



# VMT Module of SCAG Scenario Planning Model (SPM)

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# New to SPM?

## ➤ What is SPM?

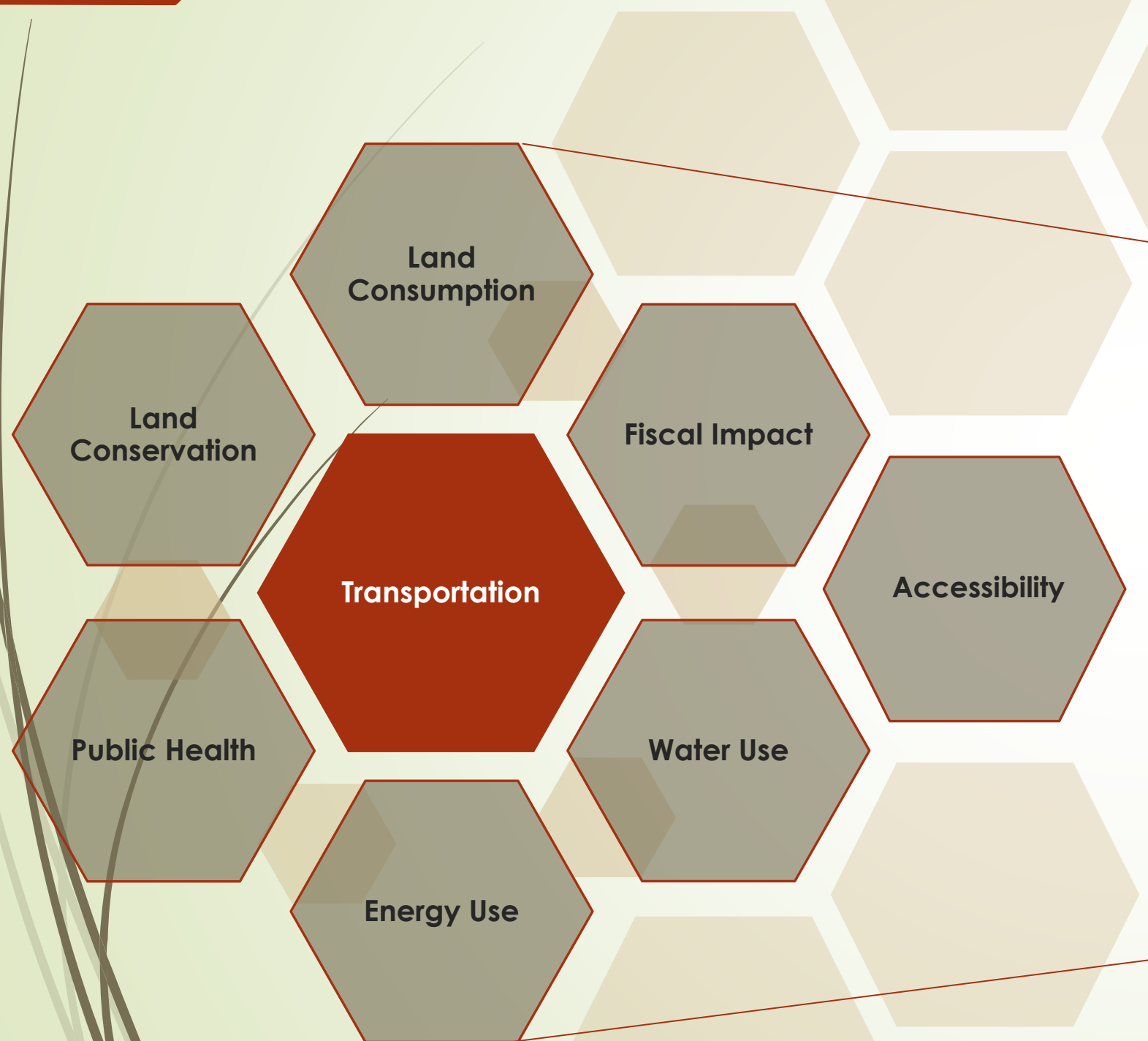
A web-based land use sketch planning tool for data management, scenario development and modeling, built with open-source software and tools

## ➤ Primary Objective

Support informed decision making by providing relative impact analysis of the issues and policy choices

	Trend/ Baseline	Existing Plans - Local Input	Networked Destinations	Dynamic Centers	Accelerated Tomorrow
Fiscal Impacts (cumulative)	Infrastructure Capital				
	\$ 29.0 billion	\$ 27.4 billion	\$ 26.4 billion	\$27.1 billion	\$26.2 billion
Land Consumption	Operations and Maintenance				
	\$ 11.3 billion	\$ 10.6 billion	\$ 10.0 billion	\$ 10.4 billion	\$ 10.0 billion
Building Energy Use (cumulative)	Greenfield Land				
	100 sq mi	99 sq mi	66 sq mi	62 sq mi	50 sq mi
Building Water Use (cumulative)	Residential Use				
	9,506 trillion BTU	9,382 trillion BTU	9,359 trillion BTU	9,424 trillion BTU	9,350 trillion BTU
Annual Household Costs	Commercial Use				
	6,040 trillion BTU	6,035 trillion BTU	6,000 trillion BTU	6,016 trillion BTU	6,001 trillion BTU
Public Health	Residential Use				
	56.6 million AF	55.7 million AF	55.3 million AF	55.5 million AF	54.3 million AF
Land Conservation	Commercial Use				
	33.1 million AF	33.0 million AF	33.2 million AF	32.7 million AF	30.8 million AF
Land Conservation	Transportation Costs (fuel + auto)				
	\$11,461	\$11,252	\$10,953	\$10,951	\$10,820
Land Conservation	Utility Costs (energy + water)				
	\$2,492	\$2,429	\$2,417	\$2,447	\$2,352
Land Conservation	Respiratory Related Health Costs				
	\$ 3,340 million	\$ 3,280 million	\$ 3,190 million	\$ 3,190 million	\$ 3,190 million
Land Conservation	Active Farmland and Natural Land Change				
	- 120,700 acres	- 195,100 acres	- 121,300 acres	- 104,800 acres	- 107,500 acres
Land Conservation	Total Carbon Stock Change*				
	- 589,000 metric tons	- 948,000 metric tons	- 689,000 metric tons	- 573,000 metric tons	- 568,000 metric tons
Land Conservation	Agriculture Production Value Change				
	\$ -94.4 million	\$ -127.6 million	\$ -82.4 million	\$ -72.1 million	\$ -72.7 million
Land Conservation	High Species Movement Potential Change**				
	- 32,200 acres	- 73,600 acres	- 47,300 acres	- 37,700 acres	- 38,800 acres
Land Conservation	Habitat Degraded***				
	151,080 acres	226,130 acres	141,600 acres	122,940 acres	123,650 acres

# Multi-Metric Analysis



## Land Consumption Module

- Greenfield Land Consumed (acre)

## Fiscal Impact Module

- Capital Infrastructure Cost (\$)
- Operations & Maintenance Cost (\$)

## Water Use Module

- Indoor/Outdoor Water Use (gal)
- Water Cost (\$)
- Water-related Energy Use (kWh)
- Water-related GHG Emissions (lbs)

## Energy Use Module

- Residential/Commercial Energy Use (kWh, thm)
- Building-related Energy Cost (\$)
- Building-related GHG Emissions (lbs)

## Public Health Module

- Respirator Health Incidences and Cost (\$)
- Obese Population (%)
- High Blood Pressure (%)
- Heart Disease (%)
- Type 2 Diabetes (%)
- Bod Mass Index (BMI) Percentile

## Land Conservation Module

- Above Ground Live Carbon Stocks (metric tons of C)
- Below Ground Carbon Stocks (metric tons of C)
- Watershed Integrity (acres)
- Urban and Agricultural Water Demand (ac-ft)
- Groundwater Recharge Potential (ac-ft/yr)
- Water Resource Priority Areas (acres)
- Habitat for Terrestrial Vertebrates (acres)
- Species Movement Potential (acres)
- Habitat Priority Areas (acres)
- Agricultural Capacity (acres)
- Agricultural Production Values (\$)

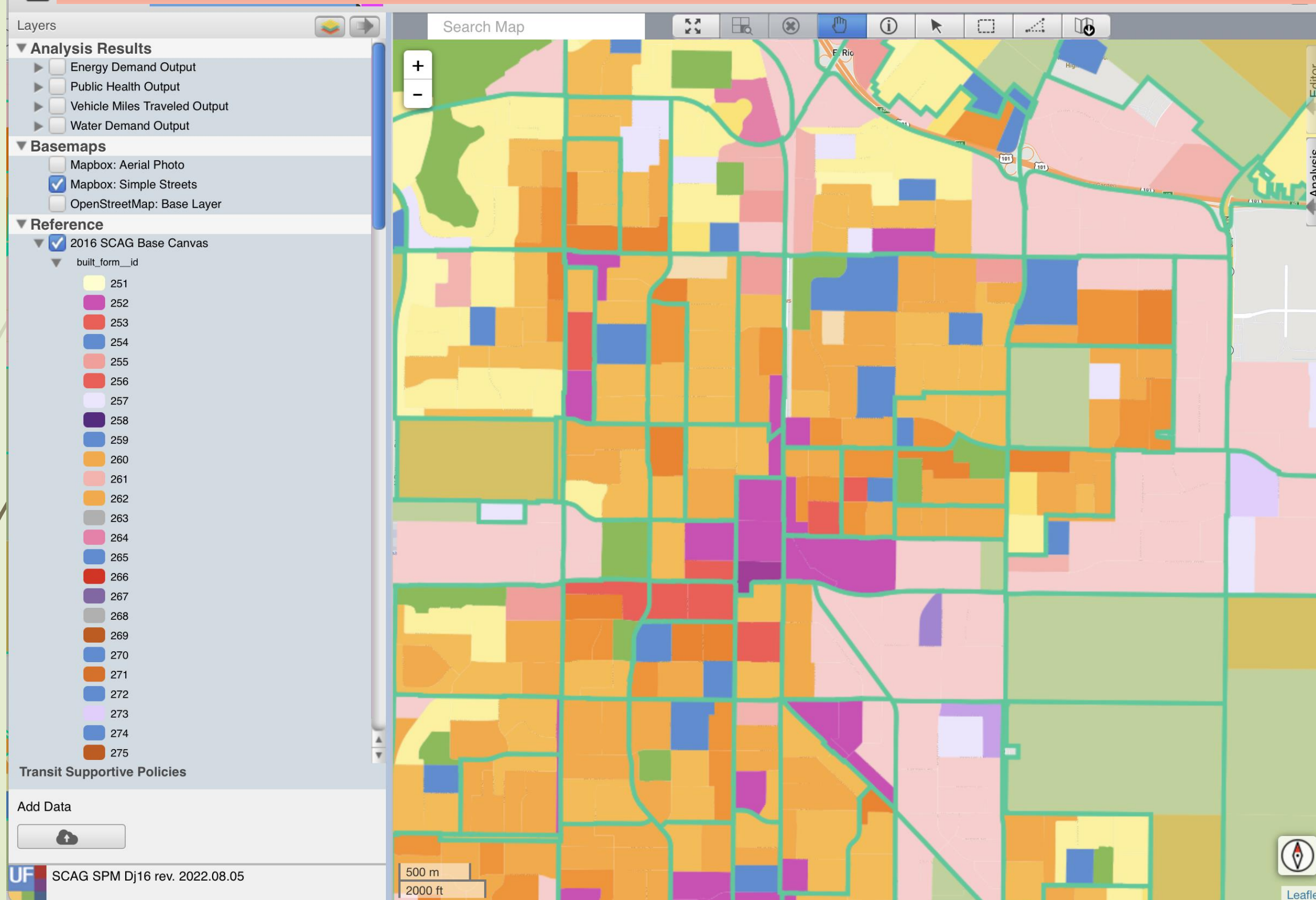
## Transportation Module

- Vehicle Miles Traveled (VMT)
- Trips by Mode/Type
- Transportation Costs(\$)

## Accessibility Module

- Number of destinations or opportunities one can reach within a specified amount of time or distance
- Travel time, in minutes, from an SPZ to the nearest Point Of Interest (POI)

# SPM Land Use Data – by Scenario Planning Zone

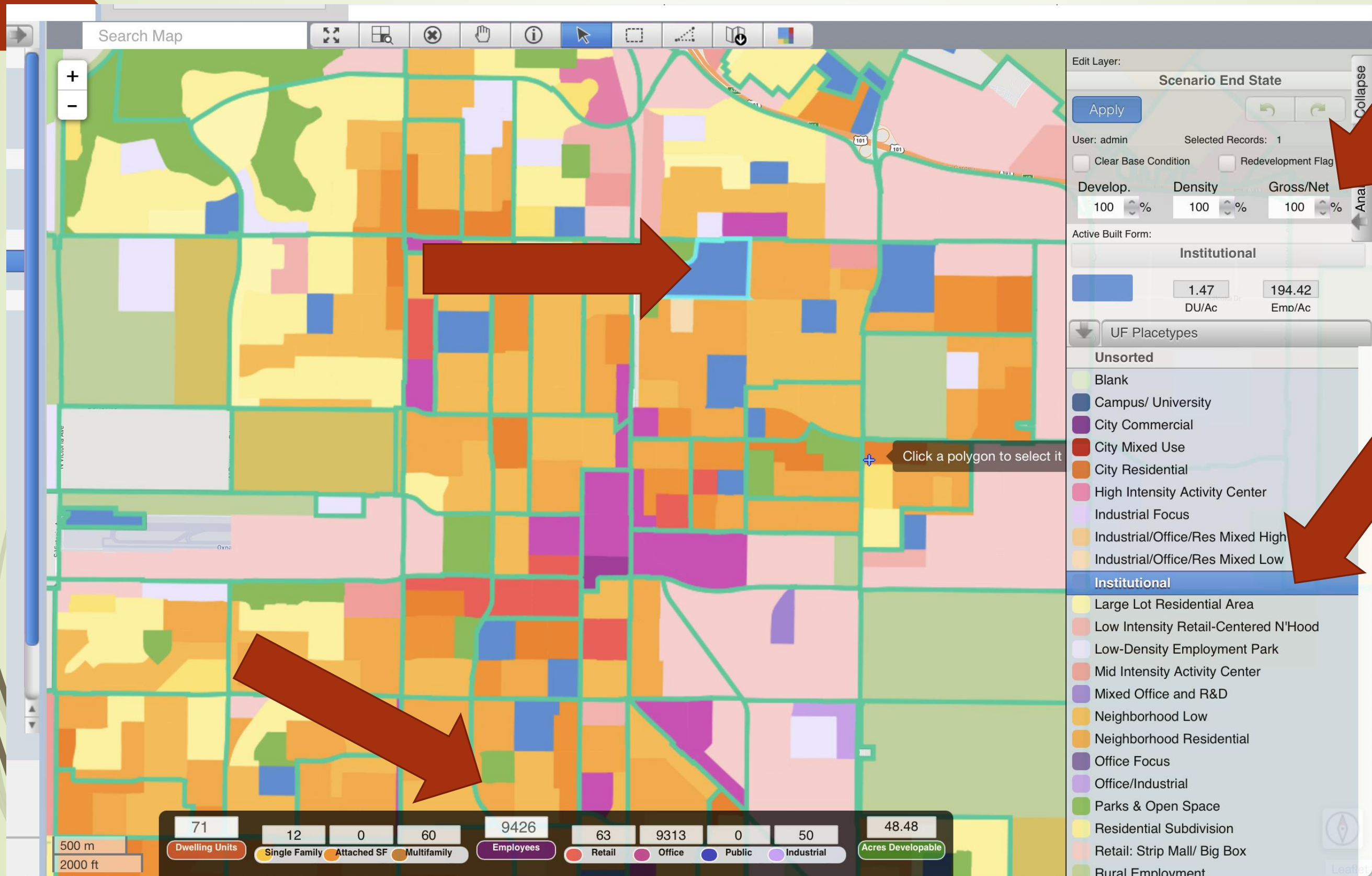


107,562 SPZs  
in SCAG

SPM's  
primary  
geographic  
unit

Developed  
by grouping  
parcels of  
uniform or  
compatible  
land uses.

# SPZ Land Use abstracted as "Place Type"



# Some "Place Types"

## Mixed Office and R&D



Land Use Mix		Residential Mix	
Residential	0%	SF Large Lot	0%
Employment	89%	SF Small Lot	0%
Mixed Use	0%	Townhome	0%
Open Space/Civic	11%	MultiFamily	0%
Built Environment		Employment Mix	
Intersections per mi <sup>2</sup>	45	Office	82%
Average Floors	2	Retail	5%
Floors Range	1 - 6	Industrial	13%
Total Net FAR	0.8		
Gross Density Range (per acre)		Average Density (per acre)	
Household	0	Household	0
Employee	25-150+	Employee	33

### Description

Representing intense suburban office/industrial/research areas, Mixed Office and R&D is characterized by a mix of employment buildings. Typical structures are 1-6 stories tall, surrounded by surface parking and some structured parking where appropriate.

## Neighborhood Residential



Land Use Mix		Residential Mix	
Residential	76%	SF Large Lot	0%
Employment	0%	SF Small Lot	95%
Mixed Use	2%	Townhome	0%
Open Space/Civic	23%	MultiFamily	5%
Built Environment		Employment Mix	
Intersections per mi <sup>2</sup>	180	Office	86%
Average Floors	2	Retail	14%
Floors Range	2 - 4	Industrial	0%
Total Net FAR	0.7		
Gross Density Range (per acre)		Average Density (per acre)	
Household	5-8	Household	7
Employee	0-3.5	Employee	3

### Description

Neighborhood Residential areas are traditional neighborhoods containing mostly single-family homes on small lots, interspersed with occasional retail spaces. Typical buildings are between 2 and 3 stories tall, with small yards and an active focus on the public realm, set in a context designed to be supportive of transit service, walking and bicycling.

## Office/Industrial



Land Use Mix		Residential Mix	
Residential	0%	SF Large Lot	0%
Employment	92%	SF Small Lot	0%
Mixed Use	0%	Townhome	0%
Open Space/Civic	8%	MultiFamily	0%
Built Environment		Employment Mix	
Intersections per mi <sup>2</sup>	40	Office	23%
Average Floors	1	Retail	5%
Floors Range	1 - 4	Industrial	72%
Total Net FAR	0.5		
Gross Density Range (per acre)		Average Density (per acre)	
Household	0	Household	0
Employee	16-25	Employee	21

### Description

Office/Industrial areas are moderate-density suburban office and industrial areas. Typical structures are 1-5 stories tall, surrounded by surface lots and truck loading bays.

## Neighborhood Low



Land Use Mix		Residential Mix	
Residential	77%	SF Large Lot	13%
Employment	1%	SF Small Lot	87%
Mixed Use	0%	Townhome	0%
Open Space/Civic	23%	MultiFamily	0%
Built Environment		Employment Mix	
Intersections per mi <sup>2</sup>	230	Office	100%
Average Floors	2	Retail	0%
Floors Range	2 - 4	Industrial	0%
Total Net FAR	0.5		
Gross Density Range (per acre)		Average Density (per acre)	
Household	0.2-5	Household	4
Employee	0-5	Employee	2

### Description

Containing a mix of single-family homes on small lots interspersed with some medium and larger lot homes, Neighborhood Low is a traditional neighborhood area designed to be supportive of walking and bicycling. Typical buildings are 2-3 stories tall, usually located within walking distance of a mixed-use neighborhood center.



# Motivations and Objectives of SPM-TM

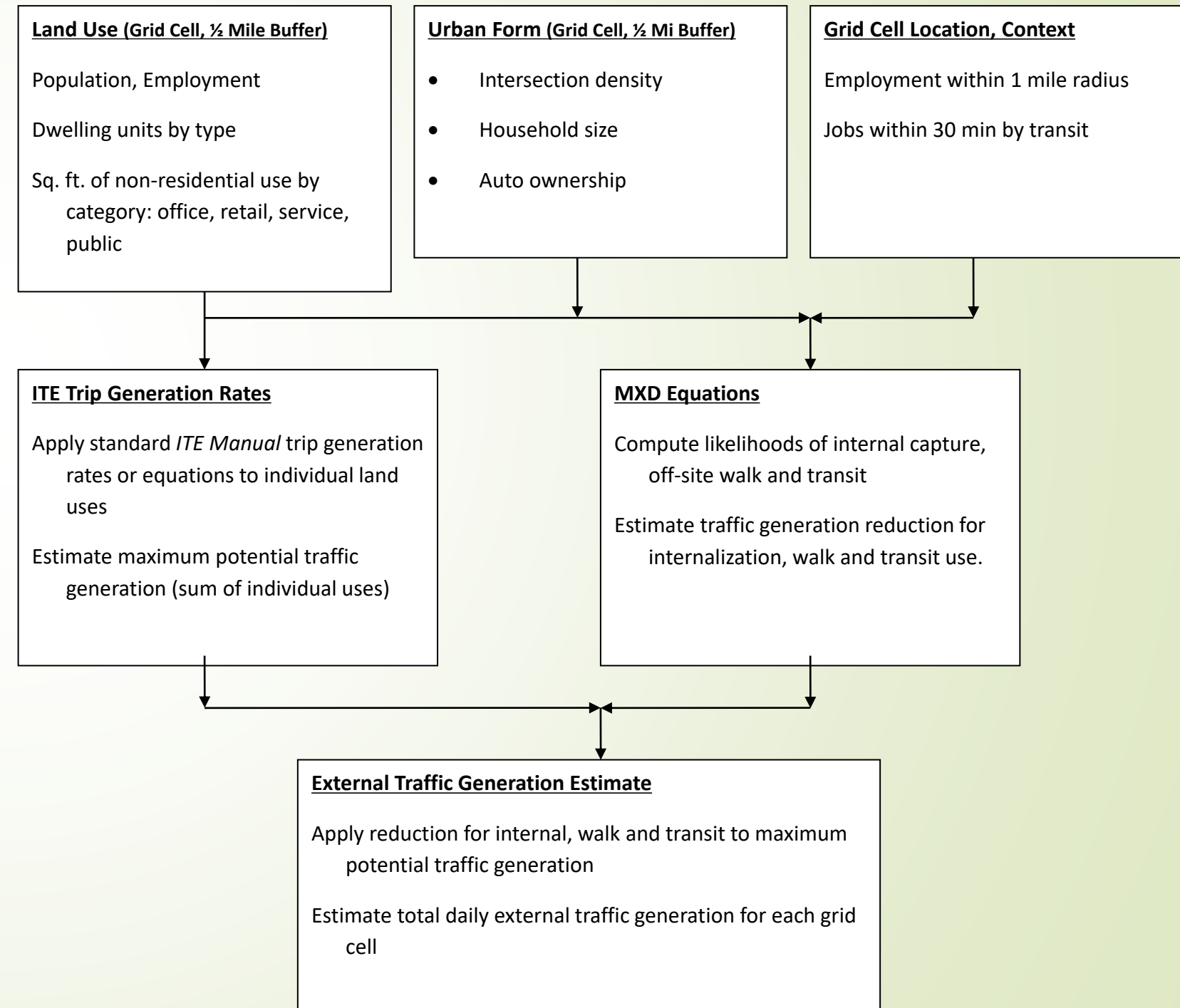
- ▶ Quantitative tool to predict VMT impact of detailed land use patterns.
- ▶ Used alongside SCAG Regional Travel Model (ABM)
  - ▶ ABM model represents behavioral detail and patterns of travel
  - ▶ SPM-TM respects ABM results for identical land use
  - ▶ Increases or decreased trips, trip distance, mode split based on detailed land use changes
- ▶ Based on SCAG data/analysis
- ▶ Compatible with other SCAG tools especially the ABM

# Previous VMT Module

- Based on land use data from mixed use developments around the nation

Region	MXDs
Atlanta	24
Boston	59
Houston	34
Portland	53
Sacramento	25
Seattle	44
Total	239

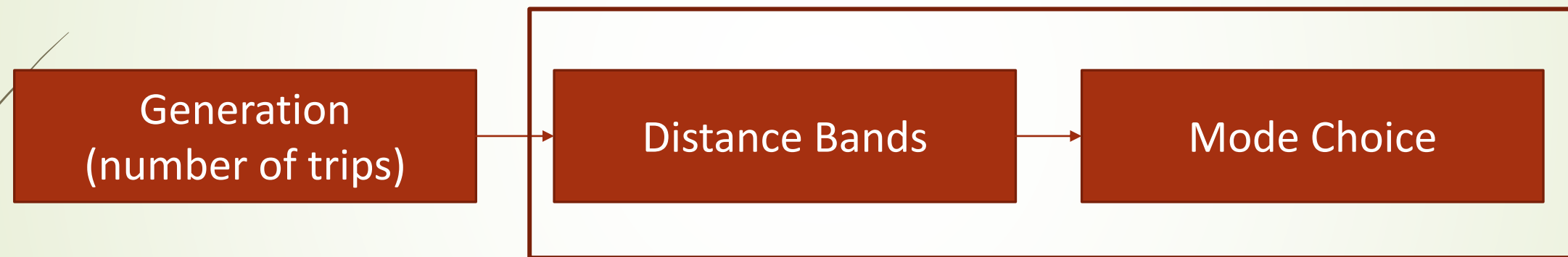
- Development characteristics and accessibility
- Internal capture and walk/transit probabilities





# SPM Travel Model Structure

## TAZ level



# Generation

## Distance Bands

## Mode Choice

# Daily Trip Generation

- Home to Work (H2W)
- Work to Home (W2H)
- Home to Other (H2O)
- Other to Home (O2H)
- Non-Home Based (NHB)
- Trip rate per person (H2W, W2H, H2O, O2H, NHB)
- Trip rate per employee (NHB)

## Generation

### Distance Bands

### Mode Choice

# Daily Trip Generation: Explanatory Variables

- Household size
- Proportion multi-unit building
- Proportion of mixed-use land use type
- Parking cost
- Intersection density
- Bike lane density
- Density of zone
- Employment within one mile of zone (including intrazonal)
- Employment between 1 and 5 miles from zone

Generation

Distance Bands

Mode Choice

# Distance Band and Mode Choice Model by Purpose

- For each purpose (H2W, W2H, H2O, O2H, NHB)
  - Distance band choice:  
Intra-TAZ, 0-1 miles, 1-5 miles, 5-20 miles, 20+ miles
  - Mode choice:  
Auto Driver, Auto Passenger, Transit, Walk and Bike
- Discrete choice model (logit model)

	Auto Driver	Auto Passenger	Transit	Walk and Bike
Intra	x	x	x	x
< 1 mi	x	x	x	x
1 – 5 mi	x	x	x	x
5-20 mi	x	x	x	x
20+ mi	x	x	x	

Generation

Distance  
Bands

Mode  
Choice

## Distance Band and Mode Choice Model by Purpose: Explanatory Variables:

- Total employment in each distance band
- Proportion Mixed Land Use in home TAZ
- Parking Cost
- Transit stops per km<sup>2</sup>
- Distance to light rail or subway/metro
- Bike Lane density



# Development and Estimation

- ▶ Load ABM Base Scenario data
  - ▶ Simulated trip list in 2016
  - ▶ Land use data by TAZ (population, residents, households, employees)
- ▶ Calculate "Observed" ABM VMT
  - ▶ Trip rates (5 per TAZ)
  - ▶ Mode choice and distance band choice (95 per TAZ)
  - ▶ Travel distance by band, segment, and mode (100 per TAZ)
- ▶ Smooth ABM Indicators
  - ▶ to remove microsimulation error, small number rate errors, and missing value errors
- ▶ Regression for trip generation
- ▶ Logit Choice model for mode and distance band

# Generation Parameters

Variable	Description	Units	Home to Work	Work to Home	Home to Other	Other To Home	Non Home Based
<b>Household Size</b>	Residents per household	RES/HH	-0.02375	-0.00592	0.05024	0.03162	
<b>Proportion Multi-Use</b>	Proportion of Multi Unit buildings	proportion			-0.08553	-0.07188	
<b>Proportion Mixed Use Land Use</b>	Sum of proportion of "mixed use" land use type	proportion	0.01786	0.01464			0.36238
<b>Land Use Density</b>	$\sqrt{\text{residents} + \text{employment} / \text{area}}$						0.07485
<b>Short Term Parking Cost</b>	One Hour short term parking cost	2011 \$					-0.08925
<b>Intersection Density</b>	Average intersection density	Intersections per sq.mi.	0.00005	-0.00004			
<b>Bike Lane Density</b>	Bike Lane Density	miles/acre	0.60086	0.46420			
<b>Employment &lt; 1 mile</b>	Employment within 1 mile of zone	jobs ('000)	0.000327	0.000161			
<b>Employment 1-5 Miles</b>	Employment in the band between 1 and 5 miles from edge of zone	jobs ('000)	0.000093	0.000045			0.000068
<b>Constant</b>		number	0.31507	0.22349	0.96388	1.08042	0.86588
<b>Daily Trips per Resident for home-based trip purposes</b>							
<b>Daily Trips per (Empoyment + 0.4 * Population) for Non Home Based</b>							

# Mode-Distance choice parameters

Variable	Description	Units	Applied To Mode Choice	Applied to Distance Choice	Trip Purpose				
					Home to Work	Work to Home	Home to Other	Other To Home	Non Home Based
Employment in Zone	ln(total employment) in zone	ln (jobs)	Intra-Zonal	Intra-Zonal	0.27344	0.26910	0.17366	0.17809	0.19894
Employment < 1 mile	ln(total employment) within 1 mile of zone	ln (jobs)	0 - 1 miles	0 - 1 miles	0.44280	0.50628	0.44929	0.45449	0.44615
Employment 1-5 Miles	ln(total employment) between 1 and 5 miles from zone	ln (jobs)	1 - 5 miles	1 - 5 miles	0.20444	0.28407	0.29182	0.28795	0.24866
Employment 5-20 Miles	ln(total employment) between 5 and 20 miles from zone	ln (jobs)	5 - 20 miles	5 - 20 miles	0.29952	0.36711	0.34608	0.35989	0.35114
Proportion Mixed Use Land Use	Sum of proportion of "mixed use" land use type	proportion	Transit, Non-motorised	Transit, Non-motorised	1.04088	1.07720	0.73514	0.64125	1.03776
Monthly Parking Cost	Monthly parking cost per day	2011 \$	Auto Driver, Auto Passenger	Auto Driver, Auto Passenger	-0.05471	-0.04126	-0.07749	-0.03753	-0.04421
Transit Stop Density	Density of transit stops per square km	stops/km <sup>2</sup>	Transit	Transit	0.00002	0.00003	0.00003	0.00003	0.00003
Light Rail Accessibility	Is TAZ greater than 1500m from light rail / subway / metro?	1 (Yes) or 0 (No)	Transit	Transit	-0.77959	-0.75452	-0.73823	-0.65095	-0.60993
Bike Lane Density	Bike Lane Density	miles/acre	Non-motorised	Non-motorised	23.95272	23.68135	14.73925	13.43217	24.08899
Auto Driver intra-Zonal Constant		number	Auto Driver	Intra-Zonal	0.00000	0.00000	0.00000	0.00000	0.00000
Auto Passenger intra-Zonal Constant		number	Auto Passenger	Intra-Zonal	-0.96839	-0.96877	-0.61325	-0.80888	-0.95518
Transit Intra-Zonal Constant		number	Transit	Intra-Zonal	-3.44659	-3.19041	-3.13417	-3.17973	-3.30260
Non-motorised intra-Zonal Constant		number	Non-motorised	Intra-Zonal	-1.39748	-1.38096	-0.47457	-0.23712	-1.47551
Auto Driver 0-1 mile Constant		number	Auto Driver	0 - 1 miles	-2.23258	-2.85638	-2.97571	-2.98719	-2.81121
Auto Passenger 0-1 mile Constant		number	Auto Passenger	0 - 1 miles	-3.12118	-3.73732	-3.53137	-3.73227	-3.66967
Transit 0-1 mile Constant		number	Transit	0 - 1 miles	-4.96527	-5.65120	-5.66351	-5.71585	-5.68219
Non-motorised 0-1 mile Constant		number	Non-motorised	0 - 1 miles	-3.64081	-4.27743	-3.59310	-3.32701	-4.40141
Auto Driver 1-5 miles Constant		number	Auto Driver	1 - 5 miles	1.95987	0.98743	0.17028	0.37189	0.79292
Auto Passenger 1-5 miles Constant		number	Auto Passenger	1 - 5 miles	1.09450	0.13577	-0.39777	-0.23774	0.02993
Transit 1-5 miles Constant		number	Transit	1 - 5 miles	-0.62513	-1.64202	-2.21213	-1.94582	-1.91063
Non-motorised 1-5 miles Constant		number	Non-motorised	1 - 5 miles	-0.57001	-1.56032	-1.76141	-1.37590	-1.83231
Auto Driver 5-20 miles Constant		number	Auto Driver	5 - 20 miles	0.25329	-0.75043	-1.33345	-1.28360	-1.30616
Auto Passenger 5-20 miles Constant		number	Auto Passenger	5 - 20 miles	-1.07486	-2.04020	-2.15337	-2.15430	-2.41537
Transit 5-20 miles Constant		number	Transit	5 - 20 miles	-2.74906	-3.82148	-3.97817	-3.99814	-4.52495
Non-motorised 5-20 miles Constant		number	Non-motorised	5 - 20 miles	-7.33075	-8.34381	-8.79732	-8.65402	-8.75391
Auto Driver >20 miles Constant		number	Auto Driver	> 20 miles	4.02827	2.89515	1.23255	1.75256	1.50070
Auto Passenger >20 miles Constant		number	Auto Passenger	> 20 miles	2.15783	1.13376	0.30042	0.64619	0.10975
Transit >20 miles Constant		number	Transit	> 20 miles	-0.29504	-0.51990	-1.67355	-1.44760	-2.46135

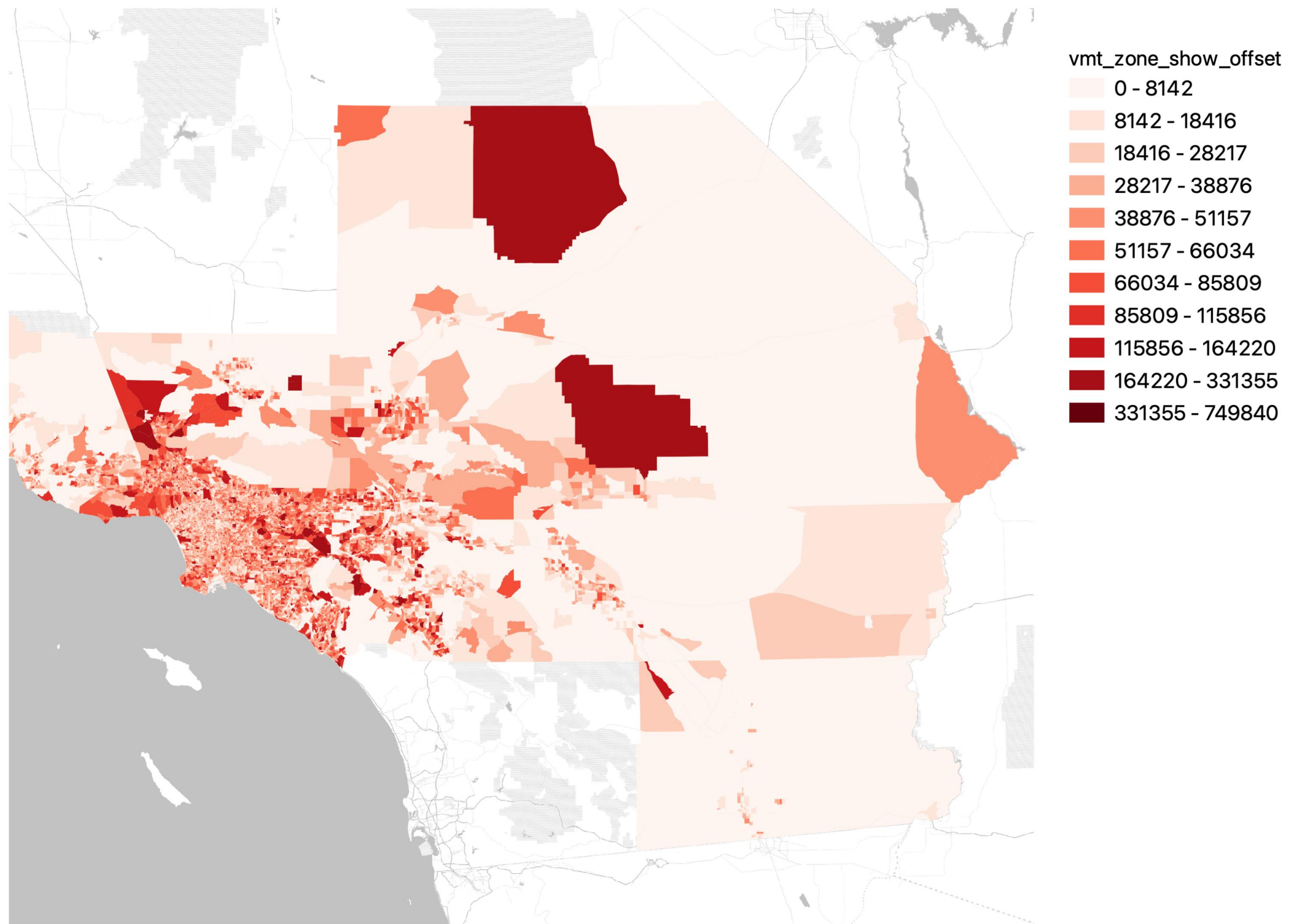




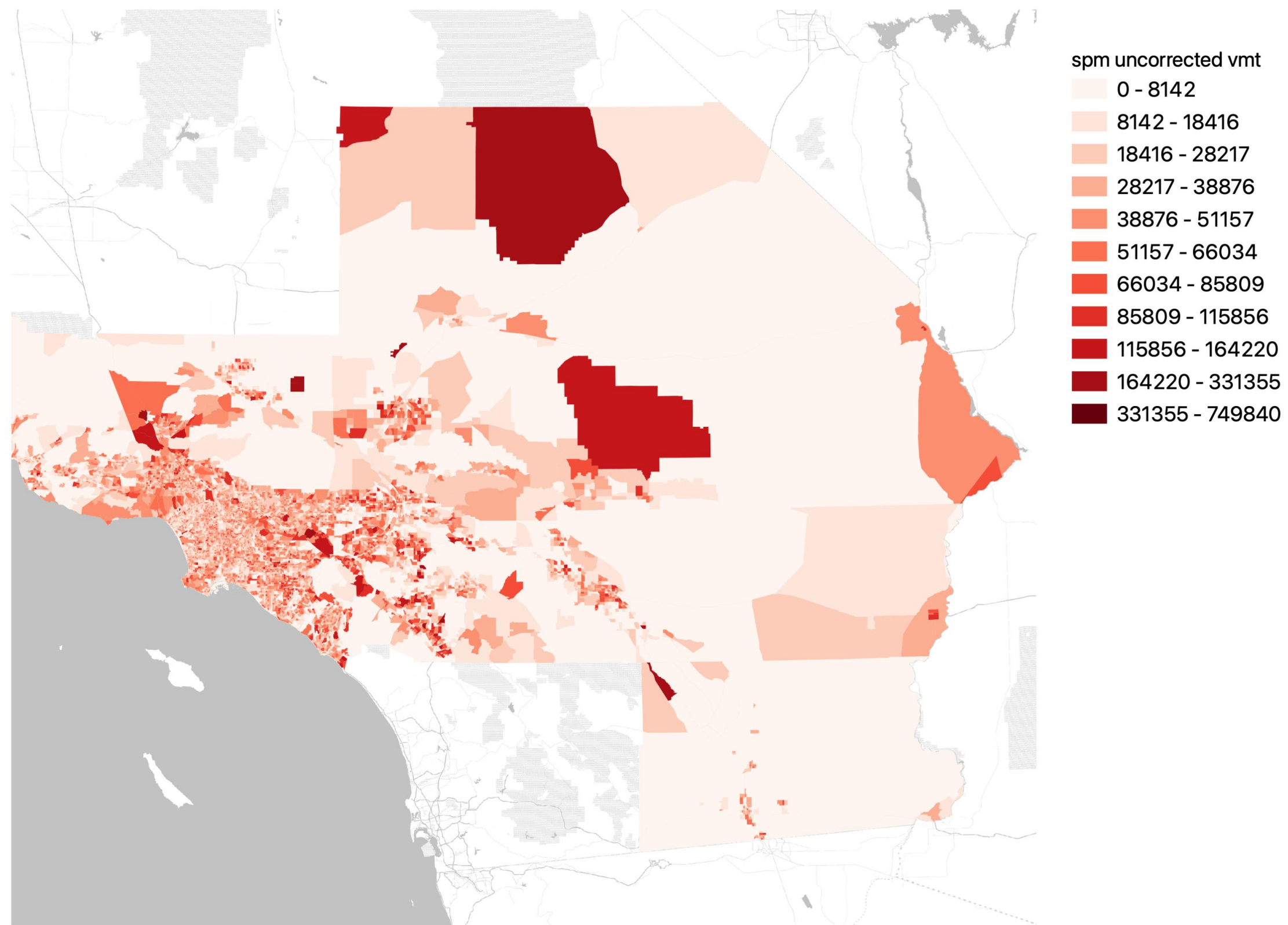
# Offsets

- Trip rate corrections by TAZ
- Mode and distance corrections by TAZ
- Represent the ABM's detailed insight into complex relationships

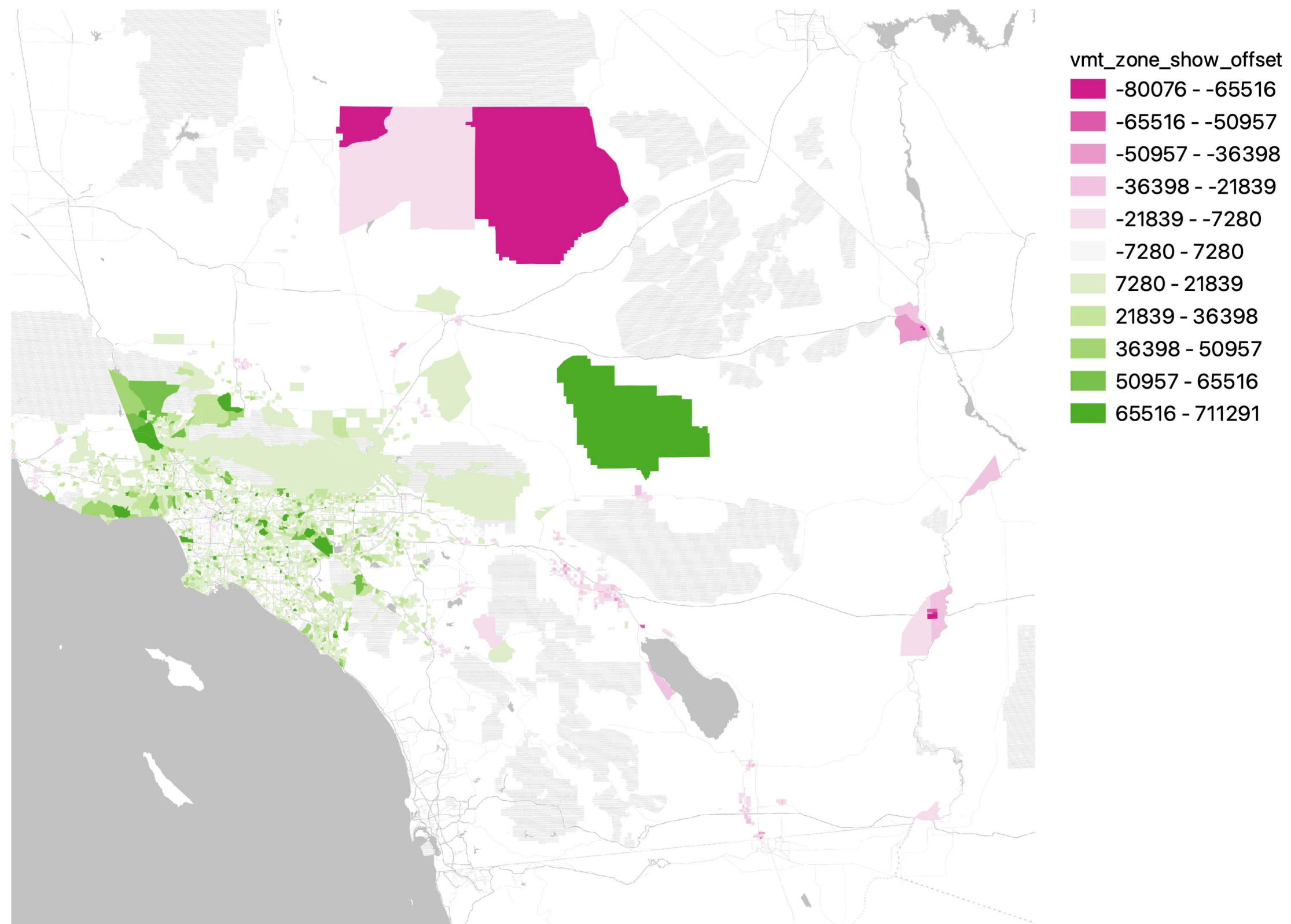
# ARM Total VMT by Trip Origin



# SPM Only VMT by Trip Origin

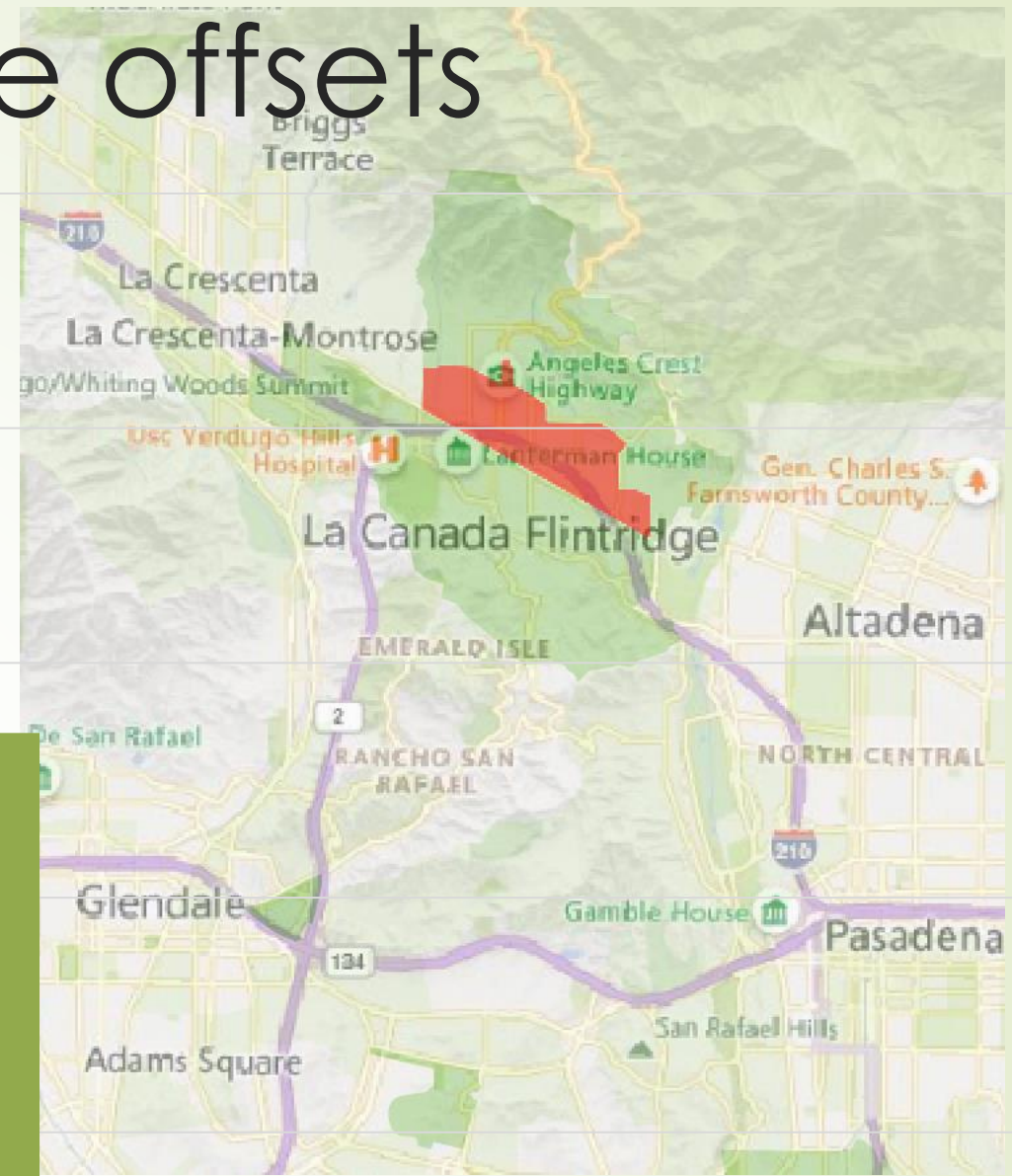
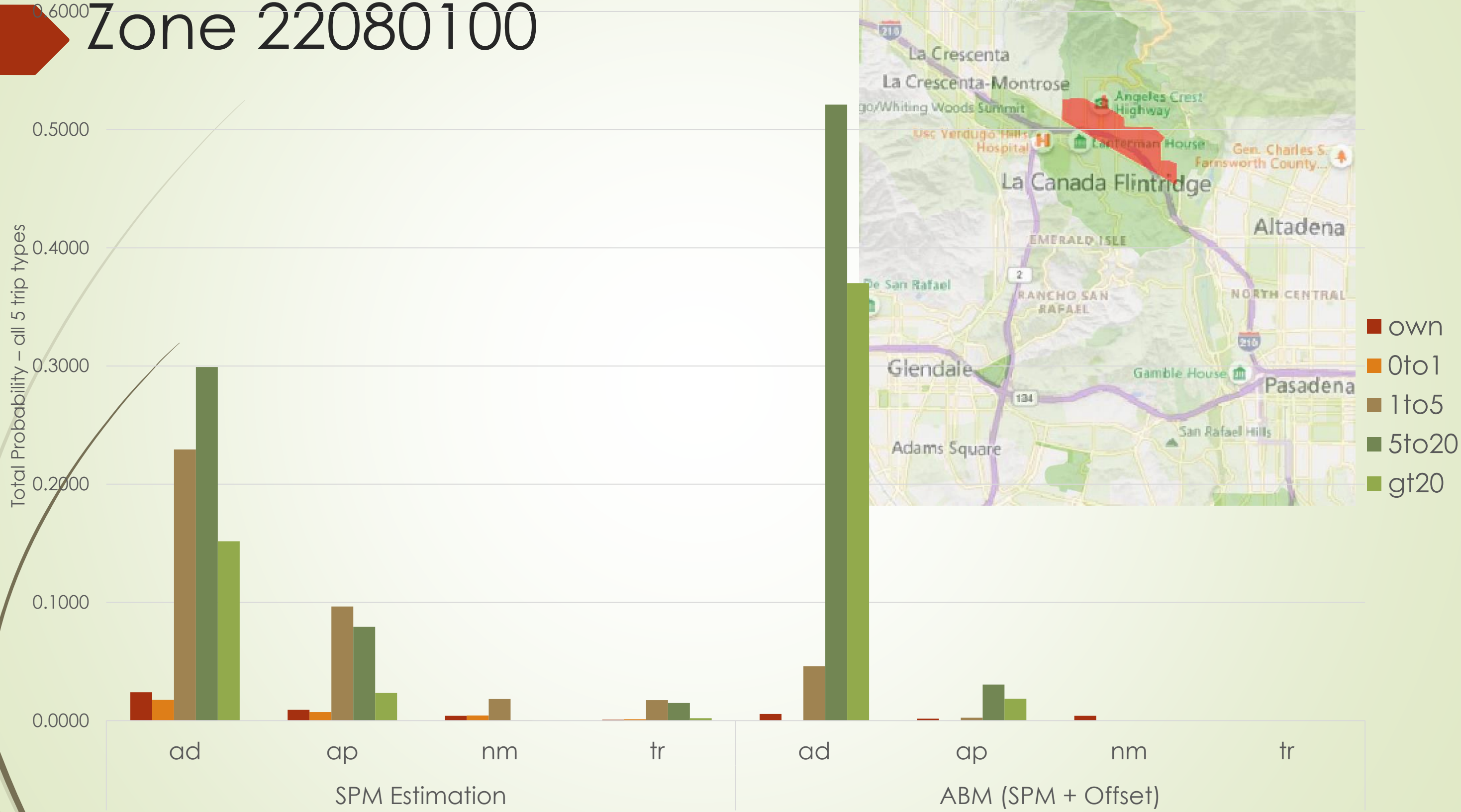


# Cumulative effect of VMT Offsets



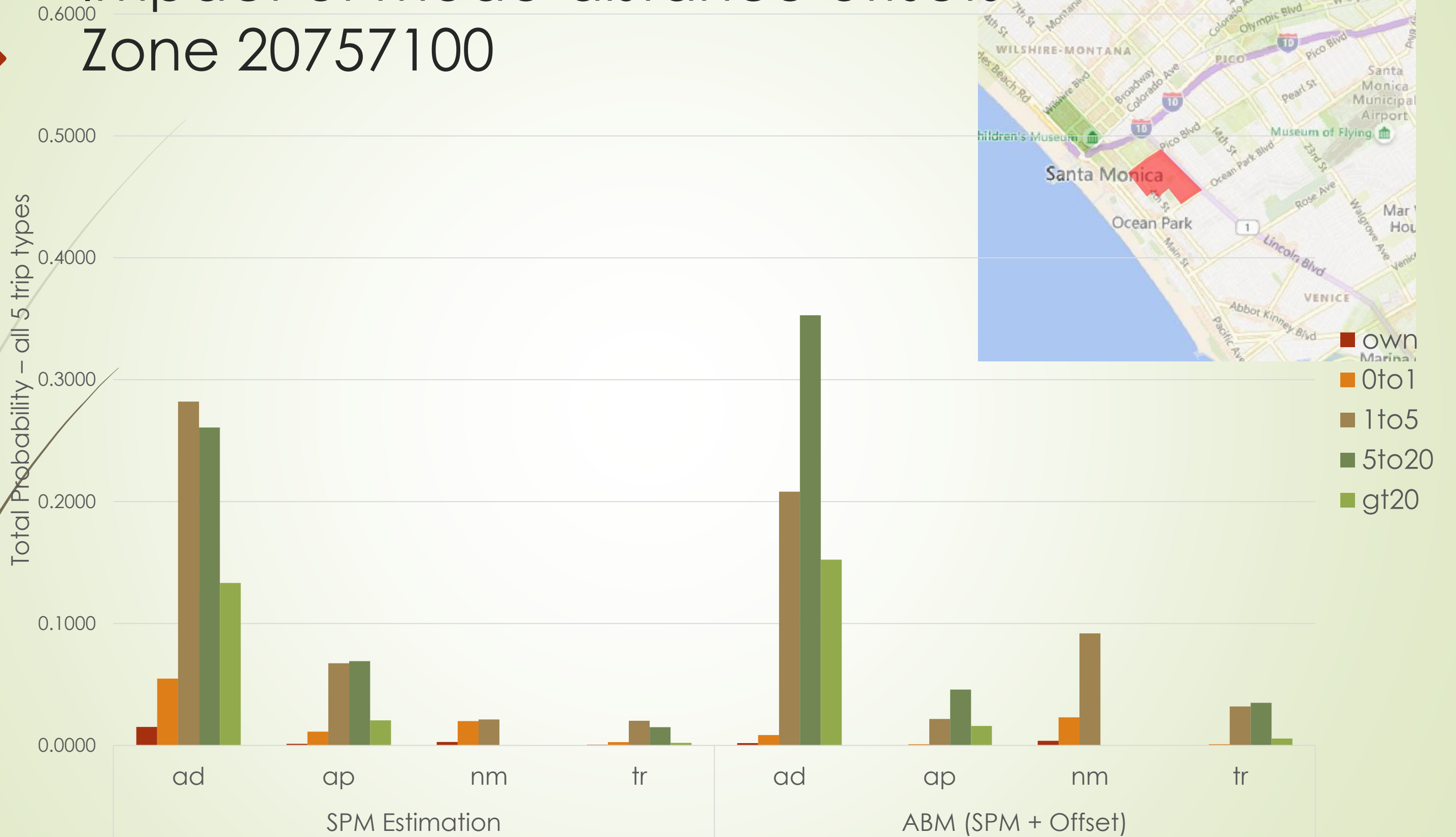
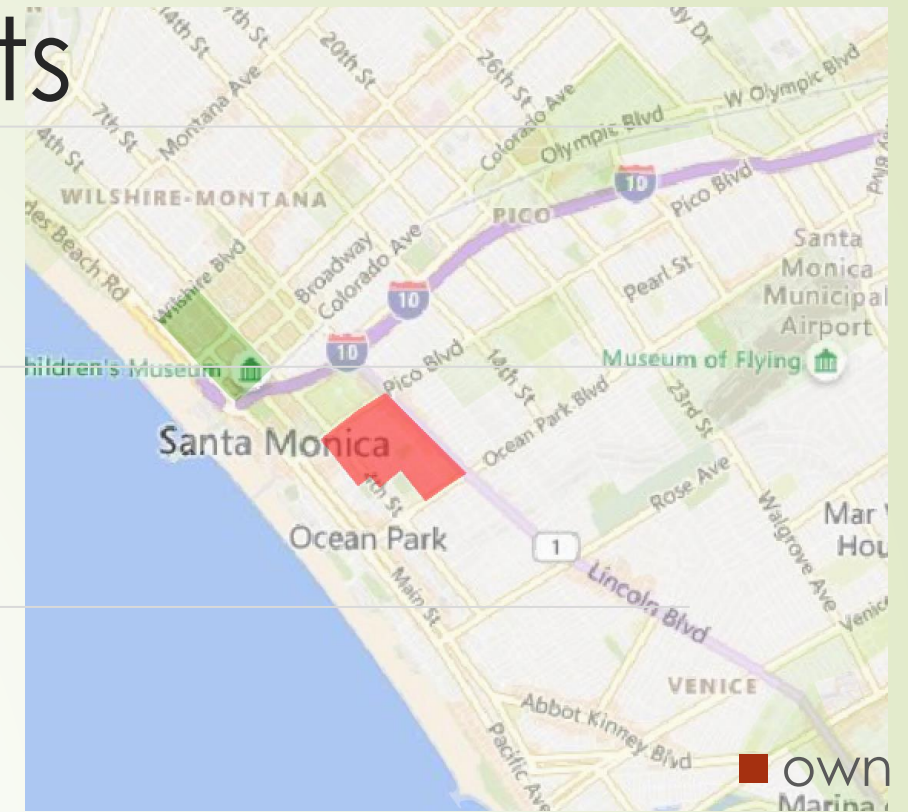
# Impact of mode-distance offsets

Zone 22080100



# Impact of mode-distance offsets

## Zone 20757100



# VMT predictions (internal person trips)

Alternative	H2O	H2W	NHB	O2H	W2H	Grand Total
ad-0to1	329,054	22,046	492,939	235,057	17,532	1,096,628
ad-1to5	14,321,605	2,866,371	17,486,142	14,452,231	2,417,824	51,544,173
ad-5to20	41,101,744	23,201,838	51,319,474	50,149,440	18,262,209	184,034,705
ad-gt20	10,288,607	47,544,732	19,113,024	25,002,633	34,271,306	136,220,302
ad-own	180,763	7,850	239,124	142,984	6,822	577,542
ap-0to1	0	0	0	0	0	0
ap-1to5	0	0	0	0	0	0
ap-5to20	0	0	0	0	0	0
ap-gt20	0	0	0	0	0	0
ap-own	0	0	0	0	0	0
nm-0to1	0	0	0	0	0	0
nm-1to5	0	0	0	0	0	0
nm-5to20	0	0	0	0	0	0
nm-gt20	0	0	0	0	0	0
nm-own	0	0	0	0	0	0
tr-0to1	0	0	0	0	0	0
tr-1to5	0	0	0	0	0	0
tr-5to20	0	0	0	0	0	0
tr-gt20	0	0	0	0	0	0
tr-own	0	0	0	0	0	0
<b>Grand Total</b>	<b>66,221,774</b>	<b>73,642,838</b>	<b>88,650,703</b>	<b>89,982,344</b>	<b>54,975,692</b>	<b>373,473,351</b>

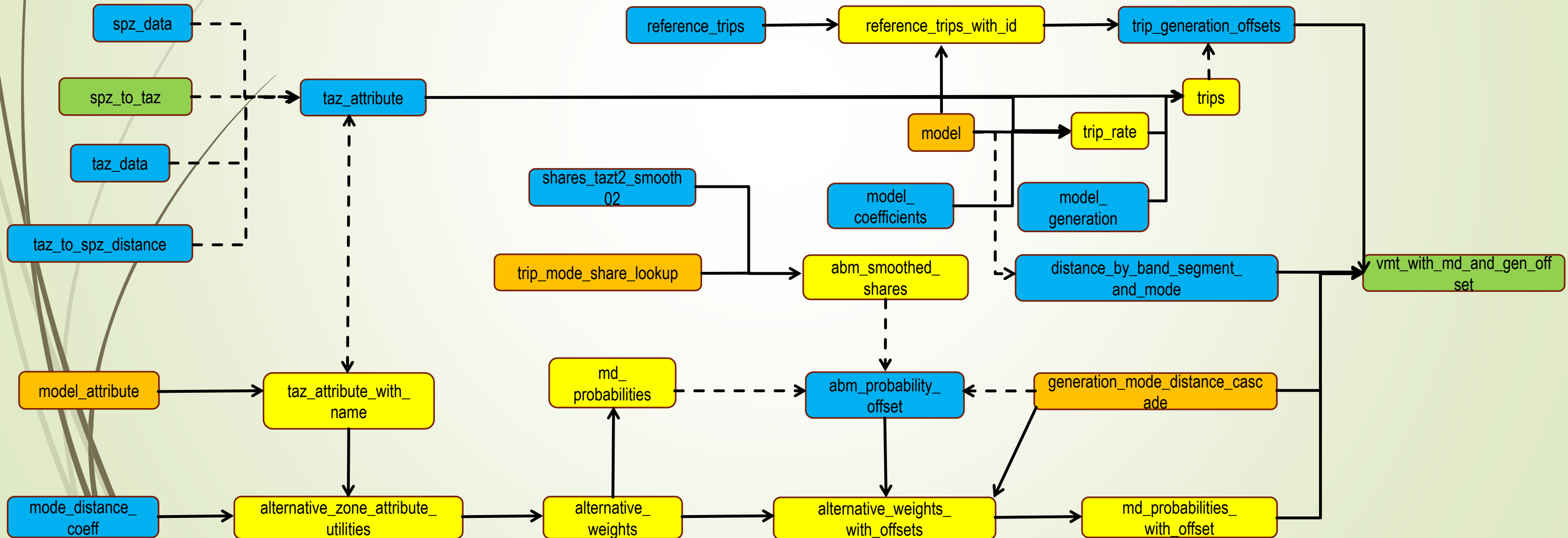
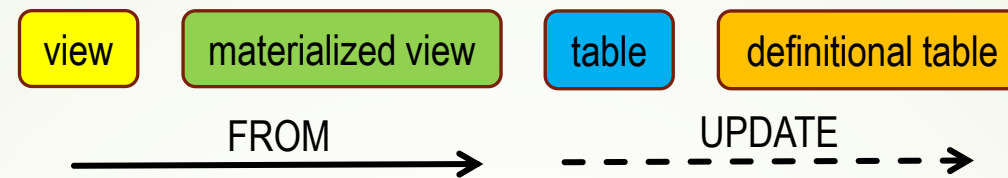


# Implementation

- PostgreSQL Database
- Quick response to changes in land use variables
  - ~4 minutes to recalculate proximity/accessibility
  - ~3 minutes to calculate VMT details by TAZ
- Load new ABM inputs to account for overall system changes or infrastructure performance
- Overnight process to change zone system (TAZ or SPZ)

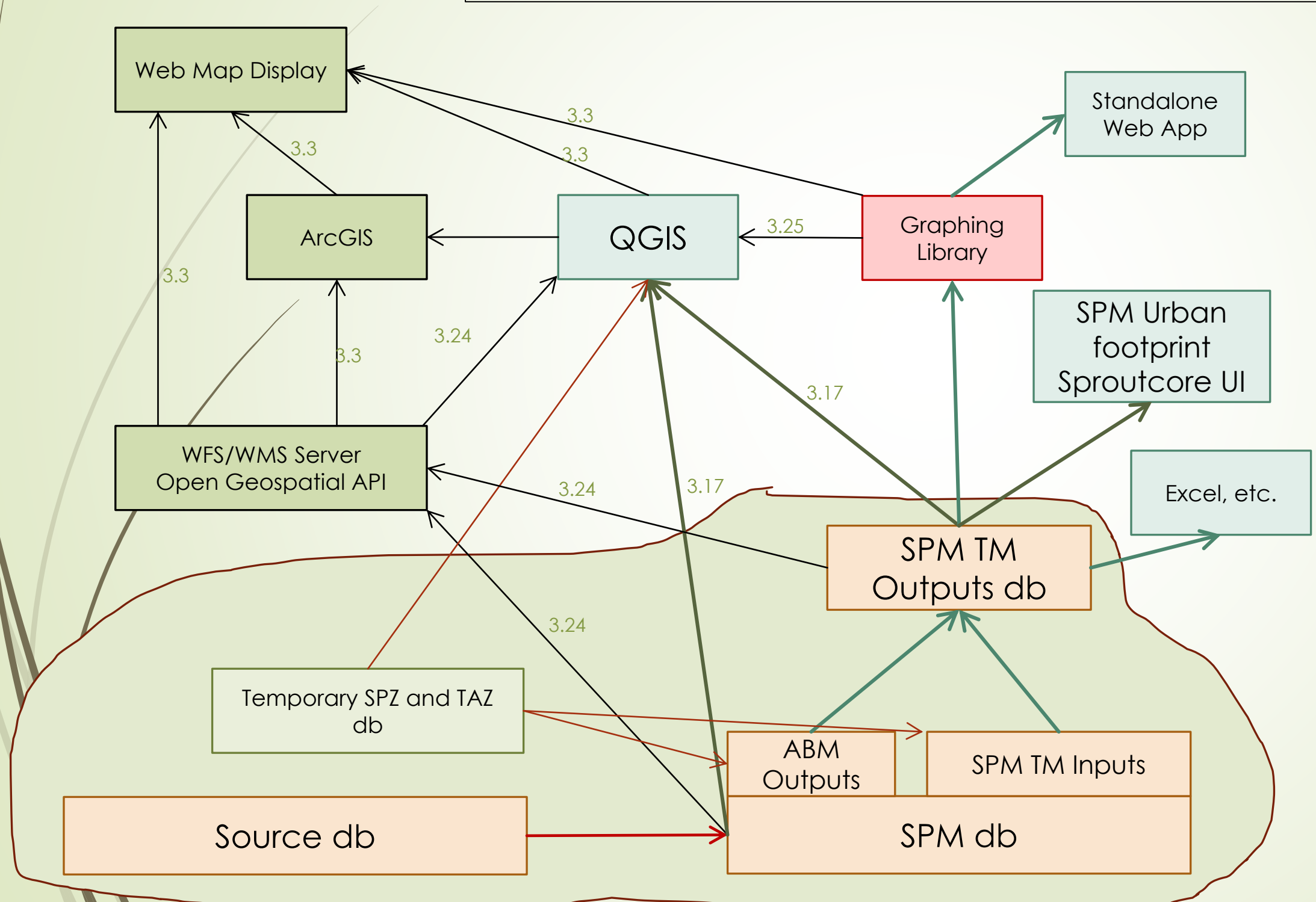
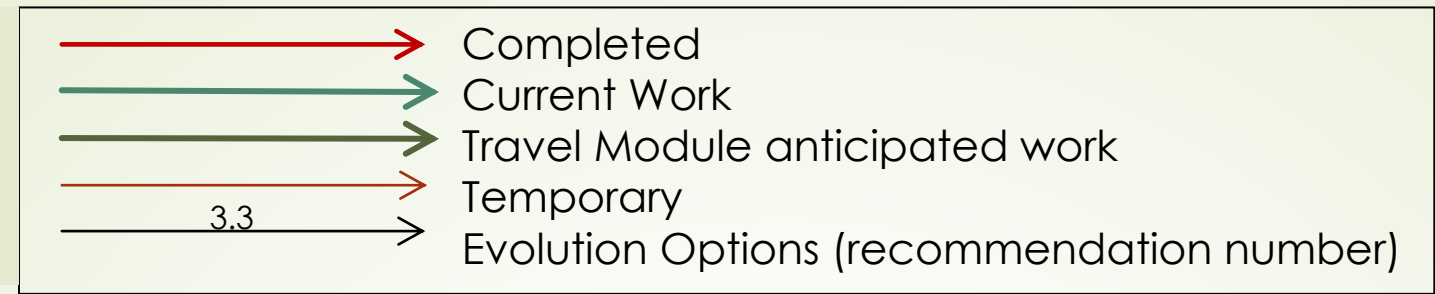


# Database Implementation



General SPM Architectural Vision

John Abraham  
September 12, 2022



- SPM database is a robust set of PostgreSQL databases
- Connected to a web-based tool called Urban Footprint
- Many other ways to interact with the SPM database
  - GIS
  - Web apps
  - 3<sup>rd</sup> party tools
  - Open Geospatial protocols



# Summary of SPM VMT/Travel Model

- SPZ data used to calculate TAZ attributes
- TAZ attributes including accessibilities lead to trip generation rates by trip type
  - From statistical estimation of 2016 patterns in SCAG region
- ABM Offsets from a particular chosen ABM scenario add additional detail:
  - Regionwide variables, such as age demographics, industry mix
  - Zonal specific trip making, such as special generators or demographics
- Accessibility by distance band and TAZ attributes lead to mode choice and distance band choice
- ABM Offsets from chosen ABM scenario add additional detail:
  - Regionwide considerations, such as transit fares, auto operating cost, or auto ownership
  - Zonal specific mode choice and distance choice, such as nearby special amenities or transit level-of-service beyond stop proximity/density.



# Conclusions

- VMT calculation fully consistent with / informed by / SCAG's Regional Travel Model (ABM)
- Quick calculation of the VMT impacts of changes in land use patterns
- Supports the multi-disciplinary evaluation of policies, by putting VMT impacts alongside the other metrics in the multidisciplinary SPM
- Database infrastructure design supports application above/beyond the existing Urban Footprint web tool.