Spatial analysis of residential development processes
uncovering the Dutch densification potential

Jip Claassens & Eric Koomen
RSA winter conference, London, UK
16 November, 2018

SPIN LAB
SPATIAL INFORMATION LABORATORY

VU VRIJE UNIVERSITEIT AMSTERDAM

Faculteit der Economische Wetenschappen en Bedrijfskunde

Context

- Dutch urban areas are rapidly transforming
  - Urban expansion and densification coincide (Broitman & Koomen, 2005)

- Urban growth projected to continue
  - Around 1 million additional houses by 2050 (7.5 million now) according to PBL (2016)
  - Heated debate in planning and building communities
  - Expand on greenfields or densify within existing urban contours?

- To inform this debate we study developments since 2000
  - How many houses have been built?
  - Where were those houses built?
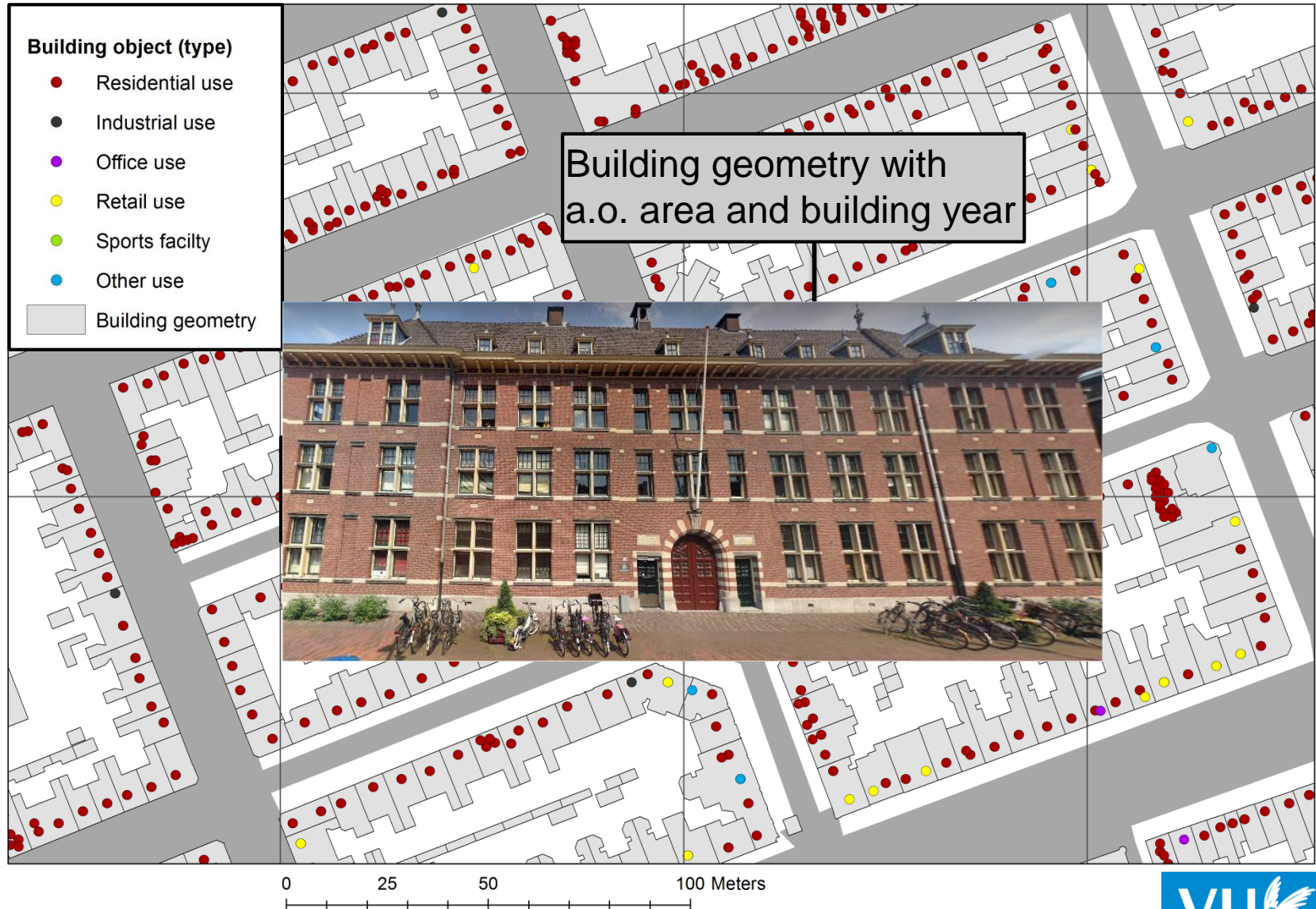 - Why were they built there?
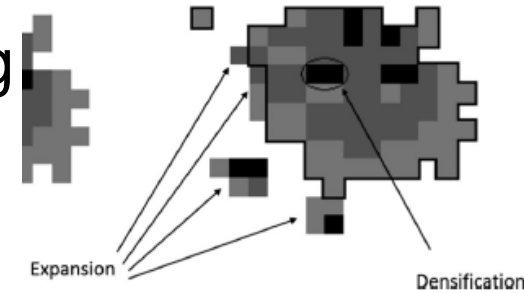
Housing development processes
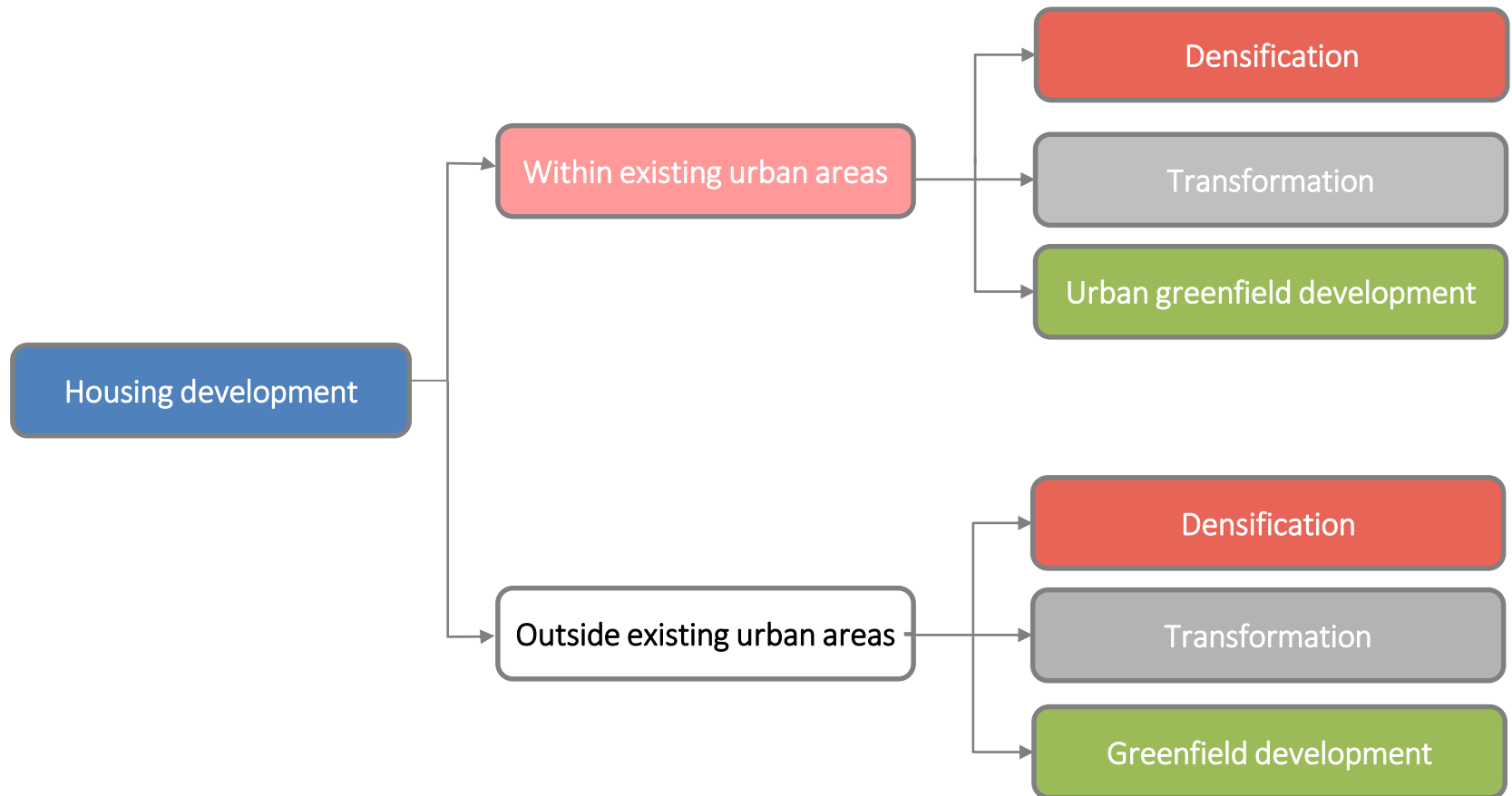
Data

- Housing density
  - Housing units per hectare (100m grids)
  - First source: Central Bureau of Statistics for 2000-2012, per grid cell, multiples of 5 units
  - Second source: basic registration buildings (Cadastral data) for 2012-2017 with building year and type, own aggregation
  - Matches official national statistics
  - Three periods of six-year each: 2000-05, 2006-11, 2012-17

Basic registration buildings

Building object (type)
- Residential use
- Industrial use
- Office use
- Retail use
- Sports facilty
- Other use
- Building geometry

Building geometry with a.o. area and building year

0   25   50   100 Meters
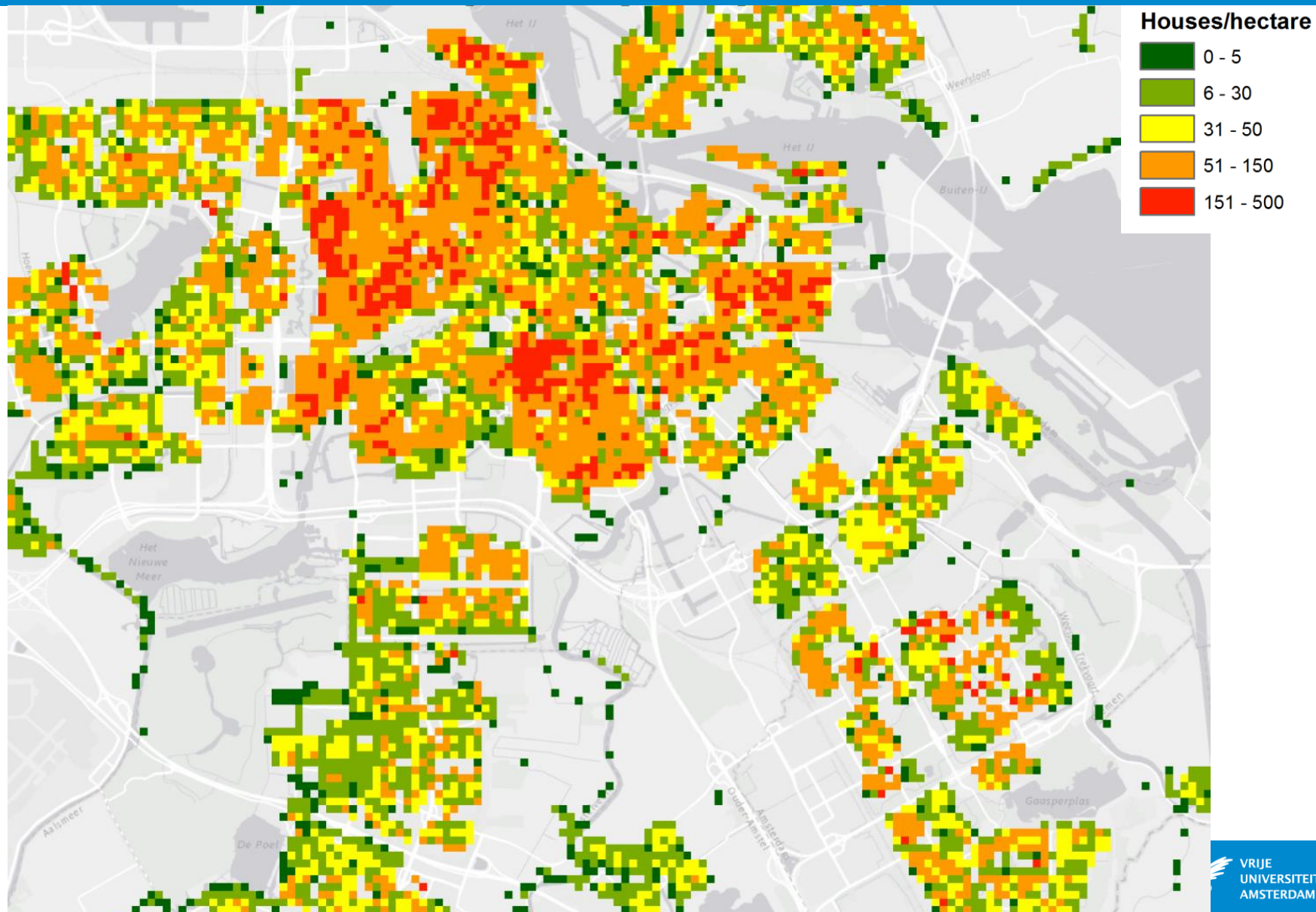
Data

- Spatial context
  - built-up areas contours (Ministry VROM, 2000)
  - land use before housing development (CBS, 2000 or earlier for building lots) -> 44 types of use aggregated into: predominantly residential, other built-up and green types of use

Number of houses in 2000

Houses/hectare
- 0 – 5
- 6 – 30
- 31 – 50
- 51 – 150
- 151 – 500

Number of houses in 2006

Houses/hectare
- 0 - 5
- 6 - 30
- 31 - 50
- 51 - 150
- 151 - 500

VRIJE
UNIVERSITEIT
AMSTERDAM
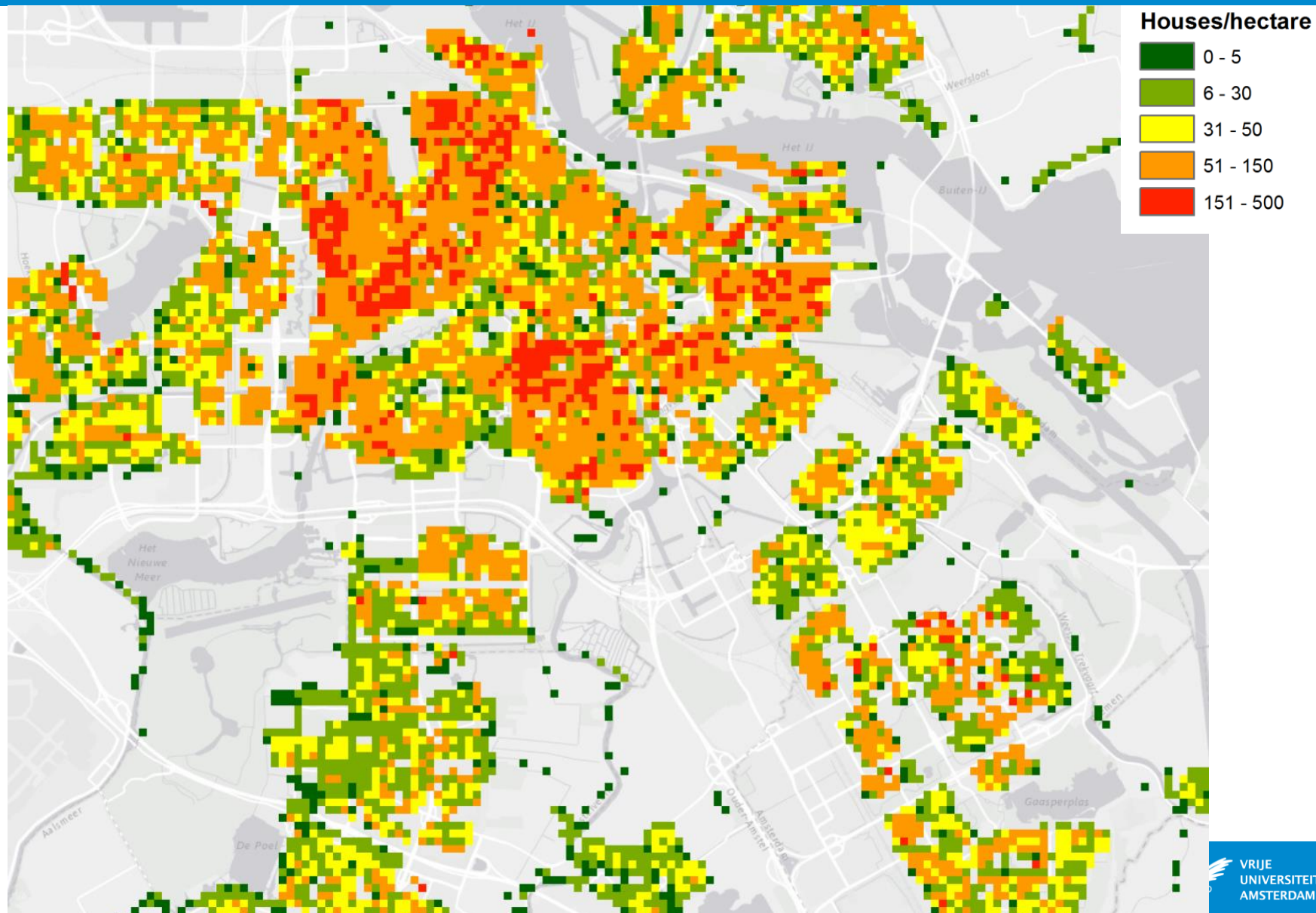
Housing density change 2000 - 2006

Houses/hectare

- ■ -220 – -20
- ■ -19 – -5
- ■ -5 – 0
- □ 0
- ■ 1 – 5
- ■ 6 – 20
- ■ 21 – 290

VRIJE
UNIVERSITEIT
AMSTERDAM
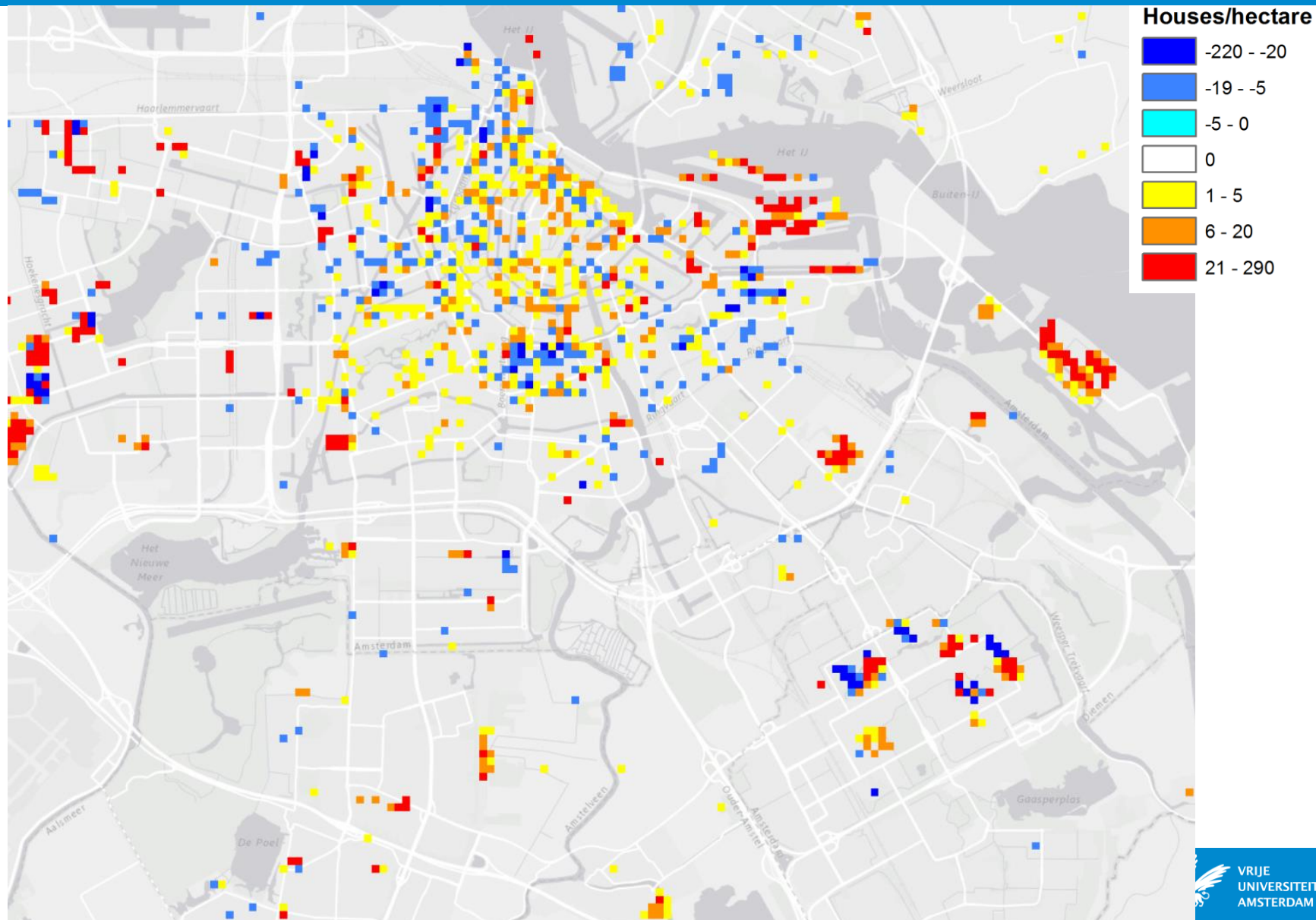
Change related to urban contours 2000
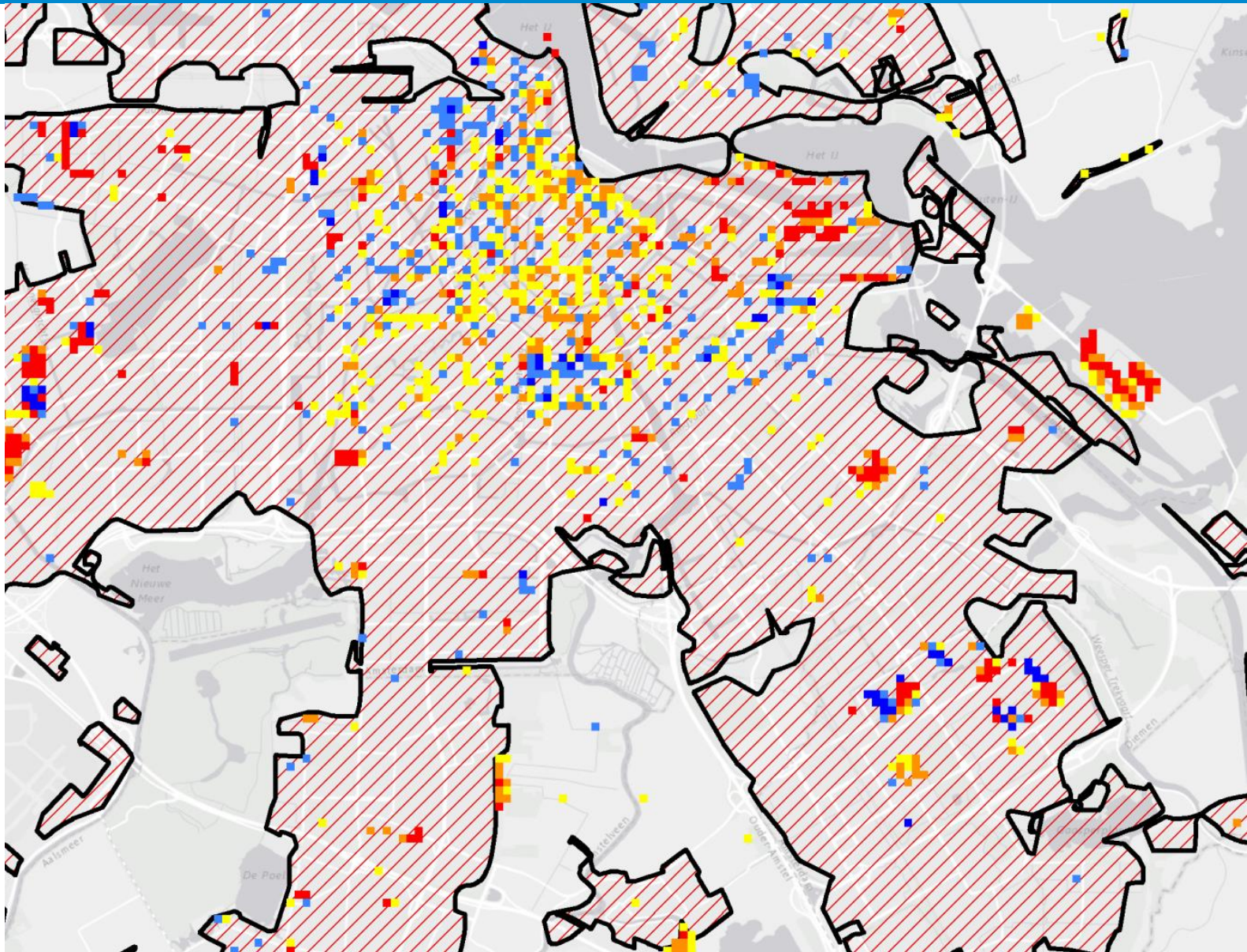
Change related to land use

	Densification
	Transformation
	Greenfield development

National results

2000-2005	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	79,790	42.3%	25%
		Transformation	44,140		14%
		Urban Greenfield	12,590		4%
	Outside Urban Area	Densification	16,775	57.7%	5%
		Transformation	29,190		9%
		Greenfield	140,305		43%

2006-2011	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	74,050	47.1%	21%
		Transformation	68,160		20%
		Urban Greenfield	21,660		6%
	Outside Urban Area	Densification	3,275	52.9%	1%
		Transformation	22,610		6%
		Greenfield	158,145		45%

2012-2017	Urban	Type	Houses	Share Urban	Share Type
BAG	Urban Area	Densification	98,741	66.9%	28%
		Transformation	113,867		32%
		Urban Greenfield	23,390		7%
	Outside Urban Area	Densification	1,204	33.1%	0%
		Transformation	4,462		1%
		Greenfield	110,006		31%

Part of the housing units included in the BAG data (last period) was actually finalised prior to 2012. These late additions are an integral part of the data and reflect Cadastre's delay in registering new houses and correcting older housing stock developments. It is not possible to consistently correct this issue, but it seems that this affects housing units both within and outside urban areas

National results

2000-2005	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	79,790	42.3%	25%
		Transformation	44,140		14%
		Urban Greenfield	12,590		4%
	Outside Urban Area	Densification	16,775	57.7%	5%
		Transformation	29,190		9%
		Greenfield	140,305		43%

2006-2011	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	74,050	47.1%	21%
		Transformation	68,160		20%
		Urban Greenfield	21,660		6%
	Outside Urban Area	Densification	3,275	52.9%	1%
		Transformation	22,610		6%
		Greenfield	158,145		45%

2012-2017	Urban	Type	Houses	Share Urban	Share Type
BAG	Urban Area	Densification	98,741	66.9%	28%
		Transformation	113,867		32%
		Urban Greenfield	23,390		7%
	Outside Urban Area	Densification	1,204	33.1%	0%
		Transformation	4,462		1%
		Greenfield	110,006		31%

Share of development within existing urban contour increases

A recent analysis of CBS that incorporates additional building specific data assumes that around 26,000 housing units may have been added by transformation between 2012 and *2015*.

National results

2000-2005	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	79,790	42.3%	25%
		Transformation	44,140		14%
		Urban Greenfield	12,590		4%
	Outside Urban Area	Densification	16,775	57.7%	5%
		Transformation	29,190		9%
		Greenfield	140,305		43%

Three (out of six) processes dominate

2006-2011	Urban	Type	Houses	Share Urban	Share Type
CBS	Urban Area	Densification	74,050	47.1%	21%
		Transformation	68,160		20%
		Urban Greenfield	21,660		6%
	Outside Urban Area	Densification	3,275	52.9%	1%
		Transformation	22,610		6%
		Greenfield	158,145		45%

2012-2017	Urban	Type	Houses	Share Urban	Share Type
BAG	Urban Area	Densification	98,741	66.9%	28%
		Transformation	113,867		32%
		Urban Greenfield	23,390		7%
	Outside Urban Area	Densification	1,204	33.1%	0%
		Transformation	4,462		1%
		Greenfield	110,006		31%

Share greenfield development decreases

Why were housing units built there?

- Two-step approach applied on 3 main processes:
  1. What is the probability of a cell being intensified?
     - Binomial logistic regression analysis
     - Dependent variable = cell intensified? (0/1)
  2. What explains the amount of intensification?
     - Linear regression analysis
     - Dependent variable = ln(amount of additional houses in cell)
     - separate analyses for three most important processes (urban densification, transformation, greenfield development)
  - Both using same set of spatially explicit variables
    - spatial policies, economic factors (accessibility) and land use

Results – Urban densification

Variables	Development present			Ln of amount of intensification		
	(1)	(2)	(3)	(4)	(5)	(6)
	2000-2005	2006-2011	2012-2017	2000-2005	2006-2011	2012-2017
Residential development zone present	2.301***	0.270**	-0.690***	0.179***	-0.194***	-0.243***
Bundling zone present	-0.256***	-0.062**	-0.090***	0.022	0.029	0.032
Designated natural area present	-0.582			-0.519***		
Deprived neighbourhood present	0.671***	0.415***	0.418***	0.411***	0.372***	0.331***
Network distance to nearest railway station (in min)	0.008***	-0.001	-0.000	-0.003**	-0.004***	-0.001
Ln network distance to nearest 100.000^{th} inhabitant (in min)	-0.150***	-0.193***	-0.268***	-0.114***	-0.099***	-0.124***
Urban Attractivity Index	3.315***	2.679***	3.751***	0.160**	-0.413***	0.487***
Housing density in 2000 (as fraction of max. value)	-10.26***	-1.209***	0.879***	-3.083***	-0.244	-0.066
Heterogeneous building year present	0.889***	1.523***	0.544***	-0.284***	-0.220***	-0.336***
Ln of residual land price	0.156***	0.052***	-0.037*	0.090***	0.055***	0.018
Land use Diversity Index	0.973***	0.858***	1.658***	-0.325***	-0.003	0.262*
Share of green land use in cell	1.663***	0.716***	-0.126	-0.073	-0.286**	0.075
Share of residential land use in cell	2.669***	1.376***	2.208***	0.035	0.022	0.633***
Share of construction land use in cell	8.497***	4.802***	1.880***	0.810***	0.571**	1.700***
Share of other built-up land use in cell	2.454***	2.440***	3.092***	0.646***	0.452***	1.394***
Located within Randstad region	0.122***	0.023	0.131***	0.091***	0.024	0.001
Constant	-6.236***	-5.149***	-4.955***	2.340***	2.339***	0.798***
Observations	208.059	208.023	208.023	11.086	11.795	25.256
R-squared				0.143	0.063	0.055
Pseudo R^2	0.071	0.085	0.083			

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Results – Urban transformation

Variables	Development present			Ln of amount of intensification		
	(1)	(2)	(3)	(4)	(5)	(6)
	2000-2005	2006-2011	2012-2017	2000-2005	2006-2011	2012-2017
Residential development zone present	2.086***	0.489**	0.689***	0.020	0.005	0.173
Bundling zone present	-0.126**	-0.157***	0.111**	0.087**	0.027	0.039
Designated natural area present						
Deprived neighbourhood present	0.424***	0.503***	0.449***	0.373***	0.359***	0.335***
Network distance to nearest railway station (in min)	-0.001	-0.017***	-0.024***	-0.008***	-0.005**	-0.011***
Ln network distance to nearest 100.000th inhabitant (in min)	0.067	0.180***	0.178***	-0.153***	-0.202***	-0.260***
Urban Attractivity Index	2.609***	2.594***	3.330***	-0.287***	-0.414***	0.412***
Housing density in 2000 (as fraction of max. value)	-1.153**	1.157***	3.669***	-1.376***	-2.069***	-0.801**
Heterogeneous building year present	2.264***	2.043***	1.090***	-0.214***	-0.347***	-0.433***
Ln of residual land price	0.297***	0.208***	0.231***	0.021	0.097***	0.121***
Land use Diversity Index	0.977***	1.062***	1.514***	0.325***	0.155**	0.444***
Share of green land use in cell	1.259***	0.680***	0.358*	-0.429***	-0.202	-0.021
Share of residential land use in cell	2.085***	1.618***	2.051***	0.250*	0.193	0.545***
Share of construction land use in cell	5.021***	3.276***	1.813***	1.272***	0.677***	1.382***
Share of other built-up land use in cell	2.085***	1.891***	2.435***	0.533***	0.421***	0.969***
Located within Randstad region	-0.074	-0.097**	-0.042	0.128***	-0.056*	-0.023
Constant	-8.565***	-7.628***	-7.807***	2.292***	2.517***	0.963***
Observations	105,528	105,528	105,528	3,450	4,624	10,216
R-squared				0.148	0.115	0.093
Pseudo R^2	0.226	0.203	0.174			

Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Results – Greenfield development

Variables	Development present			Ln of amount of intensification		
	(1)	(2)	(3)	(4)	(5)	(6)
	2000-2005	2006-2011	2012-2017	2000-2005	2006-2011	2012-2017
Residential development zone present	3.886***	3.201***	2.242***	0.325***	0.208***	0.561***
Bundling zone present	0.228***	0.304***	0.046	-0.019	0.032*	0.102***
Designated natural area present	-2.918***	-2.992***	-3.550***	-0.191**	-0.256***	-0.440***
Deprived neighbourhood present	-0.858**	0.594***	-0.207	0.154	0.408***	0.071
Network distance to nearest railway station (in min)	-0.017***	-0.015***	-0.007**	-0.001	-0.000	0.008***
Ln network distance to nearest 100.000[th] inhabitant (in min)	-0.166***	-0.433***	-0.955***	-0.087***	-0.140***	-0.268***
Urban Attractivity Index	3.341***	4.312***	4.161***	0.776***	1.180***	2.071***
Housing density in 2000 (as fraction of max. value)	-92.74***	-64.48***	-0.568	-0.228	1.567	-0.390
Heterogeneous building year present	2.786***	3.027***	1.080***	-0.387***	-0.398***	-0.286***
Ln of residual land price	1.004***	0.853***	0.772***	0.166***	0.103***	0.248***
Land use Diversity Index	0.823***	0.183**	0.490***	-0.686***	-0.579***	-0.588***
Share of green land use in cell	2.775***	3.085***	2.954***	0.525***	0.511***	0.960***
Share of residential land use in cell	7.778***	6.035***	6.143***	0.985***	1.172***	2.267***
Share of construction land use in cell	9.449***	7.457***	5.091***	0.826***	1.026***	2.787***
Share of other built-up land use in cell	2.795***	3.937***	5.460***	0.828***	0.941***	1.871***
Located within Randstad region	-0.523***	-0.591***	-0.528***	0.100***	0.109***	-0.002
Constant	-12.60***	-10.84***	-8.677***	1.449***	1.849***	-0.342***
Observations	2,971,710	2,971,710	2,971,710	9,622	11,937	26,690
R-squared				0.357	0.260	0.198
Pseudo R^2	0.330	0.264	0.158			

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

VU / VRIJE UNIVERSITEIT AMSTERDAM

Conclusions - spatial analysis

- Almost 1 million housing units added in last 17 years in the Netherlands
- Densification (25%) and transformation (21%) accommodated almost half of this increase
- Remaining half added to green fields outside existing urban areas
- Only small proportion (5.5%) added on former green areas of cities
- Data does not show signs of crises or saturation of inner city development

VU | VRIJE UNIVERSITEIT AMSTERDAM

Conclusions - statistical analysis

- Explanatory power differs per process
- Strongly decreasing impact national planning (residential development zones , deprived neighbourhoods)
- Positive impact urban attractivity (facilities)
- Recent evidence for intensification in high density and more diverse areas
- From Government policy to consumer preference?

VU | VRIJE UNIVERSITEIT AMSTERDAM

Next steps

- Improve base data
  - derive transformation from cadastral data?
  - distinguish reconstruction and redevelopment
- Improve statistical analysis
  - Add building related characteristics (building year, house type, maintenance, private vs public, mixed ownership)
  - Correct for potential selection bias (Heckman selection model?)
  - Add spatial fixed effects?
- Simulate future developments
  - unravelling costs and benefits redevelopment