

Discovering decision-relevant scenarios in large ensembles of Land Use and Cover Change projections

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Problem Statement

The motivation for our research

Consolidative vs Exploratory Modelling

Consolidative

The model

Empirical verification by comparing model outputs to observations

Consolidating data and knowledge into a single model

Generate the best possible prediction.
Replicate reality

Uncertainty is an undesirable deviation from the “true model” and needs to be reduced

Sufficient information to replicate complex systems

Projection is expected to be accurate

Validation focus

Validation procedure

Strategy

Purpose

Approach to
uncertainty

Knowledge
requirements

Model output

Exploratory

The plan / The decision

Use of a larger set of tools to establish confidence in models

Models as simulation devices to test broad set of varying assumptions. Simulations taken as potential future scenarios.

Gain insights and guide decision-making.
Understand the main factors of change and implications of potential future scenarios through experiments

Uncertainty is unavoidable and needs to be accounted for.

Insufficient knowledge or irreducible uncertainties

Projection is expected to be uncertain

Consolidative vs Exploratory Modelling

Consolidative

The model

Empirical verification by comparing model outputs to observations

Consolidating data and knowledge into a single model

One possible prediction.
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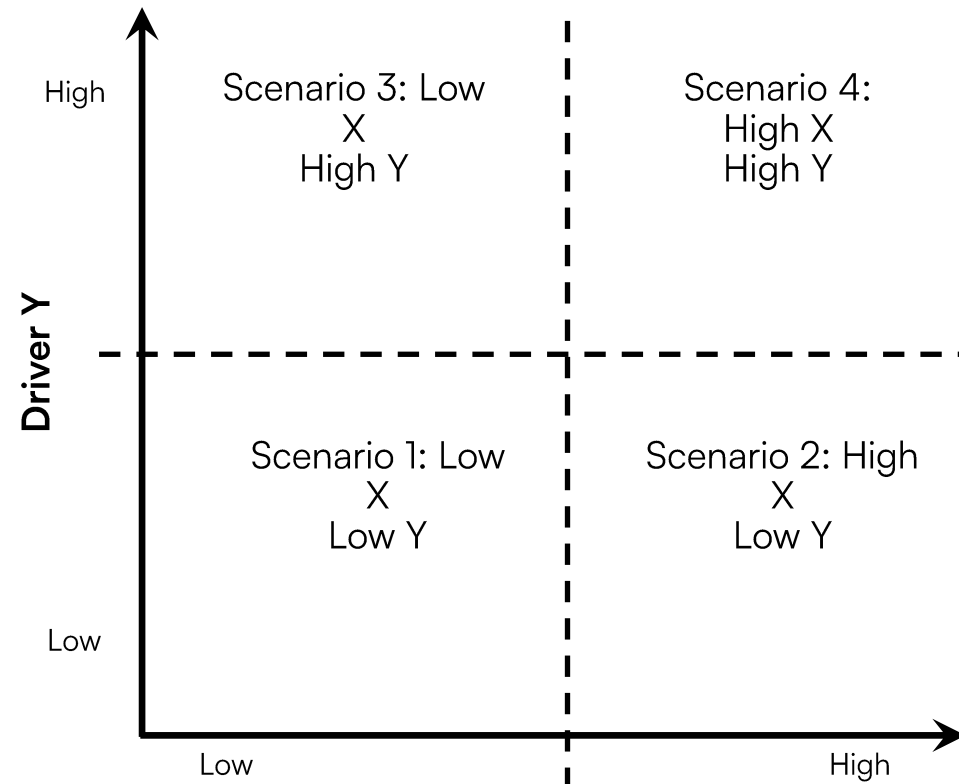
Insufficient knowledge or irreducible uncertainties

Projection is expected to be uncertain

Within the **Land Use and Land Cover Change modelling**, and especially **Urban modelling**, the consolidative approach is dominant

‘Story and Simulation’ approach to scenarios

Qualitatively defined often
using 2x2 matrix approach

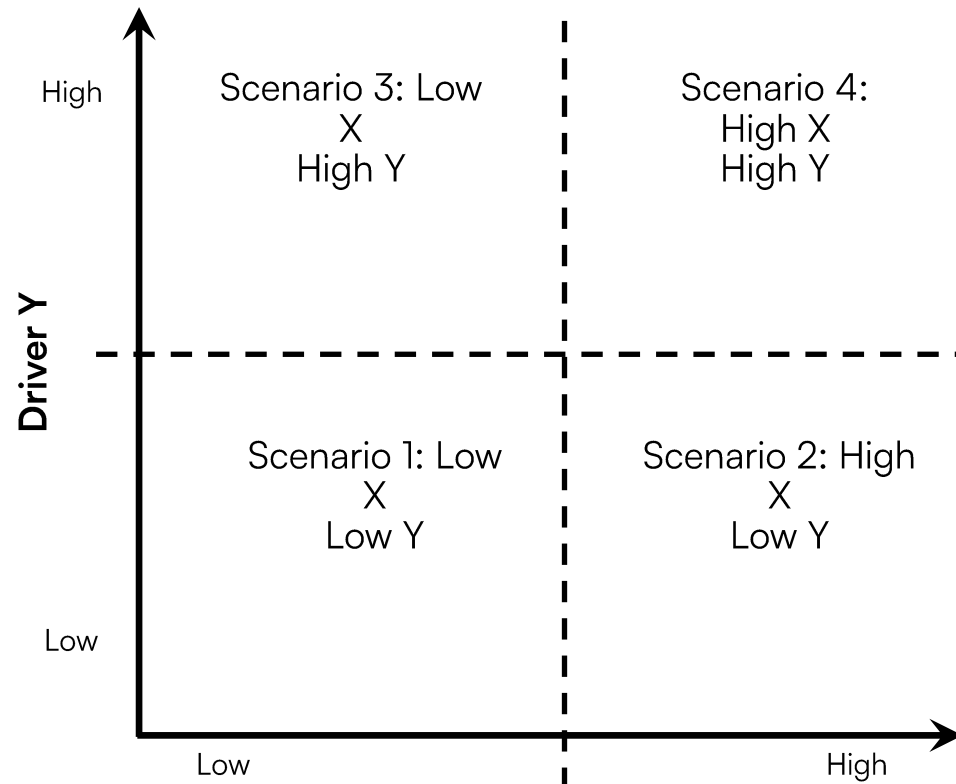


Global Shared Socioeconomic
Pathways SSPs

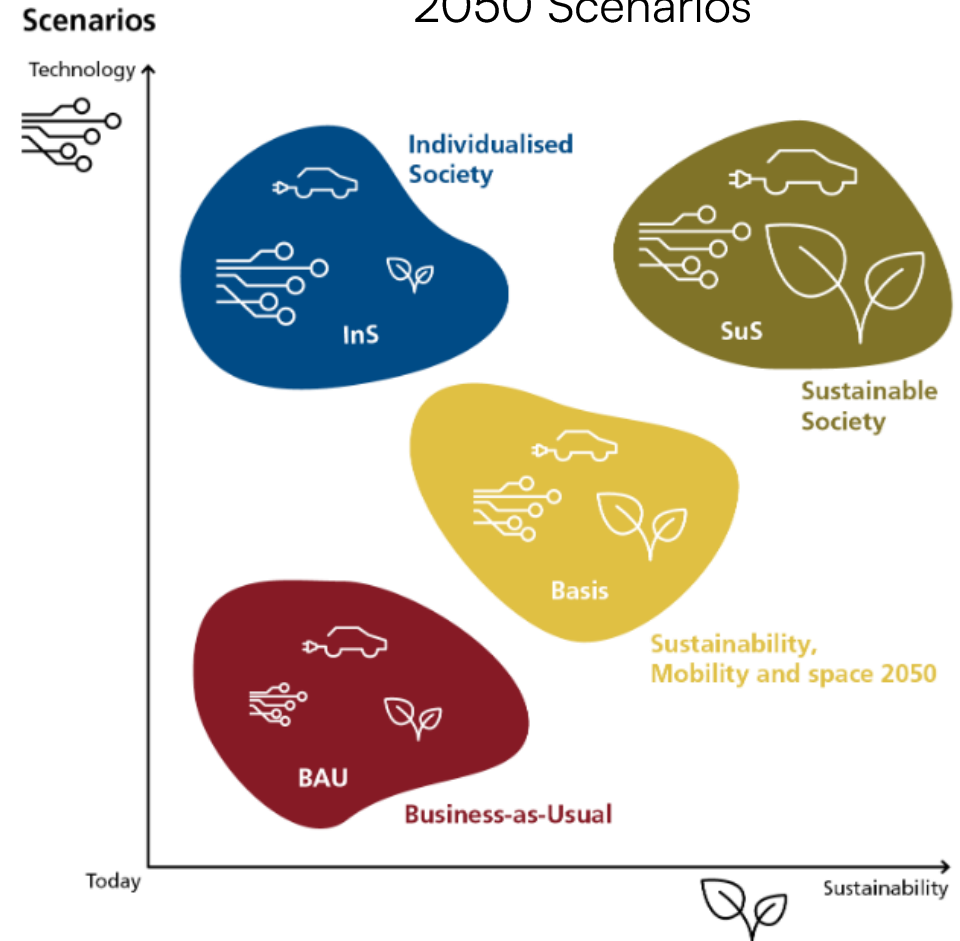


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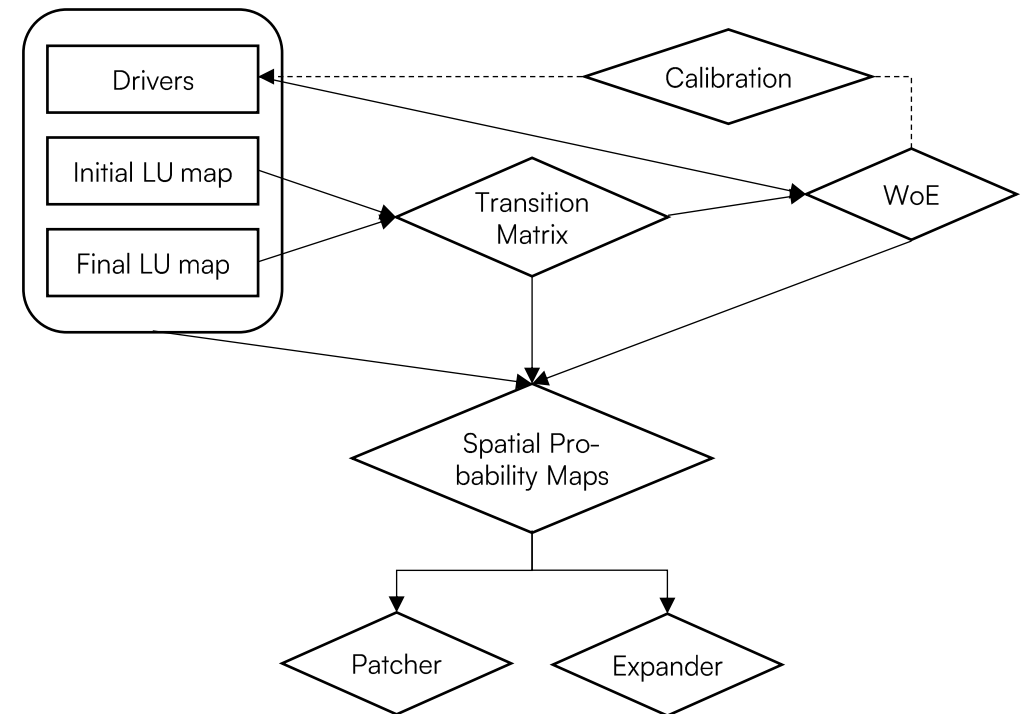
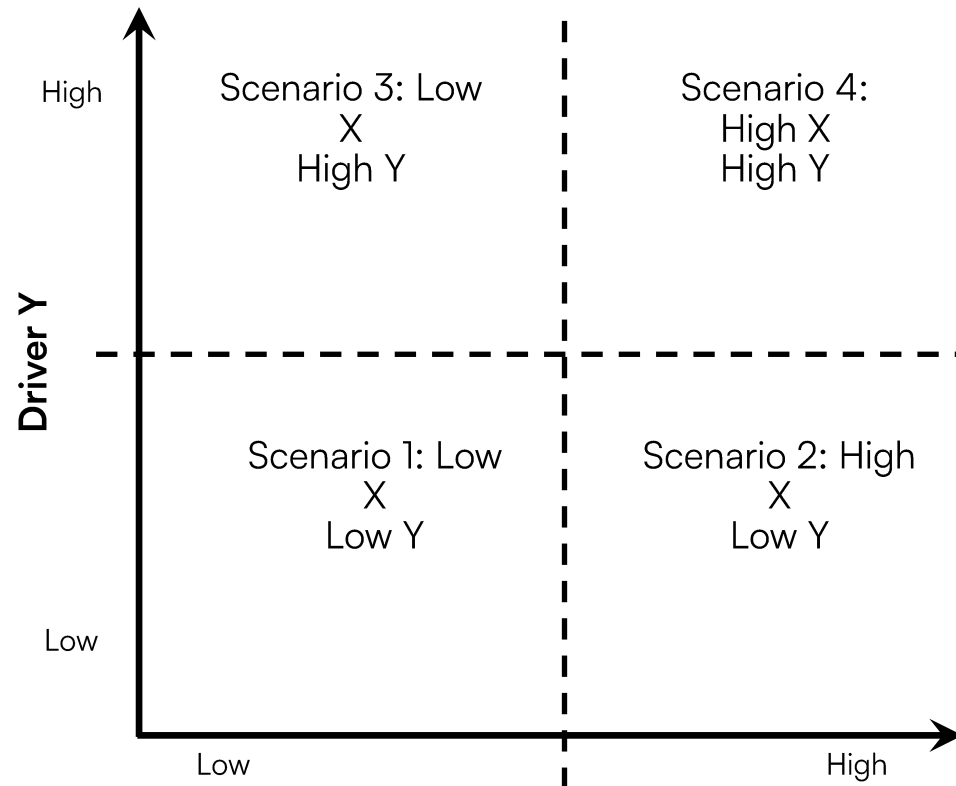
ARE's Swiss Transport Outlook
2050 Scenarios



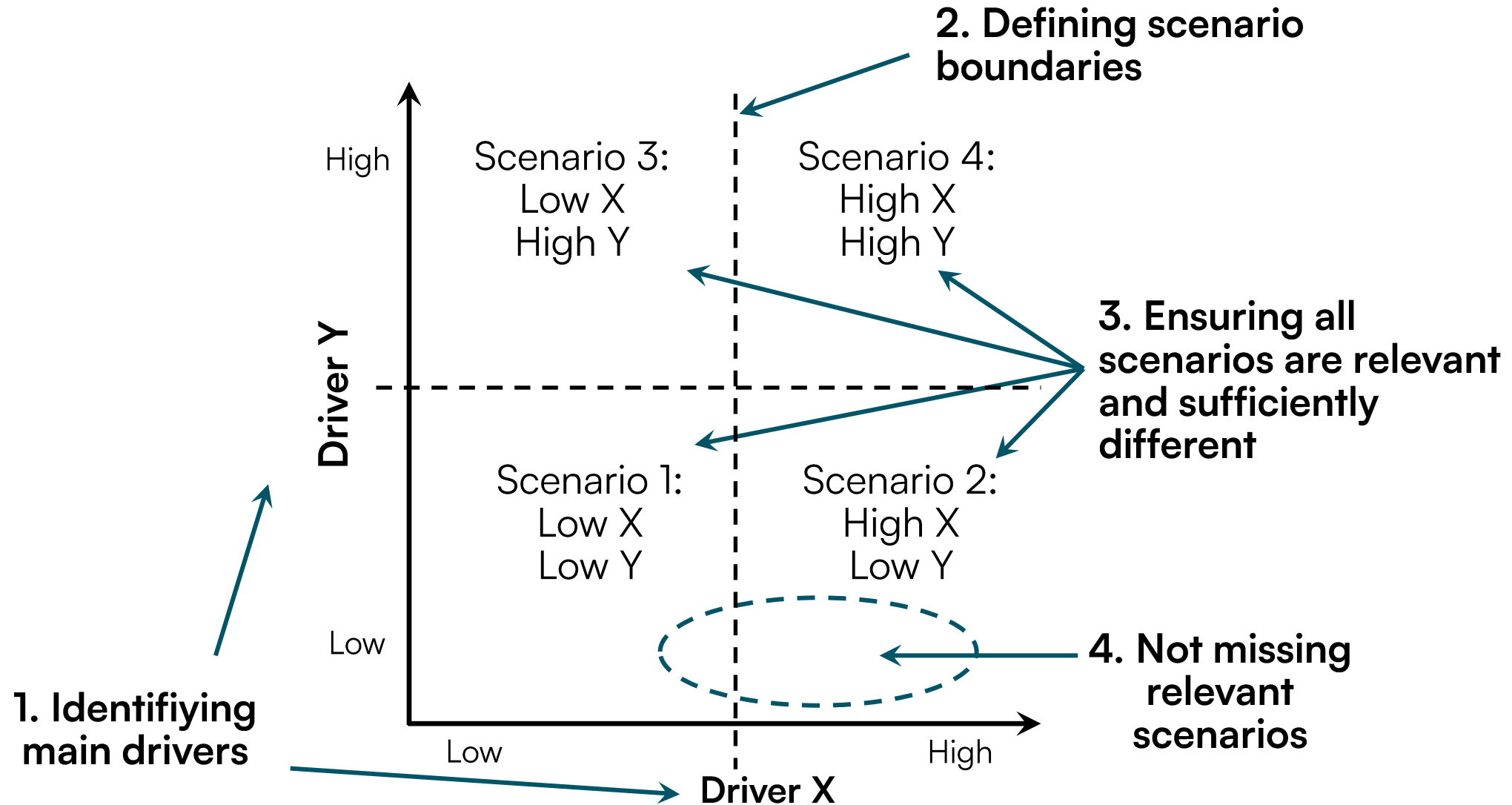
‘Story and Simulation’ approach to scenarios

Predefined limited set of “most likely” narrative scenarios

Simulation Models



Challenges...



Proposal

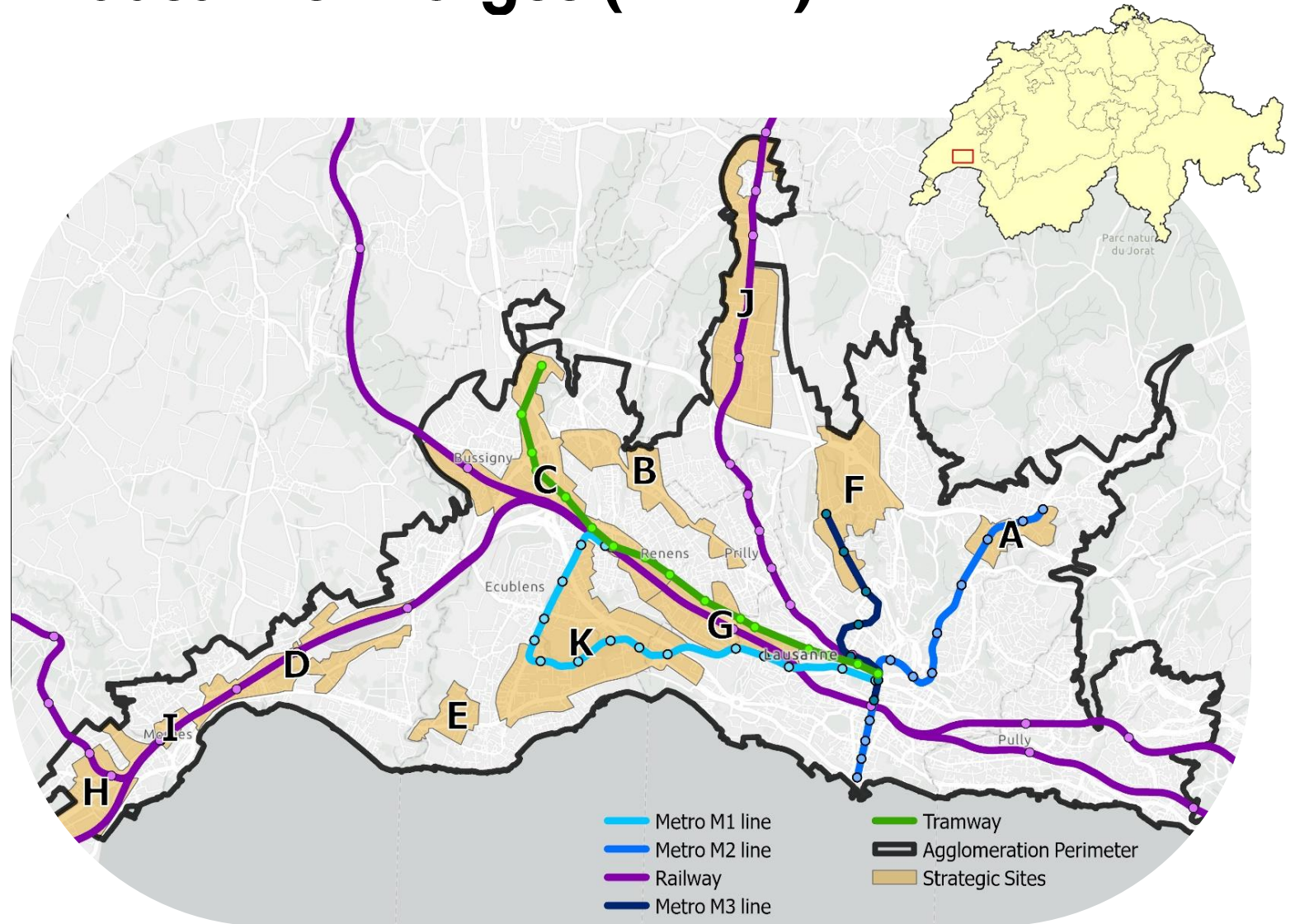
Exploratory approach using large simulation ensembles to identify most important drivers of (future) change to delineate scenario boundaries

Case Study I

Transport Infrastructure in the Lausanne Morges
Agglomeration, Switzerland

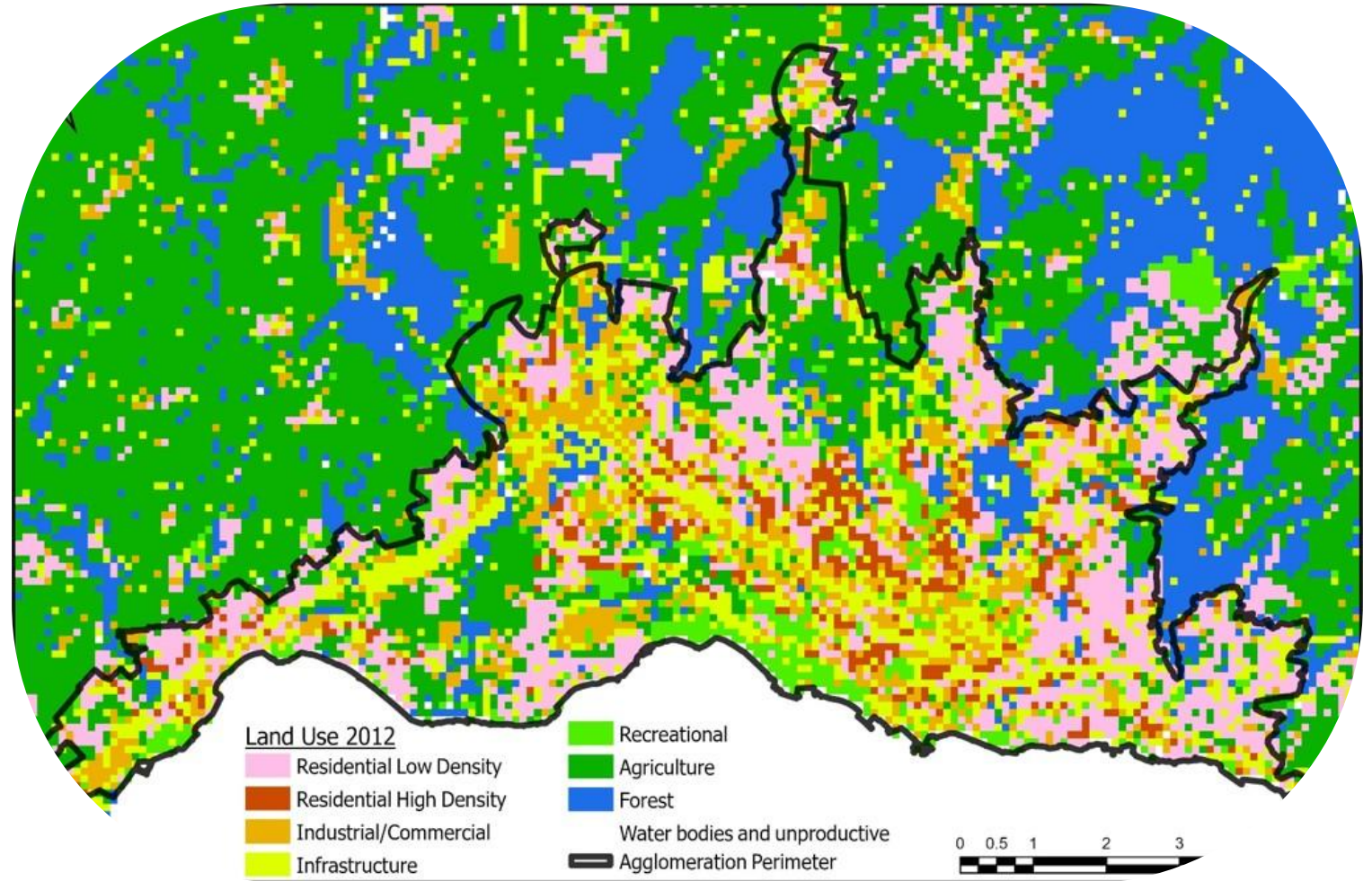
Projet d'agglomération Lausanne-Morges (PALM)

- Planning instrument to **reverse trend of urban sprawl** from the city centre to the periphery.
- Strategic sites (from letter A to K) proposed to **prioritize urban development**.
- **Multimodal transport system** to serve strategic sites suggested as one of the main policy measures.



Ensemble of Future LULCC projections

- Cellular model using **7 LULC classes**
- **5000 simulations** generated by varying **external uncertainties** and **infrastructure planning decisions**

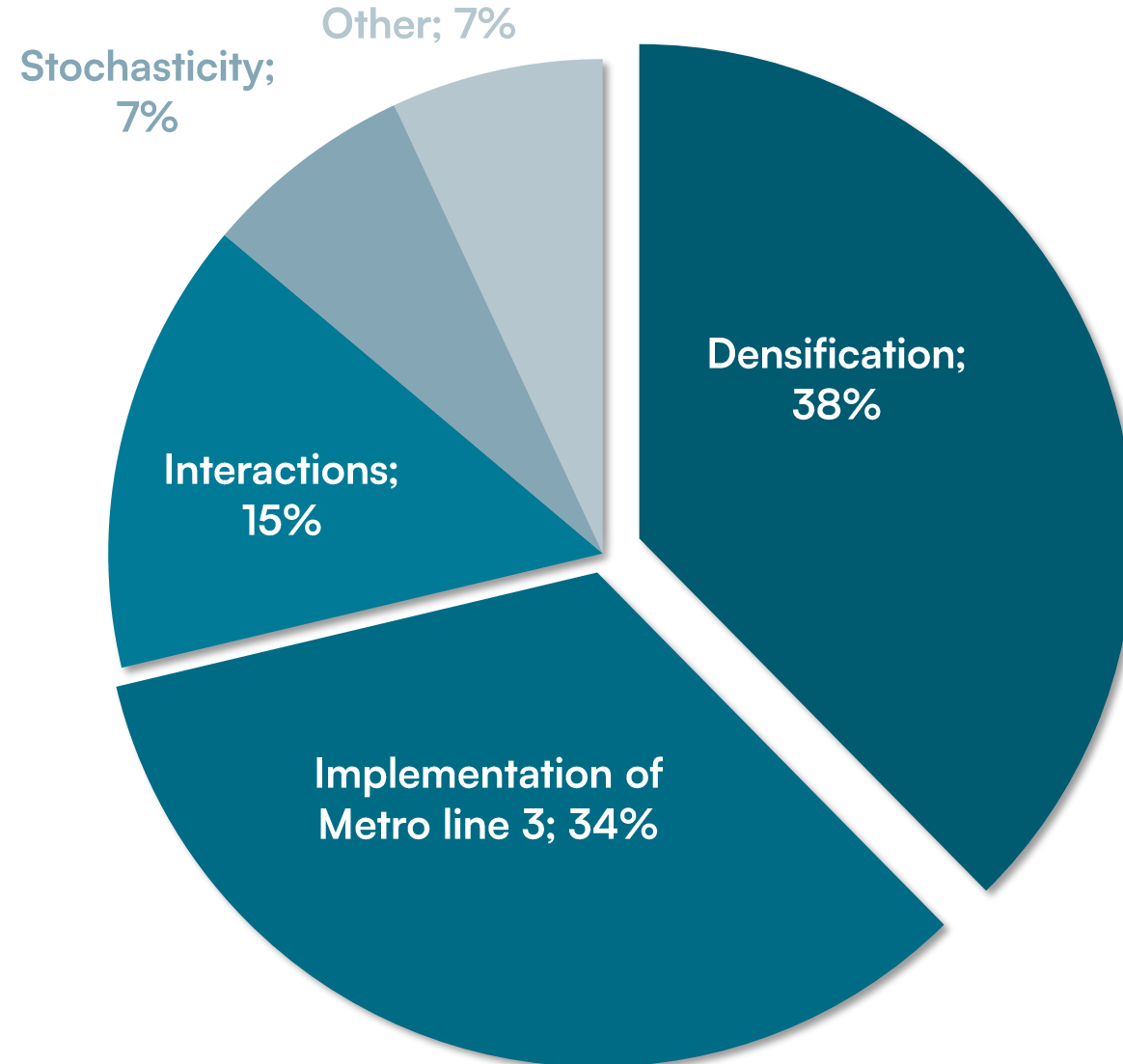


Ensemble of Future LULCC projections

Factor/driver	Min Value	Max Value	PDF	Type of Factor
Transition rate from Residential Low Density to Residential High Density	0.05%	0.20%	Uniform	External uncertainty
Transition rate from Agriculture to Residential High Density	0.01%	0.04%	Uniform	External uncertainty
Transition rate from Agriculture to Residential Low Density	0.22%	0.25%	Uniform	External uncertainty
Transition rate from Agriculture to Industrial/Commercial	0.09%	0.12%	Uniform	External uncertainty
Transition rate from Industrial/Commercial to Residential Low Density	0.2%	0.4%	Uniform	External uncertainty
Influence of urban rail infrastructure	-50%	+50%	Uniform	External uncertainty
Development of new tramway	No	Yes	Bernoulli	Planning decision
Development of new metro line 3	No	Yes	Bernoulli	Planning decision

Analysing Ensemble of Future LULCC projections

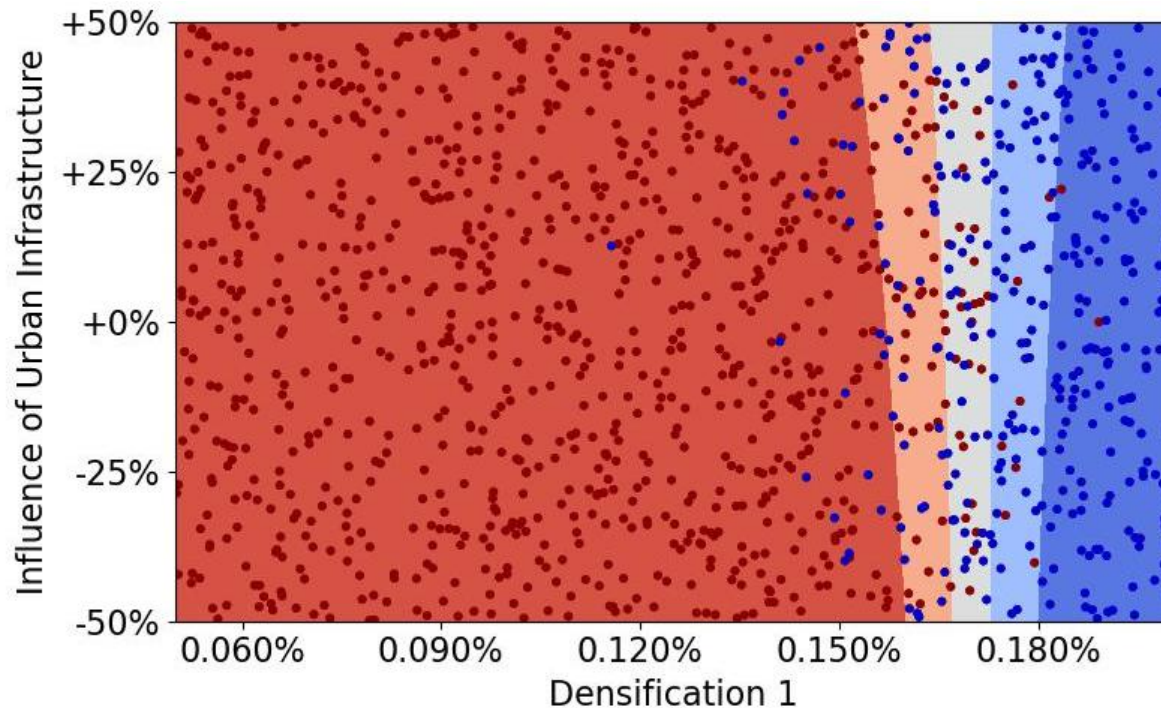
Identified the most **important drivers of change** using **Sobol indices**.



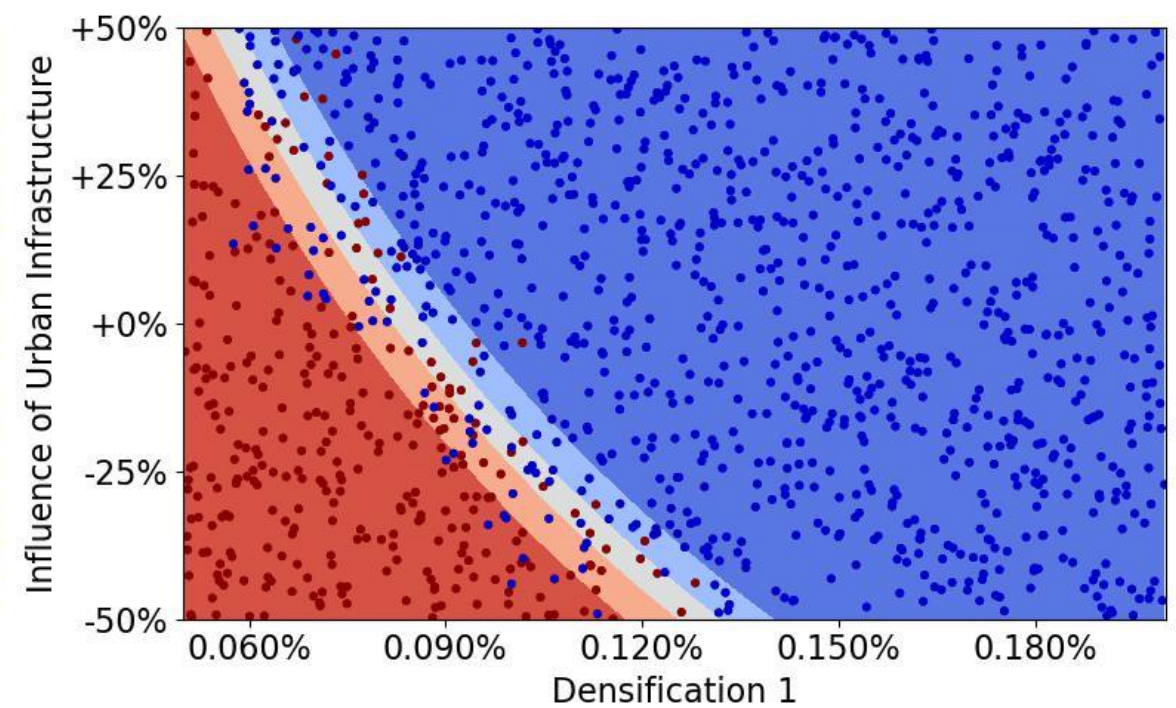
Analysing Ensemble of Future LULCC projections

Set a target (human population) and identify **scenario boundaries** as likelihood of achieving it

Without Metro Line 3



With Metro Line 3



Probability of Achieving Target Population



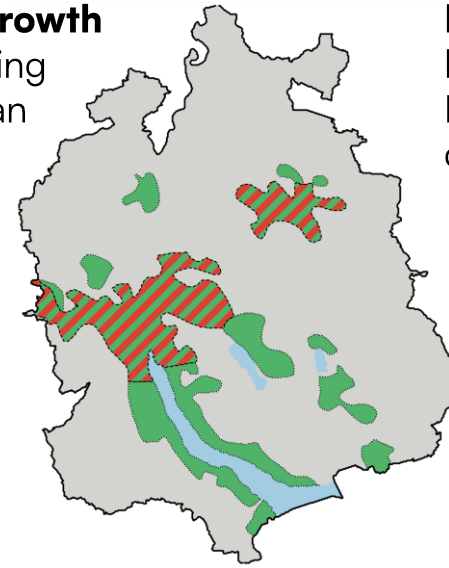
Case Study II

Urban Development in Zürich, Switzerland

Canton Zurich Structural Plan

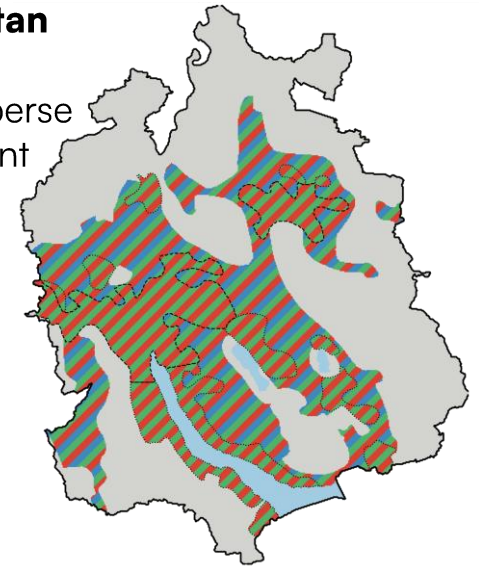
Compact Growth

80% in existing
metro & urban
areas



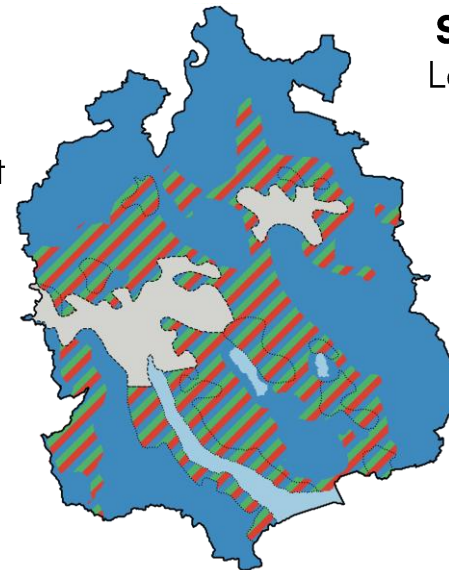
Metropolitan Expansion

High & disperse
development



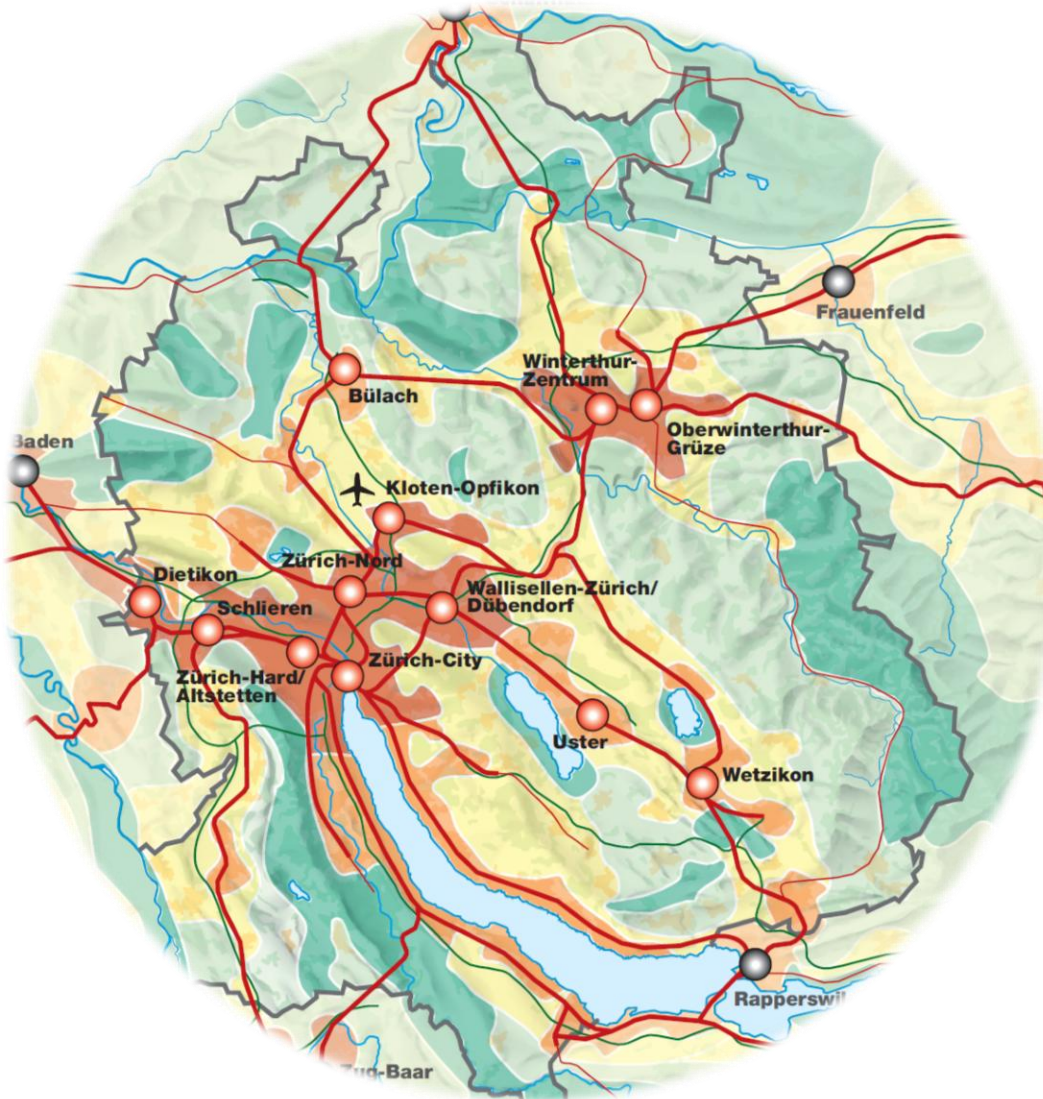
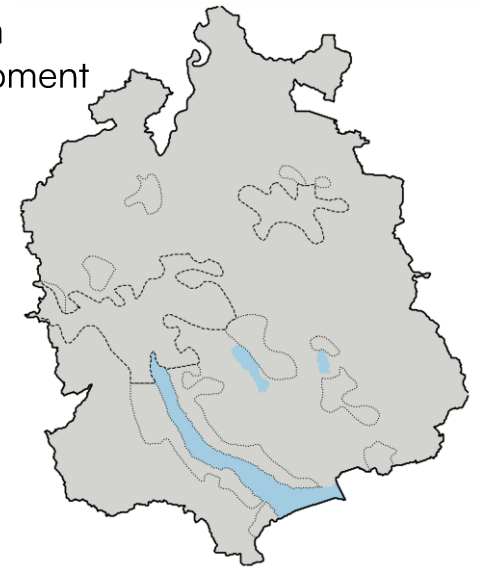
Peripheral Spread

Disperse
development

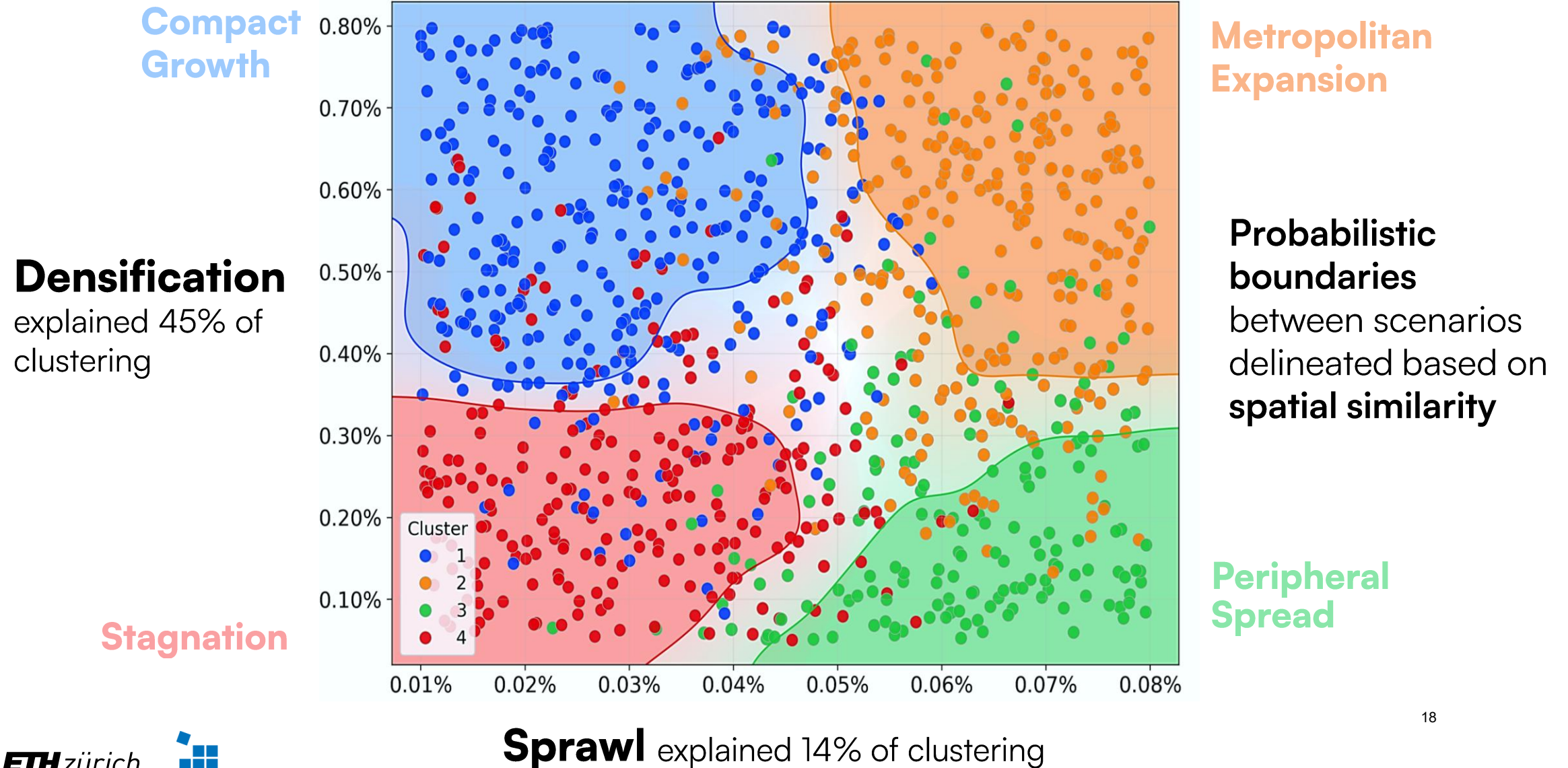


Stagnation

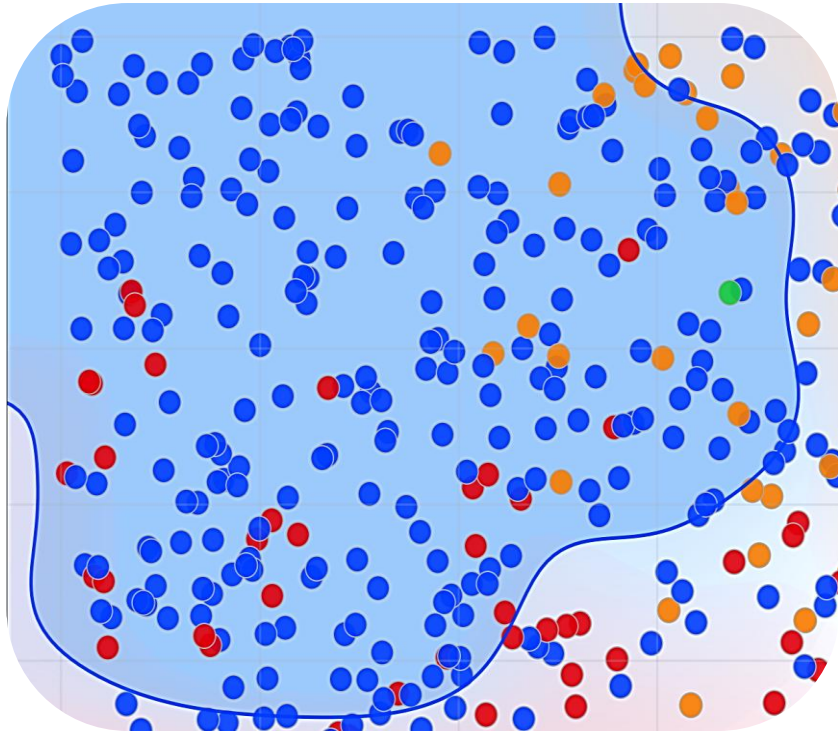
Low development



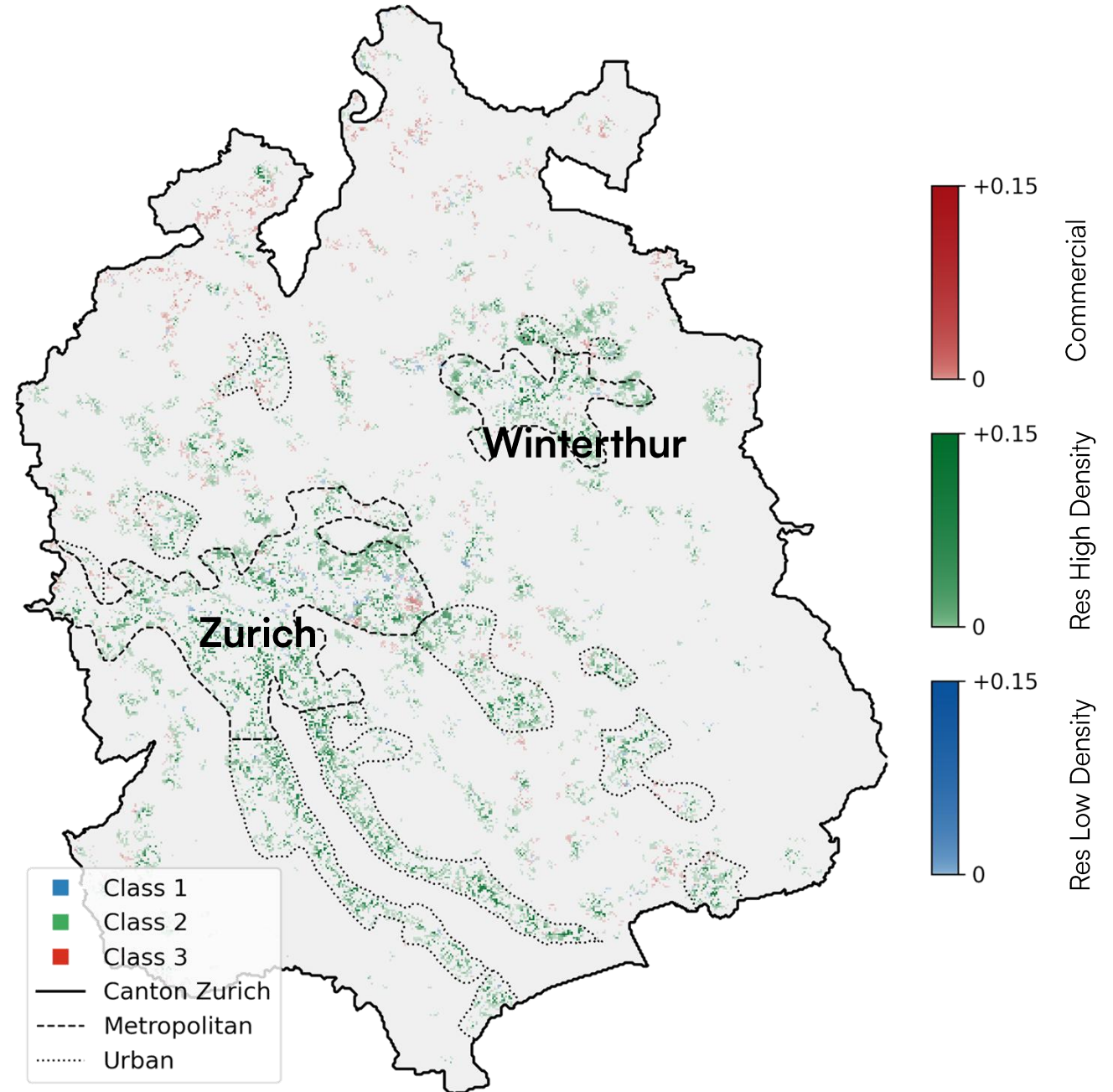
Simulation Ensemble



Compact Growth

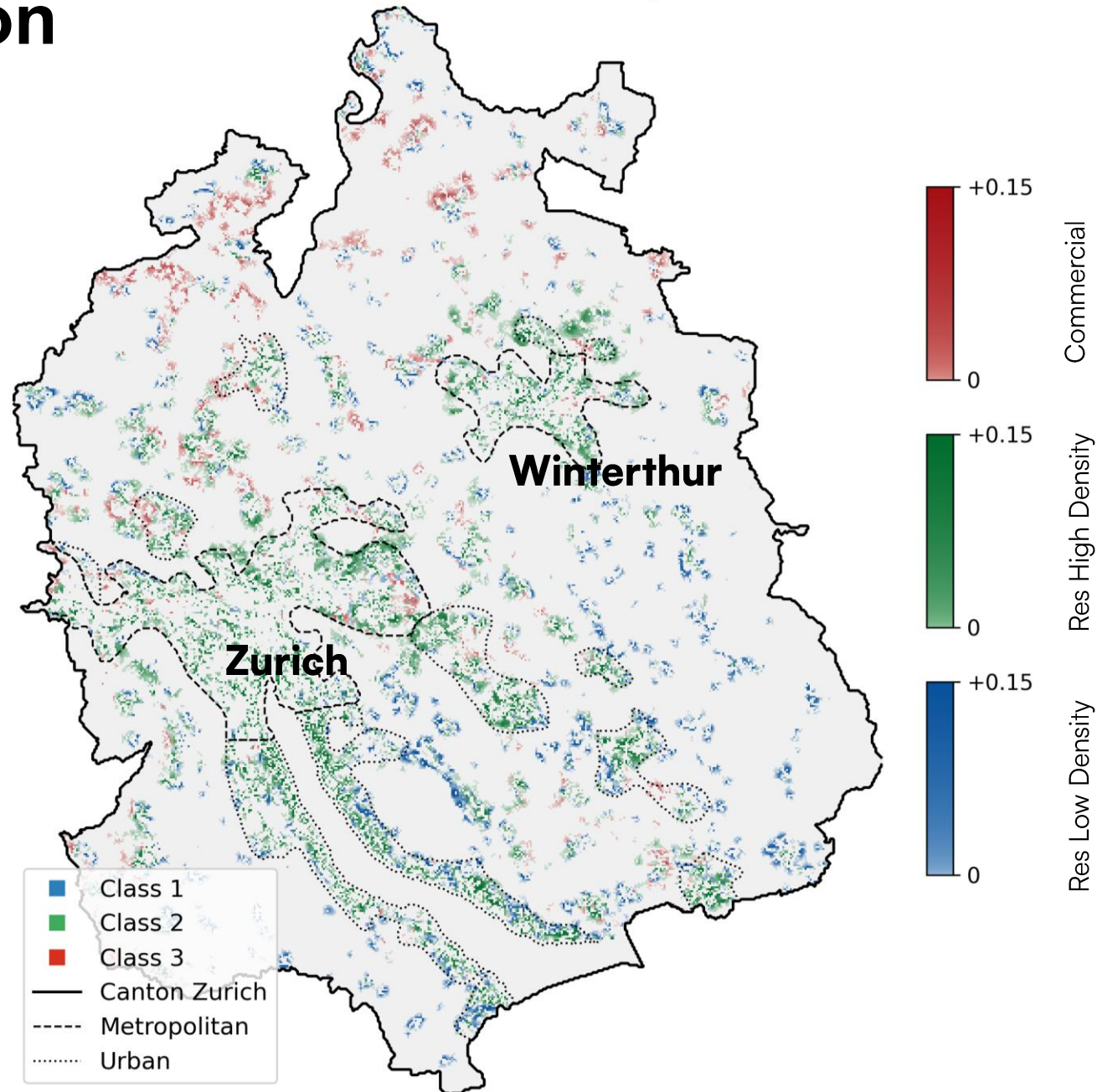
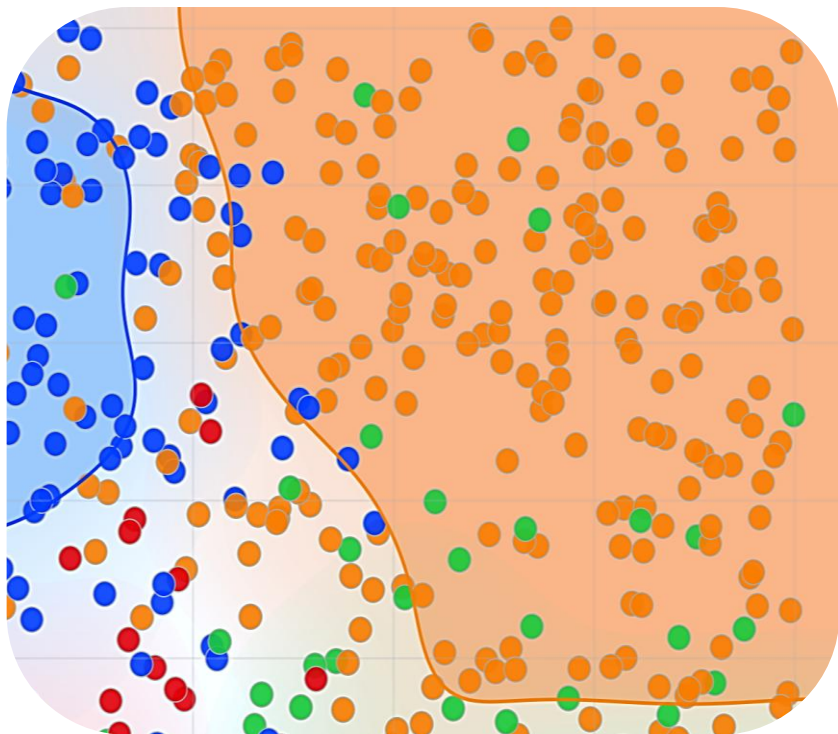


Cluster 1 (353 simulations)

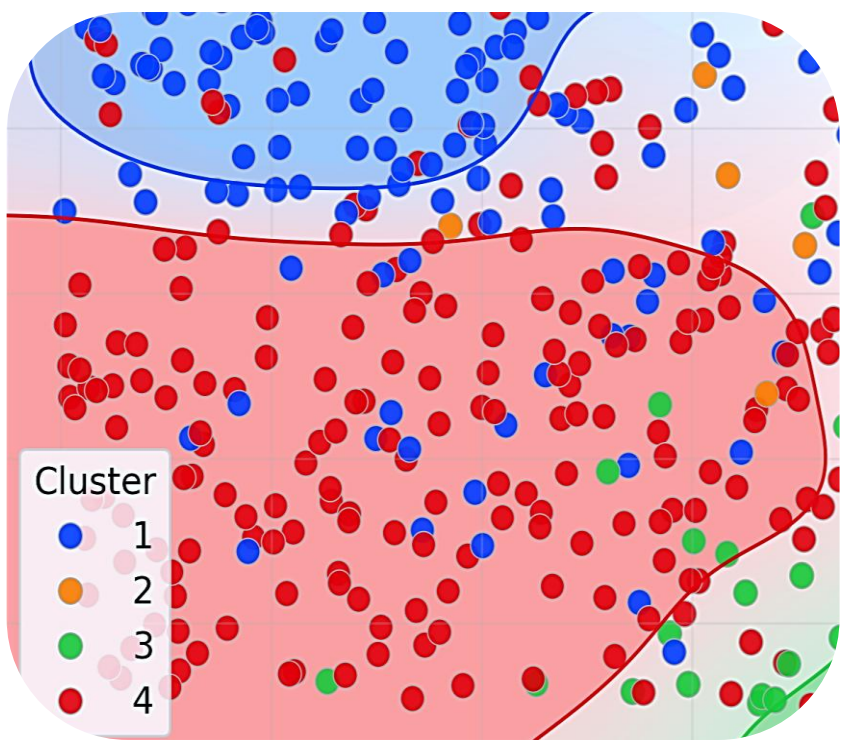


Metropolitan Expansion

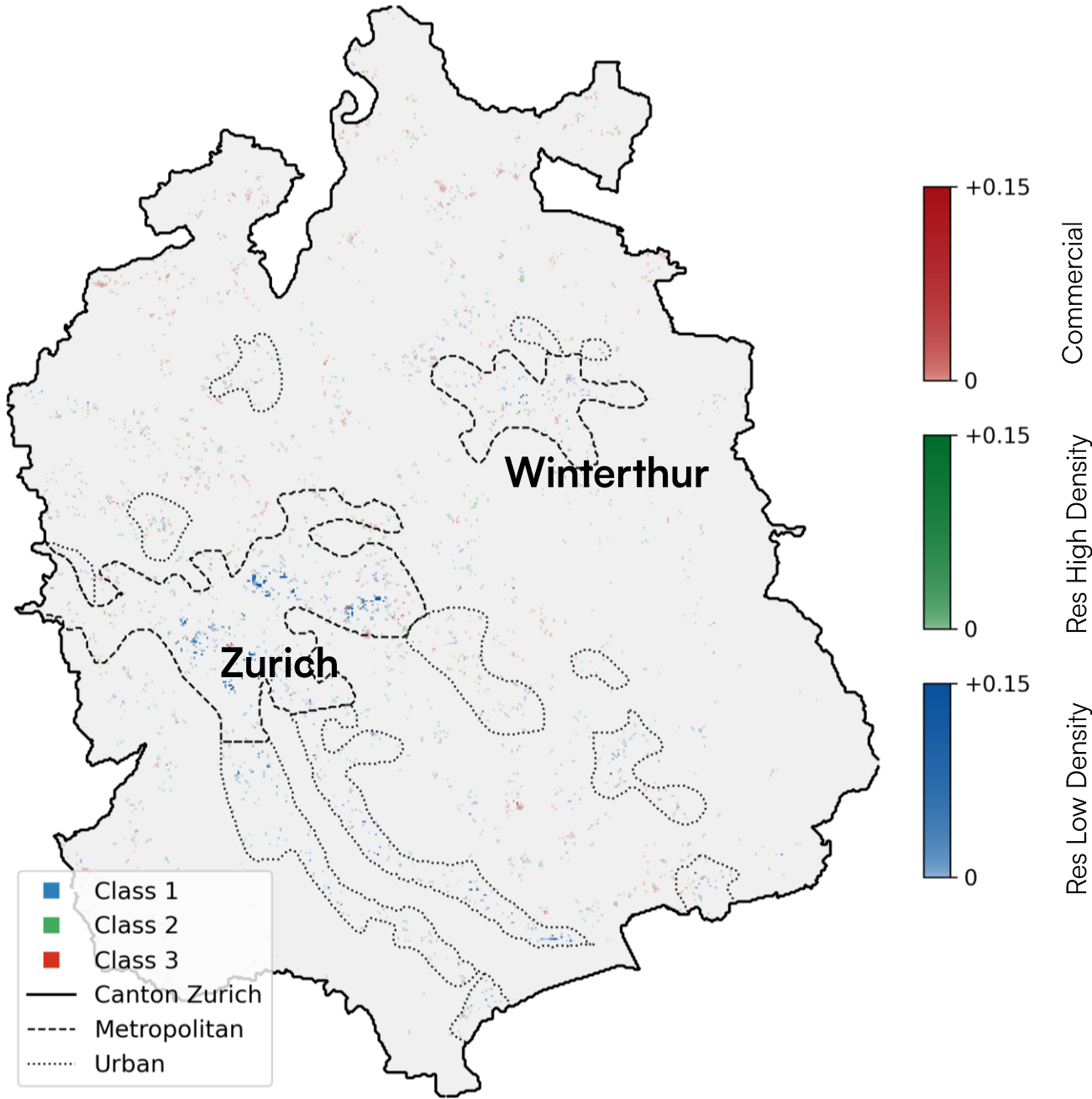
Cluster 2 (306 simulations)



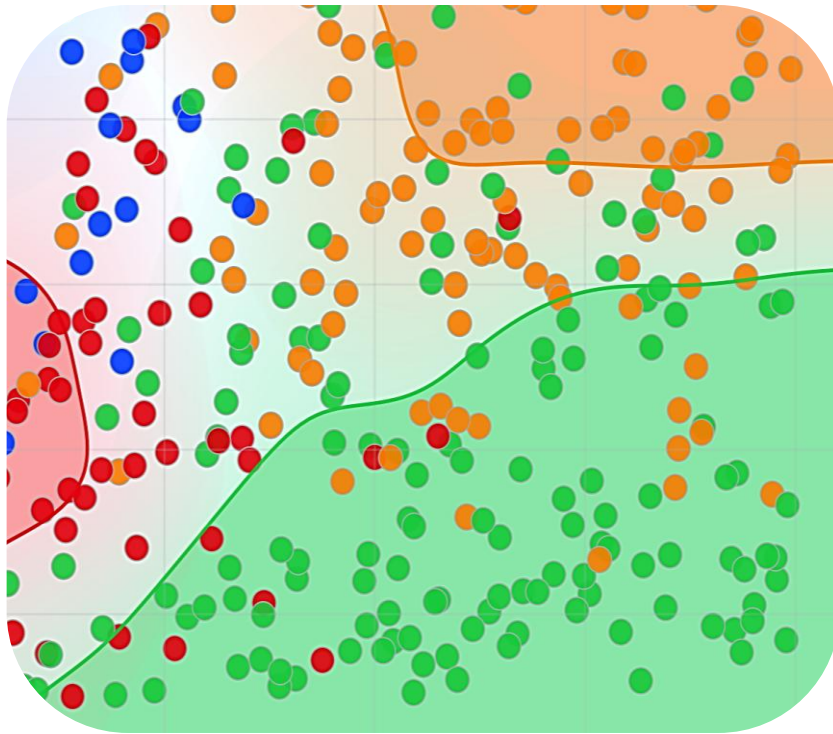
Stagnation



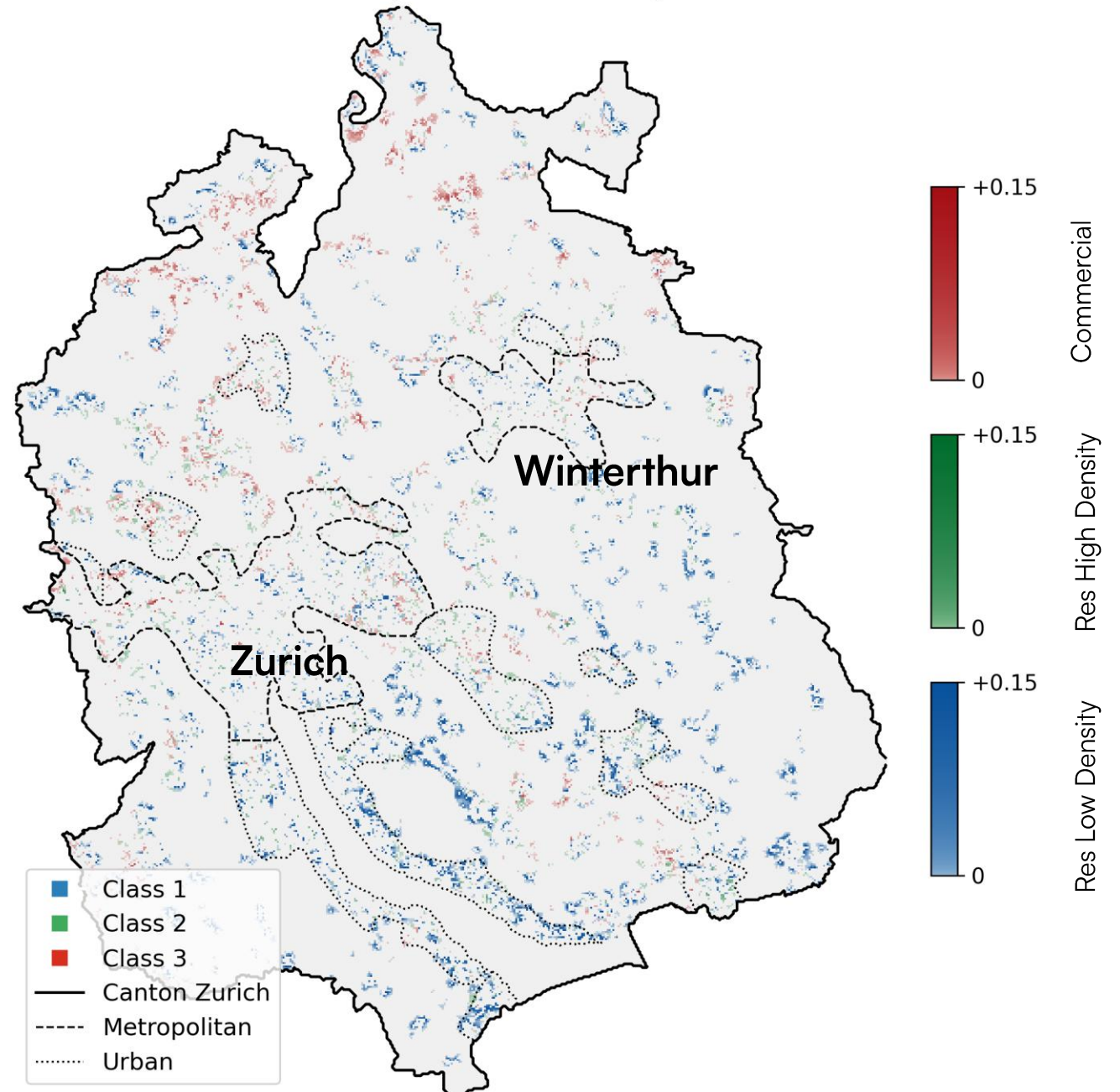
Cluster 4 (168 simulations)



Peripheral Spread



Cluster 3 (173 simulations)



Take home messages

- **Large LUCC simulation ensembles** can be used to provide planning support by identifying:
 - Relevant and important drivers of change
 - Delineating scenario boundaries.
- **Exploratory approach** using simulations as a device for exploration. Rather than predicting a few likely futures explores the uncertainty space to reveal useful insights for planning.

Further research

- Identification of scenarios using **spatial similarity metrics is more challenging** than using aggregate metrics. Further exploration of how different similarity metrics affect spatial clustering in LUCC projections is needed.
- Workflow should be further tested in real planning processes to evaluate how it can be refined to maximise insights for planners.

Thank You.

I am happy to take questions.

Connect and follow
my work

