Assessing the Completeness of Urban Green Spaces in OpenStreetMap

Christina Ludwig[1], Robert Hecht[2], Sven Lautenbach[3], Martin Schorcht[2], Alexander Zipf[1]

[1] GIScience Research Group, Heidelberg University
[2] Leibniz Institute of Ecological Urban and Regional Development
[3] Heidelberg Institute for Geoinformation Technology at Heidelberg University

State of the Map 2019, Heidelberg, Germany

What is an Urban Green Space?

Definition: Publicly accessible, vegetated land within a city.

Urban green spaces are important factors for the quality of life, because they provide recreational and cultural services to citizens.


By Marc Ryckaert


By Tomwsulcer


By Markus Gregory

Objective of meinGrün

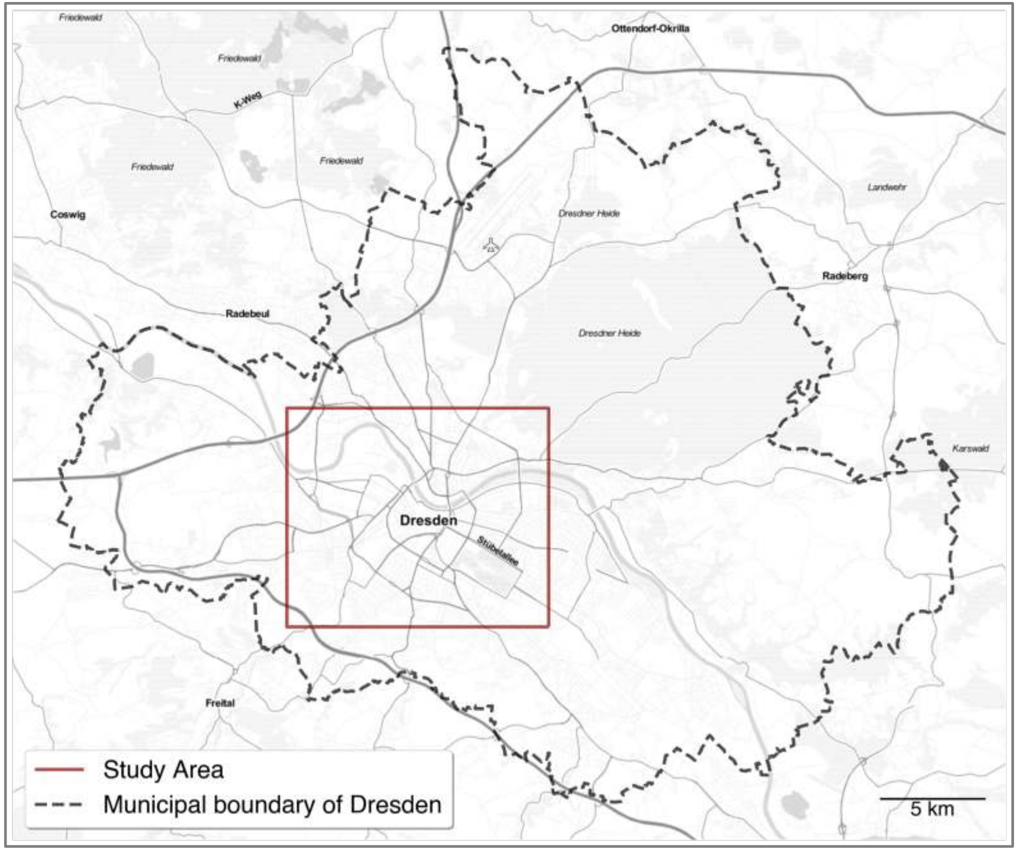
Developing a recommendation system for nearby green spaces based on personal needs and activities.

Information sources:

- Municipal data
- Satellite Imagery
- Social Media
- **OpenStreetMap**

  → Quality Assessment

Study area: Dresden, Germany



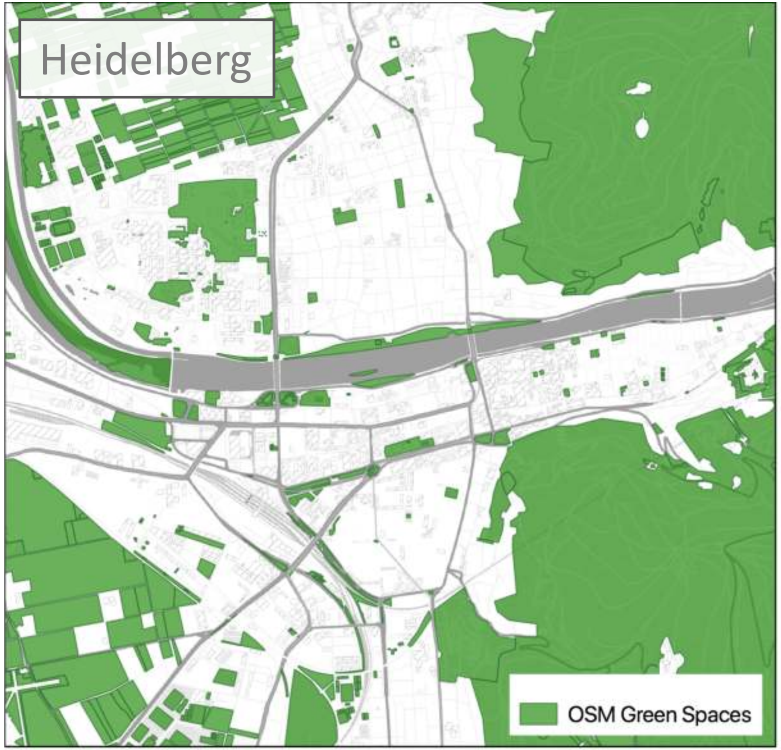
meinGRÜN

Step 1:

Extracting public green spaces from OSM

1.1 Which OSM tags indicate public green spaces?

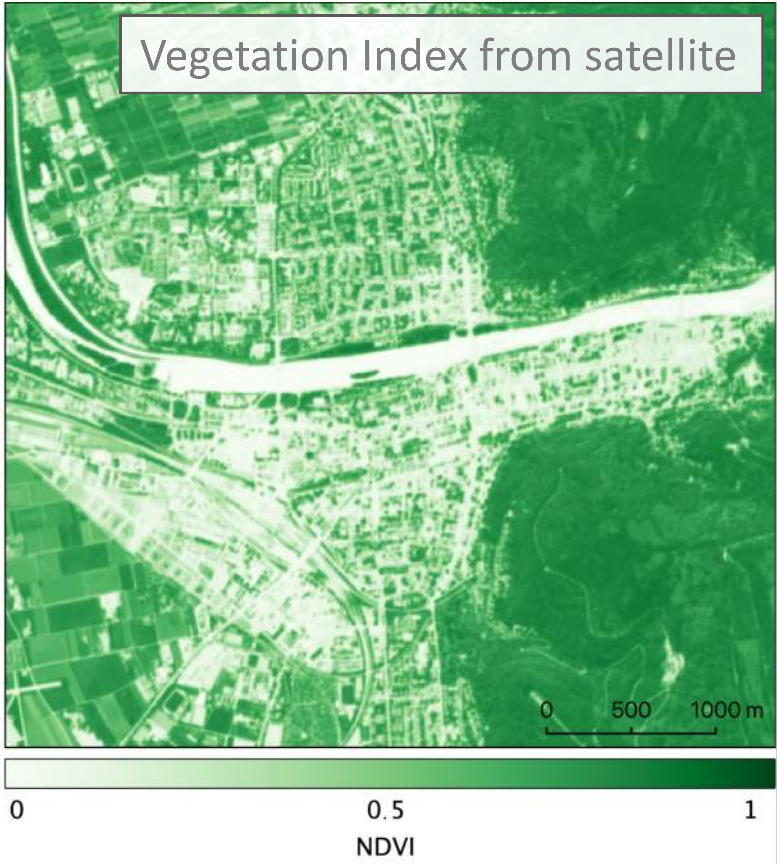
OSM Tags for Public Green Spaces



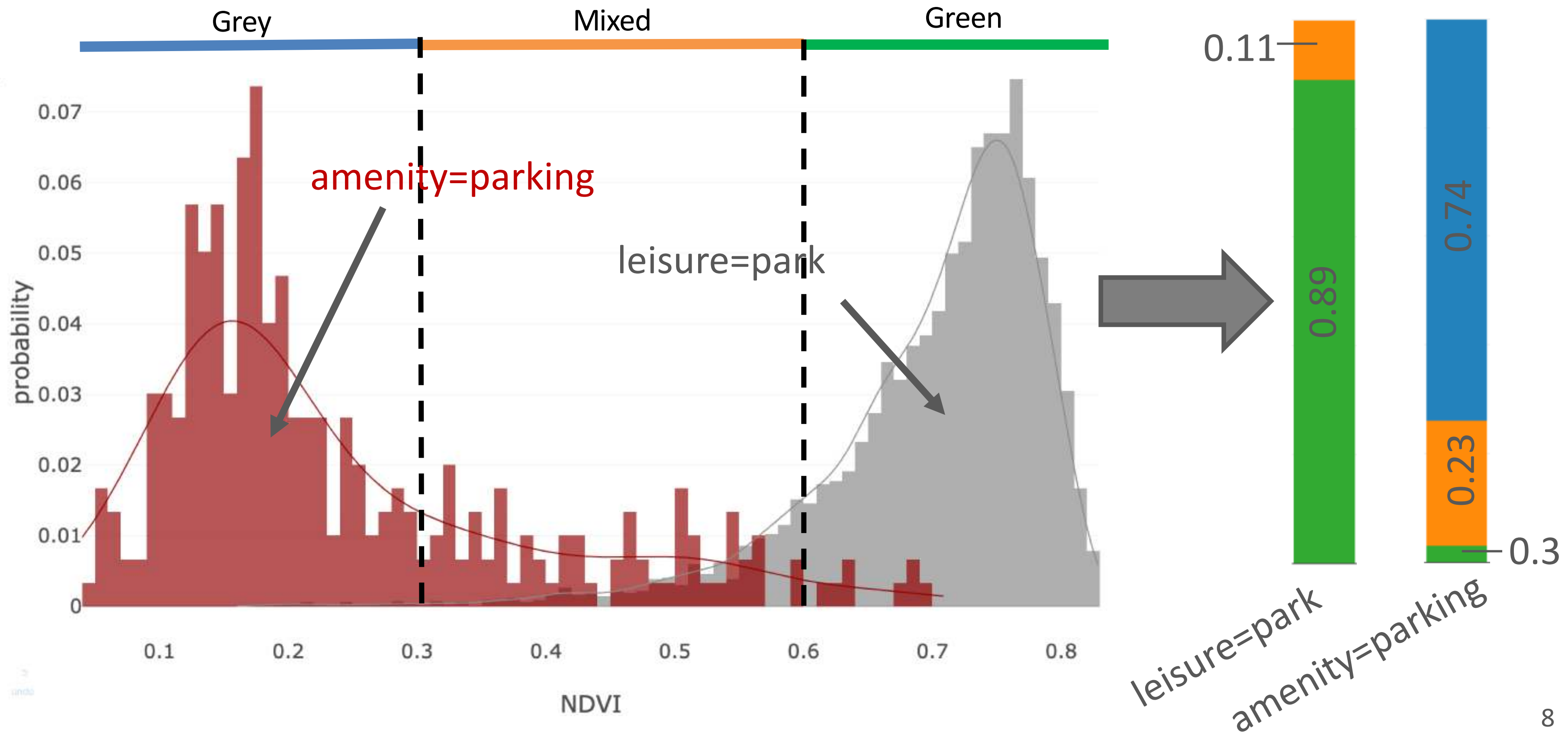
Key	Value
amenity	graveyard
landuse	allotments, cemetery, farmland, forest, grass, greenfield, meadow, orchard, recreation_ground, village_green, vineyard
leisure	garden, golf_course, nature_reserve, park, pitch
natural	wood, scrub, heath, grassland, wetland
tourism	camp_site

Novack, T., Wang, Z., Zipf, A. (2018)
Ludwig, C. & Zipf, A. (2019)

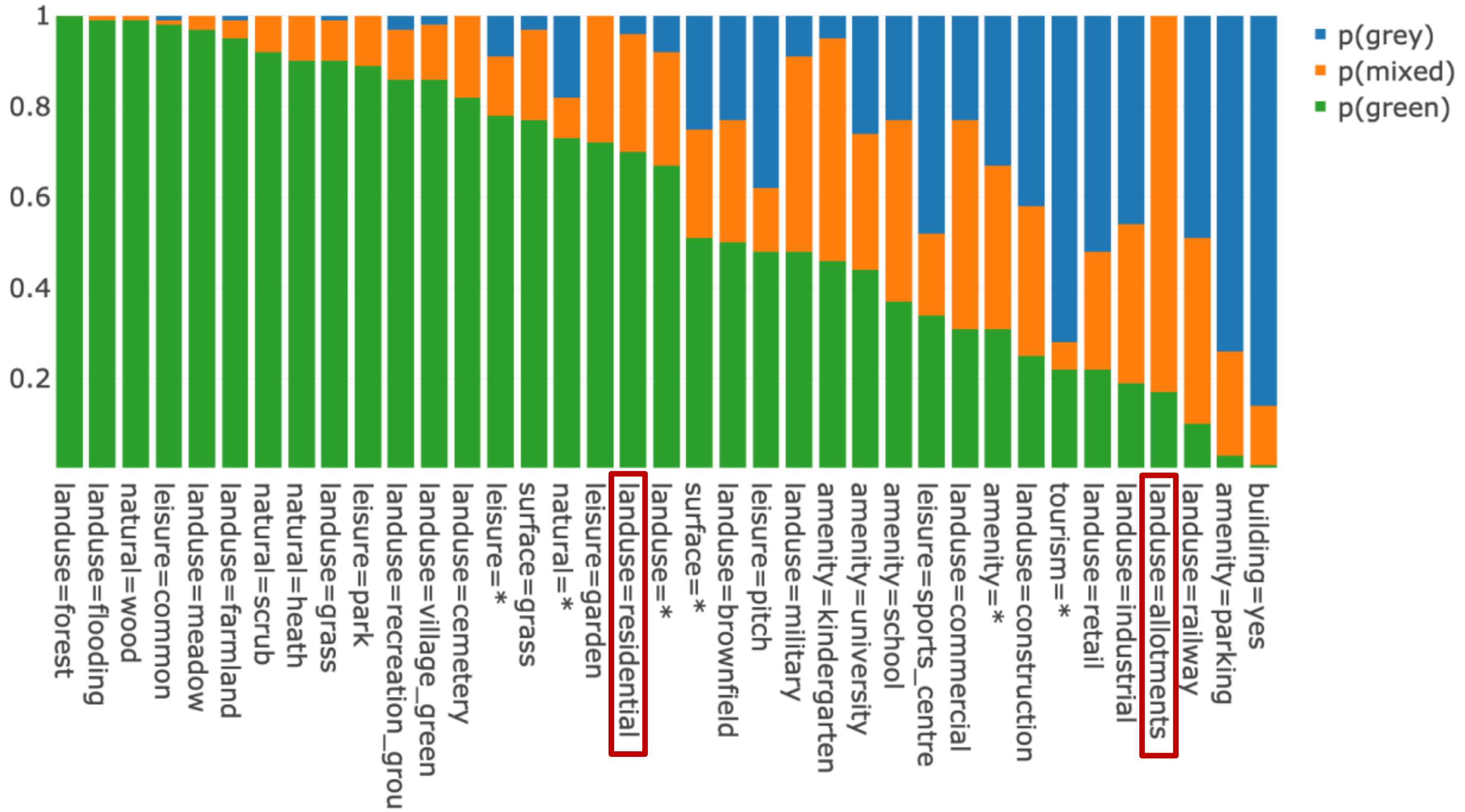
OSM Tags for Public Green Spaces



Association between OSM tags and greenness



Ranking of OSM gags for greenness in Dresden



Finding public spaces in OSM

If available, use *"access"* key.

Otherwise, assume:

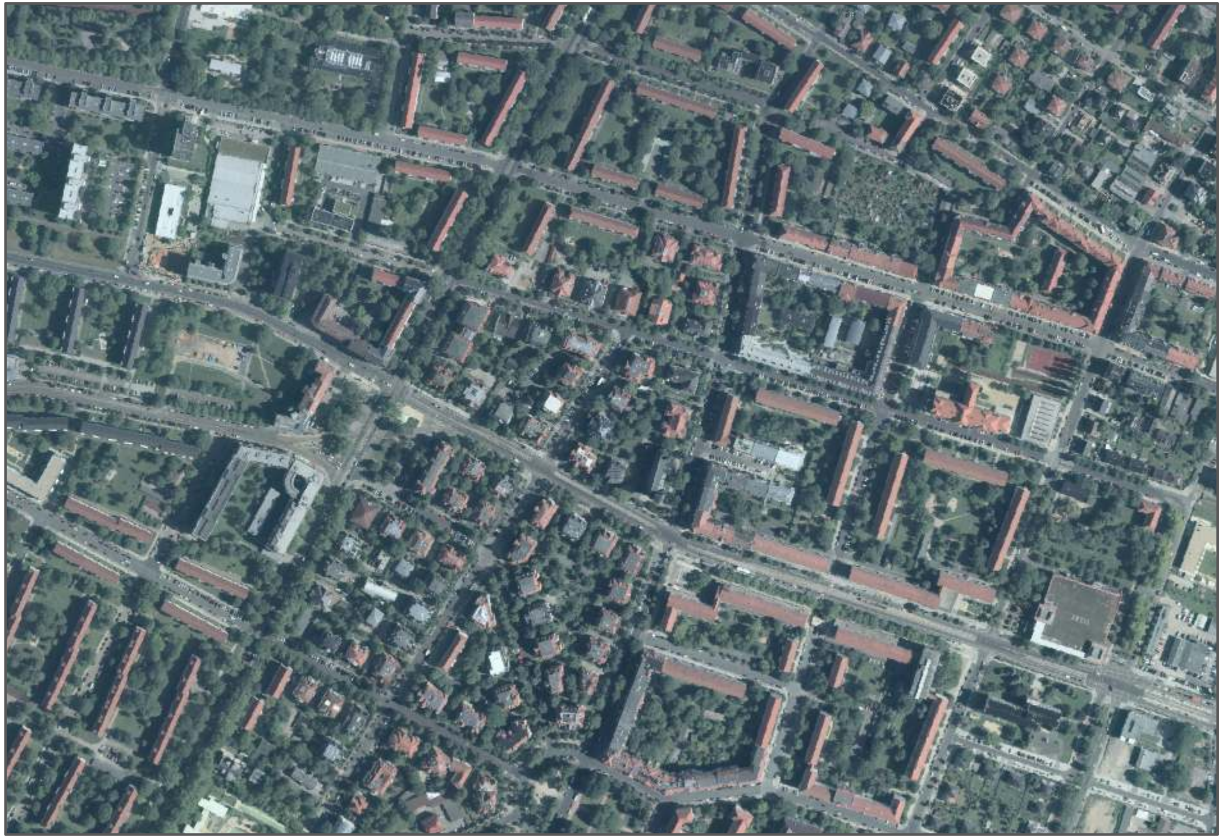
1. Everything that is mapped in OSM is publicly accessible.
2. Features with *landuse=residential* are private.

Step 1.2:

Generating a mesh of polygons with homogenous land use

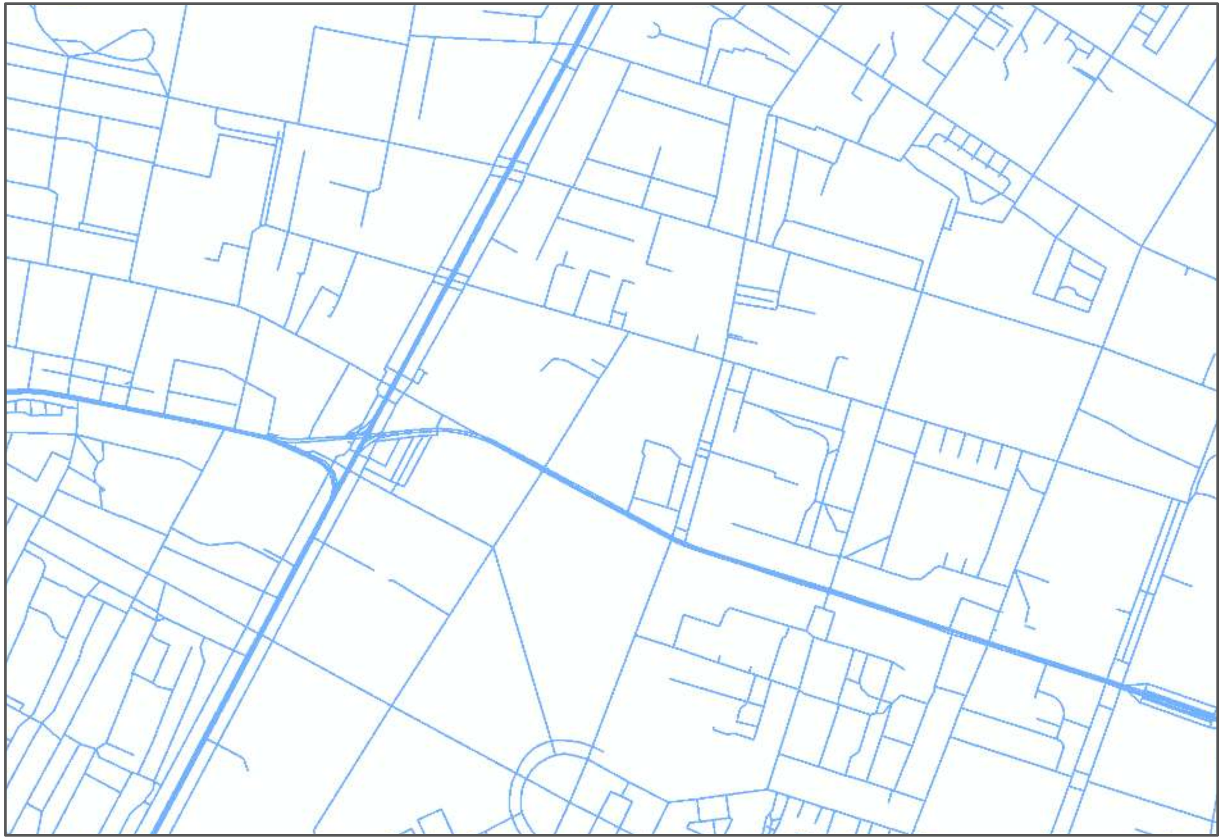
Generation of polygon mesh

Orthophoto of Dresden



Generation of polygon mesh

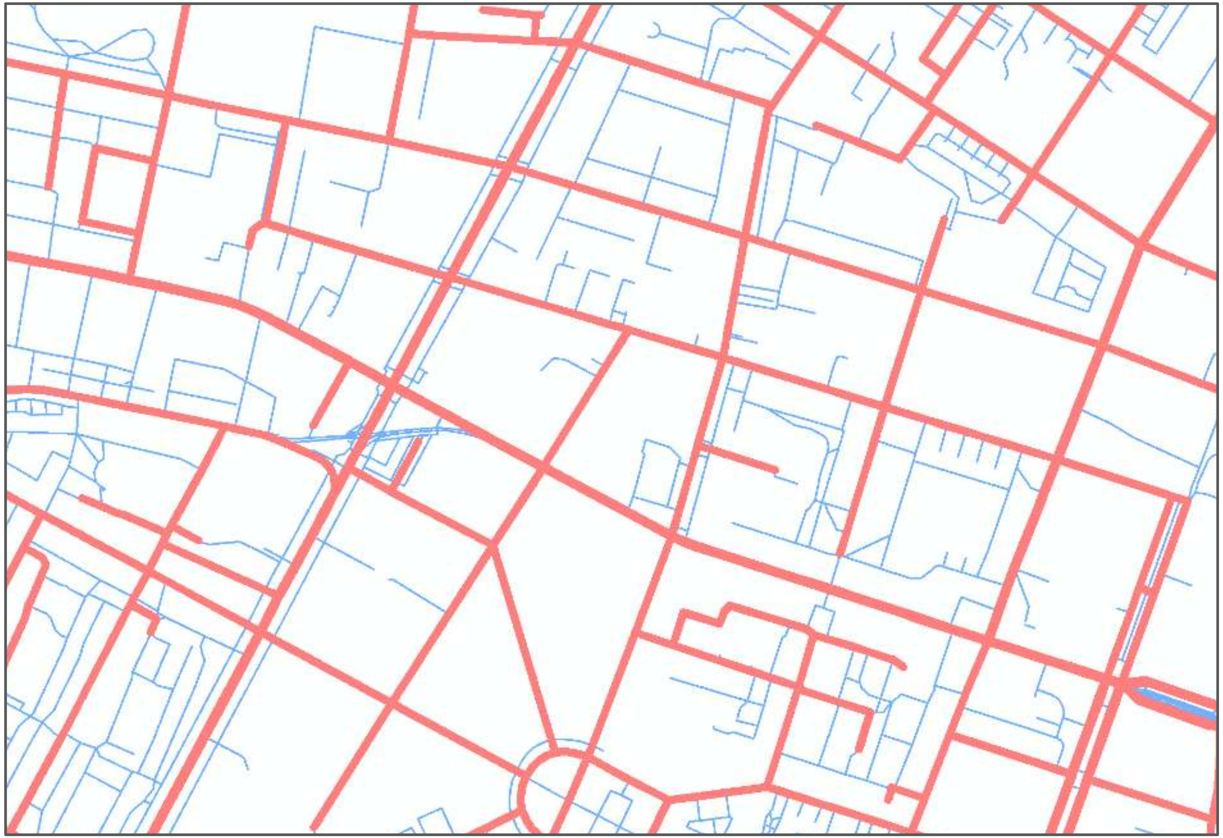
Generation of City blocks using linear topographic elements from OSM
- Road network (motorized)
- Railway network
- Water network



Generation of polygon mesh

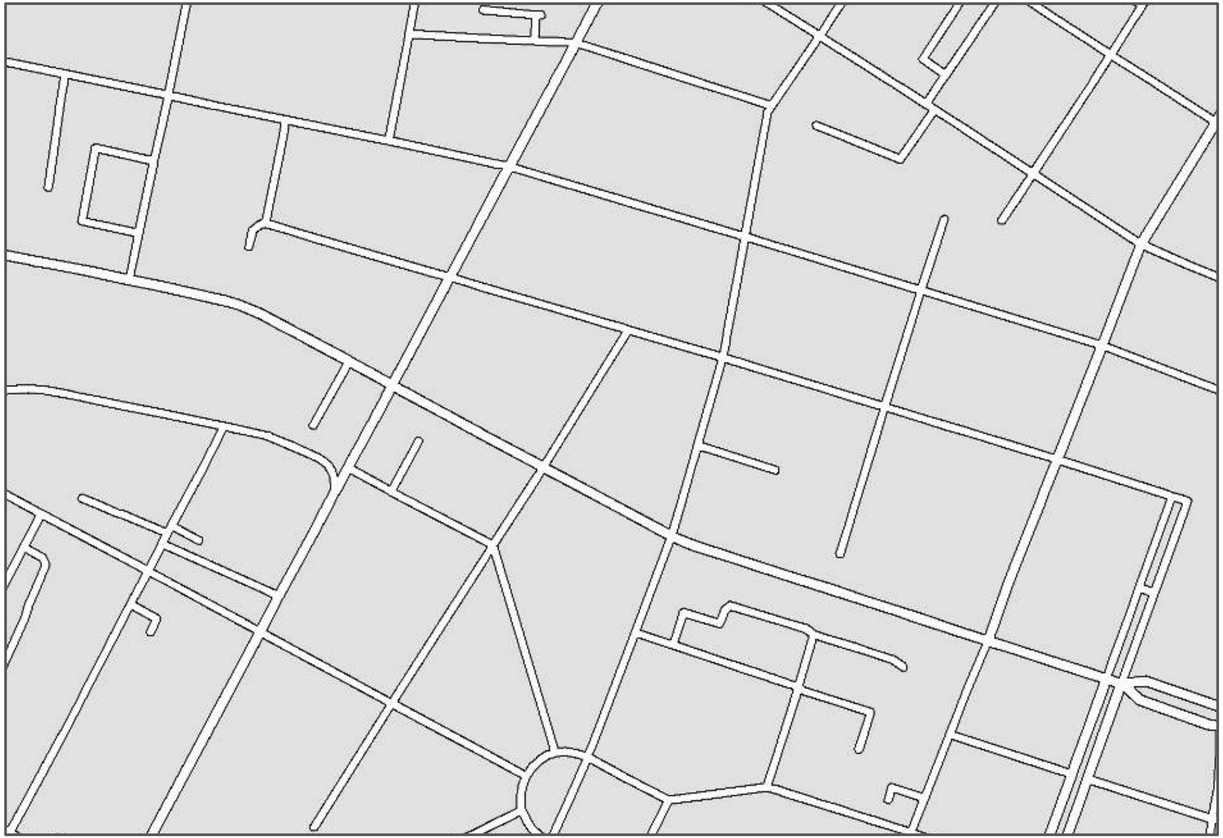
Generation of City blocks using linear topographic elements from OSM

- Road network (motorized)
- Railway network
- Water network



Generation of polygon mesh

Exclusion of areas for transport by buffering of the roads and railway tracks according to type (primary, secondary, trains, trams, etc.)



Generation of polygon mesh

Further segmentation of the city blocks using OSM objects describing land use

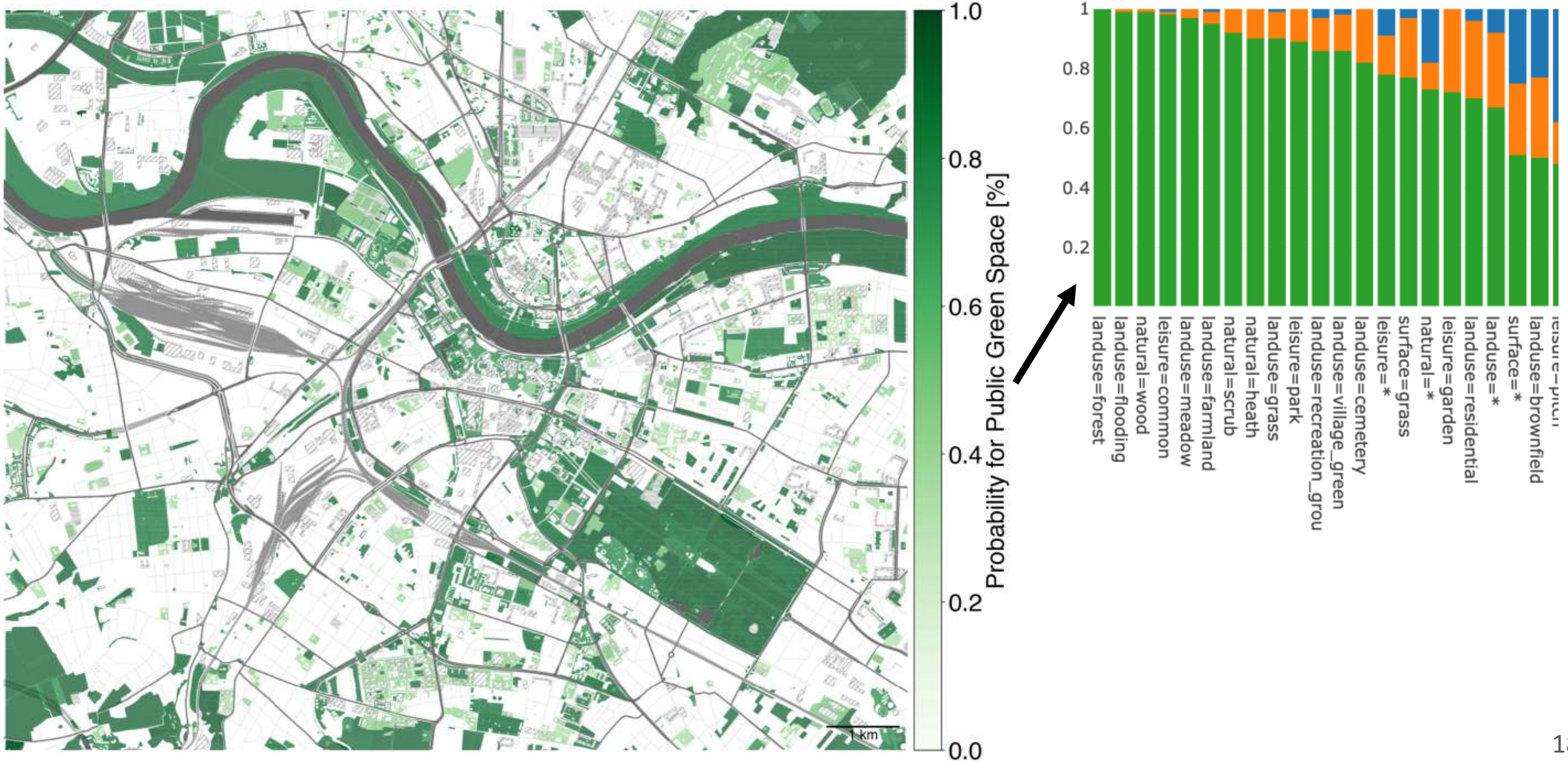
Hierarchy of objects defined by area size (e.g. *leisure=park* polygon above larger *landuse=residential* polygon)

MMU = 10 m^2

Generation of polygon mesh

Final segmentation using foot paths and buildings

Extracted public green spaces from OSM

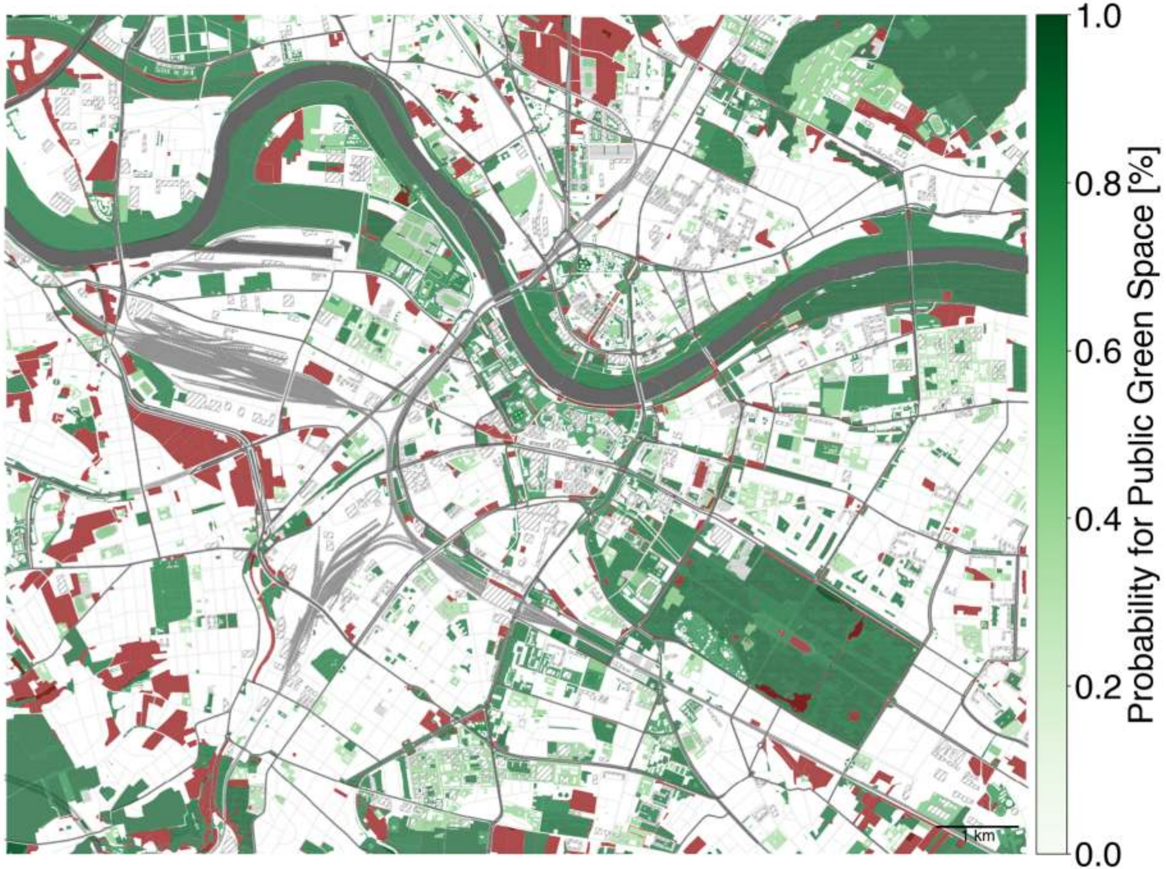


Step 2:

Extrinsic Data Quality Assessment

Comparison to municipal data

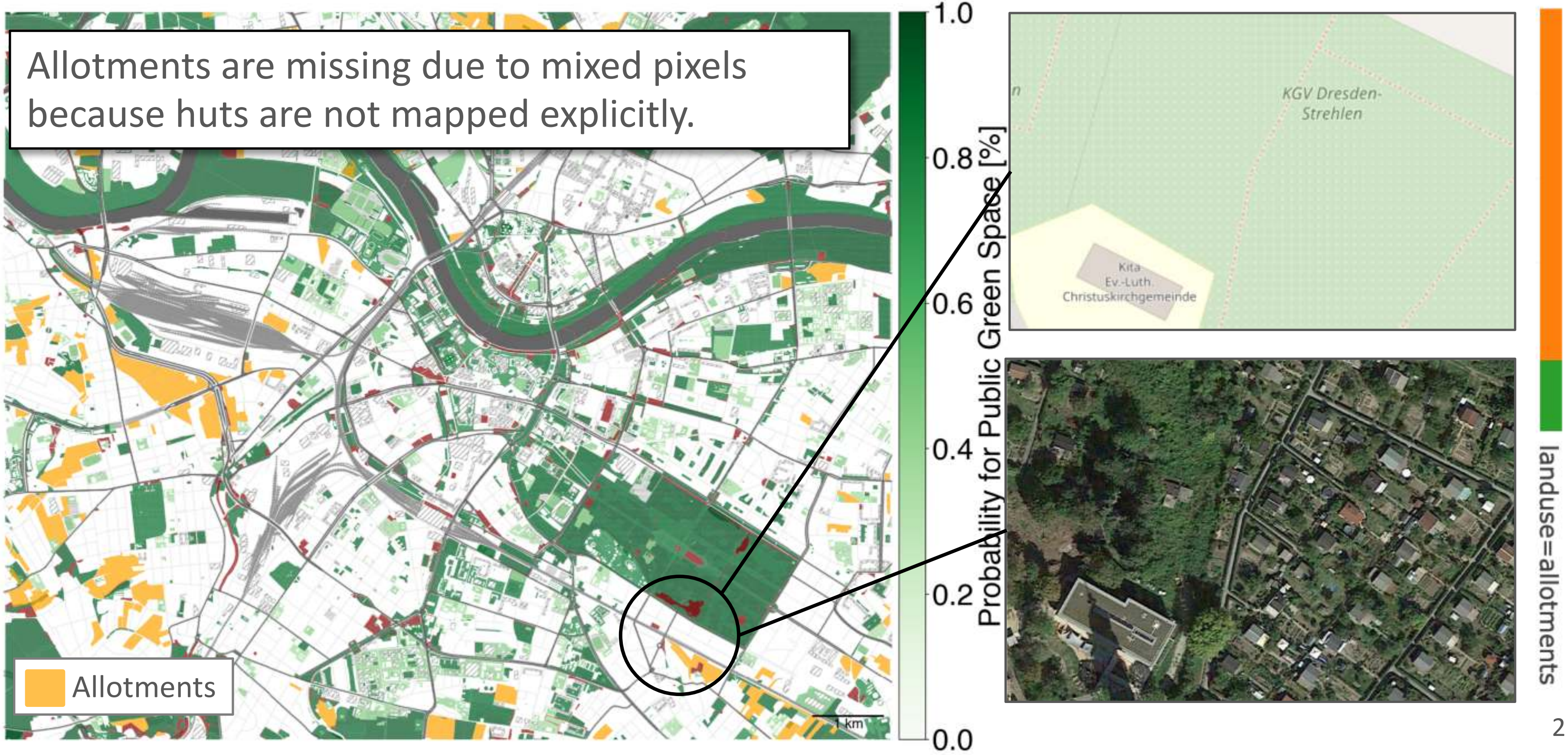
Extrinsic comparison to municipal data



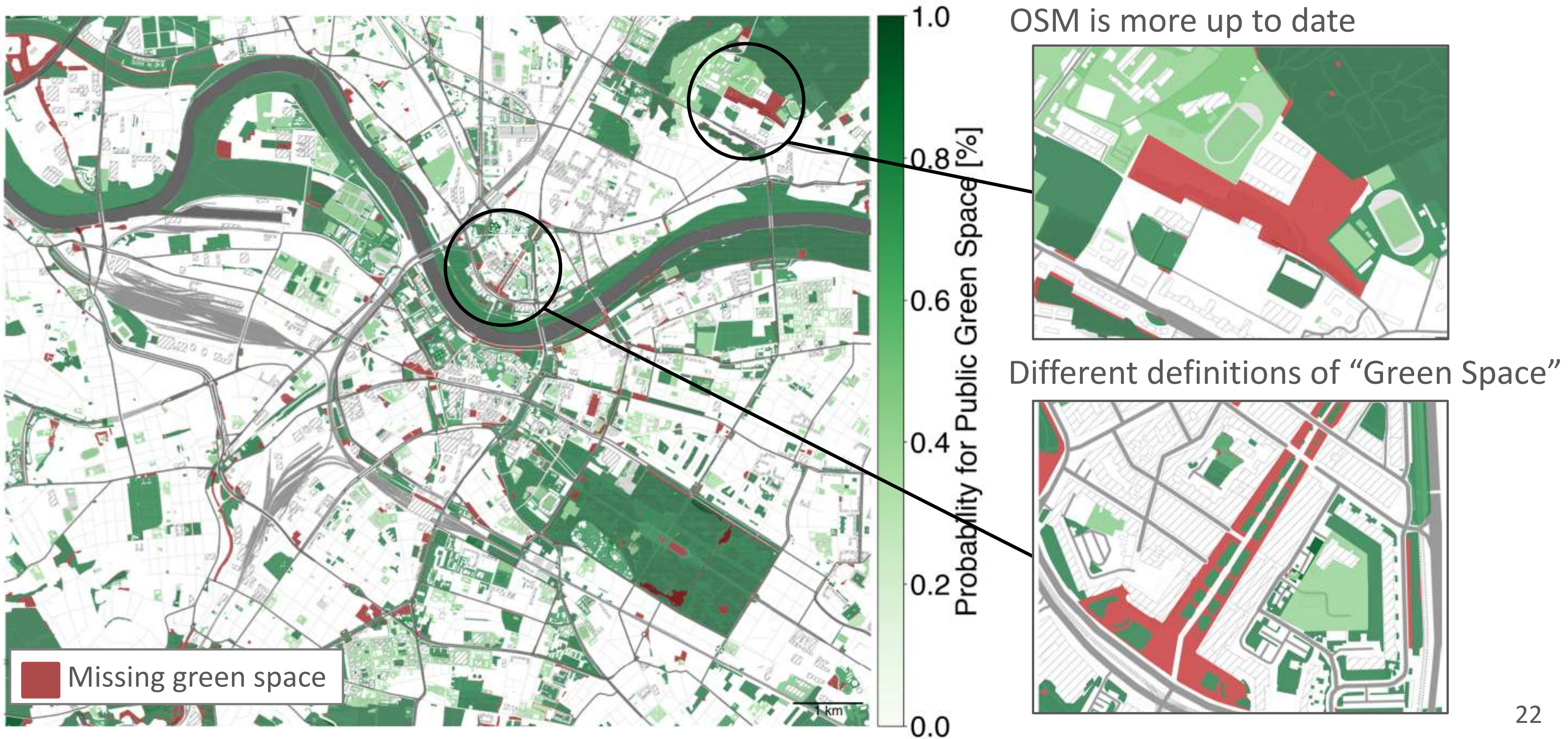
Municipal data:
- public green spaces
- parks
- cemeteries
- forests
- playgrounds
- allotments

Missing green space

Extrinsic comparison to municipal data



Extrinsic comparison to municipal data



Intermediate Conclusion

- Public Green Spaces are fuzzy geographic concepts.
- Quantitative comparison to external data difficult due to …
  - different definitions of ”green space”
  - timeliness of external data set
  - different scale at which data sets have been created.

Step 3:

(Intrinsic) Identification of Missing Public Green Spaces from OSM itself

Identifying missing public green spaces in OSM

Evidence for green spaces from geographic context

Evidence for public green spaces from geographic context:

- dense foot path network (OSM) → Public
- presence of a playground (OSM) → Public
- high vegetation index (satellite data) → Green

Evidence contains uncertainties

→ Combine evidence using Dempster-Shafer Theory

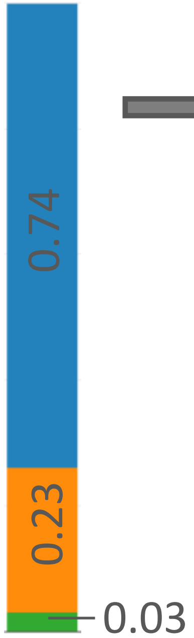
Dempster-Shafer Theory (DST)

- Framework for reasoning under uncertainty using evidence from different sources
- Evidence is converted to beliefs (or masses) using belief functions
- Beliefs can be about a set of events, not just single events

→ Uncertainty can be expressed explicitly

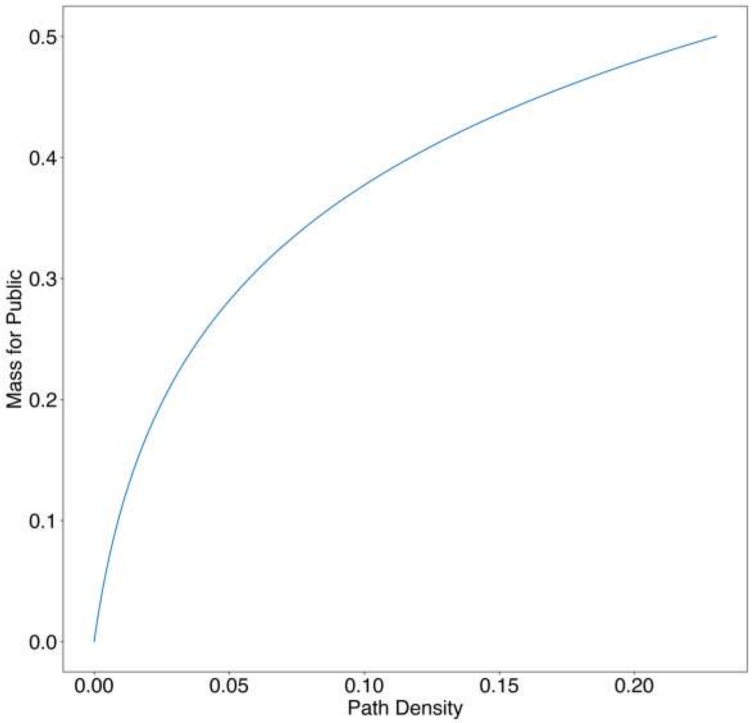
	Probability Theory	Dempster-Shafer
Fair coin	p({heads}) = 0.5 p({tails}) = 0.5	mass({heads}) = 0.5 mass({tails}) = 0.5
Total ignorance	p({heads}) = 0.5 p({tails}) = 0.5	mass({heads}) = 0 mass({tails}) = 0 mass({heads, tails}) = 1

Belief functions



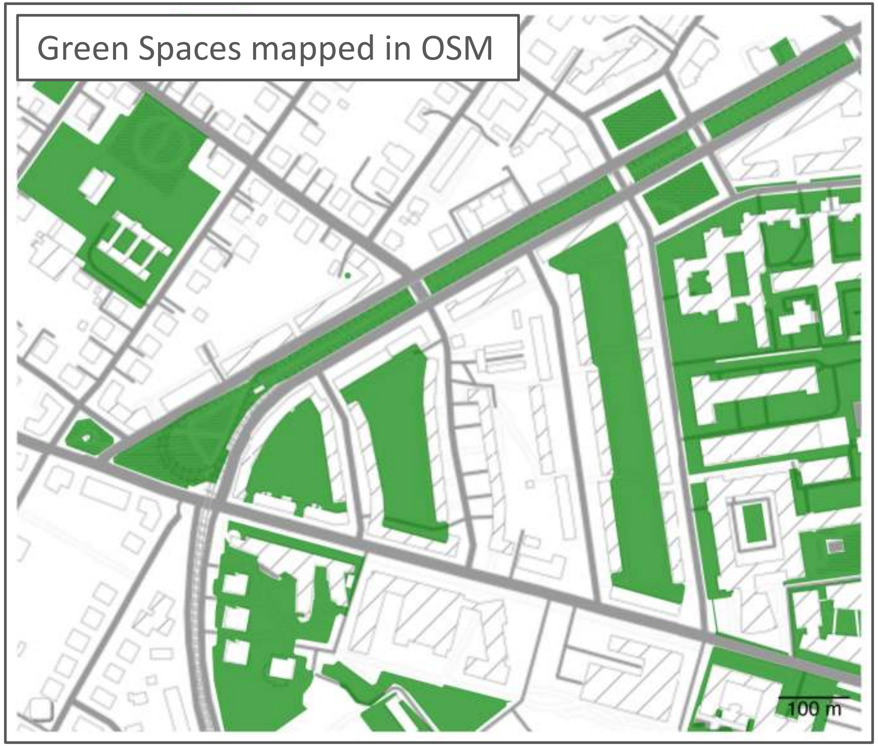
m(grey) = 0.74
m(green|grey) = 0.23
m(green) = 0.03

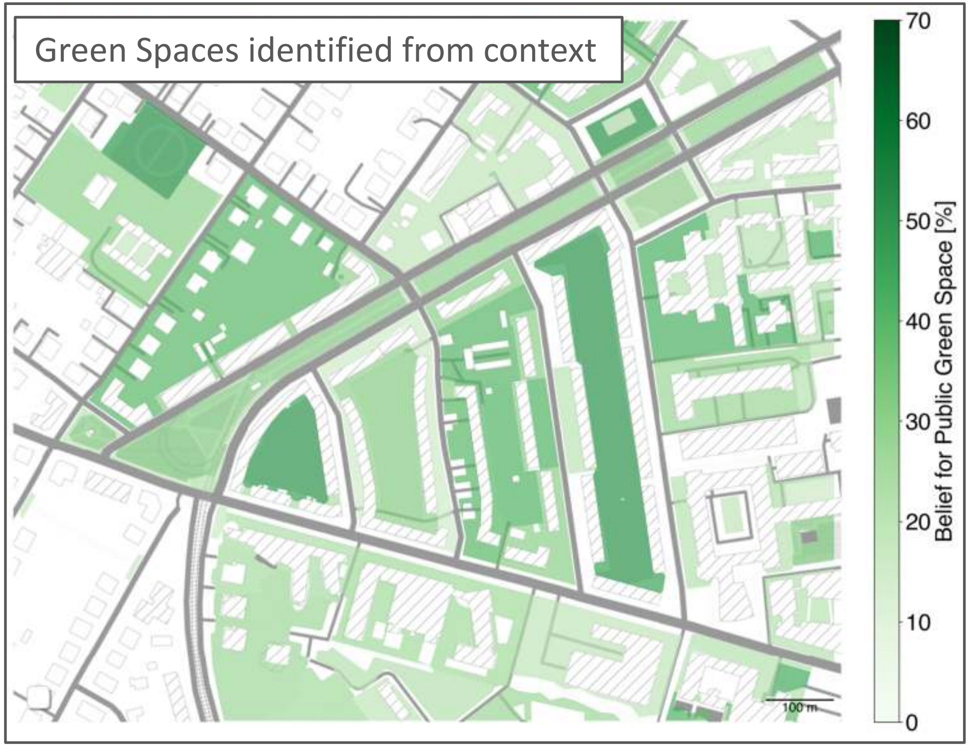
Number of Playgrounds	0	>=1
m(public)	0	0.5
m(private)	0	0
m(private|public)	1	0.5



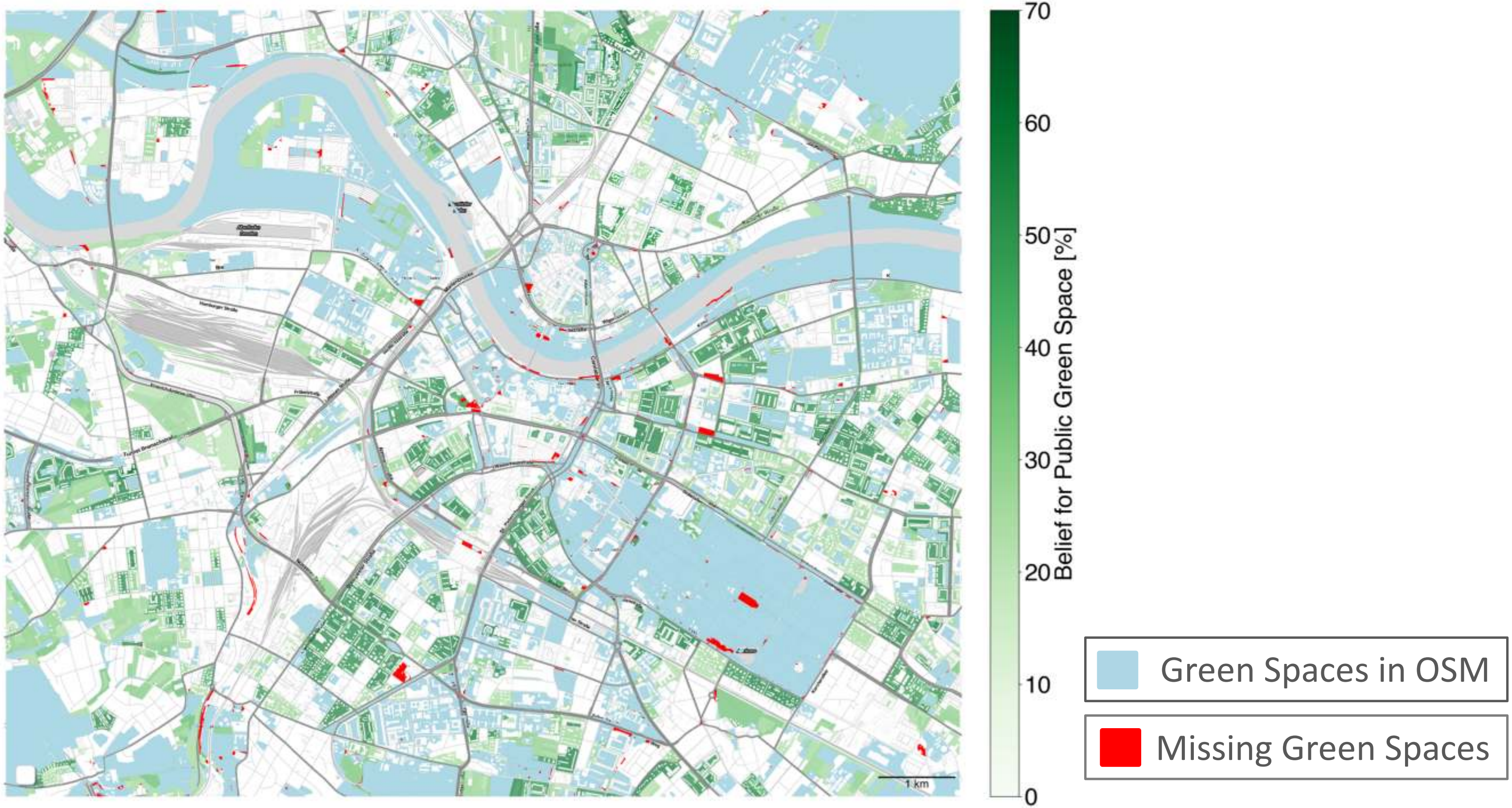
amenity=parking

Identified green spaces from geographic context





Identified green spaces from geographic context



Uncertainty of identified green spaces

Conclusion und outlook

- There are **several OSM tags that indicate public green spaces** with varying degrees of certainty.
- **Quantitative comparison is not feasible** due to fuzzy definition of green spaces.
- **Missing public green spaces can be inferred from geographic context** such as path network and playgrounds.

Outlook

- Consider **additional aspects of geographic context** as evidence (e.g. benches, building geometries)
- **Combine DST with machine learning** to define belief functions automatically and evaluate other ML methods that consider uncertainty

Thank you for your attention.

Any questions?

Christina Ludwig
GIScience Research Group
University of Heidelberg
christina.ludwig@uni-heidelberg.de

References

Novack, T., Wang, Z., Zipf, A. (2018): A System for Generating Customized Pleasant Pedestrian Routes Based on OpenStreetMap Data. Sensors 2018, 18, 3794.

Ludwig, C. & Zipf, A. (2019): Exploring regional differences in the representation of urban green spaces in OpenStreetMap. GeoCultGIS Workshop at AGILE Conference 2019.

Images:

https://upload.wikimedia.org/wikipedia/commons/2/29/Green_Gables_House_backyard.jpg

https://upload.wikimedia.org/wikipedia/commons/0/05/Gillette_New_Jersey_residential_road_in_autumn.jpg

https://commons.wikimedia.org/wiki/File:Brussels_Cinquantenaire_R04.jpg