

# The wheat from the chaff: Physical and cultural dimensions of landscapes and their impact on urbanization

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# Outline

## 1 Introduction

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- 2 An ontology of landscapes

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# Introduction

Urbanization is a main fact of the last century:

- in the U.S.: 40% urban in 1960  $\Rightarrow$  60% in 1990
- worldwide: 29% urban in 1950  $\Rightarrow$  50% in 2008
- 75% of the European population is urban

Consequence: important agricultural land uptake

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- 75% of the European population is urban

Consequence: important agricultural land uptake

$\Rightarrow$  640 000 ha of agricultural land urbanized between 2000 and 2006 in Europe

- 46% on cropland
- 32% on grasslands
- 13% on forest lands
- 9% on natural and fallow lands



# Introduction

The drivers of urbanization and urban sprawl have been well documented:

- drop in transportation costs (private car) (Glaeser and Kahn, HRUE, 2004)
- raising income
- "*flight from blight*"
- "*mis-specified*" urban policies (minimum lot size, land controls, etc.)
- amenities and periurban lifestyle (Cavailhès *et al.*, RSUE, 2003)

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One important stream of the literature: [Land-use change at the urban fringe](#)

Land use change determinants:

- land rent in several uses (urban, agriculture, etc.)
- conversion costs

# Introduction

## Periurban **quality of life** and **amenities**:

- play an important role in housing prices (Boyle & Kiel, JREL, 2001 for a review)

## **Urbanization** reduces amenities:

- public services crowding (Cavailhès *et al.*, 2009, ERE)
- views deterioration (Cavailhès *et al.*, 2009)
- people prefer low densities: negative externalities among residents (Roe *et al.*, Land Econ., 2004 ; Irwin & Bockstael, RSUE, 2004)

**landscape indicators**: share of farmland, density, number of trees,

...

# Introduction

Economists' view similar to that of **physical geographers** (objects)

⇒ quantify: objective metrics

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For **human geographers**, the landscape is more than that.

- cultural landscape: social phenomena
- weight of individual and social interactions
- history, arts, literature, customs, institutions, ...

⇒ culture shape people's perceptions (and behavior)

# Introduction



a mountain

# Introduction



a mountain



*"La montagne Sainte-Victoire  
vue de Bellevue"*  
Paul Cézanne (1885)

# Introduction



a tree



# Introduction



a tree



"Montagnes de l'Esterel"  
Claude Monet (1888)

# Introduction

For human (cultural) geographers & for the European Landscape Convention: perceptions and culture are crucial

**Definition: Landscape (Council of Europe, Florence, 2000)**

*"Landscape"* means an area, as **perceived by people**, whose character is the result of the action and interaction of natural and/or human factors

# Introduction

## Our contribution:

- 1. introduction of landscape perception in land-use change model
- 2. construction of an ontology of landscape
- interdisciplinary work involving:
  - landscapers, cultural geographers
  - computer scientists
  - GIS scientists
  - economists

# Introduction

Economic literature is sparse on the role played by culture and perception:

- behavioral finance: sentiments, moods, ... (textmining, twitter, ...)
- growth & development: trust in institutions, religion, ...
- economic outcomes: identity, social ties (social norms, ...)

We also document another important topic where culture and perceptions may play an important role.

# What is an ontology?

In computer science, an ontology is a tool to represent the knowledge we have on a real (or abstract) object.

**Definition: Ontology (Computer Science – Gruber, 1992)**

An *ontology* is a formal specification of a shared conceptualization

Over a domain, an ontology relates classes (of concepts) to their attributes and relations between concepts.

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In practice it's a database relating terms to classes of concepts functionally related.

- lexical domain: vocabulary related to a concept (holidays: sun, beach, sea, farniente, ...)
- (contextual) semantic domain: different meanings of words ("alone in the dark" vs. "the dark side of the force")

# A (geographical) ontology for landscapes

## Several steps:

- 1 build a skeleton (architecture of relation between concepts)
- 2 identify words to describe the classes
- 3 attached them to an area (spatial)
- 4 iterate

In our case: areas and the vocabulary comes from [Landscape Atlases](#)

Additional potential sources: land use ordinances, land use conflicts resolutions at the court, surveys, . . .

# An ontology for landscapes

Entrée nord depuis Paris



Entrée sud-ouest depuis Nantes

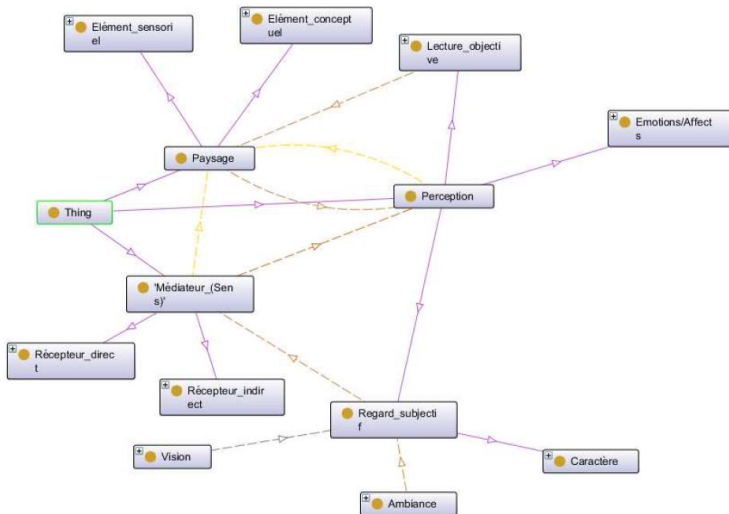


## PERCEPTION DE L'AGGLOMÉRATION ET DES FRANGES URBAINES

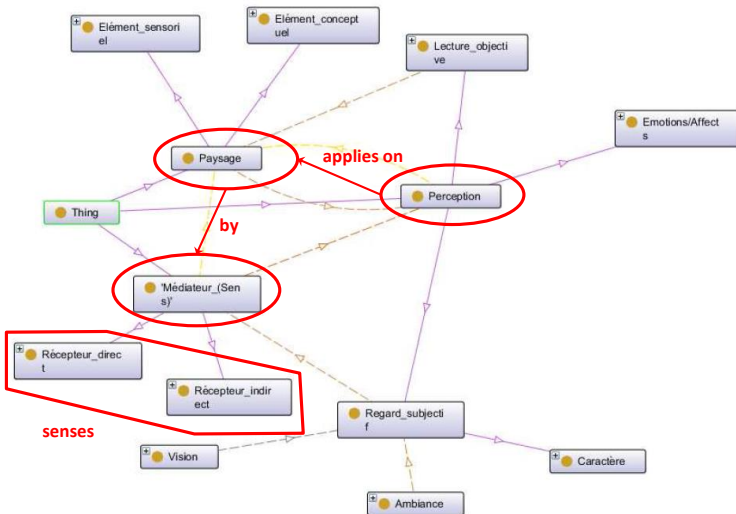
- **Une silhouette urbaine identitaire**  
Le triptyque château/cathédrale/tour Saint-Aubin constitue une association forte et identitaire. Sa position dominante lui confère un rôle prépondérant dans l'appréhension de l'agglomération : élément repère et d'appel.  
Cette silhouette s'appuie sur des bâtiments de hauteur généralement modeste, soulignant la morphologie complexe et particulière de la ville, et construite ainsi un ensemble homogène.
- **Les portes de l'agglomération angevine**
  - Dans un premier temps, ce qui frappe dans l'appréhension du territoire de l'agglomération angevine, c'est le contact franc et brutal entre urbanisation dense et espace naturel protégé et/ou de caractère aux portes de l'agglomération :
    - la confluence des BVA au niveau de l'Île-Saint-Aubin au nord,
    - la confluence Loire/Maine et prairies de la Baumette au sud,
    - la pénétration du secteur des ardoisiers à l'est (unités du plateau composite de l'est angevin),
    - la coulée verte de l'étang Saint-Nicolas qui s'ouvre sur le plateau bocager à l'ouest.
  - Dans un second temps, c'est la densité et l'imbriication des infrastructures routières qui marquent aussi fortement les franges urbaines et constituent des portes mais identitaires, plus banalisantes de cette agglomération.  
Citons comme exemple le nœud routier nord-est à l'articulation de la RN 23 et de l'A 11 en association avec les éléments divers du parc des expositions ou encore, au sud, l'échangeur des Ponts-de-Cé, nœud routier entre la rocade Est (liaison directe A.11 - Cholet) et l'accès au centre...
- **Perception des franges et des entrées**  
D'une façon générale, la perception des franges urbaines de l'agglomération joue toujours sur une association équilibrée végétal/bâti, la perception ponctuelle de grands ensembles bâtis souvent au cœur d'une végétation dense, et la dominance de la silhouette caractéristique de certains bâtiments historiques.  
En revanche, sur l'axe nord-est / sud-ouest (Paris Nantes), les entrées de ville présentent un caractère qui se banalise, dominé par les zones industrielles, zones d'activités et à vocations commerciales. Ces secteurs constituent un premier plan très fort qui occulte parfois la silhouette urbaine en arrière plan.  
**Exemples :**
  - l'entrée nord-est avec le secteur d'activité de Saint-Serge et le lycée Jean Monnet très présent sur le plateau en face,
  - au niveau de l'entrée sud-est, perception de l'agglomération en deux temps, d'abord une zone commerciale just dans l'axe de l'A.11, la silhouette caractéristique et identitaire de la ville historique qui se détache d'un front vert au dessus d'un pont.



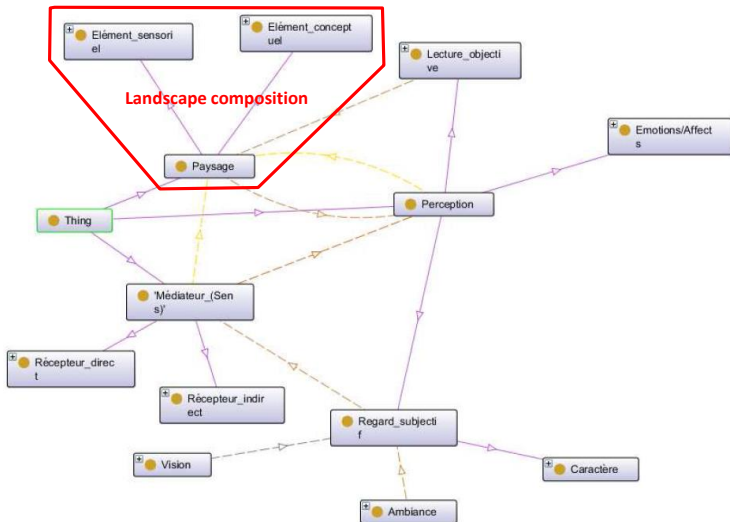
# An ontology for landscapes



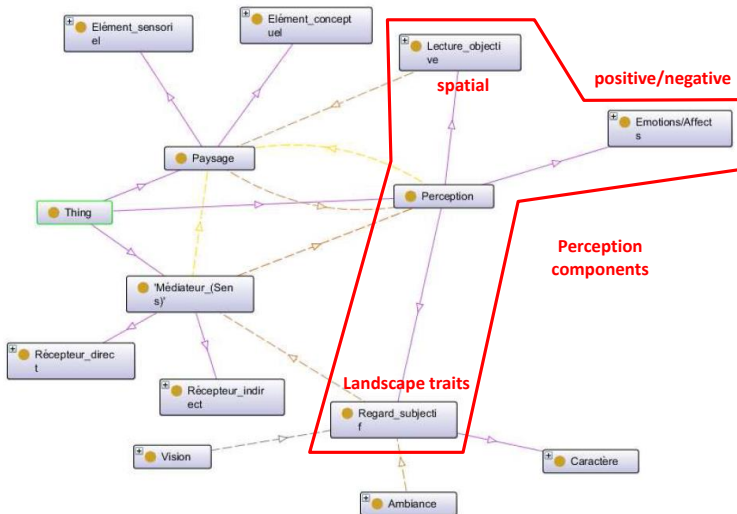
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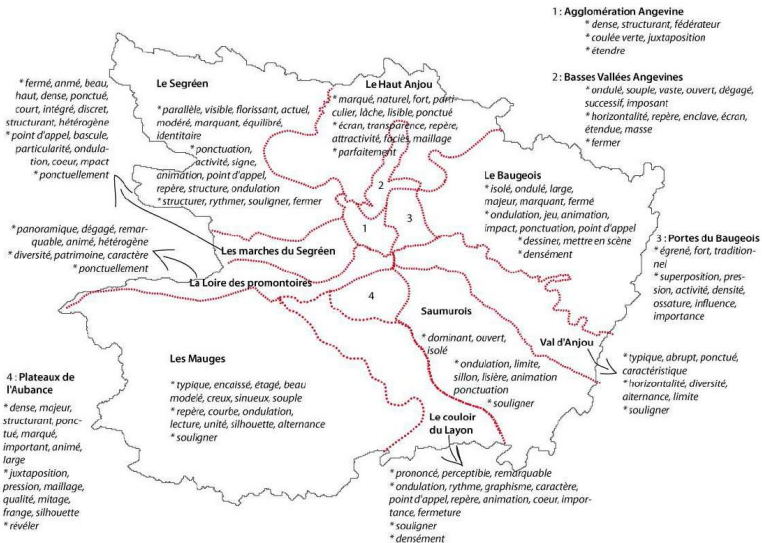
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# An ontology for landscapes



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# Theoretical framework

## A two step approach:

- 1 Explain land-use change (discrete choice model)
  - alternative land rent determinants
  - objective landscape measures (land share, landscape metrics)
  - landscape perception measures  $\Rightarrow$  landscape units dummies
- 2 Explain differences in land use conversion probability among landscape units:
  - account for different modelling options
  - internal meta-analysis

# Theoretical framework (1<sup>st</sup> step)

A landowner chooses the optimal time  $t^*$  to convert parcel  $i$  to urban use:

$$\max_{t^*} \text{NPV}_{it} \equiv \int_t^{t^*} R_a(x_{ai}, \tau) e^{-r\tau} d\tau + \int_{t^*}^{+\infty} R_u(x_{ui}, \tau) e^{-r(\tau-t)} d\tau - C(y_i, t^*) e^{-r(t^*-t)} \quad \forall t \in [0, t^*] \quad (1)$$

$R_a(x_{ai}, \tau)$  = land rent in agricultural use

$R_u(x_{ui}, \tau)$  = land rent in urban use

$C(y_i, t^*)$  = conversion costs

$x_{ai}$ ,  $x_{ui}$  and  $y_i$ : parcel's characteristics



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$x_{ai}$ ,  $x_{ui}$  and  $y_i$ : parcel's characteristics

The optimal rule:

$$R_u(x_{ui}, t^*) = R_a(x_{ai}, t^*) + rC(y_i, t^*) \quad (2)$$

# Theoretical framework (1<sup>st</sup> step)

**Deterministic rule** ( $K$  potential land uses):

$$\arg \max_k (R_k(x_{ki}, t) - rC_{jk}(y_i, t)) \geq R_j(x_{ji}, t) \quad \text{with } j, k \in \{1, \dots, K\}$$

**Stochastic rule:**

$$\arg \max_k (\bar{R}_k(x_{ki}, t) + \varepsilon_{jk it}) \geq \bar{R}_j(x_{ji}, t) + \varepsilon_{jj it} \quad \text{with } j, k \in \{1, \dots, K\}$$

with  $\bar{R}_k$  the deterministic (observed) part of land rent

# Theoretical framework (1<sup>st</sup> step)

The probability of conversion at time  $t$ :

$$\text{Prob}_i(k|j, t) = \text{Prob}_i(\varepsilon_{jkit} - \varepsilon_{jjit} > \bar{R}_j(x_{ji}, t) - \bar{R}_k(x_{ki}, t)) \quad (3)$$

Using an generalized extreme type I error distribution yields the [logit model](#):

$$\text{Prob}_i(k|j, t) = \frac{e^{\beta'_k x_{ki}}}{\sum_{\ell=1}^K e^{\beta'_\ell x_{\ell i}}} \quad (4)$$

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# Theoretical framework (2<sup>nd</sup> step)

Marginal effect on conversion probability of being in a landscape unit  $m$  ( $LU^m$ ):

$$\begin{aligned}\widehat{P}_{kui}^m &= \frac{\partial \text{Prob}_i(k = \text{urban} | j \neq \text{urban}, t)}{\partial LU_i^m} \\ &= \text{Prob}_i(k | j, t, LU_i^m = 0) - \text{Prob}_i(k | j, t, LU_i^m = 1)\end{aligned}\quad (5)$$

For each landscape unit ( $m = 13$ ):

$$\left\{ \begin{array}{l} \text{empirical mean: } \mu_P^m = \frac{1}{N^m} \sum_{i=1}^{N^m} \widehat{P}_{kui}^m \\ \text{empirical variance: } (\sigma_P^m)^2 = \frac{1}{N^m - 1} \sum_{i=1}^{N^m} (\widehat{P}_{kui}^m - \mu_P^m)^2 \end{array} \right. \quad (6)$$

# Theoretical framework (2<sup>nd</sup> step)

13 measures of  $\mu_{P_r}^m$  and  $(\sigma_{P_r}^m)^2$  and 16 model specifications  
13 × 16 = 208 observations

Internal meta-analysis: (random effects model)

$$\mu_{P_r}^m = \theta_R R_r + \theta_D D_r + u_r + \epsilon_r \quad \text{with} \quad \begin{cases} u_r \sim N(0, \tau^2) \\ \epsilon_r \sim N(0, (\sigma_{P_r}^m)^2) \end{cases} \quad (7)$$

with  $r$ : index fo model  $r$

$R_r$  a vector of Landscape Units characteristics

$D_r$  a vector of covariates describing model  $r$

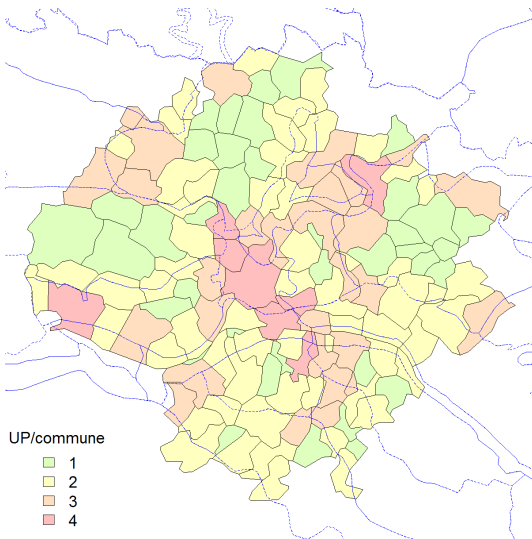
$u_r$  error term specific to each model  $r$

$\epsilon_r$  classical error term

$\theta_R, \theta_D, \tau^2$  parameters to estimated using REML

$$\mu_{P_r}^m \sim N(\theta_R R_r + \theta_D D_r, \tau^2 + (\sigma_{P_r}^m)^2) \quad (8)$$

# Data



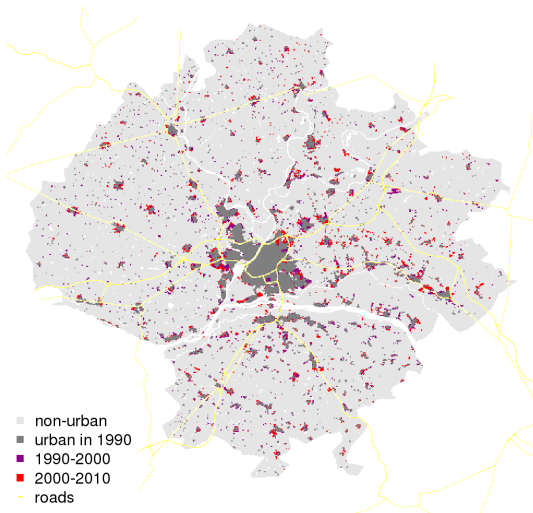
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# Data

221 087 observations (pixels) in Angers metropolitan statistical area (2000-2010)



# Data

$R_u(x_{ui}, \tau)$ :

- distances to CBD, SBD and intercity road network
- public services at SBD, population income, national park
- share of urbanized pixels in the neighborhood (500m threshold)
- **landscape**: landscape metrics

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$C(y_i, t^*)$ :

- agriculture or forest in 2000

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Results (1<sup>st</sup> step)

Covariate	model (1)		model (6)		model (16)	
	forest	urban	forest	urban	forest	urban
Intercept	-1.91***	4.41***	-1.00*	3.28***	-16.26***	5.48***
Dist. CBD	-0.17***	0.02	-0.21***	0.18***	-0.10***	0.16***
(Dist. CBD) <sup>2</sup>	0.00***	-0.00	0.00***	-0.00***	0.00	-0.00***
Dist. SBD	0.39***	-1.42***	0.37***	-1.60***	0.50***	-1.63***
(Dist. SBD) <sup>2</sup>	-0.06***	0.23***	-0.05***	0.26***	-0.08***	0.26***
Income	-0.07***	0.05**	-0.10***	0.10***	-0.05**	0.10***
Income × Dist. CBD	0.01***	-0.00	0.01***	-0.00**	0.00***	-0.00***
Dist. road	0.13***	-0.18***	0.15***	-0.13***	0.27***	-0.10***
(Dist. road) <sup>2</sup>	-0.01***	0.02***	-0.02***	0.01***	-0.03***	0.01***
Slope	0.05***	0.04***	0.06***	0.06***	0.06***	0.06***
(Slope) <sup>2</sup>	0.00	-0.00***	0.00	-0.00***	0.00	-0.00***
Park	-0.11**	0.31***	0.21**	0.53***	0.19	0.34**
Public services	0.00*	-0.00***	0.00***	0.01***	0.00***	0.00***
Public services × Dist. SBD	-0.00***	0.00***	-0.00***	0.00***	-0.00***	0.00***
Urbanized neigh. in 2000	-2.57***	10.54***	-2.33***	10.44***	-2.30***	10.28***
(Urbanized neigh. in 2000) <sup>2</sup>	4.51***	-6.74***	4.03***	-6.86***	3.50***	-6.80***
Farmland in 2000	-0.54	-7.60***	-0.51	-7.73***	-0.48	-7.77***
Forest en 2000	4.35***	-6.49***	4.34***	-6.65***	4.23***	-6.79***
Floodable	0.38***	-1.76***	0.59***	-1.72***	0.54***	-1.70***
LU	yes		yes		yes	
PRA	no		no		yes	
Counties	no		yes		yes	
OTEX	no		yes		yes	
Landscape metrics	no		no		yes	
Observations	221 087		221 087		221 087	
logL	-52 842		-52 113		-51 477	
pseudo-R <sup>2</sup>	0.647		0.652		0.656	
AIC	106 136		105 297		103 227	

\*\*\* \*\* \* : t-statistic, parameters significant at 0.01%, 0.05%, at 0.1% respectively.

Results (1<sup>st</sup> step): Estimated marginal effects ( $\widehat{P}_{kui}^m$ )

Landscape Units	Marginal Effect		Minimum		Maximum	
	$\mu_P^m$	$(\sigma_P^m)^2$	$\mu_P^m$	$(\sigma_P^m)^2$	$\mu_P^m$	$(\sigma_P^m)^2$
L'Agglomération angevine	0.0349	0.0035	0.0258	0.0024	0.0418	0.0043
La Loire des promontoires	0.0313	0.0025	0.0239	0.0015	0.0399	0.0036
Le Beaugois	0.0191	0.0012	0.0146	0.0009	0.0256	0.0015
Le Couloir du Layon	0.0242	0.0027	0.0173	0.0011	0.0340	0.0048
Le Haut Anjou	0.0255	0.0015	0.0217	0.0009	0.0314	0.0019
Le Saumurois	0.0115	0.0012	0.0075	0.0008	0.0147	0.0018
Le Segréen	0.0256	0.0019	0.0172	0.0008	0.0287	0.0025
Le Val d'Anjou	0.0150	0.0011	0.0128	0.0009	0.0198	0.0013
Les Basses vallées angevines	0.0167	0.0016	0.0116	0.0012	0.0226	0.0018
Les Marches du Segréen	0.0225	0.0019	0.0149	0.0009	0.0270	0.0026
Les Mayes	0.0145	0.0033	0.0100	0.0024	0.0208	0.0050
Les Plateaux de l'Aubance	0.0257	0.0025	0.0185	0.0011	0.0373	0.0044
Les Portes du Beaugois	0.0217	0.0016	0.0162	0.0013	0.0279	0.0022
Total	0.0222	0.0020	0.0075	0.0008	0.0418	0.0050

Results (2<sup>nd</sup> step)

	Tropes scenarios (another ontology)			
	base	controles	AIC	complete
Agri. / Env.	0.3302***	0.3300***	0.3303***	0.3301***
Anim. / Veget.	0.0414**	0.0389*	0.0409**	0.0389*
Arts / Culture	-0.0752	-0.0806	-0.0763	-0.0806
Traits	0.2815***	0.2812***	0.2816***	0.2813***
Comm. / Medias	0.5594***	0.5618***	0.5611***	0.5619***
Comport. / Sent.	0.3843***	0.3849***	0.3845***	0.3850***
Forces / quantities	-0.2905***	-0.2972***	-0.2921***	-0.2974***
Geography	0.1500***	0.1485***	0.1500***	0.1485***
Politics / Society	0.7213***	0.7214***	0.7216***	0.7216***
Transports	-0.0384	-0.0421	-0.0389	-0.0421
OTEX		0.0006		0.0005
PRA		0.0012**		0.0007
Counties		0.0006		-0.0011
Metrics		-0.0001		-0.0020
AIC			-0.0000	-0.0000
Intercept	-0.1598***	-0.1600***	-0.1162*	0.0085
Observations	208	208	208	208
$\tau^2$	1.31e-05	1.34e-05	1.32e-05	1.35e-05
$I^2$	0.835	0.838	0.836	0.839
adjusted- $R^2$	0.734	0.728	0.732	0.727
$\chi_c^2$	667.0	678.0	669.6	679.3
LRT test( $\tau^2 = 0$ )	4.93e-05	4.93e-05	4.93e-05	4.93e-05
F test	40.82	30.00	37.32	27.92

\*\*\*, \*\* and \* identify parameters significant at 0.01%, 0.05% et 0.1% respectively.



# Conclusions

## Contribution:

- A land-use change model linked to a geographical ontology
- Landscape perception and culture may play a role in explaining urbanization
- Not a major one however
- Agnew/King controversy on the role of context in human geography

## Main limits (to be overcome):

- Make use of our ontology (rather than Tropes)
- spatial (spatial probit, GAM, spatial sampling)
- zoning ?