

# Assessing the impact of land-cover changes on ecosystem services: A first step toward integrative planning in Bordeaux, France



Pedro Cabral<sup>a,e,\*</sup>, Clément Feger<sup>b</sup>, Harold Levrel<sup>d,f</sup>, Mélodie Chambolle<sup>c</sup>, Damien Basque<sup>c</sup>

<sup>a</sup> NOVA IMS, Universidade Nova de Lisboa, 1070-312 Lisboa, Portugal

<sup>b</sup> Muséum National d'Histoire Naturelle, UMR 7204 – CESCO, Paris, France

<sup>c</sup> LyRE, Centre de Recherche de Suez Environnement (Lyonnaise des Eaux) Bordeaux, France

<sup>d</sup> CIRED, AgroParisTech, 45bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne Cedex, France

<sup>e</sup> Université de Brest, UMR AMURE - Centre de droit et d'économie de la mer, IUEM, 12rue du Kergoat, CS 93837, 29238 Brest Cedex 3, France

<sup>f</sup> Ifremer, UMR M101, AMURE, Unité d'Economie Maritime, BP 70, F-29280 Plouzané Cedex, France

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## ABSTRACT

The quantification and integration of ecosystem services (ES) into urban planning decisions is becoming increasingly important. However, studies that quantify and analyze the impacts in terms of ES changes are still scarce. We analyzed multiple ES provided by the landscape of the Urban Community of Bordeaux (CUB), in France, between 1990 and 2006 as a result of land use and cover change (LUCC) with Corine Land Cover and other open data. These ES were selected with the help of local stakeholders and were calculated using a spatially explicit modeling approach with InVEST and own-produced models. It was found that all ES, except erosion regulation, have decreased as a consequence of LUCC. Results also suggest that LUCC change decisions which do not consider policy measures for ES protection tend to generate land use patterns providing lower levels of ES. This spatial explicit approach to ES modeling enables an informed discussion with stakeholders and may be used to effectively implement, monitor, and communicate future planning policies.

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## 1. Introduction

Ecosystem Services (ES) approaches are seen by many as a promising way to better take into account the ecosystems in the decision process because they seek to make visible the multiple contributions of nature to society and associated tradeoffs (Goldstein et al., 2012; Tallis and Kareiva, 2006). This is especially important for cities, as they accommodate an increasing number of the world's population, and depend on the ES beyond their boundaries to sustain long-term conditions for life, health, security, social relations and other aspects of human well-being (Gómez-Baggethun and Barton, 2013).

The production and use of information on the effects of LUCC management practices on ecosystem functioning is decisive for the design of policies able to ensure an effective provision of the desired ES (Nelson et al., 2009). However, this requires taking into account interactions between multiple human uses, which are a source of complexity for planning managers (Naem et al., 2009). ES mapping tools and quantitative biophysical indicators that

make ES values visible and help to assess the tradeoffs associated with these interactions are being increasingly used to help them face this complexity (Burkhard et al., 2013; Maes et al., 2012; Tallis and Polasky, 2011, 2009). It has also been reported that the reliability, the local relevance, and the effective use of ES knowledge can greatly benefit from meaningful stakeholder participation (Biggs et al., 2011; Koschke et al., 2014; Levrel and Bouamrane, 2008; McKenzie et al., 2014; Rosenthal et al., 2015; Ruckelshaus et al., 2015).

Given the growing importance of ES approaches and assessment tools, it is now essential to test their effectiveness in a variety of real-world decision-making contexts and practical management situations at the territorial level (MEA, 2005; Ruckelshaus et al., 2015). Although a number of studies have quantified and mapped multiple ES (Chan et al., 2006; Egoh et al., 2008; Geneletti, 2013; Goldstein et al., 2012; Leh et al., 2013; Nelson et al., 2009), such studies do not exist for France at the municipal level or, especially, for using open tools and data such as the Corine Land Cover (CLC) (EEA, 2012), which is an important European dataset for Land Use and Land Cover (LULC).

In this paper we report the results of a spatial explicit ES assessment with local stakeholders using a tool called InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), which relies on ecological information to map, quantify, and value the

\* Corresponding author at: NOVA IMS, Universidade Nova de Lisboa, 1070-312 Lisboa, Portugal.

E-mail address: [pcabral@novaims.unl.pt](mailto:pcabral@novaims.unl.pt) (P. Cabral).

distribution of ecosystem services across a landscape (Tallis et al., 2014), and other own-produced models. The ES assessment is focused on what is called the “landscape services”, which correspond to the services supplied by landscapes, i.e., the capacity of a landscape to provide goods and services to society (Lamarque et al., 2011). To measure these services, we use “ES indicators”, which represent “quantitative spatially differentiated metrics or maps related to supply of, or demand for, ES” (EPA, 2009).

The goals of this exploratory and awareness raising study are:

- (i) To identify and describe the evolution of ES in the Urban Community of Bordeaux (CUB) as an impact of LUCC between 1990 and 2006 using free tools and open data;
- (ii) To describe a strategy for studying ES changes with stakeholder engagement; and
- (iii) To highlight issues regarding the assessment of ES at a local scale and discuss how this approach can provide useful information for integrative urban planning and, ultimately, be integrated in existing formal urban planning processes.

## 2. Data and methods

### 2.1. Study area

The city of Bordeaux, capital of the region of Aquitaine, is located in southwestern France. The CUB is composed of 28 municipalities (*communes*) and covers about 57,632 ha (Fig. 1). It has a varied LULC composition including densely urbanized areas, agricultural and vineyard areas, forests, and wetlands. It is an area

characterized by low slopes and low elevation (< 105 m).

In the north of the CUB is located the Ambès peninsula, which has marsh landscapes and wildlife typically found in wetlands. This natural territory is subject to strict protection restrictions. The Jalles Park, in the west of the CUB, houses the Bruges Regional Natural Reserve, composed of marshes and diverse habitats with more than 4000 animal species (La CUB, 2013). In the west are also located the Landes forest, which is the largest maritime-pine forest in Europe. In the south, the rivers Vallée de l'Eau Bourde and the Vallée de l'Eau Blanche offer opportunities for recreation, such as fishing and hiking. On the east side of the CUB, on the right bank of the Garonne river, is located the Parc des Coteaux covering 100 ha.

The natural environment hosts a great a variety of local plant and animal species. Some of them are protected, such as the *Angelica heterocarpa*, *Mustela lutreola*, and the *Phengaris arion* (La CUB, 2013; Ruys et al., 2012). Other, more common species, are also present in these natural spaces such as foxes, otters, and orchids. There are also many local and migratory bird species on the territory of the agglomeration (Le Gall et al., 2012).

The study area presents a set of practical issues in land use planning and the CUB expectation of reaching one million inhabitants by 2030 (727,256 inhabitants in 2011). To manage this expectation the CUB launched, in 2009, a prospective approach that resulted in a policy document, the “Metropolitan Project”, which articulates a vision for the city to year 2030. Among others, the “55,000 ha for Nature” initiative aims to make compatible the demographic growth with the “respect and valuation of the natural spaces in the city, the well-being and the respect for the biological needs of plant and animal species” (CUB, 2012). Therefore, the CUB wishes to put the “collective relationship to nature”

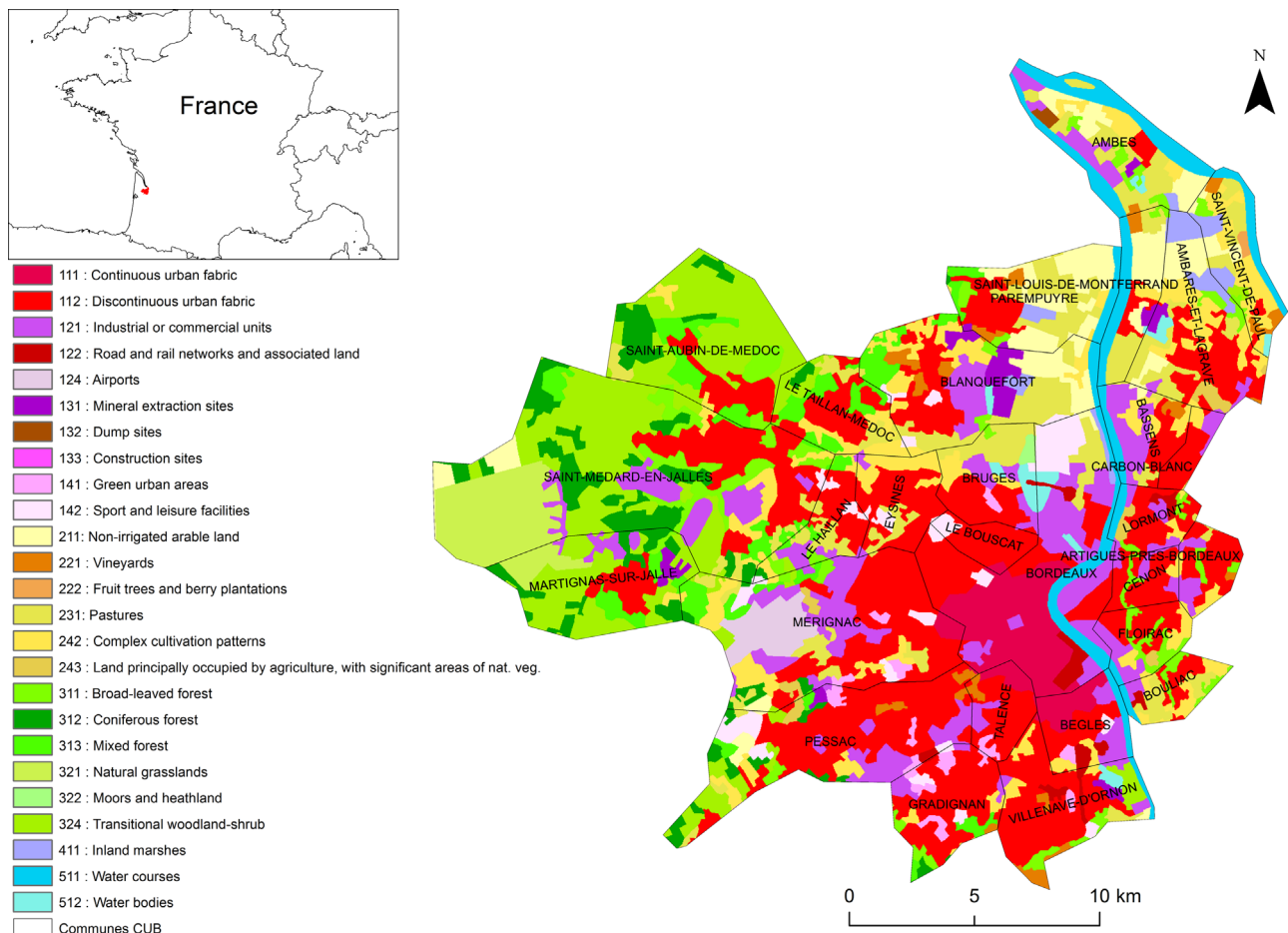


Fig. 1. The CUB and land use and land cover in year 2006 (Data sources: EEA, 2012 and IGN, 2013).

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