



Nature under pressure. Humans as a disruptive force.

Resilient Landscapes, Climate-Smart Forestry and Circular Bioeconomy.

The case of Catalonia.

Article of the CAPCIT · December 2022

The role of forests under the present scenario of global change

We are facing unprecedented global environmental changes: climate, water, food, energy security, population, and urban expansion. A paradigm shift is required to adapt to global change through the implementation of a new, feasible and sustainable socio-economic model within the planetary boundaries where forests are expected to play an essential role.

Forests cover 31 percent of the earth's surface and are a vital global ecosystem: they provide important ecosystem services (*hereinafter* ES), benefits that ecosystems bring to society and improve the welfare of populations; they are a key element in mitigating climate change by sequestering carbon to build up biomass and in the process; release oxygen and evapotranspire water; generate 1m³ of wood, trees store 1 tonne of CO₂ and release more than half a tonne of oxygen.

Furthermore, they are essential to the maintenance of life on our planet: biodiversity, water (forests provide 75% of the total freshwater volume), and soil. Approximately half of the forest area is relatively intact, with over a third being primary forest. While the net loss of forest area has decreased significantly since 1990, deforestation and forest degradation continue to occur at an

alarming rate, resulting in significant loss of biodiversity¹ (FAO, 2022).

However, global figures should be interpreted correctly when focusing on specific areas. For instance, in Europe, forest area covers 37% of EU land, capturing 10% of CO₂ emissions.

Catalonia is a 32.000 km² Mediterranean region holding a population of 7.7 million people. The most important economic sectors are industry, services, and tourism, receiving over 20 million tourists per year. Population is concentrated around the Barcelona hub and along the Mediterranean Sea coast. Even so, Catalonia is a country of forests: 65% of the Catalan territory are forests (2.1 million hectares), and 42% is wooded, forest areas constitute 30% of the Nature 2000 network, while 76% of the forest surface is private (with around 228.000 forest owners). In recent decades, the area and density of forests have increased significantly, mainly because of socioeconomic factors: agriculture, rural abandonment, and low timber prices, which are among the most representative.

Since 1990, the forested area has increased by approximately 30%, while the standing volume has doubled, resulting in a total forest area of 2.1 million hectares (65% of the total surface in the region). This creates a complex

¹ FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. <https://doi.org/10.4060/ca8642en>

scenario for a Mediterranean region where forests provide multiple essential ecosystem services beyond timber or carbon sequestration and the effects of climate change are being felt (drought, risk of extreme forest fires).

Promoting the resilience of agroforest landscapes by implementing Climate-Smart Forestry.

Socio-ecological resilience understood on a landscape scale, or applied to a landscape, can be defined as the ability of a landscape to sustain desired ecological functions, biodiversity, and social and economic activities over time, despite the multitude of known stressors and future uncertainties. However, to apply the concept of socio-ecological resilience to a particular region or landscape, an in-depth knowledge of the concept is necessary. This includes both historical conditions, current conditions, the change factors that have occurred, as well as potential future trends.

Recognizing the scale at which the concept should be applied is remarkable because the resilience of a landscape (regional scale) will focus on different elements and drivers of change, than when concentrating on smaller scales such as a forest stand, a stretch of river or a single agricultural enterprise (local scale).

In the case of Catalan Forest ecosystems and agroforest landscapes, their resilience derives from genetic diversity, species of fauna and flora, forest, agricultural and scrubland habitats, ecological functions necessary to sustain biodiversity in the long term, ecosystems, and socio-economic activities that ensure food sovereignty, blue water provisioning and other key ecosystems goods and services.

Current and future environmental and socioeconomic stressors include both chronic factors that have long-term effects on ecosystems and one-time events. Threats are loss and fragmentation of habitats, overexploitation of natural resources, increasing demand for bioproducts, fluctuations in the market prices of agricultural and forestry products, extreme climatic episodes (drought, floods), steady climate change (increase in temperature, erratic precipitation regime), invasive exotic species, wildfires, and diseases.

Wildfires are especially critical in South Europe. Only in 2022, over 720.000 ha burned in Southern European countries, representing 95% of the total area affected in Europe.

In Catalonia, 547 fire ignitions were reported and burned 78 fires of more than 1 ha and 2 extreme wildfires of more than 500 ha accounting for more than 6.000 ha

burned. In the near future, severe fire regimes are expected in Mediterranean countries due to climate change and land uses. Current fire management policies are reaching their upper limit of application because more human and economic resources allocated to extinguishing fires do not mean a direct increase in extinguishment capacity of the fire brigades.

While weather conditions largely determine fire regimes in southern Europe, fire policies should change and aim for a reduction in the overall severity of landscape-wide fires, rather than a mere reduction in total burnt area. Emphasis should be placed on the control of vegetation (fuel), in other words the management of its spatial planning and the promotion of fire-resistant and/or fire-resilient forest types.

As in many other southern European regions, in Catalonia, the abandonment of pastures and agriculture mostly in remote, mountainous areas since the mid-20th century has led to a steady increase of the forest surface, the standing forest volume has tripled over the last 40 years, and 34% of Catalan forests are estimated to be relatively young (established after 1960). Nevertheless, the forest sector represents only 0.06% of the total gross domestic product and employs ca. 32.000 people. Forest management is rarely a profitable activity because the costs of forestry operations are relatively high, mainly due to accessibility constraints, while timber prices are low.

It is estimated that annually, forests grow ca. 2.9 million m³ on average but, only 30% of this annual growth is harvested. Indeed, only 10% of the annual wood consumption comes from local forests and most of the Catalan wood transforming industries are based on low-added value forest products. The use of wood for energy (stella, pellet, and firewood) is gaining relevance in the Catalan bioenergy market and the apparent consumption in 2020 was over 0.4 million tonnes.

Catalonian forests provide multiple ecosystem services in the Mediterranean, as well as conditions for global change. However, over the last 25 years, the capacity of forests to capture carbon has decreased by 15-20% in inland and Mediterranean forests (not in Alpine biogeographical region). Forest growth and low management rates have decreased blue water and runoff by 29%, although forest ecosystems have prevented soil erosion. The risk of extreme forest fires has never ceased to increase, and the overall health of forests could be compromised due to stressful conditions, new diseases related to world trade, or adverse weather events.

Biodiversity levels have kept in general, but some decreases are reported in mature forests and bushes ecosystems, because less openings are created. Although Catalan forests are a habitat for a rich biodiversity ex-

emplary of Mediterranean ecosystems, its biodiversity has also experienced negative trends and in the last 20 years, native vertebrate and invertebrate populations have shrunk by an average of 25% and the loss in population numbers is more than 50% for species living in rivers, lakes and marshlands, 30% for farmland and grassland species and 10% in forests and scrubland species.

The underlying cause of biodiversity loss is a socio-economic model that leads to intensive resource extraction in some regions, while abandoning others, indeed, changes in land use are the main direct cause of biodiversity loss, although climate change and the arrival of invasive exotic species are also having an increasing impact² (The State of Nature in Catalonia, 2020).

To achieve the Green Deal objectives for 2030 and 2050, advanced decision support tools are being implemented and developed, to diagnose and define improved multi-objective scenarios involving multiple stakeholders in land use and landscape management (Trasobares et al., 2022)³. The challenge therefore relies on re-thinking and upgrade the principles underlying multifunctional forest management, that by its own ensures the ecological, social, and economic values of the forest ecosystems, guaranteeing the sustainable provision of goods and services, to also consider climate change mitigation purposes, biodiversity conservation, and the promotion of circular bioeconomy. Over the last few years, the term Climate-Smart Forestry⁴ (CSF) has been thereby introduced and constitutes an essential next step in the pursuit of sustainable forest management objectives and the forest sector's response to the threat of climate change.

The CSF concept considers not only forests and wood supply chains, but also the substitution effects of materials and energy. Thus, CSF builds on three main pillars: (1) *increasing carbon storage both in forests and wood products, while maintain the provisioning of other ecosystem services*; (2) *enhancing the health and resilience of forests by using adaptive forest management*; and (3) *using wood resources to substitute non-renewable, carbon-intensive materials*.

To implement CSF in Mediterranean regions, forest management options and silvicultural prescriptions could include, but are not limited to, adjustments to final thinning and cutting schedules (leading to additional growth and

higher quality raw material while reducing fire risk), re-growth with on-site species adapted to warmer and drier environmental conditions, planting site-adapted species from other provenances, or the substitution of tree species to produce wood products with higher live spans. In fact, higher harvest levels combined with effective use of forest products means that substantial increases in the production of long-lived wood products could significantly contribute to climate change mitigation, circular bioeconomy, and the provision of multiple ecosystem services, compared to reducing harvest levels with the exclusive aim of increasing forest carbon stocks. During their service life, long-living wood products act as carbon pools, and after it, they can substitute emission-intensive fossil fuels if converted to biomass for energy, or even functionally substitute other non-renewable products and materials.

Advanced modelling and decision-support tools are being implemented and developed, to first diagnose the current state of the forests and the provision of ecosystem services, but importantly, to co-design and project climate-smart multi-objective forest landscape scenarios involving multiple stakeholders. Scenarios and assessments of ecosystem services arising from these approaches provide the basis for discussing the territorial implementation of forest policies consistent with the principles of the CSF and the Catalan Bioeconomy Strategy 2030 (hereinafter EBC2030) objectives.

In turn, multi-criteria optimization tools allow depicting the trade-offs between different ecosystem services and ease agreements between different stakeholders to solve controversial situations. These evaluations are necessary to reward carbon sequestration and establish a payment system for ecosystem services, complementing traditional forestry revenue flows by internalizing forest externalities in the economy.

Towards the achievement of Green Deal objectives: Circular bioeconomy and payment for ES.

The scientific scenarios derived from this can be used for: the territorial implementation of forest policies and the recently approved EBC2030 and to reward carbon sequestration and other key ES, thus complementing traditional forestry revenue flows (payments for ES).

2 Brotons, L.; Pou, N.; Herrando, S.; Bota, G.; Villero, D.; Garrabou, J.; Ordóñez, J. L.; Anton, M.; Gual, G.; Recoder, L.; Alcaraz, J.; Pla, M.; Sainz de la Maza, P.; Pont, S. and Pino, J. (2020) The State of Nature in Catalonia 2020. Catalan Ministry of Territory and Sustainability. Government of Catalonia. Barcelona.

3 Trasobares, A.; Mola-Yudego, B.; Aquilué, N.; González-Olabarria, J.-R.; Garcia-Gonzalo, J.; García-Valdés, R.; De Cáceres, M. (2022). Nationwide climate-sensitive models for stand dynamics and forest scenario simulation, *Forest Ecology and Management*, 505:119909. <https://doi.org/10.1016/j.foreco.2021.119909>.

4 <https://blog.efi.int/adapting-forests-to-the-new-normal/>

In 2021, the Catalan Government approved the EBC2030, under the auspices of the Ministry of Climate Action, Food and Rural Agenda, the roadmap for the transition to an economic model based on the optimal use of renewable biological resources that are not currently being used to ultimately, create products with greater added value. Its main goal is to promote the sustainable development of the Catalan economy by promoting the production of local renewable biological resources.

This provides new life for forest, agri-food and marine products and ensures the sustainable delivery of ecosystem services to move towards a circular bioeconomy, taking into account the pressing need for adaptation and mitigation in the face of the climate emergency. EBC2030 will make it possible to improve the competitiveness and sustainability of the first sector, by creating jobs, connecting actors from very distant sectors and boosting the generation of knowledge as an engine of change. To achieve these goals, research and innovation are playing a fundamental role in helping to generate new proposals that allow this transition to be carried out efficiently and sustainably.

The Action Plan for the period 2021-2023 of the EBC2030 is structured around seven strategic objectives that will serve to give a new boost to the bioeconomy in Catalonia. Four of them are tightly linked to the generation of economic activity: (1) *improve the use of Catalonia's biomass through the characterization, quantification, optimization of management and distribution*; (2) *develop a business fabric based on the circular bioeconomy throughout the territory, with special attention to the first sector*; (3) *promote the use and consumption of bioproducts, bioenergy and biomaterials in the market*; and (4) *promote resilient agroforest landscapes and the sustainable provision of multiple ecosystem services in the context of the Catalan circular bioeconomy*.

In conclusion, to address nature under current pressures in a period of growing risks due to climate change and natural disturbances, changes in socio-economic and territorial models and improvement approaches for policy making must be implemented.

Regarding the socio-economic changes: (1) *promote multiple ES provision and resilience of agroforest landscapes for Green Deal implementation requires efficient mechanisms and policy approaches*; (2) *integrate and coordinate the various policy frameworks* (Bioeconomy strategy, Forest strategy, Biodiversity strategy, Farm to Fork, LULUCF, CAP, among others); (3) *EC proposed new targets⁵ which require that the entire EU LULUCF*

sector would need to remove approximately an additional 100 Mt CO₂eq./yr. by 2035 and 170 Mt CO₂eq./yr. by 2050.

In relation to the improvement of approaches for policy making, in various EU regions, support on sustainable management is more required than planting trees. In this sense, (1) *multi-objective territorial management planning and CSF provide the basis for combining mitigation and adaptation measures by identifying trade-offs between ES*; (2) *landscape level offers high potential for policy making territorial implementation* (environmental, social, economic, legal factors and main stakeholders involved); (3) *potential of financial-policy making mechanisms incentivizing bioeconomy implementation and resilience, biodiversity enhancement, by complementing forest owners/managers revenues related to market values with PES*.

⁵ <https://blog.efi.int/adapting-forests-to-the-new-normal/>

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Resilient Landscapes, Climate-Smart Forestry and Circular Bioeconomy. The case of Catalonia.	1
The role of forests under the present scenario of global change	1
Promoting the resilience of agroforest landscapes by implementing Climate-Smart Forestry.	2
Towards the achievement of Green Deal objectives: Circular bioeconomy and payment for ES.	3