COMPUTATIONAL URBAN PLANNING & URBAN MANAGEMENT

A “Scope, Simulation and Story” approach to identify future spatial development scenarios

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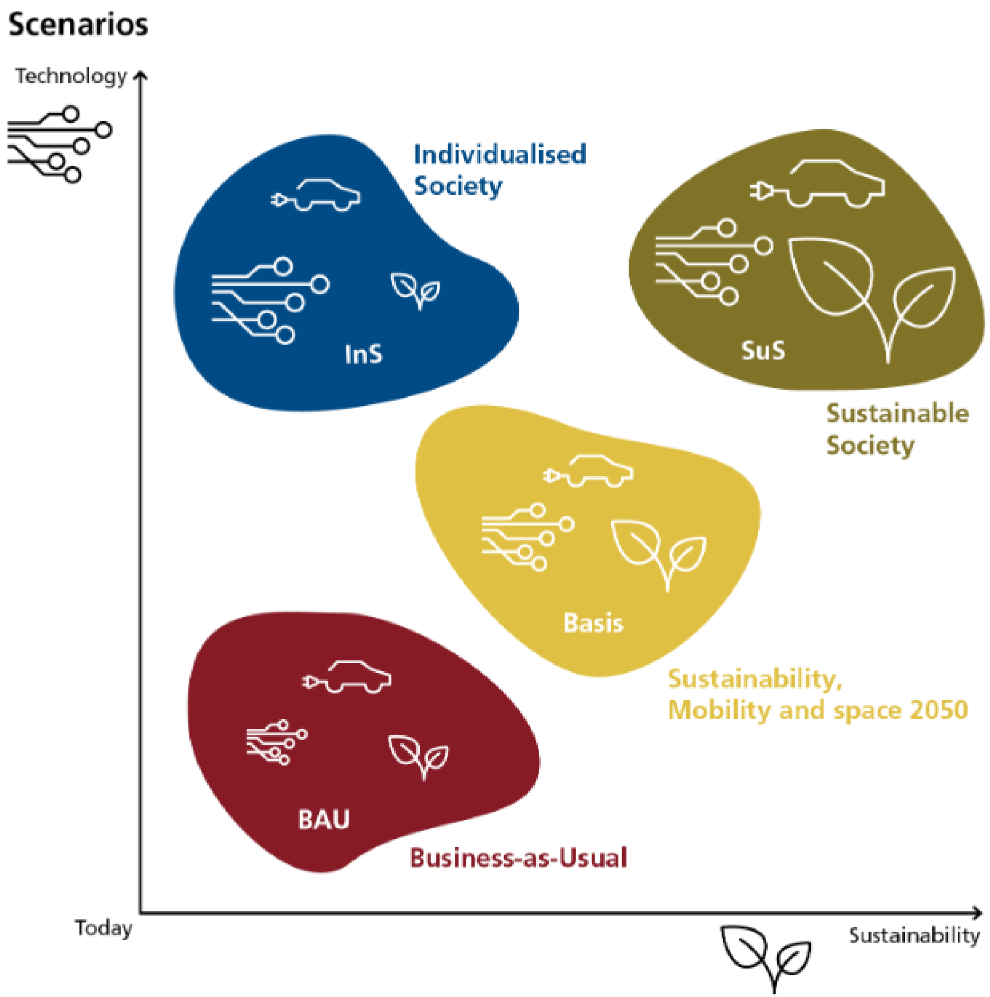
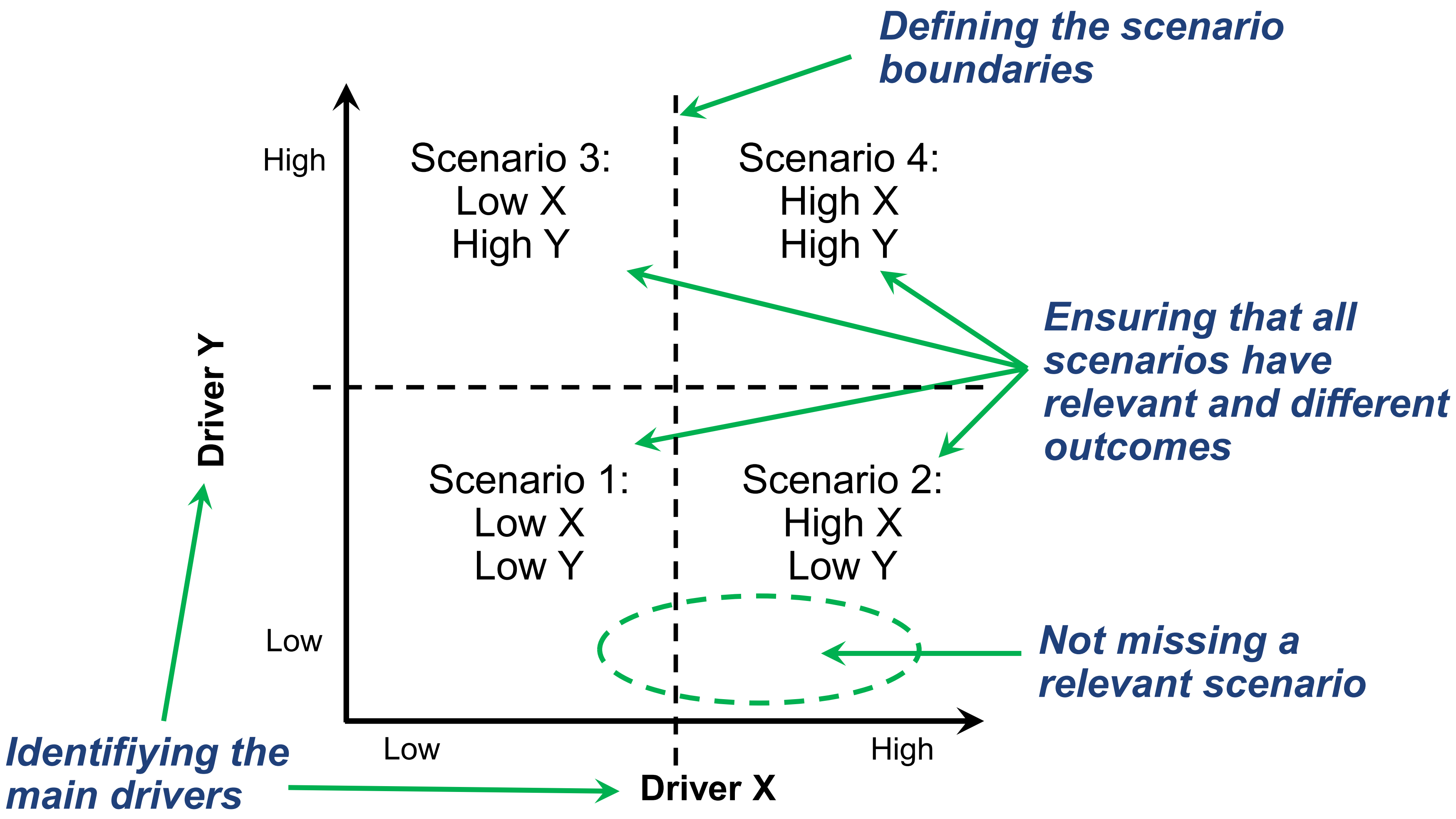
Problem Statement



ARE's Transport Outlook 2050 Scenarios:
https://www.are.admin.ch/are/en/home/mobility/data/transport-outlook/scenarios-methodology.html#1497088217

The Global Shared Socioeconomic Pathways SSPs

Problem Statement – What is challenging



Research Gap

Most scenario-planning exercises remain predominantly qualitative.

Limited set of narrative storylines → ***Simulation models***

“Story and Simulation” approach

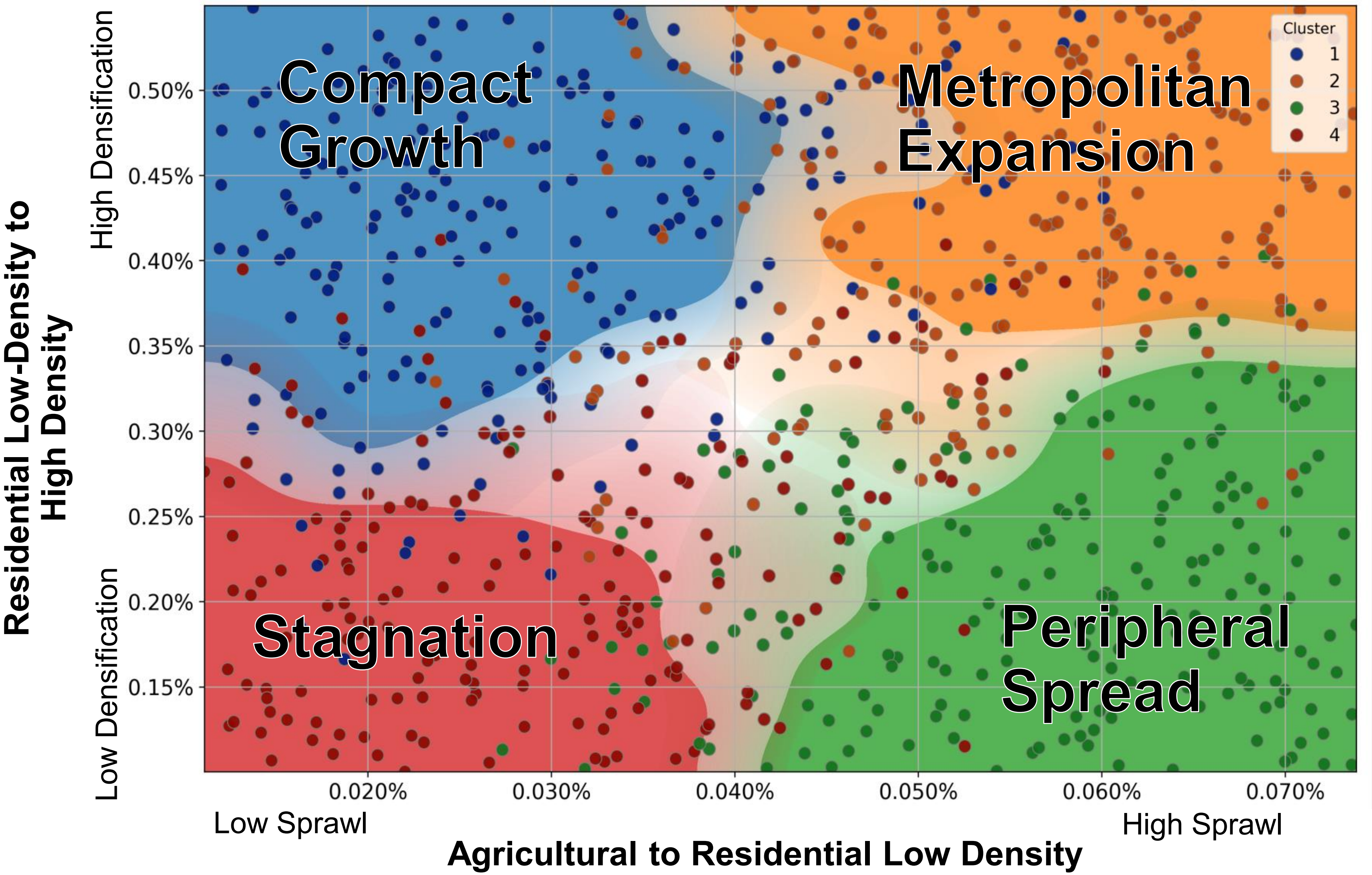
Approaches that invert this workflow, leveraging large ensembles of simulations upfront to quantitatively inform and refine the creation of scenario storylines, are still relatively uncommon.

Proposal

Probabilistic boundaries between scenarios

Y-axis explain 41% of change

X-axis explain 14% of change



Scenarios that are spatially different and relevant

A Scope, Simulation and Story approach

1: Scope

- Spatial and temporal constraints
- Potential drivers of change: Uncertainties and Planning Decisions
- Desirable Futures

2: Simulation

- Data Gathering
- Urban Development Model Selection
- Model calibration and validation
- Simulation of Ensemble of Scenarios
- Spatial clustering
- Visualisation

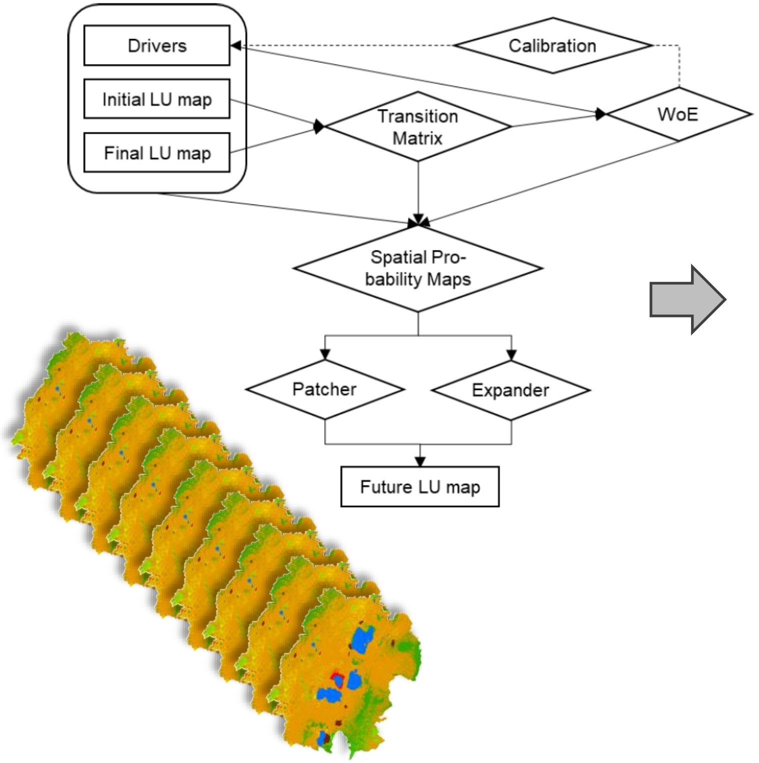
3: Story

- Iteration with stakeholders
- Scenario refinement
- Storyline development
- Proposal for action plans

A Scope, Simulation and Story approach

2: Simulation

LUCC Model



Spatial Clustering

Spatial Similarity estimation (Po/Kappa)

First Stage Seeded K-means (Only outputs)

Second Stage Seeded K-means (Refined with Inputs)

Supervised Classification (Random Forest)

Visualization

Gaussian Smoothing to show uncertainty boundaries

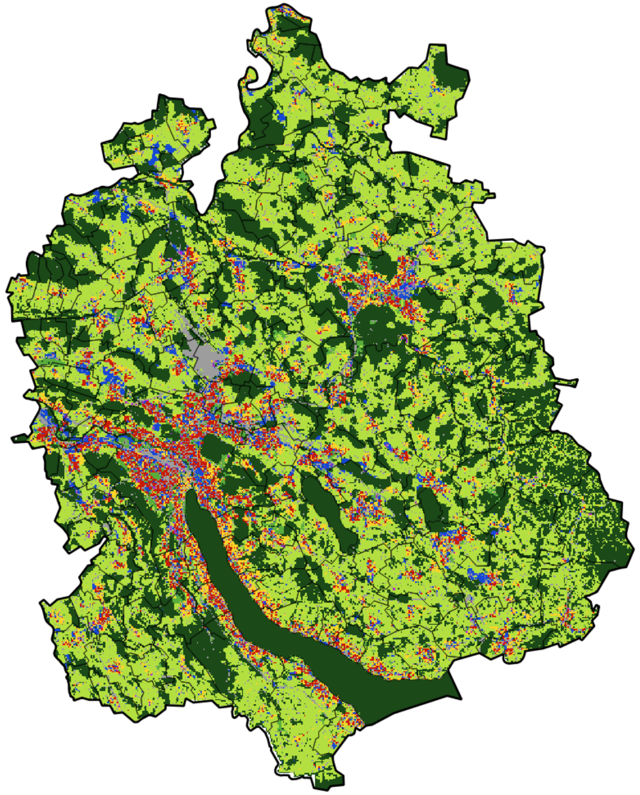
LUCC Model – Dinamica EGO

Drivers

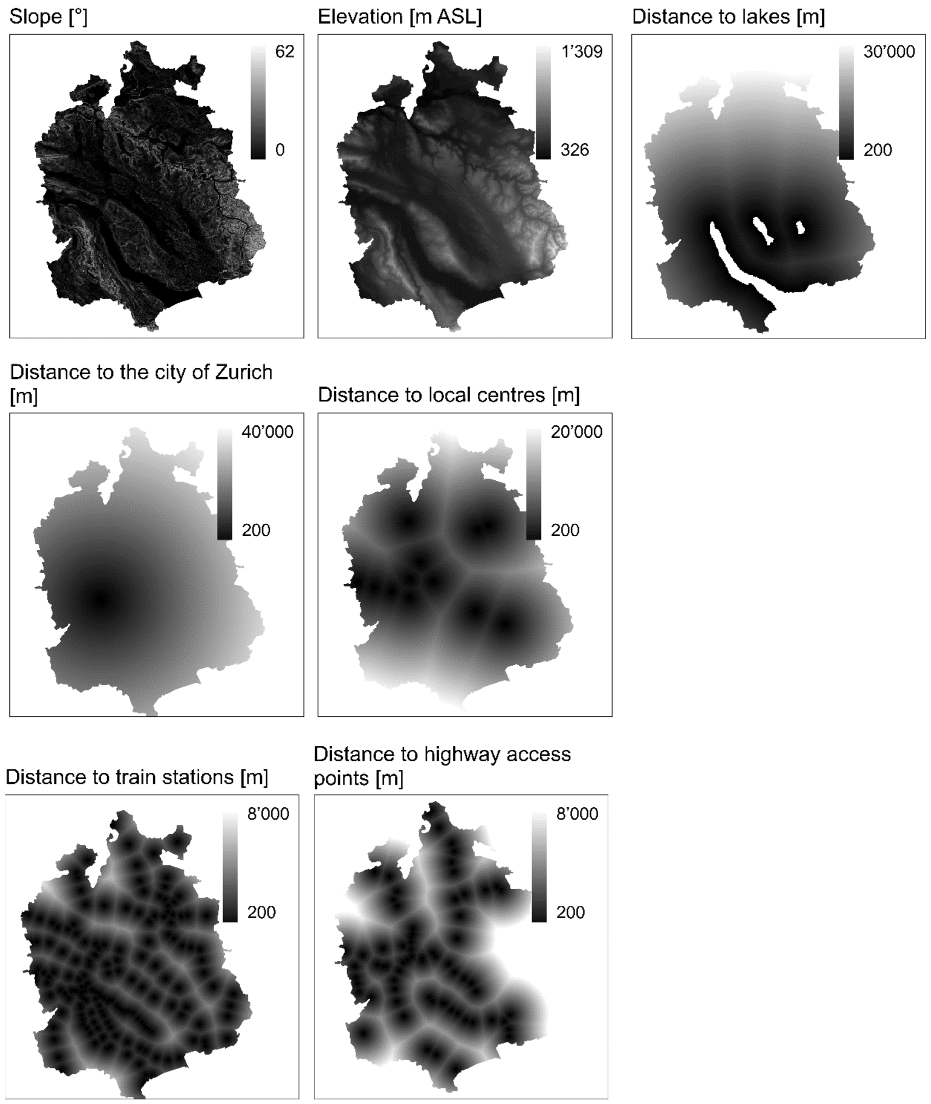
Initial LU map

Final LU map

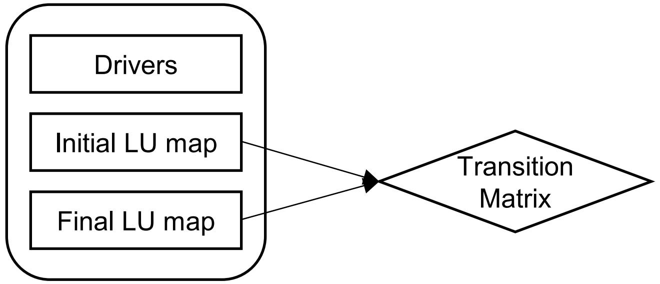
1985, 1997, 2009, 2018



1. Low-density settlement area
2. High-density settlement area
3. Industrial, commercial, and public area
4. Construction sites and fallows
5. Traffic area
6. Recreational and green zones
7. Agricultural area
8. Forest and unproductive area



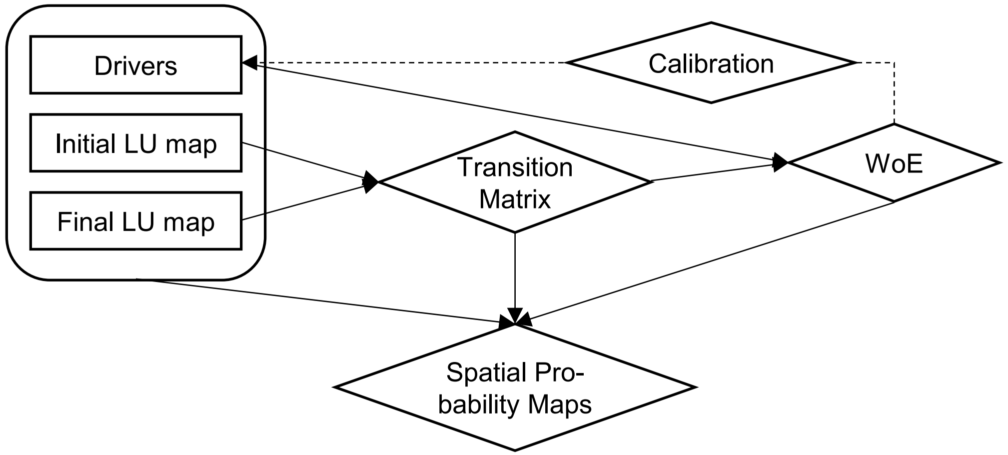
LUCC model – Transition Matrix

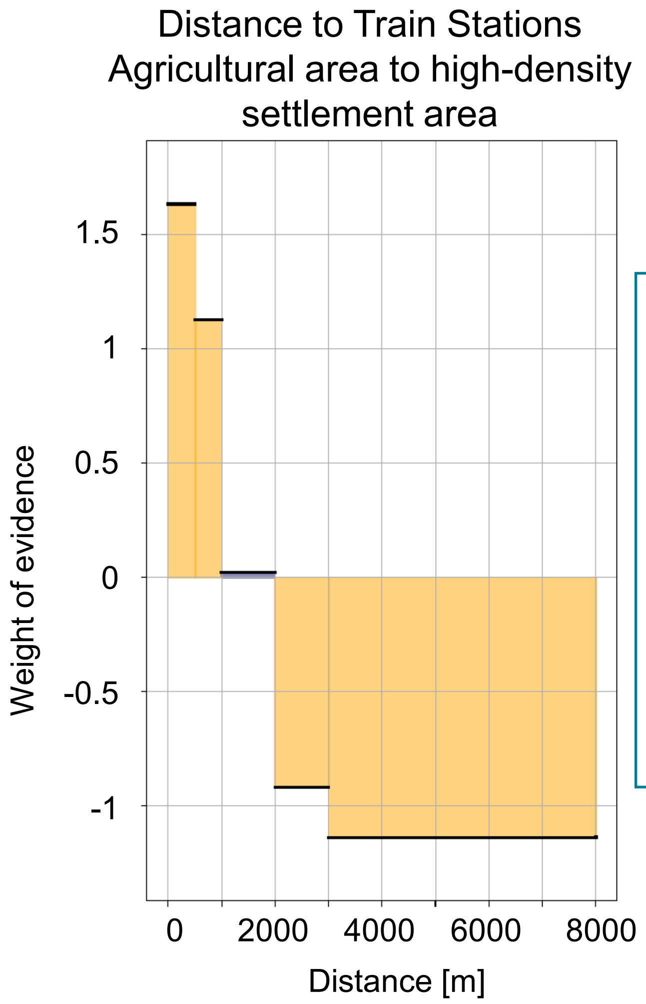


«A pixel of low-density settlement in 2009 will change to high-density settlement by 2018 with a probability of 0.35%»

To: From:	1 LDS	2 HDS	3 ICP	4 CF	5 T	6 RG	7 A	8 FU
1: Low-density settlement area (LDS)	-	0.35%		0.26%				
2: High-density settlement area (HDS)	0.14%	-		0.20%				
3: Industrial, commercial, and public area (ICP)	0.05%	0.12%	-	0.62%	0.03%	0.02%	0.24%	0.14%
4: Construction sites and fallows (CF)	4.52%	7.20%	2.88%	-	4.40%	1.40%	3.82%	1.21%
5: Traffic area (T)	0.003%	0.004%	0.026%	0.114%	-	0.005%	0.003%	0.009%
6: Recreational and green zones (RG)		0.02%	0.06%	0.32%		-	0.10%	0.02%
7: Agricultural area (A)	0.04%	0.04%	0.04%	0.10%	0.02%	0.02%	-	0.09%
8: Forest and unproductive area (FU)	0.003%	0.001%	0.003%	0.007%	0.004%	0.002%	0.047%	-

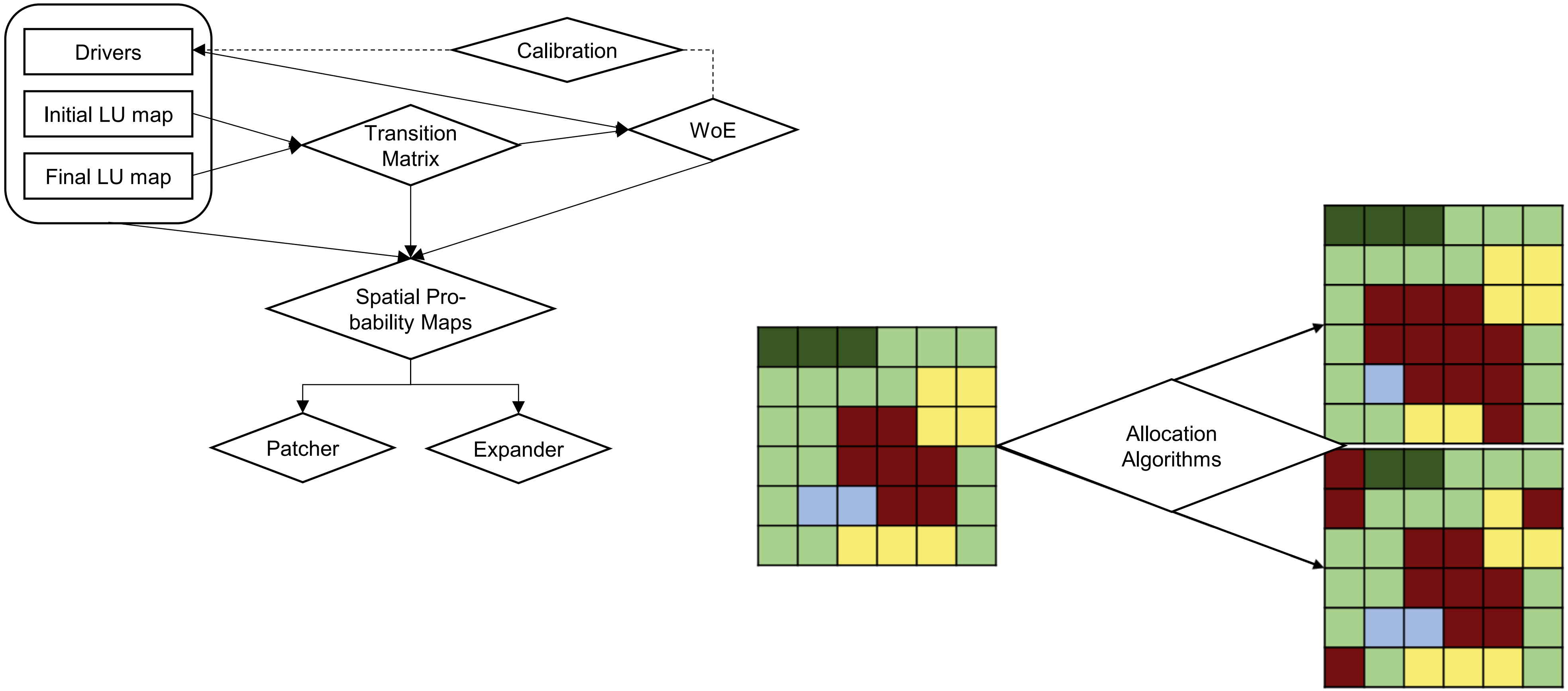
LUCC model – Drivers Weights of Evidence





«The distance to train stations is significant in explaining the transition from agriculture to high-density settlement. For > 2km from a train station it is more likely that the transition doesn't occur than that it occurs.»

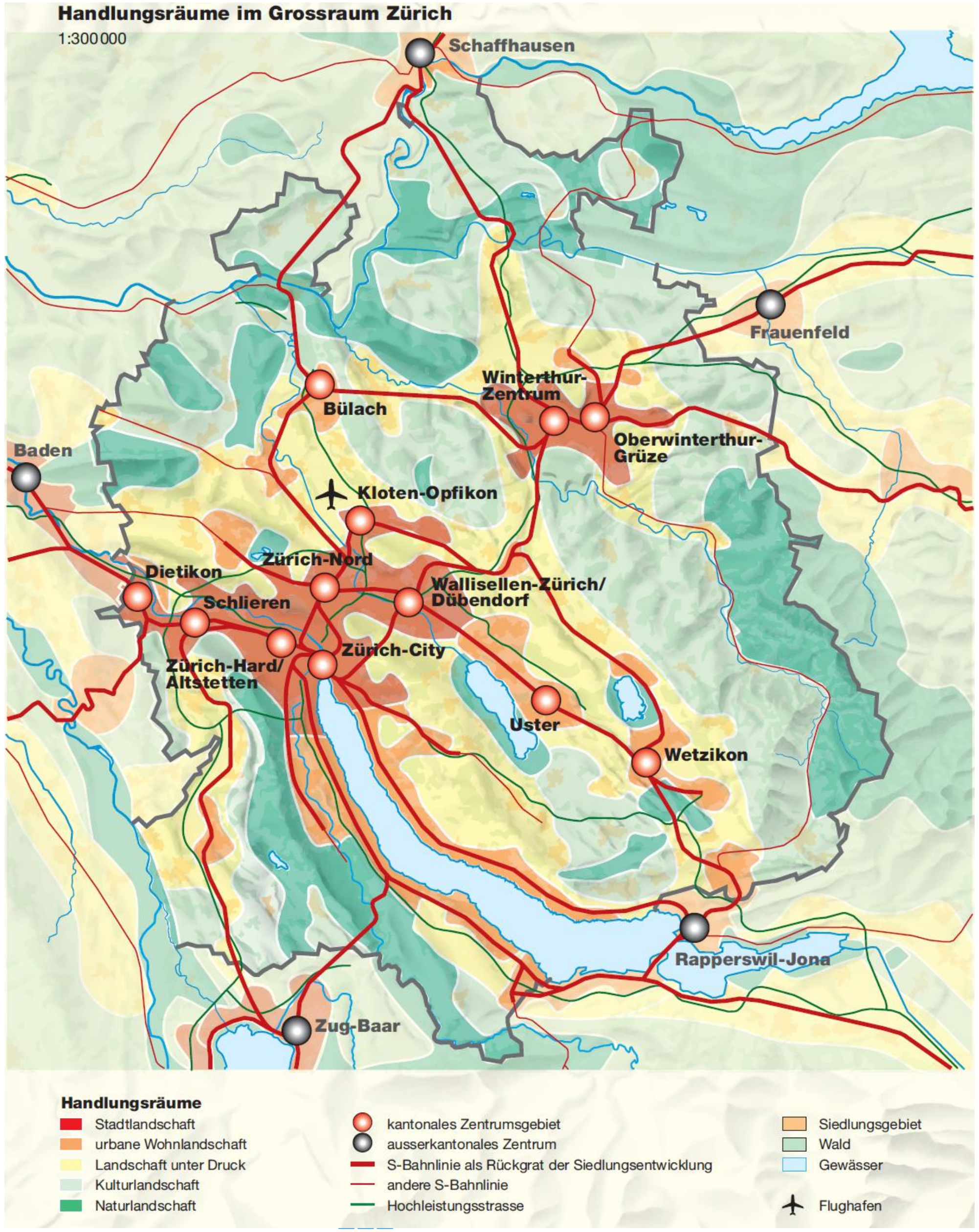
LUCC model – Allocation of predicted change



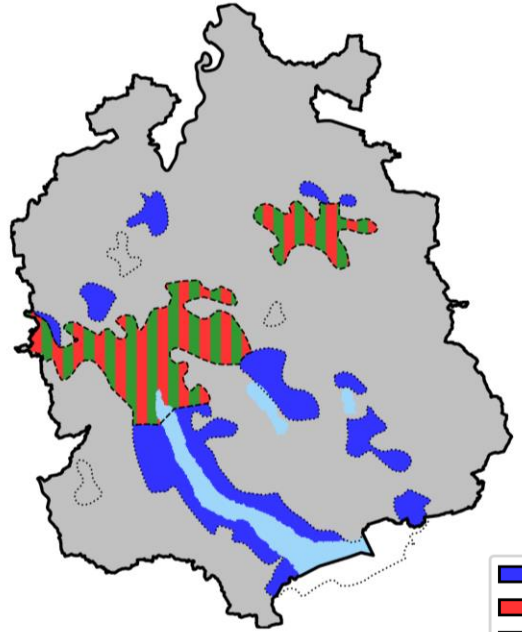
Experimental Design – 800 simulations – Latin Hypercube Sampling

Uncertain Factor	Min. Value	Max. Value	PDF*
Transition rate from low- to high-density settlement	0.25	0.35	Uniform
Transition rate from high- to low-density settlement	0.14	0.24	Uniform
Transition rate from industrial, commercial and public area to low-density settlement	0.04	0.05	Uniform
Transition rate from industrial, commercial and public area to high-density settlement	0.10	0.12	Uniform
Transition rate from agricultural area to low-density settlement	0.04	0.07	Uniform
Transition rate from agricultural area to high-density settlement	0.04	0.05	Uniform
Transition rate from agricultural area to industrial, commercial and public area	0.04	0.06	Uniform
Weights of Train Stations/Highway access points for probability surfaces	-50%/+50%	+50%/-50%	Uniform
Weights of Smaller cities/Big cities for probability surfaces	-50%/+50%	+50%/-50%	Uniform

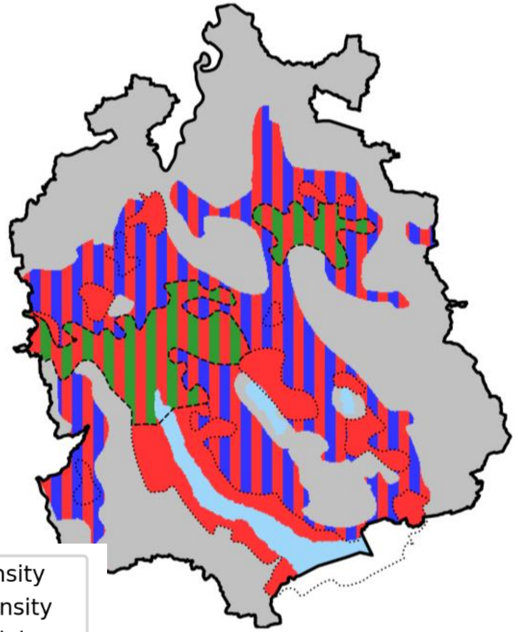
Spatial outputs - Normative



Scenario 1: Compact Growth

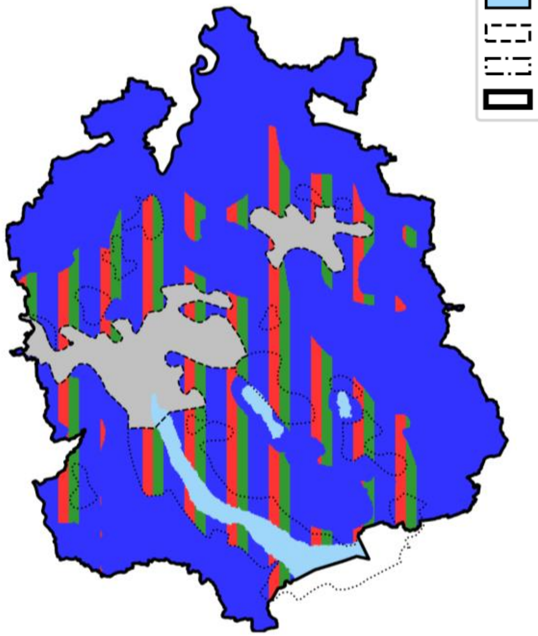


Scenario 2: Metropolitan Expansion

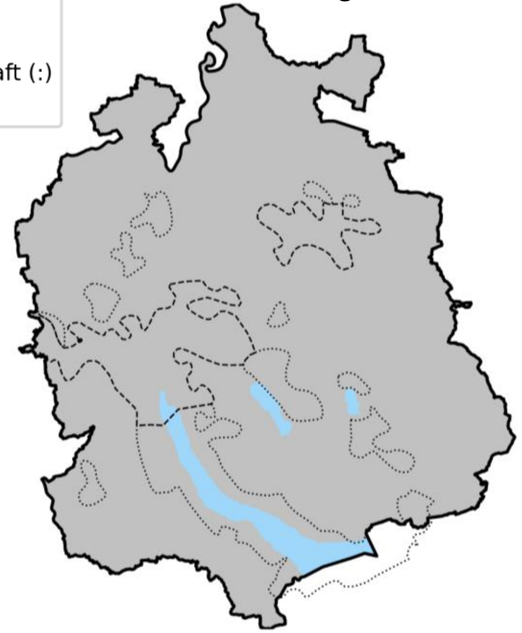


- Residential Low Density
- Residential High Density
- Commercial Industrial
- No development
- Water
- Stadtlandschaft (--)
- Urbane Wohnlandschaft (:)
- Canton Zürich (-)

Scenario 3: Peripheral Spread

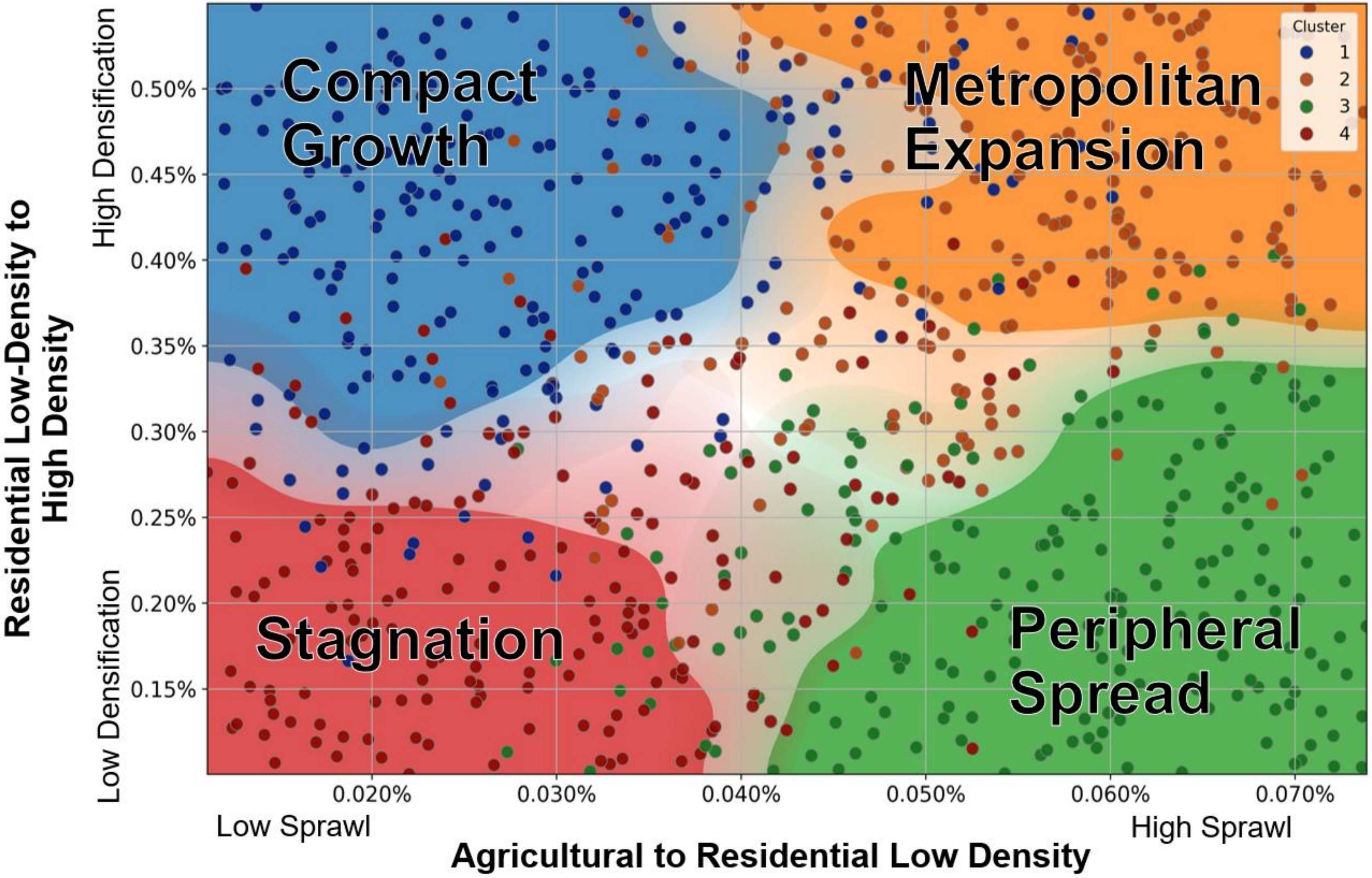


Scenario 4: Stagnation



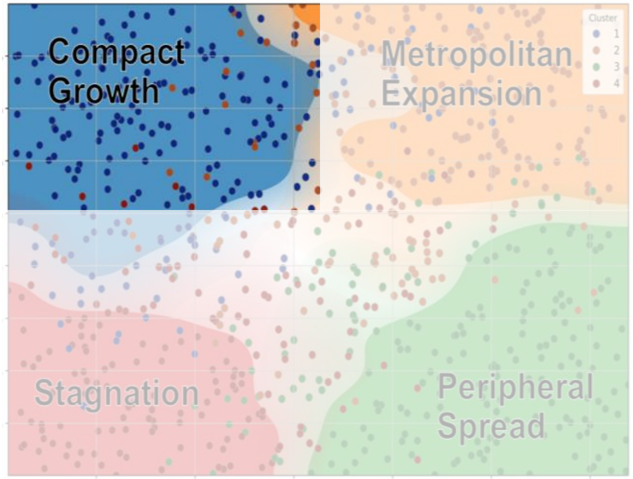
Scenario Map

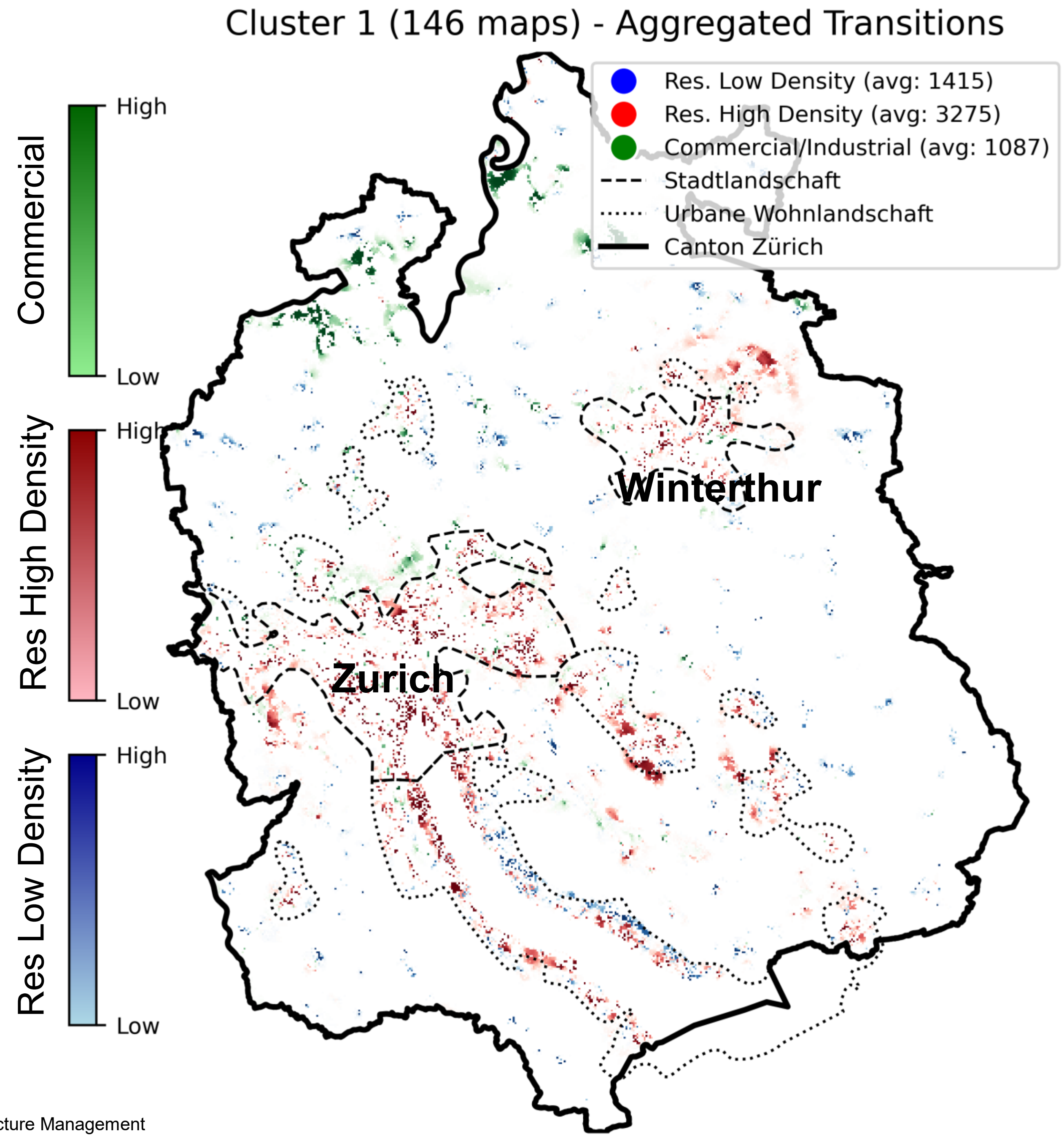
Low Density to High density	0.41
High density to Low Density	0.055
Commercial to Low Density	0.043
Commercial to High Density	0.052
Agricultural to Low Density	0.14
Agricultural to High Density	0.13
Agricultural to Commercial	0.061
Transport Orientation	0.056
Urban Structure	0.044



Spatial Scenarios

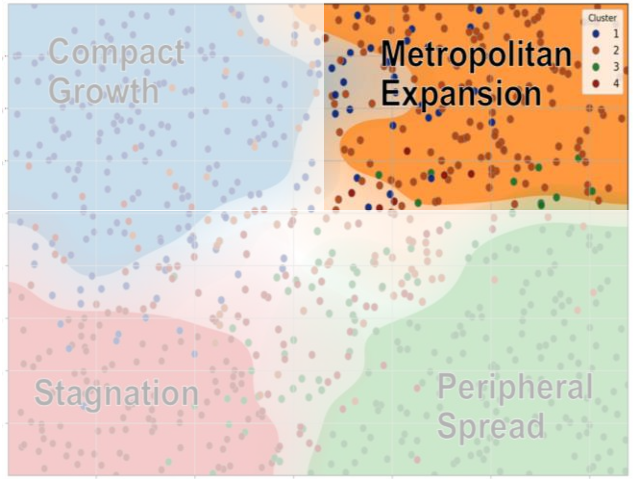
Compact Growth

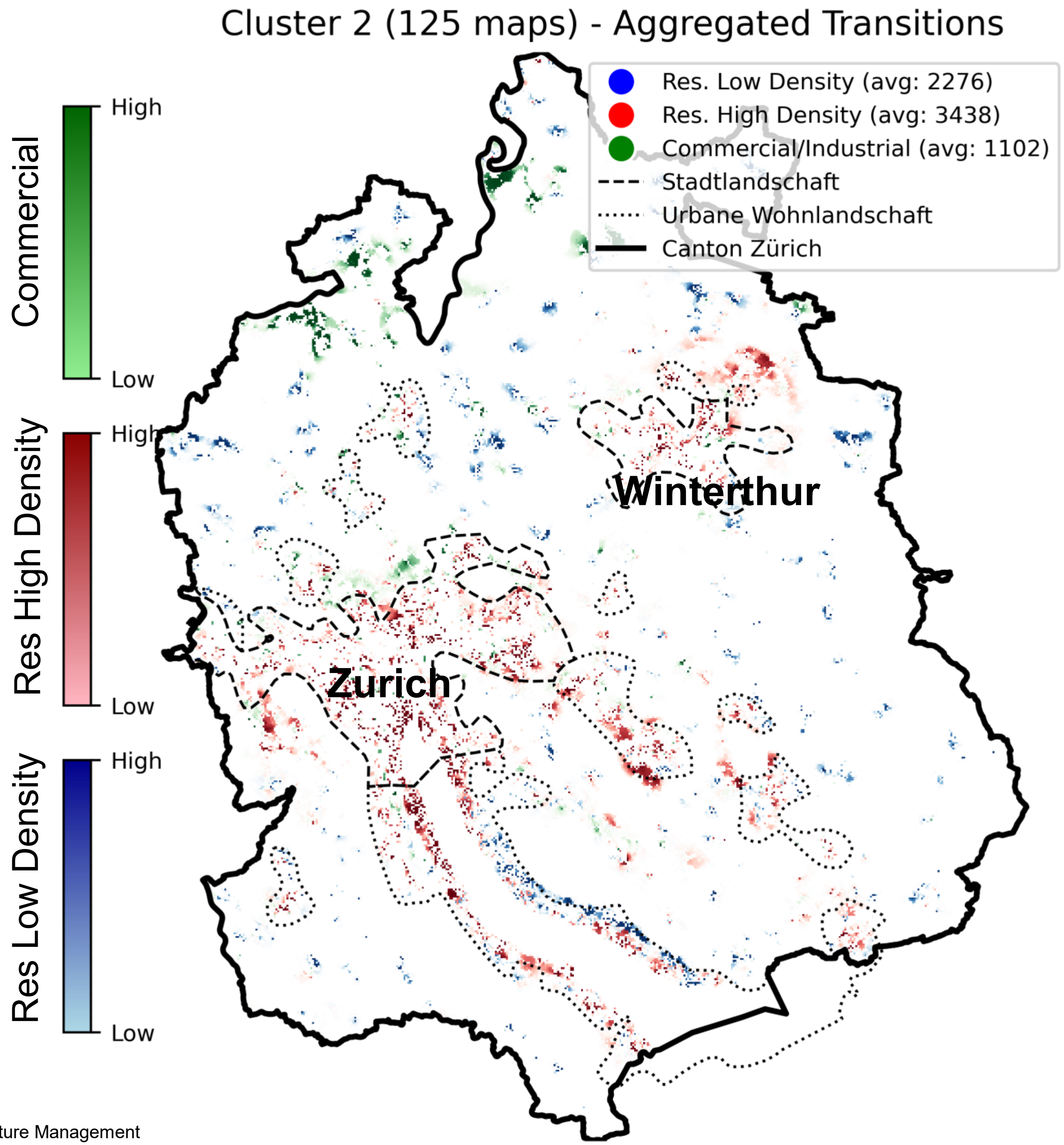




Spatial Scenarios

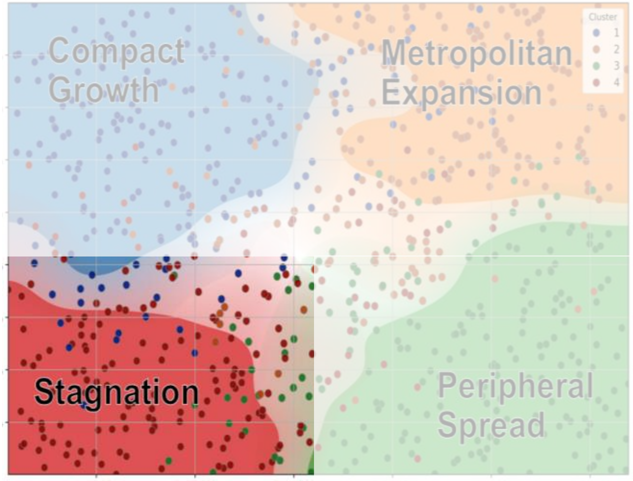
Metropolitan Expansion

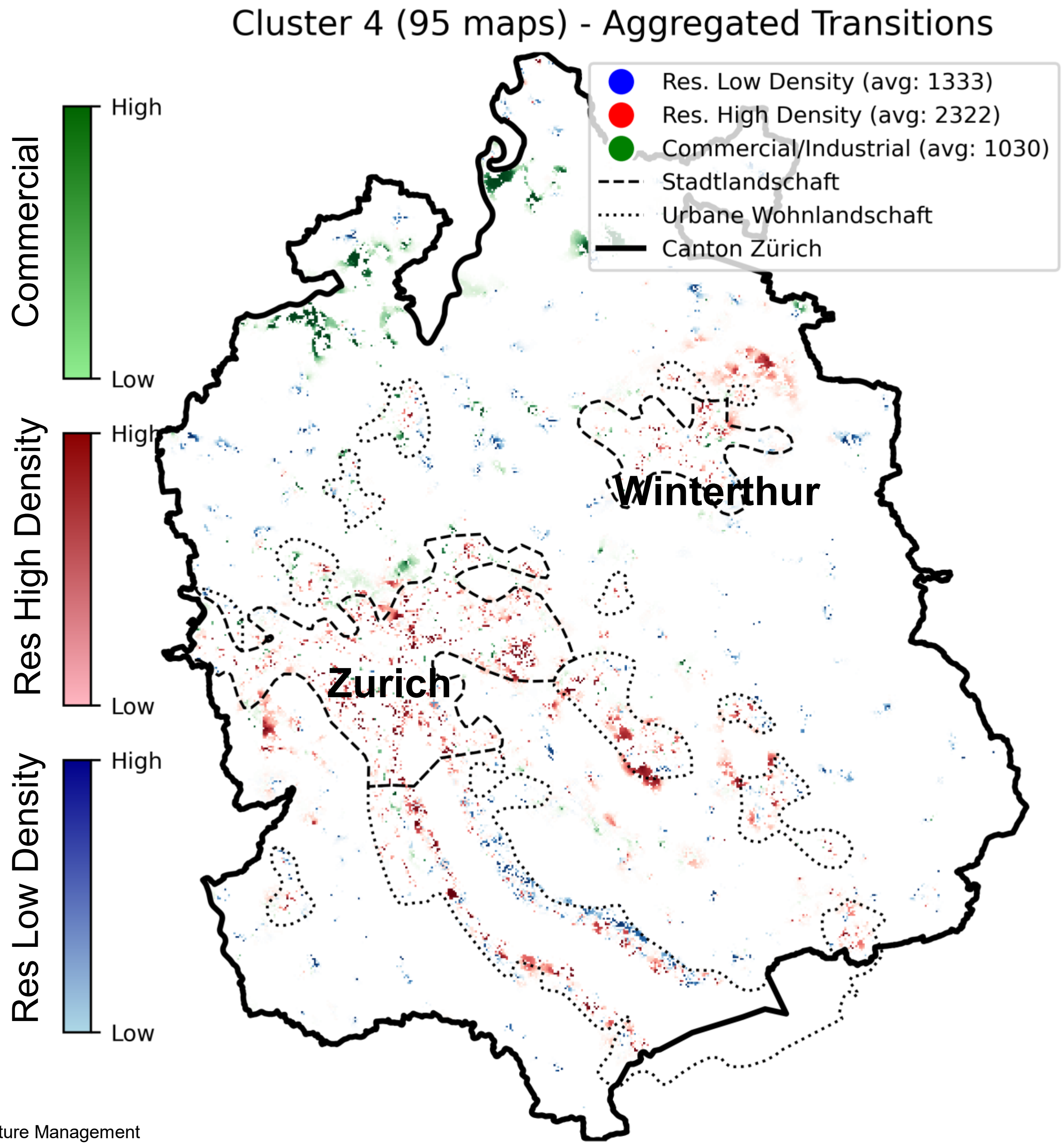




Spatial Scenarios

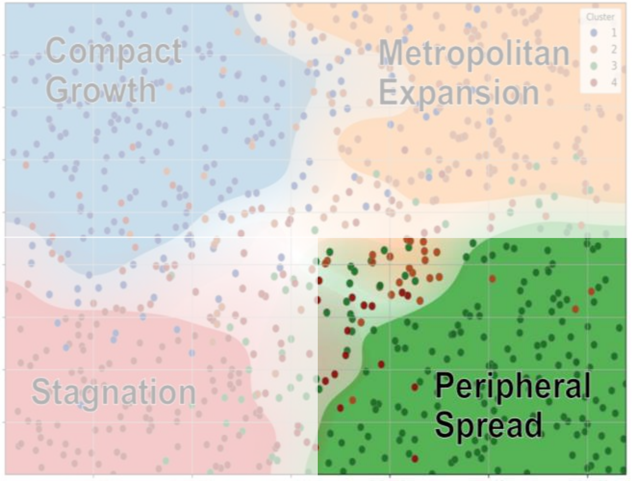
No Growth

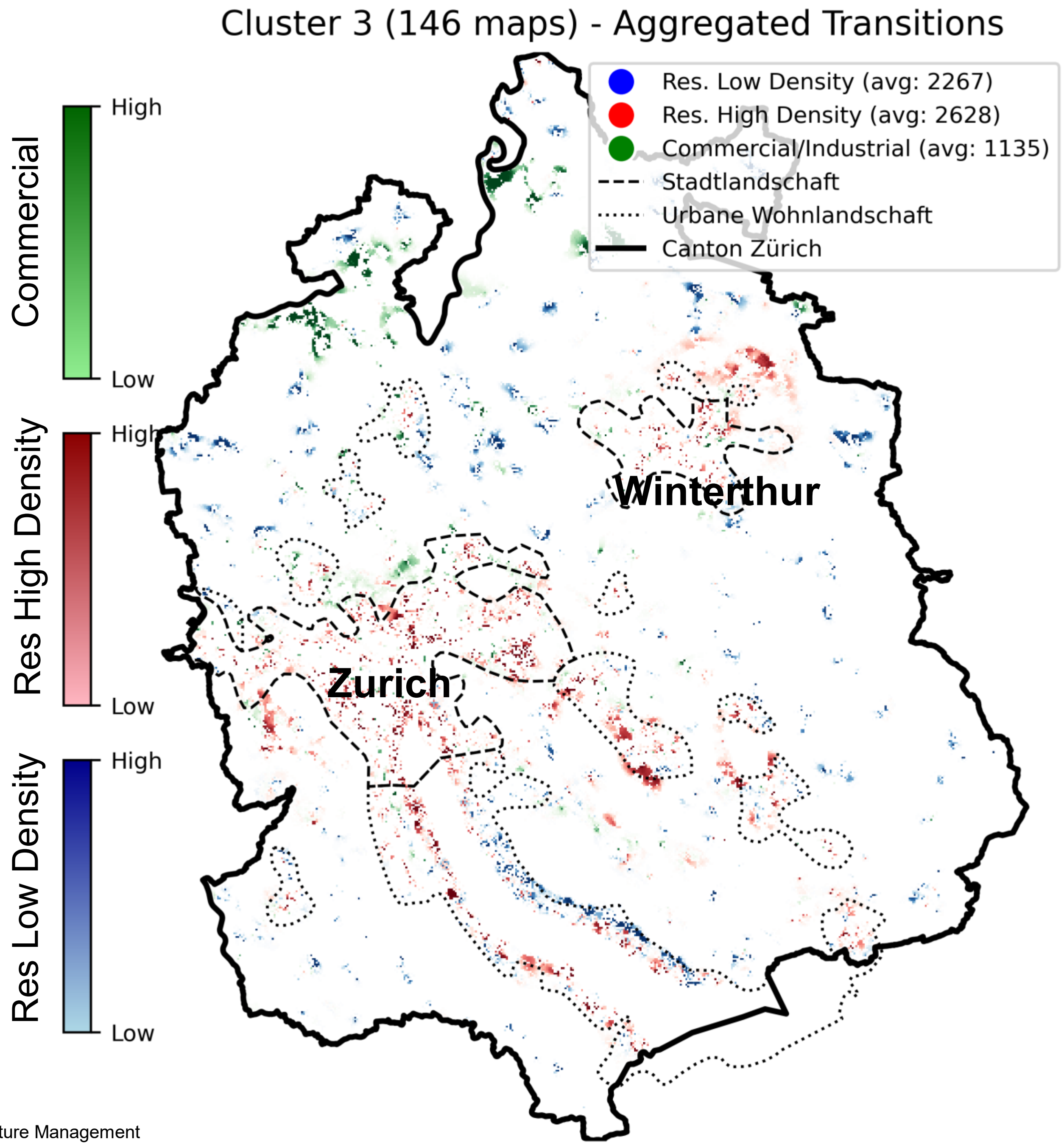




Spatial Scenarios

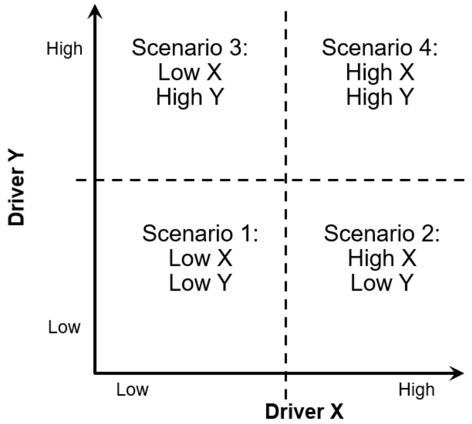
Peripheral Spread

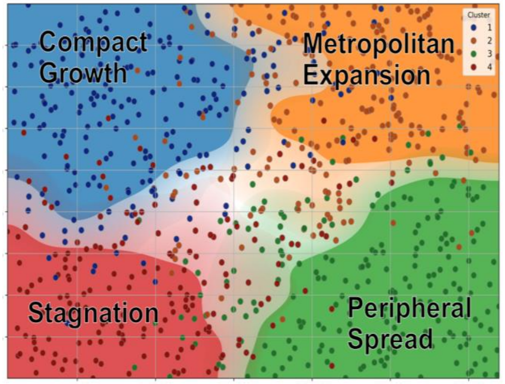




Conclusions

- We are proposing a methodology to develop scenario narratives that are informed by simulations. A “Scope, Simulation and Story” approach.
- Different and relevant spatial patterns emerge from the simulations providing insights for planning (i.e. which are the main factors producing such spatial patterns).
- There are technical challenges to measure spatial similarity, cluster spatial simulations and visualize spatial scenarios. This work contributes with a workflow and an example of how to implement such an approach to identify scenario narratives. The methodology could be adapted for other Urban Development model, not necessarily cellular automata models
- To embed this workflow into real planning processes, we propose to include participatory feedback at the beginning (the Scope) and the end (the Story) of the Simulation process.





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