Varying Influences of the Built Environment on Household Travel in Fifteen Diverse Regions of the United states

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Varying influences of the built environment on household travel in 15 diverse regions of the United States

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Outline

- Introduction
- Literature review
- Methods
- Data
- Variables
- Statistical analysis
- Results
- Discussion
- Computations
- Applications

Introduction

Urban sprawl

Highway congestion

Automobile use

Oil dependence

Physical inactivity and obesity

Climate change

THE UNIVERSITY OF UTAH

But how much effect can the built environment have on automobile use, walking, biking, and transit use?

Literature

- More than 200 Empirical Studies
- Collectively Relate All Aspects of Travel to All Aspects of Built Environment
- Vast Majority Control for Sociodemographic Differences
- Vast Majority Use Statistical Methods
- A Few Come Close to the Normative Model

Study Areas

This paper addresses the external validity issue in a different manner, by pooling household travel and built environment data from ***15 diverse U.S. regions***.

Sample

Households and trips

	Survey Date	Surveyed Households	Surveyed Trips
Atlanta	2011	9,575	93,681
Austin	2005	1,450	14,249
Boston	2011	7,826	86,915
Denver	2010	5,551	67,764
Detroit	2005	939	14,690
Eugene	2011	1,679	16,563
Houston	2008	5,276	59,552
Kansas City	2004	3,022	31,779
Minneapolis-St. Paul	2010	8,234	79,236
Portland	2011	4,513	47,551
Provo-Orem	2012	1,464	19,255
Sacramento	2000	3,520	33,519
Salt Lake City	2012	3,491	44,576
San Antonio	2007	1,563	14,952
Seattle	2006	3,908	40,450
Total		**62,011**	**664,732**

Dependent Variables

variable	description	N	Mean	S.D.
dependent variables				
anyvmt	any household VMT (1=yes, 0=no)	62,011	0.94	0.24
lnvmt	natural log of household VMT (for households with any VMT)	58,011	3.07	1.03
autotrips	household auto trips	62,011	8.4	7.11
anywalk	any household walk trips (1=yes, 0=no)	62,011	0.24	0.43
walktrips	household walk trips (for households with any walk trips)	14,672	4.08	3.51
anybike	any household walk trips (1=yes, 0=no)	62,011	0.04	0.2
biketrips	household bike trips (for households with any bike trips)	2,495	3.24	2.63
anytransit	any household walk trips (1=yes, 0=no)	62,011	0.11	0.31
transittrips	household transit trips (for households with any transit trips)	6,719	2.97	2.22

7D variables consistently defined

- **Density**
- **Diversity**
- **Design**
- **Destination Accessibility**
- **Distance to Transit**
- **Development Scale**
- **Demographics**

Individual Level Variables

- **hhsize** – Number of members of the household
- **hhworkers** – Number of workers in the household
- **hhincome**– Household income in 2012 dollars

D Variable	Measurement
Density	Density is always measured as the variable of interest per unit of area. The area can be gross or net, and the variable of interest can be population, dwelling units, employment, or building floor area. Population and employment are sometimes summed to compute an overall activity density per areal unit.
Diversity	Diversity measures pertain to the number of different land uses in a given area and the degree to which they are balanced in land area, floor area, or employment. Entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies. Jobs-to-housing or jobs-to-population ratios are less frequently used.
Design	Design measures include average block size, proportion of four-way intersections, and number of intersections per square mile. Design is also occasionally measured as sidewalk coverage (share of block faces with sidewalks); average building setbacks; average street widths; or numbers of pedestrian crossings, street trees, or other physical variables that differentiate pedestrian-oriented environments from auto-oriented ones.
Destination accessibility	Destination accessibility measures ease of access to trip attractions. It may be regional or local (Handy 1993). In some studies, regional accessibility is simply distance to the central business district. In others, it is the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. The gravity model of trip attraction measures destination accessibility. Local accessibility is a different animal. Handy (1993) defines local accessibility as distance from home to the closest store.
Distance to transit	Distance to transit is usually measured as an average of the shortest street routes from the residences or workplaces to the nearest rail station or bus stop. Alternatively, it may be measured as transit route density, distance between transit stops, or the number of stations per unit area. In this literature, frequency and quality of transit service are overlooked.

Buffer Variables

- ACTDEN – Population + employment density per square mile
- JOBPOP – Balance of jobs to population within the buffer
- LANDMIX – Entropy index that captures the variety of land uses based on acreage within the buffer
- INTDEN - Number of intersections within the buffer per square mile of gross area
- PCT4W – Percentage of 4-way intersections with the buffer
- EMP10A, EMP20A, EMP30A – Total employment within 10, 20, and 30 minutes by automobile
- EMP30T – Total employment within 30 minutes by transit
- STOPDEN – Number of bus stops within the buffer per square mile of gross area
- RAIL – Rail station located within the MXD (1 = yes, 0=no)

Statistical analysis

- **Multilevel modeling (MLM / HLM)** partitions variance between the household/neighborhood level (Level 1) and the region level (Level 2) and then seeks to explain the variance at each level in terms of D variables.

- **Two-stage "hurdle" model**
  - The stage 1 categorizes households as either generating VMT, walk, bike, transit trips or not.
  - The stage 2 model estimates the amount of VMT and number of auto, walk, bike, and transit trips generated for households with any VMT, auto, walk, bike, and transit trips.

Results

	Outcome variable is anyvmt			
	coefficient	standard error	t-ratio	p-value
Constant	3.202	0.316	10.108	<0.001
hhsize	0.385	0.052	7.347	<0.001
hhworkers	0.277	0.064	4.297	<0.001
hhincome				
base	0.0426	0.0097	4.349	0.001
sprawl_index10	-0.000226	0.000083	-2.731	0.018
emp10a	-0.0193	0.0043	-4.441	<0.001
entropyqmi	-0.891	0.082	-10.776	<0.001
stopdenqmi	-0.0033	0.0007	-4.444	<0.001
actden1mi	-0.0144	0.0028	-5.091	<0.001
intden1mi	-0.0027	0.0012	-2.168	0.03
int4w1mi	-0.0114	0.0015	-7.297	<0.001
regpop	-0.000253	0.000088	-2.866	0.014
Pseudo-R2: 0.74				

Results

	Outcome variable is lnvmt			
	coefficient	standard error	t-ratio	p-value
constant	2.846	0.063	44.619	<0.001
hhsize	0.168	0.008	20.51	<0.001
hhworkers	0.189	0.006	28.429	<0.001
hhincome	0.0026	0.0003	8.654	<0.001
emp10a	-0.0065	0.0018	-3.548	0.001
emp30t	-0.0034	0.0004	-7.951	<0.001
jobpopqmi	-0.044	0.018	-2.405	0.016
actden1mi	-0.0064	0.0028	-2.244	0.041
entropy1mi	-0.219	0.036	-6.034	<0.001
intden1mi	-0.0018	0.0002	-8.382	<0.001
int4w1mi	-0.0024	0.0005	-4.298	<0.001
Pseudo-R2: 0.22				

Results

	Outcome variable is autotrips			
	coefficient	standard error	t-ratio	p-value
constant	1.289	0.046	27.871	<0.001
hhsize	0.305	0.009	33.009	<0.001
hhworkers	0.007	0.004	1.700	0.086
hhincome	0.0015	0.0002	6.812	<0.001
emp20a	0.00104	0.00028	3.753	<0.001
entropyqmi	-0.065	0.014	-4.495	<0.001
actdenhmi	-0.0043	0.0008	-4.934	<0.001
stopdenhmi	0.0007	0.00016	-4.414	<0.001
jobpop1mi	0.022	0.012	1.809	0.07
Pseudo-R2: 0.52				

Results

	Outcome variable is anywalk			
	coefficient	standard error	t-ratio	p-value
Constant	-4.957	0.273	-18.113	<0.001
hhsize	0.419	0.023	17.524	<0.001
emp30t	0.009	0.002	4.063	<0.001
entropyqmi	0.497	0.066	7.449	<0.001
intdenhmi	0.0019	0.00033	5.902	<0.001
stopdenhmi	0.0048	0.00107	4.511	<0.001
actden1mi	0.017	0.0029	5.85	<0.001
int4w1mi	0.0088	0.002	4.404	0.001
sprawl_index10	0.0146	0.0022	6.491	<0.001
Pseudo-R2: 0.001				

Results

	Outcome variable is walktrips			
	coefficient	standard error	t-ratio	p-value
Constant	0.325	0.178	1.828	0.09
hhsize	0.164	0.0079	20.77	<0.001
hhworkers	-0.06	0.0099	-6.057	<0.001
hhincome	-0.0009	0.0002	-4.521	<0.001
emp30t	0.0031	0.0014	2.199	0.045
actdenqmi	0.00095	0.00054	1.765	0.077
int4wqmi	0.0012	0.0004	3.218	0.002
entropyhmi	0.282	0.069	4.061	<0.001
stopdenhmi	0.0018	0.00015	11.949	<0.001
sprawl_index10	0.00328	0.0017	1.929	0.075
Pseudo-R2: 0.22				

Results

	Outcome variable is anybike			
	coefficient	standard error	t-ratio	p-value
Constant	-6.689	0.52	-12.861	<0.001
hhsize	0.386	0.03	12.89	<0.001
hhworkers	0.181	0.044	4.072	<0.001
jobpophmi	0.362	0.102	3.552	0.001
intden1mi	0.0032	0.0017	1.911	0.076
int4w1mi	0.0158	0.005	3.127	0.008
sprawl_index10	0.01	0.005	1.752	0.103
Pseudo-R2: NA				

Results

	Outcome variable is biketrips			
	coefficient	standard error	t-ratio	p-value
Constant	0.714	0.068	10.481	<0.001
hhsize	0.109	0.007	14.506	<0.001
int4w1mi	0.0041	0.0008	4.948	<0.001
stopden1mi	0.0028	0.001	2.797	0.006
regpop	-0.000039	0.000018	-2.202	0.046
Pseudo-R2: 0.13				

Results

	Outcome variable is anytransit			
	coefficient	standard error	t-ratio	p-value
Constant	-4.865	0.411	-11.815	<0.001
hhsize	0.104	0.013	7.986	<0.001
hhworkers	0.321	0.037	8.624	<0.001
hhincome	-0.0081	0.0019	-4.165	0.001
emp30t	0.011	0.005	2.254	0.041
entropyqmi	0.625	0.095	6.541	<0.001
jobpop1mi	0.246	0.12	2.054	0.04
int4w1mi	0.0075	0.0028	2.666	0.008
stopden1mi	0.014	0.0028	4.874	<0.001
sprawl_index10	0.01	0.0035	2.933	0.012
Pseudo-R2: 0.71				

Results

	Outcome variable is transittrips			
	coefficient	standard error	t-ratio	p-value
Constant	0.525	0.124	4.236	0.001
hhsize	0.092	0.02	4.538	<0.001
hhworkers	-0.018	0.008	-2.203	0.028
hhincome	-0.0027	0.0002	-13.515	<0.001
emp30t	0.0021	0.0008	2.533	0.012
stopdenqmi	0.00048	0.00011	4.345	<0.001
entropyhmi	0.188	0.053	3.512	0.001
jobpop1mi	0.187	0.086	2.182	0.029
regpop	0.000066	0.000032	2.064	0.059
Pseudo-R2: 0.17				

Discussion

Generalizing across the preceding models, four conclusions emerge with great relevance to travel modeling:

- Socioeconomic, built environment, and transit service variables all influence household travel decisions, though based on the significance levels alone, the socioeconomic influences appear strongest.
- The decision to use alternative modes is influenced by different factors than the frequency of use once the decision is made, and the use of hurdle models is therefore warranted in household travel modeling.

- All the D variables influence household travel decisions, but consistent with the meta-analysis by Ewing and Cervero (2010), the strongest influences are diversity, design, and destination accessibility, and the weakest influence is density.
- The relevant built environment for travel analysis is anywhere from ¼ to one mile or more in scale, but the largest scale seems have more predictive power than the smallest scale.

Applications

- The models developed in this study have already been incorporated into Envision Tomorrow Plus (ET+), a user-friendly, transparent, and open soure scenario planning software package.

envision tomorrow
a suite of urban and regional planning tools

Cleveland, OH

Austin, TX

Kansas City, KS

San Diego, CA

Salt Lake City, UT

Others …

- The models can be used to post process outputs of conventional four-step travel demand models to accounting for density, diversity, and design effects on household travel.
- Models could also be applied to traffic impact analysis, such as adjusting ITE trip rates to reflect how greater densities and other environmental attributes would affect trip making.
- Sketch planning application
  - *climate action planning* – estimating VMT reductions in urbanized areas, and to translate these in turn into CO2 reductions.
  - *Assess health impacts* – computing increases in walking and biking through simulating changes in the D variables under future scenarios.

Norm Marshall of Smart Mobility

Cleveland National Forest Foundation

Transit and Density Advocate

SAN DIEGO COUNTY

SANDAG

- very highway oriented LRTP
- sprawl was inevitable 10 years – independent of transportation investment
- compact development inevitable, regardless of transportation investments
- putting money into express lanes – some high profile rail projects - expensive

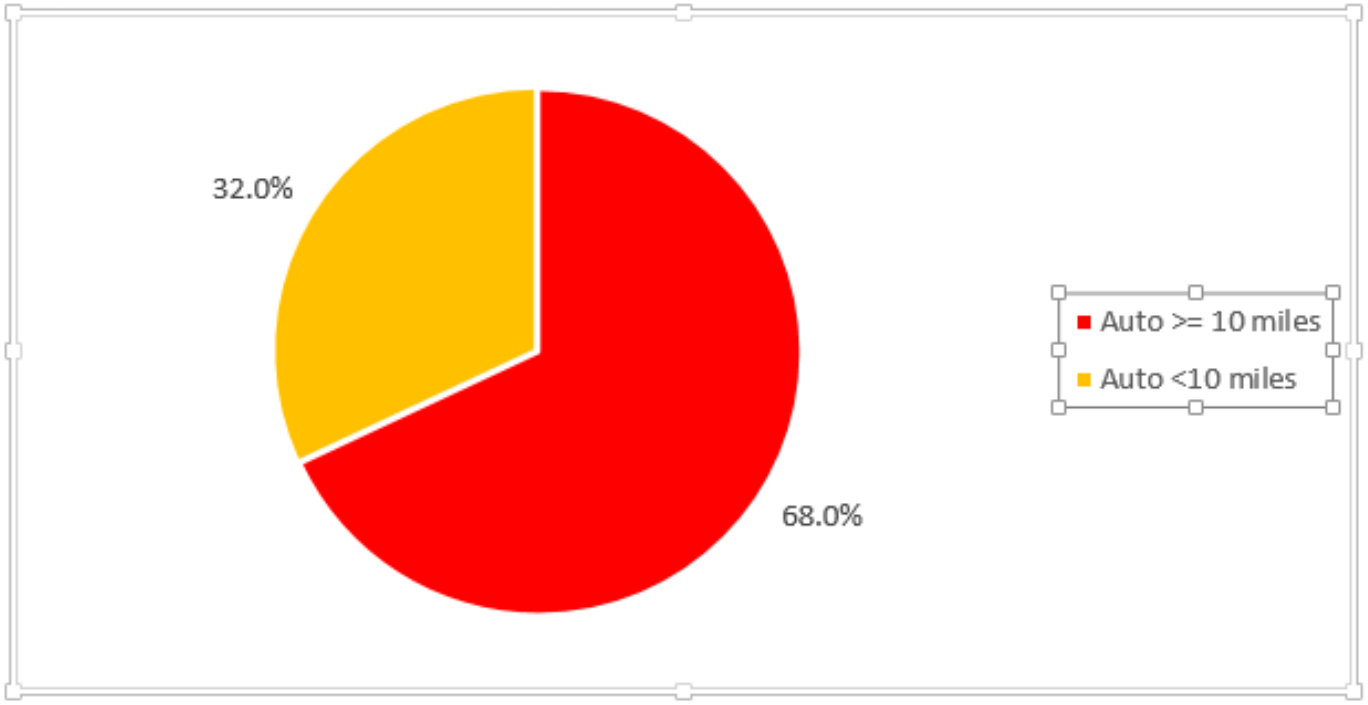
PB Study for SANDAG

- 30 percent transit mode share goals going into downtown
- 20 to 25 percent central core – 50 square miles

2012 CHTS

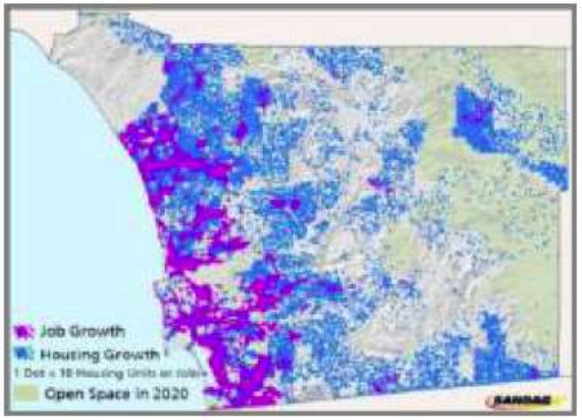
	Share of Person Trips
Auto >= 10 miles	20.2%
Auto <10 miles	66.3%
Transit	4.2%
Bike	1.5%
Walk	7.9%

2012 CHTS

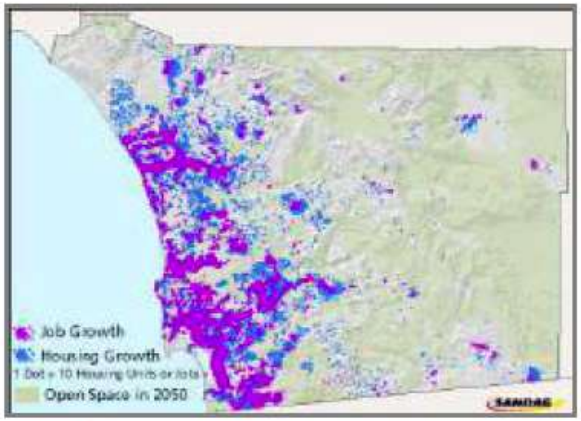


Big Claims

Series 9 Forecast:
Pre-Regional Comprehensive Plan

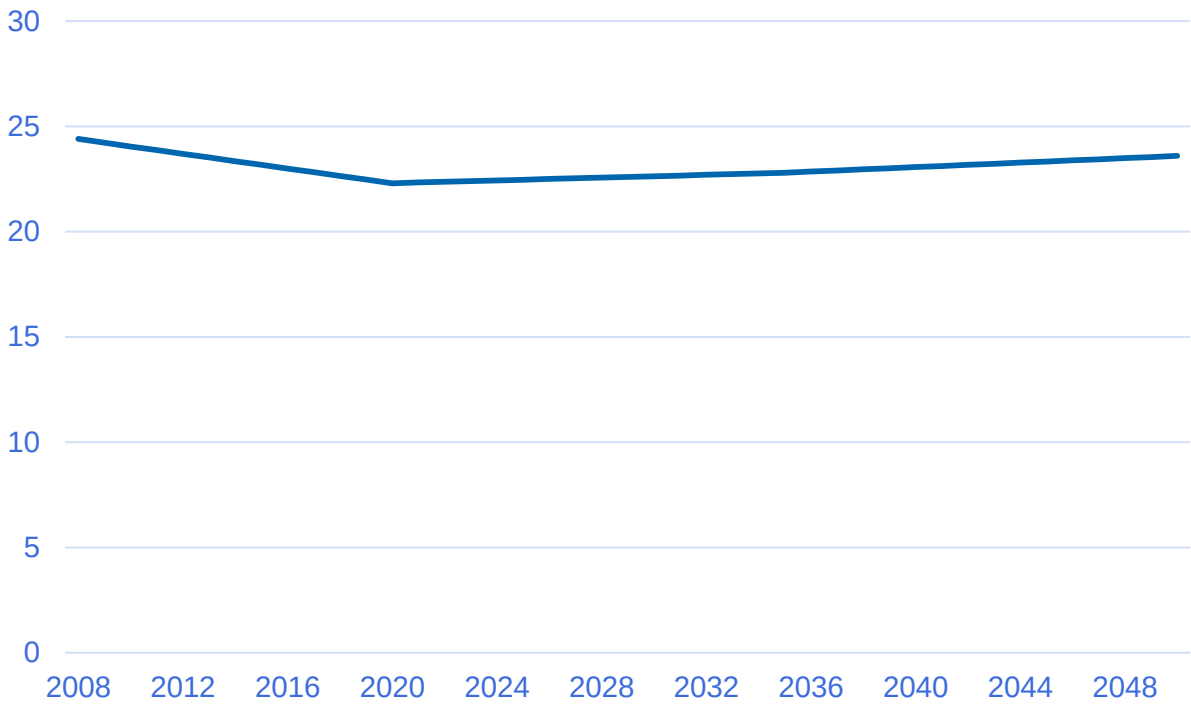


Series 13 Forecast:
Current Plans

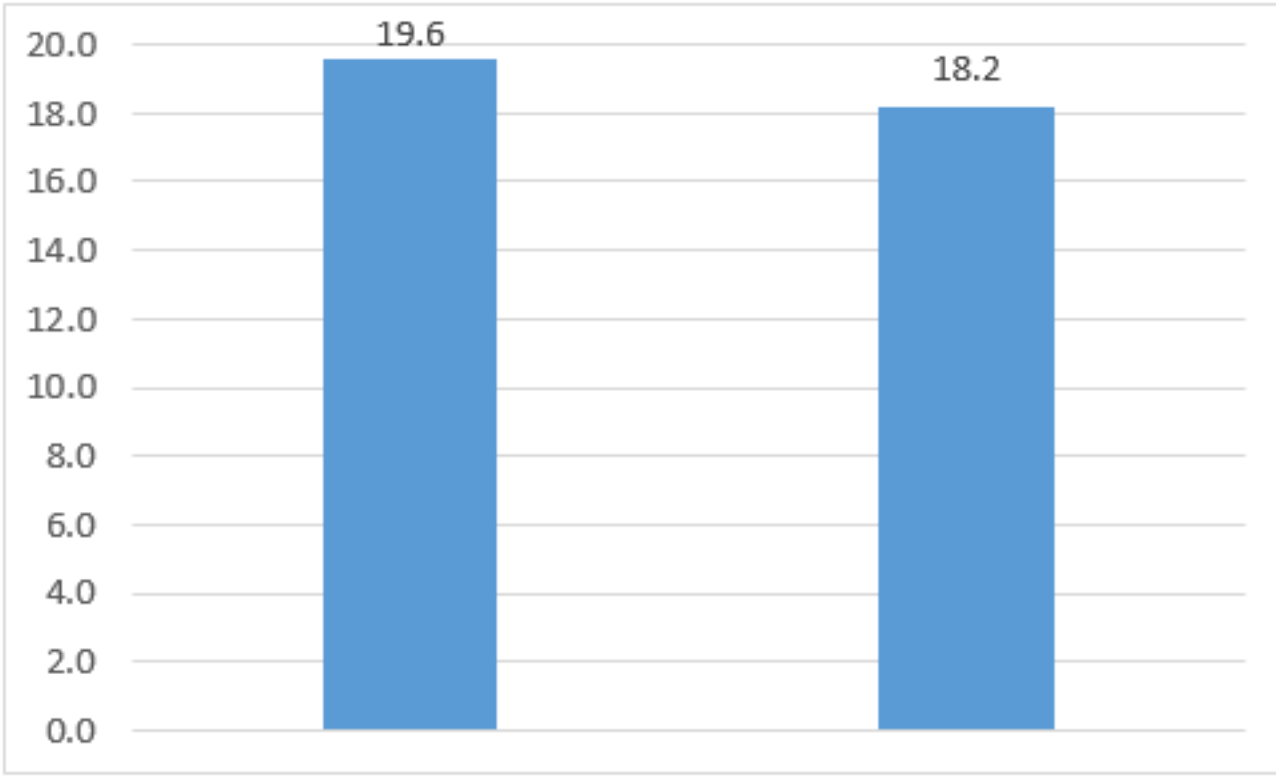


25%-30% GHG reductions

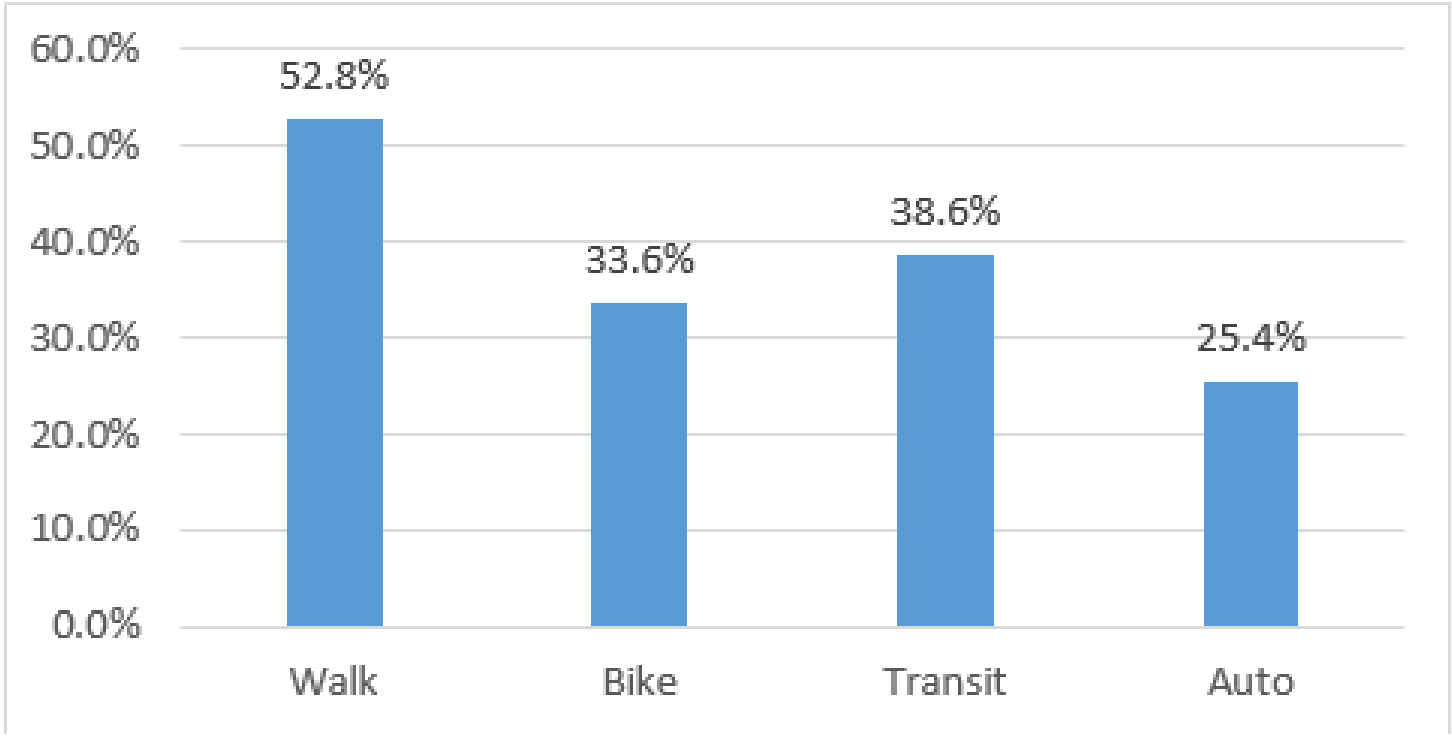
SANDAG Forecast of VMT/person



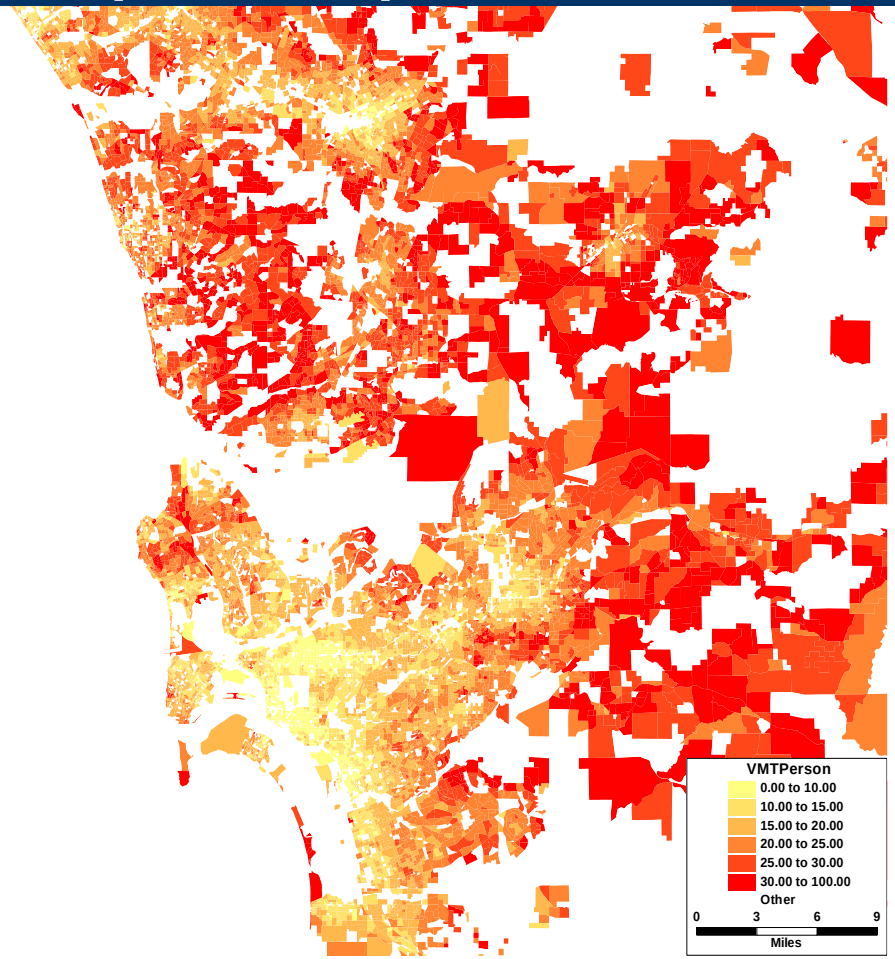
ET+ Forecast of VMT/person



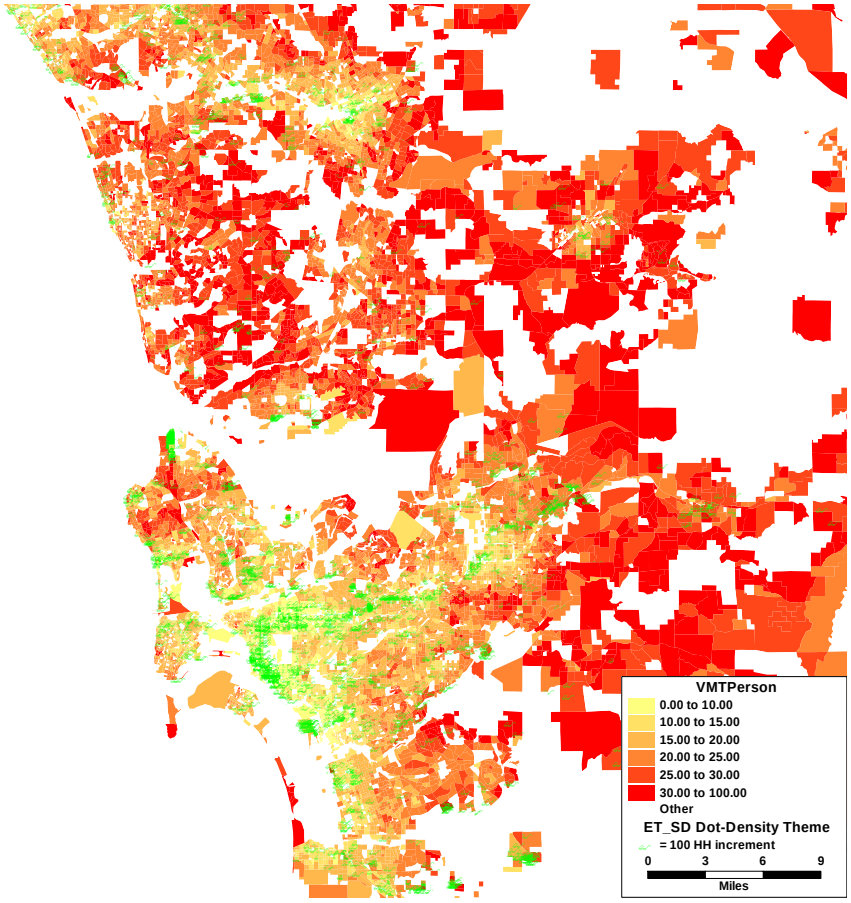
Mode Shifts with ET+



VMT per capita with ET+



Growth in Areas of Lower VMT



Thank you !