Karlsruhe Institute of Technology

Approaches to Modelling Urban Land Use Change in Response to Residential and other Pressures

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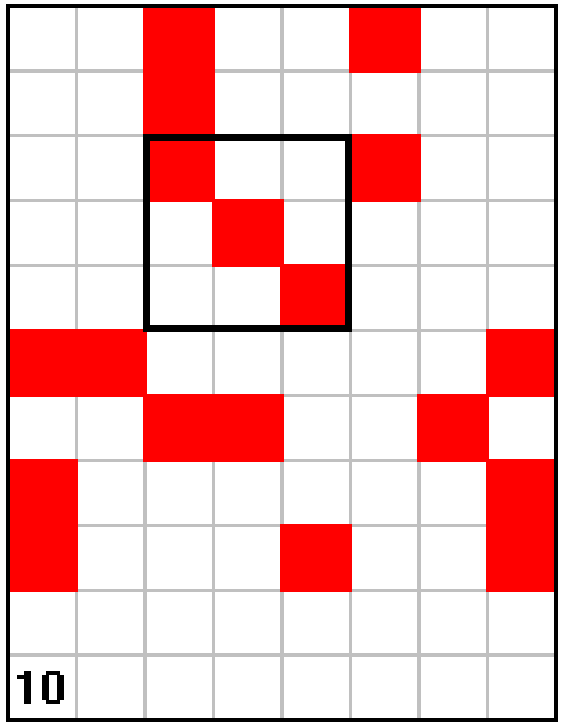
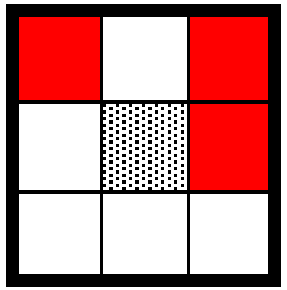
Conway's Game of Life

A basic '*cellular automaton*' invented by the Cambridge mathematician John Conway

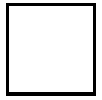
2-D ***cellular space*** consisting of identical cells

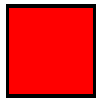


neighbourhood (Moore)



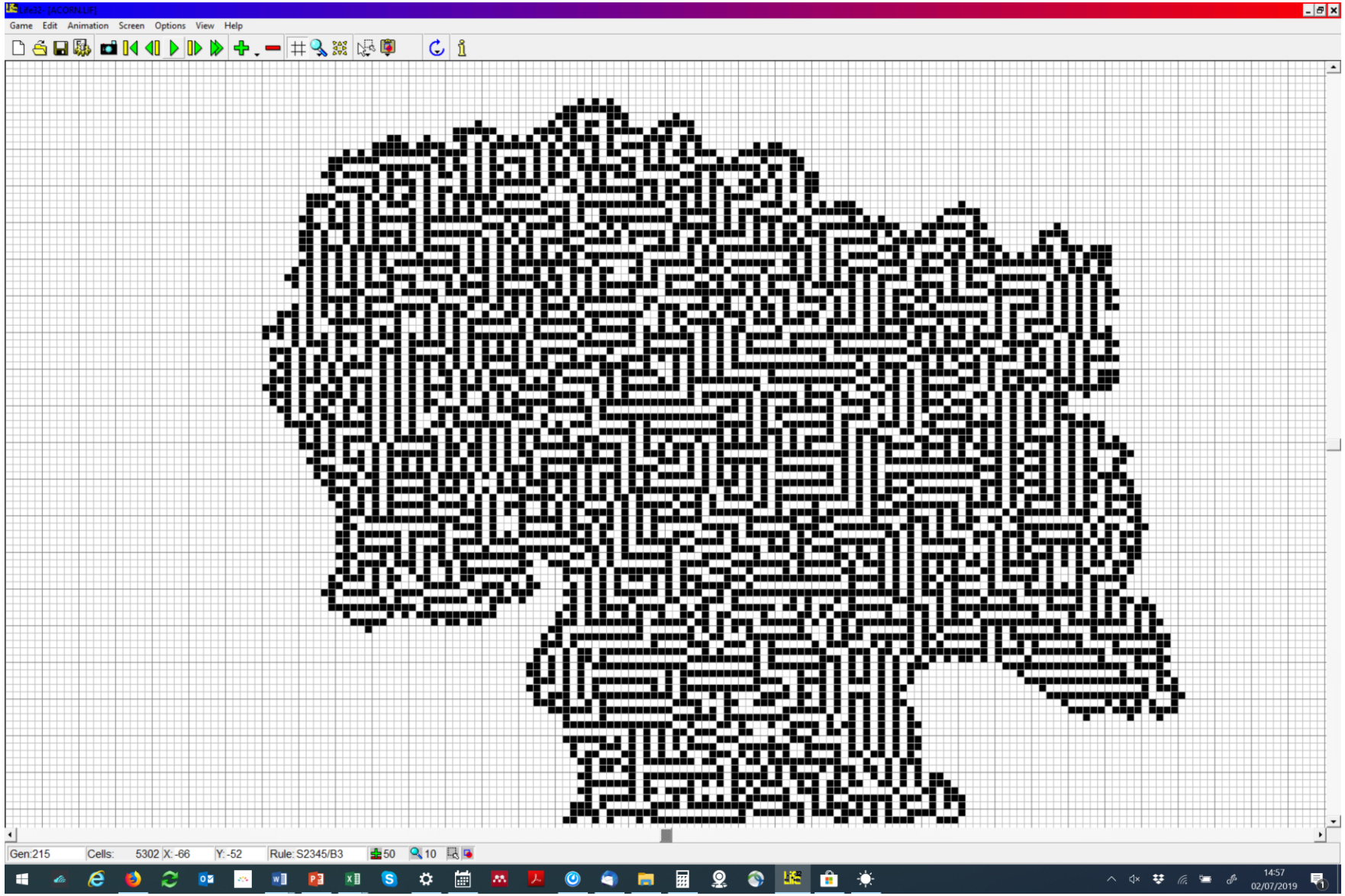
cells are in 1 of 2 ***states:***

dead, 

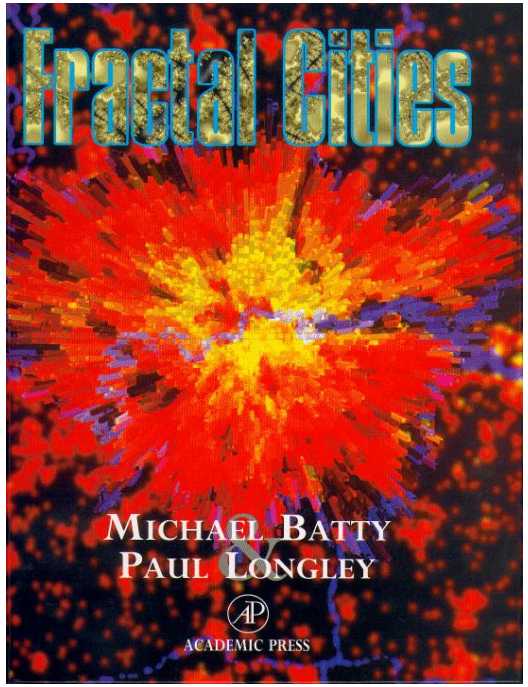
or alive 

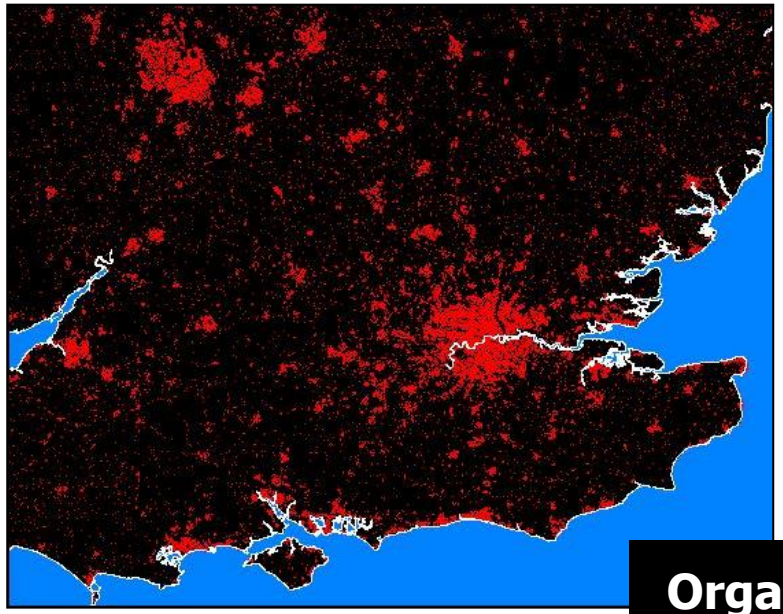
state changes due to ***transition rules:***

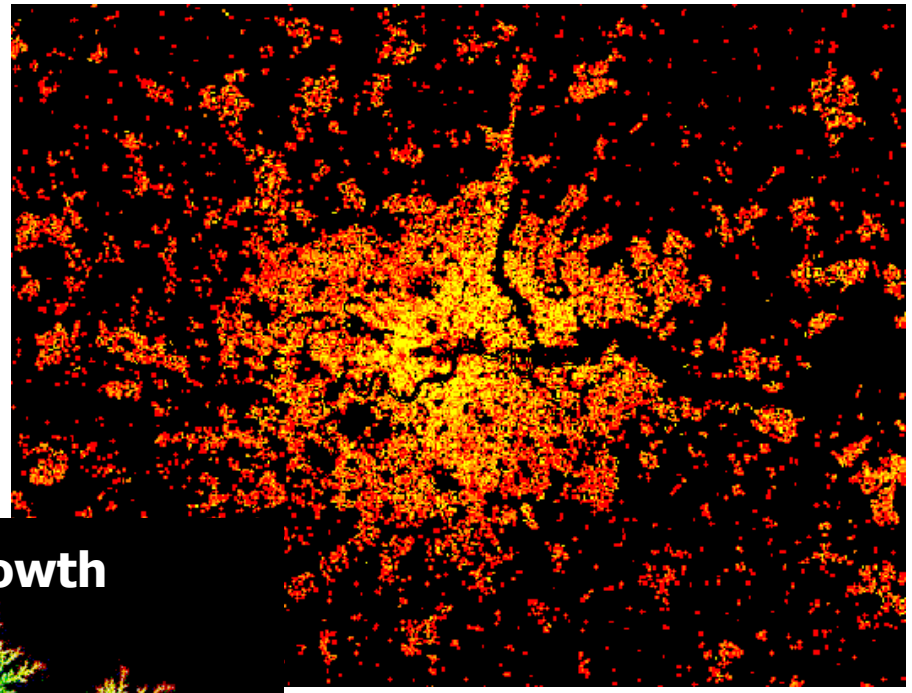
- live cell stays alive if 2 or 3 of its neighbours are alive, otherwise it dies.
- dead cell will come to life if it has 3 live neighbours.

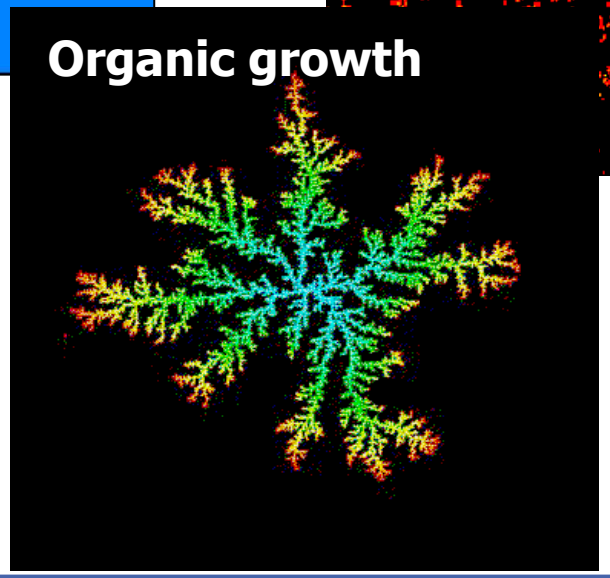

Life32 - [ACORN.LIF]
Game Edit Animation Screen Options View Help
Gen:215 Cells: 5302 X:-66 Y:-52 Rule:S2345/B3 50 10
14:57
02/07/2019

Cities as emergent properties



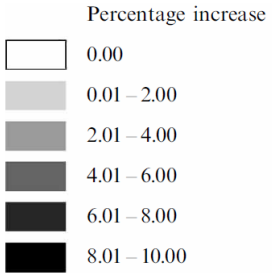






Pan-European Urban growth modelling for IPCC-SRES scenarios

- a) A1, b) A2, c) B1 d) B2
- Urban area for aggregate (NUTS2) regions based on (change in) population and GDP
- Spatial distribution (10' grid) based on neighbourhood rules, accessibility, attractiveness of the coast, …

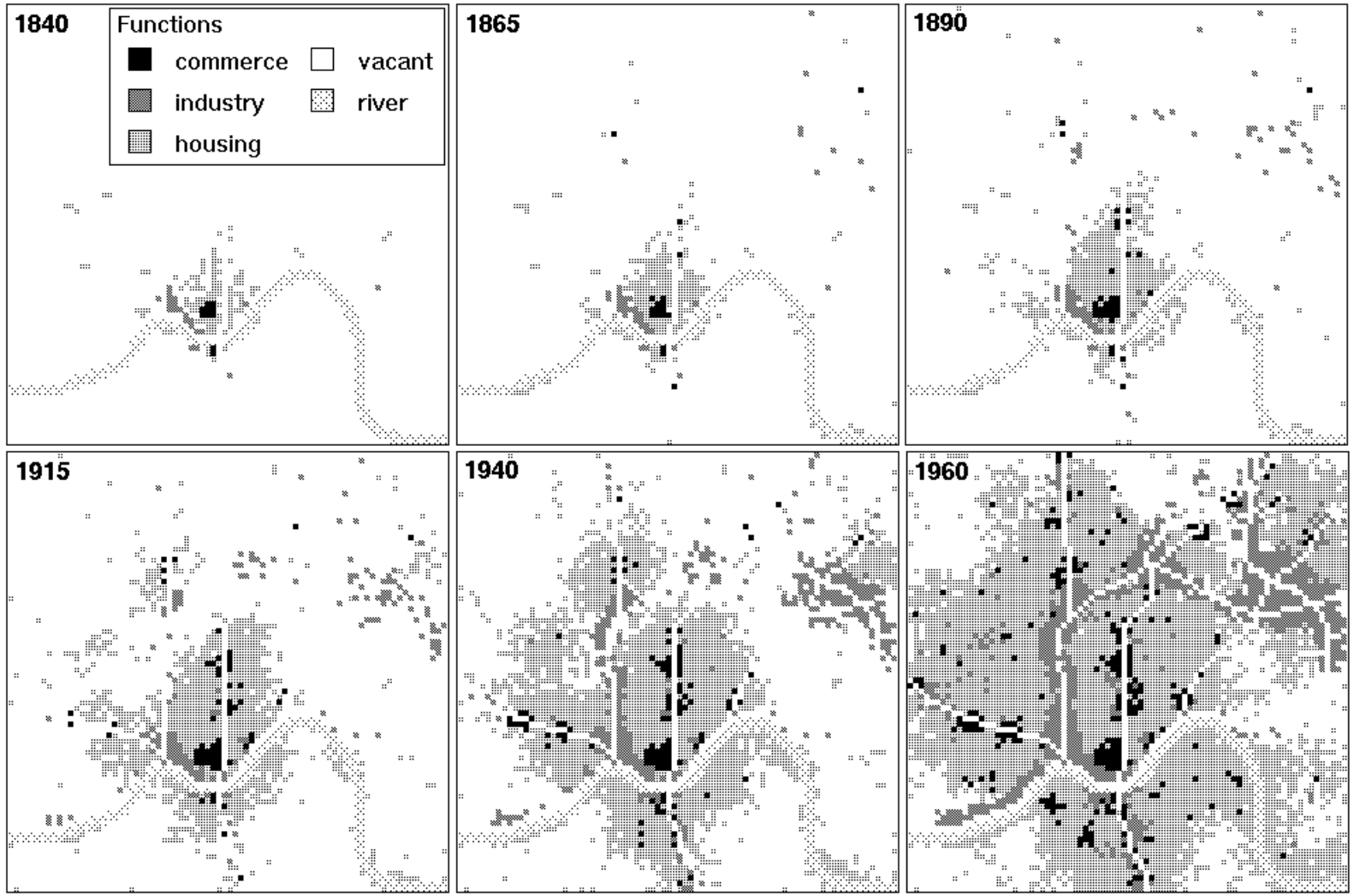


Reginster, I. and Rounsevell, M.D.A. (2006). Future scenarios of urban land use in Europe. *Environment and Planning B: Planning and Design*, **33(4)**, 619–636

Figure 2. Alternative urban maps for the future, based on the four SRES (Special Report on Emission Scenarios) scenarios: (a) A1FI, (b) A2, (c) B1, and (d) B2. Plotted is the increase in the percentage of land use over the period 2000 – 80.

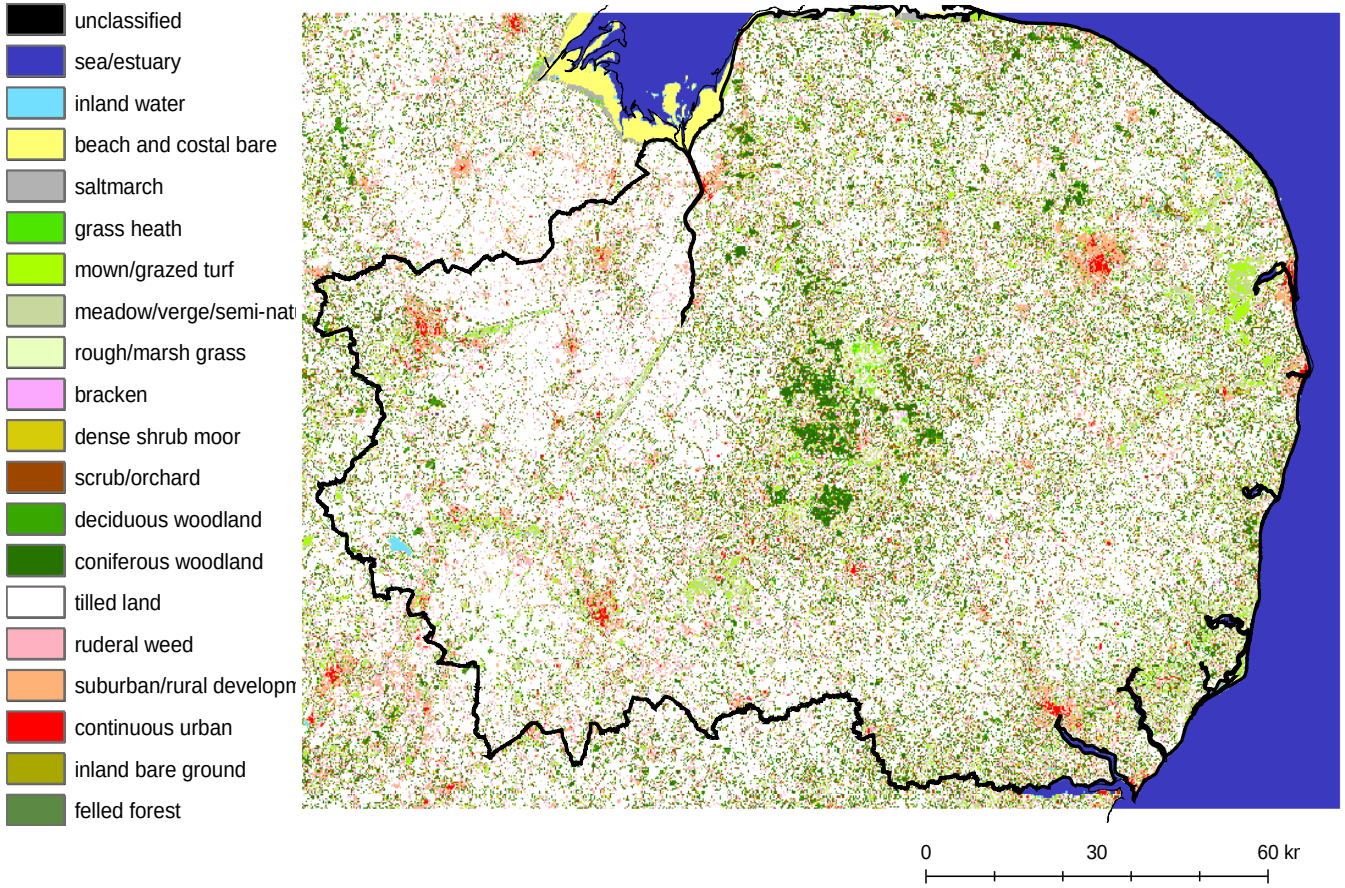
Urbanisation in Cincinnati

- Cellular automata
- Neighbourhood rules
- Push-pull factors between land use types



Engelen, G. and White, R. (1997). Integrating constrained cellular automata models, GIS and decision support tools for urban planning and policy making. In: (Timmermans, ed.) Chapter 8, *Decision Support Systems in Urban Planning*. E&FN Spon, London.

Residential housing in East Anglia: going beyond graphical representation to include agency in decision making



- Agent-Based Modelling (ABM) of residential household locations
- Exploring the increasing pressures of population growth and demographic (profile) change on the East Anglian landscape - especially the coastline
- Empirically-grounded model - ONS statistics at the level of lower super output areas (LSOAs)
- LSOAs have a minimum population of 1000 inhabitants (mean 1500) with 1425 spatial units in EA
- Analysis using PCA and cluster analysis

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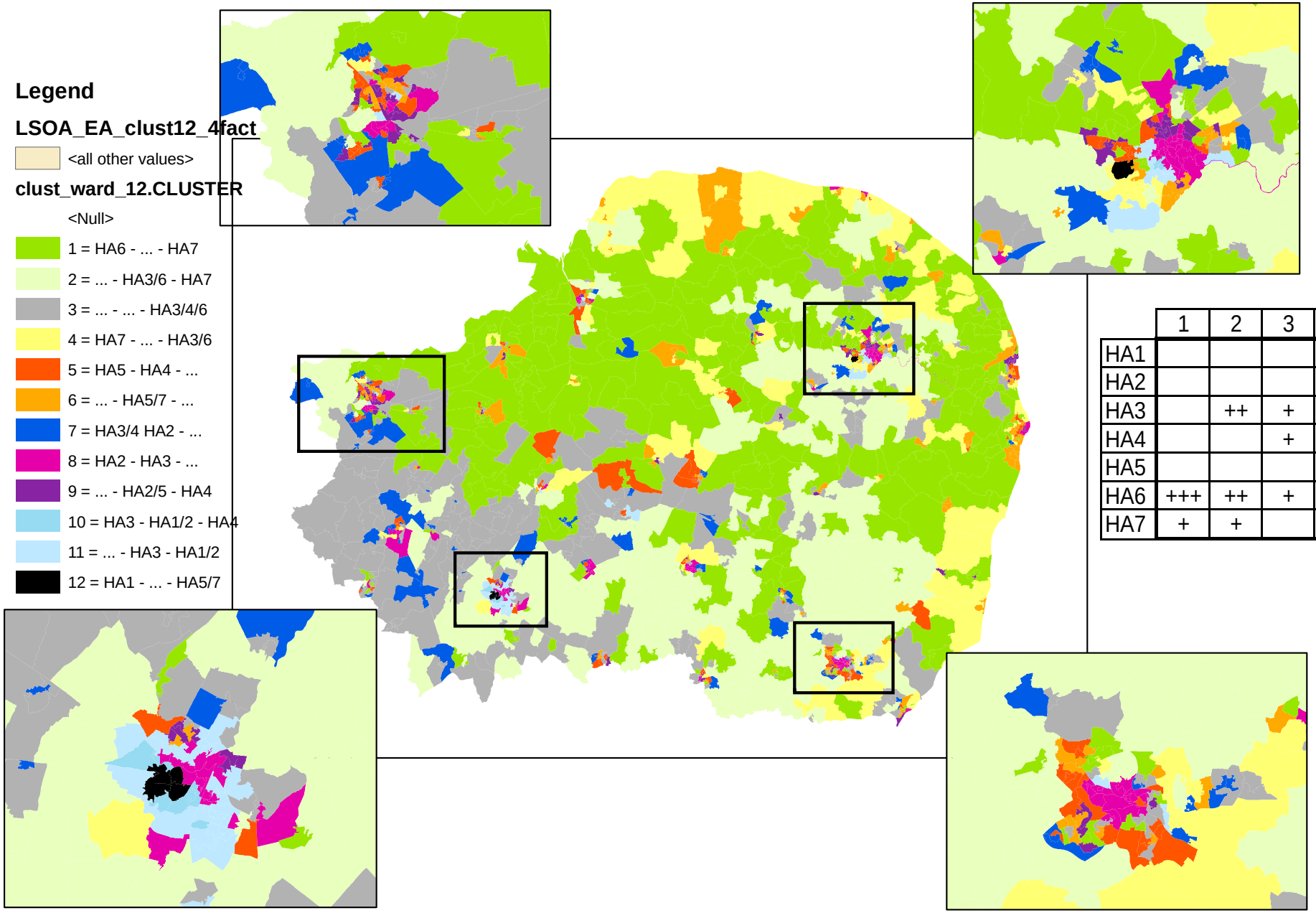
Household agent location preferences



CLUSTERS

	1	2	3	4	5	6	7	8	9	10	11	12
HA1										++	+	+++
HA2							+	+++	++	++	+	
HA3		++	+	+			+++	++		+++	++	
HA4			+		++		+++		+	+		
HA5					+++	++			++			+
HA6	+++	++	+	+								
HA7	+	+		+++		++						+

isolated student	HA1
single person	HA2
couple	HA3
couple with dep. children	HA4
single-parent family	HA5
couple with non-dep. children	HA6
all retired	HA7

Fontaine, C.M., Rounsevell, M.D.A. & Barbette, A-C. (2014). Locating household profiles in a polycentric region to refine the inputs to an agent-based model of residential mobility. *Environment & Planning B*, **41**, 163-184

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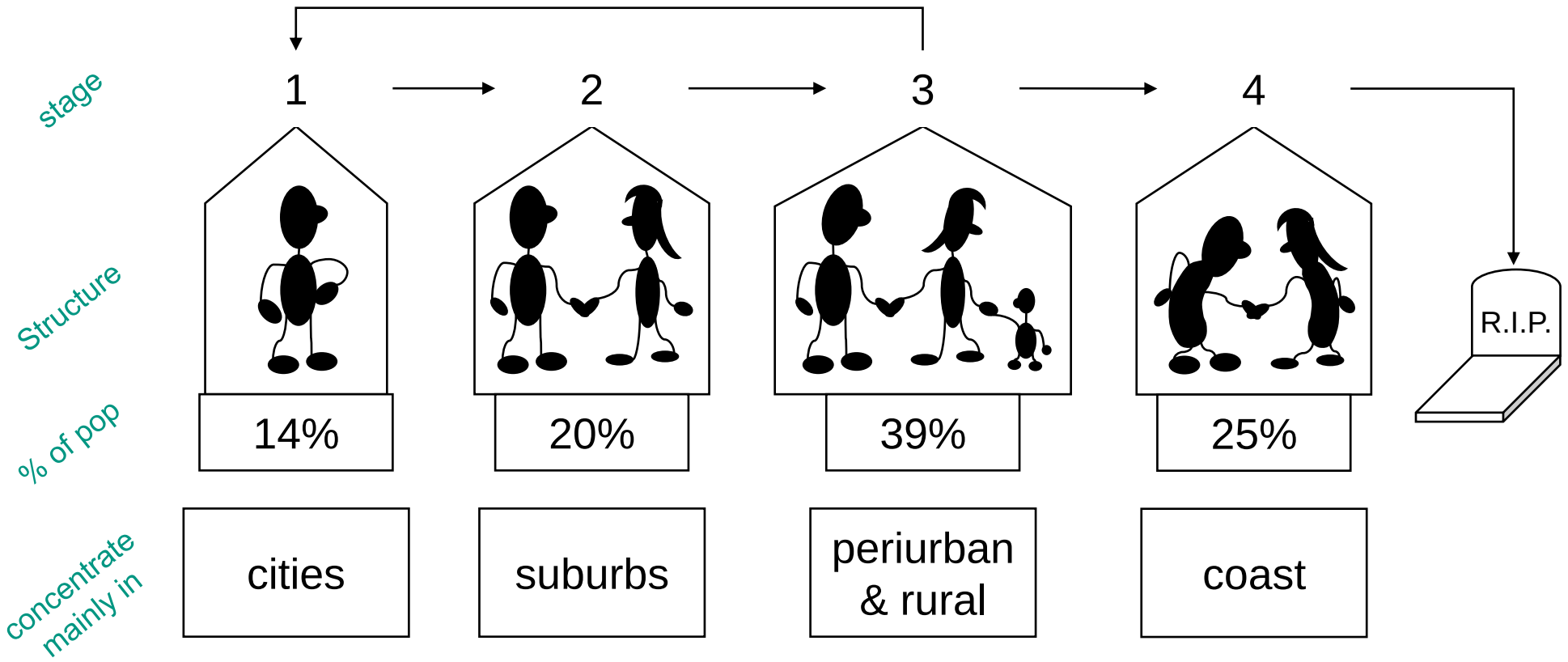

stage
1
2
3
4
Structure
R.I.P.
% of pop
14%
20%
39%
25%
concentrate mainly in
cities
suburbs
periurban & rural
coast

Observed and simulated households

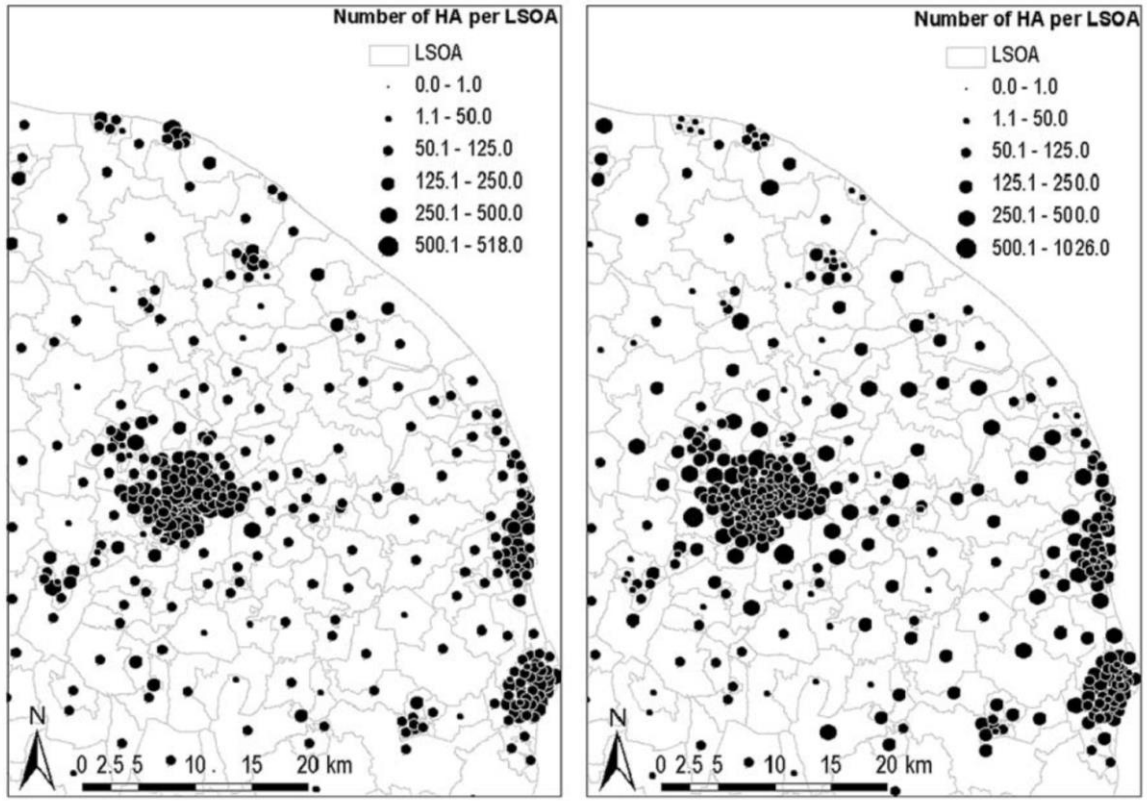
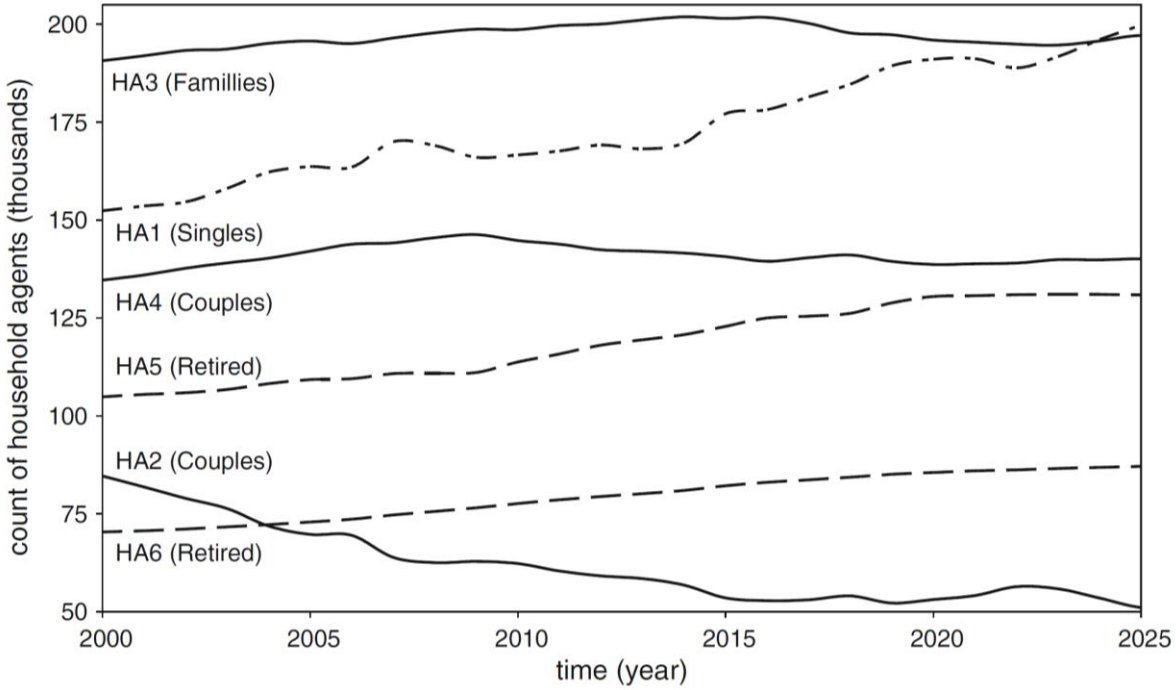


Fig. 4 Observed (*left*) and modelled (*right*) numbers of 'singles and couples' households (HA) per Lower Super Output Area (LSOA)



Fontaine, C.M. and Rounsevell, M.D.A. (2009). An agent-based approach to model future residential pressure on a regional landscape. *Landscape Ecology,* **24**, 1237-1254

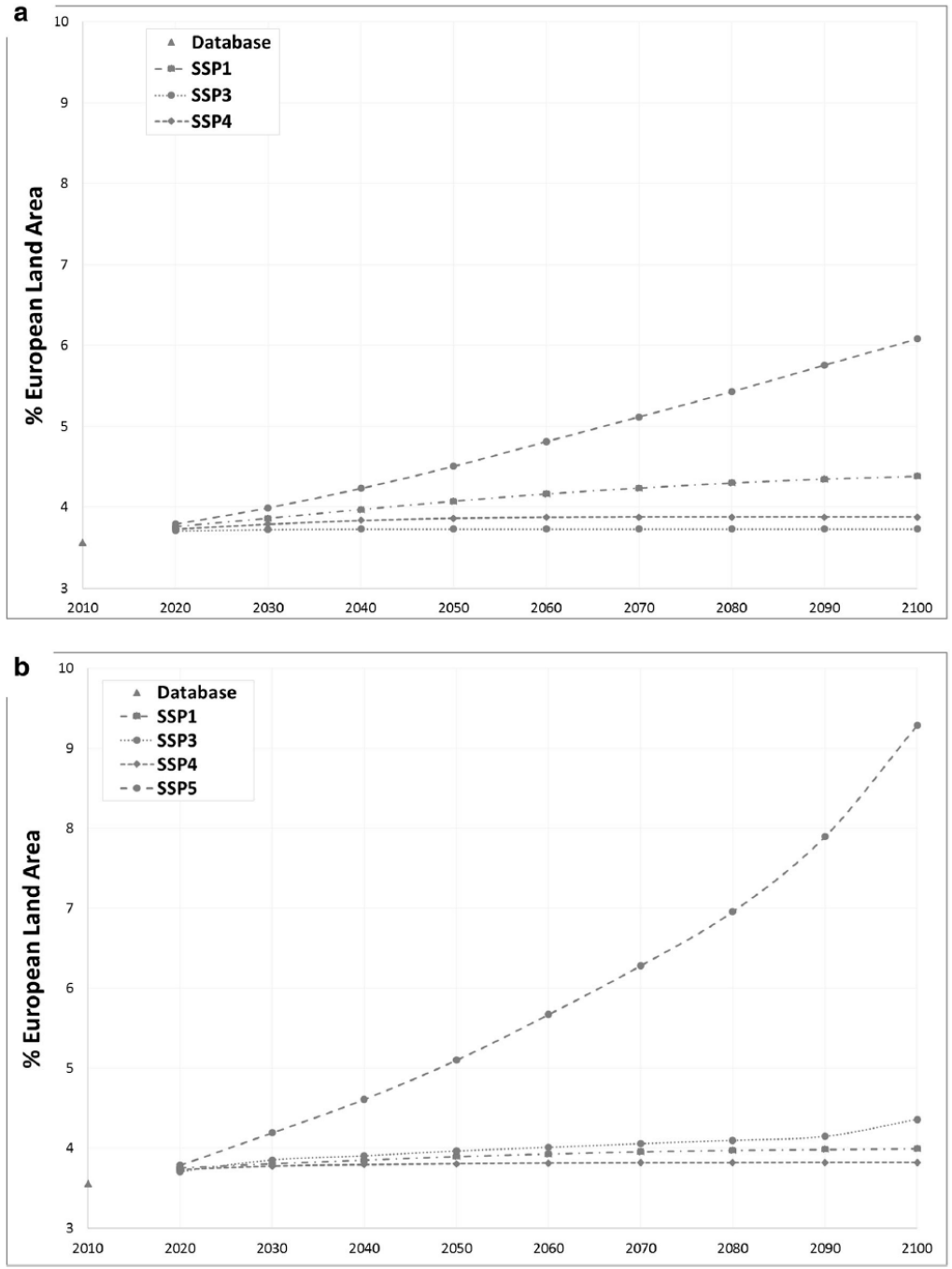


Fig. 5 Pan-European artificial surface expansion driven by **a** demographic change only and **b** demographic and societal change as defined under four socioeconomic scenarios

Socio-economic scenario modelling of urban growth in Europe (EU28+2):

The RUG model (Regional Urban Growth model), as part of the dynamic Integrated Assessment Model (dIAP)

a) Demographic change only
b) Demographic and societal change*

* based on residential location choices

Terama, E., Clarke, E., Rounsevell, M.D.A. et al. (2017). Modelling population structure in the context of urban land use change in Europe. *Regional Environmental Change*, DOI 10.1007/s10113-017-1194-5

Modelling urban growth for socio-economic scenarios

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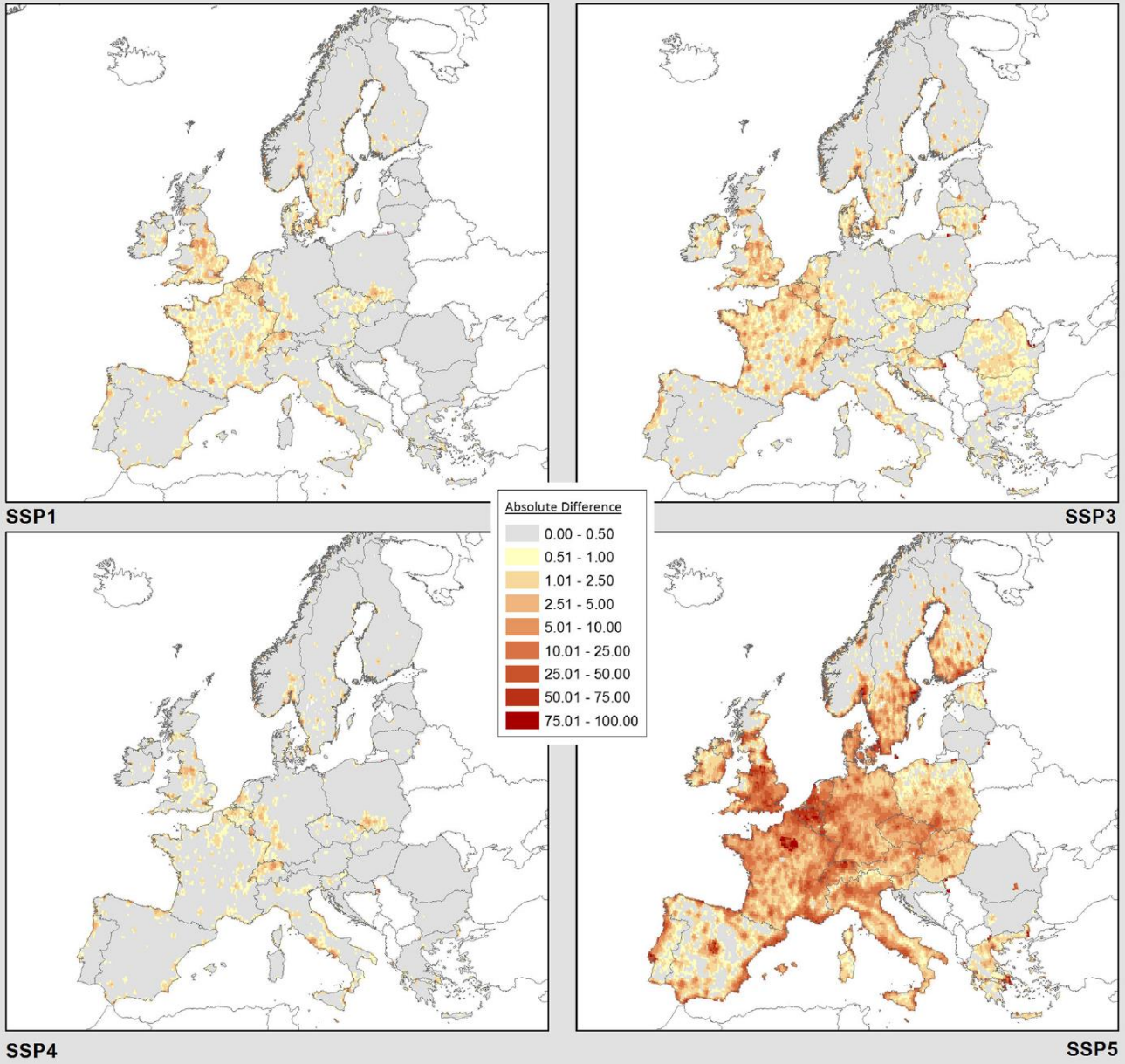
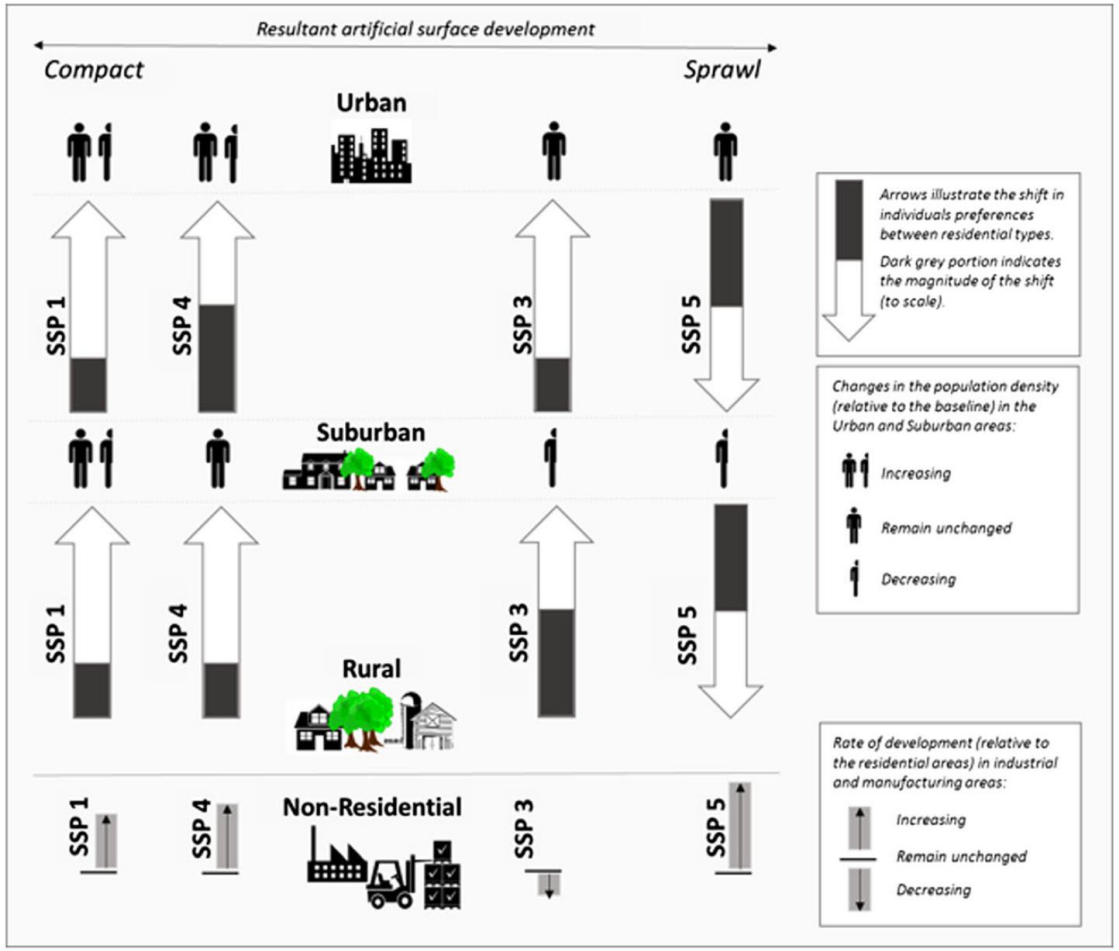


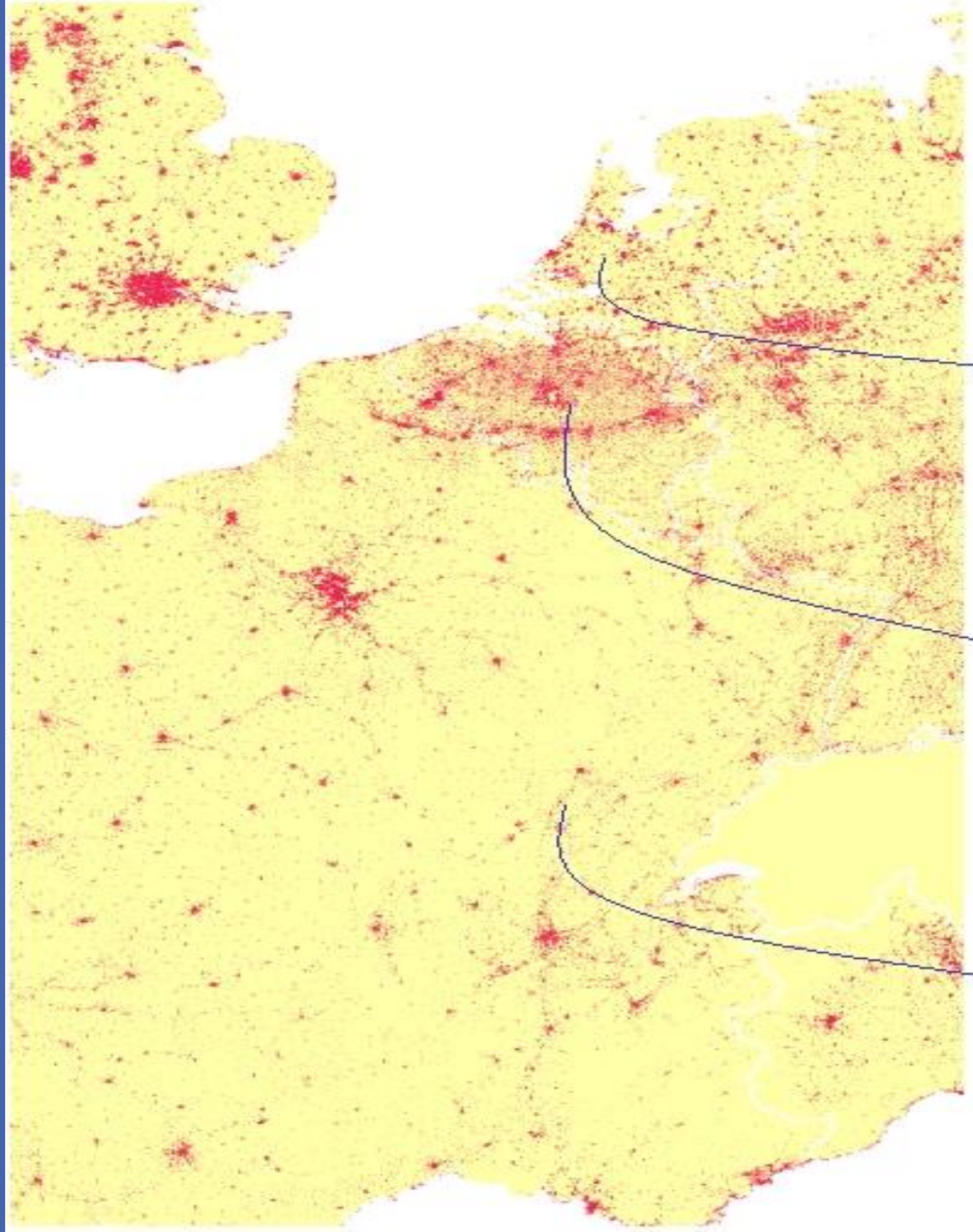
Urban areas are mapped as a % of the land area in each10' cell
Comparisons to the baseline are expressed as an absolute difference
White areas were not modelled.

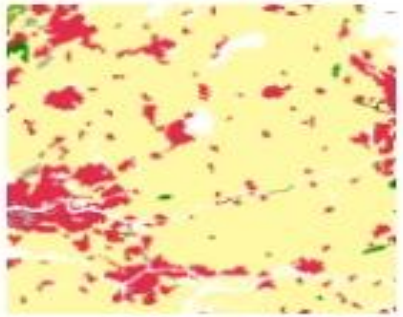
Fig. 6 The projected change, from baseline, in artificial surface extent (as a percentage of the 10′ cell land area) by 2100 under four different socioeconomic scenarios. *Darker colours* are associated with greater artificial surface expansion



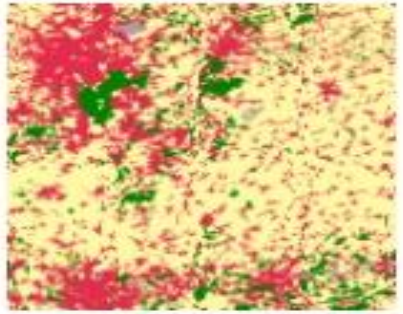
Terama, E., Clarke, E., Rounsevell, M.D.A. et al. (2017). Modelling population structure in the context of urban land use change in Europe. *Regional Environmental Change*, DOI 10.1007/s10113-017-1194-5

The role of land use planning: urban patterns in Europe





Randstad (Netherlands): compact/aggregated



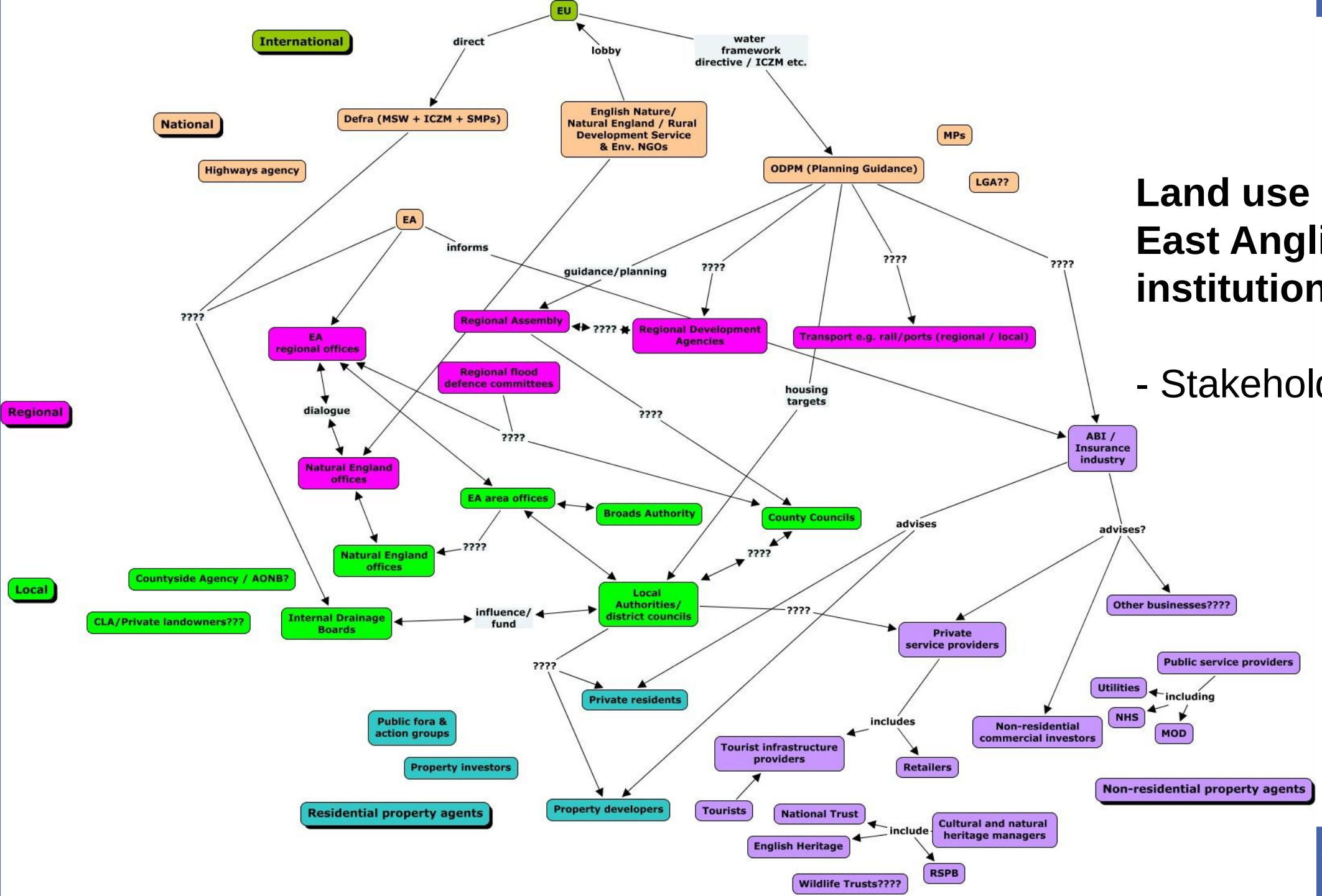
Brussels (Belgium): dispersed

South of Dijon (France): intermediate

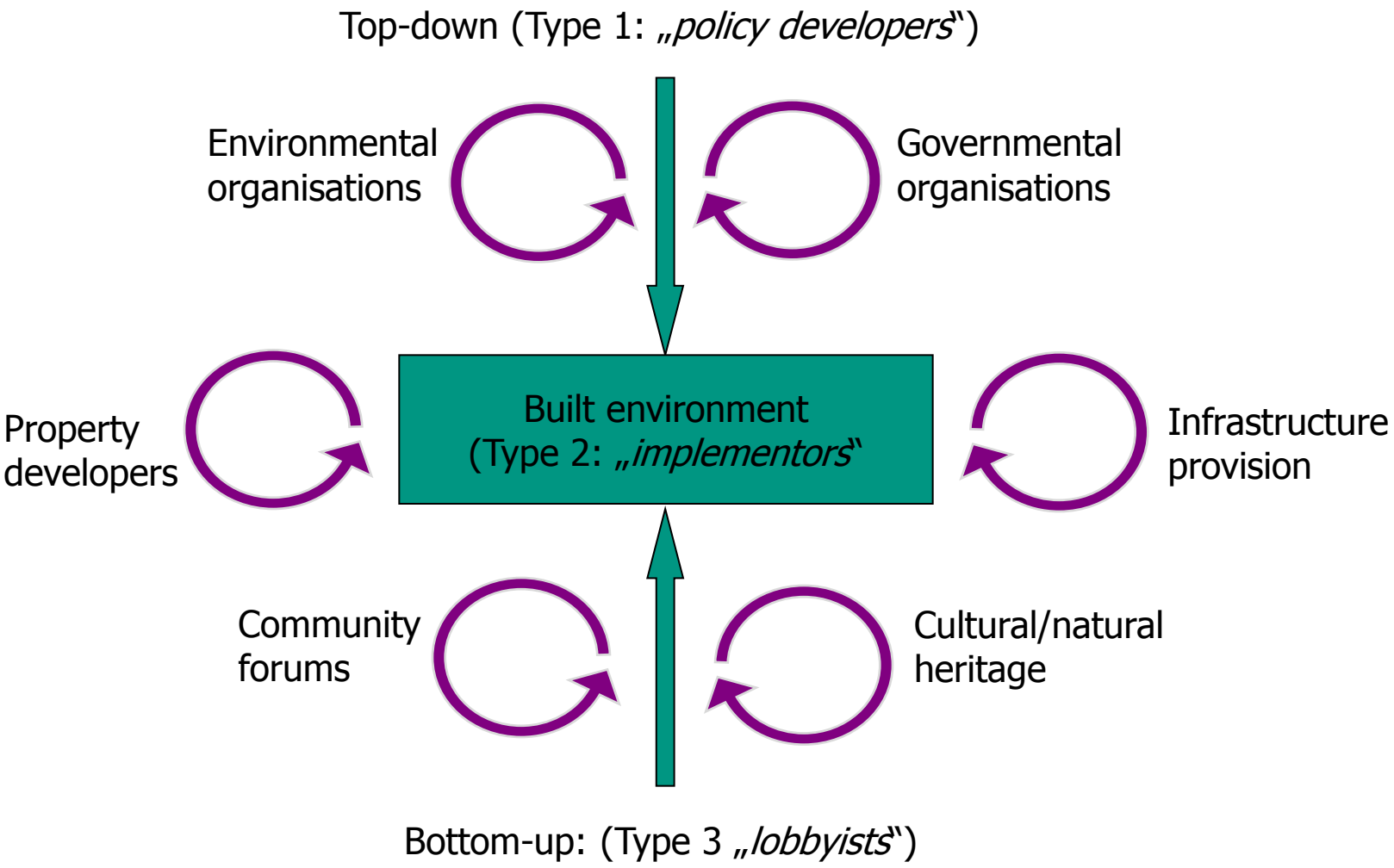
CORINE Land Cover

Land use planning in East Anglia: institutional actors

- Stakeholder mapping



Conceptual model of the UK planning process



Concluding remarks

- Many modelling methods exist at different geographic scales
- Most urban land use models are based on drivers of:
  - economics (wealth),
  - population growth,
  - demographic (profile) change,
  - societal preference (for residential locations),
  - spatial planning policy
- Methods based on agency provide opportunities to capture the complex behaviour of individual households when making residential location choices

Any questions?