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Methodological and Ideological Options

The urban political ecology of ecosystem services: The case of Barcelona

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ABSTRACT

This paper advances two arguments. First, the liveability of modern cities depends to a large extent upon urban and peri-urban ecosystems and their services. Second, these services are not only a gift of nature, but co-produced by human labour. Ecosystem services, in other words, are not just natural; they are also the outcome of historical, political, economic and social endeavours. We support our case with a study of the city of Barcelona and the adjacent Collserola Natural Park. Through an inter-disciplinary project combining biophysical, historical, and archival research, interviews and activist research we show that, first, the liveability of Barcelona highly improves because of the services provided by the ecosystem of Collserola. Second, that Collserola was not originally a pristine forest; it became one after agricultural abandonment institutional interventions and the action of social movements. If ecosystem services are co-produced by human action, and social struggles, as we argue is the case of Collserola, then this has implications for the ways ecological economists think about ecosystem services, their value and valuation. Whereas the social production of ecosystem services may seem an obvious and intuitive idea, it certainly challenges the foundational aspects of monetary valuation.

1. Introduction

Urban areas depend on ecosystems for the provision of a range of services that contribute to human well-being. These include regulating services, such as water regulation, urban cooling, and air purification, or cultural services that serve recreation or spiritual human needs (Bolund and Hunhammar, 1999; Chiesura, 2004; Gómez-Baggethun and Barton, 2013; Haase et al., 2014; Luederitz et al., 2015; Muhamad et al., 2014; Niemelä et al., 2010; Trzyna, 2014). Ecosystem services (ES) to cities are provided at the local level, but also at regional, national or global scales (Chiesura, 2004; Givoni, 1991; Tzoulas et al., 2007; van Kamp et al., 2003). Strictly defined urban ecosystems (see for instance Pickett et al. (2001)) contribute only marginally to the demand for ecosystem services of densely built up areas (Baró et al., 2015; Niemelä et al., 2010). To understand how cities are made liveable, it is necessary to also look at the contribution of urban hinterlands (Baró et al., 2014; Depietri et al., 2013; Haase et al., 2012; Larondelle et al., 2014). Peri-urban regional ecosystems are crucial for the healthiness and liveability of cities, a main concern for global human well-being as more and more people live in densely built urban areas (Elmqvist et al., 2013; MA, 2005; UNDESA, 2014).

Ecosystem services have been defined by ecological economists as "the benefits of nature to households, communities and economies" or, more specifically, as "components of nature, directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf, 2007). Ecosystems are also often referred to as "natural capital" or "those components of the natural environment that provide a long-term stream of benefits to individual people or to the society as a whole" (Liu et al., 2010). Costanza et al. (2015, p. 108) define ecosystem services as "ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being". This literature explicitly states that humans are an integral part of ecosystems. However, the supply of ecosystem services is often referred to as the result of natural forces, habitat properties, and ecosystem functions or processes, where humans are regarded as their mere beneficiaries (Boyd and Banzhaf, 2007; Costanza et al., 1997; de Groot et al., 2002, 2010; Fisher et al., 2009; MA, 2005; Wallace, 2007). In defining ecosystem services as products of "nature", the socio-economic and political factors and the human effort codetermining their provision generally remain unconsidered. In ecological economics, humans may use, damage or protect ecosystem

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services, or they may perceive and value them in one way or the other (Daly and Farley, 2010; de Groot et al., 2012; Fisher et al., 2009). However, humans do not 'produce' ecosystem services; these services, as the quotes and definitions provided above suggest, are attributable to external ecosystems, which in turn, are part of natural processes. The pre-paradigmatic ecological economics textbook diagram is telling in this respect: it considers the economy and society as smaller circles within an independent, external circle called 'nature' or 'ecosystem'. Society depends on, and may harm, the natural ecosystem; but ecological economics sees the two of them as distinct and separate; society does not 'produce' nature.

As political ecologists however have shown, urban and peri-urban ecosystem services do not just exist 'out there; they are 'entangled in social and political processes' (Ernstson, 2013). As Ernstson claims, ecosystem services are 'socially produced'. This terminology might strike ecological economists as strange, perhaps as too 'constructivist' and antithetical to the 'strong sustainability' foundation of the discipline. It should not. The hypothesis that nature is socially constructed has a long lineage in the field of urban political ecology (Swyngedouw and Heynen, 2003). If properly understood, it matches a co-evolutionary understanding of the relationship of societies to ecosystems that is also foundational for ecological economics (Kallis and Norgaard, 2010), though somewhat at odds with the textbook view of ecological economics.

According to the 'production of nature' thesis in urban political ecology, humans, ourselves a species, constantly refashion our habitats and/or environments and adapt to these transformed environments. A forest is the product of biophysical processes, but also of the human labour that has gone into the slash and burning, the plantation, the conservation or tree logging, the prescription of fires or the extinguishment of fires. Humans constantly transform bio-physical environments and have to adapt to their transformations in a co-evolutionary fashion (Norgaard, 1994).

Importantly, this is not a socially neutral process: ecological processes "become discursively, politically and economically mobilized and socially appropriated to produce environments that embody and reflect positions of social power" (Swyngedouw and Heynen, 2003, p. 6). Braun (2002), for example, in his book "The intemperate rainforest", reveals the various practices – social, discursive, political and material – through which Canada's West Coast forests have been given meaning and made the site of intense political and ideological struggle. González-Hidalgo et al. (2014) explain how different ways of imagining what a natural and sustainable forest is clash with one another when determining fire management practices. 'Wars' over the land-uses of forests are interwoven with 'wars of truth' over 'whose knowledge counts' (Sletto, 2008), or whose values matter (Martinez-Alier, 2003). These 'wars' in effect determine who has the power to transform landscapes and to what effect. Power relations play a role in ecosystem service supply, which goes generally overlooked in traditional approaches that simply perceive ecosystem services as services provided by nature (Dawson and Martin, 2015; Otero et al., 2011; Tadaki et al., 2015).

The transformation of urban and peri-urban landscapes and ecosystems is therefore a co-evolutionary process where technological and institutional interventions interact with values, imaginaries and ways of knowing as well as with ecological processes to produce what political ecologists call new 'socio-natures' (Swyngedouw and Heynen, 2003). Perhaps the word 'production' gives an unwarranted sense of intention and control of humans over this process, something that would be wrong. We use the word 'production' instead, to highlight the human effort that goes – consciously or unconsciously – into the transformation of ecosystems and the provision of their services. From this vantage point, urbanization is not always detrimental to ecosystem services (by occupying and transforming land, etc.), but can also, intentionally or unintentionally, be favourable when social, political and economic processes in the cities support the protection or enhancement of ecosystems.

In introducing a research agenda on the 'political ecology of ecosystem services', Kull et al. (2015) look at how the concept of ecosystem services can be framed in different ways and thus be mobilized for very different political projects. Instead, we are keen to support, with irrefutable data, a more prosaic point, which is, however, far from being established in ecological economics: namely, that ecosystem services are socially co-produced through human labour, intentional or unintentional, and that social movements can play a major role in their provision. To illustrate our claims, we study the case of the city of Barcelona in Spain. After looking at our evidence a reader may think that this is an obvious point. Nonetheless, ecological economics have not taken up this point yet, considering nature and the economy as distinct and separate entities. Moreover, if it were to be taken up, it would fundamentally undermine the basis for monetary valuation, a method that is still popular among (some at least) ecological economists.

Section 2 details the methods and data we apply to prove that:

i) Barcelona would be much less liveable without the peri-urban ecosystem of Collserola (Section 3);
ii) Collserola had not always been a forest, but became so after the retreat of agriculture since the mid-19th century (Section 4);
iii) It was possible to safeguard Collserola's ecosystem also thanks to the work of social movements and activists (Section 5).

The paper presents, therefore, a quantitative assessment of the ecosystem services provided by the ecosystem of Barcelona and the Collserola peri-urban park to prove that these matter for the city's liveability (Section 3). Furthermore, it also provides a historical qualitative ('co-evolutionary') account of the different periods leading to the present Collserola peri-urban forest. In this way, it sets the prerequisites for the environmental benefits now enjoyed by the inhabitants of Barcelona (Sections 4 and 5). Finally, Section 6 concludes with some reflections on the implications of our research with regard to how ecological economists may think about ecosystem services, their value and their valuation.

2. Case Study, Methods and Data Sources

The city of Barcelona is located in the region of Catalonia (Spain), of which it is the capital. With a surface of 101.9 km^2, the city's population amounted to about 1.604 million in 2015.[1] It is the densely populated core of a metropolitan region home to about 4.77 million inhabitants in 2015 (IDESCAT, 2011[2]). Northwest of the city is the Collserola mountain range (see Fig. 1), which supplies Barcelona with vital ecosystem services.

The Collserola Natural Park (covering a total area 8300 ha, of which 20.47% belong to the municipality of Barcelona) has a typical Mediterranean climate with elevations ranging between 60 m and 512 m. Thereof, 38% of its surface is covered by mixed woodlands of Aleppo pine (*Pinushalepensis*) and Holm oak (*Quercus ilex*). Owing to its agricultural past, the rest of the park consists of a diverse mosaic of land covers ranging from Mediterranean scrub (13%) to savannas and grasslands (2%) (Cahill and Llimona, 2004). The forested area of the park is not a native forest; the only remnants of the original forest are in fact present in an area of 113 ha with indigenous deciduous and evergreen oak trees in Font Groga, close to Sant Cugat (Cañas et al., 1995; CPC, 2011).

The park is situated in one of the most densely populated areas in Europe. As a result, it is enclosed by urban areas and crossed by roads and railways (Cahill et al., 2003). Given its proximity to Barcelona, it is also one of the most visited parks in the Catalan region with about 2 million visitors per year (Creel and Farell, 2008).

[1] http://www.idescat.cat/emex/?id=080193&lang=en, (Retrieved 15/01/2016)
[2] http://www.idescat.cat/pub/?id=aec&n=246 (Retrieved15/01/2016)

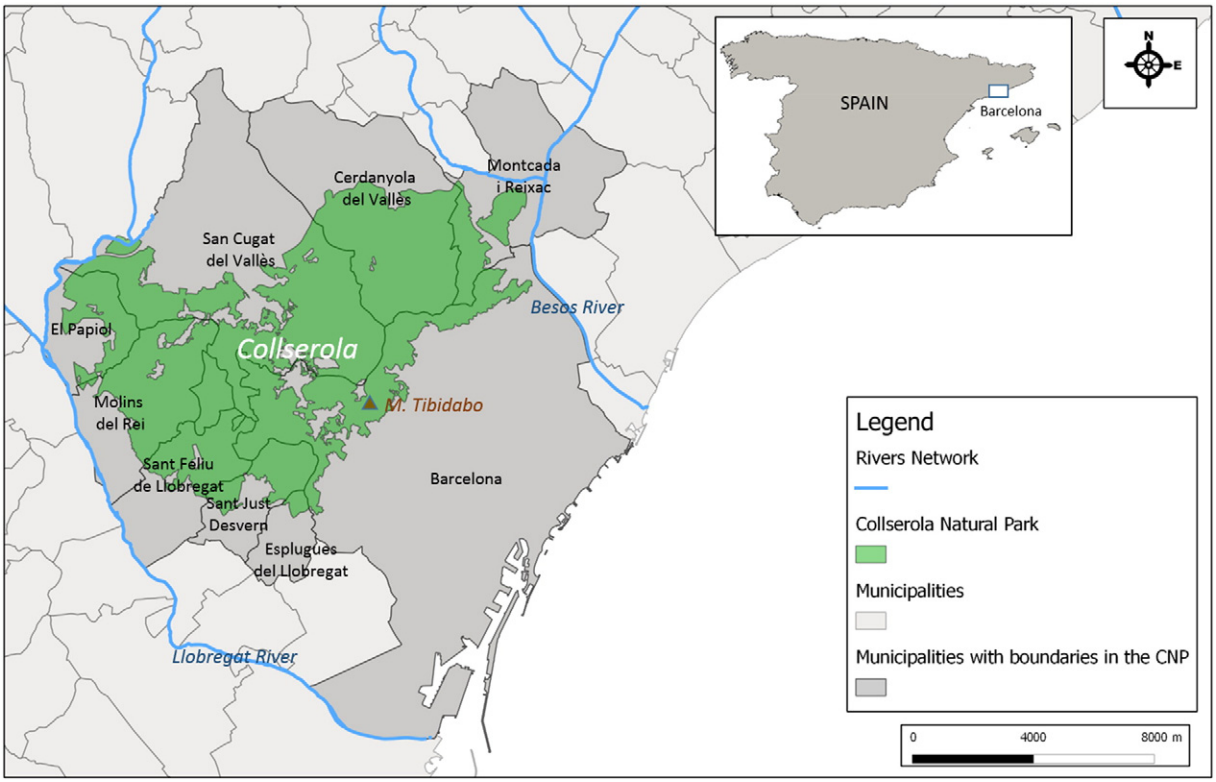

Fig. 1. Map of the case study area (own map; data sources: Generalitat de Catalunya, Departament de Territori i Sostenibilitat and Institut Cartogràfic i Geològic de Catalunya).

2.1. Assessing Ecosystem Services

As a first step, we carried out a quantitative assessment of the ecosystem services in Barcelona and assessed the contribution of the Collserola Natural Park. The first claim that this research seeks to support is that Barcelona would be a very different city without Collserola, and that the park significantly contributes to its liveability and well-being. Towards this end, we create two scenarios and estimate the provision of ecosystem services under each: scenario 1 considers the municipality of Barcelona hypothetically without the existence of Collserola (Fig. 2.A); and scenario 2 considers Barcelona with Collserola (Fig. 2.B). Scenario 1 includes the 84.6 km^2 of surface occupied by Barcelona, excluding the part of it that falls within the borders of the Collserola Park, and scenario 2 the 167.6 km^2 of the city plus the park. We compare the ecosystem services provided in each scenario to that of other cities to obtain a certain estimation of the benefits that Barcelona derives from the presence of the Collserola forest.

Numerous indicators and proxies can be used to quantify and assess ecosystem services in urban areas (see Dobbs et al. (2011); Gómez-Baggethun et al. (2013); Haase et al. (2014) for some reviews). We considered four urban ecosystem services in our study, three of which consist of regulating services (i.e. urban cooling, air purification, flood regulation),

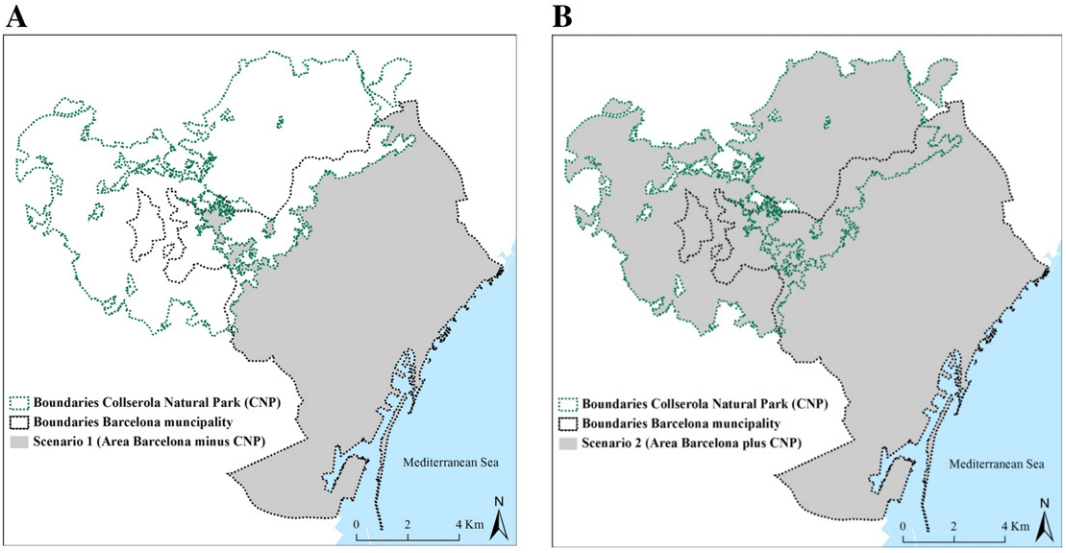

Fig. 2. A. Administrative boundaries of the Municipality of Barcelona and the Collserola Park and in grey scenario 1 (own map; data sources: Generalitat de Catalunya, Departament de Territori i Sostenibilitat and Institut Cartogràfic i Geològic de Catalunya. B. Administrative boundaries of the Municipality of Barcelona and the Collserola Park and in grey scenario 2 (own map; data sources: Generalitat de Catalunya, Departament de Territori i Sostenibilitat and Institut Cartogràfic i Geològic de Catalunya).

and one which is cultural (i.e. recreation). However, all four of them can be considered as proper urban services.[3] Thereof, one service (flood regulation), is related to directional flow, two services (urban cooling and air purification) are locally proximal (dependent on proximity and wind corridors), and recreation is related to the habits and mobility of users (Costanza, 2008). Also note that the three regulating services we have considered are non-rival services, meaning that the use of the services by one person does not preclude the use by another person (Burkhard et al., 2014). This excludes a possible overestimation of the benefits provided by the park to the city of Barcelona. By contrast, according to Burkhard et al., recreational services may be considered as rivals in some cases. Such seems to be the case for Collserola due to the high number of visitors and the conflicting recreational activities taking place in this park (La Vanguardia, 2010). We then consider that all the nine municipalities surrounding Collserola benefit from just a fraction of the recreational services provided by the park itself as detailed below.

The ability of urban green areas to uptake pollutants from the air has been assessed in different cities of the world (Cavanagh et al., 2009; Escobedo et al., 2011; Nowak et al., 2006). For the municipality of Barcelona, the air purification brought about by green infrastructure was previously estimated using the i-Tree Eco model (Baró et al., 2014; Chaparro and Terradas, 2009). Starting from the results obtained by Chaparro and Terradas (2009) and Baró et al. (2014), the receding of air pollution brought about by vegetation was derived in terms of t $year^{-1}$ km^{-2} of CO, NO_2, PM_{10}, SO_2 and O_3[4] for both scenario 1 and scenario 2. By doing so, we assumed that the air pollution removal values for each land cover class derived for Barcelona and used in Baró et al. (2014) were also applicable here for scenario 2 which includes all of Collserola, and not just for Barcelona as in the Barò et al. case. Only data from monitoring stations located in the municipality of Barcelona were in fact available.

The urban cooling potential can be calculated through various proxies. These proxies are, notably: surface emissivity (Larondelle et al., 2014; Stathopoulou and Cartalis, 2007): evapotranspiration (Larondelle et al., 2014; Larondelle and Haase, 2013; Schwarz et al., 2011); leaf area index (LAI)(Knote et al., 2009); or the percentage of tree canopy cover as a proxy of the cooling potential of tree shadow and evapotranspiration (Bowler et al., 2010). We calculated both the emissivity (which does not linearly relate to the cooling potential) and the evapotranspiration capacity (of which the relationship with heat fluxes is linear), as these provide complementary information (Larondelle et al., 2014). The coefficients of land surface thermal emissions and evapotranspiration for different land cover types were based on the look-up table derived and applied by Larondelle et al. (2014). The percentages of each land cover type, as derived from the European Environment Agency (EEA) Urban Atlas (used to obtain results comparable with those of other European cities, see Appendix A), were weighted by the corresponding evapotranspiration potential (f-value) and surface emissivity coefficient.[5]

Water infiltration in soils and groundwater recharge reduce surface runoff and can be considered as proxies of the water regulating services provided by ecosystems (Bergkamp and Cross, 2006). There are several ways to calculate flood regulation. The factors to consider can be:

a) to calculate the percentage contribution of groundwater to base flows (Egoh et al., 2008);
b) in millions of m3 of groundwater recharge per 1 km2 of grid cell (Reyers et al., 2009);
c) in terms of the presence and surface of the riparian areas (i.e. "green zones", which lie between stream channels and uplands) (Pert et al., 2010);
d) percentage of sealed surface, e.g. in the urban area (Haase and Nuissl, 2007).

Other indicators of flood regulation are the water storage capacity (buffer) in m^3, or performance indicators like “reduction of flood danger and prevented damage to infrastructure” (de Groot et al., 2010). We considered, for its simplicity, the percentage of sealed surfaces with respect to the total study area as a proxy of the infiltration capacity of the soil and the reduction of runoff.[6] We calculated this potential based on the land cover types as defined in the Land Cover Map of Catalonia 4th edition (LCMC4)[7] that corresponds to the year 2009 for both scenarios 1 and 2. We used LCMC4 as it is the most recent detailed land cover dataset available for the case study area. In scenario 2, we considered only that part of the park that slopes towards Barcelona.

The potential supply of recreational opportunities by green space represents the capacity of the ecosystem to provide possibilities for outdoor recreation, nature observation, education or hunting (Niemelä et al., 2010). Following other ES assessments in urban areas (see for instance Larondelle and Haase (2013)), all land cover types denoting green spaces (such as urban parks, private green areas, gardens, forests and agricultural land) were assumed to be capable of providing recreational services. Two simple indicators to quantify recreation potential were calculated: the percentage of green cover (from the total area for both scenarios), and the ratio between green cover and population (in m^2 per capita). As we included in our assessment of private green areas, our results for recreational services need to be considered as an upper bound estimate. Only owners of private green areas can benefit from these spaces for recreation. Excluding private recreational services would even augment and strengthen the relative contribution of Collserola to recreation. Note also that while Collserola is used for actual recreational practices (walking, running, cycling, nature observation), many of the private gardens are too small to support such activities.

The selection of green cover classes was based on a query of the LCMC4 dataset. As the surface of the municipality of Barcelona is 40.14% of the total surface of the 9 municipalities that surround the Park and because approximately 41.2% of the users of the Park come from the municipality of Barcelona (IERMB, 2009), we considered that Barcelona enjoys 40% of the recreational services provided by the park.

Finally, we carried out a non-exhaustive literature review and gathered results obtained by ecosystem services studies for other urban areas, mainly in western countries, to contextualize and compare the liveability of Barcelona with and without Collserola with that of other cities (summarized in the Appendix A).

2.2. Land Cover Changes

The second claim is that the ecosystem services that Collserola provides today are a relatively recent development in the sense that, for centuries, Collserola was not a forest; it has become one only recently. To support this claim of a ‘produced forest’, we use historical data on agricultural land use and GIS based land use data.

First, we investigated the agricultural land uses in the mid-19th century by studying specific government reports, the so-called

[3] We calculated all biophysical values of the ecosystem services using ArcGIS 10 (ESRI).

[4] Carbon oxide (CO), nitrogen dioxide (NO_2), particulate matter with diameter of 10 μm or less (PM_{10}), sulfur dioxide (SO_2) and troposphere ozone (O_3).

[5] Note that, in the results section, the cooling potential calculated through emissivity is expressed as one minus the normalized emissivity (obtained through the min–max method were the minimum and maximum emissivity is derived from Larondelle et al. (2014) ‘surface emissivity coefficients’).

[6] In vegetated areas, in fact, only 5 to 15% of the rainwater flows as surface runoff while the rest evaporates or infiltrates (Bolund and Hunhammar, 1999). In sealed urban areas, on the other hand, 60% of the rain water flows on the surface and is collected by the drainage system (Bolund and Hunhammar, 1999) or overflows. According to Pataki et al. (2011), urban landscapes with 50–90% impervious cover can lose 40–83% of rainfall to surface runoff. In the results section we report the opposite of the percentage of sealed surfaces as the actual capacity of the land to reduce flood impacts.

[7] Provided by CREAF (Centre for Ecological Research and Forestry Applications) http://www.creaf.uab.es/mcsc/.

"Amillaramientos". The "Amillaramientos" are records kept and made available in national and regional historical archives. They used to document data on agricultural activities for tax purposes, and reported on the market value and surface occupied per crop and per agricultural activity for each municipality. Until the 1850s, the compilation of 1:2000 plot maps was based on a sort of 'field work triangulation', involving a board of experts and surveyors (i.e. "geòmetres"), including a council of clerks, workers and peasants(Nadal et al., 2006). This triangulation suggests that the reported estimates might be more accurate than suggested by those who claim that landowners must have under-reported data for tax reasons (see for instance Pujantell, 2012; Vallejo Pousada, 2010).

We collected data from the reports of the municipalities, whose jurisdictions include part of the territory within the present boundaries of the Collserola Park and that could make data available (five municipalities in total). Since it was not possible to isolate changes in the areas within the park to-date, we report on data of land cover change for each municipality as a whole, assuming that this is an indication of the type of changes experienced in their territory within the confines of Collserola.

Second, for 1956 and 2009, there is data available for the area of Collserola itself. For 1956, we used the land cover map based on the aerial images derived from what is known as the 'American flight' available at the Diputació of Barcelona (LCM56, http://sitmun.diba.cat/sitmun2/inicio.jsp). For 2009, we used the LCMC4 mentioned above. Then, we calculated the percentages of agricultural land for each of the five municipalities taken into account. Using these datasets, we carried out an analysis of land cover changes between 1956 and 2009 using general types of land cover classification.

2.3. Historical and Social Changes

Our third claim is that the ecosystems of Collserola, which benefit the densely urbanized area of Barcelona, are socially (co)produced, or in other words, their services are also the result of social, political, and economic processes. There are three different processes meriting investigation. First, we want to explain the socio-economic transition of Collserola from a cultivated land to a forest since the end of the 19th century. Second, we want to understand the institutional and political battles over the conservation of the area and its designation as a protected area from the early 20th century to-date. Third, we want to elucidate the more recent post-1970s social struggles against the encroachment of urbanization processes into the area of the park and the final steps towards its creation.

A first, an indispensable source of information is the wealth of master and doctoral theses, reports, published books, peer-reviewed journal articles and websites concerning the present and the history of Collserola.

Second, we conducted a content analysis of the online digital library of the newspaper "La Vanguardia", Catalonia's largest newspaper, between 1909 and May 2014, a period when articles were available online and a keyword search is feasible. The keywords used were "Sierra de Collserola" and, from 1980 onwards, "Protección de la Sierra de Collserola". Identified were 150 relevant articles, which allowed us to record the main conflicts and socio-political processes that pertained to the Collserola ecosystems and the changes of land uses in it. The texts of these articles were coded with the software Atlas.ti (Scientific Software Development GmbH), which allowed us to yield more generalized patterns over the key issues/discourses related to Collserola and their change over time.

Third, we conducted a series of in-depth discussions with academics and conservationists knowledgeable of the history of the park. Notably, these experts were Martí Boada (Autonomous University of Barcelona), Beatriz Rodriguez Labajos (Autonomous University of Barcelona), Heleni Munujos Vinyoles (who previously worked for the "Consorci del Parc Natural de la Serra de Collserola"), Carme Rovira Badal (of the "Plataforma Cívica para la Defensa de Collserola"), and Josep-Antoni Pujantell Albos (Autonomous University of Barcelona). In our interviews, we asked about the history of the park, the main conflicts at stake, the opinion of our respective interlocutors, and we discussed threats and opportunities for the sustenance of the park's existing ecosystem services.

Fourth, the last of the authors of this article is a university researcher and an activist involved in mobilizations against urbanization in the Collserola Park. He is a resident in one of the occupied buildings on the outskirts of the park, which experiments with new frugal, ecological-economic modes of living. Blended in this article are the direct experience and observation of the movement and the insider's insights into the struggles and institutional battles, triangulated with external sources of information, such as additional interviews, documents or newspaper articles covering the same topics.

This combination of methods (historical archive, land use cadastral, newspaper content analysis, interviews, and activist research) is in many ways unique and serves as an illustration of the possibilities of how to shape the political-ecological economics of ecosystem services. That is, an analysis of ecological economics that does not only seek to 'evaluate' the 'value' of ecosystem services, but that attempts to assess what these services contribute in terms of well-being, explaining how they came to be the way they are, and thanks to whom.

3. Claim 1 — The Ecosystem Services Collserola Provides Increase Dramatically the Liveability of Barcelona

In this section we present the results of the ecosystem services assessment for scenarios 1 and 2 (see Table 1), and we compare them with the results obtained from the literature using similar methodologies in other cities (see Appendix A). The results suggest that the presence and vicinity of Collserola to the city offers a remarkable increase in the levels of ES enjoyed by city inhabitants, and contributes to the liveability of human agglomeration.

3.1. Air Pollution Removal

The air quality in Barcelona is poor. It has been estimated that 3500 lives could be saved annually in Barcelona by reducing the current levels of air pollution to meet WHO standards (Künzli and Pérez, 2007), while life expectancy would increase by about 14 months. Furthermore, economic benefits would amount to 6.4 million € per year (Pérez et al., 2009). According to WHO guidelines published in 2005, the city presents high levels of PM_{10} concentration when compared to other European cities (WHO, 2005). In all municipalities of the metropolitan area, these levels exceed the WHO standards (Pérez et al., 2009).

During daytime, air with pollutants is transported by the up-slope sea breeze from Barcelona into Collserola while the opposite happens

Table 1
Results of the ecosystem services assessment for Barcelona.

Ecosystem service	Barcelona minus Collserola (scenario 1; 84,65 km^2)	Barcelona plus Collserola (scenario 2; 167.6 km^2)
Air pollution removal (t $year^{-1}$ km^{-2} of CO, NO_2, PM_{10}, SO_2, O_3)	2.23	4.48
Urban cooling 1 (surface emissivity[a], mean value)	141.75	138.72
Urban cooling 2 (f-value for evapotranspiration potential of a land use class; mean value)	0.84	1.01
Flood regulation Impervious cover (mean %)	78.60	71.79[b]
Recreation 1 (% green cover from area)	12.92	29.27
Recreation 2 (Green cover: m^2 per person)	6.79	26.45

[a] Note that the value of emissivity expresses the opposite of the cooling potential, meaning that the higher the emissivity the lower the cooling potential.
[b] Was obtained by considering only the catchment area affecting the municipality of Barcelona.

at night-time (Soriano et al., 2001). The service provided by the vegetation of Collserola in removing pollutants from the air thus benefits the municipality of Barcelona and the metropolitan area at large. From our analysis, the total surface covered by urban vegetation of the densely urbanized area (scenario 1) has a very low capacity to purify the air (1.85 t year^{-1} km^{-2} of pollutants). This would place Barcelona in the group of the worst performing cities in the U.S., such as Buffalo and Salt Lake City (see Fig. 3), which, by contrast, have only a fraction of Barcelona's population. Instead, *with* Collserola (scenario 2), the reduction of pollutants in Barcelona by its ecosystems renders it comparable to Jacksonville, the best performing city in the U.S. Given the already low air quality of Barcelona, this ecosystem service becomes very relevant for the liveability of the city. However, even under scenario 2, the emissions of PM_{10} and NO_2 in the city far outstrip the removal capacity of its ecosystems (Ajuntament de Barcelona, 2013).

3.2. Urban Cooling

Barcelona is also vulnerable to heat stress. In the month of August, the average temperature varies from 25 to 31 °C; and 30.5 °C is the threshold beyond which the excess mortality rate of the population increases sharply (Tobías et al., 2010). This threshold was exceeded for 30 days in 2003 and caused 500 excess deaths in the city (Tobías et al., 2010). Collserola has cooler air and is easily accessible in periods of extreme heat. Colder air also flows at night into the city in the summer months easing up high night temperatures (Soriano et al., 2001). Thanks to Collserola, Barcelona, instead of being a city with a very low cooling potential (scenario 1), has very high cooling levels (scenario 2) (Fig. 4). A similar picture emerges for the cooling potential through evapotranspiration: Barcelona excluding Collserola would be in the low range of the 300 other cities sampled and analyzed by Larondelle et al. (2014), but thanks to Collserola, it ranks among those with high cooling potential (Fig. 5).

3.3. Flood Regulation

Flash floods in downtown Barcelona used to cause significant damages in the past (Barrera et al., 2006). Part of the flood problem found a solution when the drainage system was renovated in 1992, and extended with underground tanks for the collection and slow release of water. However, the high degree of soil sealing can still cause localized floods during downpours. If Barcelona did not have Collserola, 78.60% of its soil would be classified as sealed, a value comparable to the highest sealing range of other cities (see Appendix A and Fig. 6) This improves, albeit slightly, when the part of the Collserola range adjacent to the city is included, reducing soil sealing to 71.79%, even though still a far score from the best performing cities, such as Stockholm, where only 22.90% of the surface is sealed. Including the whole of Collserola, this decreases soil sealing to 40.97%, now becoming comparable to those of other northern European cities like Vienna, London, Amsterdam, Luxembourg and Copenhagen. Collserola, also plays a role in regulating water flows in the basins of the Llobregat and Besòsrivers, which threaten some of the middle-sized cities and towns of the metropolitan area of Barcelona.

3.4. Recreation

There is a high demand for recreational areas in Barcelona, as made evident by the approximately two million people that visit the Collserola Park each year (Creel and Farell, 2008). Without Collserola, Barcelona would have less than 13% green cover; with Collserola, however, it reaches almost 30%. In scenario 1, Barcelona would have lower levels than the European average (18.6%), but in scenario 2, it is comparable to green cities like Stockholm (Fig. 7). Some grey literature reports that WHO and FAO standards recommend between 9 and 15 m^2 of green areas per capita (Kuchelmeister, 1998; Mercadé Aloy, 2011). Without Collserola, Barcelona would only have 6.8 m^2 per capita of green areas. Including the Collserola Park, each person has access to approx. 26.5 m^2 of green space (See Fig. 8). It is therefore for good reason that Collserola is the so-called 'green lung' of Barcelona, although the city still ranks low if compared to other European cities. As mentioned before, the recreational area available indicated for both scenarios actually ranges in the upper tier, as we had included private green areas in our analysis. This suggests an increase in the relevance of Collserola as recreational area for all the inhabitants of Barcelona.

4. Claim 2 — Collserola Became a Preserved Forest over Time

In this section, we trace back how the ecosystem services of the forest have come to be. The historical record does not allow us to track down the evolution of specific ecosystem services. It allows us, however, to reconstruct the broader story of how Collserola has become a forest ecosystem.

The archaeological record and anecdotal historical evidence suggest that the area of what is today the forest and Park of Collserola used to be a territory with strong agricultural presence. The Romans arrived in the Peninsula in 218 BC. Collserola was a prime spot for vineyards. According to archaeological findings, the production of amphorae to transport the wine distilled from the vines of Collserola had reached the scale of

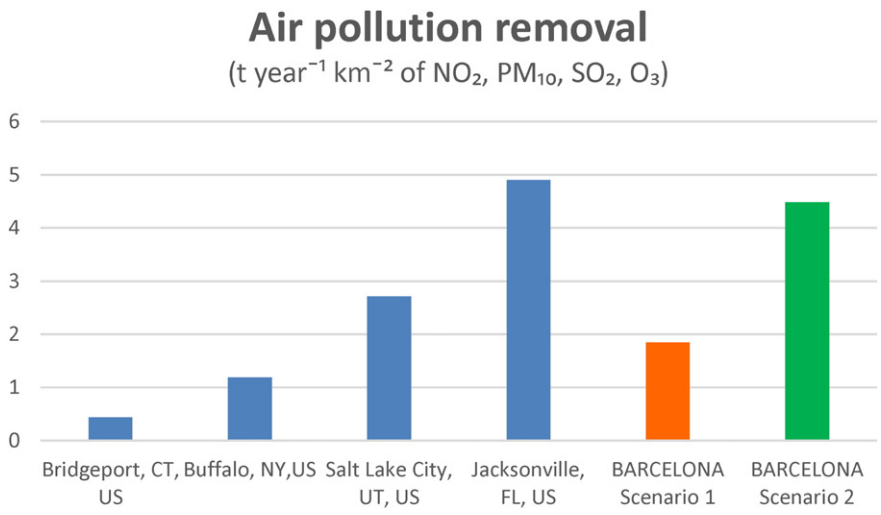

Fig. 3. Air pollution removal potential, in t year^{-1} km^{-2} of NO_2, PM_{10}, SO_2, O_3 derived for different cities from the literature (see Appendix A) and from the results obtained for Barcelona scenarios 1 and 2 (see Table 1).

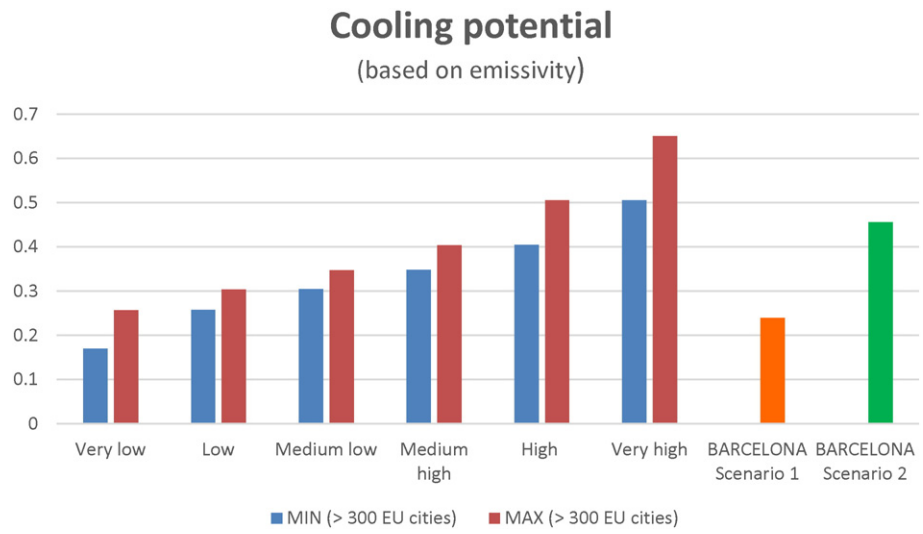

Fig. 4. Air-cooling potential calculated as one minus the normalized emissivity, both derived for different cities from the literature and from our results obtained for Barcelona scenarios 1 and 2 (see Table 1). The scale (from very low to very high) with minimum and maximum ranges for each category is derived from a study by Larondelle et al. (2014) which clustered the results of the mean emissivity of more than 300 European cities (see Appendix A).

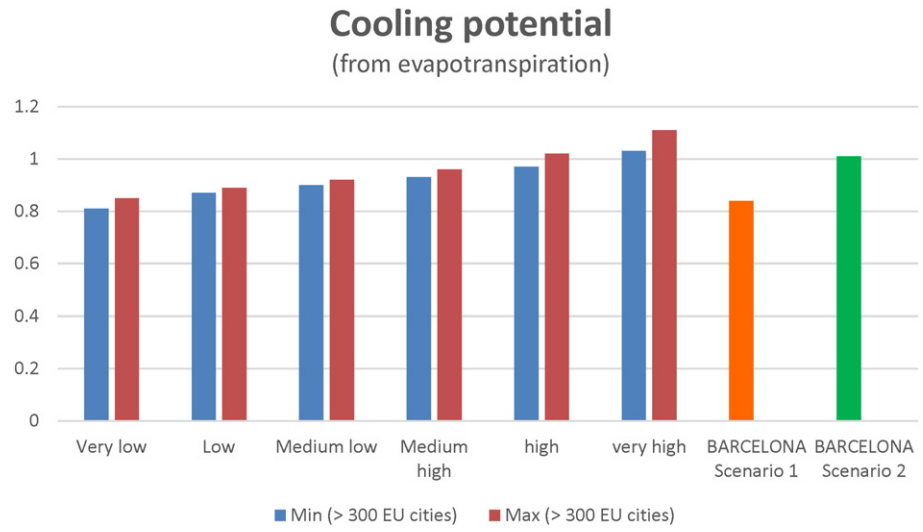

Fig. 5. Air-cooling potential in terms of evapotranspiration (f-value) derived for different cities from the literature(see Appendix A) and from our results obtained for Barcelona scenario 1 and 2 (see Table 1).

an industrial process (Centellas i Masuet et al., 2008). We also know that much later, in the 12th century, vineyards dominated the eastern and the southern part of the range (Cañas et al., 1995). Croplands spread widely into Collserola after the 16th century (Cañas et al., 1995). Villas were restructured and expanded in the hilly area throughout the 17th and 18th centuries, when the main economic activity was the cultivation of olive trees, vineyards, and wheat (Barcelona Regional Council; Cañas et al., 1995). The exploitation of black slate started at the end of the 18th century and intensified all along the 19th and 20th centuries, especially on the side of the Llobregat river bordering Barcelona on the South West (Centellas i Masuet et al., 2008). The exploiting of limestone mines was also a common activity.

In fact, our analysis of the data from the "Amillaramientos" for five municipalities, confirms this anecdotal evidence that Collserola in the mid-19th century was mostly an agricultural area, and that it was principally after the 1950s that it turned predominantly into a forest ecosystem, in line with the documented reforestation trends for Catalonia (Cervera et al., 2015). Four of those municipalities had between approx. 50 to 75% of their territory covered by agricultural land in the mid-19th century, but the percentage of land devoted to agriculture has decreased to almost 0 since then, most of the reduction taking place after the 1950s, (see Fig. 9A. to E.). Only in Sant Feliu del Llobregat, agricultural land had increased until the mid-20th century but decreased thereafter.[8] Land cover figures from 1956 until 2009 confirm the claim that as agriculture receded, the forest expanded.

Aerial photos and satellite images allow us to see what happened directly in the park itself, rather than via proxy of the municipalities to which its territories belong. Crops covered 20.67% of the Collserola Park in 1956, but only 5% in 2009. Dense forest increased instead from about 57% to approx. 68.4% (see Fig. 10). These results suggest a clear pattern of agricultural land abandonment, irrespective of any possible under-reporting by landowners in the "Amillaramientos". In particular, the region experienced an abandonment of dry land farming, such as

[8] And this is probably an accounting artifice due to the incorporation of a part of the municipality Santa Creu d' Olorda at the beginning of the 20th century (Ministerio de Administraciones Públicas, 2008), which was located more within the actual boundaries of the park.

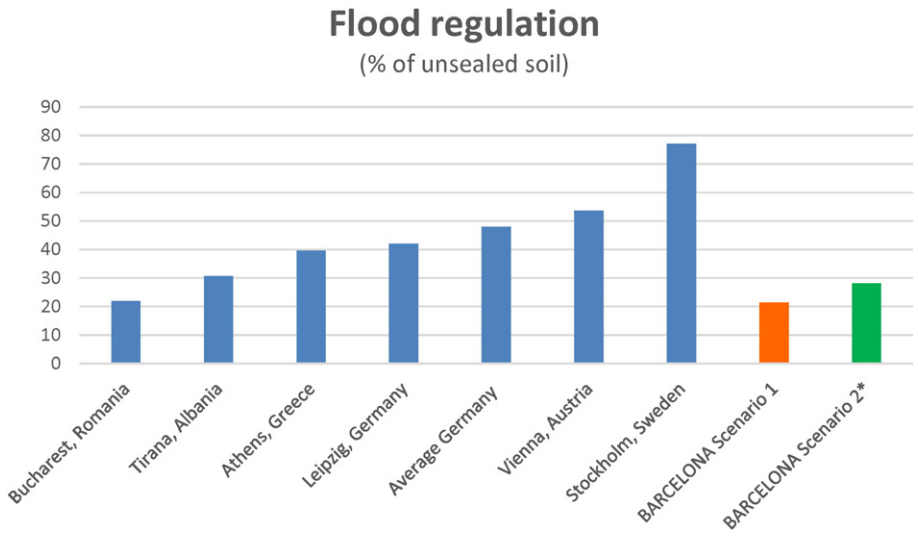

Fig. 6. Flood regulation potential in terms of 100% minus the % of sealed soil derived for different cities from the literature (Appendix A) and from our results obtained for Barcelona in scenarios 1 and 2* (Table 1). (N. B. For flood regulation in scenario 2* we took into account only the area of the Park adjacent to and that slopes towards Barcelona).

the cultivation of olives and wine in the second half of the 20th century (Pavón et al., 2003).

Land cover changes in the Collserola area followed a pattern of receding agricultural activity replaced by reforestation, as also documented for other forests in the region (Barcelona Regional Council; Cañas et al., 1995; Cervera et al., 2015; Diaz et al., 2008; Parcerisas et al., 2012). Accordingly, these changes involved a thickening of the vegetation from crop to scrubland, and from scrubland to dense woodland (Table 2).

We do not have photos from the Collserola Park itself, but a photo of the neighbourhood of Vallvidrera immediately outside the park, can give an indication of the type of changes that took place in the area (Figs. 11 to 13). In the beginning of the 20th century, the area consisted mostly of cultivations with sparse trees. Today, it has become a dense forest with houses in-between (confirming the pertinent data that shows an increase of dense woodland and sealed surfaces).

The question then is how and why did Collserola become a dense forest ecosystem, providing services to the city, which it had never done in the previous centuries? This is precisely the challenge posed by urban political ecology; the question why we cannot understand the transformation of land uses unless we understand the coevolving social, political, economic, and ideological changes that contrived to create and preserve the ecosystem of Collserola.

5. Claim 3 — Collserola was socially (Co)Produced

The next sub-sections describe how the Collserola ecosystem and its services are also the result of voluntary and involuntary socio-economic and political forces and considerable human labour.

5.1. The Abandonment of Agriculture

The mid-19th century marks in fact the peak of agricultural expansion since Roman times, tied with a shortage crisis of wood supply indicative of the acute deforestation of Collserola (Folch i Guillèn, 1977). Successive ecological, social and economic processes shaped a trajectory of the gradual abandonment of agriculture in the area or of occupation of less fertile land due to the expansion of urbanization (Olarieta et al., 2008). A key occurrence was the *Phylloxera* plague that, hitting the area in the 1880s, decimated the vineyards of Catalonia (Badia-Miró et al., 2010; Barcelona Regional Council; Cañas et al., 1995; Folch i Guillèn, 1977).

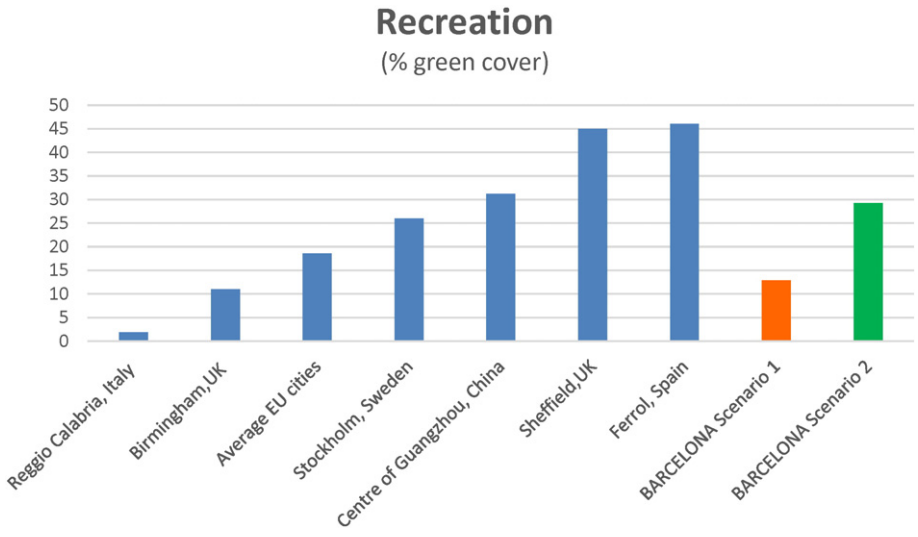

Fig. 7. Recreation potential in terms of % of green cover derived for different cities from the literature (Appendix A) and from our results obtained for Barcelona scenarios 1 and 2 (Table 1).

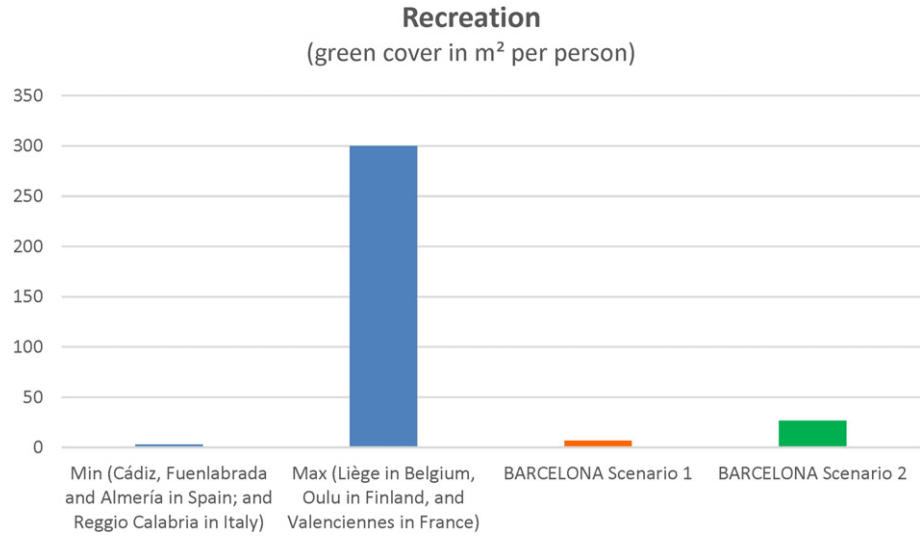

Fig. 8. Recreation potential in terms of green cover in m^2 per person derived for different cities from the literature (see Appendix A), of which only the two extreme cases (min. and max. recreation potential) are indicated here, as well as from our results obtained for Barcelona scenarios 1 and 2 (Table 1).

In the middle of the 19th century, the city of Barcelona undergoing rapid change. In 1854, its medieval walls were torn down, and the urbanization of the annexed surrounding areas started (the so-called 'Eixample', i.e. extension). This went hand-in-hand with the first industrialization; initially, this did not reduce the pressure on forests as a source of wood for energy and other uses in Spain, and agriculture continued to be widespread (Infante-Amate et al., 2015; Iriarte-Goñi and Ayuda, 2008). However, immigration as well as the good connection of the city through the port of Tarragona, led to an increase of food imports from abroad, gradually depressing agriculture in nearby areas such as Collserola (Cardona, 2009). Well after the mid-19th century, Collserola continued exploiting timber and charcoal to supply power for the textile factories and fuel to heat homes.

As Fig. 9 shows, the important transformation from an agricultural to a forest ecosystem starts in the 1950s, and from then until now, forest coverage has continued to increase significantly (see Fig. 10). It was only with the advent of the second industrial revolution, based on the consumption of electricity and oil and the displacement of wood as a source of energy (Kander et al., 2013), along with urbanization (Paül and Tonts, 2005), which favoured the withdrawal from agricultural exploitation, that reforestation in the area increased sharply.

This transition from a complex mosaic of silvo-pastoral and agricultural activities to a dense forest was a mixed blessing for Collserola, as elsewhere in Catalonia (Otero et al., 2015). The pine forest that dominates Collserola today is not in fact the optimal vegetation for the area, as mentioned in the case study description. The Aleppo pines (*Pinus halepensis*) that are prevalent were intentionally planted because they have a fast growth rate suitable for the production of wood or charcoal (Raspall et al., 2004). The displacement of firewood was a rapid process compared to the temporal scale of changes in the succession of changing vegetation and ultimately led to a homogenization of the forest with the subsequent increase of fires (Aldeguer et al., 2008; Argelich and Recio, 2009). Devastating fires kept following the successive reforestations, to the extent that Collserola today is far from being a 'natural' landscape. The reduction of farming also caused the loss of some types of ecosystems, especially of those species requiring more intense human management such as the Mediterranean cork oak (*Quercus suber*) savannas (Bugalho et al., 2011).

5.2. Planning for Conservation

In the context of gradual agricultural abandonment and reforestation, an important change in the beginning of 20th century was the emergence of intentional efforts to 'conserve' parts of Collserola in a desired landscape state. Such practical and institutional policies of conservation coevolved with the rise of a new visionary and a totally novel – and unprecedented – way of seeing the forest, no longer as an untapped resource, but as a source of escape and recreation. This in turn came hand in hand with the rapid urbanization and industrialization of Barcelona, without which the sense of 'disconnection' from nature would have never come about. Writing at the beginning of the century, poet Joan Maragall, one of the principal members of the modernist movement in Spain, exclaims in his work "La muntanya" (The Mountain) of Tibidabo in Collserola (Fig. 1):

> "[…] how fortunate is a city that is next to a mountain! All its inhabitants will climb it and will return transformed. Thereafter, in the solitude of the study, in the laid table of the family, in the activity of the industries, in the darkness of the shops, in the noise of the streets and in the large halls will reign from above the high view of the mountain peak. The straightness of the pine trees, the smell of the bushes, the free harmony of the winds, will live in the soul of the city, so that it will come to feel its mission. That is, to move on the heights and traverse the extension of the lands […]"(Maragall, 1909) (own translation).

The 'excursionism' called upon by Maragall became widely practised at the end of 19th century and in the first half of the 20th century by the bourgeoisie of Barcelona, whereas the "Centre Excursionista de Catalunya" had been founded earlier in 1876. Later on, Rafael Puig i Valls, a notable Catalan forest engineer who brought to Catalonia conservationists ideas after a visit to the United States, became one of the founders in 1920 of the Catalan Alpine Club and of the Catalan Association for Scientific Excursions (Boada, 1995). In that spirit, the bourgeois elite was also starting a back-to-nature process of building holiday homes outside the city (Tello et al., 2014). But 'excursionism' and recreation were not only a bourgeois ideal: the origins of this proto-environmentalism were also strong among Catalan anarchists, who saw in trekking and climbing not only a middle-class or 'intellectual pastime', but also an important distraction for the working class. Such recreational habits became popular with the working class 'Athenaeums' and with choral societies in the working class neighbourhoods during the first third of the 20th century (Masjuan Bracons, 2000; Tello et al., 2014). As a matter of fact, our content analysis of the Vanguardia newspaper confirms this pattern as it registers a notable increase of coverage of the theme of 'excursionism' in Collserola in the beginning of the 20th century.

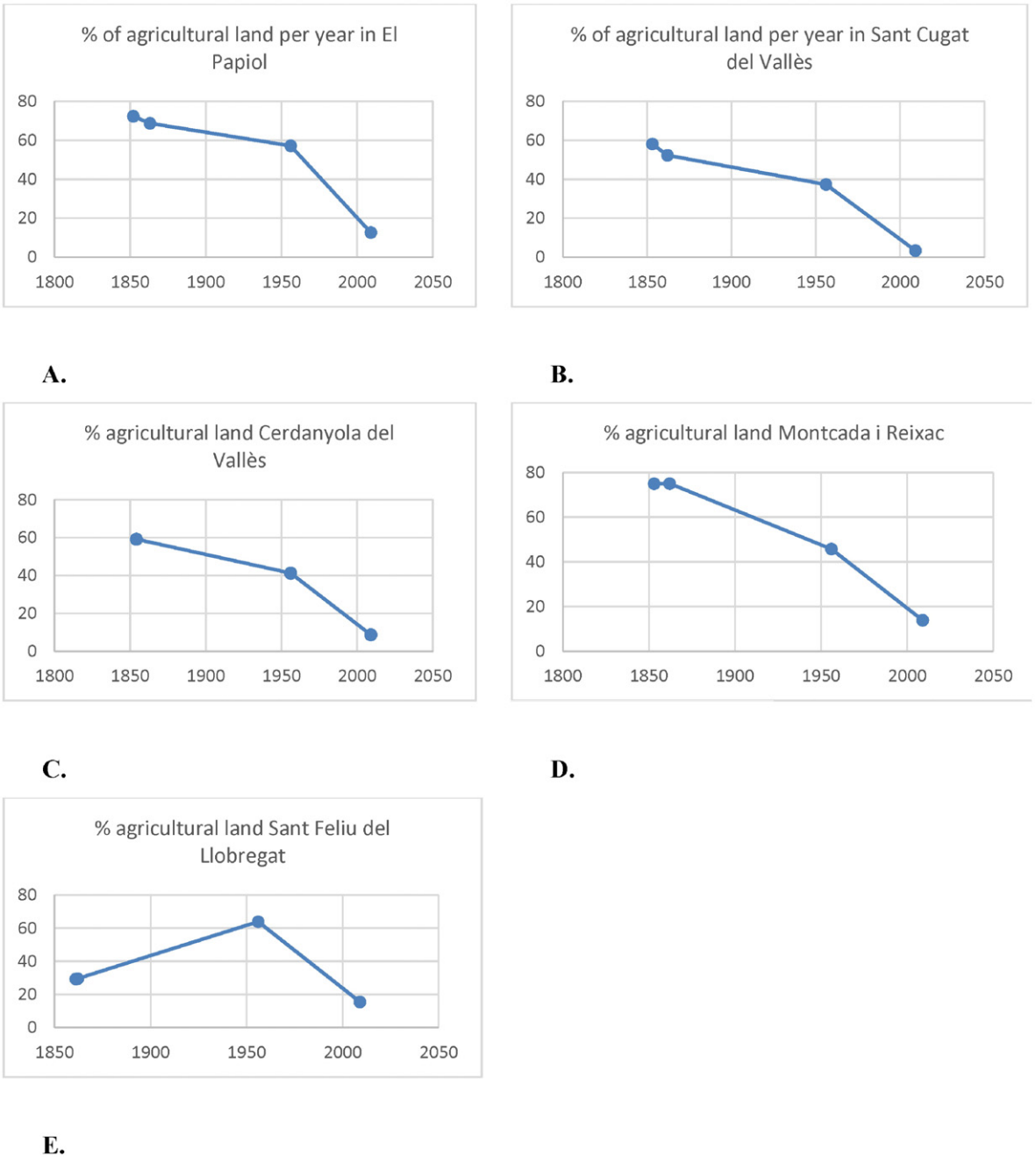

Fig. 9. A to E. Percentage of agricultural land in 5 out of 9 municipalities that have now become part of their territory located within the CNP and for different years derived from both the "Amillaramientos" and the LCMC4.

This image of conservation for recreation came to clash with that of a fast growing city (Folch i Guillèn, 1977). In 1932, the plan to construct a garden-city with infrastructures for touristic and scientific purposes on the top of the Tibidabo hill was put into action (Raspall et al., 2004). Two low-density neighbourhoods underwent development at what are the fringes of the park today: Vallvidrera, as depicted in Figs. 11–13, an extended neighbourhood of the wealthy Sarrià-Sant Gervasi district of Barcelona where villas and towers for the ultra-rich were built; and, on the other side of Collserola, La Floresta, a settlement neighbouring the town of Sant Cugat.

In Barcelona, as elsewhere in the 1930s, two conflicting urban planning models were contesting each other. These were, on the one hand, a rationalist, modernist approach dominated by cement and glass with separate zones for working and sleeping conceived for sprawling peri-urban areas. On the other hand, a conservationist, more 'romantic' approach had the aim to preserve the identity of peri-urban agglomerations and historical environments by maintaining, for instance, green and agricultural belts around the city (represented by Patrick Geddes, his disciple Luis Mumford and the concept of "Regional Planning"; see Martínez-Alier (1996)). The rationalist approach prevailed at the time in Barcelona and found its implementation through the Cerdà plan of the "Eixample", which in spite of its modernist purism foresaw green areas within each residential block, a provision that was hardly met in reality due to subsequent speculation and pressure to build in the green lots.

Geddes' approach had also its advocates in Barcelona, represented for example by the Catalan Garden City Civic Society of Cebrià de Montoliu, a Catalan town planner and architect, inspired by the idea of

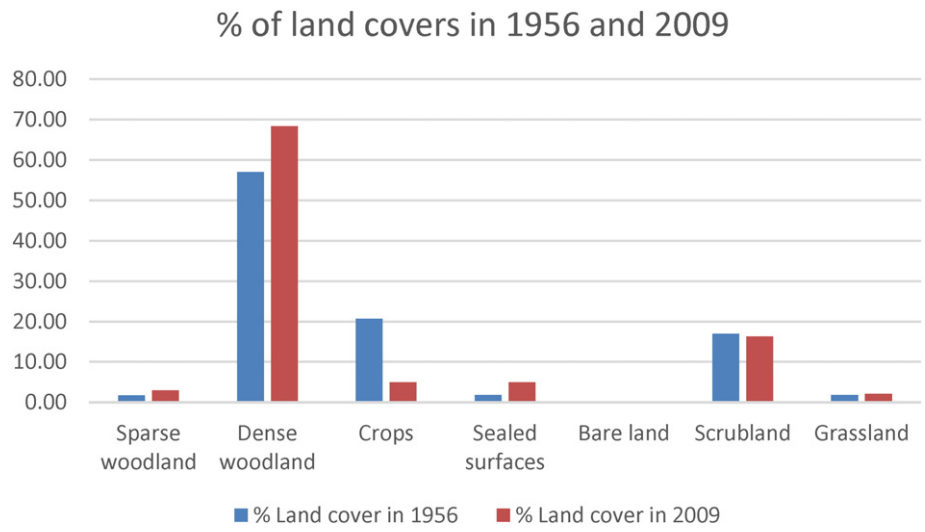

Fig. 10. Graph on the land cover percentages in the years 1956 and 2009 for the Collserola Park only (source: own elaboration).

having the cities surrounded by green belt settlements. Cebrià de Montoliu had also connections with libertarian-naturists of the time (Martínez-Alier, 1996).

This 'regional peri-urban approach' however did partially influence planning in Barcelona, especially as far as the expansion to Collserola was concerned, largely thanks to Nicolau Maria Rubió i Tudurí, a Spanish architect, landscape designer, urban planner, and writer, and his brother Santiago Rubió i Tudurí. The two brothers were commissioned with the development of the "Plan de Distribución en Zonas del Territorio Catalán" (Regional Planning) in 1932. They considered the area of the Collserola range as hardly adaptable to other uses because of the steep slopes so they proposed to preserve it as it was (Rubió i Tudurí and Rubió i Tudurí, 1932). The plan suggested a system of protected areas and forest reserves for the city and the region. Following the plan, numerous gardens were created in Barcelona, including the Park of the Font del Racó (1926) in the Tibidabo.

Moreover, the attempts at starting a Land-Use Planning made by the autonomous Catalan government during the Second Spanish Republic (1931–1939) were slowed down during the Franco regime (1939–1977). During the so-called 'autarchy years' of the 1940s and early 1950s, when Spain was isolated from the rest of the world, Collserola saw the growth of slums and shantytowns crowded by poor immigrants from the South of Spain, who resided in Collserola and other peripheral places in Barcelona's outskirts. When Spain was integrated in the Western economy and started a period of fast economic growth from the 1960s onwards, including a Green Revolution in agriculture, the pre-existing, uncontrolled urban sprawl served as the basis upon which land speculators developed real estate, without significant obstacles from a dictatorship that catered to their demands (Calavita and Ferrer, 2000). The 1963 plan for the general planning of the Barcelona province, merely established a list of possible natural parks including Collserola. During those years, a series of plans and documents as well as the press coverage we reviewed portrayed the Collserola range as a 'barrier' and an 'obstacle'. It had to be penetrated if the city of Barcelona was to expand unhindered and connect to the peripheral residential towns of Sant Cugat or La Floresta and the whole Vallès Occidental county on the other side of the mountain (towns and regions which today have indeed become suburbs of the city). Thus, the outskirts of Collserola facing the city came under increasing construction pressure given the acceleration of urbanization. The population of the Metropolitan Area of Barcelona grew from 2 to 2.7 million inhabitants in two decades from the 1960s to 1970s, with an average growth rate of 3.23% (PMPC, 1990). Collserola was encircled by settlements and infrastructures and isolated from other natural areas (Argelich and Recio, 2009; Sotoca Garcia and Carracedo García-Villalba, 2011). Urbanization within the Park developed especially along the axis Vallvidrera-Les Planes-La Floresta-Valldoreix-Sant Cugat, while an extension of the road network, passing through the park, facilitated car access.

The first serious attempt to stop this proliferation of urban sprawl was the Barcelona General Metropolitan Plan (GMP) approved in

Fig. 11. View of Vallvidrera and the Tibidabo pick in 1907 (Source: Raspall et al., 2004).

Fig. 12. View of Vallvidrera in 1902 (Source: Raspall et al., 2004).

Fig. 13. View of Vallvidrera today (Source: www.barcelonas.com).

1976, a year after Franco's death that defined the status of the area for the years to come. The GMP established special protection plans for the parks including Collserola, but it lacked the ambition of the land use planning attempts of the short-lived republican period before the dictatorship (see for instance Parcerisas et al. (2012)). This void of decisive intervention for the control of urban sprawl led to the growth of urban social movements (Calavita and Ferrer, 2000), which then engaged in the defence of Collserola, as we will see in the next section.

An institutional milestone was the 1987 Special Plan for the development and protection of the natural environment of the Collserola Park (PEPCo). It defined different zones of the park aiming to improve the quality of habitats: natural areas; semi-natural areas; and agricultural zones with scenic value. The Plan recognized the importance of the park especially as a recreational site. This notwithstanding, the Plan also chartered a road network within the park. In fact, a strong developmentalist spirit characterized the PEPCo, and foresaw a range of infrastructures in and crossing the park, such as roads and three tunnels. Among those plans were the car and train tunnel of Vallvidrera, which did materialize and have been enlarged to-date. These interventions, together with ad hoc reforestations in the core of the park produced a patchy ecosystem, with vegetation thickening at the centre of the park, while its borders and the axes of the transport system were increasingly encroached by settlements. Sealed surfaces increased between 1956 and 2009 (Fig. 9), and the population in the municipalities encircling the park grew. Collserola was then included in the "Pla d'Espais d'Interès Natural" (PEIN), a plan issued by the Catalan Government for natural areas of particular interest approved in December 1992, which intended to restrain more urbanization and the ongoing construction processes within the limits of the park.

In September 2006, the park was included in the Natura 2000 European Network of protected areas and, after a series of protests (as detailed in the next section), the Collserola range was declared Natural Park in October 2010, gaining approx. 1100 ha. With the declaration of Collserola as Natural Park, a new plan was required to substitute the PEPCo. This is the "Pla Especial de Protecció del Medi Natural i del Paisatge del Parc Natural de la Serra de Collserola (PEPNat)", whose draft is available. It specifically includes as one of its main objectives the improvement of the assessment and valuation of ecosystem services. By explicitly recognising the benefits yielded by the park in providing health, recreational and other services, it calls for an improvement of its zoning based on an improved knowledge of the ecosystem services it renders, an assessment of the demand in services, and the involvement of the population and local actors.

To note is that, overall, the main reasons given by different planning interventions and protests for the protection of the area are the preservation of biodiversity and 'wilderness'. These reasons had not yet establish a direct link to ecosystem services (this is understandable, since ecosystem services are a new concept). However, the protection of the park is also often justified in planning documents or the press for its function as 'the green lung of Barcelona', or for its recreational value and, increasingly, for the wide range of services it provides.

Table 2
Land cover type changes for the period 1956–2009 in the Collserola Park.

Main changes from one land cover type to another for the period 1956–2009	Surface (ha)	%
Sparse woodland–Dense woodland	107.32	3.38
Dense woodland–Sparse woodland	65.11	2.05
Dense woodland–Sealed surface	127.46	4.01
Dense woodland–Scrubland	317.89	10.00
Crops–Sparse woodland	96.51	3.04
Crops–Dense woodland	527.67	16.60
Crops–Scrubland	453.45	14.27
Crops–Grassland	107.77	3.39
Scrubland–Dense woodland	773.78	24.34
Grassland–Scrubland	80.17	2.52
Total	2657.14	83.60

5.3. The Battle for Collserola and the Work of the Social Movements for its Protection

After excursionists and urban planners, a new social force came to the forefront filling the void of governance during the transition from the dictatorship to democracy: environmentalists and urban social movements (Calavita and Ferrer, 2000). Environmental movements in Catalonia appeared with the fall of the Franco regime in 1977. From the first protests, there was a strong association between "Catalanism", socialism and environmentalism (Cardona, 2009). At the same time, and after the democratic transition, Barcelona became a hotbed of civic movements, including neighbourhood and thematic associations, cultural centres, cooperatives and protest movements. After the 1990s, and in the context of the post-Olympics urbanization rush in Barcelona and the Spanish housing bubble that ensued (and came to a spectacular crash in 2008), the conflicts over Collserola were accentuated.

Towards the end of the 1990s, many such groups came together blending into a movement opposing a series of projects planned in, or close to the periphery of Collserola. According to this movement, the

projected plans treated Collserola as the dumpsite of the city, where all the unwanted projects were disposed of, so this had to stop.[9] Consequently, a number of projects foreseen in the 1976 GMP met the activists' strongest opposition, such as:

- The 'Vial de Cornisa, a 16 km long highway that would cut across the entire north-west side of Collserola, impacting the stream of Vallvidrera, recognized as one of the most important ecosystems of the range;
- The aforementioned construction of three tunnels which would connect Barcelona with the other side of the range;
- The enlargement of a peripheral pedestrian road cutting across the park unleashing in their view a dramatic increase in the number of visitors;
- Real estate developments, notably in Torre Negra in the city of Sant Cugat (more on this below);
- The dumping of toxic waste;
- Hunting in the park;
- The construction of a roller coaster in the Tibidabo Amusement Park bordering Collserola, requiring the felling of centennial oaks; the movement opposed also the fragmentation and isolation of the park, demanding its connection with two other neighbouring parks (SantLlorenç del Munt and the Garraf, respectively to the North and to the East of Collserola).

Collective action finally took shape in the form of the "Plataforma Cívica per la Defensa de Collserola (PCDC)", (Civic Platform for the Protection of Collserola). Associations involved in environmental struggles founded this platform in 2000. It consists of four neighbourhood associations from Barcelona and Sant Cugat, one association from Esplugues de Llobregat, which has often practised direct action and civil disobedience, eight environmental organizations, and three informal associations from neighbourhoods surrounding the park. In 2001, the Platform produced a manifesto asking for a new protection framework for the area to supplement the existing legislation. Originally, the manifesto had been made up of three proposals calling for: (1) a revision of the GMP in terms of land use and transport infrastructure; (2) an 1100 ha extension of the protected area; (3) an enhanced biological connectivity with other green urban areas. Two more proposals followed in 2005: (4) a moratorium on further urbanization in those areas of Collserola not included in the park, and (5) a particular effort to ensure the protection of water streams and their surroundings. The manifesto marks the importance of the park's ecosystem services though it does not refer to them as such. For example, it states that river streams are good for biodiversity and therefore require a conservation of riparian forests.

Notable successes of the movement were the cancellation by metropolitan authorities in 2012 of the "Vial de Cornisa" highway and the blocking of the Torre Negra real estate development, which would have occupied 156 ha of Collserola. Forty-three landowners, led by Núñez y Navarro, one of the largest real-estate speculators in Catalonia owning 60% of the land of the Torre Negra in question, reclaimed a right to build on this area of the forest. The municipality of Sant Cugat formed an alliance together with the group 'Save Torre Negra' and the Civic Platform for the Defence of Torre Negra, itself an alliance of 80 local associations, including environmentalist, mountaineering, civic, cultural, neighbourhood, political, and trade union groups as well as associations connected to civic centres, schools, educational communities, farmers or young people. This heterogeneous civil movement managed to collect 10,000 signatures against the project, in a town with only 50,000 inhabitants. In 2009, the case reached the Superior Court of Catalonia, which defined the land as unsuitable for urbanization. The plot was finally included in the area of the Natural Park with the 2010 law ruling out compensation for the property owners.

The Platform for the Defence of Collserola organized in 2008 a march with 2000 people (La Vanguardia, April 14th, 2008). According to the Platform, the pressure of the movement was instrumental in achieving the declaration of the area as a natural park in 2010. Although local authorities and the Consortium for the protection of the Park were also working in this direction, without the pressure of the Platform, the passing of the law would have taken much longer; indeed, during the eight years that the proposal for a park had been held in Parliament awaiting decision, considerable parts of the same were urbanized. According to the new law, the park covers now 8,295,09 ha. This is an increase of 779 ha compared to previous plans. Instead, these plans had earmarked this surface for urbanization. Despite this victory, the Platform declared after the promulgation of the law that it would have been preferable to allocate the 1500 ha of land still deemed adequate for urbanization by this legislation to green areas or agricultural land and considered that the problem of urbanization at the periphery of the Park still remained unsolved. It is beyond the scope of this paper to attempt to evaluate directly the gain in terms of ecosystem services from this political victory of the Platform; what we wish to elucidate is the direct link between activist work and the protection, or rather 'production', of ecosystem services.

At present, the Platform has adopted a more moderate and conservationist approach. It has chosen to deliberate and negotiate with public authorities, influencing the decision-making process. Furthermore, it has adopted a 'nature first' approach, wanting to protect the forest from all kinds of human intrusion (an approach which is somewhat at odds with the fact that, originally, the park itself had been far from natural). Alongside the Platform, and often in coalition with it, a more radical group of activists, collectives and associations had formed that gathered publicly around the 2007 'Solana declaration', written at the squatted space of Can Masdeu at the fringes of the park. On top of what the Platform asked, the Solana declaration claimed for a buffer zone assigned to agro-forestry in non-protected parts of Collserola. It also defended the agro-ecological projects and self-managed activities of the Can Masdeu project. Compared to the Platform, the Solana declaration took a stronger stance against projects such as the roller coaster in Tibidabo or high-voltage lines and an 'opening of the park to the city' under the 'PlaCaufec' plan. Furthermore, it put extra emphasis on participatory processes, neighbourhood self-organization and the provision of ecosystem services such as regulation of atmospheric composition, water regulation, erosion control, soil regeneration and pollutants detoxification, going thus beyond the biodiversity conservation approach which was the central theme of the PCDC.

In addition to signature collection and public pressure, the Solana activists also engaged in actions that were more confrontational, such as trespassing, blockades, civil disobedience, and protest marches. In April 2008, activists entered the area of the Tibidabo Amusement Park and climbed on the old forest trees that the construction of the roller coaster required to cut down. Supporting the citizens' movement 'SOS Tibidabo', the Solana activists demanded that the Amusement Park be transformed into a museum and a starting point for educational walks into the Tibidabo Forest, signifying an alternative, non-consumerist approach to 'recreation'. In May of that year, they blocked the 'PlaCaufec' construction site promoted by the municipality of Esplugues de Llobregat for three days. This protest ended with 35 people arrested and taken to court, eight of them convicted of civil disobedience. One of the activists spent 10 days in jail in 2009. 'PlaCaufec' dated back to the metropolitan plan of 1976, and professed the intention to bury the high-voltage power lines sloping down from Collserola. Activists and residents of the area, which is close to the wealthiest district of the city, Sarrià, claimed that the project was just a pretext for the beautification and subsequent gentrification of the area, and that the real intention was the construction of pricey residential skyscrapers next to the Collserola Park. Fuelling their fears was the secrecy exercised by the authorities in developing their plans, and their intention to increase the

[9] This was already mentioned in the first study of urban ecology applied to the city of Barcelona as "exporting unsustainability" (Parés et al., 1985).

built area in the neighbourhood by 780% with respect to the original GMP. After 2008, the construction site had to close since Sacresa, the company promoting it, went bankrupt. Yet the criminal prosecution of activists kept going on until the time of writing this article.

Indeed, the conflicts among the different societal forces and visions shall determine Collserola's future and shape what it should look like. On the one hand, the authorities dream of Collserola as a central or 'metropolitan' park, meaning a park easily accessible to the city's population that will also be a source of commercial recreation. A call for proposals was issued in 2011 for the so-called '15 gates of Collserola' to 'open the city to its hills'. The inspiration here is Barcelona's preceding opening to the sea with the reconstruction of the waterfront for the Olympic Games. The call invites urban interventions to facilitate entrance to the park from the city.

Instead, the Platform envisions a strictly protected natural park, refusing to soften the current restrictive access regulations that allow entrance only to hard-core walkers and passionate nature lovers. The Platform also wants to ensure that some sports such as mountain biking are controlled. The number of people engaging in sports in the park quadrupled between 2005 and 2013, bringing it to a total of 60,000 per year (La Vanguardia, 2013). This steep increase, according to Marià Martí, director of the 'Consorci del Parc de Collserola', is responsible for the decline in the number of the animal population (La Vanguardia, 2010).

The activists of the Solana alliance instead, although they coalesce with the Platform in defending Collserola, do not imagine a 'natural forest', but a 'worked landscape', where autonomous groups can also practise low-scale agro-forestry. Their challenging vision, which they shaped and brought to paper by competing in the tender for one of the 15 gates (a tender they actually won), is to expand the park downwards, and bring the forest into the city, rather than the city into the forest. This vision has materialized in the occupied houses and community projects of Can Masdeu and Kan Pascual on the outer fringes of Collserola, where a 'de-growth' mode of living, informed by principles of ecological economics, is currently being lived and taught in practice (Cattaneo and Gavaldà, 2010).

6. Conclusion

This article mobilized multiple methods and theories of urban political ecology to argue first, that the ecosystem services of peri-urban areas can be vital for the liveability and sustainability of cities; and second, that such services are not merely a natural incidental gift, but the complex outcome of coevolving social, political and economic processes, and social and institutional struggles.

Our research has shown that the forest of Collserola enhances the liveability of Barcelona through the ecosystem services it provides. Without these services, the quality of the environment and of life in Barcelona would be much lower (notwithstanding that more should be done to reduce air pollutant emissions at the source or to increase green areas in the city for storm water absorption and urban cooling).

Second, we have also shown how Collserola is not 'natural' in any meaningful sense of the term. It is a landscape that is the product of social endeavours. Its vegetation is the result of past agricultural cultivations, forest plantations, fires and reforestation, as well as intensely resisted plans, regulations and settlements. What Collserola is today is the outcome of a long co-evolutionary process, where new ideas – such as growth, 'excursionism', conservation or agro-ecology – coevolved in parallel to new activities — such as vineyard plantations, tree logging for fuel, walks and visits, mansions and villas, working class settlements, ecological squats and community gardens - to produce the complex system that Collserola is today.

Two points are important here: First, struggle and conflict (social and political) between different ideologies and the associated interventions play a crucial role in shaping this type of forestry project. Second, urbanization seems to be a double-edged process. On the one hand, the pressure to build, seal, or fragment threatens ecosystems and the provision of their services. On the other hand, urbanization was the force that liberated the forest from plantations at the local and regional scale, and it was urban dwellers who came to appreciate the forest for its beauty and recreational opportunities (a beauty linked to the fact that this was what they were lacking in the cities). Many urban dwellers made great efforts to study and understand the forest ecosystem, and/or intervene to keep it in a condition that ensured the continuity of its functions and the provision of services. For good or for bad, it is not possible to look upon peri-urban ecosystems in isolation of, or antithetically to, the cities they are related to.

Finally, a main argument of this article is that the impetus required for the emergence of a forest ecosystem does not only come from sun and wind, or of seeds and butterflies. It is also the labour of farmers and loggers, bureaucrats and planners, foresters and fire fighters and not least, of the toil of volunteers and activists, who spend hours without any compensation writing manifestos, collecting signatures, lobbying authorities, blockading developers, tying themselves to trees or waiting for trial in prison. Some of these efforts, such as those expended by planners or scientists, may be remunerated, but much of the work, such as that of activists, is voluntary and unpaid. We do not claim of course that all of the work is done intentionally to protect ecosystem services as such (though recreation, air cleaning and temperature or flood regulation *do* figure strongly in the concerns of planners or activists), or that it is possible to link specific ecosystem services to concrete social actions. Nonetheless, it is clear that ecosystem services are not just a free gift bestowed by nature, but actively protected and (co)produced by human action and labour.

This might seem obvious, especially after reading our detailed history of the making of the forest in Collserola. The lesson, however, of considering forests and nature, as socially (co)produced is not being fully taken up by ecological economics. Ecological economists continue to distinguish between ecosystem services that are the work of nature and of other species, and social or economic services that are the result of human endeavours; or between 'natural' and 'manufactured' capital (the implicit assumption being that the former is not produced, and can only be 'used' or 'replenished'). Understanding nature as socially produced means that the conventional ecological economic view whereby society and the economy is subject to the encirclement and constraints imposed by a surrounding ecosystem has to give place to a co-evolutionary perspective where society, economy, and ecosystems constantly transform and shape one another.

This is not a trivial point. It is actually a perspective that touches some of the foundational assumptions of the discipline, especially those that provide the bases for the monetary valuation of nature. Whereas it is not an attempt to monetise or remunerate the ecosystem services of Collserola, our reading of ecosystem services as the outcome of multi agency, including human labour, has repercussions for the way to approach the question of the valuation of nature.

First, in the literature on the monetary valuation of ecosystem services, the concern is with the demand side, i.e. how much consumers are willing to pay to protect an ecosystem, or how much compensation they demand to consent to its destruction. The demand side considers the ecosystem itself as an un-priced gift of nature. How would this economic calculus change if *both* the paid and unpaid work of the planners, citizens and activists – that contribute to the development of an ecosystem – were accounted on a balance sheet? In other words, what would the foundations for monetary valuation based on consumer preference be, if there were not just consumers but also producers of these services who invest their labour in making them happen?

Second, in the more pragmatic literature on 'payments for ecosystem services', there is an implicit recognition of the labour done by 'communities' to protect forests. Typically, communities' compensations consist of either a fraction of the revenue created by selling carbon credits, or ad hoc payments related to the opportunity cost of foregoing the source of revenue from an activity that would damage the forest. However, what about urban communities and the multitude of people who have

worked over the years to produce a forest whose ecosystem services keep the habitat clean and protect a multi-billion Euro urban economy?

As Prudham (2007) notes, an understanding of nature as socially produced challenges the very notion that property rights can be set up or compensations paid for things like seeds, crops or genes (and we would add here, forests). It is as impossible to disentangle and value separately the unpaid contributions of all the farmers who have invested their labour in the evolution of a seed, as it is to keep accounts of the labour of environmentalists and activists contributing to the provision of ecosystem services in Collserola over the years. This can only mean that an ecosystem like Collserola should be guarded as a commons by and for the collectives benefitting from them, who have not been remunerated for the work expended. It is therefore only fair to tap the 'common-wealth', i.e. tax money, to fund their compensation in recognition of their hard work and management and to cover the cost of their protection.

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Appendix A. Ecosystem services assessments results for various cities derived from the literature and comparable, in terms of methods used, with the results obtained for Barcelona

Ecosystem service	City	Surface (km^2)	Inhabitants (N. circa)	Amount of service provided	Reference
Air pollution removal (t $year^{-1}$ km^{-2} of NO_2, PM_{10}, SO_2, O_3)	Jacksonville, FL, USA	2264.5	828,000	4.9	Nowak et al. (2006)
	Bridgeport, CT, USA	50.2	144,230	0.43	
	Buffalo, NY, USA	139	260,000	1.18	
	Salt Lake City, UT, USA	284.9	190,000	2.70	
Air pollution removal (t $year^{-1}$ km^{-2})	Chicago, USA	606	2,715,000	9.2	McPherson et al. (1997)
	Christchurch, New Zealand	452	348,500	0.66	Cavanagh (2008) cited in Cavanagh et al. (2009)
	Beijing, China	300	4,500,000	4.20	Yang et al. (2005)
Cooling capacity (surface emissivity, mean value)	More than 300 European cities	Various	Various	135.99–138.02 (very low) 138.03–139.44 (low) 139.45–140.23 (medium low) 140.24–140.84 (medium high) 140.85–141.50 (high) 141.51–142.72 (Very high)	Larondelle et al. (2014)
Cooling capacity (f-value for evapotranspiration potential of a land use class. Mean value)	More than 300 European cities	Various	Various	0.81–0.85 (very low) 0.87–0.89 (low) 0.90–0.92 (medium low) 0.93–0.96 (medium high) 0.97–1.02 (high) 1.03–1.11 (very high)	Larondelle et al. (2014)
Flood regulation (% of sealed soil)	Germany	Various	Various	52.00 (average)	EEA (2006)
	Leipzig (Germany)	297.6	531,809	58.00–68.00	Haase and Nuissl (2007)
	Various European cities	215	851,000	22.90 (Min. Stockholm, Sweden)	http://www.eea.europa.eu/data-and-maps/figures/mean-soil-sealing-in-european#tab-metadata
		414.90	1,741,246	46.33 Vienna (Austria)	
		412	3,074,160	60.43 (Athens, Greece)	
		41.8	726,547	69.29 (Tirana, Albania)	
		228	1,883,500	78.0 (Max. Bucharest, Romania)	
Recreation (% green cover from total area)	Sheffield (UK)	368	513,000	45.00	Fuller et al. (2010) cited in; Fuller and Gaston (2009)
	Central built-up area of Guangzhou (China)	235,5	/	31.20	Jim and Chen (2006)
	Birmingham (UK)	268	1 M	11.00	Angold et al. (2006)
	Stockholm (Sweden)	215	851,000	26.00	Bolund and Hunhammar (1999)
	386 European cities	>0.25 km^2	>100,000 inhab.	1.90 (Min.: Reggio Calabria, Italy) 18.6 (average) 46.00 (Max.: Ferrol, Spain)	Fuller and Gaston (2009)
Recreation (Green cover: m^2 per person)	386 European cities	>0.25 km^2	>100,000 inhab.	3.00 to 4.00 (Cádiz, Fuenlabrada and Almería in Spain; and Reggio Calabria in Italy) >300.00 (Liège in Belgium, Oulu in Finland, and Valenciennes in France)	Fuller and Gaston (2009)

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