GROWING COOLER

THE EVIDENCE ON URBAN DEVELOPMENT AND CLIMATE CHANGE



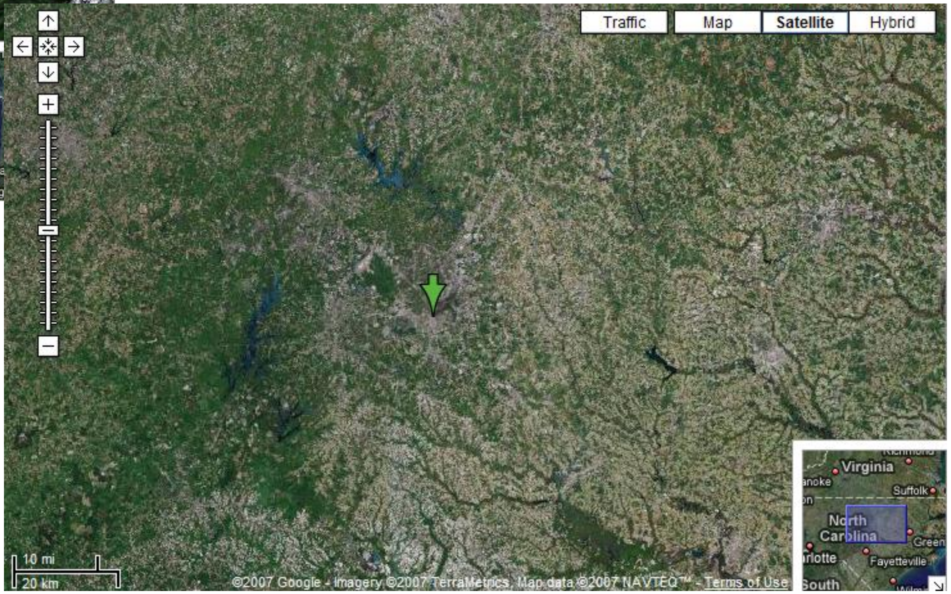
REID EWING
KEITH BARTHOLOMEW
STEVE WINKELMAN
JERRY WALTERS
DON CHEN

ULI Urban Land Institute

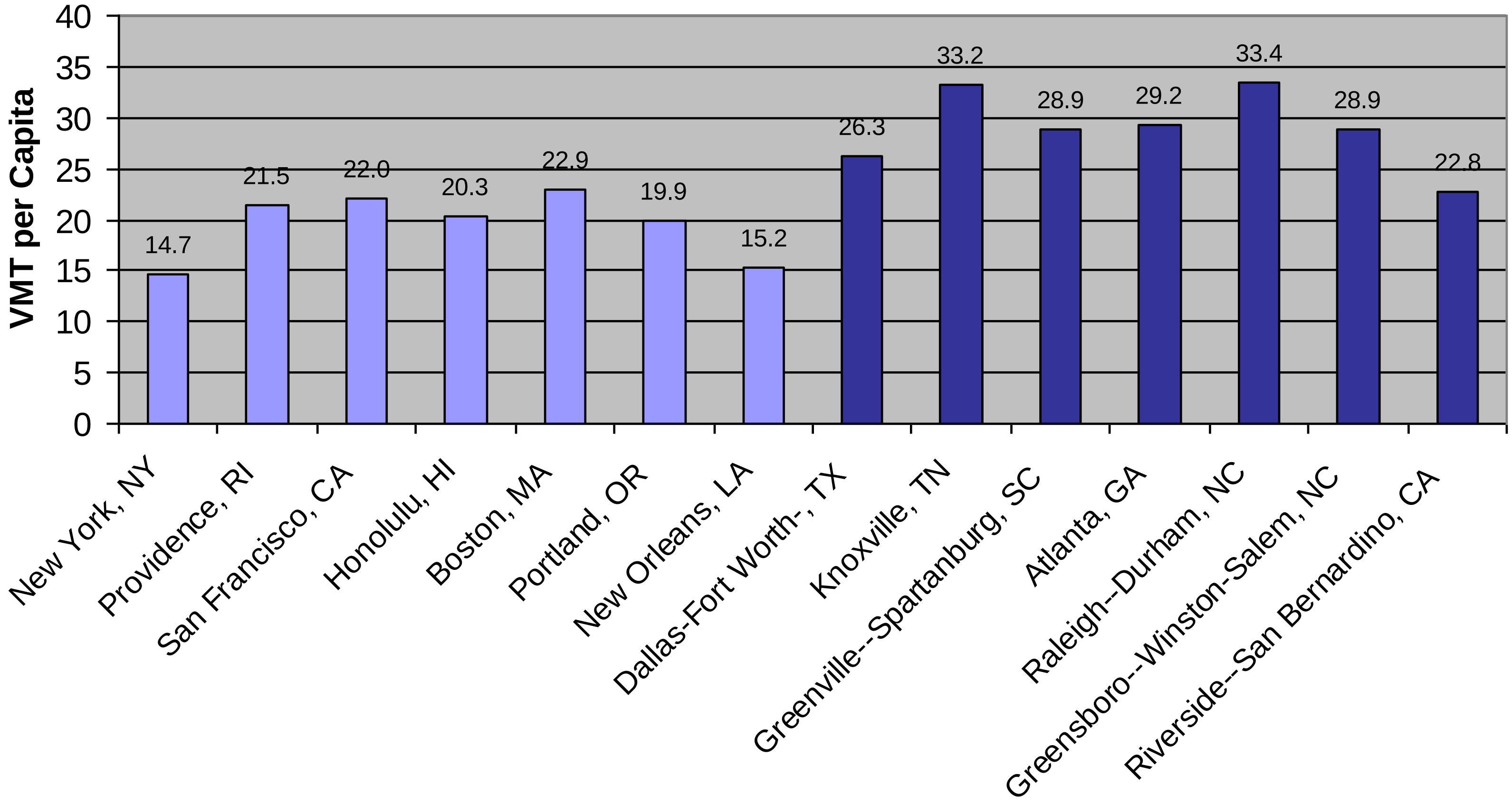
Main Question Addressed

What reduction in vehicle miles traveled (VMT) is possible in the United States with compact development rather than continuing urban sprawl?

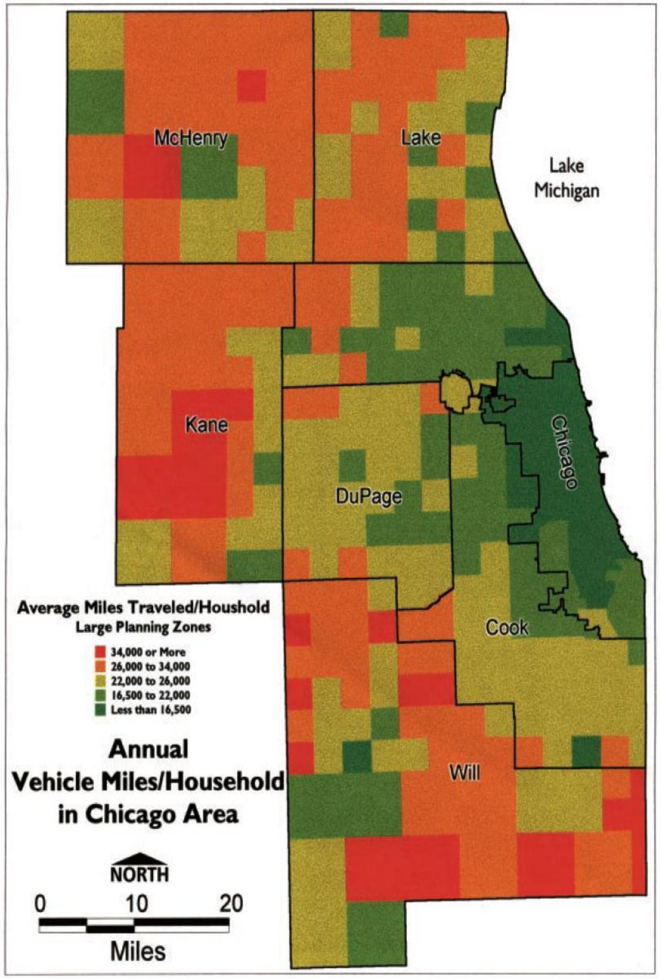
Portland vs. Raleigh



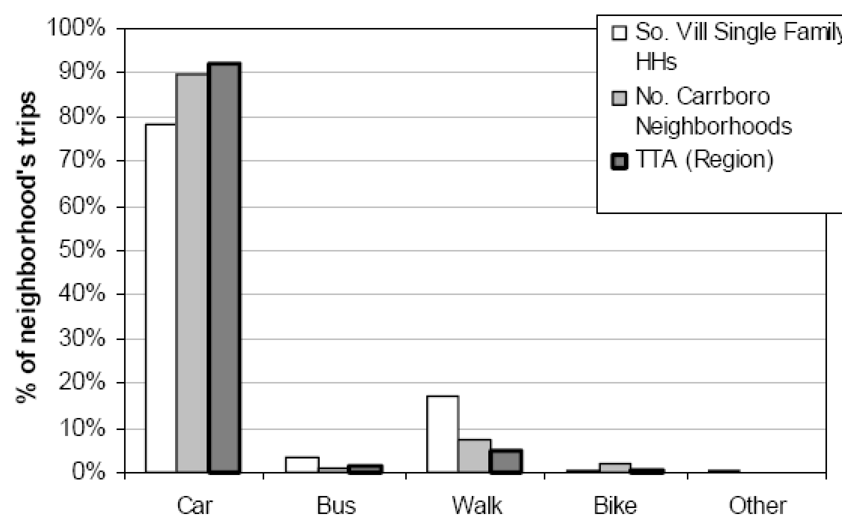
35% Less VMT with Compact Development



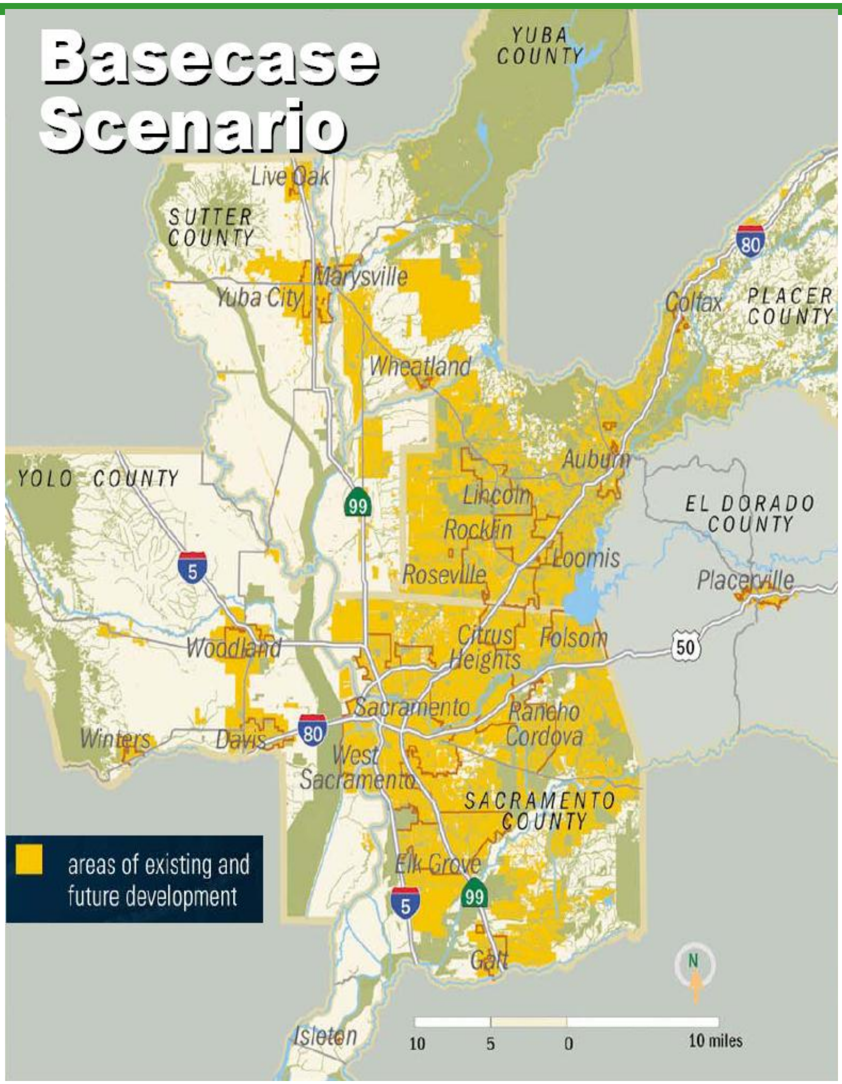
Disaggregate Travel Studies

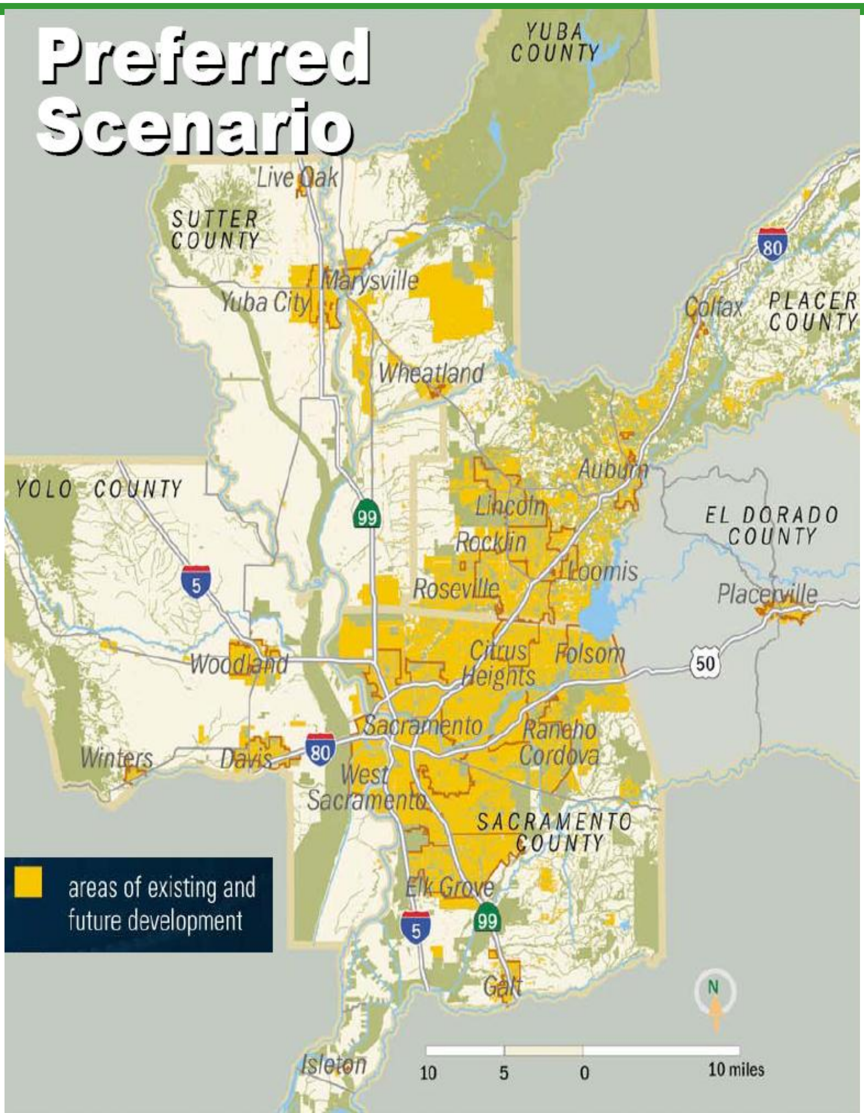


Southern Village (40% lower)



Regional Simulations



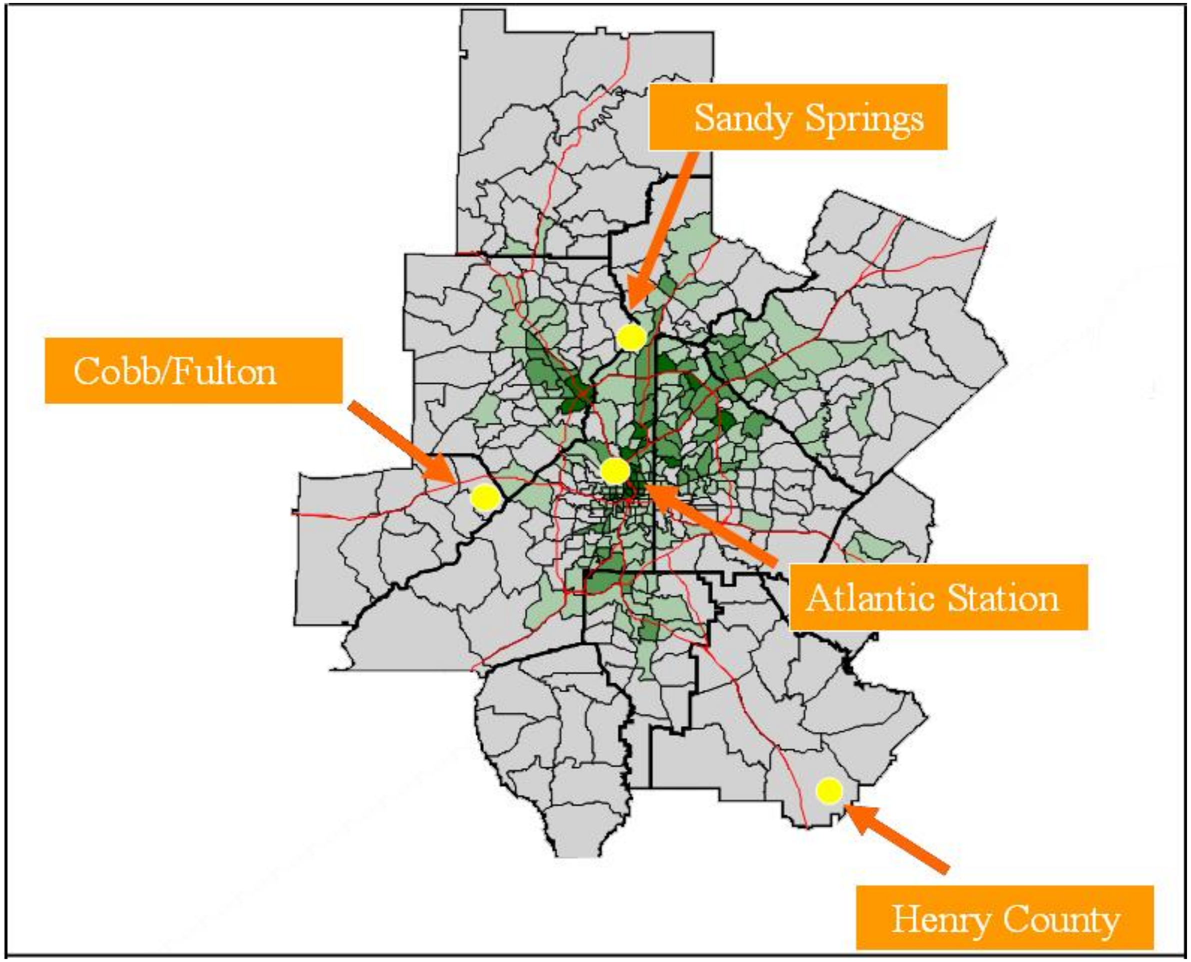


Simulation Results

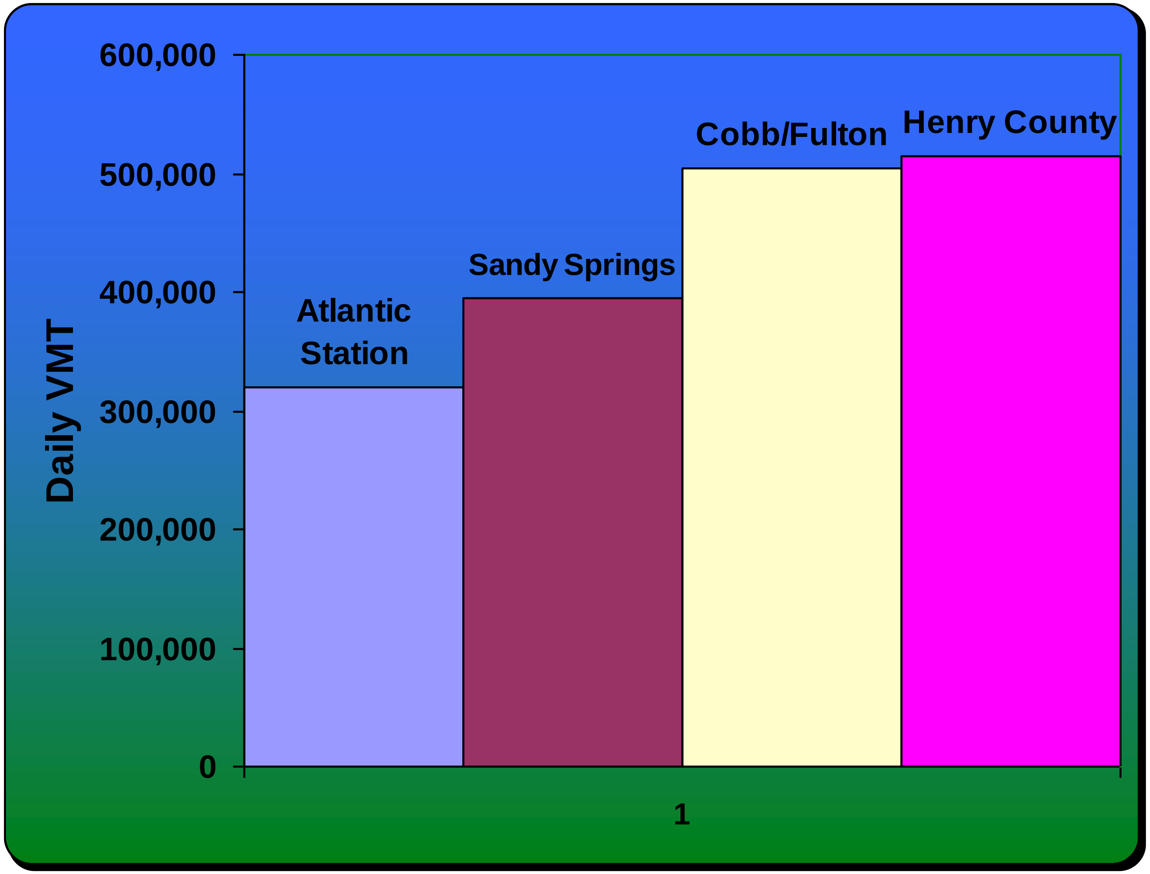
26% reduction in VMT by 2050

15% reduction in CO_2 by 2050

Atlantic Station vs. Henry County



1/3 Savings Due to Regional Accessibility



Actual Results Are Better

- 8 VMT per Day for Residents
- 11 VMT per Day for Employees

NATIONAL CENTER FOR SMART GROWTH RESEARCH & EDUCATION

Answer to 1st Question

20-40% VMT Reduction for Each Increment of Compact Development

Symbiotic Relationship

- TCRP H-46
  - Neighborhood level model (Household model)
  - Urbanized area model (VMT)

- TCRP H-45
  - Urban design measures

- HUD Sustainable Communities Grant
  - MXD operational model
  - 7D household operational model using multilevel modeling (VMT)

Multiplier Estimates

Study	Cities	Land-Use Multiplier	Methodological Issues
Pushkarev & Zupan (1982)	U.S. Metro areas with at least 2 million population	4	Correlation only; does not show causal relationship of transit
Newman & Kenworthy (1999)	32 Global cities	5 to 7	Correlation only; does not show causal relationship of transit
Holtzclaw (2000)	Matched pairs in the San Francisco Bay Area	1.4 to 9	Correlation only; does not show causal relationship of transit.
Neff (1996)	U.S. urbanized areas	5.4 to 7.5	Assumes fixed travel time budgets.
Bailey et al. (2008)	Entire U.S.	1.9	Accounts only for land-use effects caused by transit. The structural equations modeling used had relatively low explanatory power; may not be applicable to sub-national scales.
New York MTA (2009)	MTA Service Territory	1.29 to 6.34	Wide variation in results depending upon parameters selected.
Los Angeles Metro (2012)	Los Angeles County	5.3	Time series regression showed no effect; regional analysis comparing counties in greater LA produced the indicated multiplier.

Triangulate to Solid Estimates

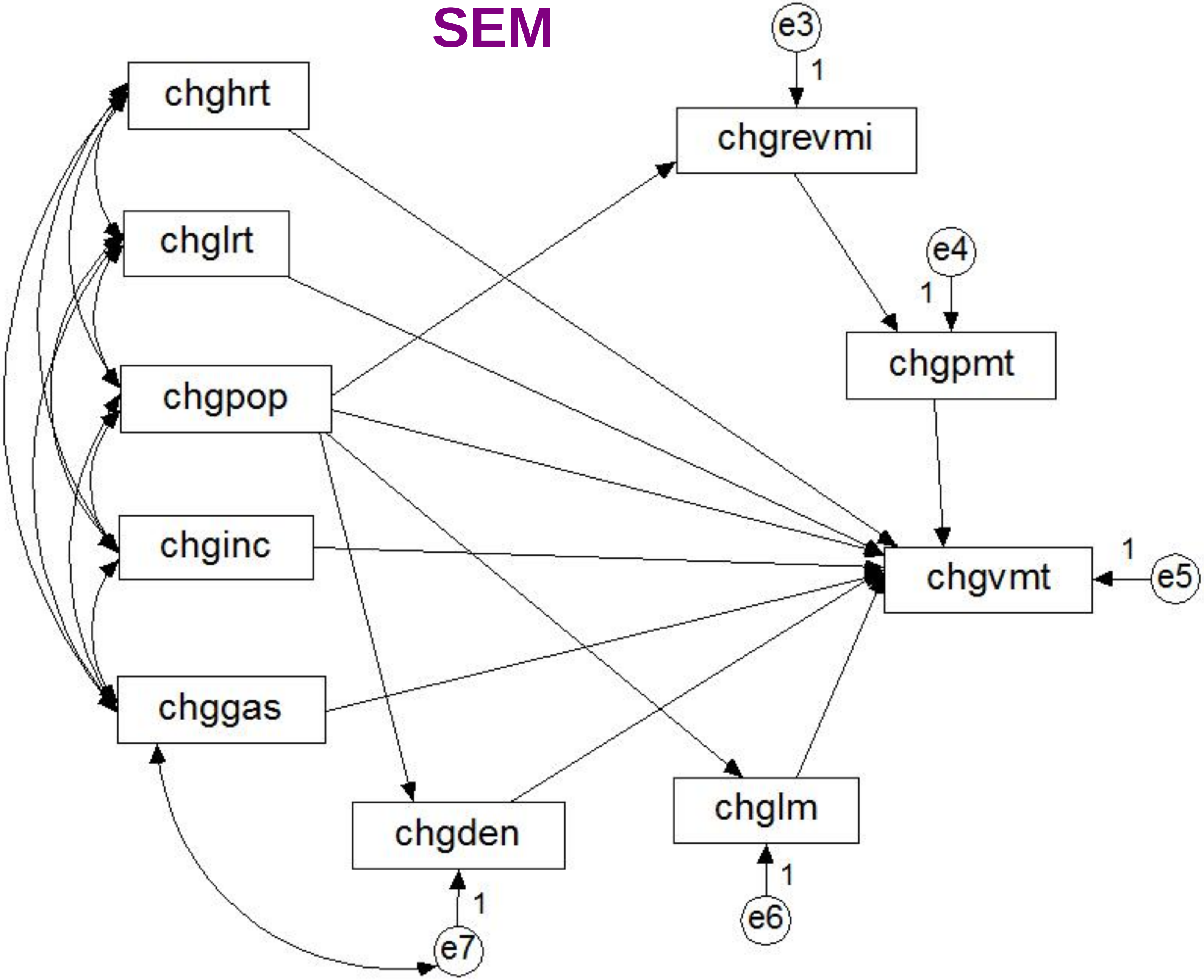
- Urbanized Area Analysis
- Station Area Analysis
- Household Level Analysis

Urbanized Area Analysis

Chapter 8

The Combined Effect of Compact Development, Transportation Investments, and Road Pricing

SEM



e3
1
chghrt
chgrevmi
chglrt
e4
1
chgpmt
chgpop
chginc
chgvmt
1
e5
chggas
chglm
chgden
1
1
e6
e7

Elasticities of VMT

	Cross Sectional	Longitudinal	Best Estimate
Population	0.97	0.874	0.95
Per capita income	0.531	0.538	0.54
Population density	–0.213	–0.152	–0.30
Highway lane miles	0.463	0.684	0.55
Transit revenue miles	–0.075	–0.023	–0.06
Transit passenger miles	–0.068	–0.03	–0.06
Real fuel price	NA	–0.171	–0.17

Average Annual Growth Rates

	Historical (1985–2005)	Trend (2007–2030)	Low-Carbon Scenario (2007–2030)
VMT	3.5	Modeled outcome	Modeled outcome
Population	1.8	1.2	1.2
Per capita income	1.2	1.2	1.2
Population density	0	0	1.0
Highway lane miles	2.0	1.5	0.5
Transit revenue miles	3.8	3.8	6.3
Real fuel price	0.4	–0.3	2.4

Urban VMT Reduction

	Elasticities of VMT with Respect to Policy Variables	Change in Annual Growth Rates of Policy Variables (% above/below Trend)	Effect on Annual VMT Growth Rate (% below Trend)
Population density	–0.30	1	–0.077
Highway lane miles	0.55	–1	–0.114
Transit revenue miles	–0.06	2.5	–0.046
Real fuel price	–0.17	2.7	–0.144
Total effect	NA	NA	–0.38

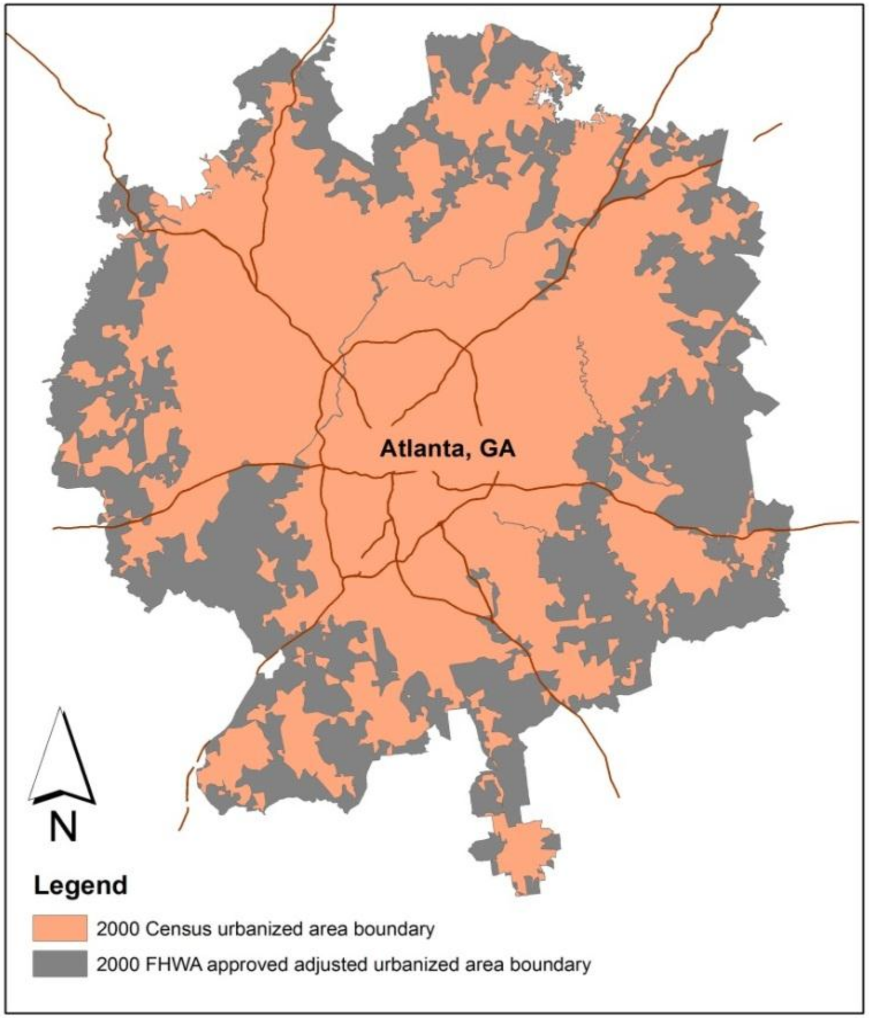
Three Shortcomings of TTI Database

- Small sample size: The 2010 TTI database contains data for 101 large urbanized areas.
- No land use variables: Previous versions of the TTI database contained one land use variable, the gross density of each urbanized area, but this measure has been dropped from more recent versions.
- Discrepancies with official databases: The current TTI database contains estimates of transit passenger miles that differ from the official figures in the National Transit Database.

New Analysis

- Update to 2010
- UA Shape Files
- 443 UAs -> 315 UAs
- Additional Variables (highway lane miles, route coverage, service frequency)
- Refined Variables (VMT, fuel prices, compactness index, income)

Census vs. FHWA UAs

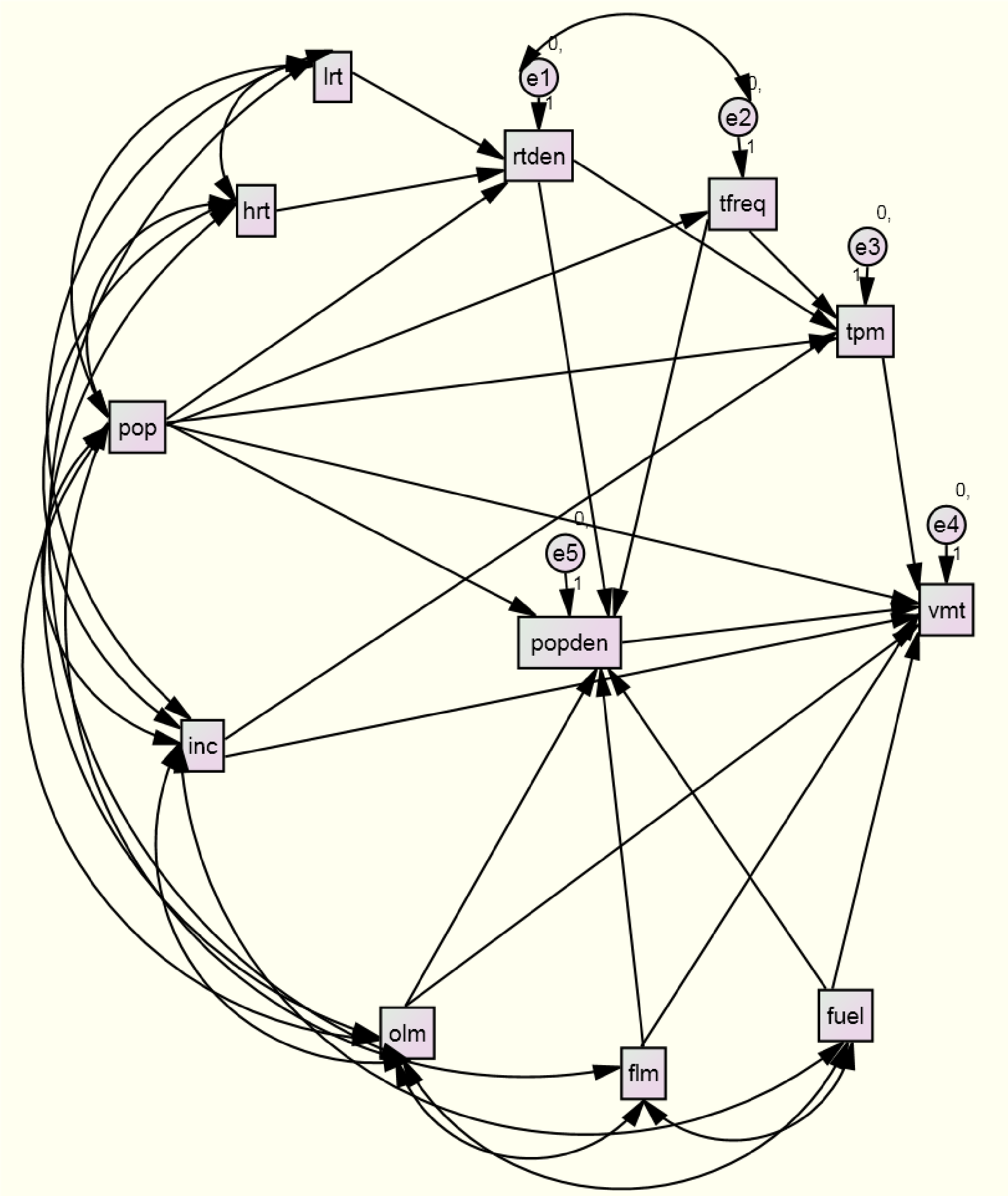


With Service Frequency and Route Density

Sample

The initial sample consisted of 443 urbanized areas. Some small urbanized areas were dropped for lack of data (fuel price, urban land area, etc.) and/or for lack of basic transportation infrastructure (both transit service and freeway mileage). Our final database consisted of 315 urbanized areas, including nearly all the large areas and most of the small ones.

Variable	Definition	Source	Mean	SD
Dependent variable				
vmt	Natural log of daily VMT per capita	FHWA Highway Statistics	3.09	0.26
Exogenous variables				
pop	Natural log of population (in thousands)	U.S. Census	12.45	1.16
inc	Natural log of income per capita	American Community Survey	10.13	0.19
fuel	Natural log of average fuel price metropolitan average fuel price	Oil Price Information Service	1.03	0.06
flm	Natural log of freeway lane miles per 1,000 population	FHWA Highway Statistics	-0.46	0.53
olm	Natural log of other lane miles per 1,000 population	FHWA Highway Statistics NAVTEQ	0.91	0.32
hrt	Directional route miles of heavy-rail lines per 100,000 population*	National Transit Database	0.04	0.23
lrt	Directional route miles of light-rail lines per 100,000 population*	National Transit Database	0.09	0.33
Endogenous variables				
popden	Natural log of gross population density	U.S. Census	7.32	0.44
rtden	Natural log of transit route density per square mile	National Transit Database	0.67	0.82
tfreq	Natural log of transit service frequency	National Transit Database	8.51	0.59
fare	Natural log of fare revenue per passenger mile	National Transit Database	-1.67	0.60
tpm	Natural log of annual transit passenger miles per capita	National Transit Database	3.76	1.12


lrt
hrt
pop
inc
olm
flm
fuel
rtden
tfreq
tpm
vmt
popden
e1
e2
e3
e4
e5
0,
1

Goodness-of-Fit

N = 315
Chi-square = 26.5
Degrees of freedom = 22
Probability level =0.23

Regression Weights

			coeff	S.E.	C.R.	P
tfreq	<---	pop	0.235	0.025	9.234	<0.001
rtden	<---	lrt	0.495	0.131	3.787	<0.001
rtden	<---	hrt	0.355	0.187	1.9	0.057
rtden	<---	pop	-0.103	0.042	-2.463	0.014
popden	<---	olm	-0.552	0.047	-11.748	<0.001
popden	<---	rtden	0.197	0.017	11.528	<0.001
tpm	<---	pop	0.141	0.041	3.44	<0.001
tpm	<---	tfreq	0.796	0.077	10.406	<0.001
popden	<---	tfreq	0.187	0.023	8.035	<0.001
tpm	<---	rtden	0.839	0.049	17.124	<0.001
popden	<---	flm	-0.108	0.02	-5.383	<0.001
popden	<---	pop	0.066	0.011	5.849	<0.001
popden	<---	fuel	0.733	0.236	3.111	0.002
tpm	<---	inc	0.902	0.208	4.345	<0.001
vmt	<---	fuel	-0.448	0.238	-1.883	0.06
vmt	<---	popden	-0.238	0.043	-5.577	<0.001
vmt	<---	olm	0.04	0.051	0.784	0.433
vmt	<---	flm	0.133	0.021	6.412	<0.001
vmt	<---	inc	0.304	0.062	4.889	<0.001
vmt	<---	tpm	-0.016	0.011	-1.427	0.154
vmt	<---	pop	0.078	0.012	6.635	<0.001

Direct, Indirect, and Total Effects on VMT

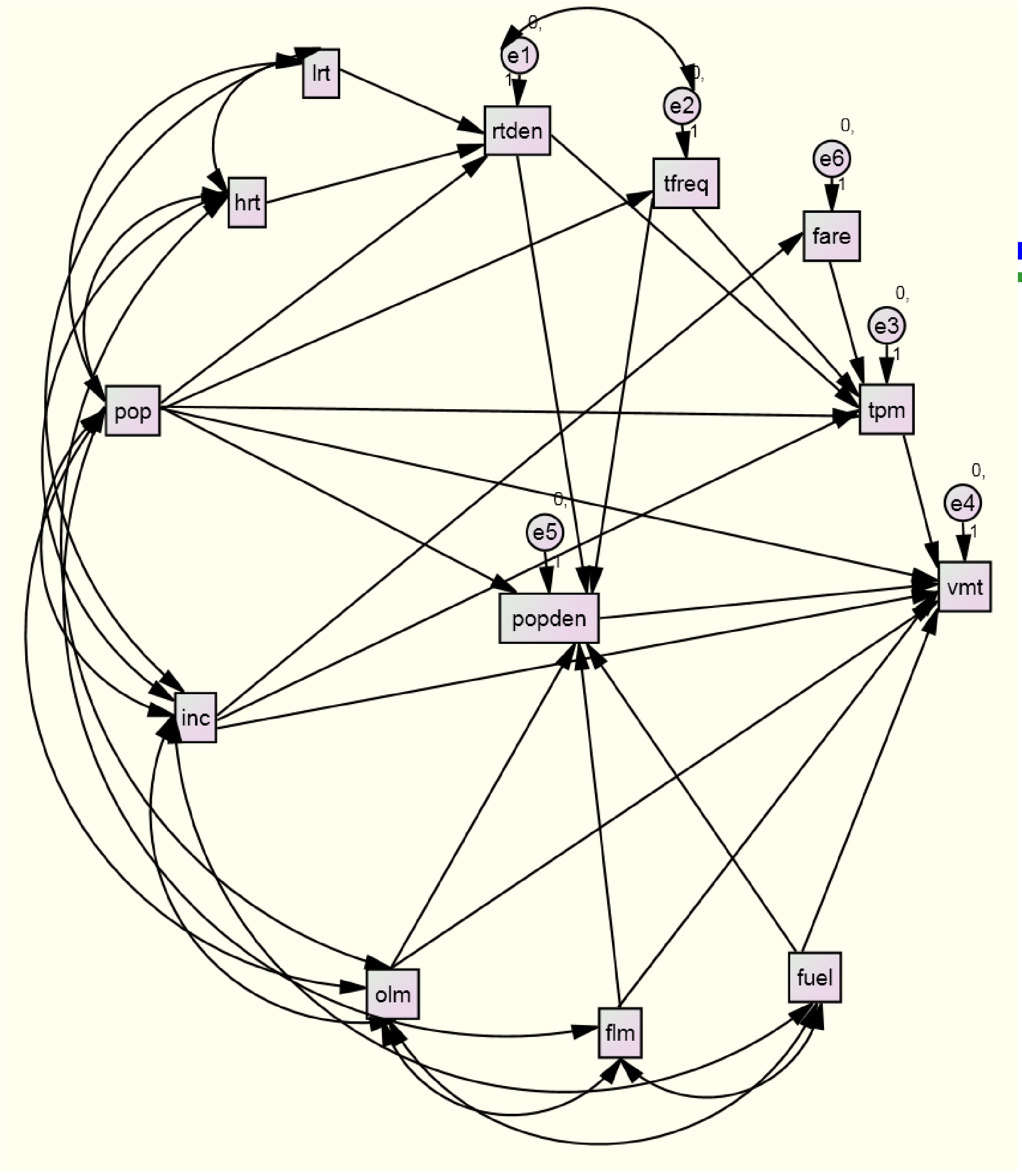
	direct effects	indirect effects	total effects
pop	0.078	-0.025	0.052
popden	-0.238	0	-0.238
inc	0.304	-0.015	0.289
olm	0.04	0.131	0.172
flm	0.133	0.026	0.159
hrt	0	-0.021	-0.021
lrt	0	-0.03	-0.03
tfreq	0	-0.057	-0.057
rtden	0	-0.06	-0.06
tpm	-0.016	0	-0.016
fuel	-0.448	-0.175	-0.623

Land Use Multipliers

rtden	
direct effect	-0.0134
indirect effect	-0.0469
LU multiplier	3.49
tfreq	
direct effect	-0.0127
indirect effect	-0.0445
LU multiplier	3.49

Sample

The final database consisted of 271 urbanized areas, including nearly all the large areas and most of the small ones.


lrt
hrt
rtden
tfreq
fare
pop
tpm
vmt
popden
inc
olm
flm
fuel
e1
e2
e3
e4
e5
e6

Goodness-of-Fit

N = 271

Chi-square = 34.2

Degrees of freedom = 32

Probability level =0.36

Regression Weights

			coeff	S.E.	C.R.	P
tfreq	<---	pop	0.235	0.028	8.382	<0.001
rtden	<---	lrt	0.495	0.125	3.973	<0.001
rtden	<---	hrt	0.406	0.178	2.274	0.023
rtden	<---	pop	-0.146	0.043	-3.387	<0.001
fare	<---	inc	0.448	0.192	2.331	0.02
popden	<---	olm	-0.544	0.052	-10.457	<0.001
popden	<---	rtden	0.203	0.019	10.516	<0.001
tpm	<---	pop	0.149	0.043	3.469	<0.001
tpm	<---	tfreq	0.735	0.08	9.229	<0.001
popden	<---	tfreq	0.192	0.025	7.695	<0.001
tpm	<---	rtden	0.81	0.054	15.134	<0.001
popden	<---	flm	-0.126	0.023	-5.538	<0.001
popden	<---	pop	0.068	0.012	5.699	<0.001
popden	<---	fuel	0.678	0.245	2.763	0.006
tpm	<---	fare	-0.156	0.062	-2.496	0.013
tpm	<---	inc	1.012	0.225	4.494	<0.001
vmt	<---	fuel	-0.5	0.24	-2.085	0.037
vmt	<---	popden	-0.252	0.044	-5.679	<0.001
vmt	<---	olm	0.008	0.055	0.152	0.879
vmt	<---	flm	0.148	0.023	6.43	<0.001
vmt	<---	inc	0.305	0.066	4.638	<0.001
vmt	<---	tpm	-0.015	0.012	-1.253	0.21
vmt	<---	pop	0.081	0.012	6.813	<0.001

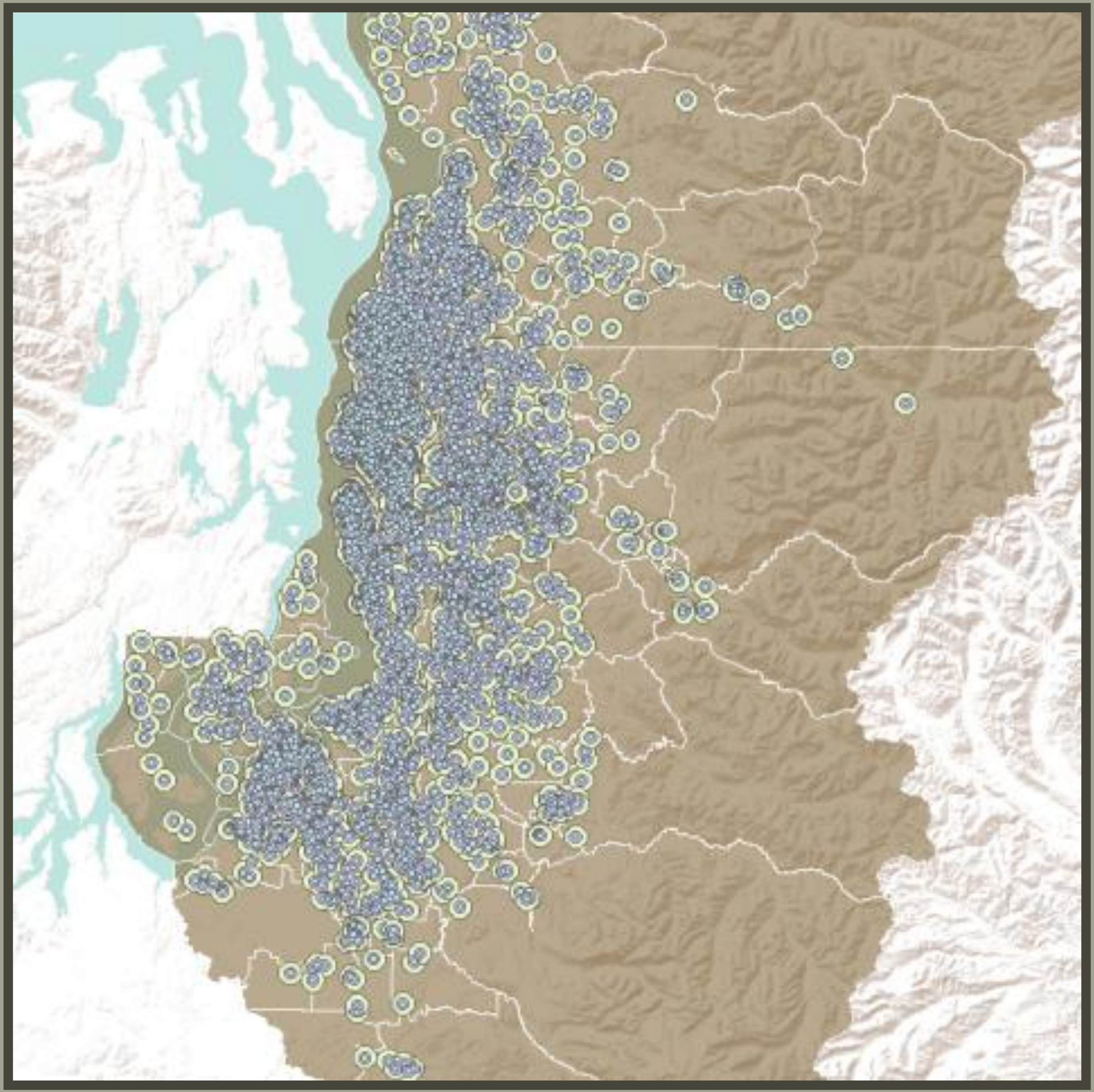
Direct, Indirect, and Total Effects on VMT

	direct effects	indirect effects	total effects
pop	0.081	-0.024	0.057
popden	-0.252	0	-0.252
inc	0.305	-0.015	0.291
hrt	0	-0.026	-0.026
lrt	0	-0.032	-0.032
tfreq	0	-0.06	-0.06
rtden	0	-0.064	-0.064
fare	0	0.002	0.002
tpm	-0.015	0	-0.015
olm	0.008	0.137	0.145
flm	0.148	0.032	0.18
fuel	-0.5	-0.171	-0.671

Land Use Multipliers

rtden	
direct effect	-0.0122
indirect effect	-0.0512
LU multiplier	4.21
tfreq	
direct effect	-0.0110
indirect effect	-0.0484
LU multiplier	4.39

Household Level Analysis



Regional Datasets

Portland

Sacramento

Houston

Boston

Austin

**Seattle*

**Kansas City*

**New York*

**SLC*

**San Francisco*

Sample Size

	households	trips
Austin	1450	14377
Boston	2599	20756
Houston	1960	20039
Portland	3832	50574
Sacramento	3520	33519
total	13361	139265

Most Attainable Regions

Closest to completion

Region	Survey Year	Survey	Land use	Transit data	TAZ data
Seattle	2006	X	X	X	X
New York	2011	Late 2012	X	X	MPO contacted
Salt Lake City	2011	Late 2012	X	X	X
San Francisco	2000	X	X	X	Unsure
Kansas City	2004	X	X	X	X

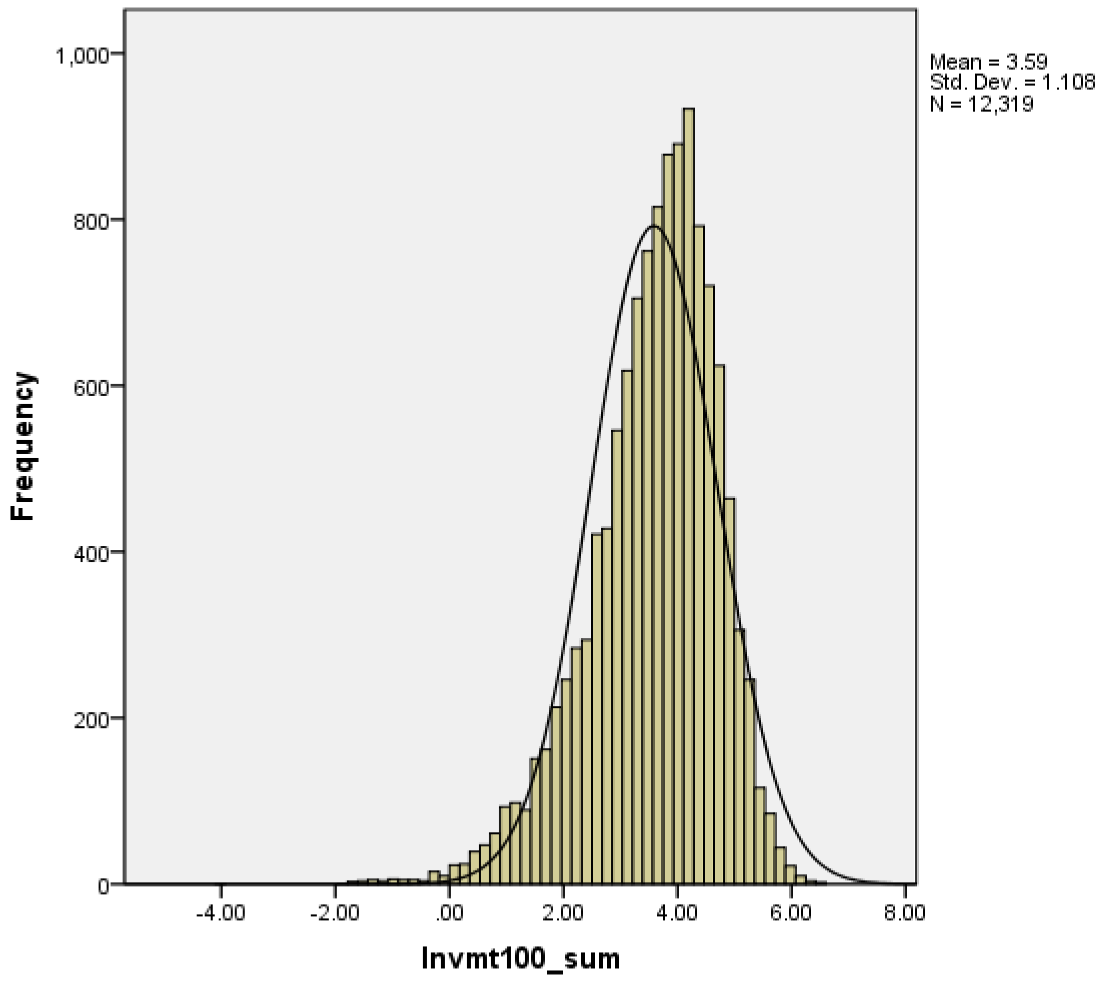
Two Mediating Variables

PROPEMP30T -> VEH -> VMT

PROPEMP30T -> ACTDEN -> VMT

Effect Sizes Estimated in Terms of Elasticities

VMT logged

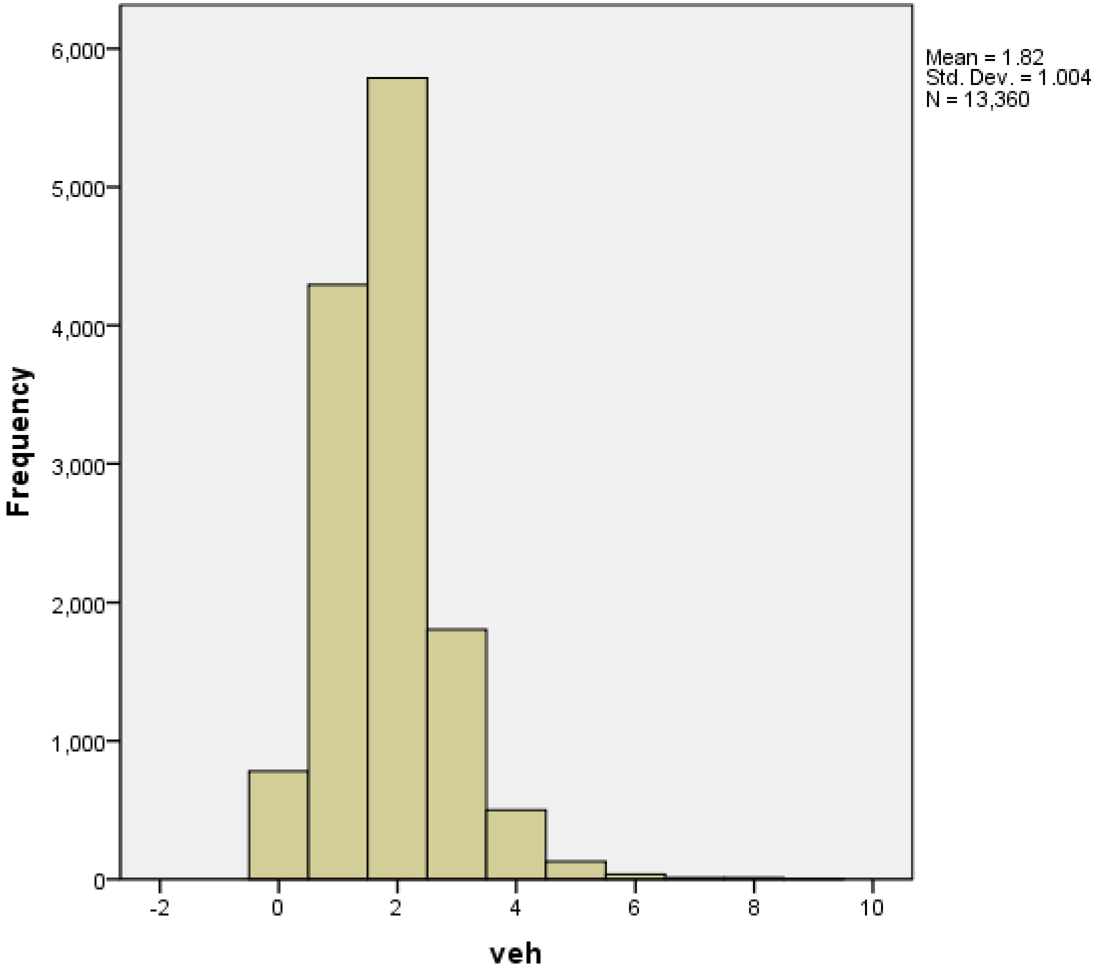


Mean = 3.59
Std. Dev. = 1.108
N = 12,319
Frequency
1,000
800
600
400
200
0
-4.00
-2.00
.00
2.00
4.00
6.00
8.00
lnvmt100_sum

VMT Model (log-linear)

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	2.758735	0.086408	31.927	4	<0.001
For HHSIZE slope, β_1					
INTRCPT2, γ_{10}	0.286962	0.008501	33.756	13346	<0.001
For EMPLOYED slope, β_2					
INTRCPT2, γ_{20}	0.180963	0.012440	14.547	13346	<0.001
For VEHICLES slope, β_3					
INTRCPT2, γ_{30}	0.113115	0.010902	10.376	13346	<0.001
For INCOME slope, β_4					
INTRCPT2, γ_{40}	0.000006	0.000001	11.037	13346	<0.001
For ACTDEN slope, β_5					
INTRCPT2, γ_{50}	-0.000003	0.000001	-4.080	13346	<0.001
For ENTROPY slope, β_6					
INTRCPT2, γ_{60}	-0.116312	0.041946	-2.773	13346	0.006
For INTDEN slope, β_7					
INTRCPT2, γ_{70}	-0.000898	0.000111	-8.091	13346	<0.001
For PROP4W slope, β_8					
INTRCPT2, γ_{80}	-0.267438	0.057600	-4.643	13346	<0.001
For PROPEMP10A slope, β_9					
INTRCPT2, γ_{90}	-1.337493	0.127613	-10.481	13346	<0.001
For TPM slope, β_{10}					
INTRCPT2, γ_{100}	-0.011978	0.001402	-8.541	13346	<0.001

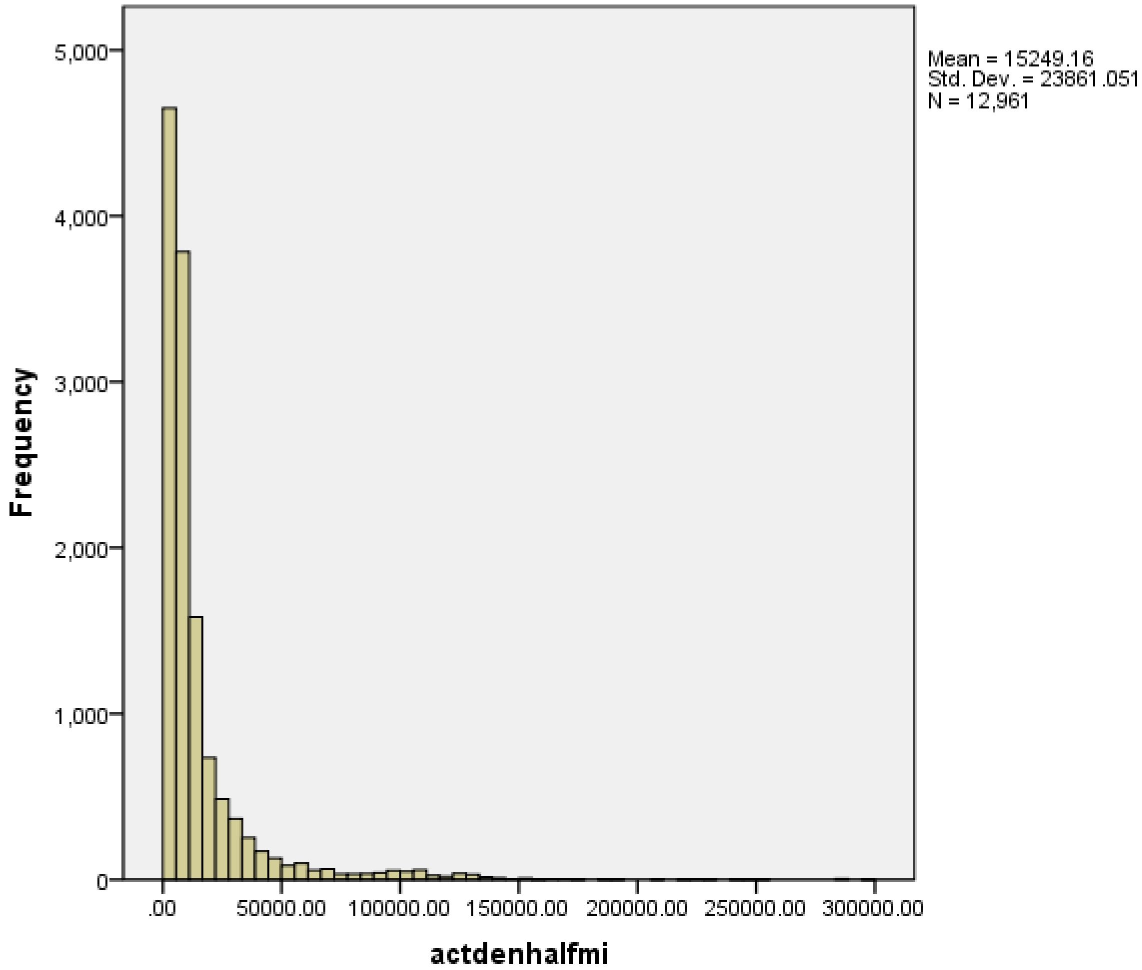
VEHICLES Absolute Values



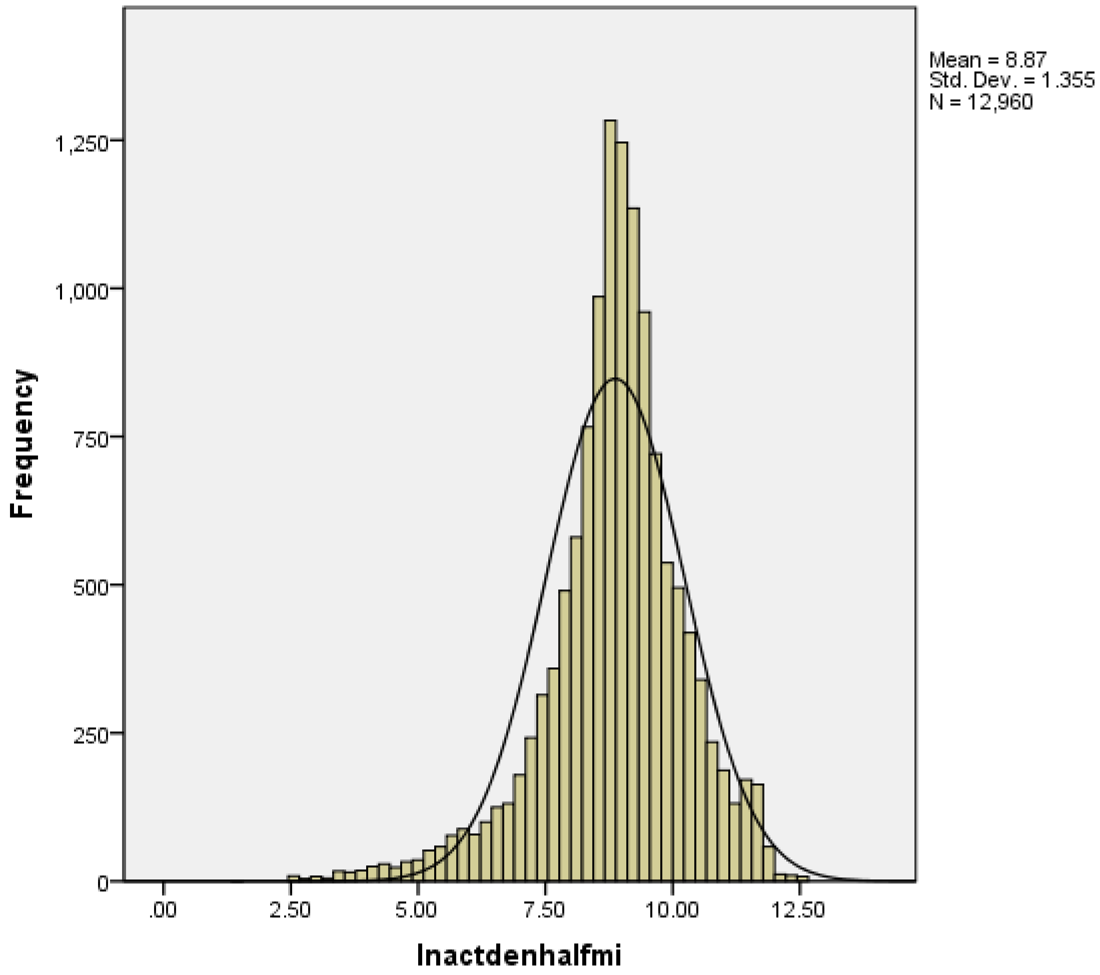
VEHICLES Model (Poisson)

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	0.325183	0.038227	8.507	4	0.001
For HHSIZE slope, β_1					
INTRCPT2, γ_{10}	0.074737	0.006465	11.560	13348	<0.001
For EMPLOYED slope, β_2					
INTRCPT2, γ_{20}	0.127354	0.009507	13.396	13348	<0.001
For INCOME slope, β_3					
INTRCPT2, γ_{30}	0.000007	0.000000	16.324	13348	<0.001
For ENTROPY slope, β_4					
INTRCPT2, γ_{40}	-0.119220	0.034339	-3.472	13348	<0.001
For INTDEN slope, β_5					
INTRCPT2, γ_{50}	-0.000629	0.000089	-7.105	13348	<0.001
For PROP4W slope, β_6					
INTRCPT2, γ_{60}	-0.150669	0.045833	-3.287	13348	0.001
For STOPDEN slope, β_7					
INTRCPT2, γ_{70}	-0.001388	0.000262	-5.295	13348	<0.001
For PROPEMP30T slope, β_8					
INTRCPT2, γ_{80}	-0.184804	0.044958	-4.111	13348	<0.001

ACTDEN Absolute Values



ACTDEN logged



ACTDEN Model (log-linear)

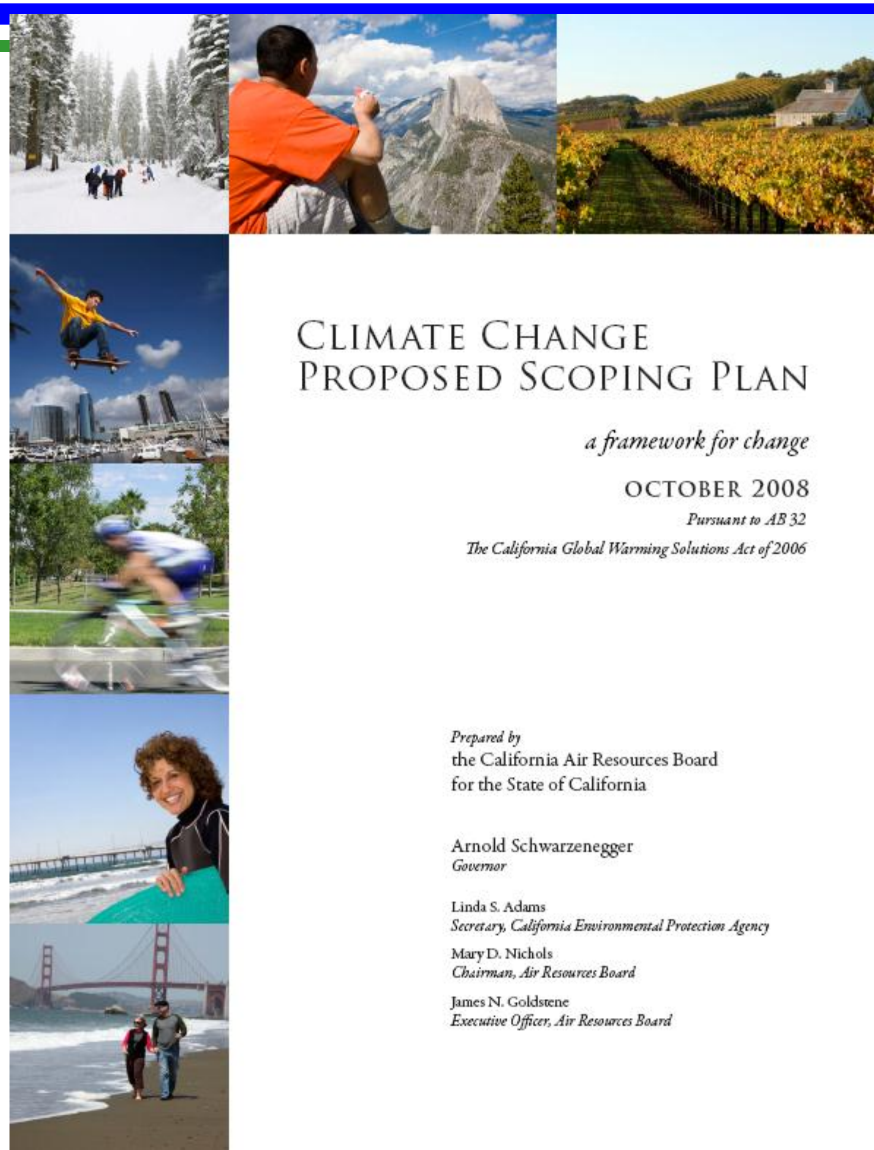
Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	7.124499	0.251255	28.356	4	<0.001
For INTDEN slope, β_1					
INTRCPT2, γ_{10}	0.003467	0.000081	42.776	13320	<0.001
For PROP4W slope, β_2					
INTRCPT2, γ_{20}	0.549743	0.045612	12.053	13320	<0.001
For STOPDEN slope, β_3					
INTRCPT2, γ_{30}	0.005843	0.000234	25.010	13320	<0.001
For PROPEMP10A slope, β_4					
INTRCPT2, γ_{40}	3.291005	0.131553	25.016	13320	<0.001
For PROPEMP30T slope, β_5					
INTRCPT2, γ_{50}	1.387583	0.059613	23.276	13320	<0.001

Effects of 100% Drop in Transit on VMT

	coeff	mean x	elasticity	100% drop
veh	0.113115	1.8231287	0.206223	2.748547
actden	-0.000003	15249.163	-0.04575	4.57805
tpm	-0.011978	1.5138169	-0.01813	1.81325

California Case Study

Implementation



CLIMATE CHANGE
PROPOSED SCOPING PLAN

a framework for change

OCTOBER 2008

Pursuant to AB 32

The California Global Warming Solutions Act of 2006

Prepared by
the California Air Resources Board
for the State of California

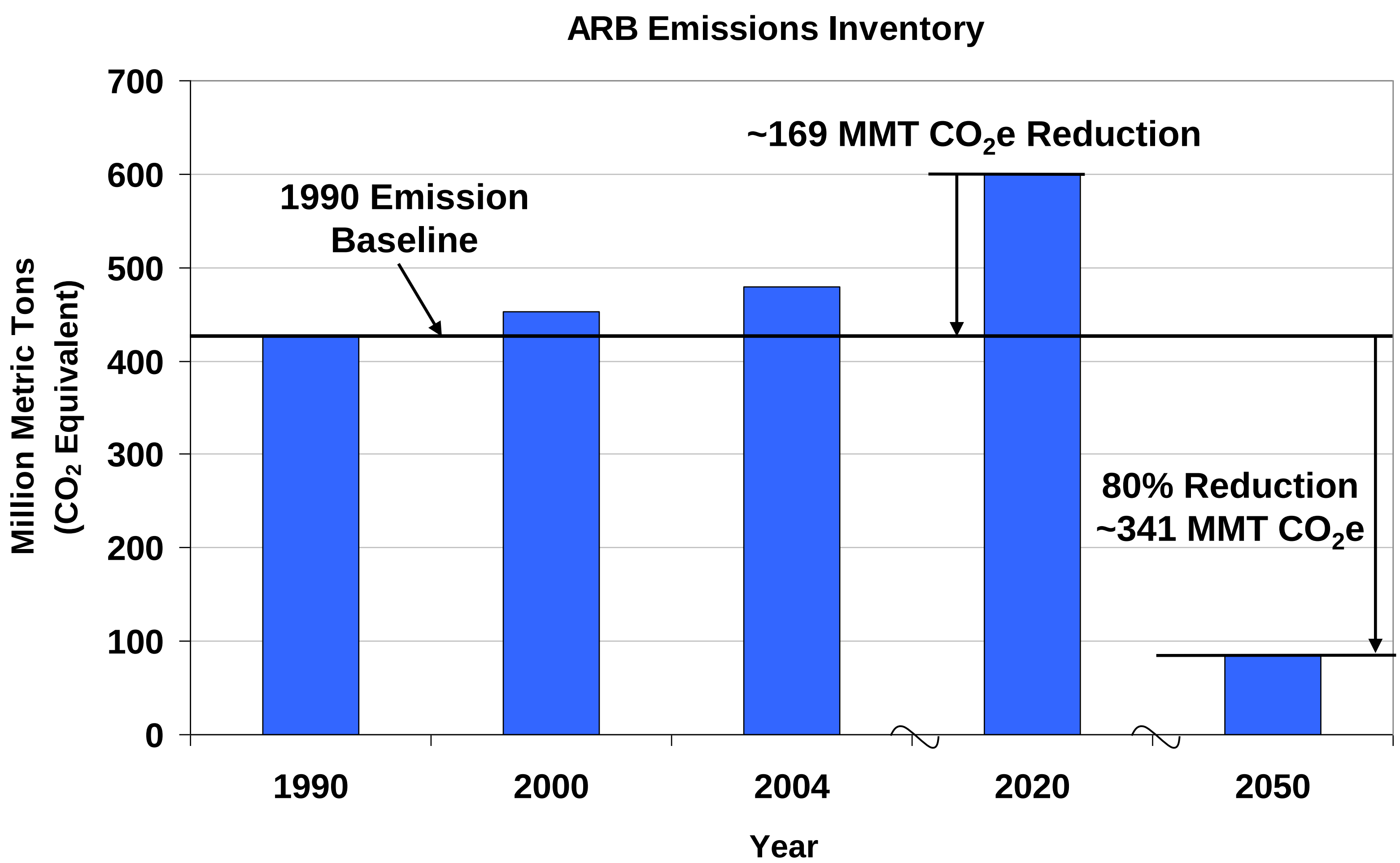
Arnold Schwarzenegger
Governor

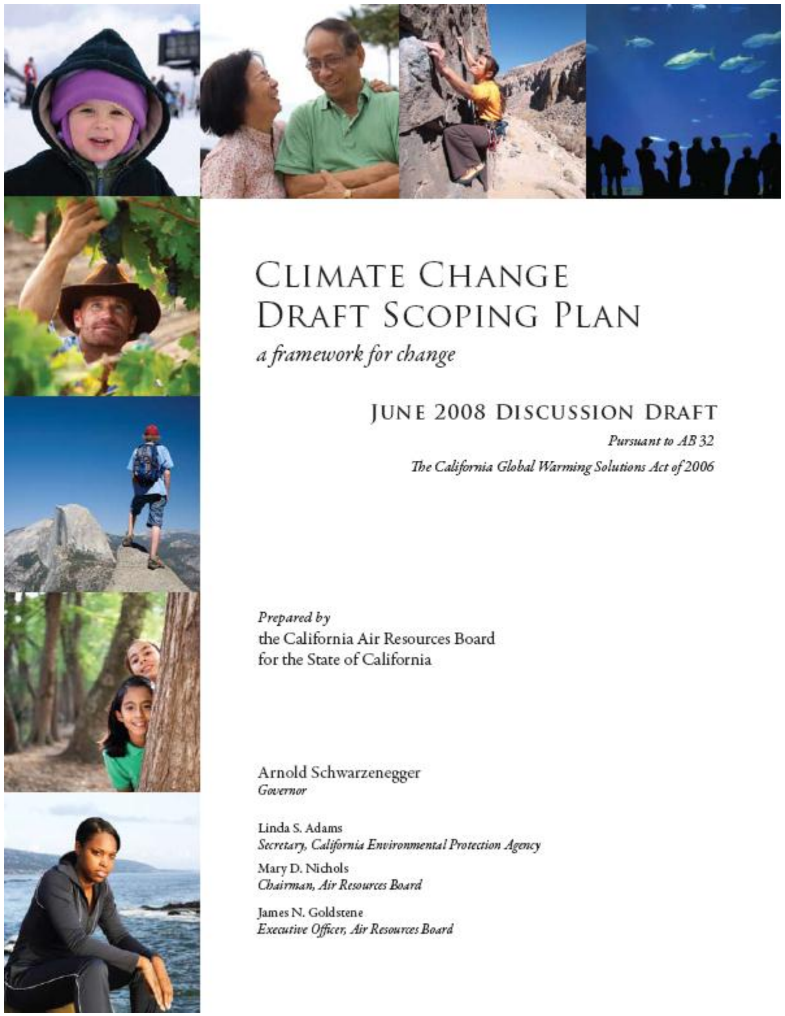
Linda S. Adams
Secretary, California Environmental Protection Agency

Mary D. Nichols
Chairman, Air Resources Board

James N. Goldstene
Executive Officer, Air Resources Board

Magnitude of the Challenge





CLIMATE CHANGE
DRAFT SCOPING PLAN
a framework for change

JUNE 2008 DISCUSSION DRAFT
Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Prepared by
the California Air Resources Board
for the State of California

Arnold Schwarzenegger
Governor

Linda S. Adams
Secretary, California Environmental Protection Agency

Mary D. Nichols
Chairman, Air Resources Board

James N. Goldstene
Executive Officer, Air Resources Board

Smart Growth Contribution

2.3 mm tons by 2020

Same Methodology

% Market Share of Compact Development

x

% of Total Development Built between 2010 and 2020

x

% VMT Reduction with Compact Development

x

Ratio CO_2/VMT Reduction with Compact Development

x

Baseline Projection of CO_2 in 2020

=

CO_2 Reduction with Compact Development by 2020

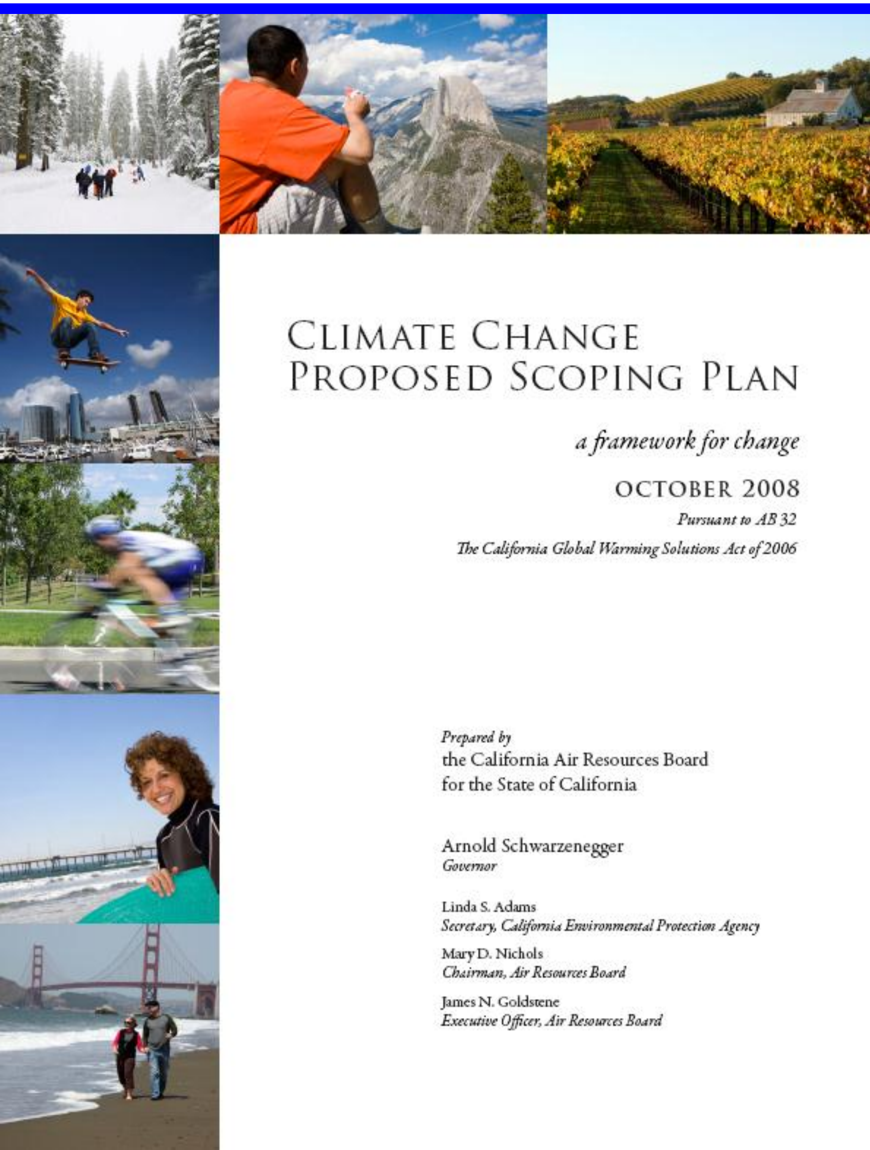
Critical Assumptions

	CARB 2020	Ewing 2020 low	Ewing 2020 high
Compact Market Share	30%	50%	70%
% Development/Redevelopment	25%	25%	25%
% VMT Reduction	30%	30%	30%
Ratio CO_2/VMT Reduction	90%	90%	90%
Baseline CO_2 Projection	115 MMT	120 MMT	120 MMT
CO_2 Reduction	2.3 MMT	4.1 MMT	5.7 MMT

Much Bigger Numbers

Table 9. Estimated CO_2 Reduction with Smart Growth in California (2010-2020)

	CO_2 Reduction (million metric tons)
VMT Reduction with Compact Development	4.1 – 5.7
VMT Reduction with Smart Transportation Policies	4.0
VMT Reduction with Measures Under Evaluation	3.3 – 4.6
<u>Total</u>	11.4 – 14.3
Building Energy Savings	*3.0 – 3.6*
Total with Building Energy Savings	*14.4 – 17.9*



CLIMATE CHANGE
PROPOSED SCOPING PLAN

a framework for change

OCTOBER 2008

Pursuant to AB 32

The California Global Warming Solutions Act of 2006

Prepared by
the California Air Resources Board
for the State of California

Arnold Schwarzenegger
Governor

Linda S. Adams
Secretary, California Environmental Protection Agency

Mary D. Nichols
Chairman, Air Resources Board

James N. Goldstene
Executive Officer, Air Resources Board

Smart Growth Contribution

5 mm tons by 2020

(just a place holder)

SB 375 – Sustainable Communities and Climate Protection Act of 2008

To reduce GHG emissions from cars and light trucks through incentives for better development patterns so people can choose to drive less

Target Provisions

Sustainable Communities requires ARB to develop regional greenhouse gas emission reduction targets for passenger vehicles. ARB is to establish targets for 2020 and 2035 for each region covered by one of the State's 18 metropolitan planning organizations (MPOs).

Target Setting

- Process for reducing GHGs through sustainable planning set forth in SB 375
- Regional GHG targets in SB 375 most "ambitious achievable"
- Outcome of CARB's decision on SB 375 targets will replace 5 mm tons
- RTAC recommends a method to assess full potential for reducing GHGs

Final Targets (2/11)

Attachment 4

Approved Regional Greenhouse Gas Emission Reduction Targets

MPO Region	Targets *	
	2020	2035
SCAG	-8	-13
MTC	-7	-15
SANDAG	-7	-13
SACOG	-7	-16
8 San Joaquin Valley MPOs	-5	-10
6 Other MPOs		
Tahoe	-7	-5
Shasta	0	0
Butte	+1	+1
San Luis Obispo	-8	-8
Santa Barbara	0	0
Monterey Bay	0	-5

* Targets are expressed as percent change in per capita greenhouse gas emissions relative to 2005.

Regional Transportation Plans

Under current law RTPs must have the following elements:

- » A policy element
- » An action element
- » A financial element

SB 375 adds a new element to the RTPs

- Sustainable Communities Strategy

Sustainable Communities Strategy

- Identify areas for housing and development
- Identify a transportation network
- Identify significant resource areas and farmland
- Set forth a development pattern that will achieve the GHG Reduction Targets if there is a feasible way to do so
- Propose an Alternative Planning Strategy if no feasible way to do so

City or county land use policies, including the general plan, are not required to be consistent with the Sustainable Communities Strategy

Only Incentives

- Future transportation funding would be directed to projects that implement the Sustainable Communities Strategy
- New provisions of CEQA would be available to local governments with local plans consistent with the regional plan

ARB Follow-Up Role

Now that the Board has adopted the GHG targets for each region, ARB's next task is to determine whether an adopted SCS, if implemented, would meet the assigned target. ARB staff will complete a technical evaluation using this general methodology and recommend to the Board whether or not the target can be expected to be met if the SCS is implemented. While land use decisions and transportation planning are local and regional responsibilities, ARB does have the role of determining whether an SCS, as part of the regional transportation plan, would achieve its emission reduction target.

First Draft SCS

The quantification of GHG emissions from the draft San Diego SCS indicates that the ARB target of a 7 percent per capita reduction in 2020 and a 13 percent per capita reduction by 2035 would be met with SCS implementation. SANDAG quantified the GHG emissions based on the results of its travel demand model, using the technical methodology provided on May 5, 2010 to ARB as required by California Government Code section 65080(b)(2)(I)(i). …The GHG quantification shows that the San Diego SCS would achieve double the 2020 target and just meet the target in 2035.

First Draft SCS

Improvements to SANDAG's modeling system are well underway, with development of an activity-based model that will do a better job quantifying travel behavior, evaluating different land use scenarios, and addressing issues such as induced demand. SANDAG staff is also pursuing improved tools to supplement travel model outputs, and to integrate land use and freight models with the region's travel model systems. These improvements are essential for future SCS development.

First Draft SCS

The SCS includes four building blocks:

- Land use component that accommodates the Regional Housing Needs Assessment (RHNA) and includes the protection of sensitive resource areas
- Transportation networks including highways, transit, and local streets and roads;
- Transportation demand management strategies; and
- Transportation system management programs and policies.