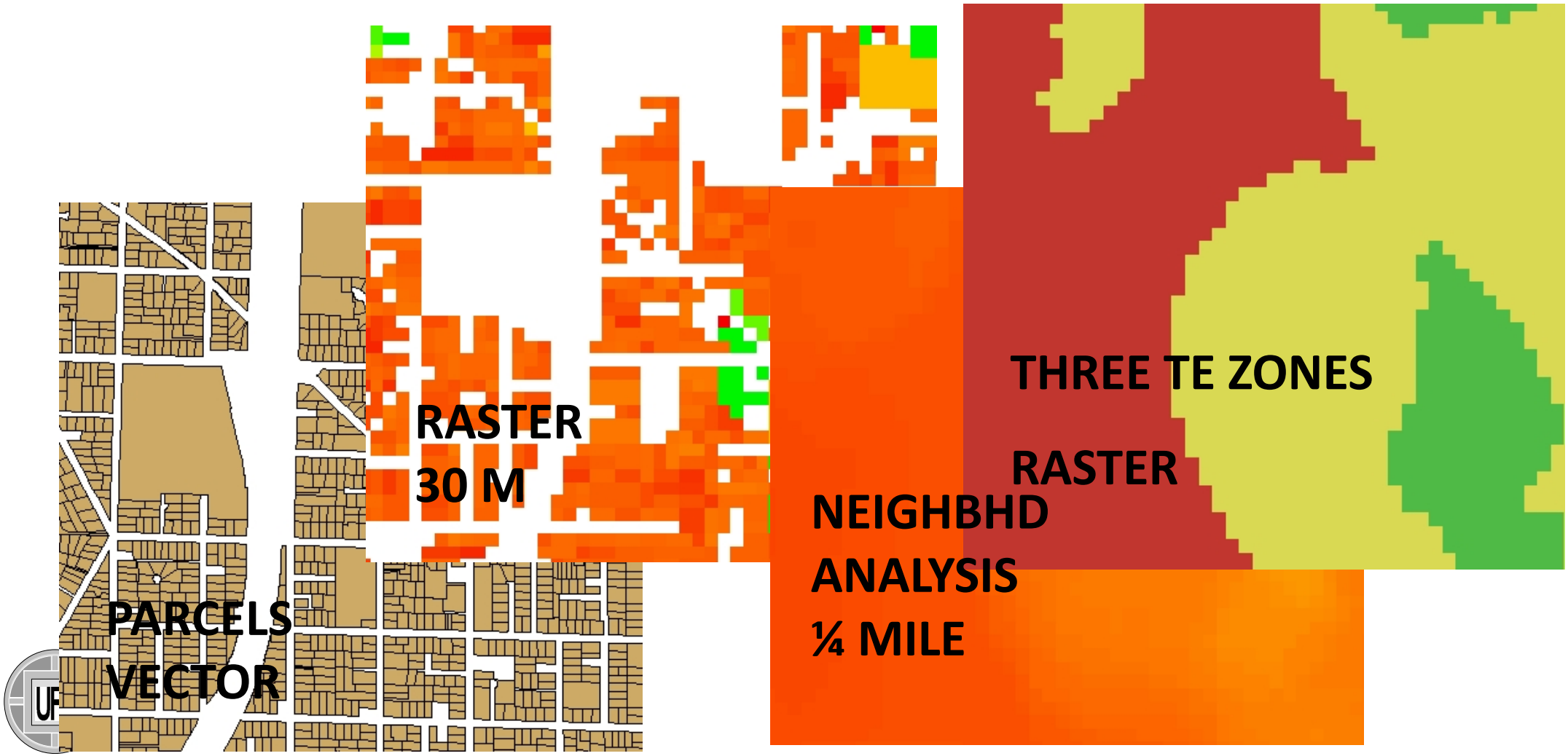
Nine variables

DOMAIN		SPECIFIED VARIABLES/MEASURES
I	Density	• Residential Density [net] • Employment Density [net]
II	Mix of uses	• Proximity to groups of destinations (NC= Neighborhood Center)
III	Network Connectivity	• Average street-block size
IV	Parking supply and management	• % at-grade parking lots in commercial parcels
V	Pedestrian environment	• Topography • Traffic volume (School / Shopping Trips)
IV	Affordable housing	• % of mean assessed residential land and improvement value

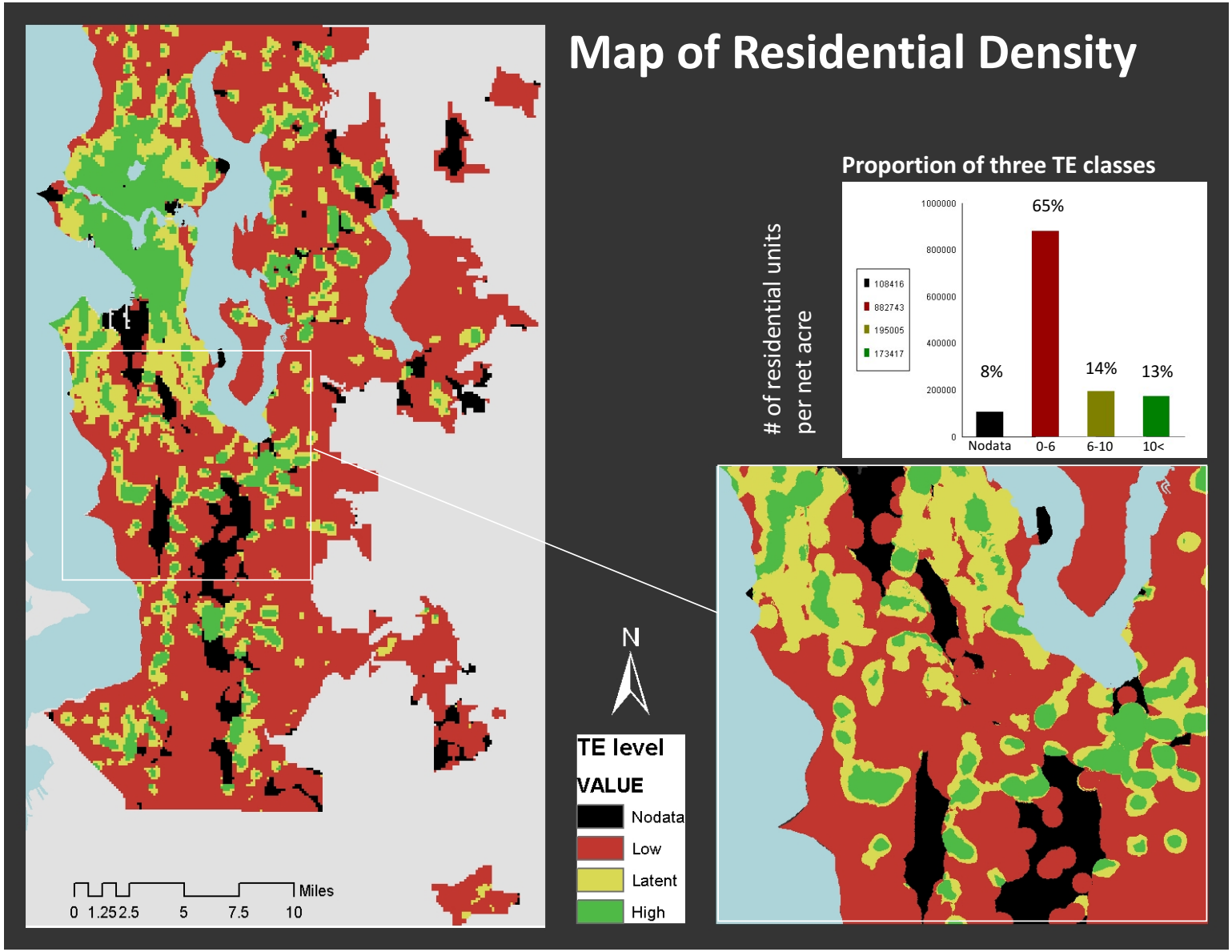
Three levels of Transportation Efficiency (TE)

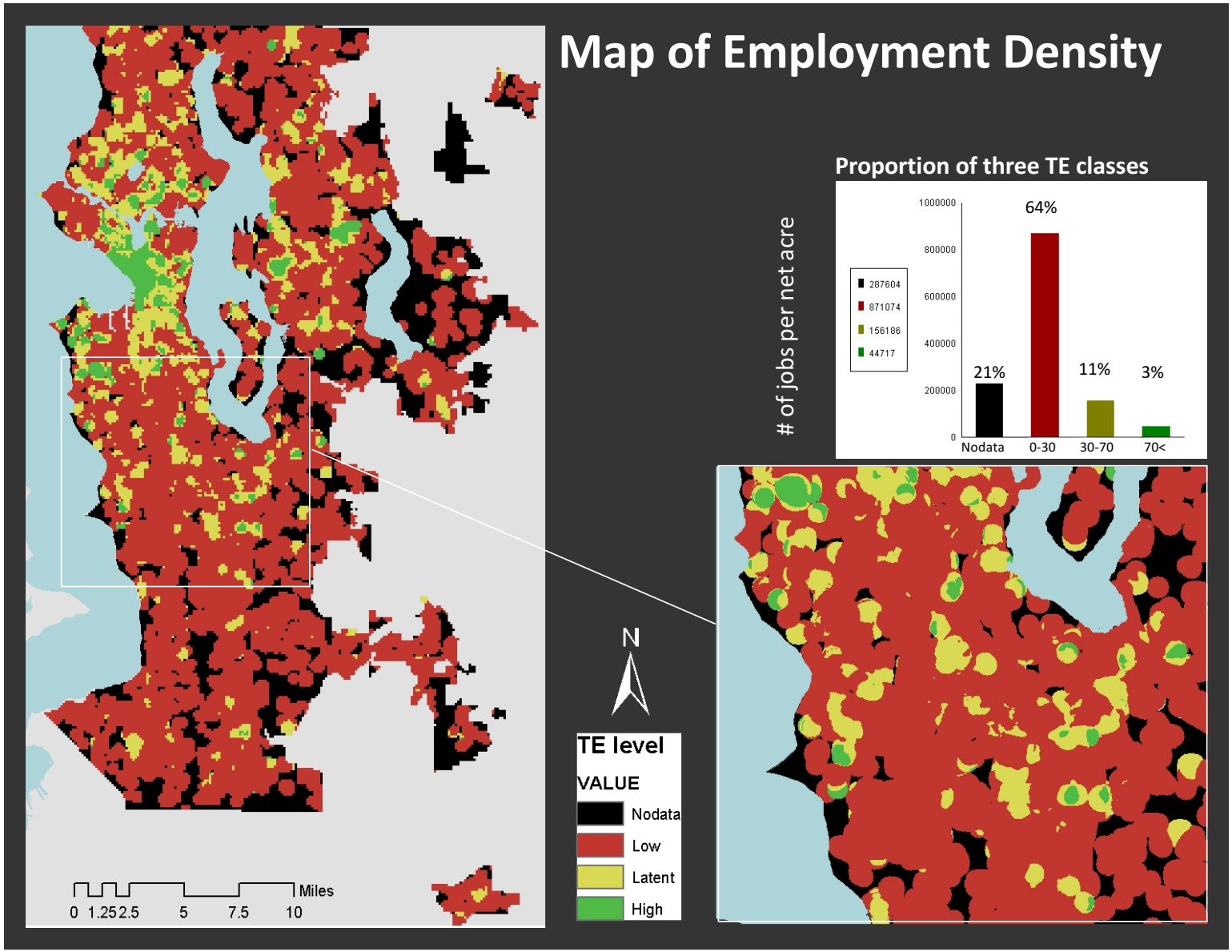
Transportation Systems		Cartographic Model		
Transportation Options	**Investment Outcomes**	**Zone/Threshold Name**	**Zone Characteristics**	**Example of Threshold Measure**
Low number and types of options	Likely to be ineffective	**Low TE**	Zones with high number of SOV and low number of transit trips	>90+ % of trips in SOV
Medium number and types of options	Likely to be highly effective	**Latent TE**	Zones with medium number of transit or para-transit trips	>75 % of trips in SOV
High number of types and options	Likely to be effective	**High TE**	Zones with high number of transit, para-transit, and non-motorized trips, and low SOV number of trips	<75 % of trips in SOV

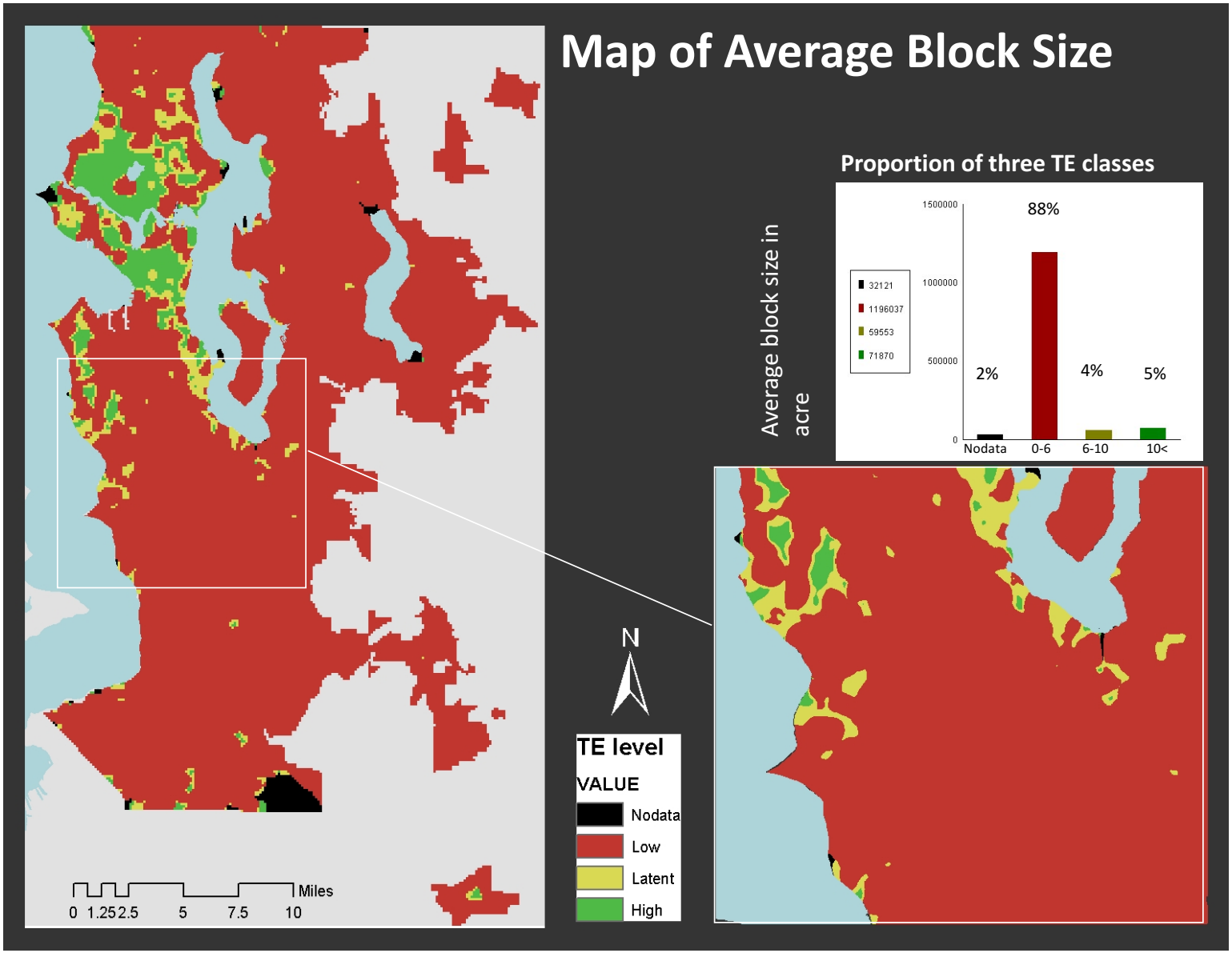
Land use data transformation

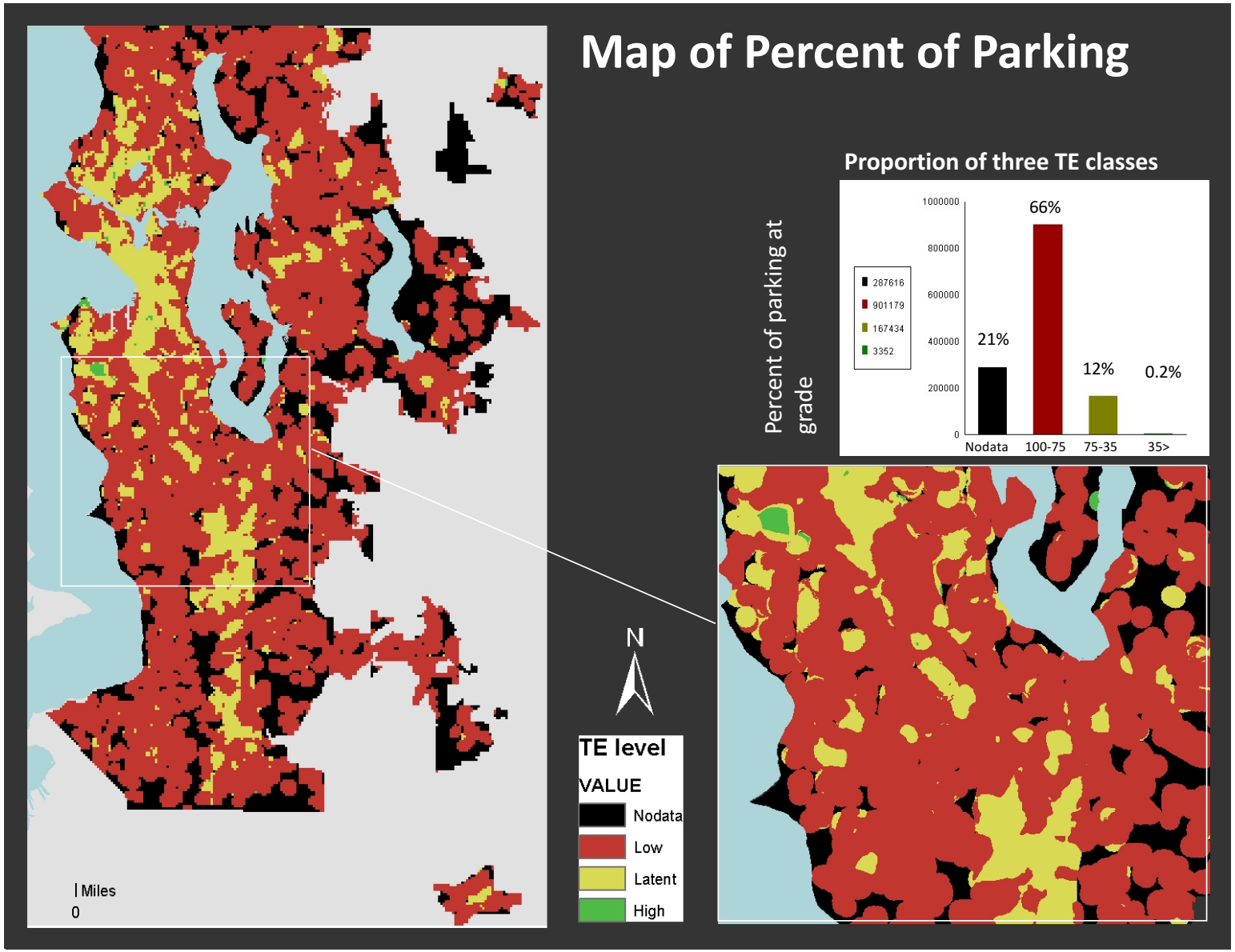


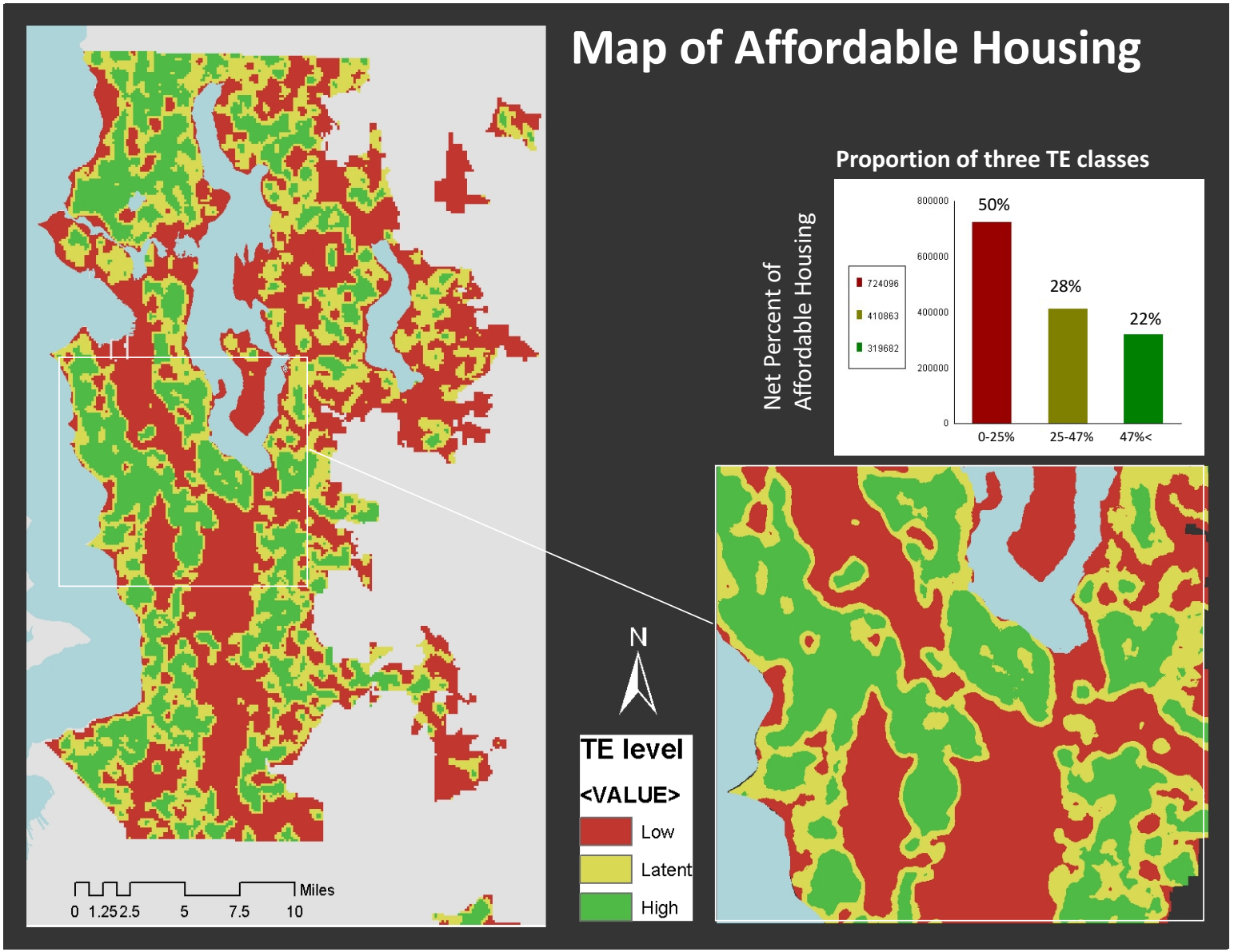
Where Are the Transportation-Efficient Areas?


Map of Residential Density
Proportion of three TE classes
# of residential units per net acre
1000000
800000
600000
400000
200000
0
108416
882743
195005
173417
65%
8%
14%
13%
Nodata
0-6
6-10
10<
N
TE level
VALUE
Nodata
Low
Latent
High
Miles
0 1.252.5 5 7.5 10


Map of Employment Density
Proportion of three TE classes
# of jobs per net acre
1000000
800000
600000
400000
200000
0
287604
871074
156186
44717
64%
21%
11%
3%
Nodata
0-30
30-70
70<
N
TE level
VALUE
Nodata
Low
Latent
High
Miles
0 1.252.5 5 7.5 10


Map of Average Block Size
Proportion of three TE classes
Average block size in acre
1500000
1000000
500000
0
32121
1196037
59553
71870
88%
2%
4%
5%
Nodata
0-6
6-10
10<
N
TE level
VALUE
Nodata
Low
Latent
High
Miles
0 1.252.5 5 7.5 10


Map of Percent of Parking
Proportion of three TE classes
Percent of parking at grade
1000000
800000
600000
400000
200000
0
287616
901179
167434
3352
66%
21%
12%
0.2%
Nodata
100-75
75-35
35>
N
TE level
VALUE
Nodata
Low
Latent
High
| Miles
0


Map of Affordable Housing
Proportion of three TE classes
Net Percent of Affordable Housing
800000
600000
400000
200000
0
724096
410863
319682
50%
28%
22%
0-25%
25-47%
47%<
N
TE level
<VALUE>
Low
Latent
High
Miles
0 1.252.5 5 7.5 10

TELUMI

Composite Layer

Binary logit model to generate weights for each land use variable

- *Dependent variable:* Dichotomized ridership data <37 versus >37 riders per bus stop per day
  - Threshold of 37 riders per stop (37x4=148 per intersection) divided the sample population of bus users into those in the top 30 percent of higher bus usage, and all the others.
  - Data distribution: 63 percent (3,356 out of 5,363) of the bus stops and 91 percent of boardings and alightings (430,684 out of 473,169) within the Seattle city limits.
- *Independent variables:* 9 TELUMI measures averaged in a quarter-mile radius buffer, centered on bus stop locations

TELUMI

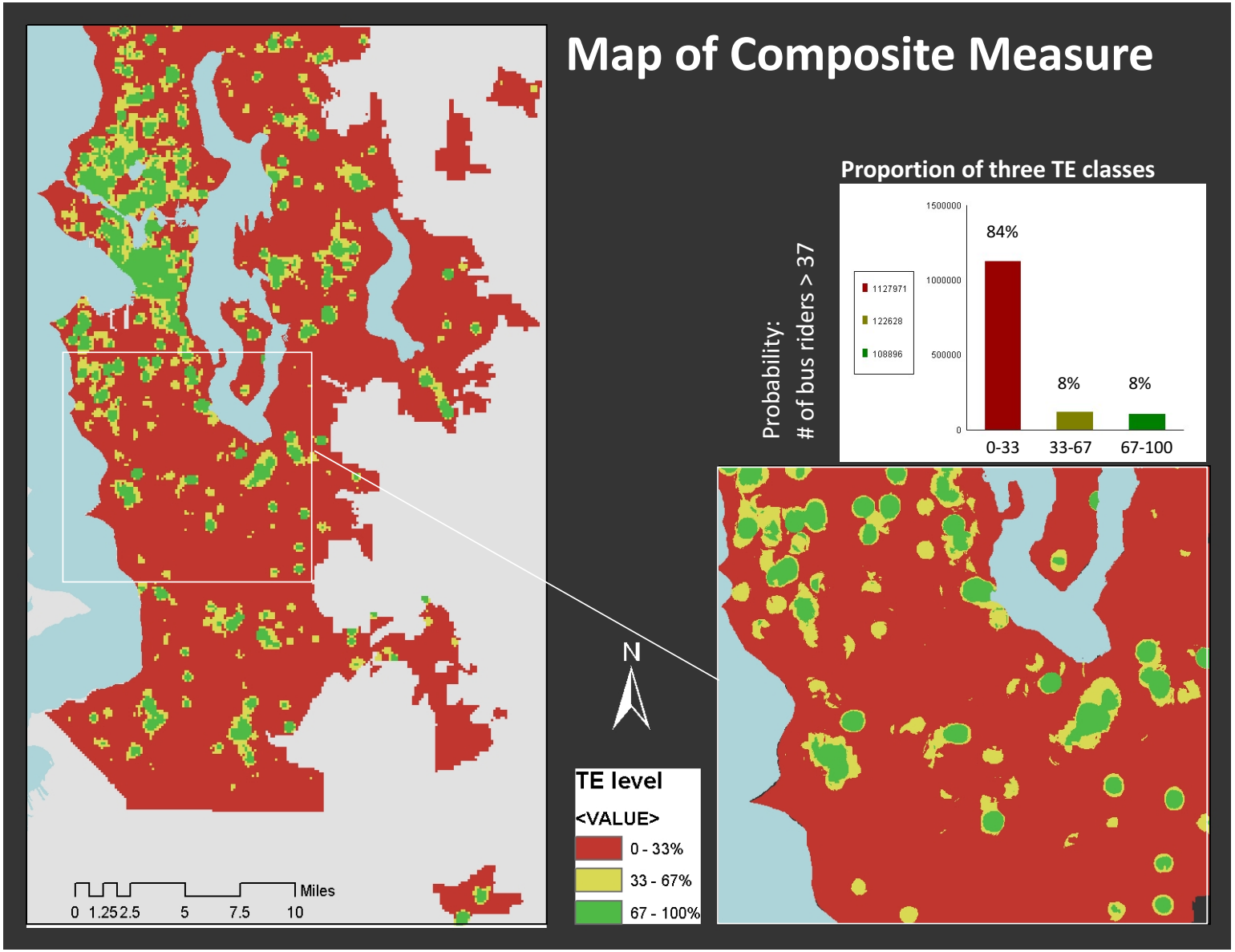
Composite Layer

Logit Model Results

Nagelkerke R-square: 0.344

Variable Name	B*	S.E.	Sign.**	Exp(B)
res_den	0.662	0.053	0	1.939
p_parking	0.506	0.076	0	1.659
nc2	0.471	0.08	0	1.602
emp_den	0.416	0.056	0	1.517
slope	0.324	0.07	0	1.383
blk_size	0.311	0.046	0	1.365
sch_traff	0.002	0	0	1.002
ret_traff	0	0	0	1
Constant	-5.181	0.179	0	0.006

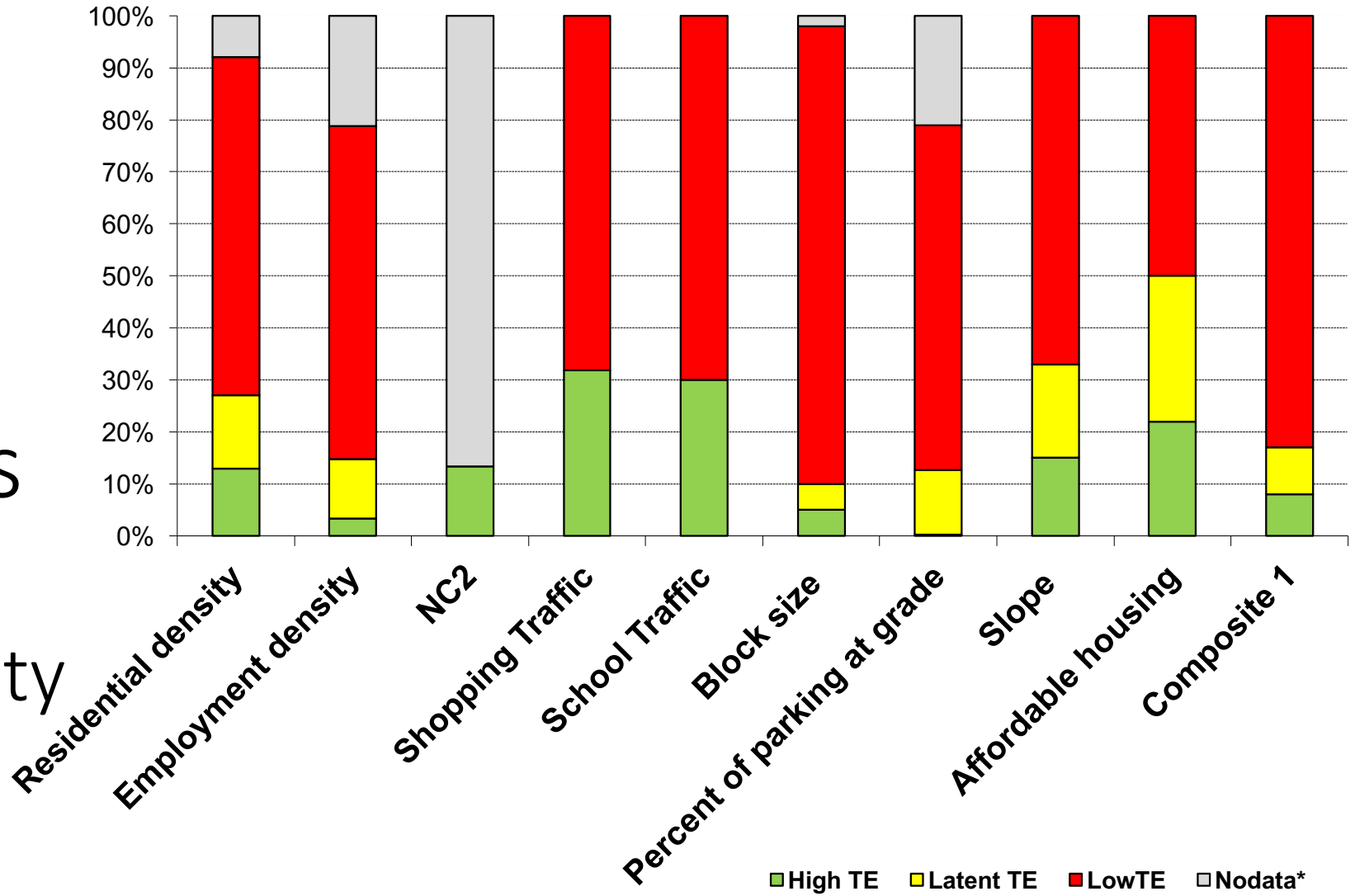
*B values are the weights applied to each variable to calculate the composite layer
**Significant at 0.99 level


Map of Composite Measure
Proportion of three TE classes
Probability:
# of bus riders > 37
1500000
1000000
500000
0
1127971
122628
108896
84%
8%
8%
0-33
33-67
67-100
N
TE level
<VALUE>
0 - 33%
33 - 67%
67 - 100%
Miles
0 1.252.5 5 7.5 10

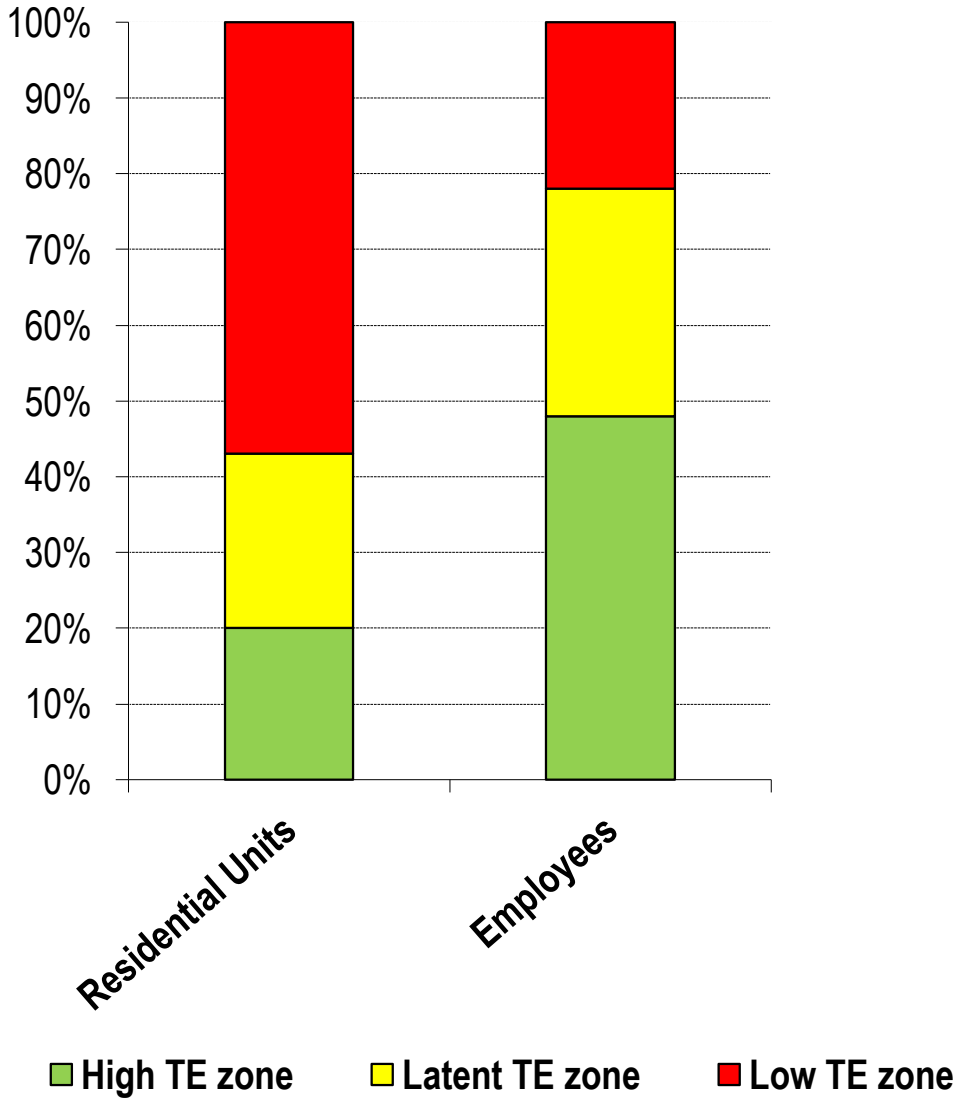
TELUMI

Areas in three TE zones

King County



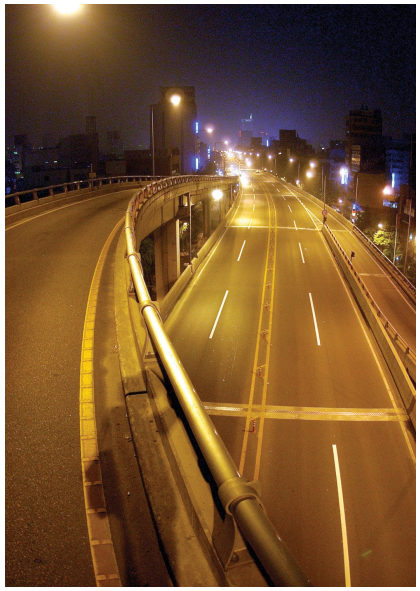
Distribution of residential units and employment in three TE Zones



Conclusions

- City planning can improve walkability and support active living
- Transport planning can incentivize transit use
- City and transport planning need to rely on spatial modeling of BE and walking/transit use behavior
- Behavior-built environment research can benefit from advances in sensor technology and exposure theory and measures
  - **Pluses of time-based exposure measures**
  - Travel mode independent
  - Cumulative exposure
  - Removal of places of intended exposure: Home, work, and places used
  - **Remaining questions**
  - Path selection bias
  - Environmental knowledge of FFR by type and location

Thank you



TRAC data summary

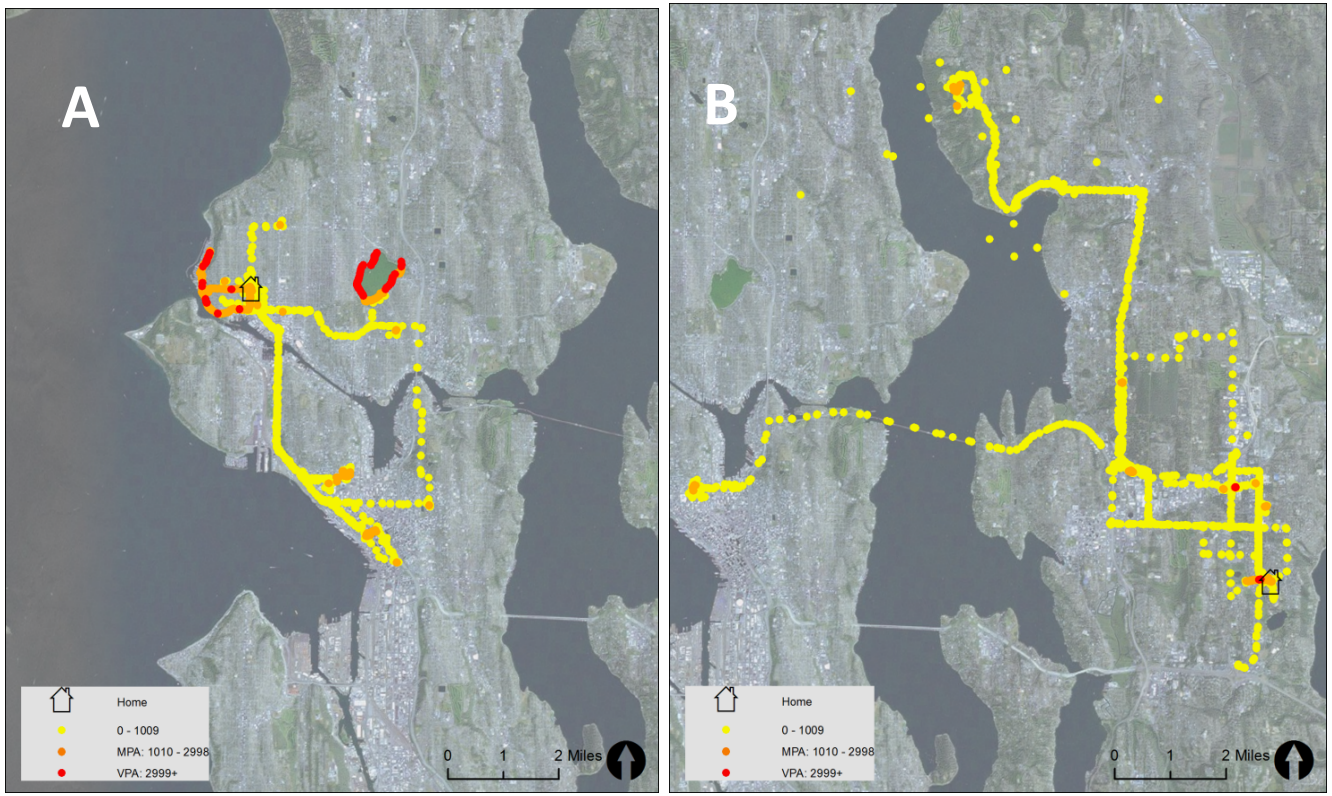
- Accelerometer data:
  - 736 participants
  - 5,195 days (7 days / participant)
  - 12,598 activity “bouts”
    - A bout contains at least 5 minutes of epochs where the accelerometer counts are > 500 for 30 seconds, during a 7 minute window
  - ~2,778 hours of activity bouts

Bout level statistics (person/day)
(n = 12,784 for 695 subjects)

description			
bout characteristics	**unit**	**mean**	**sd**
bout duration	min	14.1	12.0
mean counts within bout	count	1,524.2	581.8
sum of counts within bout	count	44,802.8	53,966.2
GPS coverage	**unit**	**number**	**%**
bouts w/ any gps record	number	8,864	70.1%
bouts w/ gps coverage >= 90%	number	6,170	48.3%

GPS and accelerometer monitoring
7 consecutive days

Minutes per day	A		B	
	Accelero-meter	GPS	Accelero-meter	GPS
Total observed	1234	262	1260	741
Total MPA	38	14	24	16
Total VPA	5	4	2	2
Total driving (travel diary)	27		70	



From Troiano et al.(2008). Physical activity in the United States measured by accelerometer. Med & Sci in Sports & Exercise.

- MPA : accelerometer count >= 1010 per 30-sec epoch
- VPA: accelerometer count >= 2999 per 30-sec epoch

Time inside buffer = sum of line segment durations

(estimated for the portion of a segment intersecting buffer)

Scully J Y et al. in progress