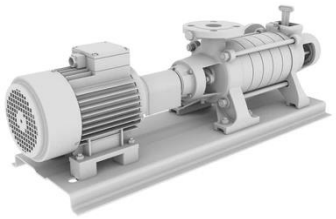
Sustainable City Development in the Era of Climate Change

Andres Sevtsuk
Associate Professor of Planning
Head, City Design and Development Program
Director, City Form Lab
Department of Urban Studies and Planning, MIT

What is technology?

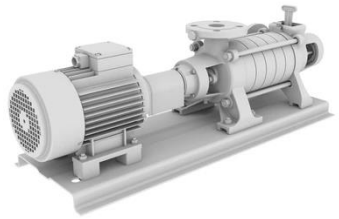
Implements



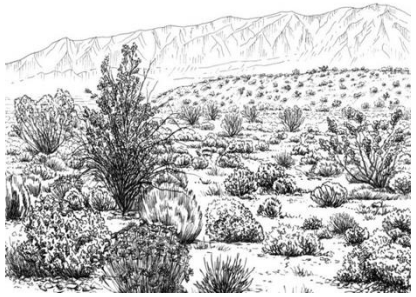
Ref: Philip Wagner, The Human Use of the Earth (New York: Free Press, 1964).

What is technology?

Implements



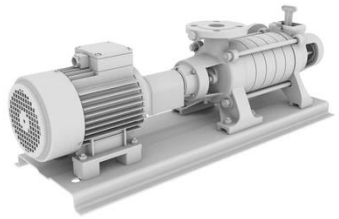
Facilities



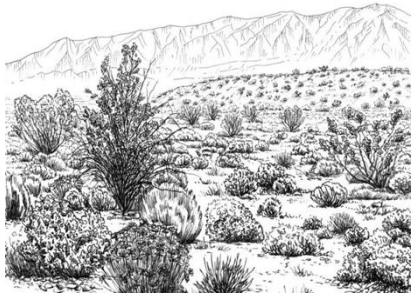
Ref: Philip Wagner, The Human Use of the Earth (New York: Free Press, 1964).

What is technology?

Implements



Facilities



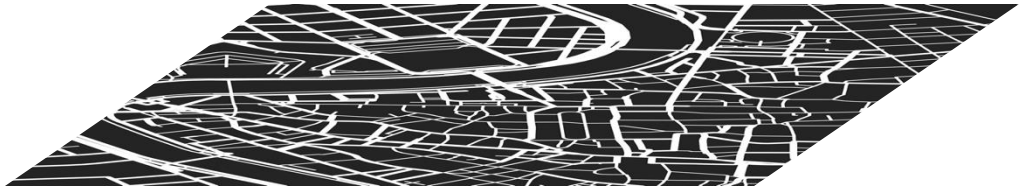
Infrastructure & Standards

Arthur, B. W. (2009). *The Nature of Technology: What It Is and How It Evolves*. Free Press.

Built Environment as Technology

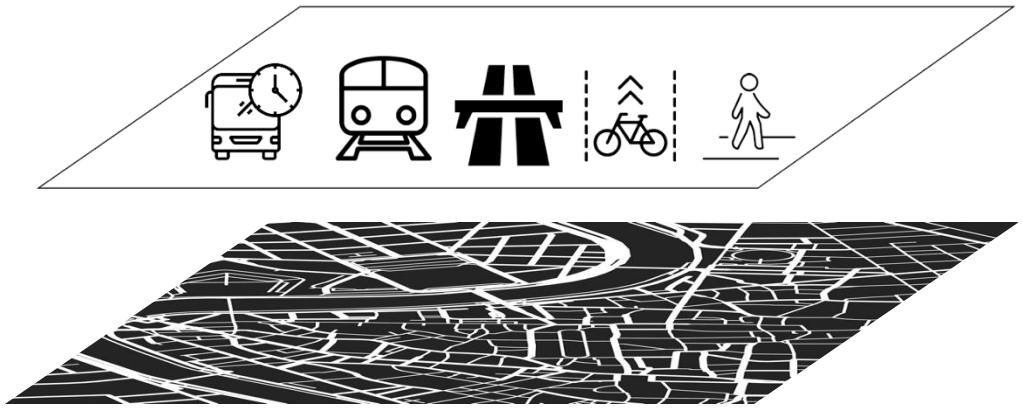
facilities and standards

Conceptual framework



Urban form

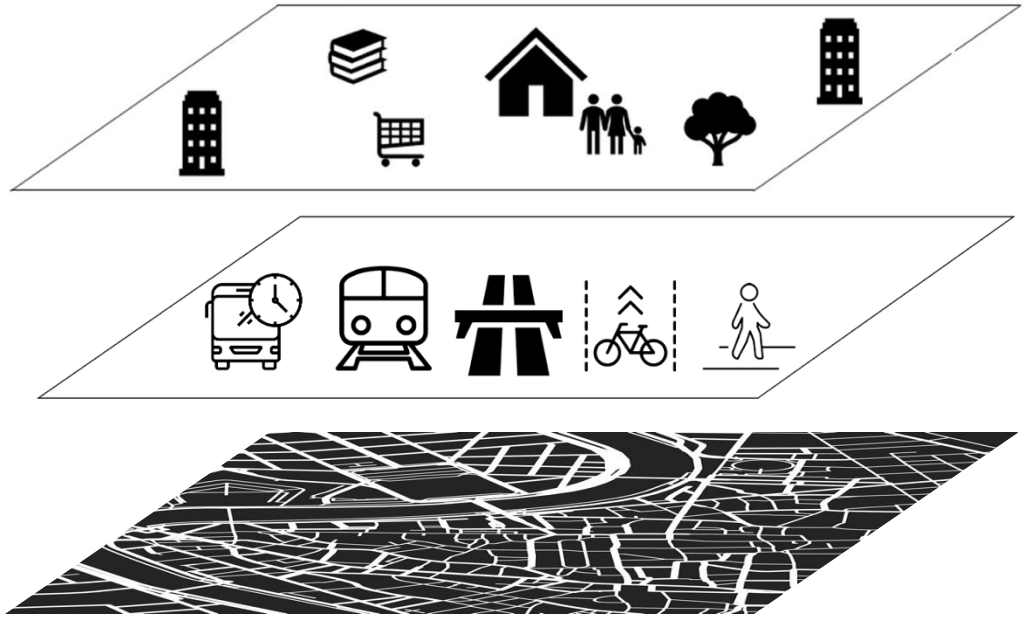
Conceptual framework



Infrastructure systems

Urban
form

Conceptual framework



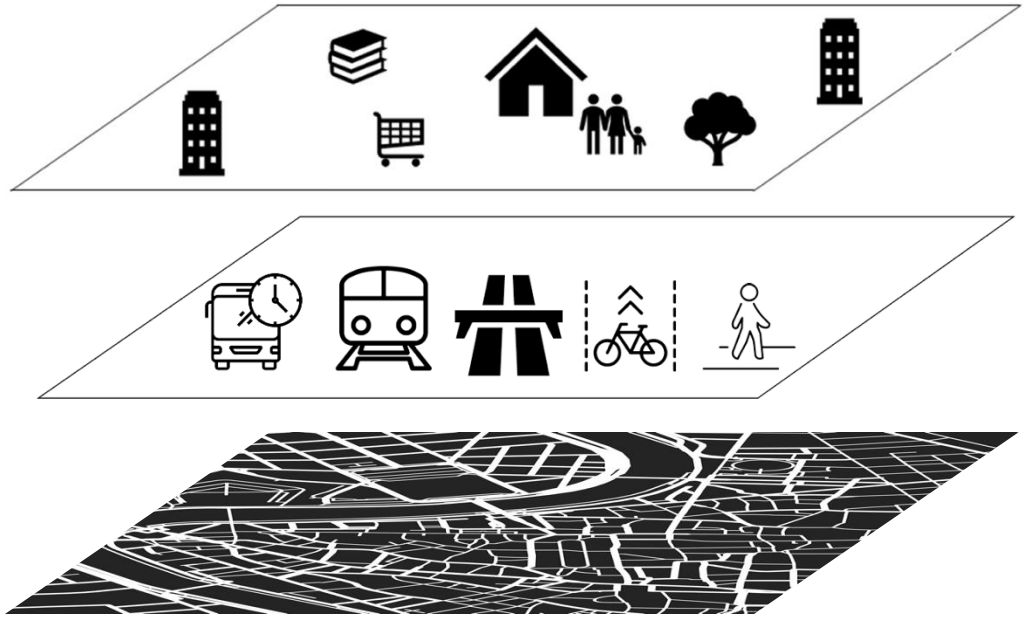
Land use patterns

Infrastructure systems

Urban form

Conceptual framework

City design



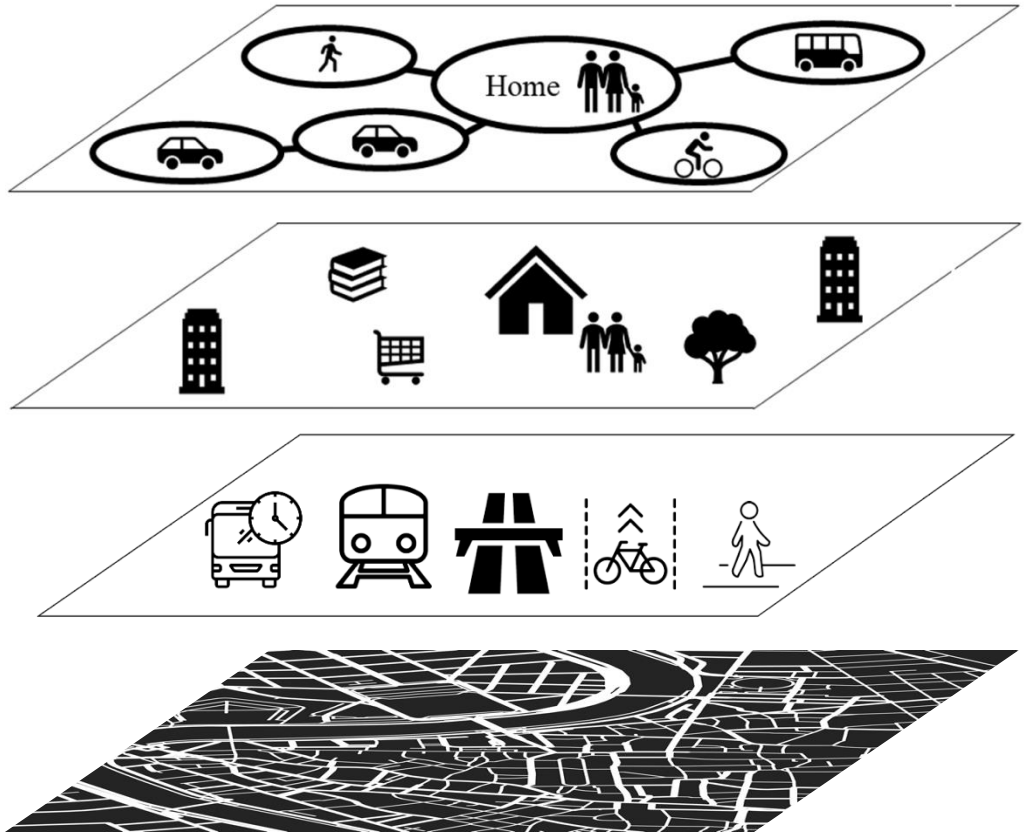
Land use patterns

Infrastructure systems

Urban form

Conceptual framework

City design



Travel behavior and activity location choices

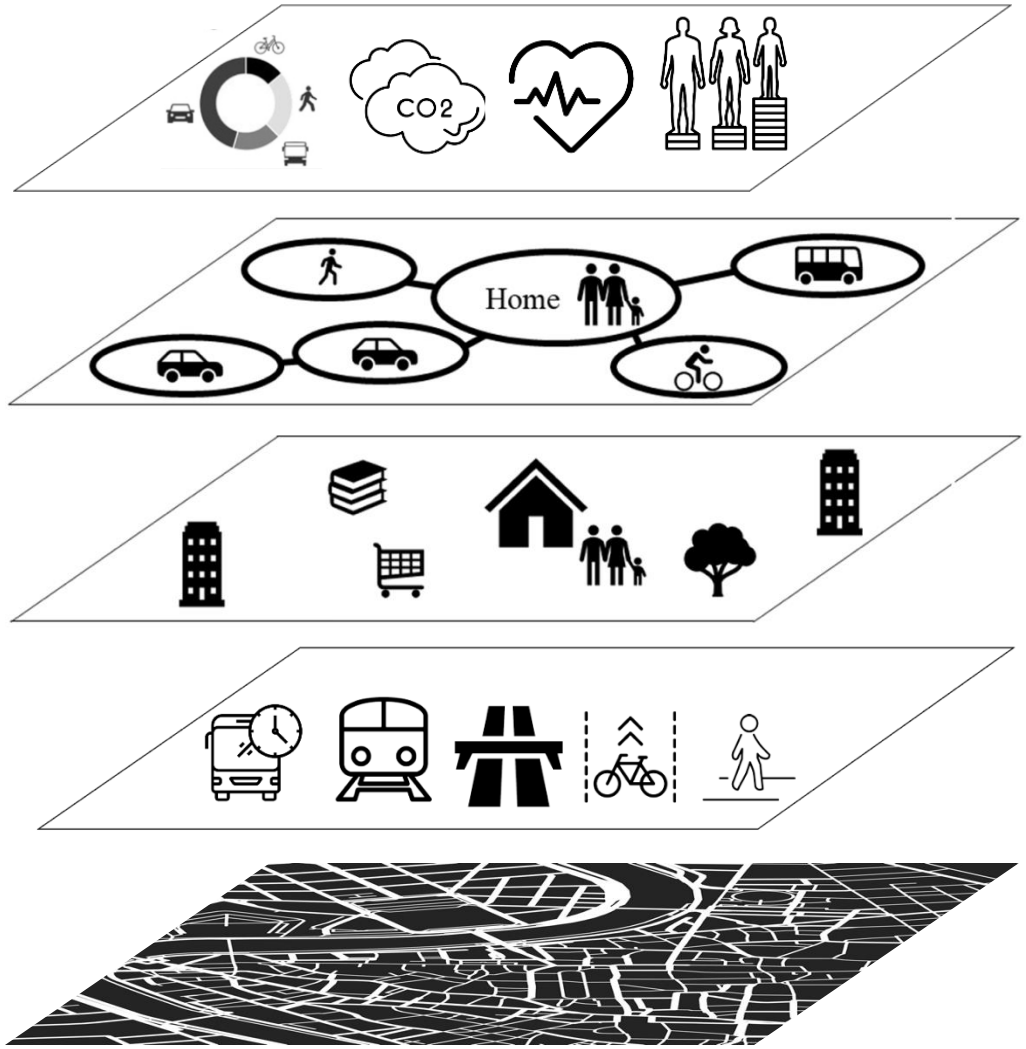
Land use patterns

Infrastructure systems

Urban form

Conceptual framework

Mobility mode share | CO2 emissions | Public health | Social equity



Outcomes of interest

Travel behavior and activity location choices

Land use patterns

Infrastructure systems

Urban form

City design

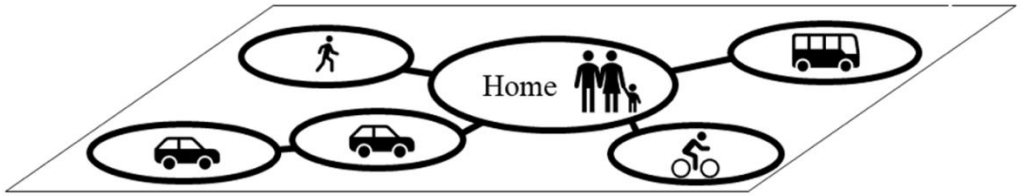
Conceptual framework

Economic development | Birth rate | Happiness

Mobility mode share | CO2 emissions | Public health | Social equity

Other outcomes of interest

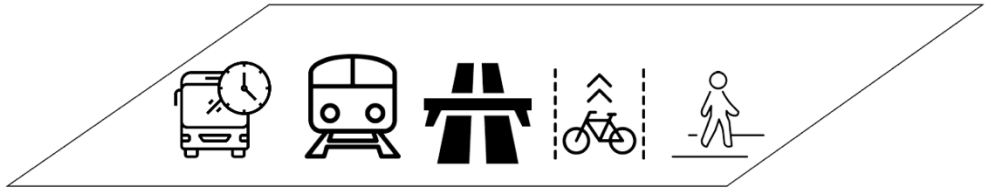
Outcomes of interest



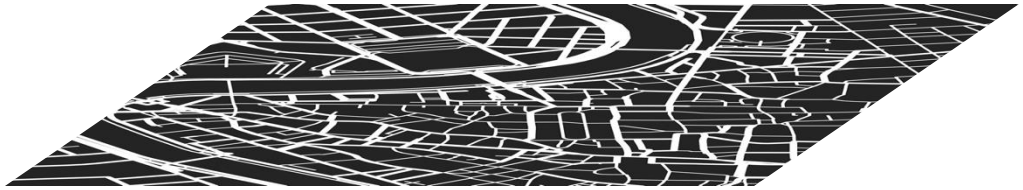
Travel behavior and activity location choices

City design

Land use patterns

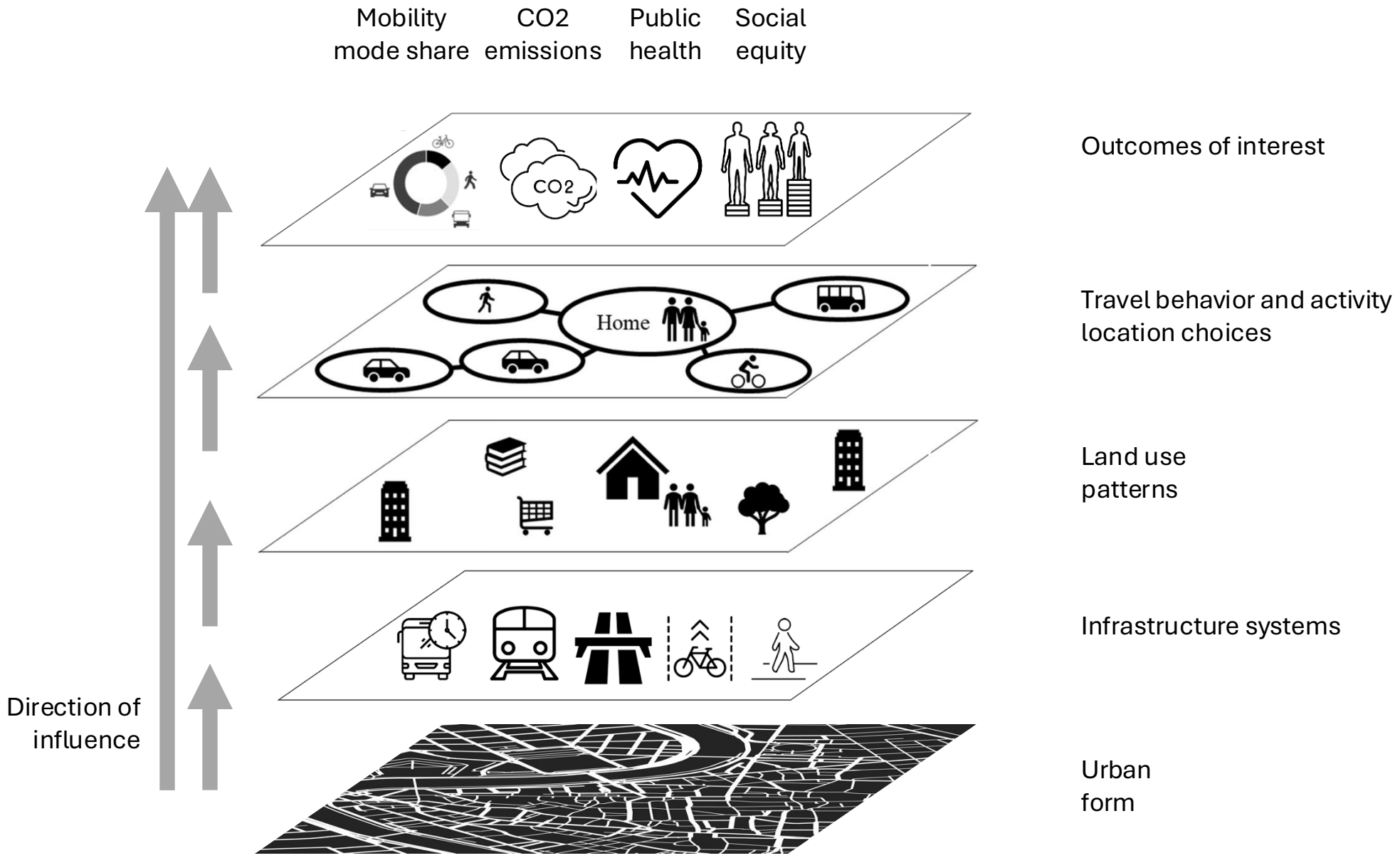


Infrastructure systems

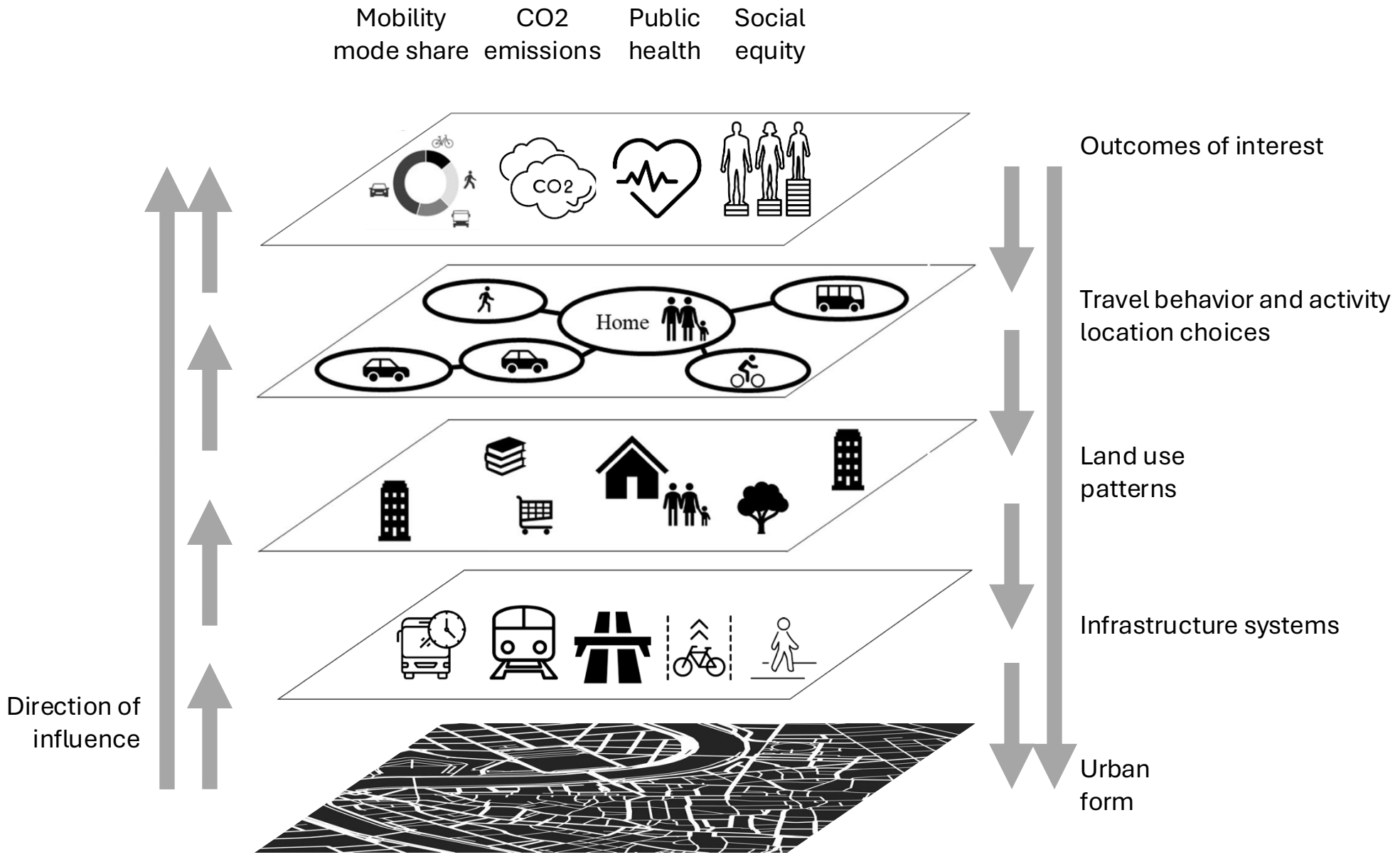


Urban form

Conceptual framework



Conceptual framework

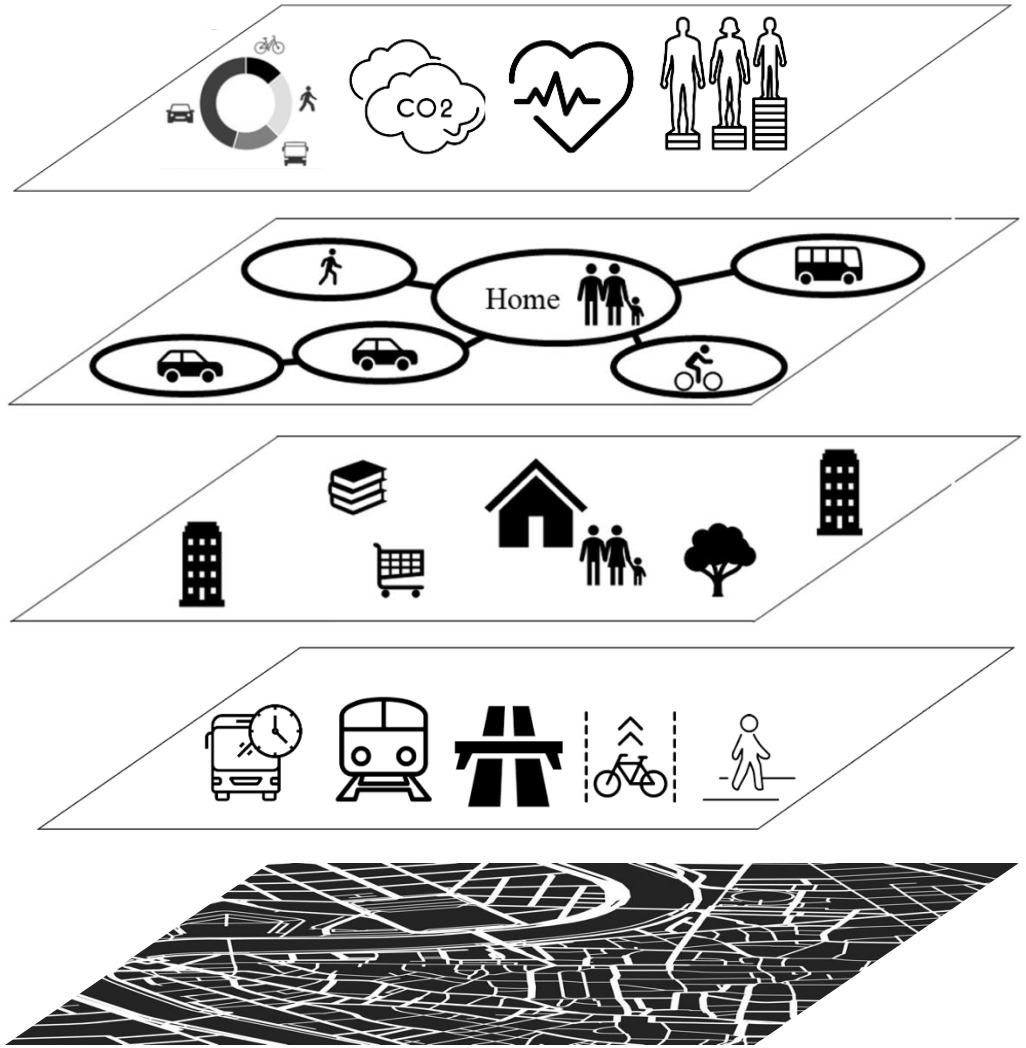


Conceptual framework

Outcomes also influenced by other factors:

Policies -
Climate -
Culture -
History -
Political economy -

Mobility mode share | CO2 emissions | Public health | Social equity



Outcomes of interest

Travel behavior and activity location choices

Land use patterns

Infrastructure systems

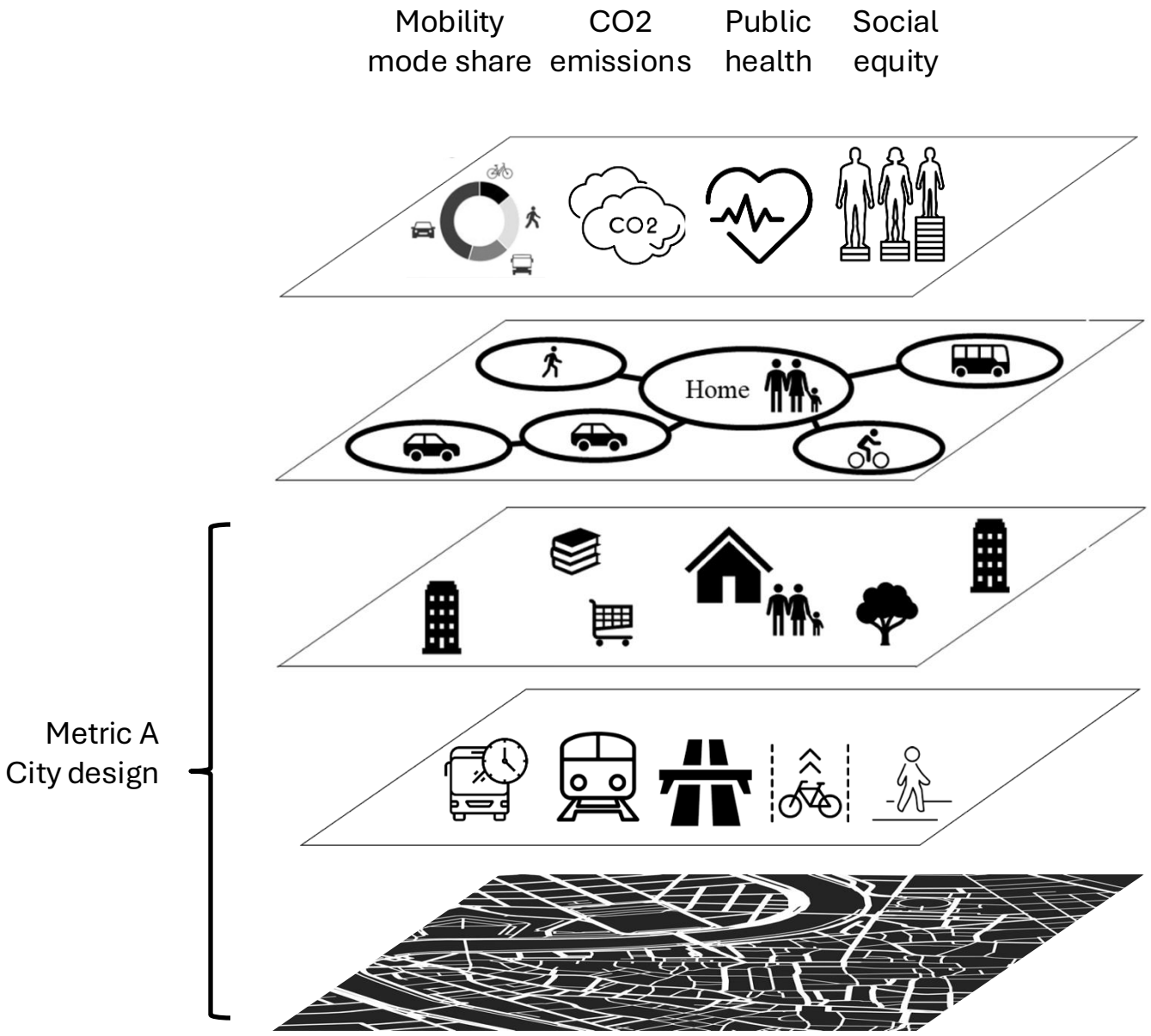
Urban form

Direction of influence

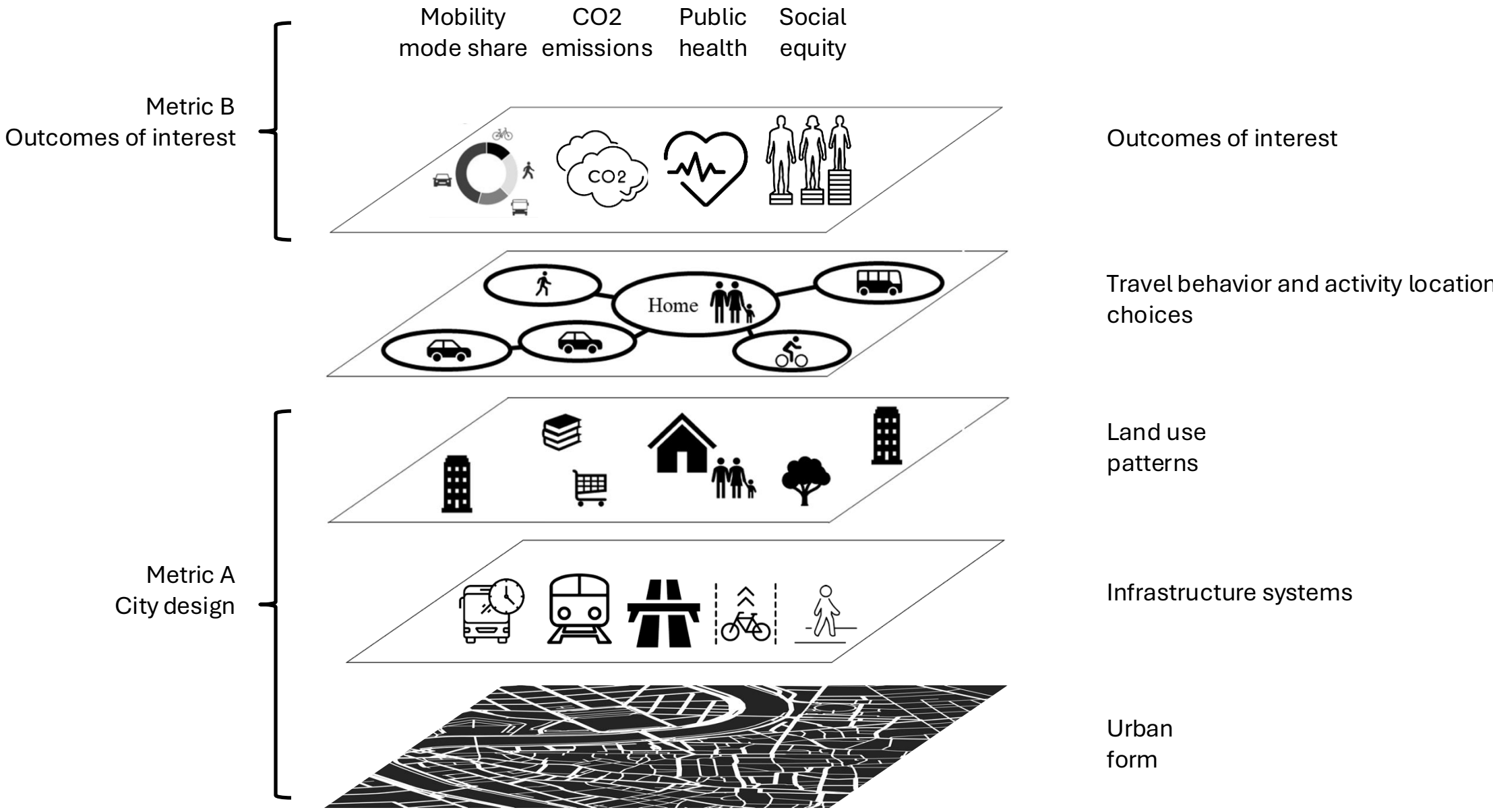
“Cities happen to be problems in **organized complexity**, like the life sciences …The variables are many, but they are not helter-skelter; they are interrelated into an organic whole.”

Jane Jacobs
Death and Life of Great American Cities, 1961

Conceptual framework



Conceptual framework

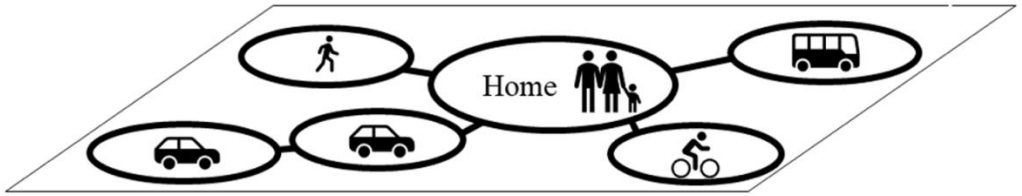


Conceptual framework

Mobility mode share | CO2 emissions | Public health | Social equity

Metric B
Outcomes of interest

Outcomes of interest

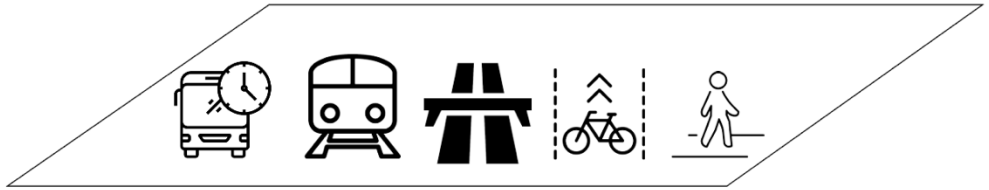


Travel behavior and activity location choices

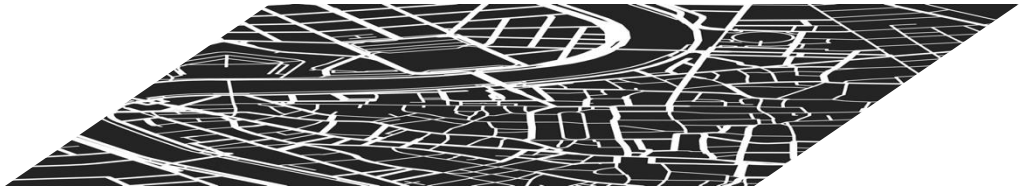
Units of Analysis
Address point
Neighborhood
City
Metropolitan Area

Land use patterns

Metric A
City design

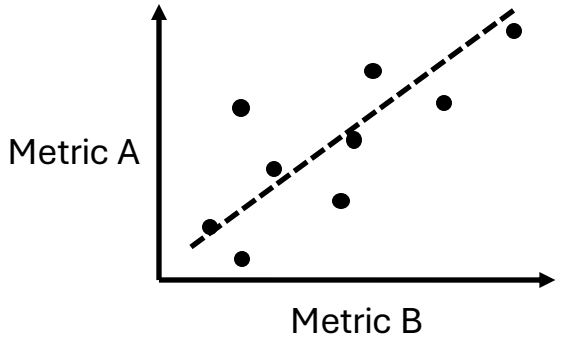


Infrastructure systems



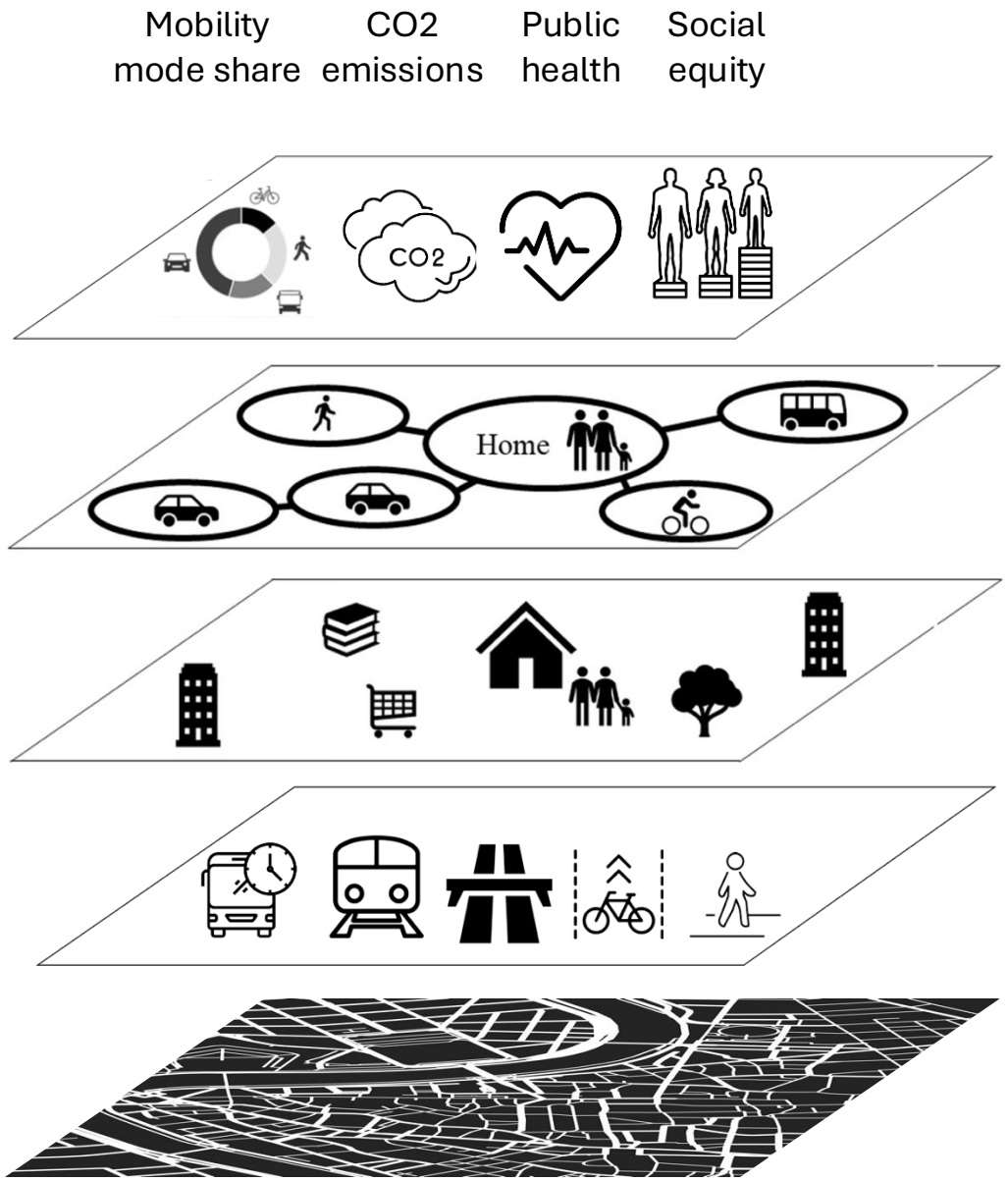
Urban form

Conceptual framework



Metric B
Outcomes of interest

Metric A
City design



Outcomes of interest

Travel behavior and activity location choices

Land use patterns

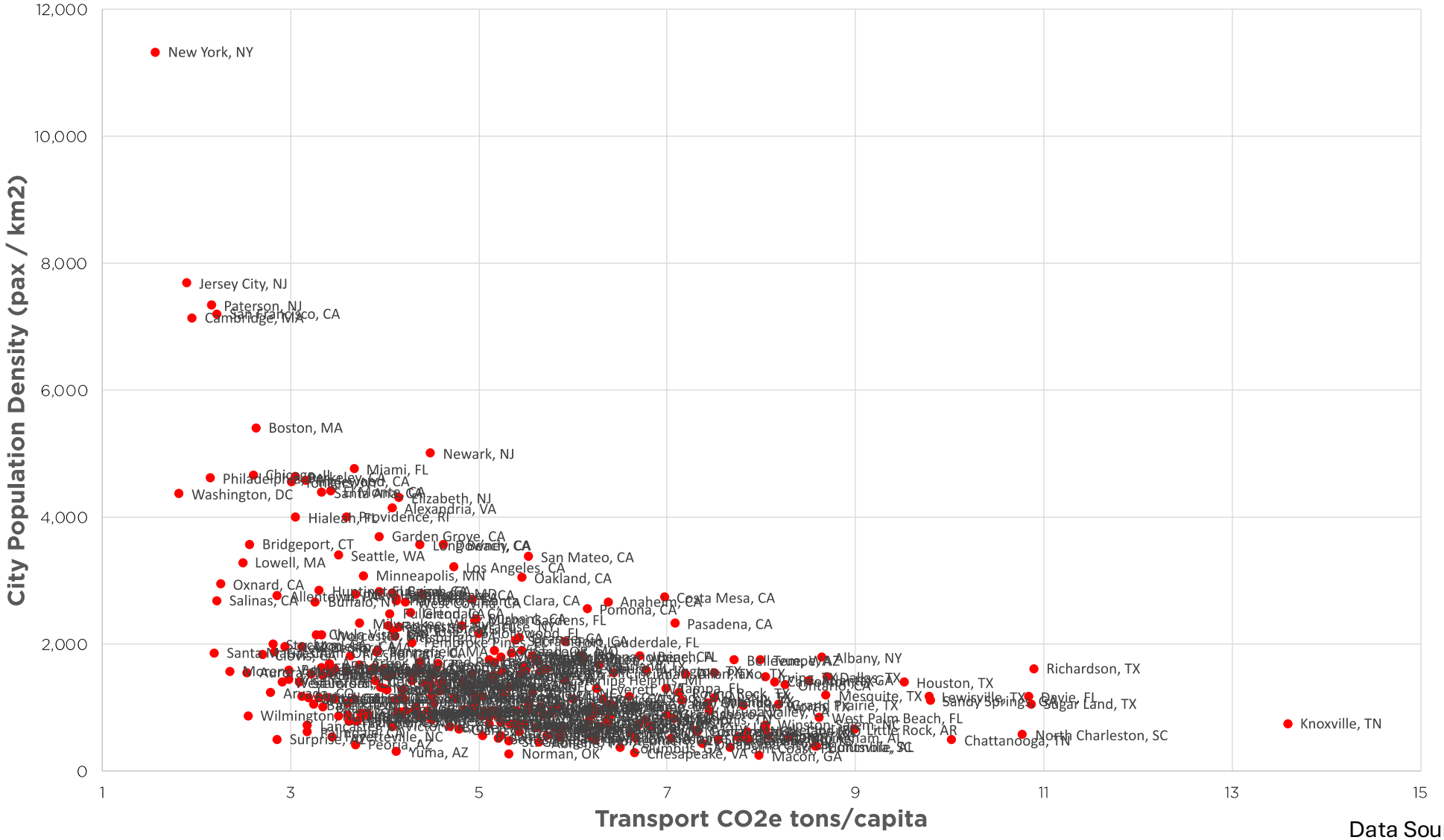
Infrastructure systems

Urban form

Effects of city design on carbon emissions and energy demand

Urban density and transport-related CO2 emissions per capita

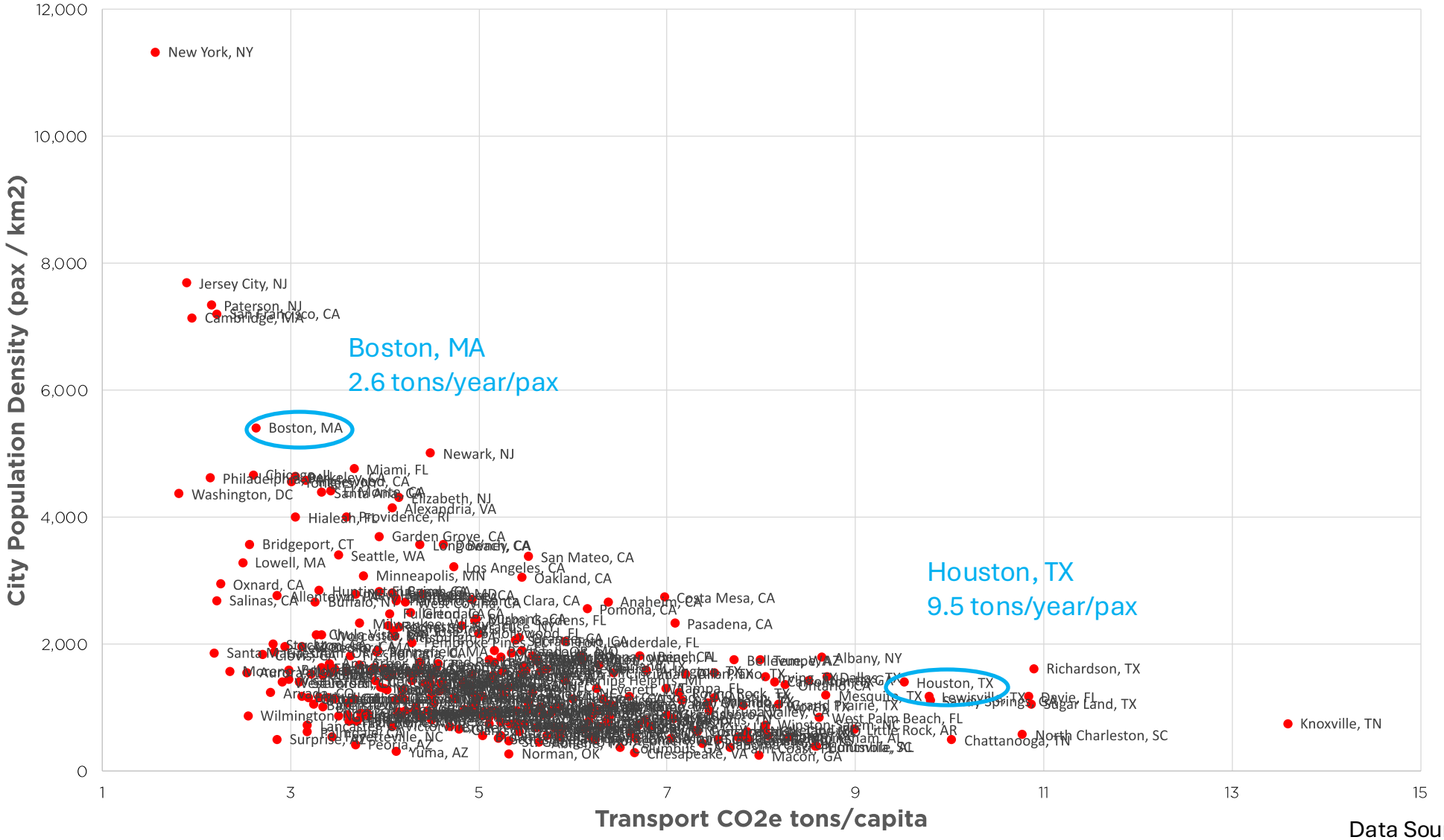
US cities > 100k pop.



Data Source: The Vulcan Project

Urban density and transport-related CO2 emissions per capita

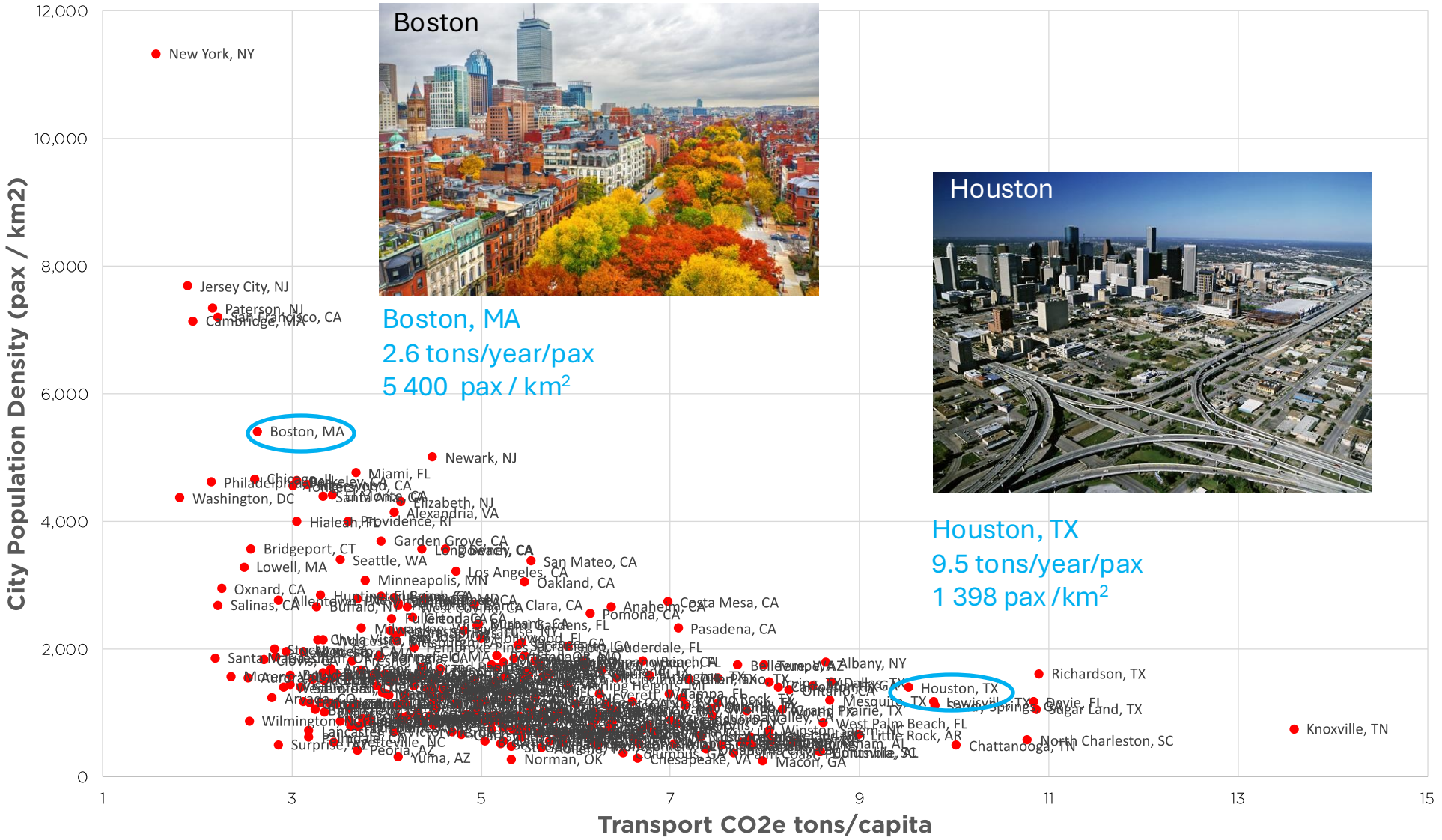
US cities > 100k pop.



Data Source: The Vulcan Project

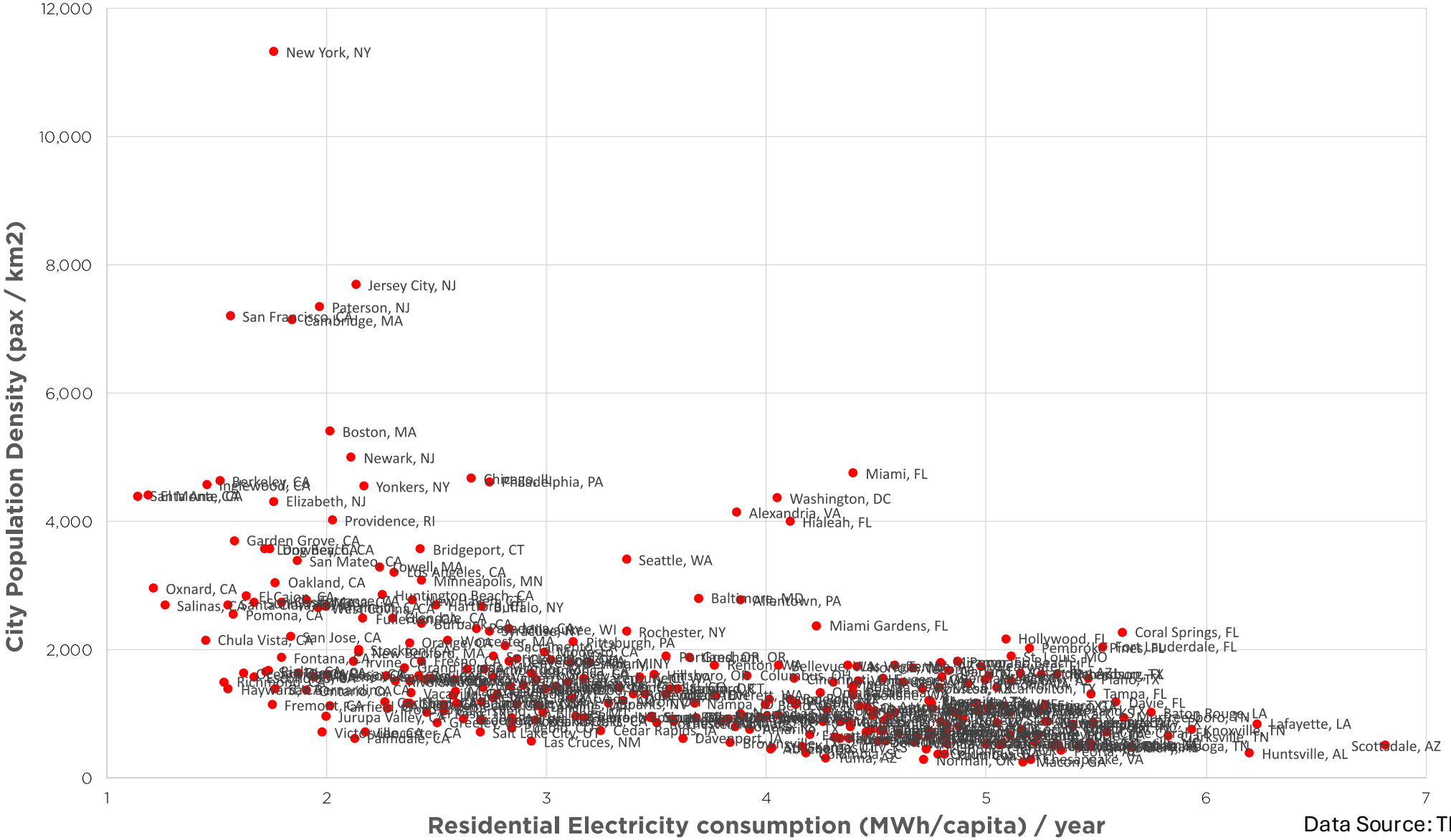
Urban density and transport-related CO2 emissions per capita

US cities > 100k pop.



Urban density and residential energy consumption per capita

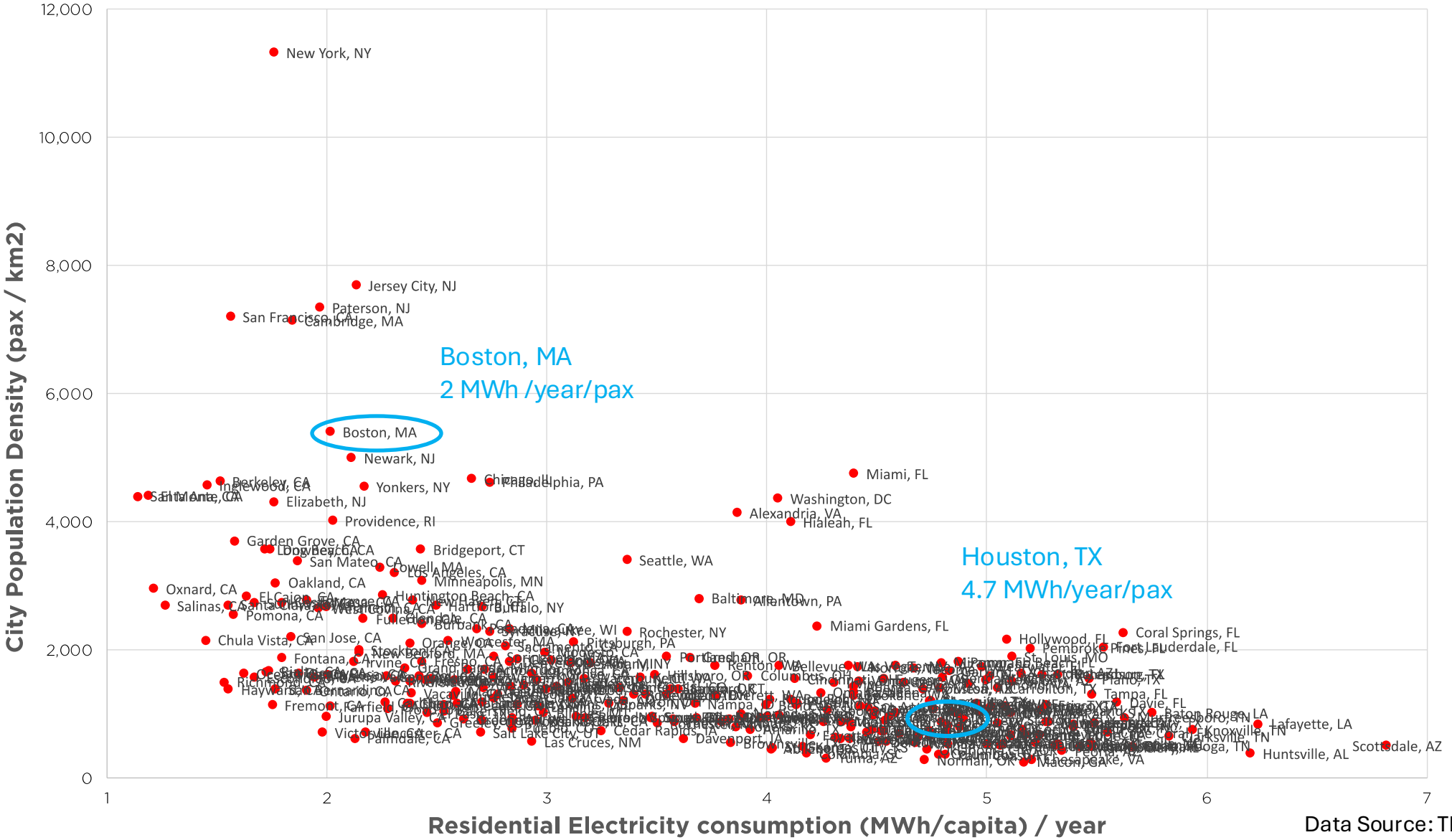
US cities > 100k pop.



Data Source: The Vulcan Project

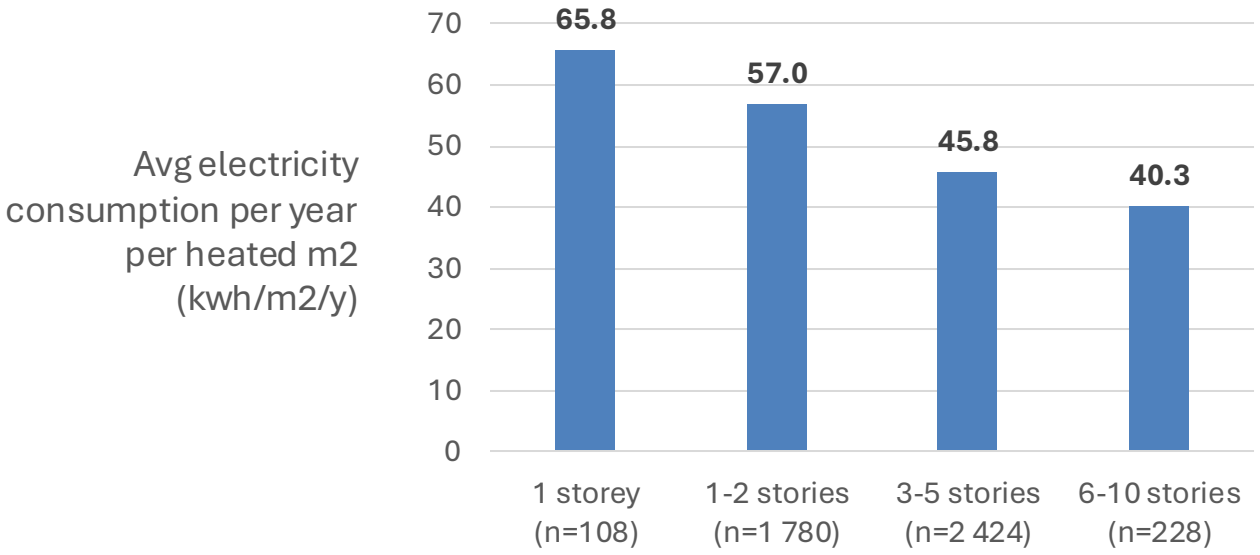
Urban density and residential energy consumption per capita

US cities > 100k pop.



Data Source: The Vulcan Project

Energy consumption by building type



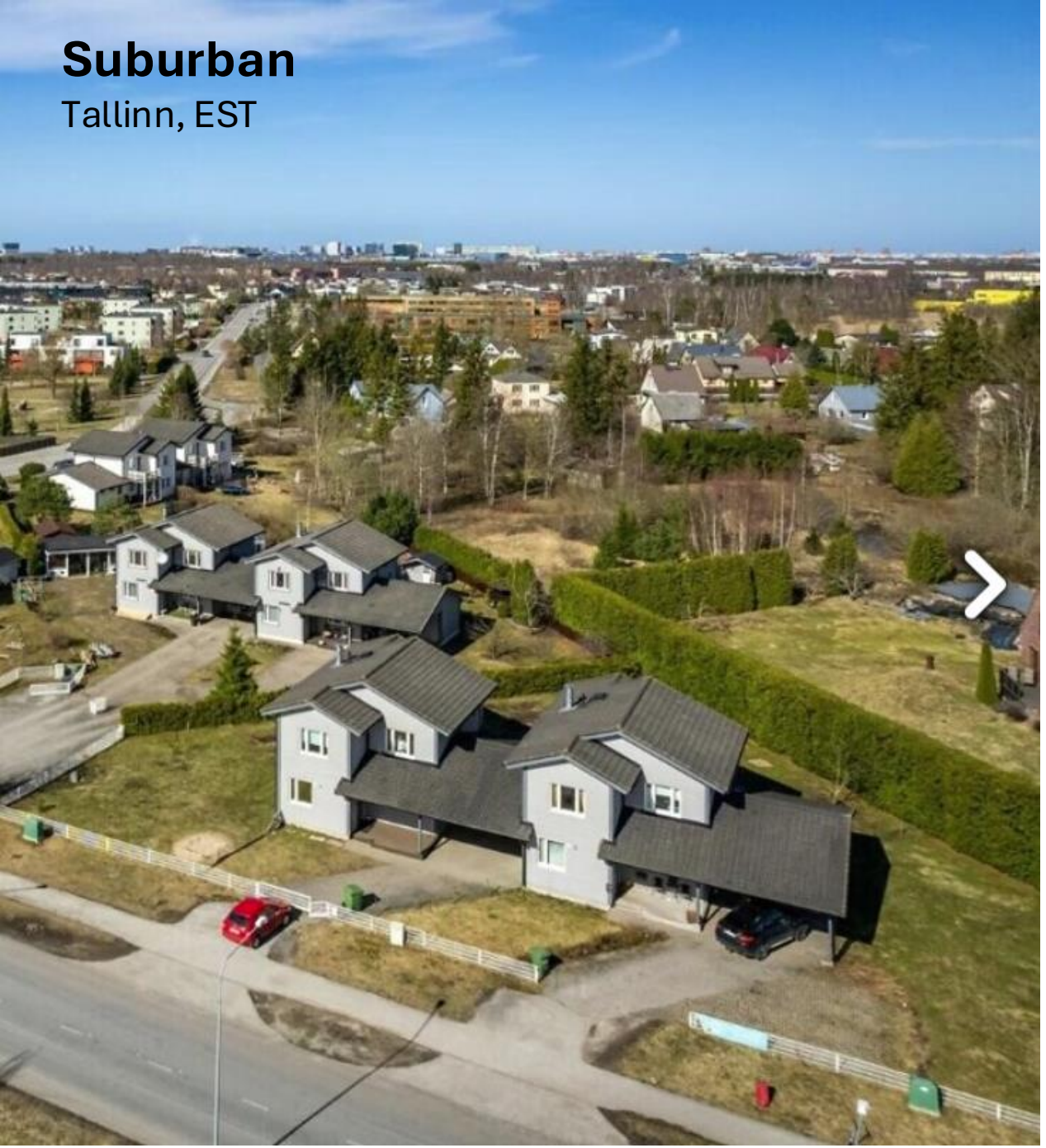
Data source: Estonian Energy 2022, analysis by Andres Sevtsuk in Estonian Construction Sector Sustainability Roadmap 2040.
https://rohetiiger.ee/wp-content/uploads/2023/04/EHITUSE-TEEKAART-2040-v1.pdf

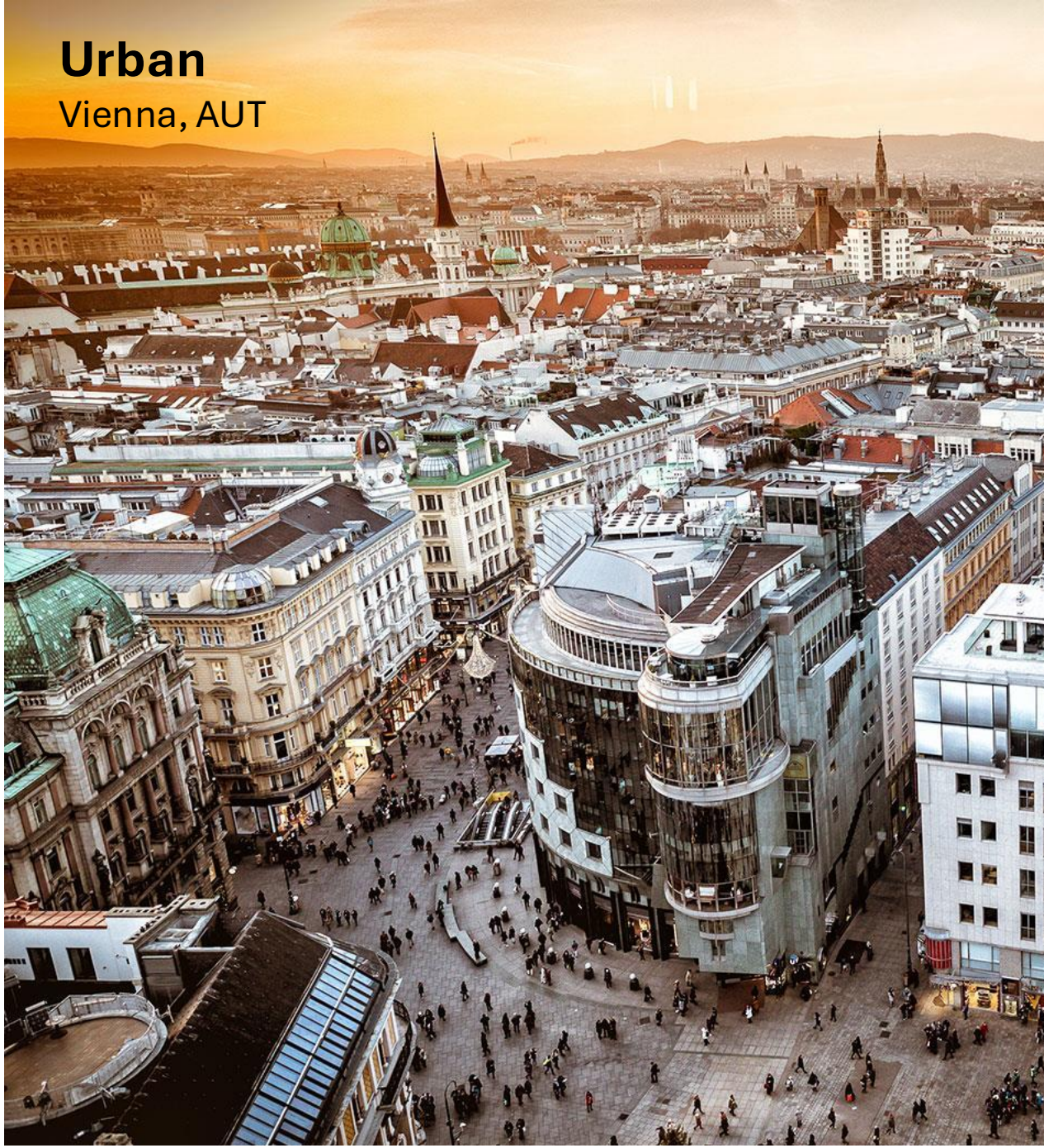
The systemic effect of city form and transportation emissions

6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), 2022

Annual transport emissions and co-benefits	Walking urban fabric	Transit urban fabric	Automobile urban fabric
Transport GHG	4 tonnes per person	6 tonnes per person	8 tonnes per person
Health benefits from walkability	High	Medium	Low
Equity of locational accessibility	High	Medium	Low
Construction and household waste	0.87 tonnes per person	1.13 tonnes per person	1.59 tonnes per person
Water consumption	35 kilolitre per person	42 kilolitre per person	70 kilolitre per person
Land	133 square metres per person	214 square metres per person	547 square metres per person
Economics of infrastructure and transport operations	High	Medium	Low

Source: Newman et al. (2016); Thomson and Newman (2018); Seto et al. (2021).


Suburban
Tallinn, EST


Urban
Vienna, AUT

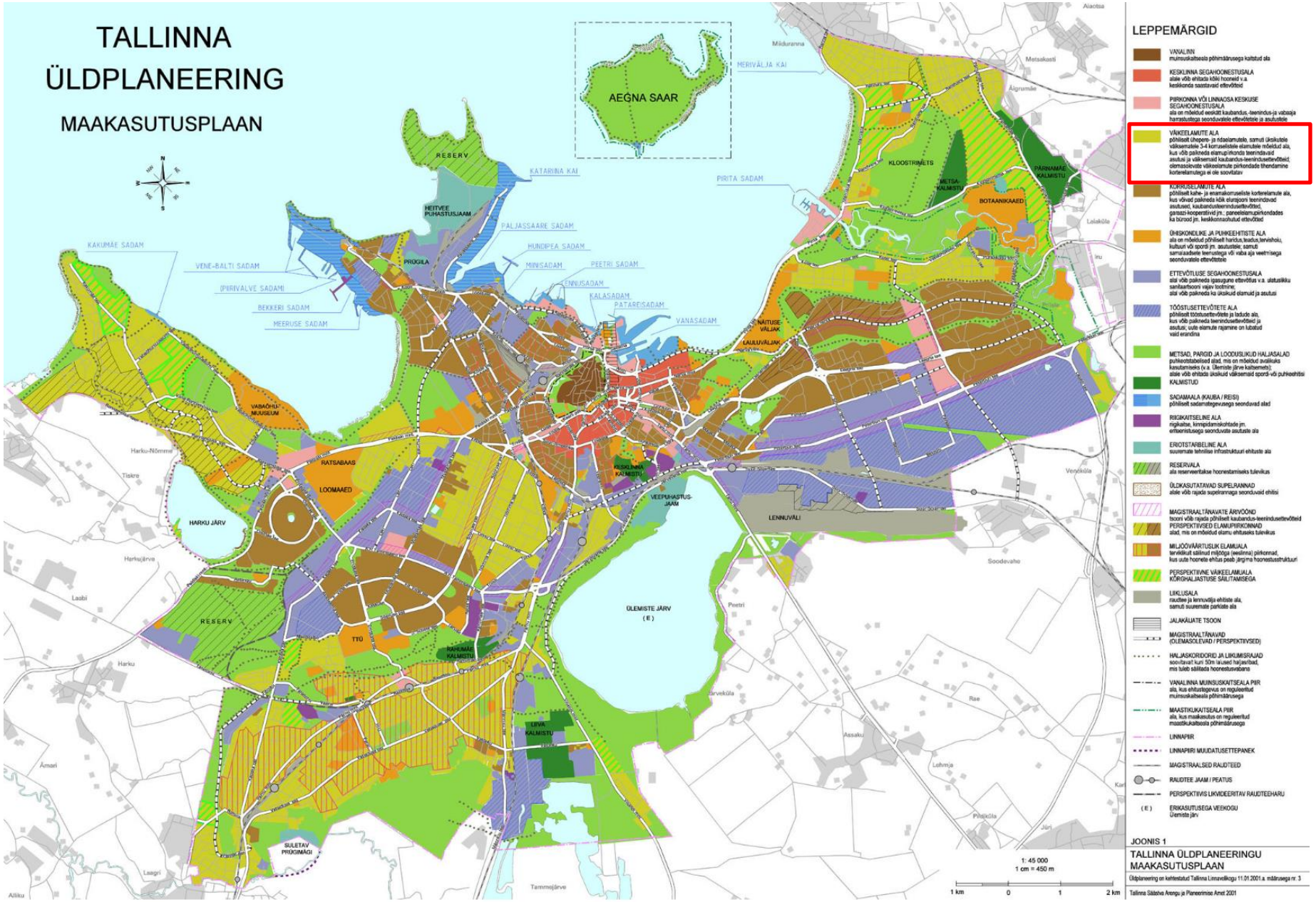
Zoning reform

1. Abolish single-family-only zoning.

2. Allow small commercial uses as-of-right everywhere.

3. Limit shopping-center construction and GFA.

4. Abolish parking minimums.



EDITORIAL

Bravo to Cambridge for ending single-family-only zoning

The city's move will create more housing and provide a valuable model for other cities in the Commonwealth.

By The Editorial Board Updated February 14, 2025, 4:00 a.m.

A single-family home at 73 Kirkland St. in Cambridge on Nov. 19, 2024, which was recently sold to a developer. ERIN CLARK/GLOBE STAFF

The Cambridge City Council voted to legalize apartment buildings throughout the city on Monday, a move that opponents have portrayed as some kind of radical step that will endanger neighborhoods and induce reckless growth.

But what is remarkable about the policy, which passed 8-1, is how practical — and, dare we say, conservative — it is. In at least this one case, other Massachusetts municipalities should follow the city's example without fear

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

1. Abolish single-family-only zoning

2. Allow small commercial uses as-of-right everywhere.

2. Allow small commercial uses as-of-right everywhere.

2. Allow small commercial uses as-of-right everywhere.

2. Allow small commercial uses as-of-right everywhere.

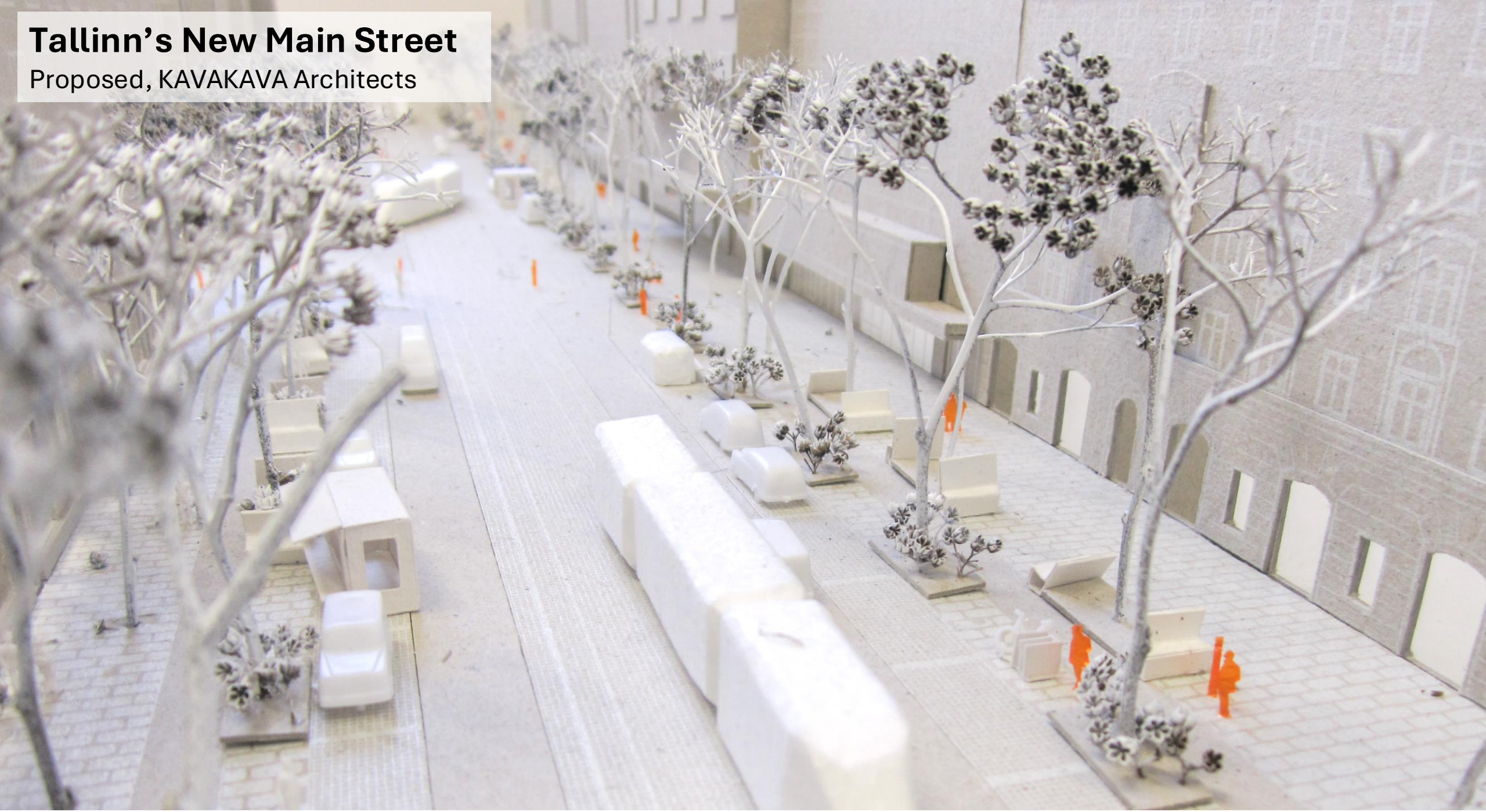
2. Allow small commercial uses as-of-right everywhere.

Tallinn’s New Main Street

Existing conditions

Tallinn’s New Main Street

Proposed, KAVAKAVA Architects

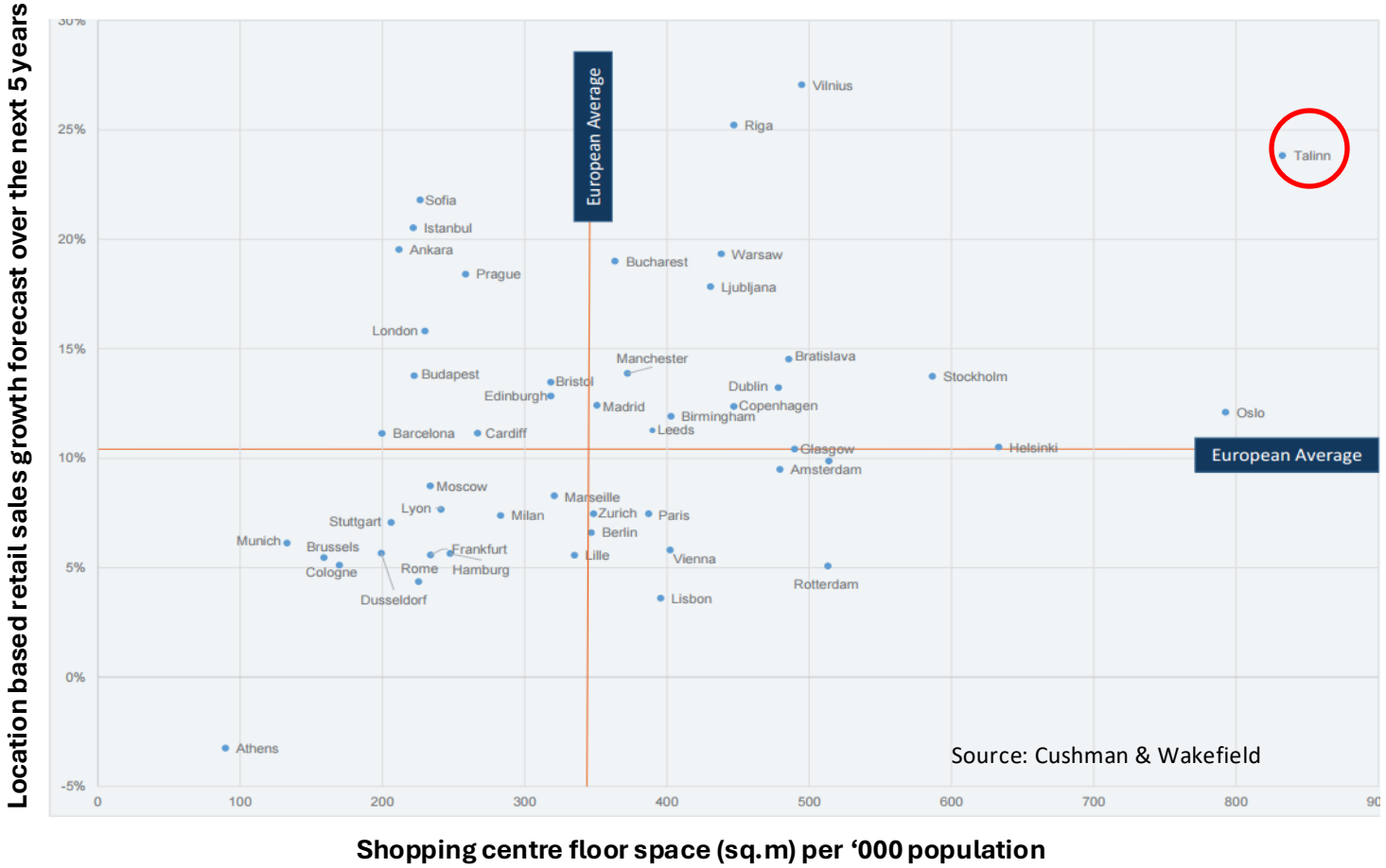


3. Limit shopping center construction to support smaller-scale street commerce.

3. Limit shopping center construction to support smaller-scale street commerce.

Tallinn has the highest amount of shopping Center space per capita in Europe!

Total leasable space in shopping Centers: 678 300 m^2
1.47 m^2 / pax
Highest ratio of all EU cities!
Source: Ober Haus Real Estate Market Report 2024

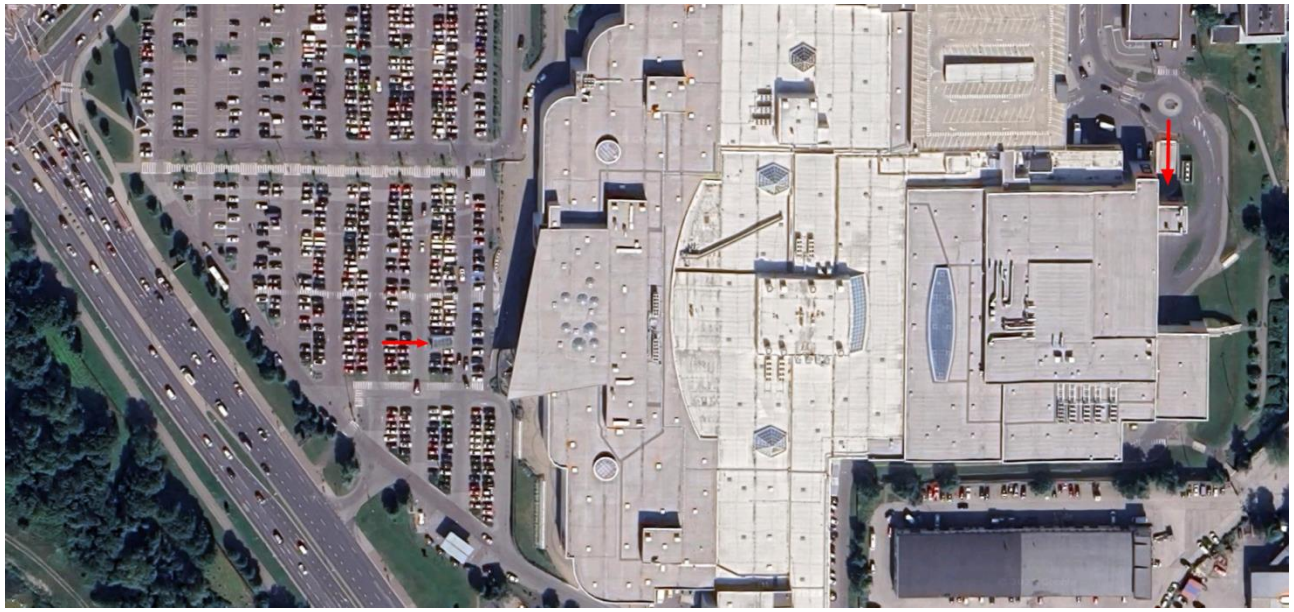


3. Limit shopping center construction to support smaller-scale street commerce.

3. Limit shopping center construction to support smaller-scale street commerce.

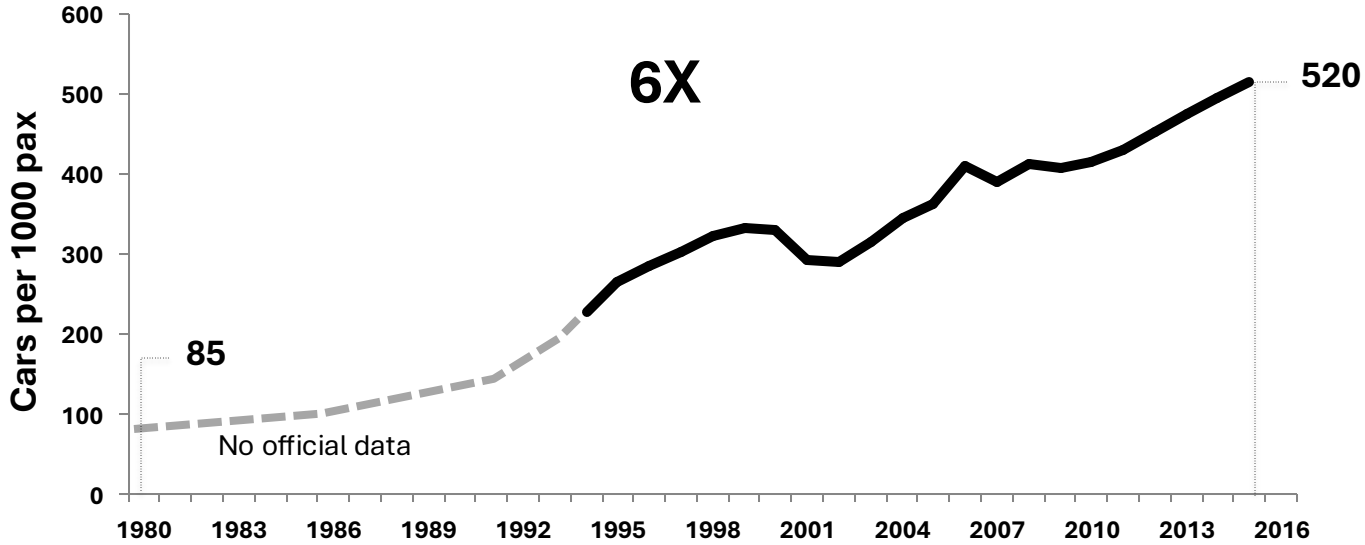
3. Limit shopping center construction to support smaller-scale street commerce.

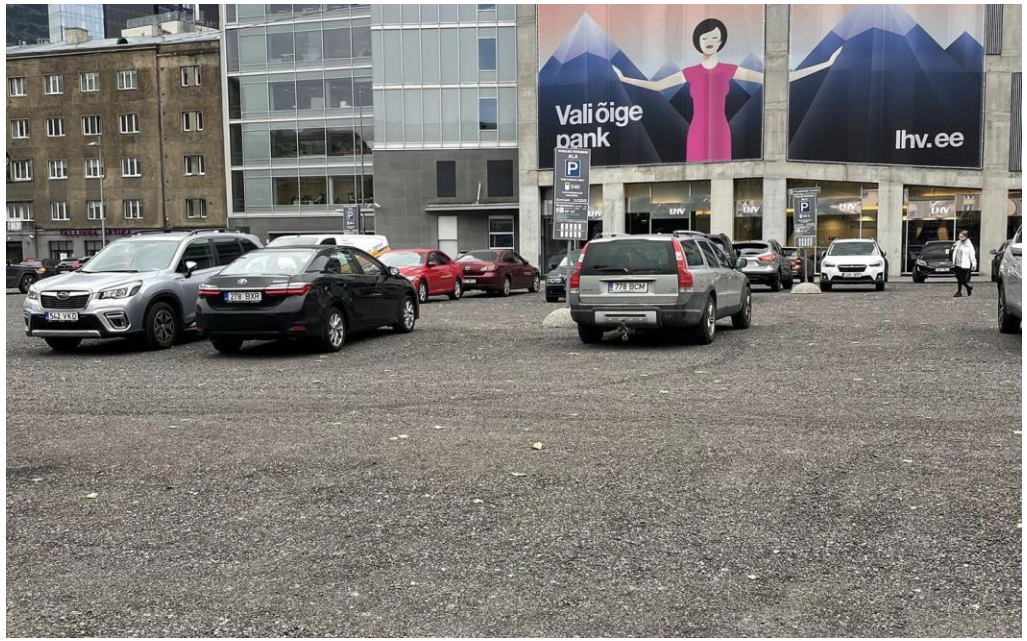
3. Limit shopping center construction to support smaller-scale street commerce.



4. Abolish parking minimums city-wide and locally implement parking maximums.

Massive car ownership growth in Estonia 1980-today





Parking minimums significantly impact housing costs and hold back valuable urban land from better uses

Dedicated parking costs in San Francisco increase residential unit costs by $50,000, on average.

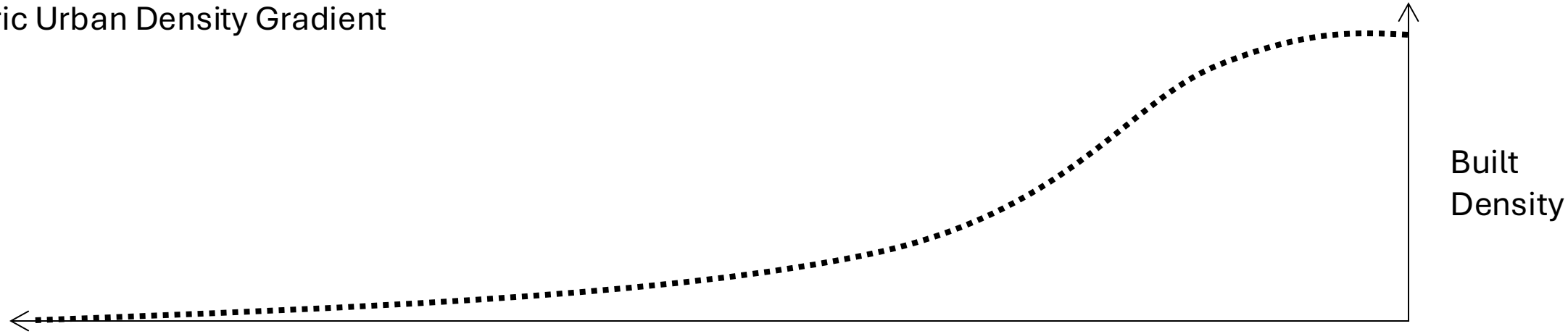
Buildings that require at least one parking space per unit have more than twice the car ownership rate of buildings without minimum parking requirements.

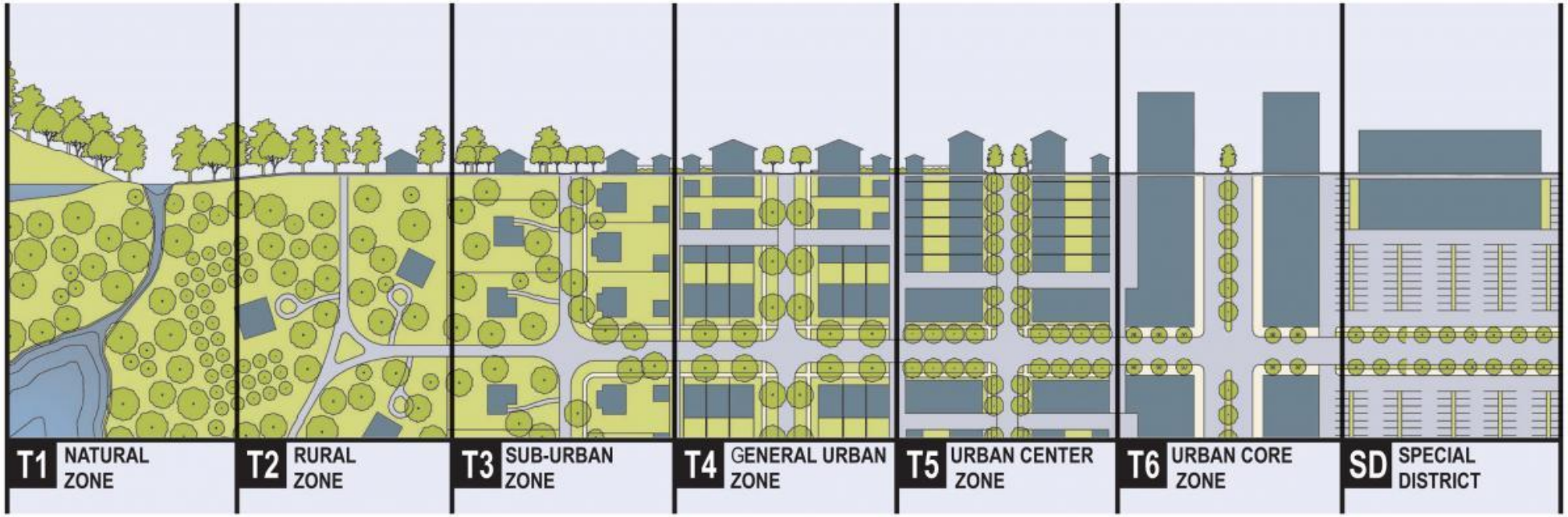
Removing parking minimums can provide savings in construction costs and make housing cheaper

Ref: Millard-Ball, A., West, J., Rezaei, N., & Desai, G. (2022). What do residential lotteries show us about transportation choices? *Urban Studies*, *59*(2), 434–452. https://doi.org/10.1177/0042098021995139

Intended outcomes of zoning reform

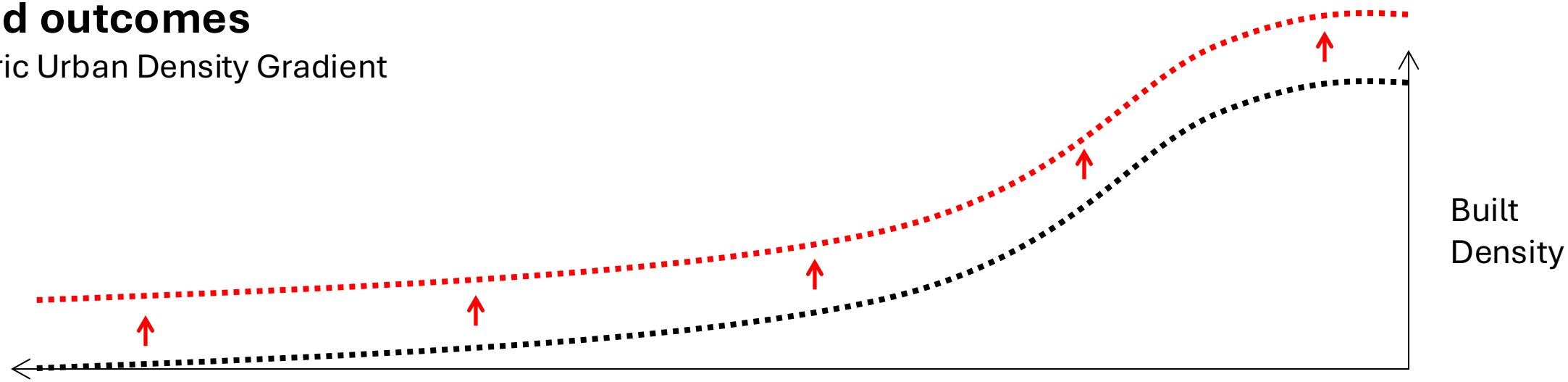
Monocentric Urban Density Gradient

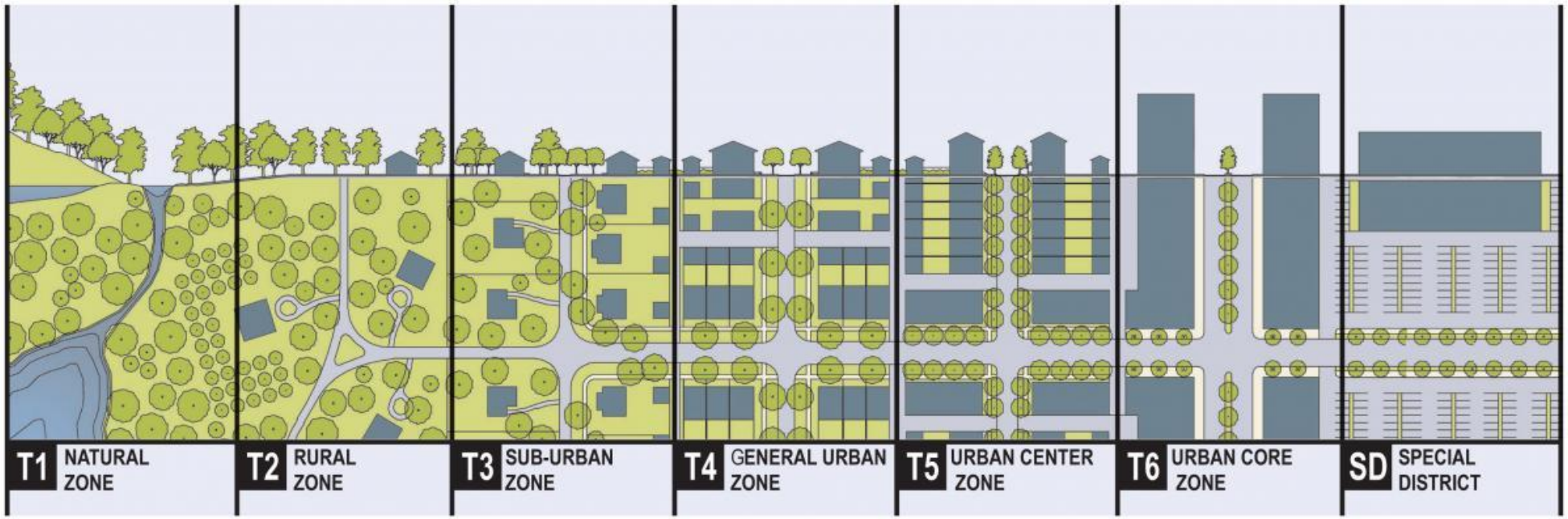




Intended outcomes

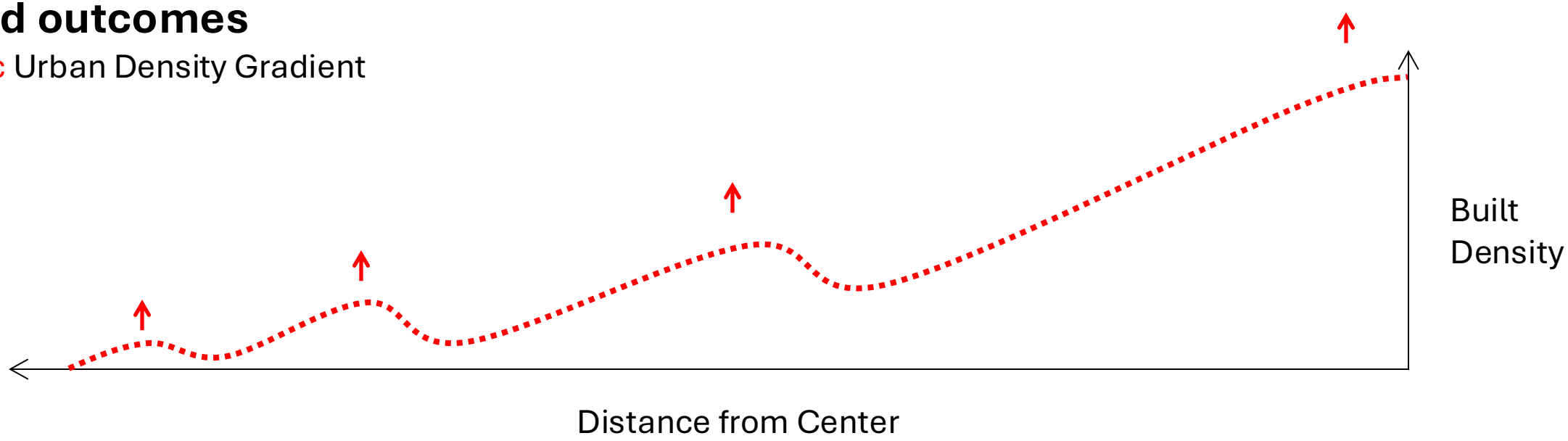
Monocentric Urban Density Gradient





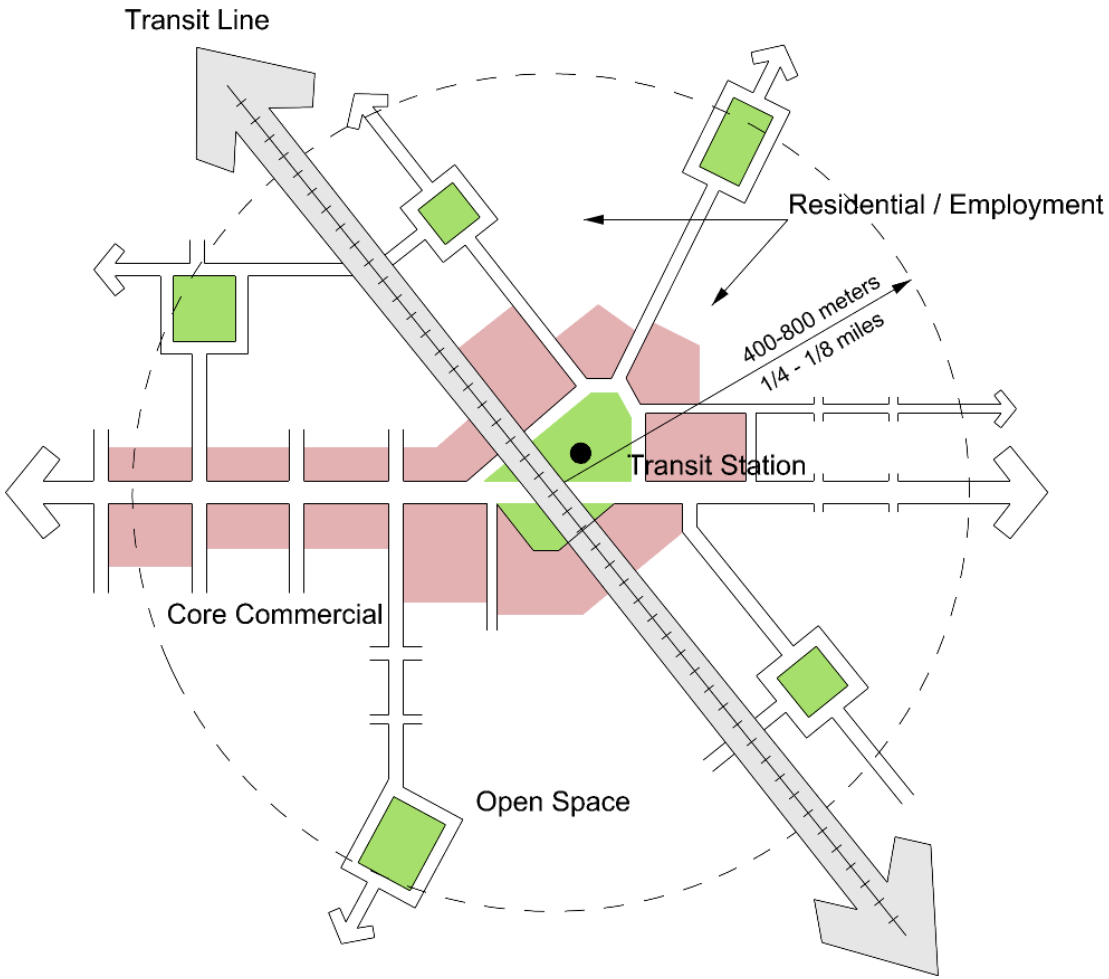
Intended outcomes

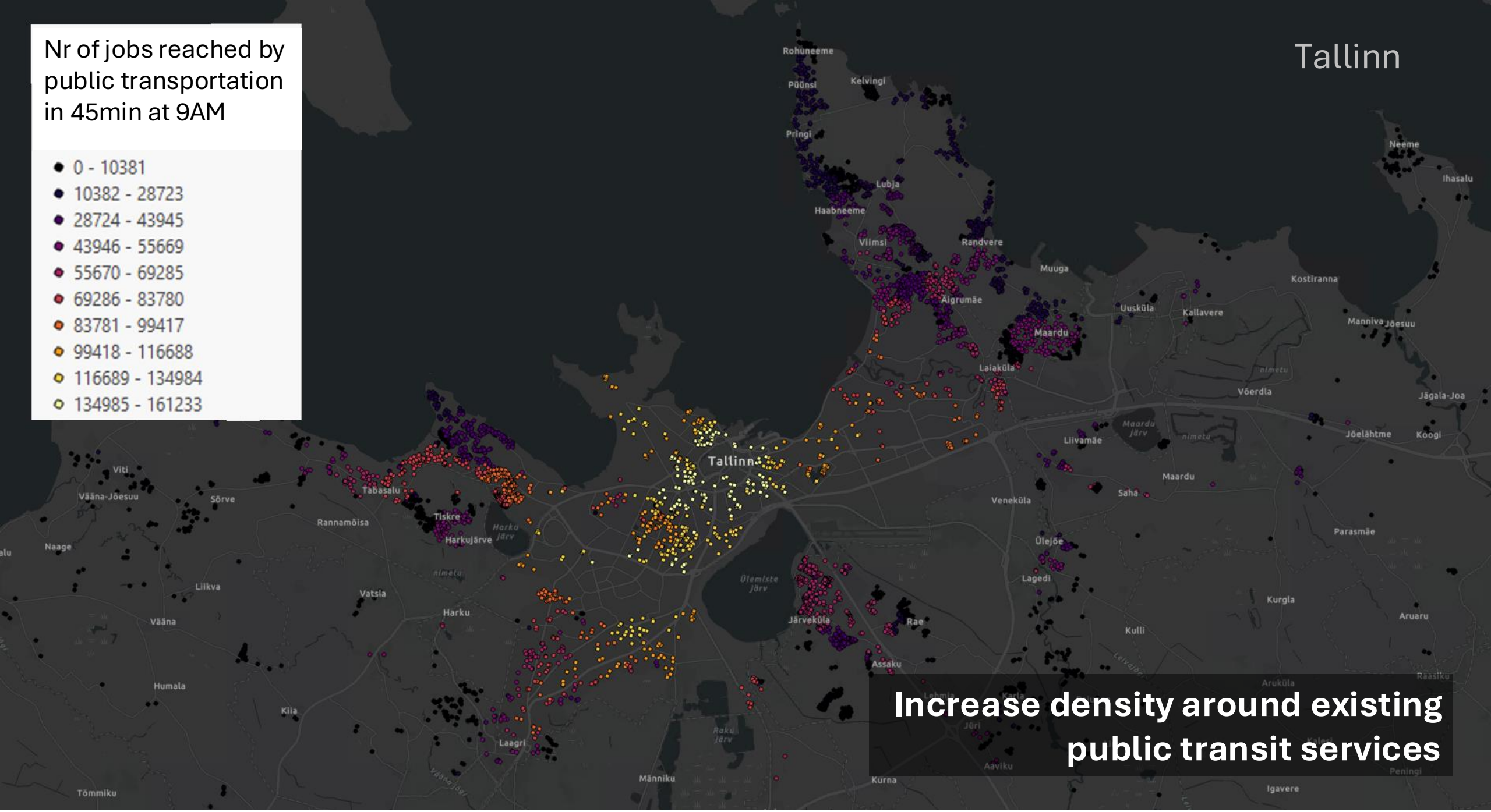
Polycentric Urban Density Gradient



Transit Oriented Development (TOD)

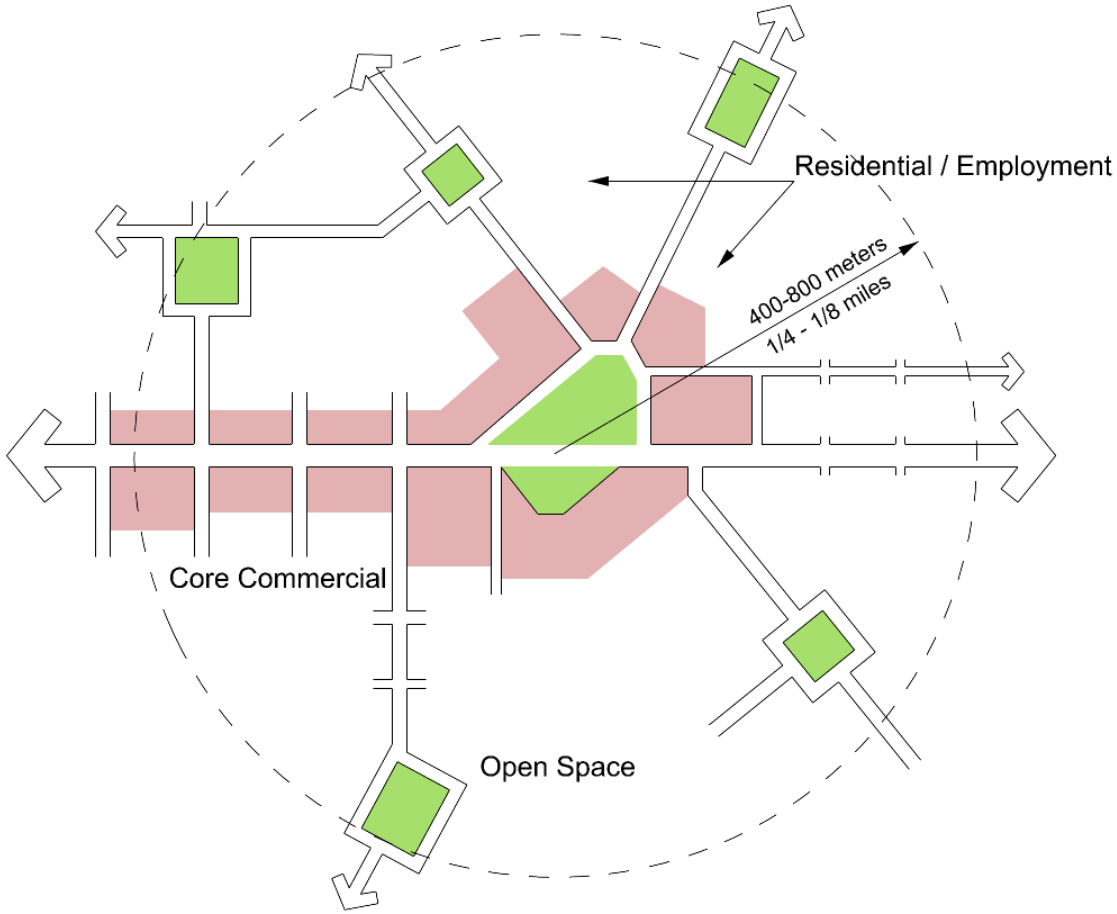
Baltic Station, Tallinn




Nr of jobs reached by public transportation in 45min at 9AM
0 - 10381
10382 - 28723
28724 - 43945
43946 - 55669
55670 - 69285
69286 - 83780
83781 - 99417
99418 - 116688
116689 - 134984
134985 - 161233
Tallinn
Increase density around existing public transit services

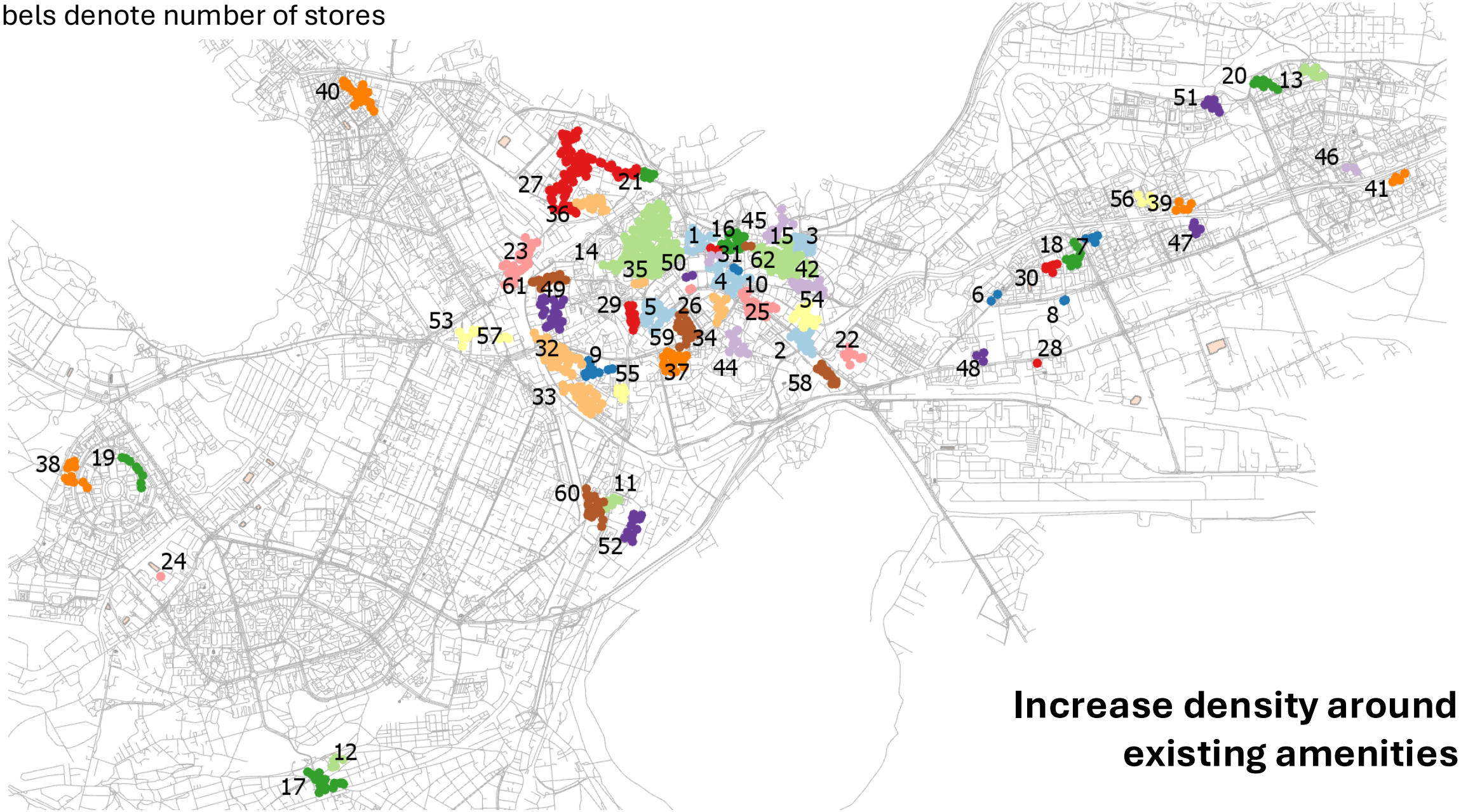
Amenity Oriented Development (AOD)

Inman Square, Cambridge



Clusters of street commerce in Tallinn

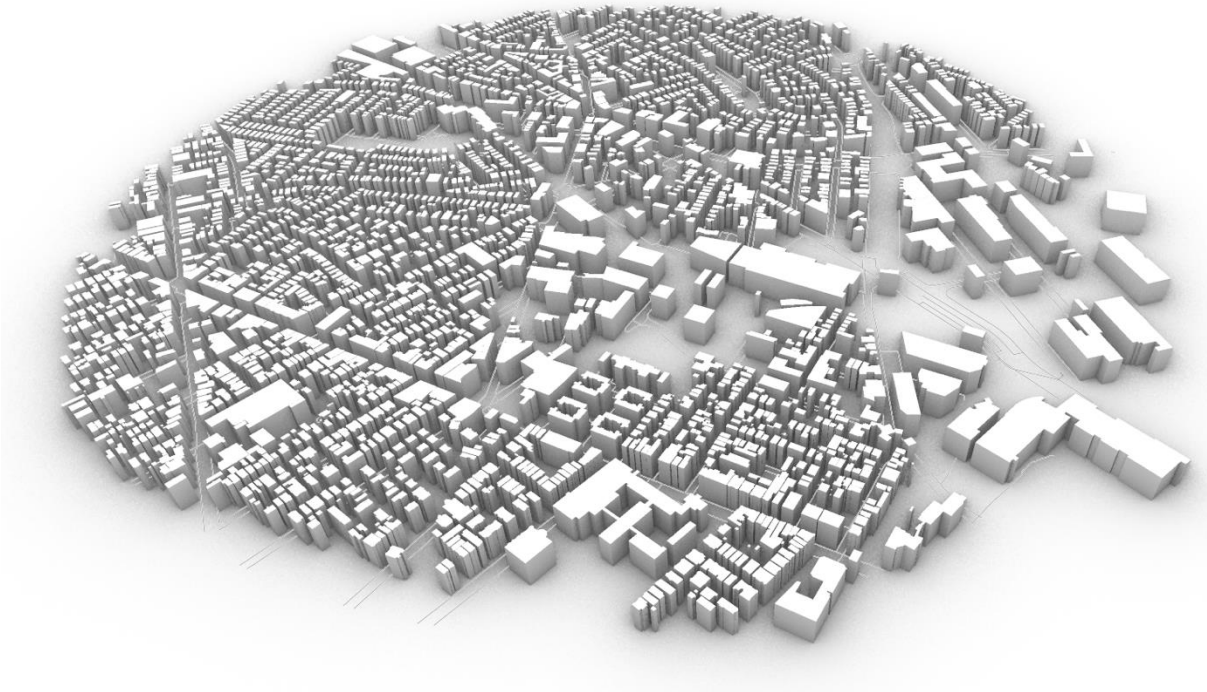
Labels denote number of stores



Increase density around existing amenities

TOD + AOD

We do not need consistently high densities everywhere…



TOD + AOD

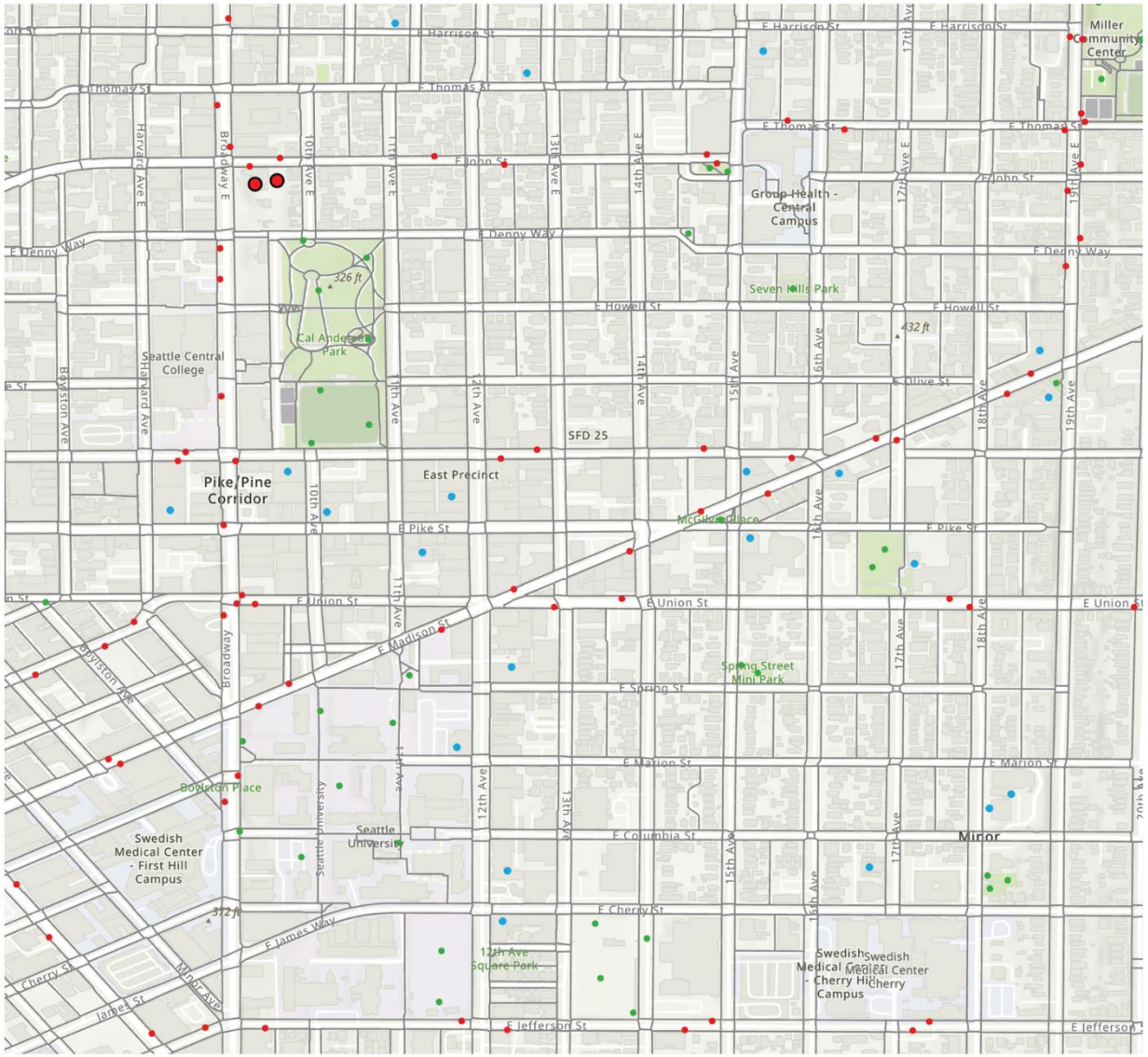
Same Gross Floor Area (GFA) but different urban forms
Density near transit and density near amenities

Daily kilometers traveled

Daily kilometers traveled

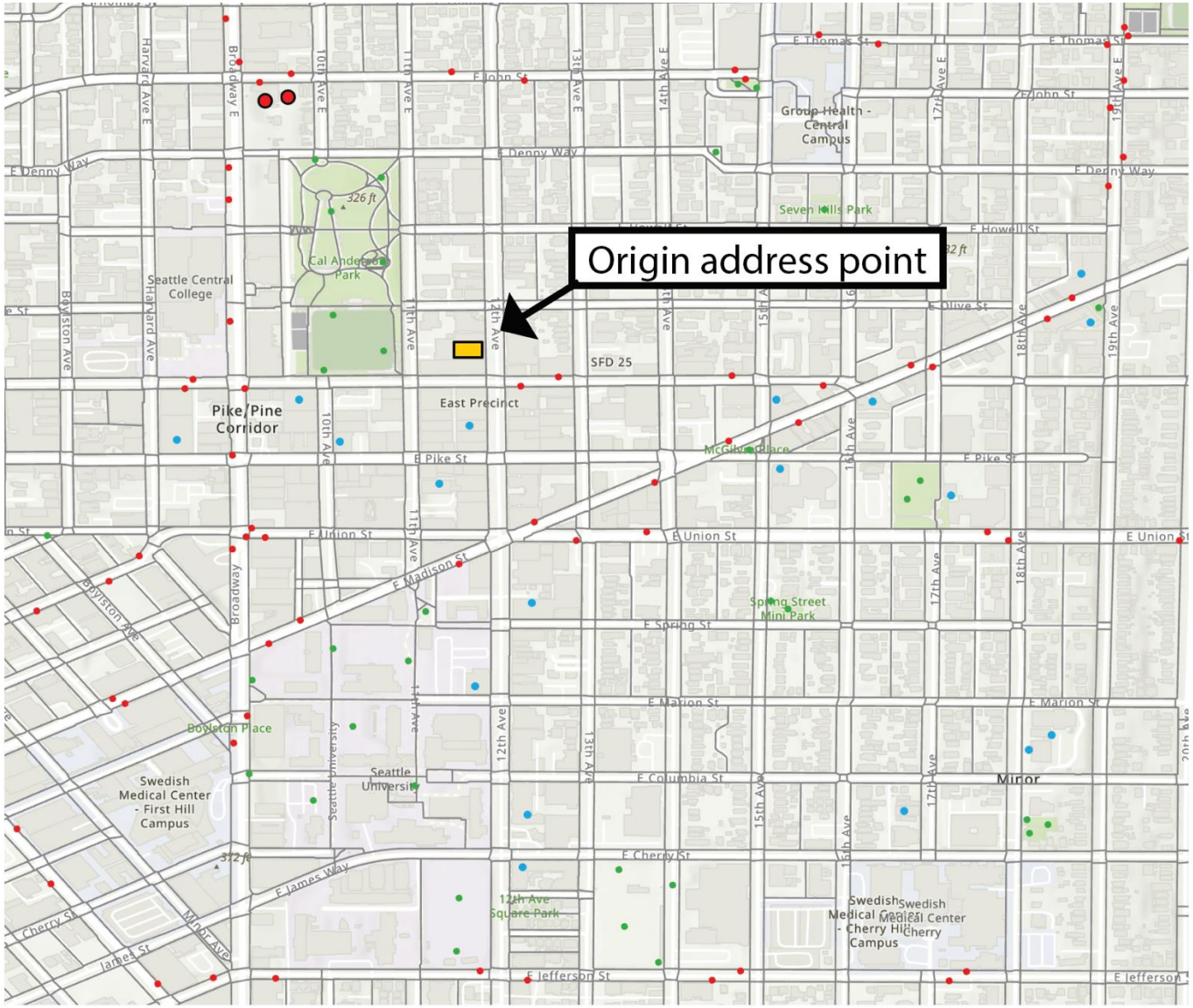
5. Set pedestrian access to a basket of daily destinations an urban development target, incentivizing more construction in areas with better access.

Ped network
Bus stop
Metro stop
School
Park



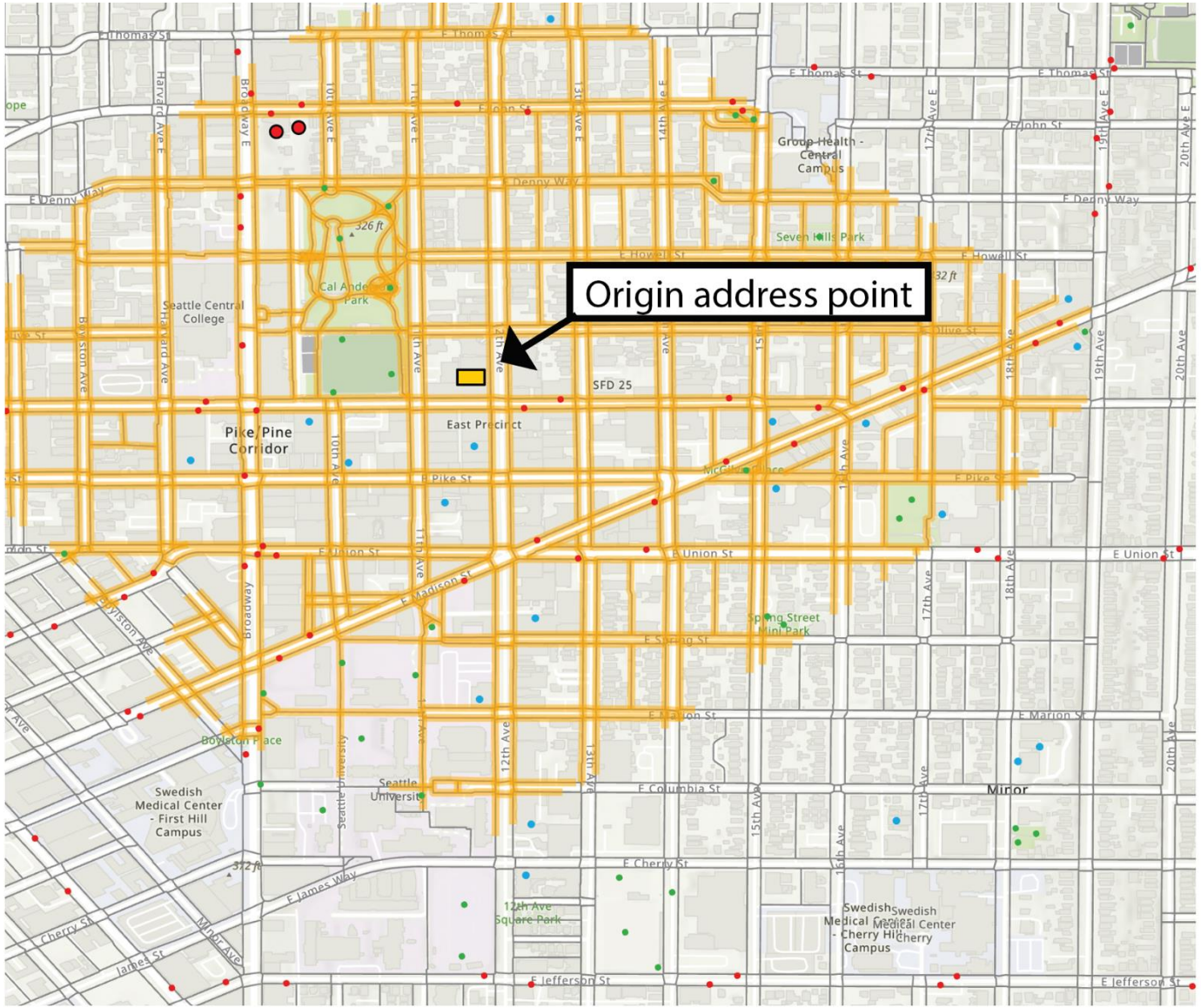
5. Set pedestrian access to a basket of daily destinations an urban development target, incentivizing more construction in areas with better access.

- Bus stop
- Metro stop
- School
- Park
- Address



5. Set pedestrian access to a basket of daily destinations an urban development target, incentivizing more construction in areas with better access.

Ped network
Bus stop
Metro stop
School
Park
Address
½-mile walkshed Group 1

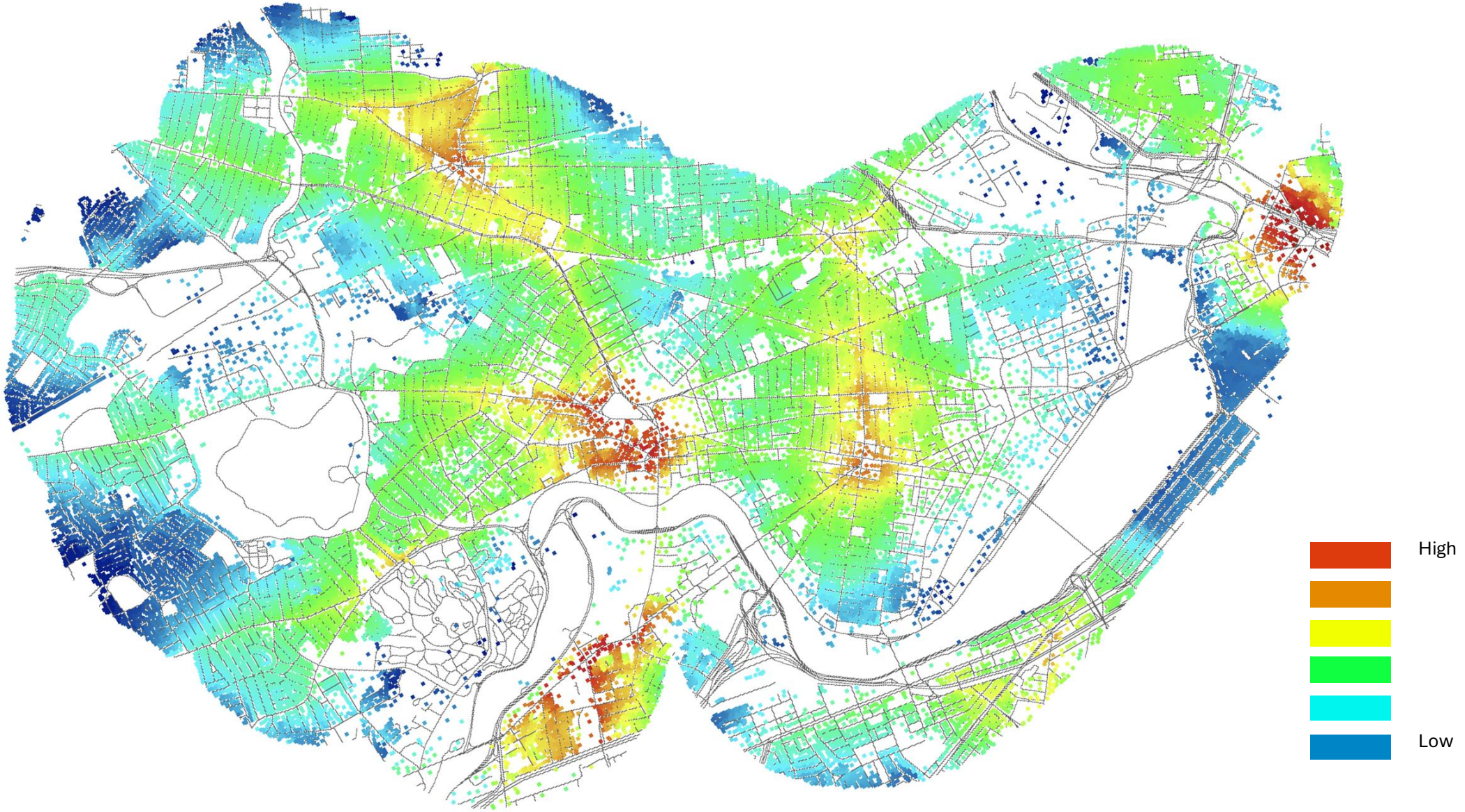


Destination categories and parameters used to compute access scores

The nr of weights indicates how many destinations at most contribute to the access score and the sum of weights represents category importance.

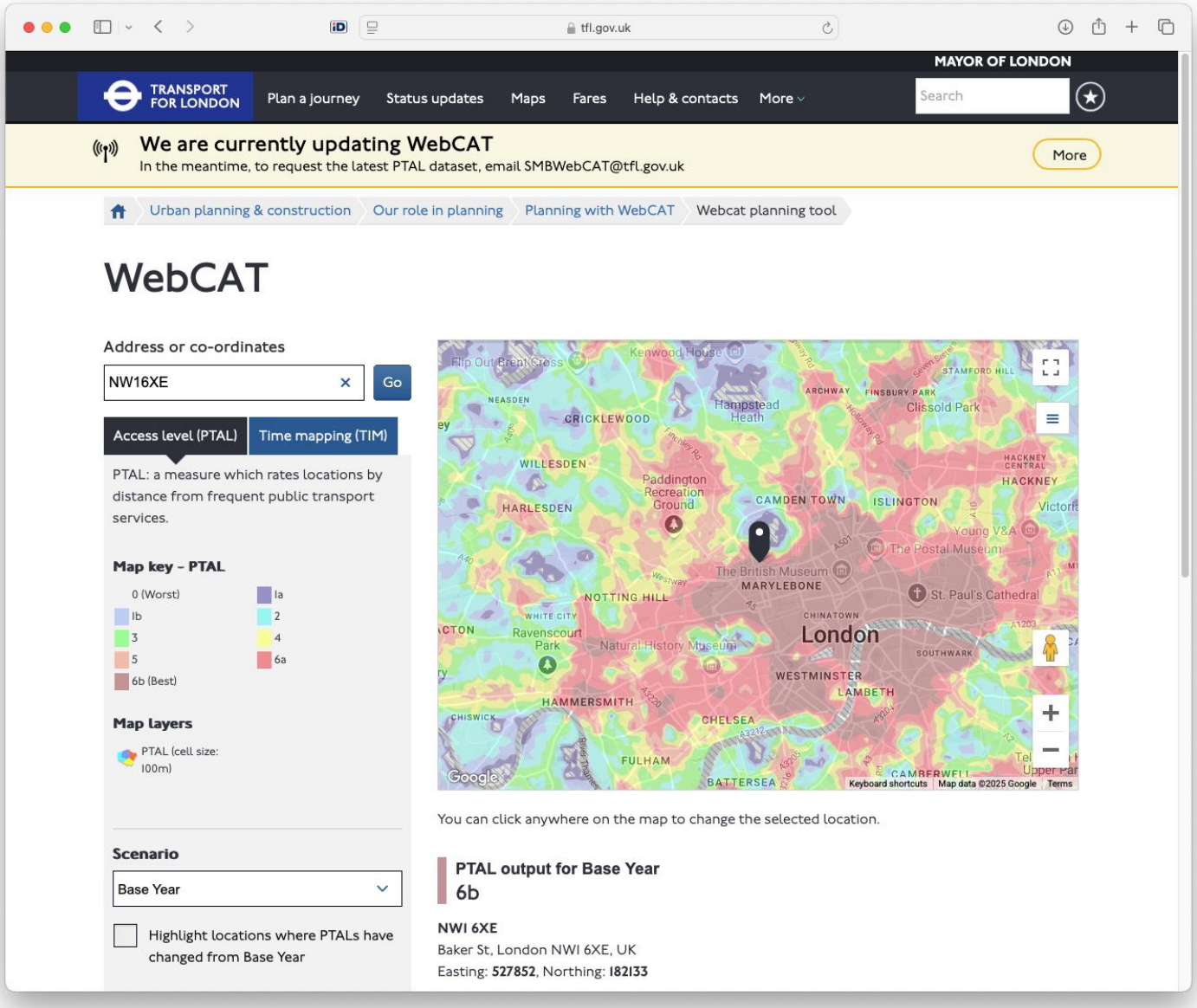
Destination	KNN Weights	sum
Grocery store	[3]	3
Retail (not grocery)	[0.5, 0.45, 0.4, 0.35, 0.3]	2
Eating & Drinking places	[0.75, 0.45, 0.25, 0.25, 0.225, 0.225, 0.225, 0.225, 0.2, 0.2]	3
Personal services	[0.5, 0.45, 0.4, 0.35, 0.3]	2
Entertainment	[0.5, 0.45, 0.4, 0.35, 0.3]	2
Parks	[0.75, 0.675, 0.6, 0.525, 0.45]	3
Schools & Daycares	[1, 1]	2
Healthcare	[0.75, 0.75, 0.5]	2
Libraries	[1]	1
Bus stops	[2, 1, 1]	3
Tram stops	[3]	3
	Max. possible accessibility score	**26**

5. Set pedestrian access to a basket of daily destinations an urban development target, incentivizing more construction in areas with better access.



5. Set pedestrian access to a basket of daily destinations an urban development target, incentivizing more construction in areas with better access.

Transport for London (TfL) uses the Public Transport Accessibility Level (PTAL) system to assess and measure the accessibility of areas to public transport, which then influences development rights based on PTAL scores.



Conclusions

- We must build denser, more mixed-use and walkable cities than in the past three decades.

Conclusions

- We must build denser, more mixed-use and walkable cities than in the past three decades.

- Achieving a sustainable mobility mode-shift should not be an abstract goal, but a realistic target we monitor and develop the city around.

Conclusions

- We must build denser, more mixed-use and walkable cities than in the past three decades.
- Achieving a sustainable mobility mode-shift should not be an abstract goal, but a realistic target we monitor and develop the city around.
- A publicly tracked accessibility metric can help prioritize new developments at opportune locations and monitor city-wide progress.

Conclusions

- We must build denser, more mixed-use and walkable cities than in the past three decades.
- Achieving a sustainable mobility mode-shift should not be an abstract goal, but a realistic target we monitor and develop the city around.
- A publicly tracked accessibility metric can help prioritize new developments at opportune locations and monitor city-wide progress.
- Density does not need to be uniform but concentrated around public transport and existing commercial and institutional amenities.

Conclusions

- We must build denser, more mixed-use and walkable cities than in the past three decades.
- Achieving a sustainable mobility mode-shift should not be an abstract goal, but a realistic target we monitor and develop the city around.
- A publicly tracked accessibility metric can help prioritize new developments at opportune locations and monitor city-wide progress.
- Density does not need to be uniform but concentrated around public transport and existing commercial and institutional amenities.
- Zoning reform can help abolish barriers to denser, urban construction.

Questions?

cityform.mit.edu
dusp.mit.edu

Andres Sevtsuk
Associate Professor of Planning
Head, City Design and Development Program
Director, City Form Lab
Department of Urban Studies and Planning, MIT

Massachusetts Institute of Technology

City Form Lab
cityform.mit.edu