

# *Using deep learning to identify (urban) form and function in satellite imagery*

*The case of Great Britain*

Dani Arribas-Bel

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[\[@martinfleis\]](#)



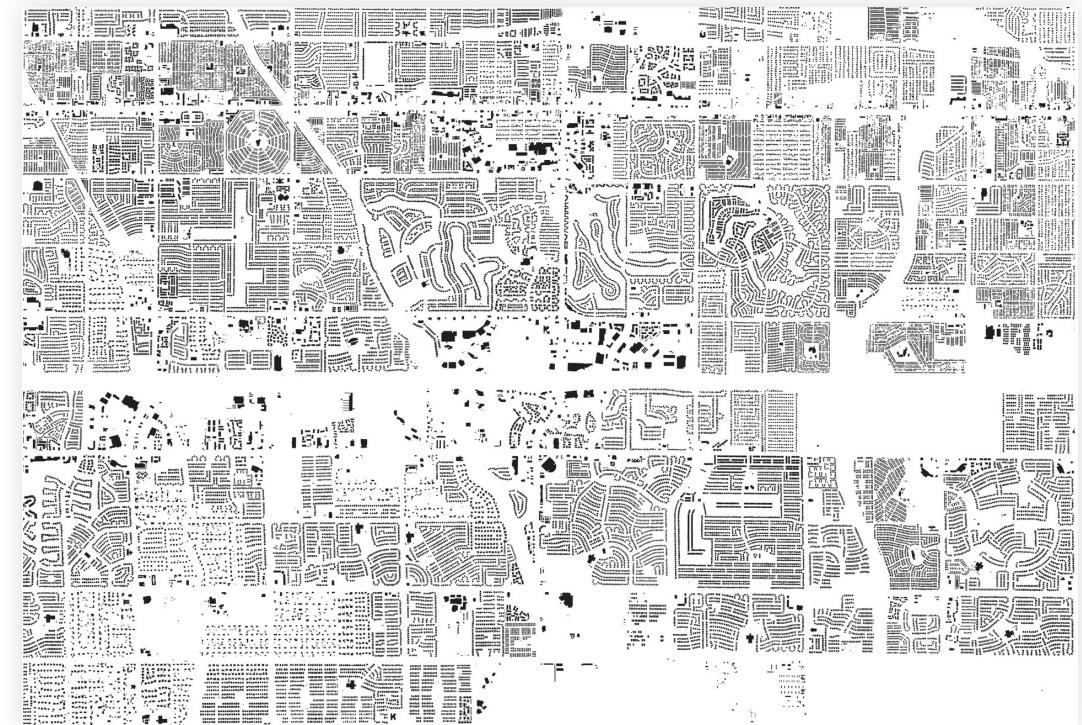
The  
Alan Turing  
Institute



Geographic  
Data Science  
Lab

“The point”

# How we arrange “stuff” in cities matters...



Source: *A map of every building in America* ([New York Times](#))

... it matters *a lot*

Journal of Urban Economics 111 (2019) 93–107  
Contents lists available at ScienceDirect  
Journal of Urban Economics journal homepage: [www.elsevier.com/locate/jue](http://www.elsevier.com/locate/jue)

The economic effects of density: A synthesis<sup>☆</sup>  
Gabriel M. Ahlfeldt<sup>a,1,\*</sup>, Elisabetta Pietrostefani<sup>b</sup>  
<sup>a</sup>London School of Economics and Political Sciences (LSE) and Centre for Economic Policy Research (CEPR), Houghton Street, London WC2A 2AE, United Kingdom  
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Cities in Bad Shape: Urban Geometry in India - American Economic Association — Mozilla Firefox

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## Cities in Bad Shape: Urban Geometry in India

Mariaflavia Harari

AMERICAN ECONOMIC REVIEW  
VOL. 110, NO. 8, AUGUST 2020  
(pp. 2377-2421)

ARTICLE  
pubs.acs.org/est

## Environmental Science & Technology

Effects of Income and Urban Form on Urban NO<sub>2</sub>: Global Evidence from Satellites  
Matthew J. Bechle,<sup>†</sup> Dylan B. Millet,<sup>†,‡</sup> and Julian D. Marshall<sup>\*,†</sup>  
<sup>†</sup>Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota 55455, United States  
<sup>‡</sup>Department of Soil, Water, and Climate, University of Minnesota, Minneapolis, Minnesota 55455, United States

Living with beauty: report of the Building Better, Building Beautiful Commission

Independent report on how to promote and increase the use of high-quality design for new build homes and neighbourhoods.

From: Ministry of Housing, Communities & Local Government  
Published: 30 January 2020

Applies to: England

Related content  
[Creating space for beauty: interim report of the Building Better, Building Beautiful Commission](#)

## Rethinking Urban Sprawl MOVING TOWARDS SUSTAINABLE CITIES



OECD

## NEW URBAN AGENDA

H | III | UN

# Form & Function

Form

*What does it look like?*

“Physical structure and appearance of cities”

Function

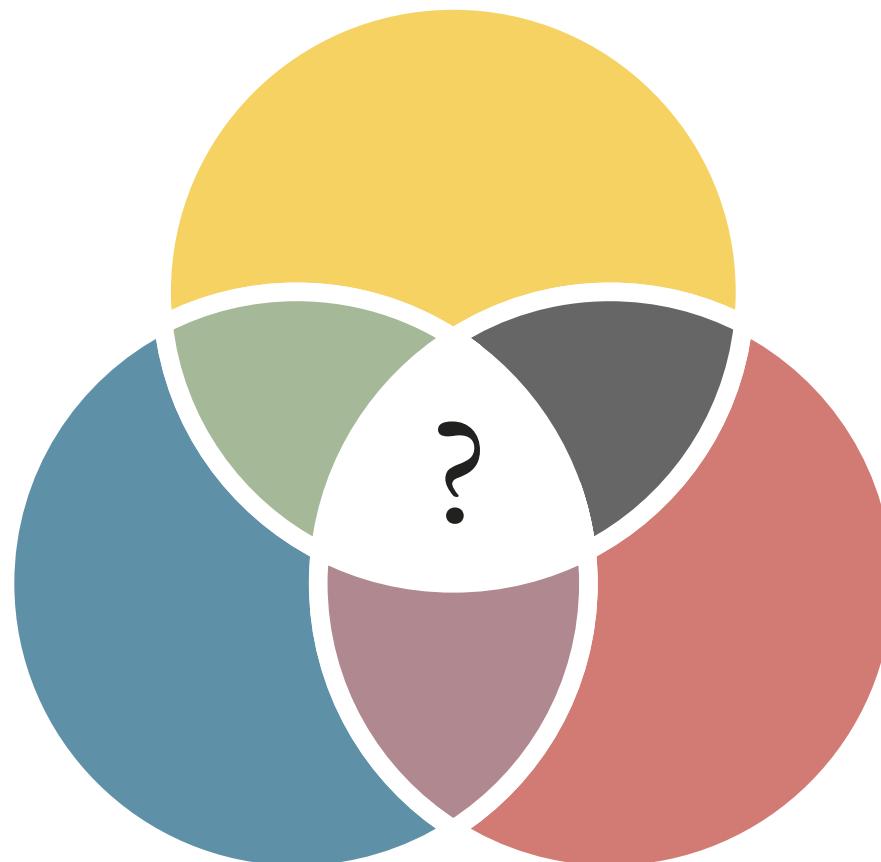
*What is it used for?*

“Activities that take place within an environment”

detailed

scalable

consistent



# Spatial Signatures

*A characterisation of space based on form and function  
designed to understand urban environments*

# British Signatures

# BRITISH SIGNATURES

Countryside (3)



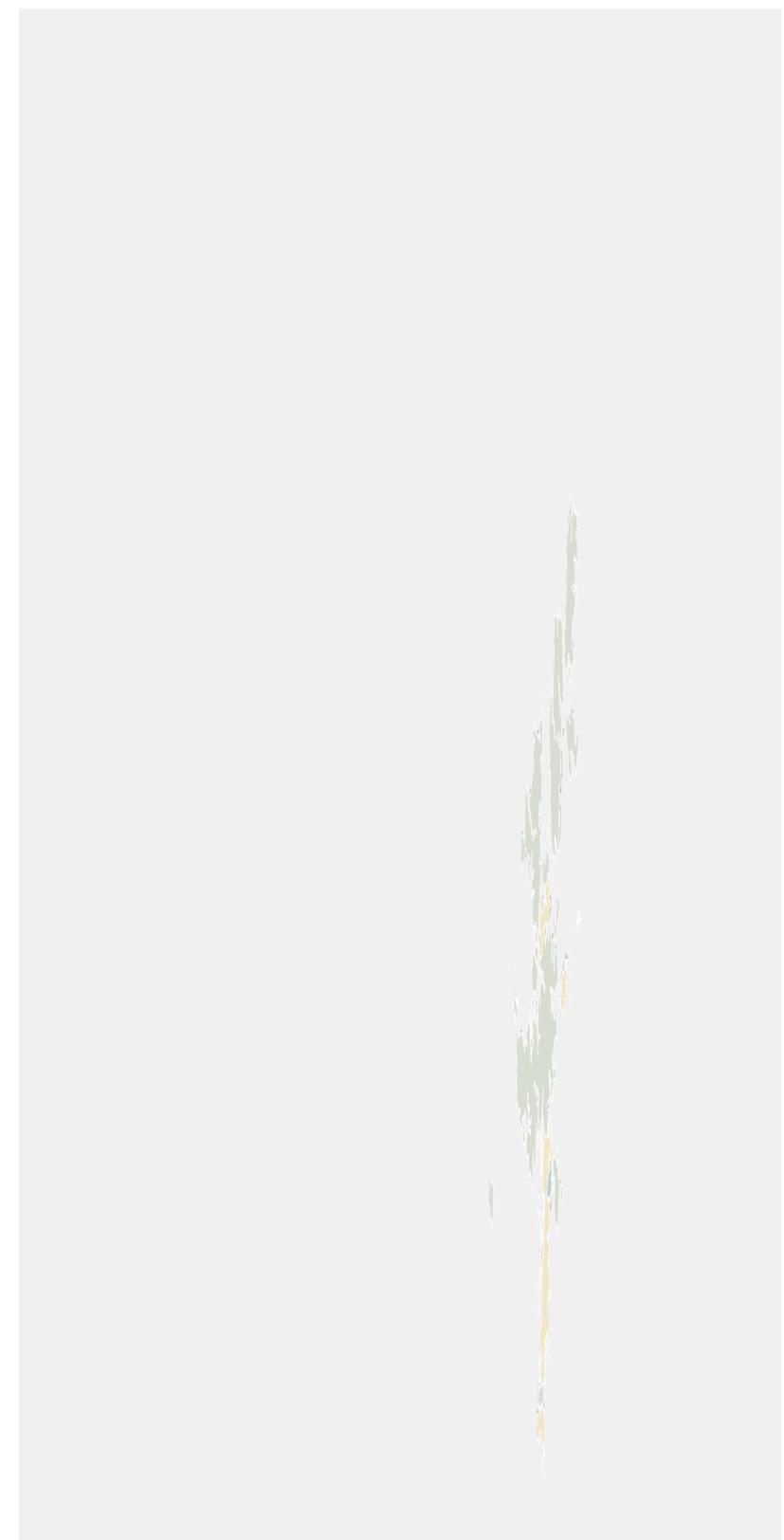
Periphery (4)

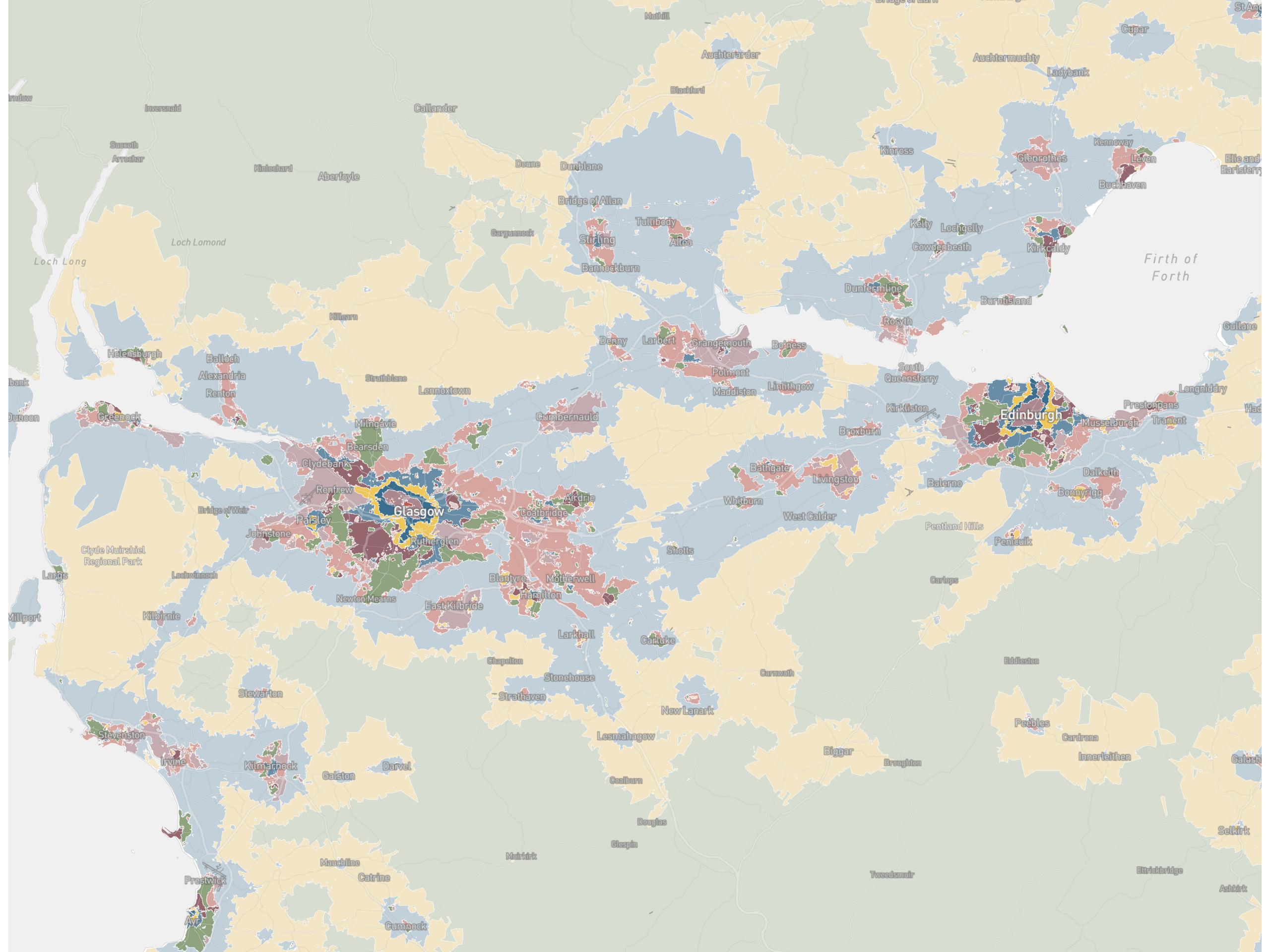


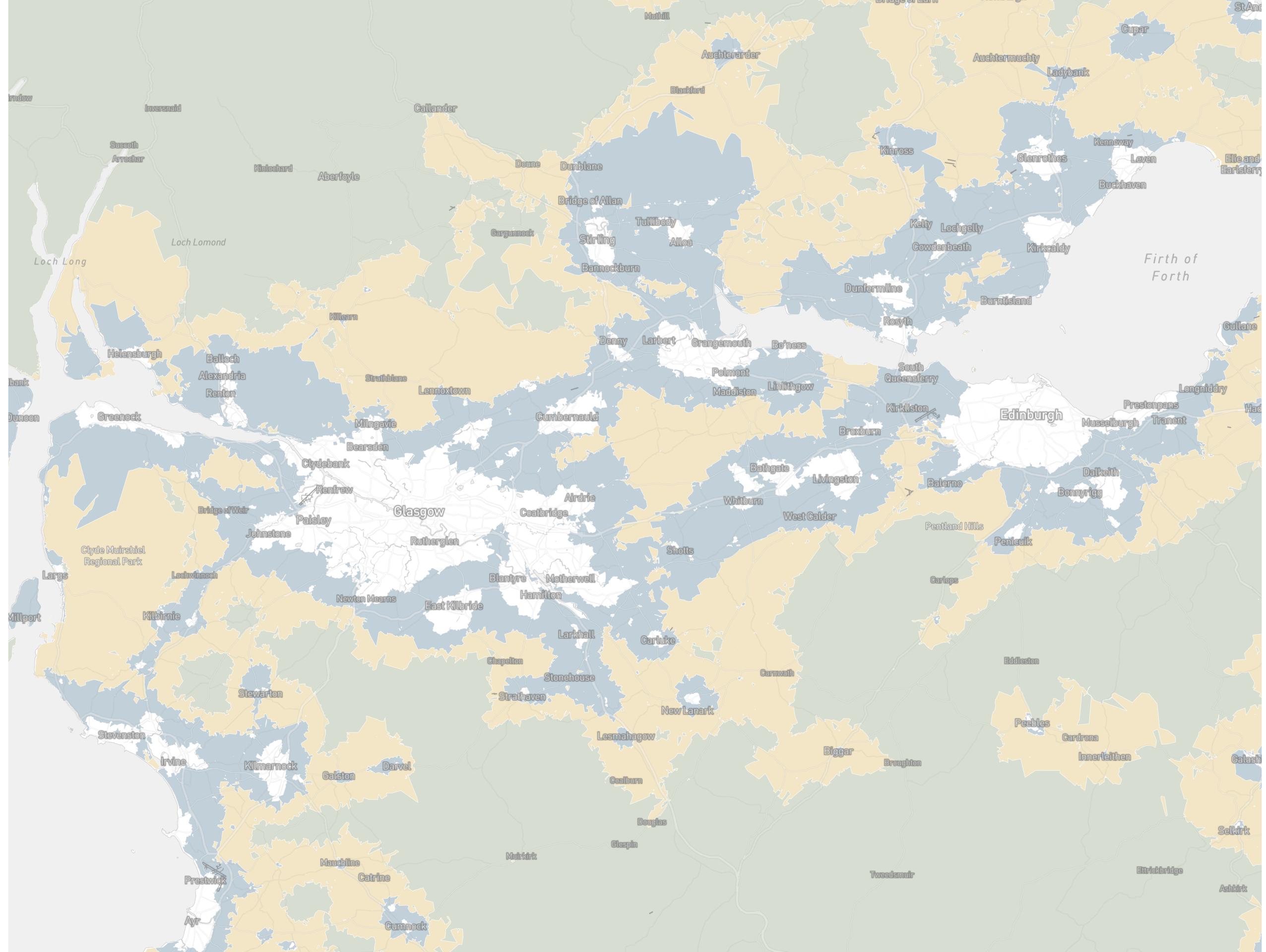
Urban (9)

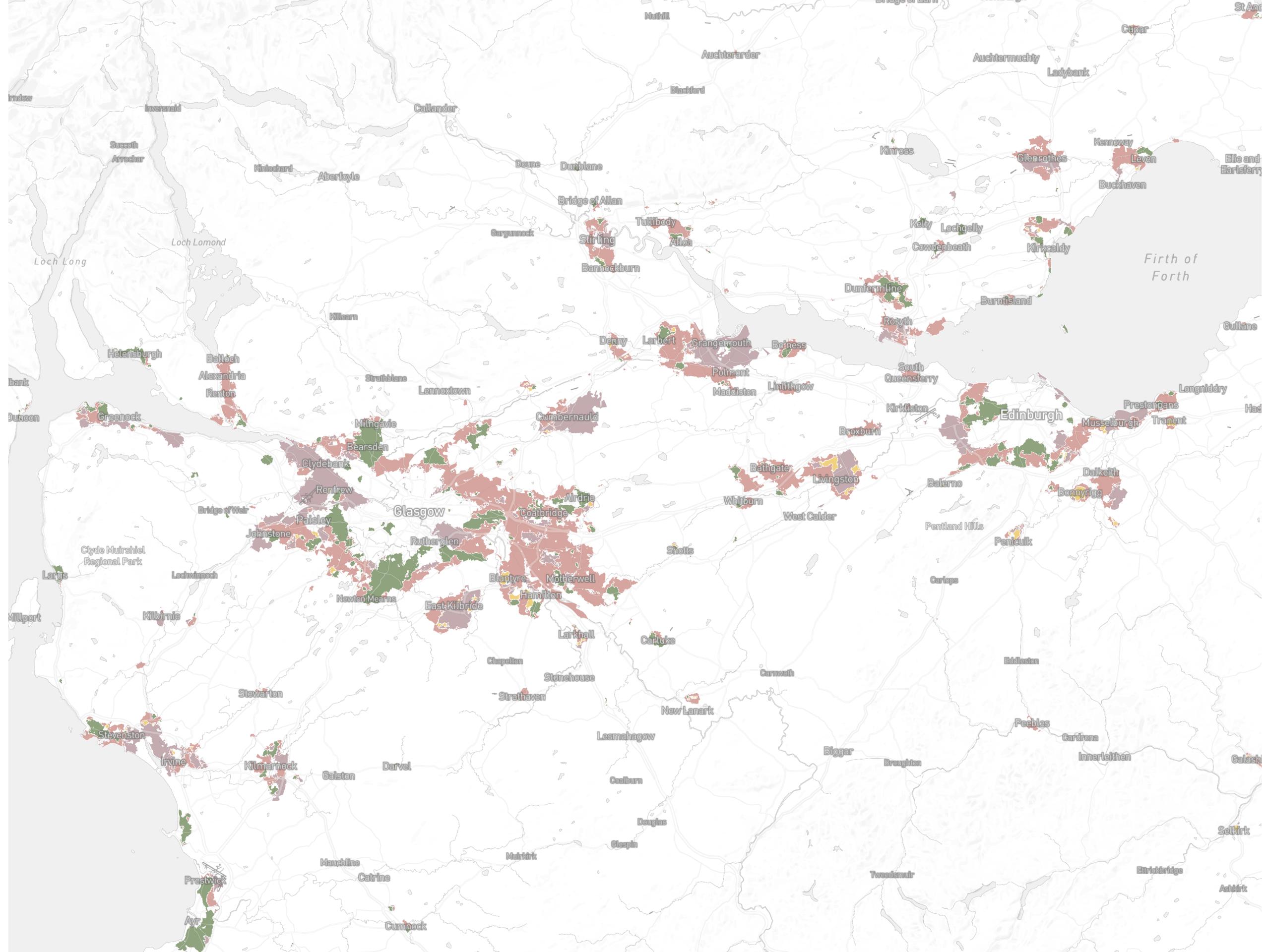


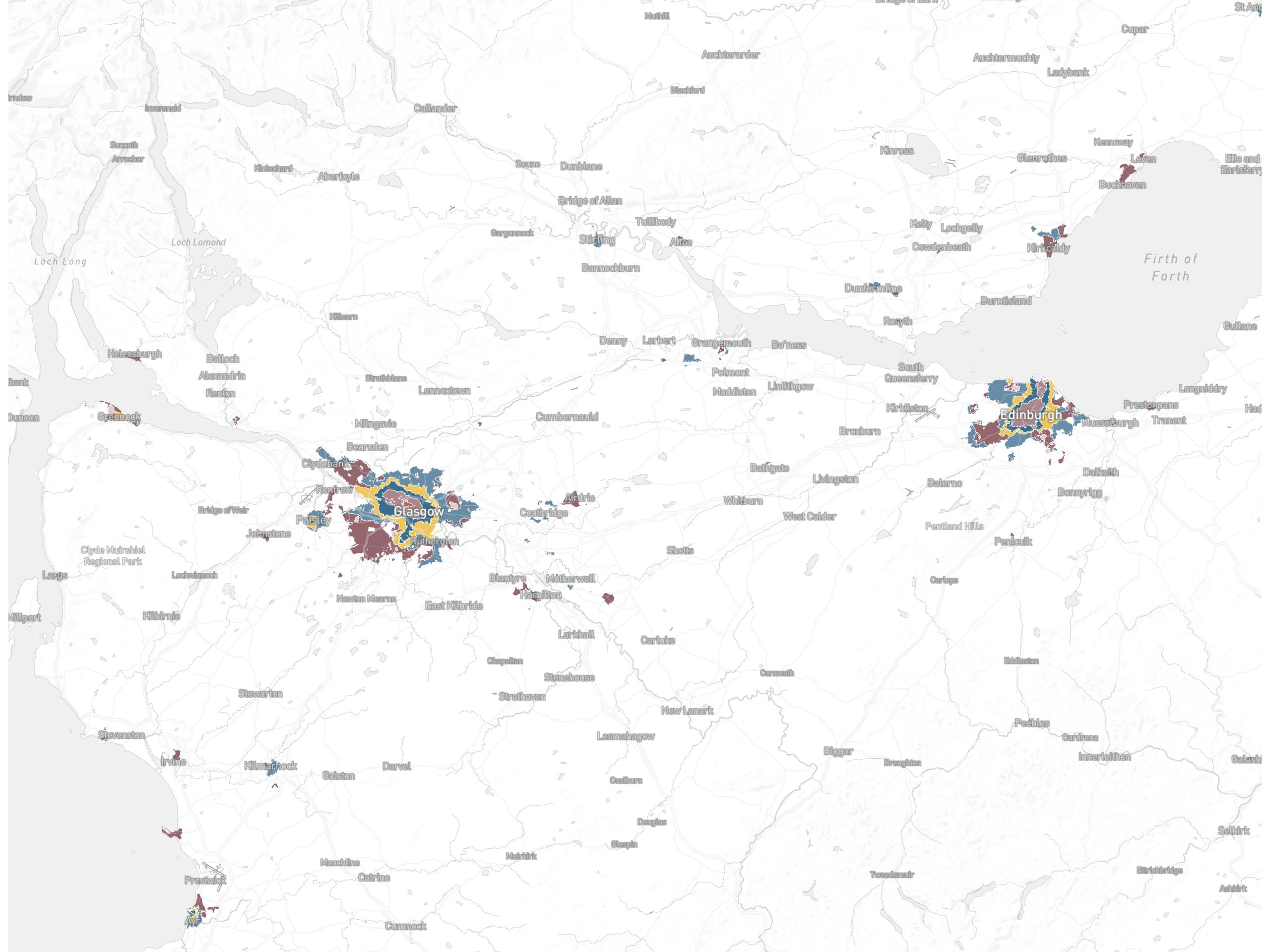
[urbangrammarai.xyz/great-britain/](http://urbangrammarai.xyz/great-britain/)

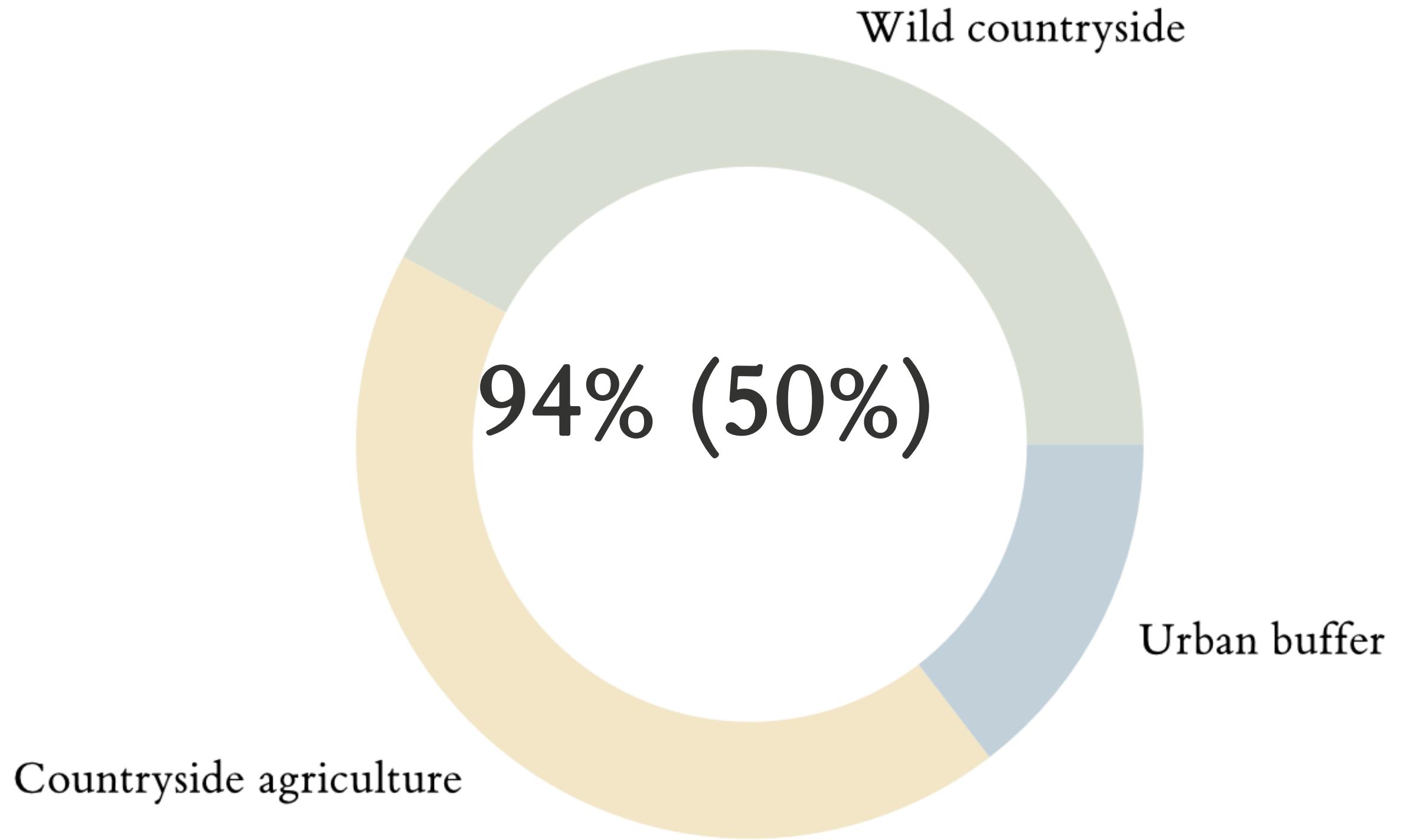


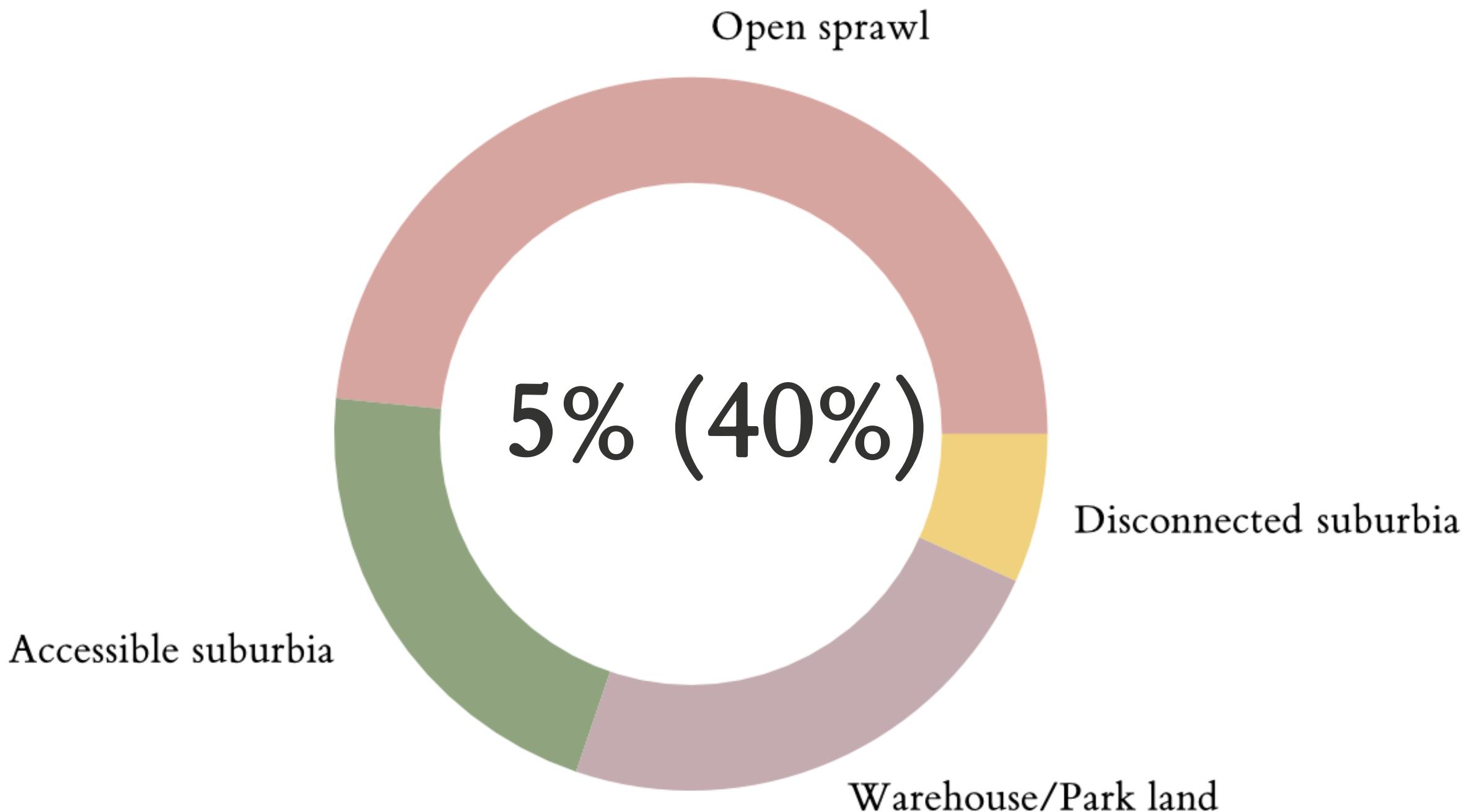


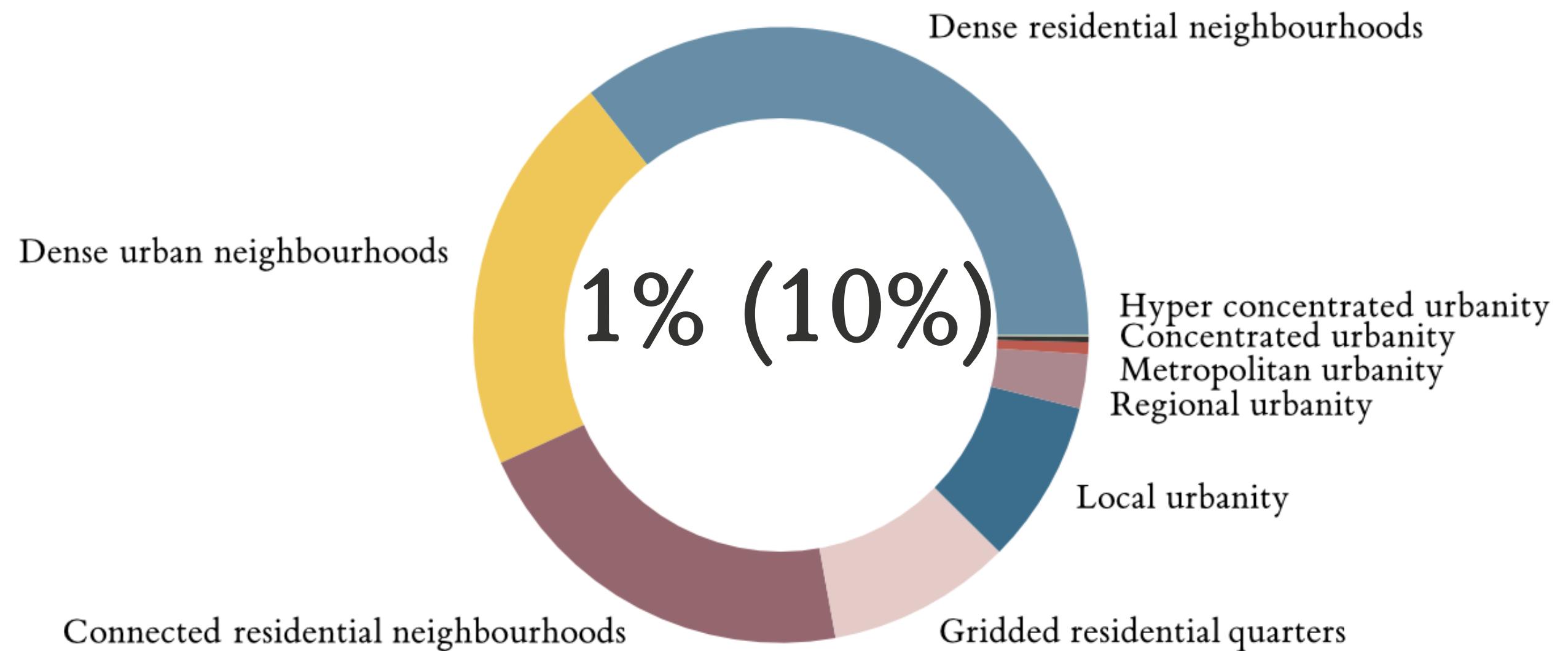










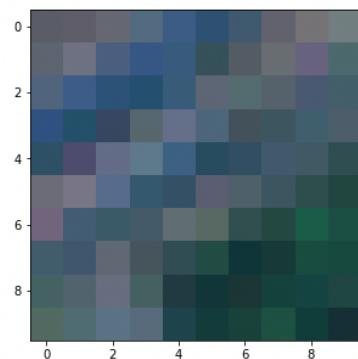




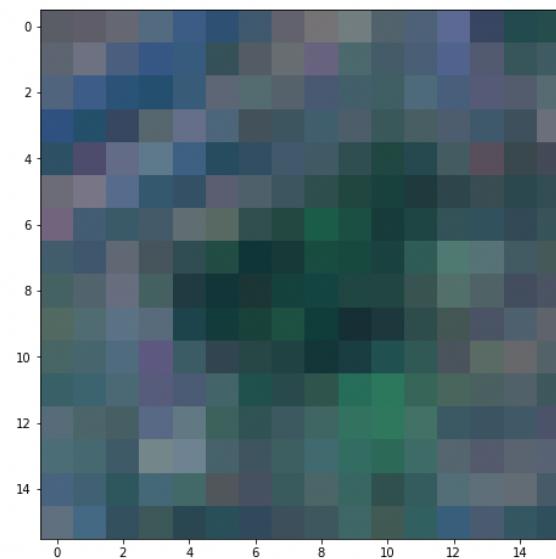


# Sentinel 2

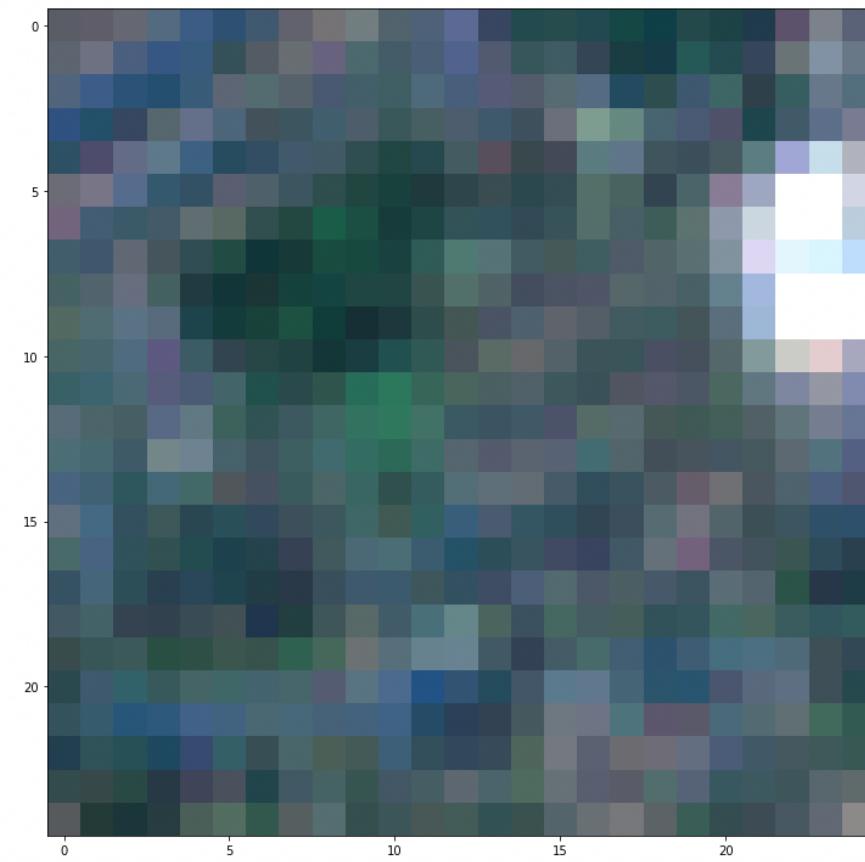
**100x100**



**160x160**



**250x250**

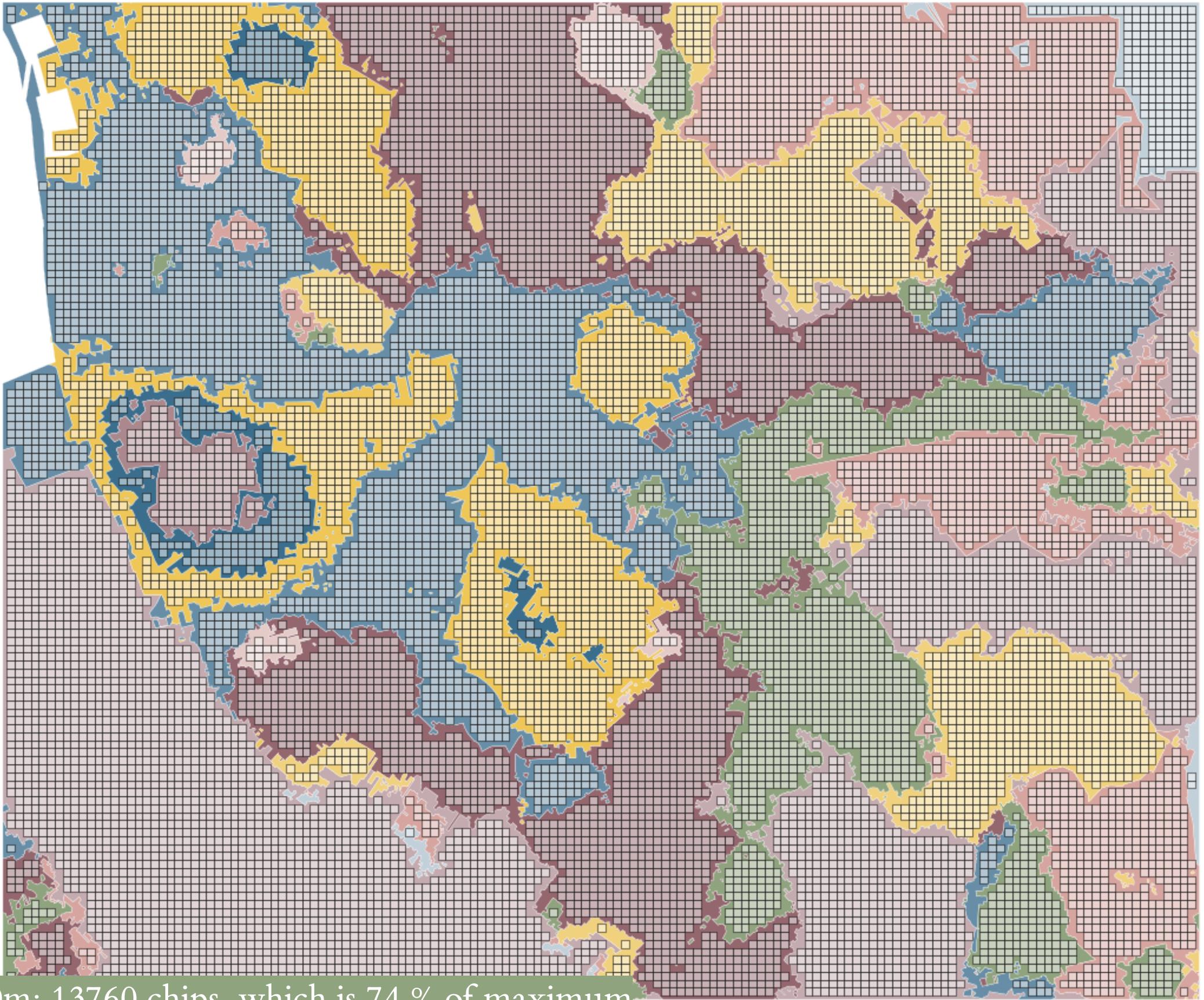


# What do we want to do?

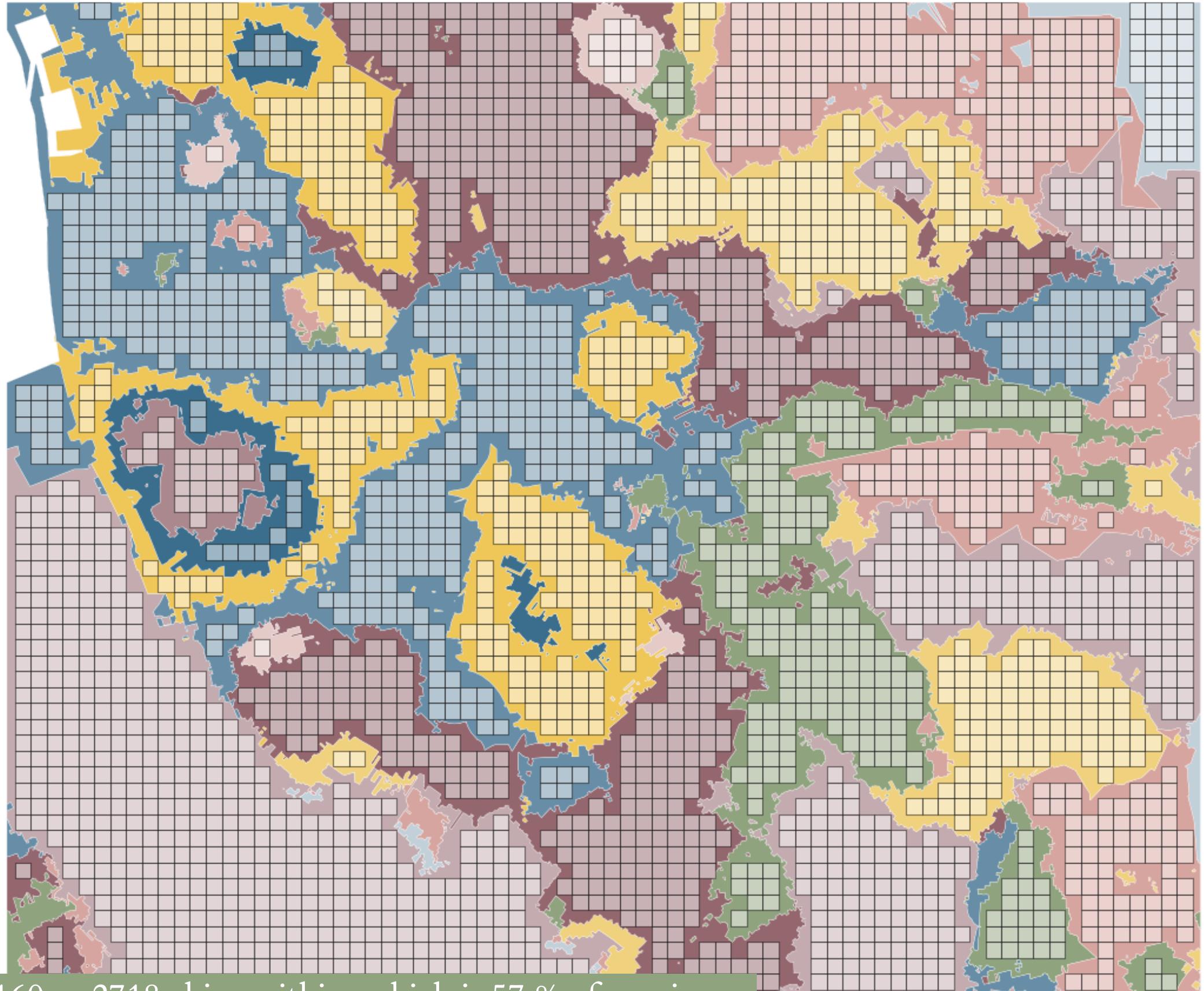
train a neural network  
understand the role of geography

# Exploration

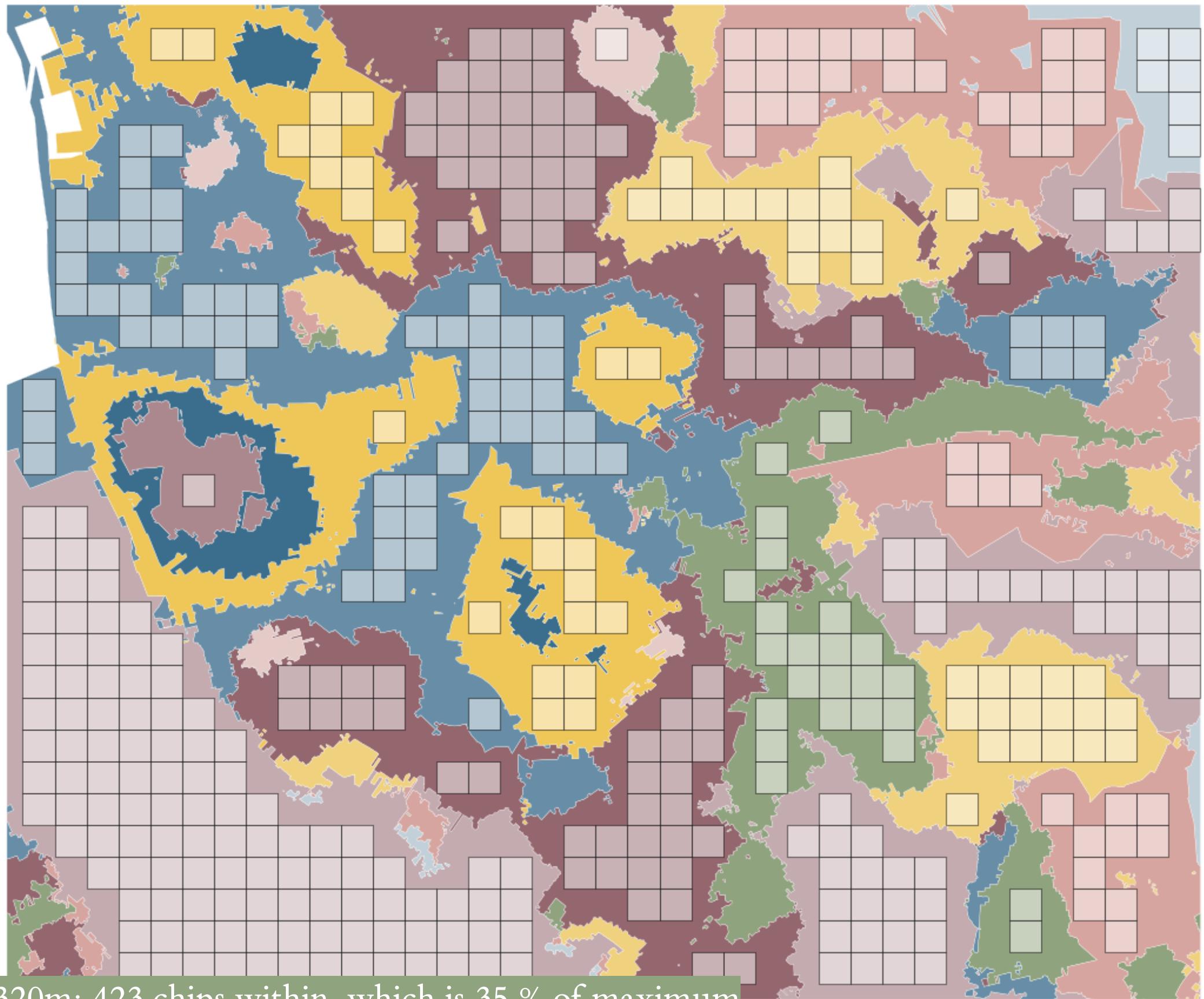
# Chip size effect



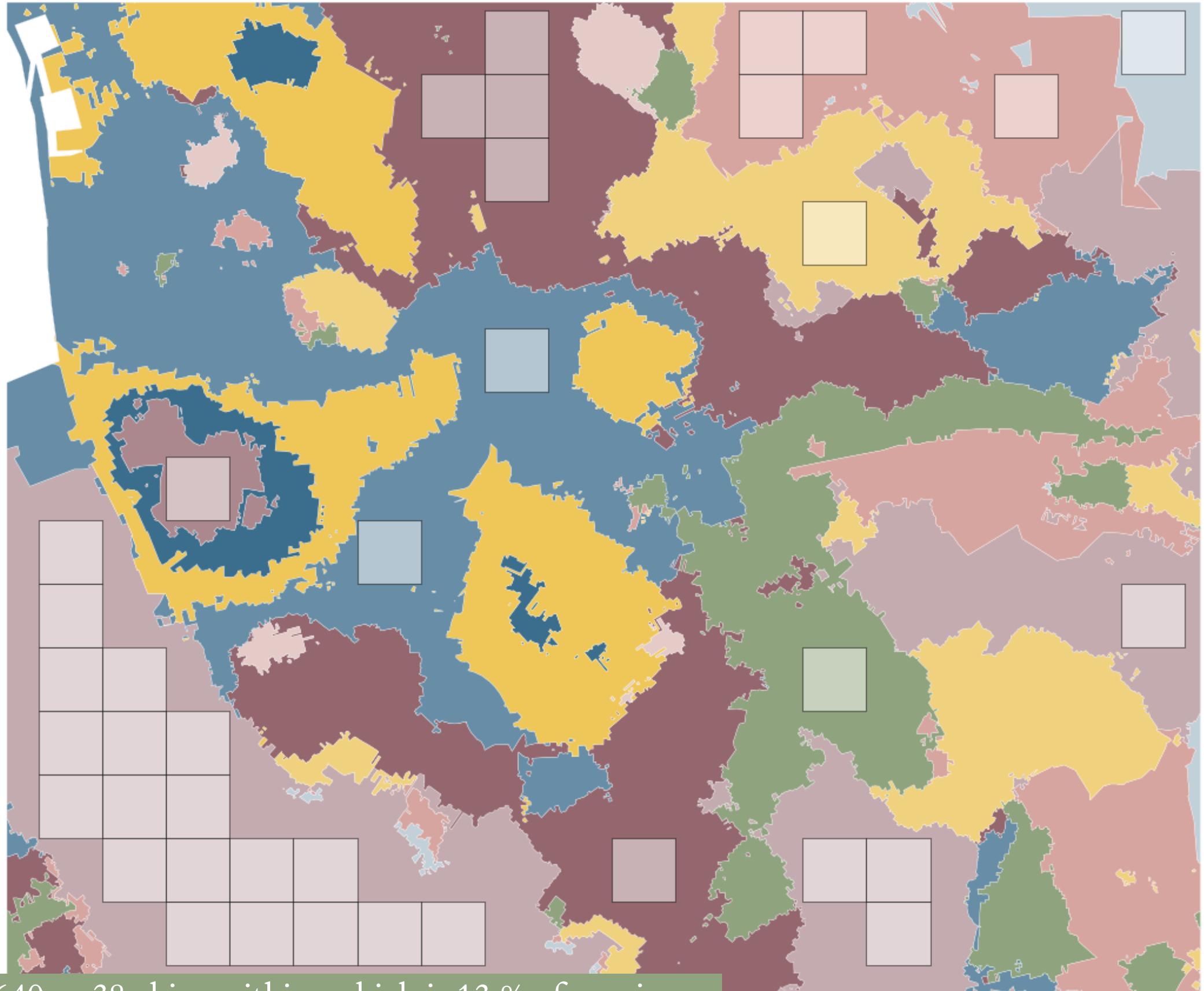
80x80m: 13760 chips, which is 74 % of maximum



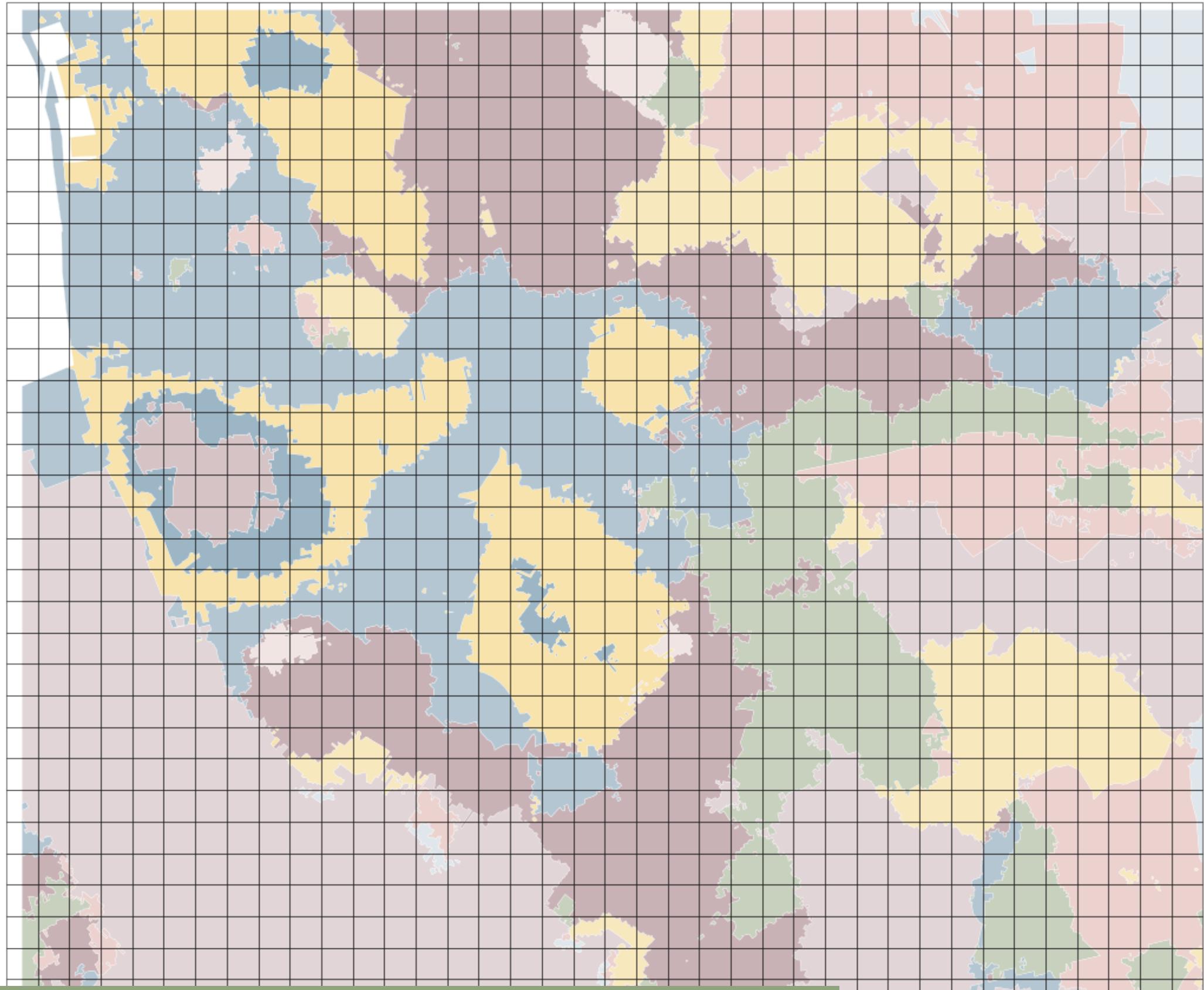
160x160m: 2718 chips within, which is 57 % of maximum



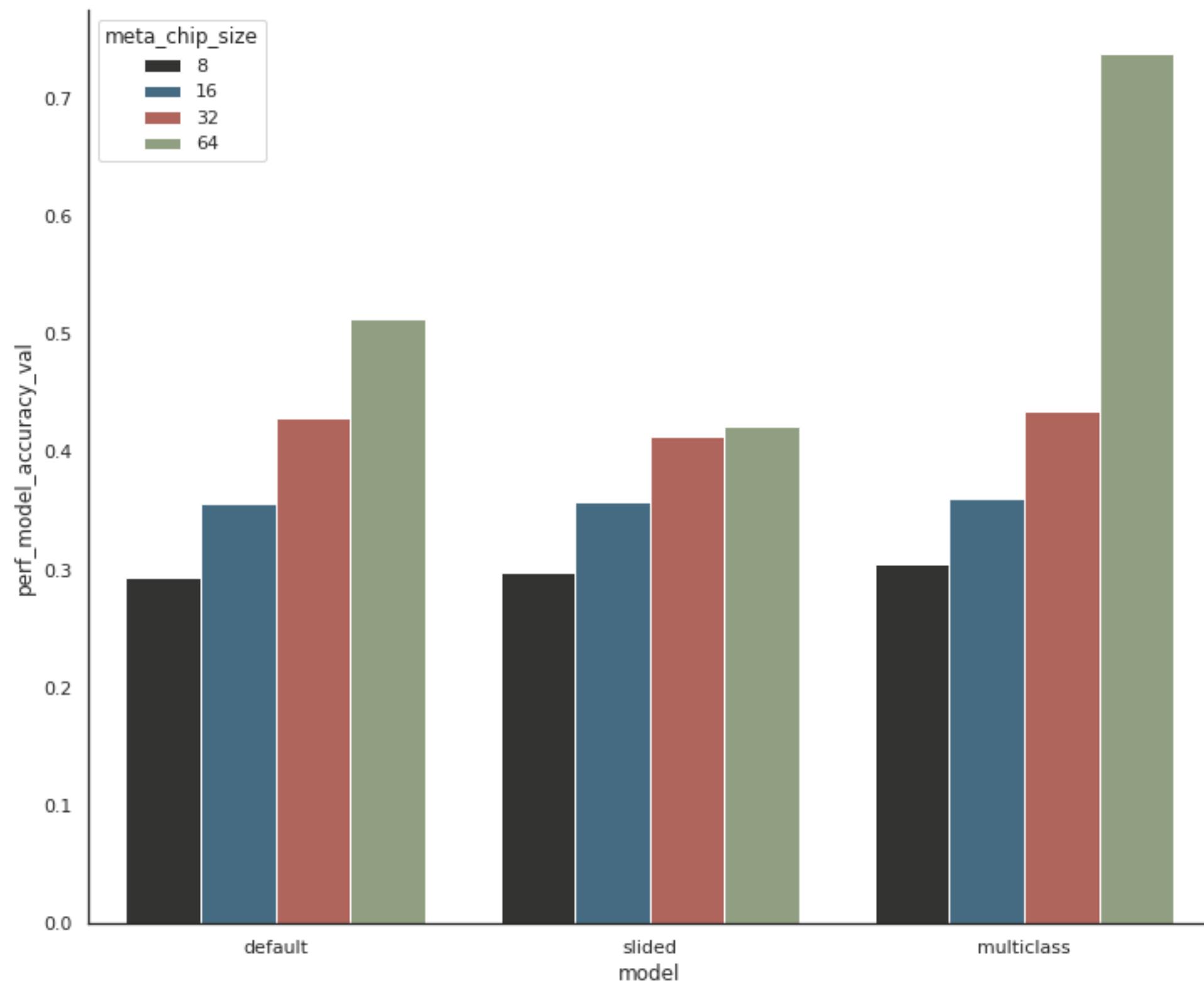
320x320m: 423 chips within, which is 35 % of maximum



640x640m: 38 chips within, which is 13 % of maximum



320x320m, chips capturing the proportion (100% of maximum)



# Current work

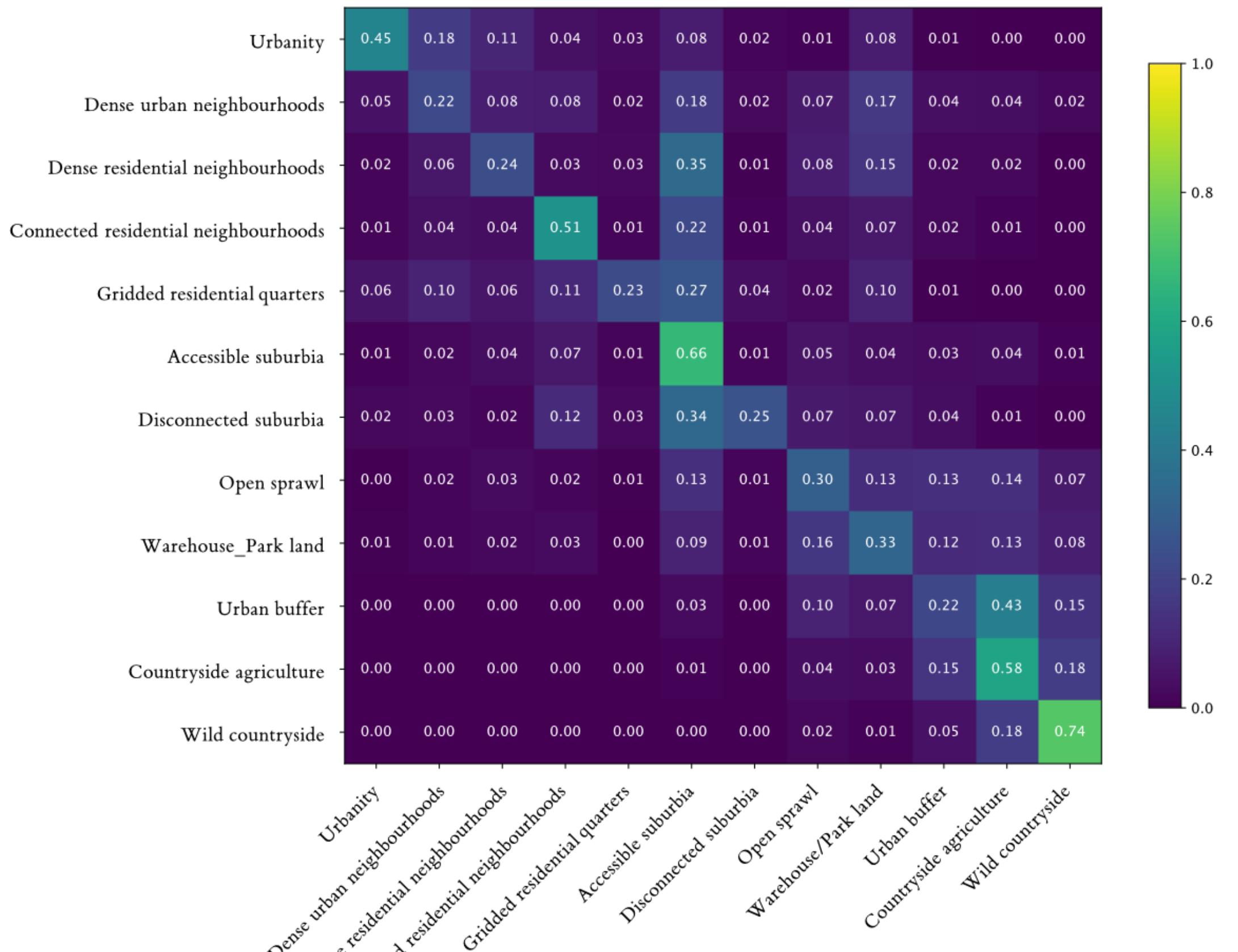
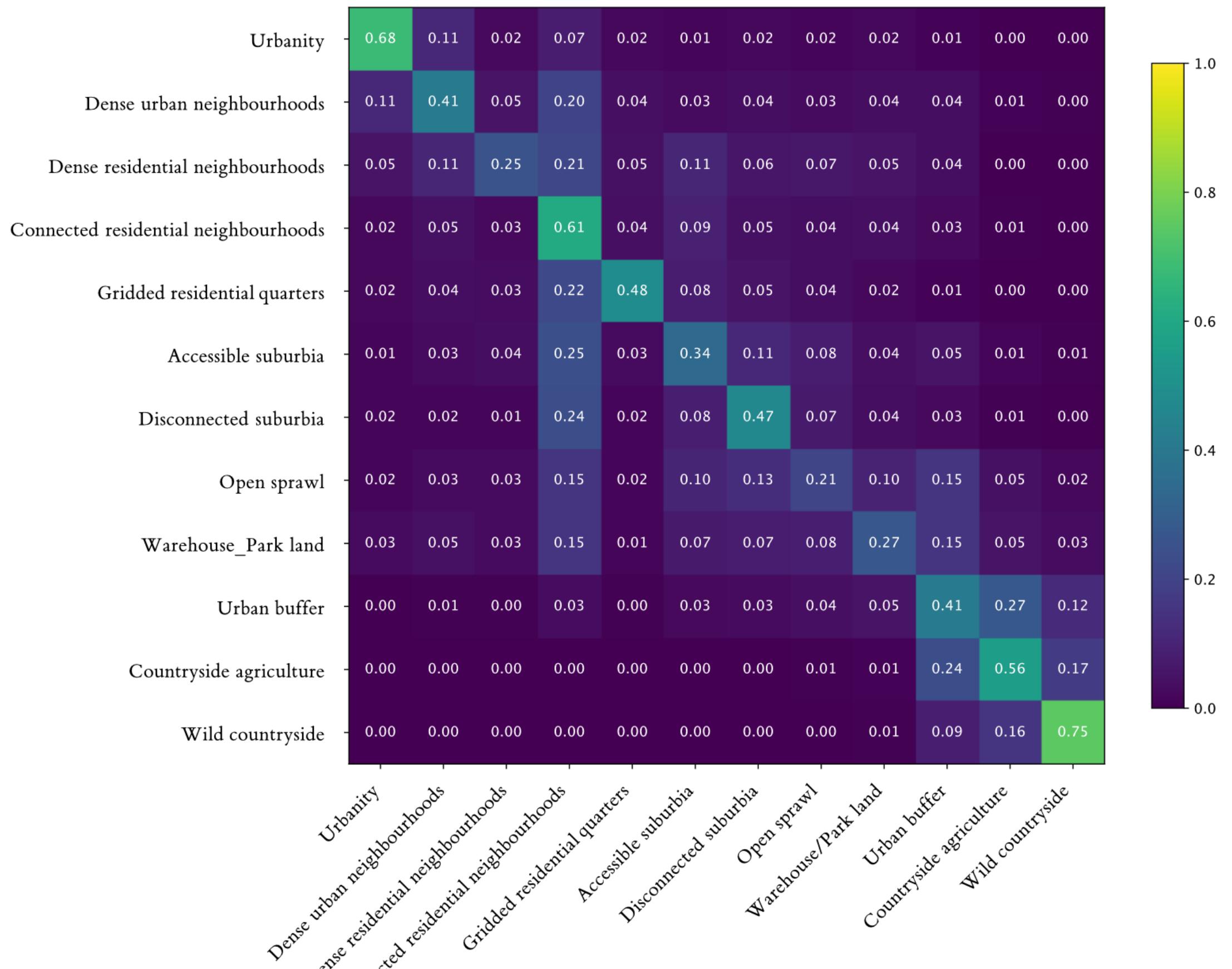


Image classification - Overall accuracy 42.8%



Multi-output regression - Overall accuracy 43.5%

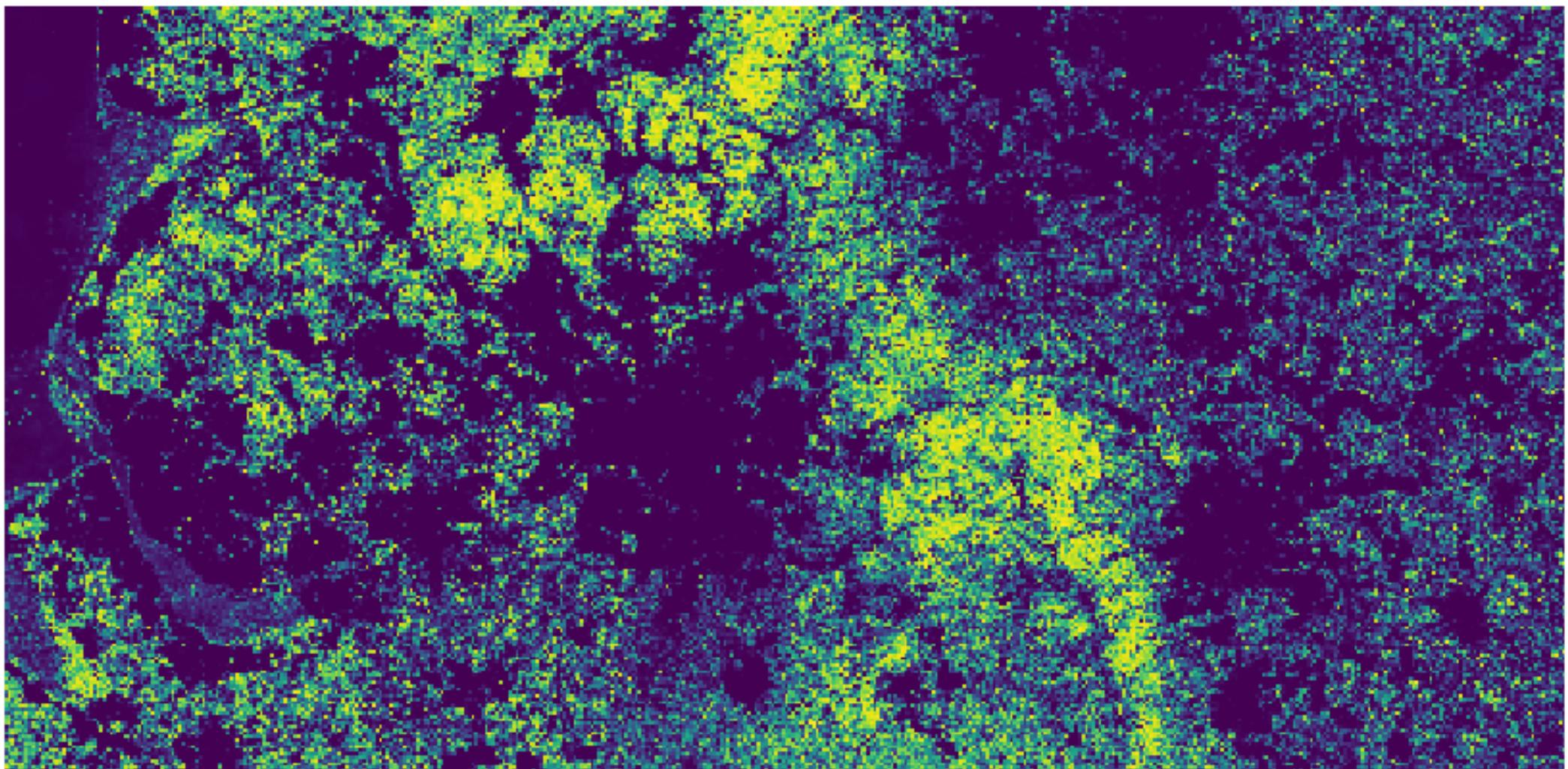
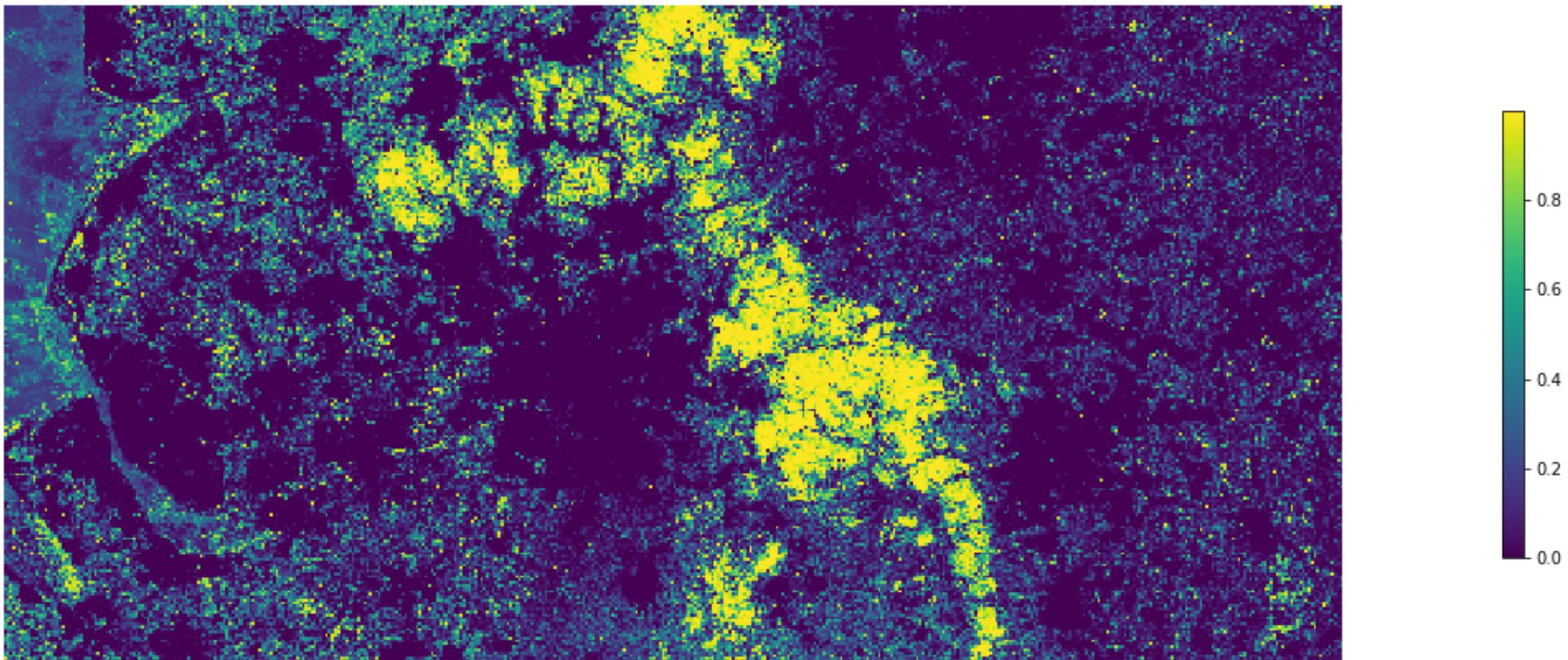


Image classification - Wild countryside



Multi-output regression - Wild countryside

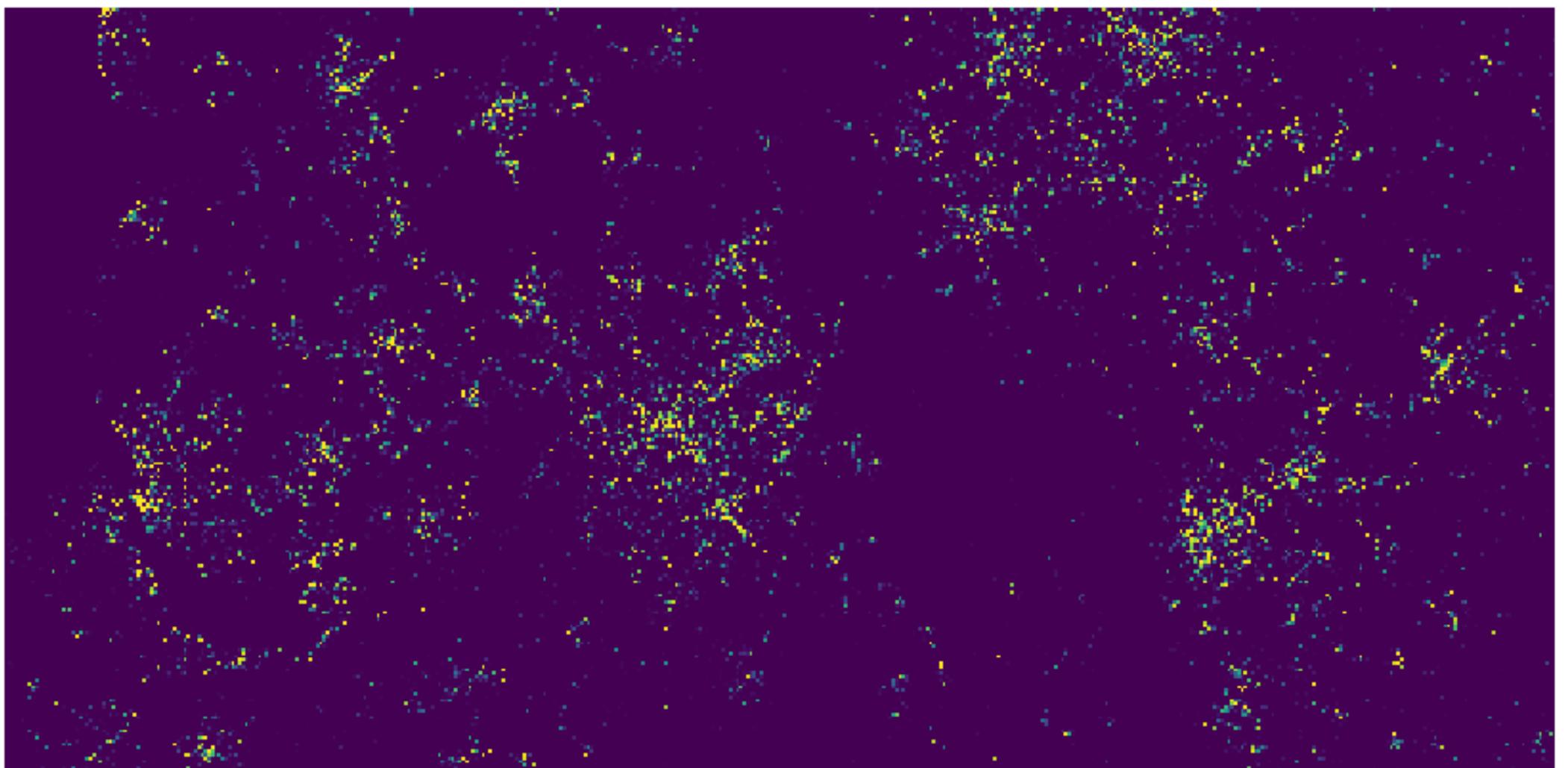
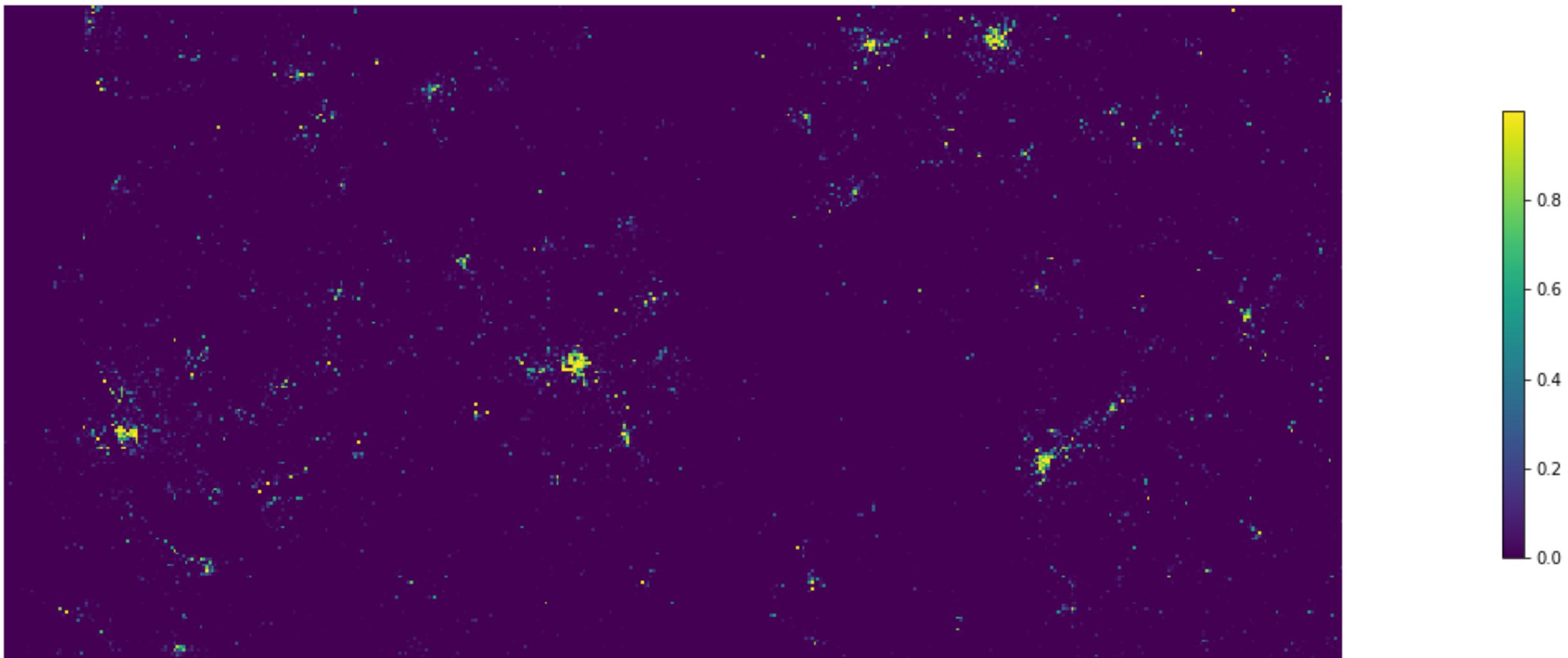


Image classification - Urbanity

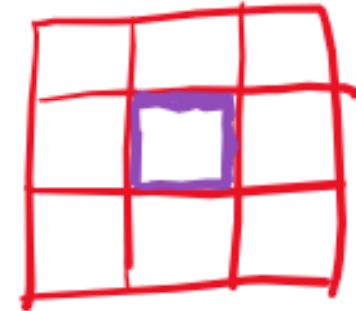


Multi-output regression - Urbanity

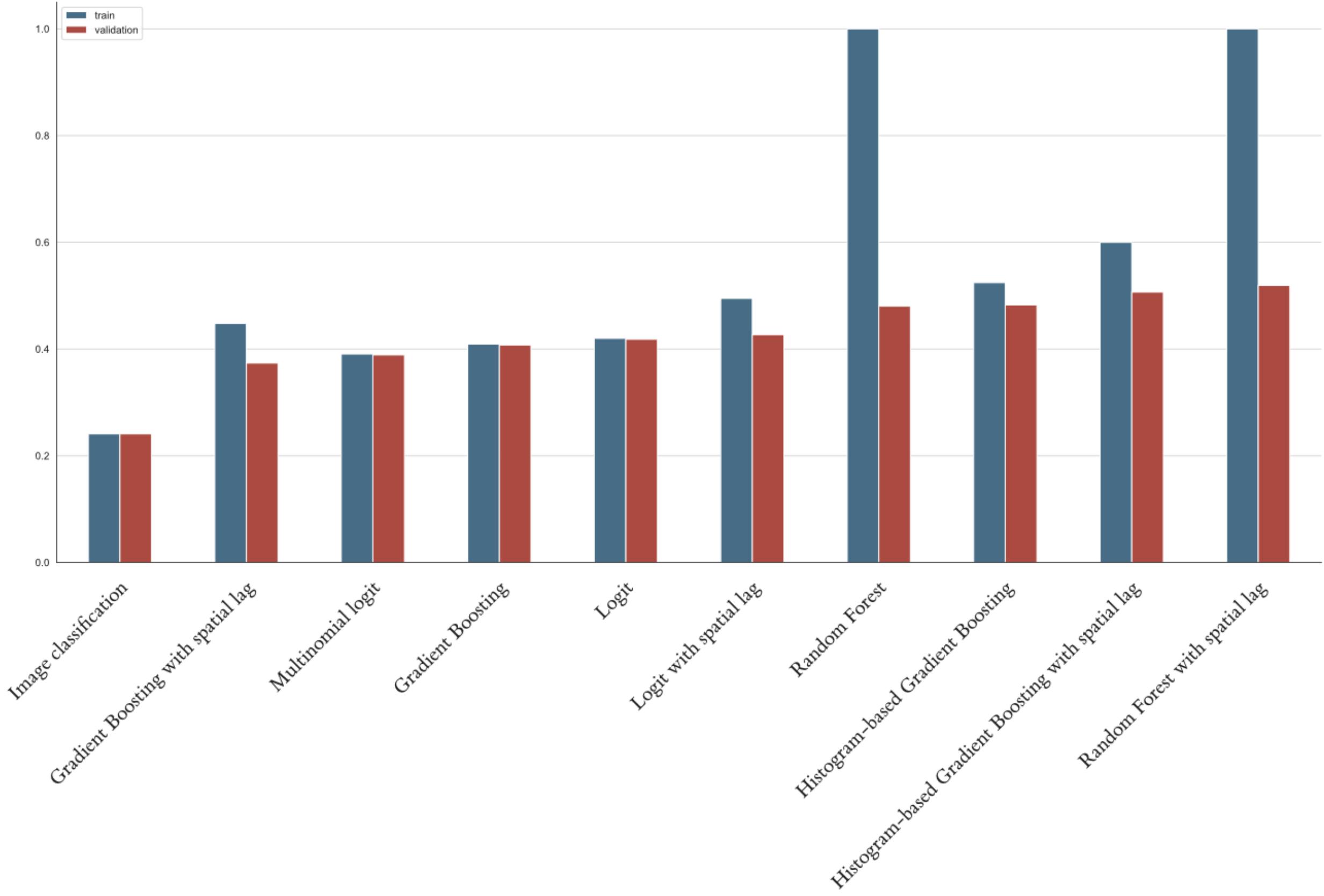
# Probability modelling

$$S_i = f \left( \sum_k P_k + \sum_k w_k P_k \right)$$

- $f$  {
  - 1. Argmax
  - 2. (MN) Logit
  - 3. Random Forest
  - 4. Grad. Boosted Trees



$$w_{P_i} = \sum_j w_{ij} P_k$$



\*the accuracy is based on a different sample than in previous cases (WIP)

# Feedback?

- Better (spatial) evaluation of model performance
- Probability modeling: *does it make (any) sense?*
- Anything else?

# *Using deep learning to identify (urban) form and function in satellite imagery*

*The case of Great Britain*

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The  
Alan Turing  
Institute



Geographic  
Data Science  
Lab

# Great Britain

# Characters

*Form*

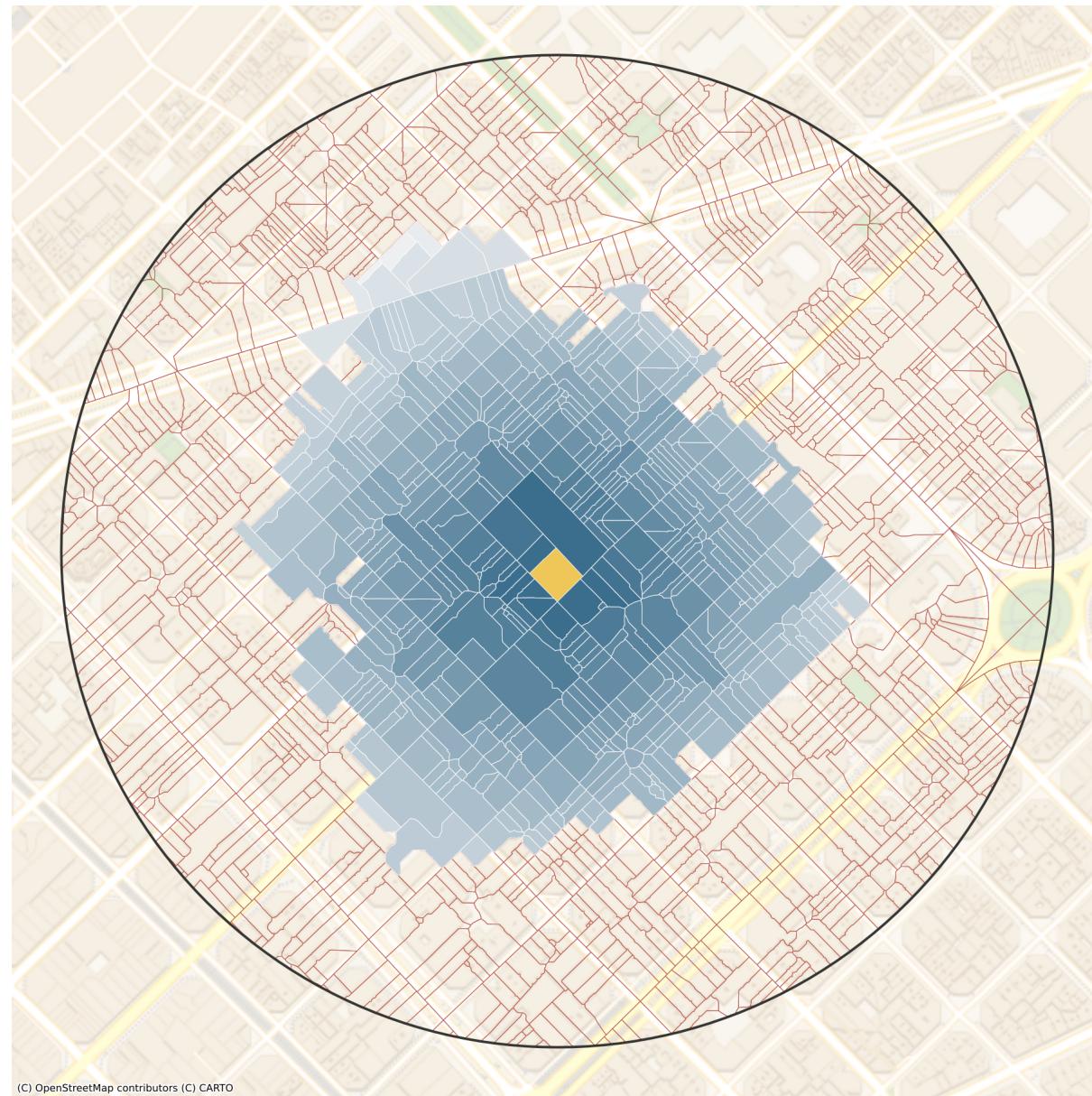
- Dimension
- Shape
- Intensity
- Connectivity
- Diversity

*Function*

- Population
- Employment
- Industry
- Land  
use/cover
- Amenity access

$N \approx 300$

# Context



# Data

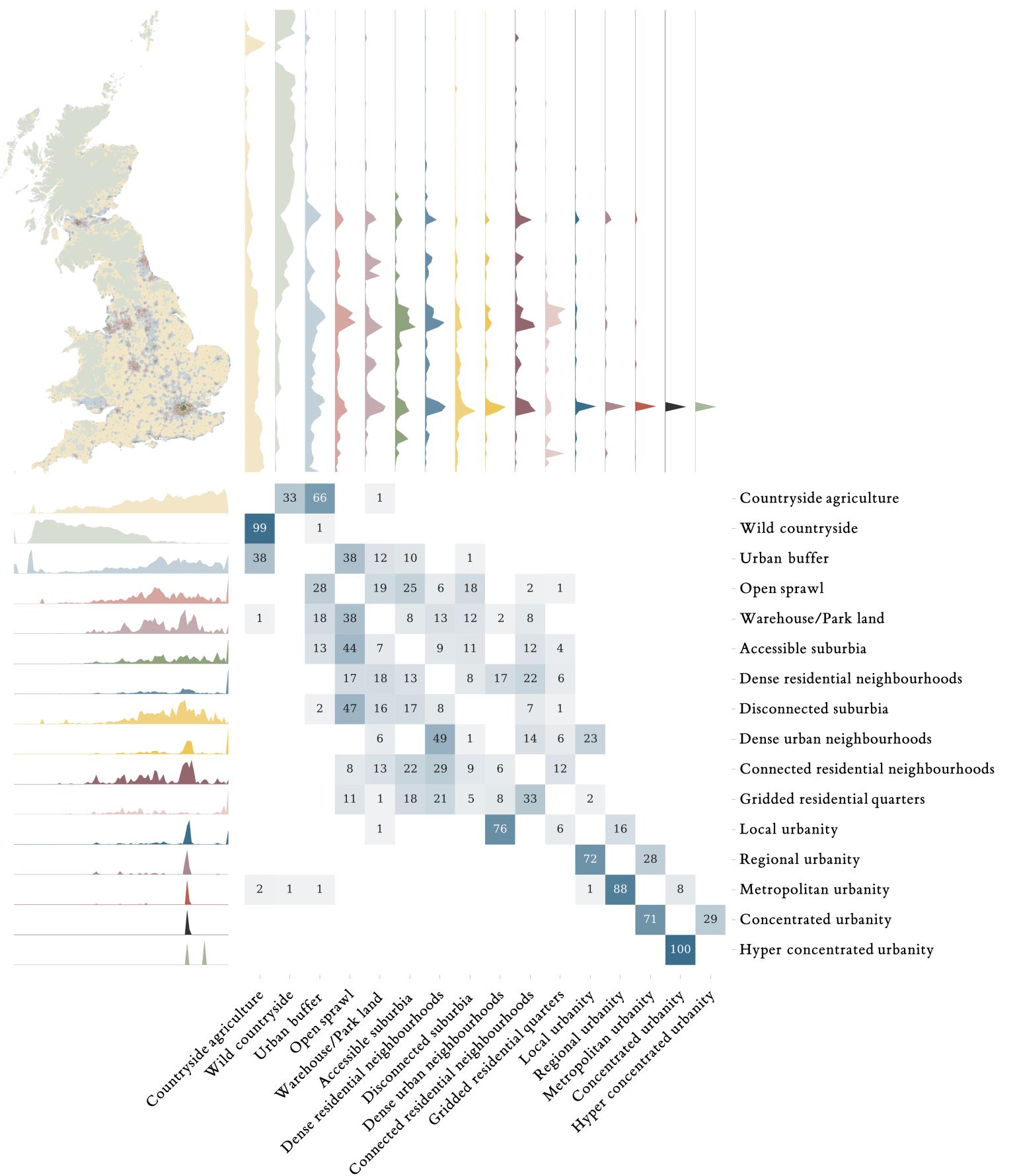
*Form*

- OS OpenMap
- OS OpenRoads

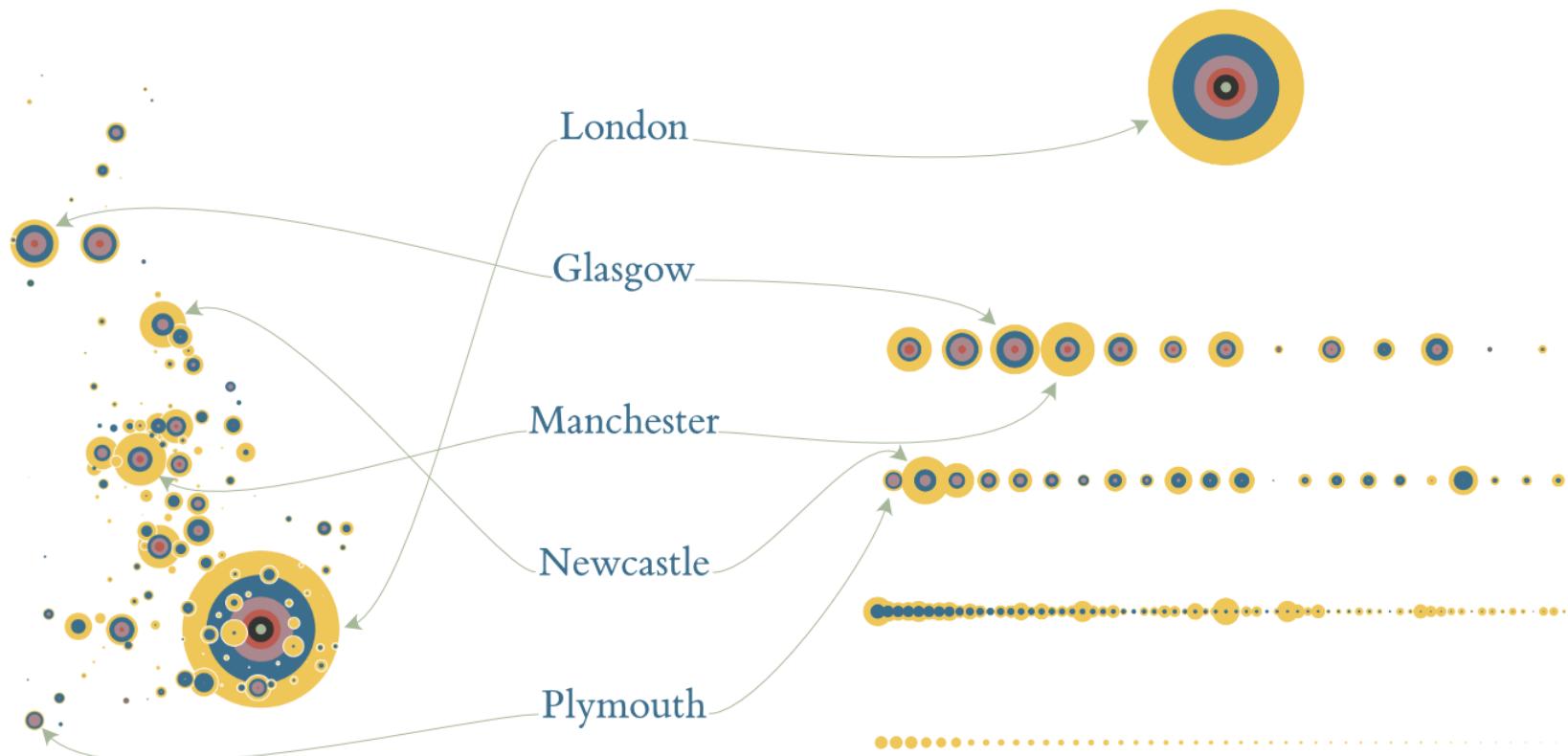
*Function*

- (Business) Census
- OpenStreetMap
- Geolytix
- Listed buildings
- CDRC
- CORINE /  
Sentinel 2
- VIIRS

# Distribution/co-occurrence



# Urban hierarchy



(Hyper) Concentrated urbanity

Metropolitan urbanity

Regional urbanity

Local urbanity

Dense urban neighbourhoods