

Pouyanne, Guillaume; Dantas, Monique; Gaschet, Frédéric

**Conference Paper**

## The Effect Of Current And Future Land Use On House Prices

53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Pouyanne, Guillaume; Dantas, Monique; Gaschet, Frédéric (2013) : The Effect Of Current And Future Land Use On House Prices, 53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/123892>

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## THE EFFECT OF CURRENT AND FUTURE LAND USE ON HOUSE PRICES

Guillaume Pouyanne (corresponding author), Monique Dantas, Frédéric Gaschet

### **Abstract:**

The control of urban sprawl often involves policies of allowable use zoning. Such policies may, however, provoke leapfrog development through their inflationary effect on the land and property markets in the area which is already urbanised. This inflationary effect results in particular from the positive external effects generated on neighbouring property by the fact of land being classified as unbuildable. This effect is dealt with in the vast amount of literature on the open space premium, where the capitalised premium in property prices arises just as much from the positive externalities generated by open space as from the absence of negative external effects generated by land conversion. However, in this literature, the premium is derived uniquely from current land use. The future use of the land, which is nevertheless a component of the premium, is rarely taken into account, and then only in terms of whether the open space is permanent or temporary.

This article proposes an evaluation of the impact of current and future land use on property prices. In order to do this we combine the actual use of land with its membership of a zoning category in a one-kilometre radius around the site of the transaction. We show that both the current use and the future use of surrounding land have an impact on the price of a transaction. It is important to take into account the classification of land as buildable: thus urban green space is certainly responsible for a positive premium, but only on condition that it is not classified as buildable. Furthermore, the fact that land is classified as unbuildable can have an ambiguous effect: forests protected as sensitive natural open spaces do bring a positive premium whereas forests protected for silviculture tend to provoke depreciation in property prices due to the nuisances associated with their exploitation.

*“Time is experienced differently depending on the quality and the use of the land on which men’s existence takes place.”*  
Michel HOST, *Valet de Nuit*, Grasset, 1986, p. 16

## Introduction

The control of urban sprawl is one of the major priorities of sustainable urban development, illustrated by the multiplication of urban containment policies (Dawkins and Nelson, 2002). In France, this is showed by a recent law requiring that “[a] reduced consumption of space” become a prime urban planning objective<sup>1</sup>. Allowable use zoning is a tool which is widely used to this end. It enables very detailed planning of future urbanisation by allocating certain areas of land to a specific use, particularly by declaring them to be unbuildable. Local authorities thus tend to contain urban growth by restricting the area which may be built upon and by increasing the area which is protected.

However, such “*malthusianisme foncier*”<sup>2</sup> (Malthusian approach to land conversion) may also aggravate urban sprawl. The protection of peri-urban land often leads to urbanisation of more distant areas which are less rigorously protected, thus increasing the area of urbanized land required to house a given population (Lichtenberg, 2011). This displacement of urbanisation is aggravated by the attraction exercised by protected open space, and disrupts the structure of the town: thus, according to Irwin and Bockstael (2004, p. 724), “*open space preservation policies can alter the evolution of development patterns not only because they create an area in which development cannot occur, but also because they may create areas that attract neighboring development.*” The consequence is leapfrog development, as may be seen beyond Seoul’s green belt (Lee and Linneman, 1998).

Leapfrog development provoked by zoning is a consequence of its action on land and property prices (Wu and Plantinga, 2003; Wu, 2006). Several recent studies have confirmed the strong correlation between the degree of restriction on land use and the price of land and housing (Glaeser *et al.*, 2005; Quigley and Rosenthal, 2005; Glaeser and Ward, 2009; Ihlanfeldt, 2007). In effect, zoning policies lead to several types of rigidity in land and property markets, thus interfering with adjustment by price (Duranton, 1997). The effect of allowable use zoning on prices acts through two main channels (Jaeger *et al.*, 2012).

First, the scarcity effect acts on the supply side. Zoning makes both building land (Wu and Cho, 2007), and the number of new buildings (Glaeser and Ward, 2009; Quigley and Raphael, 2005) scarcer. This double restriction leads to an increase in prices in land and property markets, such an increase being even greater given that the demand is inelastic to price (Podogzinski and Sass, 1994), in other words there are few or no substitute towns.

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<sup>1</sup> The so-called “Grenelle II” law or *National environmental commitment bill* introduced into the French Senate by J.-L. Borloo, Minister for Ecology, Energy, Sustainability and Territorial Development, on 01.12.2009 (art. 6).

<sup>2</sup> A typically French expression frequently used to designate the reduction in the amount of land available for building, notably by introducing regulations and in particular by zoning (Charmes, 2007).

Second, the amenity effect acts on the demand side. By freezing land use, zoning stabilises the land use externalities, which may be defined as *“the phenomenon that one person’s use of land may have external effects – positive or negative – on the uses of neighboring land”* (Ohls *et al.*, 1974, p. 429). These external effects, which are comparable to local public goods, are then capitalised in land and property values (Balsdon, 2007).

Early literature was interested above all in negative external effects of land use (polluting activities, high densities – e.g. Crone, 1983), because it was to avoid these effects that the first zoning measures were introduced which aimed to geographically separate certain urban functions (Fischel, 2004). The fact that zoning may produce positive external effects is a relatively recent preoccupation (e.g. Thornes, 2000; Lichtenberg *et al.*, 2007), driven by the vast amount of literature on open spaces.

Open space brings numerous benefits: views, recreational space, protection of wild species, sensation of privacy...The majority of studies agree on the existence of an *“open space premium”* which is capitalised in land and property prices (Irwin and Bockstael, 2001, 2002, 2004; Irwin, 2002; Bowman *et al.*, 2009; Baranzini and Schaerer, 2011; Anderson and West, 2006; Cho *et al.*, 2008; Thorsnes, 2002; Cavailhès *et al.*, 2009). The values quoted in this are, however, very heterogeneous: *“open space values vary widely by location, by type of open space, by the services provided, and by study methodology”* (McConnell and Walls, 2005, p. 3).

The service provided depends above all on the type of open space, a commodity which is heterogeneous by its very nature (Irwin, 2002, p. 466). Lutzenhiser and Netusil (2001) show, for example, that if natural open space has a positive impact on prices, this impact is negative for urban parks because of the nuisances associated with them (noise, congestion, insecurity). The controversy relates mainly to agricultural land: although this has all the characteristics of open space (Cavailhès *et al.*, 2004) and can thus produce positive external effects (Baranzini and Schaerer, 2011), agricultural activity causes a certain amount of nuisance (noise, smells...) which render negative the premium associated with proximity to farmland (Johnston *et al.*, 2001 ; Smith *et al.*, 2002).

Beyond the amenity value which they bring to the neighbourhood, open spaces equally allow people to avoid the nuisances related to urbanisation: *“rather than being valued for what it is...open space may be valued most for what it is not”* (Irwin, 2002, p. 465), i.e. not being built up. This argument is corroborated by Smith *et al.* (2002), who show the positive effect on house prices of the proximity of vacant land. This empirical result is, moreover, used by Turner (2005) to model leapfrog development. Thus, the positive external effects of open spaces and the negative external effects of built land may certainly be two sides of the same coin (Irwin and Bockstael, 2002).

Thus the urbanisation of vacant land has a negative effect on the price of surrounding housing. Now, the price of housing has a significant anticipated component, because it represents the sum of the actualised benefits that it will bring to its owner (e.g. Kiefer, 2011). It thus includes both the current and future amenities offered by open space, the latter depending on a possible conversion to residential use. It is thus appropriate to consider not only the current use of land, but also its anticipated use.

The literature addressed this question very early on, distinguishing permanent open spaces (i.e. protected by zoning, such as conservation easements) from temporary open space (i.e. classified as buildable). The added value from permanent open spaces is assumed to be higher than that from temporary open spaces because the source of external effects is longer-lasting. Geoghegan (2002) shows, for example, that the impact on prices is three times greater for a permanent open space than for a temporary one. According to Irwin (2002), the conversion of a temporary open space into a permanent open space would produce an appreciation of between 0.5% and 2% in the price of neighbouring housing. Finally, Earnhardt (2006) estimates the premium associated with the proximity of an unbuildable parcel as being 5% of the price of the house or flat, whereas if the parcel is buildable the premium is zero.

However, this distinction between permanent and temporary open space has sometimes been carried out “broadly” (Anderson and West, 2006, p. 774). An unprotected open space may remain vacant for a very long period, whereas, on the contrary, conservation easements may be revised over a relatively short period. Moreover, for temporary open spaces, no information is available about their future use. Now, this future use may strongly condition the amplitude of the impact on prices (Cotteleer *et al.*, 2012). Thus, Beasley *et al.* (1986) estimate, by means of a contingent evaluation, the willingness to pay in order to preserve one acre of cultivable land from low-density urbanisation at \$50 US per household, and that to preserve it from high-density urbanisation at \$150 US.

Thus, on the one hand, the literature on the external effects of land use concentrates essentially on the *present type* of use, whereas other authors are interested in whether or not the land is buildable in the future. These two strands of literature have rarely been combined. Few studies take these two dimensions into consideration *at the same time* and none, to our knowledge, deal with the *combined* impact of present and future land use on property prices.

In this article, we try to understand to what extent the external effects of land use are capitalised in property prices. The principal originality of our work is to adopt an intertemporal approach, which takes into account not only the present, but also the anticipated use of the land. This land use is first considered in a binary manner, as being buildable or unbuildable, then in a more detailed way, based on the type of urbanization envisaged or the reason for its protection. We show that if the first approach presents a great interest, a more precise classification of future uses allows the results to be refined.

## **Data and methods**

### ***The study area***

The study area is Arcachon Bay, an emblematic French coastal site for both landscape and ecological reasons. It is a highly attractive region for both residents and tourists. This attractiveness has led to strong urban pressure on natural and agricultural zones, which in turn has incited local authorities to implement zoning restrictions. Furthermore, it seemed more interesting to study a community with high level of amenities, because “*a community with high amenity values stands to gain more in property value appreciation from land conservation than one with low amenities, because there is*

*more to capitalize*” (Balsdon, 2007, p. 5). Recent evidence of spillover growth affecting zones beyond settlements located directly on Arcachon Bay itself has led us to choose a study area that is sufficiently extensive to combine three residential zones<sup>3</sup>: Arcachon Bay itself, North Bay and South Bay (Map).

The data were compiled from different sources (Table 3). The primary dataset is made up of 2,205 individual sales transactions between 2000 and 2006, derived from the PERVAL real-estate lawyers’ database<sup>4</sup>. This includes extensive information on each property’s characteristics. Properties are geolocalized at the parcel level. We computed socioeconomic variables from the French Census (1999 and 2006). Additional spatial variables were generated using ArcGIS© software, such as distance to the nearest beach and to the nearest city centre, and especially variables combining land uses and type of zoning, thanks to the superposition of the Corine Land Cover © (land use) and the POS<sup>5</sup> (zoning) layers (map 1 and 2). The result of this combination was systematically verified using recent aerial photos.

The French zoning system, based on the POS, allows the whole land area of a commune or a group of communes to be classified into different categories. There are five categories (cf. Table 1). The first, NA, envisages the conversion of unbuilt or partially-built spaces to residential use. The local authority makes provision for utilities for the land on which building may take place. Generally speaking these are relatively large programmes for the construction of individual houses grouped together in estates. The second category, NB, also envisages conversion, but on a different basis: the local authority does not allow for the provision of utilities for the land. Generally speaking this category caters for scattered development, i.e. construction of isolated houses. The third category, NC, renders agricultural land unbuildable in order to conserve agricultural activity. Residential building is totally forbidden unless it is for the farmers themselves. The fourth category, ND, concerns specially designated natural open space, which must be protected in order to conserve particular species or landscapes. Under normal circumstances building is completely forbidden in such zones. Category ND is sometimes used in order to protect certain land-uses from construction, for example camp sites. Finally, the fifth category, U, generally concerns zones which are already considered to be urban and on which any type of construction may take place, from high-rise flats to shopping centres.

The actual land-use, identified from the Corine Land Cover © satellite images, has been divided into six categories (Table 2): among types of land which is not built upon, we distinguish agricultural land (AGR), forests (FOR), very widespread in the region, green urban areas (GUA) such as parks or stadia, and lastly “open spaces” (OPE), which are mainly vacant land. Among types of land which is built upon, we distinguish residential uses (RES) and “harmful” uses which could potentially cause a nuisance, such as factories, airports, etc. (HMF)

**Table 1. French land use zoning classification**

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<sup>3</sup> The INSEE (French statistics bureau) defines *bassins d’habitat* as *ad hoc* groupings of several municipalities. These are the smallest territories within which households can carry out residential, work and consumption activities.

<sup>4</sup> In France, real-estate lawyers (*notaires*) are obliged to register real estate transactions, and feed them into a very rich database called PERVAL.

<sup>5</sup> The *Plan d’Occupation des Sols* (literally “Plan for the occupation of land”) is the main land-use planning document in France: it defines the use of a particular parcel for five to six years.

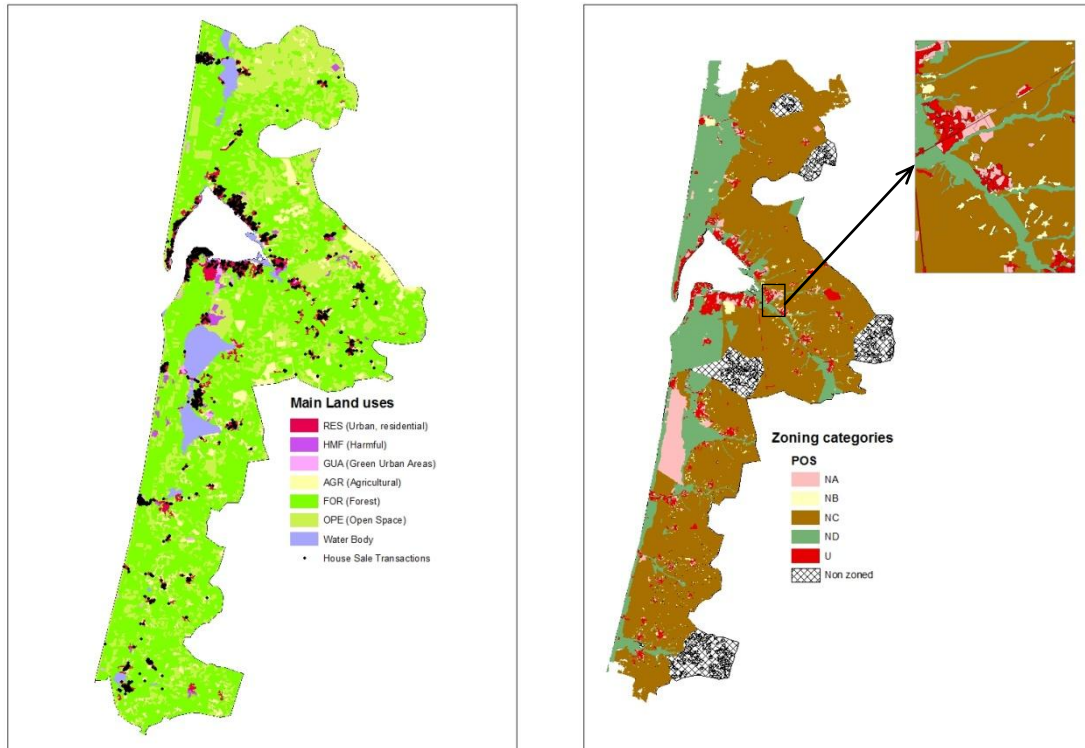
Zones		Definition
URBAN ZONES	U	Urban zones destined for habitation and/or activities. Developed or can be developed imminently since the plots already benefit from public utilities (water, roads, sewage).
NATURAL ZONES	NA	Future urbanisation zone that could soon be developed, where the local authority is prepared to install public utilities. Generally large building programs.
	NB	Zone where development is authorized, but without planned public utilities. Generally houses built on an individual basis at a low density.
	NC	Zones that should be preserved from development due to the agricultural value of the land, soil, or subsoil. These are mainly farming and forestry zones, and zones susceptible to mining or mineral extraction activities. Only farming-related developments are authorised.
	ND	Zones that should be preserved because this is a quality natural site that should be protected from potential nuisances. Such zones include spaces where the environment justifies particular protection, including forests and flood plains as well as landscapes of outstanding beauty.

**Table 2. Land use classification**

	Land use	Description
Unbuilt zones	AGR (Agricultural)	Agricultural zones
	OPE (Open Space)	Vacant land, waterfront, marina, river bank
	GUA (Green Urban Areas)	Urban green space: public park, cemetery, stadium, golf course
	FOR (Forest)	Private and public forests
Built zones	RES (Urban, residential)	Residential land use, campsite, car park
	HMF (harmful)	Airport, aerodrome, road and railway, factory

Source: Corine Land Cover ©, adapted by the authors

**Maps 1 and 2. Main land uses, house sales (left) and zoning classifications (right) in the study area**



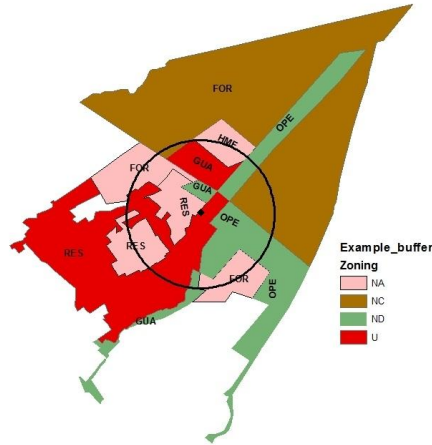
In order to estimate the combination of zoning/land use external effects on housing prices, we defined a 1-km buffer zone around each transaction<sup>6</sup> (map 3). This provides a rough estimate of what is accessible within a 15-min walk from home. The size of this buffer zone corresponds to what can be found in the literature (Cheshire and Sheppard, 2002; Irwin and Bockstael, 2004; Baranzini and Schaerer, 2011); furthermore, Cho *et al.* (2010), who estimate a distance-decay function for open space premium, find a break point between 0.5 and 1 mile (0.8 and 1.6 km), depending on the type of open space being considered.

The zoning/land use variables were computed by taking the logarithm of the total surface of the zone, provided that it is included, partly or totally, in the 1-km buffer zone (map 3). This approach appears to us to be relevant inasmuch as if an individual has access to a space within a radius of 1 km around his home, it is reasonable to suppose that he has access to the whole of this space. This computation technique has already been used by, among others, Poudyal *et al.* (2009).

**Map 3. An example of the zoning/land use areas taken into account within the 1-km radius buffer zone (located in Andernos-les-Bains)**

<sup>6</sup> According to McConnell and Walls (2005), there are three main methods for constructing open space variables: dummy variables for presence/absence in a specific range around the house, mainly in early studies (Lutzenhiser et Netusil, 2001); distance from home to open space (Bolitzer and Netusil, 2000; Sander and Polasky, 2009; Cho *et al.*, 2010); surface area of different types of land use in a specified buffer zone (Irwin, 2002; Geoghegan, 2002; Geoghegan *et al.*, 2003; Poudyal *et al.*, 2009).





### Econometric specification

We base our approach on the hedonic method, which supposes that housing price is a bundle of attributes relating to its structure and environment (Baranzini *et al.*, 2008). Under certain assumptions concerning the housing market (equilibrium, uniqueness...), the hedonic method allows one to compute implicit prices for each attribute. The reduced-form price equation is of the following form<sup>7</sup>:

$$(1) \quad \ln P_i = \alpha + \sum_t \eta_t T_i + \sum_j \beta_j S_{j,i} + \sum_k \delta_k E_{k,i} + \sum_l \gamma_l ZLU_{l,i} + \varepsilon_i$$

Where  $\ln P_i$  is the log of the price of transaction  $i$ ,  $T_i$  the dummy temporal variables for  $t = 2000$  to 2006,  $S_{j,i}$  the  $j$  structural variables concerning attributes of transaction  $i$ ,  $E_{k,i}$  the  $k$  environmental variables,  $ZLU_{l,i}$  the zoning-land use variables, and  $\varepsilon_i$  an i.i.d random disturbance term.

Some econometric problems have to be dealt with in hedonic modelling. First, multicollinearity, as some house attributes can be interlinked: a judicious choice of the dependent variables allowed us to avoid this problem, as shown by the low level of the VIFs. Second, heteroscedasticity, which could stem from the great heterogeneity of the properties, is corrected for by using White (1980)'s robust variance-covariance matrix. Third, endogeneity is a major problem in hedonic models. It may come from a simultaneous determination of price and explicative variables. Irwin and Bockstael (2001, 2002) have shed light on such an "identification problem", which illustrates the fact that if house prices are high, open space is scarce, and vice-versa. Zoning has also long been supposed to be endogenous (e.g. Pogodzinski and Sass, 1994): if zoning leads to increases in house prices (see above), high house prices may lead to a pressure for more stringent zoning by homeowners, according to the "monopoly zoning hypothesis" (Hamilton, 1978) or the "home-voting hypothesis" (Fischel, 2000). Thus, "zoning follows the market" (Wallace, 1988), and conversely.

The correction of endogeneity of the regressors was carried out using the *Feasible Generalized Spatial Two Stage Least Squares* method (Fingleton and Le Gallo, 2008). This is a three-stage procedure: first, we estimate an IV-spatial model for the spatially-lagged dependent variable and for

<sup>7</sup> Because the hedonic price function is an envelope function, there is poor theoretical basis for its specification. A Box-Cox transformation gave a very low value for the coefficient, and the log-linear form (equivalent to a null coefficient) cannot be rejected at the 5% level.

the endogenous regressors; second, we estimate the autoregressive parameter for the errors ( $\lambda$ ) with the residuals of the first stage (Kelejian and Prucha (1999)'s procedure); third, we re-estimate the model of the first stage with a Cochrane-Orcutt transformation of the variables (eq. 2):

$$(2) \quad X = [I - \hat{\lambda}W]X$$

where  $I$  is an identity matrix,  $\hat{\lambda}$  is the parameter estimated at the second stage, and  $W$  is a spatial weight matrix. Fingleton and Le Gallo's procedure offers two main advantages: first, it combines the correction of endogeneity and a spatial process; second, the choice of instruments, which is always a complex problem in applied econometrics, is solved by using "quasi-instruments" computed on the basis of a division of the endogenous variable into 3 classes.

In this paper, we adopt an explicit spatial econometric approach. There are several good reasons to take spatial interactions into account in hedonic models (Anselin, 2008). We tested spatial dependence by computing Moran's  $I$  and found significant spatial autocorrelation for housing prices, whatever the nature of spatial interaction we specified. We tried several spatial weight matrices (inverse distance, Delaunay triangulation, etc.) and we finally retained a 20 nearest-neighbours matrix, which maximized the standardized Moran's  $I$  (Moran's  $I$  standard deviate = 34.625, p-value <  $2.2 \times 10^{-16}$ ).

The two traditional spatial models, called spatial autoregressive model and spatial error model, can be written:

*SAR model (spatial autoregressive model):*

$$(3) \quad \ln P_i = \rho W \ln P_i + \alpha + \sum_t \eta_t T_i + \sum_j \beta_j S_{j,i} + \sum_k \delta_k E_{k,i} + \sum_l \gamma_l ZLU_{l,i} + \varepsilon_i$$

*SEM model (spatial error model):*

$$(4) \quad \ln P_i = \alpha + \sum_t \eta_t T_i + \sum_j \beta_j S_{j,i} + \sum_k \delta_k E_{k,i} + \sum_l \gamma_l ZLU_{l,i} + \varepsilon_i \quad \text{and} \quad \varepsilon_i = \lambda W \varepsilon_i + u_i$$

Where  $W$  is a ( $n \times n$ ) spatial weights matrix,  $\rho$  is the spatial autoregressive coefficient,  $\lambda$  is the scalar spatial error autoregressive parameter, and  $u_i$  an i.i.d spatial disturbance term. The choice of the model specification (spatial lag or spatial error) is based on the Lagrange Multiplier test statistics as well as their robust versions (Anselin *et al.*, 1996).

### **Variables and data**

The variables used to explain sale prices are representative of the structural attributes of the property (such as number of rooms, surface area, date of construction...). Some dummy variables were added for the year of the transaction, to check for time-related factors which could affect house prices, such as tax policies, interest rates, etc. The period is in an ascendant phase of the cycle, which gives robustness to the results, as implicit prices of aesthetic external effects may vary according to the position in the housing cycle (Bourassa *et al.*, 2005).

Environmental (spatial) variables were also included, such as distance to the nearest beach, as the seaside provides recreational and landscape amenities capitalised in housing prices (Parsons and

Noailly, 2004; Pompe, 2008; Dachary-Bernard *et al.*, 2011). We took in account accessibility to retail centres and basic public goods thanks to the distance to the nearest urban center, and social composition of the municipality with mean income per household<sup>8</sup>.

To take into account a possible preference for locations in the Arcachon Bay area itself (rather than in the less attractive North and South residential zones), we computed a dummy variable for properties whose nearest beach is on Arcachon Bay. Finally, in 1986, an important law was introduced in France, the *Loi Littoral* (Coastal Act), which regulates coastal construction of buildings; a dummy variable has been computed to take into account the effect of this regulation on house prices. The following tables provide descriptive statistics for structural and environmental variables (Table 3), as well as for variables obtained by cross-tabulating land use and zoning (Table 4). For some land use-zoning categories, standard deviation can be high, as there can be big parcels in categories such as NC\_FOR (forest that is to be exploited), for example (Table 4). That's why we took the log of the parcel size in the estimations.

**Table 3. Variable names, definitions and descriptive statistics for structural and environmental variables**

Variable	Definition	Source	Mean	Std. Error
PRICE	Transaction price, in Euros 2000	PERVAL	139,800.13	71,766.69
<b>Structural variables</b>				
TYPE	Dummy variable for type of housing (1 if individual detached house, 0 otherwise)	PERVAL	0.40	0.48
Y2000	Dummy variable for year of transaction (1 if transaction in 2000, 0 otherwise) ( <i>Ref.</i> )	PERVAL	0.24	0.36
Y2002	<i>Idem</i> , 2002	PERVAL	0.19	0.31
Y2004	<i>Idem</i> , 2004	PERVAL	0.25	0.38
Y2006	<i>Idem</i> , 2006	PERVAL	0.32	0.44
ROOM_1	Dummy variable for number of bedrooms (1 if one room, 0 otherwise)	PERVAL	0.13	0.23
ROOM_2	<i>Idem</i> , two bedrooms	PERVAL	0.26	0.38
ROOM_3	<i>Idem</i> , three bedrooms ( <i>Ref.</i> )	PERVAL	0.23	0.36
ROOM_4+	<i>Idem</i> , four bedrooms or more	PERVAL	0.37	0.47
LIV_AREA	House square footage (m <sup>2</sup> )	PERVAL	70.22	32.73
LOT_AREA	Parcel size (m <sup>2</sup> )	PERVAL	471.63	607.33
BATHROOM	Number of bathrooms	PERVAL	1.13	0.22
BUILT_48	Dummy variable for date of construction (1 if house built before 1948, 0 otherwise)	PERVAL	0.06	0.12
BUILT_80	<i>Idem</i> , 1948-1980	PERVAL	0.31	0.43
BUILT_92	<i>Idem</i> , 1981-1991 ( <i>Ref.</i> )	PERVAL	0.27	0.39
BUILT_99	<i>Idem</i> , 1992-1998	PERVAL	0.08	0.16
BUILT_06	<i>Idem</i> , 1999-2006	PERVAL	0.28	0.40
BUILT_LL	Dummy variable for houses subject to the regime of French Coastal Law of 1986 (1 if built after the law, 0 otherwise)	PERVAL	0.56	0.49
<b>Environmental variables</b>				
D_BEACH	Travel distance to the nearest beach (km)	GIS GREThA	3.04	2.87
ARC_BAY	Dummy for localization in the Arcachon Bay residential zone (1 if the nearest beach is on Arcachon Bay, 0 otherwise)	GIS GREThA	0.49	0.50

<sup>8</sup> We didn't take in account the controls for school quality: in France, such data is unavailable, especially for primary schools. One can have the success rate for the exams at the end of secondary school and high school. In the study area, school quality is very homogenous: success rate for the 14 secondary schools is 82.6 % (std. dev. = 0.04), and for the 5 high schools 91.6 % (std. dev. = 0.055). That's why these variables were not included in the regression.

D_CENTER	Distance to nearest urban centre with facilities, products and services (km)	INSEE 1999 Census	1.92	1.93
INCOME	Mean income per household in the municipality (€ per year)	INSEE 1999 Census	25,620.34	1,675.26

**Table 4. Descriptive statistics for zoning/land use area variables (in ha)**

		Buildable				Unbuildable				Buildable	
		NA		NB		NC		ND		U	
		Mean (ha)	Std.Dev (Nb of parcels)	Mean	Std.Dev (Nb of parcels)	Mean	Std.Dev (Nb of parcels)	Mean	Std.Dev (Nb of parcels)	Mean	Std.Dev (Nb of parcels)
Unbuilt zones	AGR	9.8	8.7 (42)	7.9	8.1 (166)	240.4	1,534.4 (67)	-	-	18.2	52.1 (34)
	OPE	17.7	17.2 (28)	7.4	4.1 (13)	984.5	2,169.5 (27)	298.9	812.2 (95)	55.7	178.2 (16)
	GUA	23.4	33.1 (16)	83.4	150.4 (17)	-	-	21.9	47.8 (31)	10.6	8.3 (14)
	FOR	75.0	445.2 (156)	10.0	21.6 (103)	1,129.3	2,211.4 (158)	276.4	1,005.1 (157)	10.4	9.1 (59)
Built zones	RES	11.5	25 (152)	14.3	12.9 (71)	-	-	8.3	7.5 (11)	22.7	44.8 (527)
	HMF	54.9	81.3 (15)	2.9	4.2 (11)	-	-	9.3	5.7 (9)	41.0	88.9 (36)

Source: GIS GREThA

## Results

Results are given in Table 5. We also give the values for price-elasticity for each category of land use in Table 6. The diagnostics show a strong spatial autocorrelation in the simple OLS model, which is common when one deals with geolocalized data relating to property prices (Anselin, 2008). As far as the **choice of spatial model** is concerned, the tests of the Lagrange multiplier designate the SEM model (eq. 4). Their robust version is highly significant for the SEM model, whereas it is not for the SAR. The SEM model has the particular characteristic of taking into account omitted variables which have a spatial influence on the price. The correction of the spatial autocorrelation may also be justified by the fact that the explanatory power of the model is much greater once the spatial autocorrelation is corrected, as is shown by the AIC and the high significance of the spatial parameter. The heteroscedasticity revealed by the significance of the Breusch-Pagan test is corrected by White's procedure. The endogenous variables, revealed by Hansen's *J* statistic, are marked with the letter "mu" in the results table; the exogenous nature of the quasi-instrument used is verified by a *C-test* (Hayashi, 2000). Finally, multiple co-linearity did not pose any problems, as shown by the low level of the mean and maximum VIF for the OLS models.

The **structural variables** of models 1 and 2 both have the expected signs. The price is higher the more recent the property, the greater the number of rooms it contains, the bigger it is and, finally, the larger the lot in which it is situated. We don't comment on these variables, inasmuch as they are essentially control variables in a hedonic model, the interesting variables being above all the environmental ones. Furthermore, they are consistent with other recent French studies (Cavailhès, 2005; Dachary-Bernard *et al.*, 2011).

A few results among the control variables do, however, merit attention. Thus the negative influence of the variable BUILT\_LL shows the sensitivity of prices to the 1986 legislation. Property built after

the introduction of this coastal protection legislation suffers a loss in value inasmuch as the regulatory framework applied to construction and to any possible future extensions is much stricter. Moreover, properties bordering Arcachon bay benefit from a premium. This “Bay effect” can be explained in several ways: first, the amenities found around Arcachon Bay are superior (in number or quality) to those found on other coasts, which can be linked to the site’s exceptional nature. Alongside these natural amenities, there may be a “snobbery” effect for people living on Arcachon Bay, because of the district’s long history (Arcachon’s development since the late 19<sup>th</sup> century as a spa town, then as a centre for tourism) and due to many inhabitants’ sense of belonging to a specific culture that is distinct from surrounding areas.

In a general manner, model 1 suggests the existence of a “hierarchy” of the three major types of unbuilt open space: a positive impact of urban green space (*developed open space*), a non-significant impact of forests and open land (*forest-open land*), a negative impact of agricultural land (*agricultural – wetlands*). This result is consistent with those of Cho *et al.* (2010).

The hypothesis which guided the formulation of model 1 was the following: the fact that construction is forbidden allows the external effects of land use to be stabilised. They then have a greater chance of being capitalised in the price, because the uncertainty of change of use is reduced. This mechanism acts in both directions, and the capitalisation obviously depends on the sign of the external effects: if they are positive, as is supposed to be the case for unbuilt spaces, the premium is positive. If they are negative, the premium is negative. And these premiums will be all the higher (in absolute terms) if the land in question is unable to be built upon, because the use in question is “fixed”: the fact that construction is forbidden thus has an ambivalent effect which amplifies the external effects of land use in both directions, be they positive or negative.

Thus it is striking to see that **harmful land uses** (HMF) only provoke negative external effects if they are unbuildable: in such cases, which often correspond to the protection of land around a factory or an aerodrome, the very low probability of a change of land use renders the negative external effects of this use perennial. On the contrary, if these zones are buildable, the coefficient is not significant, perhaps because the fact that construction is allowed gives people hope that there will soon be a change of use, which would produce fewer negative external effects. It is thus striking to see that, in model 2, only zonings NA and NB are significantly negative: in effect, inhabitants who are close to these zones, not yet completely urbanised, pay more attention to the use which will be made of the land. The presence of activities provoking a nuisance, such as shopping centres or factories, could lead one to suppose that they might be extended. On the contrary, residents near to U zones, which are more urbanised, are apparently less sensitive, perhaps because they are already accustomed to urban nuisances.

In the same way, buildable residential use (RES) has a depreciatory effect on property prices, inasmuch as the nuisances supposedly associated with this use (Irwin, 2002) could be further aggravated by new building and the likely increase in population density which would follow.

On the contrary, for land without any building one would expect a positive premium, bigger and more significant if it is unbuildable. However, this reasoning is based on the implicit postulate that

unbuilt land provides positive amenities. In fact, as was shown in the introduction, this depends on the type of land use.

For **green urban areas**, we obtain the expected result: they provide a premium only if they are unbuildable. This result had already been underlined by, among others, Smith *et al.* (2002) and Cotteleer *et al.* (2012) for golf courses, by Poudyal *et al.* (2009) for urban parks, among others. These studies did not, however, take into account the anticipation by the inhabitants of a change of use of green urban areas. Our own results show that the fact that construction is forbidden on such areas (zoned as ND) is of the highest importance in their valuation by the surrounding residents because, *a contrario*, buildable green areas are not significant. Model 2 provides more details concerning this last result: the presence of a green area classified NA or NB does not have a significant impact on the price, no doubt because, such zoning being more frequent in the peri-urban zone, there is a greater possibility that possible substitutes exist for green areas (forests, vacant lots...). On the other hand, a green space classified U would have a negative impact on prices: the perspective of the development of a green area removes an amenity for which, in a densely urban zone, there is not always a nearby substitute.

**Agricultural use** (AGR) systematically leads to reduction in the value of nearby property, whether or not the land is buildable. We find here the confirmation of several empirical results (Cho *et al.*, 2010; Cotteleer *et al.*, 2012; Smith *et al.*, 2002), for which the traditional explanation is based on the fact that the nuisances caused by agricultural land are greater than the amenities: *“The detrimental impact of noise, odors, dust and other negative spillovers are more prominent than positive impacts such as open space and a country feeling”* (Cotteleer *et al.*, 2012, p. 36). We can note that this result contradicts that of Cavailhès *et al.* (2004), who base their theoretical explanation of leapfrog development on the coexistence, in the peri-urban zone, of farmers and households, the latter valuing *“the balance, supposedly positive, of agricultural amenities minus nuisances”* (the emphasis is ours).

Moreover, the impact on the price is higher the higher the likelihood of construction (maximal for a U classification – Table 6). In effect, the depreciatory impact of agricultural land may also be linked to an anticipation of potentially nuisance-provoking uses which could be made of this land (Cotteleer *et al.*, 2012). Now, the parcels concerned are generally big, particularly well-adapted to certain nuisance-provoking uses such as a shopping centre or an industrial estate.

Beyond the “buildable/unbuildable” alternative, more precise information on the future use of the land brings a supplementary explanation of the fixing of property prices. Thus, not only does model 2 provide better explanations than model 1, it provides significant precisions compared to model 1, concerning forests and open spaces.

The best example of the ambivalence of an “unbuildable” classification is without doubt that of the **forest**. The proximity of a forest is not significant, whether or not it is buildable. This is surprising, inasmuch as several studies have shown the positive impact on prices of a protected forest near the property (Bolitzer and Netusil, 2000). Examination of model 2 allows us to better understand this result: forests classified as NC, which are forests exploited mainly for the wood and paper industry (very active in the region), have the same disadvantage as agricultural land: noise, smells, movements of heavy vehicles... On the contrary, forests classified ND constitute “exceptional natural open spaces”, often belonging to the local authority, with open access, acting as recreational areas

for many local residents. Thus the same land-use, unbuildable in both cases, may be a cause of nuisance in one case (the exploited forest), and provide amenities in the other (the protected forest). Thus there really are two types of “unbuildability”, whose final impact on prices depends on the exact land use.

In the same way there are two types of “buildability”. Only the proximity of a forest classified NB has a positive influence on prices: under the hypothesis (verified by model 1) of positive amenities produced by the proximity of a forest, the dispersed nature of the development in zones of type NB appear to cause fewer nuisances than the big, uniform developments typical of zones of type NA. We thus verify the initial intuition according to which the impact of future land use on the price cannot be reduced to a simple buildable/unbuildable alternative: in the “buildable” category, the type of future construction has a certain importance for the surrounding land.

**Open spaces** show a comparable phenomenon. Thus, unbuildable open spaces are associated with a decrease in value, contrary to what was expected. The explanation is that in fact land in this category is, as we have said, for the most part vacant land. Now, vacant land classified as unbuildable is mostly agricultural land which has been left fallow, which explains that open spaces classified NC have a negative impact on prices (model 2): neighbouring inhabitants anticipate a return to agricultural activity on this land (and the associated nuisances) in the short term.

**Table 5. Results for the OLS and spatial models**

	Model 1 : Buildable vs. Unbuildable				Model 2 : All types of zoning			
	OLS		Spatial-IV		OLS		Spatial-IV	
Intercept	4.404e+00***	108.798	4.512e+00***	54.963	4.385e+00***	107.728	4.484e+00***	55.167
TYPE	1.221e-02	1.291	5.154e-02***	5.223	1.174e-02	1.189	4.997e-02***	5.031
Y2000	<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>	
Y2002	8.357e-02***	9.178	8.643e-02***	10.439	8.800e-02***	9.752	8.711e-02***	10.553
Y2004	1.972e-01***	23.021	1.998e-01***	25.121	1.989e-01***	23.330	1.993e-01***	25.098
Y2006	2.813e-01***	33.729	3.000e-01***	38.272	2.854e-01***	34.104	3.001e-01***	38.422
ROOM_1	-2.458e-01***	-21.314	-2.645e-01***	-24.685	-2.514e-01***	-21.687	-2.648e-01***	-24.821
ROOM_2	-1.010e-01***	-11.234	-1.073e-01***	-12.927	-1.021e-01***	-11.307	-1.076e-01***	-13.007
ROOM_3	<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>	
ROOM_4+	2.525e-02*	2.565	4.204e-02***	4.684	3.772e-02***	3.833	4.594e-02***	5.105
LIV_AREA	2.514e-03***	20.005	2.278e-03***	19.826	2.543e-03***	20.324	2.282e-03***	19.817
LOT_AREA	8.331e-06***	3.747	1.018e-05***	5.019	9.598e-06***	4.392	1.070e-05***	5.317
BATHROOM	7.768e-02***	8.412	6.236e-02***	7.482	7.262e-02***	7.894	6.113e-02***	7.345
BUILT_48	-8.659e-02***	-6.278	-1.009e-01***	-7.937	-9.432e-02***	-6.880	-1.041e-01***	-8.204
BUILT_80	-2.094e-02*	-2.492	-2.947e-02***	-3.674	-1.920e-02*	-2.293	-3.013e-02***	-3.769
BUILT_92	<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>		<i>Ref.</i>	
BUILT_99	8.634e-02***	7.174	7.054e-02***	6.326	8.269e-02***	6.963	6.759e-02***	6.076
BUILT_06	9.687e-02***	11.006	8.594e-02***	9.242	9.179e-02***	10.311	8.271e-02***	8.864
BUILT_LL	-2.497e-02***	-3.716	-2.175e-02***	-3.549	-2.602e-02***	-3.892	-1.989e-02**	-3.250
D_BEACH	-4.466e-03***	-4.967	-6.401e-03**	-3.064	-1.126e-03	-1.144	-3.247e-03	-1.581
ARC_BAY	7.792e-02***	9.125	7.402e-02***	3.833	6.259e-02***	7.103	6.868e-02***	3.572
D_CENTER	-2.127e-03	-1.330	-2.497e-03	-0.805	-1.316e-03	-0.791	-1.781e-03	-0.575
INCOME	1.240e-05***	9.704	9.695e-06***	3.301	1.120e-05***	8.342	8.250e-06**	2.771
BUI_AGR	-8.710e-03***	-4.242	-8.069e-03*	-2.458	-	-	-	-
BUI_OPE <sup>H</sup>	2.888e-04	0.166	4.757e-03	1.285	-	-	-	-
BUI_GUA	-3.958e-03***	-4.122	-1.067e-03	-0.494	-	-	-	-
BUI_FOR	-4.669e-03***	-4.074	-2.230e-03	-1.224	-	-	-	-
BUI_RES	-7.130e-03***	-4.989	-5.568e-03*	-2.440	-	-	-	-
BUI_HMF	-3.894e-03**	-3.148	-2.599e-03	-1.225	-	-	-	-
UNB_AGR	-8.818e-03***	-5.848	-3.996e-03*	-1.661	-	-	-	-
UNB_OPE	-1.020e-03	-1.150	-2.943e-03*	-1.849	-	-	-	-
UNB_GUA <sup>H</sup>	1.811e-02***	9.583	1.068e-02**	2.933	-	-	-	-

UNB_FOR	1.258e-03	1.409	-2.138e-03	-1.432	-	-		
UNB_HMF <sup>μ</sup>	-1.700e-02	-1.296	-3.532e-02*	-2.044	-	-		
NA_AGR	-	-	-	-	-3.091e-03	-1.309	-8.305e-03*	-2.257
NA_OPE <sup>μ</sup>	-	-	-	-	-1.025e-02***	-4.685	-2.302e-03	-0.668
NA_GUA	-	-	-	-	-5.449e-03	-1.476	-1.821e-03	-0.332
NA_FOR	-	-	-	-	-4.200e-03***	-3.692	-2.141e-03	-1.134
NA_HMF	-	-	-	-	-4.553e-03*	-2.241	-7.403e-03*	-2.283
NB_AGR	-	-	-	-	3.526e-04	0.084	-3.396e-03	-0.630
NB_OPE	-	-	-	-	1.552e-01***	3.683	7.756e-02	1.120
NB_GUA	-	-	-	-	-4.038e-03***	-3.539	-2.996e-03	-1.182
NB_FOR <sup>μ</sup>	-	-	-	-	1.631e-03	0.606	9.174e-03*	2.359
NB_HMF	-	-	-	-	-3.879e-02**	-3.001	-5.262e-02**	-3.168
NC_AGR	-	-	-	-	-9.097e-03***	-5.510	-5.761e-03*	-2.202
NC_OPE <sup>μ</sup>	-	-	-	-	-1.848e-02	-1.591	-2.536e-02*	-2.232
NC_FOR	-	-	-	-	-3.448e-03***	-3.523	-4.673e-03***	-3.301
ND_OPE	-	-	-	-	8.272e-05	0.086	-8.040e-04	-0.493
ND_GUA <sup>μ</sup>	-	-	-	-	1.936e-02***	9.116	1.177e-02**	3.137
ND_FOR	-	-	-	-	1.598e-03 <sup>†</sup>	1.950	2.531e-03 <sup>†</sup>	1.815
ND_HMF <sup>μ</sup>	-	-	-	-	-3.025e-02*	-2.104	-5.143e-02*	-2.462
U_AGR	-	-	-	-	-2.131e-02***	-5.298	-1.773e-02**	-3.113
U_OPE	-	-	-	-	1.965e-03	0.820	2.322e-03	0.462
U_GUA	-	-	-	-	-1.345e-02***	-5.455	-1.001e-02*	-2.229
U_FOR	-	-	-	-	-4.500e-03*	-2.251	-2.761e-03	-0.944
U_HMF	-	-	-	-	-7.571e-04	-0.515	1.137e-03	0.460
λ	-	-	0.74127***	30.973	-	-	0.7282***	29.132
<b>N</b>	2,205		2,205		2,205		2,205	
<b>Adj. R2</b>	0.770				0.777			
<b>Nagelkerke R2</b>			0.80956				0.8133	
<b>AIC</b>	-2,454.6		-2,838		-2,506		-2,858.5	
<b>Breusch-Pagan</b>	159.191		143.215		211.31		187.87	
<b>Mean VIF (VIF max)</b>	1.682 (3.298)				1.792 (3.541)			
<b>Standardized</b>								
<b>Moran's I on OLS residuals</b>	34.1668***				34.9374***			
<b>LM (lag)</b>	48.4427***				85.89***			
<b>Robust LM (lag)</b>	15.0496**				1.77			
<b>LM (error)</b>	906.8412***				813.19***			
<b>Robust LM (error)</b>	873.4481***				729.07***			

Note: \*\*\*p<0.001; \*\* p<0.01; \* p<0.05; <sup>†</sup>< 0.10. *t*-ratios are in italics.

Dependent variable: ln(price of house sale); endogenous variables are marked with a  $\mu$

**Table 6. An estimation of premiums**

	NA	NB	NC	ND	U
AGR (Agricultural)	-0.83%	<i>NS</i>	-0.58%	-	-1.77%
OPE (Open Space)	<i>NS</i>	<i>NS</i>	-2.54%	<i>NS</i>	<i>NS</i>
GUA (Green Urban Areas)	<i>NS</i>	<i>NS</i>	-	1.18%	-1.01%
FOR (Forest)	<i>NS</i>	0.92%	-0.47%	0.25%	<i>NS</i>
HMF (Harmful)	-0.74%	-5.26%	-	-5.14%	<i>NS</i>

Note: Variation of the real estate price when land use in a 1-km radius rises by 1 ha.

## Conclusion

This article aims to improve our knowledge of the capitalisation of surrounding land uses in property prices, based not only on current use, but on future use of the land, the latter being taken into account by the buyer in the intertemporal calculation of house price. To date, the only contributions taking these two aspects into account at the same time only envisaged the alternative



“buildable/unbuildable” as the future land use. Thanks to the French system of land-use zoning, we are able to take into account the type of future urbanisation (dispersed or dense) when the land is buildable, and the type of use (natural or exploited open space) when it is unbuildable.

In this sense, the additional precision concerning the future use of the land is rich in information. First, for a given land use, classification as buildable has a certain influence: thus, protected green spaces really do lead to a positive premium, but their classification as a buildable zone provokes on the contrary a decrease in the value of surrounding property. Second, the unbuildable nature of land may be ambiguous: the example of the forest shows us that, although it provides positive external effects, related to the presence of wild plants and animals or the provision of recreational space for residents, this is only valid if the forest is unexploited, because in this case, the nuisances dominate.

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