EuroSDR

Data Science of Bicycle Networks

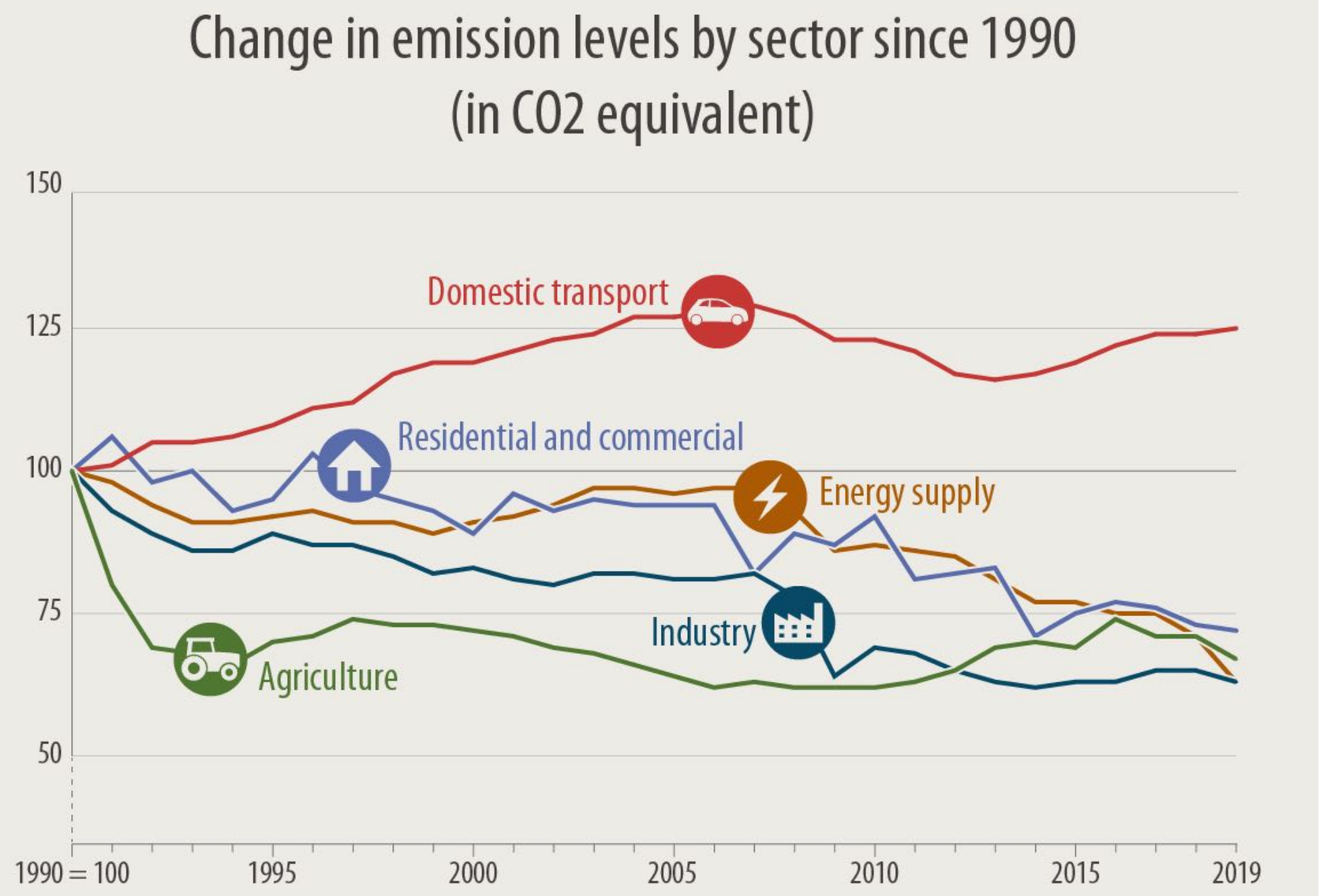
Michael Szell

.itu.dk

IT UNIVERSITY OF COPENHAGEN

Nov 6, 2024, Copenhagen

Transport plays a key role in the climate crisis



Transport represents almost a quarter of Europe's greenhouse gas emissions and is the main cause of air pollution in cities.

https://ec.europa.eu/clima/policies/transport_en

Among 60 identified actions that could change individual consumption, individual mobility choices [like cycling] *have the largest potential to reduce carbon footprint.*

IPCC AR6 WG III (2022)

Cycling is a time-tested technology that delivers on 11 SDGs

CYCLING DELIVERS ON THE GLOBAL GOALS

Shifting towards a better economy, society, and planet for all

https://unric.org/en/sustainable-development-goals-cycling/

More active travel is also an *economic* "no-brainer"

Cost-benefit analysis in EU that accounts for

- Health
- Environment
- Travel / Congestion

shows:

Gössling et al, Ecol Econ 158 (2019)

More active travel is also an *economic* "no-brainer"

Cost-benefit analysis in EU that accounts for

- Health
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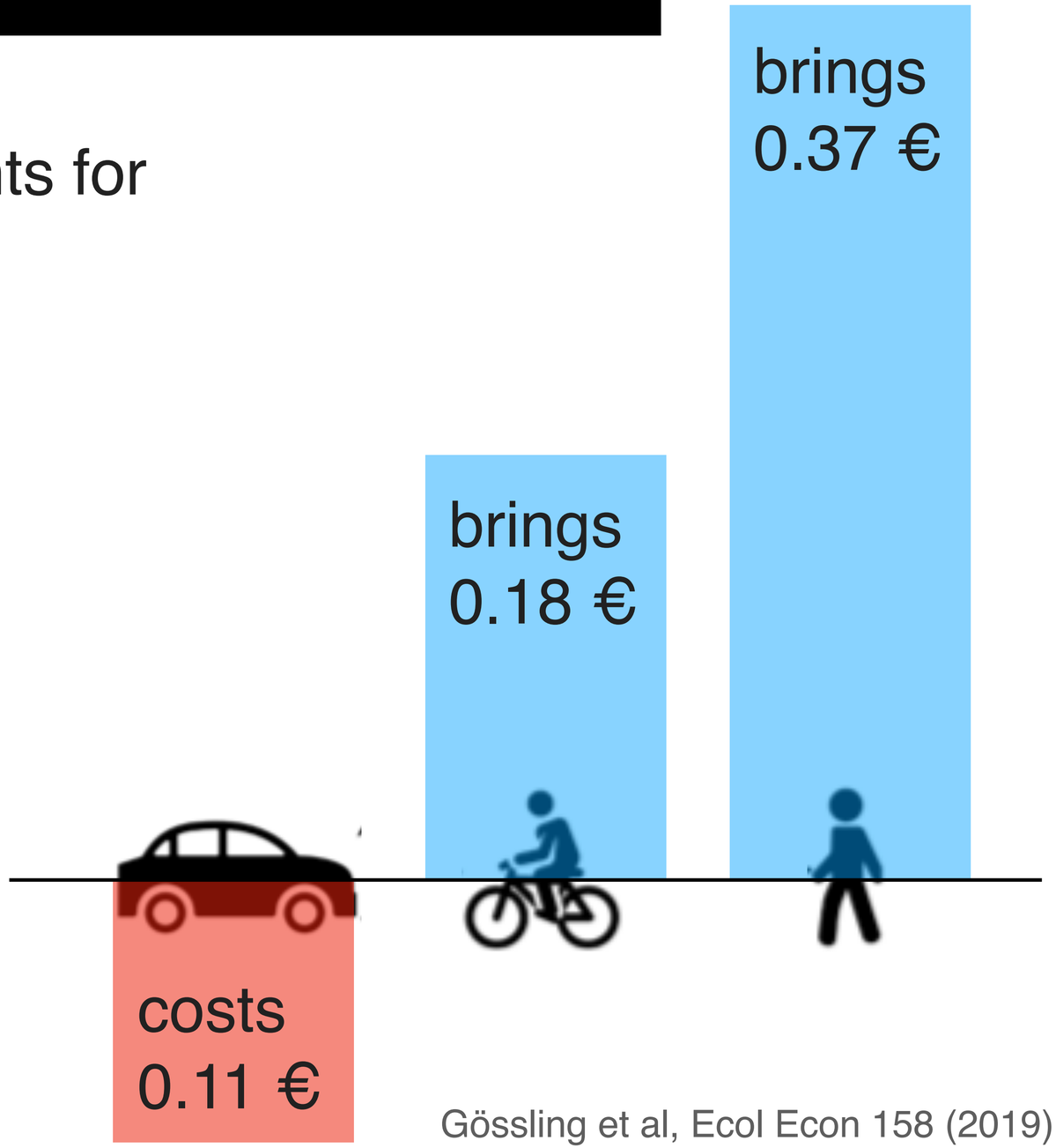
shows: 1 km travelled by



Gössling et al, Ecol Econ 158 (2019)

Data-informed planning can support a sustainability shift

Our group creates data-driven tools for sustainable mobility planning

- Create open-source tool (Python)

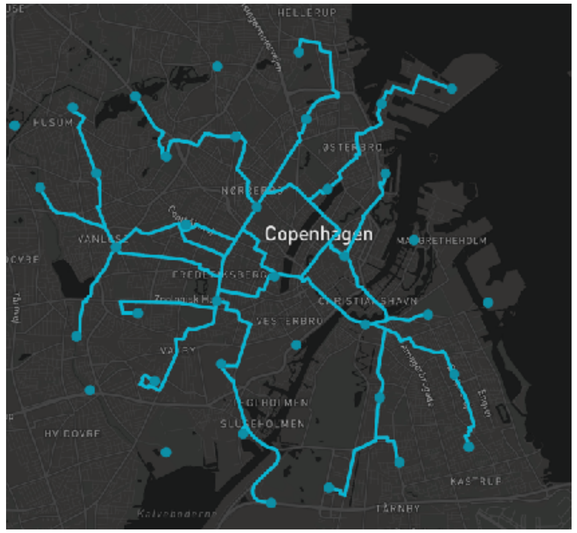
- The tool is general, not for one specific location

- Apply tool to Denmark and/or globally

Our group creates data-driven tools for sustainable mobility planning

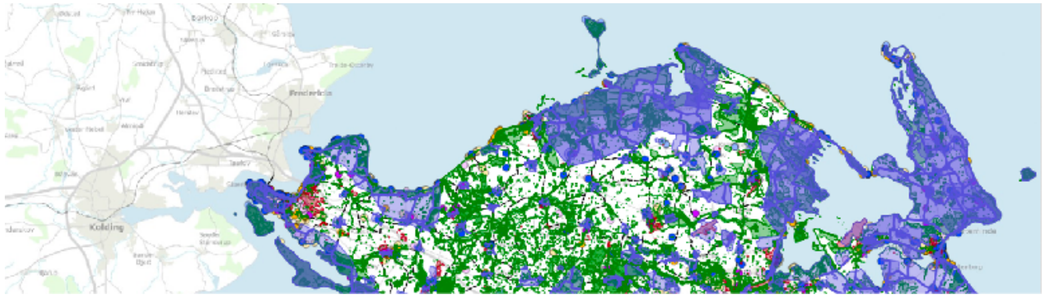
BIKEDNA

FixBike.Net



GrowBike.Net

SUPERBLOCKIFY



BikeNodePlanner

GrowBike.Net

How to build bicycle infrastructure?

We have great planning guides.

How to build bicycle infrastructure?

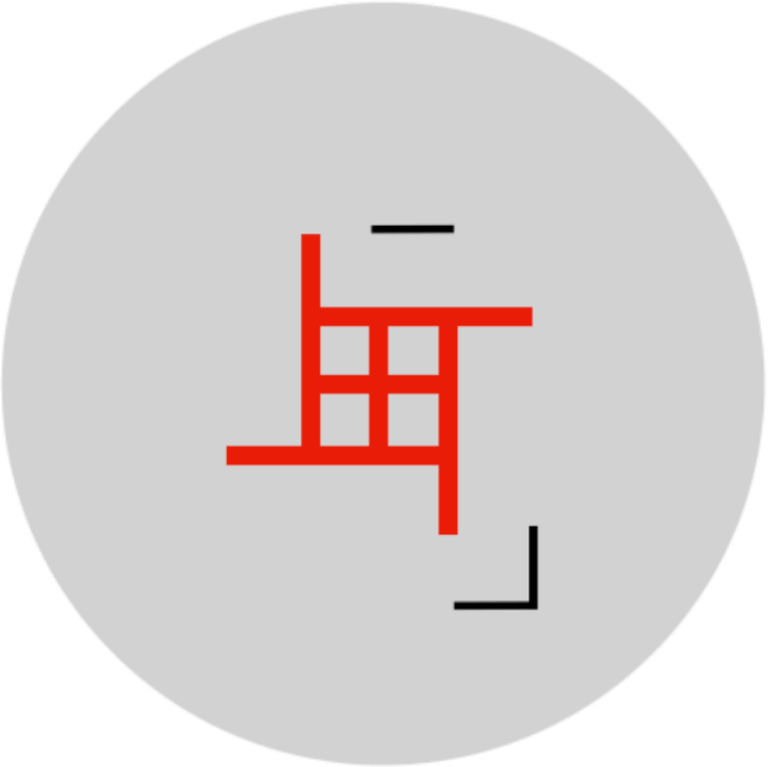
We have great planning guides.

Mostly about intersection or street design.

We don't know much from a systemic birds-eye perspective!

Most cities

Not developed



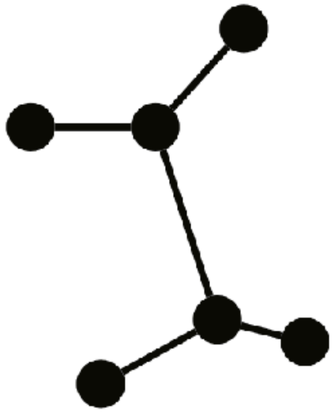
Grow from scratch

GrowBike.Net

Inspired by CROW, we want a cohesive network

Connectedness & Resilience

Minimum spanning tree



Investor's optimum

Szell et al., Sci Rep 12, 6765 (2022)

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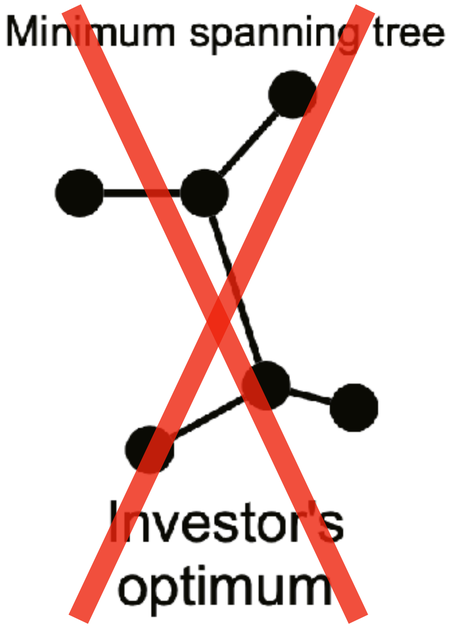
Connectedness & Resilience



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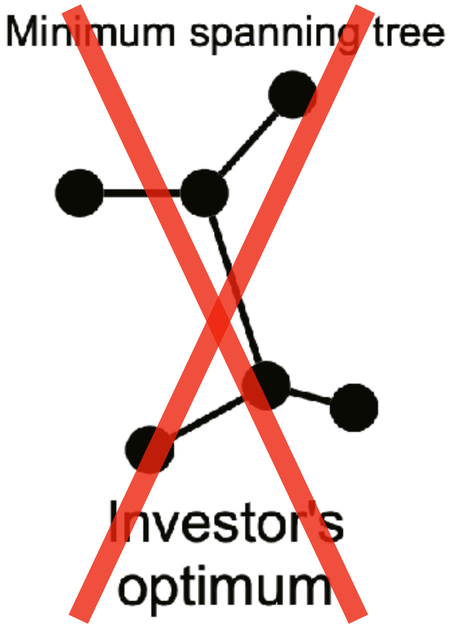

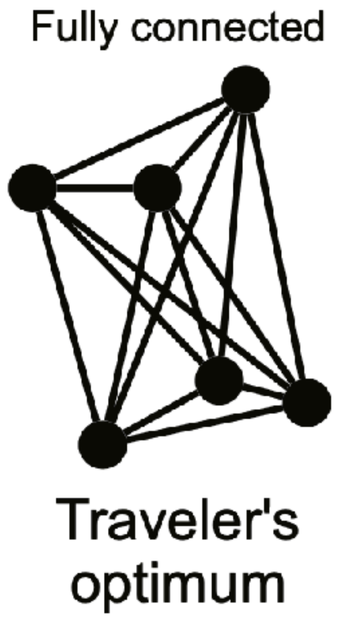

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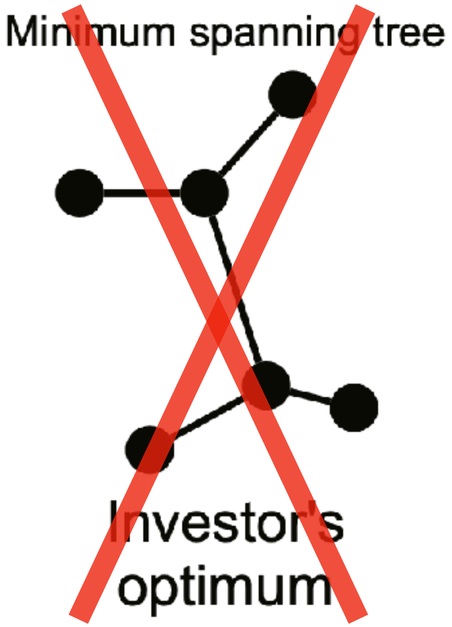

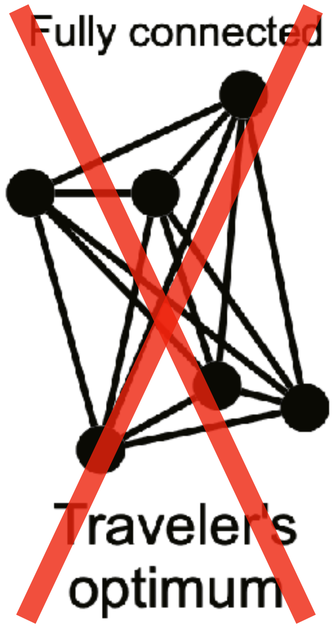

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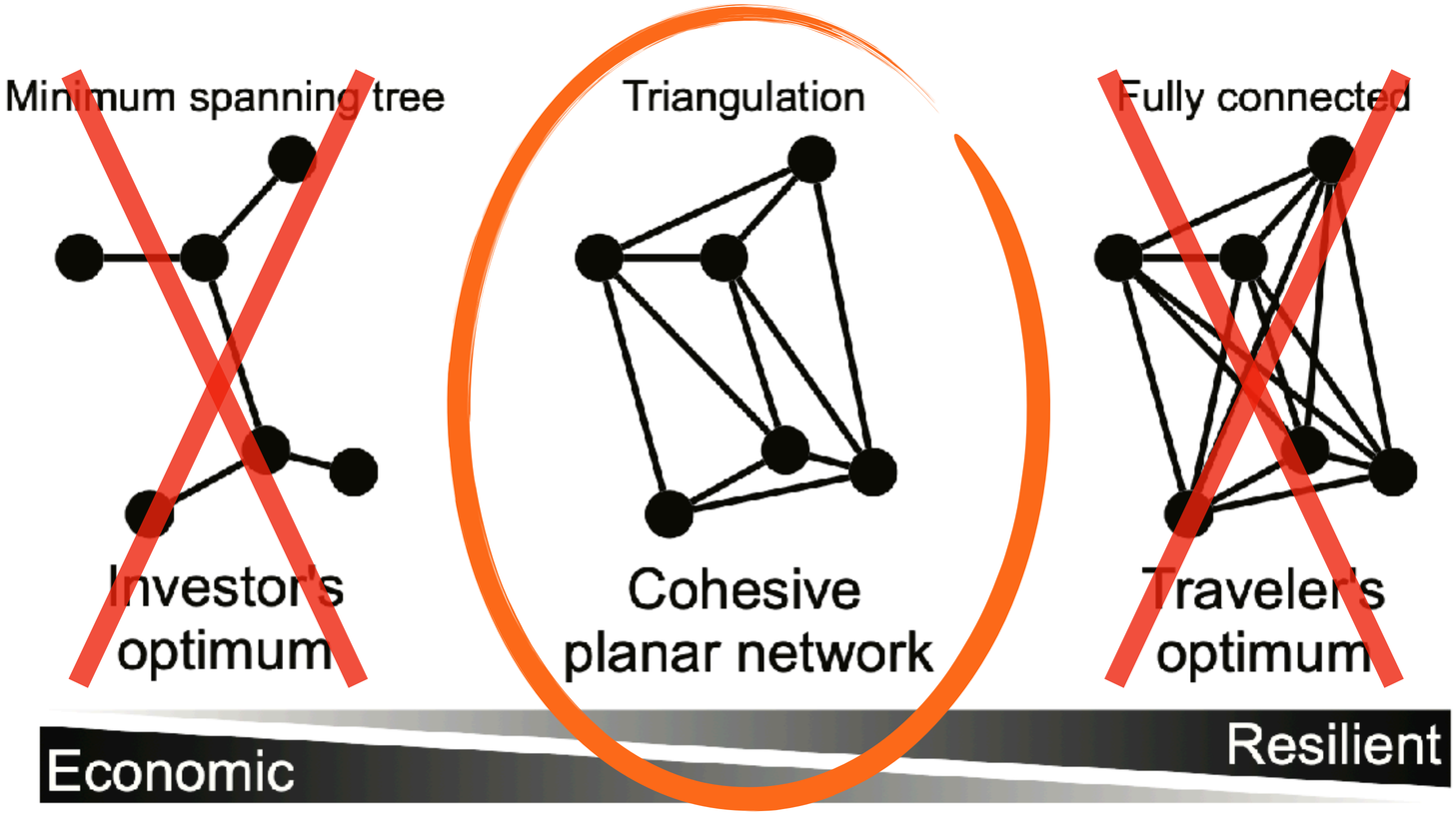
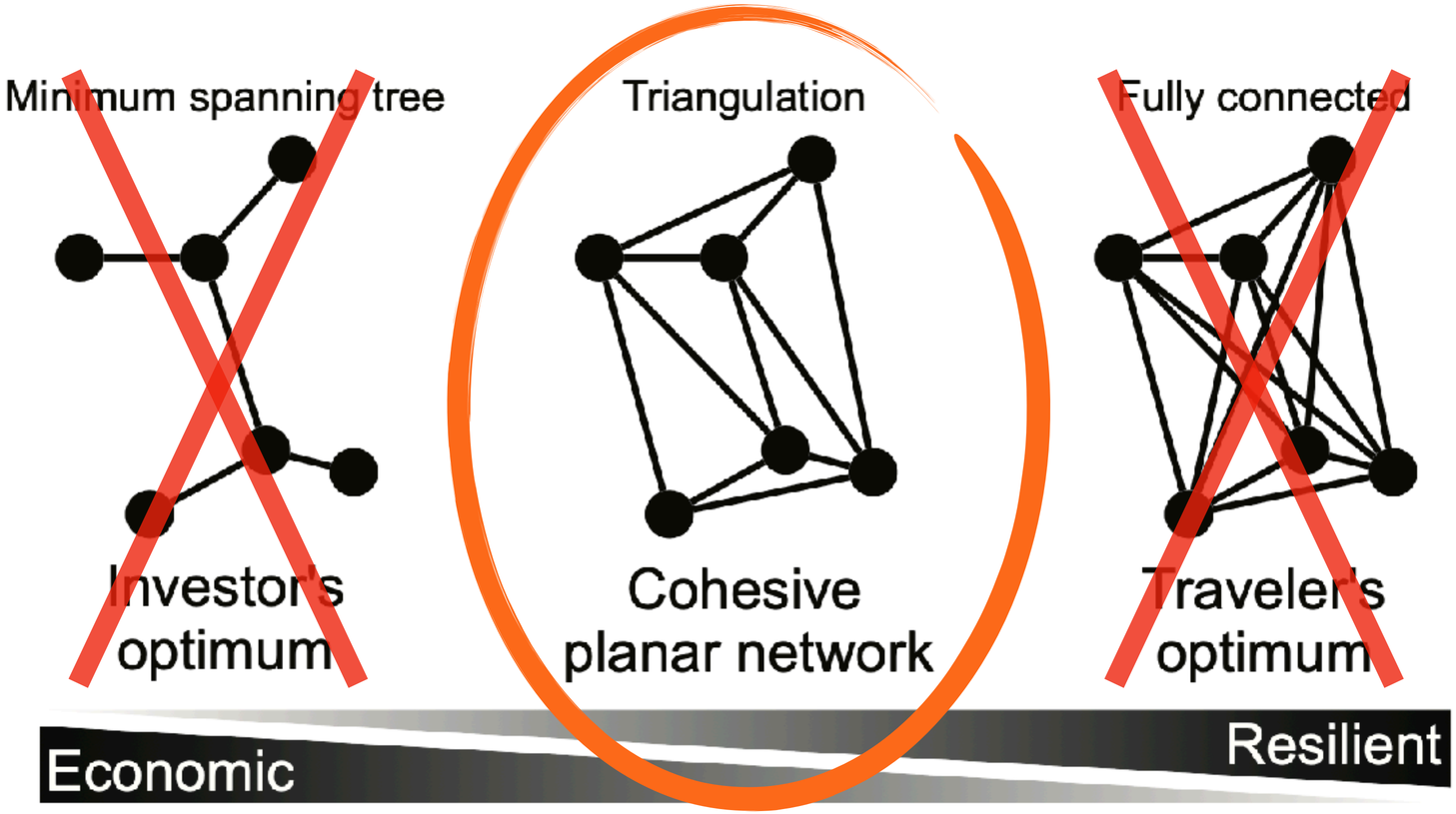


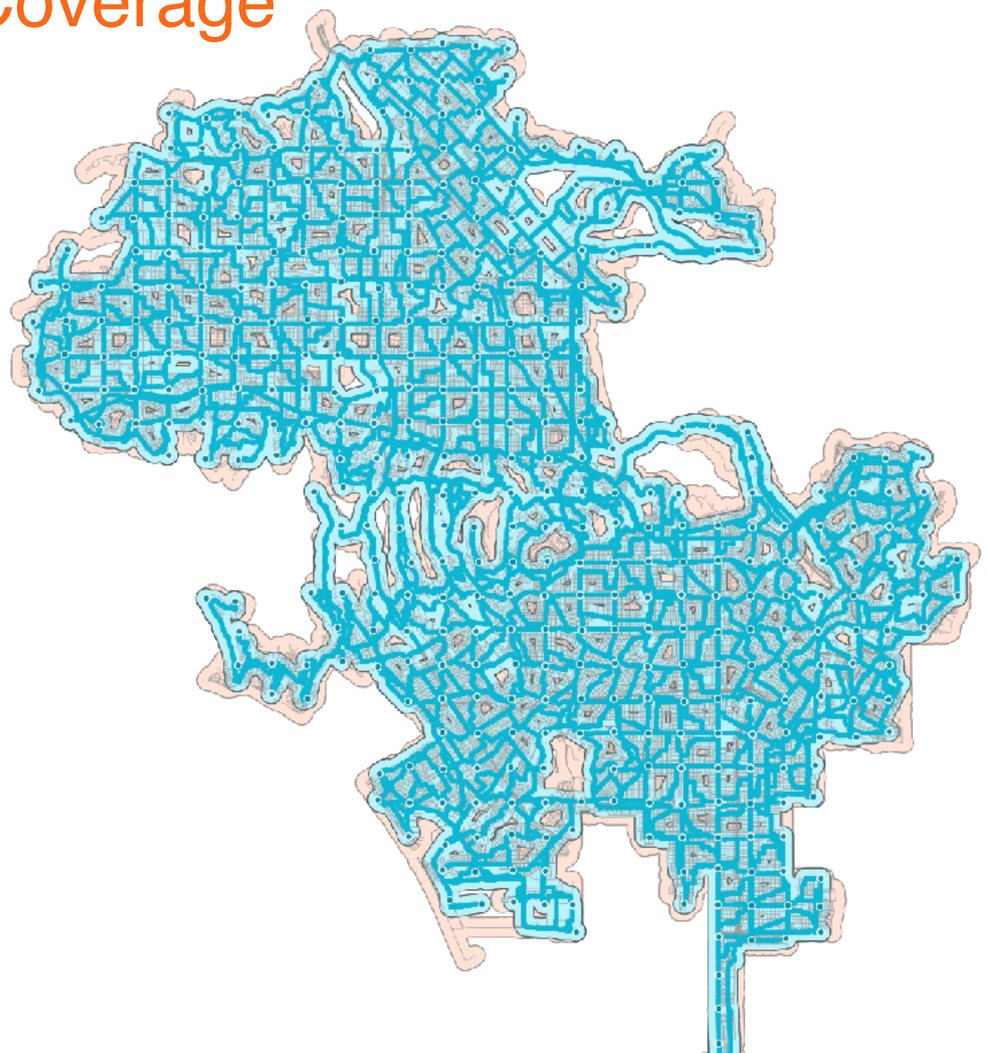
Szell et al., Sci Rep 12, 6765 (2022)

Inspired by CROW, we want a cohesive network

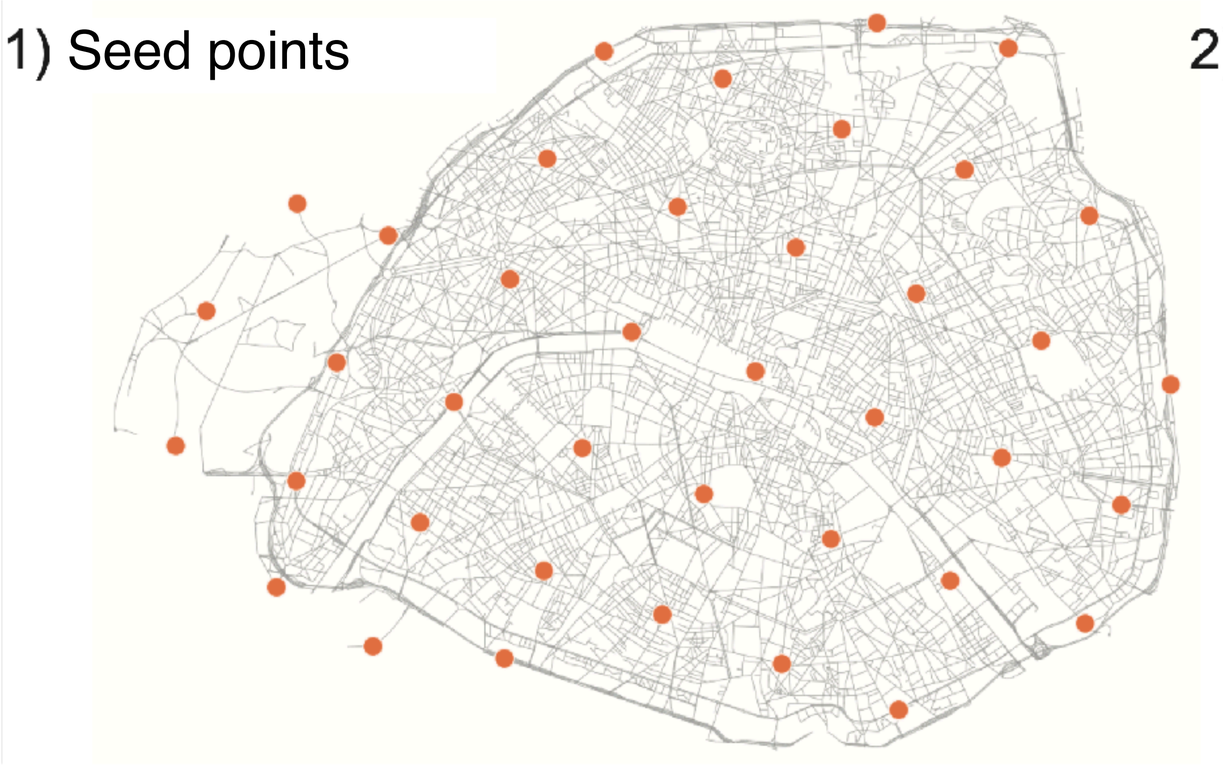
Connectedness & Resilience

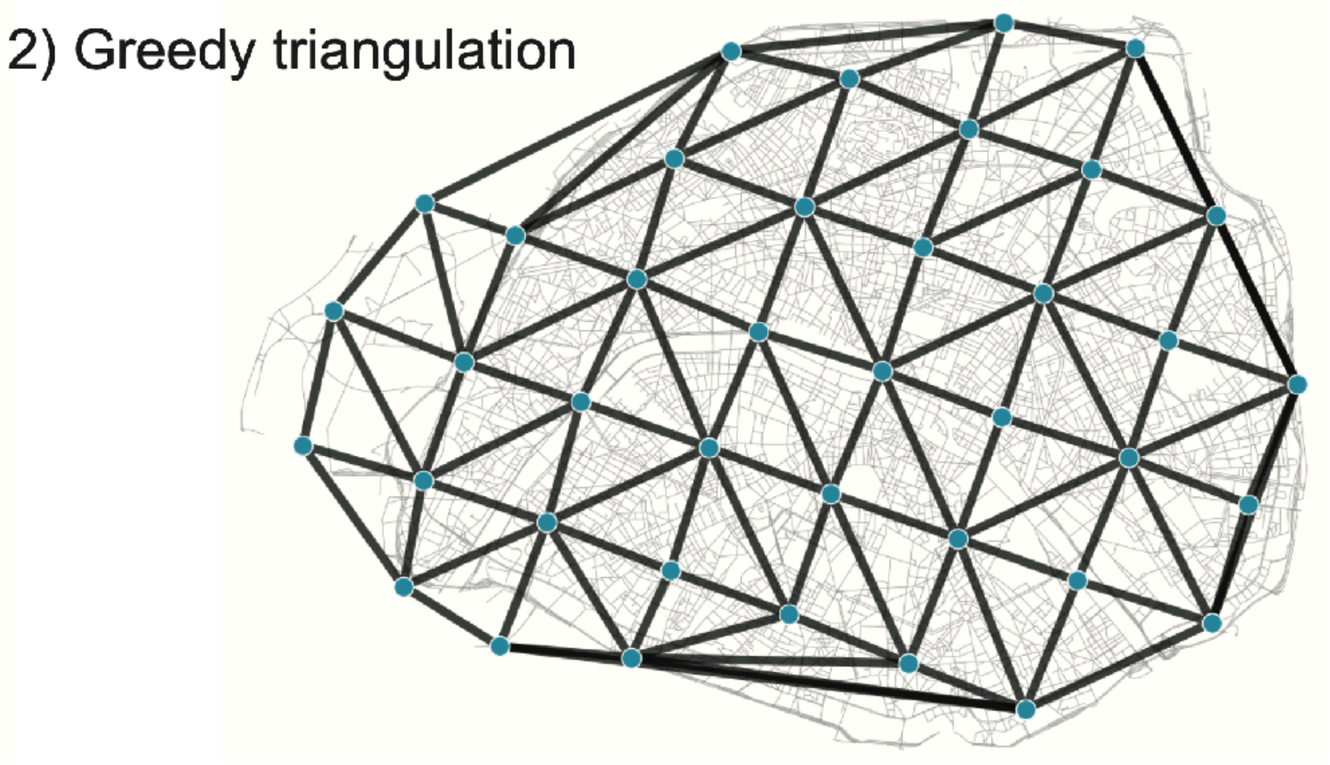
& Coverage





We build a greedy triangulation between points of interest

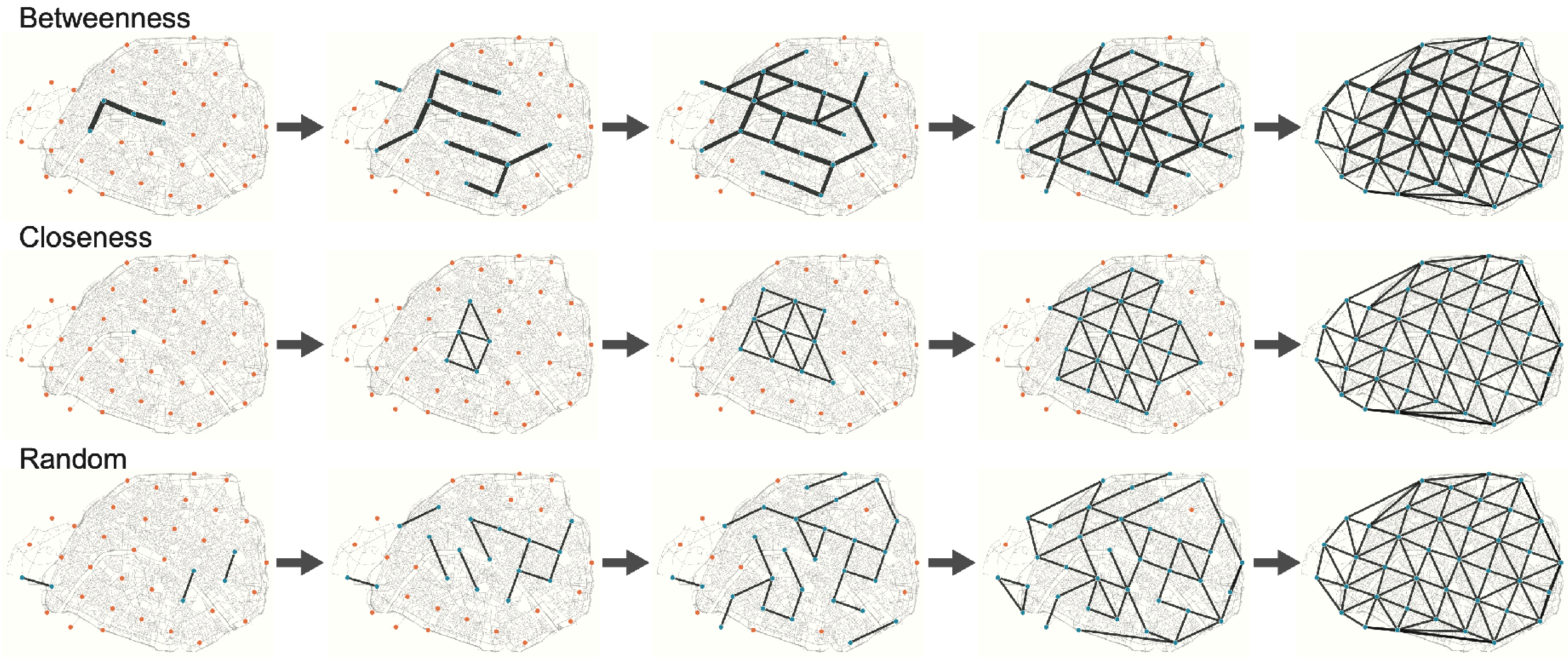




Szell et al., Sci Rep 12, 6765 (2022)

We build a greedy triangulation between points of interest

3) Order by growth strategy



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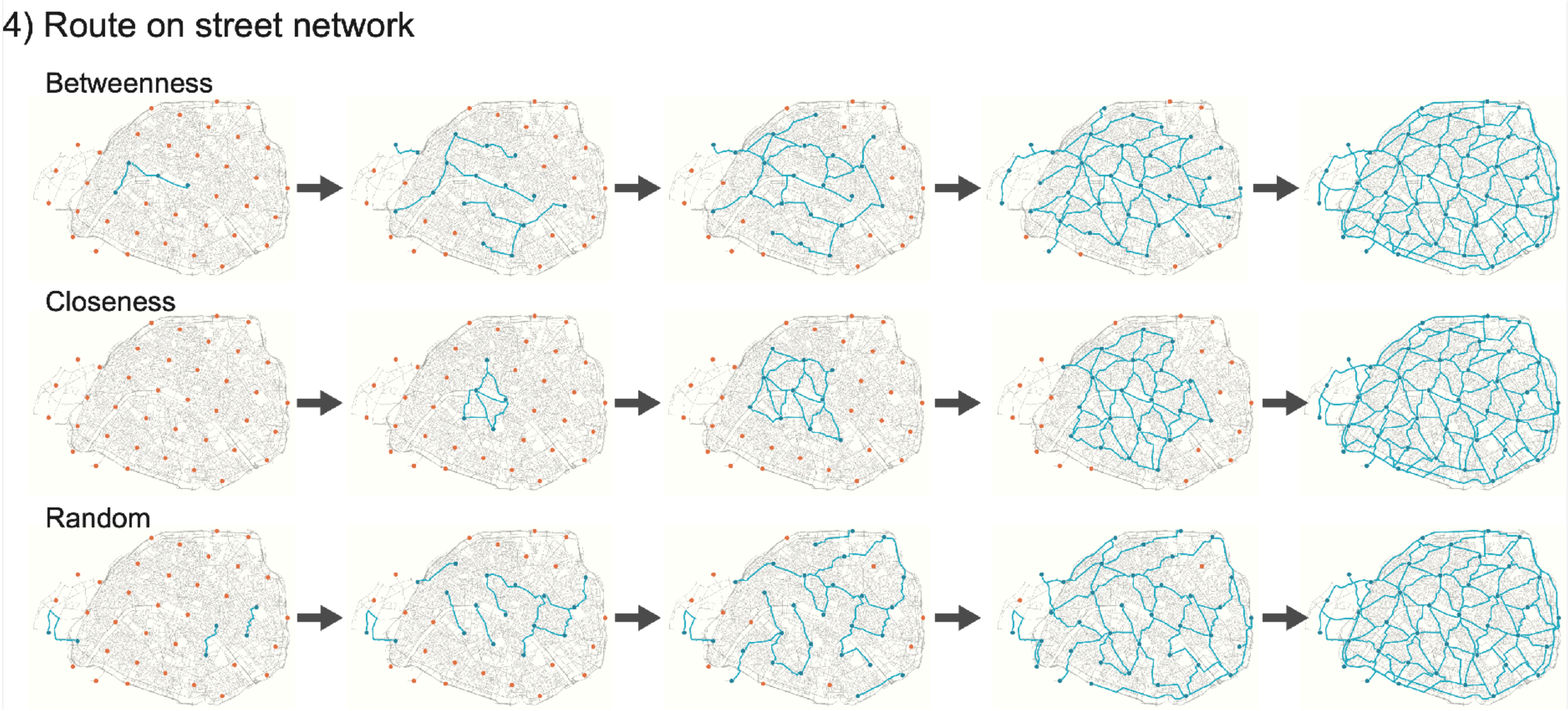
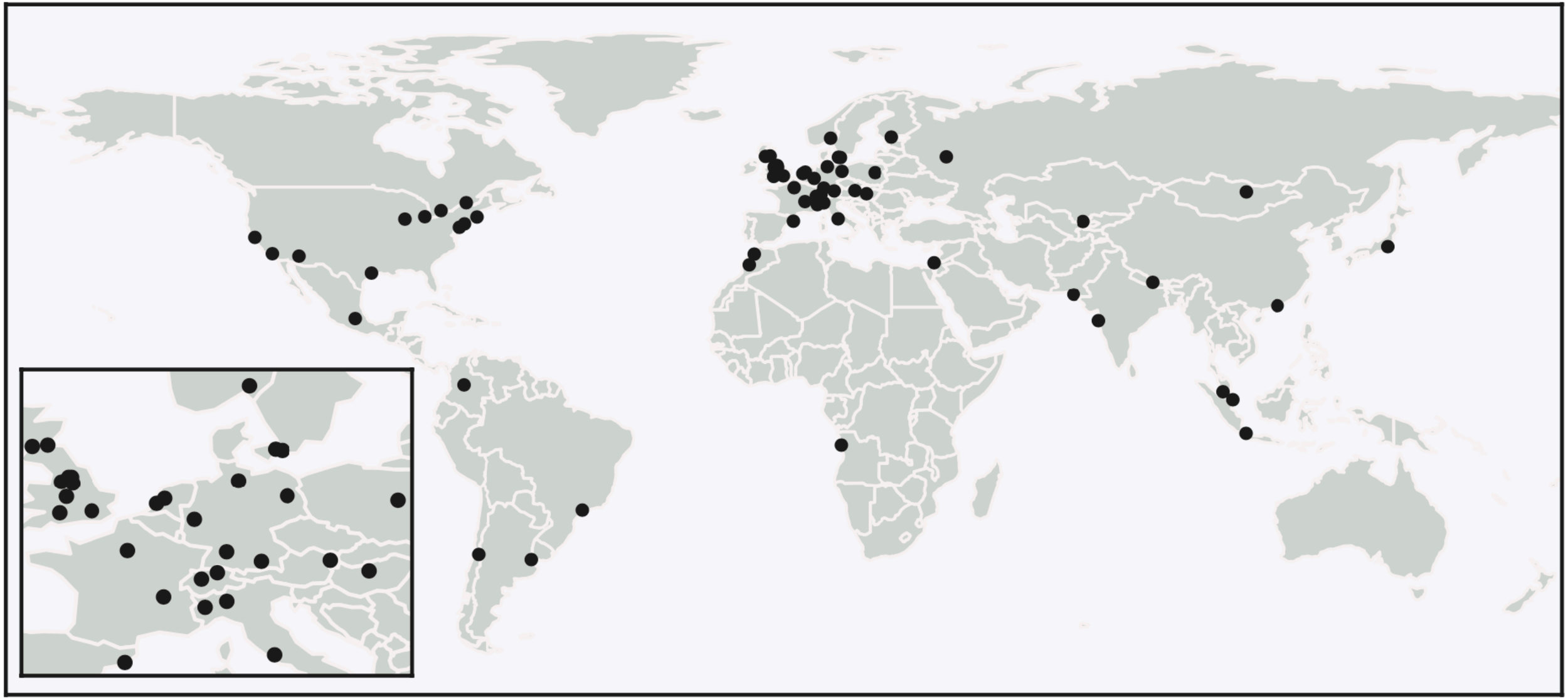


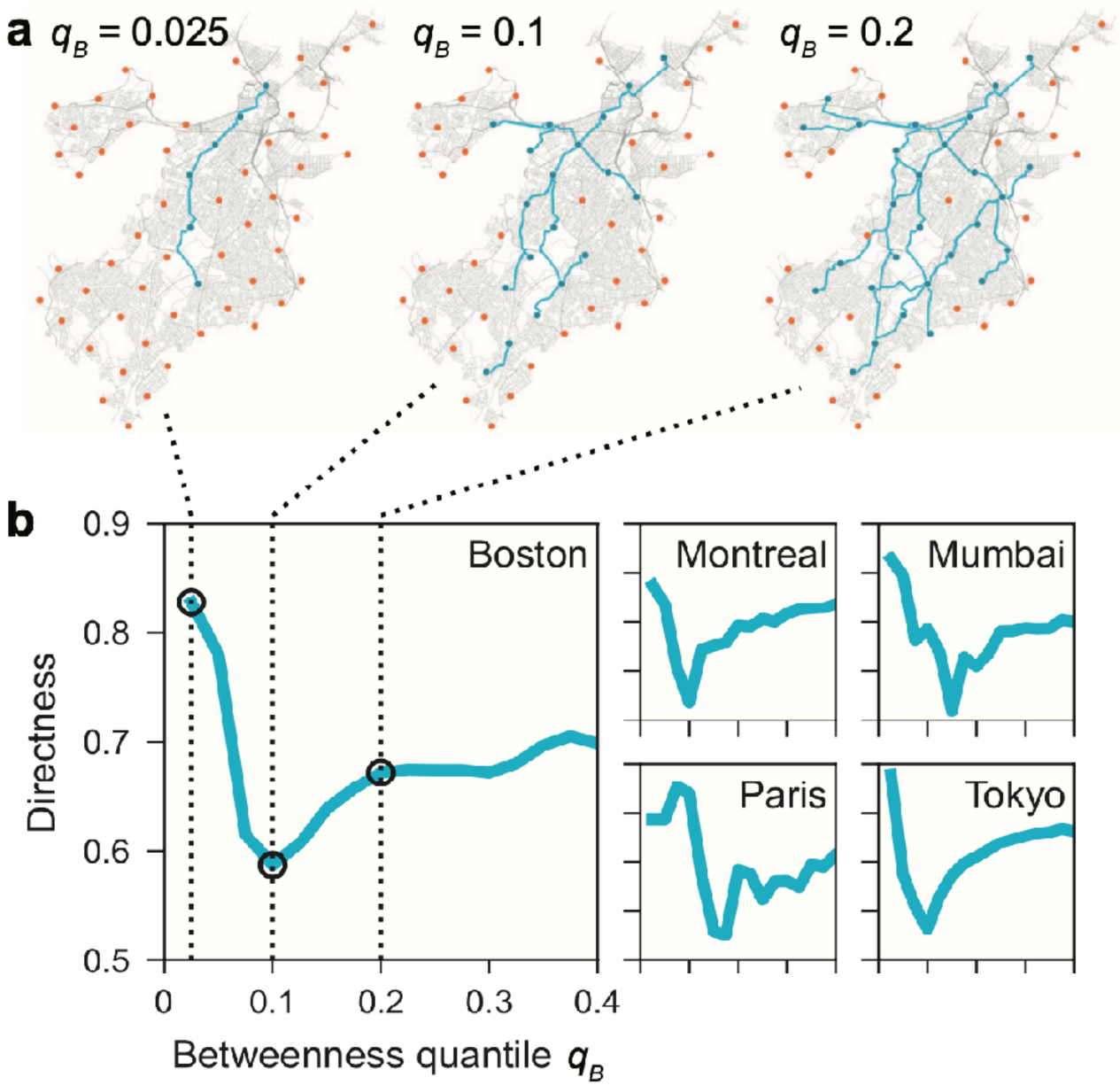
Szell et al., Sci Rep 12, 6765 (2022)

We explore 62 cities



Szell et al., Sci Rep 12, 6765 (2022)

Result 1: Investments need to surpass a critical threshold



The pieces need to connect and to form cycles

Szell et al., Sci Rep 12, 6765 (2022)

Policy implication 1: Invest persistently!

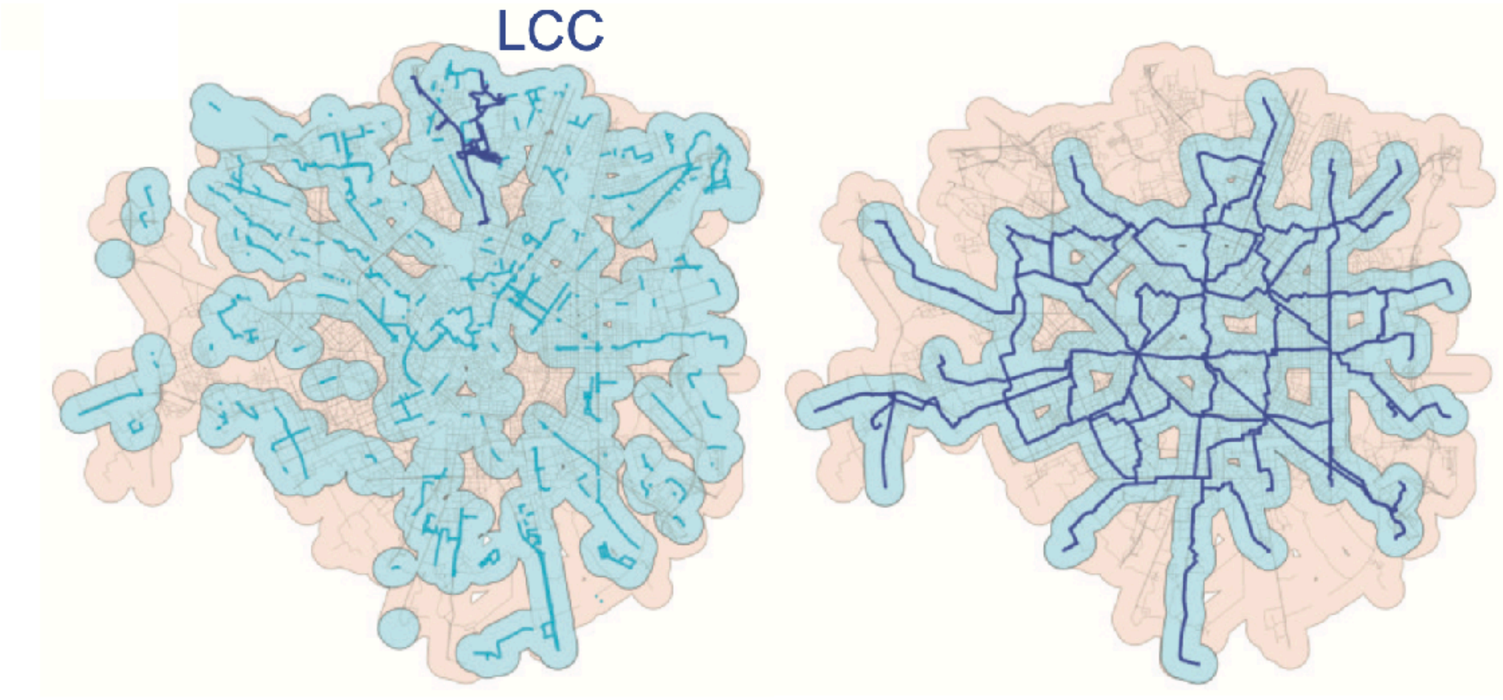
Brent Toderian @BrentToderian · Jul 30

My real advice for ambitious municipal elected leaders on building a safe, connected network of REAL (not painted lines or sharrows) bike infrastructure — direct your staff to do ALL of the work that you're currently planning to build over the next 5-10 years, ALL IN ONE YEAR.

https://twitter.com/BrentToderian/status/1420907319982915587?s=20

Result 2: It's not a network's length that matters but how you grow it

At same length, we could do much better

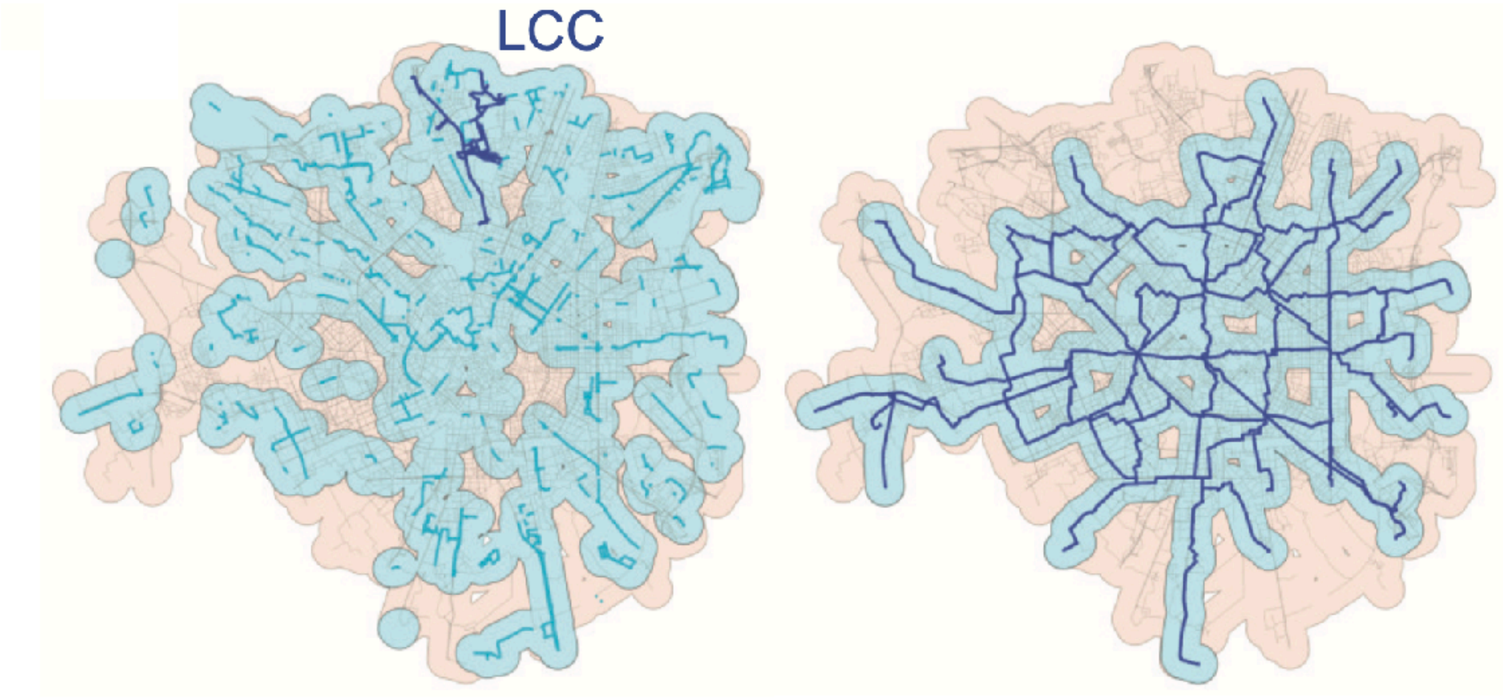


Real Milan

Synthetic Milan

Policy implication 2: Strategy matters: Build for the whole city

Avoid "random-like", piecewise growth



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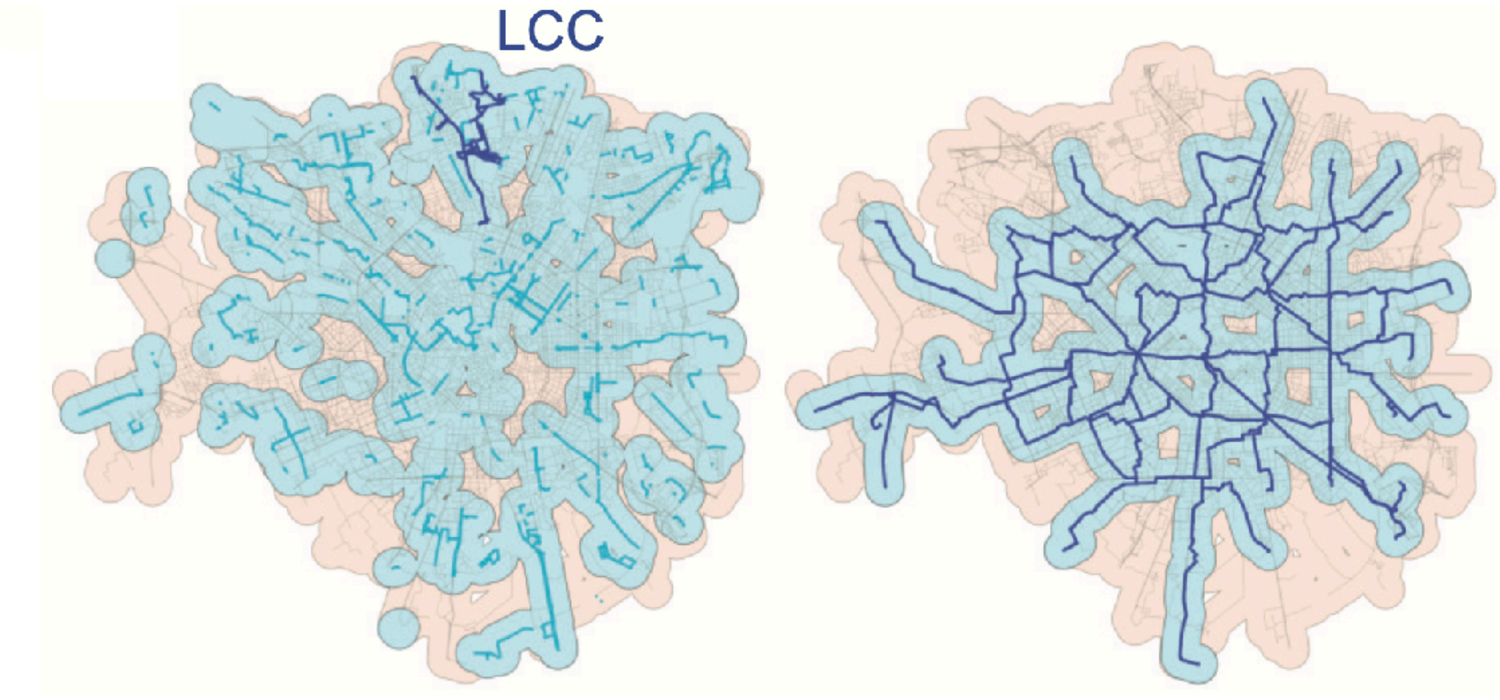
We've built many bike paths but nobody is using them, so why build more?



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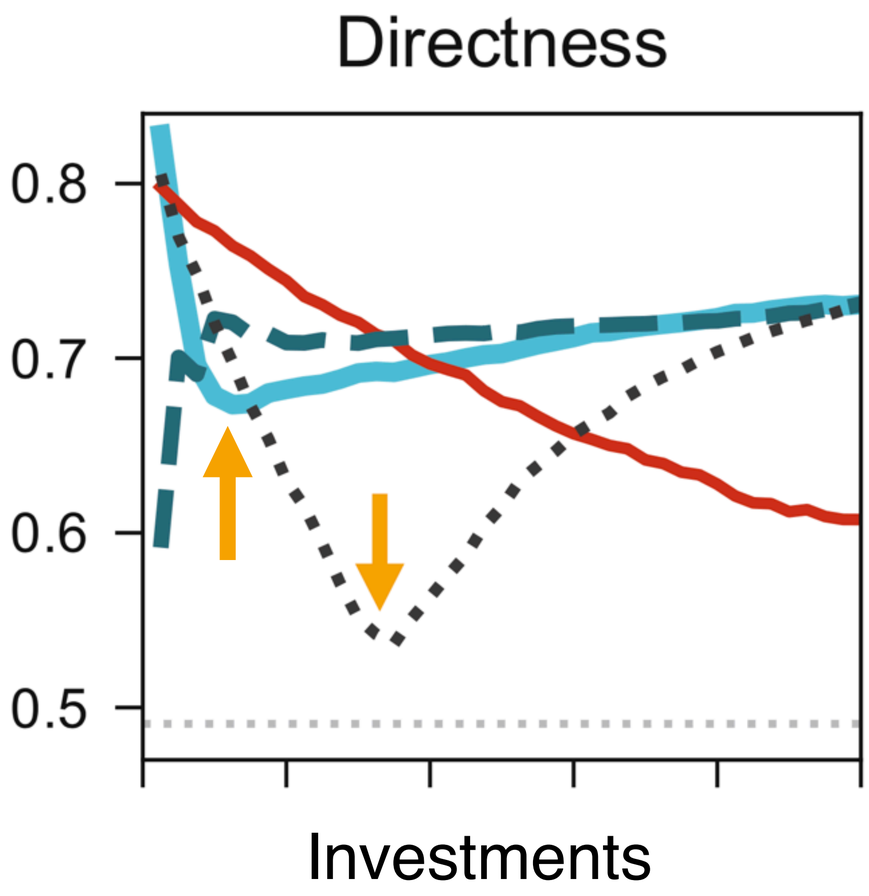
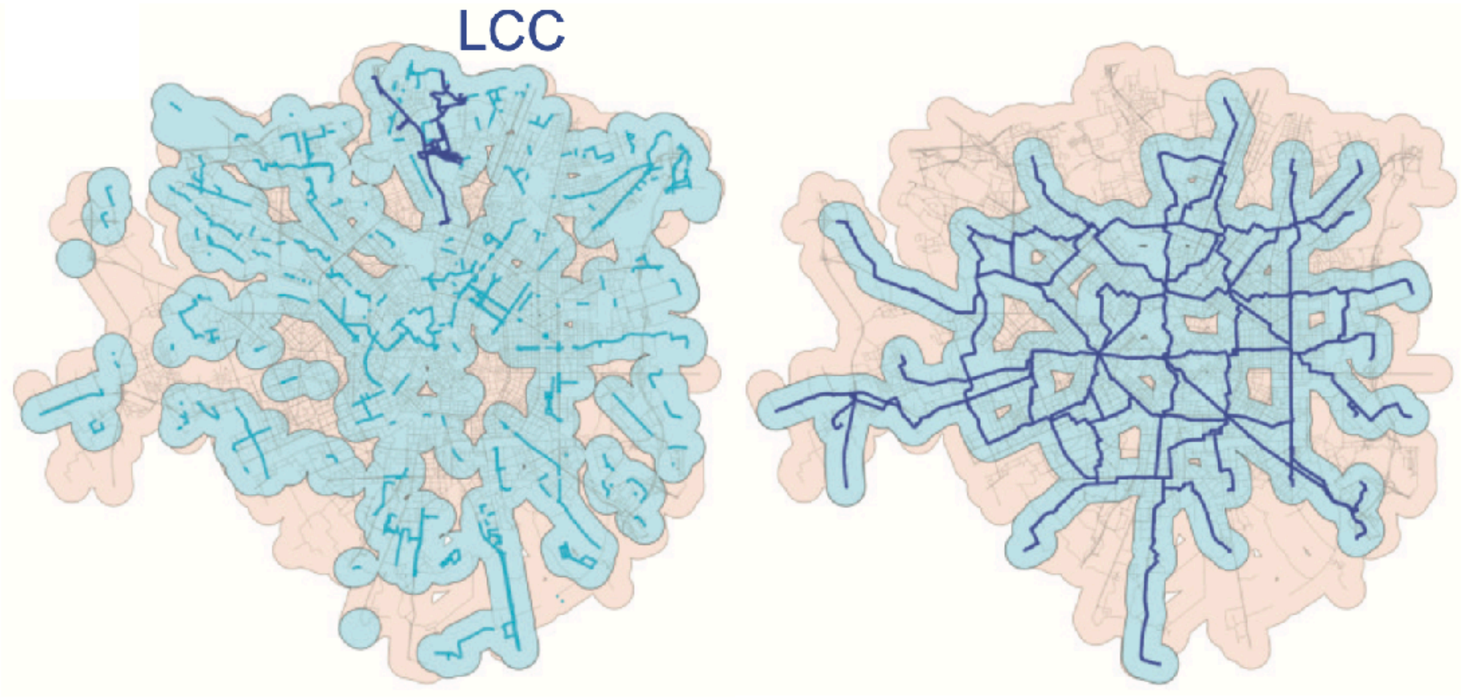


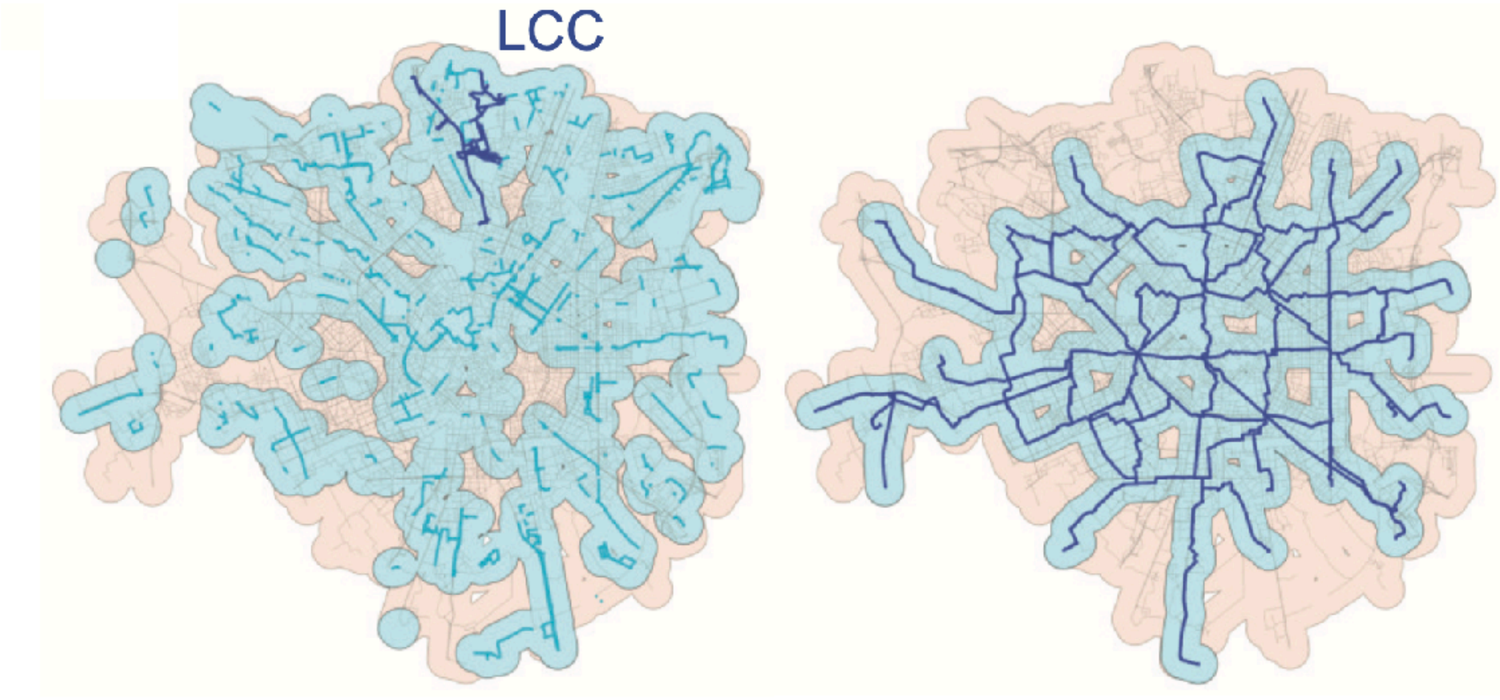


Real Milan

Synthetic Milan

Random growth needs 3x the investments than a global strategy

Easier said than done - Isn't this unrealistic??

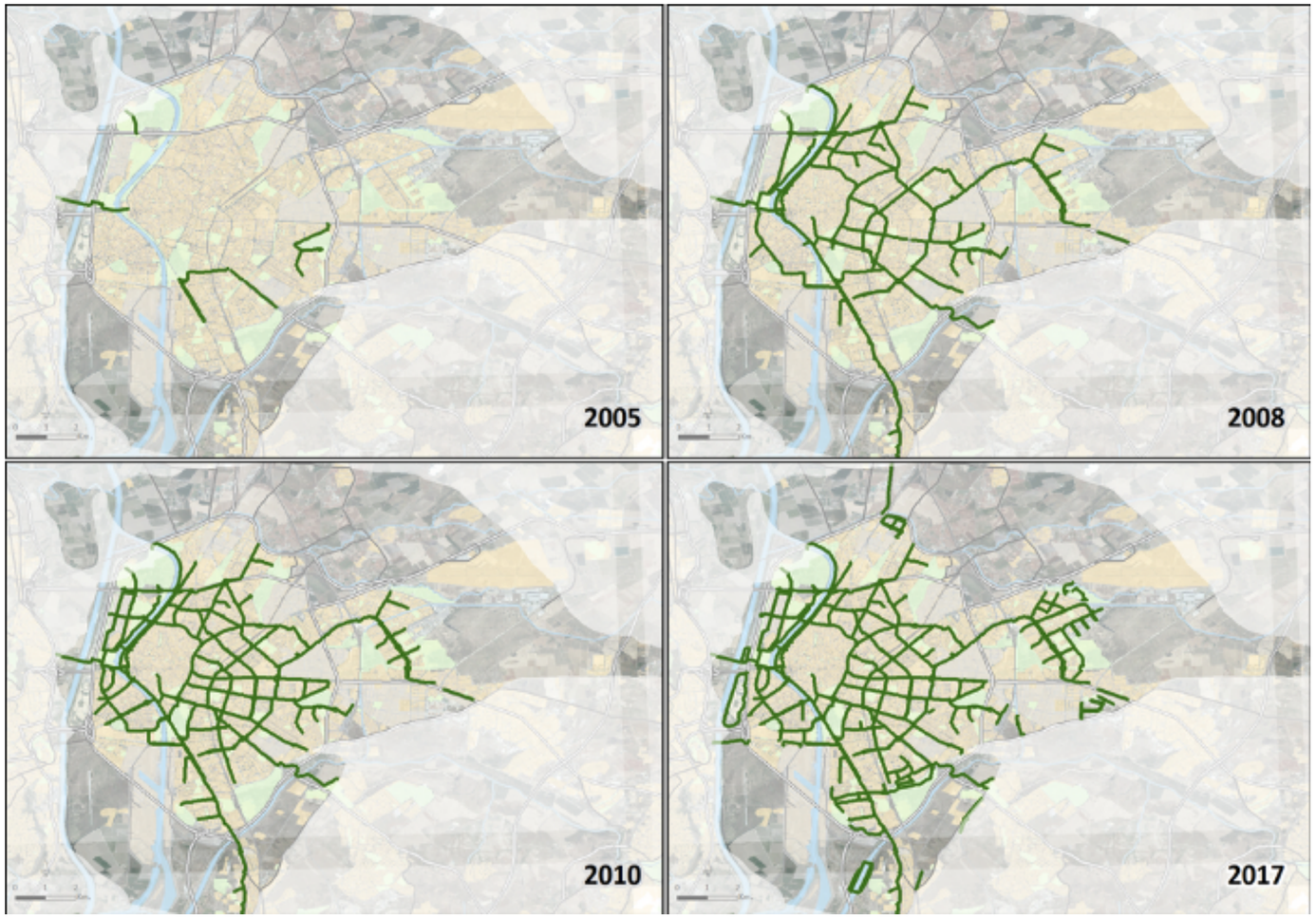


Real Milan

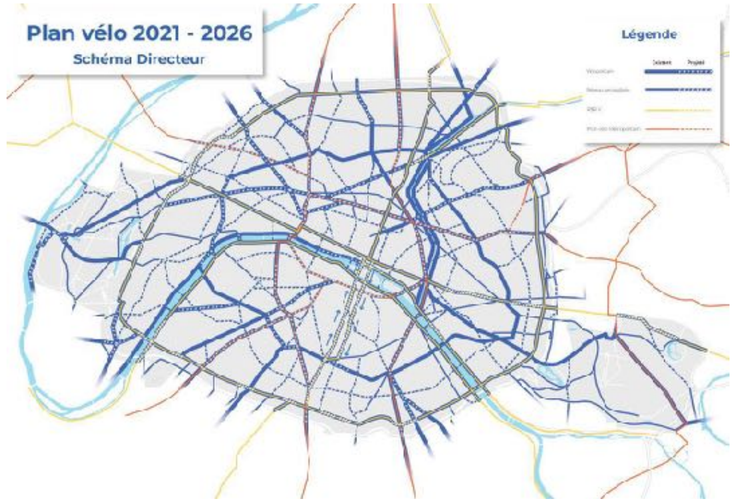
Synthetic Milan

Easier said than done - Isn't this unrealistic??

Nope: See Seville



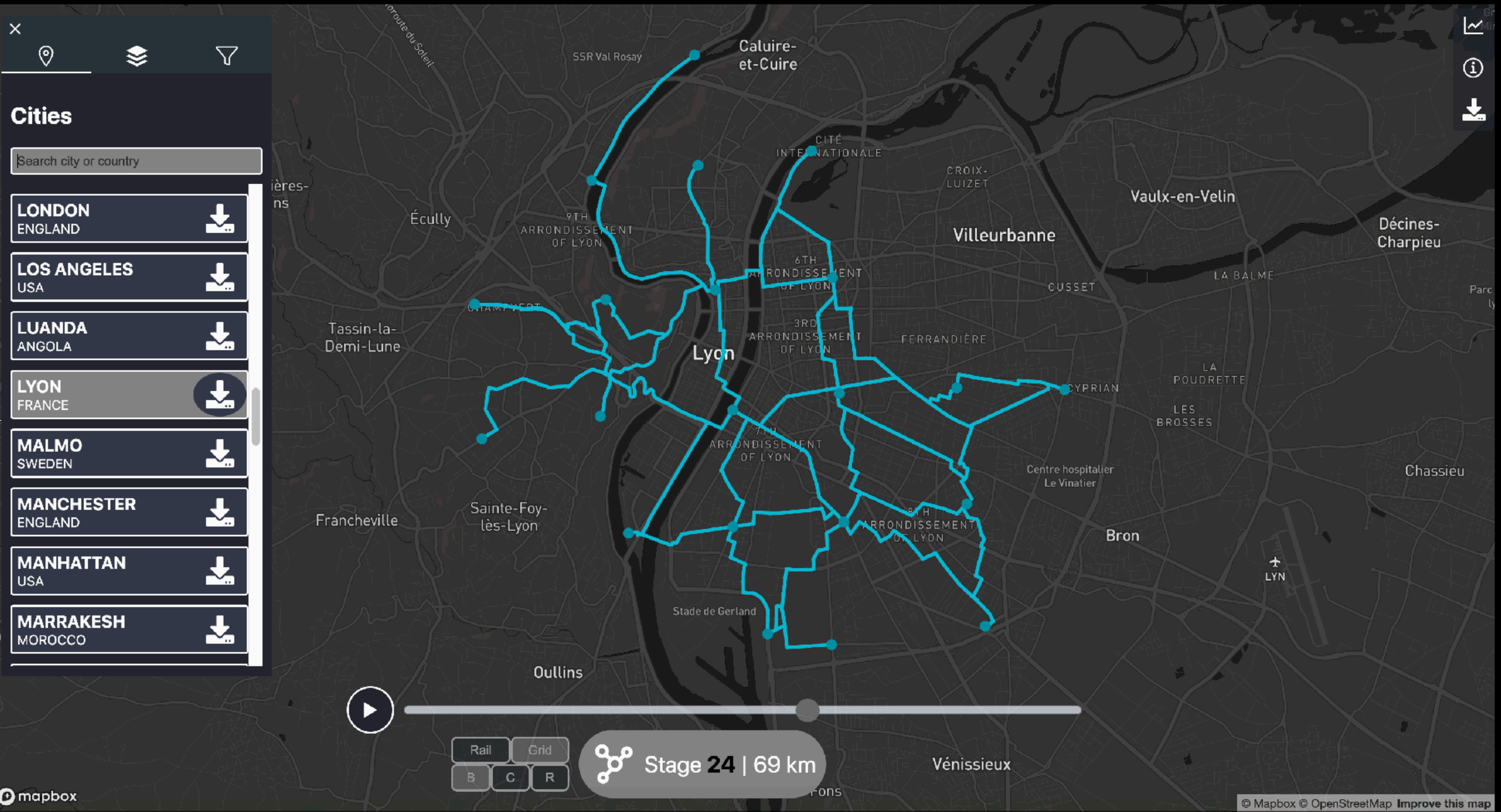
Also: Paris, Oslo, ...



There is no excuse

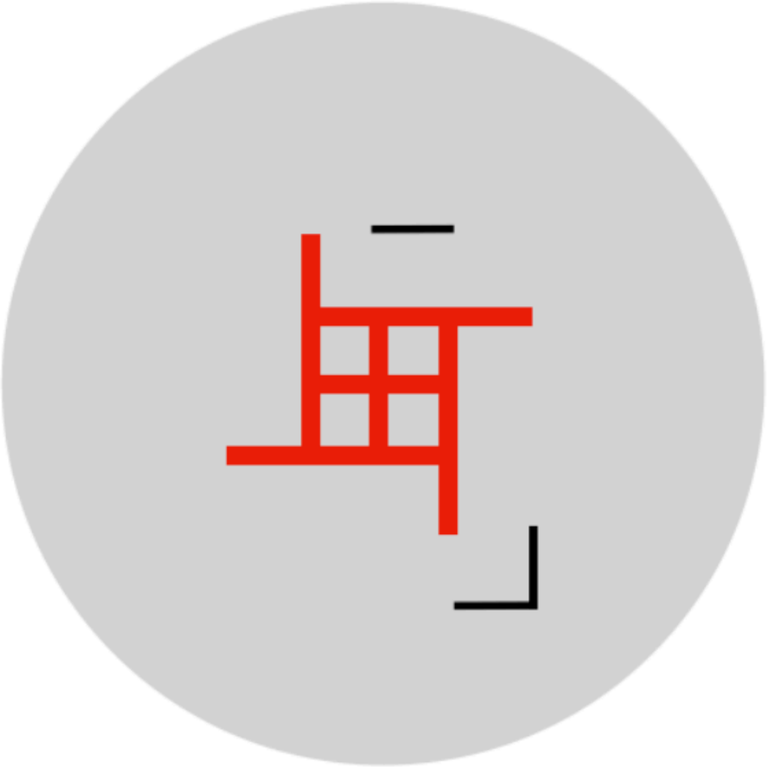
https://usa.streetsblog.org/2020/10/13/best-practices-how-seville-became-a-city-of-cyclists/

Explore your city at GrowBike.Net



Most cities

Not developed

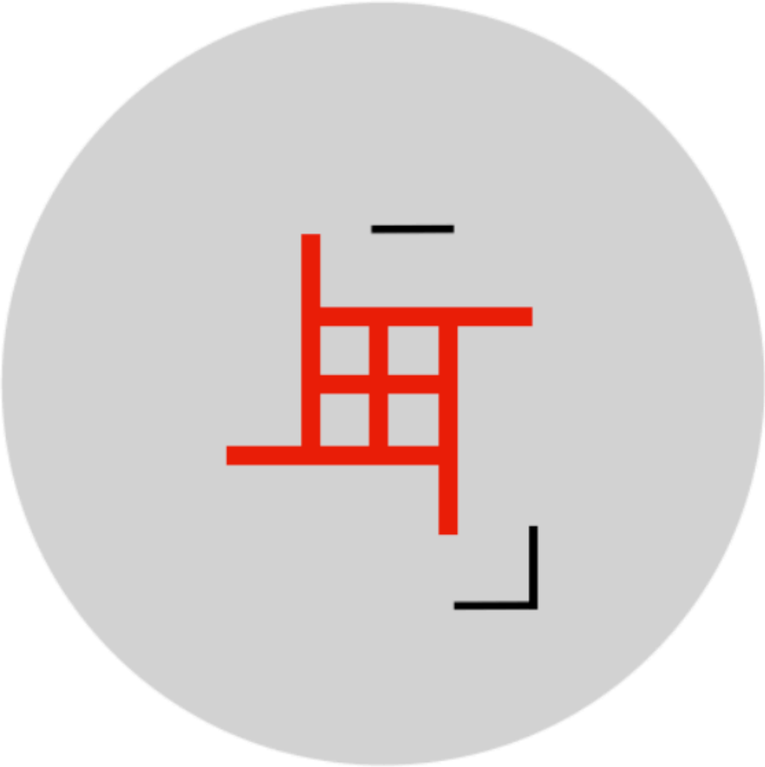


Grow from scratch

GrowBike.Net

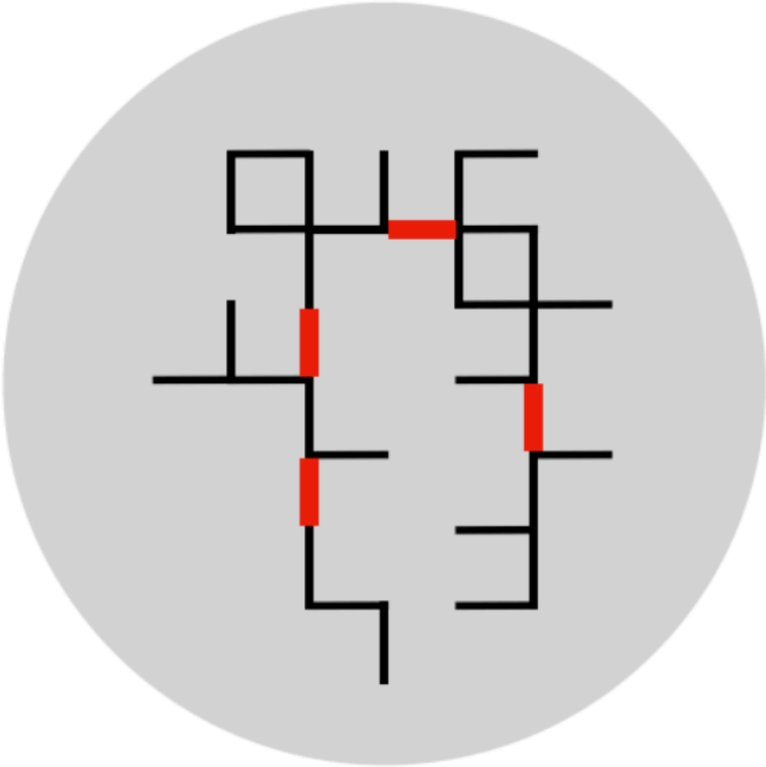
Different cities need different strategies

Most cities
Not developed



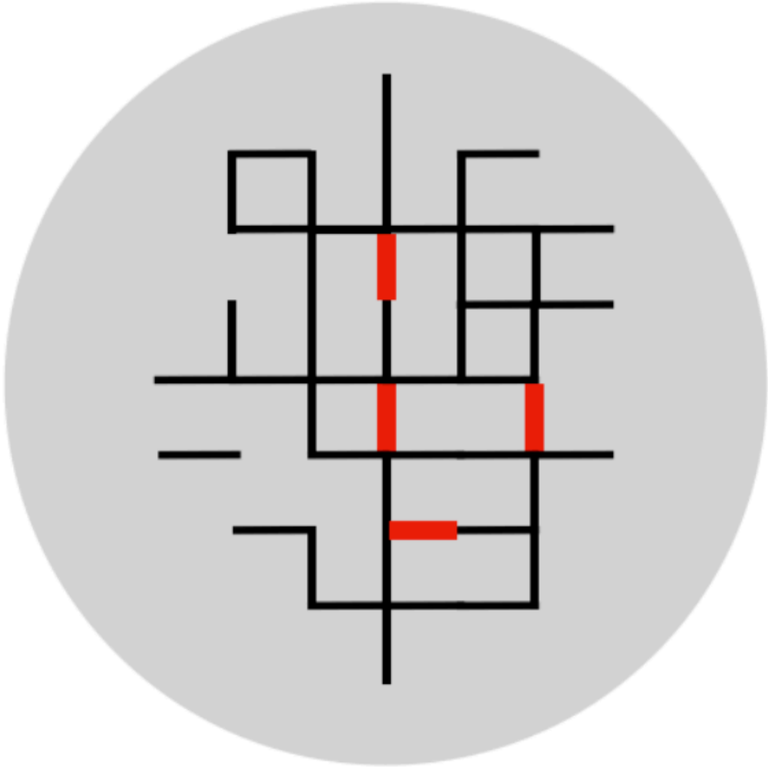
Grow from scratch
GrowBike.Net

Some cities
Developed but disconnected



Connect components
LinkBike.Net

Few cities
Developed and mostly connected



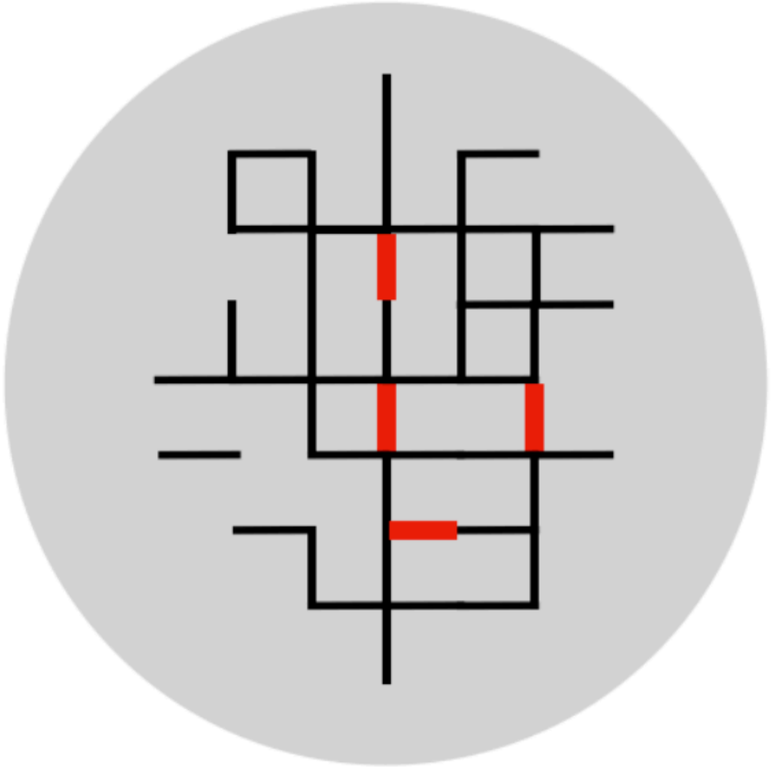
Find missing links
FixBike.Net

Fixing bicycle networks

Anastassia Vybornova

Few cities

Developed and mostly connected



Find missing links

FixBike.Net

How to find the missing links in well-developed networks?

In Copenhagen, most of the network is 1 connected component.

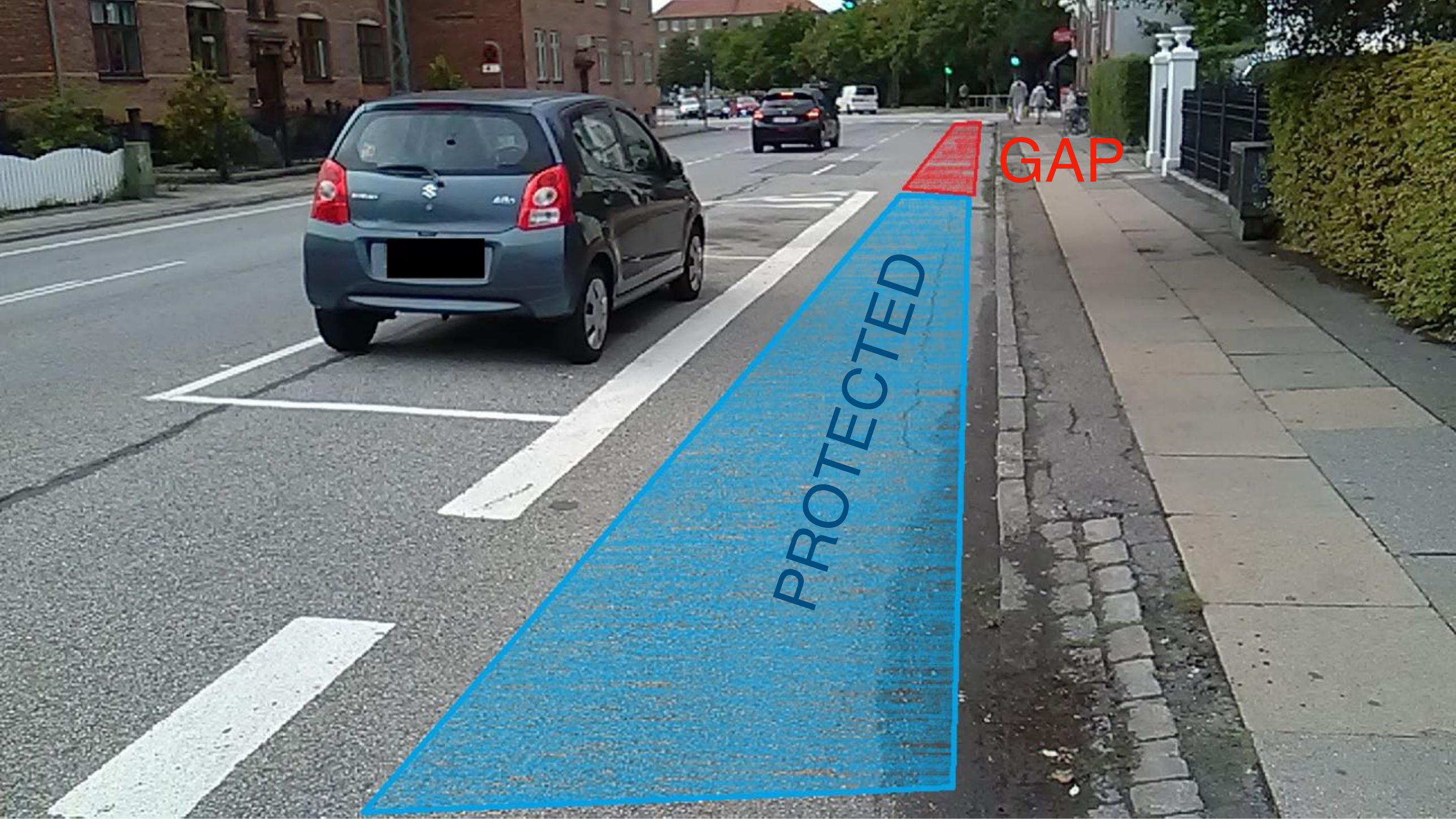
Anastassia Vybornova

How to find the missing links in well-developed networks?

In Copenhagen, most of the network is 1 connected component.

Still, there are a lot of "missing links".

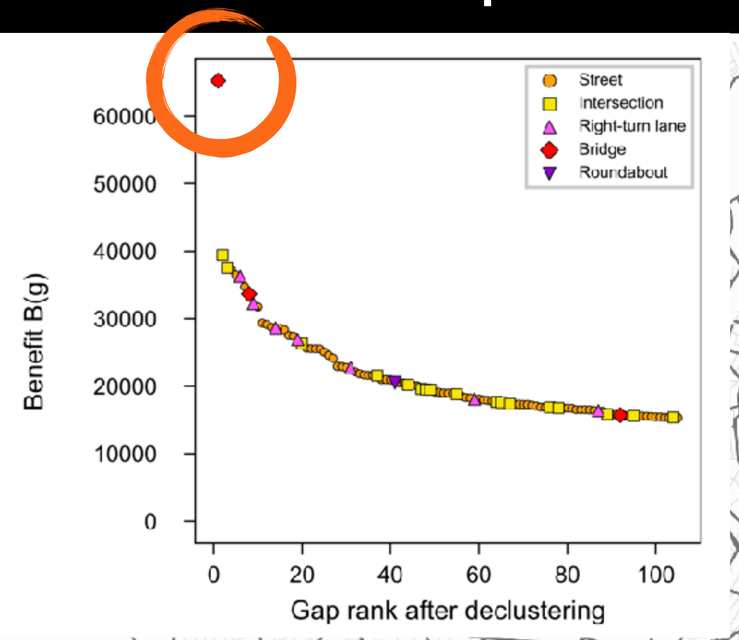
How to find them?
How to prioritize them?

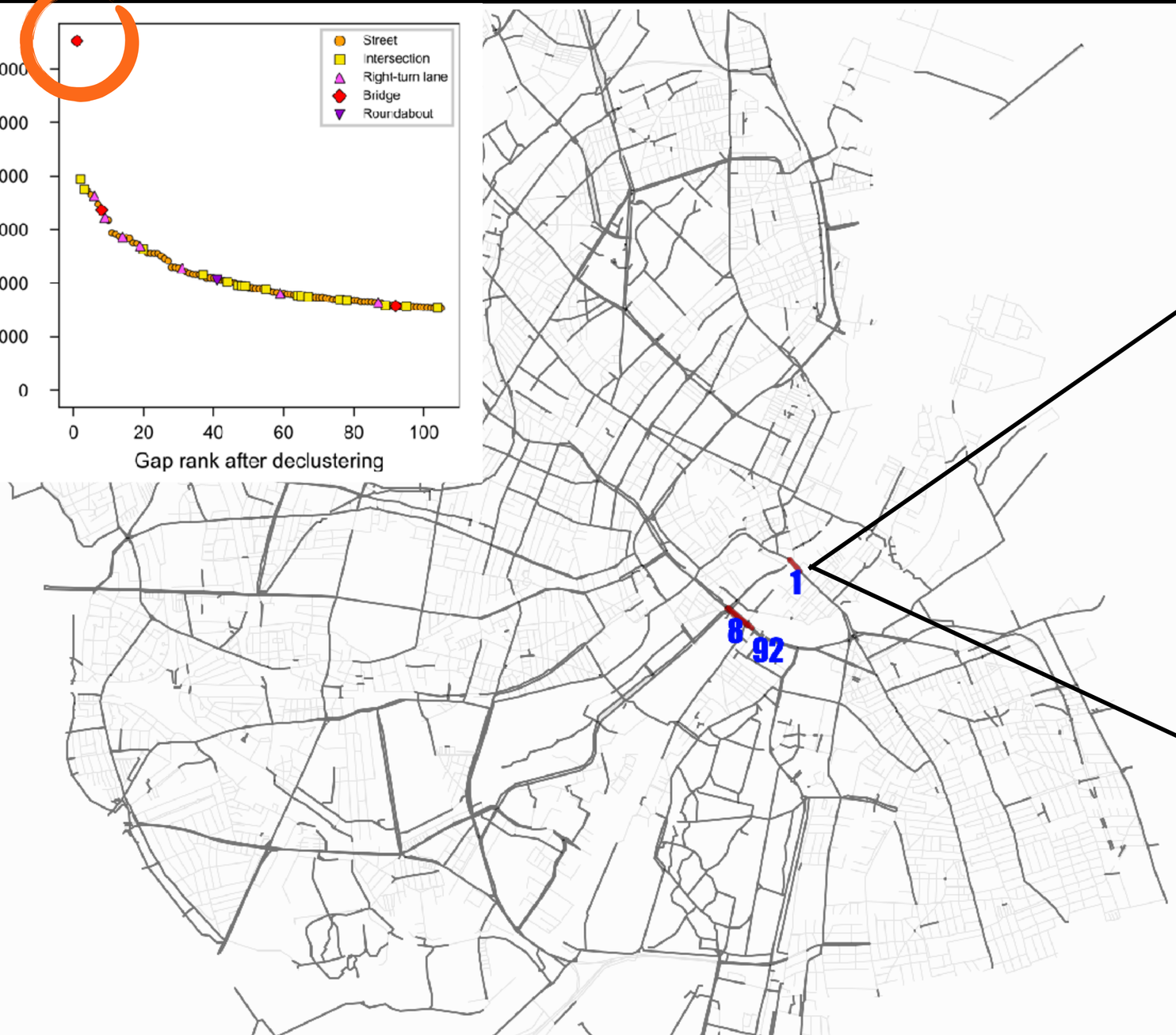

GAP
PROTECTED

From map to gap: IPDC

1) Identify gaps
2) Prioritize gaps
3) Decluster gaps
4) Classify gaps

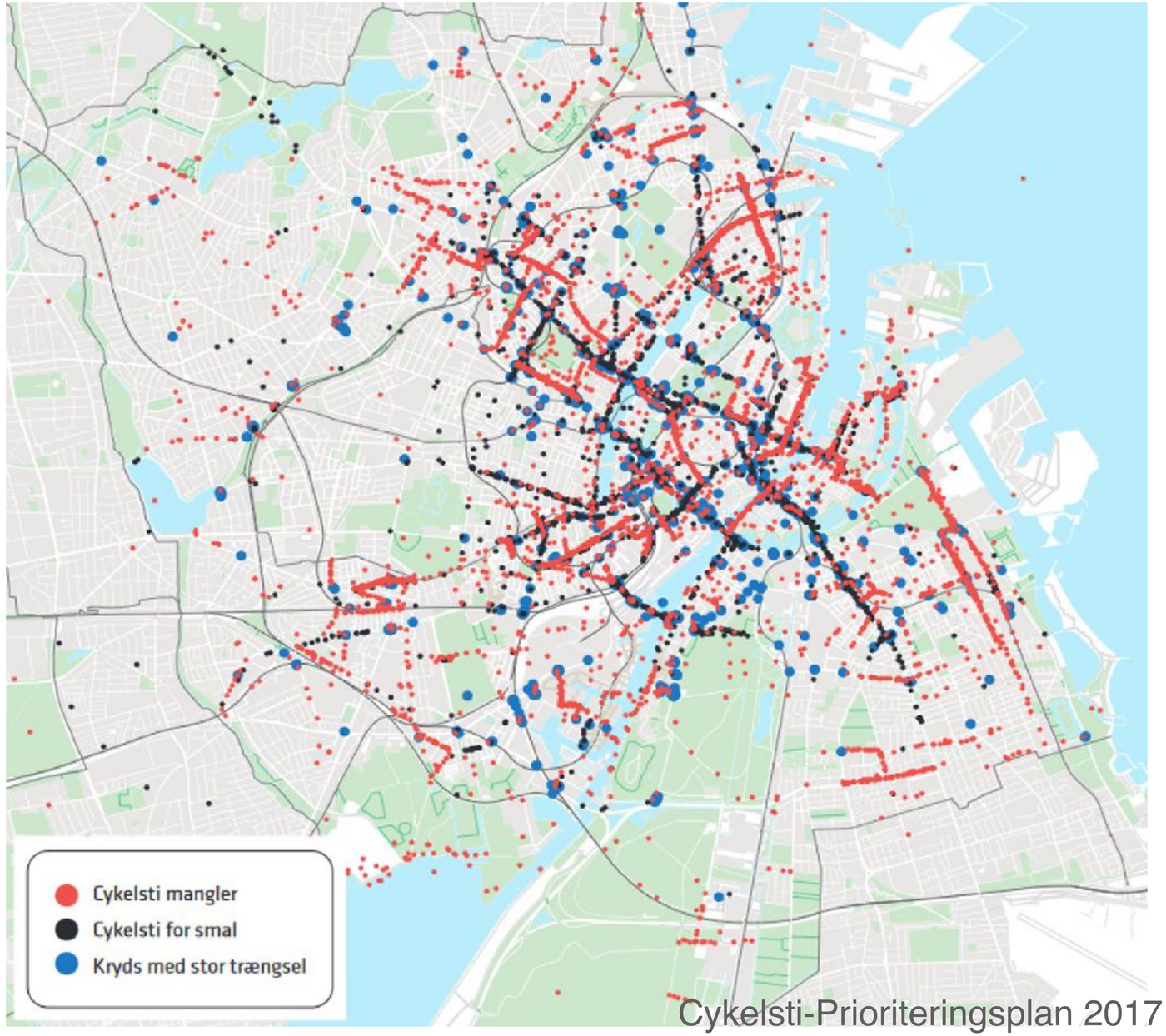
The most important gaps are bridges





Vybornova et al, Geographical Analysis (2022)

Evaluation: Comparison with Cykelsti-Prioriteringsplan

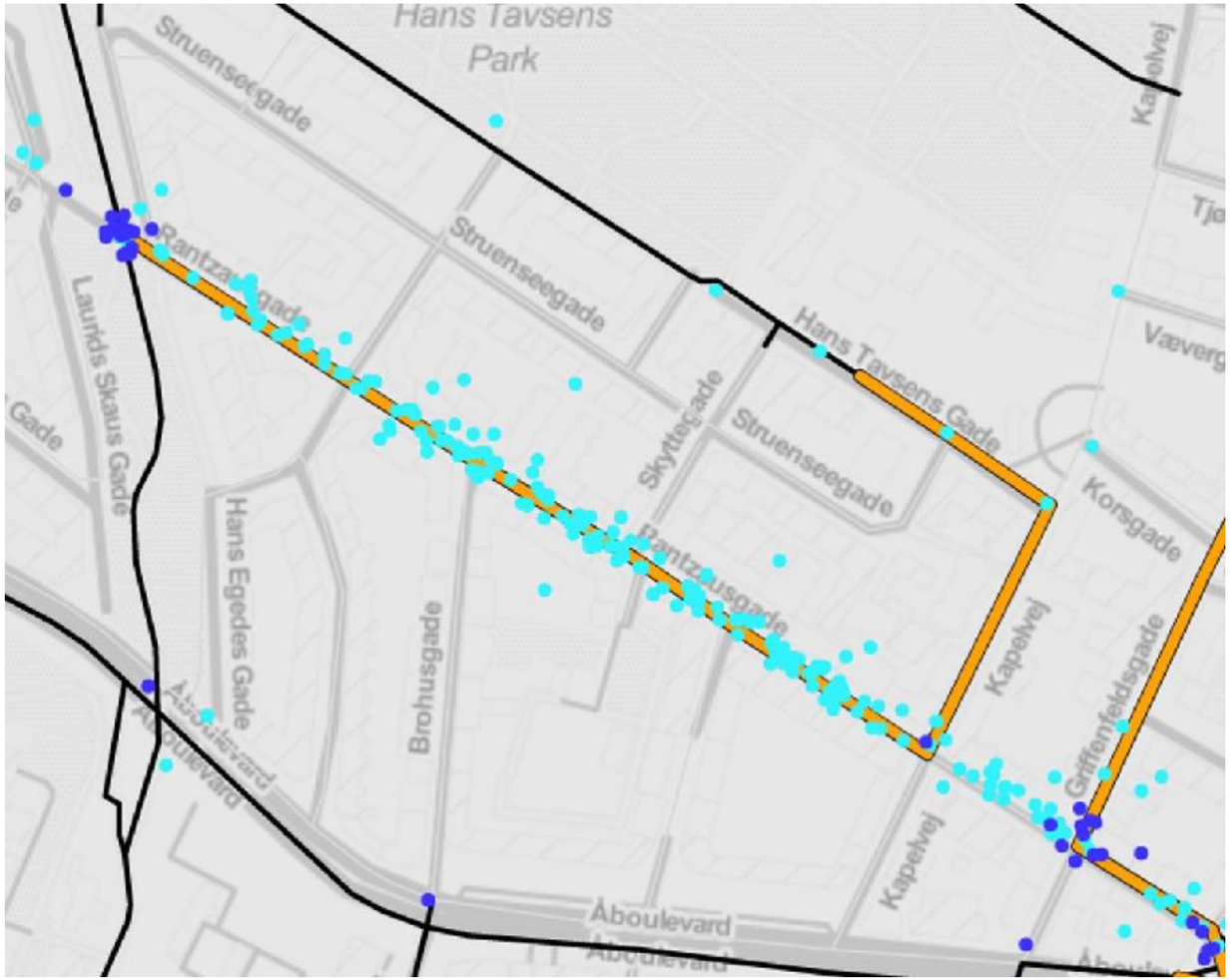


Cykelsti-Prioriteringsplan 2017

Evaluation: Comparison with Cykelsti-Prioriteringsplan

Evaluation: We find many overlaps

Nørregade

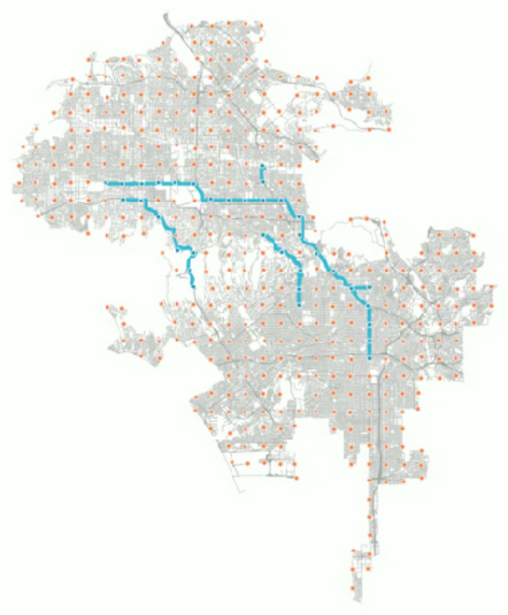


Rantzausgade

If your city is:

not developed

Los Angeles

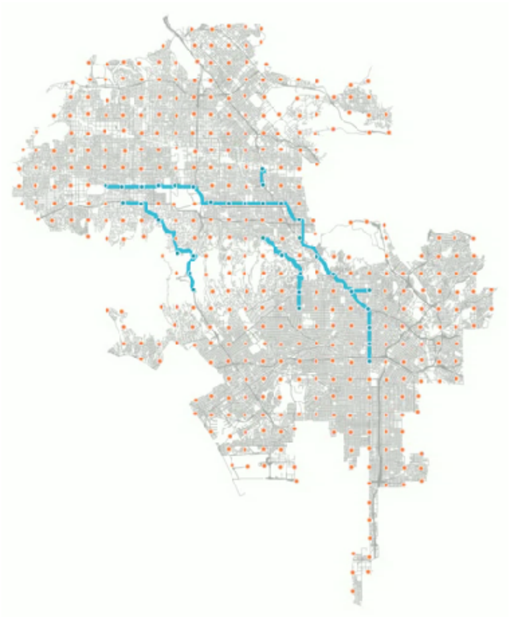


Grow persistently with focused investments

If your city is:

not developed

Los Angeles



Grow persistently with focused investments

medium developed

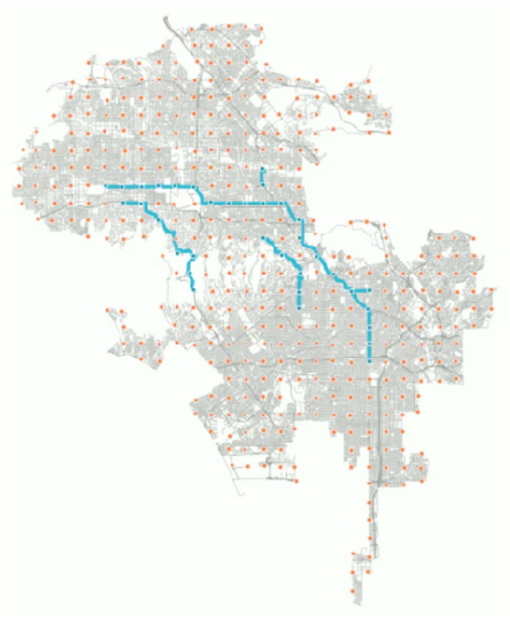
Budapest

Connect with right strategy

If your city is:

not developed

Los Angeles



Grow persistently with focused investments

medium developed

Budapest

Connect with right strategy

well developed

Copenhagen

Close the most important gaps

If your city is:

not developed

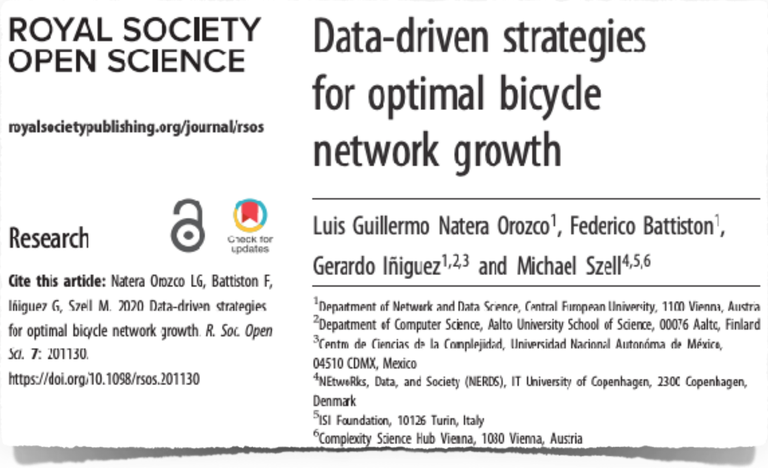
scientific reports

OPEN **Growing urban bicycle networks**

Michael Szell[1,2,3], Sayat Mimar[4], Tyler Perlman[4], Gourab Ghoshal[4] & Roberta Sinatra[1,2,3,5]

Grow persistently with focused investments

medium developed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Research

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https://doi.org/10.1098/rsos.201130

Data-driven strategies for optimal bicycle network growth

Luis Guillermo Natera Orozco[1], Federico Battiston[1], Gerardo Iñiguez[1,2,3] and Michael Szell[4,5,6]

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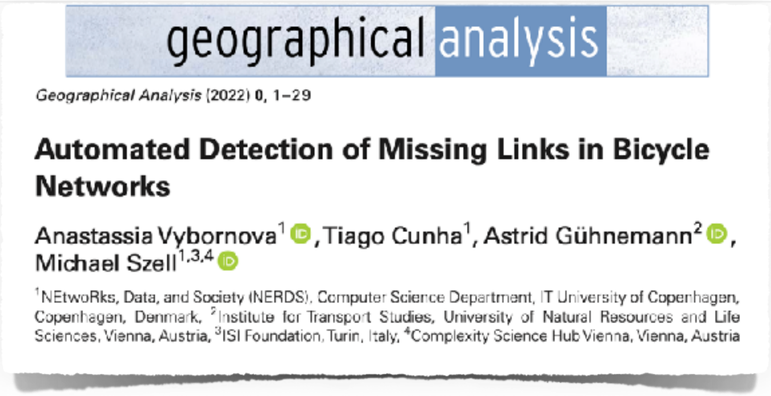
[2]Department of Computer Science, Aalto University School of Science, 00076 Aalto, Finland
[3]Centro de Ciencias de la Complejidad, Universidad Nacional Autónoma de México, 04510 CDMX, Mexico
[4]NEtwoRks, Data, and Society (NERDS), IT University of Copenhagen, 2300 Copenhagen, Denmark
[5]ISI Foundation, 10126 Turin, Italy
[6]Complexity Science Hub Vienna, 1080 Vienna, Austria

Connect with right strategy

well developed


geographical analysis

Geographical Analysis (2022) **0**, 1–29

Automated Detection of Missing Links in Bicycle Networks

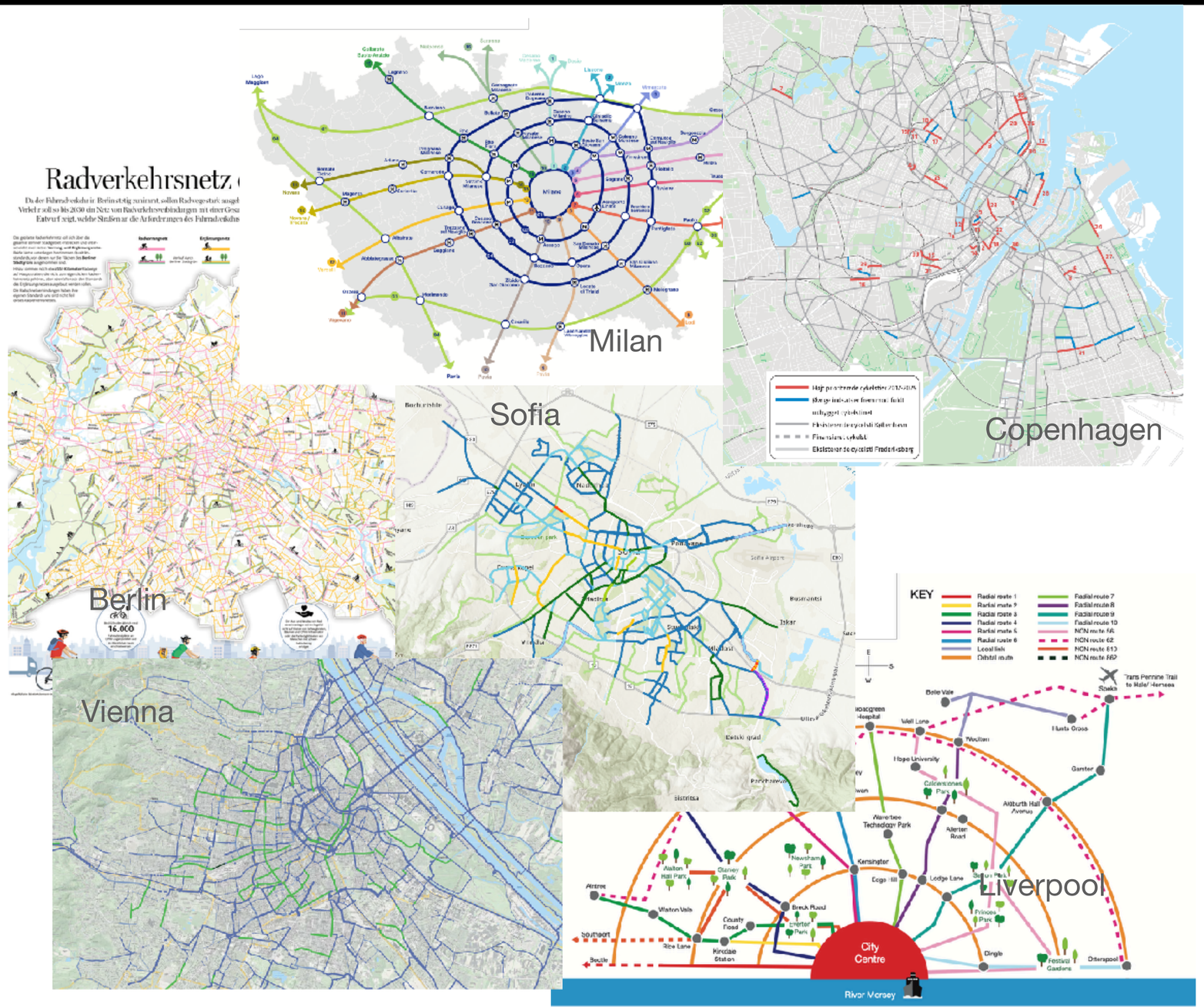
Anastassia Vybornova[1], Tiago Cunha[1], Astrid Gühnemann[2], Michael Szell[1,3,4]

[1]NEtwoRks, Data, and Society (NERDS), Computer Science Department, IT University of Copenhagen, Copenhagen, Denmark, [2]Institute for Transport Studies, University of Natural Resources and Life Sciences, Vienna, Austria, [3]ISI Foundation, Turin, Italy, [4]Complexity Science Hub Vienna, Vienna, Austria

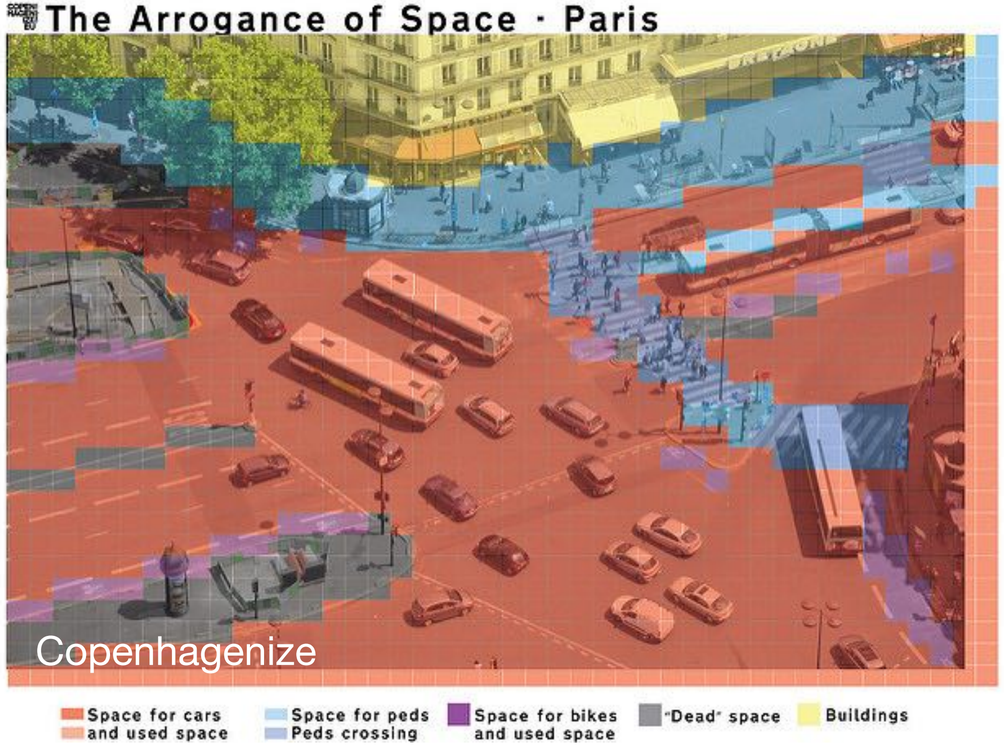
Close the most important gaps

How good is our Data?

We need data to plan more sustainable cities



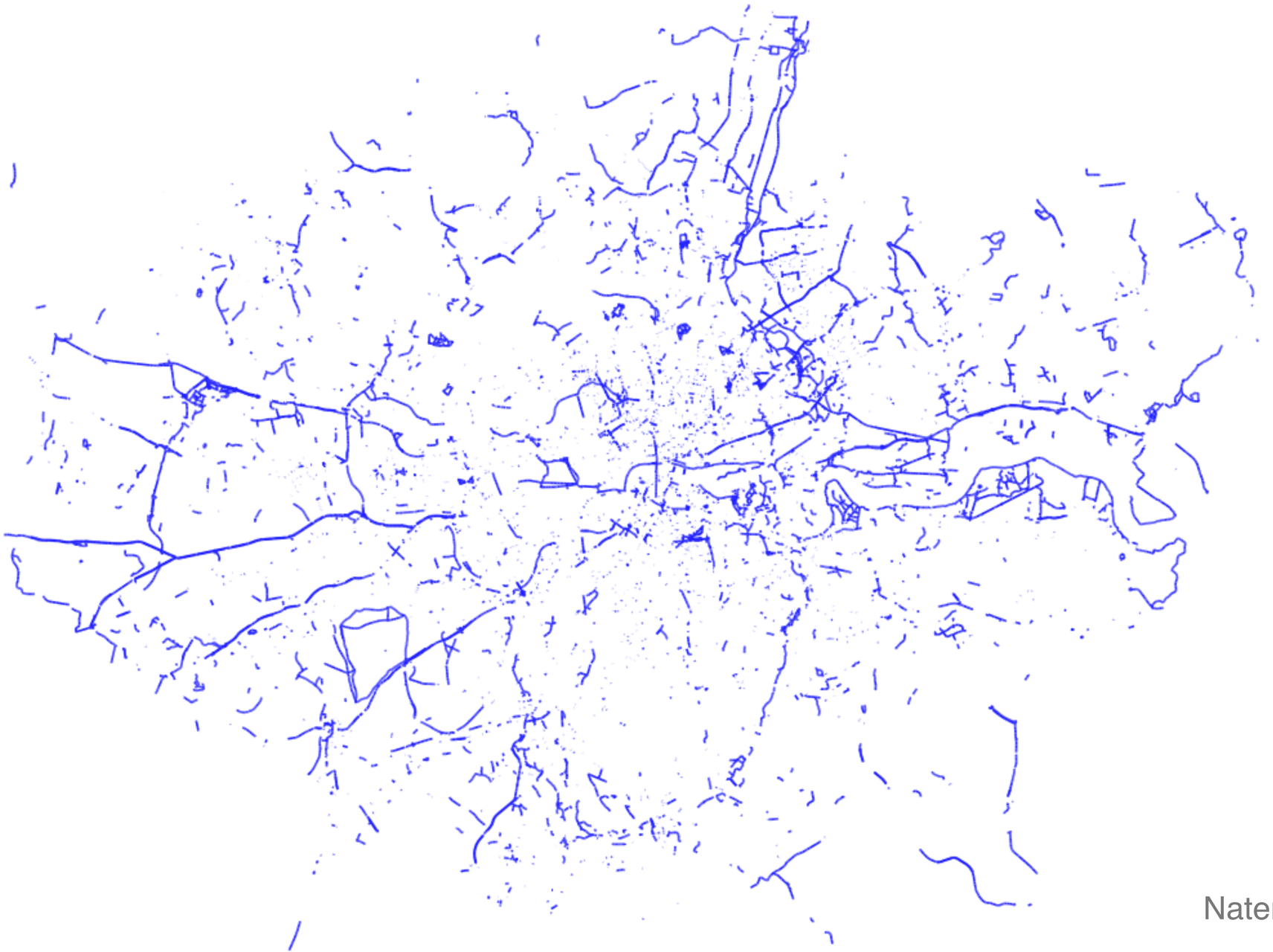
Cycling is marginalized - BOTH in infrastructure and data



Data reflects priorities

Data influences priorities and decisions

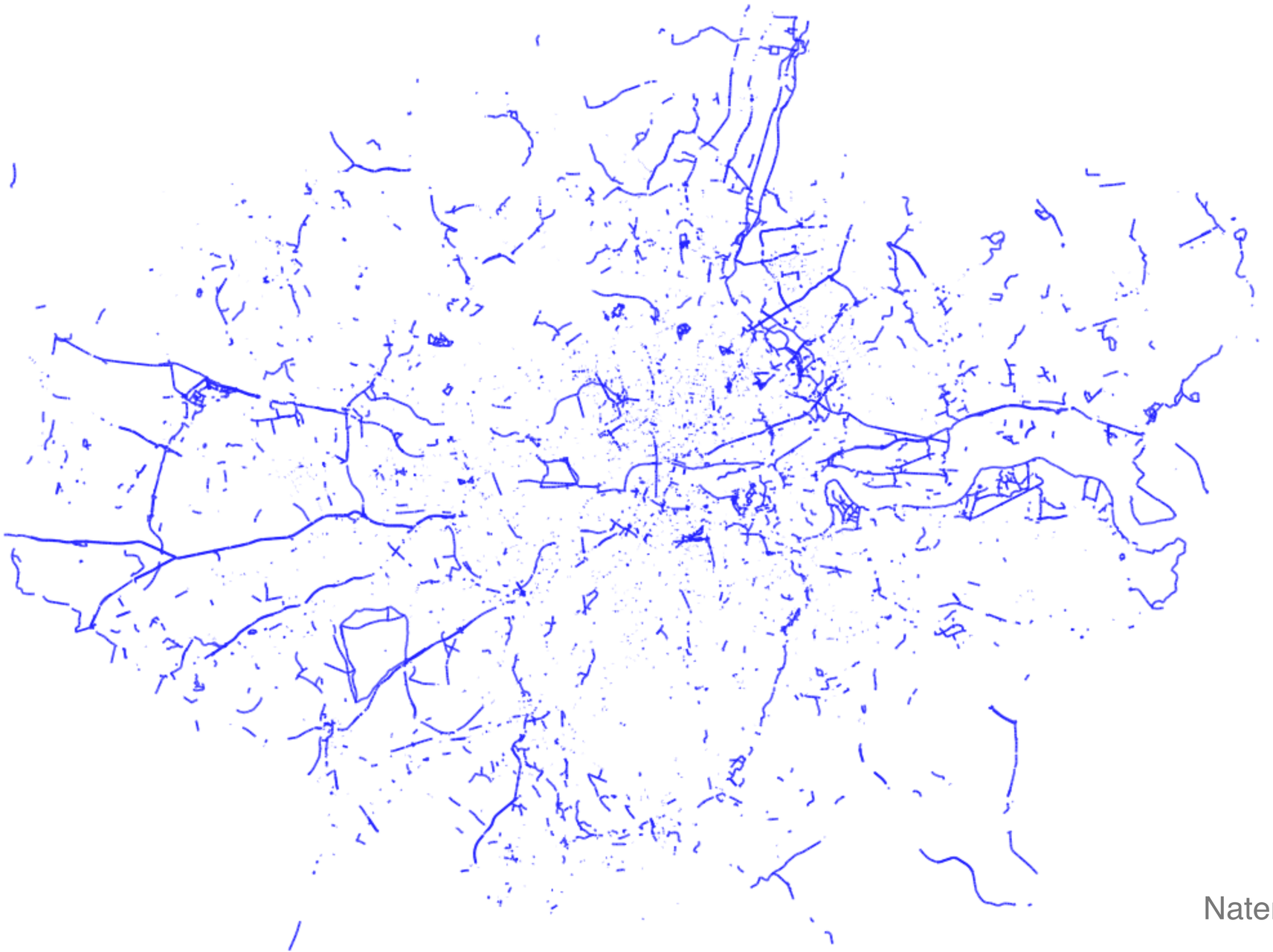
Bicycle networks are highly fragmented



How much of this is just missing data?

Natera Oroczo et al, R Soc Open Sci 7 (2020)

Bicycle networks are highly fragmented



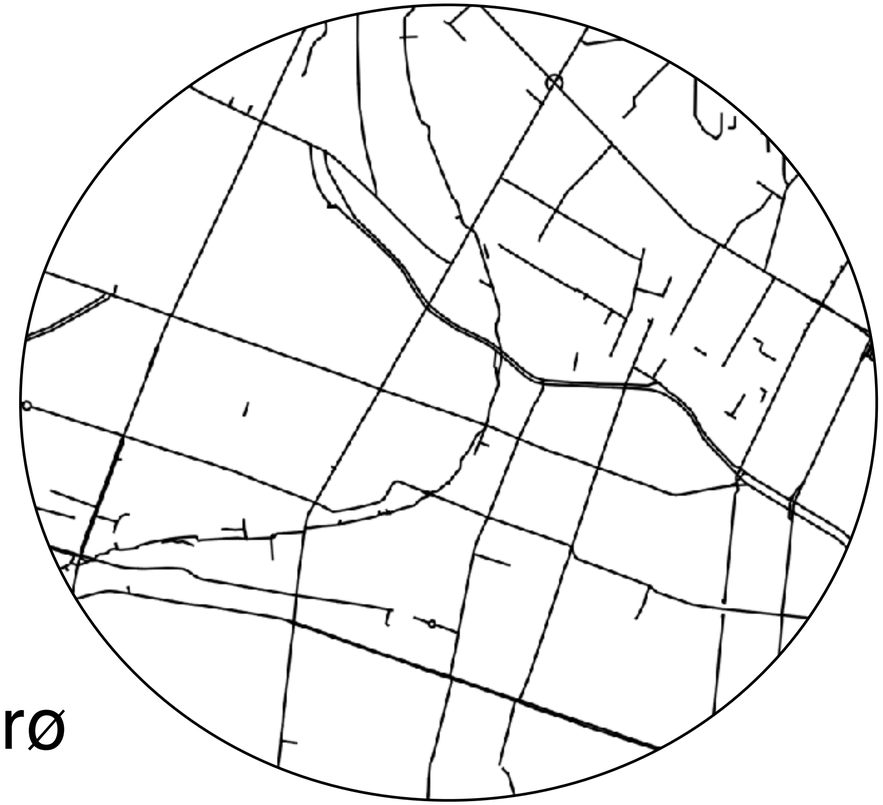
How much of this is just missing data?

Where?

Natera Oroczo et al, R Soc Open Sci 7 (2020)

BIKEDNA

Bicycle Infrastructure Data & Network Assessment

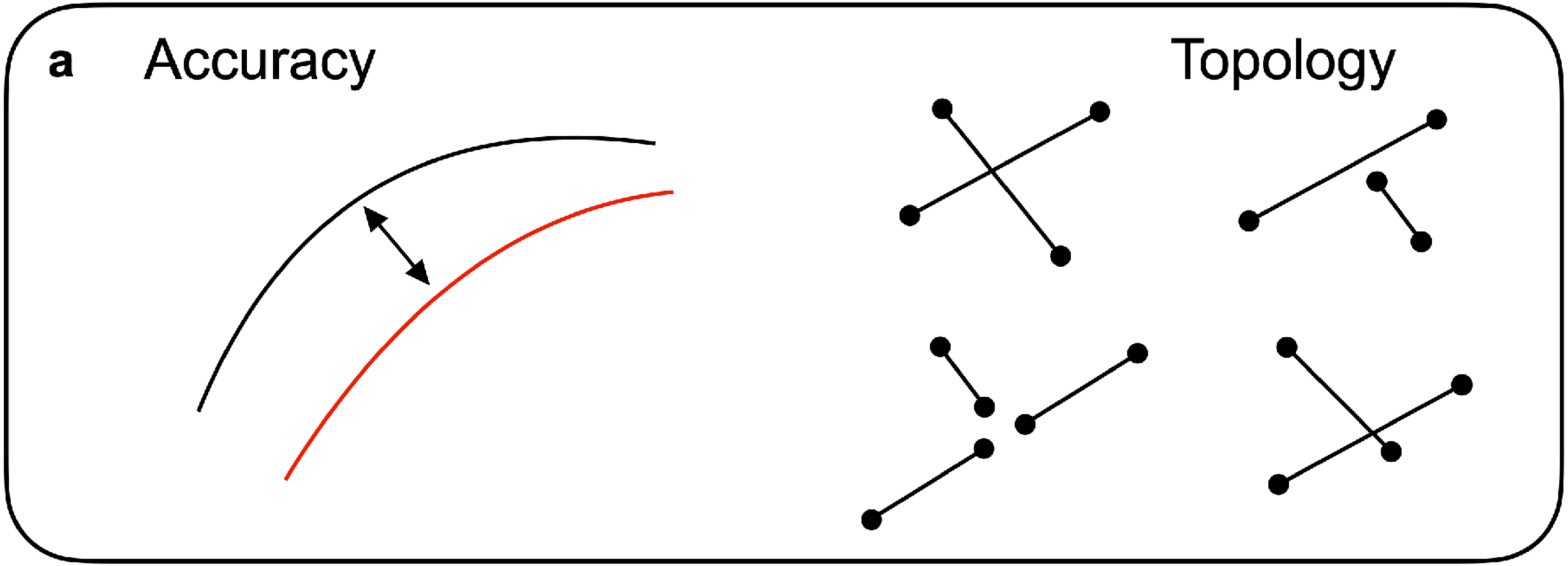


Ane Rahbek Vierø

+ jupyter

Funded by The Danish Road Directorate

We care less about accuracy, more about topology



Haklay et al., The Cart J 47:4 (2010)

Neis, Zielstra & Zipf, Fut Int 4,1 (2012)

README.md

BikeDNA: Bicycle Infrastructure Data & Network Assessment

This is the repository of BikeDNA, a tool for assessing the quality of OpenStreetMap (OSM) and other bicycle infrastructure data sets in a reproducible way. It provides planners, researchers, data maintainers, cycling advocates, and others who work with bicycle networks a detailed, informed overview of data quality in a given area.

▶ Background

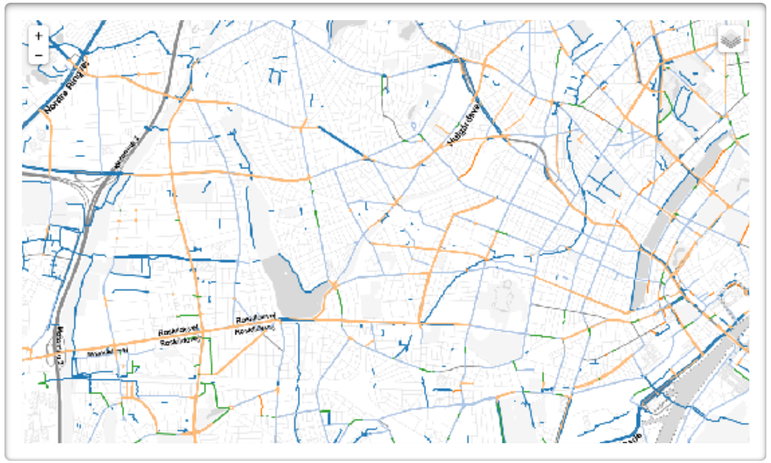
Workflow

BikeDNA consists of Jupyter notebooks that analyze bicycle infrastructure data sets. It therefore requires an installation of Python, including tools for Jupyter notebook.

https://github.com/anerv/BikeDNA

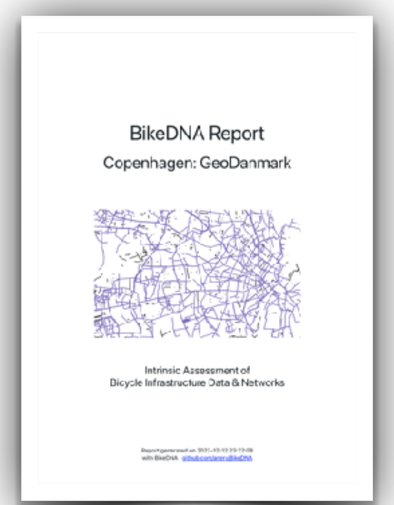
Features of BikeDNA

Data + network quality
(completeness, consistency, accuracy)



Intrinsic+Extrinsic data analysis

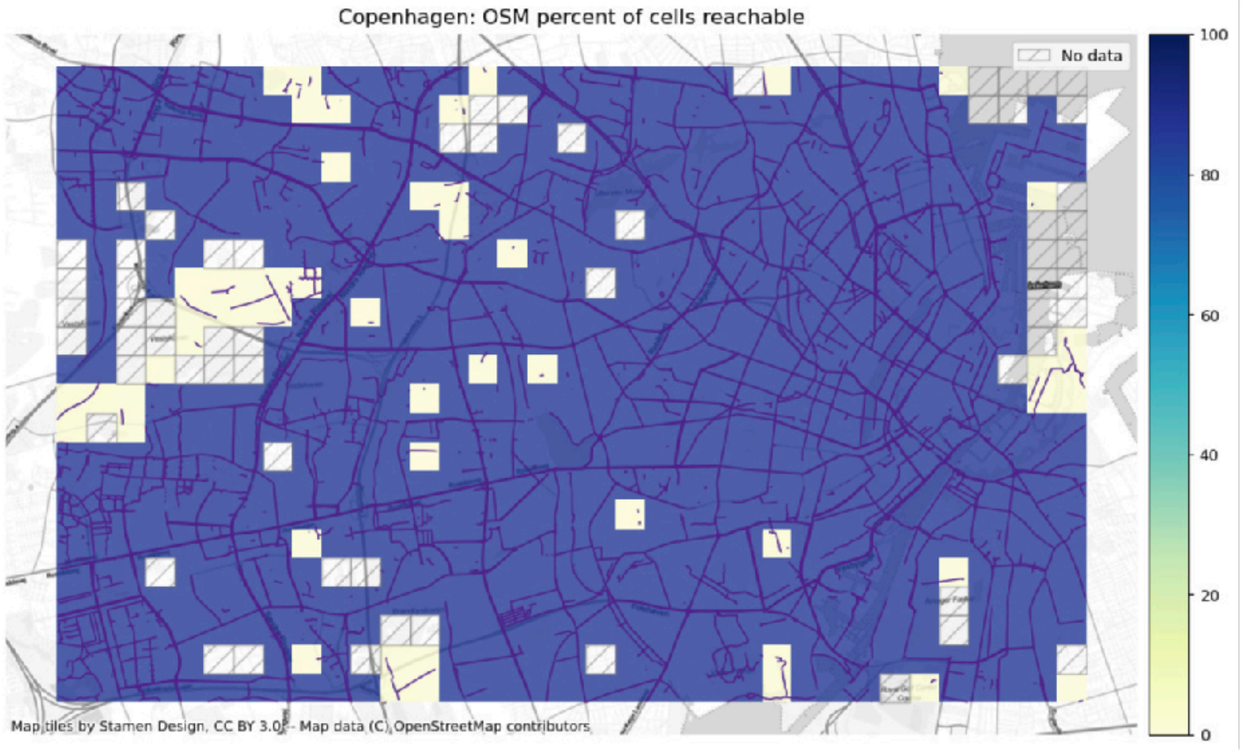
Creates
HTML+PDF
reports

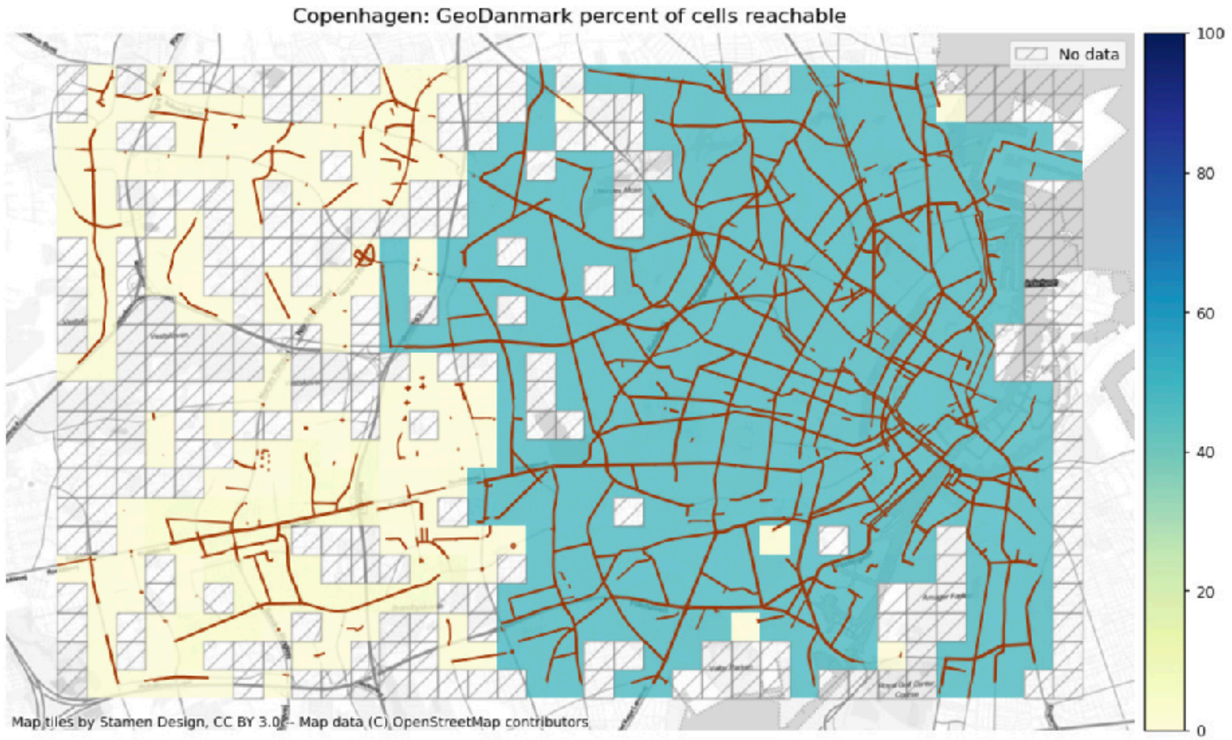


A.R. Vierø, A. Vybornova, M. Szell. Env Plan B 51(2), 512-528 (2024)

https://github.com/anerv/BikeDNA

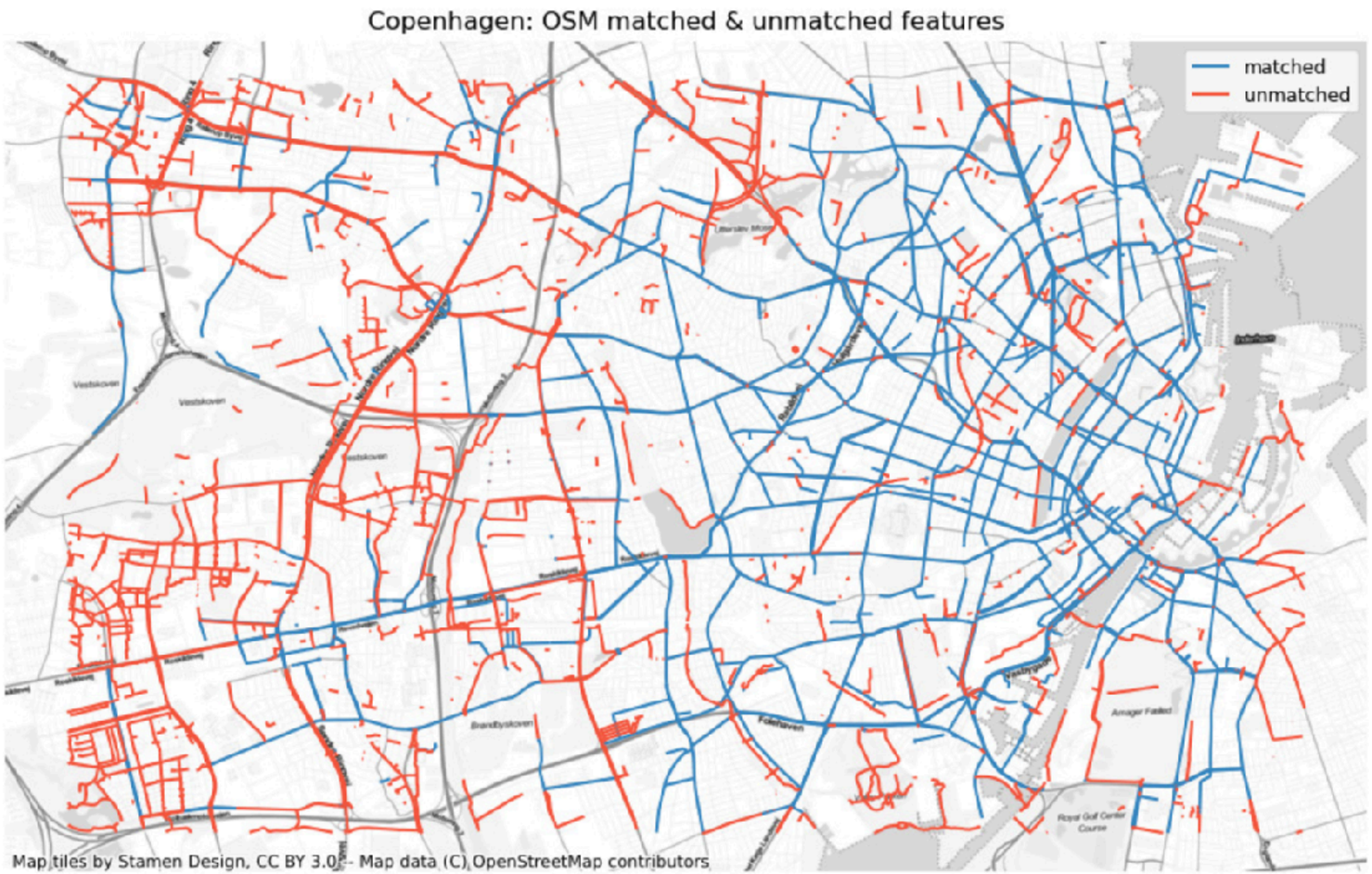
We applied BikeDNA to all of Denmark: OSM vs GeoDanmark





OSM has better connectedness

We applied BikeDNA to all of Denmark: OSM vs GeoDanmark



- The two data sets are complementary in some aspects
- None is complete or perfectly fit for research and planning

We applied BikeDNA to all of Denmark: OSM vs GeoDanmark

Details:

Geographical Analysis
An International Journal of Theoretical Geography

Geographical Analysis (2024) **0**, n/a

How Good Is Open Bicycle Network Data? A Countrywide Case Study of Denmark

Ane Rahbek Vierø[1], Anastassia Vybornova[1], and Michael Szell[1,2,3]

A.R. Vierø, A. Vybornova, M. Szell. Geographic Analysis (2024, in print)

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We conflated the 2 data sets to study Denmark well (work in progress)

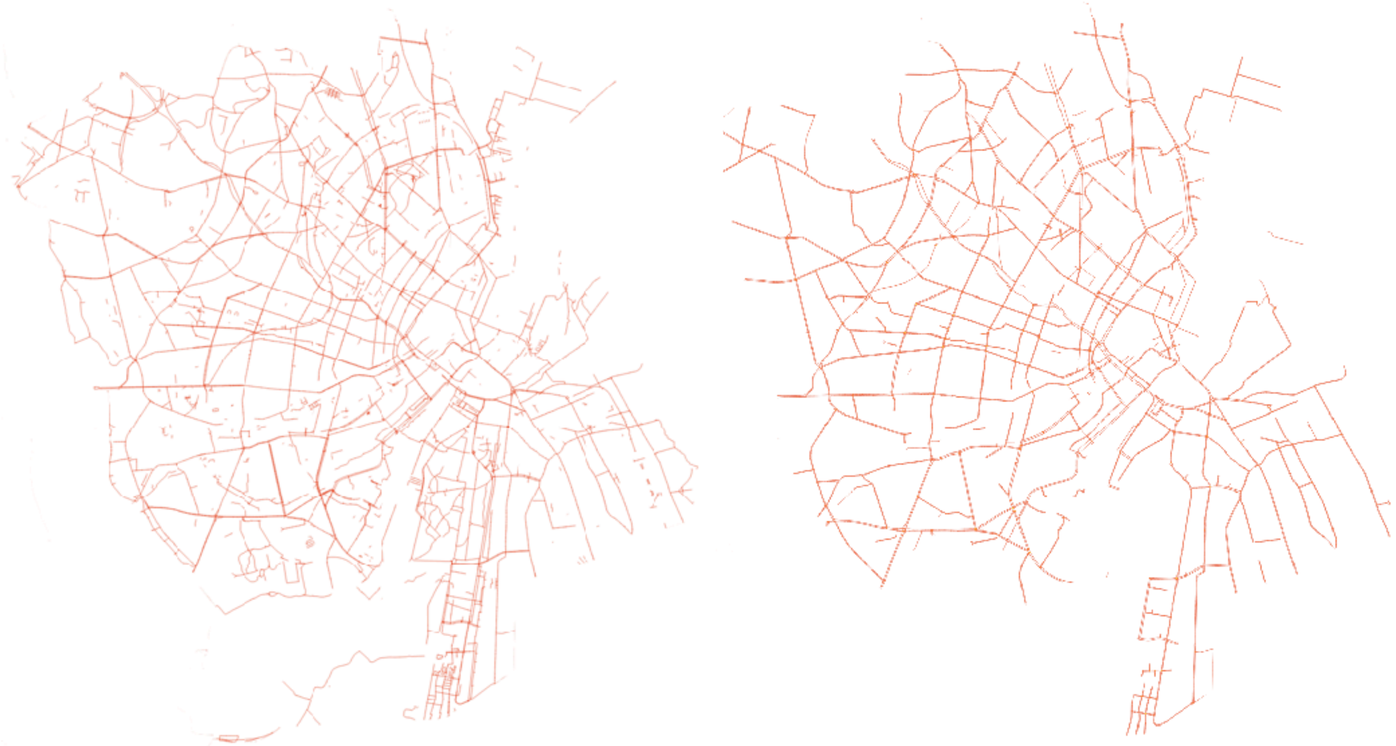
A.R. Vierø, A. Vybornova, M. Szell. Geographic Analysis (2024, in print)

There are still unsolved challenges

No ground truth

Key take aways

Data quality matters



Key take aways

Data quality matters

Quality data not a given

Key take aways

Data quality matters

Quality data not a given

Data (quality) is political

We lack data+research on

- Cyclist traffic behavior
- Cyclist flows
- Bicycle networks
- ...

but..

..Building sustainable cities is a political, not a technical question

You cannot optimize yourself out of an unsustainable political system

Our work: Data-driven tools to help sustainable urban planning

ROYAL SOCIETY OPEN SCIENCE

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Research

Cite this article: Natera Orozco LG, Battiston F,

Data-driven strategies for optimal bicycle network growth

Luis Guillermo Natera Orozco[1], Federico Battiston[1], Gerardo Iñiguez[1,2,3] and Michael Szell[4,5,6]

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Ane Rahbek Vierø[1], Anastassia Vybornova[1], Michael Szell[1,2,3]

www.nature.com/scientificreports

scientific reports

OPEN **Growing urban bicycle networks**

Michael Szell[1,2,3], Sayat Mimar[4], Tyler Perlman[4], Gourab Ghoshal[4] & Roberta Sinatra[1,2,5,3]

growbike.net

fixbike.net

geographical analysis

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michael.szell.net

Vejdirektoratet

NERDS .itu.dk