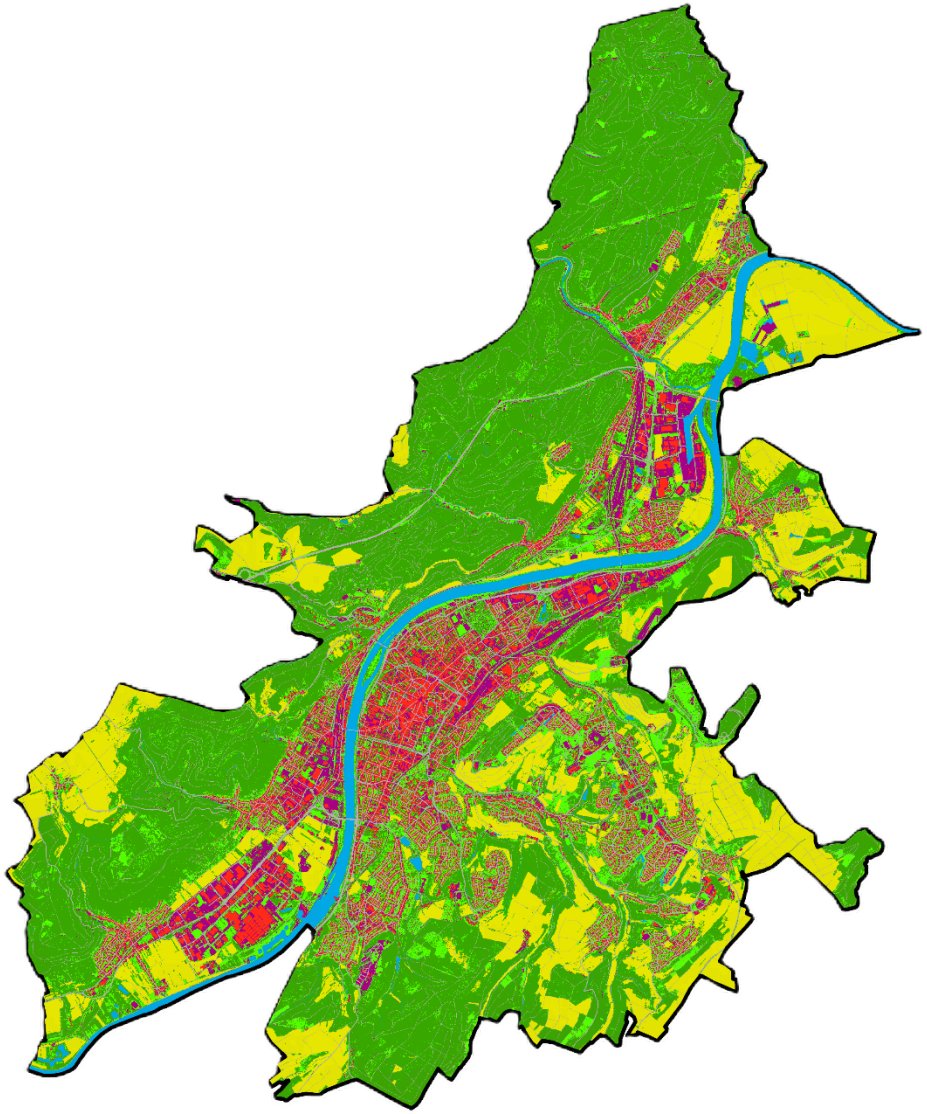

eDNA meets Remote Sensing

Assessing biodiversity in heterogeneous urban landscapes

Trier University, Geoinformatics, Research Initiative RLP

Marvin Bock

Christopher Caratiola, Arndt Schmidt,
Ralf Münnich, Thomas Udelhoven,
Henrik Krehenwinkel, David Frantz

AK Fernerkundung 2025 | Bochum | 29.09 – 30.09

The Research Initiative

Securing sustainable environment-human relations through the use of microsimulation methods

The Research Initiative

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Securing sustainable environment-human relations through the use of microsimulation methods

An interdisciplinary initiative

Department IV
- Economical- and Social Sciences
- Financial Sciences
- Communal- and Environmental Economics
- Non-Linear Optimization

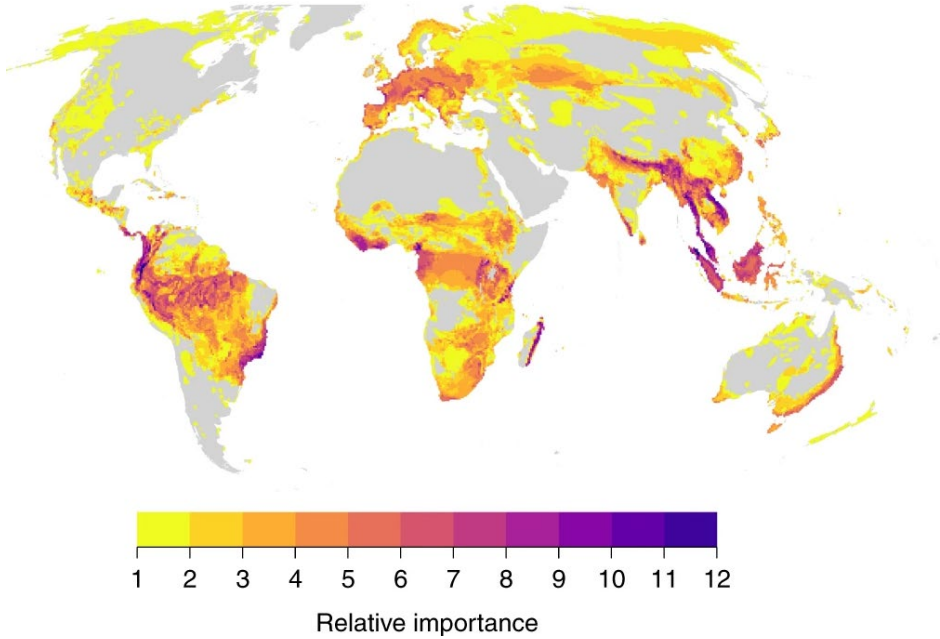
Department VI
- Geoinformatics – Spatial Data Science
- Remote Sensing and Geoinformatics
- Biogeography
- Hydrology

Biodiversity under pressure

Over the last half century…

- Land use intensification and urbanisation brought high pressure on biodiversity in rural and urban areas alike

Global hotspots of threat – Harfoot et al. (2021)



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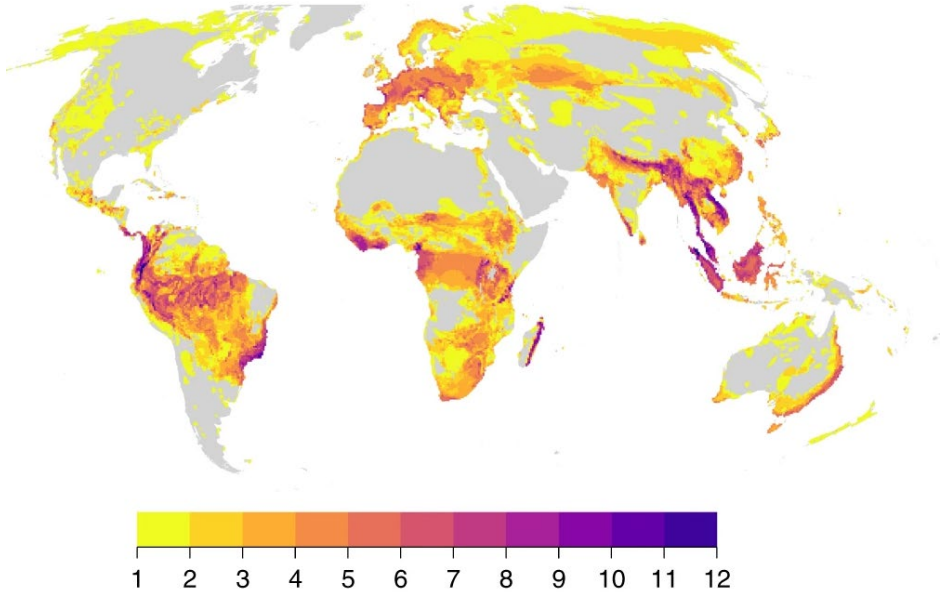

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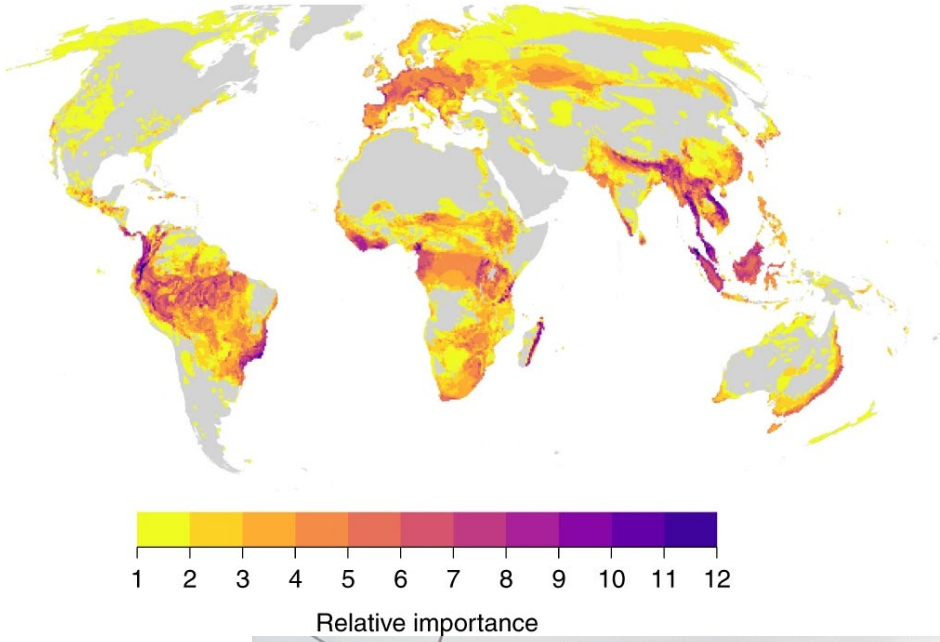

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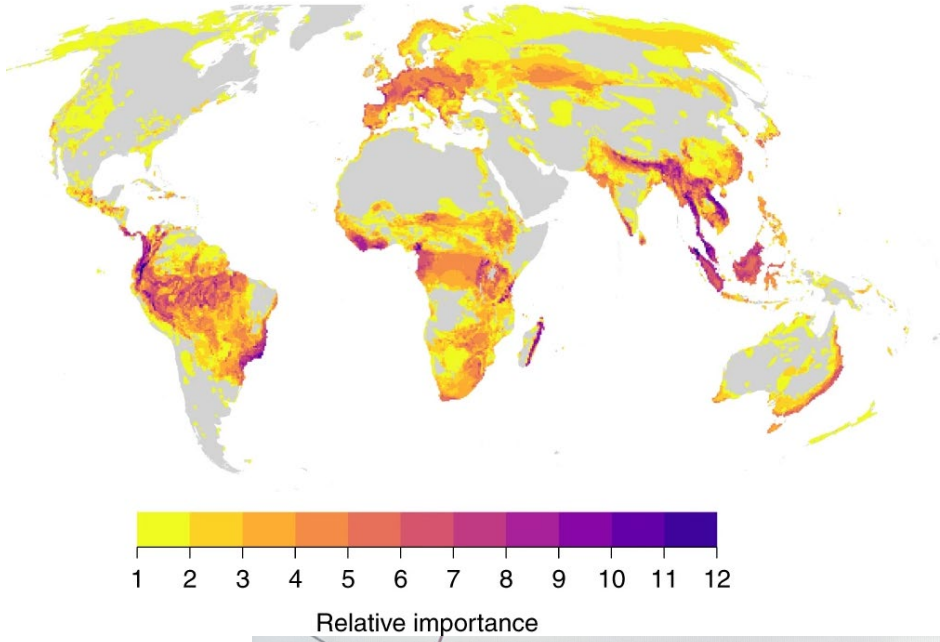

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…and biodiversity?

So, we want to know !

We ask…

- How is the distribution of biodiversity, and ideally species, in heterogenous urban landscapes?

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But…

- How to handle land cover class heterogeneity and unevenness of spatial coverage?

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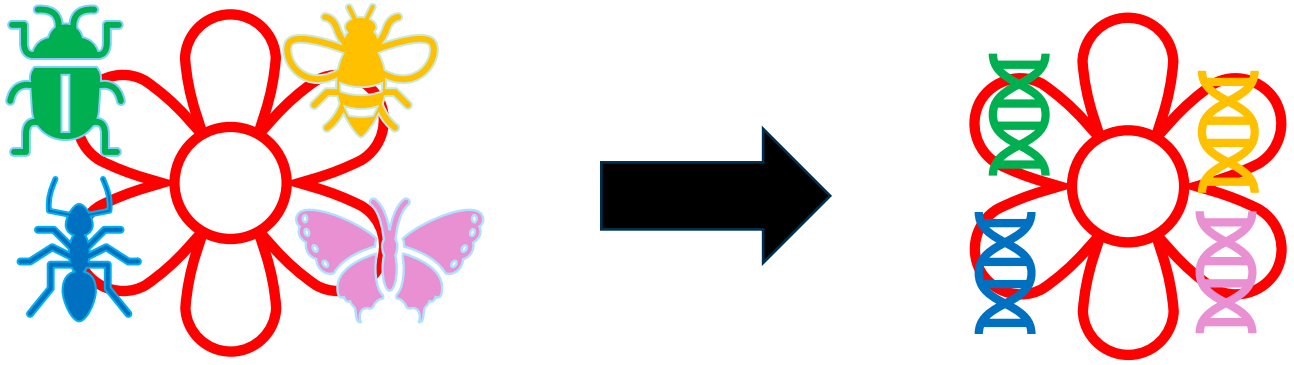
A stratified sampling design is needed!

But…

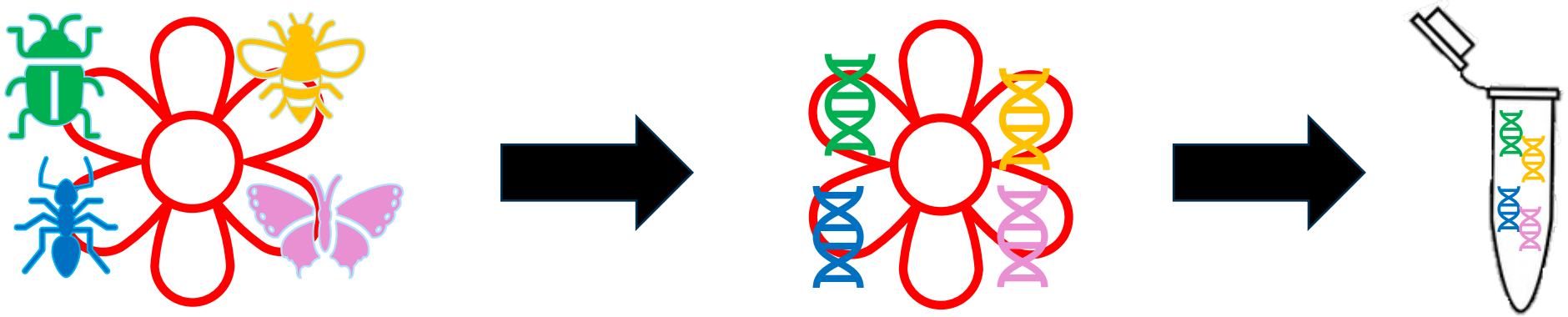
- How to handle land cover class heterogeneity and unevenness of spatial coverage?

Who is Edna?

It is eDNA!



It is eDNA!



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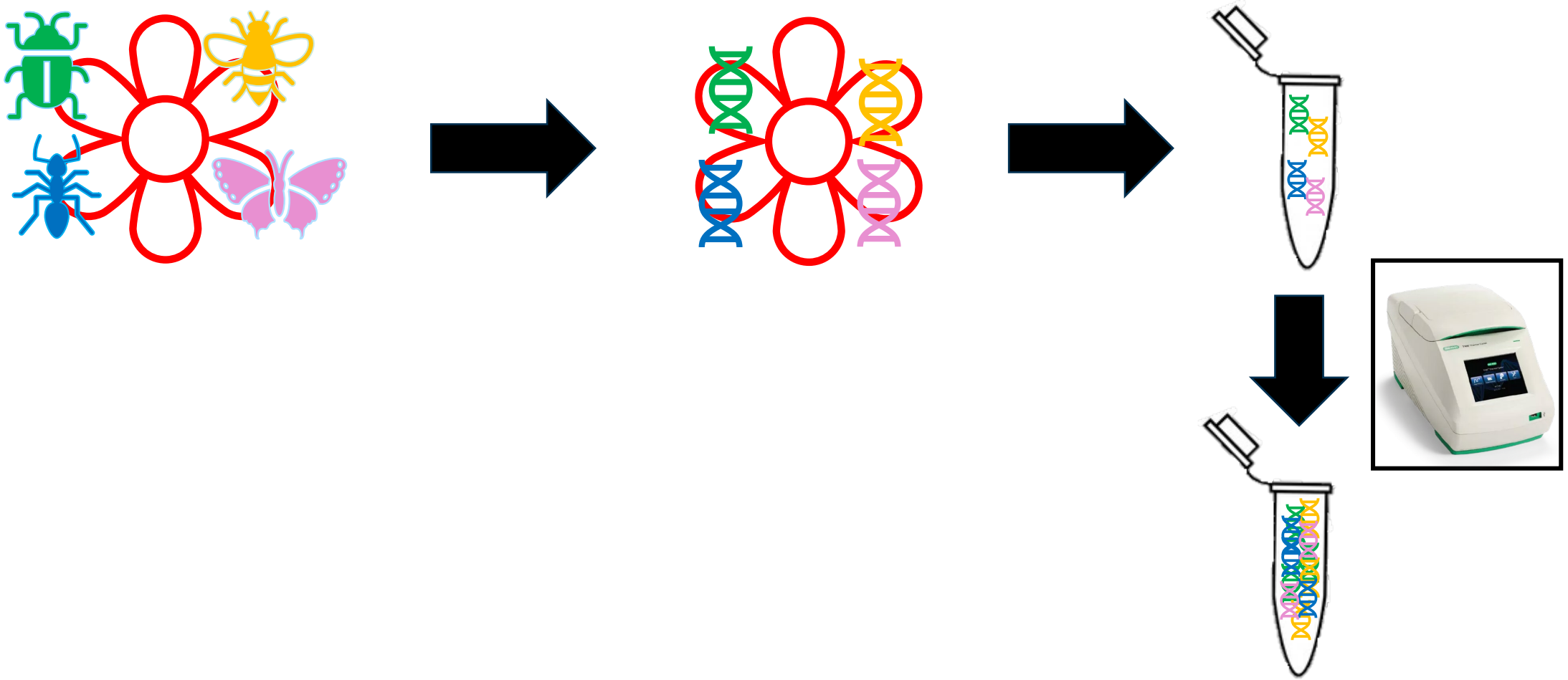

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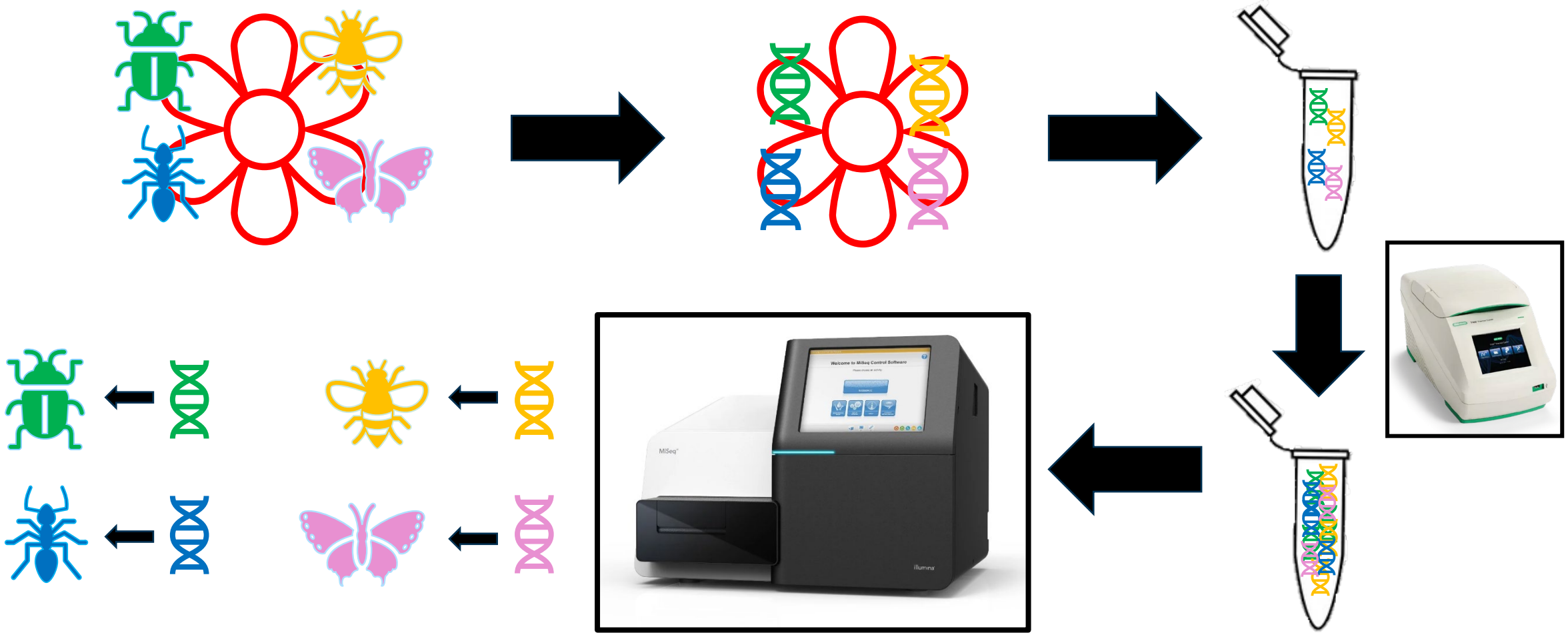

Workflow and status quo

UNIVERSITÄT TRIER

Input Data

Land cover classes – 1m

- Agrarian
- Canopy
- Open green
- Open bare
- Buildings
- Streets
- Water & rivers

Workflow and status quo

UNIVERSITÄT TRIER

Input Data

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Data from Surveying and Cadastre Administration (VermKV) of Federal State RLP

- Canopy processed according to Münzinger et al. (2022) from LiDAR, 3D CityGML LoD2 and 20cm RGBI Orthophotos
- ATKIS and Land Survey Register
- Open Green / Open Bare by 20cm RGBI Orthophotos

Workflow and status quo

Input Data

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Fractions – 10m

Workflow and status quo

UNIVERSITÄT TRIER

Input Data

Stratification

Land cover classes – 1m

- Agrarian
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Fractions – 10m

Aitchison

- Distance in simplex space
- Cellwise to centered log-ratio

Workflow and status quo

UNIVERSITÄT TRIER

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Fractions – 10m

Aitchison

- Distance in simplex space
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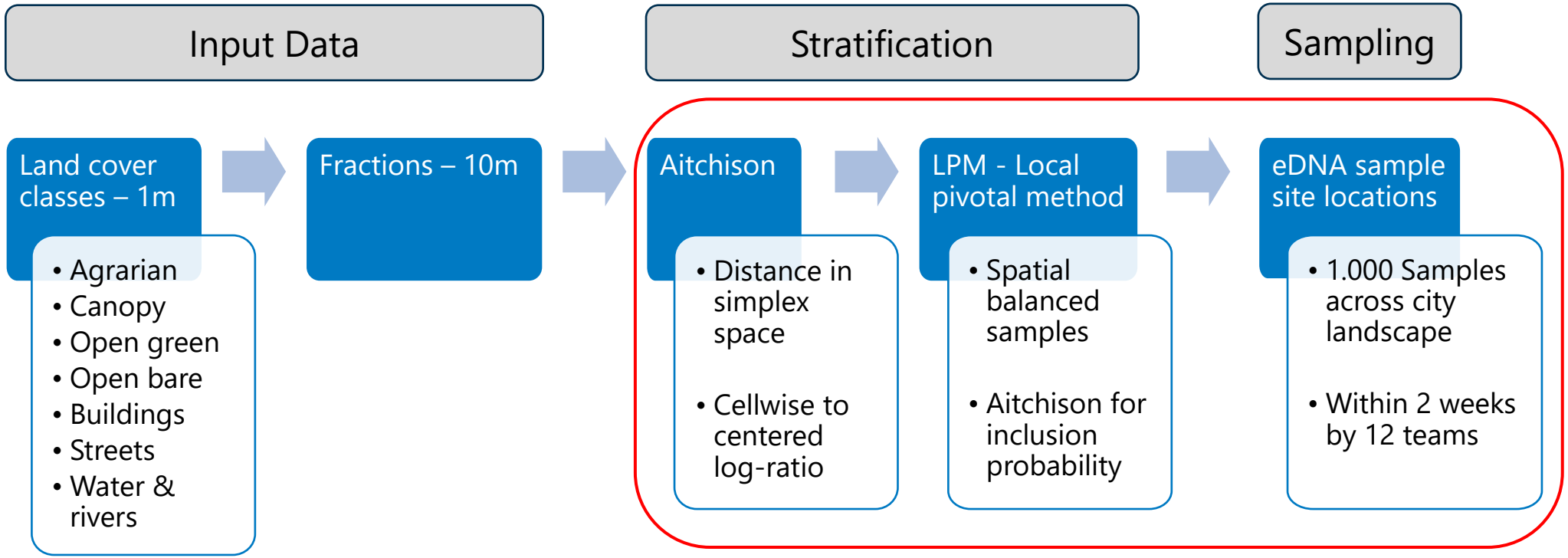
LPM - Local pivotal method

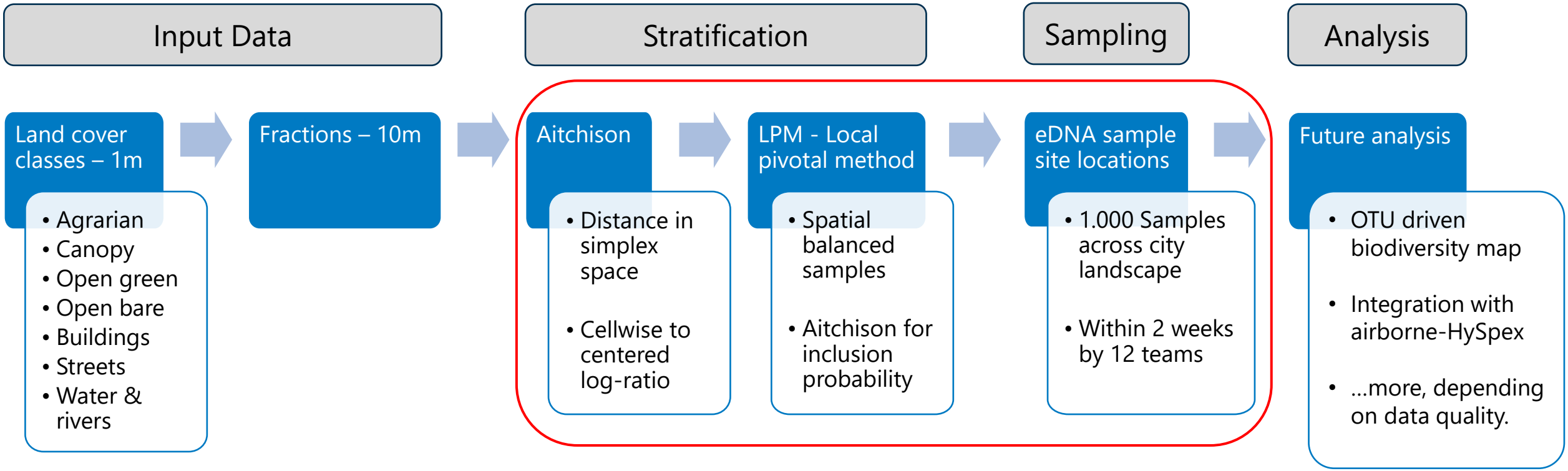
- Spatial balanced samples
- Aitchison for inclusion probability

Workflow and status quo



Workflow and status quo

UNIVERSITÄT TRIER



Workflow and status quo

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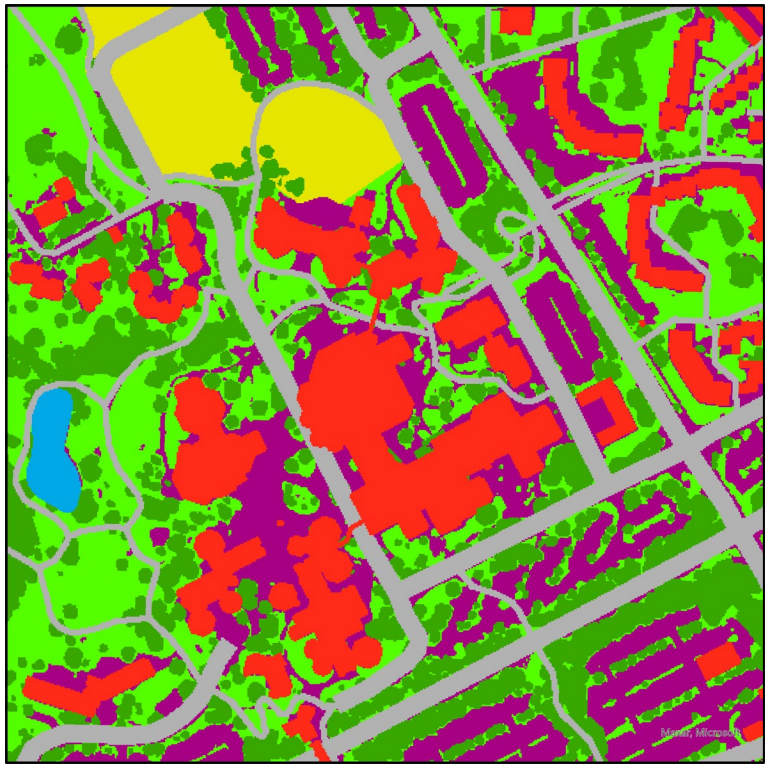
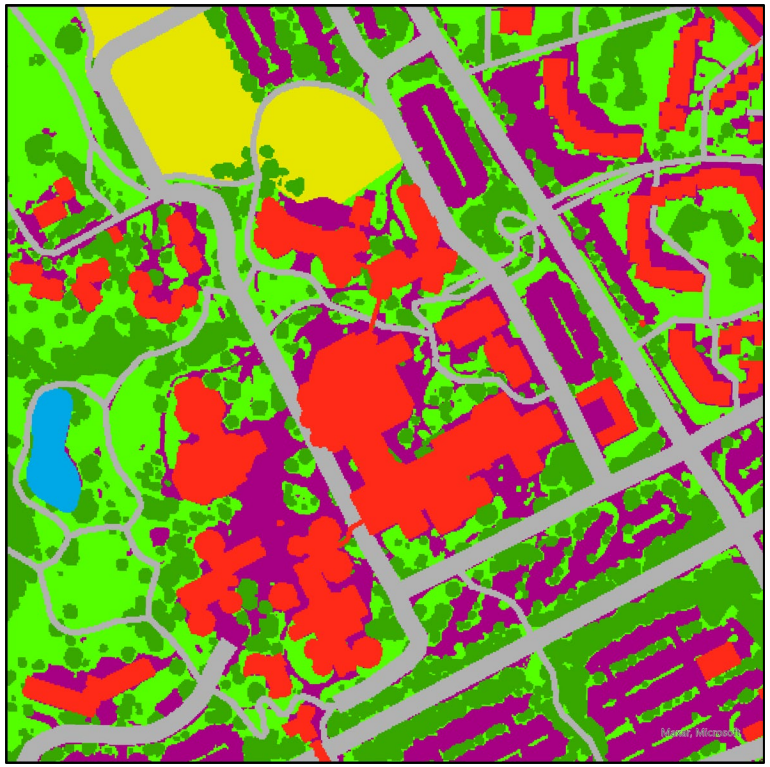
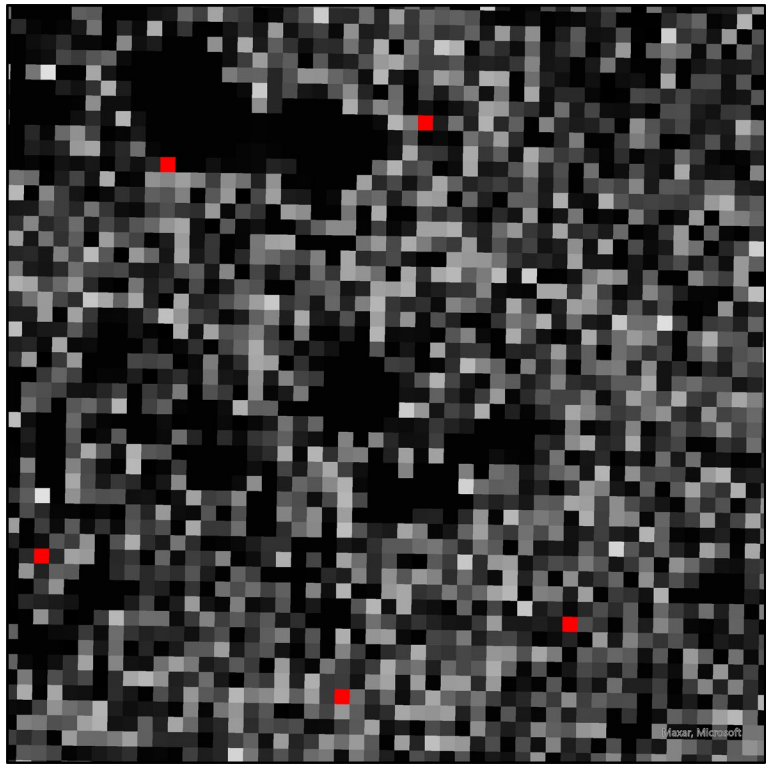
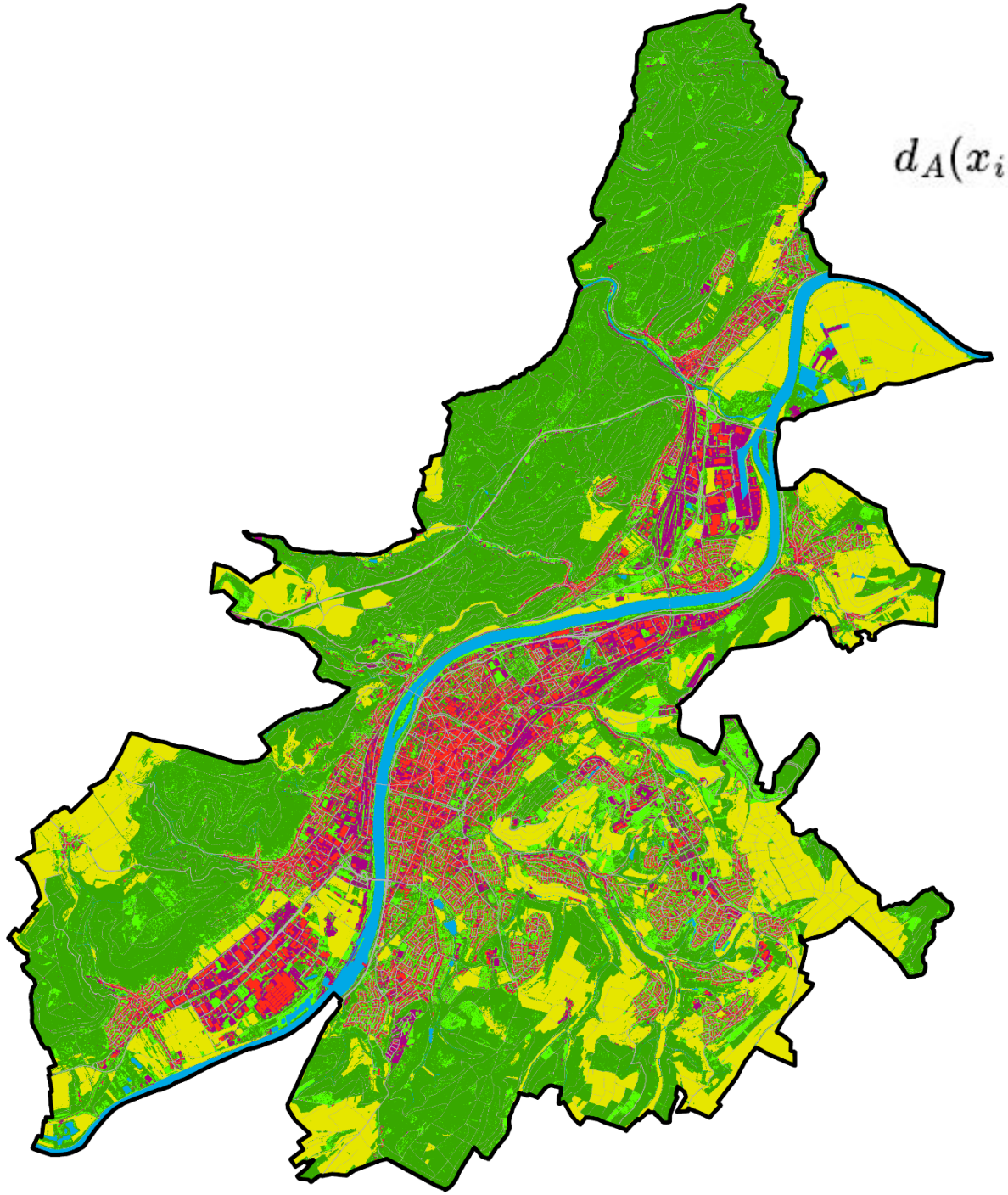


Workflow and status quo



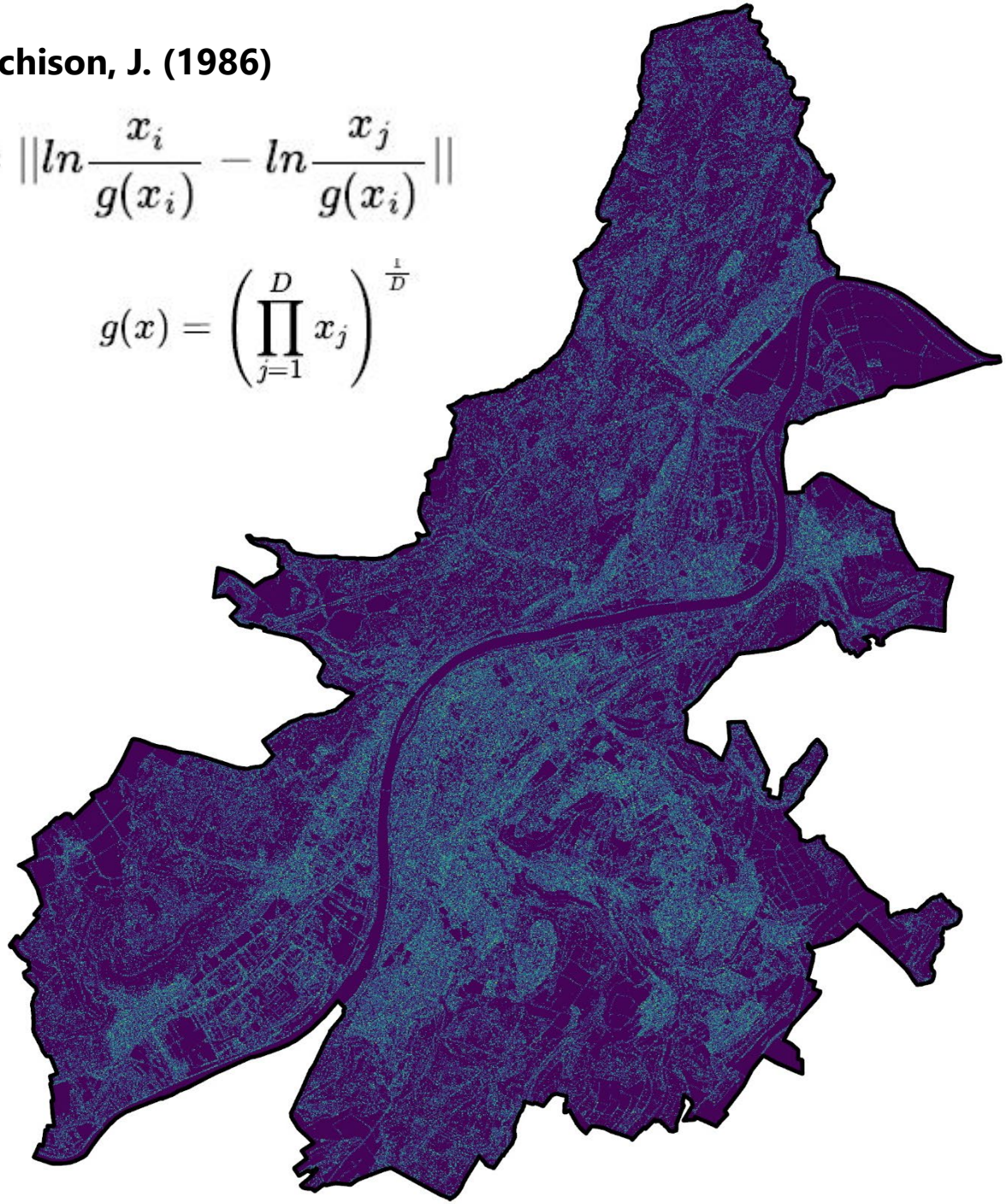


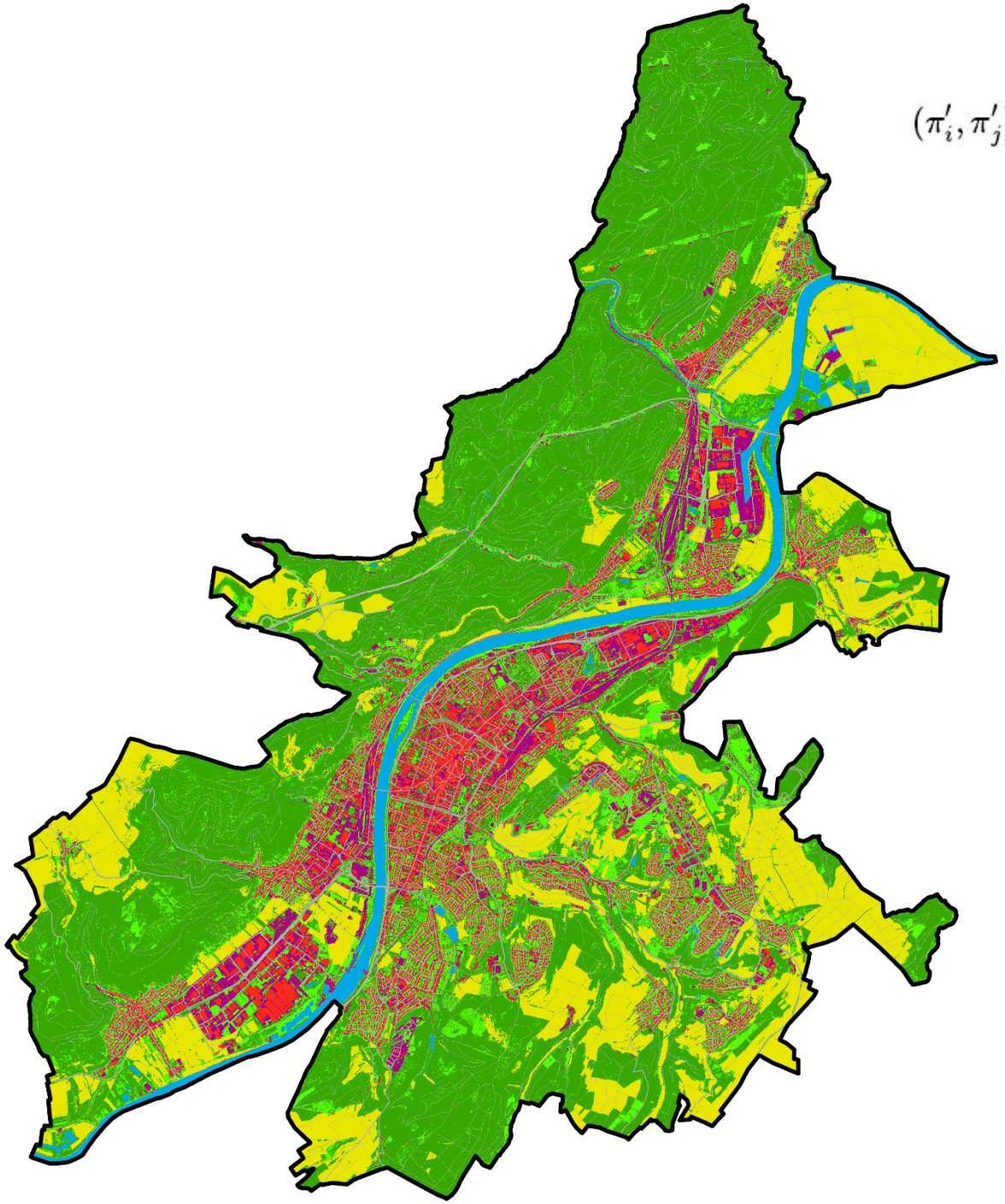


Aitchison, J. (1986)

$$d_A(x_i, x_j) = ||ln\frac{x_i}{g(x_i)} - ln\frac{x_j}{g(x_i)}||$$

$$g(x) = \left(\prod_{j=1}^{D} x_j\right)^{\frac{1}{D}}$$

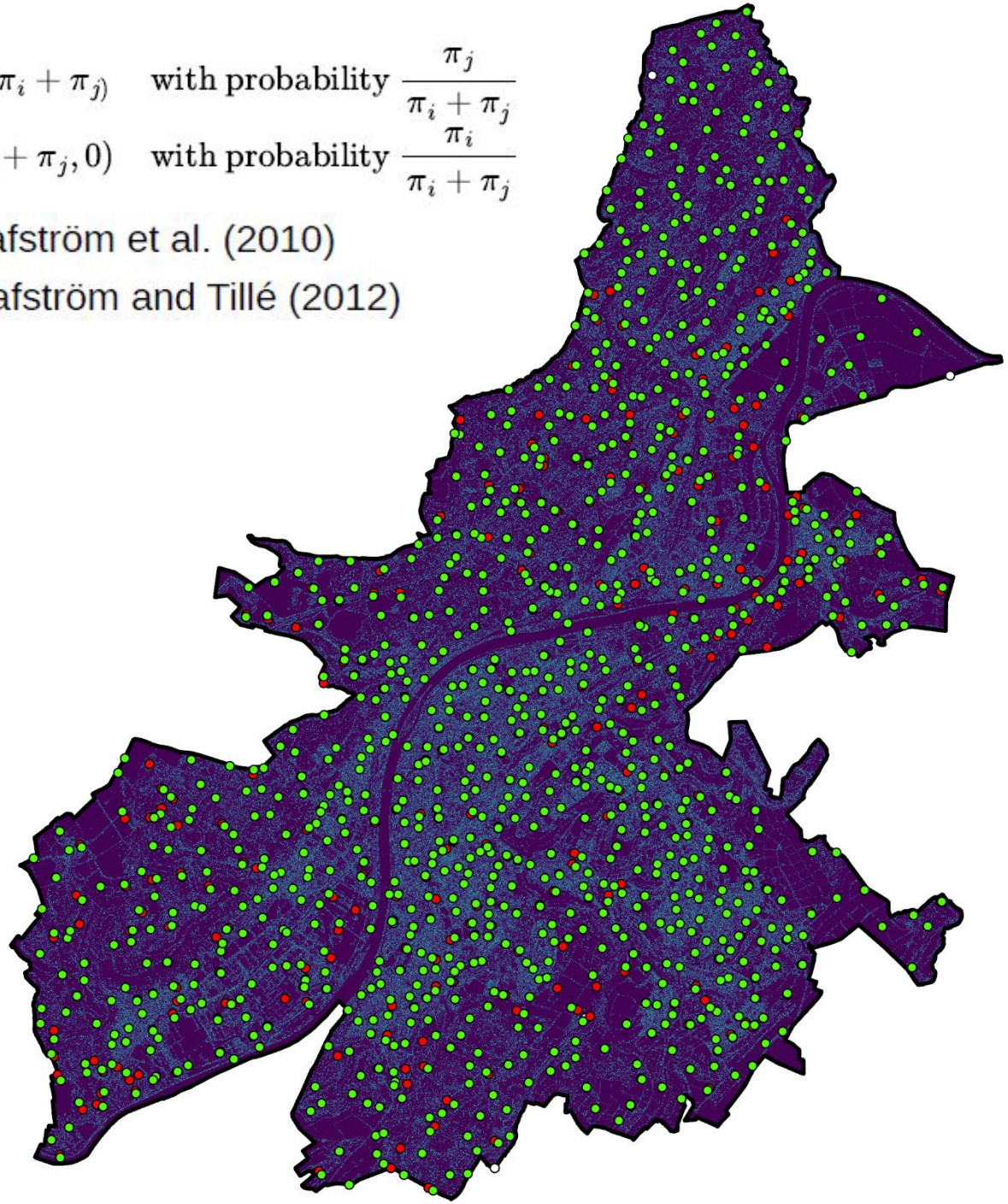


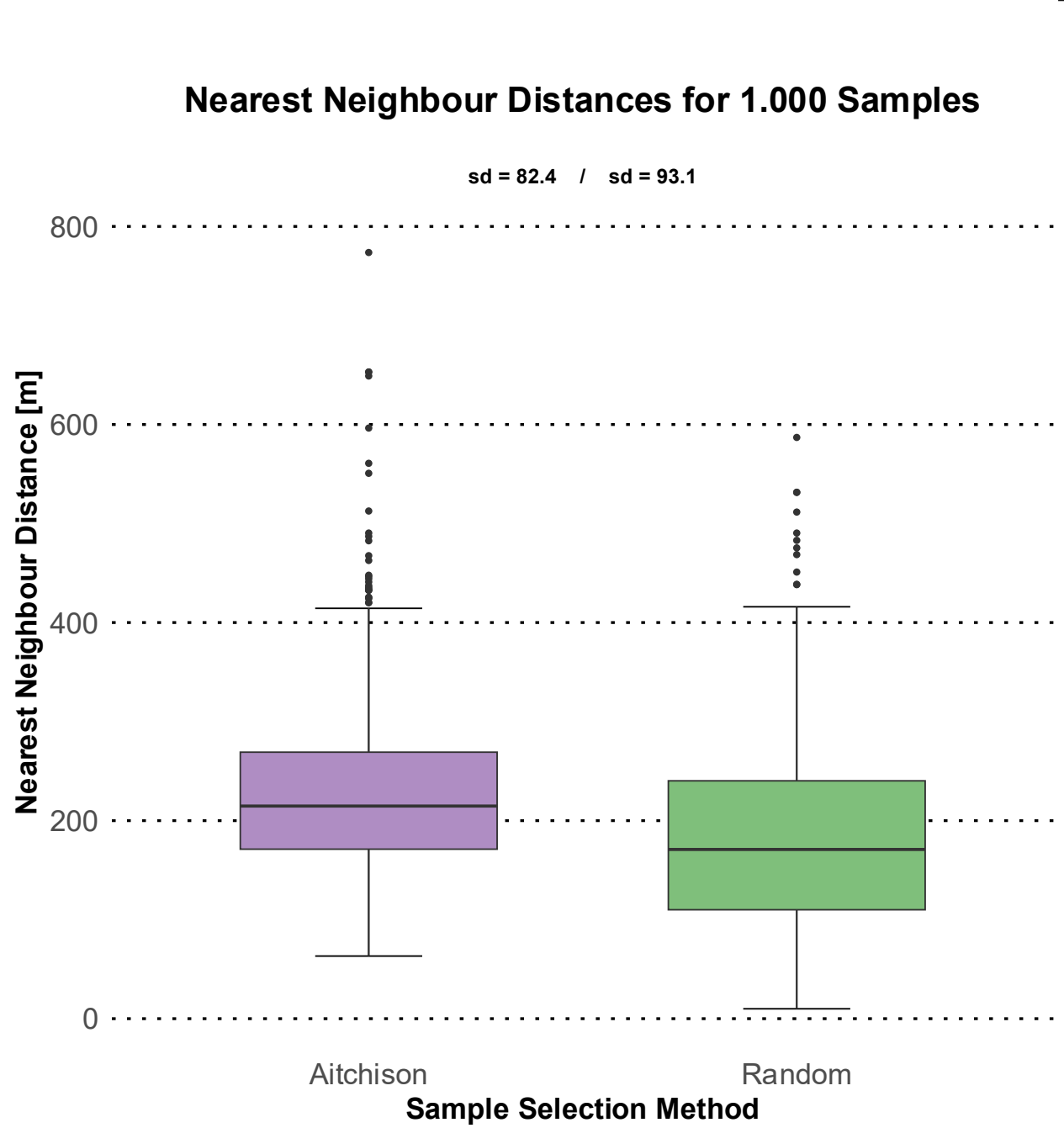


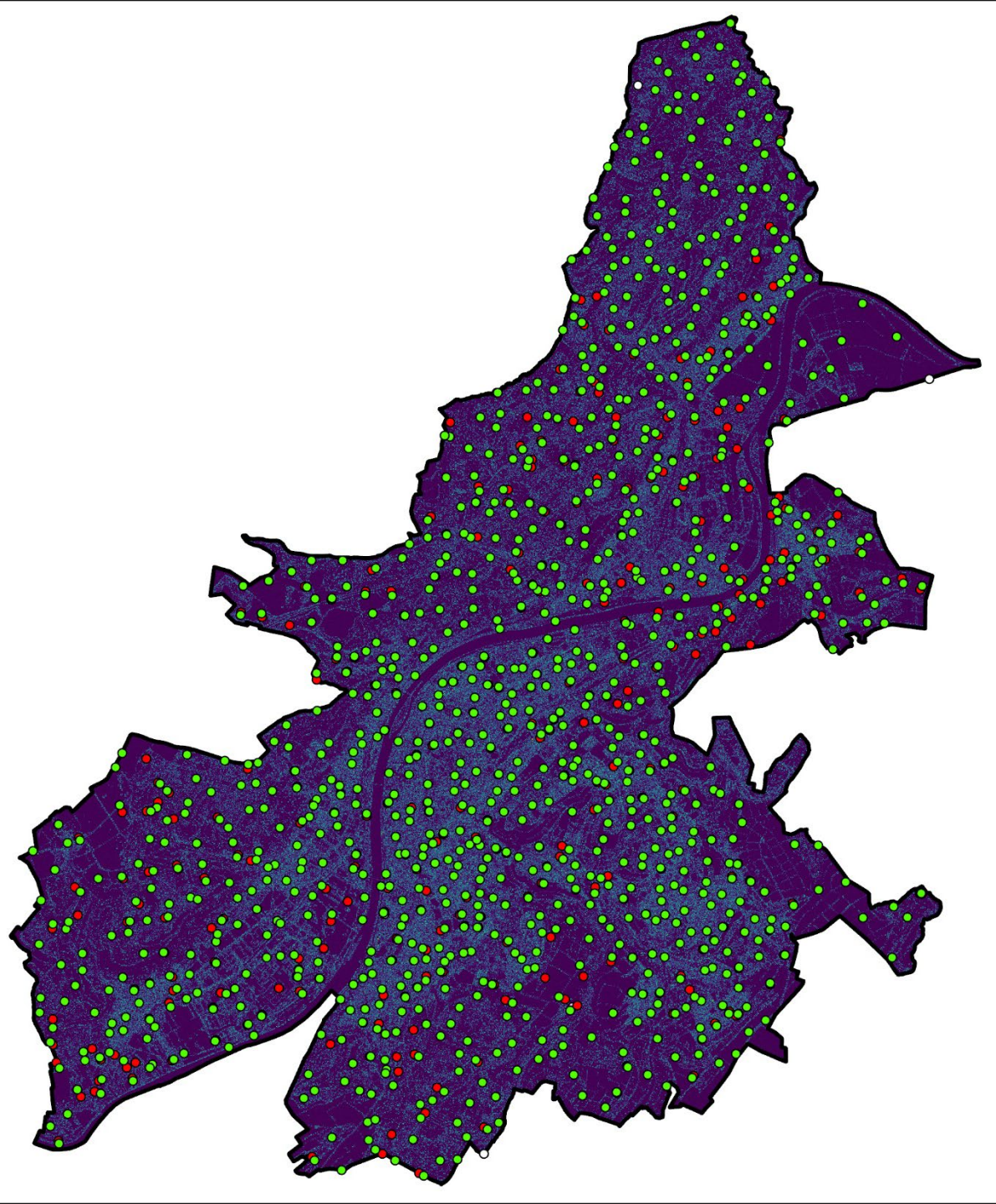
$$(\pi_i', \pi_j') = \begin{cases} (0, \pi_i + \pi_j) & \text{with probability } \dfrac{\pi_j}{\pi_i + \pi_j} \\ (\pi_i + \pi_j, 0) & \text{with probability } \dfrac{\pi_i}{\pi_i + \pi_j} \end{cases}$$

Grafström et al. (2010)

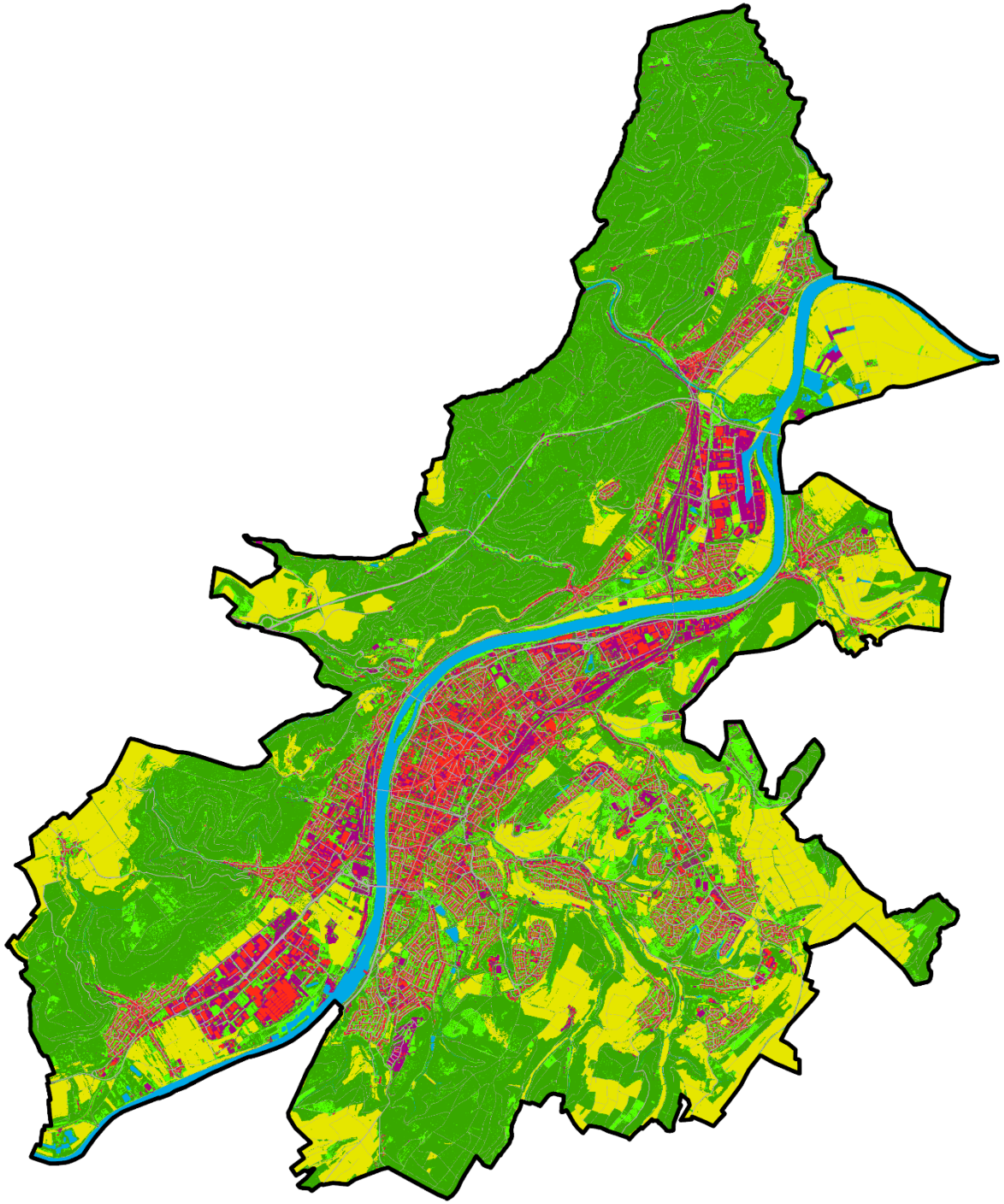
Grafström and Tillé (2012)

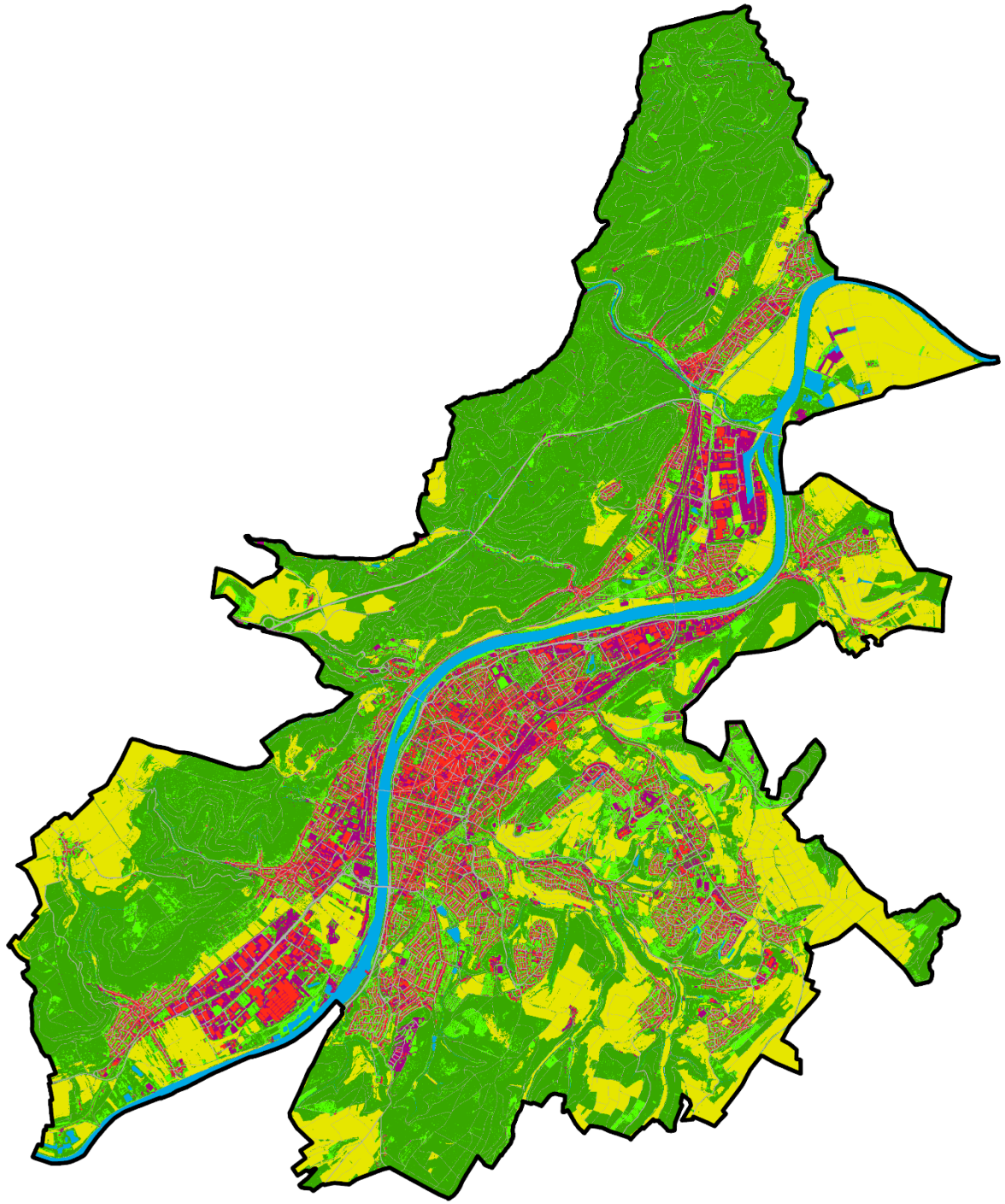


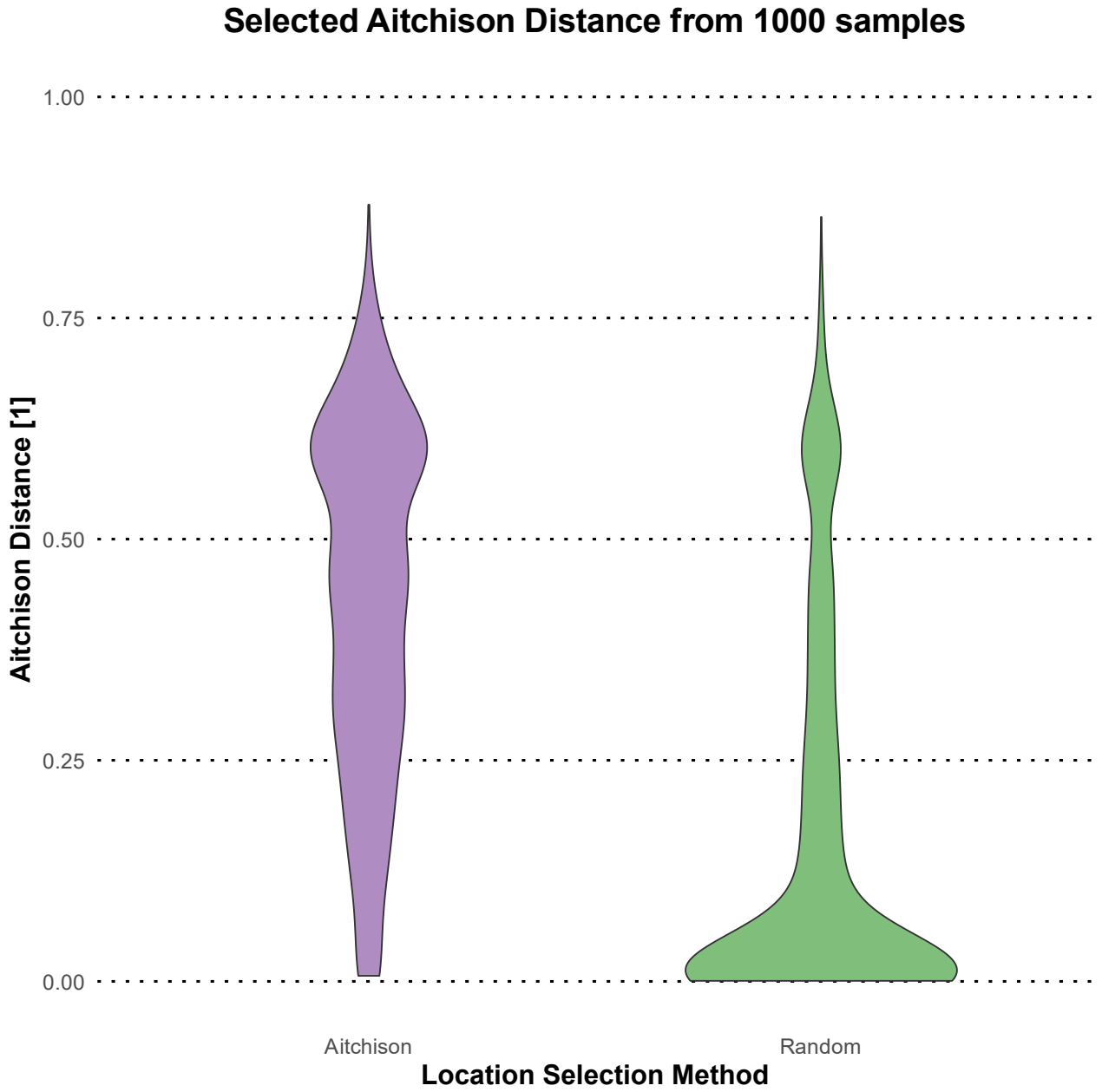




eDNA meets Remote Sensing



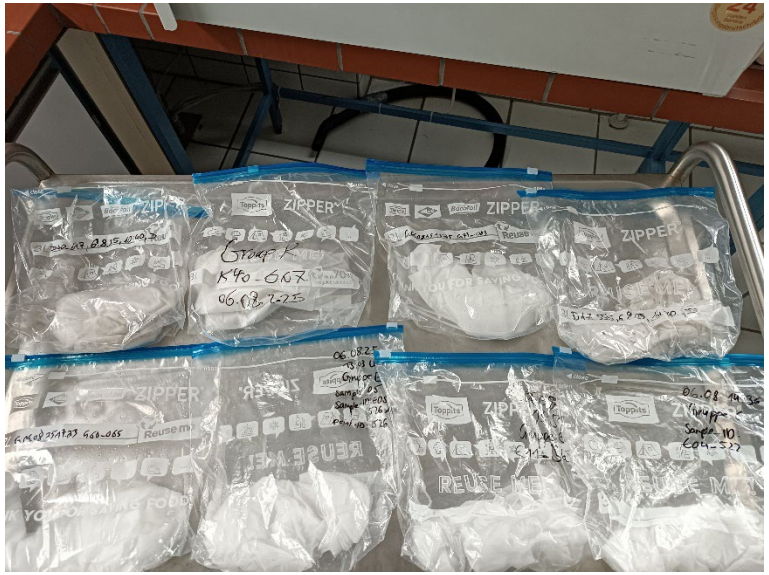



Selected Aitchison Distance from 1000 samples
1.00
0.75
0.50
0.25
0.00
Aitchison Distance [1]
Aitchison
Random
Location Selection Method

The survey…

- Was conducted from 03.08. till 16.08.2025 by 12 teams of each 2 persons

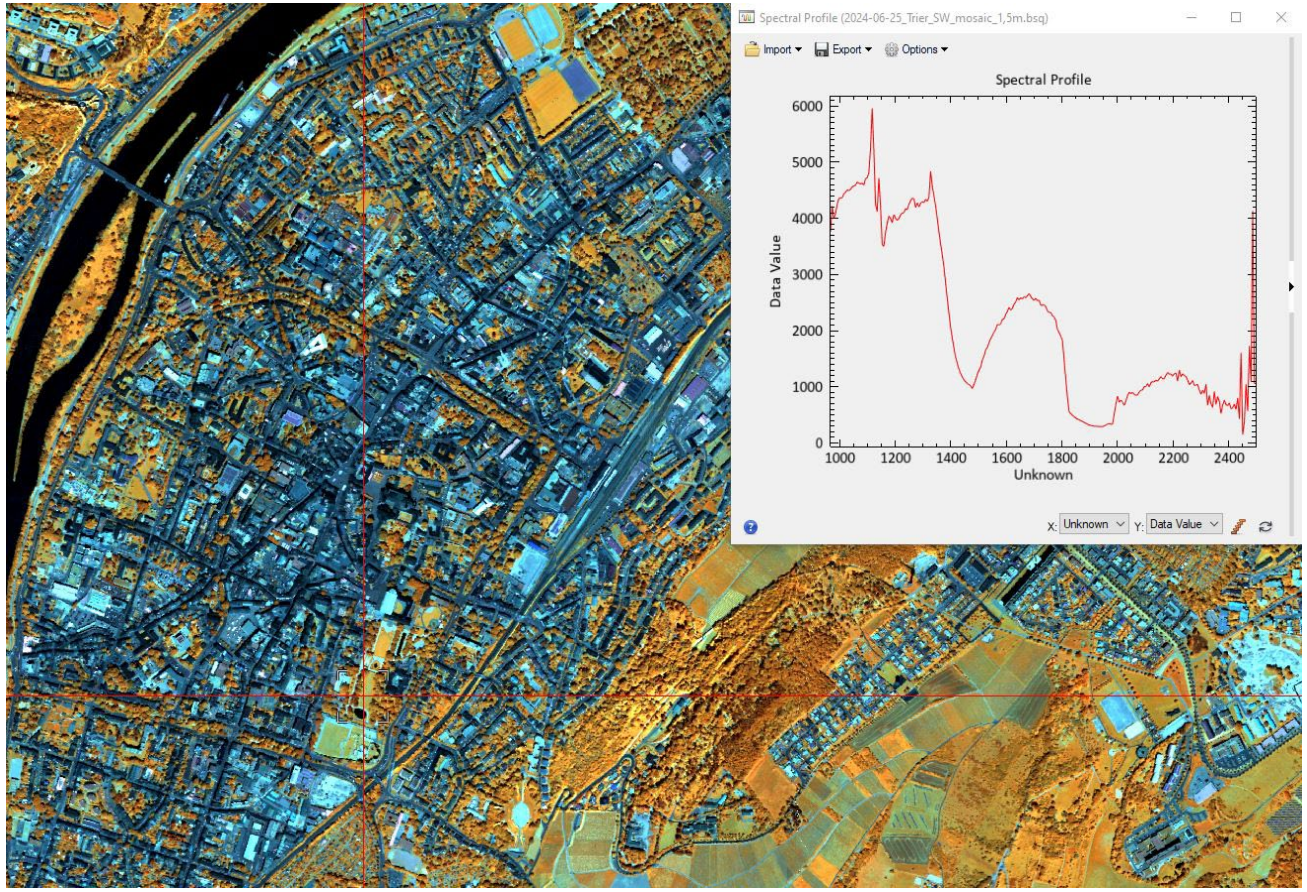
The survey…



- Was conducted from 03.08. till 16.08.2025 by 12 teams of each 2 persons
- We gathered 996 georeferenced samples and 56 blanks, including pictures of the surroundings
- Samples are currently being processed in the Lab

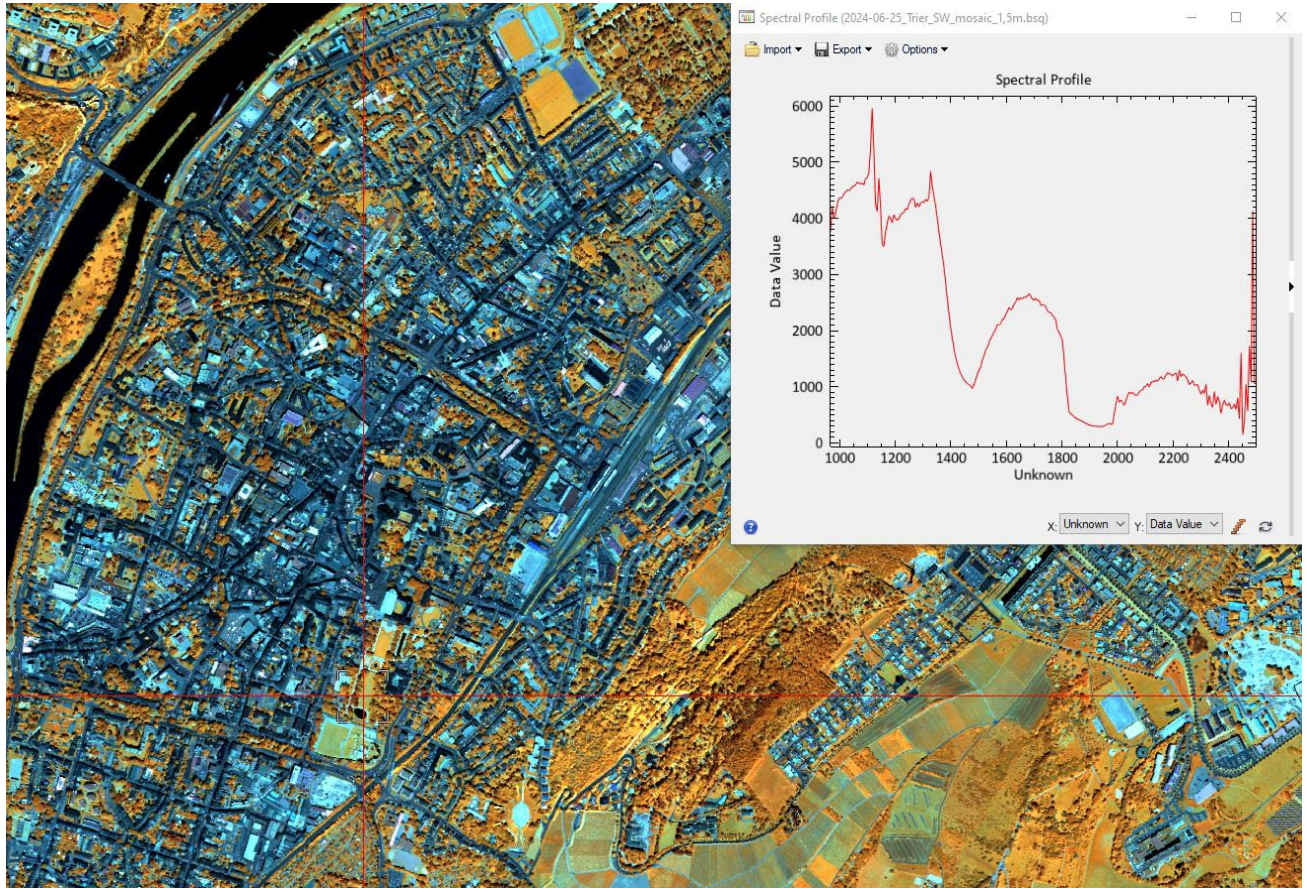
Outlook – Future Analysis

- Modelling and mapping of biodiversity in Trier



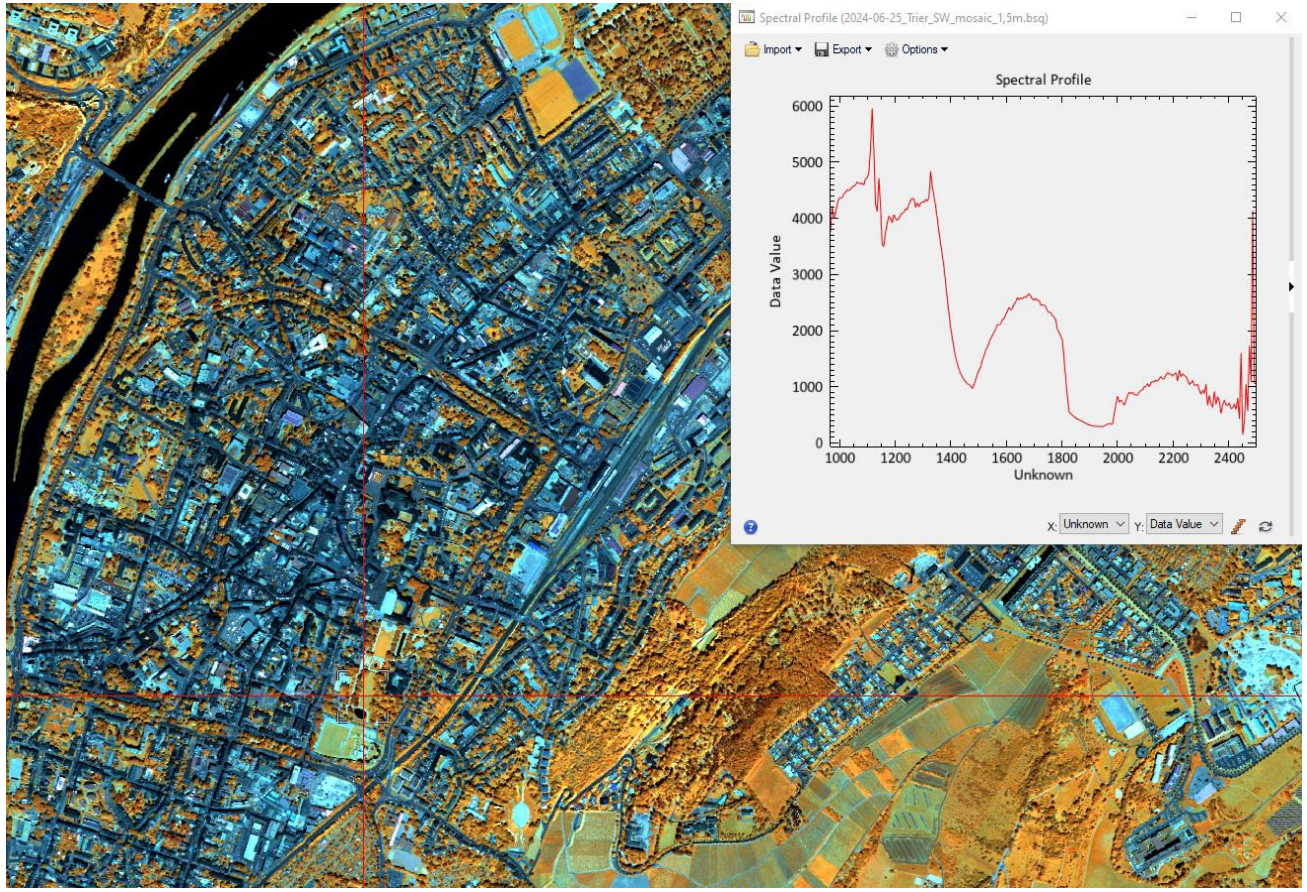
Outlook – Future Analysis

- Modelling and mapping of biodiversity in Trier
- Spatial patterns and distribution corridors for species richness and composition



Outlook – Future Analysis

- Modelling and mapping of biodiversity in Trier
- Spatial patterns and distribution corridors for species richness and composition
- Species compositions shifts and dependencies with rural surroundings



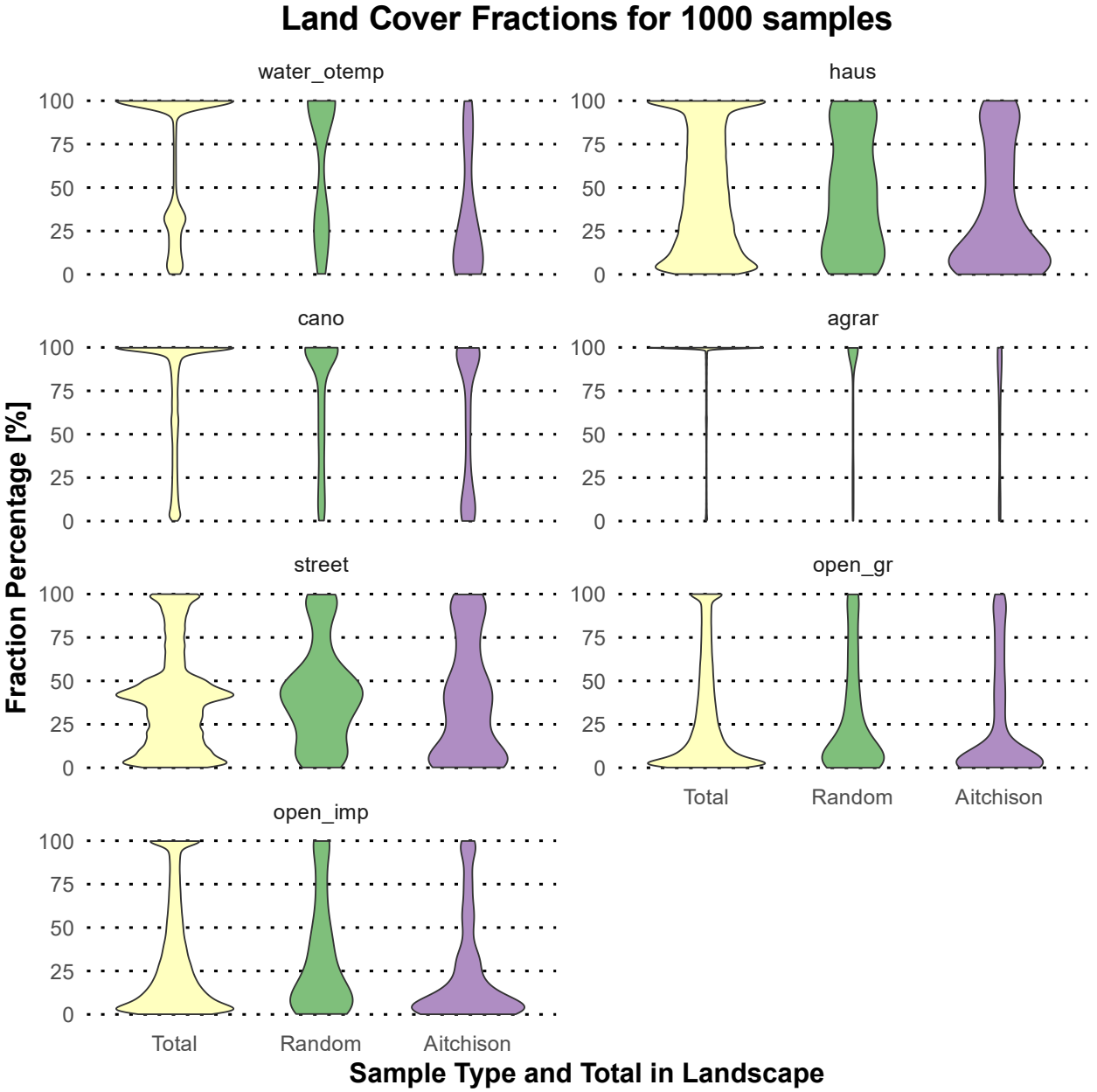
Questions?

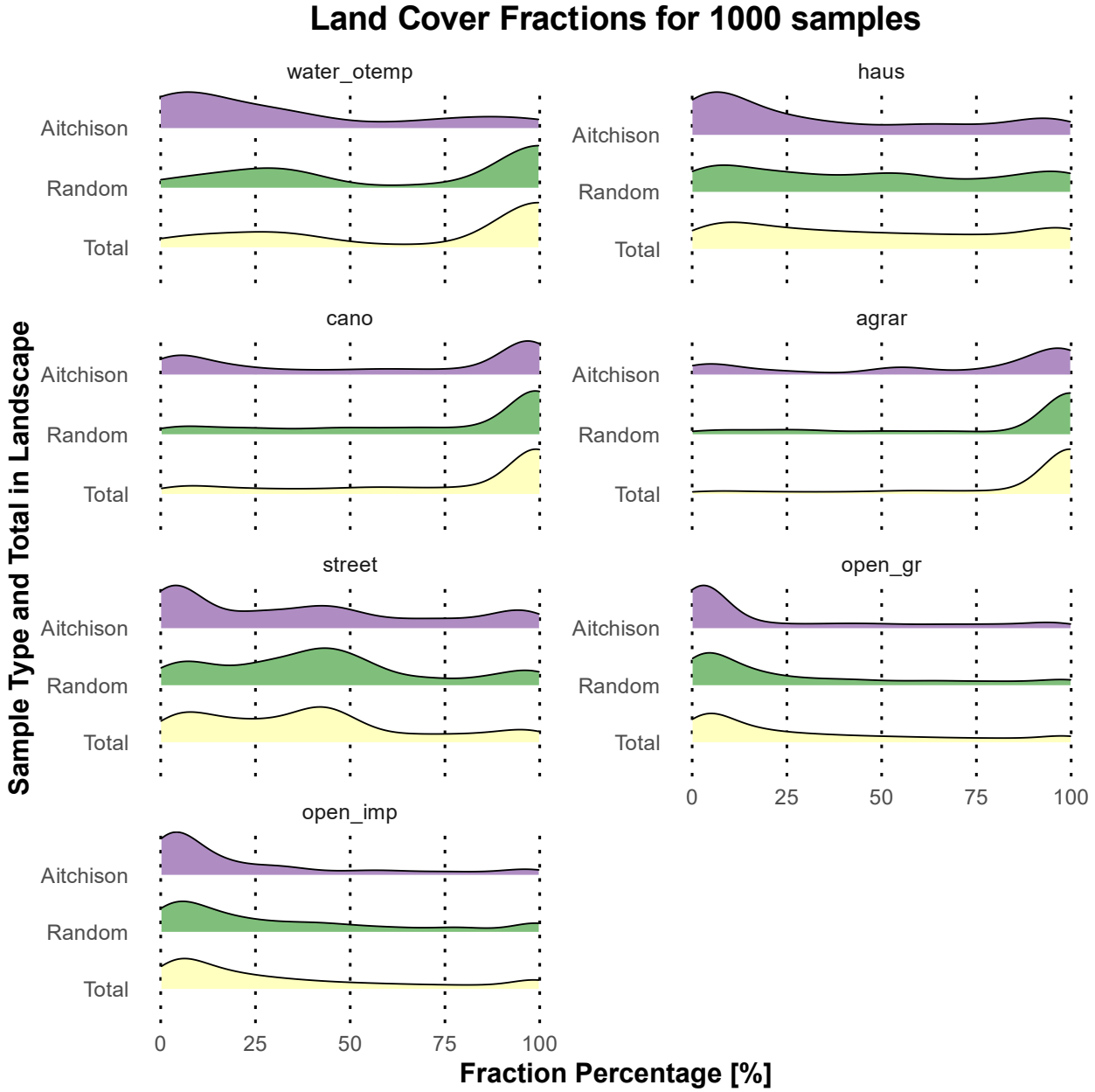
Thanks for Watching

Geoinformatics - Spatial Data Science

Contact
Marvin Bock
bockm@uni-trier.de

Institute Webpage
https://www.uni-trier.de/universitaet/fachbereiche-faecher/fachbereich-vi/faecher/geoinformatik


Land Cover Fractions for 1000 samples
water_otemp
haus
cano
agrar
street
open_gr
open_imp
100
75
50
25
0
Fraction Percentage [%]
Total
Random
Aitchison
Sample Type and Total in Landscape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50
75
100
Fraction Percentage [%]

Distribution over Trier city compartments

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Copernicus Urban Atlas class	Global	Random mean	Aitchison mean	Aitchison Difference	r_sd	a_sd
Forests	43.303	43.279	37.826	5.5	1.605	0.865
Arable land (annual crops)	11.266	11.280	4.548	6.7	1.010	0.536
Industrial, commercial, public, military and private units	7.799	7.792	9.581	-1.8	0.867	0.690
Pastures	7.635	7.662	4.392	3.2	0.839	0.566
Discontinuous dense urban fabric (S.L. : 50% - 80%)	7.549	7.551	14.316	-6.8	0.876	0.813
Other roads and associated land	3.845	3.844	7.555	-3.7	0.591	0.791
Water	3.086	3.098	0.861	2.2	0.541	0.268
Discontinuous medium density urban fabric (S.L. : 30% - 50%)	2.821	2.822	5.022	-2.2	0.528	0.589
Herbaceous vegetation associations (natural grassland, moors...)	2.282	2.297	2.560	-0.3	0.473	0.407
Permanent crops (vineyards, fruit trees, olive groves)	2.122	2.123	1.127	1.0	0.458	0.290
Continuous urban fabric (S.L. : > 80%)	2.118	2.116	3.712	-1.6	0.449	0.472
Sports and leisure facilities	1.982	1.980	2.786	-0.8	0.434	0.374
Green urban areas	1.442	1.444	2.105	-0.7	0.385	0.403
Railways and associated land	0.908	0.899	1.109	-0.2	0.298	0.294
Fast transit roads and associated land	0.497	0.495	0.619	-0.1	0.217	0.217
Discontinuous low density urban fabric (S.L. : 10% - 30%)	0.325	0.335	0.518	-0.2	0.164	0.202
Land without current use	0.291	0.309	0.308	0.0	0.164	0.139
Isolated structures	0.266	0.288	0.409	-0.1	0.160	0.187
Discontinuous very low density urban fabric (S.L. : < 10%)	0.183	0.218	0.364	-0.2	0.123	0.131
Wetlands	0.135	0.178	0.158	0.0	0.096	0.066
Mineral extraction and dump sites	0.107	0.158	0.146	0.0	0.081	0.064
Port areas	0.038	0.115	0.116	-0.1	0.039	0.037