SIMULATING A SYNTHETIC POPULATION OF ESTABLISHMENTS

Diem-Trinh Le, Giulia Cernicchiaro, Chris Zegras, Joseph Ferreira
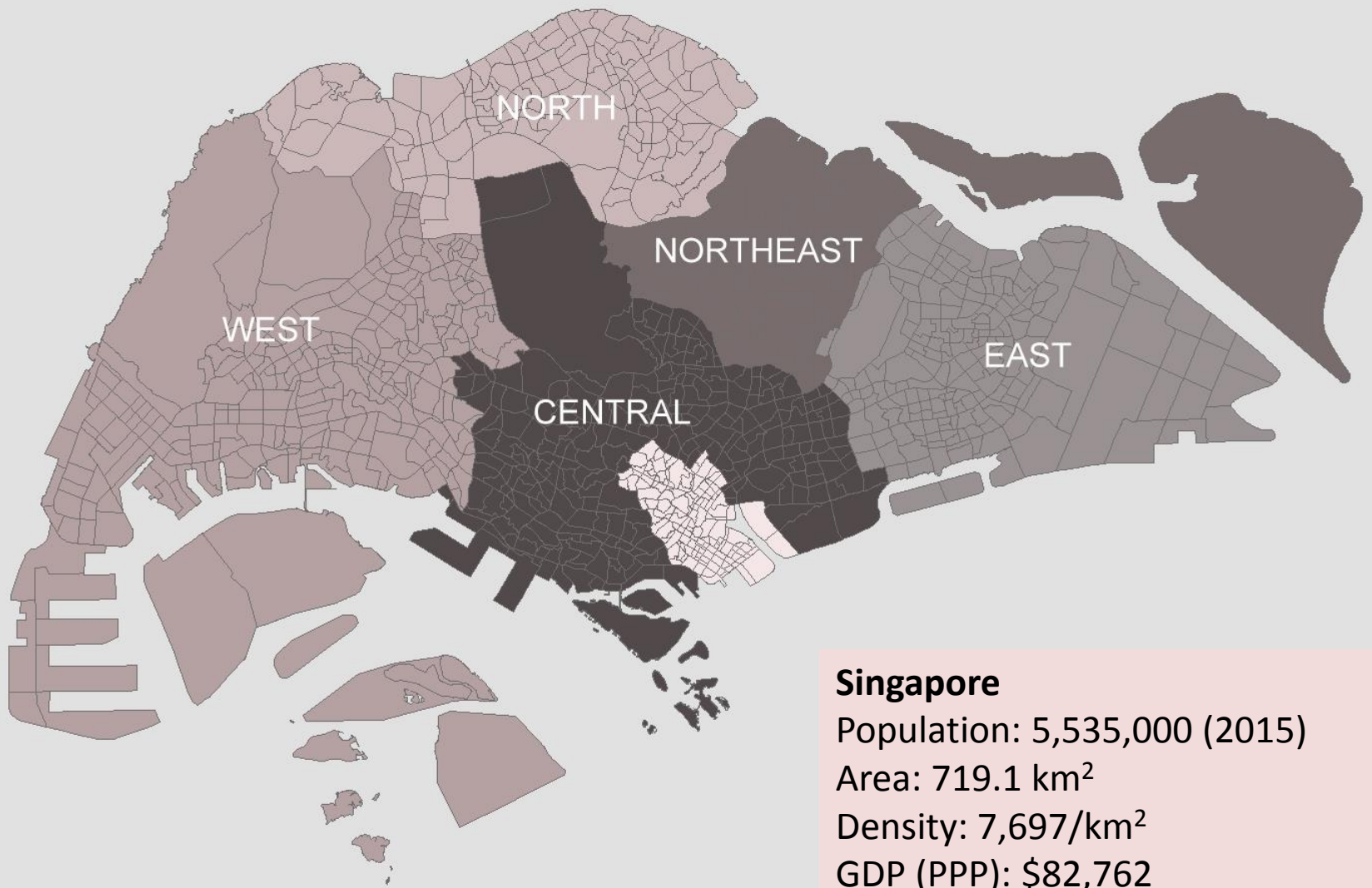
mobil.TUM 2016

SimMobility-Long-Term Group
MIT: Joseph Ferreira, Chris Zegras, Roberto Ponce Lopez, Jingsi Shaw
SMART: Yi Zhu, Diem-Trinh Le, Chetan Rogbeer, Gishara Indeewarie
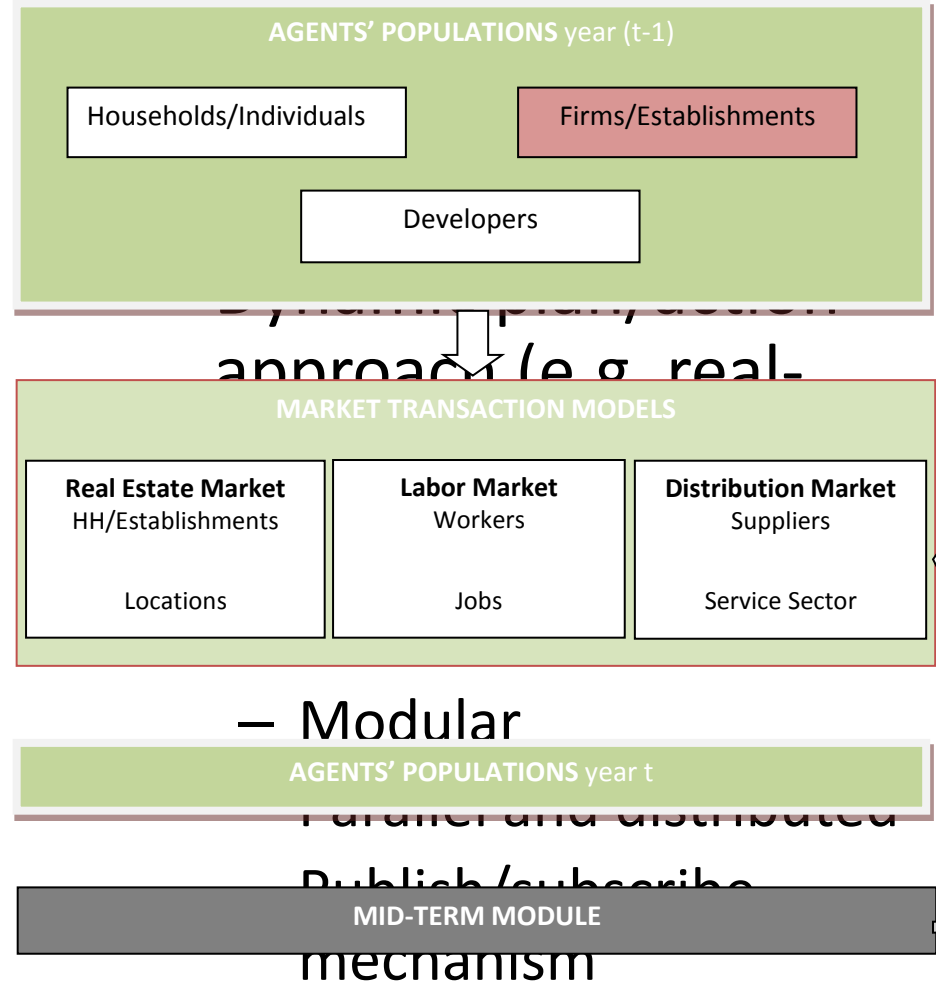NUS: Mi Diao

NORTH

NORTHEAST

WEST

EAST

CENTRAL

Singapore
Population: 5,535,000 (2015)
Area: 719.1 km²
Density: 7,697/km²
GDP (PPP): $82,762

SimMobility Framework

LONG-TERM
Land development and location choices

AGENTS' POPULATIONS year (t-1)

Households/Individuals

Firms/Establishments

Developers

Dynamic plan/action approach (e.g. real-

MARKET TRANSACTION MODELS

Real Estate Market
HH/Establishments

Locations

Labor Market
Workers

Jobs

Distribution Market
Suppliers

Service Sector

– Modular

AGENTS' POPULATIONS year t

Parallel and distributed

Publish/subscribe

MID-TERM MODULE

mechanism

3

HOW TO SIMULATE A POPULATION OF FIRMS?

- How many firms?
- What kind of firm?
- How much floor area is occupied?
- How many workers?

Step 1: Data Collection

- ✓ List of business entities registered at ACRA
- ✓ Building data
- ✓ National statistics: total employment, total occupied area, etc.
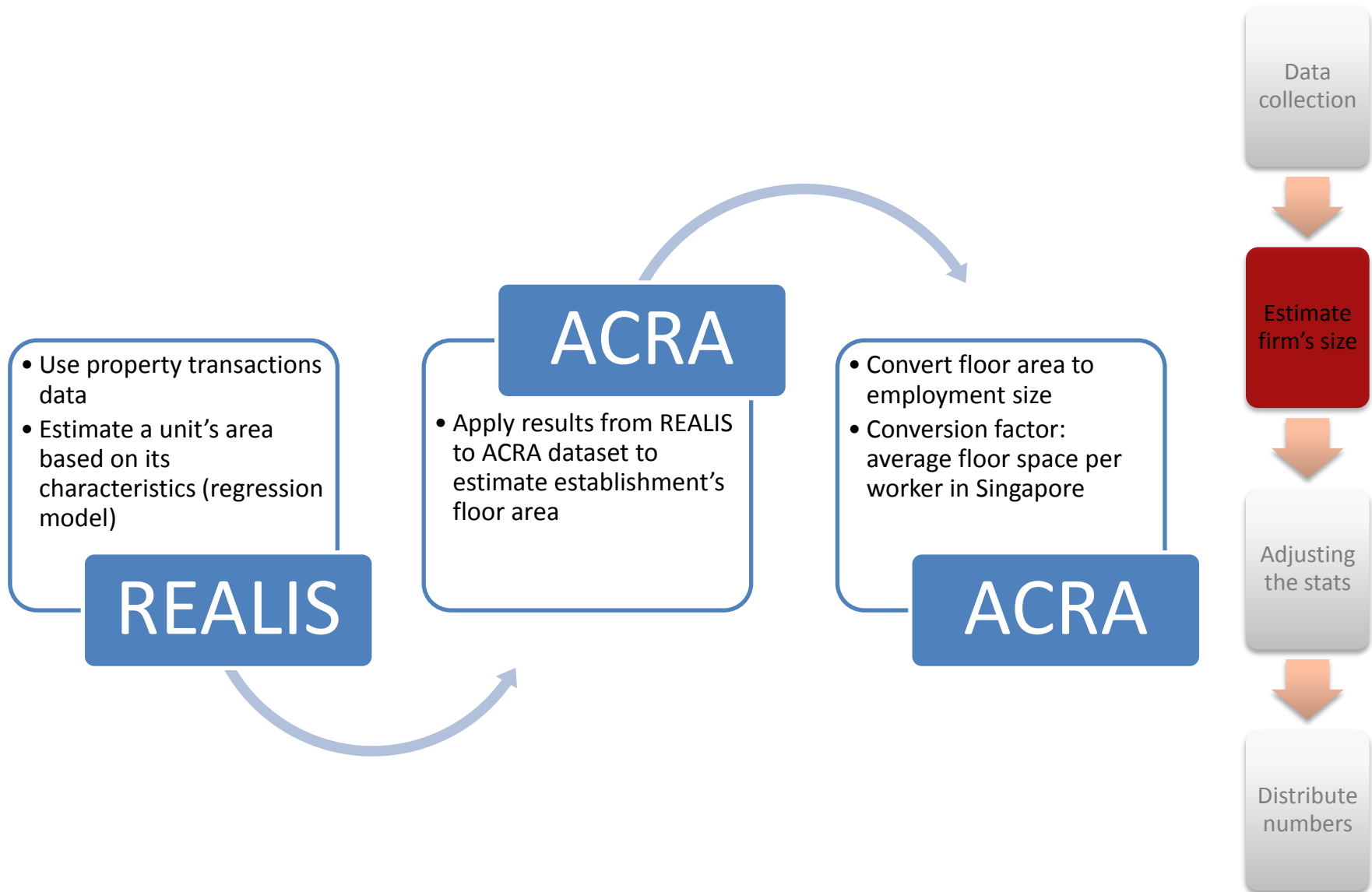- ☐ Establishments' floor size and number of workers

Data collection

Estimate firm's size

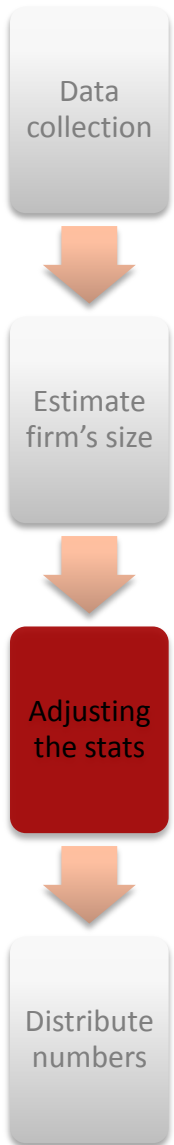Adjusting the stats

Distribute numbers

REALIS

- Use property transactions data
- Estimate a unit's area based on its characteristics (regression model)

ACRA

- Apply results from REALIS to ACRA dataset to estimate establishment's floor area

ACRA

- Convert floor area to employment size
- Conversion factor: average floor space per worker in Singapore

Data collection

Estimate firm's size

Adjusting the stats

Distribute numbers

Step 3: Adjust The Numbers

1. Method: Iterative proportional fitting (IPF).
2. Marginal controls: Official statistics from different government agencies.

Planning Area		Industry type	Industry 1	Industry 2	Industry k
	Floor type	No. of Jobs.	N^j_1	N^j_2	N^j_k
AMK	Office	$N^j_{pa,ft=office}$			
	Retail	$N^j_{pa,ft=retail}$			
	Warehouse	$N^j_{pa,ft=warehouse}$			
	Industrial	$N^j_{pa,ft=industrial}$			

MOM

REALIS

The adjusted number of jobs in each industry for each planning area $N^j_{pa,k}$

Data collection

Estimate firm's size

Adjusting the stats

Distribute numbers

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$$\sum_{i \in pa} n_{i,k}^{j} = N_{pa,k}^{j}$$

$$\sum_{i,k \in ft} n_{i,k}^{e} = N_{ft}^{e}$$

$$\sum_{e \in i, ft} n_{e}^{f} = N_{i, ft}^{f}$$

- Establishment e
- Building i
- Industry type k
- Number of employees j
- Occupied floor area f
- Floor type ft
- n_{ik}^{c} the number of estabs/jobs/ floor area in building i of industry k.
- N_k : the total numbers of estab. (c = e), jobs (c = j), and floor size (c = f) of a particular industry type in Singapore.
- $N_{i,ft}$: the total numbers of estab. for a particular building and floor type.

Data collection

Estimate firm's size

Adjusting the stats

Distribute numbers

8

Step 4: Distribute Jobs & Establishments to Buildings
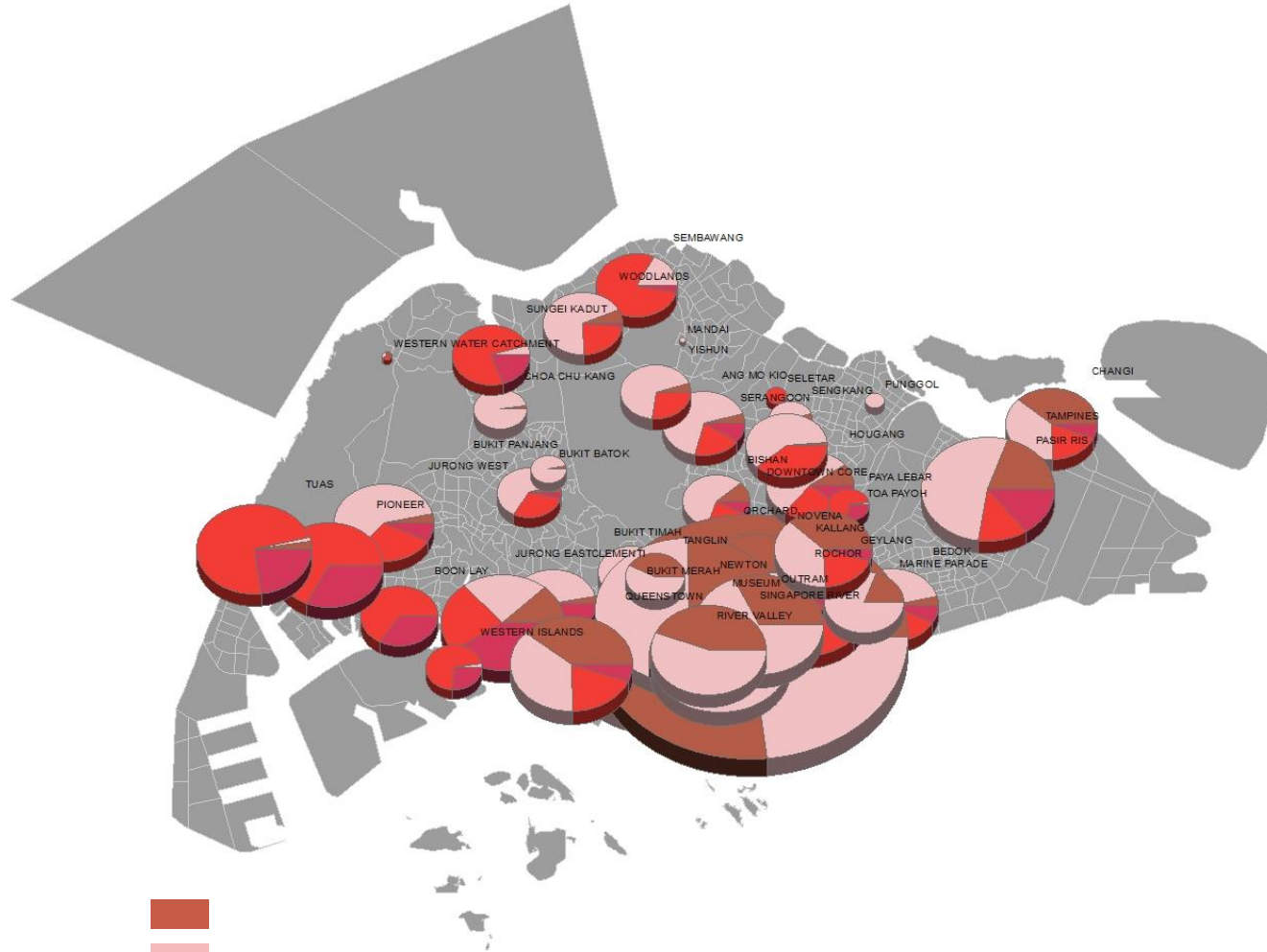
Office
Retail
Industrial
Warehouse

Data collection

Estimate firm's size

Adjusting the stats

Distribute numbers

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Summary of Estab. Pop. Syn.

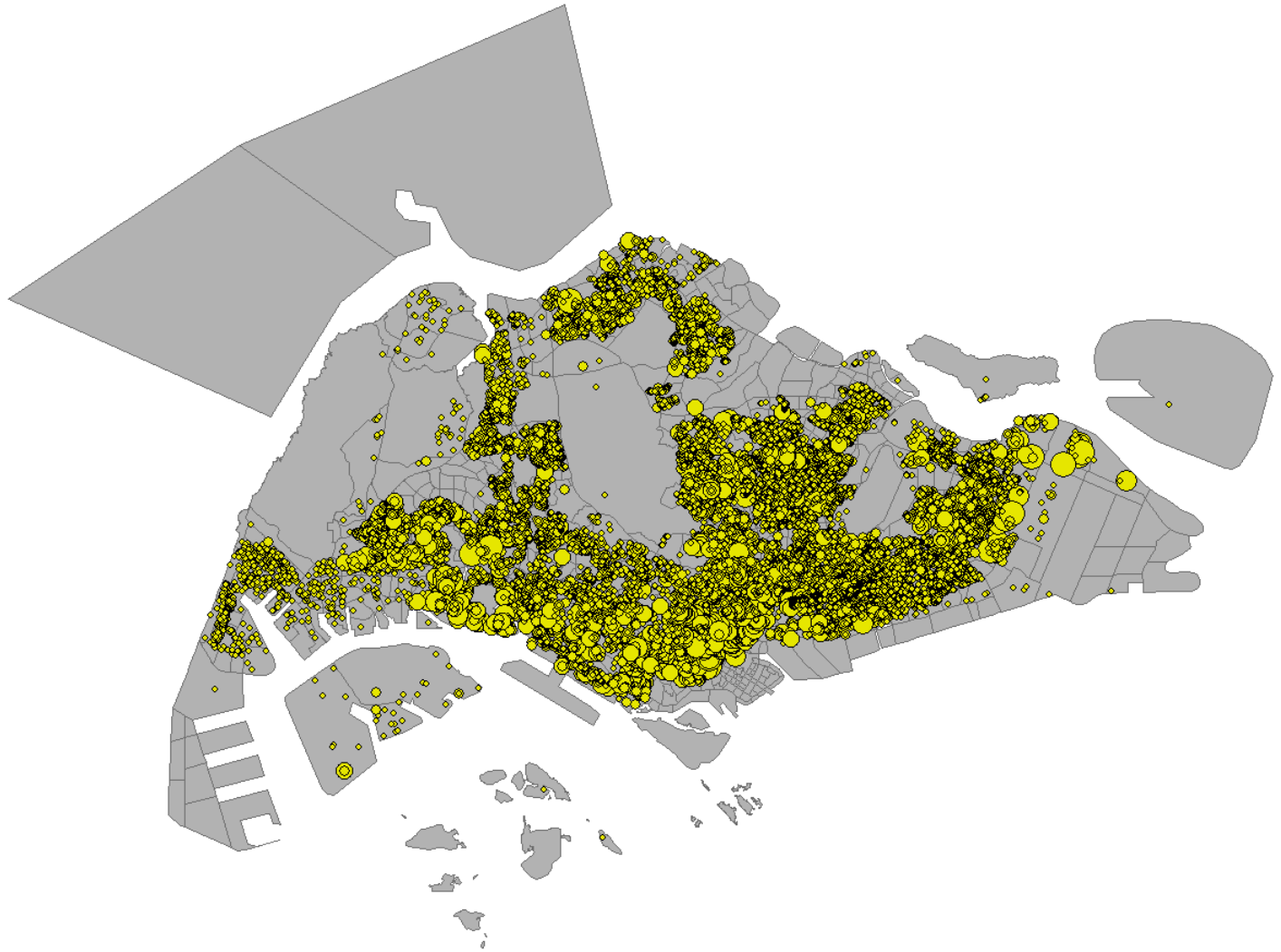| Floor type	Establishments		Jobs	
	Pop. Syn	*SingStats*	*Pop. Syn.*	*SingStats*
Office	56,800		1,170,284	
Retail	76,648	139,718	1,341,222	2,580,200
Manufacturing	16,368	9,577	533,610	535,000
Warehouse	10,184	11,076	215,337	217,700
Total	**160,000**	**160,371**	**3,260,453**	**3,332,900**

Buildings and Estab. by Job Size
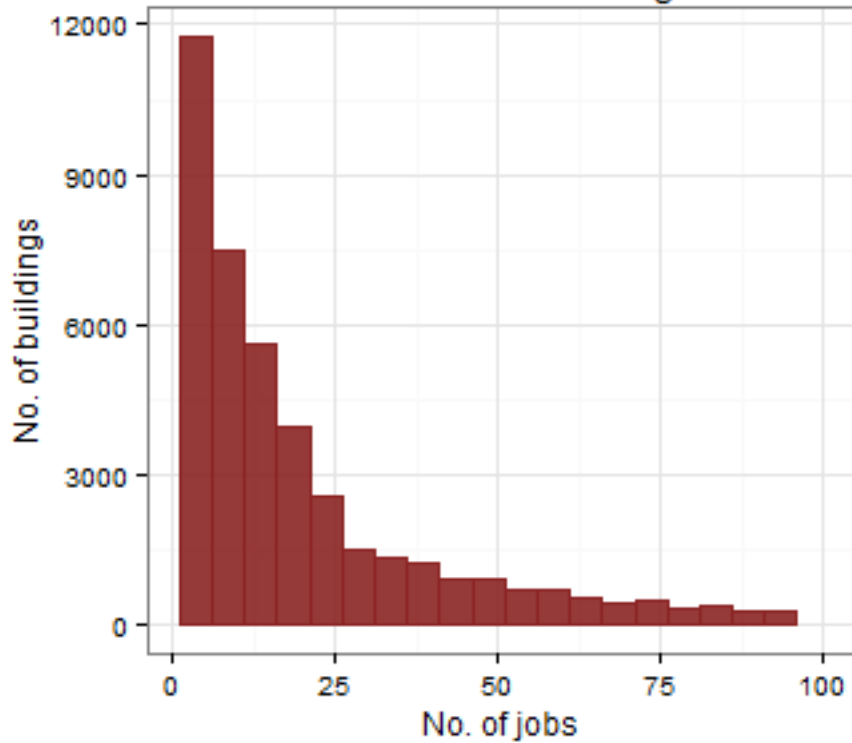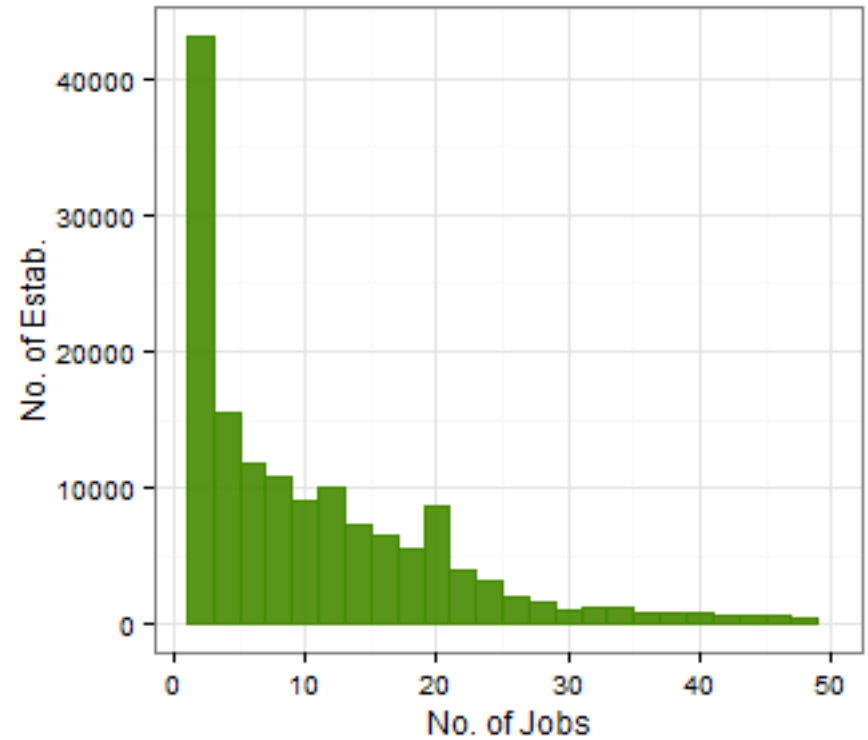
Locations of estab. with office floor type
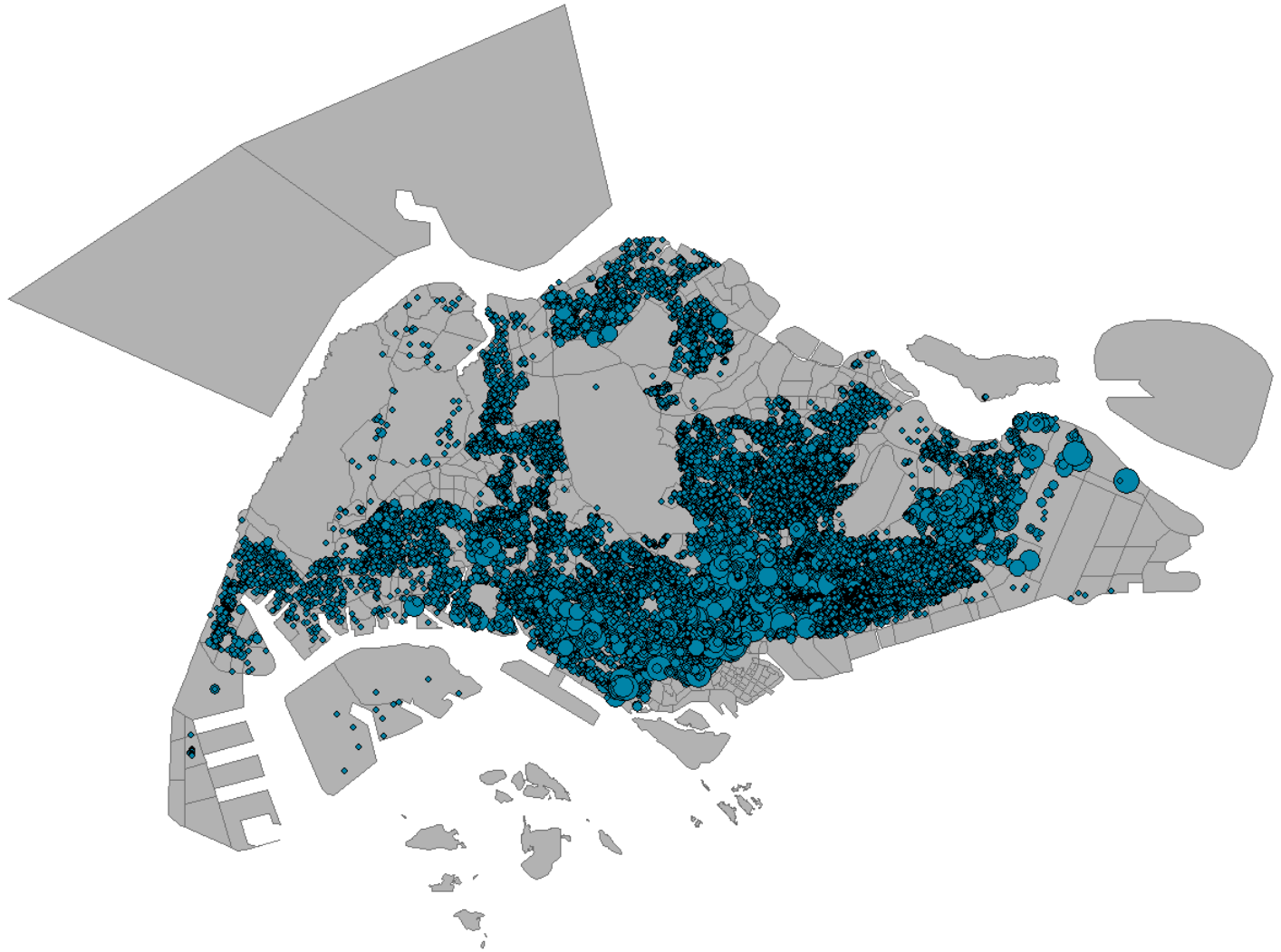
Locations of estab. with retail floor type
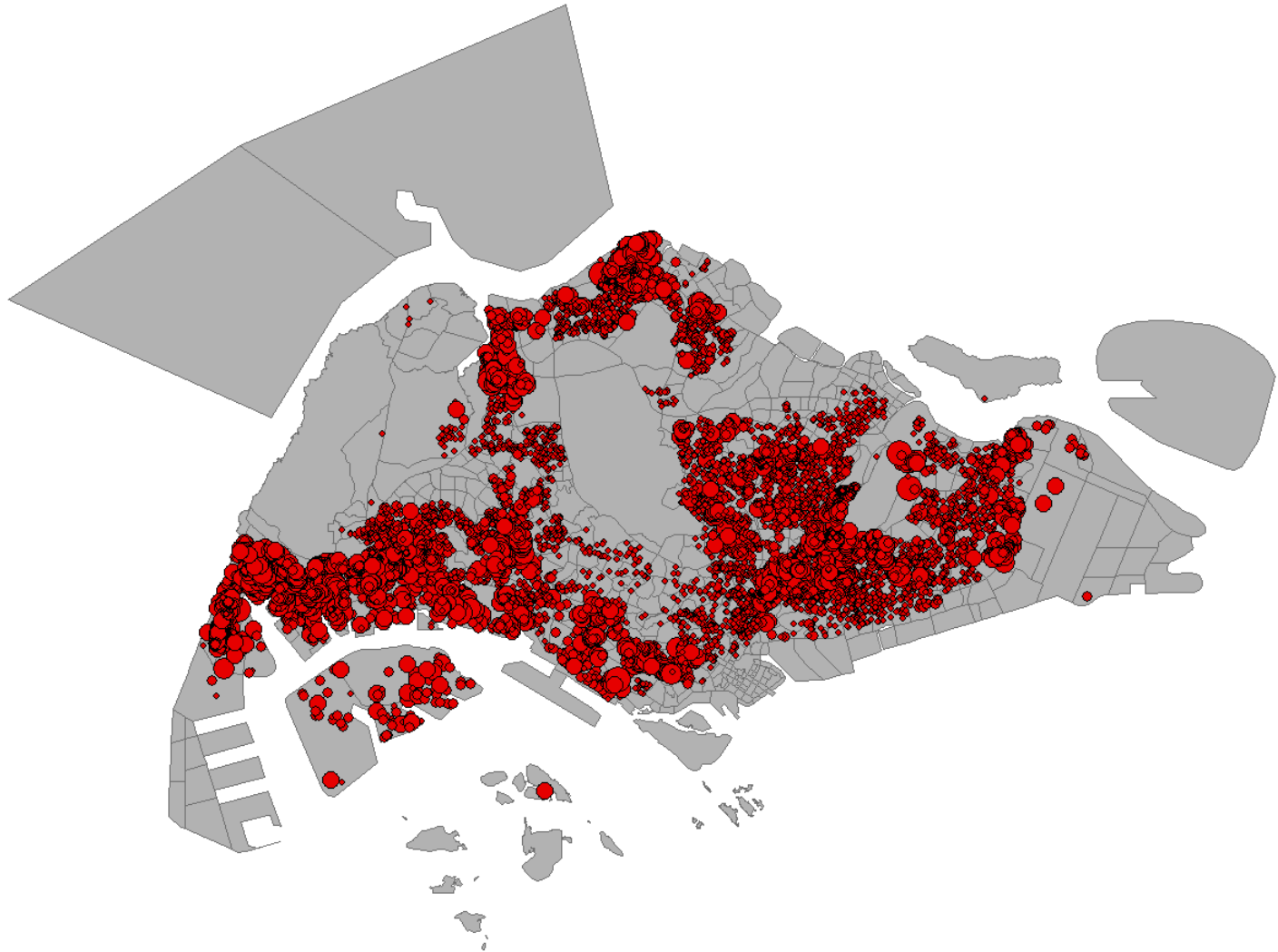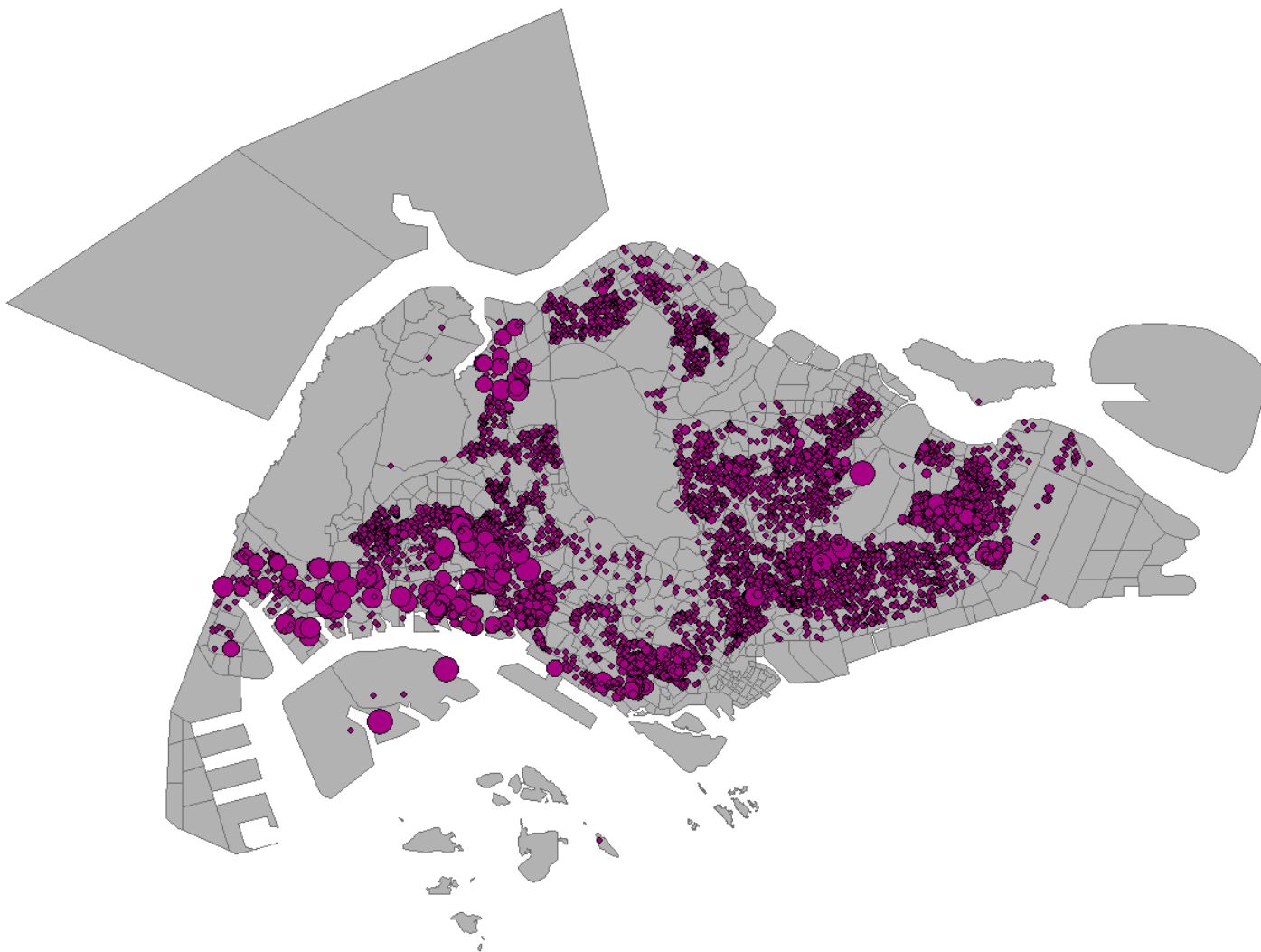
Office jobs at zonal level

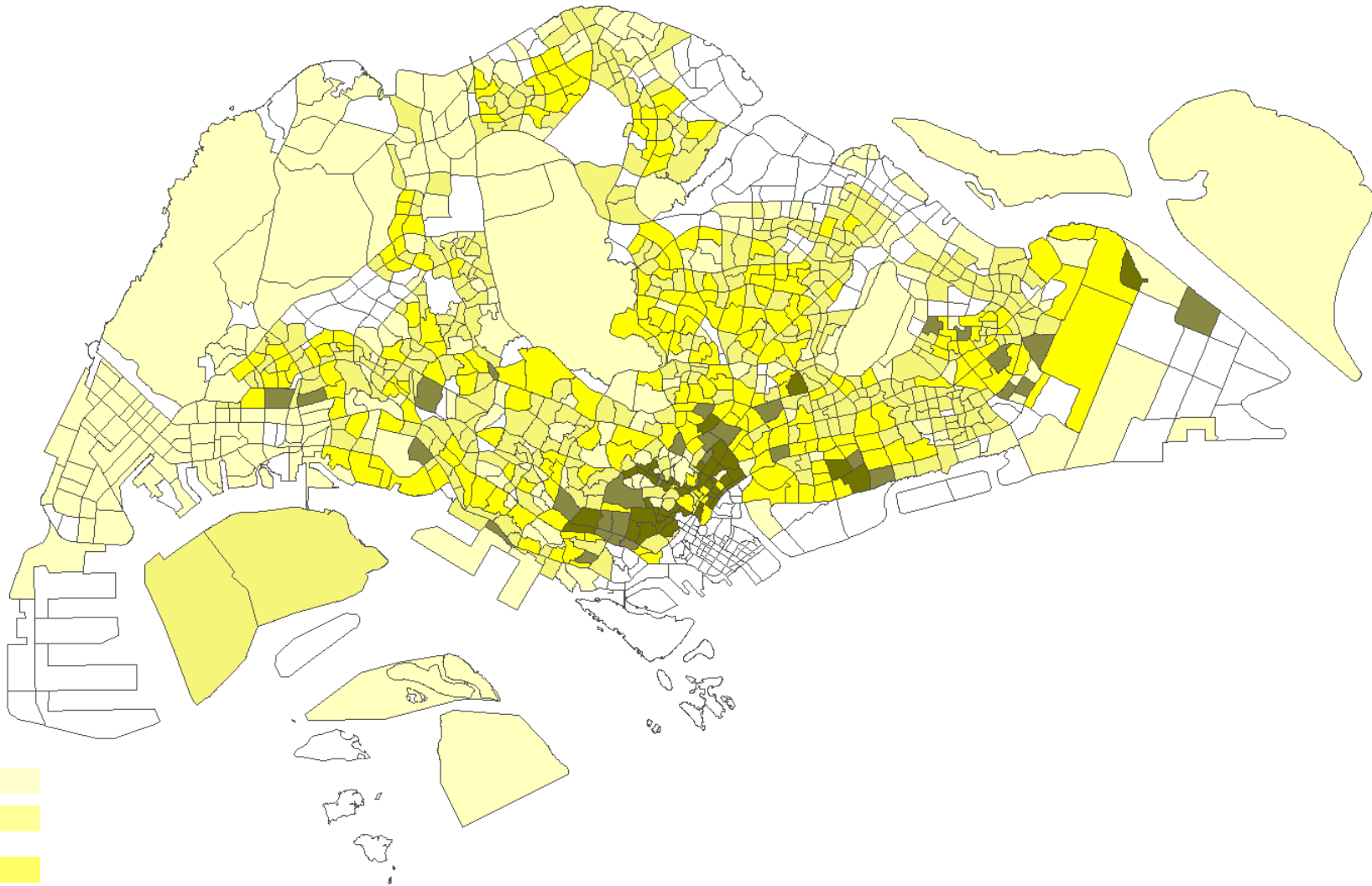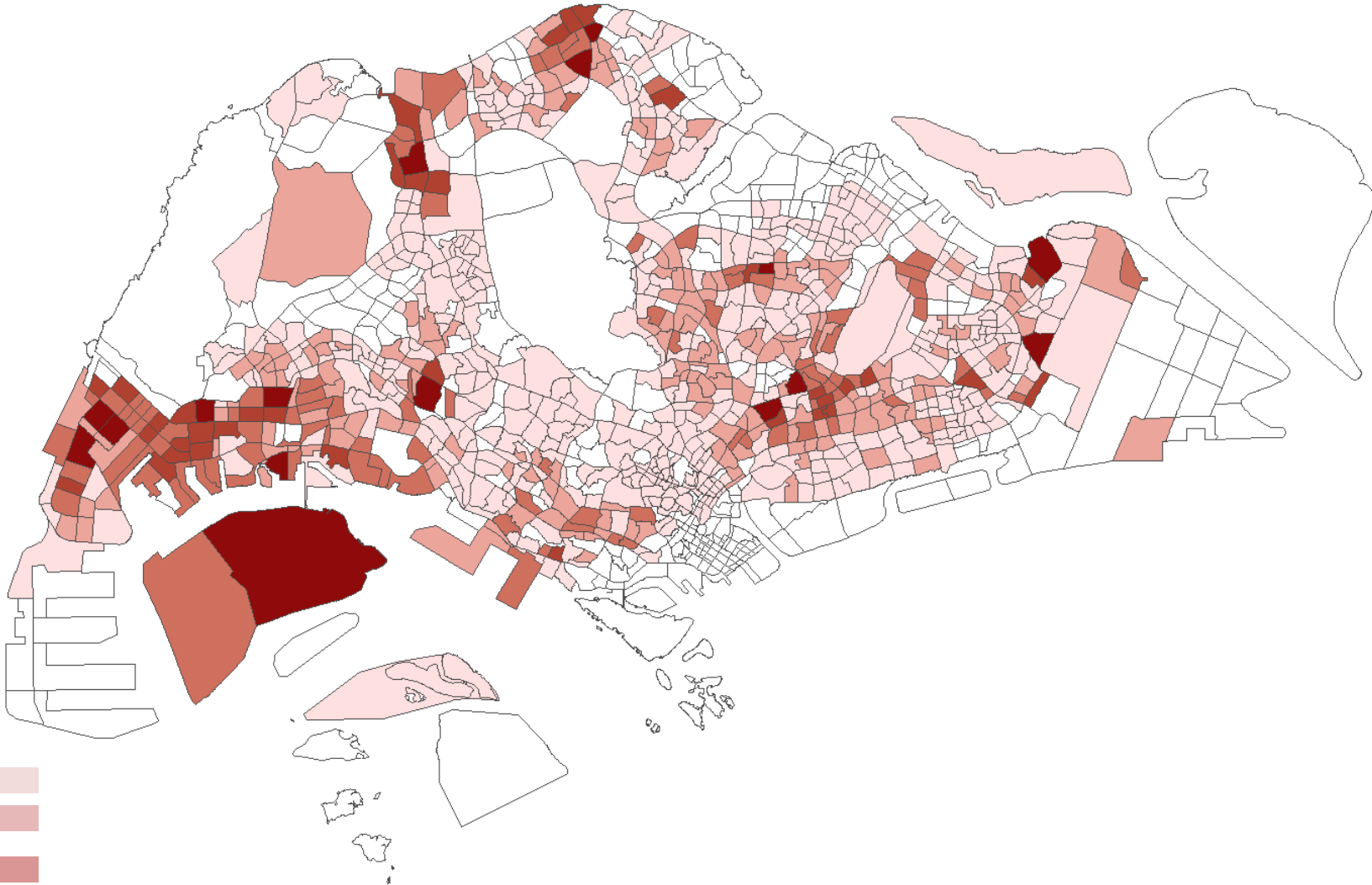|	
1-200	
201-1000	
1001-3000	
3001-5000	
>5000	

16
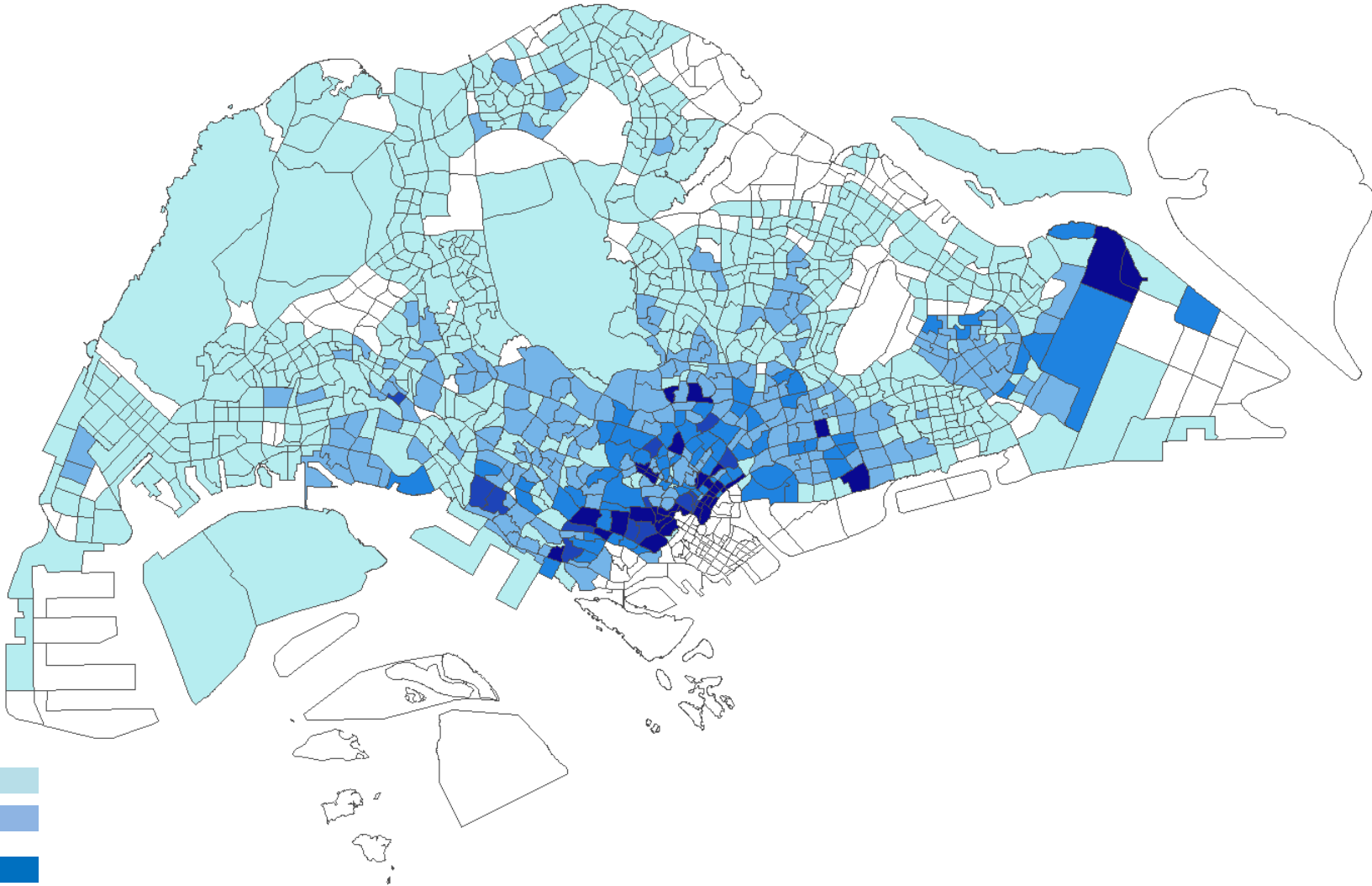
Retail jobs at zonal level
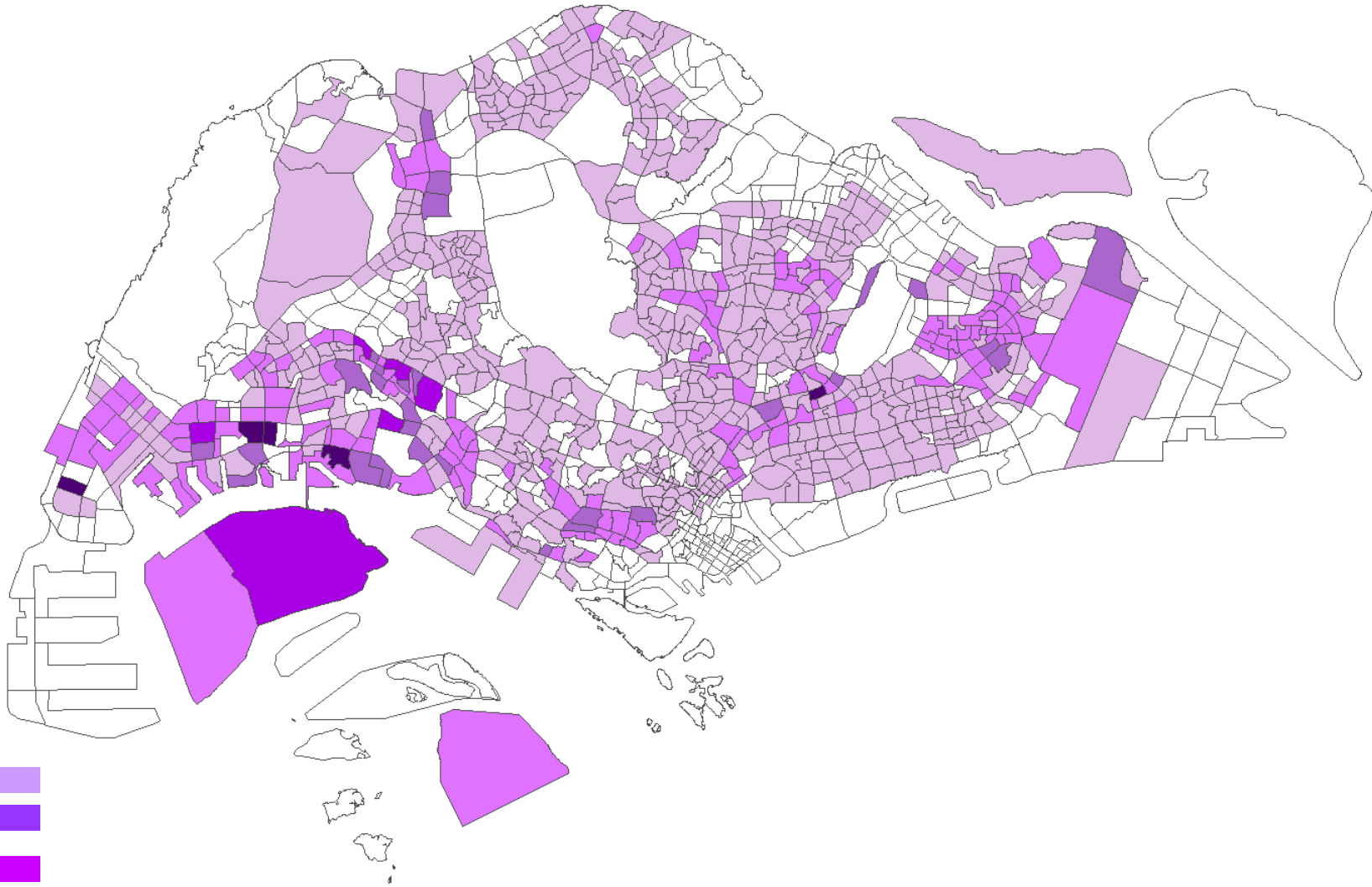
1-200
201-1000
1001-3000
3001-5000
>5000

17

Industrial jobs at zonal level

Legend:
- 1-200
- 201-1000
- 1001-3000
- 3001-5000
- >5000

18

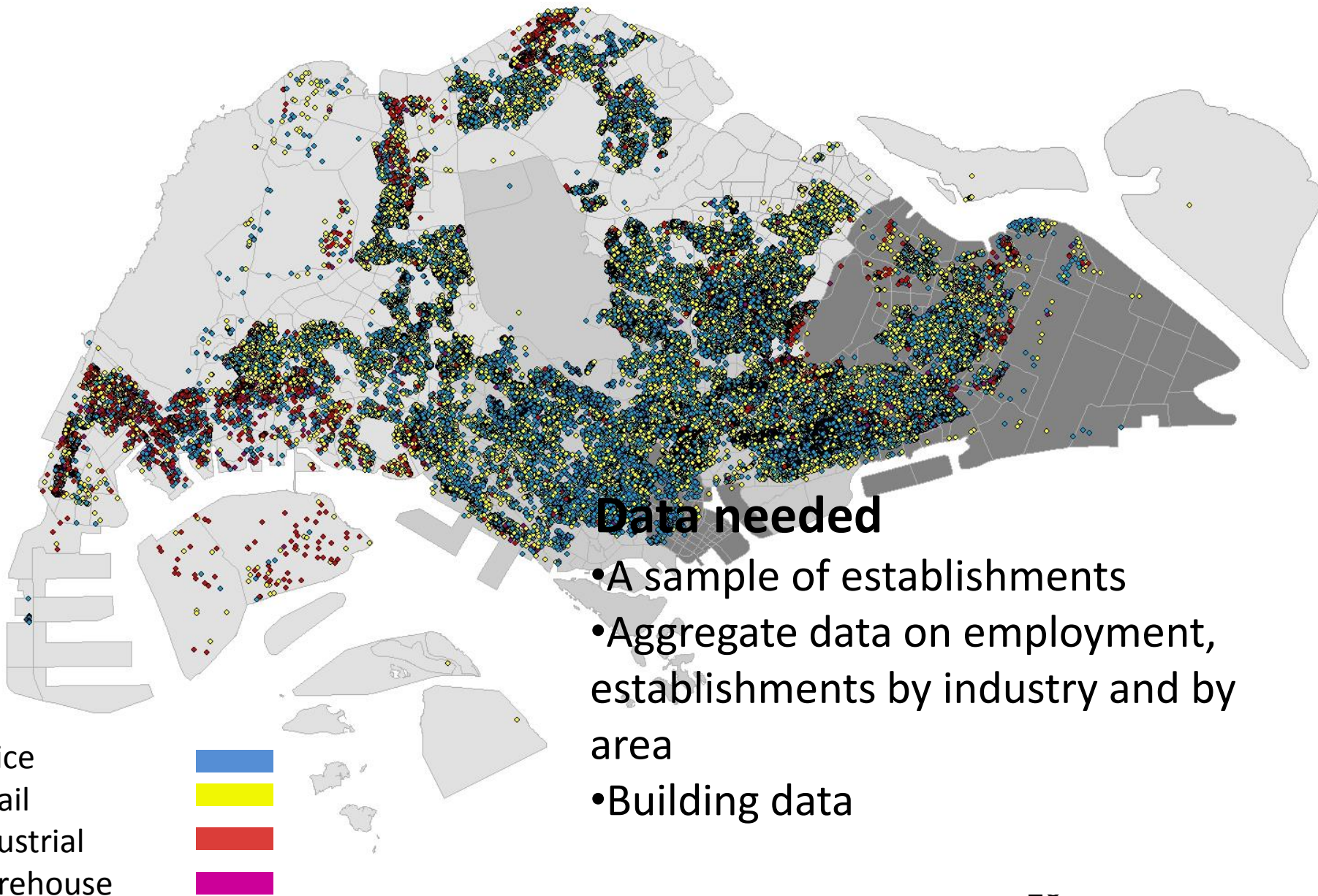Warehouse jobs at zonal level

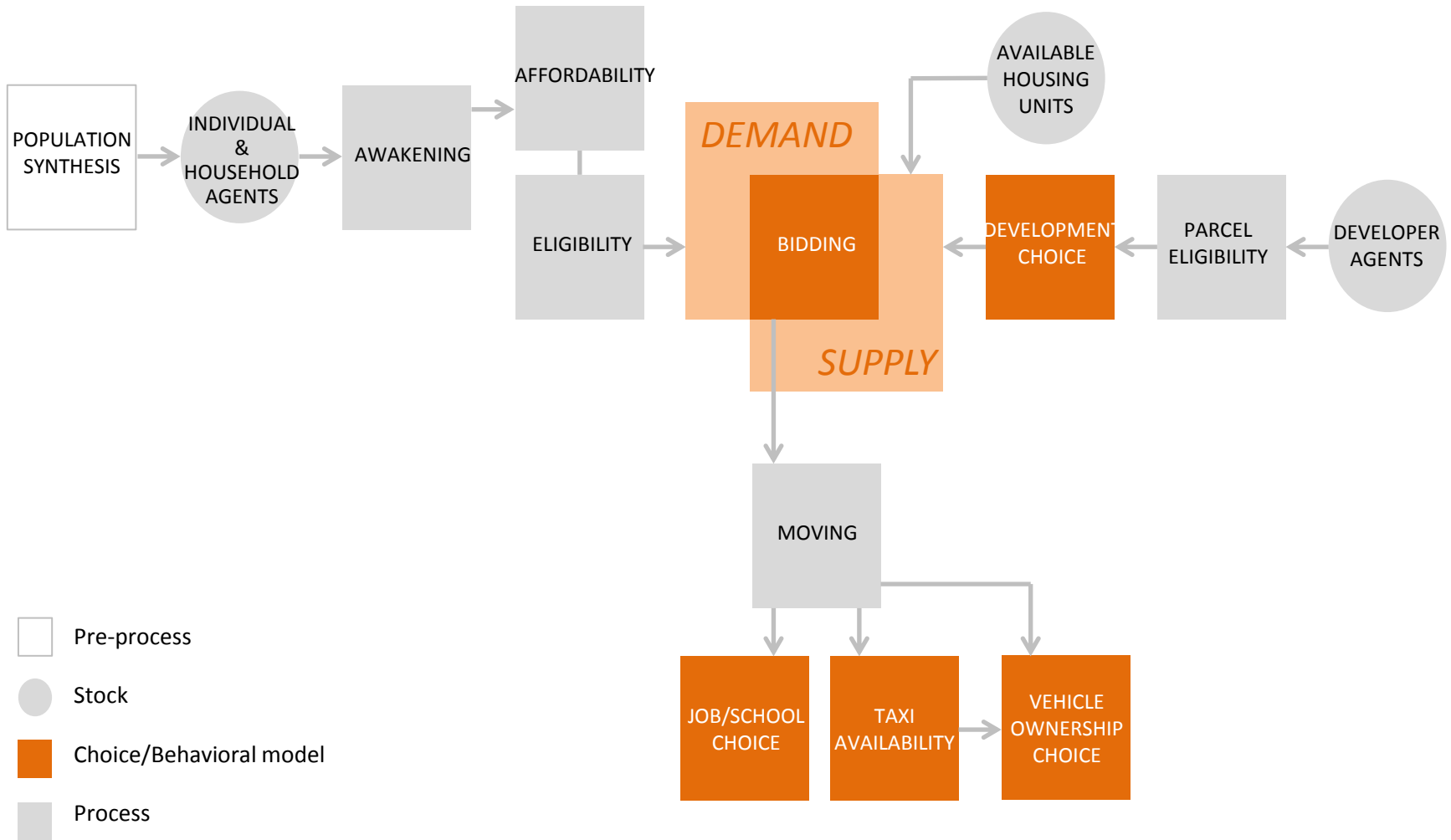1-200
201-1000
1001-3000
3001-5000
>5000

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Data needed

- A sample of establishments
- Aggregate data on employment, establishments by industry and by area
- Building data

Office

Retail

Industrial

Warehouse

Thank You & Further Information

- SMART website http://smart.mit.edu

- Future Urban Mobility Lab http://ares.lids.mit.edu/fm/

- Adnan, M. et al., 2016. SimMobility: A Multi-scale Integrated Agent-based Simulation Platform. In *Paper Presented at the 95th Annual Meeting of the Transportation Research Board Forthcoming in Transportation Research Record*.

- Ben-Akiva, M., 2010. SMART – Future Urban Mobility. *Journeys*, (November). Available at: http://www.lta.gov.sg/ltaacademy/doc/J10Nov-p30Ben-Akiva_FutureUrbanMobility.pdf.

- Cernicchiaro, G. & Ferreira, J., 2015. How to build a synthetic population for the service sector using directory websites. In *Paper presented at the 14th International Conference on Computers in Urban Planning and Urban Management*.

- Zhu, Y. & Ferreira, J., 2015. Data integration to create large-scale spatially detailed synthetic populations. In S. Geertman et al., eds. *Planning Support Systems and Smart Cities*. Heidelberg: Springer, pp. 121–141.

- Zhu, Y. & Ferreira, J., 2014. Synthetic Population Generation at Disaggregated Spatial Scales for Land Use and Transportation Microsimulation. *Transportation Research Record: Journal of the Transportation Research Board*, 2429, pp.168–177. Available at: http://dx.doi.org/10.3141/2429-18

APPENDICES

- [Number of ACRA establishments by role and type.](#)
- [Conversion factor](#)
- [Building data](#)
- [Location of ACRA establishments.](#)

LT-Housing Market Models

POPULATION SYNTHESIS

INDIVIDUAL & HOUSEHOLD AGENTS

AWAKENING

AFFORDABILITY

ELIGIBILITY

DEMAND

BIDDING

SUPPLY

AVAILABLE HOUSING UNITS

DEVELOPMENT CHOICE

PARCEL ELIGIBILITY

DEVELOPER AGENTS

MOVING

JOB/SCHOOL CHOICE

TAXI AVAILABILITY

VEHICLE OWNERSHIP CHOICE

Pre-process

Stock

Choice/Behavioral model

Process

ACRA Establishments Role/Branch/Type

Classification	2012	2015	15/12
Manufacturer	28,281	33,290	1.18
Supplier/Wholesaler	67,489	90,020	1.33
Retailer	46,665	64,914	1.39
Carrier	2,695	3,575	1.33
Other	137,778	200,302	1.45
Total by Role	**282,908**	**392,101**	1.39
Entity without branches	264,996	373,540	1.41
Entity with branches	4,801	5028	1.05
Branches	13,111	13533	1.03
Total by Branch	**282,908**	**392,101**	1.39
Business entities	84,200	124,527	1.48
Business branches	13,111	13,533	1.03
Company entities	178,436	242,496	1.36
LLP entities	7,124	11,428	1.60
LP entities	37	124	3.35
Total by Type	**282,908**	**392,108**	1.39

ACRA Data Sample

ACRA dataset of live entities in Feb. 2015 minus entities registered after 31/12/2012.	
Description	**Unique values**
Total number of establishments	*282,907*
Unique Entity Number	269,796
SSIC1	858
Full address	142,642
Postcode	37,566

ACRA Sample	
Description	**Unique values**
Total number of establishments	*142,642*
Unique Entity Number	134,894
SSIC1	826
Postcode	37,566

*SSIC: Singapore Standard Industrial Classification

Conversion Factor

Floor Type	Average
Office	9.282070
Retail	4.013971
Industrial	58.57063
Warehouse	33.01842

Industry Type and Floor Type

SSIC	Section	Floor type
C	Manufacturing	Industrial
H	Transportation and Storage	Warehouse
J	Information and Communications	Office
K	Financial and Insurance Activities	
L	Real Estate Activities	
M	Professional, Scientific and Technical Activities	
N	Administrative and Support Service Activities	
G	Wholesale and Retail Trade	Retail
I2	Food Service Activities	
P	Education	
Q	Health and Social Services	
R	Arts, Entertainment and Recreation	
S	Other Service Activities	

Regression Models

- Two regression models:
  - Floor type "office" and "retail":
    - Commercial property transactions 1995-Oct 2015
    - 16383 observations
  - Floor type "industrial" and "warehouse"
    - Factory/warehouse property transactions 1995-Oct 2015
    - 23289 observations
- Predictors:
  - Location
  - Building type
  - Floor level
  - Floor type

Building Data

- Building dataset by Yi:
  - Number of buildings: 109,709.
  - Info: location, building type, est. total space, est. floor area for different floor types *(*not for all buildings)*.
- What was added:
  - Occupied floor area for each floor type.
  - Number of jobs for each industry type (15 types).
  - Number of establishment for each industry type.
  - No. of buildings that were assigned with jobs: 45,814.

Establishment Population Synthesis

- List of buildings
  - Building ID
  - Location (planning area, postcode)
  - Number of jobs for each industry

- List of establishments
  - Establishment ID
  - Location (planning area, postcode)
  - Size (floor area occupied and number of jobs)
  - Floor type
  - Industry type (SSIC section)

- List of jobs
  - Job ID
  - Establishment ID
  - Industry type
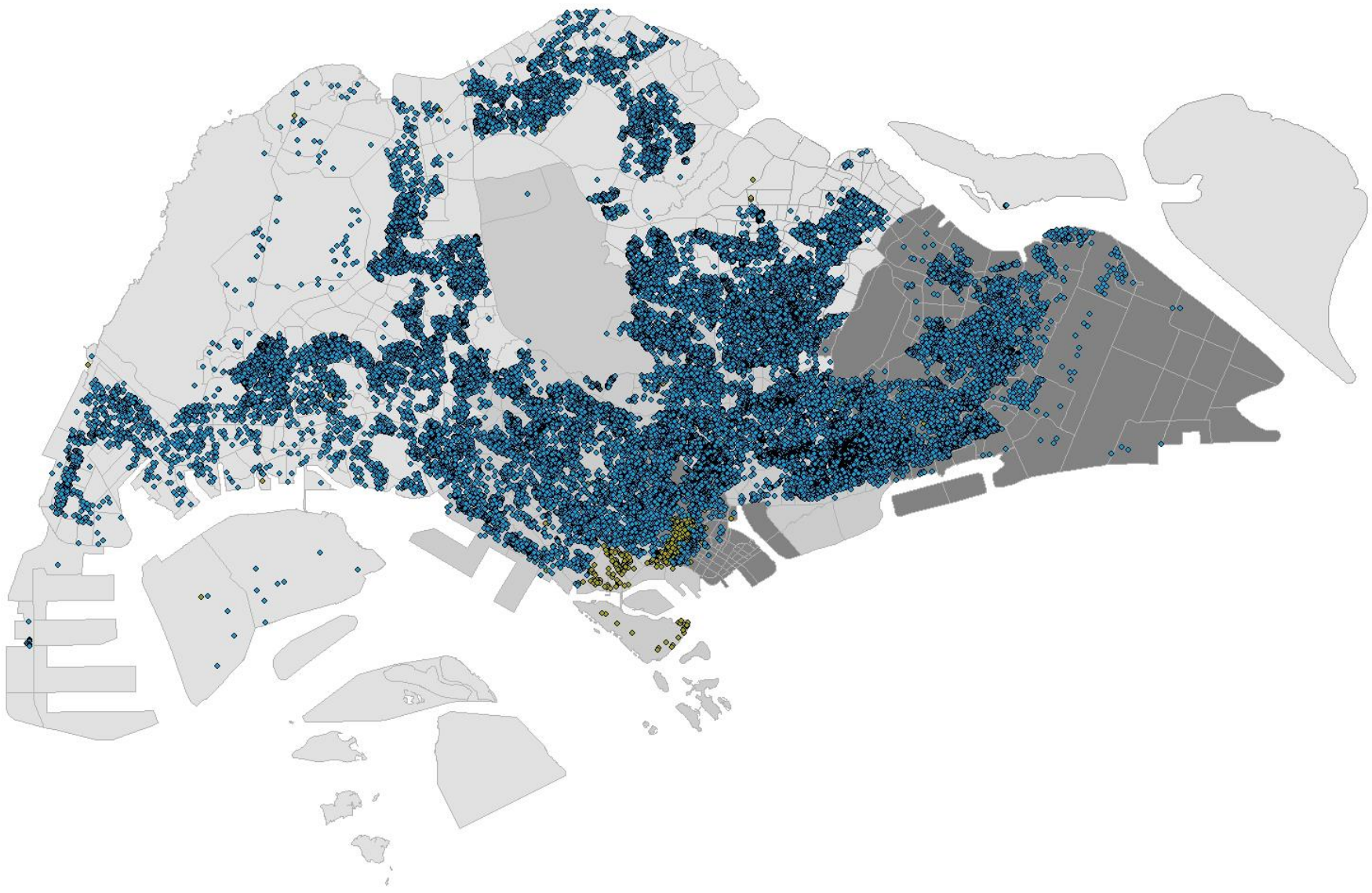 - Location (planning area, postcode)
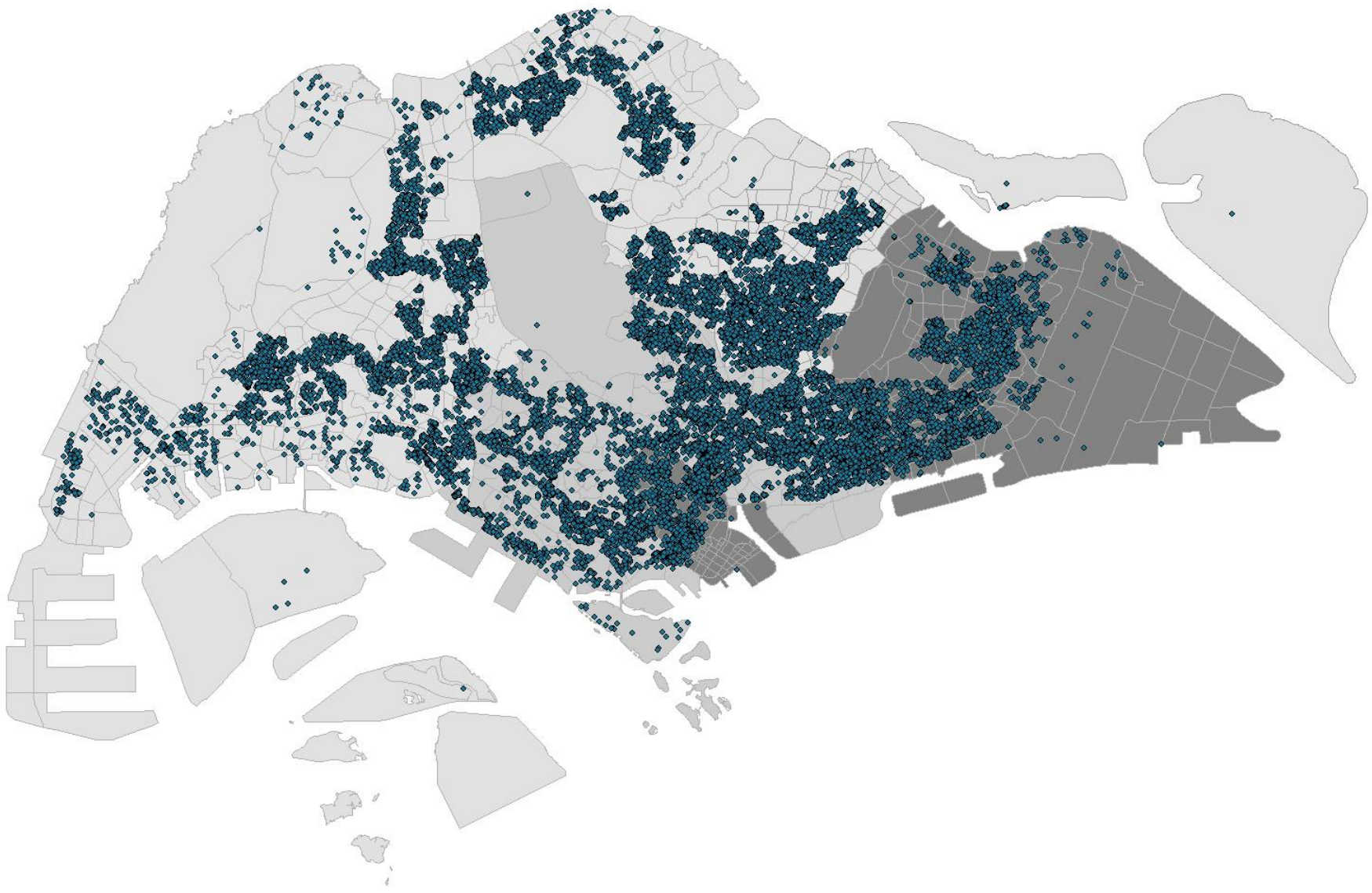
SYN POP VS. ACRA

Locations of ACRA estab. with office floor type

Locations of syn. pop. estab. with office floor type
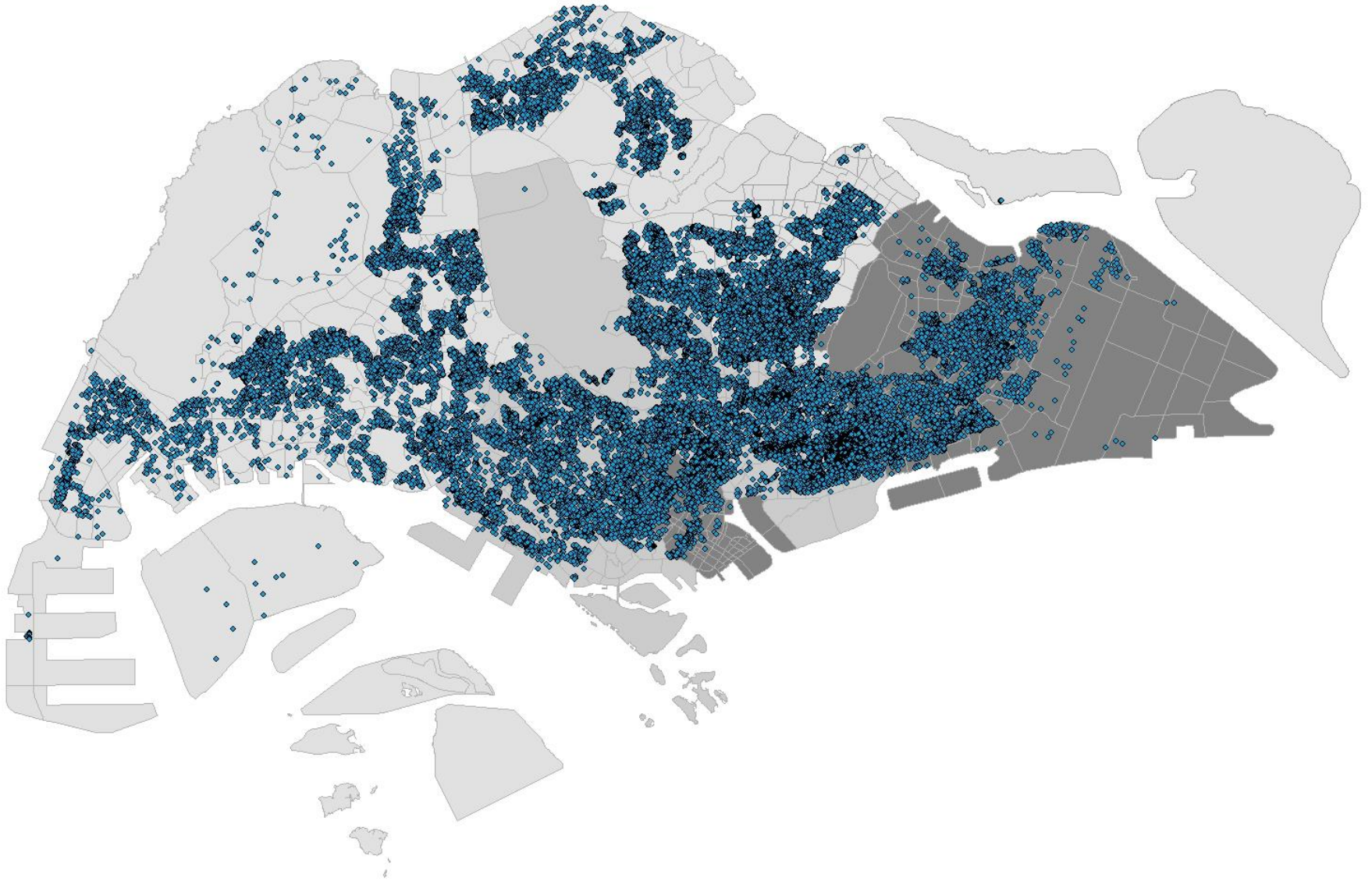
Locations of ACRA vs. syn. pop. estab. with office floor type

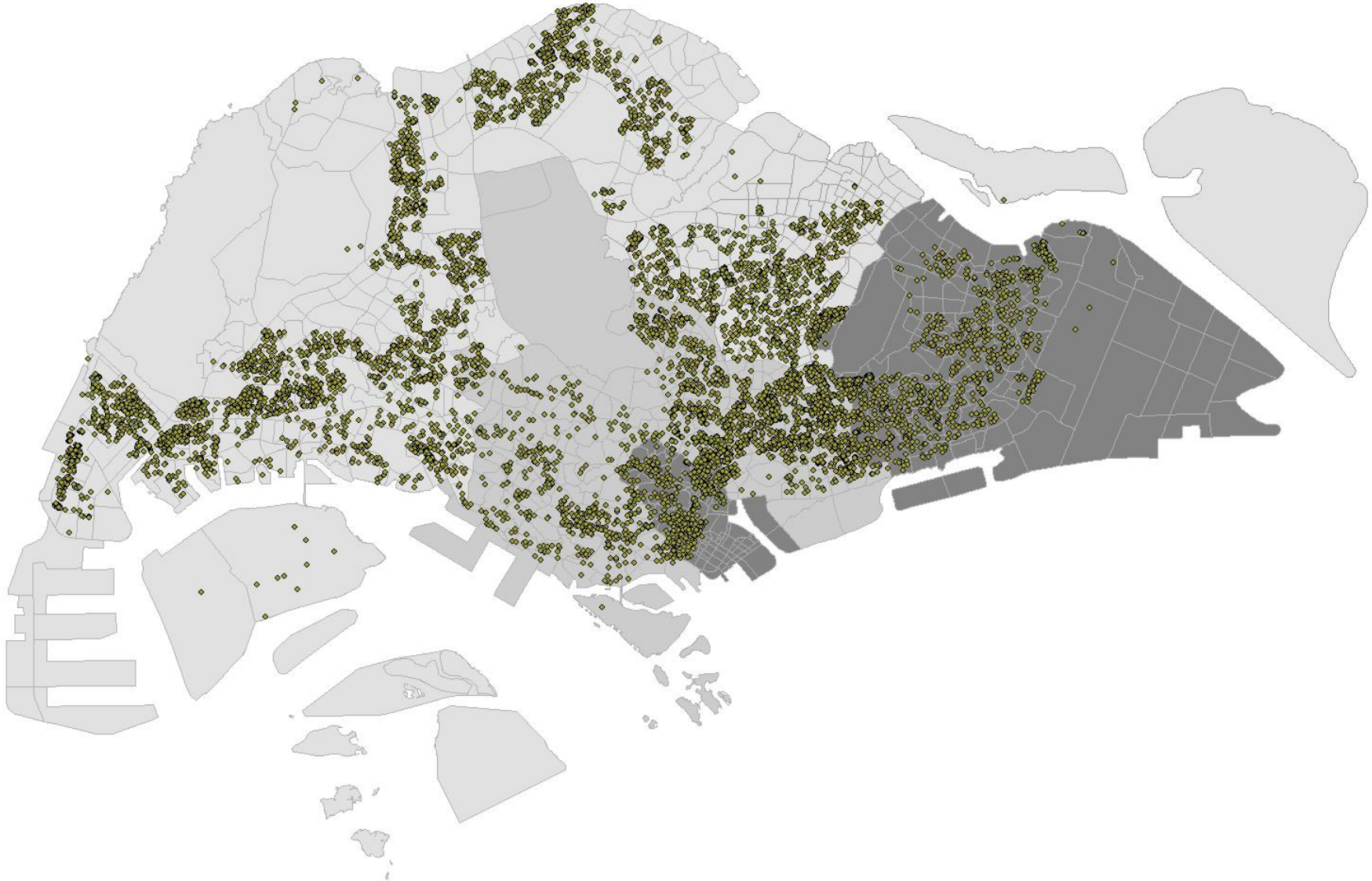# Locations of ACRA estab. with retail floor type

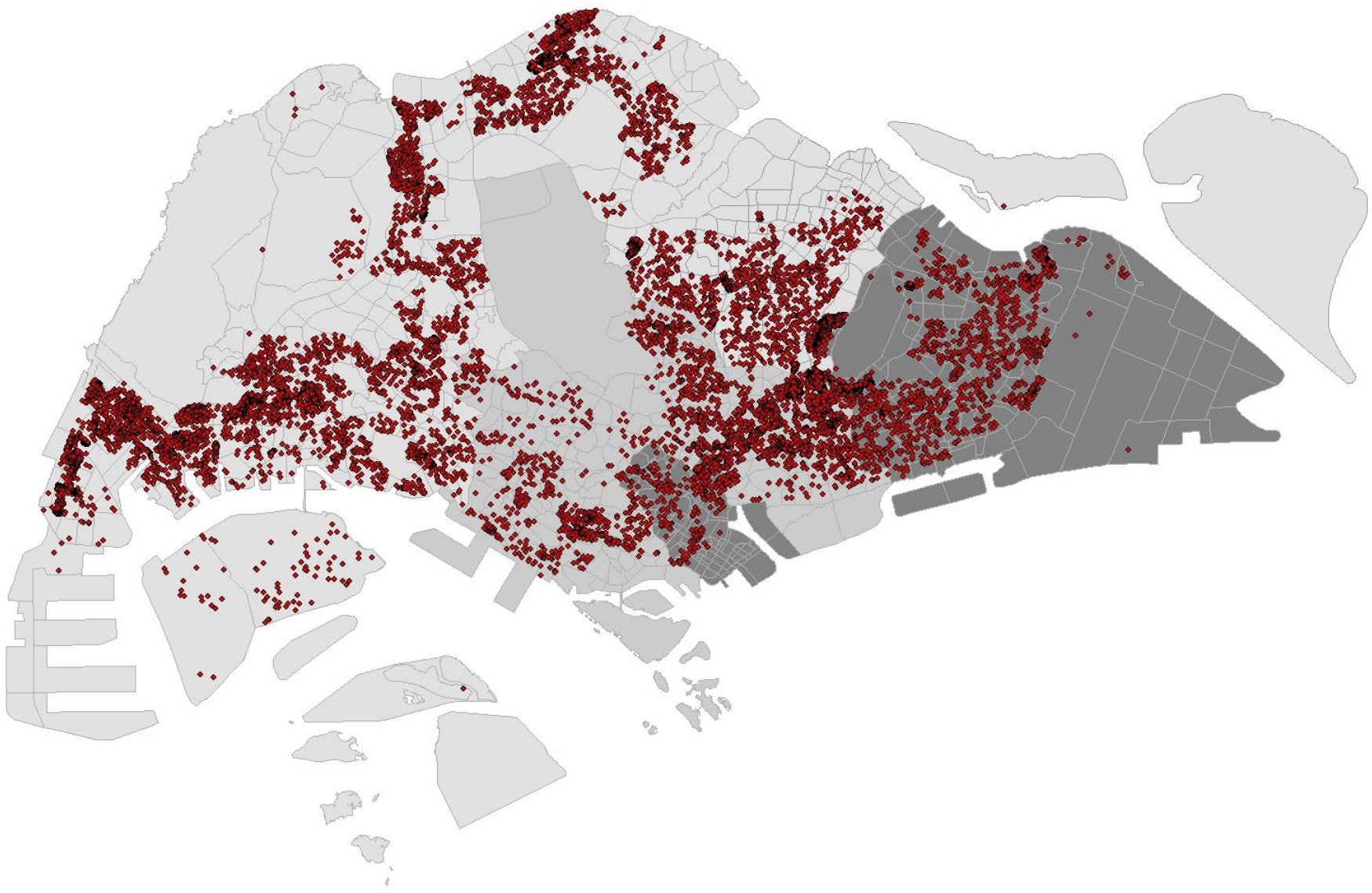# Locations of syn. pop. estab. with retail floor type

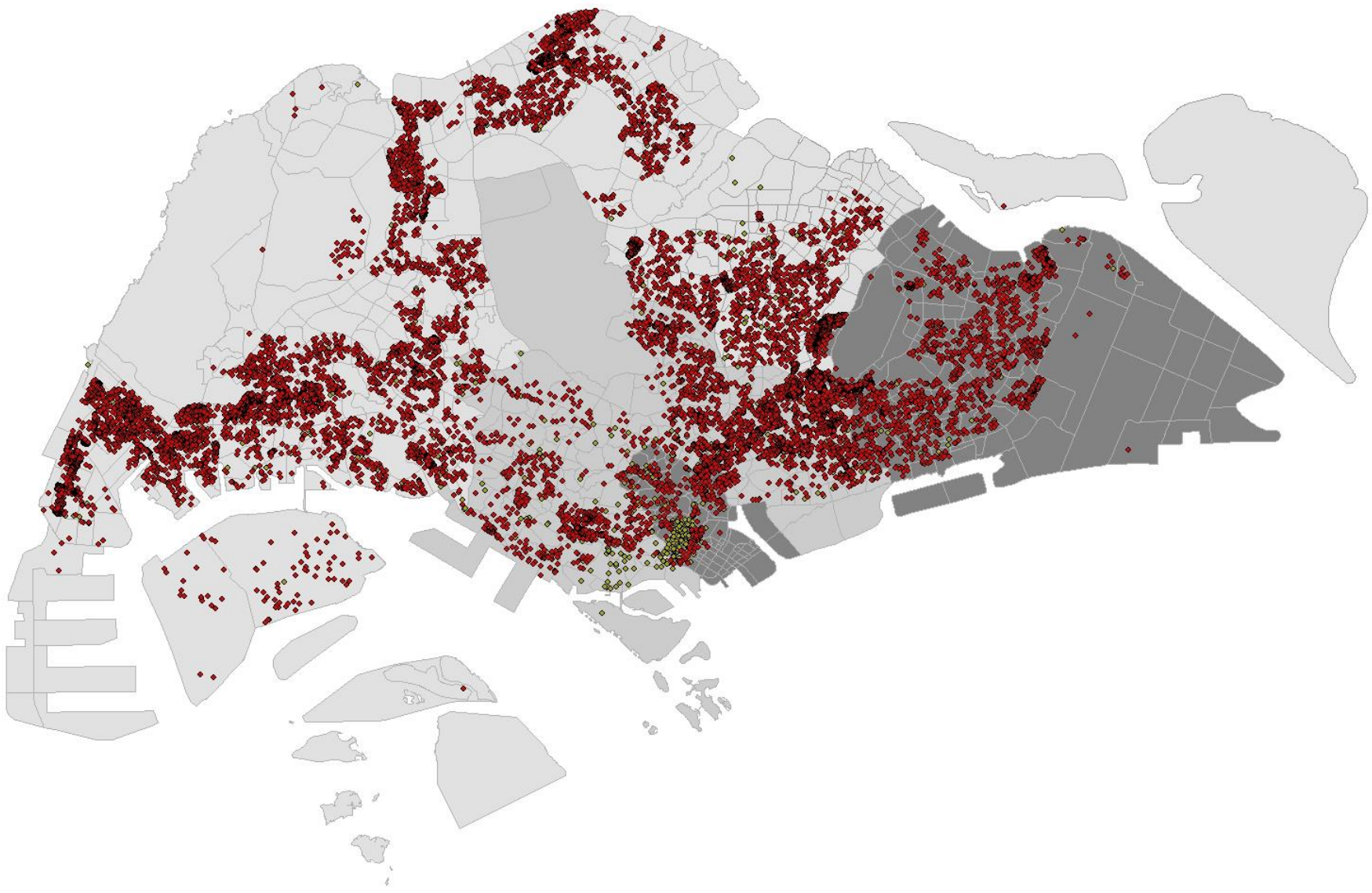# Locations of ACRA vs. syn. pop. estab. with retail floor type

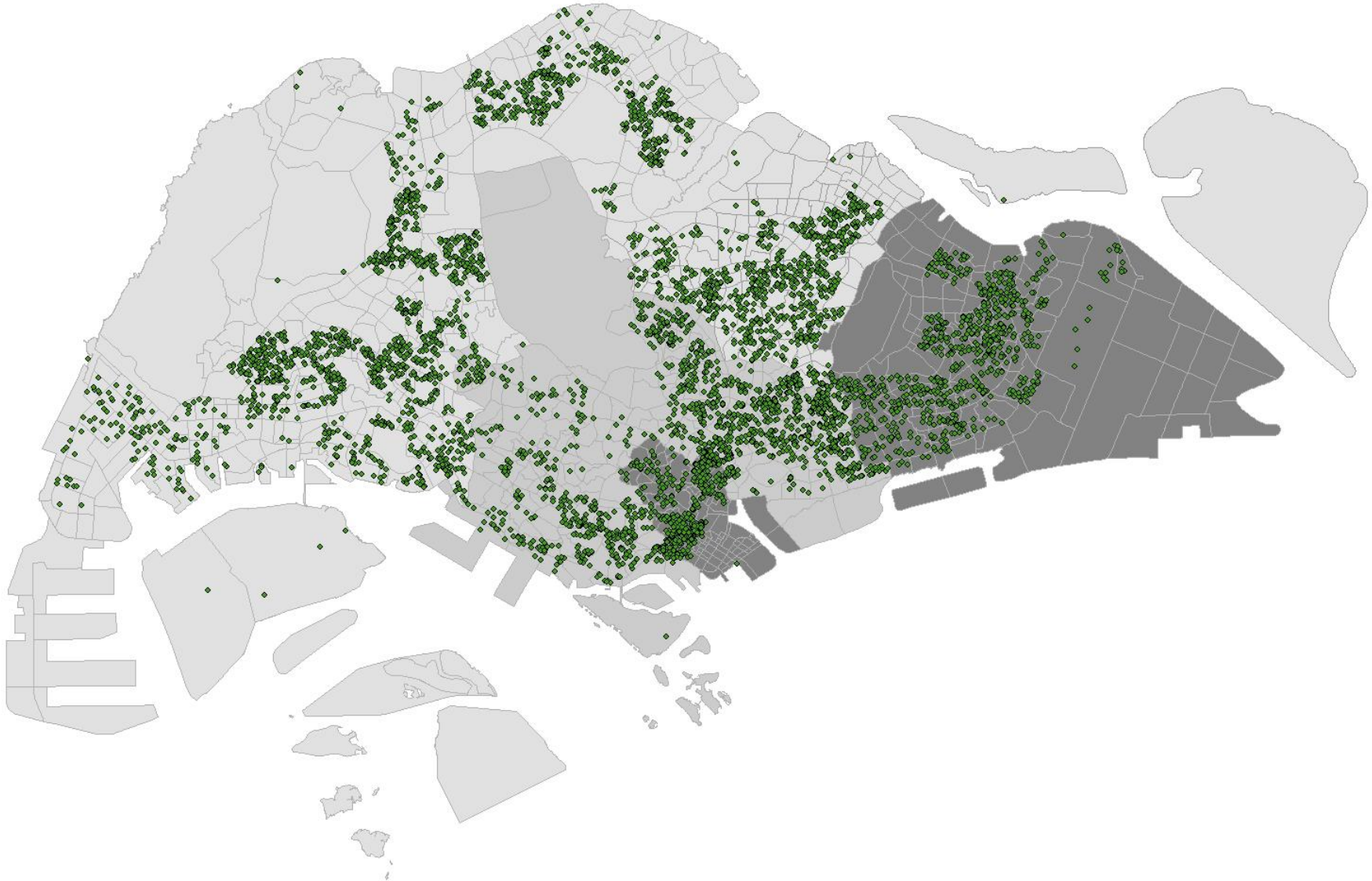# Locations of ACRA estab. with industrial floor type

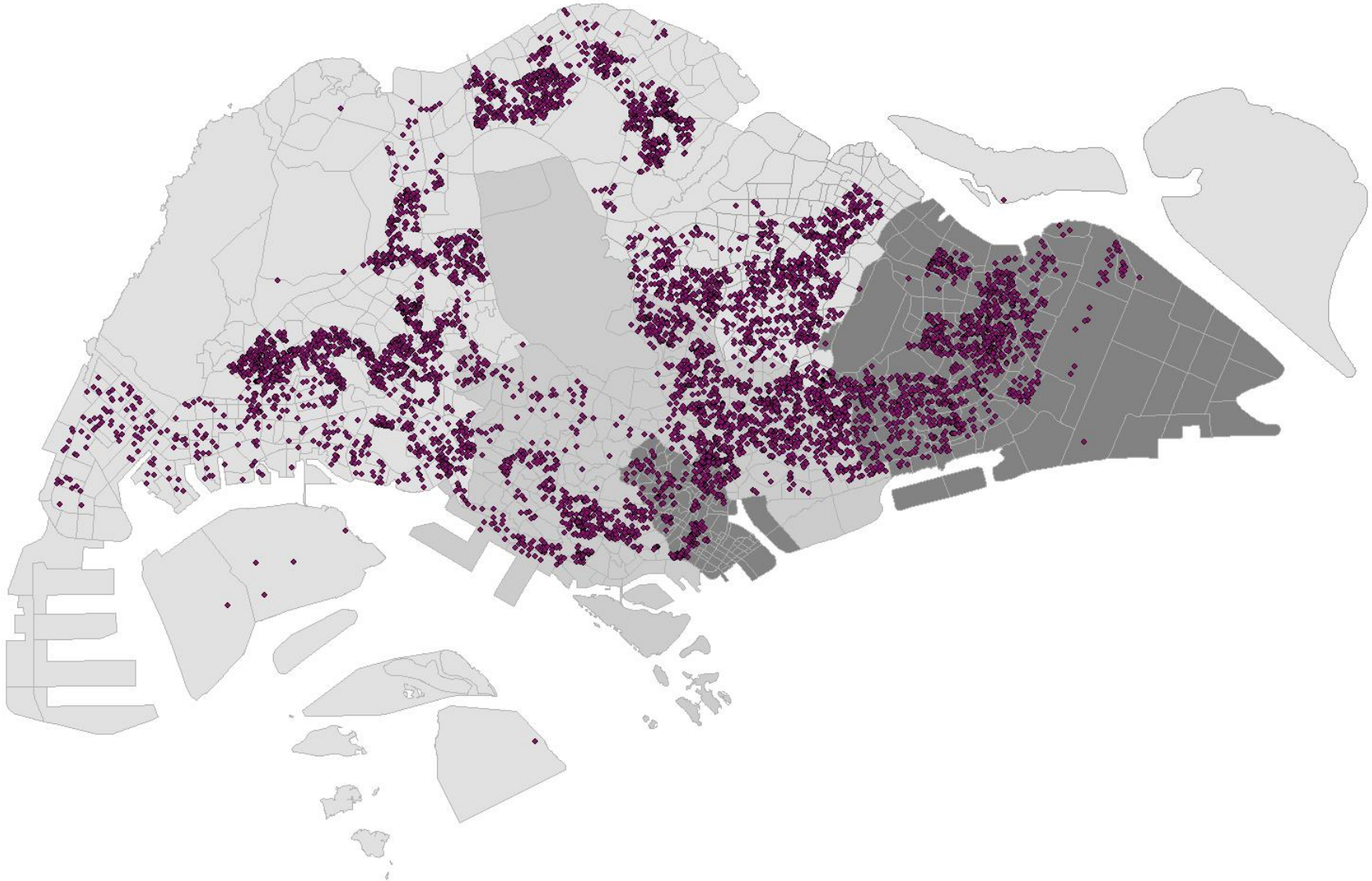# Locations of syn. pop. estab. with industrial floor type

Locations of ACRA vs. syn. pop. estab. with industrial floor type

Locations of ACRA estab. with warehouse floor type

Locations of syn. pop. firms with warehouse floor type

Locations of ACRA vs. syn. pop. estab. with warehouse floor type