Spatial Input-Output Models: PECAS

Webinar 4 of an 8-part TMIP Webinar series on land use forecasting methods.

1. **PECAS Overview**
    a. **Background**
    b. **Theoretical Basis**
    c. **Software Implementation**
    d. **Data Inputs and Outputs**
2. Anatomy of the Model
3. Application in Practice
4. Comparison and Assessment

PECAS Background

- PECAS (the Production, Exchange and Consumption Allocation System) is an urban and regional modeling tool to support transportation and economic planning
- Developed by Dr. Doug Hunt and Dr. John Abraham, University of Calgary
- Contains two principal models:
  - Activity Allocation (**AA**): an aggregate, equilibrium **Spatial Input-Output Model**
  - Spatial Development (**SD**): a disaggregate **State-Transition** model
- Developed initially as part of an Oregon Department of Transportation (ODOT) Statewide Modeling project as a replacement for a 1st generation statewide model using TRANUS
- Recently, CalTrans implemented a contract with UC Davis to support development of a California Statewide PECAS model, and to support MPOs within the state in the development of metropolitan level PECAS models

Application:

Current Applications (from model developers)

- Oregon, USA State-wide
  - part of larger modelling system with micro-simulation components
- Ohio, USA State-wide
  - Model designed and used as basis for data collection
- Sacramento Area, USA
  - Part of larger modelling system with micro-simulation components
- Calgary Region, Canada
  - Design for new urban level modelling system
- Edmonton Region, Canada
  - Design for new urban level modelling system
- Baltimore Metropolitan Area
  - Design for new urban level modelling system

The State of the Practice: Survey of MPOs in 2010

Currently Using

	Used in last projection series	Used in last RTP update
PECAS	1	0
OPUS/UrbanSim	3	4
CUBE Land	0	0
Places3	0	0
CommunityViz	0	0
DRAM/EMPAL	5	3
Home Grown	6	5
Other	0	1

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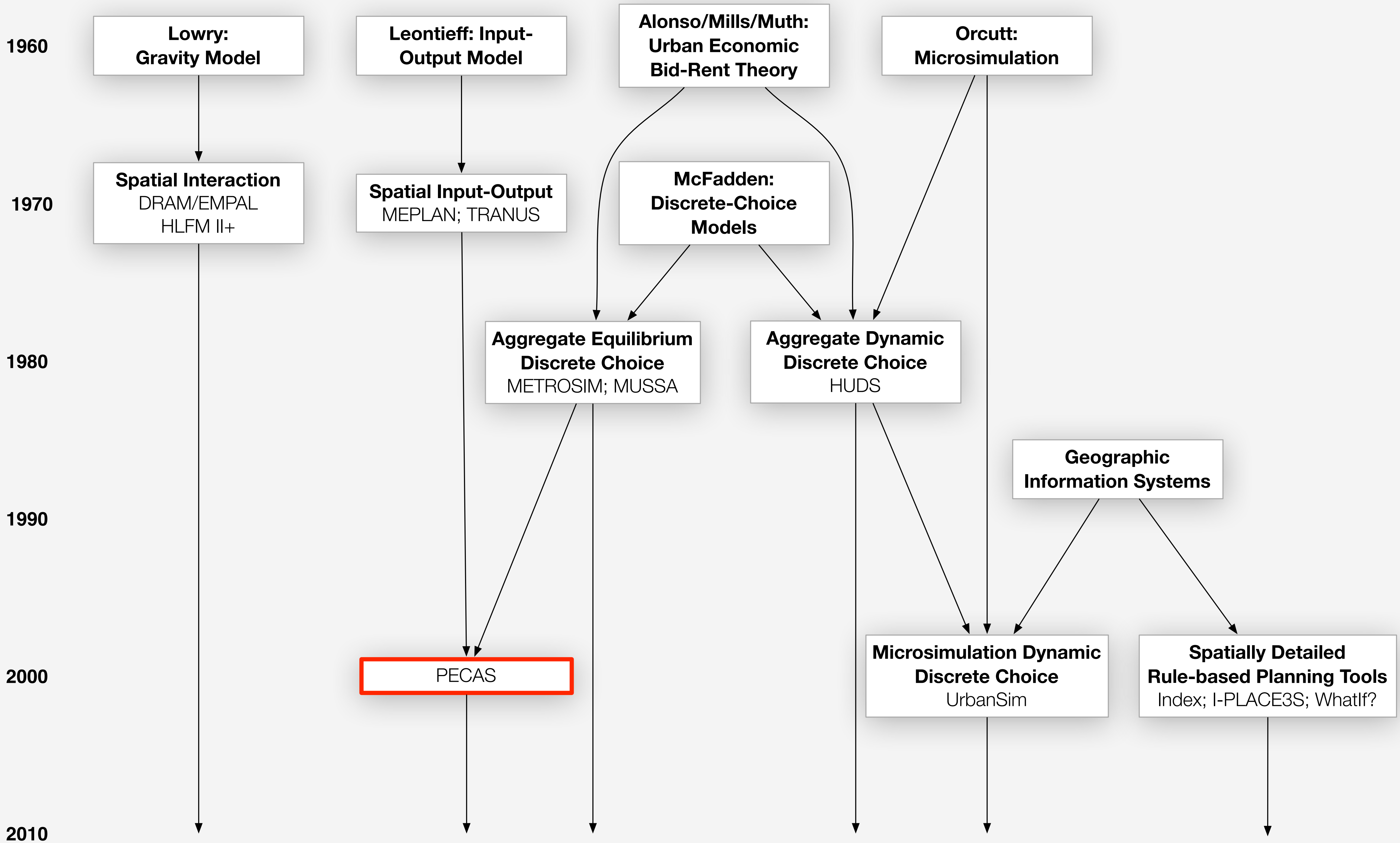
Evolution of Land Use Model Frameworks



PECAS Overview: Activity Allocation (AA)

- Core of PECAS is a spatial input-output model
- Aggregate model representing monetary flows in the economy between Land Use Zones (LUZ) (usually aggregations of TAZs)
- Monetary flows translated to commodity flows between sectors and LUZs
- Static equilibrium; solves for exchange and consumption prices by LUZ
  - Does so annually whereas older models did so once for the entire time period
- Commodities include labor (provided by households), real estate (residential and commercial floorspace), and other goods and services

PECAS Overview: Spatial Development (SD)

- State transition style model of stochastic change of cells or parcels to alternative land use
- Followed initial version of UrbanSim (1998) parcel and gridcell developer model using this approach (later UrbanSim versions moved to other formulations)
- Unlike AA, SD is disaggregate, at gridcell or parcel level
- Uses pricing (rents) from AA and development costs

Theoretical Basis: Input-Output Models

- PECAS's core (the AA) is a spatial input-output model
- This venerable approach represents an economy as a matrix
  - cells contain values representing the amount of economic activity (production or consumption) for a particular combination of sectors
  - equations represent the interlinkages between portions of the economy and allow changes in one area to be traced through to other areas
  - tracking the activities and flows by geographic location makes the table **spatial**
- Now a brief review of this approach

Example I-O Expenditure Table for Retail

In order to produce a **total output of $20000**, the retail sector consumes inputs for its production process. Assume the following inputs are purchased to produce the $20000 of retail output, based on the production process for retail:

	Retail
Basic	$5000
Retail	$2000
Services	$3000

Example I-O Expenditure Table for All Local Industries

Each other industry also requires inputs to produce the total output shown at right.

	Basic	Retail	Services
Total Output	$10,000	$15,000	$20,000

	Basic	Retail	Services
Basic	$1,500	$5,000	$1,000
Retail	$2,500	$2,500	$5,000
Services	$3,000	$3,000	$2,000

Example I-O Direct Input Requirements Matrix

This table shows the standardized inputs per dollar of output for each industry, also known as **technical coefficients.**

	Basic	Retail	Services
Basic	0.15	0.33	0.05
Retail	0.25	0.13	0.25
Services	0.30	0.20	0.10

Multiplier Effects

	Basic	Retail	Services
Total Output	$10000	$15000	**$25000**

First Iteration

Multiplier Effects

	Basic	Retail	Services
Total Output	$10000	$15000	**$25000**

→ **Induced Consumption**

First Iteration

Multiplier Effects

	Basic	Retail	Services
Total Output	$10000	$15000	**$25000**

Induced Consumption

First Iteration

	Basic	Retail	Services
Basic	$1,500	$5,000	**$1,000**
Retail	$2,500	$2,500	**$5,000**
Services	$3,000	$3,000	**$2,000**

Multiplier Effects

	Basic	Retail	Services
Total Output	**$10,500**	**$16,250**	**$25,250**

Induced Consumption

First Iteration

	Basic	Retail	Services
Basic	$1,500	$5,000	**$1,000**
Retail	$2,500	$2,500	**$5,000**
Services	$3,000	$3,000	**$2,000**

Multiplier Effects

	Basic	Retail	Services
Total Output	$11,302	$17,344	$26,510

Induced Consumption

After Convergence

	Basic	Retail	Services
Basic	$1,695	$5,781	$1,326
Retail	$2,826	$2,891	$6,628
Services	$3,391	$3,469	$2,651

Economic Flows Can be Split by Region (Spatial I-O)

Economic Activities		Region A			Region B			Final Demand and Exports	Total Demand
		Basic	Retail	Services	Basic	Retail	Services		
Region A	Basic								
	Retail								
	Services								
Region B	Basic								
	Retail								
	Services								
Final Payments and Imports									
Total Inputs									

Economic Flows Can be Further Split into Commodities Produced and Consumed (Make and Use Tables)

Economic Activities		Region A			Region B			Final Demand and Exports	Total Demand
		Basic	Retail	Services	Basic	Retail	Services		
Region A	Basic								
	Retail								
	Services								
Region B	Basic								
	Retail								
	Services								
Final Payments and Imports									
Total Inputs									

Economic Flows Can be Further Split into Commodities Produced and Consumed (Make and Use Tables)

Non-Residential Floorspace

Housing

Labor

Goods and Services

Economic Activities		Region A			Region B			Final Demand and Exports	Total Demand
		Basic	Retail	Services	Basic	Retail	Services		
Region A	Basic								
	Retail								
	Services								
Region B	Basic								
	Retail								
	Services								
Final Payments and Imports									
Total Inputs									

PECAS Software Architecture

- Base PECAS system consists of two major Java modules (the AA and the SD) and supporting infrastructure
- Model runs initiated using DOS shell or Python script
- Most data stored and passed between modules in CSV format
  - Scenario inputs and parameters are set by creating CSV files
  - Most model outputs are also in many CSV files
- Parcel information is stored in a database such as SQL Server or PostGIS
- Data preparation requires GIS and statistical software
- Loose integration with travel model through squeezed skims in CSV
- Runs on a multi-processor server
  - Calibration can take days for a single run
  - Multi-decade projections can take hours

Activity Allocation (AA) Module

Inputs and Data Sources (1)

- Aggregate economic flow: IMPLAN
  - Demargined for wholesale and retail
- Synthetic households by TAZ
  - Census PUMS
  - Census SF 3 summary files
  - Automated in Python
- Synthetic employment (by industry and occupation)
  - CTPP
  - InfoUSA
  - Automated in Python
- Technology options
  - Aggregate economic flow; Census PUMS; cluster analysis

Source: Shengyi Gao (et al)

Activity Allocation (AA) Module

Inputs and Data Sources (2)

- Floorspace inventory
  - EIA Space use survey
  - Synthetic employment
  - Existing land use
- Transport costs
  - BTS commodity flow survey
  - Midday skims from the travel model
  - Logsum of mode choice by trip purpose
- Rent
  - DataQuick transactions in 2000 (residential and non-residential)
  - CoStar (non-residential)
- Vacancy rate
  - Census SF 3 summary files
  - CoStar data
- Imports and exports
  - BTS commodity flow survey
  - IMPLAN
  - TradeViewTM, zepol

Source: Shengyi Gao (et al)

Space Development (SD) Module

Inputs and Data Sources (1)

- General land use plan
  - Generalized city/county general land use plans
  - 35 land use types
- Base parcel database
  - Existing land use type
  - Zoning
  - Year built
- Rent modifier
  - Distance to freeways
  - Distance to ramps
  - Distance to highways
  - Distance to beaches
  - Distance to parks
  - Distance to schools
  - Distance to rail roads

Source: Shengyi Gao (et al)

Space Development (SD) Module

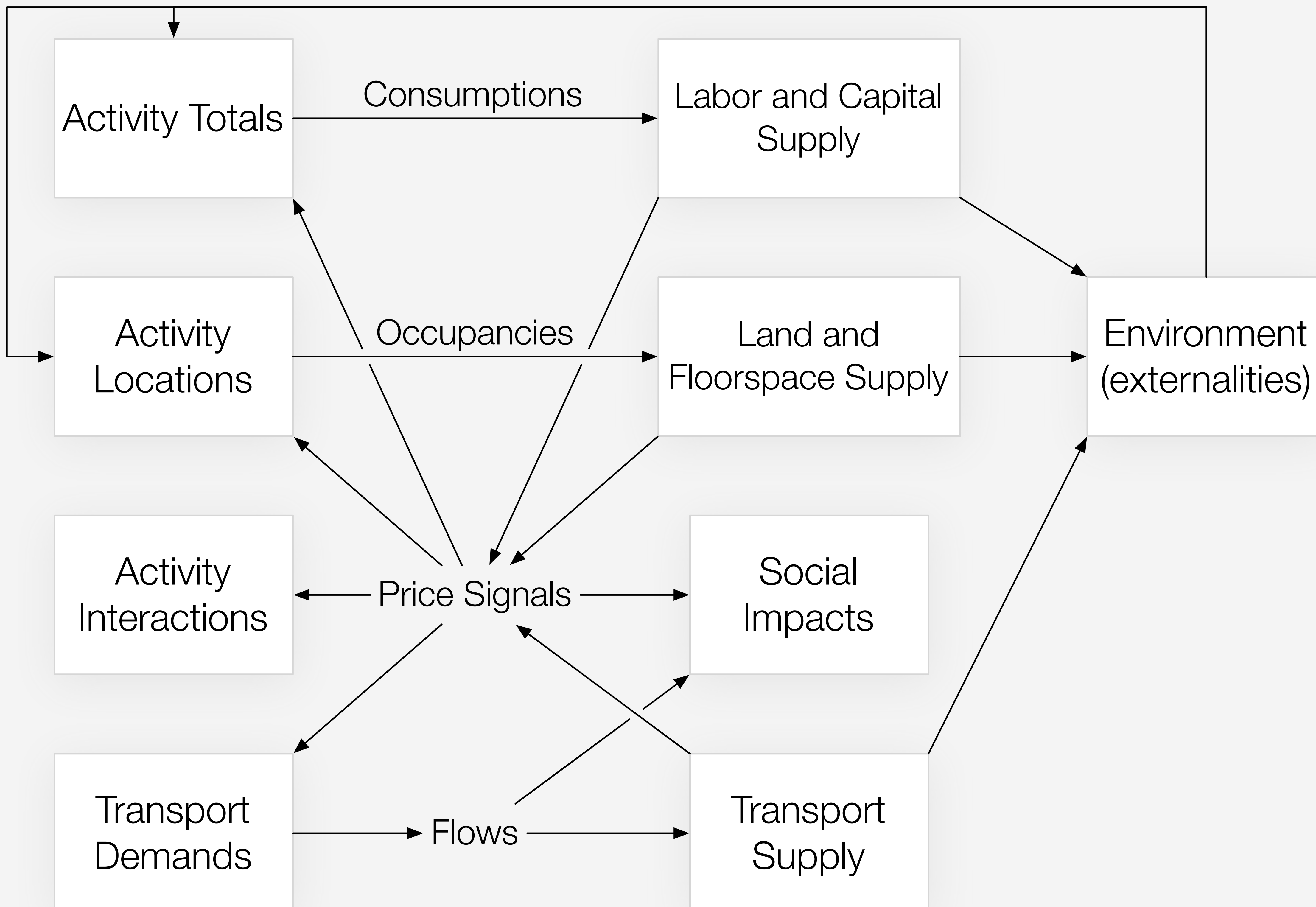
Inputs and Data Sources (2)

- Construction cost
  - RSMeans data
- Maintenance cost
- Typical FAR
- Density rent discount
- Demolition costs
- Age discount
  - Multiple sources
- Maximum/minimum intensity
  - Zoning ordinance
- Development fees
  - HCD database

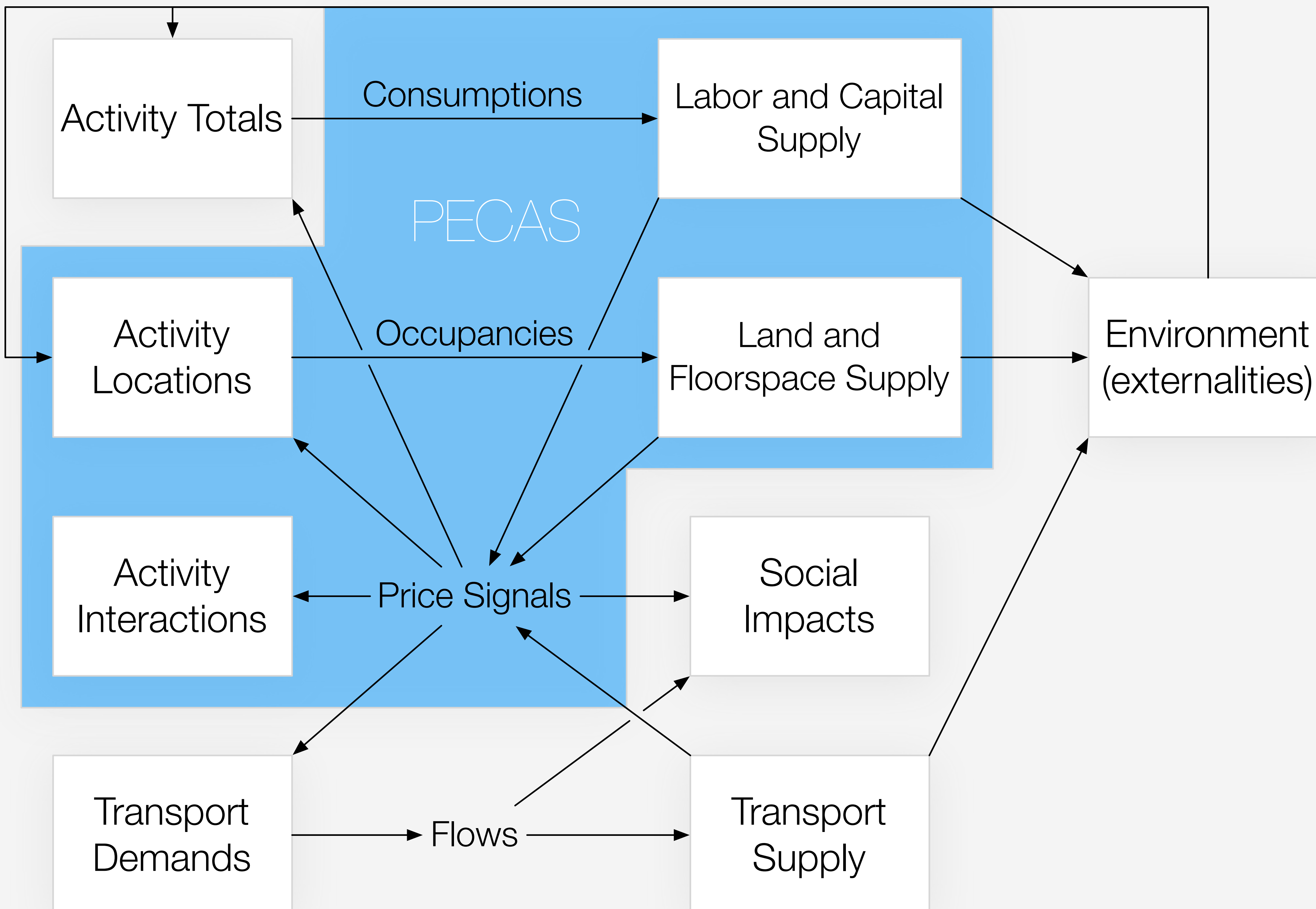
Source: Shengyi Gao (et al)

1. PECAS Overview
2. **Anatomy of the System**
    a. **Model Design**
    b. **Software Architecture**
    c. **Estimation, Calibration, and Validation**
3. Application in Practice
4. Comparison and Assessment

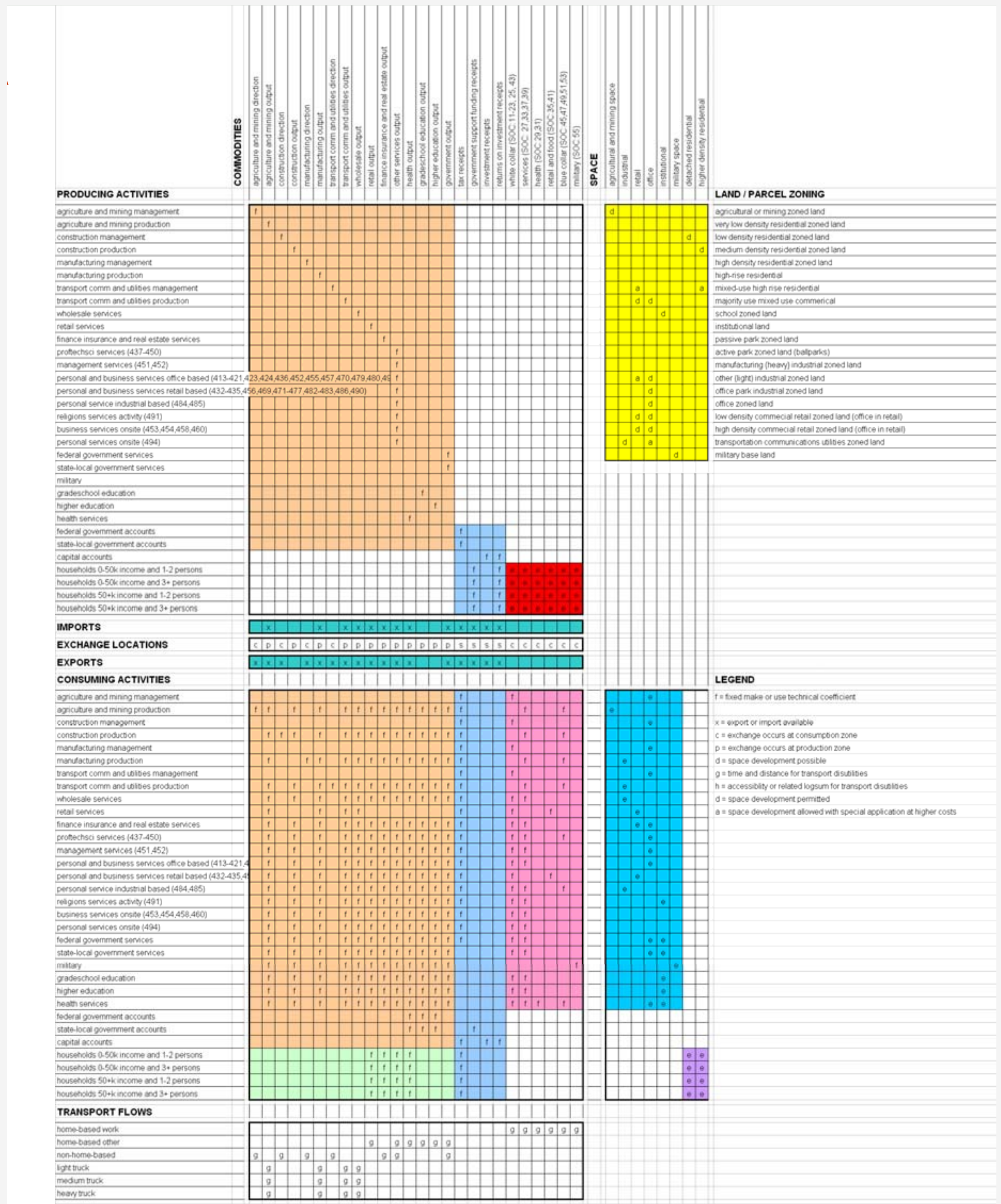
Economic Interactions



PECAS Overview

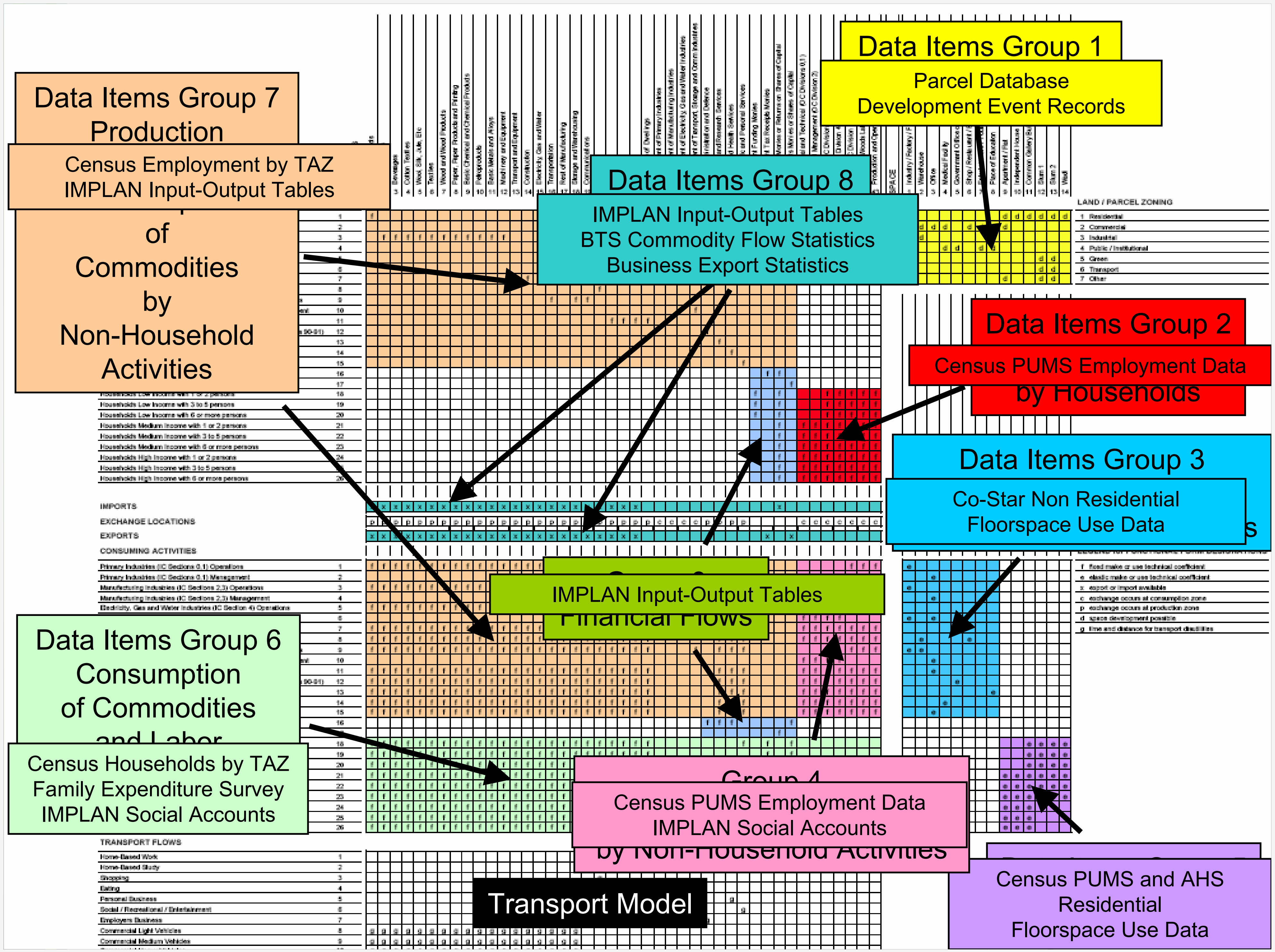


Model Design Diagram



source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

Model Design Diagram Details



source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

Activity Allocation (AA) Module

- Aggregate spatial input-output model
- Represents interaction of activities through commodity flows
  - Food shipping to a processing plant to store
  - Person driving to work
- Travel model provides the yearly description of disutility of movement between locations (congestion) that underly activity interaction
  - e.g Congestion might move two interdependent industries closer together
  - e.g. A new highway might drive development of new subdivisions
- Connection with SD
  - Activities occupy floorspace build by the SD
  - Spatial choices of activities drive prices that motivate SD developer

Activity Allocation (AA) Module

Activities and Commodities

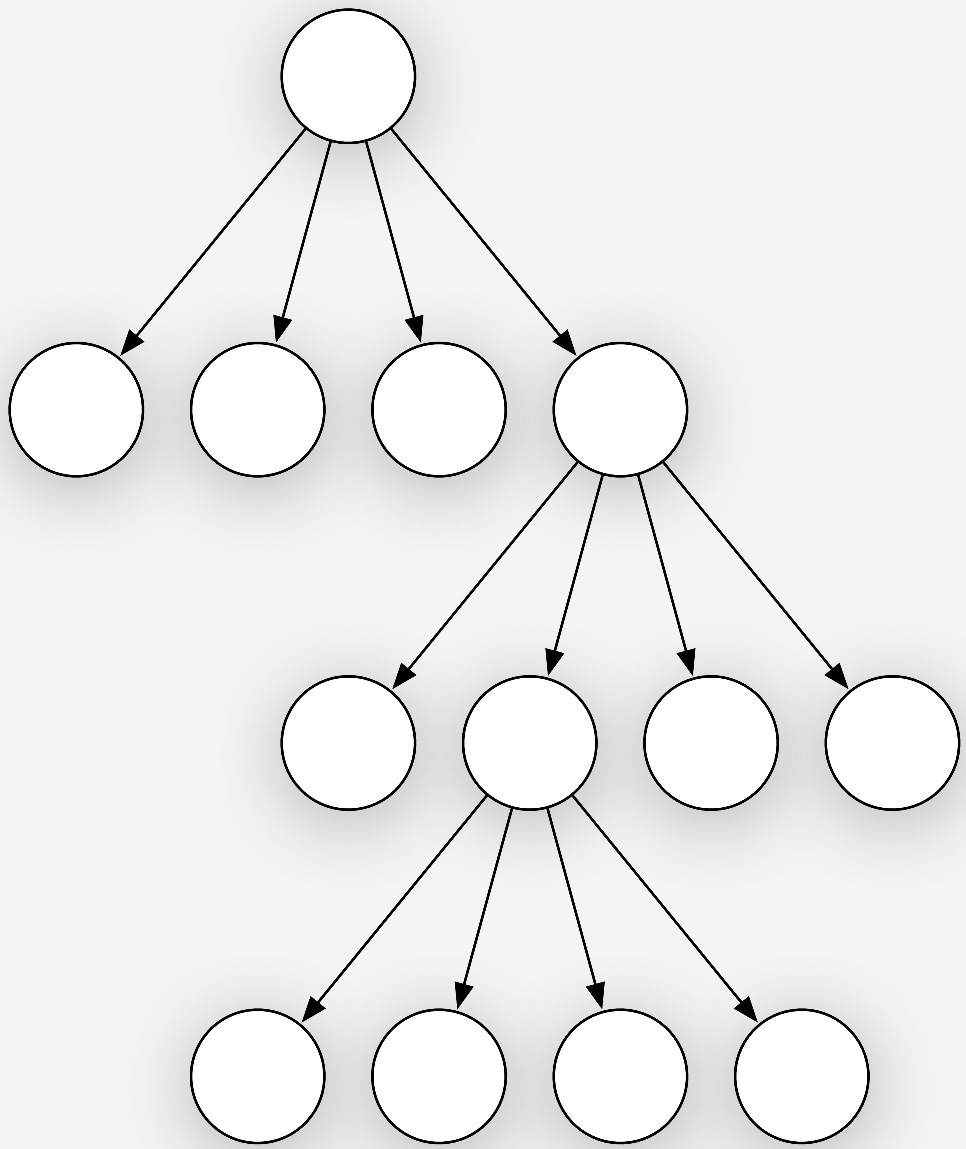
- Activities
  - Industries: 63 (electricity utilities emphasized)
  - Households: 25, including 5 all seniors household types
- Commodities
  - Goods and services: 60 (including fuel, electricity, GHG permit, agriculture water use, etc.)
  - Labor: 19
  - Space: 38 (14 residential types; 24 non-residential types)
- Zone system
  - Land use zone: 526
  - Floorspace zone (TAZ): 5191

Counts are from California State model application

Source: Shengyi Gao (et al)

Activity Allocation (AA) Module

Decision Tree



Location Choices

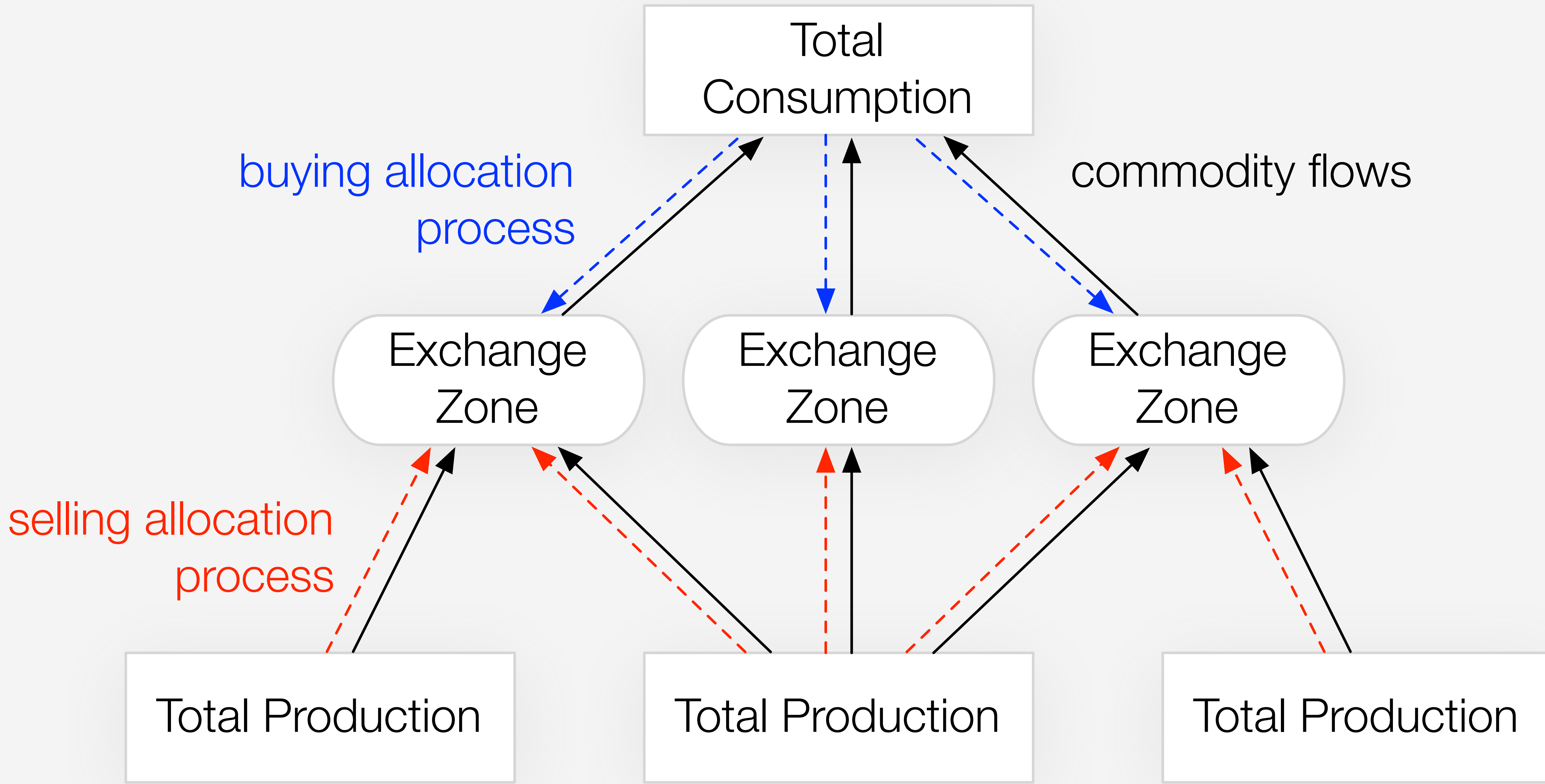
Production/Consumption Choices

Exchange Location Choices

Economic Interactions

Production - Exchange – Consumption

Make and use with exchange zones



Economic Interactions

Production - Exchange – Consumption

1: production allocation

allocating production activity to zones

2: technology selection

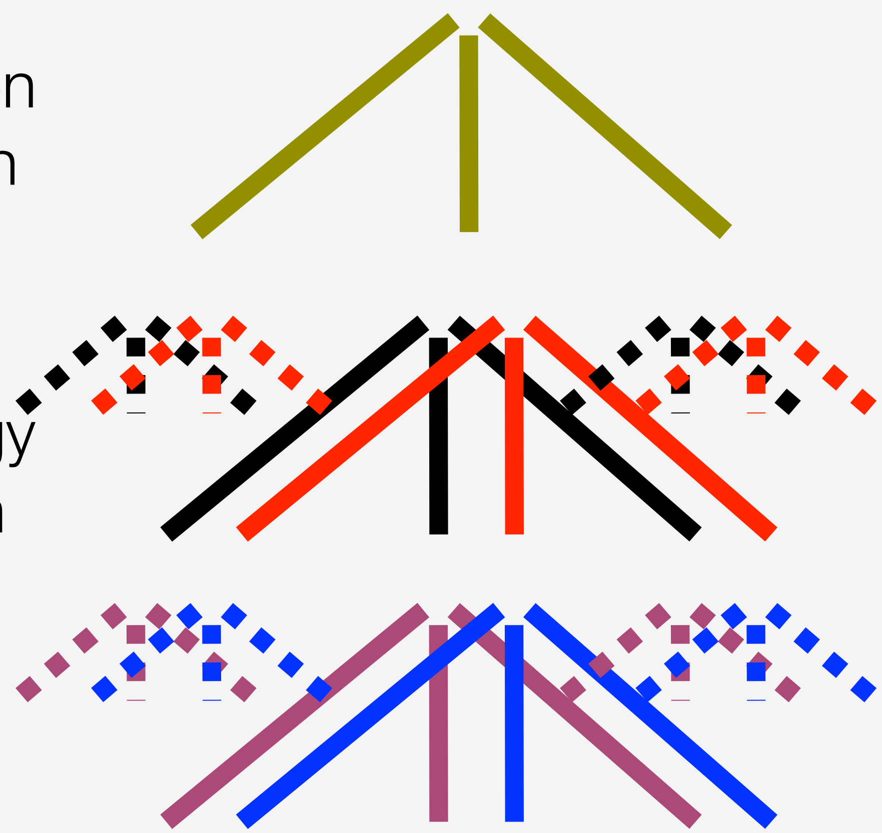
allocating production to commodities

allocating consumption to commodities

3: selling allocations buying allocations

allocating produced commodities to selling locations

allocating consumed commodities to buying locations



3-level nested logit model

Activity Allocation (AA) Module

Joint Discrete Utility

Additional utility associated with location l for activity a

Additional utility associated with production option p

Stochastic error terms

$$U^{a}_{lpe_1e_2\ldots e_n} = V_l^a + \varepsilon_l^a + V_p + \varepsilon_{lp} + \sum_{n=1\cdots N_p} \left|\alpha_{pn}\right| s_{pn} \left(V_{e_n l} + \varepsilon_{e_n lp}\right)$$

Quantity of commodity produced or consumed under production option p

Utility of exchanging and shipping one unit of commodity between l and e

Source: Atlanta Regional Commission

Space Development (SD) Module

- Disaggregate process at the parcel level
  - Grid cells or parcels
- Represent developers' actions
- Connection with AA
  - From AA: current year space price at LUZ level
  - To AA: quantity of the spaces for next year AA
- Space is a commodity consumed by the activities in the AA model
  - Unlike other commodities, space cannot be transported
  - Different activities consume different types of space
    - e.g. in Atlanta there are 8 PECAS space types (A/D/S/M/O/R/L/H)
- Rents are space prices
- Zoning rules limit the type of space the can be developed on a parcel

Source: Atlanta Regional Commission

Space Development (SD) Module

Development Events

- Year-by-year step
- Possible development events
  - E0: no change
  - En: new space type and quantity
  - Er: alter or renovate
  - Ed: derelict
- Two step process for each parcel
  - Selection of development events and update space type
  - Update space amount
- Data needs
  - Permits
  - Parcel level data
  - Rents

Source: Atlanta Regional Commission

Space Development (SD) Module

Rents

- Space prices are rents for the use of space
- Per unit of space per unit of time
- Rent equation: $Rent_h = Price_{h,z} \cdot \pi_{g \varepsilon G} LEFac_{g,h}$
  - Space price at LUZ level in AA (done by AA & SD integration)
  - Local-level effects due to:
    - Density of development around the parcel
    - Age of the structure
    - Local Effects: distance from (or proximity to) local-level influences
      - Expressway
      - Interstate exit
      - Major road
      - School
      - Marta
      - Green space

Source: Atlanta Regional Commission

Space Development (SD) Module

Simulation of Transitions

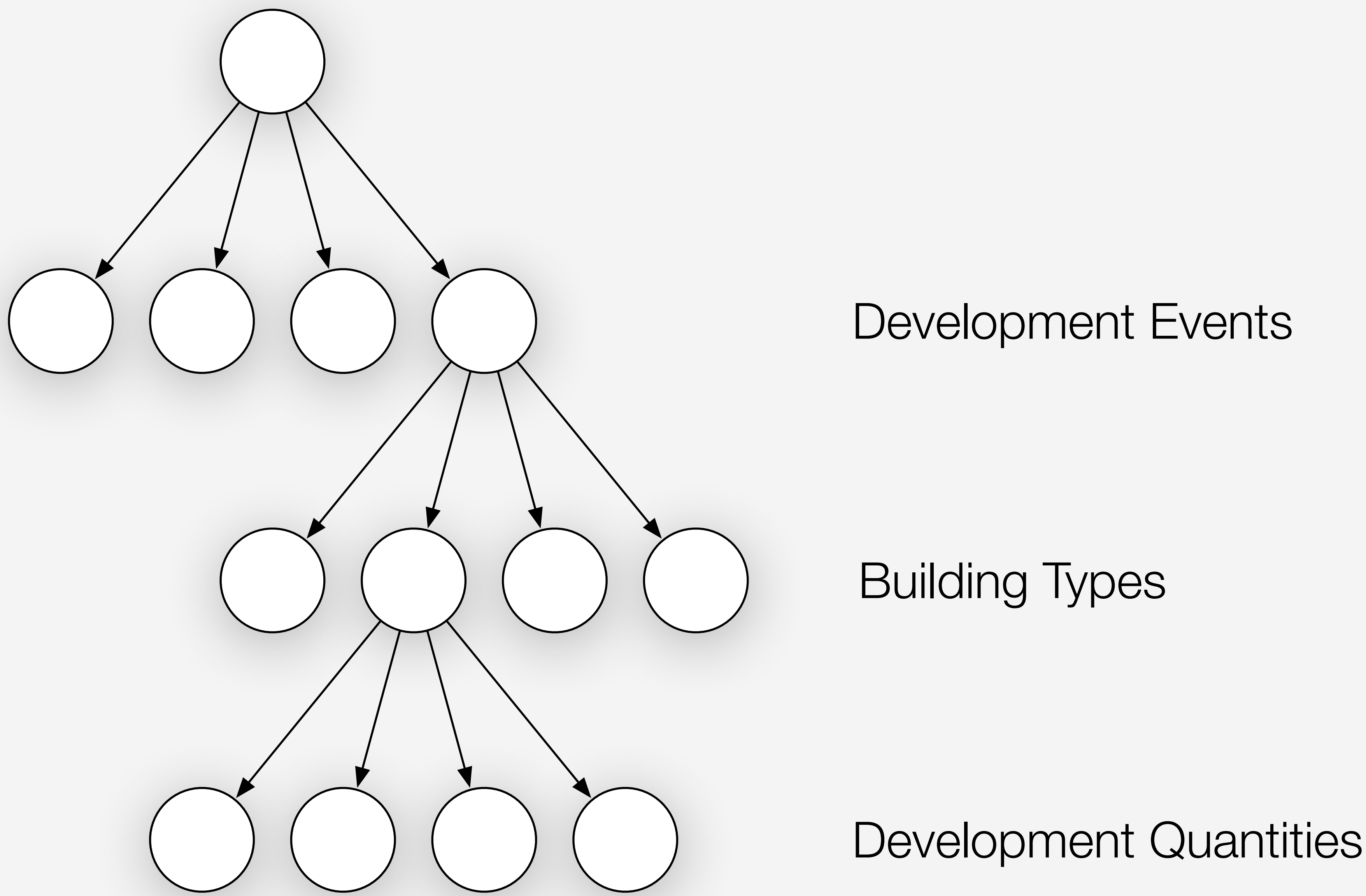
Parcel-by-parcel microsimulation

zoning dictates set of alternatives

Source: Atlanta Regional Commission

Space Development (SD) Module

Decision Tree



Space Development (SD) Module

Joint Discrete Utility

Rent less amortized construction cost per unit space

Additional Rent less development costs per unit land

$$RU_{hjp} = T_{hjp}\, j + lTr_{hjp} + l\varepsilon_{s} + l\varepsilon_{q}$$

Space quantity (building size)

Land quantity (parcel size)

Stochastic error terms

Source: Atlanta Regional Commission

Space Development (SD) Module

Parcel Level Data and Derived Floorspace

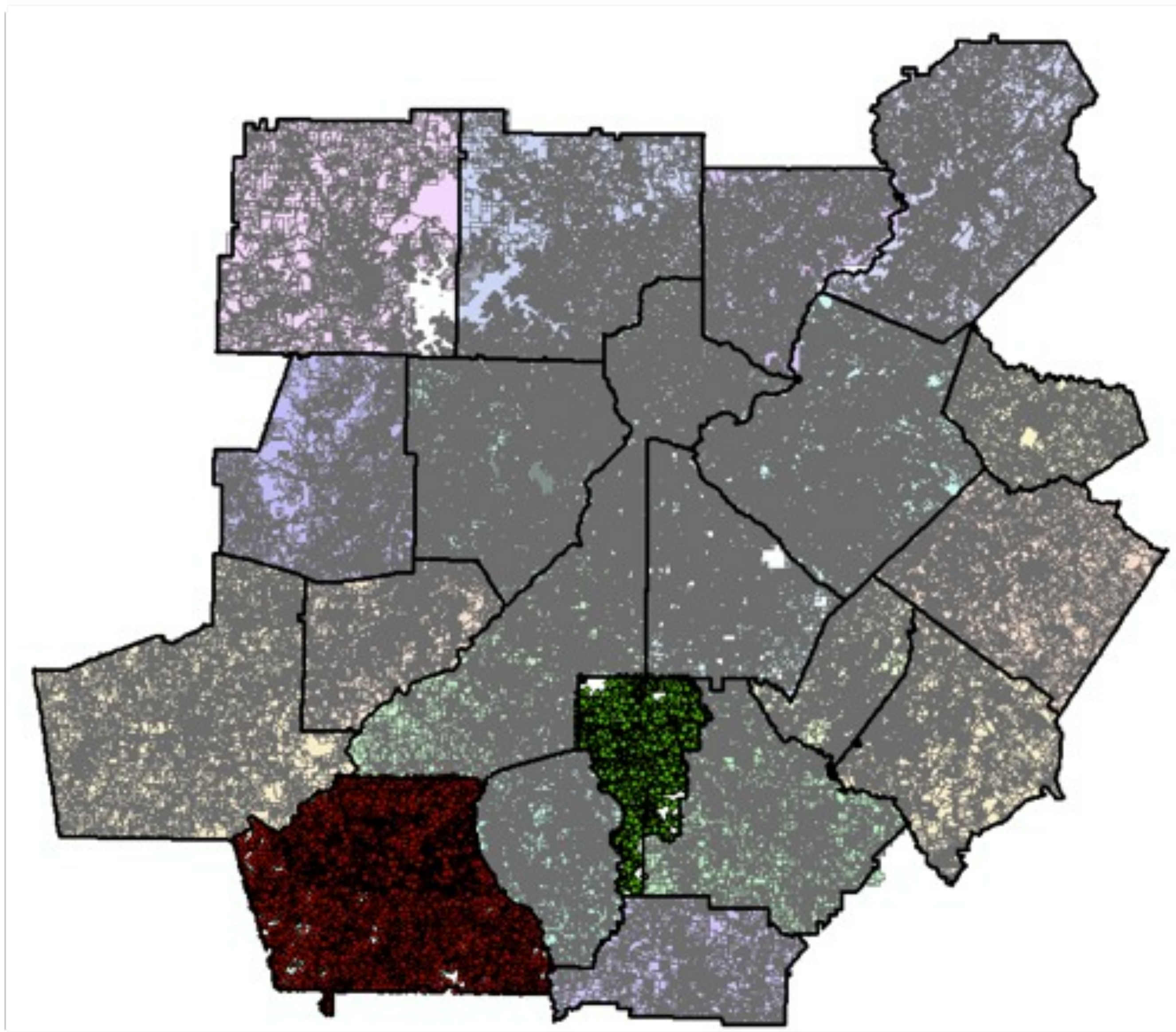
- For each parcel:
  - Area of the parcel
  - Existing space type
  - Existing space quantity (building floorspace)
  - Structure year
  - **Zoning rules (allowable uses and density range)**
  - Cost and fees (associated with development of each permitted space type and quantity)
- Challenges (20 Counties: every dataset is different)
  - Parcel features and ID
  - Parcel attributes (building floorspace, space type…)
  - Geocoded points for Clayton…
  - Combine parcel with tax assessors' data
  - Updates
- 20-county parcels are cleaned and loaded
  - About 2 million parcels are cleaned
- Benefit other planning projects

Source: Atlanta Regional Commission

Space Development (SD) Module

Parcel Level Data and Derived Floorspace

20-County parcel features



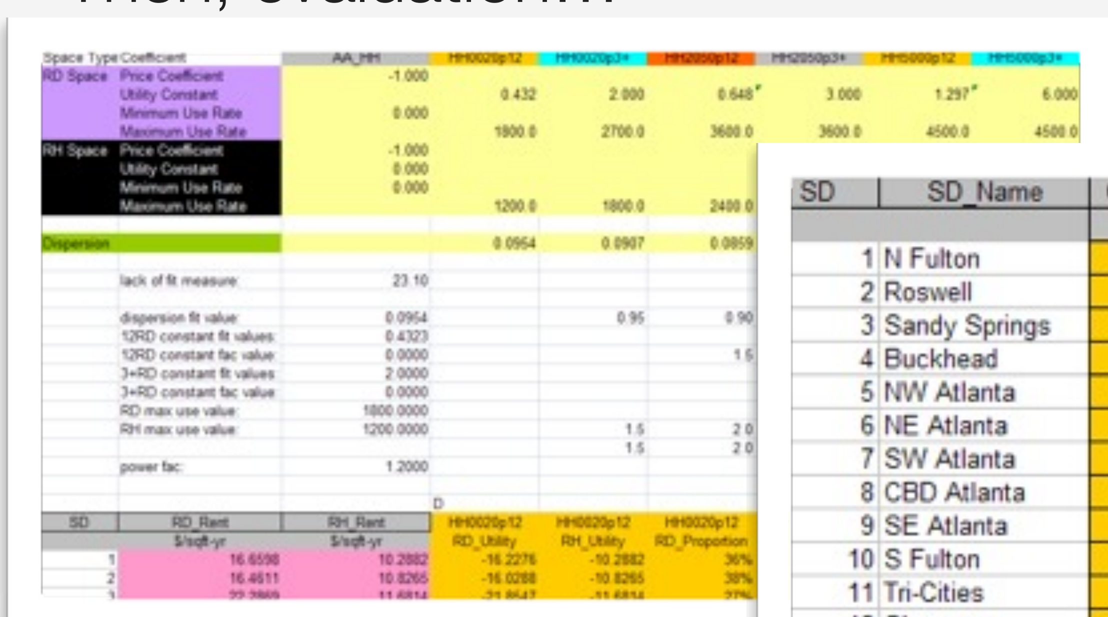
Source: Atlanta Regional Commission

County	Parcels
Barrow	28,184
Bartow	42,167
Carroll	50,633
Cherokee	93,866
Clayton	88,723
Cobb	228,690
Coweta	55,348
DeKalb	230,888
Douglas	39,140
Fayette	42,808
Forsyth	77,639
Fulton	341,017
Gwinnett	260,371
Hall	77,103
Henry	72,839
Newton	44,374
Paulding	59,670
Rockdale	34,780
Spalding	29,616
Walton	36,561
Total	**1,934,417**

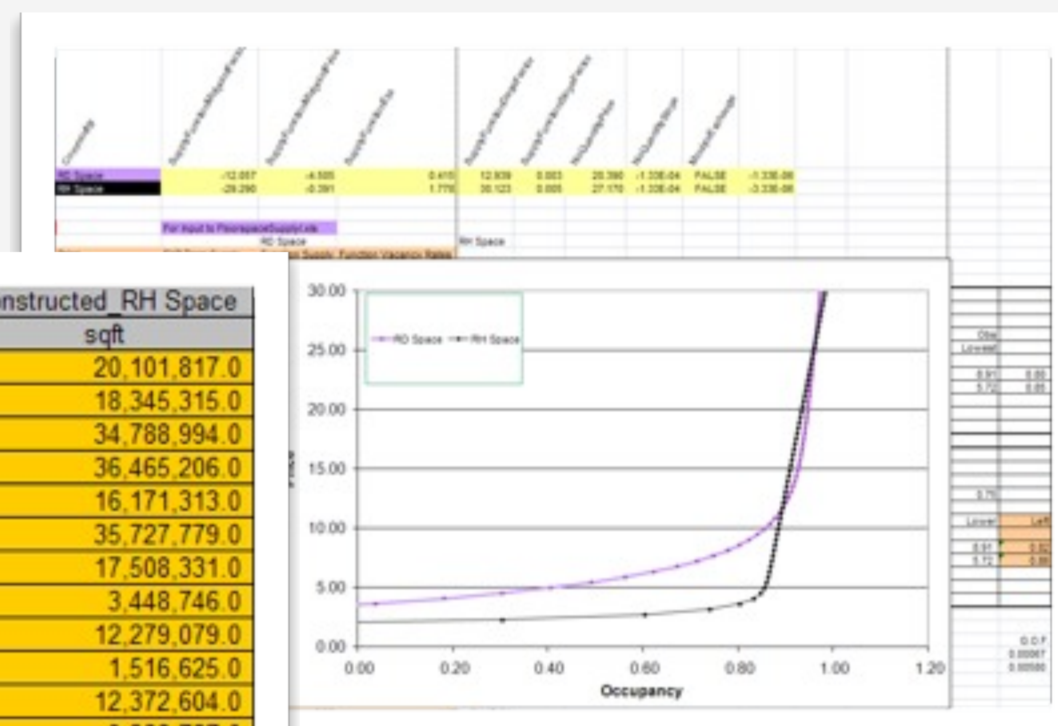
Space Development (SD) Module

Parcel Level Data and Derived Floorspace

- Why do we need the derived space?
  - The quality of the parcel space data: very inconsistent
  - The (in) consistency between employment and space
  - Mixed use issues
- Derived using NAICS employment and Landpro
- New space totals at LUZ and disaggregate to TAZ
- Then, evaluation…



SD	SD_Name	Constructed_RD Space	Constructed_RH Space
		sqft	sqft
1	N Fulton	110,515,538.0	20,101,817.0
2	Roswell	64,773,653.0	18,345,315.0
3	Sandy Springs	49,058,149.0	34,788,994.0
4	Buckhead	41,611,473.0	36,465,206.0
5	NW Atlanta	18,885,490.0	16,171,313.0
6	NE Atlanta	17,768,487.0	35,727,779.0
7	SW Atlanta	33,331,016.0	17,508,331.0
8	CBD Atlanta	9,229.0	3,448,746.0
9	SE Atlanta	22,217,219.0	12,279,079.0
10	S Fulton	25,942,133.0	1,516,625.0
11	Tri-Cities	18,434,674.0	12,372,604.0
12	Shannon	32,497,313.0	9,382,727.0
15	W Cherokee	9,352,658.1	8,067,218.6
16	N Cherokee	3,869,757.2	3,458,062.4
17	E Cent Cherokee	50,037,301.9	43,281,518.7

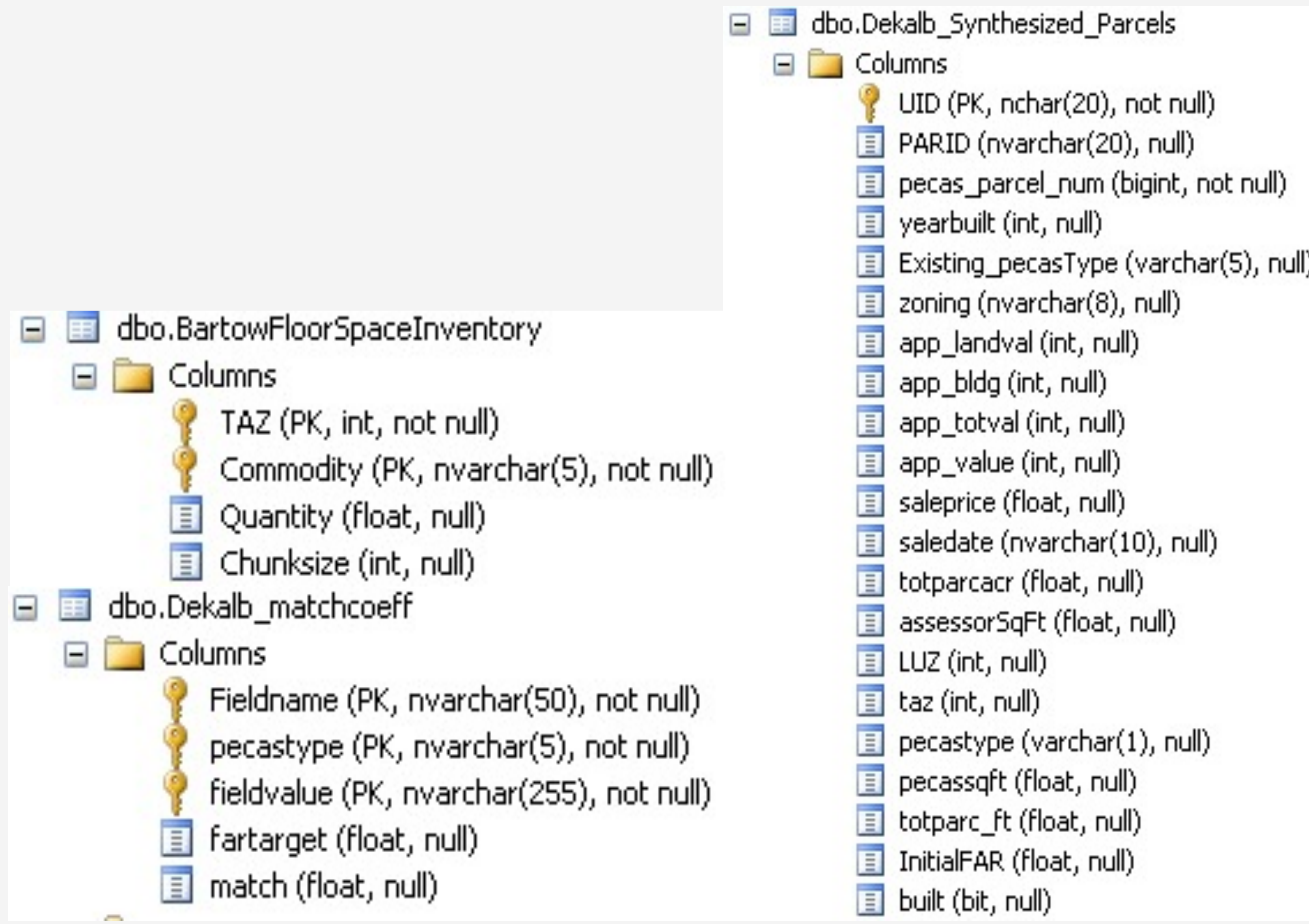


Source: Atlanta Regional Commission

Space Development (SD) Module

Parcel Level Data and Derived Floorspace

- FloorSpace Synthesizer Tool
- Based on existing space type, quantity and zoning…
- Calibration

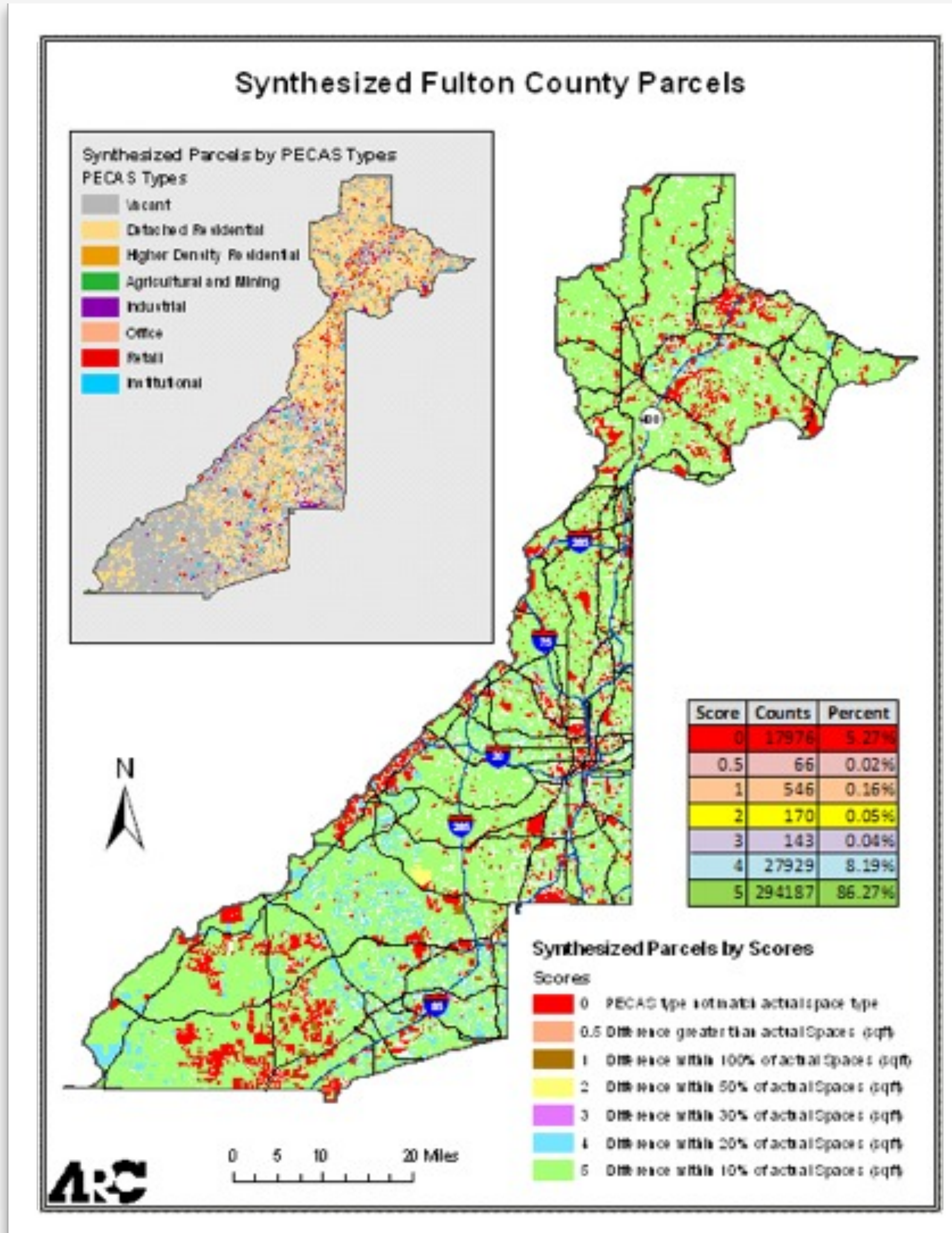


Source: Atlanta Regional Commission

Space Development (SD) Module

Parcel Level Data and Derived Floorspace

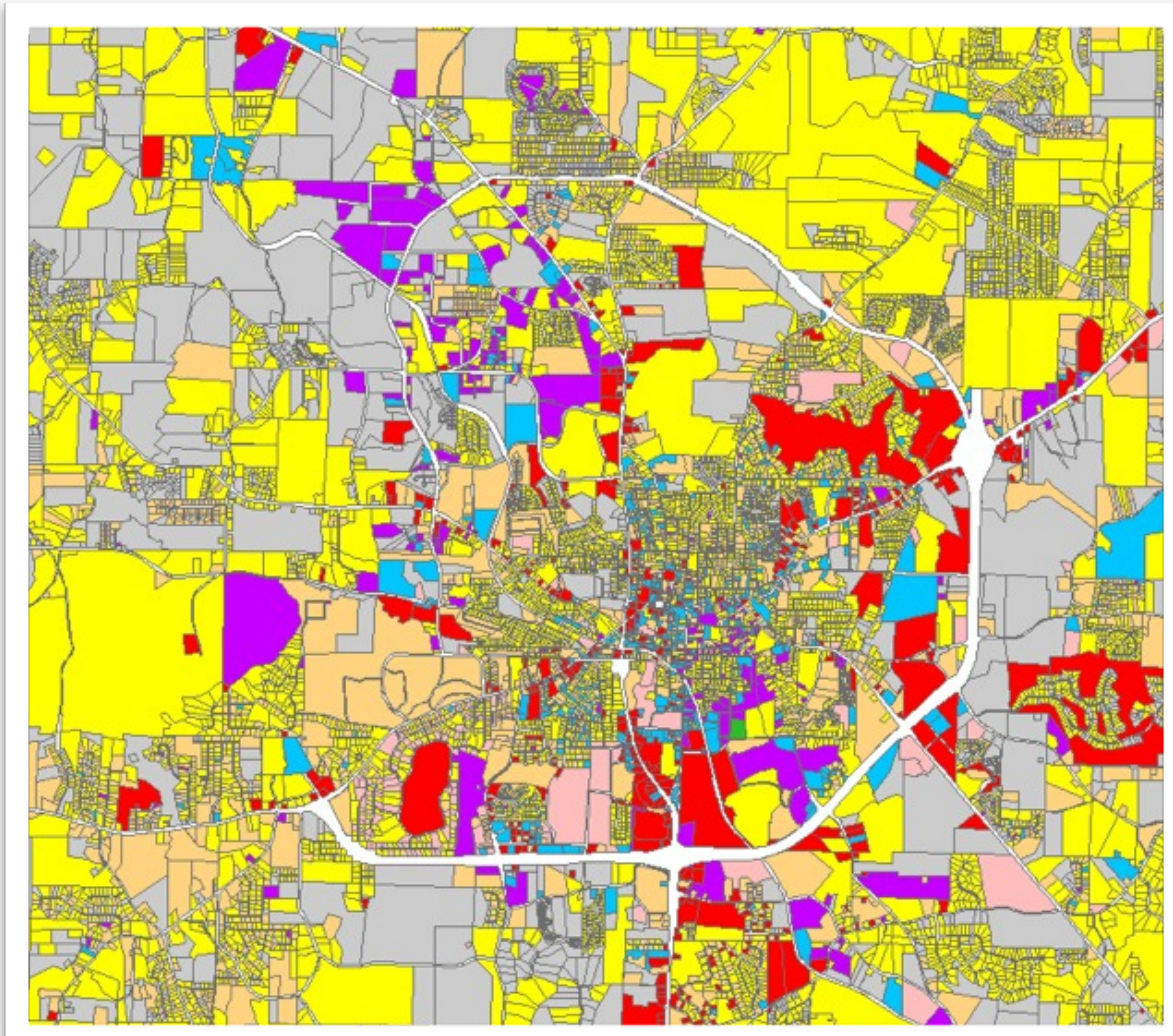
- Calibration tasks:
  - Evolution of initial synthesized results
  - Directing synthesized development to actual built-on parcels
  - Directing the correct space type to the parcel
  - Directing the synthesized built space to developed parcel in amount resembling actual quantities



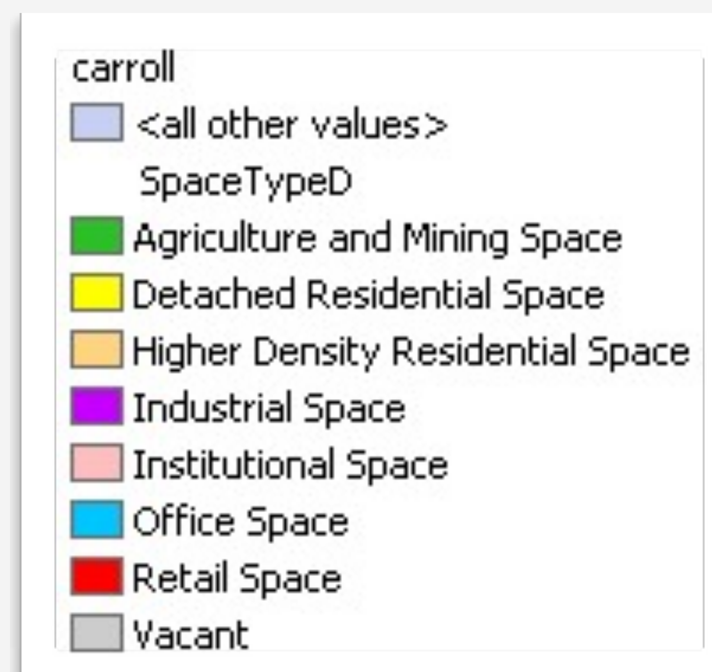
Source: Atlanta Regional Commission

Space Development (SD) Module

Parcel Level Data and Derived Floorspace

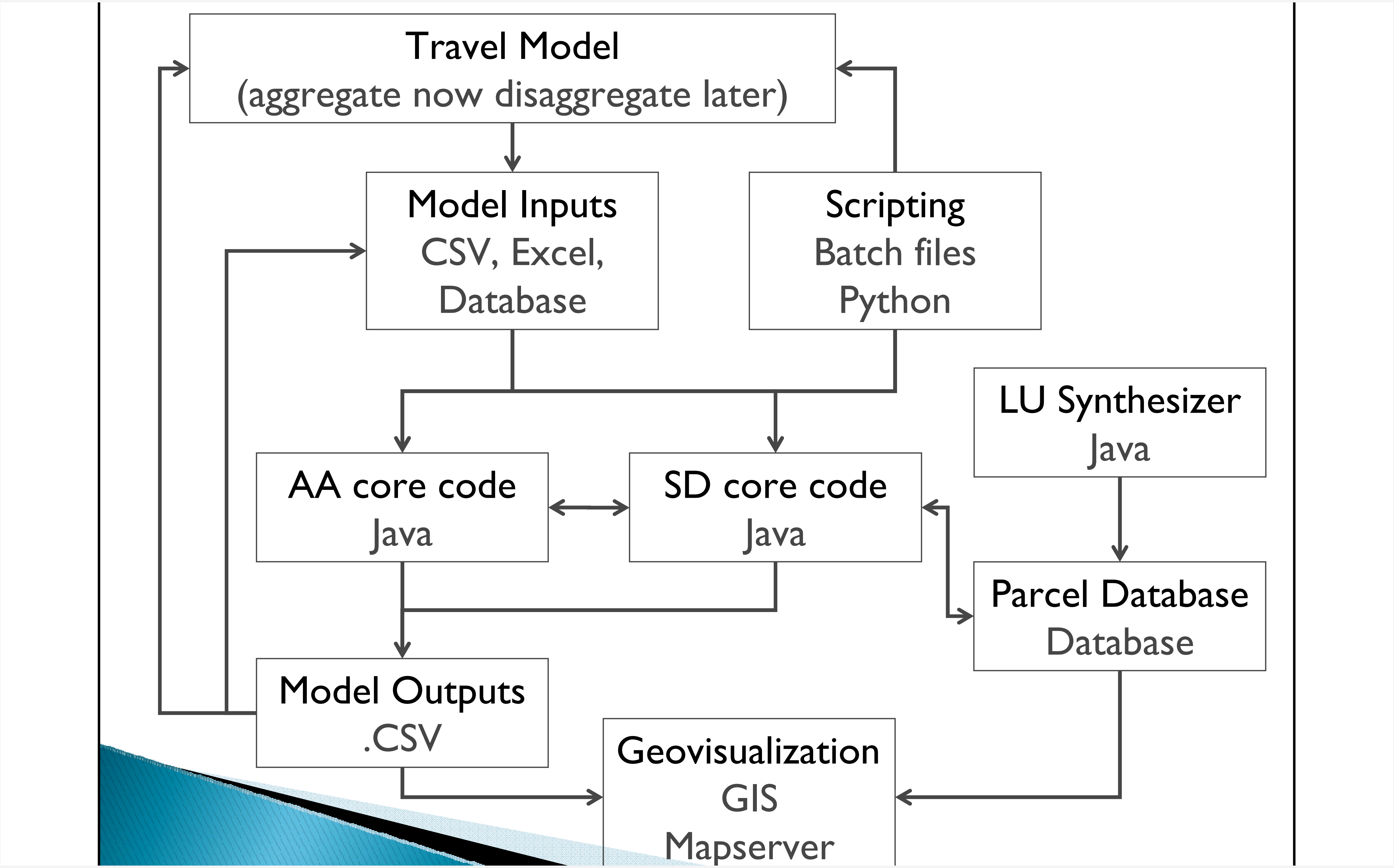


Synthesized Results



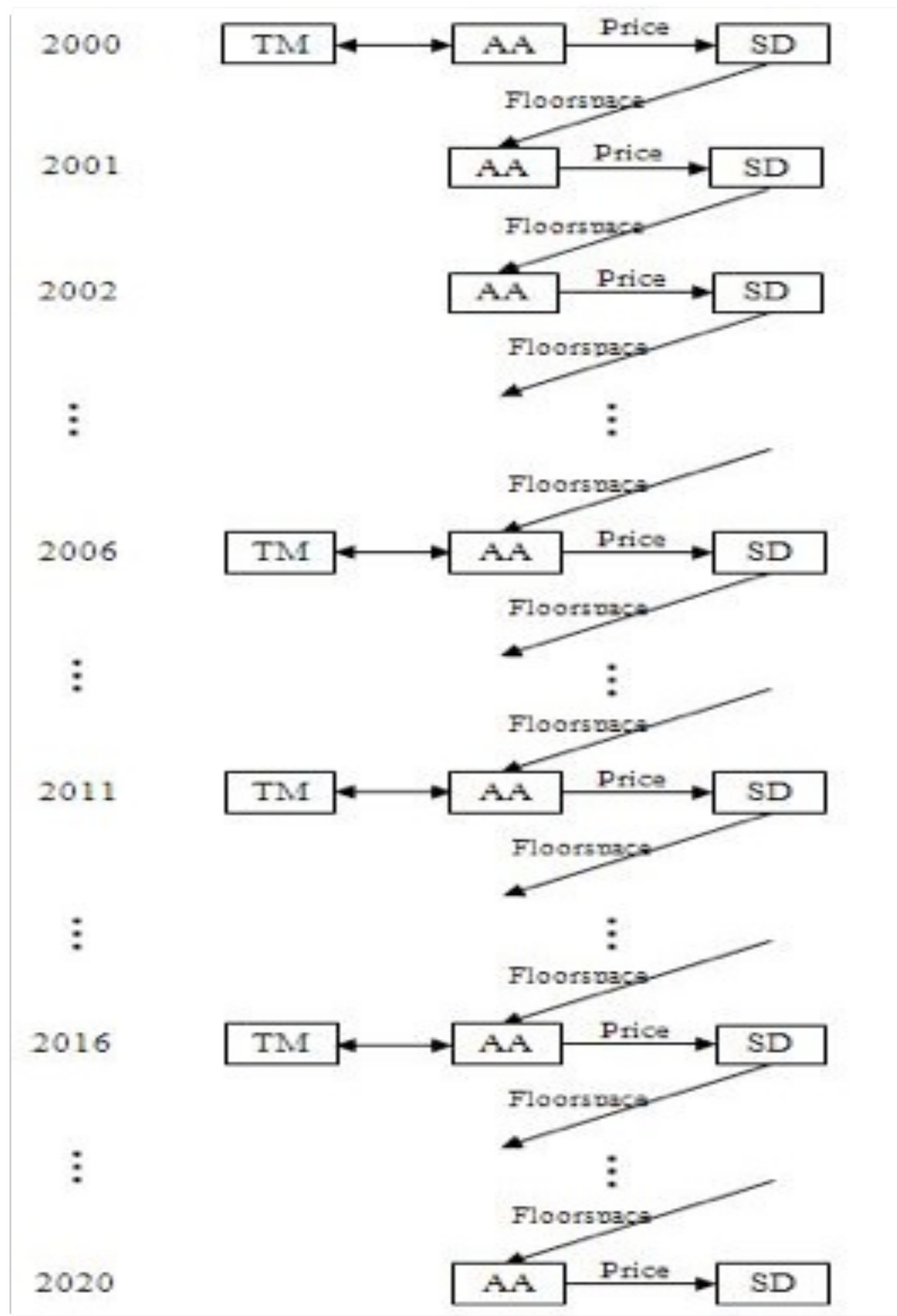
Source: Atlanta Regional Commission

Full PECAS System Through Time



source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

Integrating PECAS and Travel Model



PECAS 3-Stage Calibration Approach

- **Stage 1** - the S1 parameters
  - Consider each module separately
  - Based on specific, separate dataset
  - Often ‘disaggregate data’
  - Often statistical estimation
  - Fixed for remainder of calibration
- **Stage 2** - the S2 parameters
  - Consider each module separately
  - Based on module hitting targets
  - Often ‘aggregate data’
  - Some also S3 parameters
  - Specialized software developed
- **Stage 3** - the S3 parameters
  - Consider all modules linked together
  - Based on module hitting targets
  - ‘Aggregate data’
  - Certain S2 parameters also S3 parameters, process updates these in response to total model behaviour
  - Specialized software developed

Calibration Targets

AA Calibration Targets

- Buying and selling choice
  - Distance to buy or sell
  - CFS survey
- Technology choice
  - Synthetic population
  - PUMS
  - Cluster analysis
- Location choice
  - Synthetic population
  - Synthetic employment

SD Calibration Targets

- Transition constant
  - Building permit
  - Parcel data at two time points
- Dispersion parameter
  - Existing land use

Source: Shengyi Gao (et al)

1. PECAS overview
2. Anatomy of the System
3. **Application in Practice**
4. Comparison and Assessment

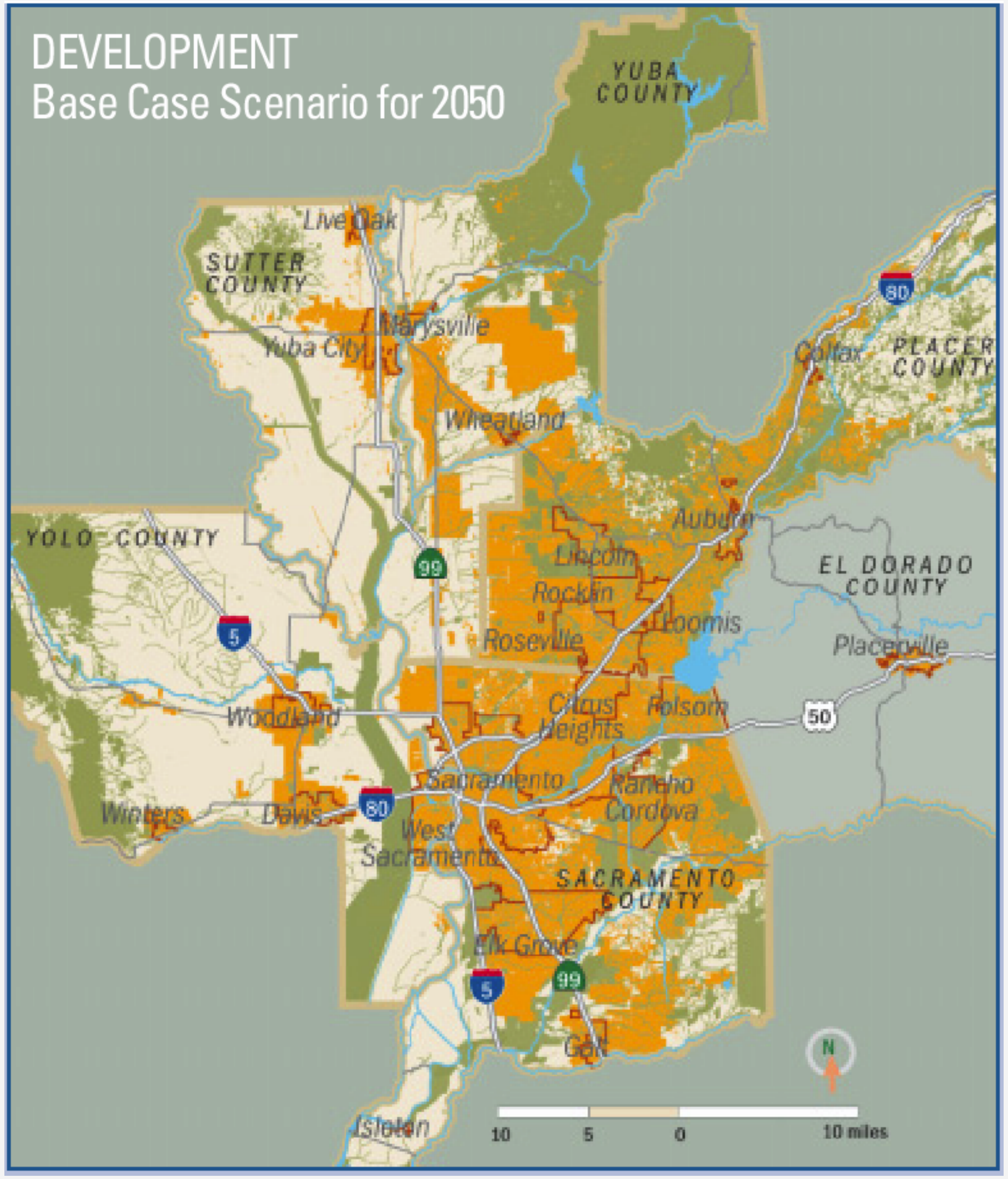
Sacramento Blueprint Study

SACRAMENTO REGION

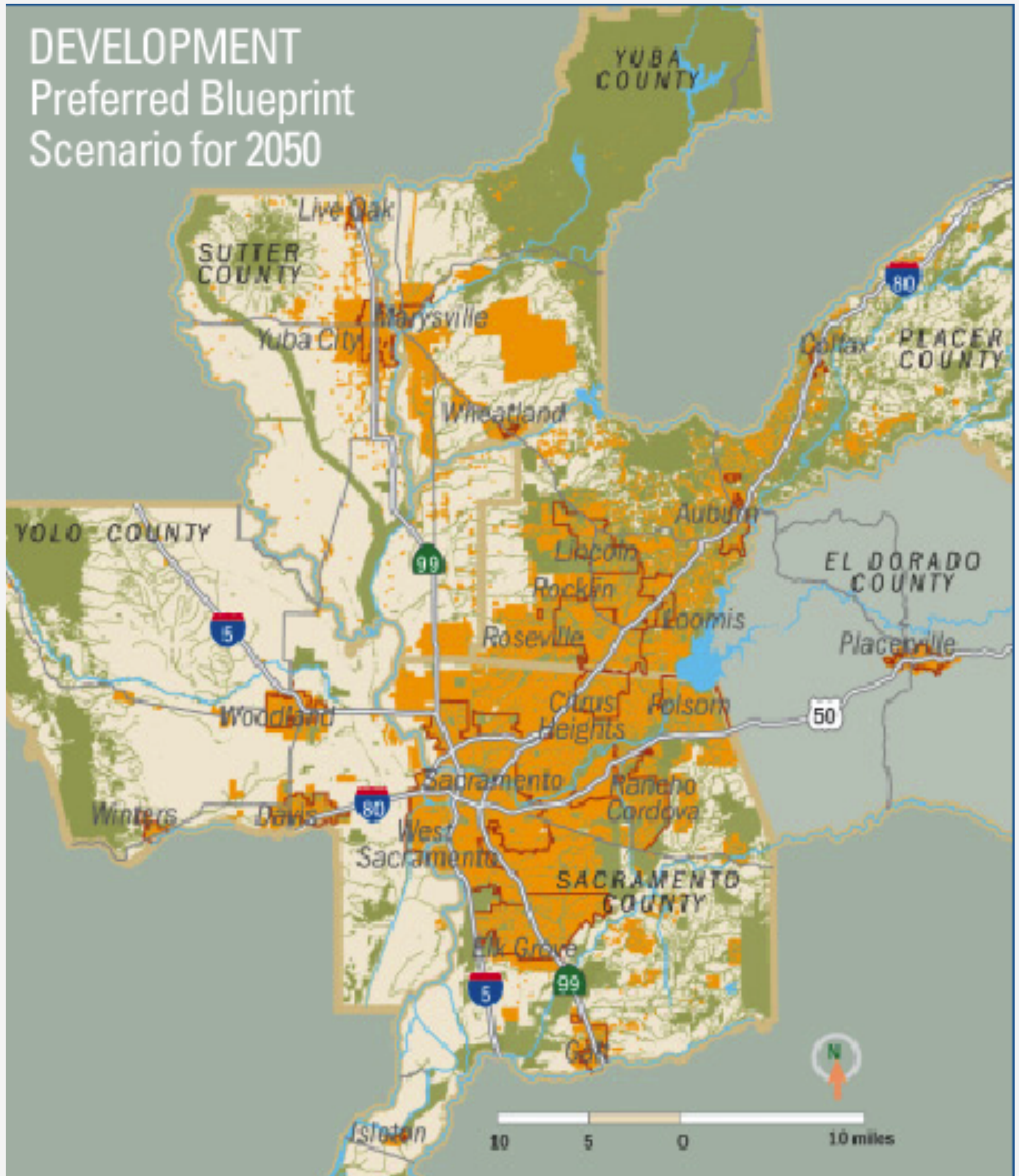
Blueprint

TRANSPORTATION / LAND USE STUDY

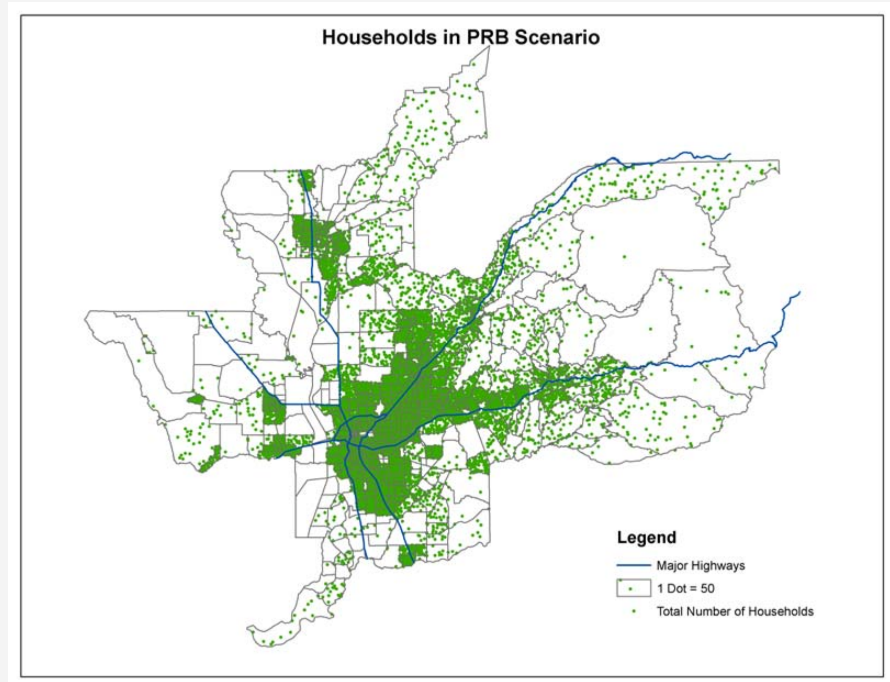
Sacramento Blueprint Study



Sacramento Blueprint Study



SACOG Equity Analysis



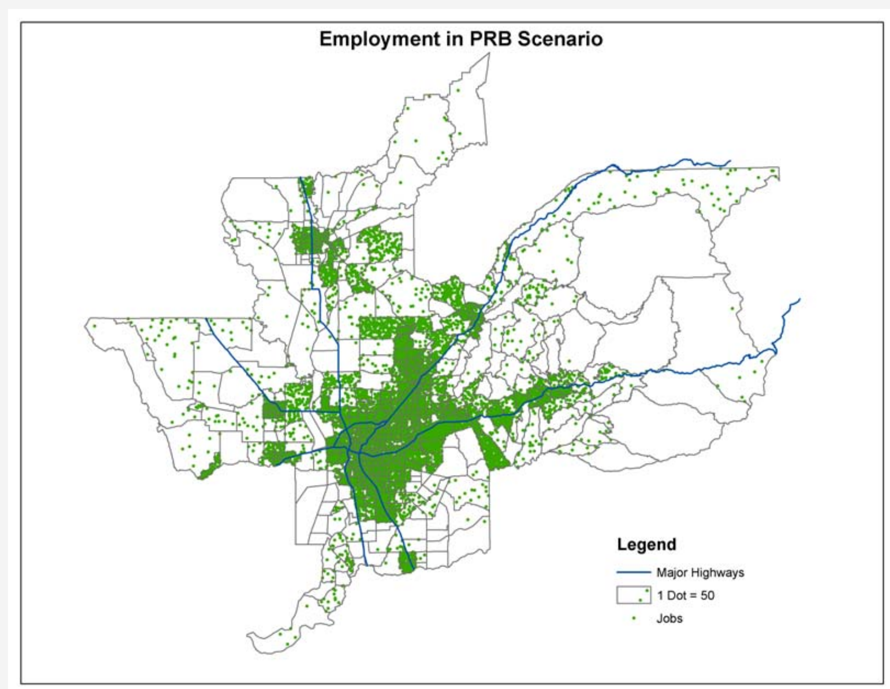
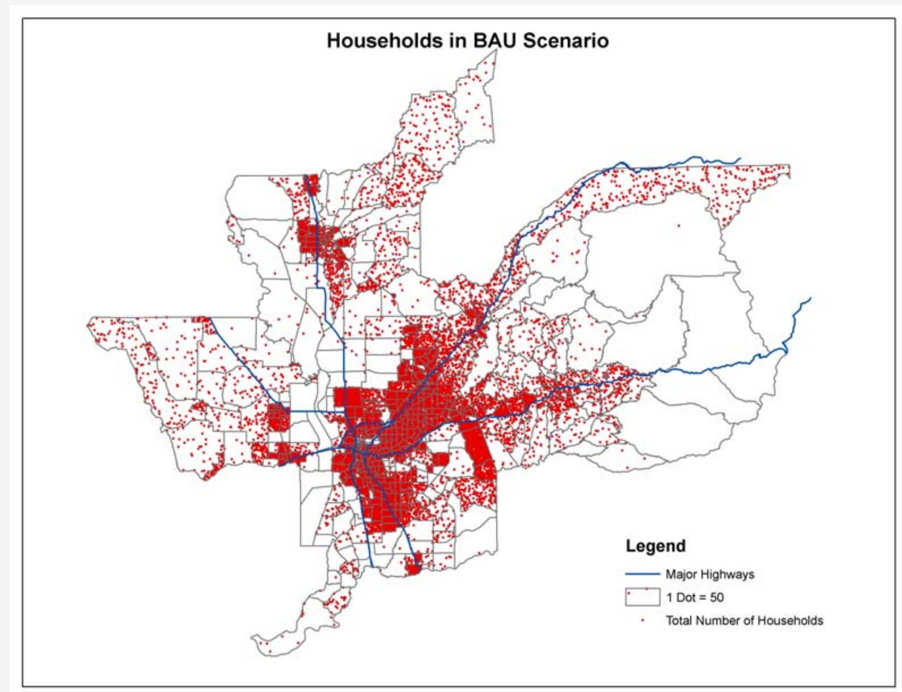


FIGURE 2 Household and employment location in the PRB scenario

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis



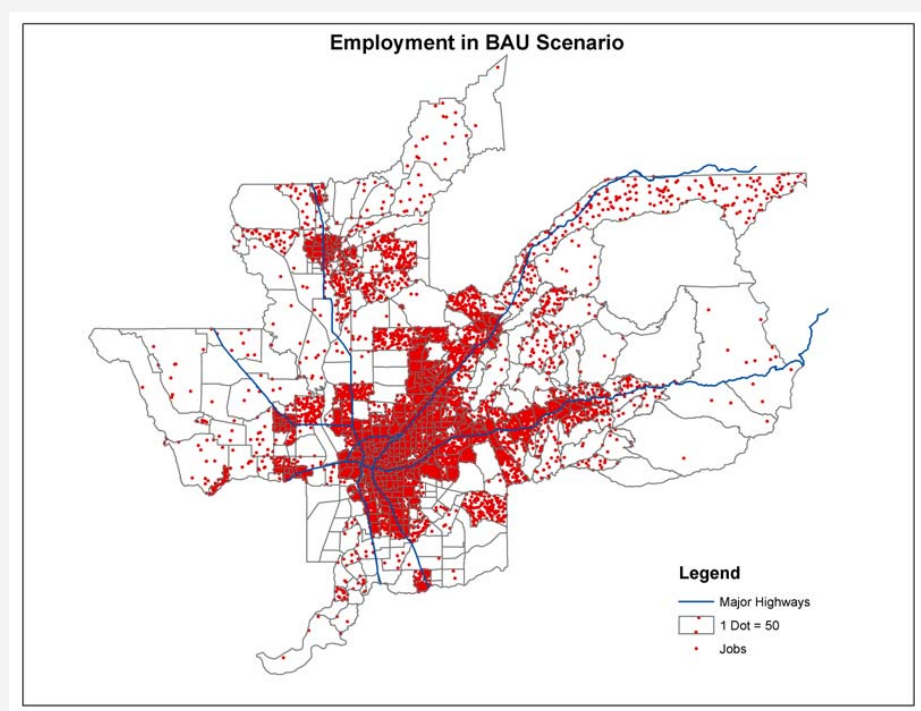
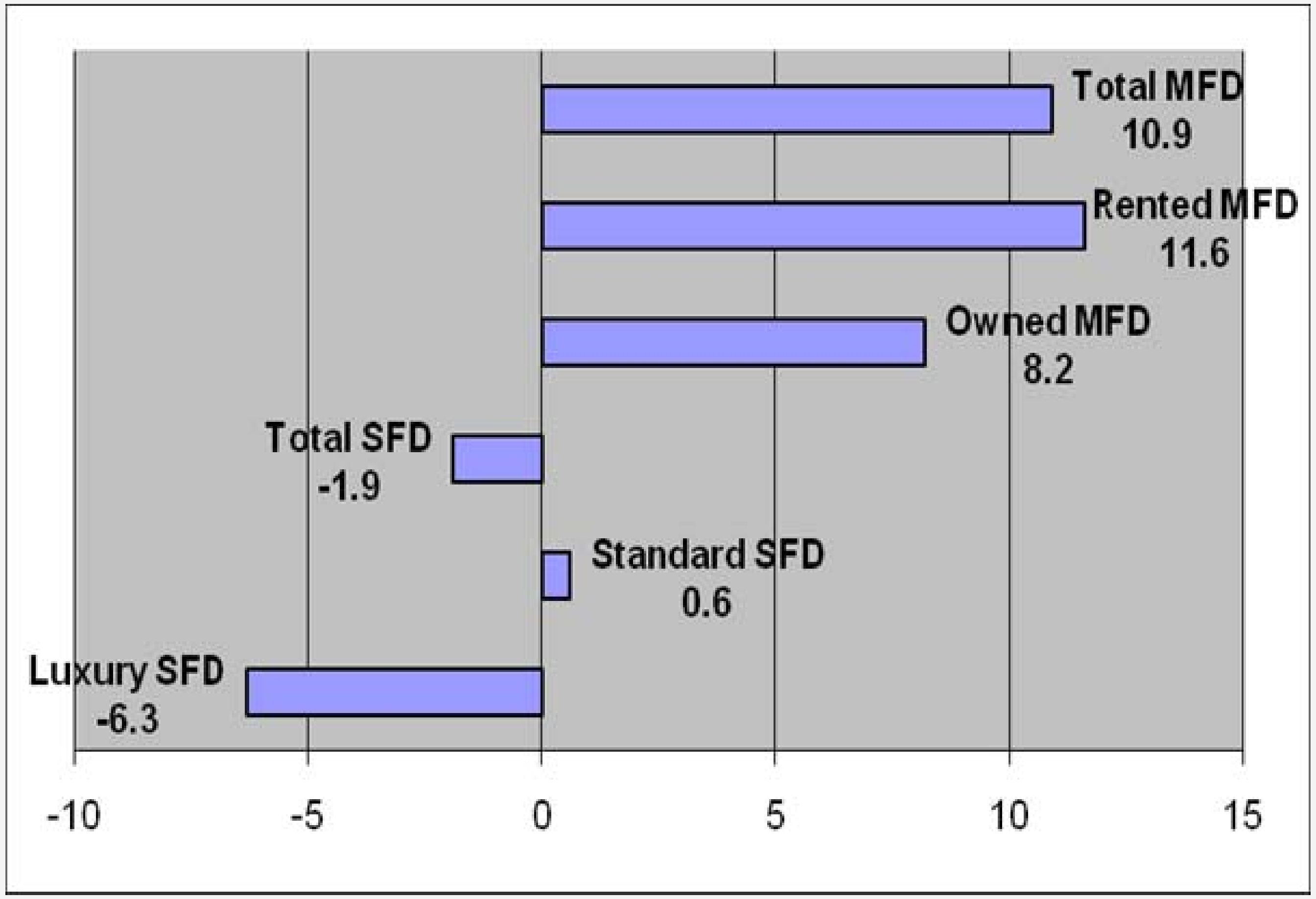


FIGURE 1 Household and employment location in the BAU scenario

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

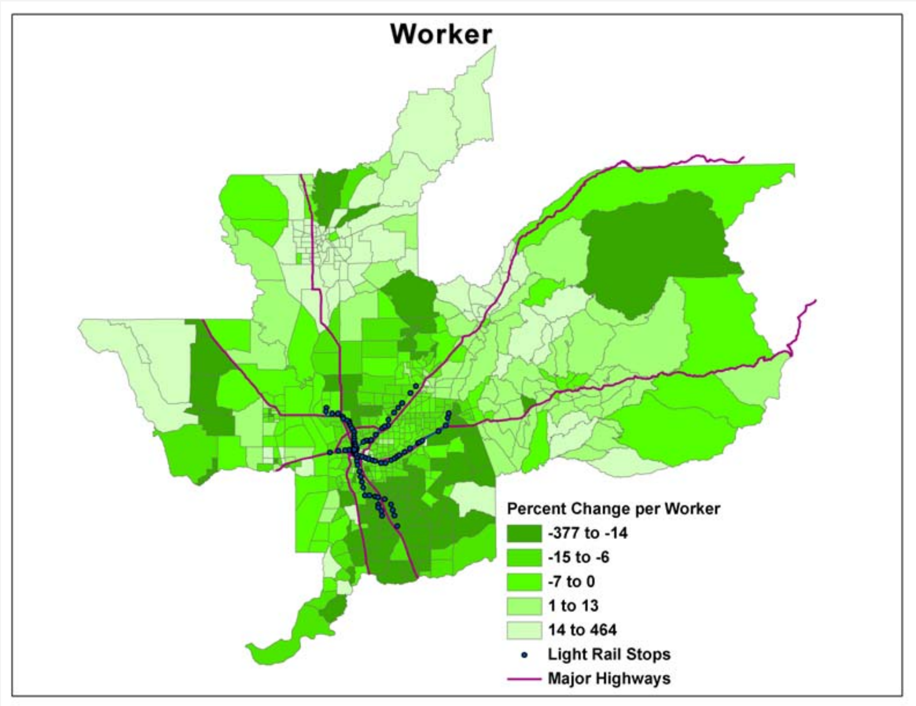
FIGURE 3 Percent Change in Dwelling Units by Type Between the BAU and the PRB

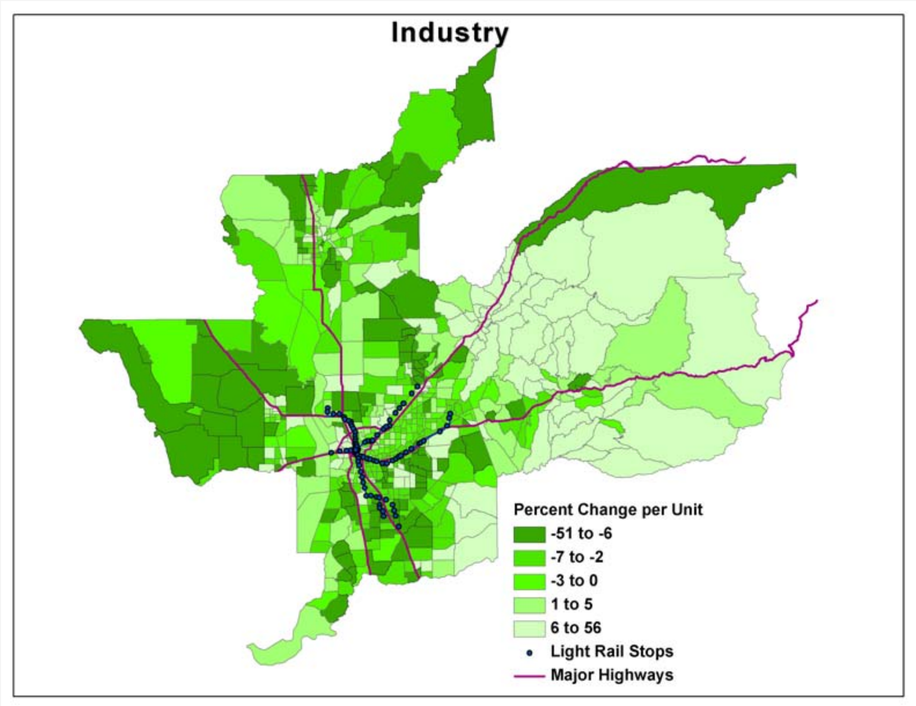


SFD=single family dwelling units; MFD=multi family dwelling units

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis





source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

TABLE 1 Average Annual Transport Cost (TC) by and across Labor Group(s) (2000 U.S. nominal dollars)

Labor Group	Change in TC (dollars)	Percentage Change in TC	BAU: TC as Income Share	PRB: TC as Income Share
Agriculture	-326	-11.8	6.0	5.2
Construction	-303	-11.1	5.8	5.2
Educators	-170	-6.6	5.8	5.6
Entertainers	-372	-14.2	5.7	5.0
Food	-250	-9.9	5.5	5.0
Health	-306	-11.9	5.3	4.8
Maintenance & repair	-300	-11.1	5.9	5.3
Managers	-339	-13.0	5.5	4.8
Non-retail sales	-426	-15.9	5.7	4.9
Office & administrative	-323	-12.7	5.4	4.8
Production	-293	-10.9	5.9	5.3
Professionals	-351	-13.4	5.4	4.8
Retail sales	-256	-9.9	5.5	5.0
Service	-306	-12.0	5.4	4.9
Transport	-281	-10.6	5.9	5.4
Total	**-307**	**-11.8**	**5.5**	**5.0**

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

TABLE 2 Change in Average Annual Rent by and across Household Class(es) (2000 U.S. nominal dollars)

Income Class ($1,000)	Total Change (dollars)	Percentage change
less than 10	-1,248	-6.4
10 to 19	-1,299	-6.0
20 to 39	-1,702	-8.0
40 to 49	-1,833	-7.9
50 to 99	-1,933	-6.7
100 to 199	-309	-0.7
200+	505	1.0
Total	**-1,526**	**-6.1**

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

TABLE 3 Total Annual Value of Owned Homes (2000 U.S. nominal dollars)

Household Income ($1,000)	BAU ($100,000)	PRB ($100,000)	Percentage Change
less than 10	7,840	7,788	-0.7
10 to 19	13,384	13,201	-1.4
20 to 39	38,520	37,578	-2.4
40 to 49	20,868	20,258	-2.9
50 to 99	124,620	121,462	-2.5
100 to 199	78,739	78,122	-0.8
200 or more	15,298	15,415	0.8
Total	**299,268**	**293,823**	**-1.8**

TABLE 4 Change in Average Annual Wage Income by and across Labor Group(s) (2000 U.S. nominal dollars)

Labor Group	Total Change (dollars)	Percentage Change
Agriculture	-50	-0.1
Construction	-282	-0.6
Educators	-802	-1.8
Entertainers	-925	-1.9
Food workers	-752	-1.6
Health workers	-847	-1.7
Maintenance & repair	-731	-1.6
Managers	-922	-1.9
Non-retail sales	-951	-2.0
Office & administrative	-892	-1.9
Production	-670	-1.4
Professionals	-980	-2.0
Retail sales	-759	-1.6
Service	-749	-1.5
Transport	-719	-1.6
Total	**-783**	**-1.6**

23

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

TABLE 5 Total and Average Consumer or Producer Surplus for PRB Scenario Relative to the BAU Scenario (2000 U.S. nominal dollars)

Industry Activities	**Total ($100,000)**	**Average (per million dollars of production)**
Agriculture	254	13,819
Construction	944	8,783
Manufacturing	962	5,588
Transport	249	12,336
Communication	483	9,630
Wholesale trade	996	8,532
Retail	5,354	20,345
Restaurants	2,281	51,192
Financial	1,961	18,934
Real estate	1,330	6,804
Business services	1,200	15,477
Automotive services	308	13,994
Amusement services	197	46,647
Education	717	36,163
Personal services	697	35,366
Non-profit organizations	565	48,809
Professional services	1,213	17,099
Government	2,916	15,501
Total	**22,626**	**15,028**
Household Income Class ($1,000)	**Total ($100,000)**	**Average per Household**
less than 10	731	1,008
10 to 19	1,226	1,074
20 to 39	1,617	647
40 to 49	254	229
50 to 99	-1,966	-442
100 to 199	-1,384	-668
200+	-151	-454
Total	**327**	**27**

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

SACOG Equity Analysis

TABLE 6 Total and Change in Annual Values of Space Categories (2000 U.S. nominal dollars)

	BAU Total ($100,000)	PRB Total ($100,000)	Total Change ($100,000)	Average Change
Industry Space				
Agriculture & Mining	43	48	5	0.3
Industrial	3,424	3,504	79	0.1
Office	22,561	22,729	169	0.1
Retail	24,205	24,240	35	0.0
Medical	26,152	26,200	48	0.1
Primary School	7,434	7,436	1	0.0
Colleges & Education	2,653	2,655	1	0.0
Government Office	31,015	31,002	-13	0.0
Total	**117,488**	**117,813**	**325**	**0.0**
Residential Space				
Luxury SFD	195,707	185,408	-10,299	549.0
Standard SFD	153,245	152,531	-714	-243.0
Owned MFD	8,976	9,322	345	-1017.0
Rented MFD	26,510	27,069	559	-1537.0
Total	**384,438**	**374,330**	**-10,108**	**-820.0**

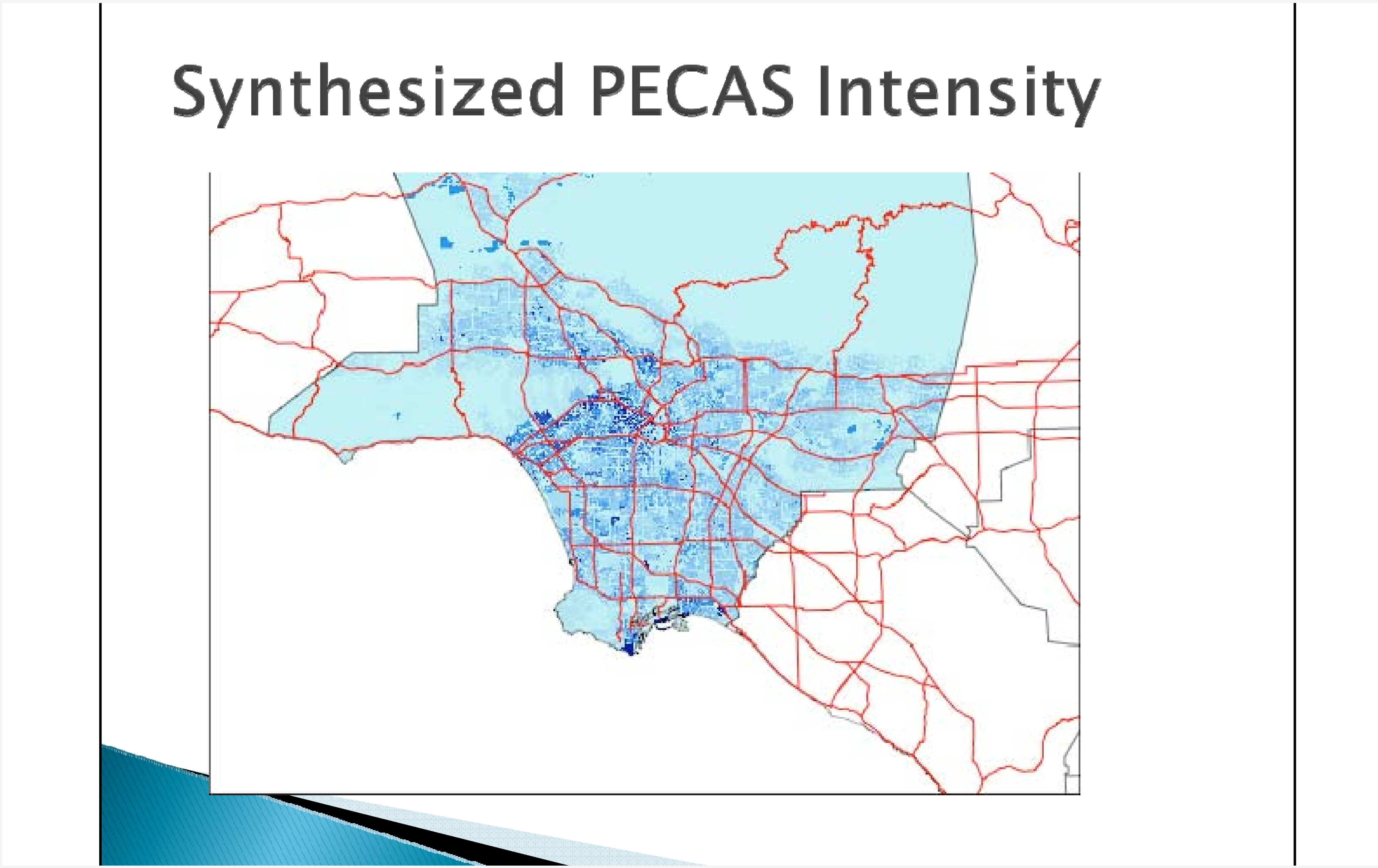
SFD=single-family development; MFD=multi-family development

source: Equity Analysis of Land Use and Transport Plans Using an Integrated Spatial Model. Rodier, Abraham, Dix, and Hunt. UCD-ITS-RR09-46

CalSIM

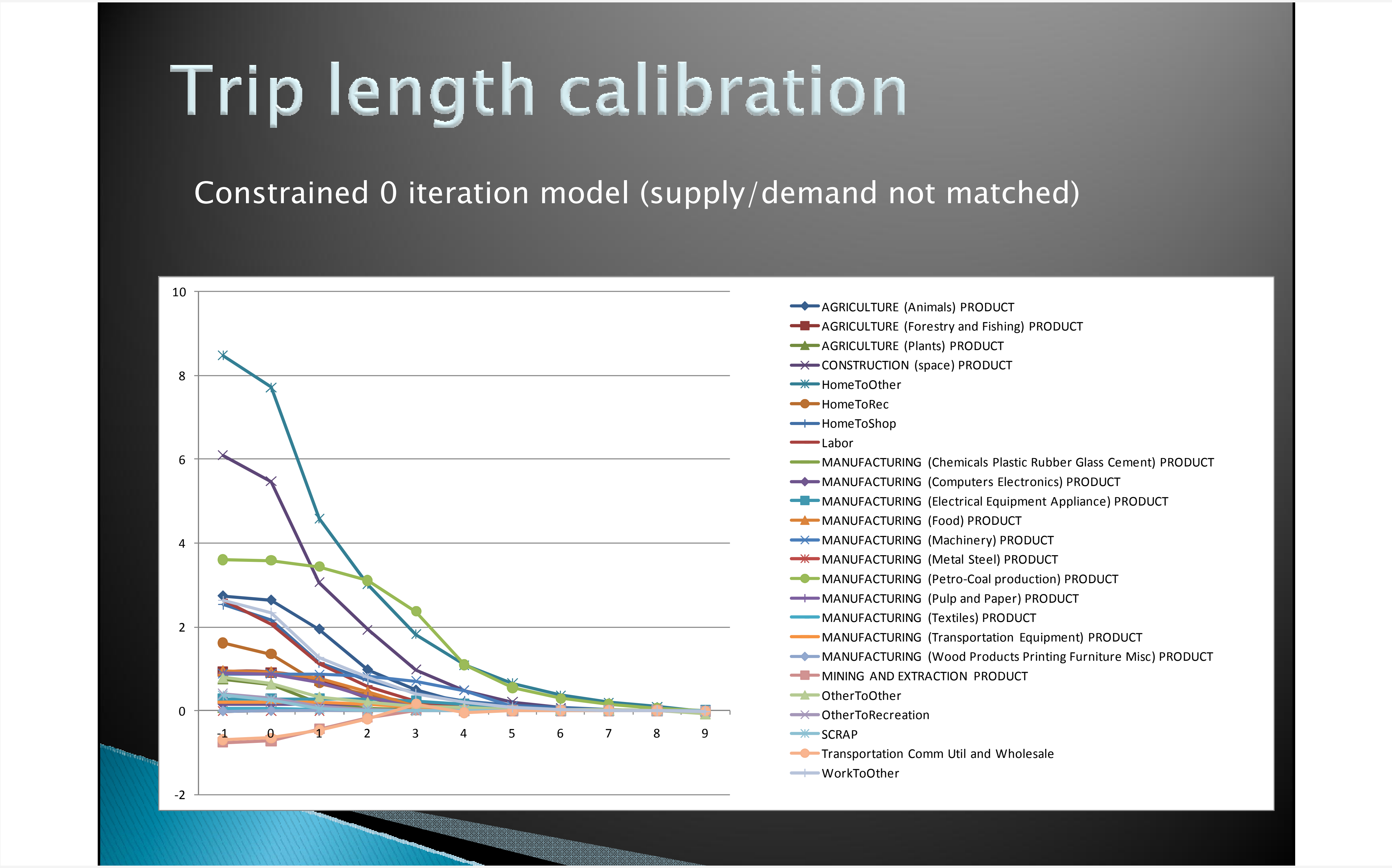
- California Statewide Integrated Model
- Integrated PECAS land use model and new statewide activity-based transportation model
- Spurred by California SB375: land use related reductions from autos and light trucks
- Funded by CalTrans in conjunction with metropolitan-level upgrades
- Massive data collection and imputation effort
- Timeline
  - Transportation model built and calibrated during 2010
  - Land use model calibration ongoing
  - Metropolitan models ready by 2015
- Preliminary results

CalSIM



source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

CalSIM



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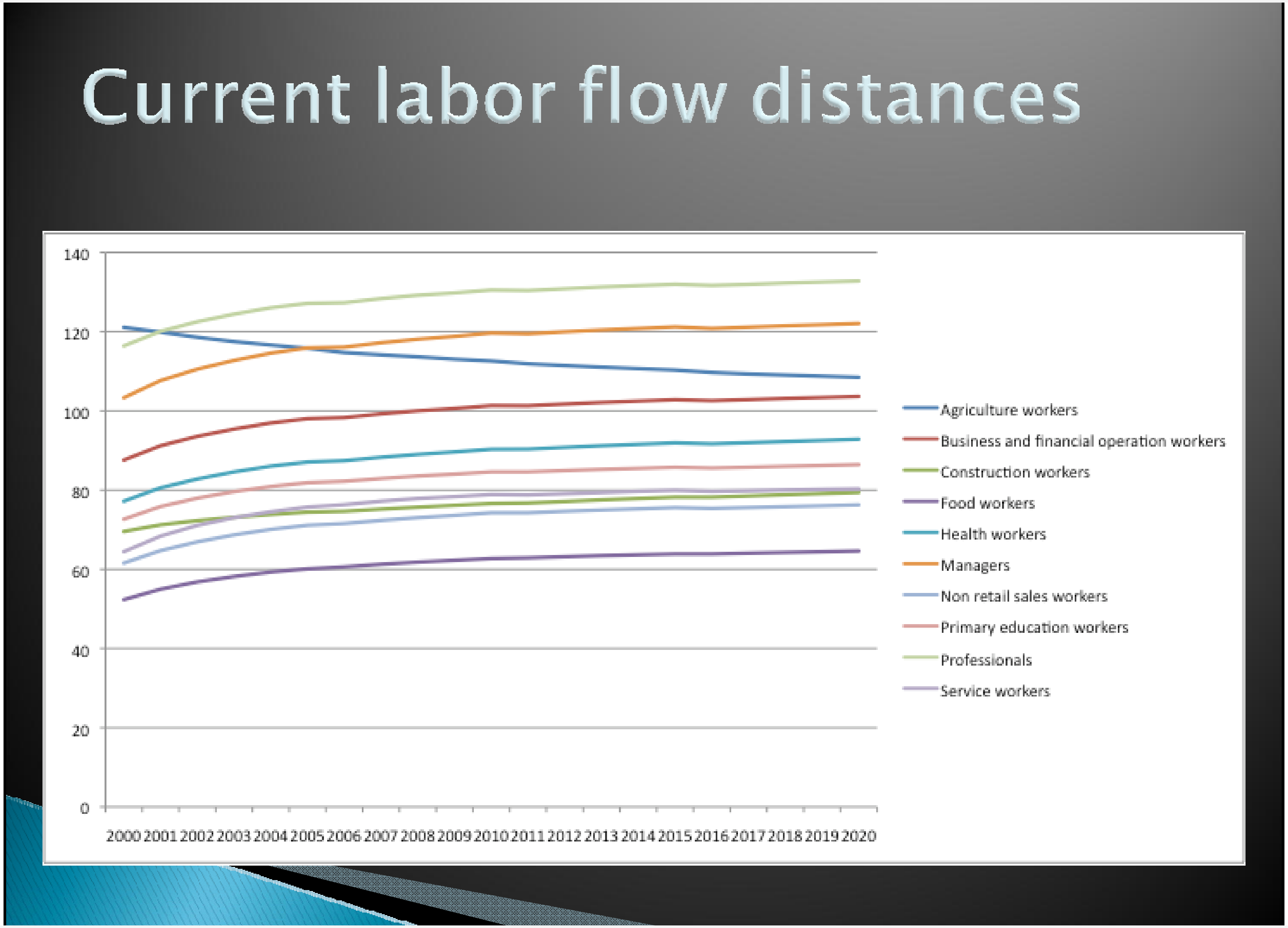

source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

CalSIM

SD Calibration

- Develop Target space quantity transitions
- 10 counties selected to represent low med and high growth situations, plus San Francisco as a special county
  - Low: Sacramento, San Diego, Orange County
  - Med: Amador, Inyo, Shasta
  - High: Fresno, Imperial, Placer
  - San Francisco

source: Developing California Integrated Land Use/Transportation Model. Gao, Lehmer, Wang, McCoy, Johnston, Abraham, and Hunt. Presented at TRB 2010

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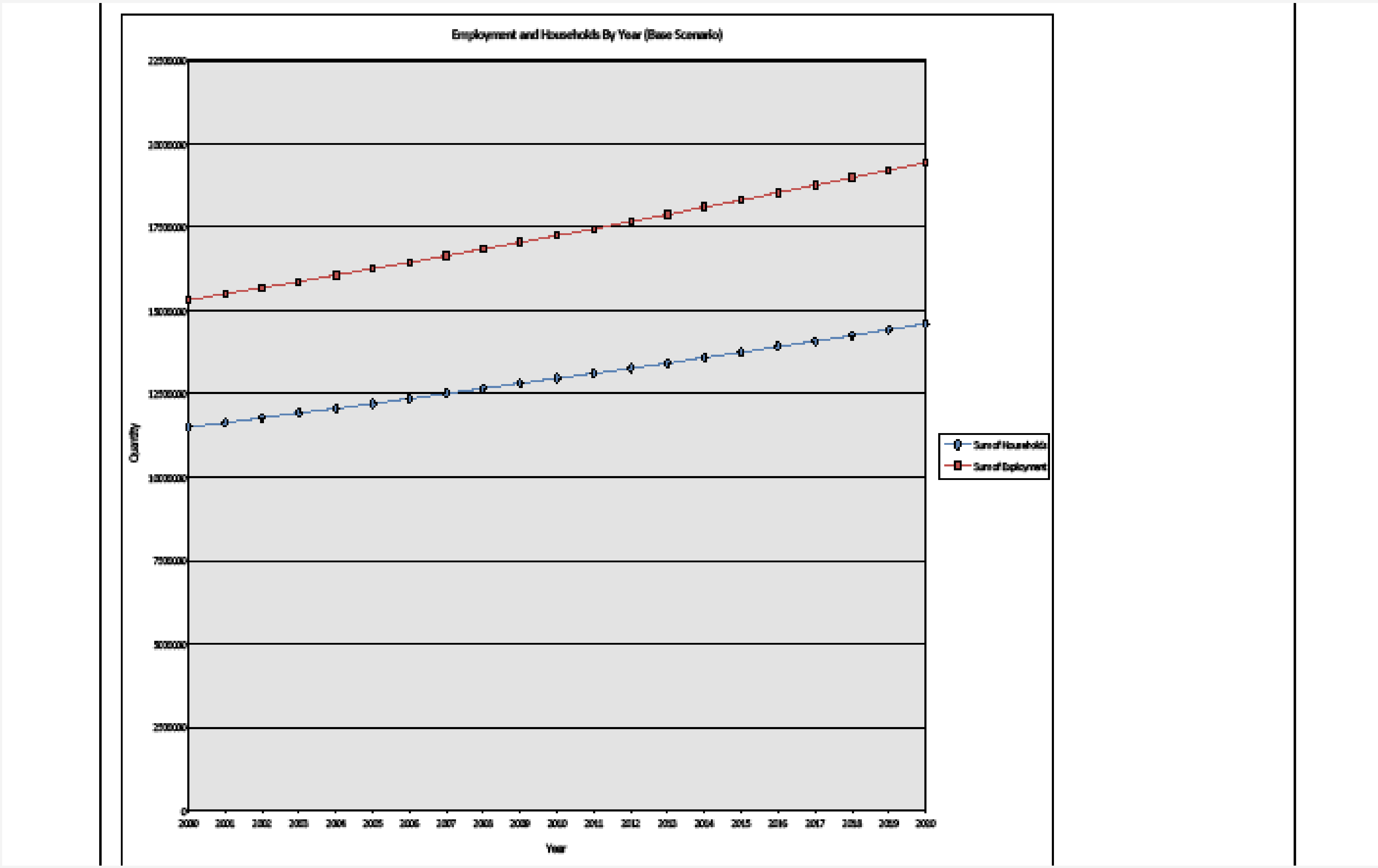

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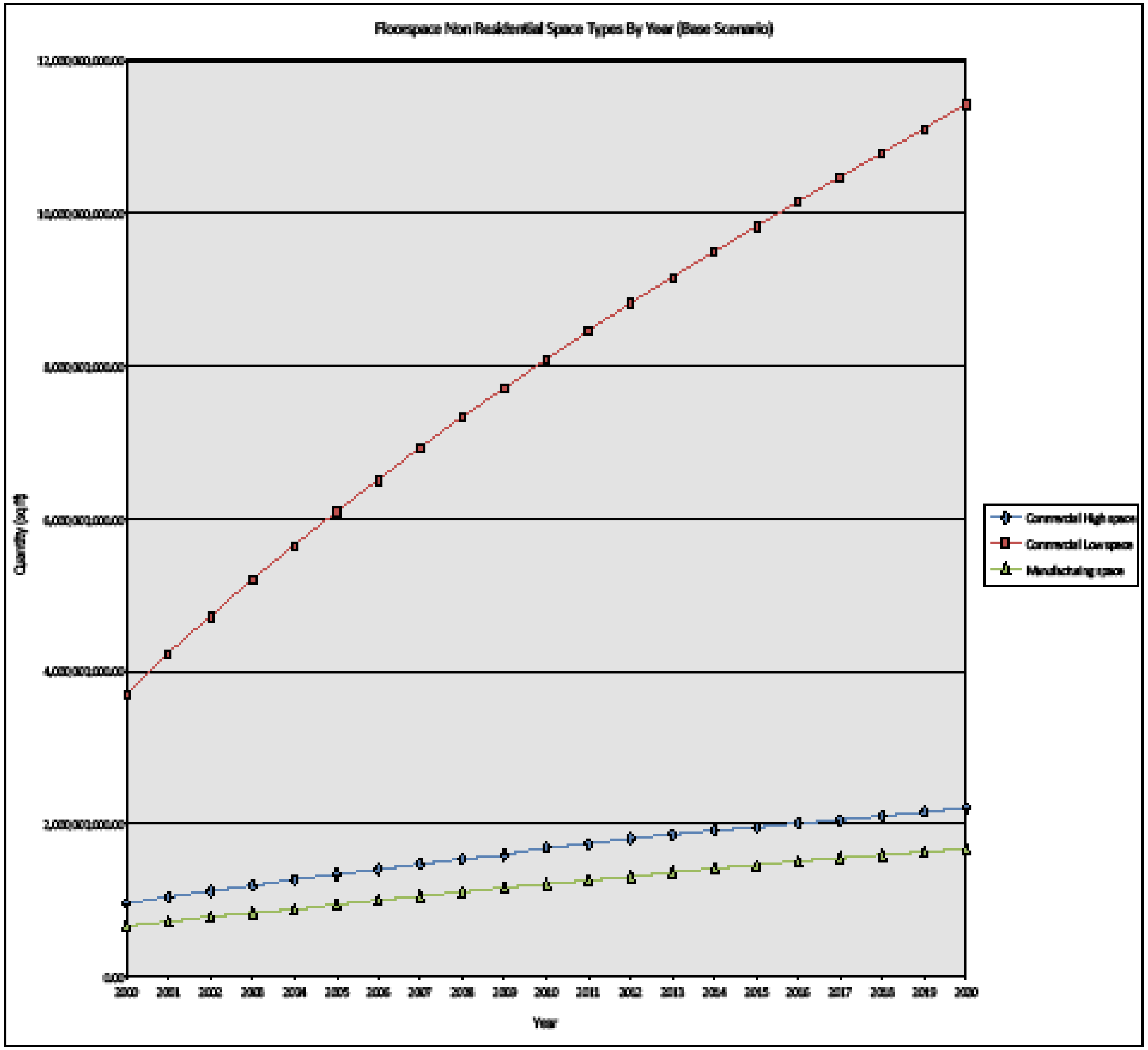

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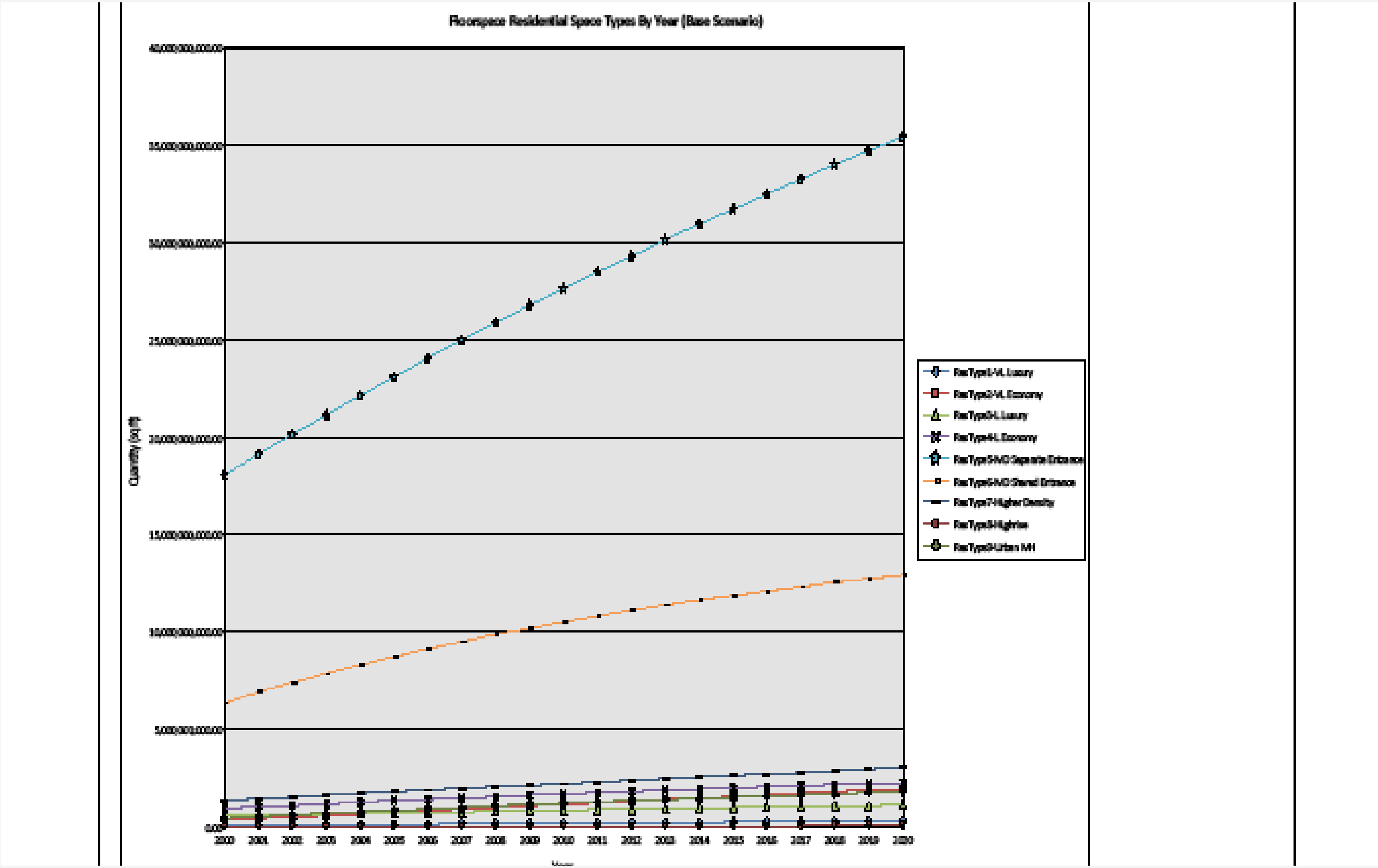

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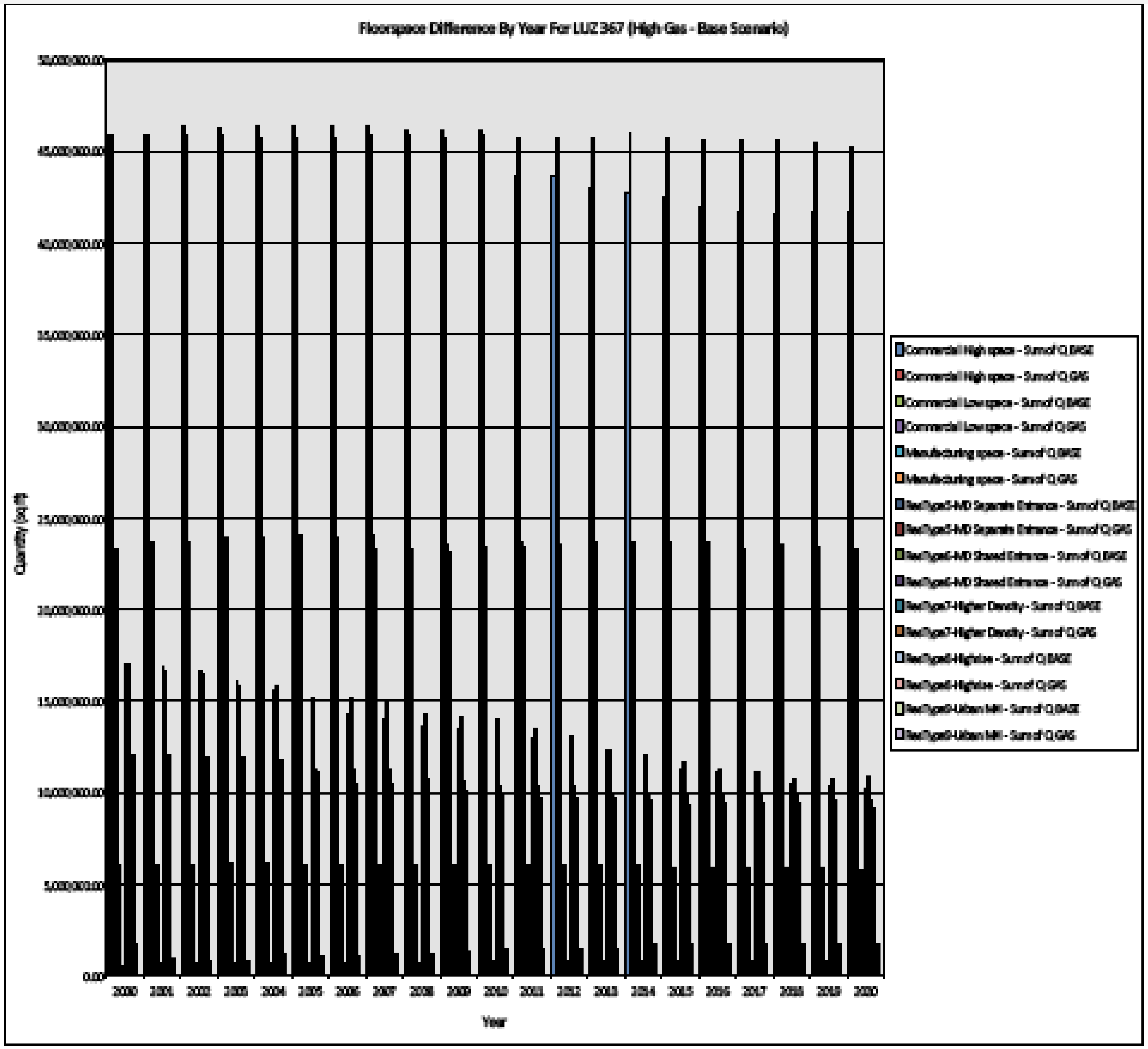

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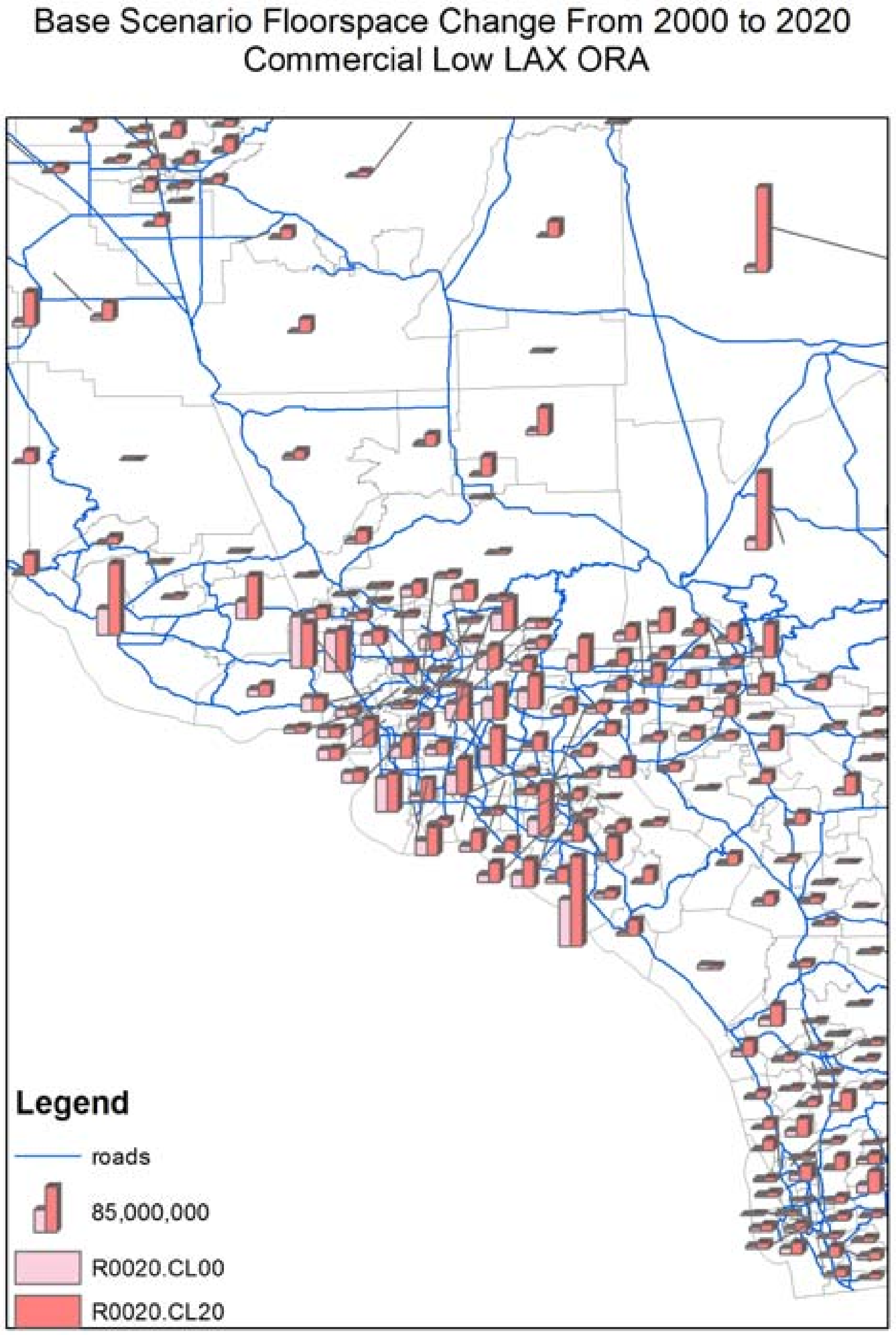

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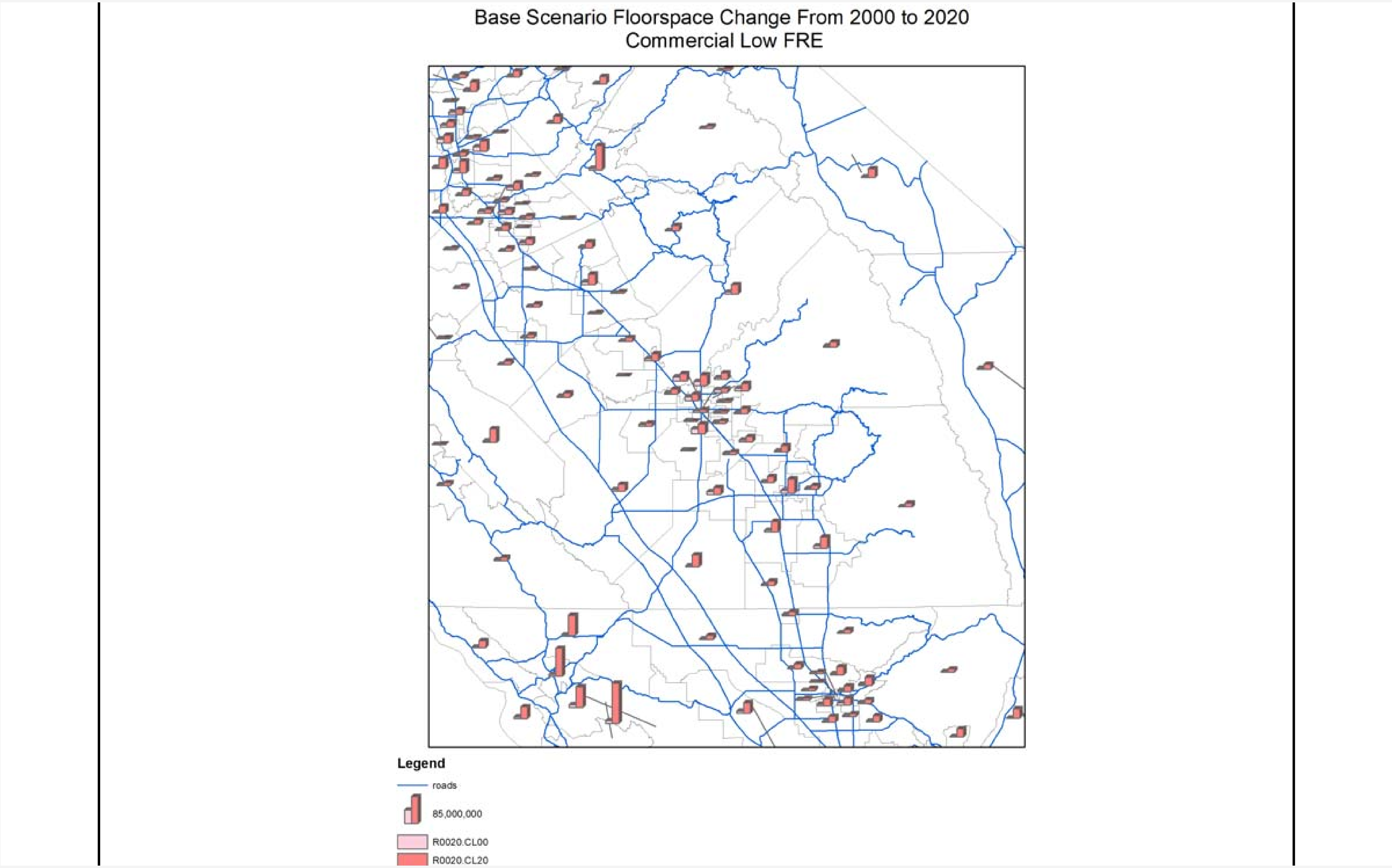

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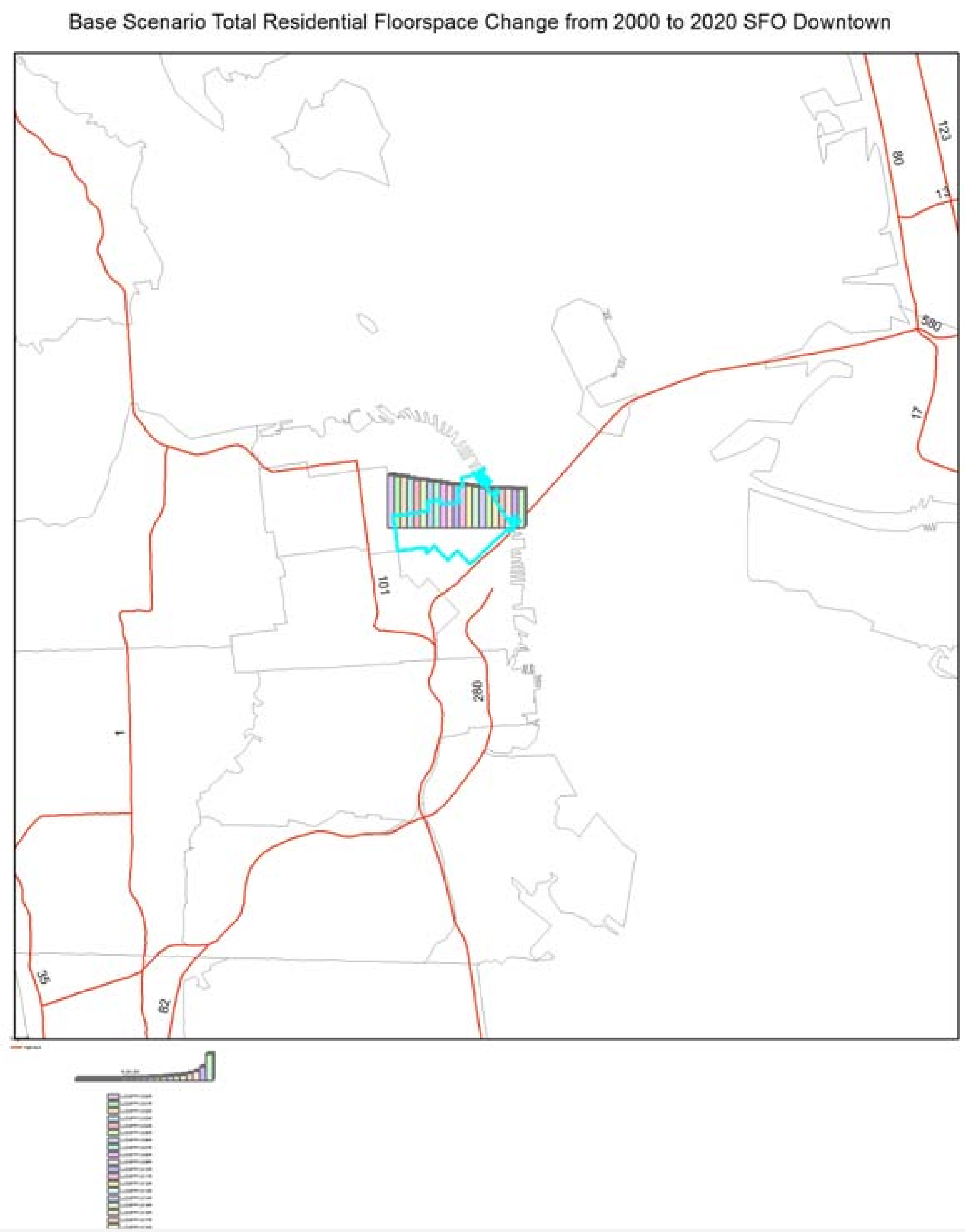

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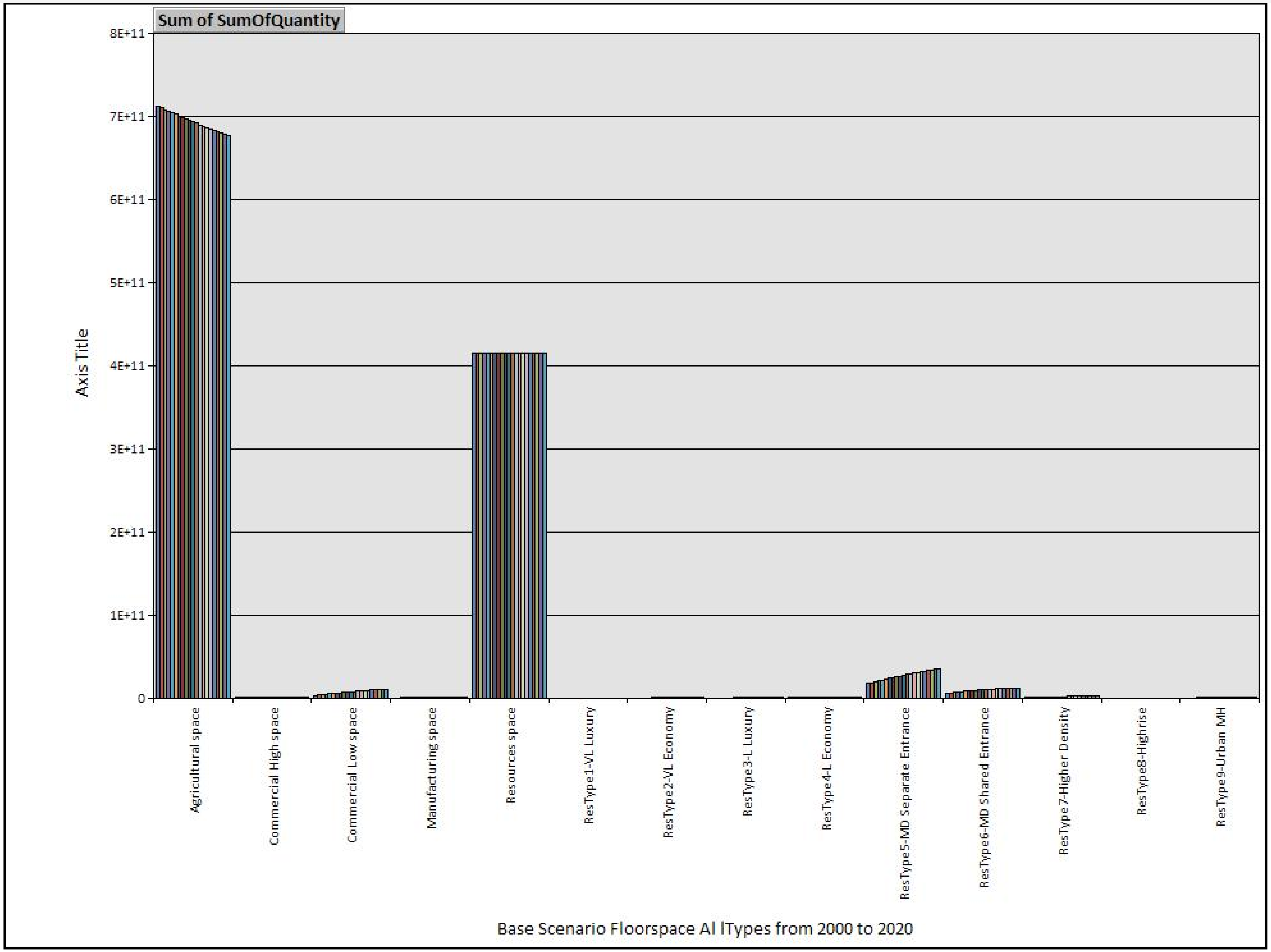

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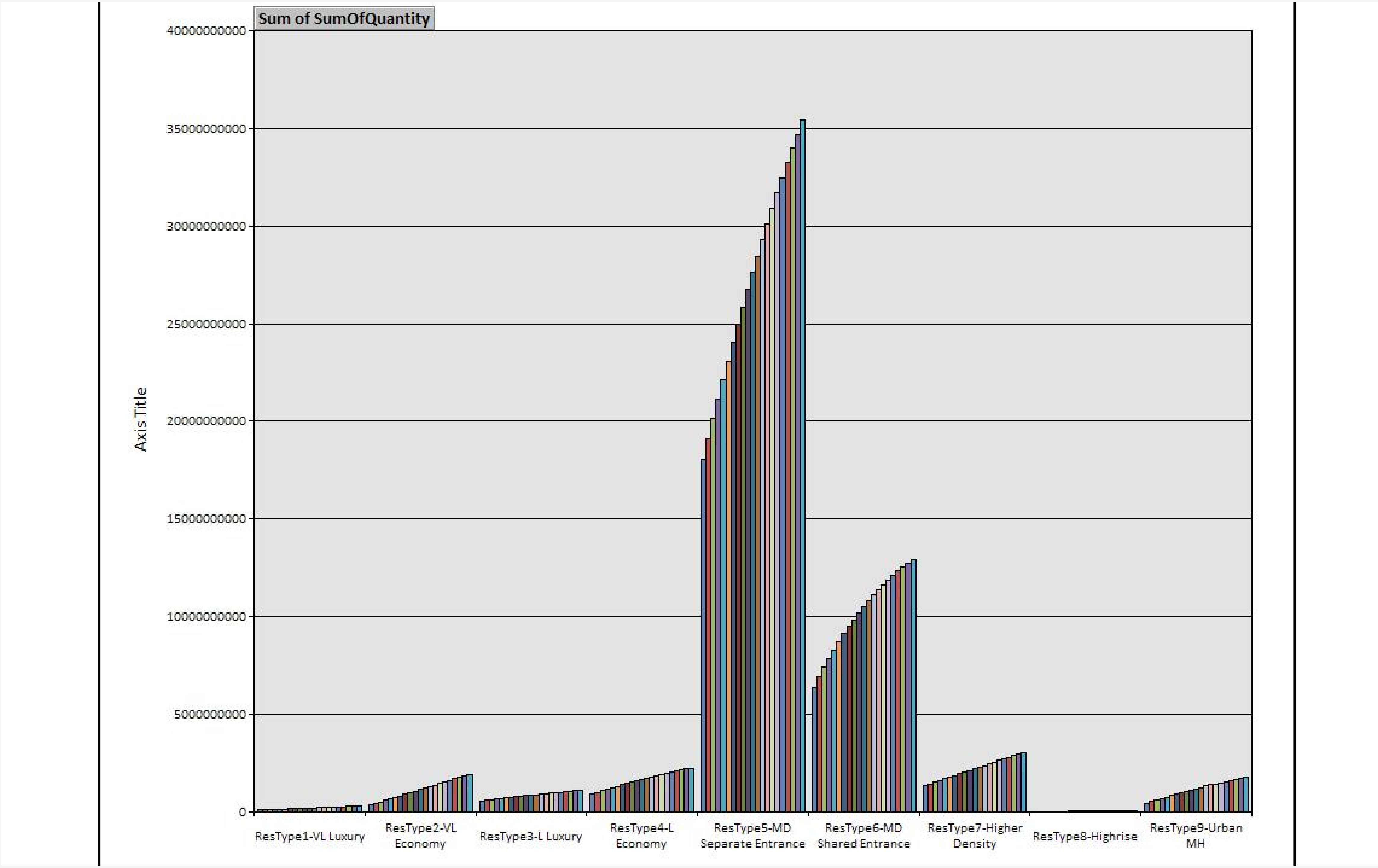

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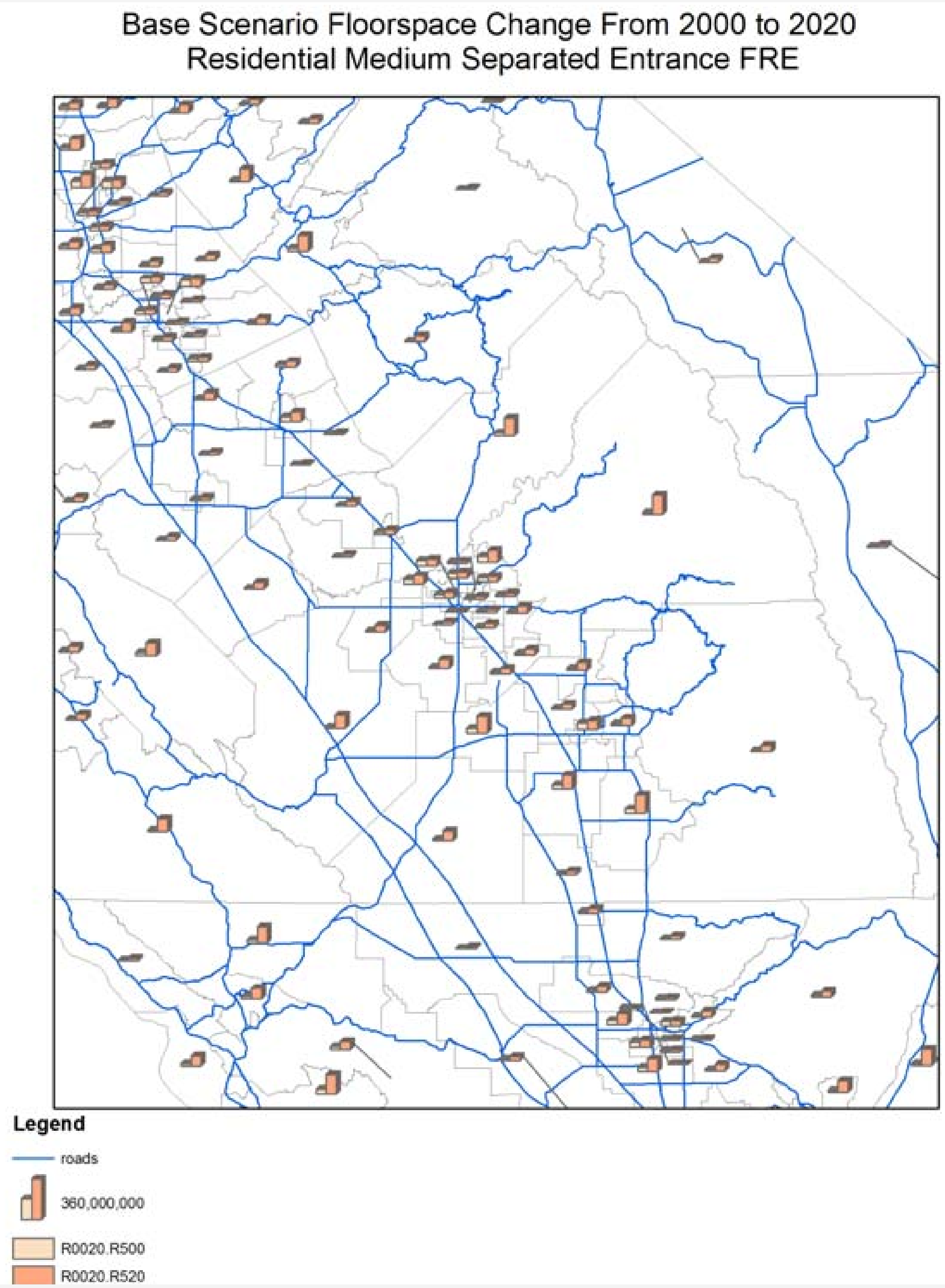

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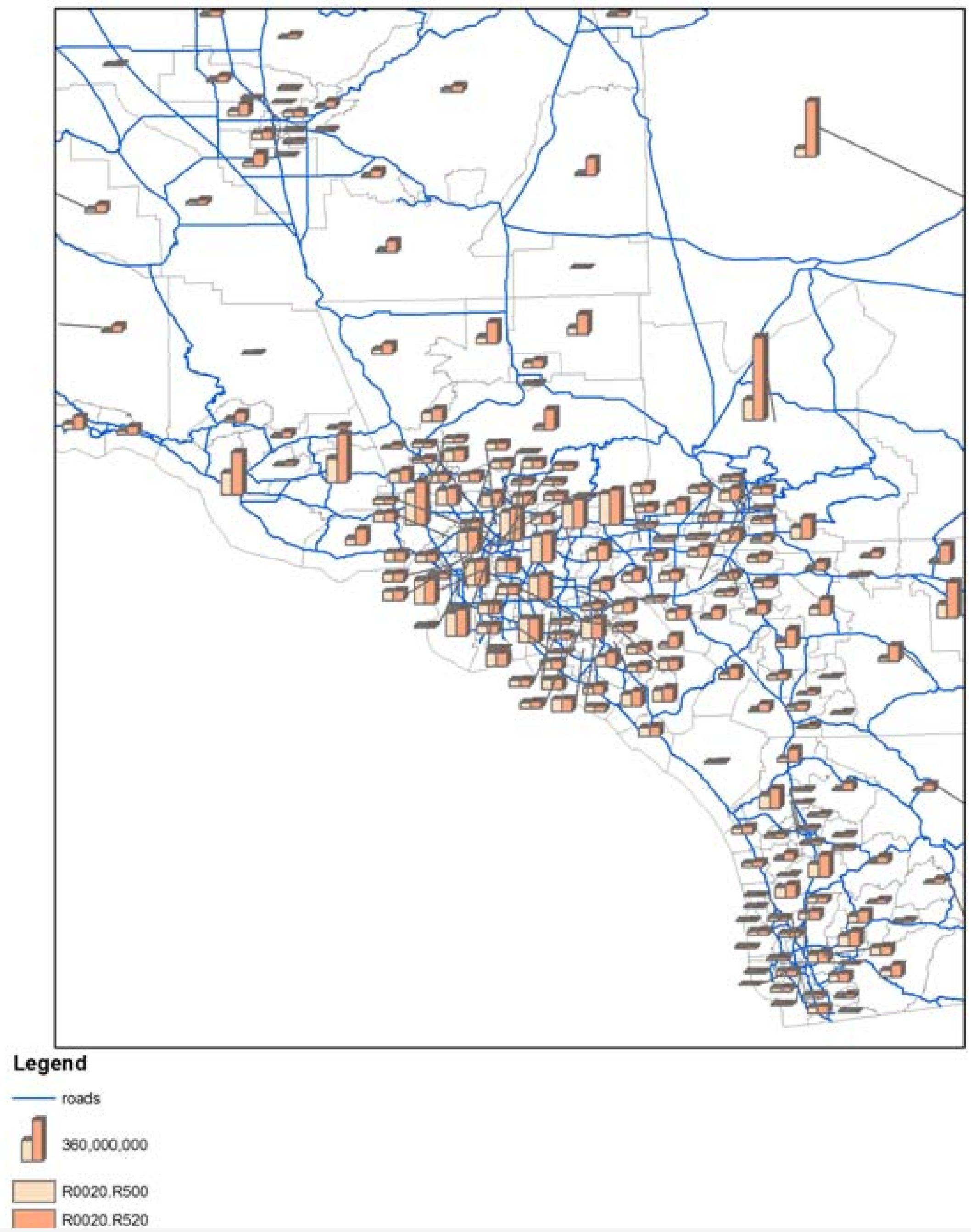
CalSIM

Base Scenario Floorspace Change From 2000 to 2020
Residential Medium Separated Entrance LAX ORA SDG



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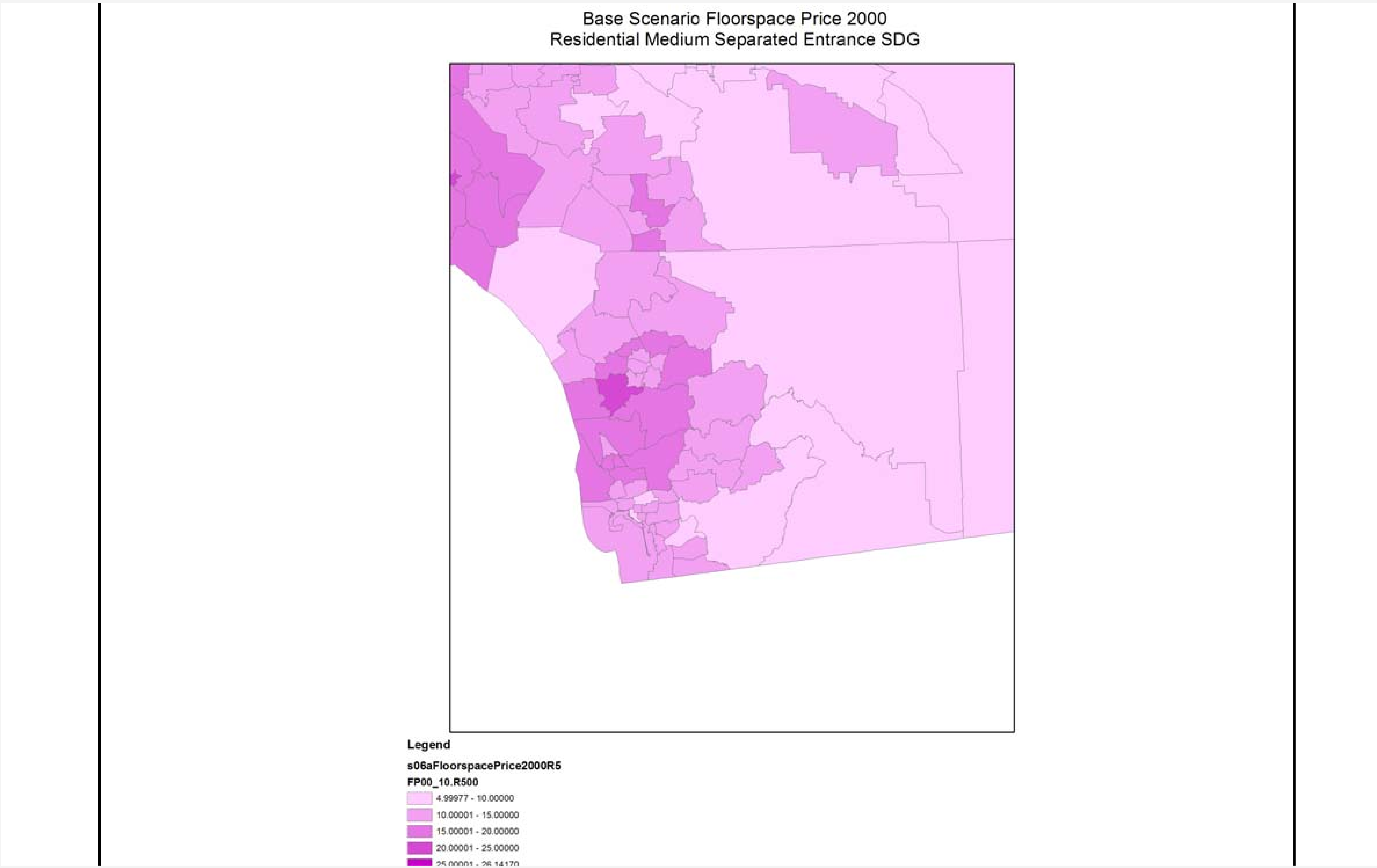

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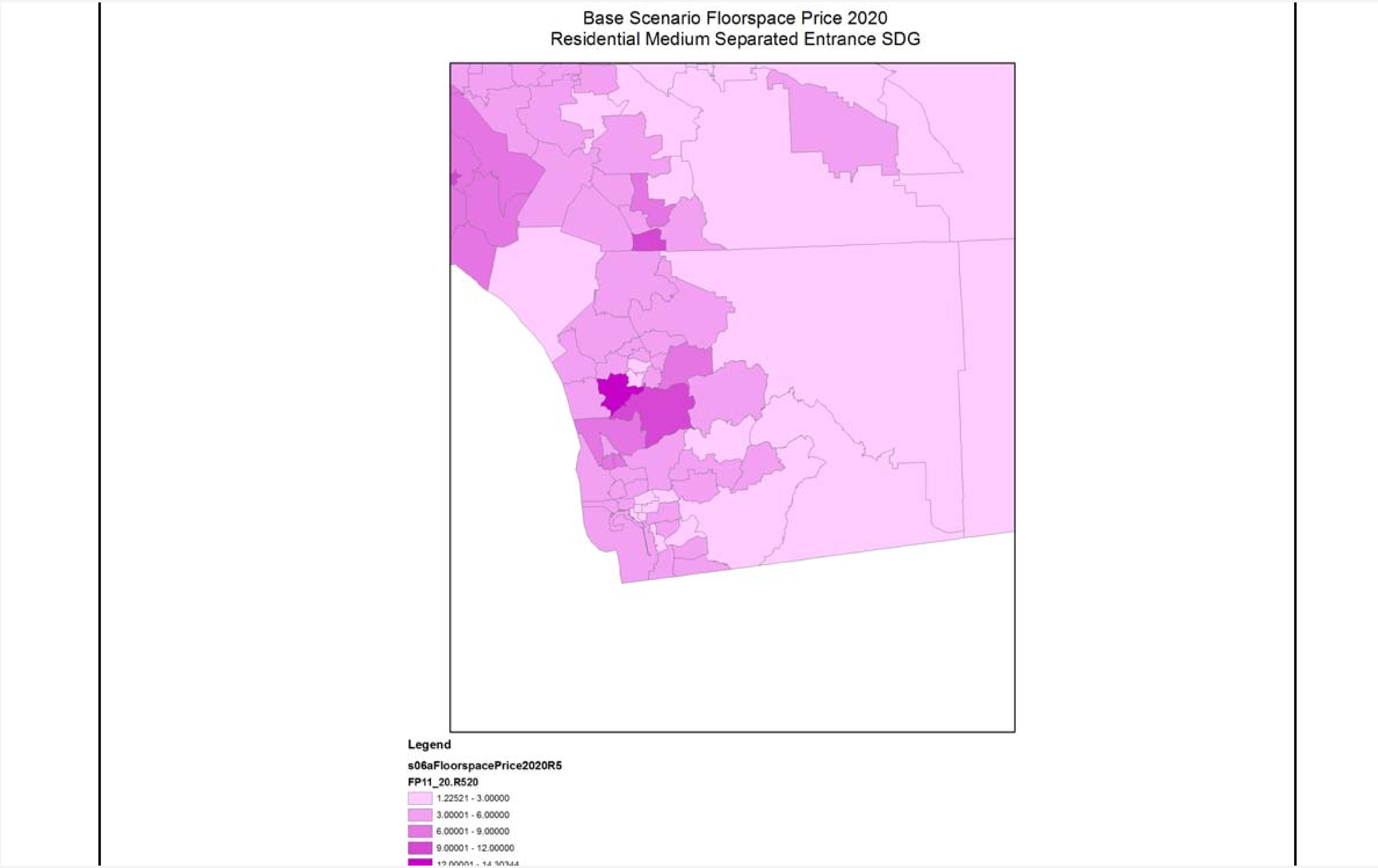

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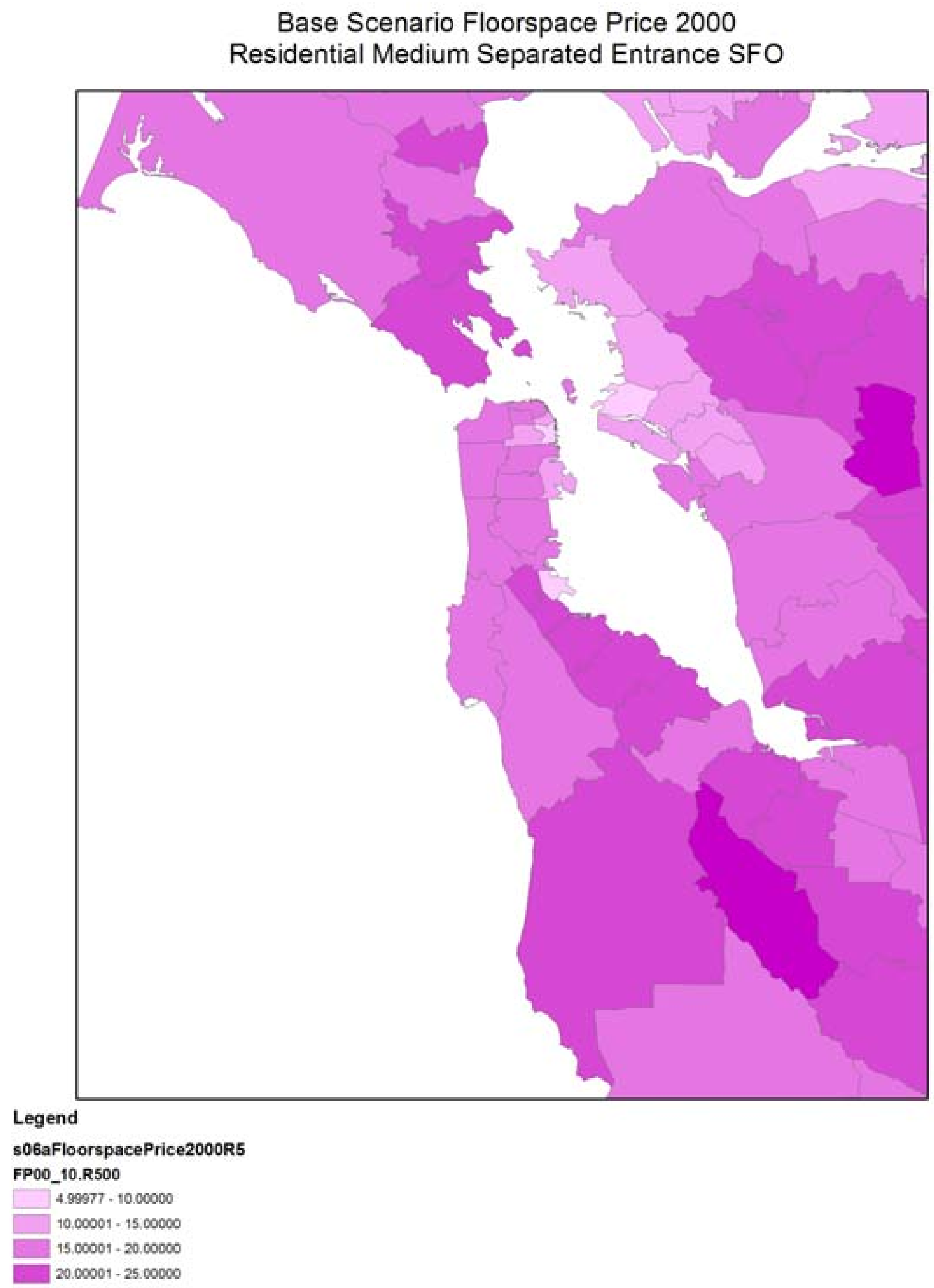

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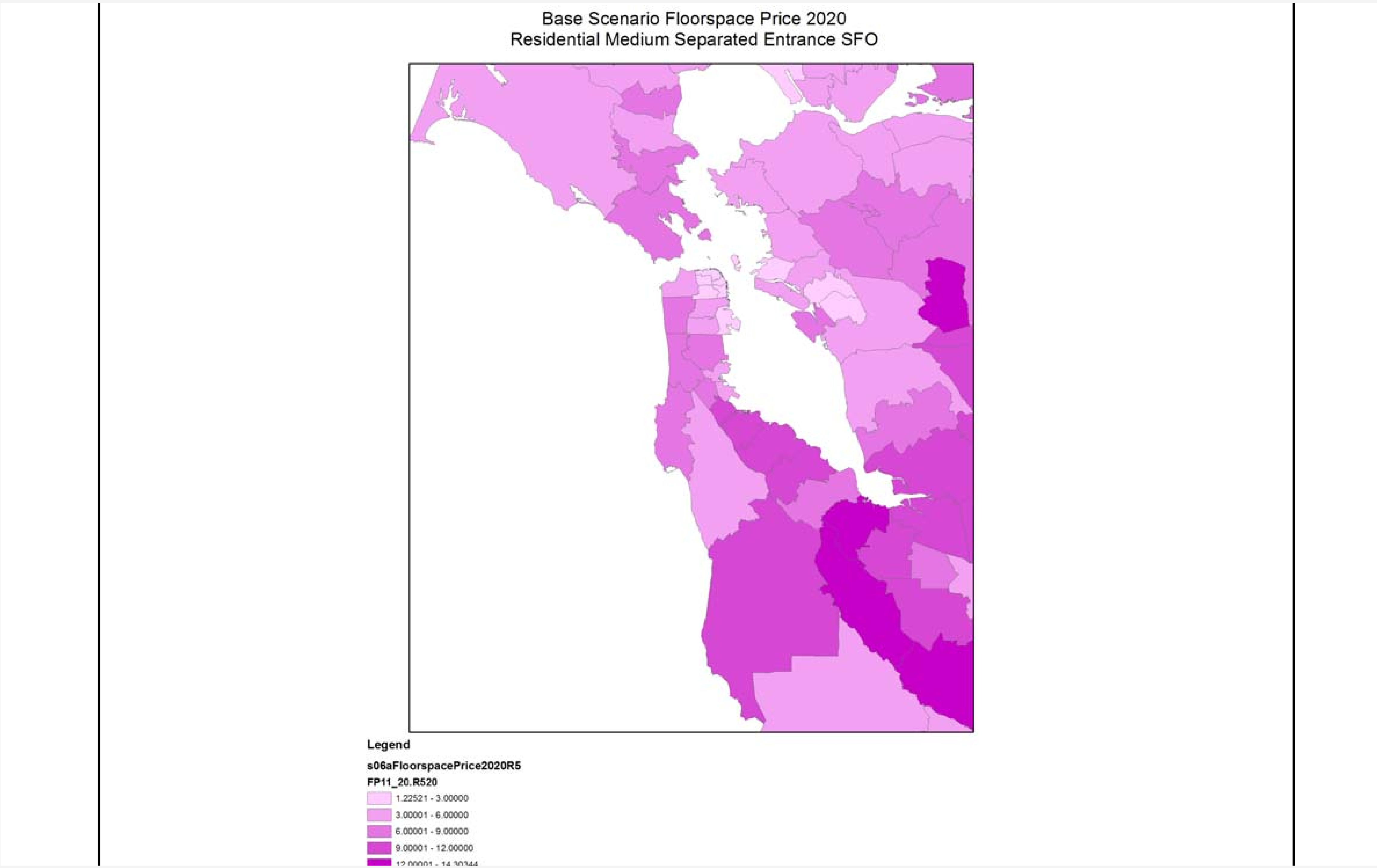

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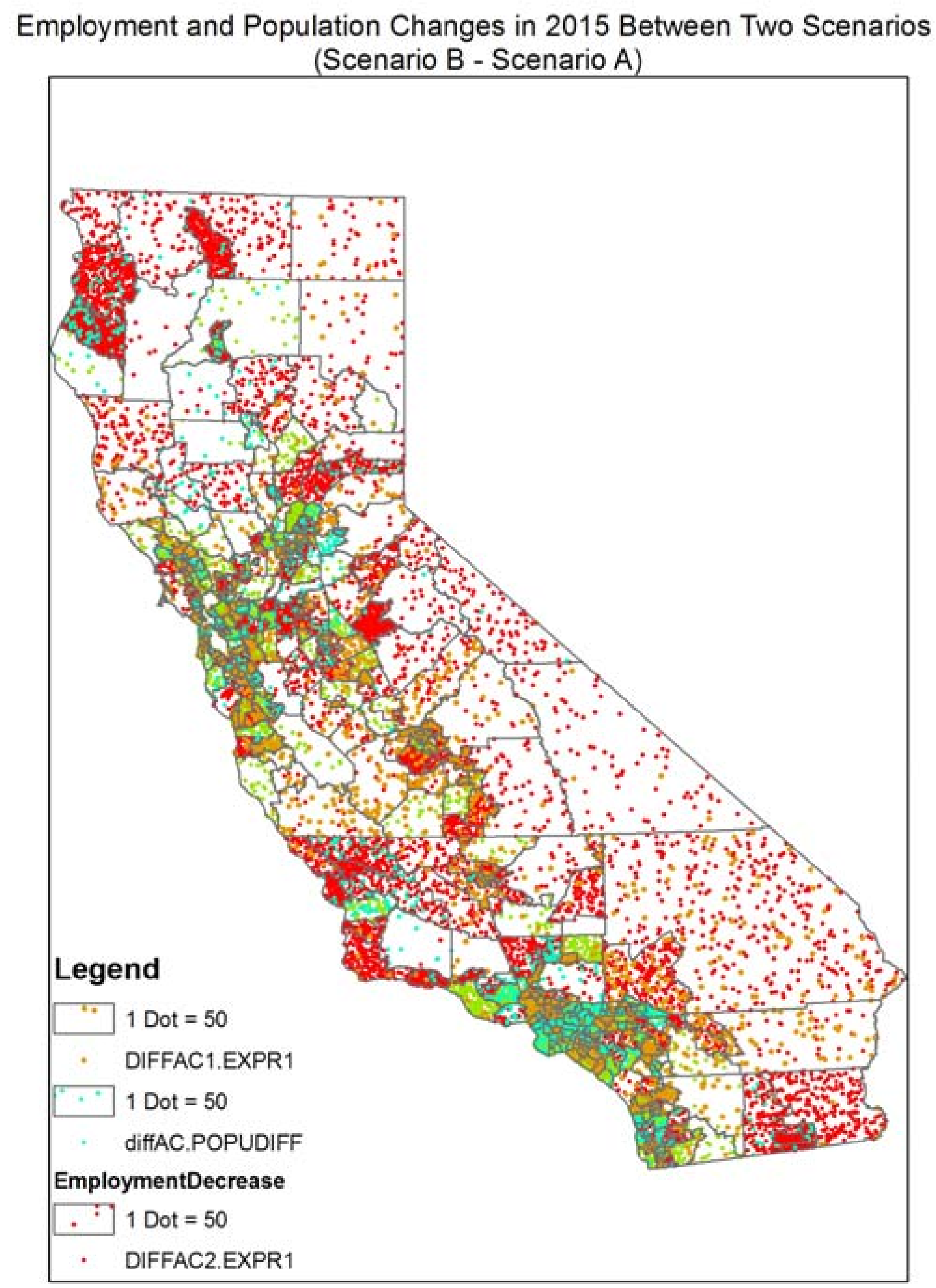

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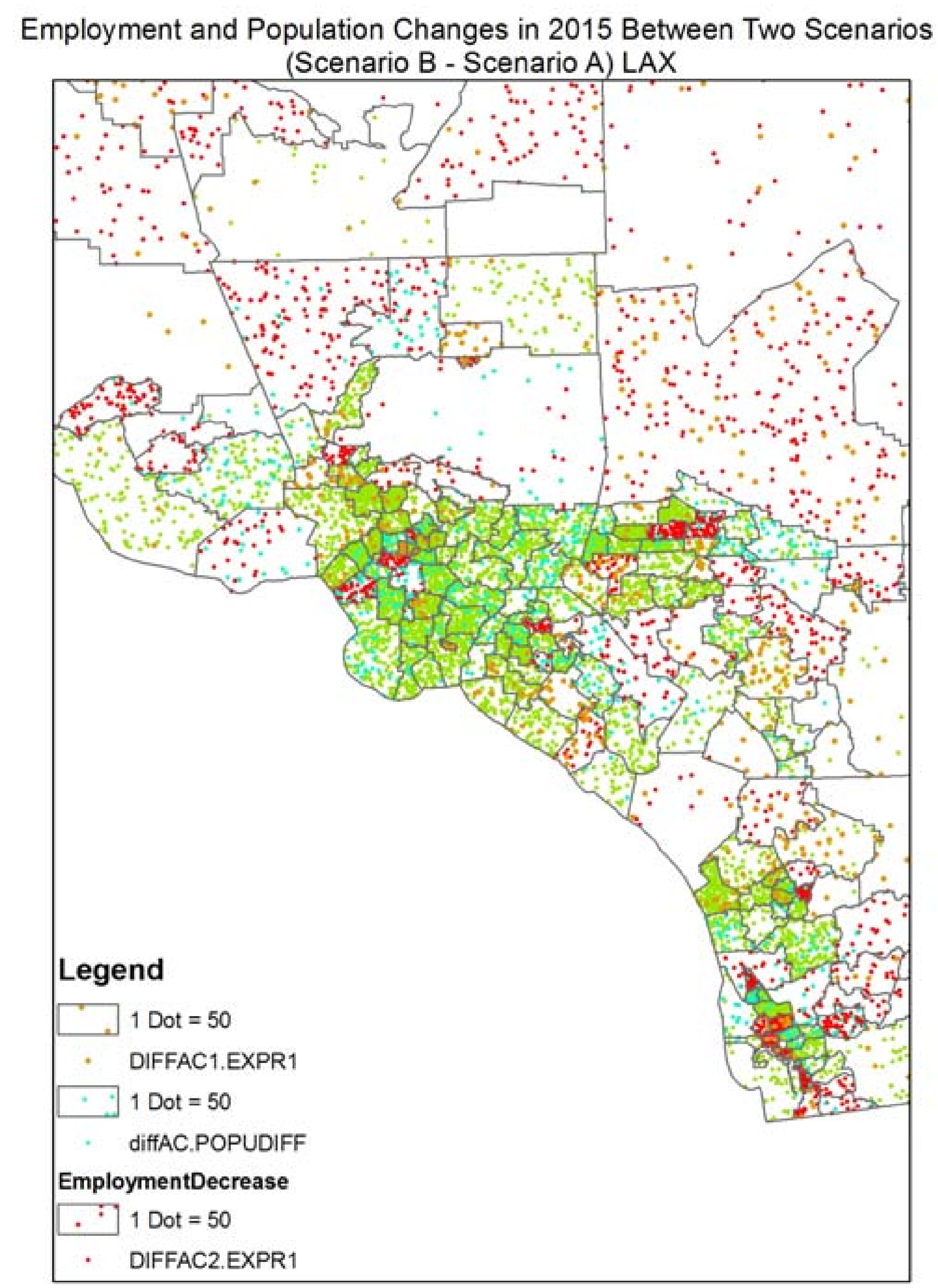

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1. PECAS overview
2. Anatomy of the System
3. Application in Practice
4. **Assessment**

Strengths of Input-Output Models

- I-O Models provide a concise summary of the economic flows in the economy
- Multipliers from I-O models are used widely to predict the impact of changes in output of a sector on the broader economy - the multiplier effect
- With suitable data, national I-O models can be localized to states or possibly lower units of geography
  - Keep in mind the model represents economic flows between every geographic unit and every sector, as in an international trade model - so the data requirements to generate a highly disaggregate I-O model are immense

Limitations of Input-Output Models

- Wikipedia's article on Input-Output models provides the following assessment:
  - "Input-output is conceptually simple. Its extension to a model of equilibrium in the national economy is also relatively simple and attractive but requires great skill and high-quality data. One who wishes to do work with input-output systems must deal skillfully with industry classification, data estimation, and inverting very large, ill-conditioned matrices. Moreover, changes in relative prices are not readily handled by this modeling approach alone."
- I-O model theory does not account for the effects of changes in relative prices on production functions of firms, and therefore on the I-O structure
- I-O model does not allow flexible substitution among inputs and price adjustment
- I-O model deals only with monetary flows in the economy, not quantities of employment, households, population, etc.
- I-O model is an aggregate, static equilibrium model, with no capacity to represent effects of heterogeneous agents, temporal dynamics, changes in production technology

Strengths of the PECAS Model System

- Built on a half-century of Input-Output modeling of macro-economies dating to Leontieff's 1960's model of U.S. economy, and spatial input-output models of MEPLAN and TRANUS from approximately 1970
- The spatial input-output framework has been used over several decades outside the U.S., and is beginning to see more use in the U.S., especially at a statewide scale
- Integrates interregional trade with and supports modeling of freight due to the relationship between trade and the movement of goods by mode at a time when logistics is becoming increasingly important in many cities
- The model development process can be started with IMPLAN, commercially available data that many U.S. regional planners already use
- Has been extended in PECAS to include not only origin and destination markets but also exchange markets
- Provides a static equilibrium framework, but can be run annually
- Is marketed as open source software (but not clear that it is downloadable)

Limitations of PECAS Model System

- Theory for price adjustment and its integration with I-O model needs development
- Spatial extensions to include production, consumption and exchange locations is complex and abstract
- Data is not readily available for the large number of assumptions to be made especially at the the metropolitan spatial scale, much must be synthesized.
- Creation of quantities of population, jobs, and commodity weights for freight movement are all derived by translating dollars flows to quantities
- AA module is an aggregate, static equilibrium model - not microsimulation
- SD module is a loosely coupled land transition model at a cell or parcel level, lacks demand side at comparable level of detail
- Model estimation/calibration is difficult and to our knowledge no applications have been developed without substantial consulting involvement by developers
- There is limited experience with fully operational applications. No MPOs had used PECAS for official Regional Transportation Plan updates in a 2010 survey by Maricopa Association of Governments; only one reported having used it in their projection series.

Questions and Discussion

PECAS Links:

http://www.hbaspecto.com

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