

Determinantes da expansão urbana dispersa na Área Metropolitana de Lisboa no período entre 1991 e 2011

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Objectivos

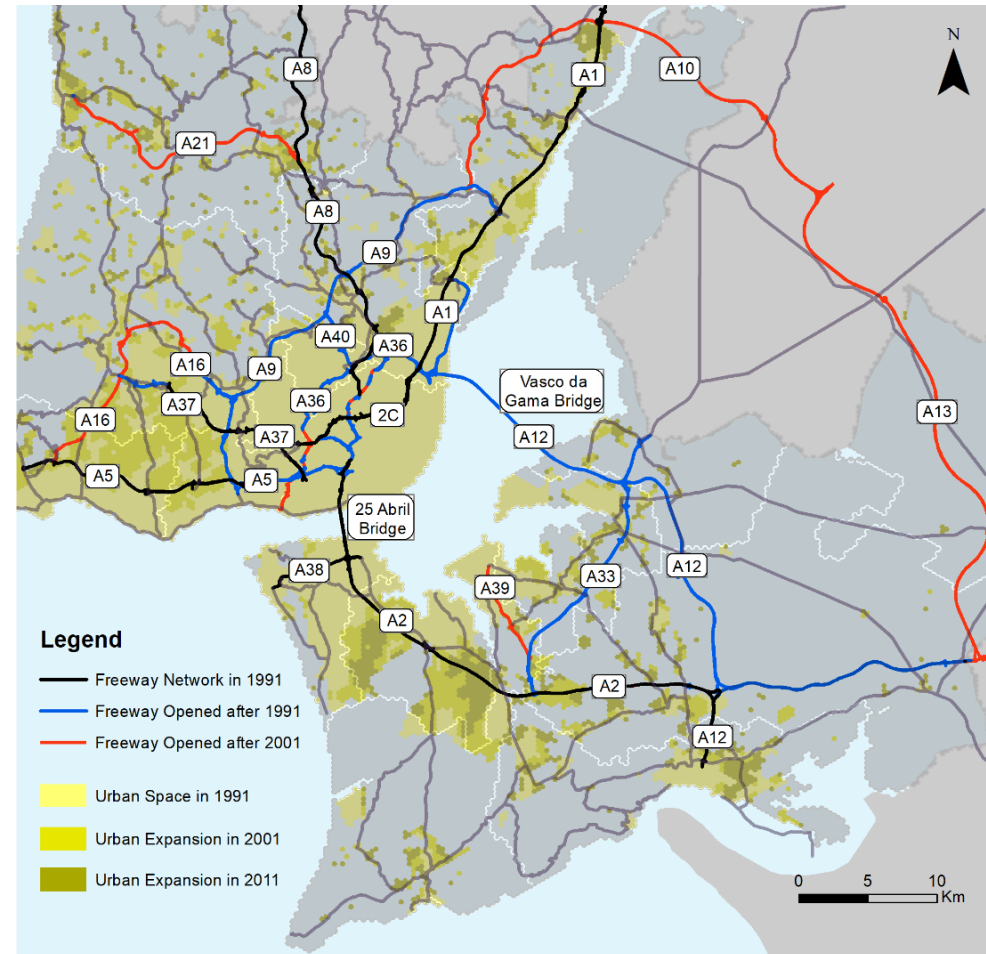
- **Medir os níveis de *Urban Sprawl* na AML**
 - Segregação de usos do solo (habitação, comércio e indústria)
 - Monofuncionalidade num território fragmentado e disperso
 - Ausência de planeamento urbano eficaz
 - Localização periférica
 - Dependência do automóvel e da rodovia
- Identificar as causas do Sprawl

AML

- 1/3 da População de Portugal Continental
- 36% do PIB

Variáveis analisadas

- Demografia e Socioeconomia
- Políticas e infraestruturas de Transportes
- Padrões de Commuting
- AUGIs
- Instrumentos de Planeamento



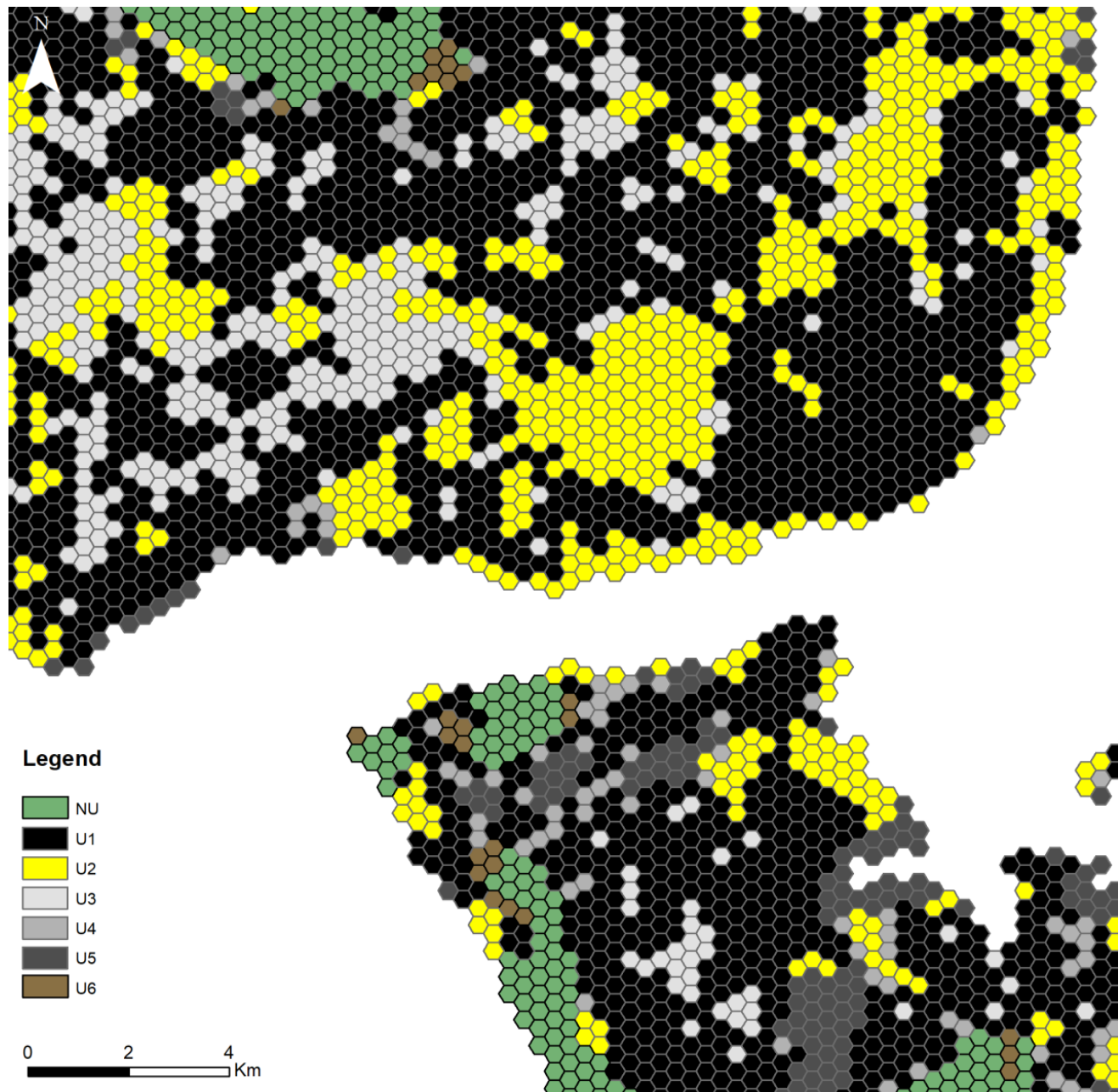
Medição do espaço urbano

- Subsecções urbanas – densidade populacional (2000 hab/km² or 350 fogos/km²)



- Incorporação de usos urbanos não residenciais – CLC (classificação 1.*)
- Rede hexagonal – melhores propriedades estatísticas
- Incorporação de vazios e áreas intersticiais a menos de 400 m das áreas urbanas existentes.

Medição do Espaço Urbano



Métodos (I)

- Classificação das diferentes células em diferentes classes - LCA (Latent Cluster Analysis) – classificar e determinar o número de classes

$$\prod_{i=1}^n \sum_{\kappa=1}^G \tau_{\kappa} \phi_{\kappa}(x_i | \mu_{\kappa}, \Sigma_{\kappa}) \quad \phi_{\kappa}(x_i | \mu_{\kappa}, \Sigma_{\kappa}) = (2\pi)^{-\frac{p}{2}} \exp \left\{ -\frac{1}{2} (x_i - \mu_{\kappa})^T \Sigma_{\kappa}^{-1} (x_i - \mu_{\kappa}) \right\}$$

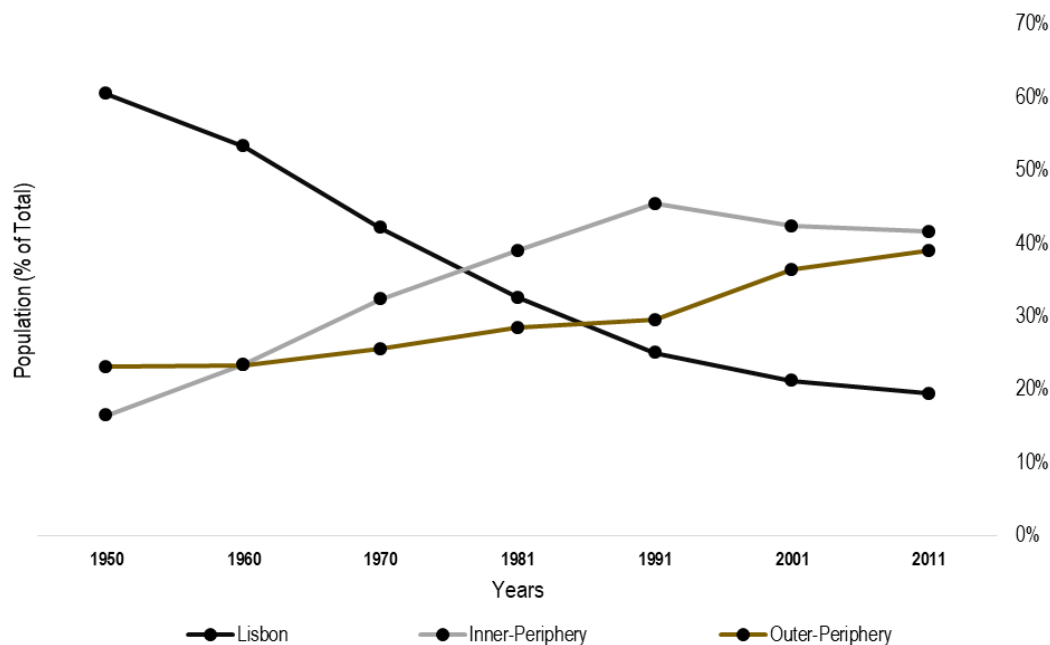
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|---|-------|--|
| • Low-density population | ————— | Density Population (DPKm ²) |
| • Mono-functional uses | ————— | Level of Multi-Use (CNERB) |
| • Fragmented and scattered across the territory | | |
| • Lack effective spatial planning | | |
| • Often located in the fringe of urban centers | < | Distance to the closest municipality center (RDistMun1) |
| • Development mainly projected around the car and roads | | Distance to the Lisbon Metropolitan Area CBD (RDistAMLCBD) |

Patterns of Sprawl (Land use classification)

Cell Type	Description	CNERB	DPKm ²	RDistMun1
1	Mono-use low-density residential areas far from the nearest municipal center	= 1	<= 7000	> 4500
2	Mono-use low-density residential areas closer to the nearest municipal center	= 1	<= 7000	<= 4500
3	Multi-use low-density residential areas far from the nearest municipal center	=> 2	<= 7000	> 4500
4	Multi-use low-density residential areas closer to the nearest municipal center	=> 2	<= 7000	<= 4500
5	Medium-density residential areas	n/a	> 7000 and <= 16000	n/a
6	High-density residential areas	n/a	> 16000	n/a
61	Mono-use industrial and commercial areas far from the nearest municipal center	= 1	n/a	> 4500
62	Mono-use industrial and commercial areas closer to the nearest municipal center	= 1	n/a	<= 4500
63	Multi-use industrial and commercial areas closer to the nearest municipal center	=> 2	n/a	<= 4500
70	Road and rail, port areas, airports, mine, dump and construction sites	n/a	n/a	n/a
80	Artificial and non-agricultural vegetated areas	n/a	n/a	n/a
90	Non-urban	n/a	n/a	n/a

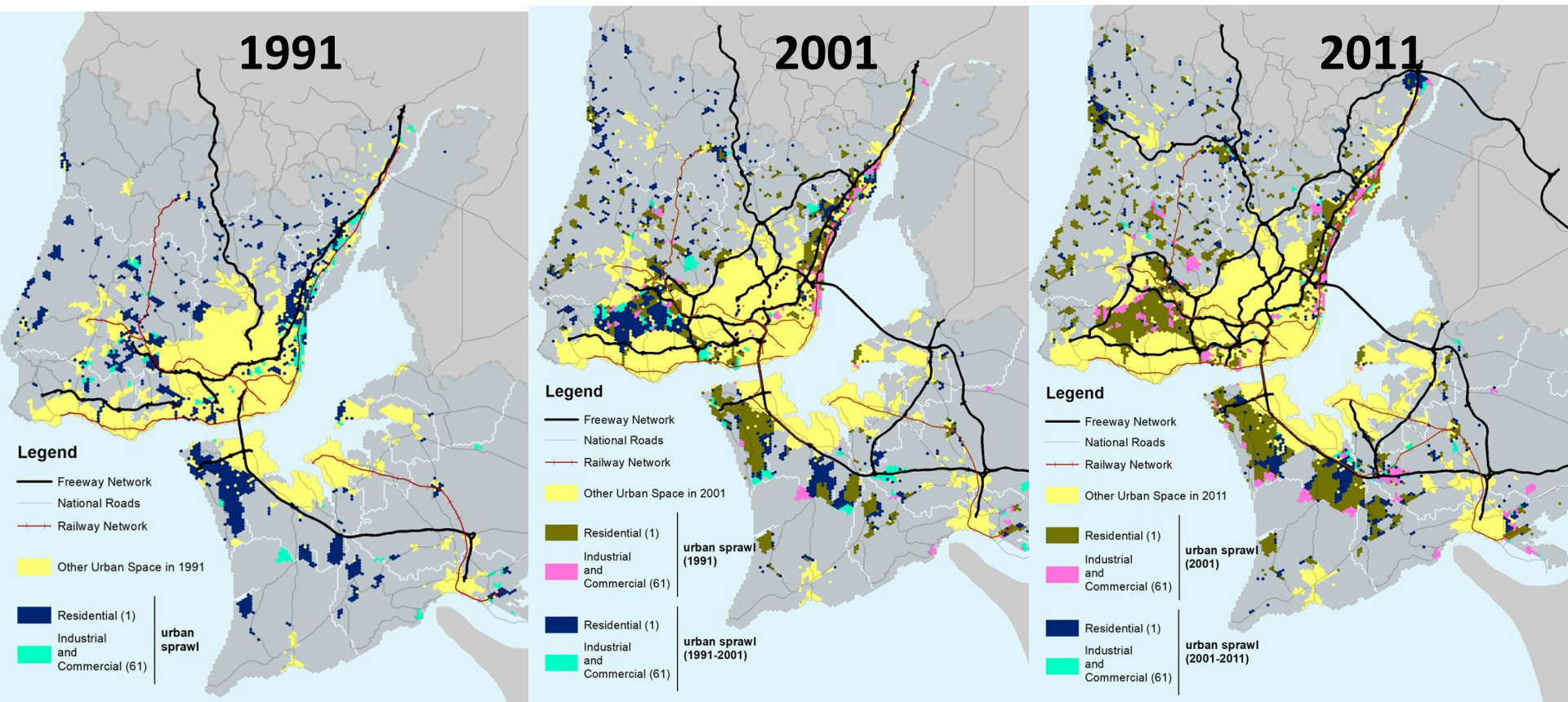
Cell Type	Description	CNERB	DPKm ²	RDistMun1
1	Mono-use low-density residential areas far from the nearest municipal center	= 1	<= 7000	> 4500
61	Mono-use industrial and commercial areas far from the nearest municipal center	= 1	n/a	> 4500

Evolução do Sprawl



	1991		2001		2011	
	1 Low-Dens. Mono-U Far	61 Ind & Com Mono-U Far	1 Low-Dens. Mono-U Far	61 Ind & Com Mono-U Far	1 Low-Dens. Mono-U Far	61 Ind & Com Mono-U Far
Km²	10.8	4.1	14.5	6.9	16.2	7.4
Population	306675		340574		430917	
Growth area (%)			34%	68%	12%	7%
Growth Population (%)			11%		27%	

Evolução espacial do *Sprawl*



Infraestruturas rodoviárias e *Sprawl*

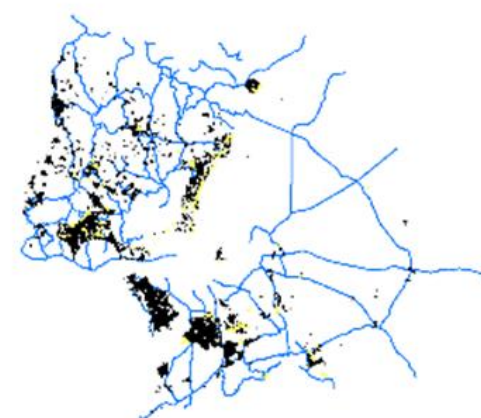
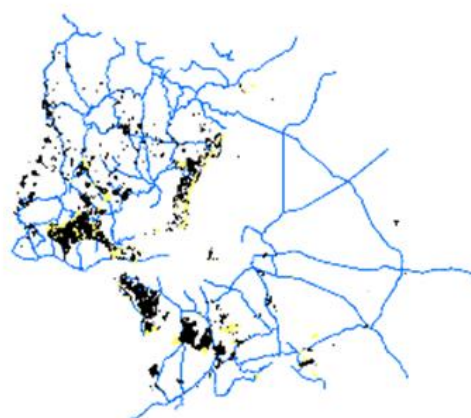
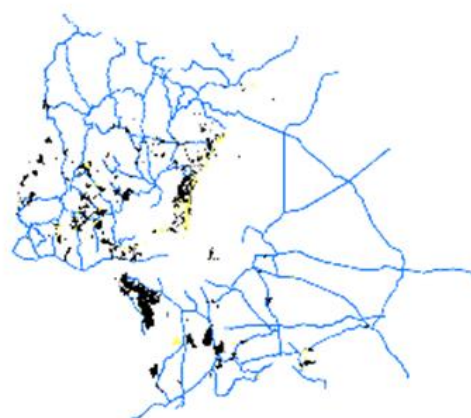
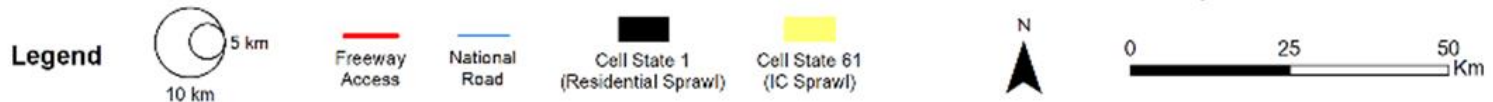
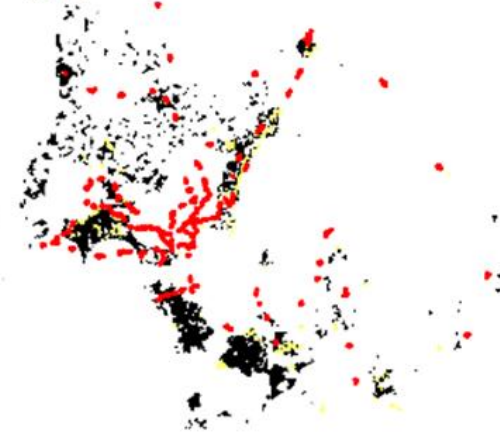
1991



2001



2011



Métodos (II)

- A probabilidade de cada célula pertencer a uma determinada classes foi modelada com o recurso a um modelo logit incorporando efeitos especiais.

$$U_{in} = V_{in} + \varepsilon_{in}$$

$$P_n(i) = \text{Probability} (U_{in} \geq U_{jn}) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}}$$

Model	Number of Estimated Parameters	Final Log Likelihood	Likelihood Ratio Test	Rho- Square	Adjusted Rho- Square	Final Gradient Norm	AIC	BIC
Panel	127	-68007.168	270491.543	0.665	0.665	1.341	136269	137311
Panel SE	146	-62293.098	281919.682	0.694	0.693	1.278	124879	126077
Panel SE & TE	150	-59125.489	288254.901	0.709	0.708	1.077	118552	119783

Resultados

Alternative / Cell State

Type	Indicator	1	2	3	4	5	6	61	62	63	70	80	
Accessibility	EPRo1	0.462	0.429	0.506	0.577	-0.237	0.534	0.312	0.345	0.37			
	Free25	0.0973*	0.699	0.66	0.534	1.78	1.01	0.356	0.468				
Transportation	Free5	0.122	1.16		1.89	1.71		1.17	0.507	1.33			
	Free10	0.363	-1.63		-4.03	-4.41		-1.14		-3.25			
	Na05	0.185		0.587					0.257	0.7			
	Na1		0.497							-2.13			
	Na25	0.155	0.539										
	Na5	-1.08	-3.94	-2.96	-4.52			-3.44					
	Ra05		0.598		1.2	0.575	0.525		1.21	1.46			
	Ra1				0.563	0.718	0.622				1.03		
	Ra25	0.158	0.465			1.16	1.11		1.25	1.7			
	Ra5	0.154	0.254							-1.2			
	Land-Use	PUrban	2.07	1.24	1.13	0.807	1.57	2.8					
PotUrban		1.5	0.619	0.635								1.59	
PFacil		0.198									1.15	0.43	
PotFacil		0.929									2.73		
PIndus								2.66	2.62	2.27			
PotIndus								1.59	2.37		1.97		
REM		-0.728	-1.09	-1.36	-2.33	-3.29	-2.2	-1.06	-2	-4.4			
RAM		-0.924	-1.5	-1.14	-3.84								
Spatial Effects	MN350Cell1			1.4			-0.684					-0.899	
	MN350Cell2	-5.04		-4.32									
	MN350Cell5	-0.613	1.14	2.15	1.92	4.67	2.58						
	MN350Cell61					0.964*		6.95					
	MN350Cell63	1.09			-2.32*	1.26				5.49			
	MN350Cell6	-4.13			-0.989	0.419							
Time Effects	Year		-0.236				-0.179	-0.754		-3.26			

Conclusões(I)

- A proximidade de infraestruturas de transporte aumenta a probabilidade de urbanização, incluindo *Sprawl*. Mas os efeitos são diferentes por tipo de infraestrutura
 - Auto-estradas – a probabilidade aumenta com a distância às Aes
 - Estradas Nacionais – a probabilidade diminui com a distância às Ens
 - Caminho de Ferro – a probabilidade aumenta com a distância ao CF (nula para distâncias curtas)
- Uma maior acessibilidade aumenta a probabilidade de urbanização mais densa.
- Evidências de que as infraestruturas de transporte contribuem globalmente para o sprawl, mas induzem densidade na sua proximidade.

Conclusões(II)

- Instrumentos de planeamento são também relevantes:
 - Células classificadas como urbanas ou como urbanizáveis aumentam a probabilidade de *Sprawl*. Particularmente relevante no caso das áreas urbanizáveis.
 - As reservas Ecológica e Agrícola são eficazes em reduzir o *Sprawl*-
 - Células classificadas como industriais ou áreas de expansão industrial aumentam a probabilidade de ocupação por áreas industriais mais intensamente do que *Sprawl* industrial.
- Relativa proximidade á costa aumenta a probabilidade de *Sprawl* e a proximidade a actividades de agricultura intensiva reduz a probabilidade de *Sprawl*

Conclusões (III)

- Há evidência de efeitos espaciais. A proximidade de zonas urbanas mais densas reduz a probabilidade de *Sprawl*.
- Efeitos temporais – efeito de redução da densidade nas células mais densas (classe 6).
- Limitações:
 - Abordagens mais sofisticadas para a modelação de efeitos espaciais.
 - Passar de um modelo estático (probabilidade de pertencer a um determinado estado) para um modelo dinâmico (probabilidade de transitar entre estados).

Muito obrigado

Questões, Comentários?

Anexos

Indicators	Tag	Level	Value	% of Cells			Indicators	Tag	Level	Value	% of Cells			
				1991	2001	2011					1991	2001	2011	
Freeway Access at a Radius Distance of	0.5km	Hexagon	Binary / Kilometers	FAcc05 / CFAcc05	3.9	6.5	7.9	Existent Urban Space	ExUrban	Hexagon	Binary	12.9		
	1km			FAcc1 / CFAcc1	7.8	12.2	15.0	Potential Urban Space	PotUrban			7.0		
	2.5km			FAcc25 / CFAcc25	19.6	29.3	36.2	Existent Facilities	ExFacilities			18.2		
	5km			FAcc5 / CFAcc5	34.6	52.6	62.6	Potential Facilities	PotFacilities			2.0		
	10km			FAcc10 / CFAcc10	58.6	83.7	92.7	Existent Industry	ExIndustry			2.1		
National Road at a Radius Distance of	0.5km	Hexagon	Binary / Kilometers	NAcc05 / CNacc05	33.9	33.9	33.9	Potential Industry	PotIndustry	Hexagon	Binary	1.4		
	1km			NAcc1 / CNacc1	52.4	52.4	52.4	Ecologic Municipal Reserve	REM			26.5		
	2.5km			NAcc25 / CNacc25	82.3	82.3	82.3	Agricultural Municipal Reserve	RAM			37.4		
	5km			NAcc5 / CNacc5	96.2	96.2	96.2	Ecologic Regional Reserve	REN			2.1		
Railway Station at a Radius Distance of	0.5km	Hexagon	Binary / Kilometers	RSAcc05 / CRSAcc05	2.9	3.2	3.3	Agricultural Regional Reserve	RAN	Hexagon	Binary	2.3		
	1km			RSAcc1 / CRSAcc1	7.0	7.7	8.0	Non-Aedificandi	MNonAed			0.3		
	2.5km			RSAcc25 / CRSAcc25	20.3	22.5	24.0	Non-Aedificandi by Transportation Infrastructures Buffers	INonAed			14.6	16.3	17.8
	5km			RSAcc5 / CRSAcc5	39.3	42.3	44.6	Expected Low Density in Potential Urbanization	ELDPU			0.8		
				MTAcc05 / CMTAcc05	0.6	1.0	1.8	Expected Medium Density in Potential Urbanization	EMDPU			4.8		
Metro Station at a Radius Distance of	0.5km	Hexagon	Binary / Kilometers	MTAcc1 / CMTAcc1	1.0	1.6	3.0	Expected High Density in Potential Urbanization	EHDPU	Hexagon	Binary	0.6		
	1km			MTA25 / CMTAcc25	2.2	3.0	5.6	Inside of an Illegal Urban Areas	AUGI			10.7		
	2.5km			MTAcc5 / CMTAcc5	4.5	5.4	9.9	Previous Settlements at a Radius Distance of	PS1			21.3		
	5km			FSAcc05 / CFSAcc05	0.2	0.2	0.2	5km	PS5			65.0		
Fluvial Station at a Radius Distance of	0.5km	Hexagon	Binary / Kilometers	FSAcc1 / CFSAcc1	0.6	0.6	0.6	10km	PS10	Hexagon	Binary	86.9		
	1km			FSAcc25 / CFSAcc25	2.6	2.6	2.6	0.5km	Hop05			0.8	0.9	0.9
	2.5km			FSAcc5 / CFSAcc5	7.4	7.4	7.4	1km	Hop1			2.0	2.1	2.3
	5km			CrossF	2.2	4.5	5.8	2.5km	Hop2_5			6.6	7.0	7.8
				CrossR	2.0	2.2	2.4	5km	Hop5			16.6	17.3	20.0
Crossed by Freeway Crossed by Railway	0.5km	Hexagon	Binary / Kilometers	CrossF	2.2	4.5	5.8	High-Schools at a Radius Distance of	HS05	Hexagon	Binary	4.4	4.6	4.8
	1km			CrossR	2.0	2.2	2.4	1km	HS1			10.2	10.6	10.9
	2.5km			Universities at a Radius Distance of	5km	HS2_5	25.2	26.1	26.5					
	5km			Shopping Malls at a Radius Distance of	0.5km	HS5	45.7	47.2	47.6					
				1km	Shop05	0.2	0.4	1.0						
2.5km	Shop1	0.5	1.1	2.8										
5km	Shop2_5	2.3	4.8	11.3										
	Shop5	6.9	12.1	24.9										

Anexos

Indicators	Tag	Level	Value	Average (Std. Dev.)		
				1991	2001	2011
Employed Population by Sector 1	EUPS1	Hexagon	Count	0.7 (4.9)	0.5 (2.4)	0.3 (1.5)
Employed Population by Sector 2	EUPS2			10.9 (43)	11.3 (40.5)	7.4 (24)
Employed Population by Sector 3	EUPS3			27.6 (121,8)	35.2 (133.4)	37.1 (125.6)
Population with Basic Education	UPBE			4.3 (17.5)	16.9 (63.7)	17.9 (61.8)
Population with High School	UPHS			9.5 (44.9)	15.4 (61.8)	16.9 (58.4)
Populaton with University Degree	UPUD			4.7 (29.4)	10.2 (49.5)	17.1 (70.4)
Dwelling Ownership	DO		11.2 (62.6)	24.1 (91.6)	27.6 (93.9)	
Dwelling on Rent	DR		16 (71)	10.2 (50.7)	11.3 (50)	

Indicators	Tag	Level	Value	% of Cells		
				1991	2001	2011
Majority of the Neighborhood in 350m is Cell type 1	MNei350Cell1	Hexagon	Binary	4.0	6.7	8.5
Majority of the Neighborhood in 350m is Cell type 2	MNei350Cell2			6.4	6.8	8.3
Majority of the Neighborhood in 350m is Cell type 3	MNei350Cell3			0.1	0.1	0.0
Majority of the Neighborhood in 350m is Cell type 4	MNei350Cell4			0.1	0.4	0.2
Majority of the Neighborhood in 350m is Cell type 5	MNei350Cell5			1.5	1.7	2.4
Majority of the Neighborhood in 350m is Cell type 6	MNei350Cell6			1.1	1.1	0.8
Majority of the Neighborhood in 350m is Cell type 61	MNei350Cell61			0.7	1.5	1.4
Majority of the Neighborhood in 350m is Cell type 62	MNei350Cell62			0.7	1.0	1.0
Majority of the Neighborhood in 350m is Cell type 63	MNei350Cell63			0.1	0.1	1.4
Majority of the Neighborhood in 705m is Cell type 1	MNei705Cell1			3.1	6.3	7.8
Majority of the Neighborhood in 705m is Cell type 2	MNei705Cell2			5.6	7.1	8.6
Majority of the Neighborhood in 705m is Cell type 3	MNei705Cell3			0.0	0.0	0.0
Majority of the Neighborhood in 705m is Cell type 4	MNei705Cell4			0.0	0.2	0.1
Majority of the Neighborhood in 705m is Cell type 5	MNei705Cell5			1.1	1.7	2.6
Majority of the Neighborhood in 705m is Cell type 6	MNei705Cell6			1.0	1.0	0.5
Majority of the Neighborhood in 705m is Cell type 61	MNei705Cell61			0.4	1.2	1.1
Majority of the Neighborhood in 705m is Cell type 62	MNei705Cell62			0.4	0.7	0.8
Majority of the Neighborhood in 705m is Cell type 63	MNei705Cell63			0.0	0.1	1.1
Majority of the Neighborhood in 1050m is Cell type 1	MNei1050Cell1			2.7	6.1	7.7
Majority of the Neighborhood in 1050m is Cell type 2	MNei1050Cell2			5.6	7.1	8.6
Majority of the Neighborhood in 1050m is Cell type 3	MNei1050Cell3			0.0	0.0	0.0
Majority of the Neighborhood in 1050m is Cell type 4	MNei1050Cell4			0.0	0.2	0.1
Majority of the Neighborhood in 1050m is Cell type 5	MNei1050Cell5			1.0	1.7	2.5
Majority of the Neighborhood in 1050m is Cell type 6	MNei1050Cell6			1.0	0.8	0.4
Majority of the Neighborhood in 1050m is Cell type 61	MNei1050Cell61			0.3	0.8	0.7
Majority of the Neighborhood in 1050m is Cell type 62	MNei1050Cell62			0.3	0.6	0.7
Majority of the Neighborhood in 1050m is Cell type 63	MNei1050Cell63			0.0	0.1	0.7

Indicators	Tag	Level	Value	Average (Std. Dev.) % of Cells		
				1991	2001	2011
Altimetry	Alt	Hexagon	Binary	83 (71.2)		
	Slope			1.7 (1.06)		
Water Bodies	W05			10.1	10.2	10.1
	WB1			16.3	16.6	16.6
	WB2_5			33.2	34.1	34.5
	WB5			58.8	60.3	62.1
No Productive Areas	WB10			87.1	87.3	89.7
	Nop05			70.4	69.3	68.8
	Nop1			81.4	81.2	80.6
	Nop2_5			93.8	93.4	92.8
Intensive Agriculture Areas	Nop5	99.5	98.6	98.3		
	Nop10	100.0	100.0	100.0		
	lop05	69.6	69.6	69.9		
	lop1	80.0	80.0	81.4		
Extensive Agriculture Areas	lop2_5	91.8	91.8	94.4		
	lop5	98.3	98.3	99.0		
	lop10	100.0	100.0	100.0		
	Eop05	50.3	48.0	51.0		
Mines and Dumps Areas	Eop1	67.4	65.0	68.9		
	Eop2_5	91.5	90.3	93.2		
	Eop5	99.7	99.2	99.5		
	Eop10	100.0	100.0	100.0		
	Mop05	2.8	4.8	4.7		
	Mop1	5.3	8.9	8.8		
	Mop2_5	15.2	24.1	23.3		
	Mop5	32.4	51.5	49.7		
	Mop10	58.5	86.6	84.7		