

Essay

Impacts of Use and Abuse of Nature in Catalonia with Proposals for Sustainable Management

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Citation: Peñuelas, J.; Germain, J.; Álvarez, E.; Aparicio, E.; Arús, P.; Basnou, C.; Blanché, C.; Bonada, N.; Canals, P.; Capodiferro, M.; et al. Impacts of Use and Abuse of Nature in Catalonia with Proposals for Sustainable Management. *Land* **2021**, *10*, 144. <https://doi.org/10.3390/land10020144>

Academic Editor: Andrew Millington
Received: 12 November 2020
Accepted: 27 January 2021
Published: 2 February 2021

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Abstract: This paper provides an overview of the last 40 years of use, and in many cases abuse, of the natural resources in Catalonia, a country that is representative of European countries in general, and especially those in the Mediterranean region. It analyses the use of natural resources made by mining, agriculture, livestock, logging, fishing, nature tourism, and energy production and consumption. This use results in an ecological footprint, i.e., the productive land and sea surface required to generate the consumed resources and absorb the resulting waste, which is about seven times the amount available, a very high number but very similar to other European countries. This overexploitation of natural resources has a huge impact on land and its different forms of cover, air, and water. For the last 25 years, forests and urban areas have each gained almost 3% more of the territory at the expense of agricultural land; those municipalities bordering the sea have increased their number of inhabitants and activity, and although they only occupy 6.7% of the total surface area, they account for 43.3% of the population; air quality has stabilized since the turn of the century, and there has been some improvement in the state of aquatic ecosystems, but still only 36% are in good condition, while the remainder have suffered morphological changes and different forms of nonpoint source pollution; meanwhile the biodiversity of flora and fauna remains still under threat. Environmental policies do not go far enough so there is a need for revision of the legislation related to environmental impact and the protection of natural areas, flora, and fauna. The promotion of environmental research must be accompanied by environmental education to foster a society which is

more knowledgeable, has more control and influence over the decisions that deeply affect it. Indeed, nature conservation goes hand in hand with other social and economic challenges that require a more sustainable vision. Today's problems with nature derive from the current economic model, which is environmentally unsustainable in that it does not take into account environmental impacts. Lastly, we propose a series of reasonable and feasible priority measures and actions related to each use made of the country's natural resources, to the impacts they have had, and to their management, in the hope that these can contribute to improving the conservation and management of the environment and biodiversity and move towards sustainability.

Keywords: natural resources; ecological footprint; overexploitation; Catalonia; European countries; environmental research; education and policies; sustainability

1. Introduction

In 1976, during a time of social and political upheaval, both in Catalonia and in Spain as a whole, the Catalan Institution of Natural History published the book *Natura, ús o abús. Llibre blanc de la gestió de la natura als Països Catalans*¹ (Nature, Use or Abuse. White Book on Nature Management in the Catalan Countries) [1]. At a time when the foundations of a promising future were being laid in all fields, nature conservation was no exception, and the scientific community and naturalists were quick to contribute their knowledge. The book was used to systematize and transmit this knowledge to society in general. The second edition of this book², corrected and updated in 1988 [2], was published in a new political context in which signs were already emerging, despite its early days, that environmental issues were not going to progress as much as was hoped and in which the deterioration of the nature, despite some undeniable progress, was continuing.

Forty years since the first edition, it is hard to resist taking stock of what has happened over this period and to demonstrate that the commitment of the academic and technical fields to improving the environment is still intact, though perhaps somewhat diminished. It is for this reason that we here have aimed to provide an overview of these last 40 years of Catalonia's environmental policies. Unlike Folch et al. [1,2], the scope of our analysis has been broadened and shifted from a conservation-centric approach to a more sustainable one, in which nature conservation is no longer separated from other social and economic challenges. Moreover, we have aimed to conduct a proactive, action-oriented, study and to provide a set of proposals, supported by sound technical and scientific arguments, that will help to define the environmental agenda and to demonstrate the need for their implementation to move towards sustainability, both in Catalonia and in other countries.

2. Methods

We gathered specific data on the use of natural resources in the different socioeconomic sectors with the corresponding sectorial policies during the last 40 years in Catalonia. We then analyzed how these different uses and sectorial policies have affected nature conservation and sustainability. We thereafter suggested the main changes that should be introduced in the short and medium term in these policies for a sustainable use of natural resources. We obtained our data from official reports of both administration and non-governmental organizations and scientific articles searched in the web of science and google scholar for each one of the sectors with the corresponding key words. The data sources are detailed in the corresponding references cited in the text. We also based our analyses in the know-how of the local scientific experts in each one of the studied sectors and policies, requesting them not to separate nature conservation from other social and

¹ <https://natura.llocs.iec.cat/sumari-de-la-1a-edicio/>

² <https://natura.llocs.iec.cat/sumari-de-la-2a-edicio/>

economic challenges. Based on all these materials we thereafter provided a set of proposals to develop the environmental agenda and to approach sustainability.

3. Results

3.1. Use of Natural Resources

3.1.1. Extractive Activities

In the chapter entitled “Aproximació al medi natural” (Introduction to the natural environment) in the 1976 edition of the White book [1], professors Joan Rosell and Josep Trilla stated: “The main characteristic of the geology of Catalonia is probably that there is no predominant lithological formation, rather a large variety, to the extent that it is a microcosm of every geological stage”. With this claim, the authors were ahead of their time in defining geodiversity and, moreover, they considered it to be the most characteristic trait of the geology of Catalonia. From a more up-to-date perspective, it should also be emphasized that the mineral kingdom acts as an ecosystem support service (which provides the basis for soils and biodiversity and which conditions the availability of water) and one of supply, basically of rocks and minerals, either for use as raw materials or as an energy source.

In 2014, there were 1041 extractive activities in operation in Catalonia covering a total of 7035 hectares, 0.23% of the non-developable land. The number of extractive activities has increased significantly with respect to the 800 that were in operation in 1988, the most important differences being due to an increase in operations extracting materials for use as aggregates in the manufacture of concrete, cement, tarmac and other construction and infrastructure applications. Table 1 shows the mining production in Euros.

Table 1. Mining production in Catalonia in 2016. Source: Statistical Institute of Catalonia with data from the Ministry of Energy, Tourism and Digital Agenda.

| Mining Production (in Euros) | |
|--------------------------------------|-------------|
| Energy products | 29,077,782 |
| Metallic minerals | 0 |
| Non-metallic minerals (potash mines) | 274,663,679 |
| Quarry products | 101,523,585 |

As for the other geological materials extracted in Catalonia (gypsum, chalk, ornamental rocks, slates, salts, and other minerals), the number of extractive activities has not changed much but the surface area taken up by these operations with respect to 1988 has increased with the granting of extensions of the valid concessions. Extraction of potassium salts is the only active underground mining activity in Catalonia, while there is only one active operation involving minerals used for energy, the Casablanca oil platform, off the coast of Tarragona.

Given that extractive activities alter the environment and have an impact that requires remediation, legislation has been in force since 1981 that governs the restoration of mined land. However, due to the changes in the perspective and views on the value of nature and the progress in scientific and technical knowledge that has taken place over these 40 years, this legislation needs to be reconsidered and made more effective. Examples such as the salt mine dumps from the extraction of potassium salts in the Bages region and the unsuccessful reuse as gas stores of the pits left from the exploitation of energy fields off the Catalan coast clearly show that the focus of the legislation needs to be improved.

The mineral kingdom also provides cultural ecosystem services. In the case of Catalonia, these are classified in the Inventory of Geological Areas of Catalonia³, which includes 157 spaces and covers a total area of 150,000 hectares (about 5% of Catalonia), despite it being a preventive tool without any specific management tools or regulations. In Catalonia,

³ http://mediambient.gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/sistemes_dinformacio/inventari_despais_dinteres_geologic/

two initiatives have been granted the status of Geopark by UNESCO: The Central Catalonia Mining and Geological Park (2011) and the Conca de Tremp-Montsec Geopark (2018).

3.1.2. Effects on Soils

The diversity of the climatic, geological and topographic conditions of Catalonia has resulted in a diversity of soils, enhanced even more by the preservation of a patchwork of ancient soils from before the ice age. The soil mapping carried out in Catalonia has been disjointed and heterogeneous and it was not until recently that the Cartographic and Geological Institute of Catalonia began preparing the Soil Map at a scale of 1:25,000 (304 sheets), although only 33 sheets have so far been published.⁴

Soil management problems over the last 40 years include pollution, mainly associated with old industrial areas, improper use of wastewater treatment sludge and nitrate contamination of agricultural origin. Other problems that affect the conservation and quality of land in Catalonia include changes in land use, such as the transformation of agricultural land from dryland farming to irrigation farming, the increase of urban development, and forest fires. It should also be noted that until the last few decades, soil quality was not taken into account in territorial planning, and despite the fact that current regulations allow for the inclusion of soil quality as a criterion for allocating uses and giving priority to the conservation of the most productive soils, this practice has not yet become widespread.

Soil erosion results in an almost irreversible deterioration of the resource on an ecological and human scale. To evaluate the magnitude of the problem in Catalonia, the best information available comes from the bathymetric monitoring of reservoir infilling. The study [3] identifies the reservoir with the highest rate of loss of capacity (equivalent to the degree of infilling) in Catalonia as the Sant Ponç reservoir (El Solsonès region), with a 0.94% annual loss of capacity. This data makes it possible to estimate an overall erosion rate for the whole reservoir basin (317 km²) of 8.7 tonnes/ha/year, but taking into account erosion damage is very variable and there are areas that suffer virtually no erosion, this data indicates that some areas of the basin have much higher erosion rates which therefore require corrective measures.

Agricultural practices, as applied in industrialized countries during the second half of the 20th century, in many cases have not favored the conservation of organic matter in the soil [4] nor stopped erosion or soil contamination, which calls into question the sustainability of the prevailing farming systems.

3.1.3. Agriculture and Animal Husbandry

Since 1982 to the present day, there has been a reduction of the area used for dryland farming by 301,921 ha, while the area used for irrigation farming has increased by 47,137 ha (Table 2). The abandonment of dryland farming as a consequence of its poor profitability and, in many cases, the difficulty of mechanizing cultivation, due to the orography of the soil, has led to a growth of forested areas. This has led to the loss of a permanent human presence (human, social, and environmental deterioration) in large areas of the territory because of the abandonment of towns (loss of heritage and landscape), especially in mountainous areas. The occupation of land by growing urban areas and infrastructures has been particularly significant on flat agricultural land.

An analysis of the correlation between population growth and available arable land reveals the fragility of the food capacity of a given territory, which can be expressed by the amount of productive land available per inhabitant (m²/inhabitant).

⁴ <<http://www.icgc.cat/Administracio-i-empresa/Descarregues/Cartografia-geologica-i-geotematica/Cartografia-de-sols/GT-IV-Mapa-de-sols-1-25.000>>

Table 2. Distribution of the type of cultivation and availability of arable land per inhabitant in Catalonia. Source: Idescat.

| Year | Type of Cultivation (ha) | | Total (ha) | Population of Catalonia | Amount (m ² /Person) | |
|----------------|--------------------------|--------------|------------|-------------------------|---------------------------------|------------|
| | Dryland | Irrigation * | | | Dryland | Irrigation |
| 1982 | 870,838 | 218,697 | 1,089,535 | 5,962,723 | 1460 | 367 |
| 2015 | 568,917 | 265,834 | 834,751 | 7,424,754 | 766 | 358 |
| 2015/1982 (ha) | −301,821 | +47,137 | −254,784 | +1,462,031 | −694 | −9 |
| 2015/1982 (%) | −34.67 | +121.55 | −23.38 | +124.52 | −47.54 | −2.45 |

* 75% of the water for irrigation corresponds to surface water and 25% to groundwater. Gravity irrigation is used in 60% of the irrigated area, sprinklers in 10%, localized irrigation systems in 29% and other systems in 1%.

Catalonia population increased 24.7% whereas productive land decreased almost 40% between 1982 and 2015, a factor that must be taken into account when considering approaches to the food self-sufficiency of the country.

Comparing this availability of land per inhabitant with other European Union countries, it can be seen that Catalonia has a relatively low ratio, much lower than the average value for most European countries (Table 3).

Table 3. UAA* ratio per inhabitant in different European countries. Source: Government of Catalonia (2015); presentation of the draft of the Act on Agricultural Land Use.

| Country | UAA * (Millions of Hectares) | Population (Millions of Inhabitants) | Ratio (m ² /Inhabitant) |
|-------------|---------------------------------|---|---------------------------------------|
| Spain | 24.9 | 46.6 | 5355 |
| Netherlands | 1.9 | 16.4 | 1159 |
| France | 27.5 | 65.8 | 4119 |
| Germany | 16.9 | 80.6 | 2097 |
| UK | 16.1 | 64.1 | 2512 |
| Portugal | 3.8 | 10.5 | 3333 |
| Italy | 12.7 | 59.8 | 2124 |
| Catalonia | 1.1 | 7.5 | 1526 |

* UAA: Total area taken up by arable land and permanent grassland.

As for the agricultural labor force, it decreased from 6.65% of the employed people in Catalonia in 1975, to 1.83% in 2019. From a territorial point of view, on average each agricultural worker has gone from managing around 10 ha in 1975 to double the number (19.8 ha) in 2017, or to put it another way, the average size of farms has grown significantly, to the detriment of small farms.

In terms of animal husbandry, it is important to note the significance of pig farming in Catalonia, but also the problems it causes in its surrounding environment, both due to the continuous restructuring it requires and its environmental effects (high water consumption, slurry production, groundwater contamination, carbon emissions, etc.) and, in particular, the fact that many of the proposals aimed at resolving its issues have not quite succeeded or have simply failed.

In Catalonia there are more than 7.7 million pigs (piglets, pigs for fattening and for breeding) and in 36 years (1982–2018) the number of pigs has almost tripled (298%) (Figure 1). Catalonia is one of the countries with the highest density of pigs, with 242.27/km², surpassed only by the Netherlands, with 290.54/km², and Denmark, with 294.91/km².

Seventy-five percent of fattening farms (which represent 64% of pig stocks) are linked to companies in the agribusiness. The agribusiness, which includes the pig sector, represents 3.6% of Catalonia's GDP and 18.6% of industrial GDP, and is one of the most dynamic exporting sectors in the Catalan economy.

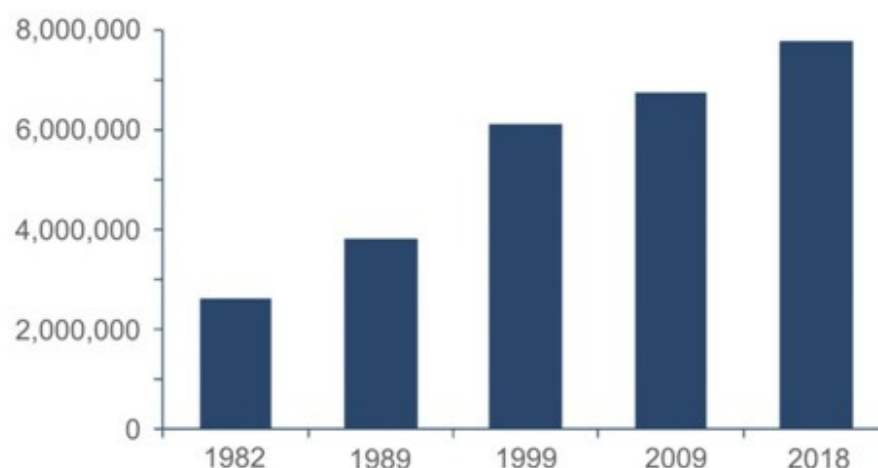


Figure 1. Number of pigs. Source: Idescat and the Pig Observatory of the Department of Agriculture, Livestock and Fisheries (DARP, from the Catalan Government), 2016 Annual report of the pig sector.

Aside from economic interests, space for agriculture has never been a political priority, as demonstrated by the General Territorial Plan of Catalonia, which was approved in 1995, and outlines the land that is suitable for urban development. If it were to be implemented it would lead to the disappearance of agricultural land from sectors of the territory with a gradient of less than 20%, which contain the soils of the highest agricultural value. The Act on Agricultural Land,⁵ a very basic and unambitious law, was recently approved. The lack of sufficiently powerful Catalan legislation has meant that some public authorities and institutions have begun to promote land banks, funds, exchanges and inventories and mechanisms in their local area to encourage access to land and to prevent farmland from being abandoned.

Meanwhile, with the application of the Common Agricultural Policy (CAP), Europe has achieved a significant increase in agricultural productivity and consumers are able to purchase livestock products at reasonable prices. But this has resulted in significant differences in agricultural income, the depopulation of many rural municipalities and a considerable environmental impact, to the extent that traditional farming, with roots in the region, has given way to big business. By way of example, 19% of the beneficiaries of the CAP subsidies granted to Catalonia receive 80% of the total amount, as it is also common in many European countries (Table 4) [5].

Table 4. Distribution of beneficiaries of EU subsidies in Catalonia (2015). Source: Soler and Duch, 2017.

| Beneficiaries | Beneficiaries | | Millions of Euros of Subsidies Received | | Average of Euros Received (€/Beneficiary) | |
|---------------------|---------------|-----|---|-----|---|-------|
| | Number | % | Number | % | Number | % (*) |
| Large beneficiaries | 9801 | 19 | 294,000,000 | 80 | 29,997 | 421 |
| Small beneficiaries | 41,813 | 81 | 74,000,000 | 20 | 1770 | 25 |
| Total beneficiaries | 51,631 | 100 | 368,000,000 | 100 | 7120 | 100 |

* Percentage in relation to the Catalan average.

Agricultural activity must be reoriented towards food production, while guaranteeing the presence of people in the territory and maintaining biodiversity and the landscape. However, to achieve this we must rethink Catalonia's approach to agriculture and livestock farming and prevent the continuous depletion of agricultural assets—especially of those belonging to families with a farming tradition—and promote the emergence of new farmers.

⁵ <<https://portaljuridic.gencat.cat/eli/es-ct/1/2019/06/17/3>>

This can only be achieved if people have access to land, a problem that is endemic to Catalonia where land speculation is rife.

Despite this, there is no shortage of initiatives in the agricultural sphere aimed at ensuring it remains an active space for livestock production, incorporating proactive values of management, biodiversity, environmental quality and other factors. Some of these include actions related to cultivated agrobiodiversity, the promotion of organic farming and agroecology, the creation of plant defense groups, agricultural parks, and the recovery of agricultural spaces.

It is worth mentioning in this regard the incipient development of organic farming, which didn't really begin to emerge until 2010. If in 2000 the total area devoted to organic farming was 10,827 ha, 18 years later it now stands at 210,818 ha. Most of Catalonia's organic farming area is pasture (69%), followed by cropland (20%) and forest (11%). The main crops are the Mediterranean trilogy: Vines 8% (16,680 ha), olive trees 4% (8395 ha) and cereals and legumes for grain 3.5% (7461 ha). Vegetables make up 0.4% (814 ha) and fruit 0.6% (1332 ha) (Table 5).

Table 5. Evolution of the organic farming area in Catalonia and number of producers. Source: DARP; Organic Food and Agriculture Observatory.

| | Evolution of Organic Farming | | | | | |
|-------------------------------|------------------------------|--------|--------|--------|---------|---------|
| | 2000 | 2001 | 2005 | 2010 | 2016 | 2018 |
| Total organic farming area | 10,827 | 50,789 | 54,189 | 83,506 | 171,937 | 210,818 |
| Useful organic farming area * | 6945 | 43,544 | 41,820 | 67,543 | 152,741 | 186,997 |
| Organic crop area ** | — | 5217 | 9348 | 17,903 | 34,914 | 41,230 |
| Number of producers | 327 | 552 | 683 | 1247 | 2496 | 2889 |

* Total area—forest area, scrubland and wild harvesting. ** Total organic area—organic forest area, scrubland and wild harvesting—organic pasturelands, meadows and foraging area.

Catalonia does not yet have a legally recognized form or model of protection for the conservation of agricultural resources or for the development of a territorial project as a method of managing, improving and consolidating agricultural spaces. However, the form of the agricultural park has emerged as a way of expressing the will of certain sectors of the public administration and the agricultural sector to preserve, order, manage and develop an agricultural space. The few already established initiatives include the Baix Llobregat Agricultural Park (1998) and the Gallecs Protected Natural Area (2005), both within the metropolitan area of Barcelona, which face untold pressures in the face of urban and infrastructure encroachment. Despite the exemplary and successful nature of these initiatives, the form of the agricultural park is not yet formalized in legislation.

The species used in agriculture and livestock farming are, for the most part, not native to our country and, since their domestication, have been under constant pressure to obtain the most appropriate varieties or breeds. Despite the existence of ancient varieties supposedly native to Catalonia, or mainly cultivated here, and the fact that these varieties are still cultivated and are gaining notoriety in local markets, the conservation of plant genetic resources in Catalonia is carried out without a centralized strategy for the collection, conservation and use of traditional germplasm, so that despite significant economic and human efforts, the genetic diversity conserved ex situ is not a significant representation of the historical diversity cultivated in Catalonia, nor of the diversity currently cultivated in situ. It is worth noting that the geographical coverage of ex situ conserved material is small [6].

Catalonia has some native domestic breeds, but many have been lost and most of them are critically endangered, largely due to the intensification of livestock farming and the replacement of native breeds with theoretically more productive foreign ones. Therefore, today there are only 14 recognized breeds in the Catalogue of Official Breeds of

the Ministry of Agriculture, Fisheries and Food⁶. Researching and studying other ancestral populations of which a very small number of specimens could still remain might enable the classification of some new breeds.

3.1.4. Forest Management

In relation to forest areas, the main change in recent decades has been the increase in forest cover, from 1,218,500 hectares in 1993 to 1,348,600 hectares in 2009 [7], which represents an average increase of 8100 ha per year, indicating that a rapid transformation of the landscape is taking pace, in which forests are playing an increasingly important role.

This data also shows that many of the forests in Catalonia are young. Data from the national forest inventories (IFN2, IFN3) shows that approximately 40% of the tree trunks in the forests of Catalonia are less than 10 cm in diameter. Taking the territory of Catalonia as a whole, the forested area is quite large, but these forests are of mediocre quality in terms of species biodiversity and regulation of ecosystem processes. However, even these poor-quality forest areas provide a number of important services. For example, they are the main carbon stock of Catalonia's terrestrial ecosystems with about 50 Mg C ha⁻¹, and they have a carbon sequestration capacity of about 1.3 Tg C year⁻¹ [7].

The socio-economic changes in which many different factors are involved, including an energy transition from fossil fuels to plant-based fuels, a demographic transition (involving an exodus of the rural population to urban areas), and changes in nutritional habits, the industrialization of the agricultural sector and the globalization of the economy have strongly impacted the current state of Catalonia's forests. This trend coincides directly with what is happening in other territories with a similar socioeconomic and geographical environment, whether in Europe or in North America.

In Catalonia, the proportion of private property (77%) over public property is significant, except in the mountainous areas of the Pyrenees. This is evident in the percentage of timber extracted privately, which represented 85% of the total in 2018.⁷ The available data indicates that forests are still being exploited, despite their poor economic yield, and that silviculture continues to be carried out in forests, but the continued growth of forest areas means that many of these new forests contribute little to the provision of timber, although this does not preclude them from providing other services.

Forest fires have been one of the critical issues in the management and conservation of Mediterranean basin forests since the 1970s, and Catalonia has suffered wave after wave of fires that have resulted in successful fire-fighting strategies (Figure 2). A large part of the public resources allocated to forest management is devoted to fighting forest fires. For example, in 2017, the Government of Catalonia allocated more than 15 million euros, of which ten and a half were for forest fire prevention. However, if each fire is simply extinguished with absolute efficiency without taking other measures to reduce the amount of fuel, then all this does is ensure there will be larger and more intense fires in the future. This is called the "extinction paradox" of forest fires [8].

The decreased use of forest firewood and timber, coupled with the abandonment of crops and pastures, have contributed to the accumulation of fuel and have resulted in larger more intense fires. Therefore, the most effective strategy is a combination of agroforestry landscapes with breaks in the forest cover distributed throughout the territory and the usual practices of reducing the number of ignitions [9].

Forests will also have to face up to a future where there will be more general aridity and more variable climatic conditions resulting in extreme episodes. In recent years, a significant number of cases of forest decline have been reported with leaf loss or even tree mortality. The causes can be many, but there is physiological and statistical evidence, coinciding with long and intense periods of drought, that a deficit of water is one of them. The results indicate that an average of about 30,000 ha are affected each year, which may

⁶ <<https://www.mapa.gob.es/en/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo-razas/default.aspx>>

⁷ Data from the Department of Agriculture, Livestock, Fisheries and Food, Directorate-General of Forest Ecosystems and Environmental Management.

then gain some resilience after two or three years, though this may be disrupted by new dry spells.

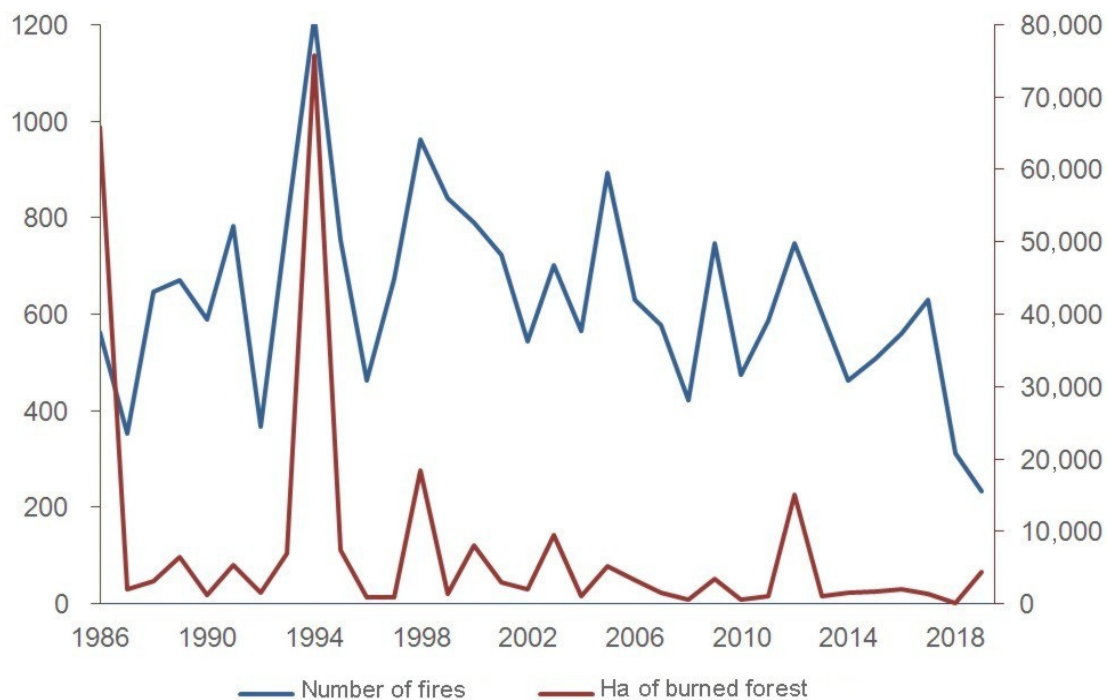


Figure 2. Evolution of forest fires in Catalonia (1986–2019). Source: Government of Catalonia. Department of Agriculture, Livestock, Fisheries, and Food. Directorate-General of Forest Ecosystems and Environmental Management. Forest Fire Prevention Service.

The value of forest areas has meant that they are well represented in the network of protected natural areas, which is probably due, on the one hand, to the social identification of the value of nature in forests and on the other due to the inaccessibility of mountain areas for agricultural or urban uses. As a result, about 40% of the forest cover in Catalonia is included in the Natura 2000 Network. It is worth noting that the value of these spaces lies not only in their nature as forest ecosystems, but also in the species that live there, which are themselves also the object of conservation initiatives. However, the capacity of protected area agencies to manage forests is quite limited and highlights one of the main challenges of the future: How to reconcile preserving their natural heritage with exploiting them for the services they provide, including those of supply.

3.1.5. Fishing and Aquaculture

The extraction of renewable sources from the sea mainly involves capture fisheries (both professional and recreational) and aquaculture. Both bring social and economic benefits to the coastal towns that engage in these activities and health benefits to the consumer, but they also have a strong impact on the exploited ecosystem.

With regard to commercial fishing, in Catalonia, about 250 species are extracted and sold, all but one (red coral) for human consumption. Sixteen species accounted for 80% of the total catch, and two, sardines and anchovies, accounted for 52% (2018 data).

Figure 3 shows the evolution of total catches since 1960, which marked the beginning of a remarkable surge promoted by the implementation of favorable policies during the 1970s. After a period of growth and then fluctuations, typical of phases of overexploitation, since 1996 catches have steadily declined. In 2018, 27,225 tonnes were caught according to data from the Directorate-General for Maritime Affairs and Fisheries. While fleet numbers have declined in the 21st century, it must also be said that their extractive capacity has increased due to the technological advances and new materials used by fishing boats.

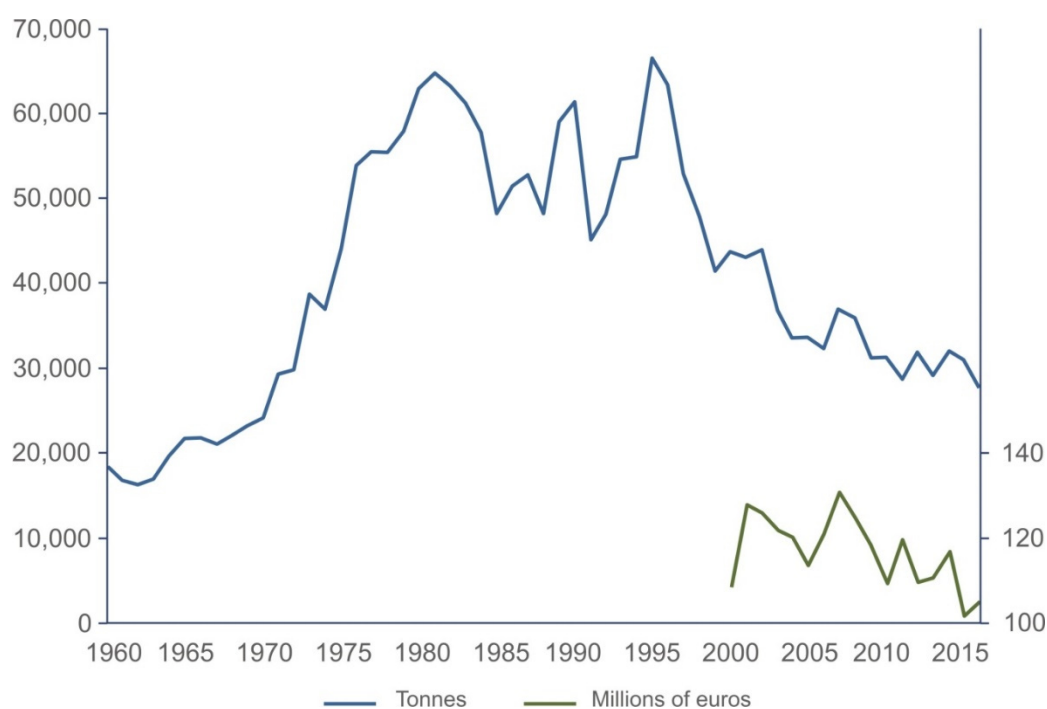


Figure 3. Total catches (1960–2017) and revenue (2000–2017) in Catalonia from commercial fishing (all types of fishing). Source: Prepared by the authors based on data from the Ministry and from the Government of Catalonia.

Fishing is carried out using very diverse methods and fishing gears, each with a very different impact on both the species and their habitat (Table 6). Trawler fishing has probably the biggest impact on the seabed and is widespread in Catalonia: The 240 trawlers in the region represent 31% of the fleet, 32% of the total capture and 59% of the profits. Tuna fishing is also significant, regulated by the International Commission for the Conservation of Atlantic Tunas (ICCAT) which in 2017 awarded Catalonia a quota of 1142 tonnes, which is caught in less than a week, between the months of May and June. Red coral extraction has been intense due to its high value, as a result of which 90% of the population studied on the Catalan coast is now in a poor state of conservation. This, along with poaching has led to a moratorium on its extraction.

Table 6. Professional fishing in Catalonia (2016).

| Method and Gear | Number of Boats | Catch (Tonnes) | Amount (€ Million) | Price (€/kg) |
|-------------------|-----------------|----------------|--------------------|--------------|
| Trawling | 239 | 8989 | 59.21 | 6.6 |
| Artisanal * | 383 | 1723 | 13.44 | 7.8 |
| Purse seine | 82 | 16,959 | 24.47 | 1.4 |
| Tuna | 6 | 1122 | — | — |
| Demersal longline | 38 | 161 | 1.54 | 9.6 |
| Pelagic longline | 14 | 365 | 2.32 | 6.3 |
| TOTAL | 762 | 28,197 | 100.98 | 3.6 |

* Trammel, gillnet, small scale longline fishing, Atlantic bonito gillnetting, big-scale sand smelt fishing, pot fishing, fish trap, Mediterranean sand eel fishing, dredges, and rakes.

The deterioration of fishing grounds in Catalonia is becoming more and more evident and is being acutely felt by fishermen. This decline in biomass is not only caused by fishing, though this is the main factor, but also by environmental factors such as climate change or river flow regulation [10]. The gradual increase in the number of recreational fishermen along the coast, coupled with the increase in tourism, has resulted in recreational fishermen annually catching almost as much as artisanal fishermen with significant repercussions on certain species of fish and the marine environment.

In recent years, several management plans have been put in place, involving scientists, fishermen and the authorities with positive results, although these management plans are quite limited in terms of species and geographical area. Therefore, a more global approach is needed to include all fishing activity along the Catalan coast and the integration of other activities carried out at sea.

Along similar lines, several protected natural areas have been established where fishing at sea is regulated and there are even some reserves set by fishermen themselves. However, these only make up 0.7% of the total fishing area, while experts recommend that at least 20% should be protected for the measure to be effective.

It is worth noting that fish provide a valuable source of polyunsaturated acids which are not found in meat. Unfortunately, they are also the main source of pollutants in the human diet. This aspect is especially relevant in the area of the Catalan–Balearic Sea, where the consumption of fish is significant. Data obtained in Menorca shows that the concentrations of organochlorine compounds in the food produced on the island are generally low compared to those in other European Union countries. By contrast, the mercury levels in fish and shellfish caught in nearby areas and consumed on the island are higher than those found in other seas and oceans, with a percentage of around 65% exceeding the maximum limit for human consumption set by the European Union [11]: 0.5 mg/kg or 1 mg/kg depending on the species. This means that the intake of this neurotoxic metal by children on the island is more than double the maximum recommendation of the European Food Safety Authority [12].

These higher concentrations of mercury compared to other nearby seas and oceans are characteristic of the Western Mediterranean and also affect the consumption of the population of Catalonia. In fact, several studies carried out in populations in the Iberian Peninsula and rest of Europe show that the people in Spain and Portugal (mothers and children) have the highest concentrations of this metal in their hair for the whole European Union [13–16].

In terms of aquaculture, Catalonia annually produces about 1000 tonnes of fish (sea bass and sea bream) and 4000 tonnes of bivalve molluscs, of which more than 90% are mussels. This production is equivalent to 15 to 20% of capture fisheries (close to 30,000 tonnes), but the profit obtained is proportionally less. Catalonia, according to IRTA reports, ranks fifth among the Spanish autonomous communities in aquaculture production (in tonnes), behind Galicia, Murcia, Valencia, and Andalusia.

While progress is being made towards sustainable aquaculture, which takes into account the effects of aquaculture farms on marine habitats, there are issues that have indirect environmental effects that need to be improved, such as minimizing the use of flours and oils from wild fish (sardines, anchovies, etc.) to feed many of the fish that are farmed, which are carnivorous.

3.1.6. Nature Tourism

Almost every society in every historical period has made use of the natural environment for leisure purposes, but in recent decades this type of use of resources has become more widespread. In the case of Catalonia, one of the first turning points occurred at the end of the 19th century when hiking became widespread, maintaining its tradition and popularity today.

The long-standing tradition of hiking in Catalonia is evidenced by the fact that several hiking organizations are over hundreds of years old and that the Federation of Hiking Organizations is the fourth largest federation with 40,000 members, although the actual number of the practitioners of the multiple modalities that can be grouped under hiking is at least four or five times this number. In recent decades, the practice of competitive group sports has also grown exponentially. And as a result of this growing trend, it is becoming more and more common to hear about hyper-frequentation, with the number of people visiting natural areas exceeding their capacity of reception, which is having a severe impact on some areas. The existing regulatory and planning framework, which is too imprecise and vague, does not provide an adequate solution to this problem [17].

Hunting and fishing in inland waters are probably the two oldest forms of use of the natural environment for the purpose of sport and leisure. It should be remembered that 97% of the territory of Catalonia can be used for hunting, though according to Idescat the number of hunting licenses has decreased from 104,085 in 1996 to 37,452 in 2018, even though the Catalan Federation of Hunting is the third largest federation, behind the football and basketball federations, in number of licenses. The current trends show there is a hunting crisis as evidenced by two significant facts: The number of valid hunting licenses has followed a clear downward trend—a decrease of 64%—, and at the same time the average age of the members of hunters' societies has gone up, indicating a low generational renewal rate.

The fishing situation is different. The evolution of the number of licenses indicates an upward trend or with annual fluctuations that maintain the number of licenses in force at around fifty thousand, 53,742 in 2019 according to Idescat. While the number of catch-and-release stretches and the number of fishing refuges have been increased, the presence of invasive non-native fish species is one of the main problems in river areas. According to the Catalan Water Agency, 50% of rivers suffer biological contamination by invasive species.

Sporting activities in the natural environment have grown considerably, be it adventure tourism or mountain biking. Some of these activities in particular have a significant potential impact, which could be severe depending on their quantitative and geographical extension, as a result of which they are starting to be regulated. However, as has traditionally happened with motorized traffic, monitoring compliance with these regulations is rather lax.

Despite the fact that Catalonia is not an alpine country and it does not have the best climatic conditions for a permanent snow line, it has a considerable skiing tradition and is home to the largest number of ski resorts and the largest skiable area in Spain. According to Idescat, in 2018 there were 10 alpine skiing resorts in Catalonia, with 128 ski lifts, 2666 snow cannons and 480 km of skiing area. However, over the years, three of these resorts, Llessui, La Tuca, and Rasos de Peguera, have closed, a project to create a new resort in Vall Fosca has failed, and more than half of the resorts have become publicly owned and acquired by the Government of Catalonia to avoid bankruptcy and ensure this tourist sector stays afloat in mountain regions.

From the point of view of economic and social impact, it is clear that the growth of winter sports and ski resorts has contributed decisively to the development of mountain regions, acting as a real economic driver at a time when a crisis in primary sector activities looked like it might lead to the depopulation of some of the villages in these regions, and helping to stop the processes of demographic decline which had become more acute since the 1950s. But it should be noted that the economic momentum generated by ski resorts has more to do with the development of the service sector and, in particular, the construction sector, than with the practice of skiing.

Added to the irregular precipitation and temperatures typical of Catalonia's climate system, there are other issues that arise from potential increases in average temperature as a result of climate change. The projections of the Third Report for Climate Change in Catalonia⁸ [18] indicate that, in the current scenario, there are three resorts which are not viable without artificial snow production and the technical viability of all these resorts is in doubt in the second scenario, that is, even with artificial snow production. With these forecasts in mind, initiatives are required which take into account for seasonality and can consolidate tourism all year round, diversifying offers, destinations and activities, though these should avoid adopting the current approach of turning ski resorts into a sort of theme park in the summer, as is the case at the moment. Most of the resorts could become infrastructures or service centers suitable for nature tourism activities, operating in harmony with the nearby protected natural areas.

⁸ http://cads.gencat.cat/web/.content/Documents/Publicacions/tercer-informe-sobre-canvi-climatic-catalunya/TERCER_INFORME_CANVI_CLIMATIC_web.pdf

The first evaluation of the system of protected natural areas in Catalonia [19] concludes that protected natural areas, and especially those with special protection which have management bodies and tools in place, not only do not constitute an impediment to economic development but are significant economic drivers, linked mainly to the service sector, especially in the mountainous regions where they have replaced the primary sector; agricultural activities have also benefited from the existence of protected areas, through infrastructure investments, direct subsidies and the creation of a local consumer market. The 2015 study on the economic and social impact of protected areas⁹ [20], quantified the economic impact of protected natural areas and, after analyzing 16 areas, the number of visitors to these spaces in 2012 was estimated at almost seven million. The contribution of these sixteen natural areas to the gross added value of economic activities was 192.4 million euros.

In short, protected natural areas play an important role in tourism and leisure activities linked to the natural environment, with the advantage that these spaces are subject to planning and regulations which can ensure the better management of these types of activities and the adoption of measures that guarantee their compatibility with the preservation of the natural values on which they are based.

In Catalonia, as in other tourist destinations in the Mediterranean, there are clear examples of how coastal areas have deteriorated and, in parallel, how their appeal as tourist attractions has declined. In the case of the frequentation of natural areas, which as a mass phenomenon is more recent, there is still time to take the necessary measures to ensure the sustainability and quality of this form of tourism. Proposals for these areas which promote projects that completely ignore the sustainability of the natural resources in the name of economic growth and job creation should be avoided at all costs.

3.1.7. Energy Consumption

The increase in energy consumption caused by the urbanization process in Catalonia can be seen in the graph below (Figure 4) [21]. It shows the evolution of electricity consumption by type of energy source between 1981 and 2015. Only 22% of the total electricity consumed came from renewable sources.

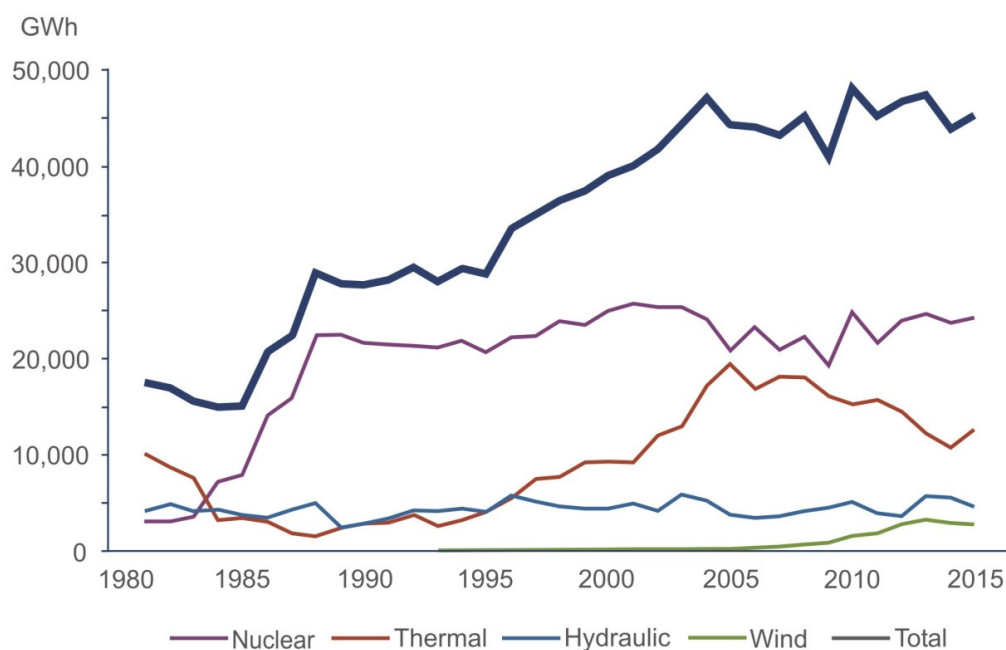


Figure 4. Electricity consumption in Catalonia. Source: Neila, 2003; ICAEN; prepared by the authors.

⁹ https://obrasociallacaixa.org/documents/10280/586356/impacto_economico_y_social_espacios_naturales_protegidos_catalunya_ca.pdf/7bba22d9-8563-483b-9eee-9325bcdb44c5

Primary energy consumption in Catalonia in 2017 was 25,517 ktoe (thousands of tonnes of oil equivalent), while final energy consumption (calculated via meters or estimates) was 13,912 ktoe, 55% of the primary energy consumed; the 45% difference is what was lost in the transformation of energy from primary to final. Primary energy production in 2017 was 7780 ktoe, 30.5% of total primary energy consumption, which means that the rest was imported, so the consequent impacts were externalized.

The percentage distribution of the sources used in energy production in Catalonia again shows the scant weight of renewable energy and the country's dependence on external sources (Table 7).

Table 7. Energy production by source (%), 2017. Source: ICAEN.

| Energy Source | % |
|---------------------|------|
| Nuclear | 82.1 |
| Renewable energy | 14.5 |
| Non-renewable waste | 1.8 |
| Oil | 1.6 |
| Coal | 0.0 |
| Natural gas | 0.0 |

The energy system affects the environment in many other ways: Primary sources of energy are extracted from nature, space is needed to install the facilities (production plants, reservoirs, wind farms, transport networks, etc.), and the environment is the recipient of the difference between primary and useful energy and of the emissions and waste generated. A good example is CO₂ emissions in Catalonia (Table 8), which in 2017 totalled 45,073 tonnes, of which 32,442 came from energy processing. Another example is the estimate (due to a lack of official data) that, under “normal” operating conditions, Catalonia's nuclear plants dump more than 6000 curies of radioactive material into the biosphere every year [22].

Table 8. Distribution of CO₂ emissions in Catalonia by sector. Source: Catalonia Climate Change Office (2015).

| Sector | % |
|---------------------------------|-------|
| Energy processing | 71.97 |
| Non-energy industrial processes | 13.71 |
| Agriculture | 8.76 |
| Waste treatment and disposal | 5.54 |

The issue of whether it is possible to consume energy from 100% renewable sources is no longer in doubt after the publication of the study “100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World” [23]. However, generating 100% of our energy from renewable sources is not synonymous with sustainability, though its impacts would be substantially reduced.

3.1.8. Ecological Footprint

If we want to redress unsustainable trends, we need to abandon the obsolete economic indicators that have been used as a guide to measure the wealth of countries (especially GDP) and replace them with others that show whether human activities in a country are sustainable or not, that is, if they are in balance with the regenerative capacity of the biosphere. The ecological footprint is one of the most widely used sustainability indicators in the world because it measures the productive land and sea area that is needed to generate the resources consumed by a particular country and the amount that would be necessary to absorb the emissions and waste, which is basically an initial indicator of its degree of sustainability.

Shortly after the ecological footprint indicator was presented internationally in 1994, Barcelona City Council decided to use it in its calculations for the city. To do this, those responsible first calculated the ecological footprint of Catalonia, using data from 1996 mainly, and applied the average value obtained to the population of the city of Barcelona. It should be noted that the proponents claim that they did not have all the necessary information, such as data on domestic trade, and that they used the population recorded in the census for Catalonia, which at the time was 6,090,040 inhabitants, without taking into account tourism (Table 9) [24].

Table 9. Ecological footprint of Catalonia per capita in 1996. Source: Relea and Prat, 1996.

| Categories | EF (ha/Person) |
|---|----------------|
| Space for urban settlements and transport links | 0.03 |
| Space for food production (crops) | 0.49 |
| Space for food production (pastures) | 0.99 |
| Space for forestry production | 0.08 |
| Space associated with energy consumption and CO ₂ absorption | 1.02 |
| Space associated with the sea | 0.65 |
| Total | 3.26 |

This value, multiplied by the approximately 6 million inhabitants at that time, gave an ecological footprint of 19,853,530 ha, in other words 6.5 times larger than the total area of Catalonia. And since the bioproductive area (or carrying capacity) of Catalonia was calculated to be 1 ha per person, in 1996 the ecological deficit of Catalonia was estimated to be −2.2 ha/person.

Seven years later, the Advisory Council for Sustainable Development carried out a new calculation of the ecological footprint of Catalonia. Most of the data used in this second calculation came from official sources from 2001 (Table 10) [25].

Table 10. Ecological footprint of Catalonia per capita in 2005. Source: Mayor et al., 2005.

| Categories | EF (gha/Person) |
|---|-----------------|
| Space for urban settlements and transport links | 0.033 |
| Space for food production | 2.03 |
| Space for forestry production | 0.043 |
| Space associated with energy consumption | 1.60 |
| Space associated with the import of goods | 0.21 |
| Total | 3.92 |

This time, however, a second calculation was carried out taking into account tourists. In 2001, Catalonia received 20,485,000 foreign tourists and 4,751,800 Spanish tourists, so around 25 million in total. Given their respective average stays, this was calculated as being the equivalent to 442,508 permanent residents. Therefore, the real population of Catalonia was estimated to be 6.8 million. If you divide by this number of inhabitants, the value of the ecological footprint per person would be 3.67 gha/person, slightly lower than the standard calculation.

Although the methodologies used for the two standard calculations were not identical, since the second version included more complete data, it shows that the ecological footprint of Catalonia increased from 3.26 to 3.92 gha/person between 1996 and 2001. Given the population increase, this means that, in absolute terms, the ecological footprint of the population of Catalonia as a whole increased from 6.5 to 7.7 times its own surface area. Therefore, during this period, Catalonia clearly regressed in its move towards sustainability.

At the European level, the countries with the highest ecological deficit in 2005 were Spain (−4.4 gha/person), Greece (−4.2 gha/person) and Belgium (−4 gha/person) [26]. Catalonia (as of 2001 data) was therefore around the average.

3.2. Impacts of the Natural Environment

3.2.1. Territory

Land Cover

The territory of Catalonia is immersed in a process in which its cover and use is changing in line with what is happening in the rest of Mediterranean Europe: An increase in forest area resulting from agricultural abandonment, the intensification of agriculture in more productive areas and urbanization strongly linked to the growth of metropolitan areas and the development of tourism along the coast. This has resulted in the loss of some of the most important values of the Mediterranean landscape, which has a profound effect on biodiversity conservation and on the ecological functioning of the territory, and consequently on the provision of environmental functions and services.

In the specific case of Catalonia, an analysis of the change in land cover based on the land use maps generated by the Cartographic and Geological Institute of Catalonia and by CREAM/UAB¹⁰, using Landsat satellite images, shows that between 1987 and 2012, in relation to the territory as a whole, the forest area increased by 2.6% and built-up areas by 2.8%, while cropland was lost in an area equivalent to almost 5% of the territory (Figure 5).

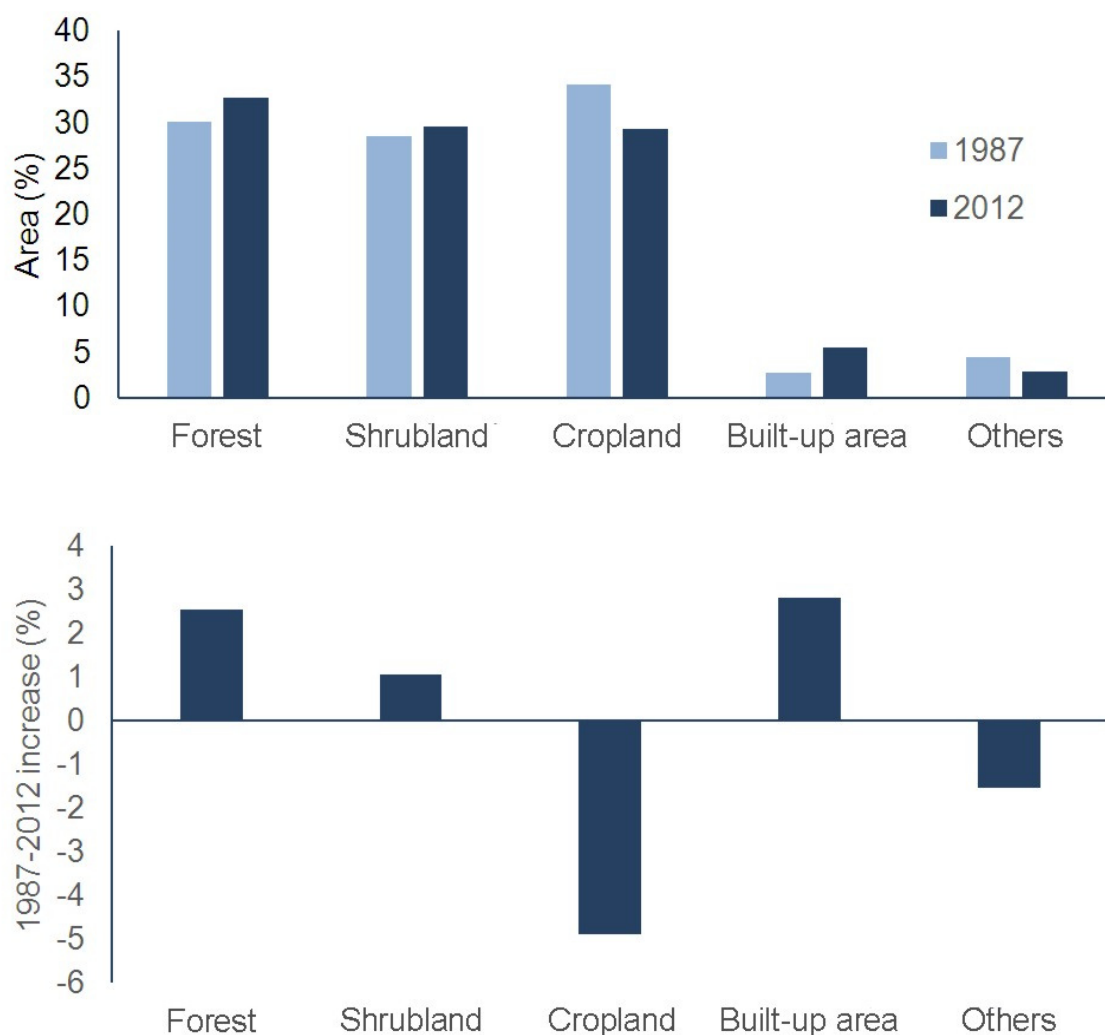


Figure 5. Percentage of the main types of land cover in Catalonia in 1987 and 2012 and increase (as a percentage with respect to the total territory) between these years. Source: ICGC-CREAM/UAB.

¹⁰ <<https://www.creaf.uab.es/mcsc/>>

The metropolitan area of Barcelona, the most densely populated and urbanized area of Catalonia, follows a similar trend, although with slightly different percentages. The built-up area increased by 7.5% and the forest area by 4%, while cropland decreased by an area equivalent to 8.8% of the total.

If the calculation is made for the last half century, using data obtained from the black and white airborne photogrammetry carried out by the United States Army between 1956 and 1957¹¹, the results corroborate the trends observed in more recent years and also the results obtained for the metropolitan area of Barcelona.

These changes have led to a simultaneous increase in fragmentation, cover diversity and ecological connectivity. In the case of the province of Barcelona over the last five decades (Table 11), the increase in fragmentation is manifested in a decrease in the landscape grain size, with a 20% increase in the number of polygons and a 10% decrease in the average size, and a 10% increase in the diversity of cover.

Table 11. Average values of various landscape metrics calculated using the land cover maps of the province of Barcelona in 1956 and 2009 and variation in their average values. Source: Calculations from the MCSC of 2009 and the MCS56_B.

| | 1956 | 2009 | Variation 2009/1956 |
|-------------------------|-----------|-----------|---------------------|
| Fragmentation | | | |
| Average area (ha) | 14,853.7 | 13,791.0 | −7.2% |
| Total perimeter (km) | 267,975.5 | 264,639.5 | −1.2% |
| Number of polygons | 286,785.0 | 344,131.0 | 20.0% |
| Polygons/Cover | 5515.1 | 6145.2 | 11.4% |
| Diversity of covers | | | |
| Number of covers | 52.0 | 57.0 | 9.6% |
| Shannon Diversity Index | 2.62 | 2.89 | 10.3% |
| Shannon Evenness Index | 0.46 | 0.50 | 8.7% |
| Connectivity | | | |
| ICT (Log (ha)) | 1.73 | 2.42 | 39.9% |

This simultaneous increase in fragmentation and diversity of covers did not result in a reduction in the province's average connectivity, which increased by 40% as a whole, largely due to the increase in forest cover, which is concentrated in mountainous areas and in areas where agricultural land was abandoned, but the trend is in contrast to what occurred in the coastal and pre-coastal plains which were much more affected by urbanization.

Recent changes to the landscape have had a very discernible impact on the metropolitan area of Barcelona, where the built-up area (urban, commercial, roads, etc.) has increased significantly, accompanied by a smaller increase in forest area, all to the detriment of farmland. As a result, biodiversity and the functioning of metropolitan ecosystems have been strongly affected by their fragmentation in a highly artificialized landscape. It is also worth noting the significant loss of ecological connectivity that has been taking place, largely due to the artificialization of the landscape matrix and the proliferation of infrastructure that increases the barrier effect.

This territorial dynamic has very diverse effects on the conservation of biodiversity. First of all, it has resulted in a gradual closing off of the landscape, due to agricultural abandonment and the subsequent growth of wooded areas, affecting the populations of those creatures which require an open habitat, including many species of birds and butterflies [27], while on the other hand, it has led to a recovery of forest biodiversity.

¹¹ <<http://sitmun.diba.cat/wms/servlet/CSA56?request=getcapabilities&service=WMS>>

Especially in the metropolitan area, biological communities have been depleted and simplified, with a gradual loss of the most sensitive species and the proliferation of more general ones [28]. In this context, the risk of invasion by non-native species increases significantly, as has been seen in the case of non-native plants [29,30]. Meanwhile, those plant species and communities of greater interest often find themselves restricted to less dynamic areas, as has been observed in certain marshes in the Llobregat Delta [31].

Urbanization

In Western Europe, the origins of recent urbanization processes lie in the economic, social, and political changes that have taken place, in particular, since the 19th century. Initially, this process was relatively limited in area. However, not only has it accelerated since then, but the urban way of life has become widespread across the whole territory. While in 1880 barely 1763 ha of the current metropolitan area of Barcelona (323,966 ha) were dedicated to urban uses, in 1956 this number stood at 11,369 ha and in 1994 it was 45,035 ha [32]. Other estimates indicate that the area dedicated to these uses currently (2006) exceeds 80,000 ha [33].

In Catalonia, the process of population concentration, which had been a constant territorial trend since the 19th century, reached its peak in between 1960 and 1981. The most significant change took place between 1981 and 1996, when the slowing population growth, the relocation of industry, the improvement of communications and the emergence of new forms of tourism propagated the spread, de-concentration and dispersal of urbanization, breaking the traditional urbanization pattern characterized largely by its compactness, and creating a new model based on the establishment of a large number of low-density settlements occupying large areas of land. With a boost in economic activity, mainly the result of the real estate boom which took place between 1996 and 2008, urban areas grew across almost the entire territory, leading even to a demographic recovery largely thanks to significant positive migratory balances. Since 2008, with the advent of the so-called economic crisis, this urbanization drive seems to have weakened, though not to the extent of reversing the main trends [34].

The Gini concentration index reflects this evolution (Table 12). Throughout most of the century its value had only grown, reaching 0.872 in 1981, after which it began to decline slightly. Meanwhile, the population has continued to increase, with varying degrees of intensity (Table 13).

Table 12. Gini population concentration index by municipality in Catalonia (1900–2017). Source: Prepared by the authors based on censuses standardized by the BBVA Foundation and IVIE (Valencian Institute of Economic Research), as of November 2015; the data for the years 1996, 2008, and 2017 are from the census of the INE (National Institute of Statistics).

| Gini Population Concentration Index | | | | | | | | | | | | | | |
|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1900 | 1910 | 1920 | 1930 | 1940 | 1950 | 1960 | 1970 | 1981 | 1991 | 1996 | 2001 | 2008 | 2011 | 2017 |
| 0.646 | 0.654 | 0.679 | 0.724 | 0.749 | 0.780 | 0.816 | 0.855 | 0.872 | 0.867 | 0.860 | 0.854 | 0.847 | 0.846 | 0.848 |

Table 13. Population growth, absolute numbers and cumulative annual growth in Catalonia. Source: Prepared by the authors based on censuses standardized by the BBVA Foundation and IVIE (Valencian Institute of Economic Research), as of November 2015; the data for the years 1996, 2008, and 2017 are from the census of the INE (National Institute of Statistics).

| Absolute Population | | | | | Average Annual Growth | | | |
|---------------------|-----------|-----------|-----------|-----------|-----------------------|-------|---------|--------|
| 1960 | 1981 | 1996 | 2008 | 2017 | 60–81 | 81–96 | 96–08 | 08–17 |
| 3,888,485 | 5,956,414 | 6,090,040 | 7,364,078 | 7,555,830 | 98,473 | 8908 | 106,170 | 21,306 |

The urbanization process has been characterized by four main trends: Population concentration followed by increasing settlement dispersion, the spreading of urban areas, the integration of regional territories into metropolitan networks and the coastalization of the population and activity. These trends have produced benefits but have also had important environmental implications, in terms of changes in land cover and effects on the natural environment, increases in energy consumption and changes to the water cycle and air pollution.

In the context of climate change, a strictly urban factor that should be considered a new climate risk is the heat island phenomenon that occurs in large cities, with Barcelona being the most obvious example in Catalonia. When comparing the temperature of the city center with the surrounding area, it has been found that the nights in the city center are, on average, more than 1.9 °C warmer than in the immediate surroundings. These minimum temperatures have a critical effect on human health, especially during heat waves, which are becoming more severe and frequent.

As well as issues such as the prevailing energy model or traffic reduction, the greening of cities also plays a key role in improving the habitability of urban areas. In the city of Barcelona, green space increased from 437 ha in 1980 to 1130 ha in 2016. The model for maintaining these green areas and gardens was initially predominantly intensive, and it was not until the 1990s that a more environmentalist view was taken: Water conservation, reduction in the use of phytosanitary products, biodiversity acknowledgment, environmental education, etc. It was not until recently that a more sustainable vision began to emerge. This approach goes beyond simply creating green spaces and takes a holistic perspective of nature in the city, viewing it as a green infrastructure that offers a whole series of services for the city [35].

Coastalization

As in other areas of the European Mediterranean coast, the Catalan coast is a good example of excessive urban growth, dispersed and unconnected to the biophysical matrix of the territory and the ecosystem services it provides. In 1976, the White book *Llibre blanc de la gestió de la natura als Països Catalans* (White Book on Nature Management in the Catalan Countries) already noted that the coastline was the most threatened area in the country in terms of nature conservation. Forty years later, it is fair to say that even though most of the natural areas that had escaped the urbanization process have been safeguarded under different legal forms of protection, the pressures and threats that the Catalan coast was subjected to have not disappeared completely and, in certain cases, they have even increased or new ones such as global climate change have emerged.

Coastal landscapes still face the threat of excessive demographic pressure, an avalanche of sun-seeking tourists, the spread of urbanization and the artificialization of the coastline. There is data that clearly illustrates this situation: Coastal towns occupy 6.7% of the Catalan territory, and in 2016 they accounted for 43.3% of the total population; tourism has grown from two million in 1960 to more than nineteen million in 2017; between 1993 and 2009, some coastal towns increased their urbanized area by more than 60%.

There has been a clearly speculative component to all this urban development along the coast, which has often ignored the values of the environment and the services it provides. The most illustrative case is the beaches, which despite being the main tourist attraction are in a very delicate situation. The lack of new sediment has contributed to erosion along 177 km of beach, 72% of the total [36], a situation which could be exacerbated by sea level rise resulting from global climate change, which according to one scenario in the projections of the IPCC Fifth Assessment Report [37] would increase by 2.7 to 5.8 mm/year, accompanied by an increase in extreme sea storms. And when attempts have been made to correct these effects, since beaches are the main source of coastal tourism, the measures taken have involved rigidizing the coast with permanent construction work or regenerating the beach with sands extracted from the nearby seabed, measures that in no way attack the root of the problem.

The measures taken to try to correct the existing urban planning deficits and to improve the landscape quality of both the urban space and the natural environment have not stopped the trend of intensive construction along the coast. This has been largely fueled by the belief that the territory is an unlimited resource and by the enormous capital gains generated by the transformation of agricultural or forest land into developable land, criteria that are far removed from considerations about environmental sustainability and preserving the value of the landscape.

Natural Hazards

The social and economic impact of natural hazards, both in developed and developing countries, has steadily increased in recent years and this trend is expected to continue. This increase is not only due to a possible exacerbation of extreme natural phenomena as a result of climate change but is largely the result of a dearth of territorial management and planning policies and the little consideration given to natural hazards.

Flooding is the leading cause of damage from natural causes in Catalonia, as a result either of flooding in large river basins, of sudden surges in streams, or of coastal floods. The vast majority of municipalities are exposed to flood risk (Table 14) and the inhabitants of many areas have to live with severe episodes of flooding, some of which have been catastrophic [38].

Table 14. Flood risk in Catalonia by municipality. Source: INUNCAT Plan, 2016.

| Flood Risk in Catalonia by Municipality | |
|--|-----|
| Number of municipalities at very high risk | 204 |
| Number of municipalities at high risk | 180 |
| Number of municipalities at medium risk | 108 |
| Number of municipalities at moderate risk | 258 |
| Number of municipalities at low risk | 196 |

Currently, the main problem associated with flood risk is related to the large amount of urbanized land located in flood zones, which is therefore exposed to flood risk because the urban development of the mid-20th century onwards barely took into account the flood risk of the area in which it took place. The Catalan Water Agency (ACA, from the Catalan) has been working on river planning for some time now and it has produced flood maps (with danger and hazard levels) for all river basins and coastal areas.¹² The relevant European regulations have generated the corresponding regulatory documents which are essential for planning the management of the territory and, above all, for proper urban planning. Despite this, the most commonly used tool to protect against floods is the INUNCAT civil protection plan, a form of reactive planning that is activated when weather forecasts indicate that it is necessary.

Apart from the requirement to comply with regulations in all new construction and urban planning projects, one of the main problems today is that there is not yet a plan or program in place for protecting the urbanized areas in flood zones that were built before the current regulations were in force. In Catalonia, 15% of urbanized land is located in flood zones [39].

Other natural hazards which occur with certain frequency include landslides, avalanches and seismic activity. The impact of landslides can be significant [40] and there is a relationship between increased damage and increased land use, especially from buildings and roads. The Cartographic and Geological Institute of Catalonia (ICGC, from the Catalan) has mapped landslide risks as part of its 1:25,000 scale map for the prevention of

¹² <http://aca-web.gencat.cat/recursos/sig/public/VisorPEF.html>

geological hazards,¹³ but not even a quarter of the maps have been completed. There is also a landslide database called LISCAT.¹⁴

Avalanches have a significant impact in the Pyrenees and the level of vulnerability and exposure has increased in recent decades [41]. The ICGC keeps a good record of avalanche cases and manages the Catalonia avalanche database.¹⁵ There is also a Special Avalanche Emergency Plan in place in Catalonia (ALLAUCAT) as part of the civil protection framework.

Seismic activity is of a moderate to low level, with the most important seismic sectors located in the Pyrenees. In Catalonia, the ICGC is responsible for managing the Catalan Seismic Network with 21 broadband stations and an accelerometric network,¹⁶ and coordinates the seismic hazard and risk assessment processes that must be followed for both earthquake resistant construction and for the preparation of the Special Plan for Seismic Emergencies in Catalonia (SISMICAT) in the area of civil protection.

The only area where there is a history of recent volcanic eruptions and where there could be considered to be active volcanoes is the region of La Garrotxa. The most recent volcanic eruptions occurred 9000 years ago, but signs of volcanic activity as recent as 5000 years ago have been detected [42,43]. According to the recommendations of the International Association of Volcanology, an active volcanic zone is one where there has been some activity in the last 10,000 years.

3.2.2. Air

The problem associated with the atmosphere, with the climate, is not an exclusively environmental issue, but one that is related to the economic, and in particular, the energy model. The effects of climate change are very evident in Catalonia (Figure 6): The increase of air temperature at ground level between 1950 and 2014 is estimated at 0.23 °C per decade; precipitation has decreased by 1.2% per decade, although this value is not statistically significant; over the same period the frequency of extreme weather events has increased [44].

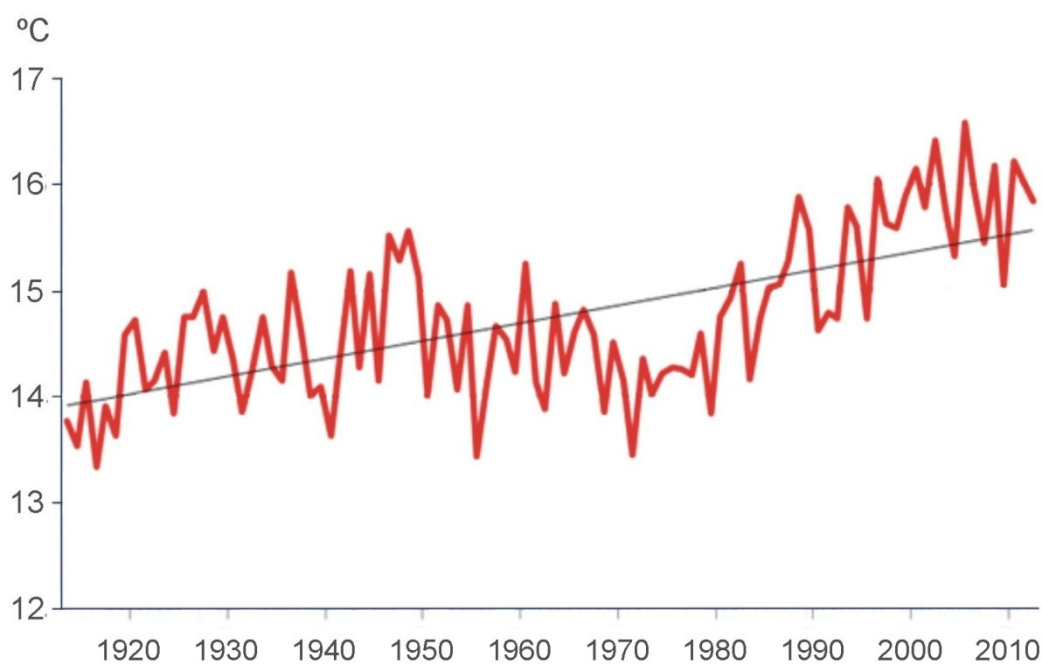


Figure 6. Evolution and linear trend of the average annual temperature for the first century of records of the Fabra Observatory (1914–2013), in °C. Source: RACAB and Martín-Vide, 2017.

¹³ <http://www.icgc.cat/ca/Administracio-i-empresa/Eines/Visualitzadors-Geindex/Geindex-Riscos-geologics>

¹⁴ <http://www.icgc.cat/Administracio-i-empresa/Serveis/Riscos-geologics/Base-de-dades-d-esslavissades-LLISCAT/Base-de-dades-d-esslavissades-LLISCAT-Acces>.

¹⁵ <http://www.icgc.cat/ca/Administracio-i-empresa/Eines/Bases-de-dades-i-catelegs/Base-de-dades-d-allaus-de-Catalunya-BDAC>

¹⁶ <http://www.icgc.cat/Ciutada/Explora-Catalunya/Terratremols/Sobre-la-xarxa-sismica-i-accelerometrica>

Bearing in mind that in Catalonia, according to the 2015 census, about 95% of the population live in urban centers, improving air quality is as much an environmental issue as it is a public health one. Over the last 40 years, existing air quality control networks have helped improve air quality awareness and the detection and monitoring of air pollution episodes, providing air pollutant concentration data that covers a sufficient period to be able to analyze its evolution¹⁷.

Generally speaking, the permitted average annual values of the different pollutants have not been exceeded, but the permitted hourly values of some pollutants, such as nitrogen and sulfur oxides and PM10 particles, have been exceeded in urban and industrial areas and on major roads. Ozone is a special case, because the highest levels of tropospheric ozone have been recorded in relatively rural areas, on the leeward side of major cities, exceeding the threshold for notifying the public of 180 µg/m³ per hour on average, although very rarely exceeding the warning level of 240 µg/m³.

The time series analysis of pollutant concentrations shows a certain stabilization or even a decrease since the beginning of the century; in no case has an increase in any of the analyzed pollutants been detected. Road traffic is one of the main causes of air pollution and, on a different scale, road transportation is one of the main sources of planetary CO₂ emission around the world. Therefore, energy transition is the only way to a cleaner and more sustainable model.

3.2.3. Water

Since the implementation in Catalonia of the provisions of the European Union Water Framework Directive, the state of aquatic ecosystems has improved considerably. However, despite major investments in environmental remediation, most ecosystems have not been completely restored, with only one third (36%) of rivers, reservoirs, ponds, wetlands, coastal lagoons, estuaries, bays, and coastal waters classified as being in good condition (Table 15).

Table 15. Number and percentage of bodies of water in the Catalonia River Basin District. Evaluated in accordance with the protocols and metrics required by the Water Framework Directive (2000/60/EC) between 2013 and 2015. Source: Management Plan for the Catalonia River Basin District, published on the ACA website¹⁸.

| Bodies of Water | In Good Condition | In Bad Condition | Without Enough Data to be Evaluated | Total |
|---------------------------------------|-------------------|------------------|-------------------------------------|------------|
| Rivers | 86 (35%) | 145 (58%) | 17 (7%) | 248 (65%) |
| Reservoirs | 10 (77%) | 3 (23%) | - | 13 (3%) |
| Ponds and wetlands | 8 (30%) | 16 (59%) | 3 (11%) | 27 (7%) |
| Transitional waters (coastal lagoons) | 5 (20%) | 17 (68%) | 3 (12%) | 25 (7%) |
| Coastal waters | 16 (49%) | 15 (45%) | 2 (6%) | 33 (9%) |
| Groundwater | 13 (35%) | 24 (65%) | - | 37 (10%) |
| Total | 138 (36%) | 220 (58%) | 25 (6%) | 383 (100%) |

This situation is not unique to Catalonia and is also evident in other parts of Europe, especially in those basins with a high population density. However, it is exacerbated in those Mediterranean areas with a shortage of water, as is the case for most Catalan basins.

The physicochemical quality of many rivers and streams in Catalonia has improved in the last twenty years, with the treatment of more than 97% of the population's wastewater. Inputs currently received by rivers could be diluted and integrated into the environment if they were dispersed across sufficiently abundant river systems, as is the case in many Central European areas, but in the case of Catalonia the low levels of water flow and the

¹⁷ <http://mediambient.gencat.cat/ca/05_ambits_dactuacio/atmosfera/qualitat_de_laire/avaluacio/>

¹⁸ <<http://aca.gencat.cat/ca/plans-i-programes/pla-de-gestio/>>

concentration of discharge at certain points result in eutrophication and a lack of quality in certain areas: About thirty stretches of river (12% of all bodies of water), despite there being a sanitation system which complies with European regulations, show signs of alteration [45].

Aquatic systems are also subject to other pressures which prevent them from being in good condition. These factors include morphological alterations, changes to the flow regime, the presence of invasive non-native species, nonpoint source pollution and emerging contaminants.

Alteration of morphological quality adversely affects 54% of the bodies of water [46]. This is caused by the occupation of riverbanks and of river areas, the loss of riversides and diversity of habitats and major alterations in morphology due to flooding and changes to the course of the river. Changes to the hydrological regime caused by extracting, diverting or regulating water flows for different uses have reduced the quality of the bodies of water by 17%. Moreover, 13% of aquatic ecosystems suffer from river continuity issues.

Different forms of nonpoint source pollution, such as nitrates and pesticides generated by agriculture and livestock farming, is one of the main problems affecting groundwater. Excess nitrates have contributed to the deterioration of 41% of all groundwater sources. So-called new contaminants or emerging contaminants (medicines, personal care and household products, biocides, etc.) affect 21% of the rivers and 28% of the groundwater in Catalonia [45]. The traditional sanitation systems currently in operation are not designed to adequately treat these new contaminants.

All of these effects on inland bodies of water are transmitted to coastal bodies of water, especially through the inputs of the major river courses and thanks to the intense urban and industrial activity along the coastline [47,48], to the extent that land-to-sea inputs, and especially discharges during rainstorms, affect more than 50% of coastal water bodies [45].

One of the consequences is the proliferation of harmful algae, a phenomenon controlled by a number of processes. Despite being a natural phenomenon, in recent decades the frequency of detection and the number of species considered toxic has increased. The supply of nutrients from inland waters and the artificialization of the coastline are among the factors that contribute to this phenomenon. Most algal blooms are harmless, but in some cases the dominant species produce toxins or can lead to large accumulations of organic matter, which also create aesthetic and economic problems.

4. Discussion

4.1. Nature Management

4.1.1. Economics and Taxation

In view of the above data, it is clear that more than an environmental issue, what we are talking about here is a problem with the current economic model which is environmentally unsustainable. It is based on the constant increase of capital, which leads to the unlimited and growing demand for resources. Moreover, the amortization of the environment is replaced by a strategy of constant externalization of dysfunctions. This is the problem: The current model does not penalize, or penalize enough, socio-environmentally negative externalities. And if they are not penalized, sustainability becomes a pipe dream. Sustainability is precisely the economic reinternalization of negative externalities.

For decades, productive activity has consistently resorted to socio-environmental externalization. Air and water pollution, changes to the structure of the territory and landscape, or improper waste disposal have been some of the most visible manifestations of this externalizing approach. However, as outdoor space has gradually shrunk, we have had to choose between reducing externalities or finding new outdoor spaces in which to externalize dysfunctions in a more or less concealed manner. Hence the strategy of displacing polluting industries to the Third World (externalization in space) or entrusting radioactive waste to future generations (externalization in time).

In any case, what is not remedied via a principle of internalization is eventually paid for via social sanctions: Unrest, protests, and, in short, difficult governance. The heavy

socio-environmental costs of today's externalizing production model have been systematically circumvented, as if we could make them disappear just by ignoring them. The reality is that environmentalists, hastily discredited in the eyes of many due to real or supposed errors in their message or delivery, are essentially telling the truth, they are right because they are denouncing real dysfunctions, whose profoundly serious causes most people are still unaware of.

Perhaps the clearest example of this issue is climate change, which is basically the result of the systematic release (externalization in space) of gases resulting from the combustion of fossil hydrocarbons, with a subsequent increase in the greenhouse effect, which eventually leads to global warming and changes to the atmospheric (wind, rainfall, and temperatures) and oceanic (general circulation) regime. The result is severe weather abnormalities, melting of ice sheets and rising sea levels (in Catalonia it increased by 8.5 cm between 1990 and 2017: [49]). All of this results in a deterioration of biodiversity and serious upheaval of agronomic and urban planning strategies, in other words of economic ones.

The identification, valuation, and incorporation into the balance sheet of environmental assets and the re-internalization of costs inherent in the idea of the circular economy, including environmental services, could be a way of promoting the necessary paradigm shift. Therefore, the best approach would be to consider environmental assets of companies as part of their equity. If environmental values, including the landscape, were clearly identified and measured, this would result in new form of balance sheet that would completely change the current scenario [50].

Given that the current economic system evidently neglects public goods, with natural heritage being no exception, the authorities have so far acted very timidly, suggesting possible economic incentives for positive conservation activities and disincentives for negative ones, as a first step toward making the markets work more efficiently.

Currently, incentives specifically created for conservation purposes in Catalonia are very limited with little impact, such as a reduction of inheritance and donation tax for the acquisition of natural heritage assets located in protected natural areas, or the deduction of the part corresponding to the Autonomous Community from the full quota of personal income tax for monetary donations to environmental, natural heritage conservation and land stewardship organizations. There are a few other initiatives at the State or municipal level, but this does not change the overall perception that tax incentives for conservation as a whole are negligible.

It is worth mentioning an example of a municipal initiative, which despite not falling within the strict definition of environmental taxation, is of considerable interest: Several Catalan municipalities have decided to allocate a percentage of property tax (IBI, from the Catalan) to the development of municipal policies for natural heritage management. Despite the interesting nature of these initiatives, the underlying problem with municipal finances is that from a tax revenue point of view, the current regulations incentivize land use changes over natural heritage conservation and management policies. In other words, at the municipal level it is more attractive to urbanize land than to implement conservation and management policies [51].

It should be noted that tax instruments are predominantly designed to discourage bad practices (by applying the "polluter pays" principle) rather than to incentivize good practices. In Catalonia, the environmental tax instruments implemented so far have mainly focused on energy, water, air pollution, and waste, while in terms of natural heritage the few initiatives carried out have opted for tax benefits.

Although it is true that environmental taxes on water, waste, air, and energy have an indirect effect on the conservation of natural heritage and biodiversity, these instruments should focus more directly on conservation or new ones should be created. This would require the involvement of other government departments and not simply those responsible for environmental policies, something which has not really happened up to now. Some proposals have been put forward regarding taxes on land rezoning, on certain actions

taken on non-developable land, on extractive activities, etc. These proposals should also include new tax instruments that incentivize good conservation practices.

Genuine environmental tax reforms are needed, with the creation of new taxes but also reforming and increasing other existing taxes. This new fiscal approach is hampered by the reality that Spain lags behind most of Europe when it comes to implementing environmental taxation (specifically, 1.83% of GDP compared to the European average of 2.40%, 2017) and Catalonia, except in terms of water and waste, and more recently emissions from commercial aviation, has not been pioneering or especially active in this matter until recently.

Aside from tax incentives, and in view of the lack of public funds made available for the conservation of natural heritage, it is clear that new resources are required and that the additional revenue needed could be obtained with the implementation of a long-awaited new instrument, the Natural Heritage Fund of Catalonia, which, in accordance with the Climate Change Act of 2017,¹⁹ would be allocated 50% of the proceeds from the carbon dioxide emission tax on mechanically propelled vehicles.

4.1.2. Environmental Policy

From the point of view of natural heritage and biodiversity management in Catalonia, it is clear that the institutional and financial resources required to implement an effective natural heritage and biodiversity management policy have not been made available. This situation is even more surprising considering that in Catalonia there is a tradition of movements and associations (hiking and conservationist organizations, Scouts) which have always been strongly identified with the natural environment.

Over the last few decades, government authorities have suffered from the following dysfunctions, shortcomings and inertia:

- Lack of cross-cutting perspective in relation to the natural heritage and biodiversity protection policies, which have been viewed merely as sectoral policies, complementary and often subject to urban planning or agricultural policies.
- Lack of clarification and delimitation of the competency framework across different authorities and between planning and management functions.
- Interdepartmental disputes and conflicts with the interests, conceptions and views of the problems to be managed.
- Lack of accumulation of expertise due to the dispersion of competencies and instability in administrative bodies, which results in duplicate and contradictory policies.
- Excessive bureaucratization, lack of transparency and lack of subsidiarity in management.
- Practically no processes for evaluating the implemented policies.
- Historical shortage of human and economic resources.

In terms of results, the achievements of these 30 years of governance are very modest. The recently approved Natural Heritage and Biodiversity Strategy of Catalonia²⁰ [52] indicates that some natural heritage milestones have been achieved, though the calculation for Catalonia by the Living Planet Index highlights an alarming downward trend, with a 22% decrease in the population of 258 vertebrate and invertebrate species for the period 2002–2016.

Currently, both at the parliamentary level and in terms of the actions of the Government of Catalonia, the most important contributions to improving nature management policies are as follows: The restoration of powers to the Department of Territory and Sustainability (Directorate-General for Environmental Policies and the Natural Environment); an increase of the budget allocations for parks in recent budgets; the creation of the Natural Heritage Fund; the implementation of the Natural Heritage and Biodiversity Strategy of

¹⁹ <<https://portaljuridic.gencat.cat/eli/es-ct/1/2017/08/01/16>>

²⁰ http://mediambient.gencat.cat/web/.content/home/ambits_dactuacio/patrimoni_natural/estrategia_patrimoni_biodiversitat/Estrategia_patnat_biodiversitat_EN.pdf

Catalonia; the modification of the Catalan Civil Code giving more legal support to land stewardship; the announcement of the creation of the Natural Heritage Agency.

But although these changes may help overcome some of today's chronic shortcomings, new challenges are appearing on the horizon which need to be firmly dealt with:

- The conflict of interests and views between conservation and the interests of large property owners in the forestry sector.
- The precarious situation of the livestock sector (difficulty in accessing land, lack of generational renewal, aversion to change towards more sustainable forms of management).
- Changes in the social and cultural uses of natural spaces (hyper-frequentation and practices that damage the natural environment. This is even more a challenge when comparing the efforts made to promote the spaces where these activities are carried out with efforts devoted to their effective protection).
- The political, judicial and social permissiveness towards infringements in the natural environment, resulting in a very high percentage of complaints being filed away.
- The new recognition of environmental services offered by natural areas and the need for new taxes for funding.
- The socialization of a "new culture of territory".

4.1.3. Legislation and Protection of Nature and Biodiversity

Legislation with an Environmental Impact

Despite the powers of the Government of Catalonia in nature conservation matters and the measures that have been adopted in recent decades, the competency framework has been shown to be inadequate and poorly adapted to current conservation requirements. Catalan legislation is currently fragmented and outdated, despite its fairly advanced beginnings (Protected Natural Areas Act,²¹ Protection of Animals Act,²² Plan for Areas of Natural Interest,²³ etc.). All of these shortcomings indicate that conservation policies are too weak, that there is over-reliance on State legislation, and they demonstrate the urgent need for comprehensive legislation on conservation of the natural environment, biodiversity, and geodiversity. Despite this, the root cause has more to do with the insufficient political will of the institutions of self-government than to the aforementioned limitations of competencies.

For almost 40 years, the Government of Catalonia has not been capable of adopting general strategies in line with its biodiversity policies. It was not until 2018 that the Government of Catalonia approved the Natural Heritage and Biodiversity Strategy of Catalonia.

Apart from measures to protect natural areas and species typical of any environmental policy, specific measures have also been adopted through sectoral legislation. Agricultural authorities have traditionally been resistant to such measures, so there are no regulatory measures in Catalan agricultural legislation that apply directly to the protection of natural areas or wild species, despite the fact that the value of agricultural spaces in preserving biodiversity has been repeatedly emphasized. Forestry regulations are not much more advanced in terms of protected areas and protected or endangered species. One area which is lacking is the existence of a differentiated forest policy for the system of protected natural areas.

Hunting legislation is outdated and poorly adapted to reality, though some protective forms, such as national hunting reserves and hunting refuges, have had a generally positive effect. Meanwhile, new legislation has not yet been approved for inland fishing,²⁴ which is more modern and advanced in guaranteeing the sustainability of fishing and the protection

²¹ <<https://portaljuridic.gencat.cat/eli/es-ct/1/1985/06/13/12>>

²² <<https://portaljuridic.gencat.cat/eli/es-ct/dlg/2008/04/15/2>>

²³ <http://mediambient.gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/senp_catalunya/el_sistema/el_pla_despais_dinteres_natural_de_catalunya/documentacio_del_pein/>

²⁴ <<https://portaljuridic.gencat.cat/eli/es-ct/1/2009/12/23/22>>

of biodiversity, and the previous regulatory framework is mostly still in force. In relation to maritime fishing, current regulations provide a better framework for its sustainability.

Catalonia's water legislation is possibly the most advanced, in large part in order to comply with the provisions of the Water Framework Directive, and the corresponding management plans propose specific measures for the conservation, protection, improvement and restoration of the aquatic environment and ecosystems, a good example being the declaration of a significant number of natural river reserves. Worth mentioning is the Climate Change Act, which contains numerous references to biodiversity protection, not only in terms of mitigation and, especially, adaptation to climate change, but also certain mandates that go further and fill in legislative gaps in relation to nature conservation. Also of note is the possibility of allocating the climate fund provided for by this legislation to the conservation of biodiversity.

Over the years, environmental legislation has established various administrative mechanisms of a preventive nature that apply prior to the authorization or approval of certain plans, programs or projects of works or activities. Therefore, as a consequence of mandatory compliance with European legislation, since 1988 an environmental impact assessment must be included in any plans in Catalonia and a strategic environmental assessment since 2006. Since then, thousands of plans, programs and projects have been assessed, with positive results overall in terms of environmental integration, but also with many limitations and cases of unsuccessful application. Environmental assessment is still often perceived as an obstacle to be avoided as much as possible and it runs the risk of being restricted to a mere bureaucratic procedure, limited to enforcing minor corrections to the technical documentation submitted by developers. A pending issue, especially in strategic environmental assessment, is environmental monitoring of the assessed tools, which is very limited due to the lack of resources of environmental bodies. The problems and shortcomings mentioned above, which are quite common to other countries, have limited its effects so it has failed to fully achieve its strategic goals.

From the point of view of land use and urban development, the degree of planning in Catalonia is exhaustive, though the main objective and driver has been the development of urban areas and infrastructures. This has led to an excessive consumption of land, mainly at the expense of agricultural land and with very negative effects on the environment as a whole. The bursting of the real estate bubble was the logical consequence of a form of urban development in which construction plans, rather than land-use planning tools, had been used to generate expectations and capital gains at the service of a speculative market. All the competent authorities, with some honorable exceptions, played the game, often under the pretext that they were obtaining transfers of public land in return which were, however, not always necessary or suitable. More recent urban development regulations emphasize sustainable urban development following land-use models that promote urban compaction, prevent the spread of residential complexes and buildings, and preserve the ecological functions of the land.

In the face of urban development, the Plan for Areas of Natural Interest helped protect virtually every large area of natural interest from urban development, but the lack of an equivalent plan for agricultural areas, long-awaited but still non-existent, meant that these areas were indiscriminately affected. The two urban planning master plans for coastal areas, which protected most of the areas still classified as non-developable land, also had positive, though somewhat limited, effects. Moreover, urban planning at the municipal level has generally applied the urban classification of non-developable land to most municipal land, but this measure has not been accompanied by regulatory frameworks which provide adequate or effective protection. It is too easy to modify and rarely is it accompanied with any active management of the land in question.

Planning at the territorial level has been more consistent and all of today's generation of partial territorial plans follow common conceptual and formal basic criteria, including the promotion of diversity in the territory and the maintenance of a connection to its biophysical matrix, protecting natural, agricultural and non-developable areas, preserving the

landscape as a social and economic asset of the territory, and regulating land consumption. However, the rules established by the partial territorial plans for the protection of open area systems are insufficient and do not provide for actions that can remedy previous urban development errors. Nevertheless, the open spaces defined in the territorial plans could be the basis for defining Catalonia's green infrastructure, understood as a strategically planned network of natural and semi-natural areas, designed and managed to offer a wide range of ecosystem services.

It is also worth mentioning the Landscape Protection, Management and Planning Act,²⁵ which transposes into the Catalan legal system the concepts and commitments contained in the European Landscape Convention. One of its main tools are the landscape catalogues, which define the major units of the landscape of Catalonia, provide a diagnosis of these and propose landscape quality objectives that must be achieved. Transposing these into law is the purpose of the landscape guidelines that should be incorporated into the territorial plan regulations. Although the purpose of the landscape policy is not to protect nature, it could contribute to this goal.

Protected Natural Areas

The protection of natural areas in Catalonia presents formidable challenges, due to the combination of a very rich and diverse natural heritage, covering a small area with a high degree of intrinsic vulnerability, and of very intense and widespread pressures and impacts as a result of a high population density, a very high number of tourists and the disproportionate amount of intensive livestock farming, the sum of which puts pressure on the natural environment equivalent to a permanent population of some 23 million people, living in less than 30% of the territory of Catalonia, since the mountainous terrain means flat areas are few and far between.

The history of the protected natural areas of Catalonia since the reestablishment of democracy in Spain can be divided into four phases: The first, from 1978 to 1985, when Catalonia's Protected Natural Areas Act was approved; the second, from 1985 to 1992, when the Plan for Areas of Natural Interest (PEIN in Catalan) was approved; the third, from 1992 to 2006, when the Natura 2000 network was approved, and the last phase, from 2006 to the present day, marked by a succession of crises.

The results of the first and only evaluation carried out between 2002 and 2004 of the system of protected natural areas²⁶ [19], for which some aspects were updated later, reveal that the model of protected natural areas in Catalonia is an extensive and very complex system that covers a very rich and diverse natural heritage, subject to intense pressures and impacts, which has never had the adequate resources to fulfil its needs. It is a model predominantly managed by public authorities, despite the fact that most of the areas are private or communal property, which is governed by an outdated legal framework, with over-bureaucratized structures and procedures and with little public participation, especially of local populations. A model in which nature conservation is not usually the priority, which is why the protection it offers is less effective than it should be, but which nevertheless has enabled the deployment of a wide range of activities and services which have produced some very positive socioeconomic effects. A model that has suffered from a chronic lack of administrative coordination, with numerous internal dysfunctions and poor application of the disciplinary system. A model for which some key aspects are unknown, due to a lack of monitoring, for which not enough applied research has been carried out to meet the objectives it sets out and the results of which have barely been assessed.

The system of protected natural areas in Catalonia is very extensive. At the end of 2018, the system covered 32% of the country, a total of 1,110,228 ha, of which 1,024,591 were on land and 85,637 were in the sea [53]. The natural areas protected by international bodies cover 465,917 Ha (Table 16). In Spain, this proportion is surpassed by several autonomous

²⁵ <<https://portaljuridic.gencat.cat/eli/es-ct/1/2005/06/08/8>>

²⁶ http://ichn.iec.cat/Avaluacio_Espais.htm

communities, with the Canary Islands at the top of the ranking, where the system of protected natural areas covers 47% of the territory and in which areas with a high level of protection are more numerous, extensive and significant.

Table 16. Natural areas protected by international bodies. Source: Ministry of Agriculture and Fisheries, Food and the Environment of Spain (2017).

| Size of Natural Areas Protected by International Bodies | | |
|---|-----------|-----------------------|
| Place | Area (ha) | Year of Incorporation |
| Ramsar Convention on Wetlands | | |
| Aigüestortes National Park | 39,979 | 2007 |
| Ebro Delta | 7736 | 1993 |
| Lake of Banyoles | 1033 | 2002 |
| Wetlands of the Alt Empordà | 4784 | 1993 |
| Biosphere Reserves (UNESCO) | | |
| Montseny massif | 30,120 | 1978 |
| Terres de l'Ebre area | 367,729 | 2013 |
| Specially Protected Areas of Mediterranean Importance (SPAMI) | | |
| Cap de Creus Natural Park | 13,932 | 1995 |
| Medes Islands | 604 | 1995 |
| Total | 465,917 | |

The system of protected natural areas in Catalonia as a whole is very unevenly balanced in terms of levels of protection, with most of the areas covered by lower levels of protection (IUCN category V) and very few areas under high levels of protection (IUCN categories I-IV). This has become more accentuated in recent years, as shown in Table 17.

Table 17. Equivalence between the forms of protected natural areas in Catalonia and the categories of IUCN protected areas. Source: Catalan Institution of Natural History (2018).

| IUCN Equivalence | Forms of Protection in Catalonia | Protected Area | |
|------------------|---|----------------|------|
| | | 2005 | 2018 |
| I | Strict nature reserve | 0.3 | 0.2 |
| II | National park | 2.1 | 1.4 |
| III | Natural place of interest | 1.7 | 1.1 |
| IV | Partial nature reserve | 2.3 | 1.6 |
| | Wildlife nature reserve | | |
| V | Natural park, peripheral protected areas, natural areas of interest, areas in the Natura 2000 network | 93.6 | 95.7 |

Most protected natural areas, especially those belonging to the Government of Catalonia, suffer from a serious lack of planning and management tools, even in natural parks or natural places of national interest (PNIN, in Catalan) created over 20 years ago, as shown in Table 18. It is estimated that only 18% of the areas included in the Plan for Areas of Natural Interest (PEIN, in Catalan) have any form of planning tool.

The resources allocated to managing protected natural areas in Catalonia have been clearly insufficient, although there are major differences between the authorities that manage them. The protected natural areas that depend on the Government of Catalonia have suffered the most in this regard with cuts to their resources and budgets, in some cases by up to 60%, since 2008. Most of these cuts have not yet been recovered completely. The protected natural areas with the best allocation of resources have always been those controlled by the Provincial Council of Barcelona. The only evaluation ever carried out on the system of protected areas, using data from 2003–2004, revealed that more than 70% of the economic resources were allocated to less than a third of the area covered by protected

areas that are actively managed, which represent only 12% of the entire protected area of Catalonia.

Table 18. Availability of planning and management tools in the system of protected natural areas in Catalonia. Source: Natural Environment Planning Service (situation as of the end of 2017).

| Area | Number of Areas | Area (ha) | | % of the Total Land Area | With a Planning Tool ** | | With a Management Tool *** | |
|---|----------------------------|-----------|--------|--------------------------|-------------------------|-----------|----------------------------|--------------|
| | | Land | Marine | | Number of Areas | % of Area | Number of Areas | % of Area |
| PEIN | 184 | 1,019,922 | 85,629 | 31.77 | 39 | 18.0 | — | — |
| ENPE * (especially protected natural area) | 19 | 313,591 | 5529 | 9.77 | 8 | 23.4 | 6 | 20.7 |
| National park | 1 | 13,900 | — | 0.43 | 0 | 0 | 1 | 100.0 |
| Natural park | 14 | 256,352 | 5529 | 7.98 | 7 | 35.4 | 3 | 19.9 |
| PNIN | 7 | 12,032 | — | 0.37 | 4 | 41.19 | 0 | 0.0 |
| RNI (strict nature reserve) | 6 | 1830 | 20 | 0.06 | 5 | 99.8 | 0 | 0.0 |
| RNP (partial nature reserve) | 58 | 12,879 | 933 | 0.40 | 34 | 41.2 | 0 | 0.0 |
| Natura 2000 | 117 (115 SAC 73 SPA) | 979,904 | 85,614 | 30.52 | — | — | 115 (SAC) 9 (SPA) | 100.0 5.9 |

* Includes wildlife reserves and peripheral protection areas. All ENPEs are included in the PEIN and the Natura 2000 network. ** Corresponds to the PEIN and ENPE areas with plans for the protection of the environment and the landscape. *** In the case of ENPEs managed by the Government of Catalonia, it refers to approved use and management plans; in the case of ENPEs managed by the Provincial Council of Barcelona, it refers to plans for public use.

Most protected natural areas do not have monitoring programs in place and the few that do are those that are actively managed. The results are not periodically evaluated; the only evaluation of the effectiveness of the system as a whole, carried out between 2002 and 2004, revealed that the conservation of the natural areas with the highest protection level was not very effective. Fortunately, the application of European directives on habitats and birds now means that there is an obligation to evaluate the conservation status of habitats and species every six years. During the last evaluation (2013–2018)²⁷, the data obtained was quite categorical: In reference to the Habitats Directive, it was found that 75% of species and 58% of habitats of European interest were in a poor state of conservation (Figure 7). However, this situation is not unique to Catalonia. Other EU countries are in a similar situation. The only data available on the trend of the last 12 years is at the State level and shows that between the 2007–2012 evaluation and the 2013–2018 evaluation in Spain, the conservation status of both habitats and species declined by more than 10%.

²⁷ <http://mediambient.gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/senp_catalunya/el_sistema/xarxa_natura_2000/informes-aplicacio-2013-18-habitats-ocells/ponencies-jornada-directiva-habitats-ocells/>

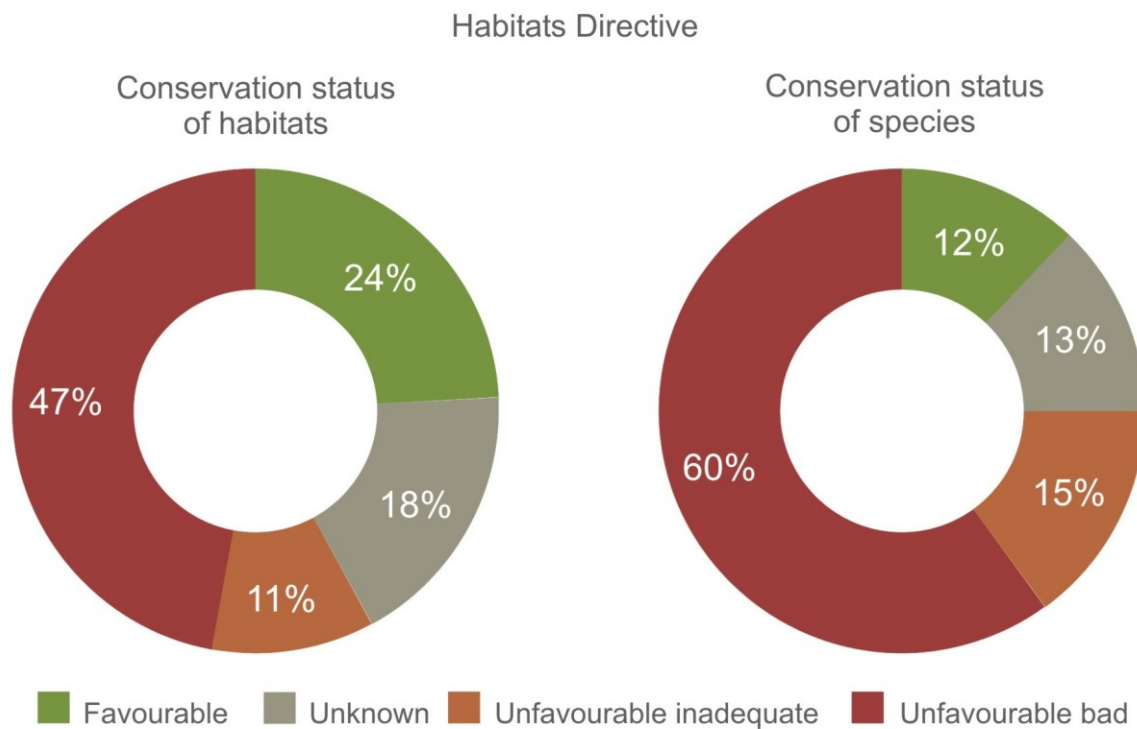


Figure 7. Conservation status of habitats and species under the Habitats Directive (2013–2018). Source: Sub-Directorate General for Biodiversity and the Natural Environment, Department of Territory and Sustainability, 2019.

Flora

The first edition of the White book *Llibre blanc de la gestió de la natura als Països Catalans* (White Book on Nature Management in the Catalan Countries) in 1976 expressed concern about the loss of plant biodiversity intuitively, since at the time there were no completed floristic catalogues and no IUCN evaluation methodologies had been developed. The first national Red Book was not published until the late 1980s [54]. Subsequent contributions since the 1990s, with the publication of red lists and books, conservation biology studies, and the practice of preserving protected natural areas and protecting species have led to further knowledge and diagnosis of the flora. Despite all this, in recent decades there have been extinctions, population decline and habitat destruction. There has also been a clear and troubling loss, since the end of the last decade of the 20th century and the start of the current century, of certain aspects of knowledge on biodiversity, which may be related to the lack of importance given to studies on biodiversity, the reduction of funding for this type of research and the reduction of subjects related to the study and cataloguing of biodiversity in university curricula. This has led to the disappearance of research lines and groups that were pioneers at the end of the last century, at least at the State level.

In 2010 the red book *Llibre vermell de les plantes vasculares amenaçades i endèmiques de Catalunya* (Red Book of Endangered and Endemic Vascular Plants of Catalonia) [55] was published, a key work in determining the conservation status of vascular flora which followed the IUCN assessment criteria. This catalogue includes 199 species, 5.5% of the Catalan flora, divided in different categories: 46.7% are considered vulnerable, 26.1% endangered, 18.6 critically endangered, and 8.6% extinct. One of the groups of taxa where the percentage of endangered species is most significant is that of endemic plants. Of the 126 endemic or subendemic taxa in Catalonia, 21 are considered endangered, that is, 16.7% of the endemic flora according to data for 2010.

In terms of the distribution of endangered flora, more than half of the UTM squares in Catalonia (10×10 km) contain endangered taxa. However, the distribution of endangered flora is not homogeneous, with just over 5% of UTM squares containing a significant

number, especially those that comprise some of the most important wetlands and certain high mountain sectors.

Of the 199 endangered species, only 24 (12.06%) could be considered threatened by intrinsic factors, 75.4% are subject to threats caused by human activity (infrastructure, frequentation, urban development, and forestry work), 20.4% are threatened as a result of biotic causes, which in many cases are also of anthropic origin (overgrazing, rural abandonment, non-native flora, etc.), and only 4.2% are endangered as a result of potential natural hazards (avalanches, wildfires). In terms of climate change, numerous studies and models indicate that it could lead to the disappearance of populations of several species of endangered plants or a loss of their potential habitat.

If knowledge about the conservation status of vascular flora is still insufficient, though much more detailed than during the period of the White books published in the 1970s and 1980s, the same cannot be said for the groups of non-vascular plants, fungi, lichens, and other organisms traditionally studied by botanists, though bryophytes are perhaps, to some extent, the exception.

There are no documented trends about the variation of the degree of threat to flora as a whole nor about the evolution of its conservation status, although there is sporadic data on certain taxa or geographical areas where monitoring is carried out, mostly from the last ten years.

Flora conservation policies began with the Plan for Areas of Natural Interest (1992) but this provided only passive protection to flora with no obligation or effectiveness. The Catalogue of Endangered Flora of Catalonia²⁸ of 2008, revised in 2015, protects 245 species of vascular flora (6.8% of the total), 83 of them considered “critically endangered” and 162 “vulnerable” and also protects 40 bryophytes, 21 lichens and 20 fungi. In accordance with current regulations, a protection or conservation plan should be devised for each of these species, depending on their degree of endangerment, but none have been drafted despite the expiry of the deadlines for doing so. This does not mean that actions have not been carried out from time to time to protect the flora, improve habitats, monitor endangered species and control the non-native flora, especially in protected natural areas.

The Catalan Flora Conservation Strategy 2014–2020 [56] was commissioned by the Government of Catalonia in 2014, but none of its main proposals have been implemented, although some have been integrated into the Natural Heritage and Biodiversity Strategy of Catalonia [52]. The same could be said of ex situ conservation strategy [57].

Fauna

The protection of fauna is regulated at the State and autonomous community levels (Protection of Animals Act), but it provides a type of preventive protection that in many cases has been ineffective. For decades now, there have been calls for the approval of a catalogue of endangered species, which would be the basis for authorities to draw up the corresponding recovery and conservation plans. In Catalonia, five recovery plans have been approved, two for fish (Spanish toothcarp and Valencia toothcarp) and three for birds (bearded vulture, bittern and Audouin’s gull), and one conservation plan for the otter, but this has been carried out without the prior drawing up of a catalogue of endangered species.

A total of 29 species of native fish live in the inland bodies of water of Catalonia, of which 14 (about 50%) are severely threatened (extinct or critically endangered) according to the criteria of the IUCN. Recovery plans only exist for two of these species (Spanish toothcarp and Valencia toothcarp). The habitat area of endangered species has shrunk by more than 60% over the last few decades and their populations are therefore clearly declining. If 40 years ago 14 non-native or introduced species were detected in freshwater systems, today this number stands at 30 (more than double) and some of these are considered invasive [58].

²⁸ <<https://portaljuridic.gencat.cat/eli/es-ct/d/2008/08/26/172>>

The use made of water systems, habitat alteration, pollution, introduction of non-native species, fishing and aquaculture are still the main factors affecting inland fish. Recreational fishing is still the main reason behind introduced species, either because many of these are of interest for fishing itself or because they are used as live bait.

In Catalonia, there are 15 species of amphibian and 37 species of reptiles (including the four species of sea turtle). Of these, 17 are considered endangered. One introduced reptile species (the Florida tortoise), because of its invasive and expansive tendencies, has become a threat to conservation and certain other introduced species, of the more than 20 listed, may have the same effect if appropriate management measures are not taken.

The threats faced by the various species of amphibian and reptiles are very diverse, though essentially they involve the destruction, degradation, and fragmentation of habitat. Road traffic poses a serious threat, as does the emergence of new diseases caused by viruses and fungi.

The 2012 red list of Catalan breeding birds is the most recent study available on this subject and was drafted by a scientific association following the regional criteria promoted by the IUCN [59]. The analysis of the data [60] shows a decrease in the extinction risk of 4.3% of the species in the period from 2002 to 2012. If we calculate an index for the proportion of species that would survive in the near future without additional conservation actions, between zero (all species will be extinct) and 1 (all species are no longer in any threat category), a value of 0.84 is obtained, which indicates a moderate extinction risk.

The scientific community has warned that the most important threats for bird populations are climate change, biological invasions, and changes in land use. Despite advances in the protection of natural heritage, there are still several fronts regarding the sustainable conservation of birdlife. These include the increasing loss and fragmentation of habitat due to urban expansion, an increase in the road network and intensive agriculture, changes due to climate change and the lack of adequate hunting regulations.

Of the 84 species of land mammals in Catalonia, 31 could be classified as endangered and there are two species and one subspecies which are extinct. Of the species in existence today, two are non-native invaders. The brown bear and the wolf are two examples of species that have re-inhabited Catalonia after disappearing from the country. The brown bear has returned as a result of a reintroduction program while the wolf has arrived a result of the natural expansion of the population in Italy which first passed through the French Alps. Another positive example is the otter, which expanded in the 1990s and currently occupies almost all the major river basins of Catalonia. What once was an endangered species is no longer under threat.

4.1.4. Research

When the first edition of the White book was drafted in the 1970s, research on the subject was only just beginning. This does not mean that good work was not done, particularly in those aspects of knowledge more closely related to the territory, such as the description of the vegetation, fauna and geology of the country. From the late 1960s to the early 1980s, university departments and research institutes began to fill with a critical mass of young researchers. This group of young researchers promoted certain initiatives that had a significant impact on the academic community and also on those sectors directly involved with the natural environment in Catalonia, including the White book itself, the *Història Natural dels Països Catalans* (Natural history of the Catalan Countries) and *Biosfera* (Biosphere), seminal publications which inspired the next generation of scientists to expand into the international arena. More scholarships for doctoral studies, incentives to study abroad and facilitating attendance at international conferences meant that the research in the country as a whole began to take on a more international outlook.

The turn of the century marked a turning point and references to research carried out in Catalonia increased exponentially in international scientific literature. The emergence of European research programs with the increasing participation of Catalan groups led to a significant increase in available resources. Paradoxically, international projects promoted

increased collaboration between groups within the country from very diverse disciplines: The biology of organisms, ecology, microbiology, environmental chemistry, Earth science, meteorology, and others, which usually did not interact on national projects. In the last decade, disciplines with a systemic view such as ecology and environmental science have experienced a clear proportional growth, likely due to the increasing awareness of the global change that is taking place. Since the 2008 economic crisis, growth has stalled in some disciplines. If we take into account the lag time between scientific production and its dissemination through citation by other researchers, the consequences of the decline in research funding from the State over the last 10 years have not yet been completely felt. It should also be borne in mind that Catalonia does not have its own competitive tendering for funding research projects with public resources.

Various types of indicators can be used to demonstrate this change, but they all lead to a similar diagnosis. Figure 8 shows the number of citations in international journals of works by researchers based in Catalonia.

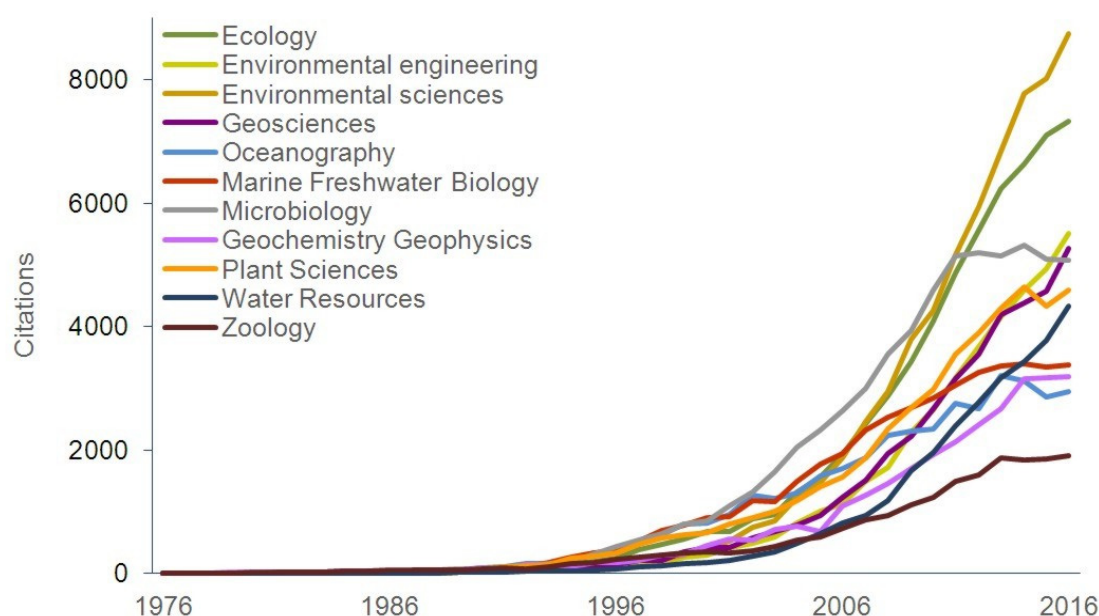


Figure 8. Citations of publications involving researchers based in Catalan institutes and centers. They are grouped by fields related to environmental research according to the Web of Science database. The English names have been used to avoid translation ambiguities. Source: Prepared by the authors.

The growth that took place in the late 1990s and at the beginning of the 21st century generated human capital and research infrastructures that, over the last decade, have mitigated, at least superficially, the effects of the cuts to funding resulting from the economic crisis and the political decisions taken in its wake (Figure 9) [61]. However, there are a number of shortfalls that will need to be addressed in the immediate future. First, that of human capital, with the average age of research staff increasing at an alarming rate, and with young aspiring scientists accepting that they might have to leave to pursue their careers in another country. Second, the research infrastructure is at risk of becoming obsolete, since for the most part, research groups are carrying out their work using the infrastructure that was developed in the past. Third, research centers suffer from the problems endemic to the institutions on which they depend, as is the case of the universities, the CSIC (Spanish National Research Council), and CERCA (Research Centers of Catalonia) in Catalonia. Despite this, the Catalan research system as a whole has maintained its pursuit of excellence, so if there was a clear political will to do so and if the necessary resources were allocated, a fast and efficient transformation of the system would be perfectly viable.

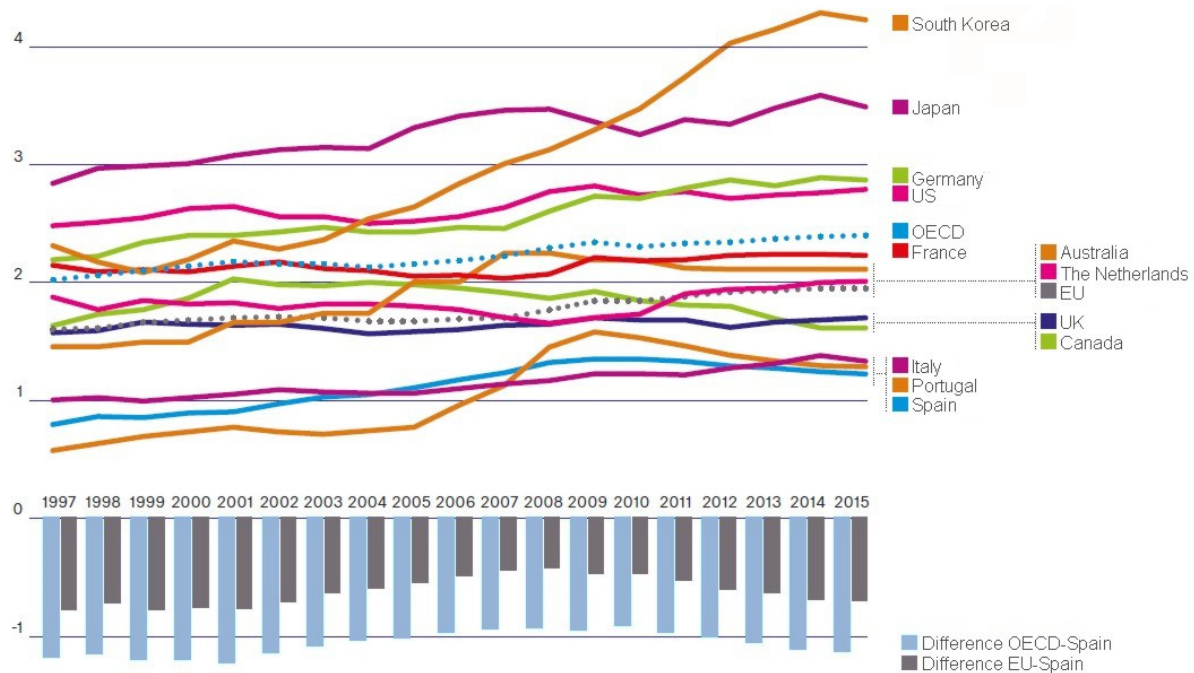


Figure 9. Evolution of Spain's R&D expenditure as a percentage of gross domestic product compared to other countries. Source: OECD; Sanz and Cruz, 2017.

4.1.5. Schools and Universities

Over the last few years, several factors, including climate change, high resource consumption and conflicts in different parts of the world, which have resulted in the displacement of millions of people, have made sustainability a fundamental challenge. A change is needed in the relationship between society and nature, which requires a change in our way of thinking and in our outlook and priorities as a society. Only education, directed at all ages and all social spheres, can drive this change. Today, environmental education and sustainability awareness have generated a commitment to the future of society and the planet.

The principles of sustainability at a basic level in pre-school, primary and secondary education were introduced in the 1970s in a completely voluntary and altruistic manner, when schools started promoting environmental education activities led by teachers motivated by the environmental information they had learned from environmentalist and naturalist groups, which in those years were very active.

In recognition of those schools which were very active in environmental issues and to further promote these activities, in 1998 the Department of the Environment of the Government of Catalonia, in collaboration with the Catalan Society of Environmental Education, created the Green Schools Programme, aimed at primary and secondary schools that demonstrated a willingness and commitment to promote environmental education among their pupils. In 2011, the Catalan Schools Towards Sustainability Network was created, which brings together all Catalan schools active in environmental issues. Here they can share training and experiences in sustainability education matters. In the 2019–2020 academic year, the Green Schools Programme network is made up of 747 schools.²⁹

European, Spanish and Catalan universities have been teaching about environmental issues for many years now and have put in place structures and programs that incorporate environmental sustainability at the university level. In the final decades of the last century, courses and qualifications were created specifically focused on the environment and on the changes caused to our planet by human activity. During the 1992–1993 academic year,

²⁹ <http://mediambient.gencat.cat/ca/05_ambits_dactuacio/educacio_i_sostenibilitat/educacio_per_a_la_sostenibilitat/escoles_verdes/>

the Autonomous University of Barcelona created a bachelor's degree in Environmental Sciences which was initially taught as the university's own degree, until it was granted official degree status and the initiative was extended to other Catalan and Spanish universities. Postgraduate, master's, and doctoral programs were also launched in this same field of knowledge.

Despite all this, significant changes are still needed in the education system. Environmental matters should be analyzed in a cross-disciplinary manner across all blocks of knowledge, but to this day the compulsory education curriculum is still based on the large blocks of traditional knowledge, despite the fact that teachers and schools operate with personal initiative and discretion. It is also the case that even those teachers who are most committed to sustainability require training in innovative teaching techniques, and they are generally provided with little academic support to incorporate aspects of sustainability into their teaching activities.

In the field of environmental research, the Government of Catalonia has set up several centers including the CREAM (Centre for Research on Ecology and Forestry Applications), the CTFC (Forest Sciences and Technology Centre of Catalonia) and the ICTA (Institute of Environmental Science and Technology). These centers have made rapid progress towards scientific excellence, with CREAM now a Severo Ochoa Centre of Excellence and the ICTA a María de Maeztu Unit of Excellence, recognitions that are only granted to centers that have a proven scientific impact and leadership at an international level and that actively collaborate with their social and business environment.

On another note, universities have implemented campus greening plans. The objective is to adopt policies that promote sustainability in management, teaching and research, which can be incorporated into the dynamics of the universities and the statutes of each institution.

In 2010 an international ranking, known as GreenMetric,³⁰ was launched to assess the degree of commitment of each university to sustainability. This allows universities to share their experience and best practices in sustainability matters and to measure their level of sustainability. The 2019 edition was attended by 780 universities from 83 countries around the world. Of the five Catalan universities that participated (Table 19), two are in the first quartile: The Autonomous University of Barcelona and the University of Girona.

Table 19. Catalan universities included in the GreenMetric ranking. Source: GreenMetric.

| Universities, 2019 Edition | Position in the Ranking (about 780) |
|------------------------------------|--|
| Autonomous University of Barcelona | 16 |
| University of Girona | 94 |
| Rovira i Virgili University | 170 |
| University of Barcelona | 171 |
| University of Vic-UCC | 218 |

4.1.6. Environmental Education

Aside from these matters related to environmental education at school and university level, it should be remembered that both the first edition (1976) and the second (1988) of the White book already referred to environmental education at a time when Catalonia was experiencing a period of extreme social vitality. The first nature trail in the forest of Santiga (1975) and the nature school at Can Leonart (1978), in the Montseny massif, were inaugurated at the same time as the International Environmental Workshop in Belgrade (1975) and the Intergovernmental Conference on Environmental Education in Tbilisi (1977), initiatives promoted by UNESCO and considered milestones in the international environmental education movement.

³⁰ <<http://greenmetric.ui.ac.id/>>

The emergence of environmental education in Catalonia in the 1970s was followed by its formalization with the creation of environmental education entities during the 1980s, such as the Catalan Society of Environmental Education (1985). Subsequently, in the 1990s, this activity spread throughout the country received official recognition, as evidenced by the inclusion of the Directorate-General of Environmental Education into the new Department of the Environment of the Government of Catalonia, created in 1991, the involvement of local authorities in creating programs and resources for the knowledge of cities and the immediate environment, and the growing educational activity of protected natural areas. The number of entities and centers dedicated to environmental education in Catalonia rose from 20 in 1983 to about 200 in 2003.

It was at that point that environmental education was consolidated, as demonstrated by the work of the Catalan Society of Environmental Education and by the fact that its work was used as part of the basis for the Catalan Environmental Education Strategy, which was published in April 2003 [62]. It was at this time that the Green Schools program was launched, which, despite its ups and downs, is still in operation today. The turn of the century was also a time when private conservation initiatives and those carried out by nature conservation and research associations began to bear fruit.

The impact of the economic crisis of 2008 was keenly felt by environmental education which until recently had to endure a period of resistance and even of being rolled back. Today there is more awareness in society than ever before about the need for environmental education, but it is still not given the priority it requires. The Government of Catalonia's commitment to environmental education in the 1990s was not consolidated to the extent it should have been. Some government projects have been rendered almost ineffective, such as the Catalan Environmental Education Strategy itself, which has not been monitored. Others have managed to continue in operation but have been weakened by the scarce resources that have been devoted to them, such as the Green Schools project. Fortunately, this fundamental program at school level has not failed completely and has received a boost since its inclusion in the Catalan Schools Towards Sustainability Network created in 2009. Several city and town councils have continued to carry out their environmental education programs, and the Barcelona Provincial Council has maintained its activity, mainly in the network of parks that it manages. Although institutional support for individual environmental education initiatives has become scarce, some have remained true to their purpose and with admirable perseverance. An area which has taken off in recent years through a network of public participation is that of citizen science.

In recent years, a great deal of work has been done on environmental education, but not enough on its objectives. Awareness and interest in environmental issues has certainly increased among the general public, but very little of this translates into real changes in people's unsustainable lifestyles. This trend is not unique to Catalonia. In *The Failure of Environmental Education* [63], the authors criticize the failed efforts of environmental education to reach its full potential in the fight against climate change, biodiversity loss and environmental degradation, and they believe that environmental education is not keeping pace with environmental degradation. Jaume Terradas has also often referred to the failure of environmental education because, despite being an extraordinary success in terms of the abundance of initiatives, "when we look at the results of all this considerable activity regarding the stated objectives, not much has been achieved" [64]. In view of this fact, Pablo Meira [65] believes that "to a certain extent, it is not just that environmental education is in crisis, which it is, but that environmental education itself is symptomatic of an existing socio-environmental crisis".

4.1.7. Companies

In the first White book (1976), Ramon Margalef already lamented the lack of sensitivity and willingness of companies in relation to nature. Most companies today are at the polar opposite of conservation, which is not their core business, and those that do care are simply paying lip service through their social responsibility plans or as a public relations exercise.

The business world needs to learn through taxation, incentivization or penalization, that the conservation of nature is also part of its future, that the loss of biodiversity adversely affects the health of Catalonia and, therefore, its long-term production capacity. In many cases, and very much in the opposite vein, the pressure applied by business lobby groups for the construction, for example, of new infrastructures, is done without the slightest regard for the environmental repercussions.

The impact of the media and social pressure, along with the desire of certain companies to maintain a positive reputation, has led some of these to adopt business strategies which take into account nature conservation to an extent that goes beyond the legal requirements. As a result, these companies have established foundations and associations or they give donations all aimed at preserving the environment.

An example is the Club-EMAS business association, created in 2006 and whose objective is environmental improvement through participation in the EMAS, a European eco-management and audit scheme. There are 58 member companies of this voluntary environmental improvement in Catalonia but only 5 are accredited, a negligible proportion of the more than 600,000 companies established in Catalonia. Even if we take into account only those with more than 10 employees that still represents about 50,000 companies. Another voluntary standard regarding responsible environmental management is the ISO:14001 certificate, which is also based on EMAS, and which around 140 companies in Catalonia are certified in. If we look at the actions that these companies take in terms of measures to preserve the environment and biodiversity, their impact is even more negligible, if not non-existent, since most focus on minimizing waste, water pollution or improving air quality.

One of the most important business initiatives regarding nature conservation was the creation of the Territory and Landscape Foundation by Caixa Catalunya in 1997 aimed at acquiring natural areas to devote them to the conservation of nature and its biodiversity. The economic crisis of 2009 affected the bank behind this initiative, but the activity of this foundation has continued under the auspices of the more generic Catalunya-La Pedrera Foundation.

Some of the positive, though minor, initiatives being undertaken by different companies include: The European Charter for Sustainable Tourism, which engages tourism companies in the conservation of protected natural areas; the circular economy, which since 2015 is being promoted as a European strategy and which the Government of Catalonia has incorporated in the national industry pact; the GRI (Global Reporting Initiative) sustainability reports that some large companies are beginning to include in their annual financial statements; projects such as Tandem.cat, which promote collaboration between companies and non-profit organizations to develop innovative environmental projects with social value; patronage, which seems to be more widespread, though there is no concrete data that corroborates this; adherence to the UN Sustainable Development Goals, etc.

4.1.8. Non-Governmental Organizations and Associations

1976 was a turning point in the history of nature conservation in Catalonia, due to two closely connected events: On the one hand, the publication of the first edition of the White book *Natura, ús o abús. Llibre blanc de la gestió de la natura als Països Catalans* (Nature, Use or Abuse. White book on Nature Management in the Catalan Countries), which laid down the fundamental ideological and scientific foundations for nature conservation in Catalonia, and on the other, the creation of the League for the Defence of Natural Heritage (DEPANA), which was the first Catalan association created to carry out the task of protecting nature, something that was very necessary in the country. Looking back, it was a very creative period, with visionary and generous people, capable of posing new challenges for a society that was just emerging from many years of dictatorship.

After 1976, a large number of environmentalist or conservationist entities were created, which have been instrumental in curbing many of the impacts associated with the Catalan development model. It is best not to think about what might have become of many of the

emblematic places and corners of the country, full of biodiversity and geodiversity, had it not been for all these associations. But these have not simply resorted to campaigning against things. They have also worked towards promoting environmental education and awareness, engaging people in environmental volunteering and launched demonstration and innovation initiatives to showcase new ways of addressing nature conservation.

It is also true that after these 40 years, Catalonia does not have any organizations of the size and solidity found in other European countries or a very environmentally aware society. There are obviously socio-cultural and socio-economic reasons for this but there are also aspects intrinsic to these organizations that have prevented them from growing and being effectively consolidated or coordinated: Weakness in governance and accountability systems; territorialism that hinders progress towards integrating structures; a tendency towards professionalization that in some cases has led these organizations to put aside volunteering and to become service companies; difficulties in working with other sectors, etc.

The first relevant data on the existence of conservation organizations in Catalonia are the environmental yearbooks published by the UNESCO Centre of Catalonia between 1998 and 2004. This publication did not merely list the organizations, but also included explanations on the main activities that they carried out. In the first edition of 1998, about a hundred organizations were recorded, growing to two hundred in 2004, a year in which the yearbook provided evidence of a network that was full of vitality and with huge potential to influence environmental policies.

A later piece of research, the 2015 Barometer of the Environmental Third Sector³¹, which was based on quantitative data collected and processed to give a global and updated view of the sector (Figure 10), provided a huge amount of information including the number of members, volunteers and staff of these organizations and their economic volume. More recently, the 2018 Environmental Barometer³² has recalculated some of this data, making it possible to see the evolution of the sector (Table 20).

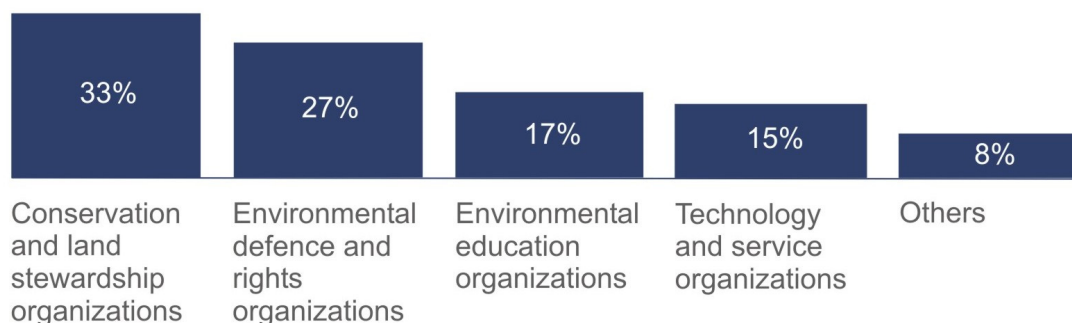


Figure 10. Priority area of action of Catalan environmental third sector organizations. Source: 2015 Barometer of the Environmental Third Sector.

Table 20. Overall figures and estimates for the environmental third sector in Catalonia. Source: 2015 Barometer of the Environmental Third Sector and 2018 Environmental Barometer.

| | 2013 | 2014 | 2017 |
|--------------------|-------------|-------------|-------------|
| Organizations | 220 | | – |
| Volunteers | 5522 | 5769 | 6513 |
| Members | 24,855 | 26,680 | 26,753 |
| Remunerated staff | 356 | 306 | 431 |
| Volunteering hours | 79,976 | | – |
| Economic volume * | €19,275,884 | €18,506,046 | €23,538,961 |

* 0.0093% of Catalan GDP in 2013 and 0.01% in 2017.

³¹ <<https://www.observatoritercersector.org/LinkClick.aspx?fileticket=uUN9CpK53qA%3d&tabid=1015&portalid=13&mid=4149&language=ca-ES>>.

³² <<http://www.xct.cat/mm/file/2019/BarometreAmbiental2018.pdf>>.

4.2. Priority Actions

In accordance with the diagnosis described in the previous sections, we propose a series of measures and actions that could contribute to improving the conservation and management of the environment and biodiversity and help progress towards greater sustainability.

4.2.1. Use of Natural Resources

Extractive Activities

Geological resources must be used in a more sustainable manner and not solely based on economic parameters, so the following measures should be given priority:

- Develop a master plan for extractive activities based on the capacity of the territory and a forecast of supply needs, capable of balancing social and economic needs with the preservation of the natural environment and the provision of ecosystem services.
- Update the regulations on the restoration of extractive and mining activities to make them more effective and to include the experience gained up to now.

Soils

Soil conservation and management should not be neglected and should be prioritized in the following areas:

- Finish the soil mapping started by the Cartographic and Geological Institute of Catalonia.
- Take into account soil quality in territorial and urban planning and ensure the growth of urbanized land and infrastructures does not affect the best soils.
- Make meaningful progress in the effective restoration of soils contaminated by industrial, mining or waste treatment activities.
- Rethink current agricultural practices regarding soil conservation, since in many cases they have not helped preserve organic matter in the soil nor have they prevented erosion or salinization and have even been the cause of its contamination.
- Apply protocols and action measures across the board to reduce irreversible soil loss and promote ecosystem recovery after forest fires.
- Complement environmental regulations, both in Catalonia and in Europe, with specific legislation on soils in line with what has already been done with regard to water, air quality, and biodiversity.

Agriculture and Animal Husbandry

- Determined efforts are required to stem the loss of cropland. Until specific and effective regulations on agricultural land are available, the following measures must be taken:
- Ensure that urban growth, industrial and service spaces and infrastructure are not at the expense of the best agricultural land.
- Safeguard agrosilvopastoral activity in the least populated regions to help maintain a territorial, environmental and social balance.
- Promote access to land for new farmers and enable the territorial growth of certain farms with insufficient land.
- Resolve the current contradiction between the existence of agricultural parks and the lack of a legal form that establishes their necessary planning, management and development tools.

A response is required to the growing importance of food supply with food plans based on criteria of self-supply, self-sufficiency, and sustainability, giving priority to productive systems that respect the health of people and the environment (organic farming, biodynamic agriculture, agroecology, traditional varieties and breeds, etc.) and redesign models that, like the pig farming model, generate a whole series of problems that in Catalonia have not been resolved and that continue to affect the health of people and the environment.

The agricultural and territorial policies promoted by the European Union and the Government of Catalonia itself must be reformulated to prevent on the one hand the loss of the traditional agriculture with roots in the territory and on the other hand the promotion of large companies and corporations seizing land and controlling production. The CAP should be redesigned to encourage productive activities that focus on food production and promote rural development and environmental protection.

The process of safeguarding breeds of livestock and agricultural varieties requires more support. To overcome the current limitations in the conservation of plant genetic resources, a comprehensive conservation plan is recommended that focuses on the following tasks:

- Organize collection campaigns and carry out an inventory of all existing material in germplasm banks and verify their viability.
- Establish measures to ensure the long-term conservation of materials, both *ex situ* and *in situ*.
- Phenotypically and genotypically classify the collected material and promote its use in productive agriculture and research.

Forest Management

A priority in forest management is the establishment of a model for the sustainable use of forests that guarantees their multifunctionality and which does not focus solely on forests with productive value. The conservation of natural heritage is a key aspect of forest management, which is why efforts should be focused on: Enhancing the emblematic species of forest environments; preserving certain forest spaces, especially mature forests, to keep them free from anthropic pressure; strengthen the network of protected areas as a testing ground, actively involving their managers, etc.

Forest policy and management must be reassessed in view of the effects of climate change, for which the following is required:

- Bring the services associated with the carbon sequestration of forests and the corresponding maintenance of carbon stocks under the auspices of forest management.
- Adopt a long-term strategy for forest fire management.
- Integrate water management into forest management.
- Bear in mind other threats associated with global change, such as forest decay, spread of pests, introduction of non-native species, and pollution.
- Actively include in forest policies the broad set of forest areas that currently do not have tree cover.

Forest policies should also be made more transparent, through evaluations of the effectiveness of the various forest management tools and the publication of their results.

Fishing and Aquaculture

Overfishing of most species must be dealt with more decisively and more detailed regulations are required on fishing along the whole Catalan coast. Some of the recent initiatives in this regard may be a good first step. The focus should be on trawling, since it is the fishing method with the greatest environmental impact.

The sustainability of mariculture could be improved by promoting the cultivation and consumption of macroalgae, filter species and herbivorous or omnivorous fish over today's predominantly carnivorous fish.

The coverage of protected marine areas is currently very small. This should be increased and the most sensitive habitats should be protected. The following measures should be taken in these protected areas with regard to fishing:

- Adoption of more artisanal fishing methods and less intense activity than what is provided for in the general regulations.
- Reduction in the impact on vulnerable species to ensure their recovery.
- Increased surveillance to tackle illegal fishing.

- Periodic monitoring (biological, social, and economic) of artisanal and recreational fishing.
- Removal of fishing nets and gear lost at sea.

Within the framework of the fishing regulations, the reserves promoted by fishermen themselves where fishing is banned or restricted must be reinforced, a co-management model of these fishing areas of interest must be proposed and their scientific supervision and continued surveillance must be ensured.

Nature Tourism

To guarantee the sustainability of tourism and leisure activities in the natural environment, a regulatory framework is needed that is more ambitious than the existing partial and outdated regulations:

- Approve a Catalan Hunting Act that overrides the pre-democratic regulations currently in force and helps meet today's hunting challenges.
- Implement the Act on the Sustainable Management of Inland Fisheries, which is currently paralyzed.
- Overcome the shortcomings of regulations such as the Act on Motorized Access to the Natural Environment, the Decree Regulating Photographic, Scientific and Sporting Activities that Affect Wildlife Species and the Decree Regulating Physical and Sporting Activities in the Natural Environment.
- Re-design the Master Plan for Mountain Resorts to adapt it to a new context in which most ski resorts have become economically unfeasible, encouraging them to become service centers for nature tourism activities.
- Establish a new tax framework for properties in highly frequented natural areas to offset the environmental services they provide.

Energy Consumption

Progress is required on the National Agreement for Energy Transition in Catalonia to implement a new sustainable energy model focused on achieving 100% renewable energy consumption by 2050 and to stop all other planned energy infrastructures that contravene the new energy model.

At the same time, the various planning tools must set aside the appropriate areas so that the new energy model is provided with enough space (on land, in rivers, in the sea, in buildings, etc.) for the new renewable and sustainable energy facilities.

Ecological Footprint

Current economic indicators that are used to measure the wealth of countries (especially GDP) should be abandoned and replaced with others that show whether the human activities in a country are sustainable or not. The ecological footprint, one of the most widely used sustainability indicators around the world, should be calculated periodically and publicized, and the appropriate measures should be taken to reduce it.

4.2.2. Impacts on the Natural Environment Territory

Traditional agroforestry mosaics and their role with regard to the conservation of natural heritage must be safeguarded throughout the territory, ensuring that they are better represented in the networks of protected areas and that they are taken into account in the various forms of territorial planning and in agricultural policies.

Ecological connectivity must be guaranteed and strengthened by establishing regional corridors that allow ecological flows between the main sections of green infrastructure in Catalonia. The Sectoral Territorial Plan of Ecological Connectivity must be approved and implemented.

Metropolitan landscapes should be integrated into the green infrastructure taking into account the following priorities:

- Avoid further fragmentation of metropolitan natural areas and maintain the integrity of the remaining natural areas.
- Launch ambitious defragmentation policies in severely transformed areas to recover lost connectivity.
- Ensure that transitional spaces between built-up land and adjacent natural areas act as buffers, reinforcing, for example, networks of periurban and metropolitan parks heavily used by people.

Given the trends in the urbanization process of Catalonia, the bases of current territorial and urban planning must be re-assessed to stop the ongoing process of urbanization and artificialization of the land and the expansion of urban uses throughout the territory.

Ecologically managing a city's green infrastructure means doing more than simply creating green spaces and offering the usual park and garden services; it is a global change that requires adaptations in the structure and resources of the corresponding municipal services. In parallel, innovative urban design models must be promoted to maximize nature in the city (new types of gardens, green walls and roofs, urban allotments, landscaping of plots, private gardens, tree networks, green corridors, living soils, use of buildings by wildlife, etc.).

Restricting the urbanization of the coast must be a priority for all local government authorities and they need to move in the following direction:

- Appropriately assess, from a territorial and urban planning perspective, the biophysical matrix of the territory, both in terms of the protection of its natural values and the provision of ecosystem services.
- Permanently protect and safeguard the sectors of the coastline that have not yet been transformed, either as protected natural areas or through the application of zoning plans or the like.
- Strictly apply the provisions of the Act for the Protection of the Coast, avoid further permissive reforms and reverse those that have unfortunately been approved.
- Be more rigorous in the application of the corresponding urban development mechanisms.
- Plan on the creation of a body, similar to the French Conservatoire du Litoral, to influence coastal management policies.

Beach erosion and shrinking should be tackled with medium- and long-term policies and actions, such as the establishment of river basin plans to ensure sufficient flow and sedimentary contribution to the mouth of water courses or the implementation of measures to overcome obstacles to the longitudinal transport of sediment along the coast. The management of beaches, and of the whole coast, should not be understood merely as the management of a tourism resource. Rather it must be managed taking into account its ecological, recreational and coastal protection functions.

The following actions are required to deal with natural hazards (floods, landslides, avalanches, subsidence, earthquakes, volcanic eruptions, etc.):

- Improve thematic mapping and databases and ensure that they cover all natural hazards and that they do so at the appropriate scale.
- Draw up technical guides and zoning maps showing risks of natural hazards which must be incorporated under regulations in all forms of territorial management, urban planning and structures and facilities planning.
- Adopt a priority plan for the protection of existing urbanized sectors which are exposed to certain risks, especially in flood areas which are already urbanized and for the road and rail network exposed to landslides.
- In the case of seismic risk, the current seismic-resistant construction regulations must provide for a specific regulation for buildings and structures built before the regulations came into force, as well as for the strengthening of architectural heritage monuments and buildings.

Air

All aspects of the Climate Change Act must be implemented to meet the challenges posed by this issue in Catalonia.

Measures should be taken to improve air quality in terms of NO₂, PM10 particles, tropospheric ozone (O₃), and H₂S. In this regard, decisive action is required to promote Catalonia's energy transition as a way of combatting air pollution, with particular emphasis on the phasing out of vehicles that use fossil fuels.

The Atmospheric Pollution Surveillance and Forecasting Network should provide coverage of the entire territory and ensure that continuous and long-term data sets are obtained.

Water

To mitigate the pressures that still affect aquatic ecosystems and achieve their gradual recovery, the following steps must be taken:

- Design and implement a reliable plan for the morphological recovery and connectivity of aquatic ecosystems in Catalonia (rivers, wetlands, coastal lagoons, etc.).
- Establish and implement a maintenance or ecological flow regime as well as one for flooding (or for generating flows) that reproduce the natural flow regime of the various water courses.
- Reduce the nonpoint source pollution, mainly excess nitrates and pesticides, especially in groundwater.
- Reinforce the physicochemical quality of bodies of water in highly urbanized areas with advanced treatments to remove emerging contaminants.
- Increase the reuse capacity of the wastewater generated, both to increase the availability of the resource and to improve the quality of bodies of water.
- Take further action in emblematic aquatic spaces subject to significant pressures in which, in spite of the knowledge available, not enough action has been taken. This would be the case of the Ebro Delta, the regression of Posidonia meadows or the salinization of the Cardener and Llobregat rivers.
- Adopt a plan of action to prevent the spread of non-native species and the introduction of new, potentially invasive, ones.

Newly created river natural reserves should be further developed and integrated into the system of protected natural areas, establishing the corresponding management measures. The territorial reach of these protected areas should be expanded, especially in the Ebro basin.

4.2.3. Nature Management

Economics and Taxation

Given that sustainability is the economic reinternalization of negative externalities, companies should ideally ensure that their financial accounts are complete and accurate with the inclusion of these often-neglected items.

Taxation can be used to transfer environmental costs to those responsible and create incentives for good management. In this regard, new environmental taxation measures should be proposed, such as a land use change tax, for certain actions on non-developable land or for extractive activities, and part of the funds raised by other environmental taxes should be allocated to the conservation of natural heritage and to establish fiscal instruments that incentivize positive conservation practices.

The long-awaited Natural Heritage Fund of Catalonia must be urgently deployed, which, in addition to the funds initially provided, could be endowed with the proceeds of the newly proposed taxes and other income from fines, donations, budgetary contributions, etc.

Local authorities should take advantage of the small margin offered by the Act Governing Local Tax Offices to fiscally incentivize conservation at a local level until the general legal framework can be reformed. In this regard, councils should try to become less dependent on revenues linked to urban development.

Environmental Policy

The policy for protecting the natural environment and biodiversity of Catalonia must be viewed as a strategic and cross-cutting priority, overcoming the marginalization that has characterized it so far (fragmentation of powers, lack of resources, subordination to other sectoral policies, etc.), implementing initiatives that have been postponed for years (Natural Heritage and Biodiversity Strategy, Natural Heritage and Biodiversity Observatory, Natural Heritage and Biodiversity Agency, Natural Heritage Fund, etc.) and also overcoming recognized but poorly resolved issues: Ensuring there are sufficient resources to execute established policies and planned actions; being uncompromising in the face of breaches affecting natural heritage; promoting transparency and accountability; etc.

Legislation and Protection of Nature and Biodiversity

Priority actions in terms of powers, legislation, policies, institutions and strategy must focus on the following actions:

- Adopt the conservation of natural heritage, biodiversity and geodiversity as a national policy.
- Complement and update the current legislative framework and make progress in enacting an Act on Natural Heritage and Biodiversity that guarantees the transversality of conservation policies.
- Establish an operational strategic framework for conservation policies based on the development of a Catalan Natural Heritage and Biodiversity Strategy.
- Create and implement a new model of nature management governance that guarantees the powers, organizational and budgetary stability of the responsible administrative bodies.
- Involve citizens and institutions as much as possible in the drawing up and application of conservation policies, by re-designing the existing participatory bodies.
- Improve awareness and monitoring of the status of biodiversity and natural heritage. A good idea would be to create a specific observatory that collates, evaluates, and monitors data and facilitates access to it.
- Reverse the regression of biodiversity policies that has taken place, especially during the 2010–2015 period, and reinforce actions in certain important areas of conservation that have traditionally been more neglected, such as flora, the marine environment or invasive non-native species.

The following actions are necessary to improve legislation on nature conservation, territorial development and the integration of nature protection into sectoral legislation:

- Update and complement nature conservation regulations, especially in the provision of an appropriate disciplinary regime.
- Provide legal coverage to the various inventories and catalogues of natural heritage elements (Inventory of Wetlands of Catalonia, Inventory of Spaces of Geological Interest in Catalonia, Inventory of Unique Forests of Catalonia, etc.).
- Improve the application of environmental assessment tools for plans and projects and prevent them from become purely bureaucratic procedures.
- Redesign the Government of Catalonia's policy on land use in a way that emphasizes the preservation of non-developable land, and not like the preliminary draft of the Land Act which does not contain a single reference to biodiversity or natural heritage.
- Make progress in establishing active management measures for land which is classified under urban and territorial planning regulations as non-developable.
- Reassess the sectoral planning of transport infrastructures to reduce land consumption and the effects on the biophysical matrix and opt for more efficient modes of transport.
- Further integrate, both in regulatory and organizational terms, landscape and nature conservation policies.
- Implement the principle of prevalence of environmental protection in sectoral regulations in relation to the use of natural resources.

- An in-depth analysis is required on the application of European funds in Catalonia, especially those related to the common agricultural policy which have an impact on the conservation and improvement of biodiversity and natural heritage.

With regard to the system of protected natural areas, the following actions should be carried out:

- Assign the policy of protected natural areas and the management of all natural areas subject to protection to the department with the appropriate environmental powers.
- Review and update regulations on protected natural areas and those related to the protection of species or habitats. The proposed Act on Natural Heritage and Biodiversity should not be used as an excuse to further delay the necessary reform of current regulations.
- Complement and improve the coherence of the system of protected natural areas with: The declaration of new protected natural areas to form a more balanced and representative network (primary forests, flora reserves, marine ecosystems, areas of geological interest, scope of plans for the recovery or conservation of endangered species, etc.); increase the degree of protection of the most valuable areas or those that are subject to more pressures to redress the current bias in favor of those forms with a lower degree of protection; create new legal forms of protection to cover the identified deficiencies (cross-border areas, private nature reserves, local protected areas, natural areas included in catalogues or inventories, etc.) and standardize other forms associated with sectoral policies.
- Work to ensure that in all actively managed protected areas, their management bodies are endowed with all the necessary executive powers from the different sectors of the administration with territorial impact.
- Increase and diversify sources of funding for the system of protected natural areas and redirect investments towards actions that are genuinely related to the conservation objectives of each protected natural area.

Priority actions in terms of the functioning of protected natural areas must focus on the following:

- Provide protected natural areas with the necessary economic and human resources to carry out their functions and achieve the objectives for which they have been created.
- Define the conservation objectives of each protected natural area in a clear and concrete manner.
- Promote a new governance model for protected natural areas by implementing truly participatory instruments and prioritizing the conservation of natural heritage and the public interest over the defense of local or corporate interests.
- Promote management research and independent scientific advice in the decision-making of the managing bodies of protected natural areas.
- Continuously monitor the state of the natural, cultural and landscape heritage of protected natural areas and assess the effectiveness of their planning and management.

Progress is required in the following areas related to the protection of flora and fungi:

- Bring species protection policies in line with other nature conservation policies.
- Catalogue plant and fungal biodiversity and periodically assess the conservation status of listed species.
- Draw up and apply conservation or recovery plans for all species included in the Catalogue of Endangered Flora of Catalonia.
- Define the important action areas for plants and ensure that they are included in the different forms of protected natural areas or ensure they have their own specific forms of protection.
- Ensure there is sufficiently accurate public data available on the distribution of endangered species to be used particularly in the process of environmental assessment.
- Promote the collation and research of knowledge on traditional uses of flora and disseminate the results.

- Reinststate the Catalan Strategy for the Conservation of Flora and the Catalan Strategy for the Ex Situ Conservation of Wild Vascular Flora and implement every aspect of these strategies.

A policy for the protection of species of fauna is needed which is coherent and endowed with the necessary means, requiring the following actions:

- Draft and make public the list of species of fauna, their state of conservation and the scope of distribution and do so with the necessary degree of detail so that this information can be used in the development and application of any other sectoral policies which could have an impact on these species.
- Urgently approve the catalogue of endangered fauna of Catalonia and deploy the necessary means and resources to draw up and implement the corresponding recovery and conservation plans.
- Focus more on controlling invasive non-native species.

In relation to other issues mentioned previously, the conservation of fauna critically requires the resolution of a whole series of problems throughout the territory: Fragmentation and loss of connectivity, both on land and in river networks; the barrier effect of infrastructures; habitat degradation (disappearance of ponds and water sources, loss of open habitats, urbanization of coastal areas, damage to primary forests, alteration of riparian spaces, insufficiency of river flows, etc.); presence of certain pollutants in inland waters; etc.

4.2.4. Education, Training and Research

Research

To urgently overcome some of the shortfalls of research due to a lack of sufficient funding, the following is needed:

- Take measures to prevent the ageing of research staff in research centers and universities and enable postdoctoral researchers to access senior research positions.
- Reassess the criteria used to evaluate researchers, especially those working in the field of the environment and biodiversity, given that in these cases bibliometric methods are not always the most suitable criteria.
- Prevent research infrastructure from becoming obsolete.
- Prevent research centers from suffering from the endemic problems of the institutions on which they depend: Poor job descriptions and distribution of tasks and responsibilities; regulations designed more for monitoring administrative management than for stimulating research, etc.

More specifically, a funding program is needed for the long-term observation and monitoring of the natural environment. This program could include both very technological proposals and very participatory aspects by amateur naturalists and the public in general.

Environmental research could be one of the sectors in which the country stands out if it is properly articulated. Issues related to global change could be the unifier of environmental research and the pathway to its social recognition.

Schools and Universities

The experience of the Catalan Schools Towards Sustainability Network should be taken advantage of, extending the model (educational and organizational model, and management of the center and relationship with the environment) to all schools in Catalonia so as not to rely on the voluntary discretion of the teaching staff. In addition, issues related to biodiversity, the environment and sustainability should be adequately included in the school curriculum.

More action on environmental sustainability is needed at the university level, both in terms of management and in terms of teaching and research, and sustainability should be included as an indicator of university quality.

Environmental Education

To reinforce the role of environmental education in establishing new ways of viewing the future as a society and moving towards ways of life that benefit people more and have less of an impact on the environment, the following areas need to be addressed:

- Recover the importance that used to be given to environmental education in public institutions.
- Strengthen environmental education in the formal education system, both in primary and secondary schools and at the university level.
- Promote environmental volunteering through service-learning and community service.
- Revive environmental education in protected natural areas with a well-designed strategy that engages with the local population and visitors.
- Help maintain the involvement of environmental education associations and the high-quality facilities of private initiative.
- Place the challenges of sustainability at the forefront of the media and cultural debate.

4.2.5. Social Framework

Companies

Companies need to assimilate environmental issues, including the conservation of natural heritage, into their culture, not simply as a symbolic response to political and social pressures. In this regard, the corresponding regulations must be implemented so that environmental legislation covers not just pollution or waste-related issues but also everything that refers to biodiversity, the preservation of the territory, the landscape, etc.

Non-Governmental Organizations and Associations

The limitations, in size and stability, that these organizations still have must be overcome, by resolving the sociocultural and socioeconomic causes as well as any intrinsic causes that hinder their consolidation: Small size and low membership numbers; difficulties in management and leadership; excessive localism; little collaboration with other organizations; lack of generational renewal, poorly developed communication strategies and difficulties in engaging with young people, etc.

Volunteering must be the basis of the functioning of the organizations. Professionalization must be kept at the right level to achieve better technical results while ensuring these organizations, under the guise of conservationist entities, do not become service providers.

These organizations must encourage the participation of scientists in their activities, bridging the gap that has developed between the academic and volunteer fields.

5. Final Remarks and Relevance

This essay provides an overview of the last 40 years of use, and in many cases abuse, of the natural resources in Catalonia. This overview is relevant to the many countries of Europe that have socioeconomic characteristics very similar to Catalonia. The use of natural resources in these countries made by mining, agriculture, livestock, logging, fishing, nature tourism, and energy production and consumption results in an ecological footprint, which is about seven times the amount of productive land and sea surface required to generate the consumed resources and absorb the resulting waste. In all these countries, this overexploitation of natural resources has a huge impact on land and its different forms of cover, flora, fauna, air, and water. In most of these countries neither environmental policies nor legislation go far enough. The series of reasonable and feasible priority measures and actions here proposed regarding Catalan natural resources should be also applied to these European countries to improve the conservation and management of natural resources and thus move towards sustainability.

When the White Book on Nature Management was published in the Catalan Countries in 1976 [1], there was no specific policy for the protection of nature in Catalonia so the main contribution of that work was to lay the foundations and define the priorities that should

guide the adoption of a true policy of preservation of the different components of nature. After more than 40 years, when considering the biodiversity crisis and thinking about how to redefine the corresponding policies, it made no sense to just repeat the same exercise and a new approach had to be taken. Faced with the new paradigm of sustainability, the choice was to go beyond the strict nature conservation policies and analyze how the different sectoral policies affect them.

The results obtained in this broader analysis, which are those presented in this essay, show that nature conservation policies—the protection of spaces, species, and habitats—are essential and it is urgent to implement them in their full extent but also show that by themselves they are insufficient to stop the loss of biodiversity and the unsustainable degradation of the environment. The solution to this problem seems to be more in the need for a profound change in other sectoral policies than just in the adoption of more measures to protect biodiversity. This essay shows that as long as the degree of unsustainability is predominant in urban planning, energy, agriculture or tourism, to give a few examples, or that the principles of sustainability are not integrated into the governance or in educational policies or in the functioning of companies, it is difficult to achieve the objectives of preserving biodiversity and protecting the environment.

This essay provides specific data on the effects and impacts of different sectoral policies on biodiversity conservation and suggests the main changes that should be introduced in the short and medium term in these policies. This is perhaps the main result of this essay, to show through a concrete example, that of Catalonia, how to reorient policy and action to overcome the biodiversity and environmental crisis. It is precisely through this more global, sustainable approach that this essay can serve as a guide and inspiration for other countries in a similar socio-economic context.

In 2018, the Government of Catalonia approved the Strategy for the Natural Heritage and Biodiversity of Catalonia 2030 [52] but despite the proposals made in relation to nature conservation, its impact on other sectoral policies is minimal. In 2020, the European Union adopted the EU Biodiversity Strategy for 2030 [66], a document that recalls that “nature is in a state of crisis” and sets out a series of proposals to create a coherent network of protected natural spaces, to recover nature in the EU and to bring about a transformative change. This strategy already has an impact on some sectoral policies, especially agricultural, the greening of cities and a new model of governance, but again their impact on all these sectoral policies remains low.

This essay is a wake-up call, it shows that change is needed, that the current socio-economic model is unsustainable, but that public policies, despite the “big” statements, are moving towards sustainability at a slower pace than necessary. The contribution of this essay is not only to highlight and quantify this contradiction but also to propose specific lines of action and do so through a specific example, that of Catalonia, in which other countries can easily be reflected.

Author Contributions: Conceptualization, J.P. (Josep Peñuelas), J.G. (Josep Germain), D.S., and R.F.; methodology, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, all co-authors. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Institut d’Estudis Catalans (IEC).

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results”.

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