Integrating Land Use Simulation into Transportation Modeling: Applications in science and practice

2008 Border to Border Transportation Conference
McAllen, Texas · 18-20 November 2008

Rolf Moeckel | Parsons Brinckerhoff

(a) Land Use & Transportation

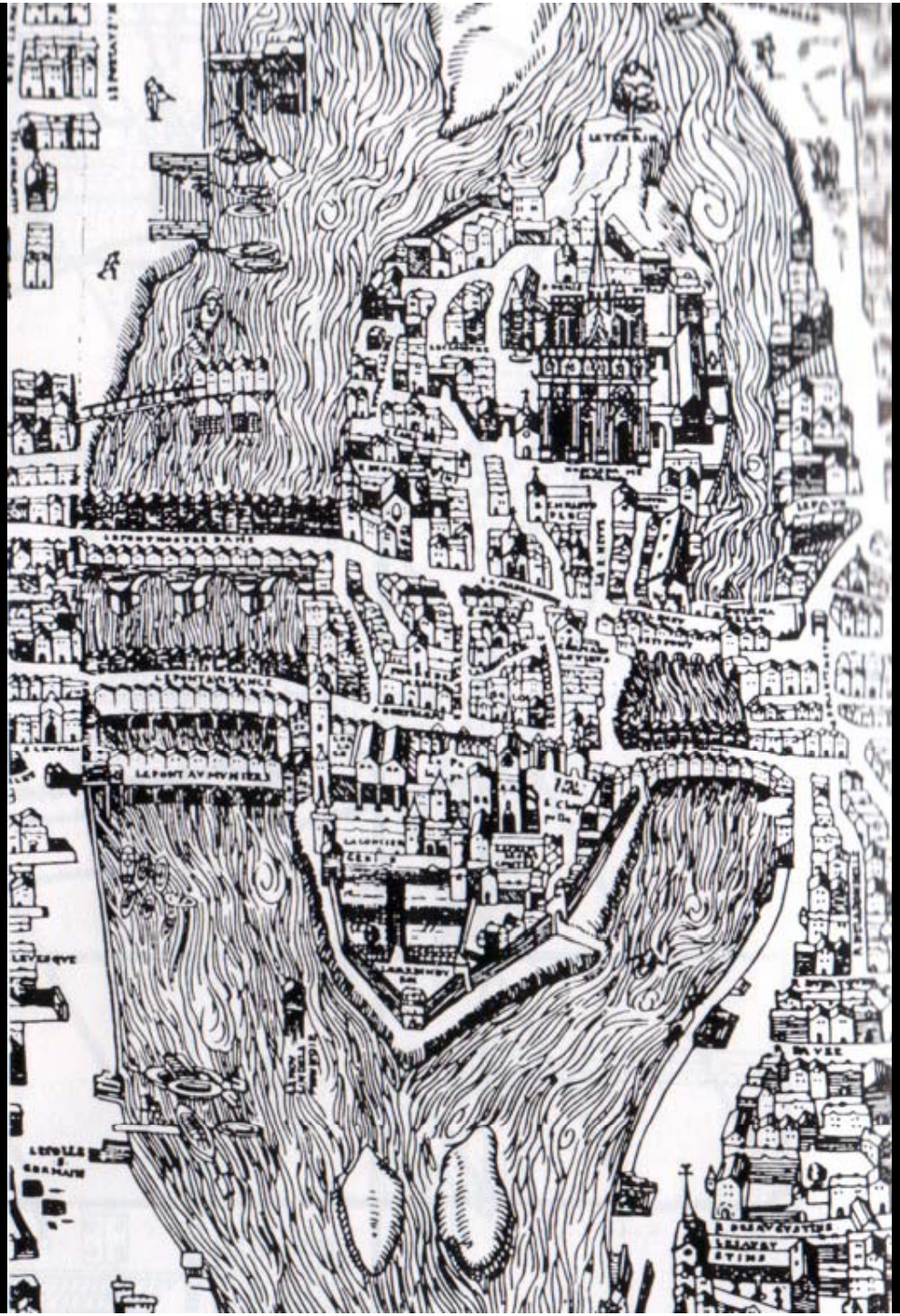
(b) Integrated Modeling

(c) Example 1: SEAM

(d) Example 2: ILUMASS

(e) Conclusions

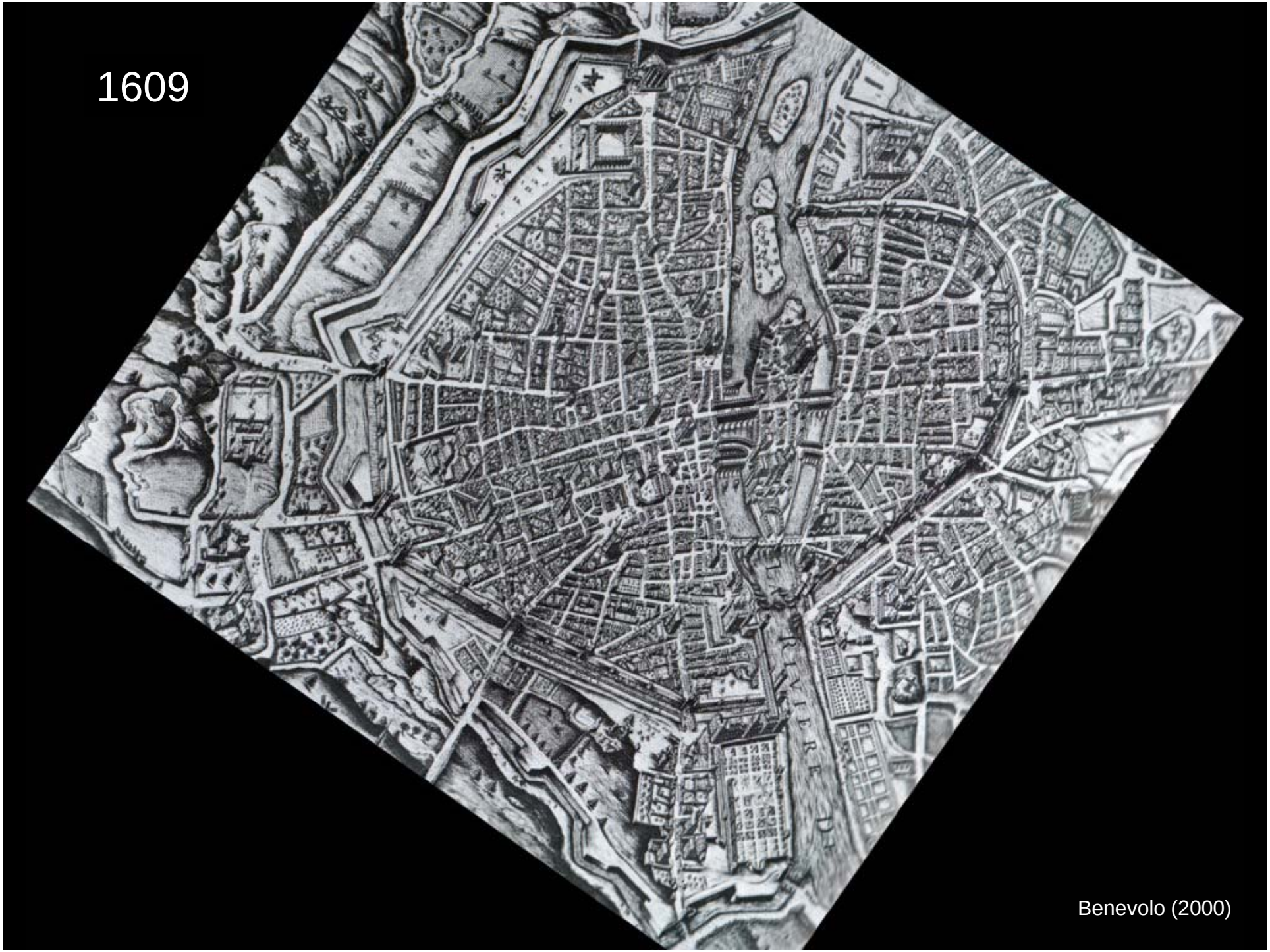
1350



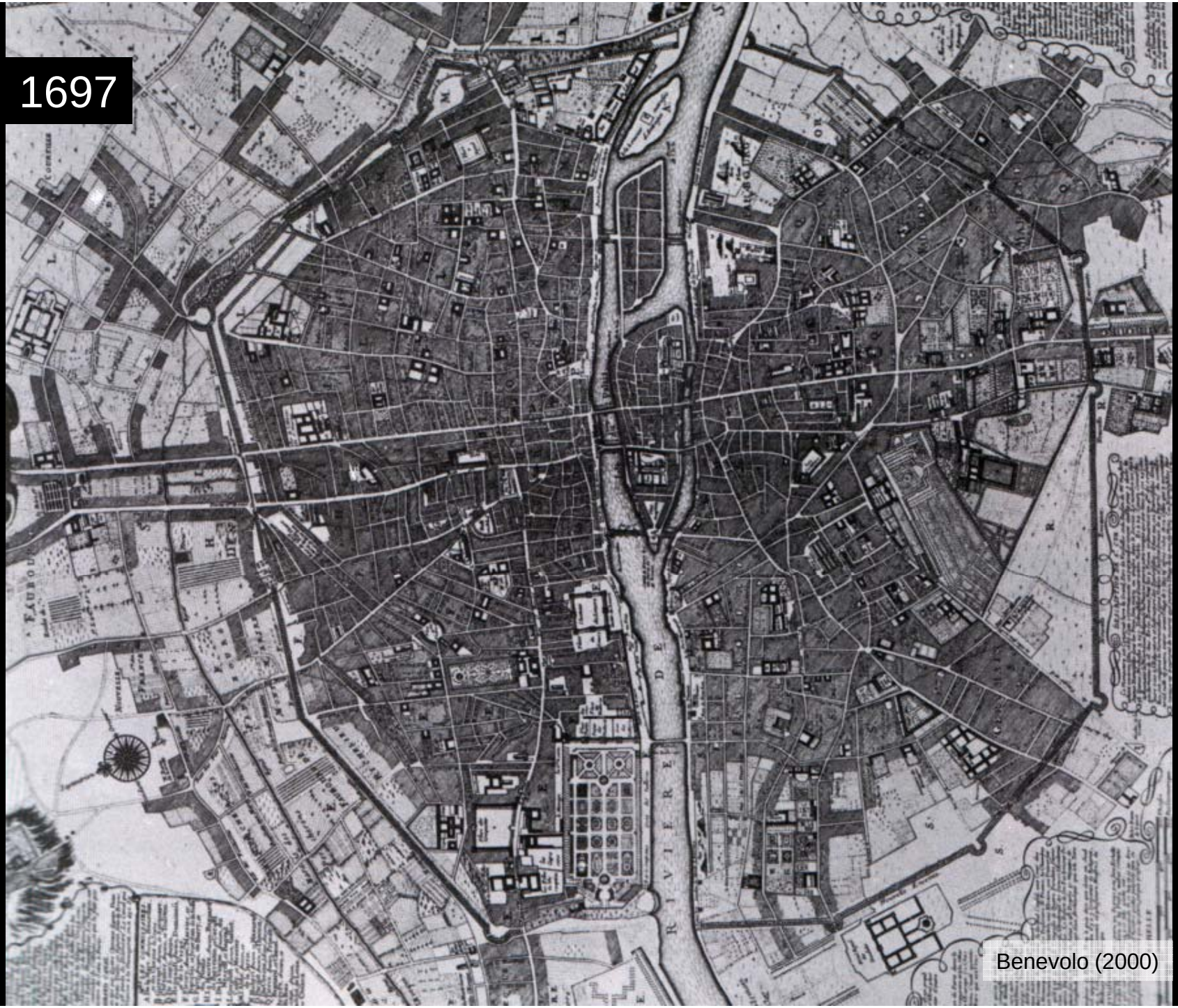
Benevolo (2000)

1500
Benevolo (2000)

1609

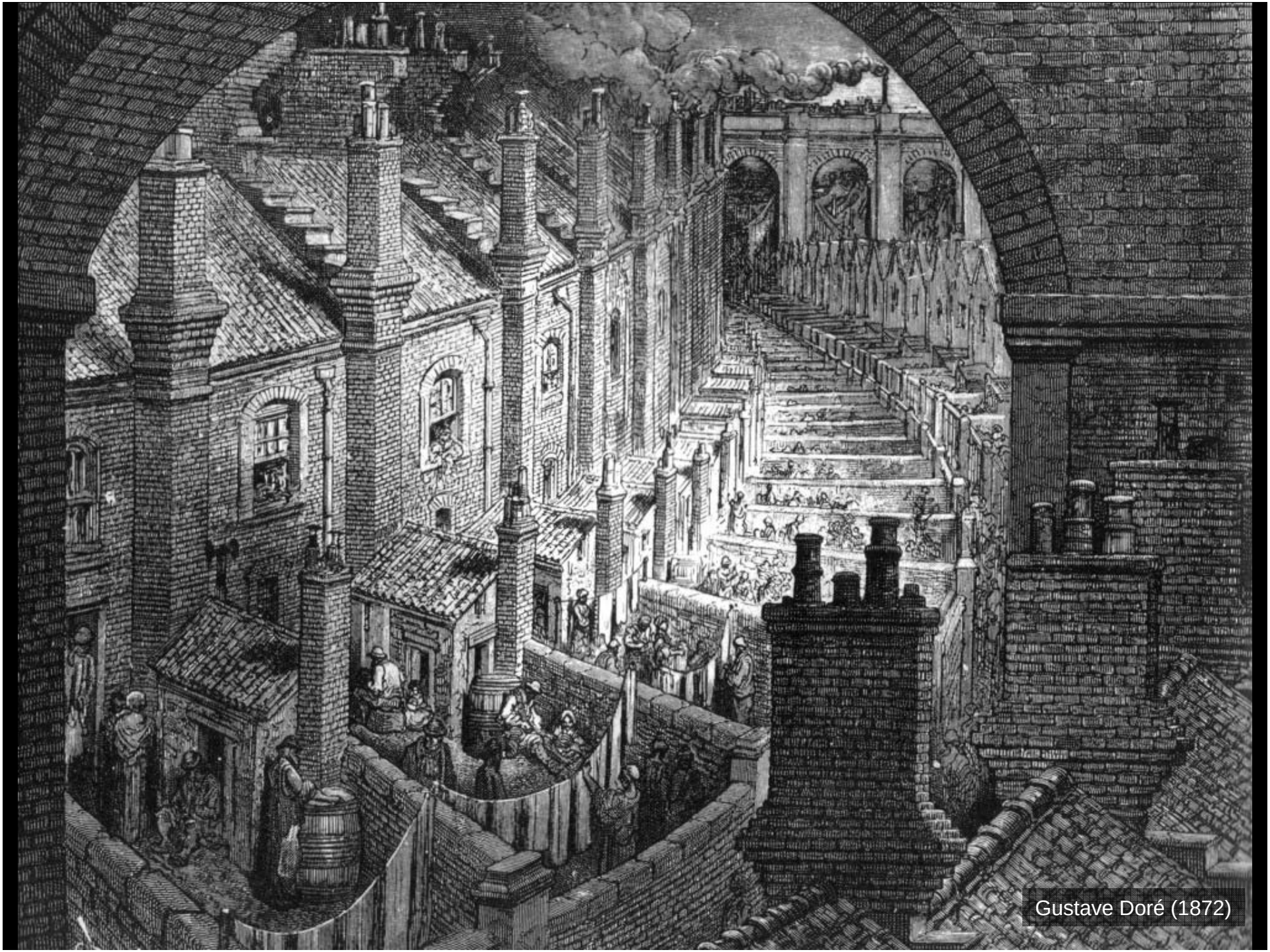


Benevolo (2000)

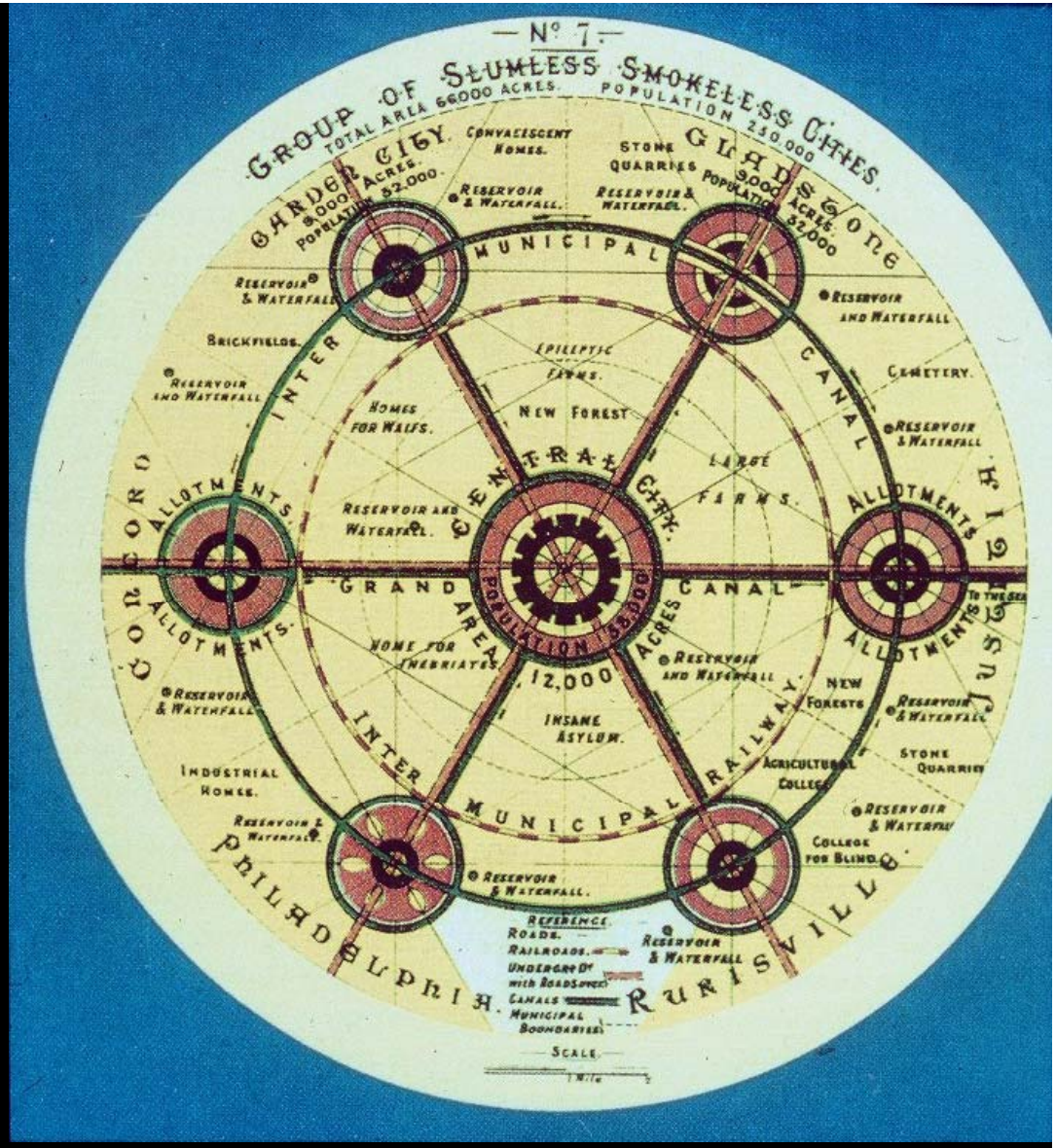

1697
RIVIERE DE
Benevolo (2000)

Mission stations 1823

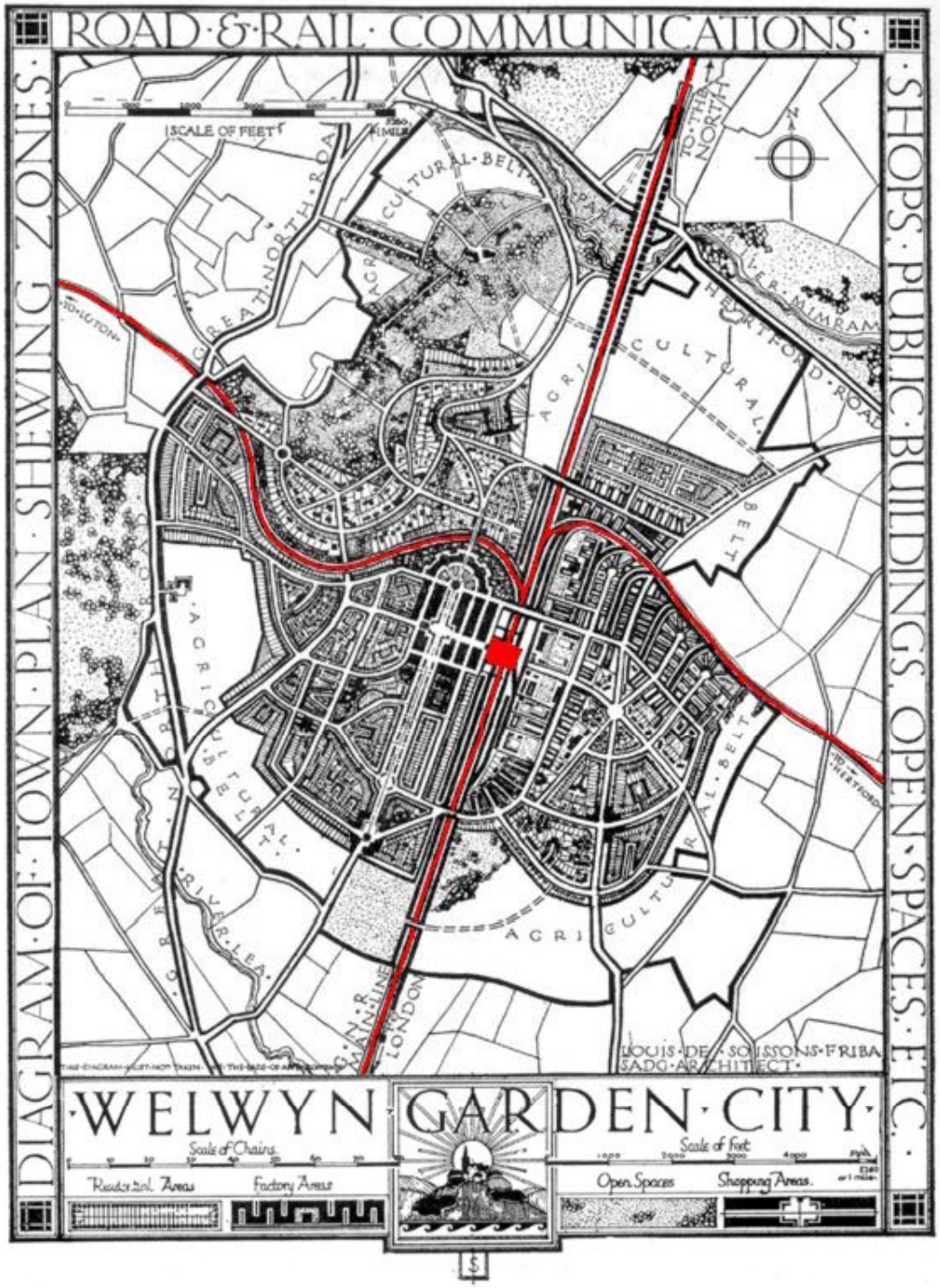
Braunger (1998)


Gustave Doré (1872)

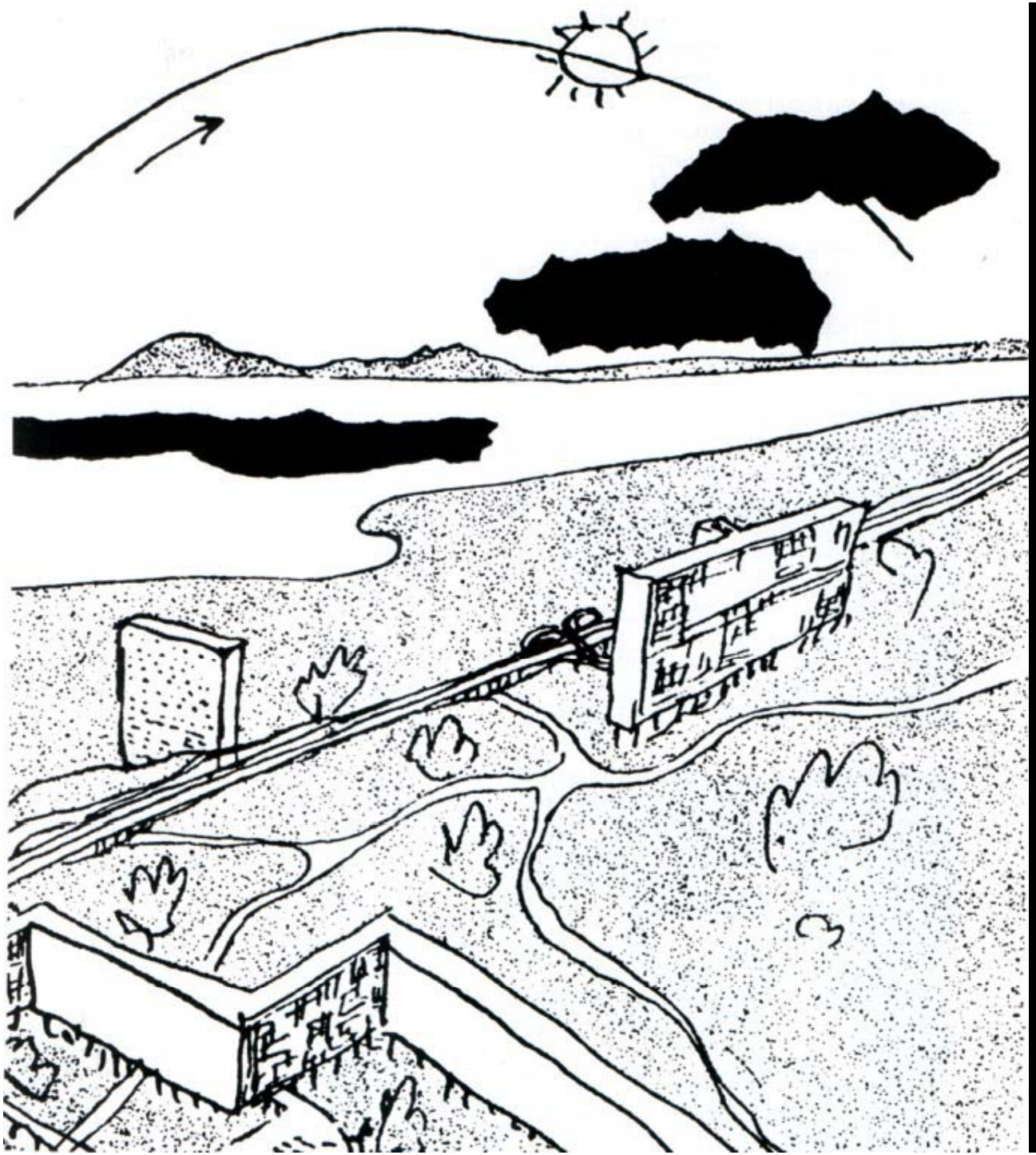
HEALTH of the COUNTRY
COMFORTS of the TOWN
LETCHWORTH
The FIRST GARDEN CITY


No 7
GROUP OF SLUMLESS SMOKELESS CITIES
TOTAL AREA 66000 ACRES
POPULATION 250,000
GARDEN CITY
GLADSTONE
CONCORD
PHILADELPHIA
RURISVILLE
MUNICIPAL
INTER
CANAL
CENTRAL CITY
GRAND
CANAL
RAILWAY
ALLOTMENTS
NEW FOREST
LARGE FARMS
INSANE ASYLUM
HOME FOR INEBRIATES
HOMES FOR WAIFS
EPILEPTIC FARMS
BRICKFIELDS
CEMETERY
INDUSTRIAL HOMES
STONE QUARRIES
AGRICULTURAL COLLEGE
COLLEGE FOR BLIND
RESERVOIR & WATERFALL
REFERENCE
ROADS
RAILROADS
CANALS
MUNICIPAL BOUNDARIES
SCALE

Howard (1902)


ROAD·&·RAIL·COMMUNICATIONS·
DIAGRAM·OF·TOWN·PLAN·SHEWING·ZONES·
·SHOPS·PUBLIC·BUILDINGS·OPEN·SPACES·ETC.·
SCALE OF FEET
TO THE NORTH
TO LUTON
GREAT NORTH ROAD
AGRICULTURAL BELT
RIVER MIMRAM
HERTFORD ROAD
AGRICULTURAL BELT
AGRICULTURAL BELT
RIVER LEA
G.N.R. MAIN LINE
LONDON
TO HERTFORD
LOUIS·DE·SOISSONS·FRIBA
SADG·ARCHITECT·
·WELWYN GARDEN·CITY·
Scale of Chains
Scale of Feet
Residential Areas
Factory Areas
Open Spaces
Shopping Areas

Frank Lloyd Wright (1934)



Le Corbusier (1936)

Hayden (2004)

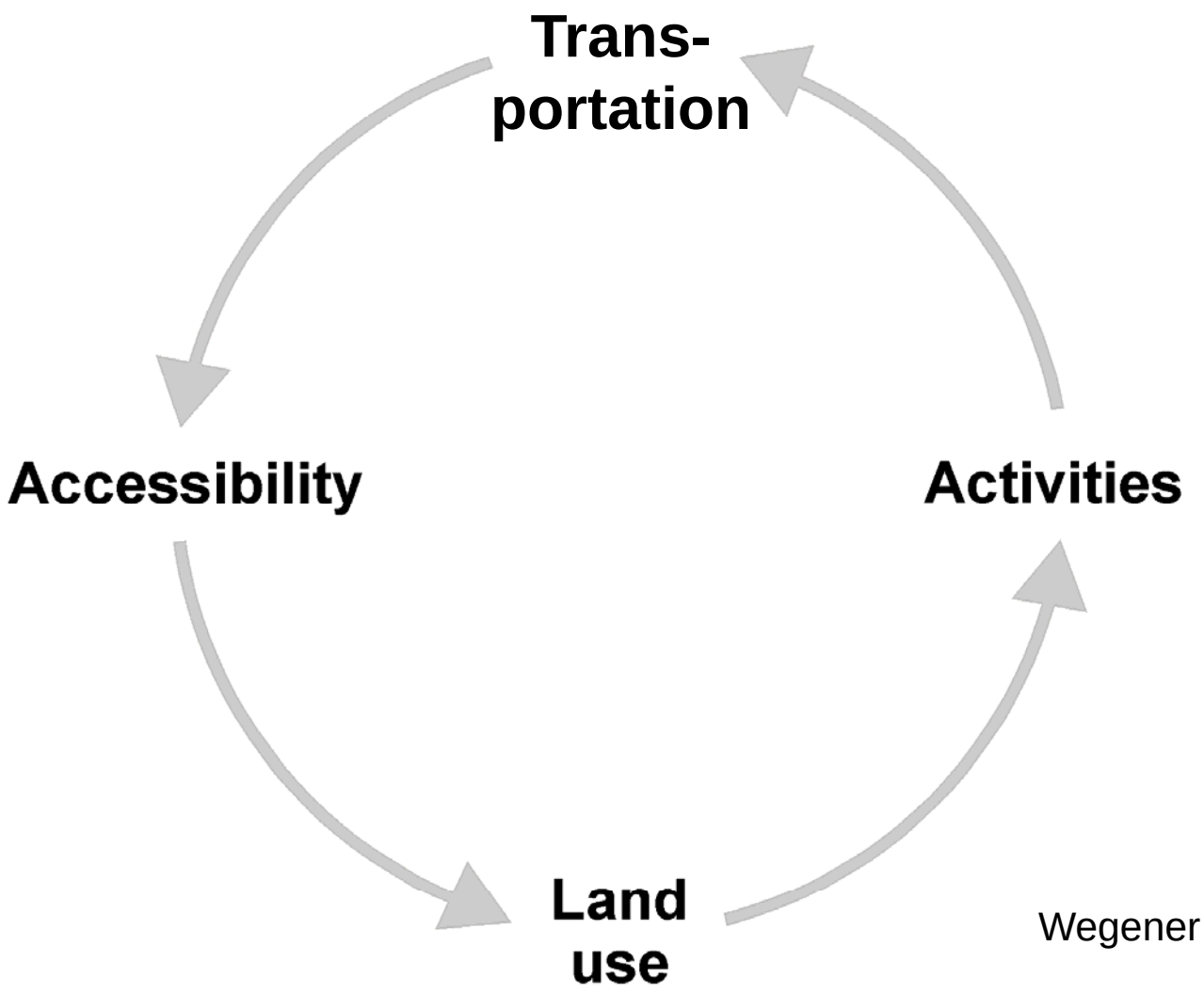
Hayden (2004)

Hayden (2004)

Katz (1994)

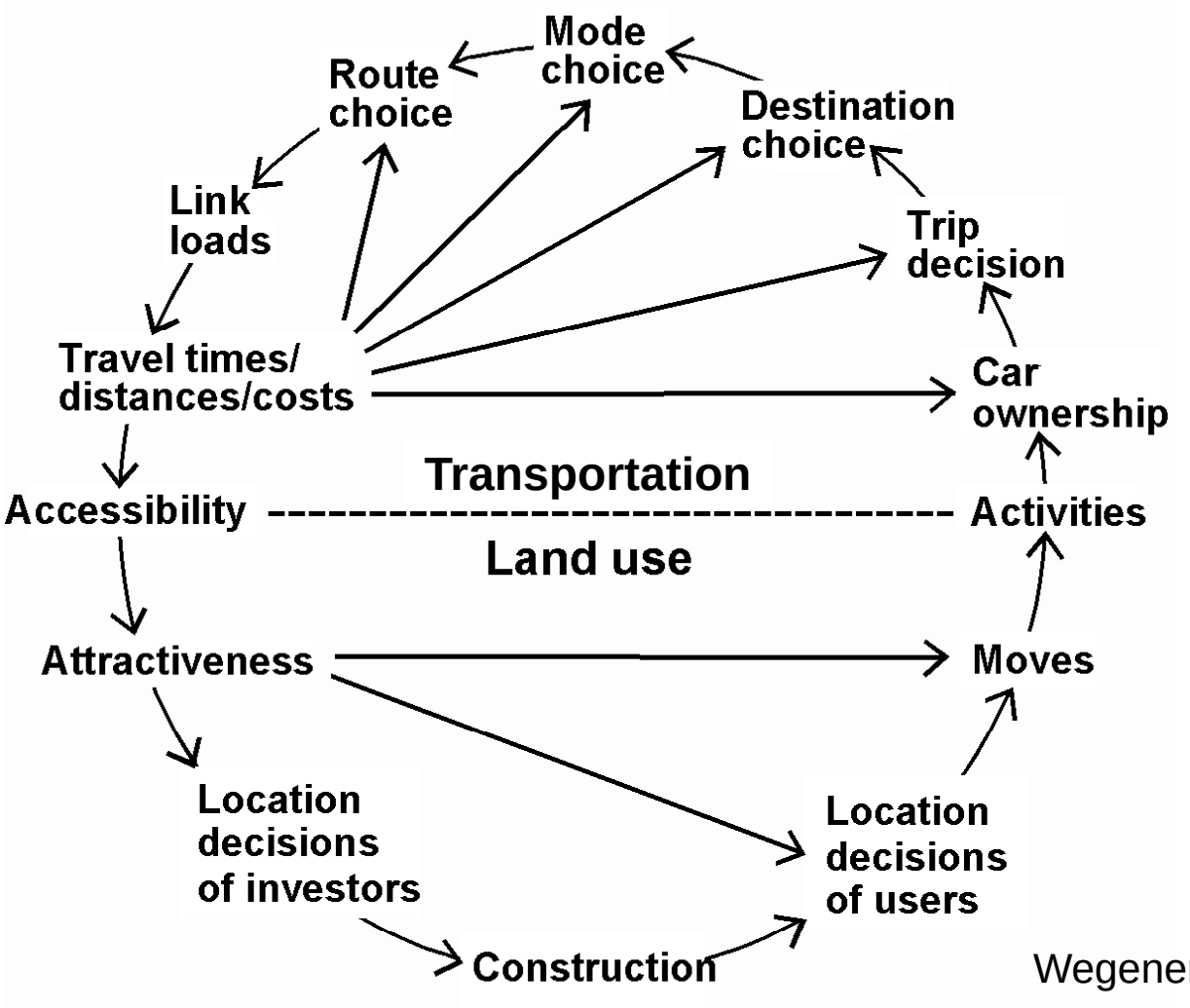
Hillsboro

Interaction of Land Use and Transportation



Wegener (1994)

Interaction of Land Use and Transportation



Wegener (1994)

(a) Land Use & Transportation

(b) Integrated Modeling

(c) Example 1: SEAM

(d) Example 2: ILUMASS

(e) Conclusions

Land Use Model Components

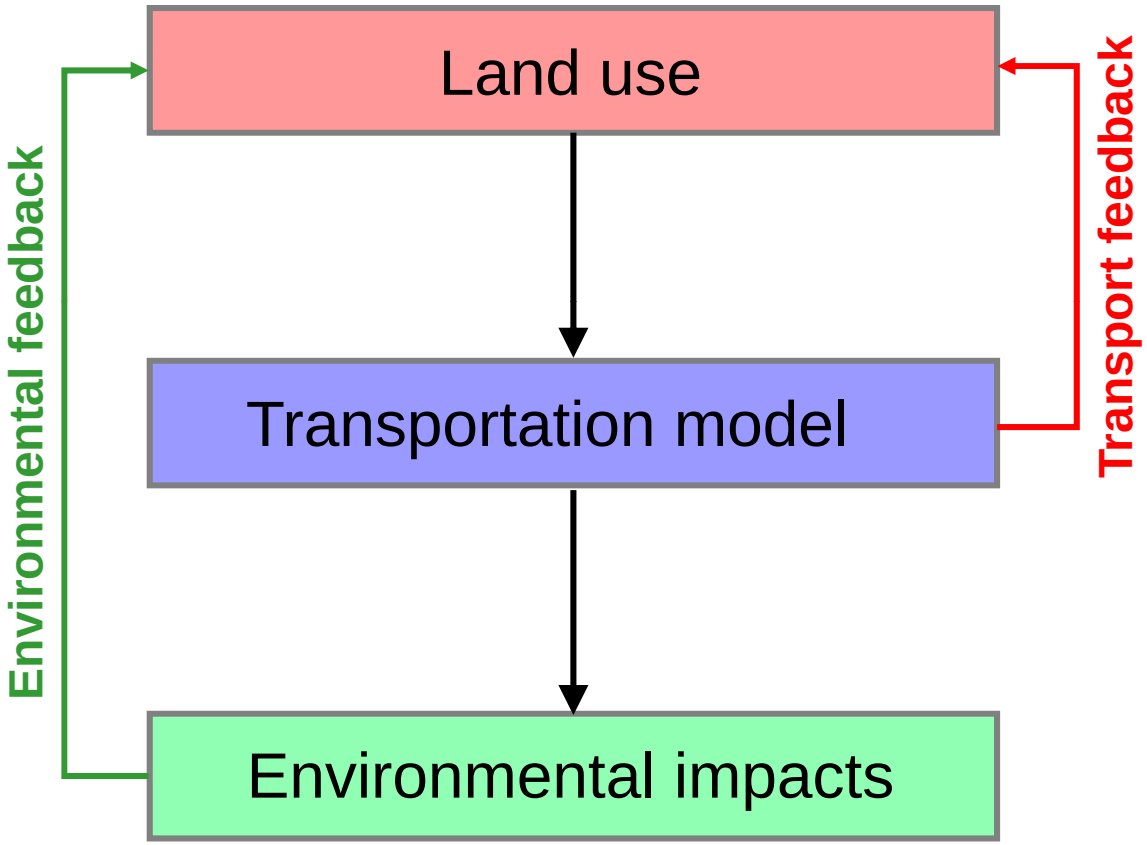
Population:
commonly Households, sometimes Persons

Employment:
commonly Jobs, sometimes Firms

Dwellings:
Dwelling units or floorspace

Non-residential floorspace:
commonly floorspace, sometimes premises

Concept of integrated simulation models



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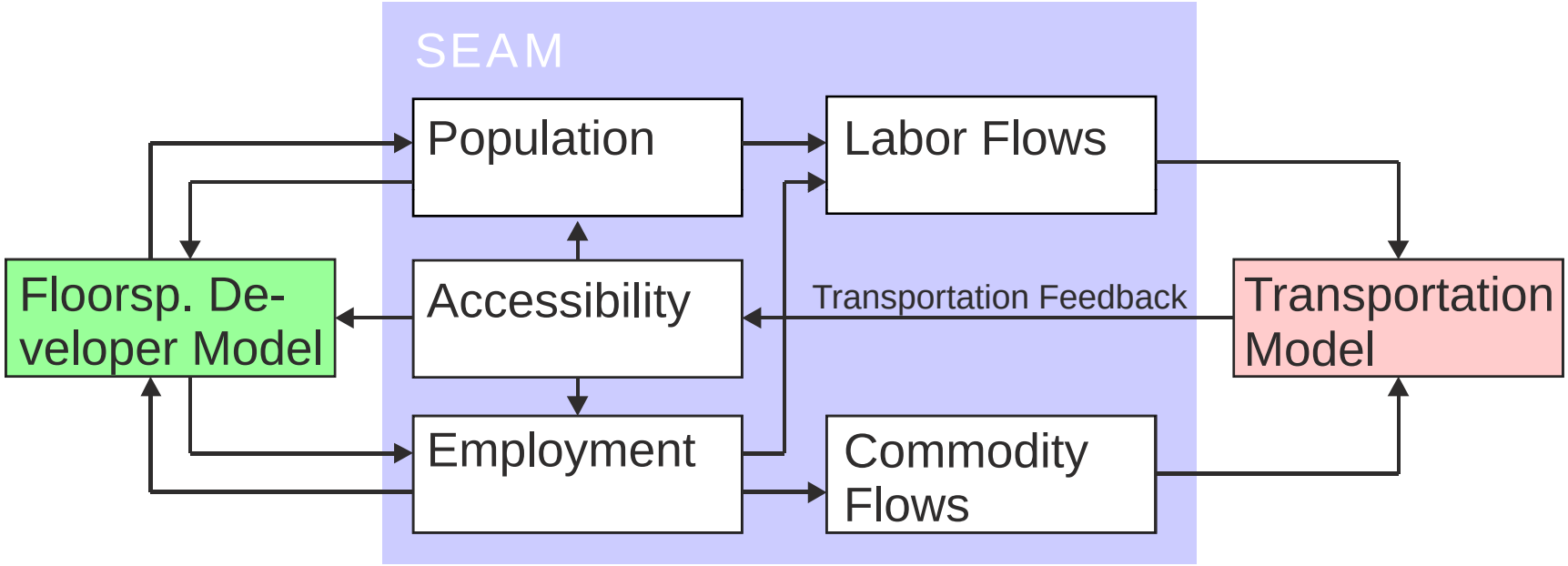
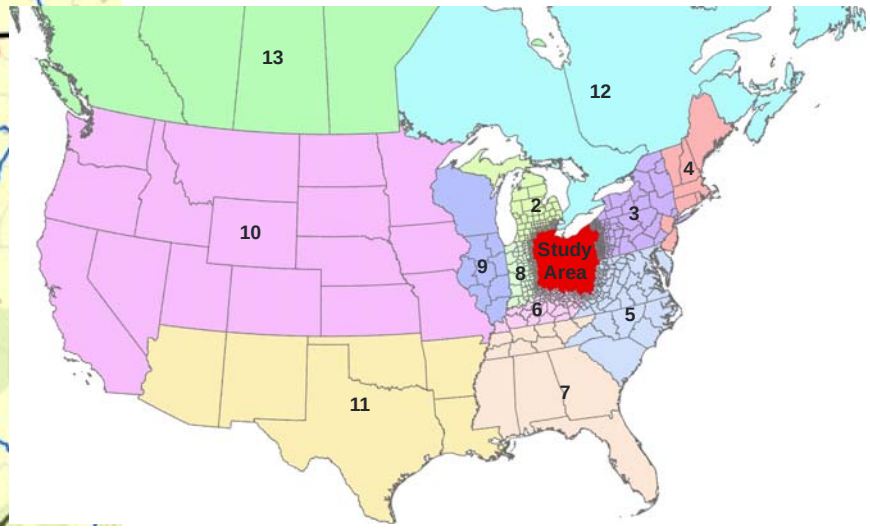
SEAM: Simple Economic Allocation Model



SEAM: Two-layer model design



SEAM: Simple Economic Allocation Model

- Iterative Proportional Fitting used to estimate employment
- Initial employment estimate based on location utility

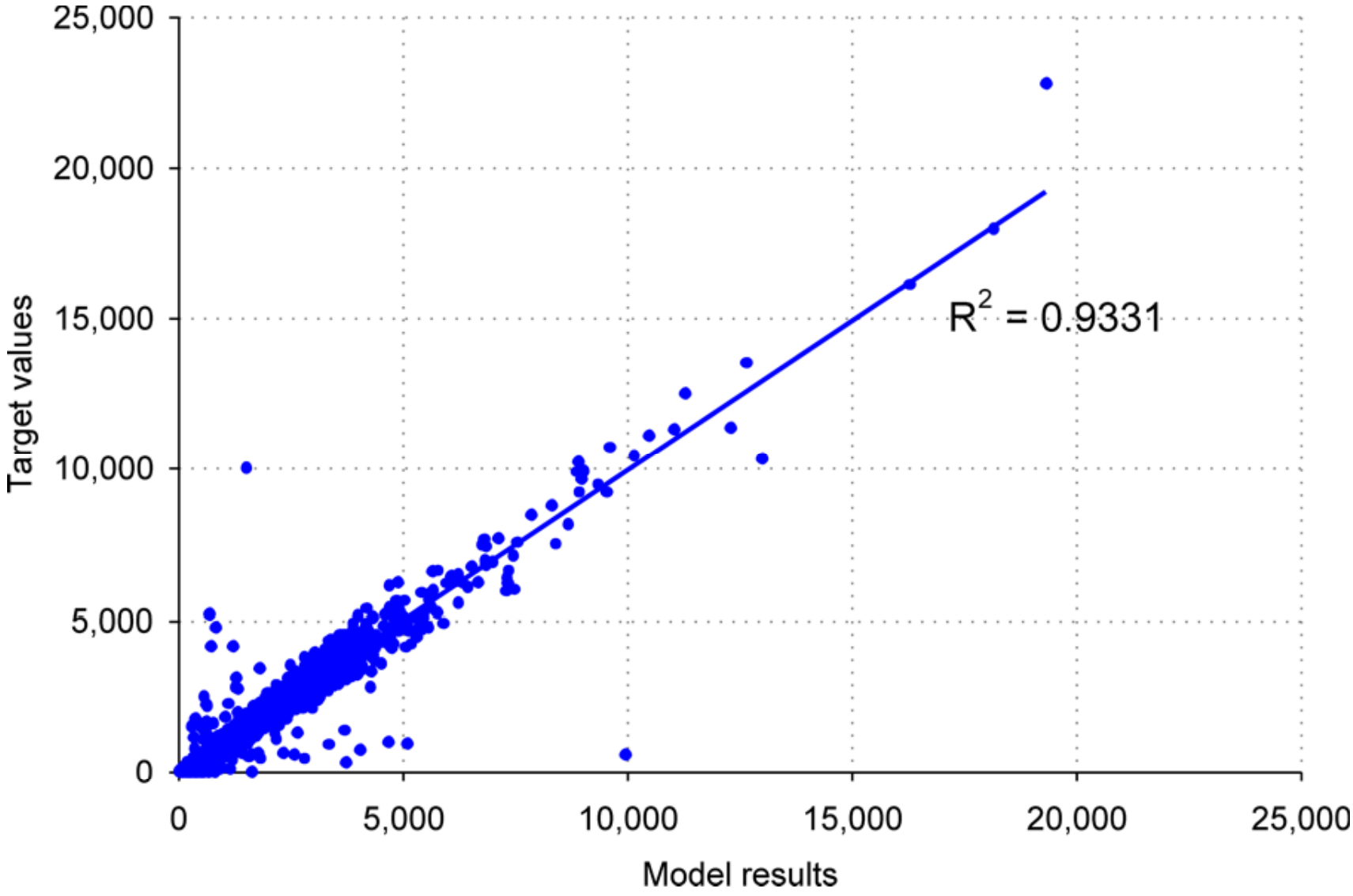
Zone	**Ind. 1**	**Ind. 2**	**…**	**Ind. 23**	**Jobs by Zone**
1	$u_{i,f}$ = 6.46	$u_{i,f}$ = 9.04		$u_{i,f}$ = 1.06	1,681
2	$u_{i,f}$ = 7.91	$u_{i,f}$ = 1.79		$u_{i,f}$ = 6.95	4,917
3	$u_{i,f}$ = 2.15	$u_{i,f}$ = 5.49		$u_{i,f}$ = 0.29	1,985
…					
5002	$u_{i,f}$ = 18.47	$u_{i,f}$ = 1.30		$u_{i,f}$ = 4.82	615
Jobs by type	106,654	79,535		328,227	8,302,143

SEAM: Simple Economic Allocation Model

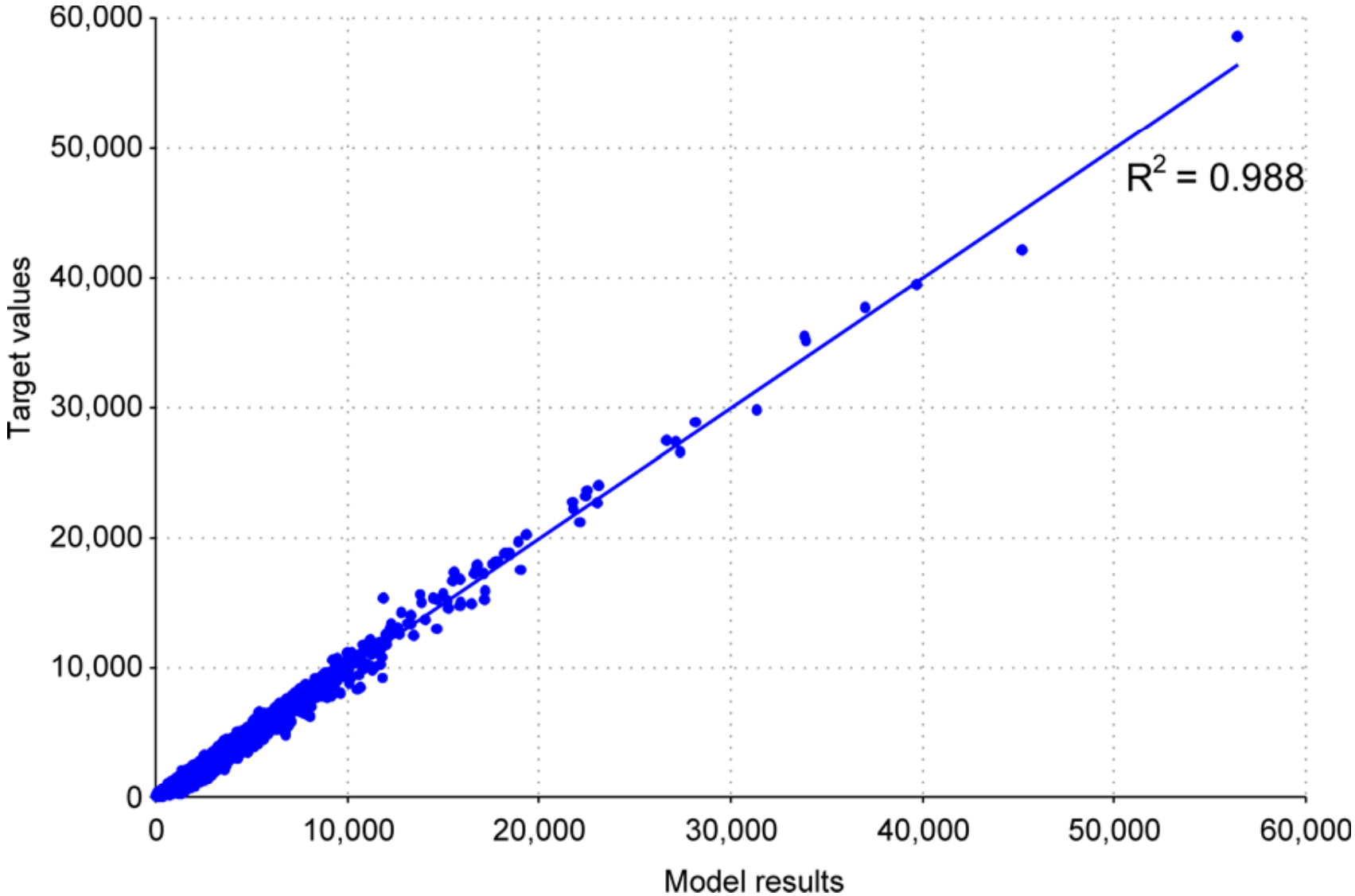
- Iterative Proportional Fitting used to estimate labor flows
- Initial estimate based on travel impedance

TAZ	1	2	...	5002	9001	…	9868	Workers at home (origin)
1	$u_{o,ij}$ = 0.91	$u_{o,ij}$ = 0.31		$u_{o,ij}$ = 0.06	$u_{o,ij}$ = 0.02		$u_{o,ij}$ = 0.02	160
2	$u_{o,ij}$ = 0.49	$u_{o,ij}$ = 0.98		$u_{o,ij}$ = 0.63	$u_{o,ij}$ = 0.01		$u_{o,ij}$ = 0.07	24
...								
5002	$u_{o,ij}$ = 0.04	$u_{o,ij}$ = 0.15		$u_{o,ij}$ = 0.96	$u_{o,ij}$ = 0.20		$u_{o,ij}$ = 0.03	61
9001	$u_{o,ij}$ = 0.08	$u_{o,ij}$ = 0.04		$u_{o,ij}$ = 0.51	$u_{o,ij}$ = 0.00		$u_{o,ij}$ = 0.00	521
...								
9533	$u_{o,ij}$ = 0.62	$u_{o,ij}$ = 0.31		$u_{o,ij}$ = 0.28	$u_{o,ij}$ = 0.00		$u_{o,ij}$ = 0.00	348
Jobs at work (destination)	32	8		91	419		530	6,529
			Internal zones		External zones			

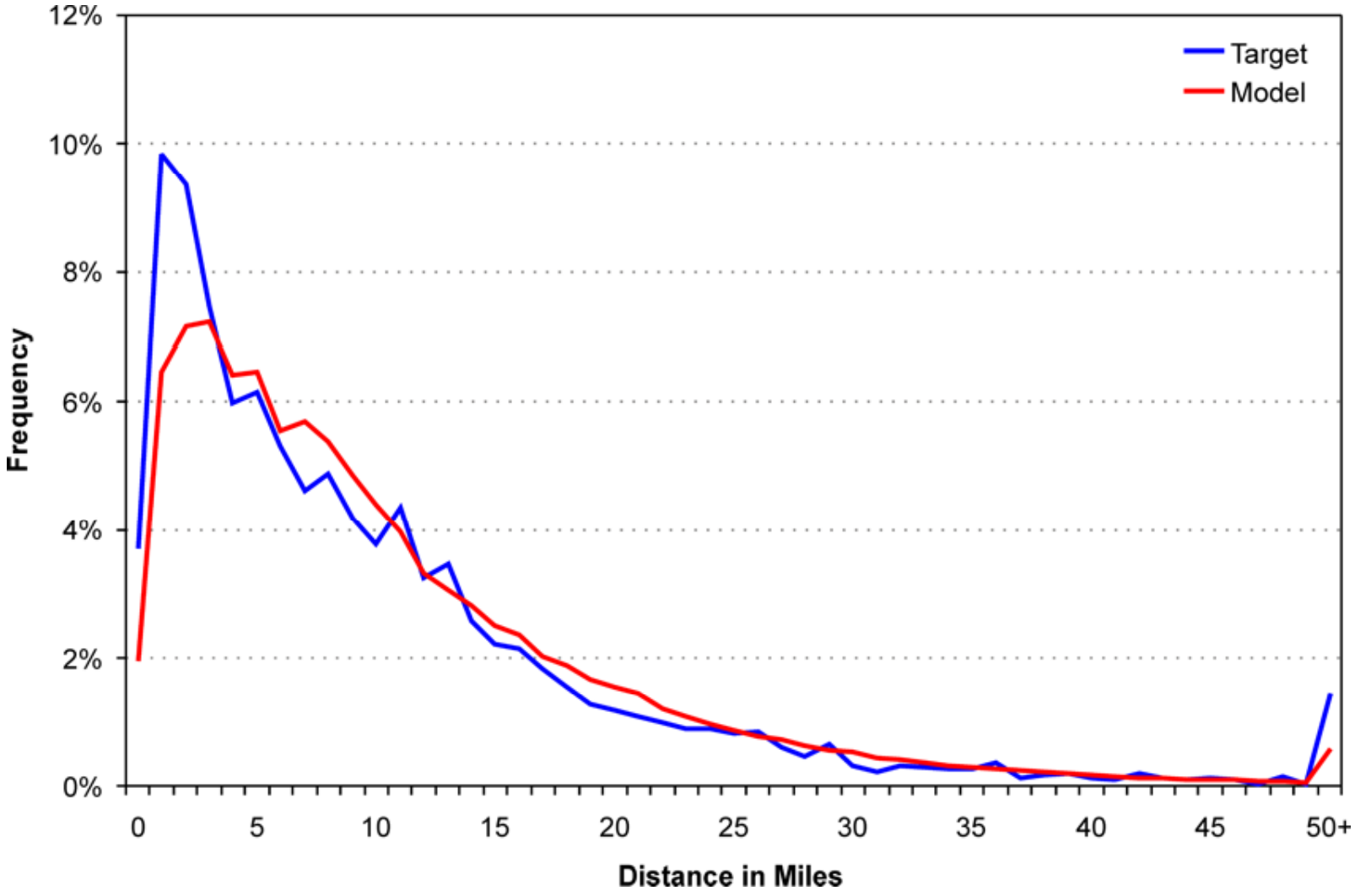
SEAM: Total population validation



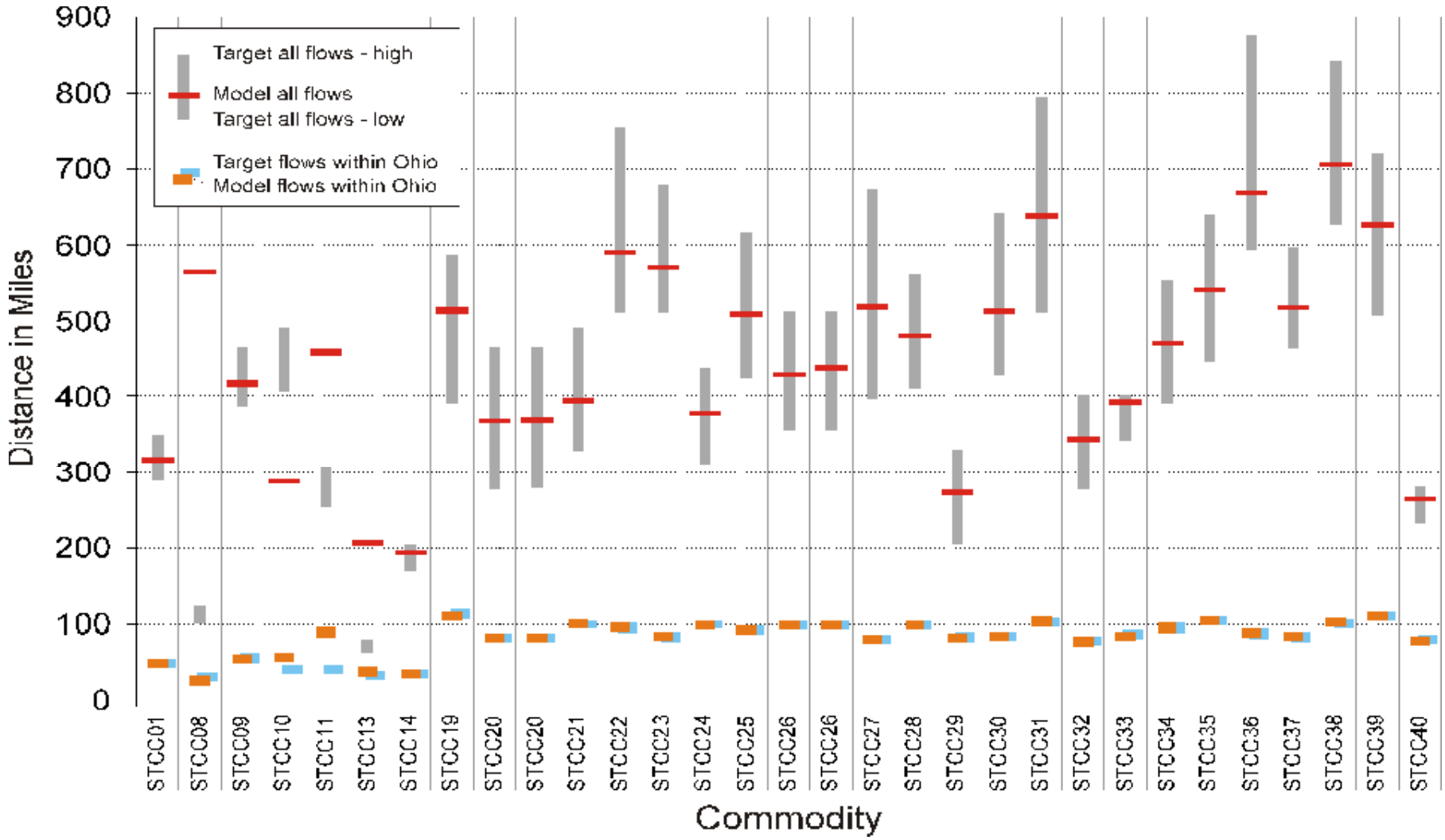
SEAM: Total employment validation



SEAM: Labor-flow distance validation



SEAM: Commodity-flow distance validation



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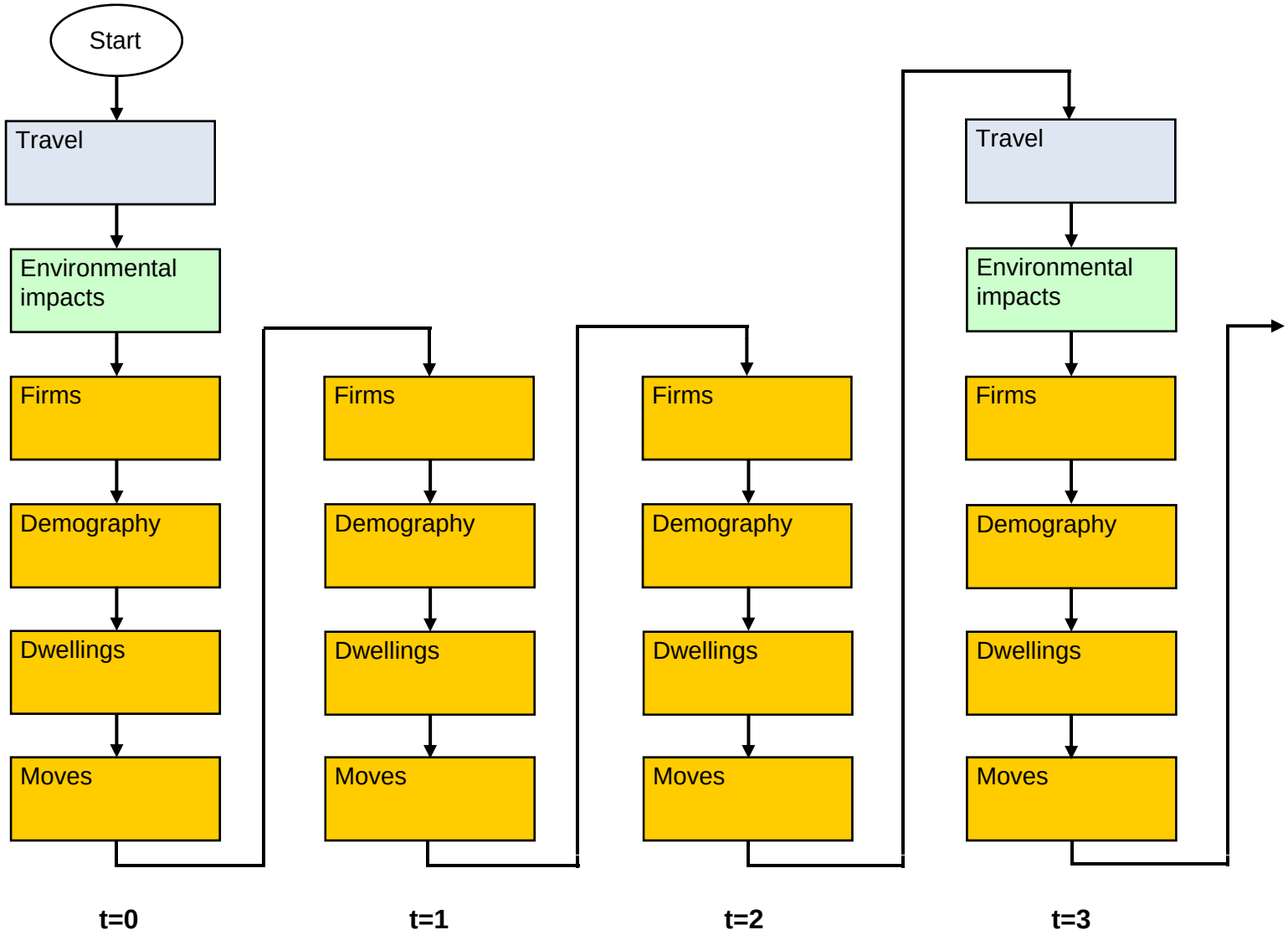
The ILUMASS Project

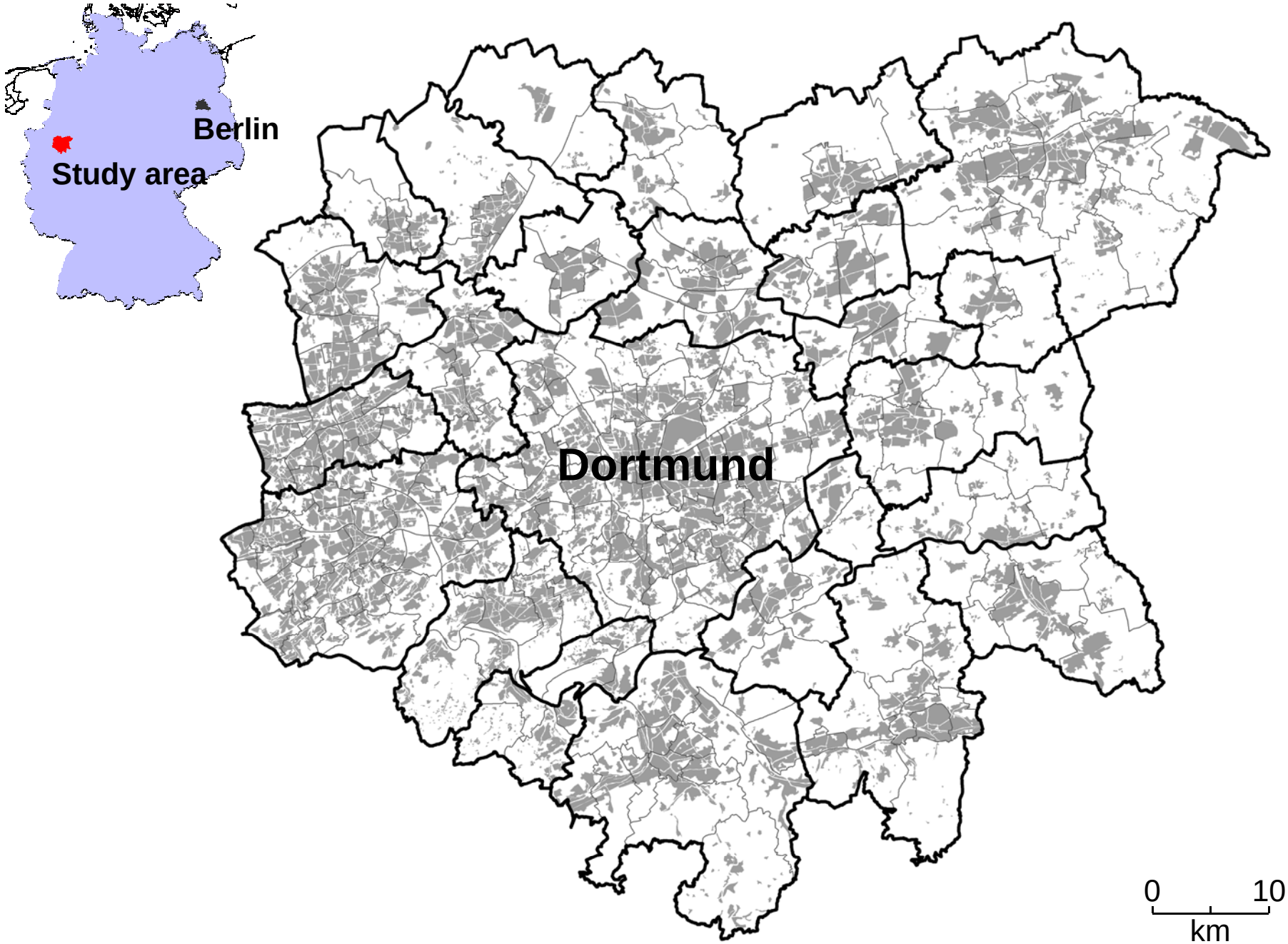
The project ILUMASS (Integrated Land-Use Modelling and Transport Systems Simulation) was a research project of several German universities and research institutes funded by the German government in 2001-2005.

The ILUMASS model simulates microscopically

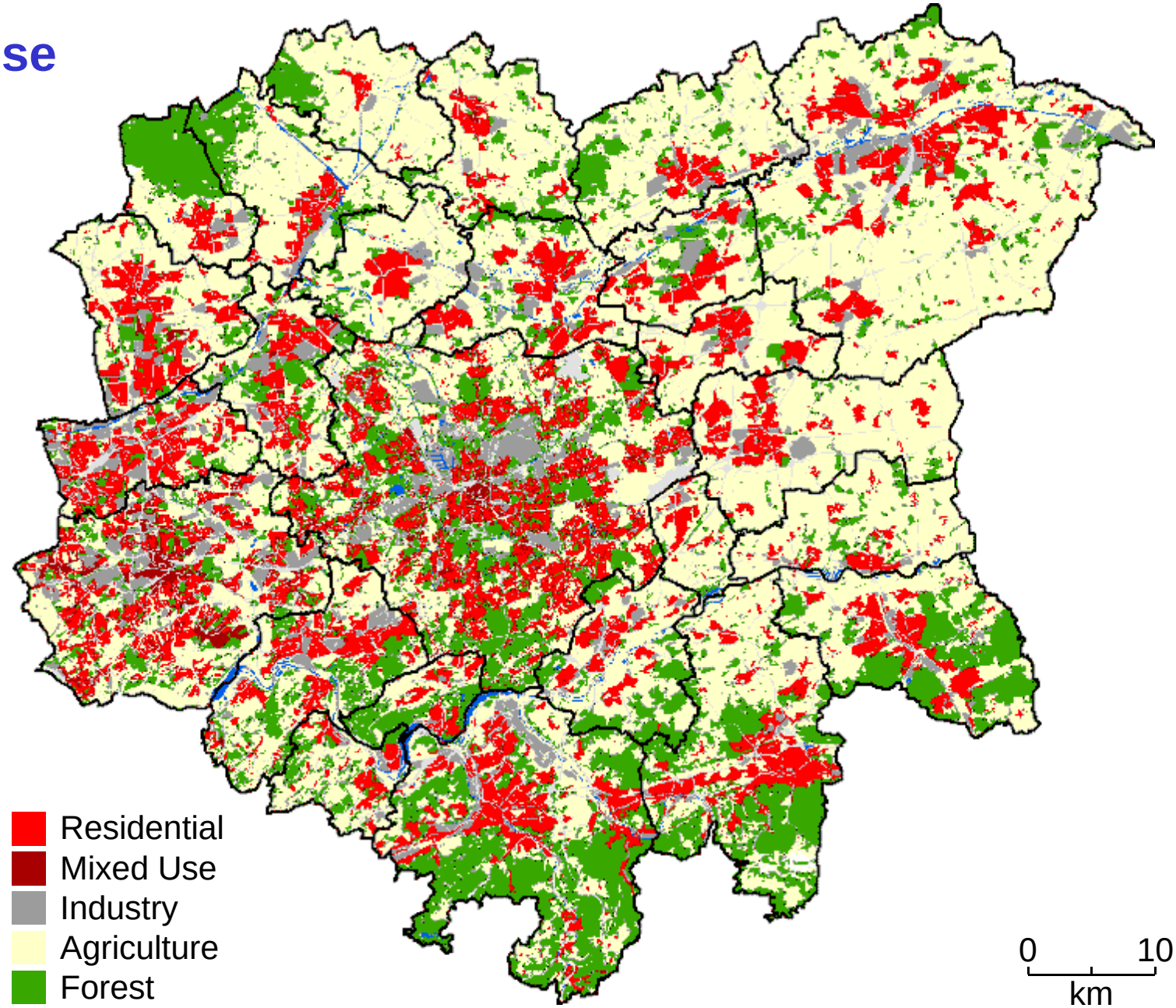
- land use,
- activities,
- travel demand and
- environmental impacts.

Modules of the ILUMASS model

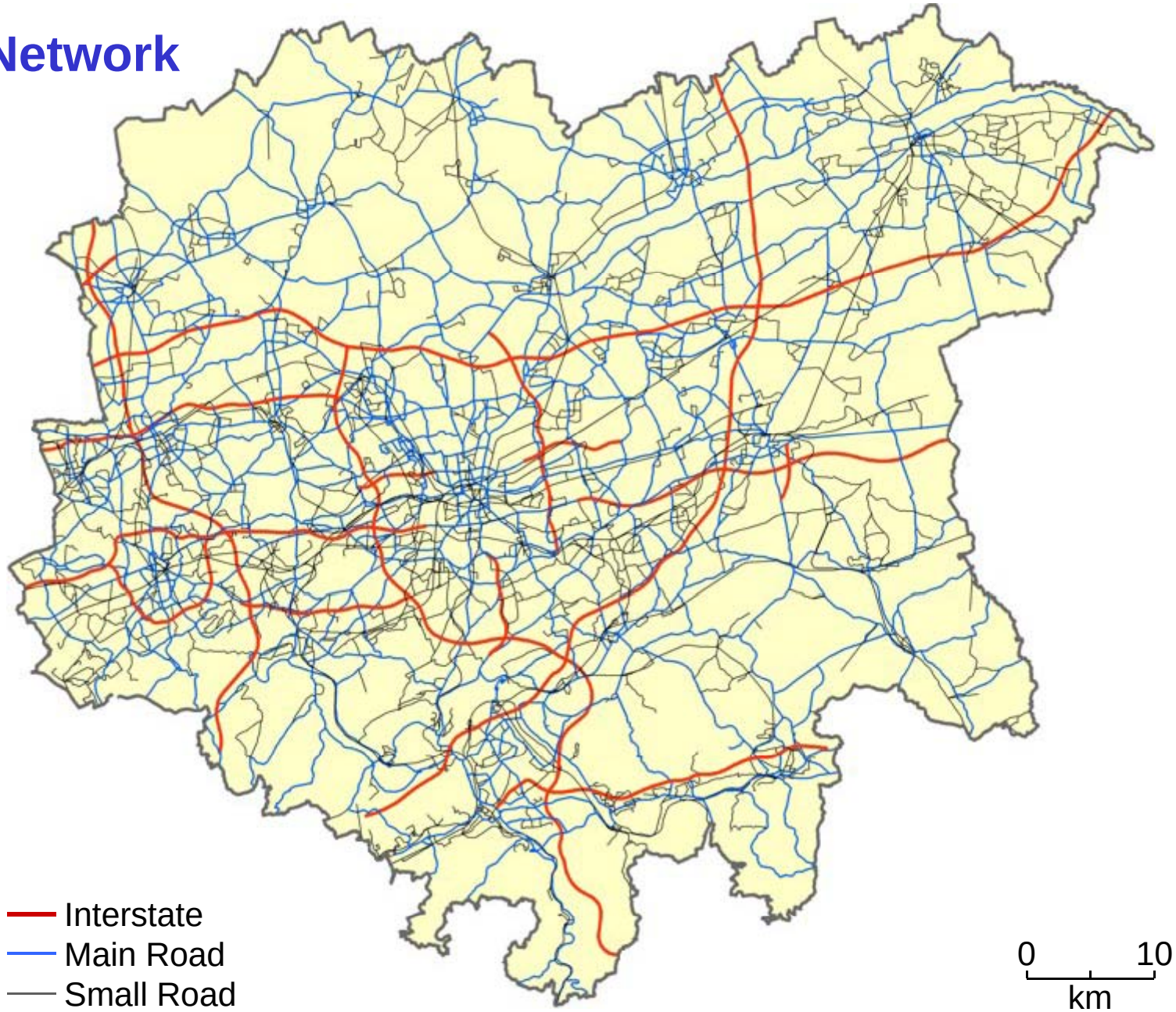



Berlin
Study area
Dortmund
0
10
km

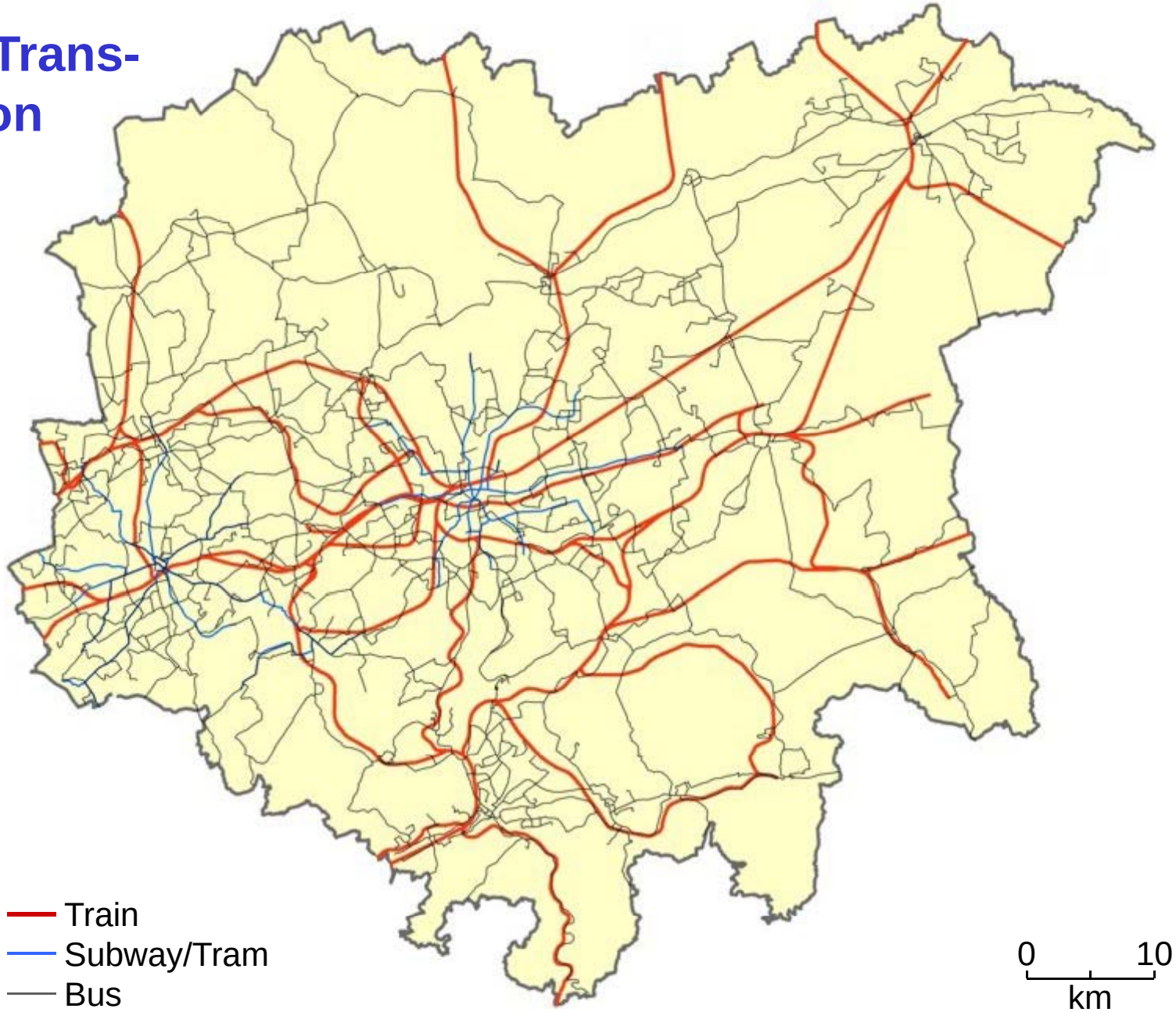
Land Use 2000



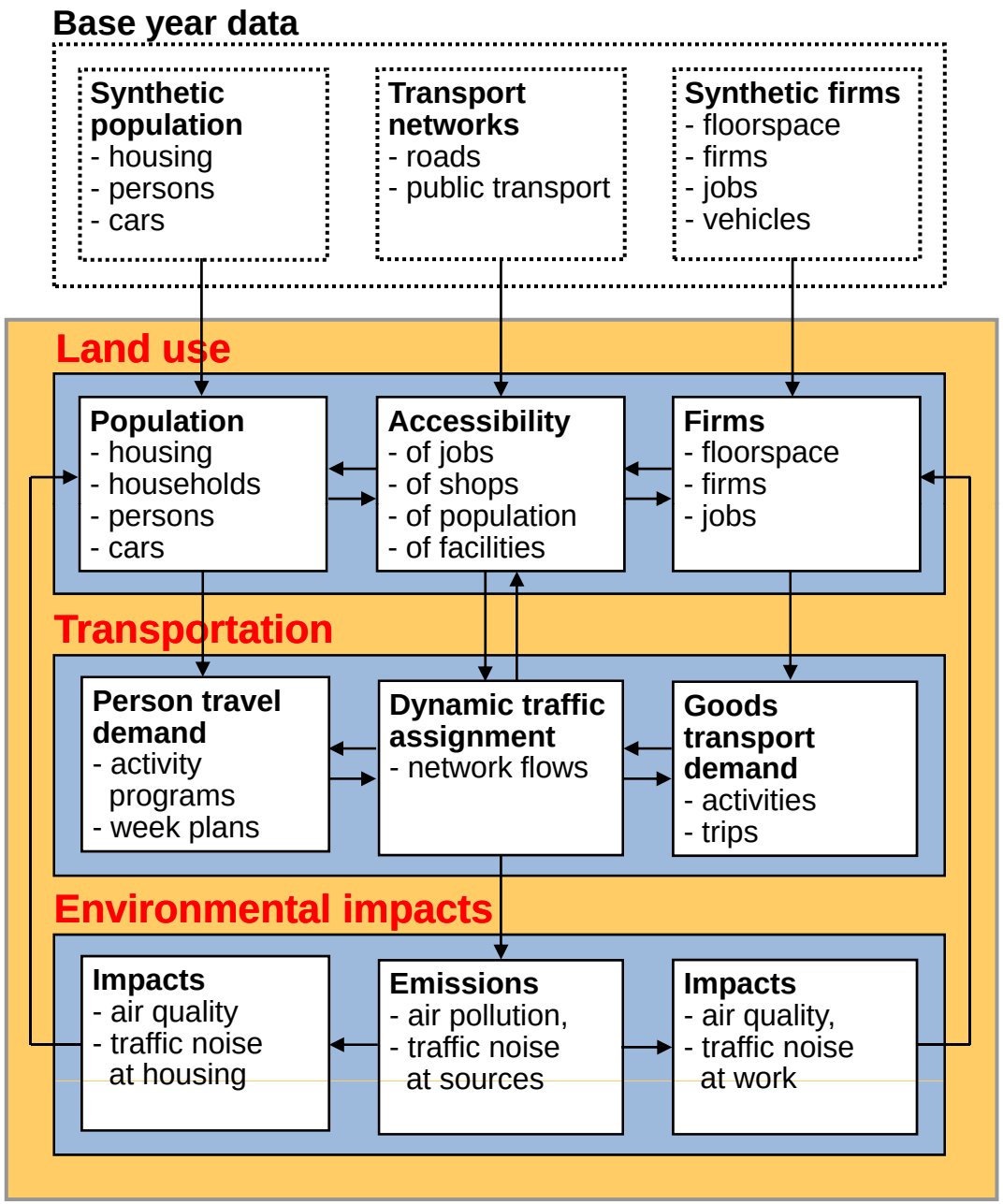
Street Network 2000



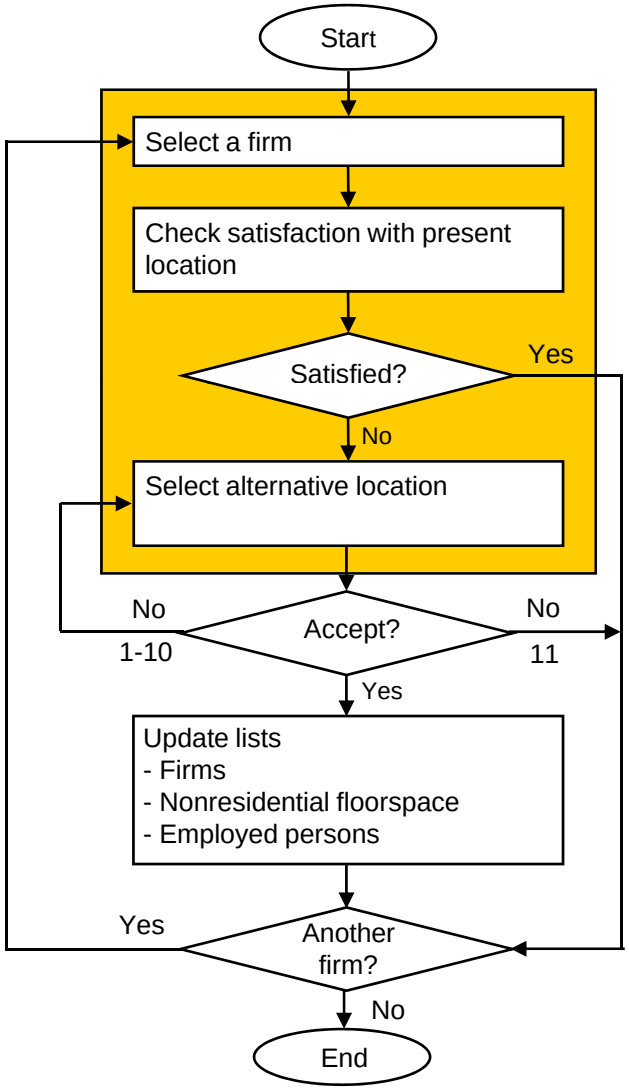
Public Transportation 2000

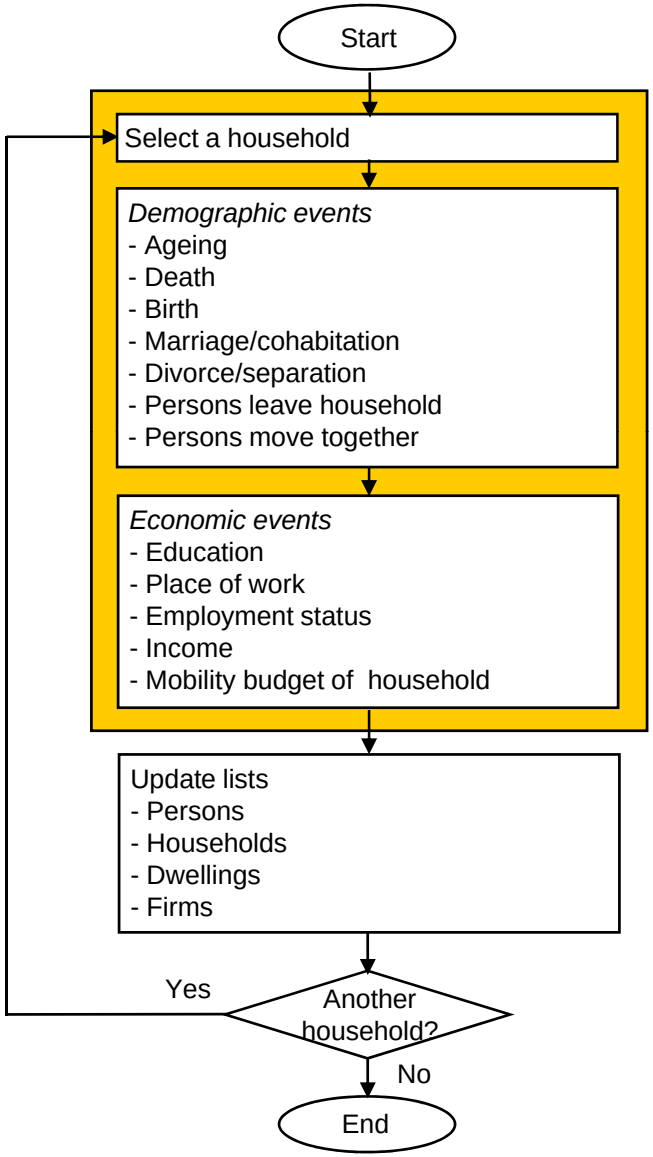


Model overview

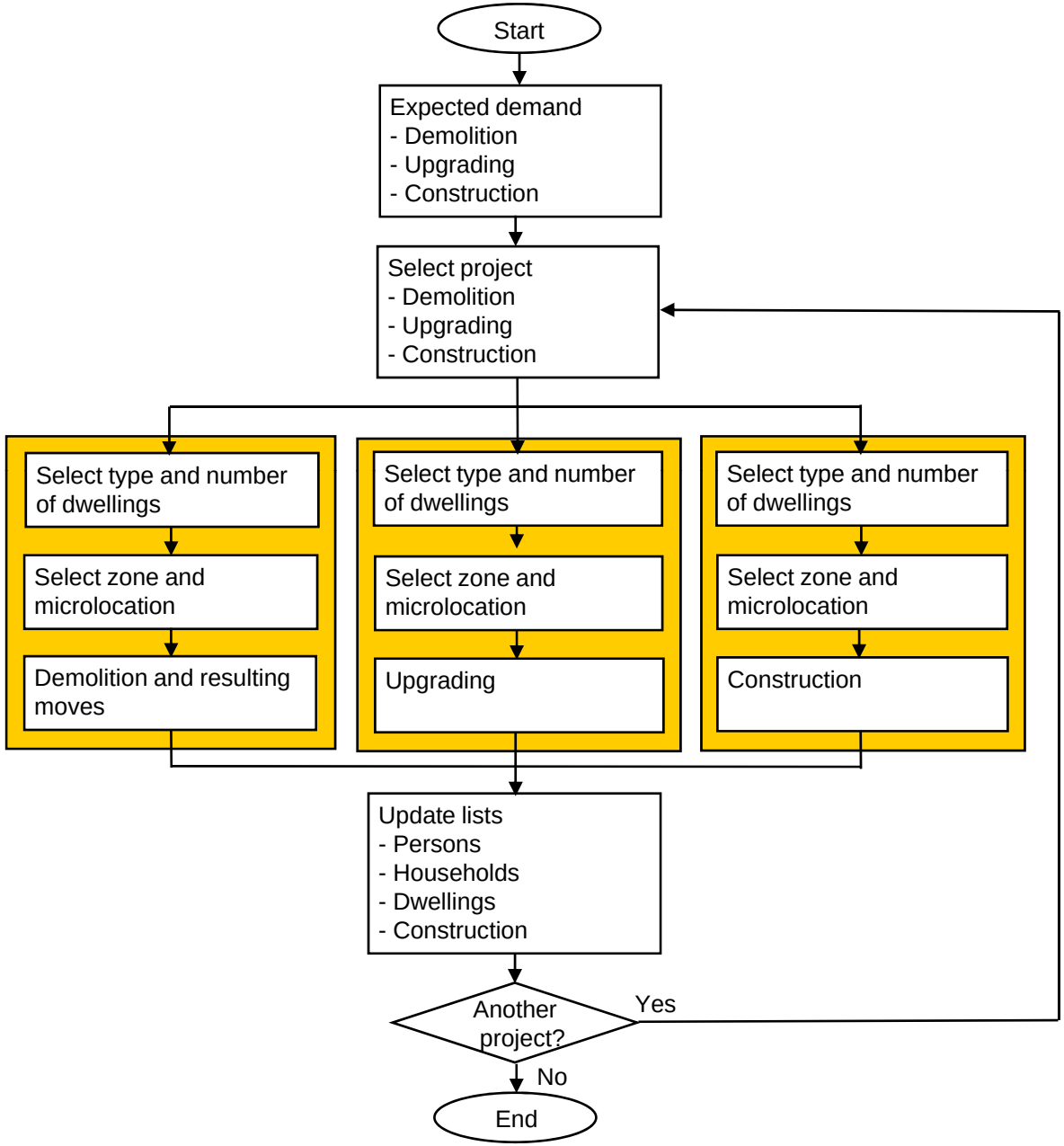


Firms and households

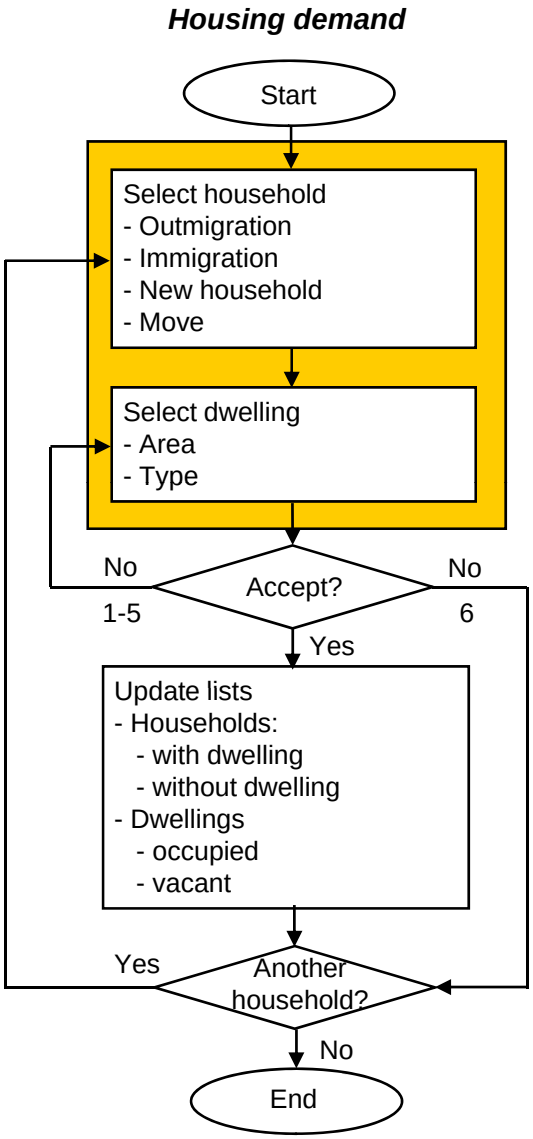


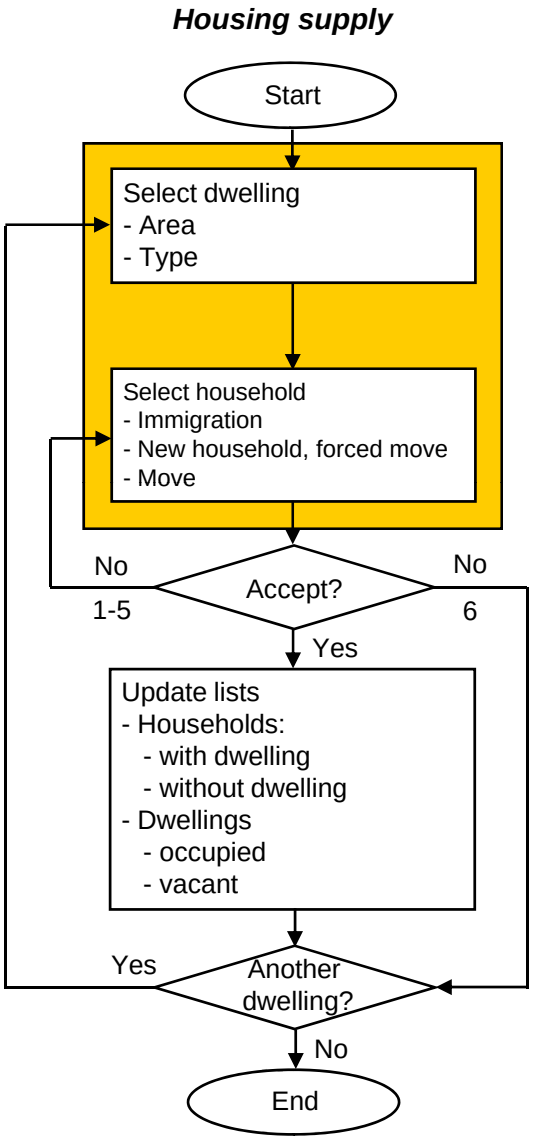


Dwellings

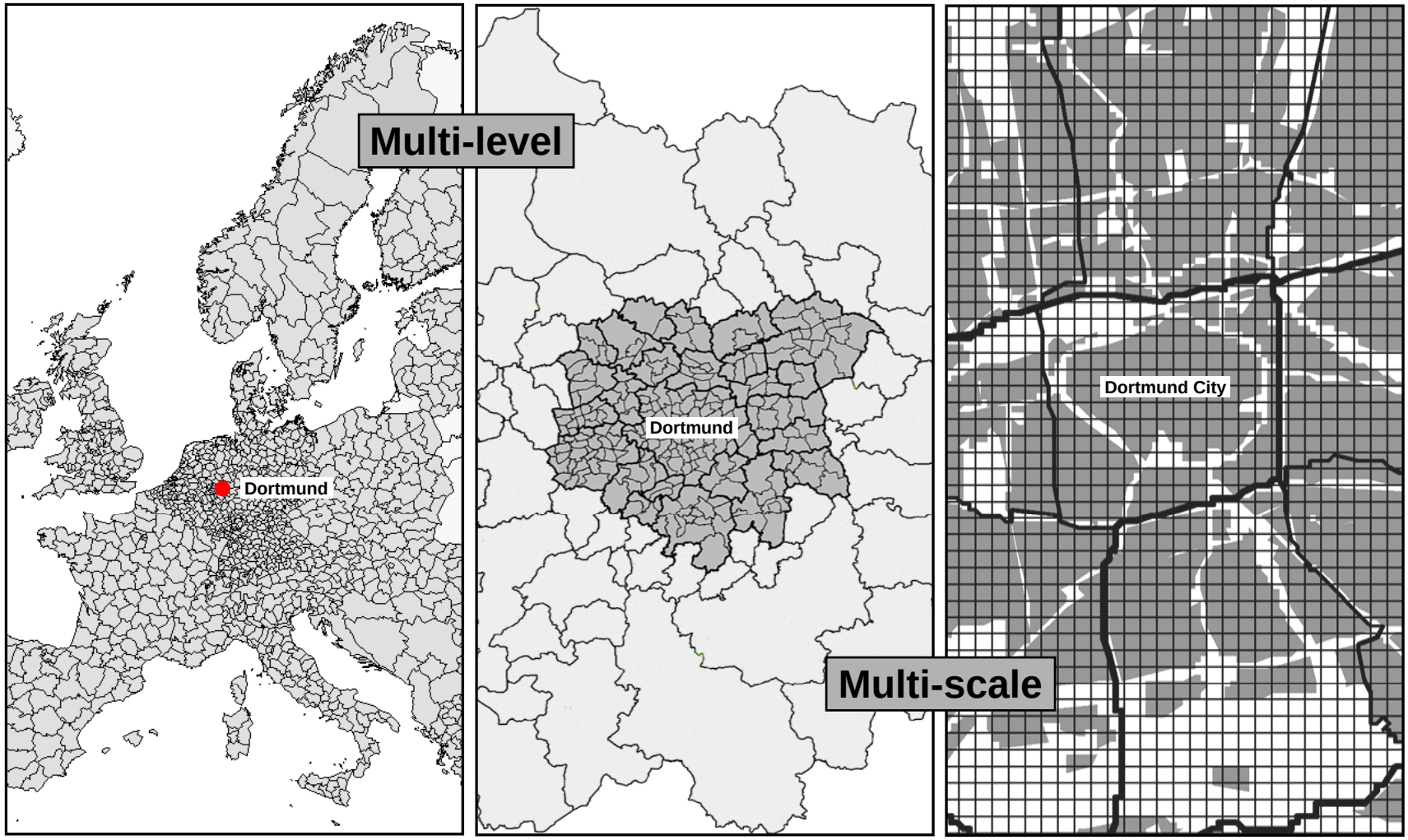

Start
Expected demand
- Demolition
- Upgrading
- Construction
Select project
- Demolition
- Upgrading
- Construction
Select type and number of dwellings
Select zone and microlocation
Demolition and resulting moves
Select type and number of dwellings
Select zone and microlocation
Upgrading
Select type and number of dwellings
Select zone and microlocation
Construction
Update lists
- Persons
- Households
- Dwellings
- Construction
Another project?
Yes
No
End

Moves


Housing demand
Start
Select household
- Outmigration
- Immigration
- New household
- Move
Select dwelling
- Area
- Type
Accept?
No
1-5
No
6
Yes
Update lists
- Households:
- with dwelling
- without dwelling
- Dwellings
- occupied
- vacant
Another household?
Yes
No
End


Housing supply
Start
Select dwelling
- Area
- Type
Select household
- Immigration
- New household, forced move
- Move
Accept?
No
1-5
No
6
Yes
Update lists
- Households:
- with dwelling
- without dwelling
- Dwellings
- occupied
- vacant
Another dwelling?
Yes
No
End

Model levels



Regions *Zones* *Raster cells*

Typical Model Run

ILUMASS

ILUMASS Dortmund Model

File Edit View State Window Help

ILUMASS Dortmund Modell

Scenario: 000

OK

Exit

Model parameters	par000
Preference parameters	atr001
Regional control totals	zrm000
External zones	zxz000
Zonal data	zd000
Household data	zhw000
Transport networks	zvm000
Transport costs	zvk000
Planning policies	zpm000
Base year	2000
Start of simulation	2000
Length of simulation period	1
Number of simulation periods	30
End of simulation	2030

Presentation

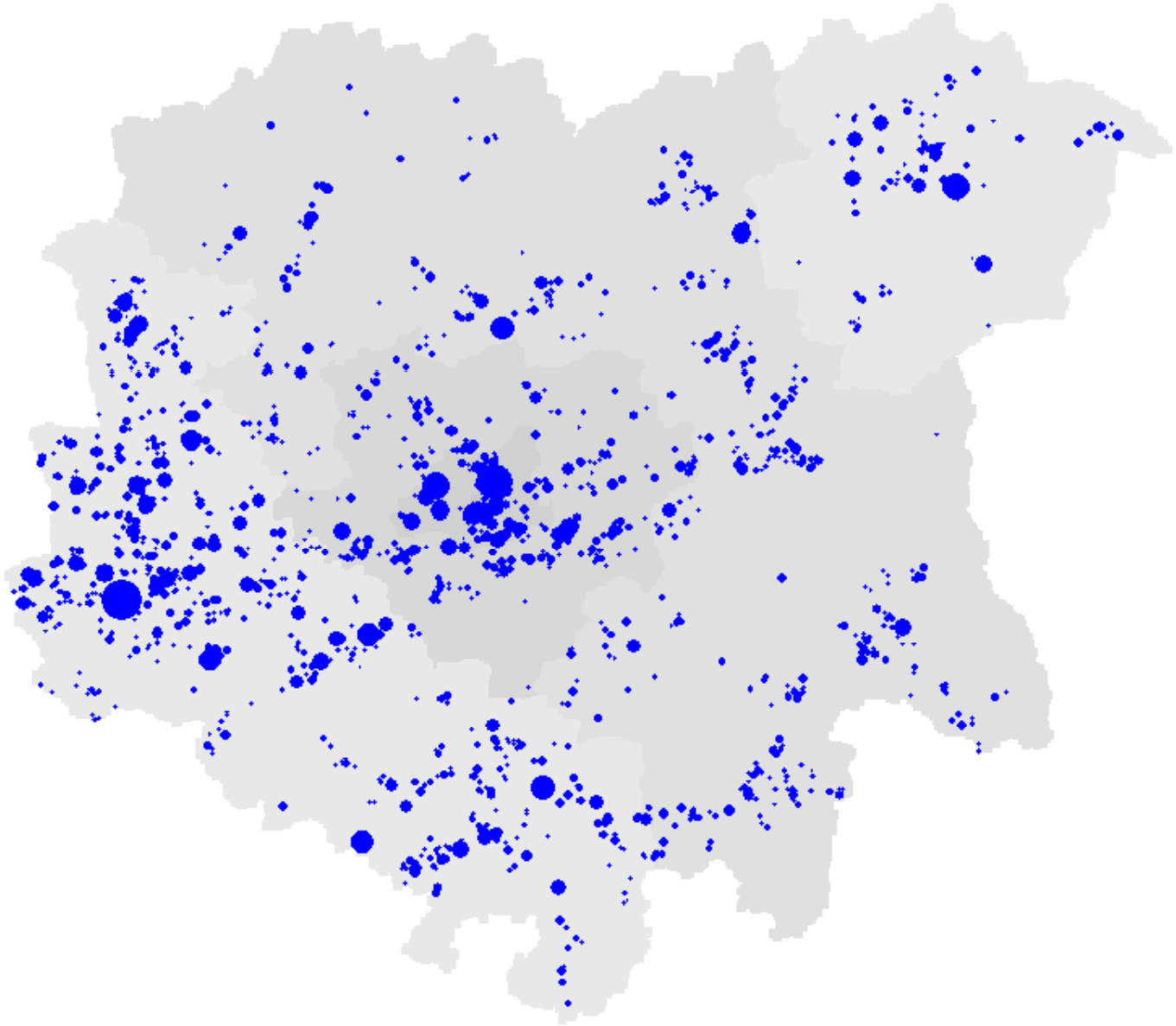
- (•) Animation
- ( ) Results
- ( ) Text

Modules

- [x] Transport
- [x] Households
- [x] Dwellings
- [x] Moves
- [x] Firms — Settings...
- [x] Write list files in 2030

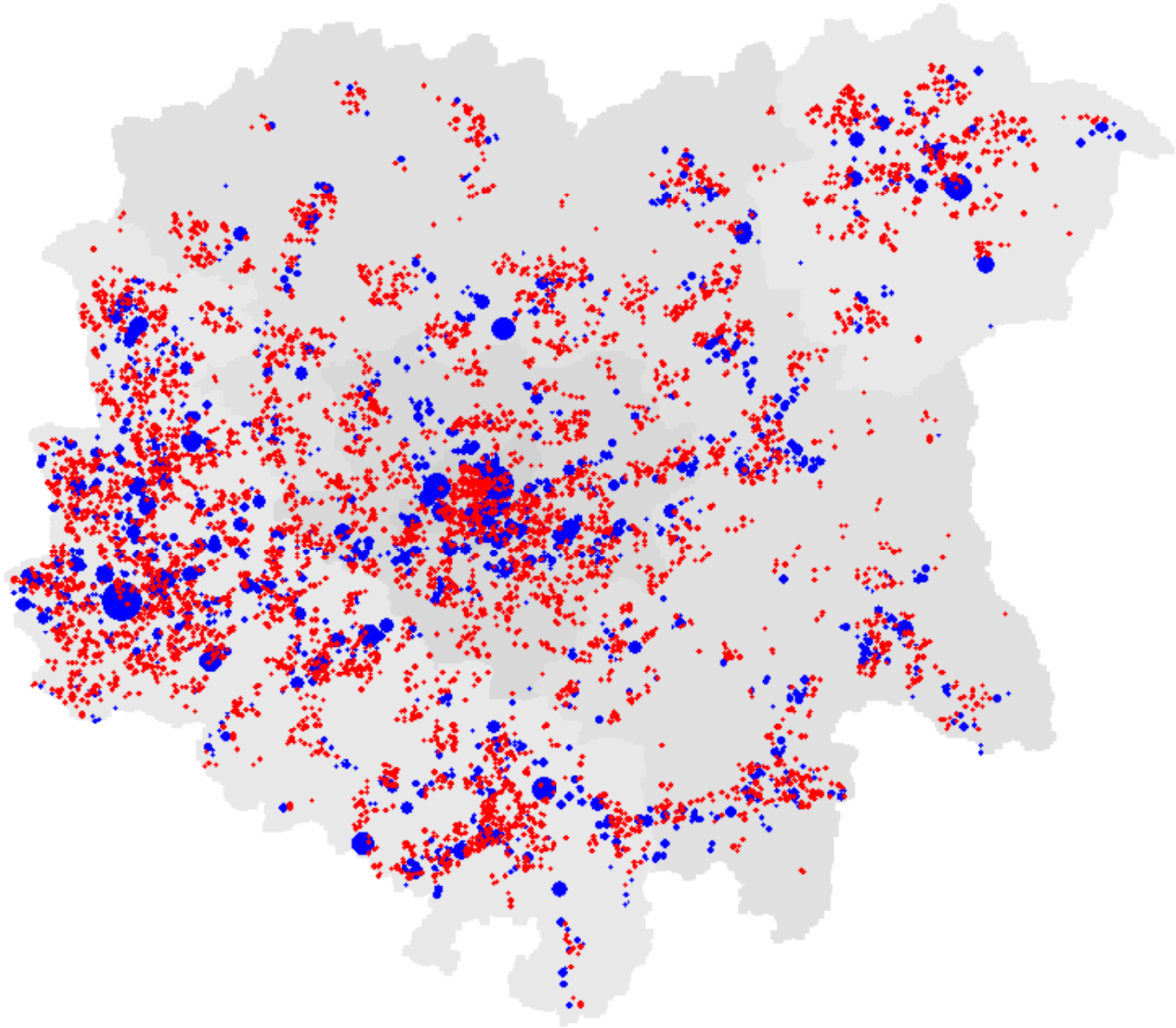
Model parameters

Micro data



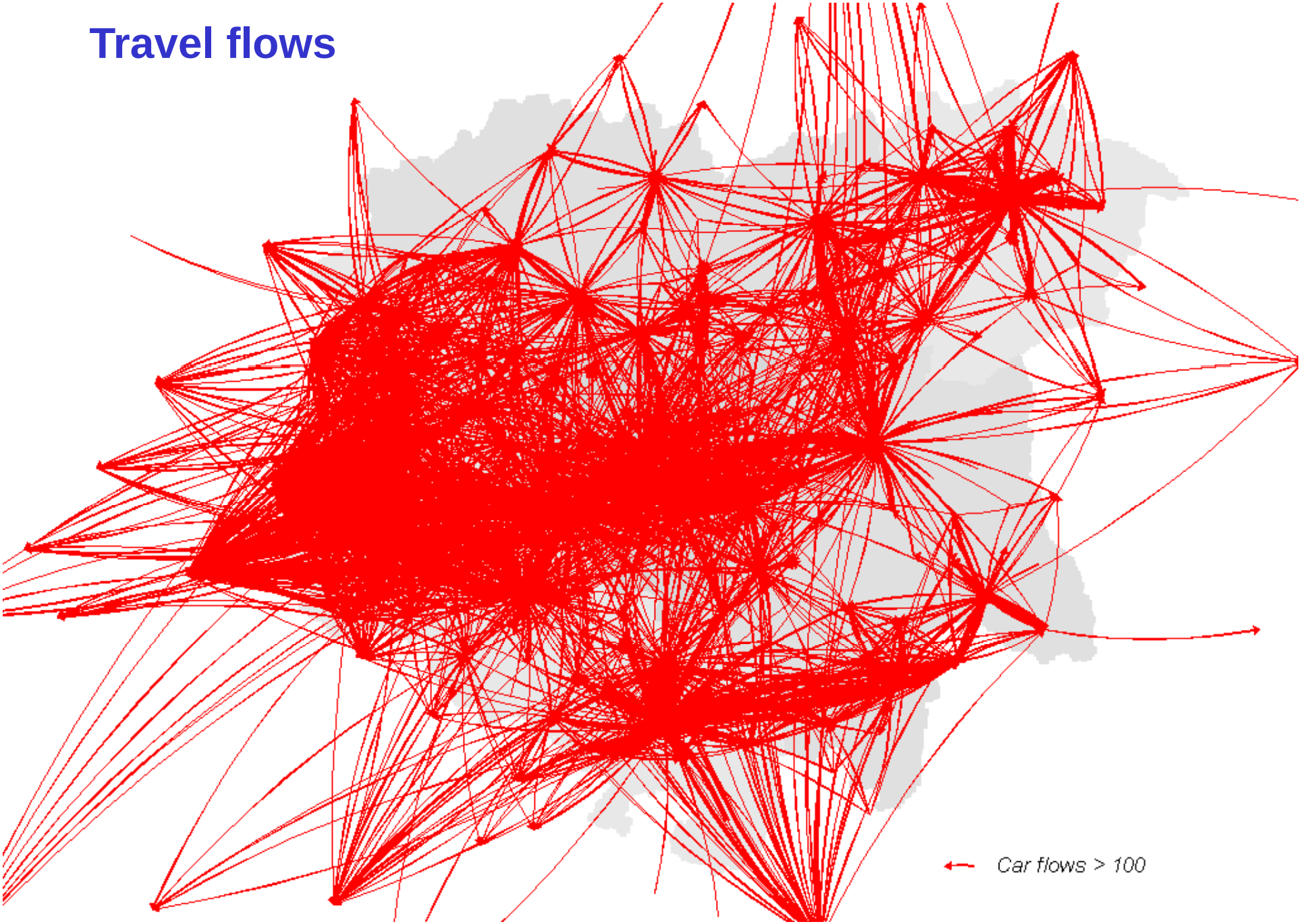
- *Businesses*

Micro data

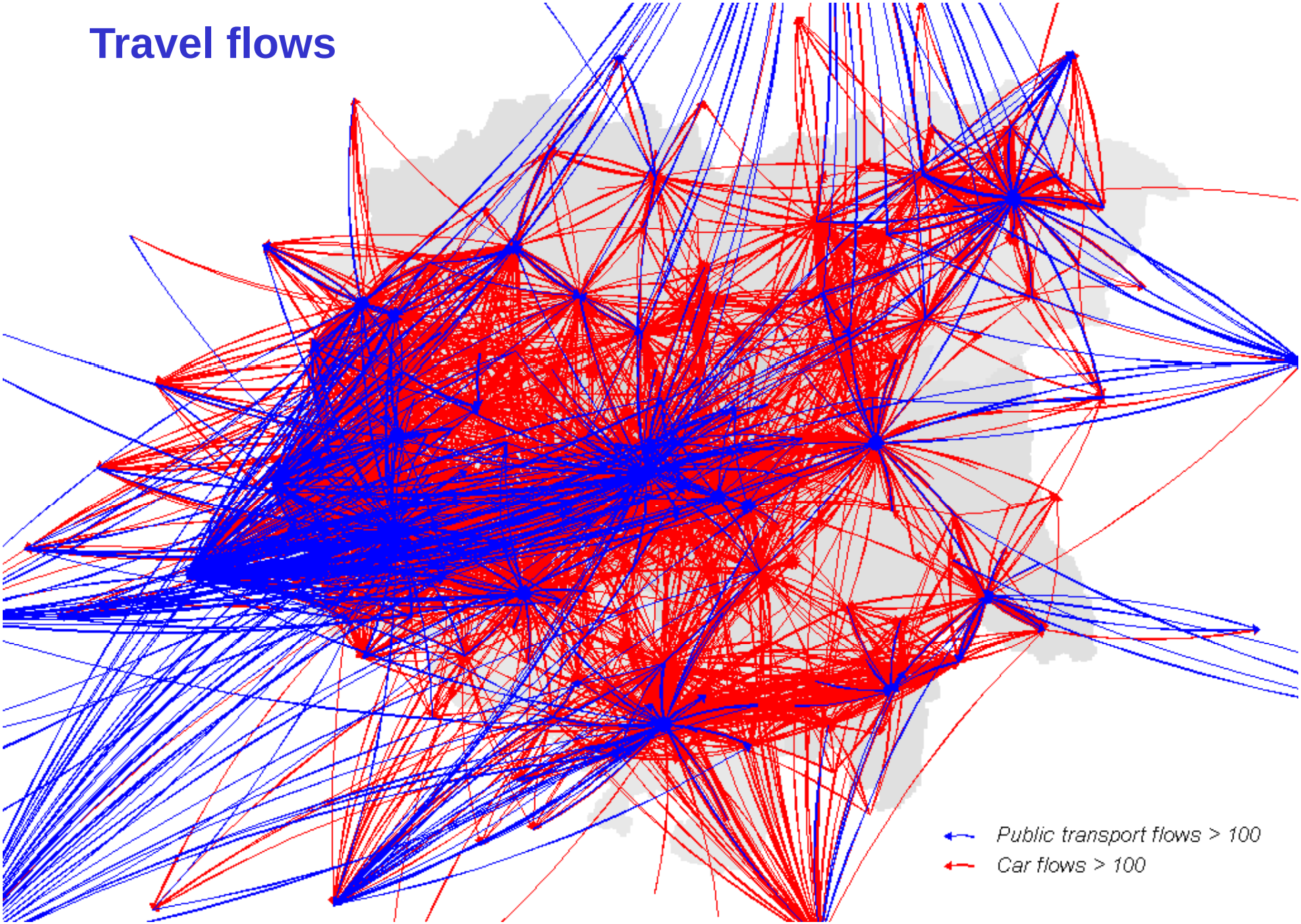


- *Businesses*
- *Households*

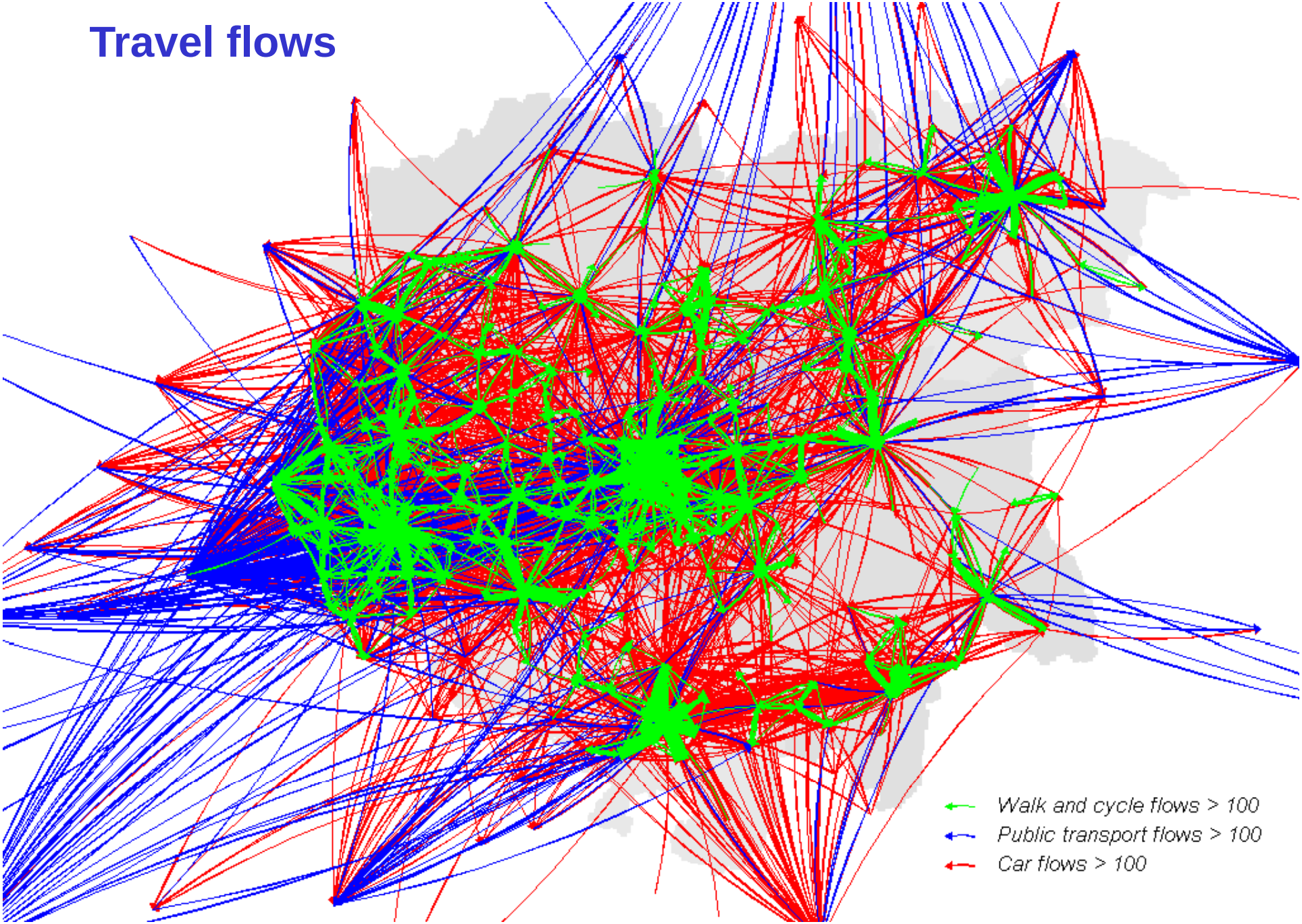
Travel flows



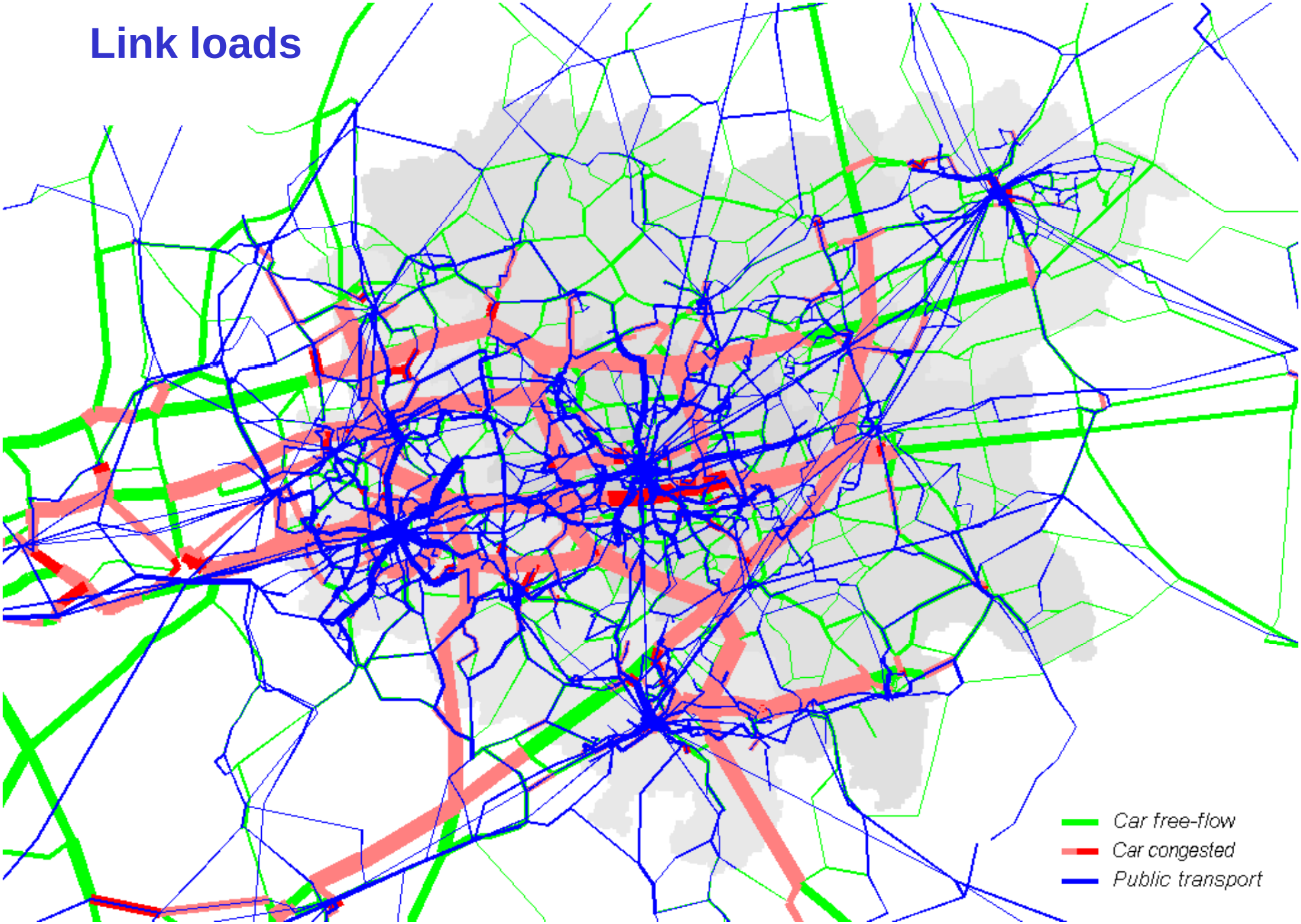
Travel flows



Travel flows



Link loads



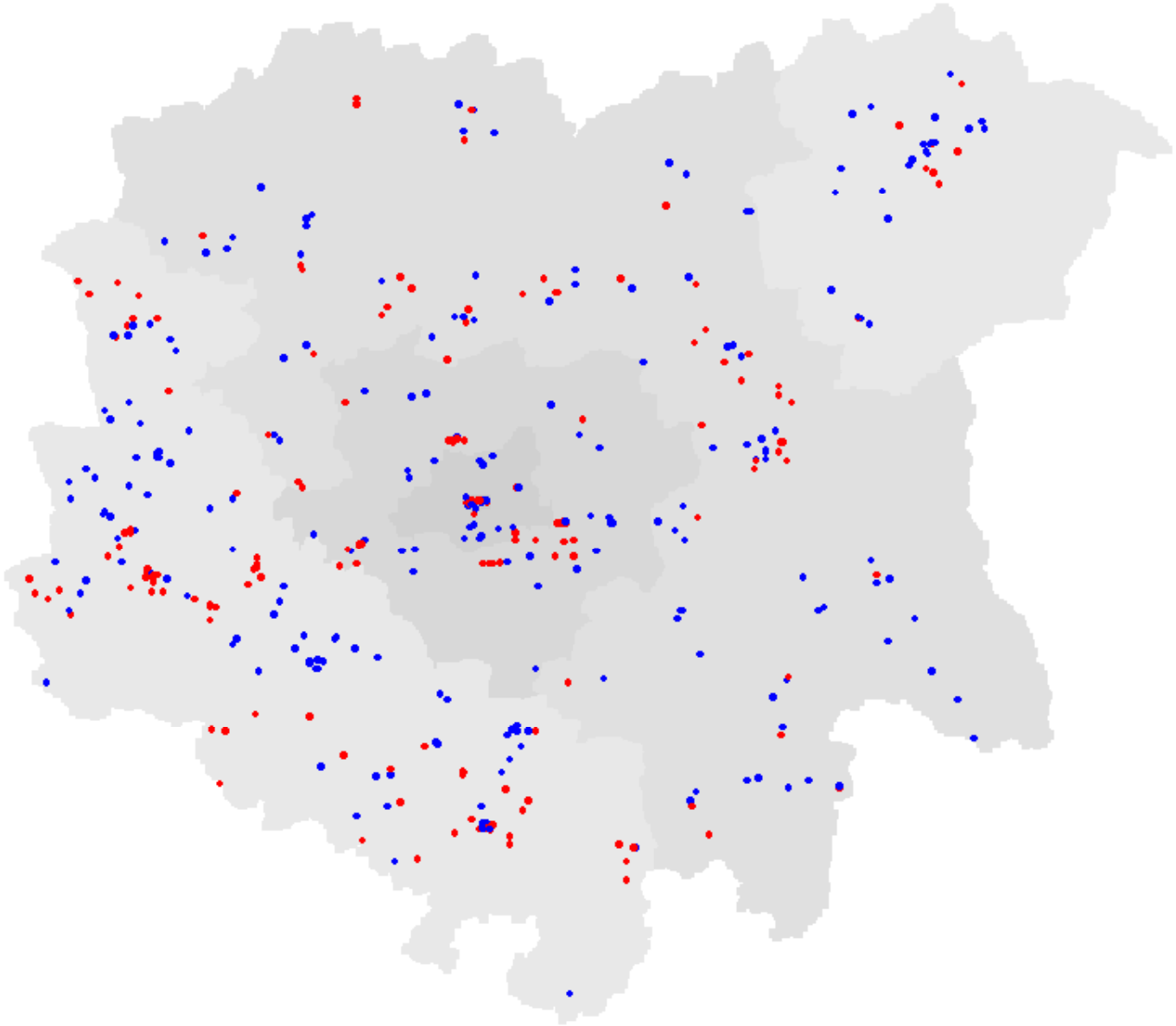
Air quality

NO_2

Traffic noise

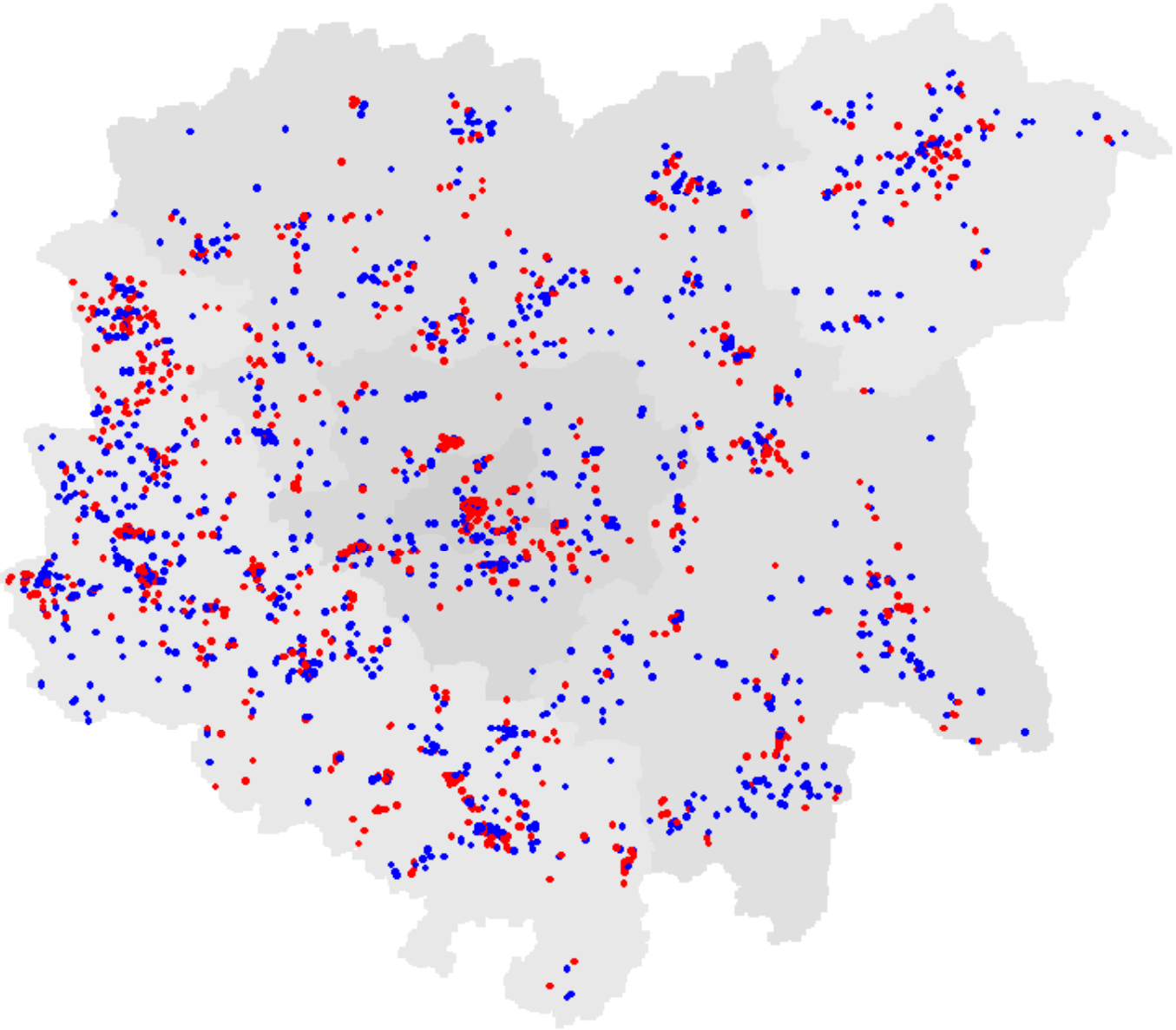
dB(A)

Firms



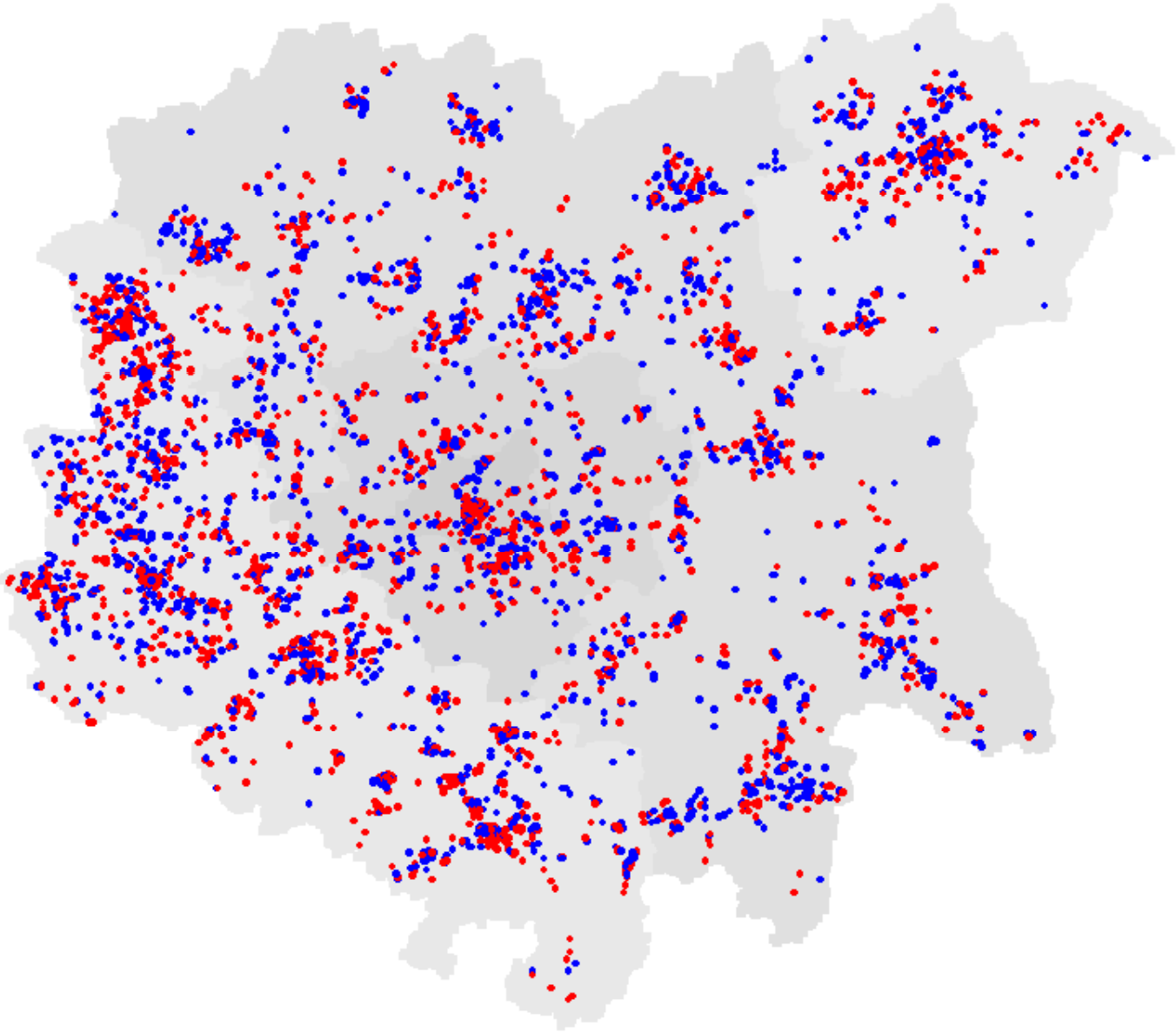
- *New businesses*
- *Business closures*

Firms



- *New businesses*
- *Business closures*

Firms



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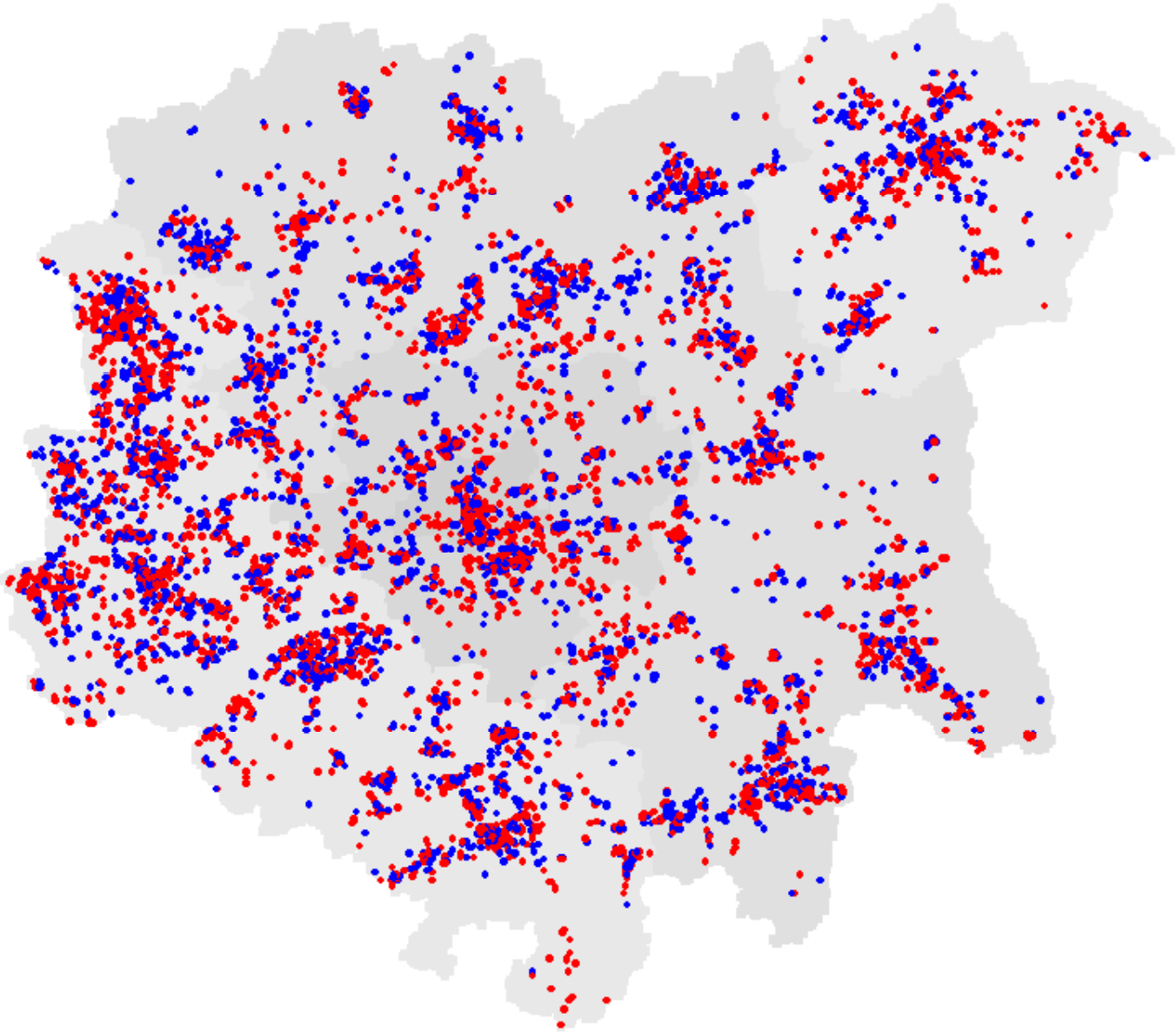
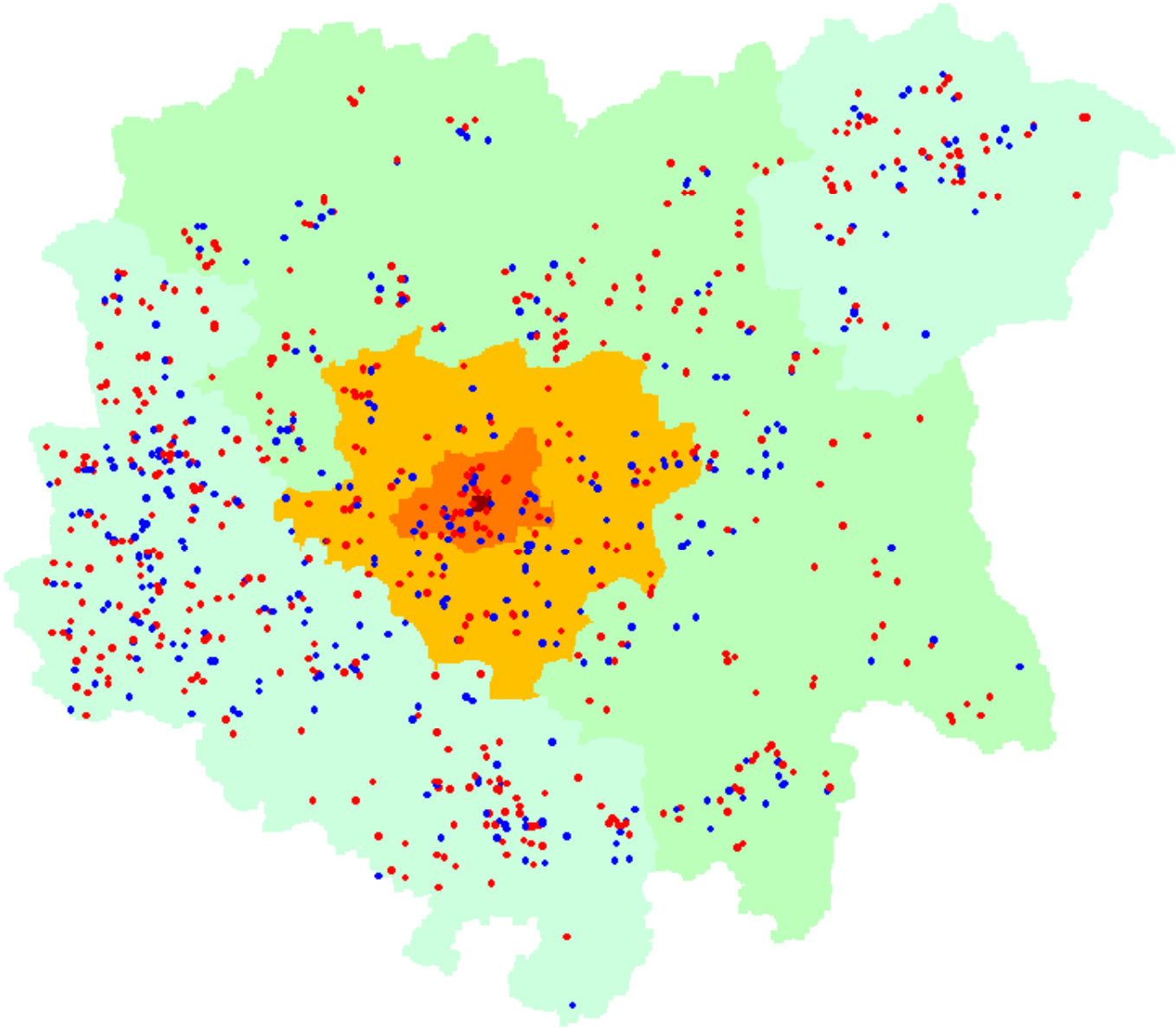
Firms



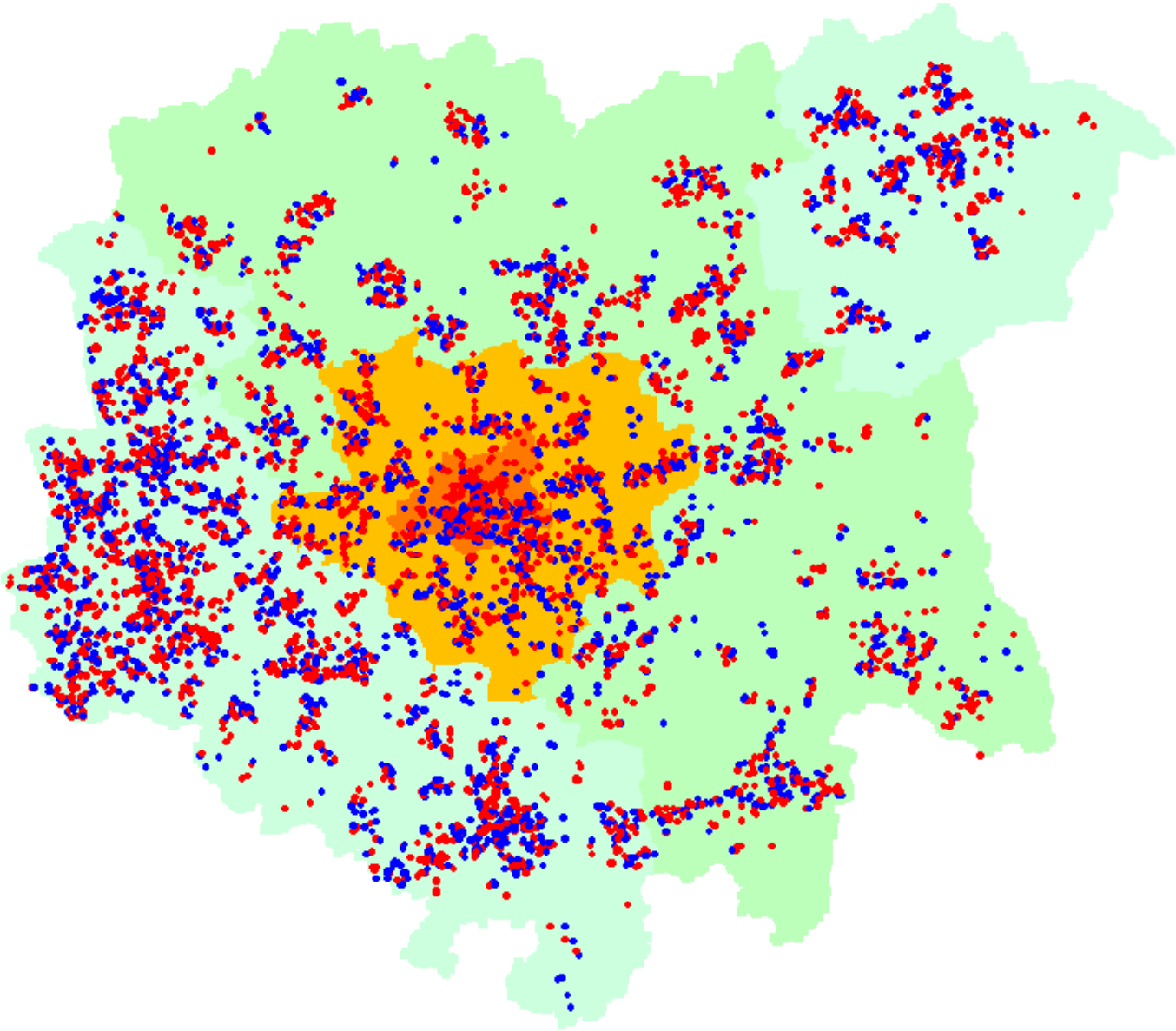
- *New businesses*
- *Business closures*

Households



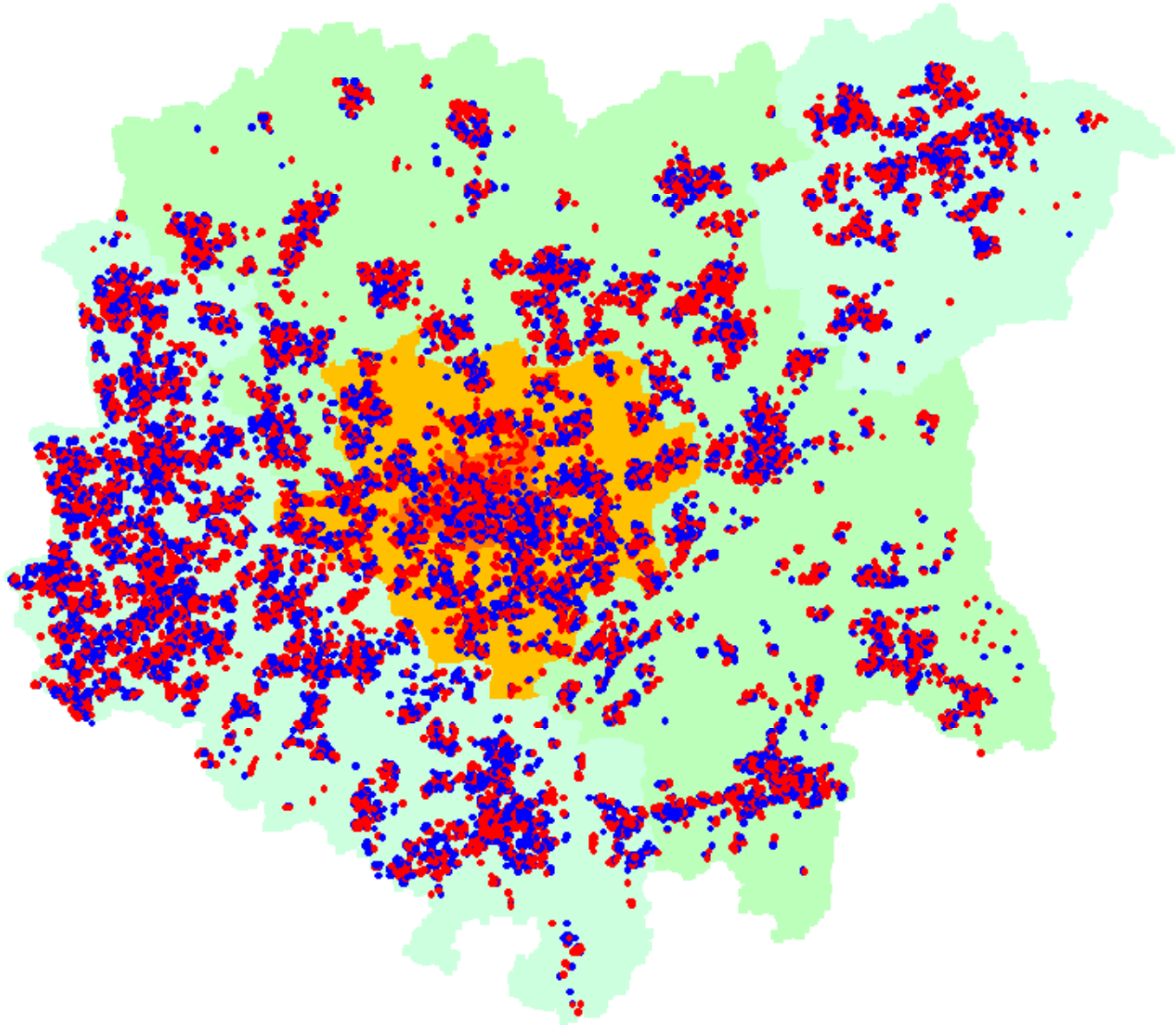
- *Births*
- *Deaths*

Households



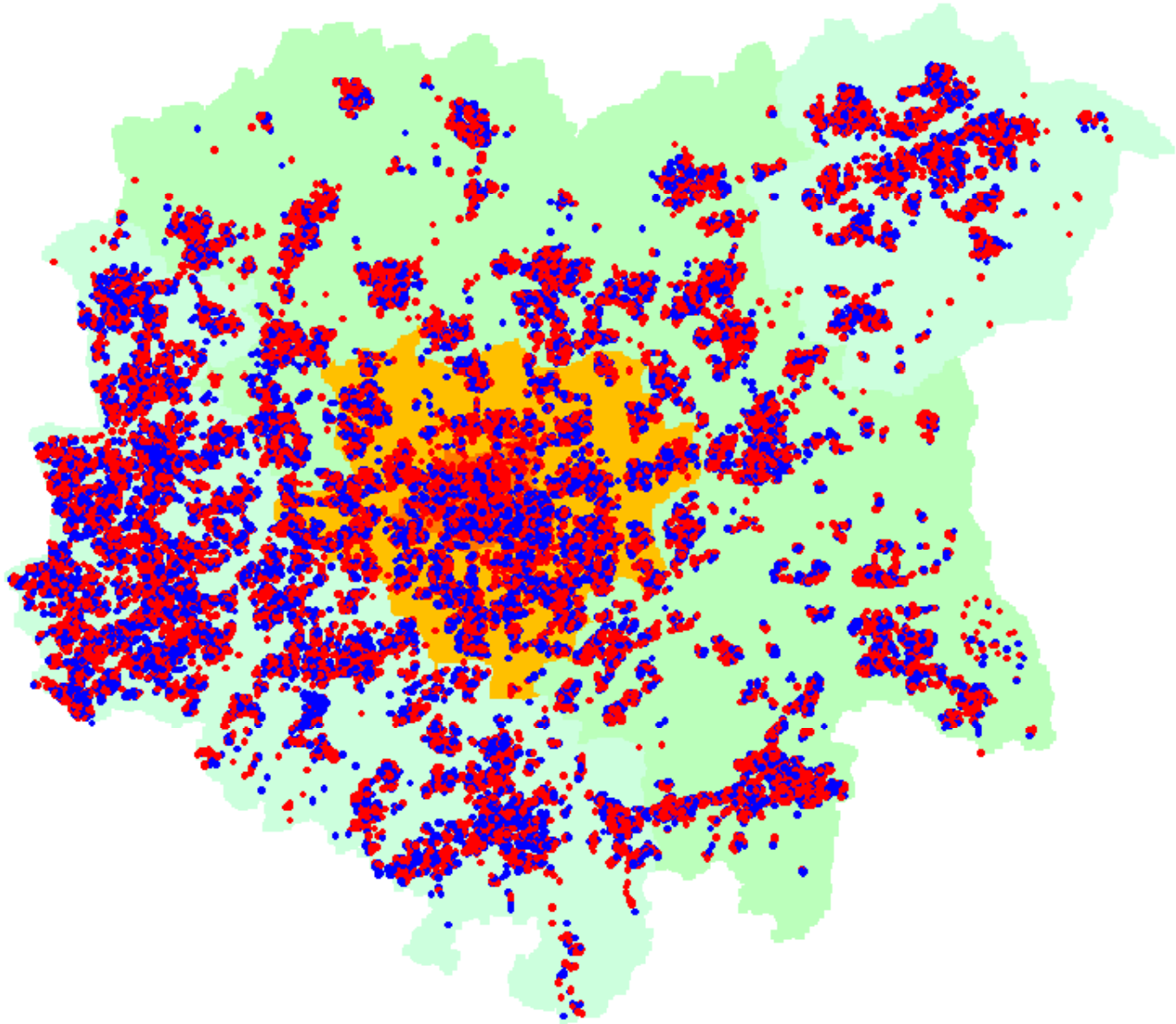
- *Births*
- *Deaths*

Households



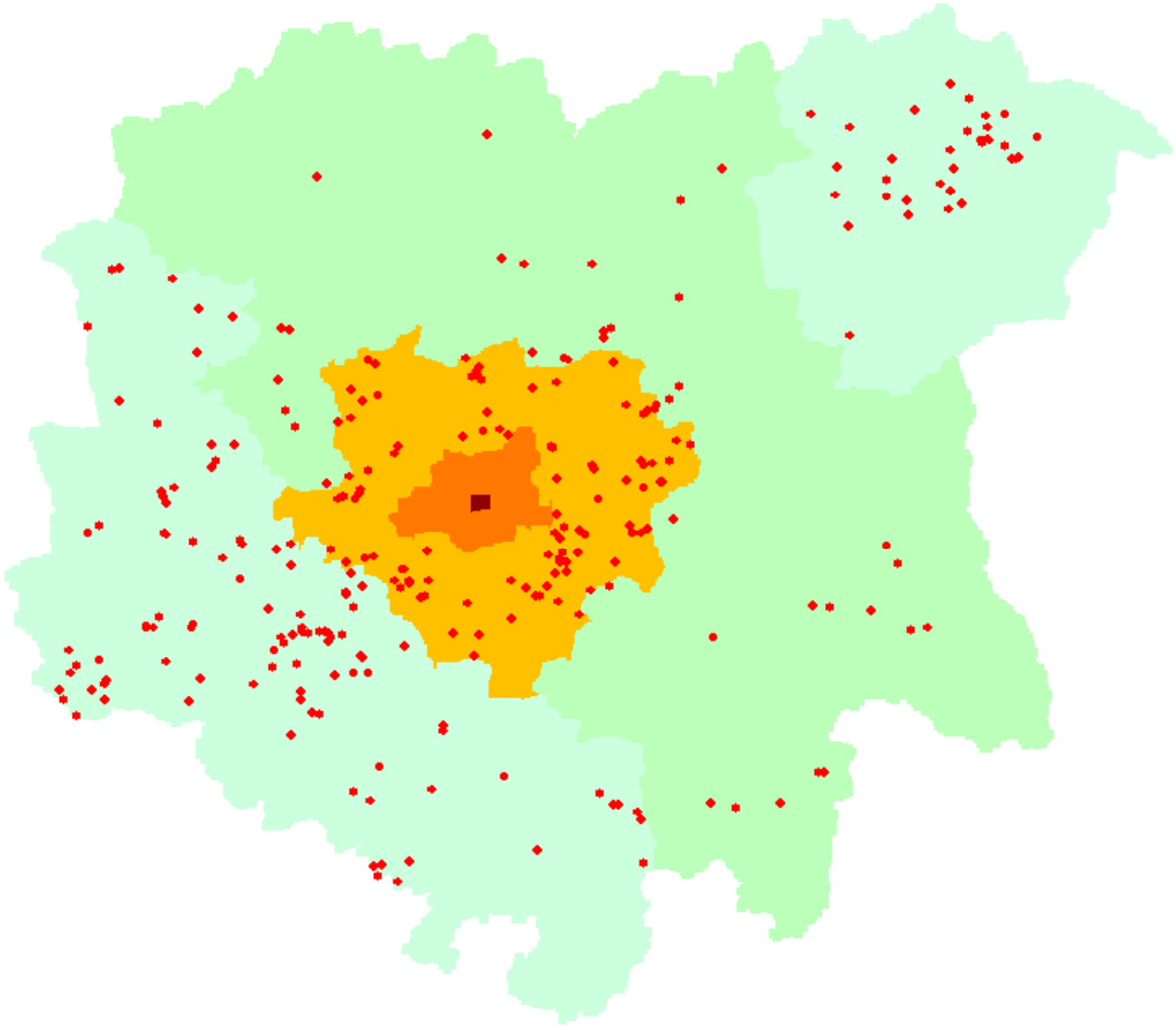
- *Births*
- *Deaths*

Households



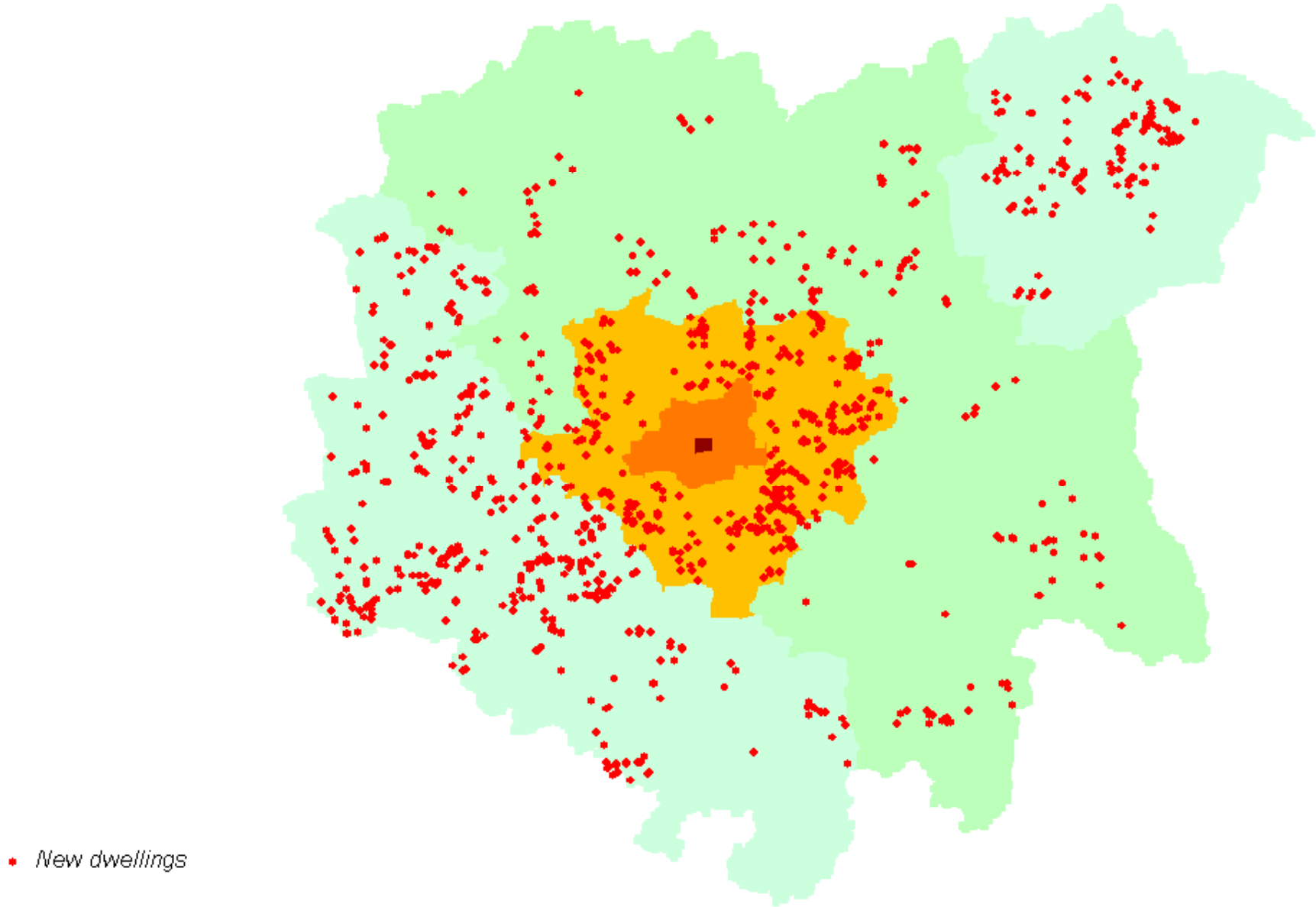
- *Births*
- *Deaths*

Dwellings

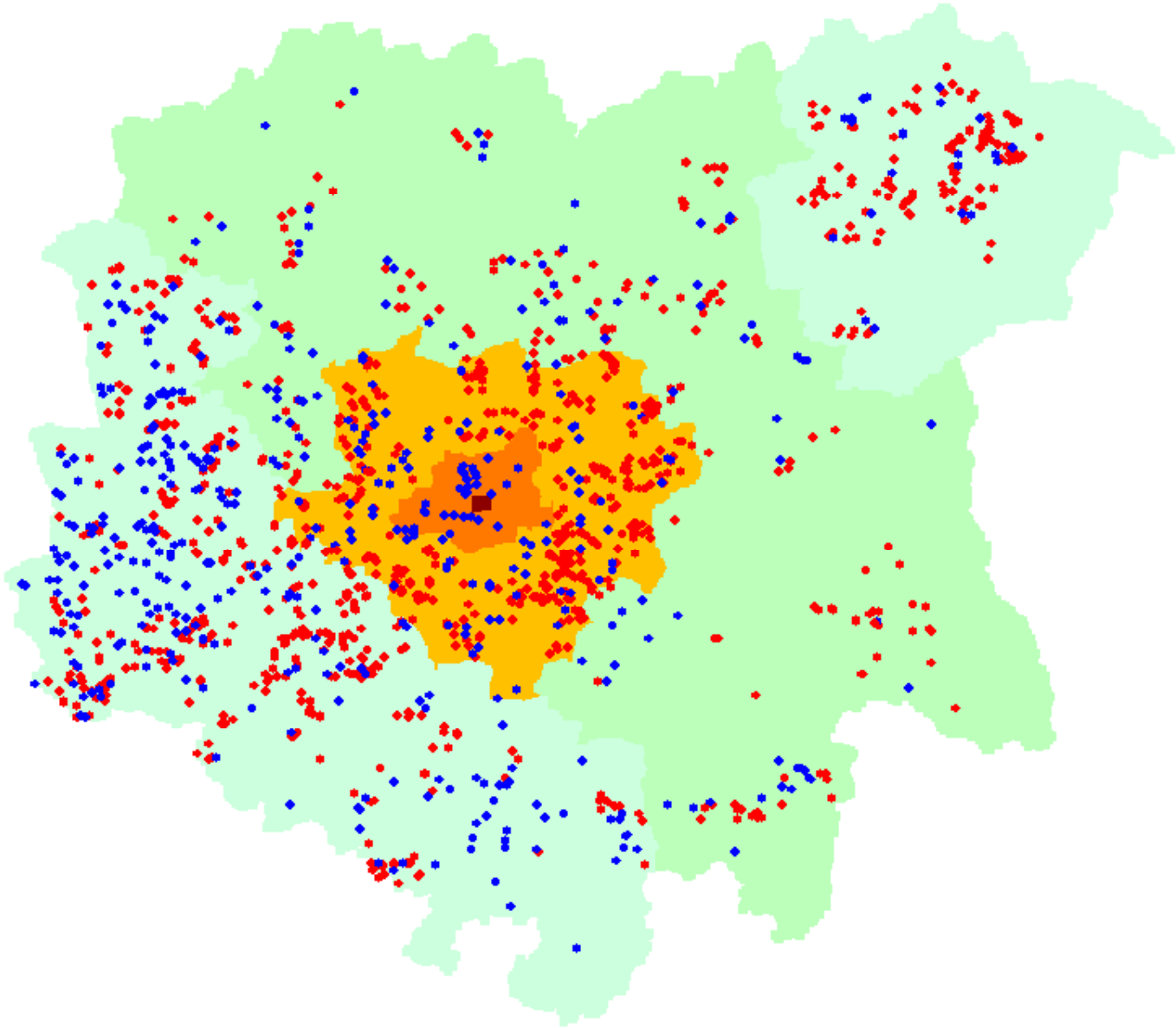


New dwellings

Dwellings

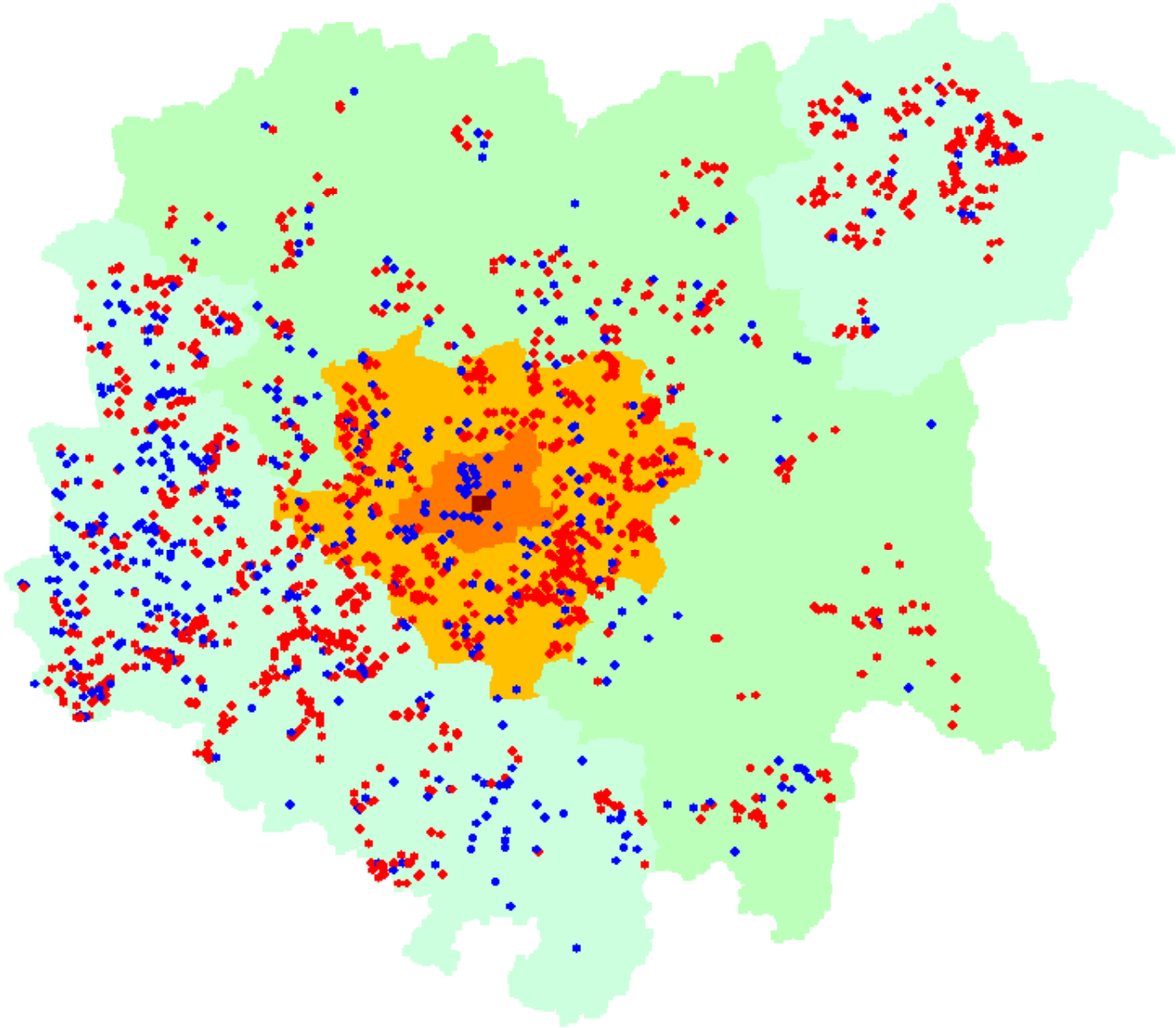


Dwellings



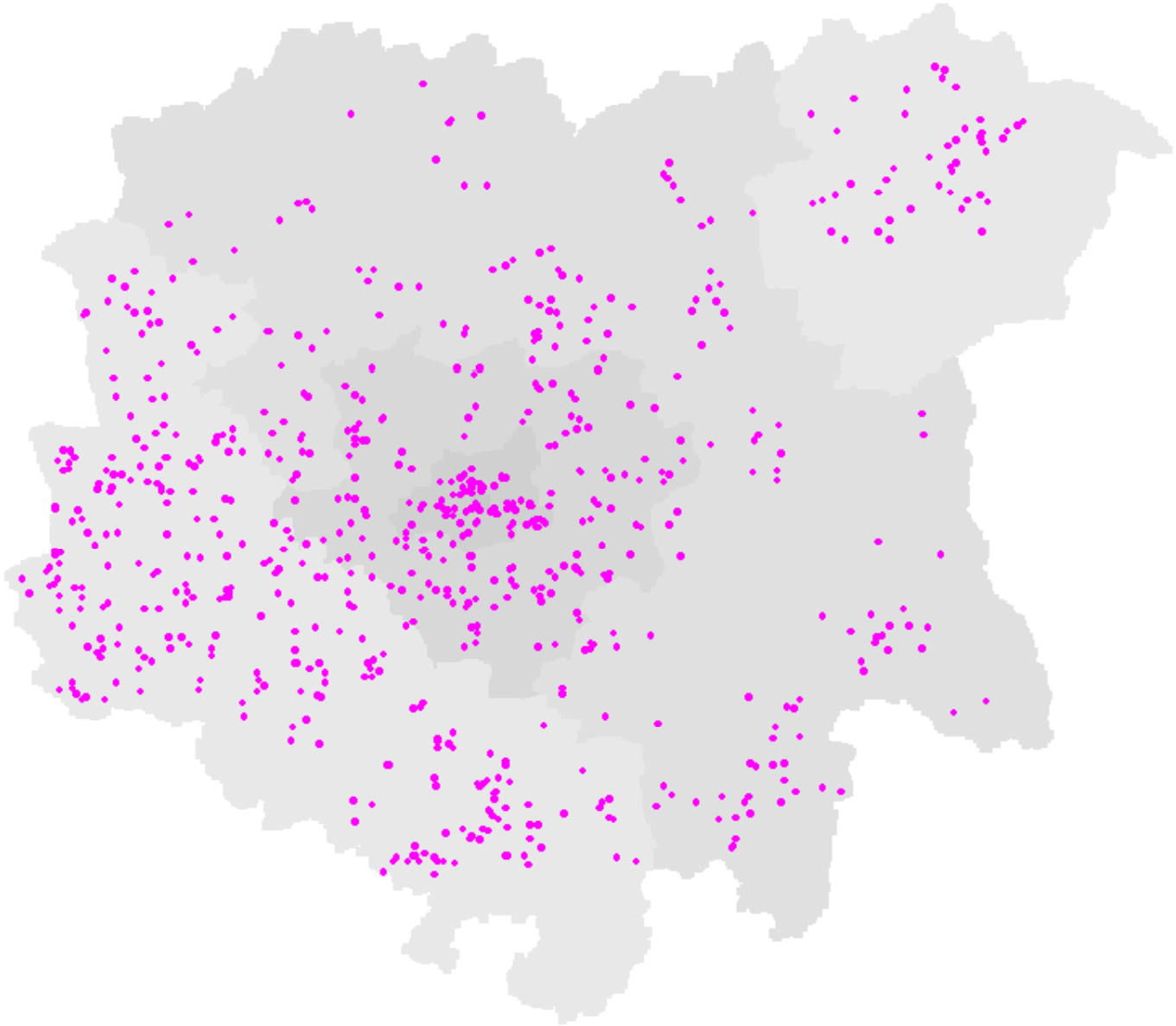
- *Demolitions*
- *New dwellings*

Dwellings



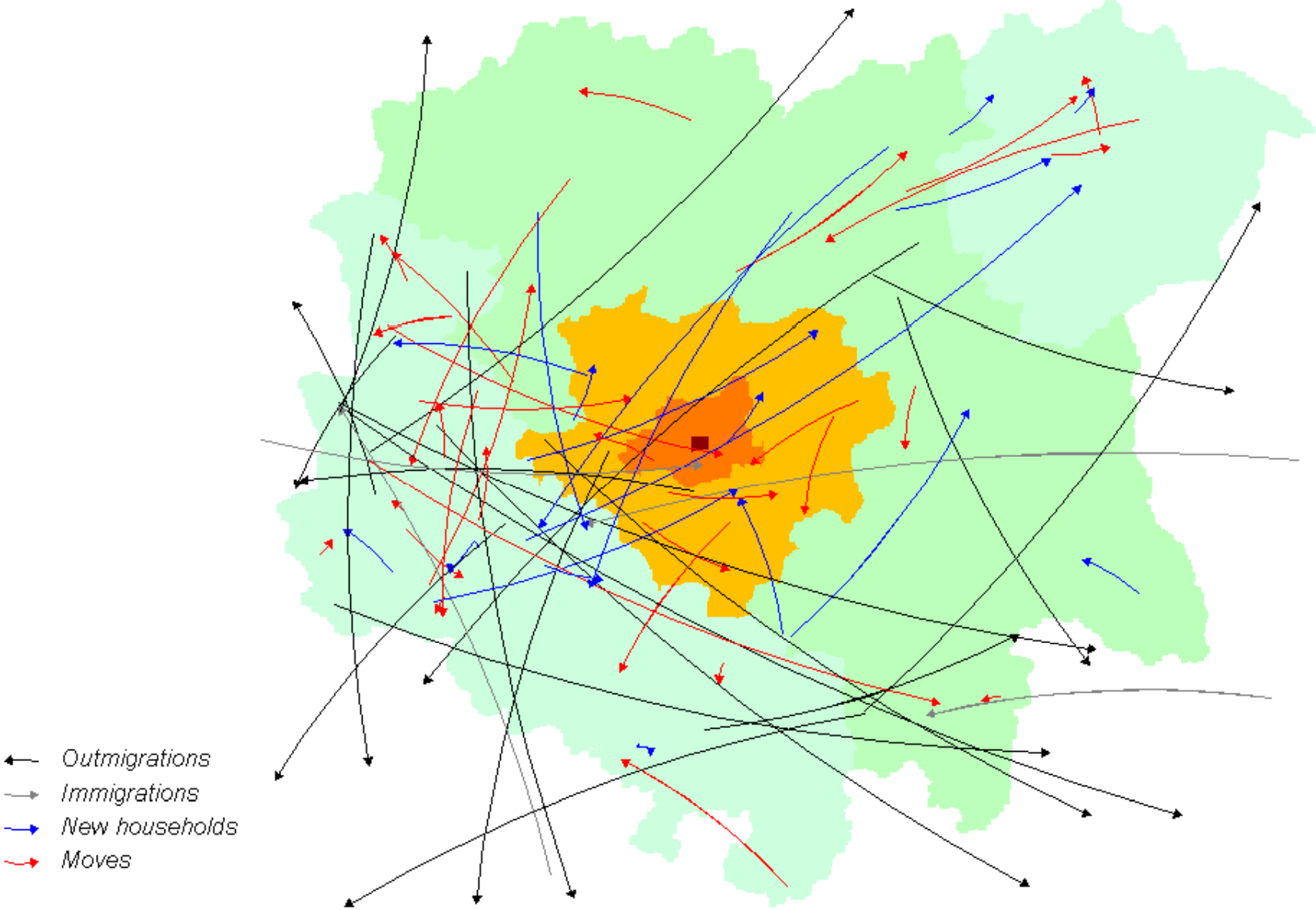
- *Demolitions*
- *New dwellings*

Vacant dwellings

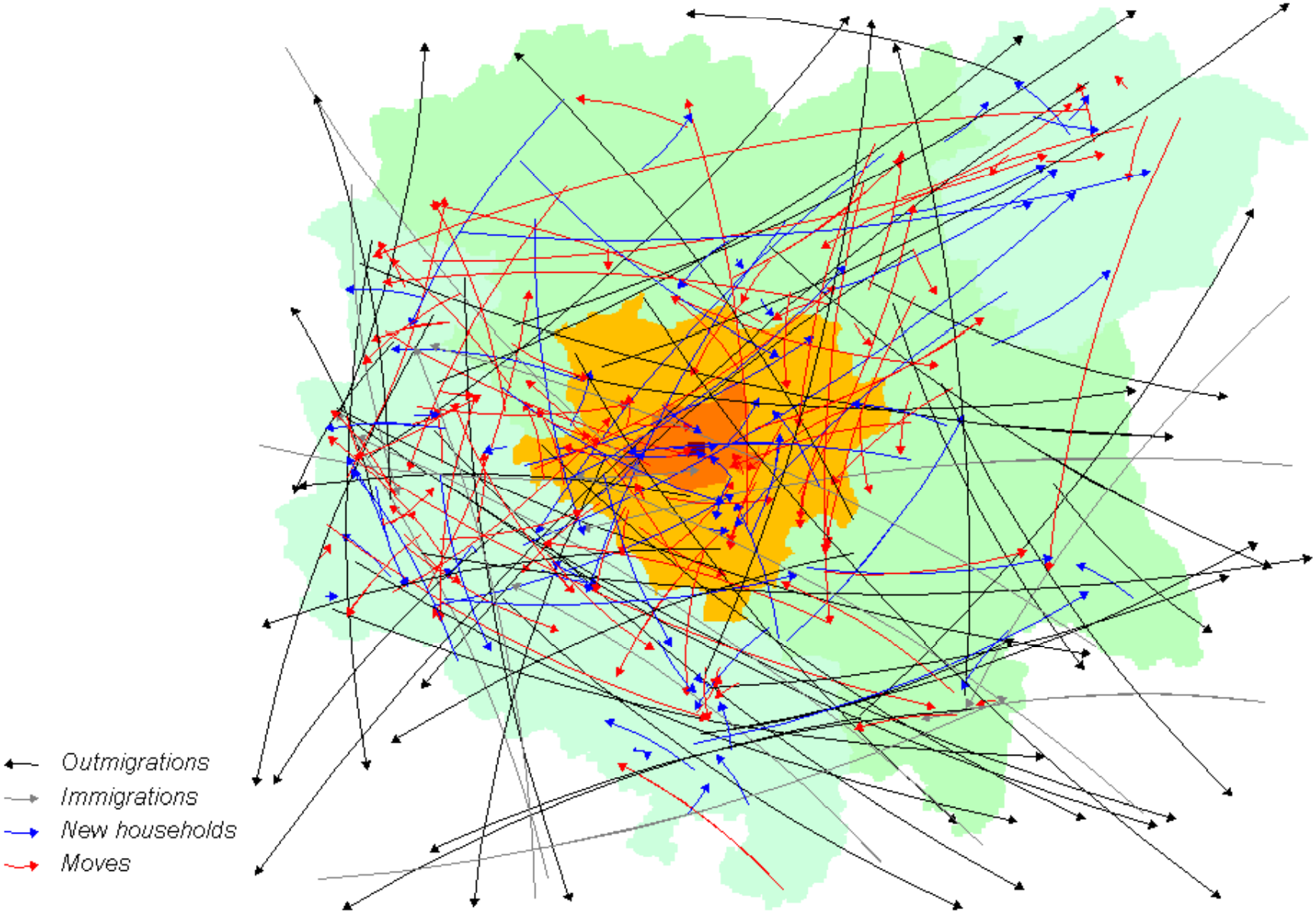


Vacant dwellings

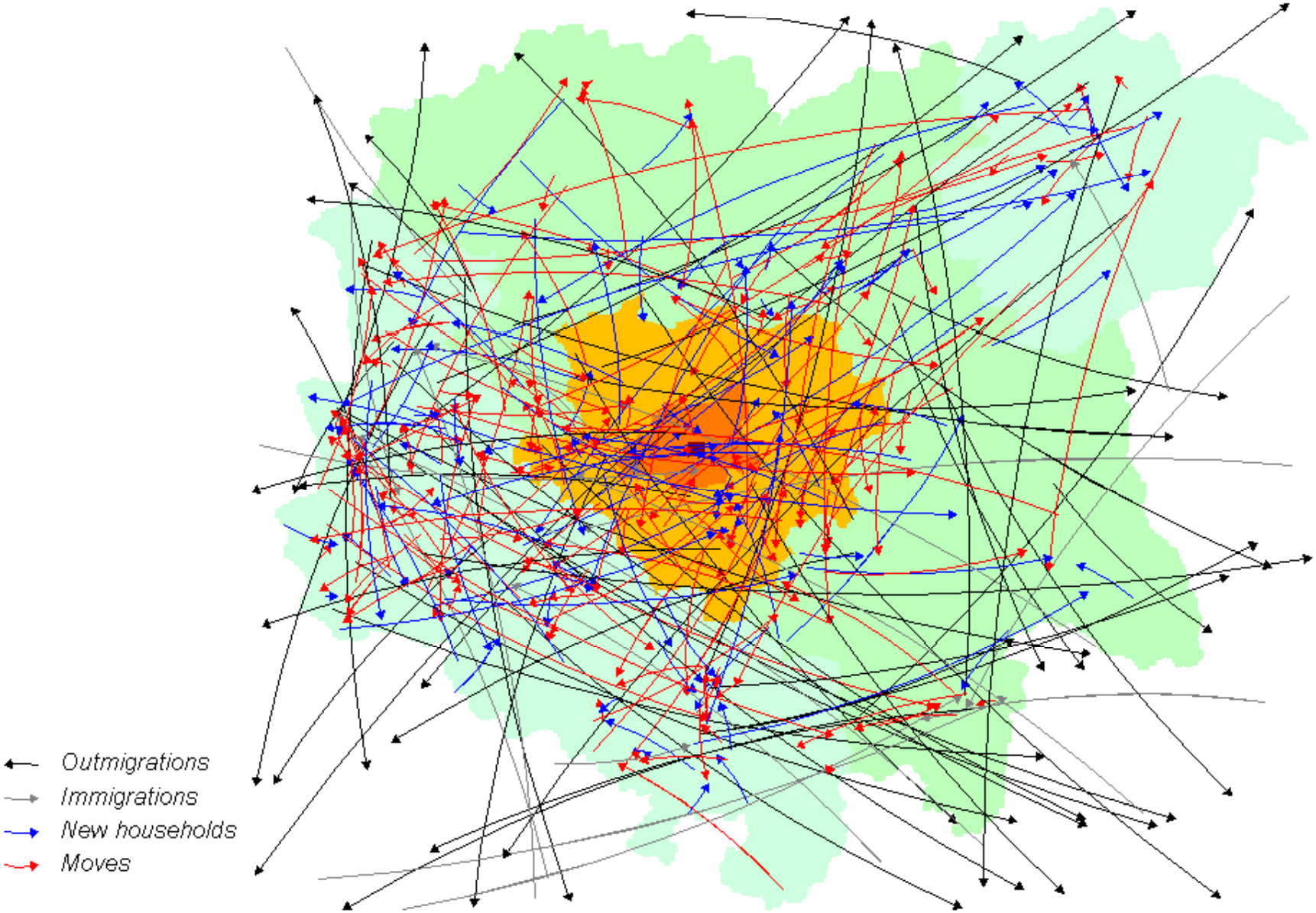
Moves



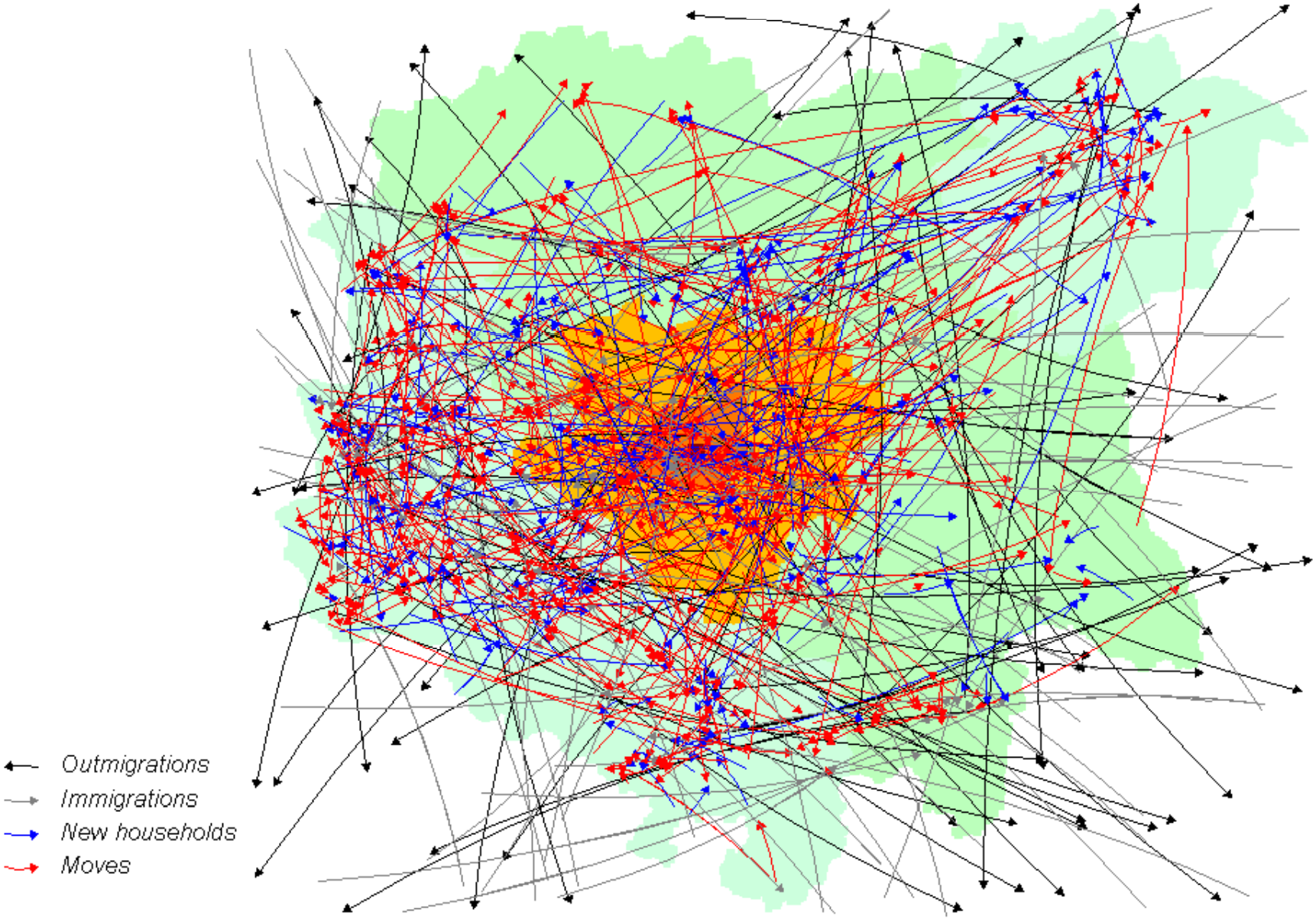
Moves



Moves

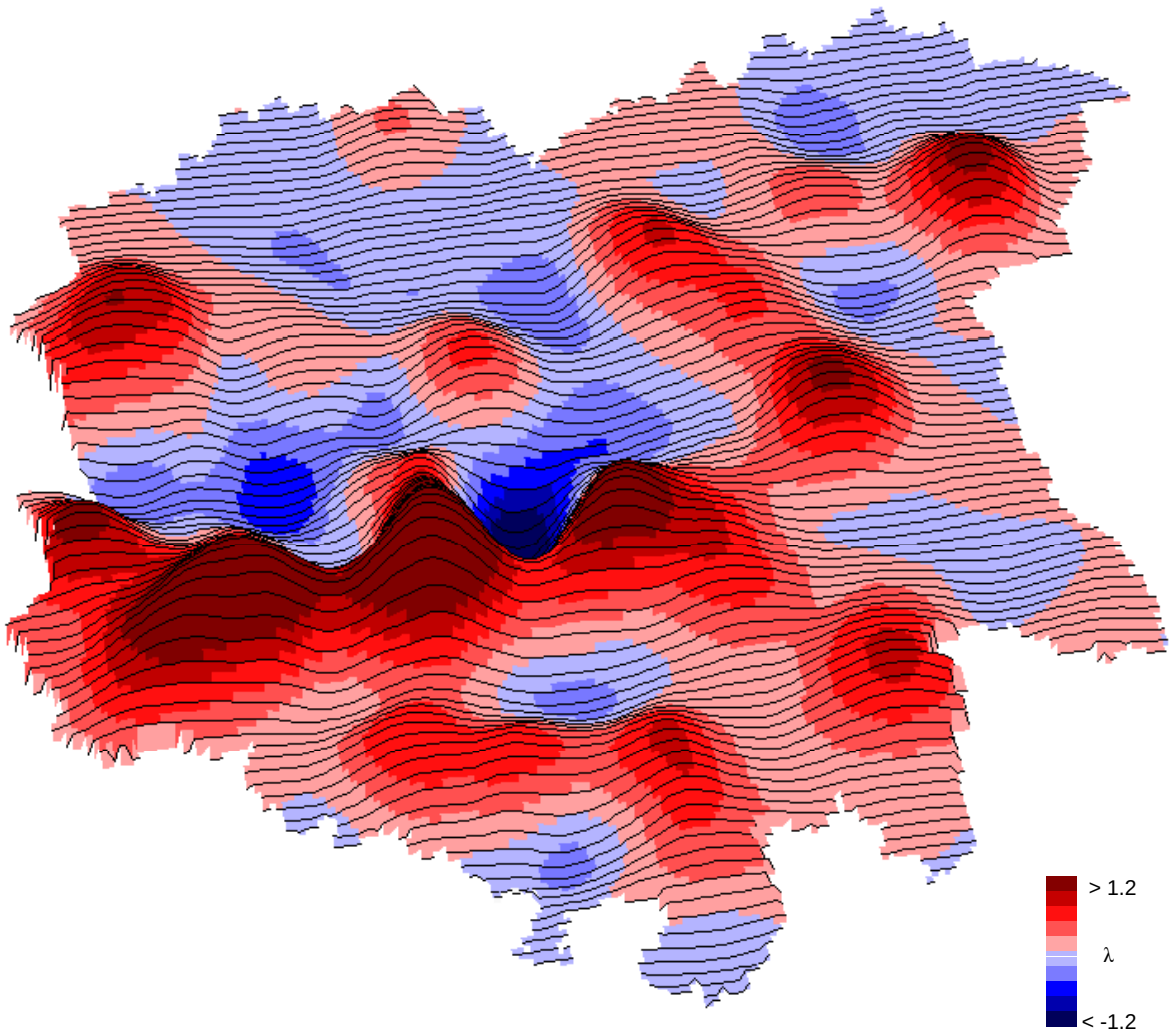


Moves



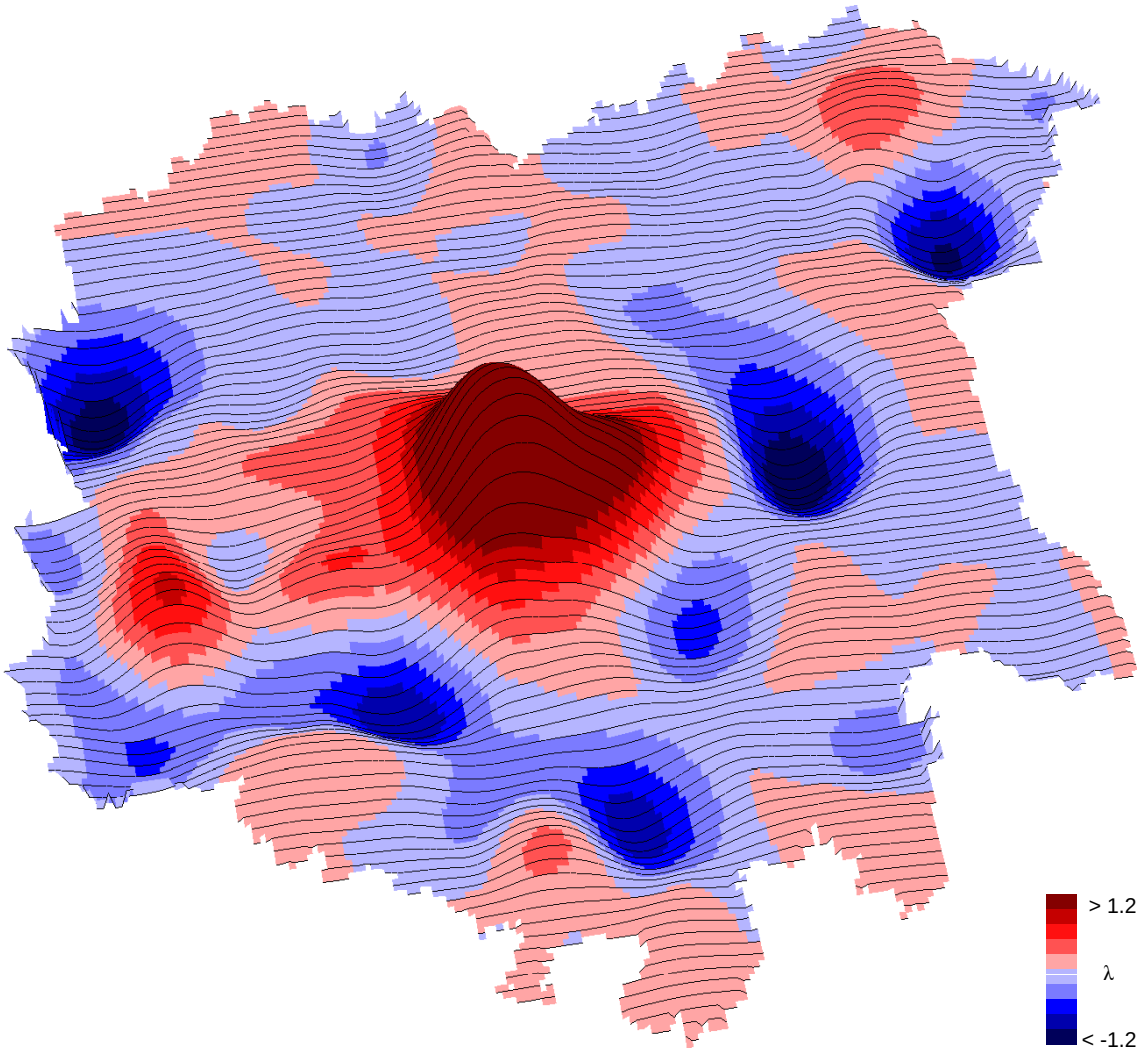
Base Scenario

Total Employment (2000 to 2030)



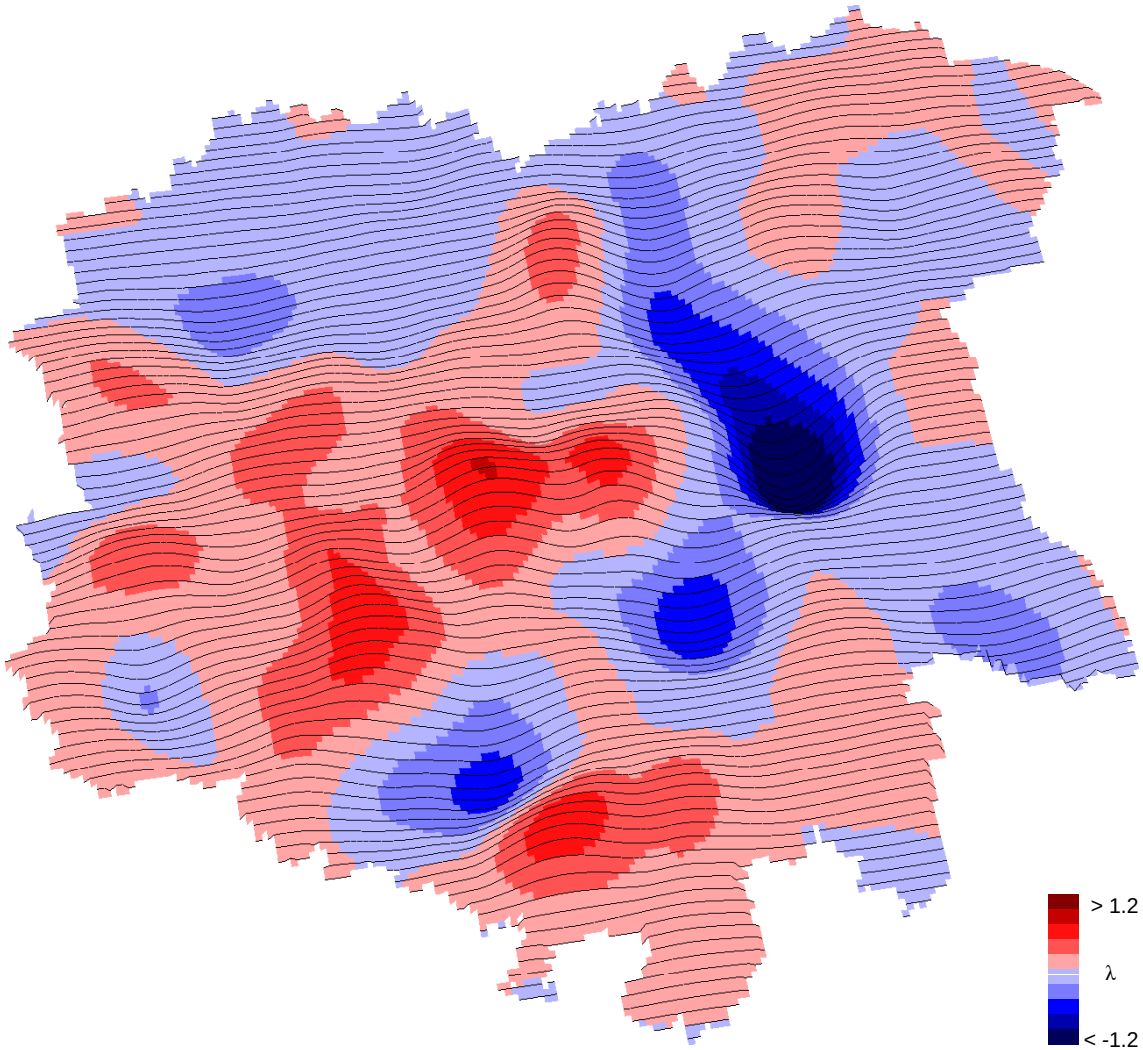
Compact City Scenario

Total Employment



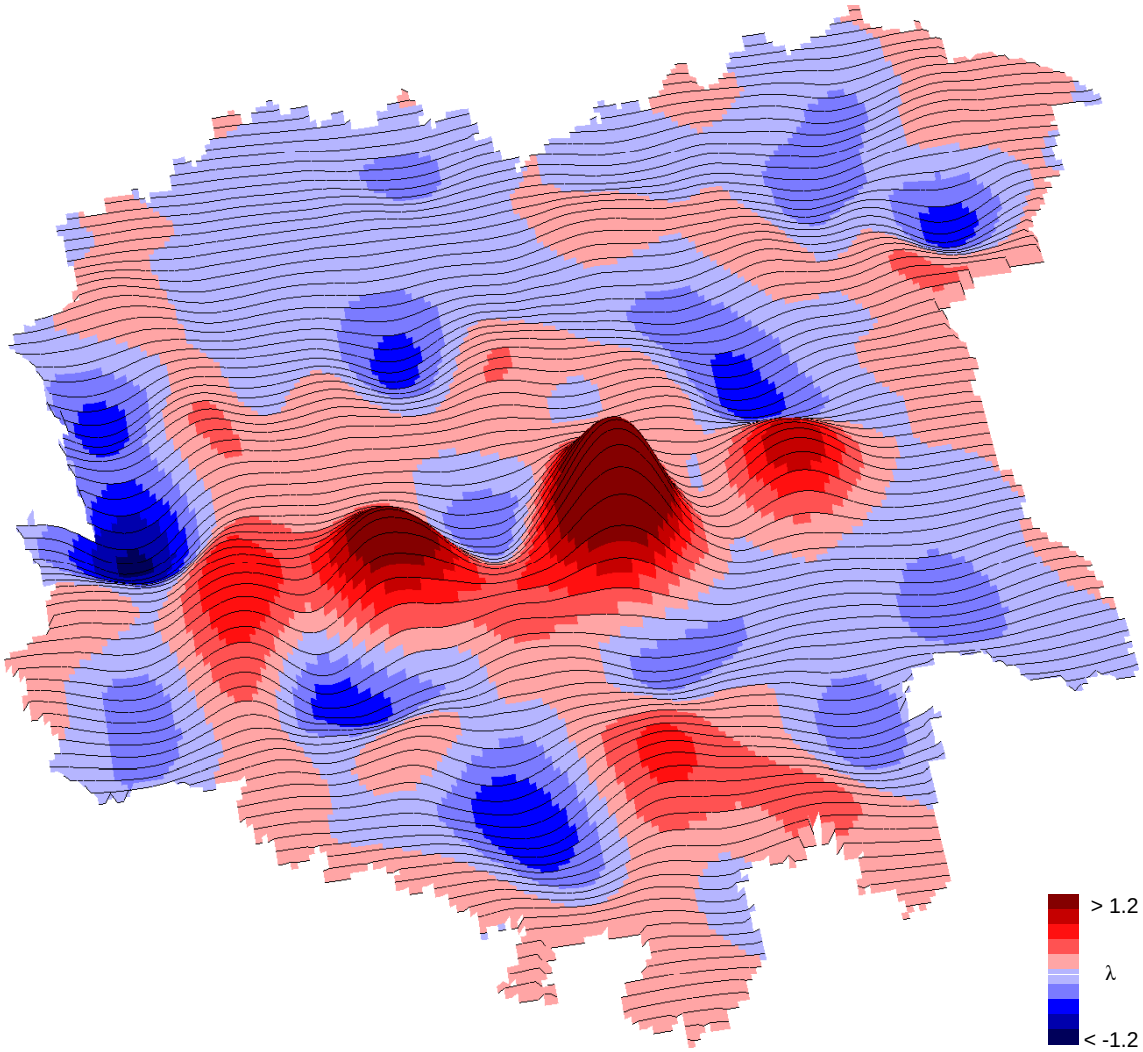
Decentralized Concentration Scenario

Total Employment



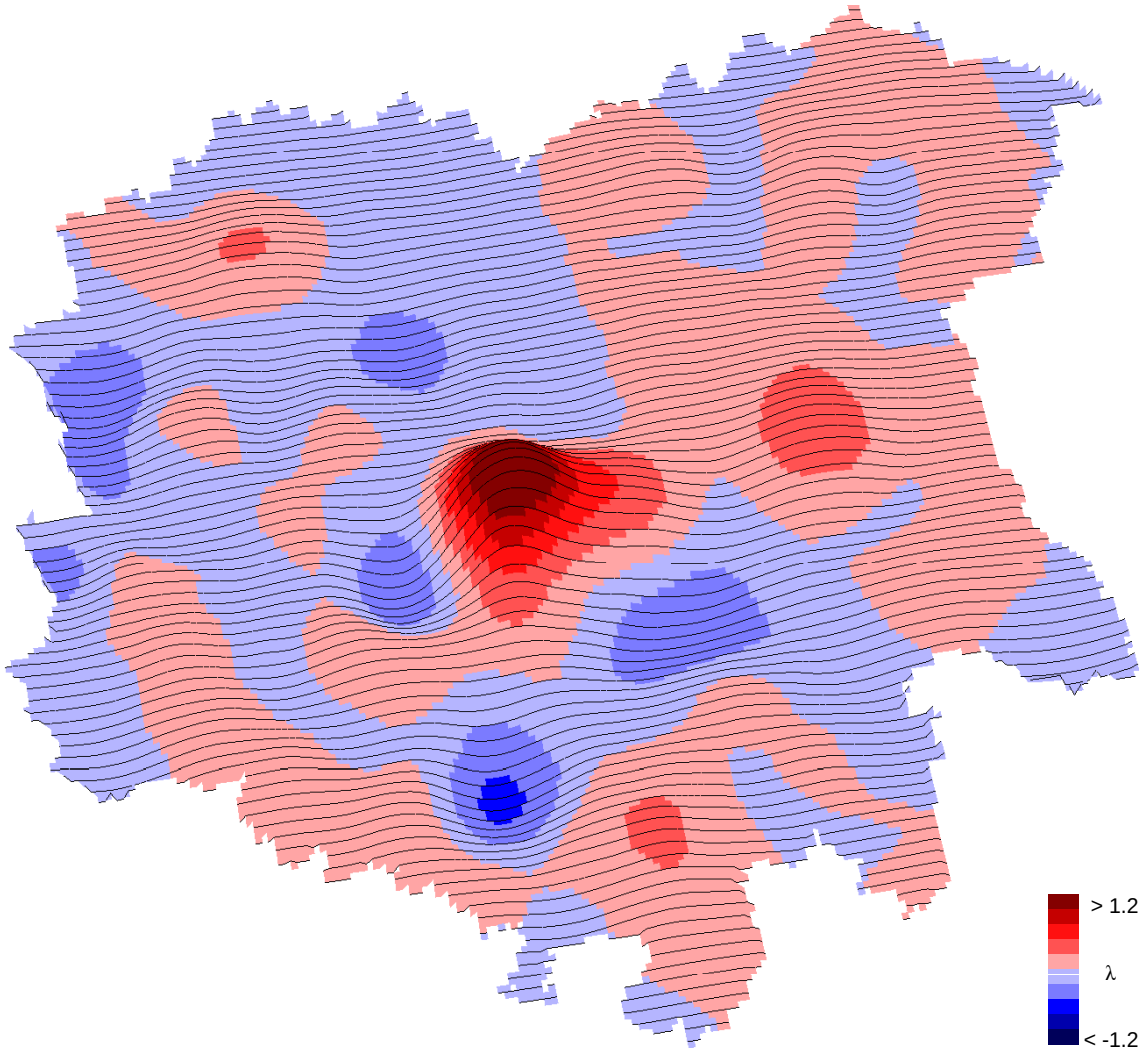
Everything Goes Scenario

Total Employment



Regional Cooperation Scenario

Total Employment



(a) Land Use & Transportation

(b) Integrated Modeling

(c) Example 1: SEAM

(d) Example 2: ILUMASS

(e) Conclusions

Conclusions, or what is the right model?

Under constraints of ***data collection*** and of ***computing time***, there is for each planning problem an optimum level of ***conceptual***, ***spatial*** and ***temporal*** resolution.

This suggests to work with balanced ***multi-scale models*** which are as ***complex*** as necessary for the planning task at hand and as ***simple*** as possible but no simpler.

Future urban models will be ***modular*** and ***multi-scale*** in ***scope***, ***space*** and ***time***.