

Review

Working in (Slow) Progress: Socio-Environmental and Economic Dynamics in the Forestry Sector and the Contribution to Sustainable Development in Europe

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Abstract: Forest ecosystems are increasingly subject to disturbances, such as extreme (climate) events, fires and pathological outbreaks, which exert significant (and still poorly quantified) economic impacts, despite their intrinsic resilience. How forest management addresses these challenges will have profound effects on human health, environmental diversity, (ecological and economic) productivity and the ability of forest ecosystems to recovery from exogenous shocks. Assuming forests as ensuring ecosystem services that are vital to society and human well-being, in addition to providing wood material, a better knowledge of forest ecosystems appears a key requirement to delineate a developmental strategy that guarantees environmental protection objectives and achievement of climate and energy targets. In the context of Sustainable Development Goals of the United Nations 2030 Agenda, the information available on forest management practices in Europe still seems not completely suitable to provide a comprehensive overview of ecosystem conditions, their economic value, and their biodiversity. Based on a literature review, the present contribution focuses on recent dynamics of the forestry sector in Europe, delineating the inherent complexity in the environmental-economic nexus. Additionally, the extensive use of a key natural resource such as wood exerts social implications for local districts adapting to ecological change—from climate warming to landscape transformations. In line with earlier studies, our paper confirms the role of the technical-economic dimension of forestry in sustainable development paths of districts and regions, affecting together (i) short-term economic dynamics, (ii) the growth prospects of the sector, (iii) the organization of the supply chain, (iv) the interconnections between companies, and (v) investment strategies at large. One of the major issues is the low reliability of official statistics to provide a coherent picture of the actual status of forest resources. At the same time, forestry practices are pivotal in maintaining habitats and species while increasing the timber production that remains (too) sustainable. This is the policy direction constantly given by the European Commission to stimulate over time public bodies and private (in whose hands is about 60% of European forests) to start virtuous paths in the circular economy with considerable repercussions in terms of additional jobs, recycled materials, mt of CO₂ equivalent avoided, and increase in community added value. In this context, forestry should assure a more 'holistic' contribution to sustainable development paths at various spatial scales. This means concentrating on both economic and environmental targets based on the identification of significant (ecological-economic) dimensions that may delineate

future lines of investigation and policy intervention, while increasing between member countries and regional authorities.

Keywords: natural resources; official statistics; wood; circular economy; European Union

1. Introduction

Recovery from the great recession has not coincided with a persistent and spatially homogeneous economic growth in Europe. The effects of the pandemic crisis and, more recently, of the geo-political conflict on the Eastern edge of the continent—with the related energy implications—outline an underlying uncertainty about future socioeconomic dynamics [1,2]. This uncertainty has significant but equally heterogeneous repercussions on the individual productive sectors limiting, in many cases, the ability to transition towards a truly circular economy and an exquisitely sustainable development path [3]. Despite the contribution of general and sector policies, these challenges were mainly managed, often successfully, by regional and local markets even before the pandemic [4]. Thanks to the pervasiveness of climate change on a global and local scale, the supply chains most exposed to continuous transformations reflecting the ecological transition were also the most sensitive to environmental, territorial and social issues [5,6].

At the same time, it was demonstrated how forest ecosystems are increasingly subject to disturbances, such as extreme (climate) events, fires, pathological outbreaks and human activities at large [7–18], which exert significant (but still poorly quantified) economic impacts [19–22]. How forest management addresses these challenges will have profound effects on human health, environmental diversity, (ecological and economic) productivity and the resilience of forest ecosystems to exogenous shocks. In addition to providing wood material, forests ensure multiple—and relevant—ecosystem services that are vital to society and human well-being [23–28]. A focus on environmental sustainability reduces risk profiles for businesses and for society as a whole, and stimulates innovation and entrepreneurship, making production chains more competitive [29,30]. The International Panel for Climate Change (IPCC) has confirmed the importance of forests and the productive sectors connected to them, demonstrating how CO₂ emissions can be reduced by up to a third through natural solutions. This means promoting businesses and management strategies that ensure the resilience of forest ecosystems and the economic vitality of connected supply chains [31]. The forestry sector fulfills multiple functions in Europe, providing socioeconomic benefits that include new jobs and growth opportunities in rural areas, and consolidating, at least indirectly, some recreational functions typical of old-growth woods [32,33]. Extensive research has consistently demonstrated that spending time in forests can effectively reduce stress, improve moods, and even aid in the recovery process from illnesses [34–37]. Numerous studies have also examined the effectiveness of forest-related clinical programs in enhancing the well-being of diverse groups, including delinquents, psychiatric patients, emotionally disturbed children, and individuals with mental health issues [38,39].

To increase the knowledge about the contribution of natural places to the health and well-being, several international initiatives, such as the European initiatives COST action E39 (<https://www.cost.eu/actions/E39/>, accessed on 16 June 2023), have been largely diffused showing that forests play a crucial role in providing ecosystem services, offering a wide range of recreational/tourism activities such as hiking, picnicking, and biking. As a result, there was a growing emphasis in recognizing the potential of woodlands as spaces for recreational purposes, stress relief and relaxation [35].

In addition to the economic benefits directly generated by forestry, wood remains a vital input in the manufacturing industry, also retaining significant uses as a source of energy, likely growing in the current geopolitical scenario [2,40]. This appears to be a positive aspect on the one hand, given the forest heritage, even if it is considered negative on the

other hand, being potentially in competition with uses of wood with higher manufacturing added value. At the same time, companies—especially furniture factories—suffer from a structural problem of dependence on foreign supplies [6,41].

Official data show, at least indirectly, how the intrinsic vulnerability of forest formations appears increasingly evident and progressively more associated with the economic and social dynamics of local districts, representing a source of volatility and uncertainty, and reducing the potential resilience of entire regions to global changes [42–46]. This is particularly true in economically deprived contexts such as inland and marginal areas in the old continent, where it is systematically difficult to do business and where the surrounding conditions (accessibility, permeability to innovation, networking, openness to the global economy) are disadvantageous [47–52].

Based on a literature review, the present contribution focuses on recent dynamics of forestry in Europe, delineating the inherent complexity in the environmental-economic nexus characteristic of the forest sector. The extensive use of a key natural resource such as wood has important social implications for local districts adapting to continuous ecological change, from climate warming to landscape transformations [53–62]. In line with earlier studies, our paper confirms the importance of the technical-economic dimension of forestry in sustainable development paths of districts and regions [63–66], affecting together (i) short-term economic dynamics, (ii) the growth prospects of the sector, (iii) the organization of the supply chain, (iv) the interconnections between companies, and (v) investment strategies at large.

At the same time, this contribution documents how the complexity of forestry and the intrinsic relationship with other economic sectors and ecological issues cannot be reduced to overly simplified interpretations grounded on exquisitely ‘technical’ points of view. On the contrary, our study supports the introduction of interpretative frameworks of forestry as providing a ‘holistic’ contribution in sustainable development paths at various spatial scales. This can be realized exclusively by identifying relevant environmental, social and economic targets of forestry, in turn delineating future lines of theoretical research and empirical investigation.

To address the deserving question of sustainable development in any production sector with relevant impacts on the environment, the article is organized as follows: Section 2 provides a brief analysis of recent dynamics in forest resources with a focus on the European continent. Section 3 is focused on the environmental effects of forestry. Section 4 delineates the economic use of forest resources and the wood-furniture supply chain in Europe, summarizing official statistics and introducing a brief analysis of the productive interconnections between forestry and furniture industry. Section 5 summarizes European policies’ framework and recent innovations in forest planning with a sustainability perspective. Section 6 concludes the study with an open discussion on the main issues at stake when debating the environmental and economic contribution of forestry in advanced economies, possibly distinguishing central locations from more peripheral places, where forestry represents a relevant added value in rural systems that should be better tuned with the aspect of environmental protection.

2. Forest Resources: Analyzing Recent Dynamics in Europe

In the world, forest area continues to shrink by an alarming 4.7 million hectares per year on average, with deforestation advancing at a rate of 10 million hectares per year [67]. Over the past 10 years, the countries with the largest net (annual average) forest area losses were Brazil, the Democratic Republic of the Congo, Indonesia, Angola, Tanzania, Paraguay, Myanmar, Cambodia, Bolivia, and Mozambique [67]. However, awareness of the importance of forest protection measures has grown: in the last 30 years, protected forest areas have reached approximately 726 million hectares, almost 200 million more than in 1990 [67,68]. Focusing on Europe, among the most recent initiatives launched, Natura 2000 network is the largest coordinated network of protected sites stretching over 18% of the EU’s land and almost 6% of marine areas (covering about 850,000 km², see

<https://land.copernicus.eu/local/natura>, accessed on 13 June 2023). This network originates from two Directives (Habitats and Birds Directives, i.e., 92/43/EC and 2009/147/EC) aimed at preserving threatened species within their habitats and assuring long-term survival of ecological functions [69], while taking into account socio-economic, cultural and local requirements.

In this context, forest trends observed in the European continent fit into a more general pattern characteristic of advanced economies, which see a consolidation of forest areas, especially in marginal places of developed countries [70–75]. As a matter of fact, forest expansion—mainly driven by large-scale reforestation programs—was one of the major changes in land-use over the last 200 years in Europe [76–80]. At the same time, rural exodus has accelerated the technological changes that have allowed the intensification of agricultural systems on smaller areas, freeing up land for the (often spontaneous) forest recolonization, above all on abandoned and previously cultivated land [81–89].

In the 50 years following World War II, forest area in Western Europe increased by almost 30% [90,91]. Growth was slower in both Central-Eastern and Southern Europe (20% and 16%, respectively), while in Northern Europe, forests already represented the dominant land cover in the middle of the last century [92]. Expansion of forest cover has, however, continued almost everywhere to the present, although it has leveled off since the early 1990s, with the exception of Western Europe. Between 1990 and 2020, wooded area in Europe increased by 10.2 million hectares (+6.0%, see the report [93]). There were around 180 million hectares of woodland and other forest land in the European Union (EU)—27 (Figure 1) in 2020 (around 45% of the total area, excluding inland waters), corresponding to 5% of global forest area [93]. As a demonstration of long-term trends, afforestation (natural or man-made) and deforestation in recent years have been concentrated only in a few European countries, involving respectively less than 0.4% and 0.3% of land conversions [93].

In 2020, Sweden boasts the largest forest area in Europe, with assets estimated at 30.3 million hectares [94]. The second largest area was recorded in Spain (28.0 million hectares), while Finland (23.2 million hectares) was the only other Member State concentrating over 20 million hectares [95,96]. Next, France (18.1 million hectares), Italy, and Germany (both with around 11 million hectares) had significant forest resources in respect with smaller countries [97]. Forests account for at least half of the total area in 8 member states in 2020. The highest proportions relative to the national area were recorded in Finland (76.2%), Sweden (74.5%), and Slovenia (62.8%). In Estonia, Latvia, Spain, Portugal, and Greece, around 50–60% of the total land area is forested, as opposed to historically forestless countries (Netherlands, 11%; Ireland, 12% and Denmark, 16%). Sweden is the only member state to record a moderate contraction of the forest area between 1990 and 2020 (−0.4%), while the largest increases, greater than 8%, were recorded in three Mediterranean European countries (Croatia, Italy and Cyprus) in the same period [93,98].

The current composition and structure of forests in Europe also reflects a variety of human disturbances. According to the European Environment Agency [99], only 26% of forest species and 15% of forest habitats have been classified in a favorable conservation status. It was estimated how forests remove around 430 million tons of atmospheric CO₂, storing 13% of Europe's greenhouse gas emissions, hosting a dominant part of terrestrial biodiversity, and contributing significantly to climate change mitigation [100].

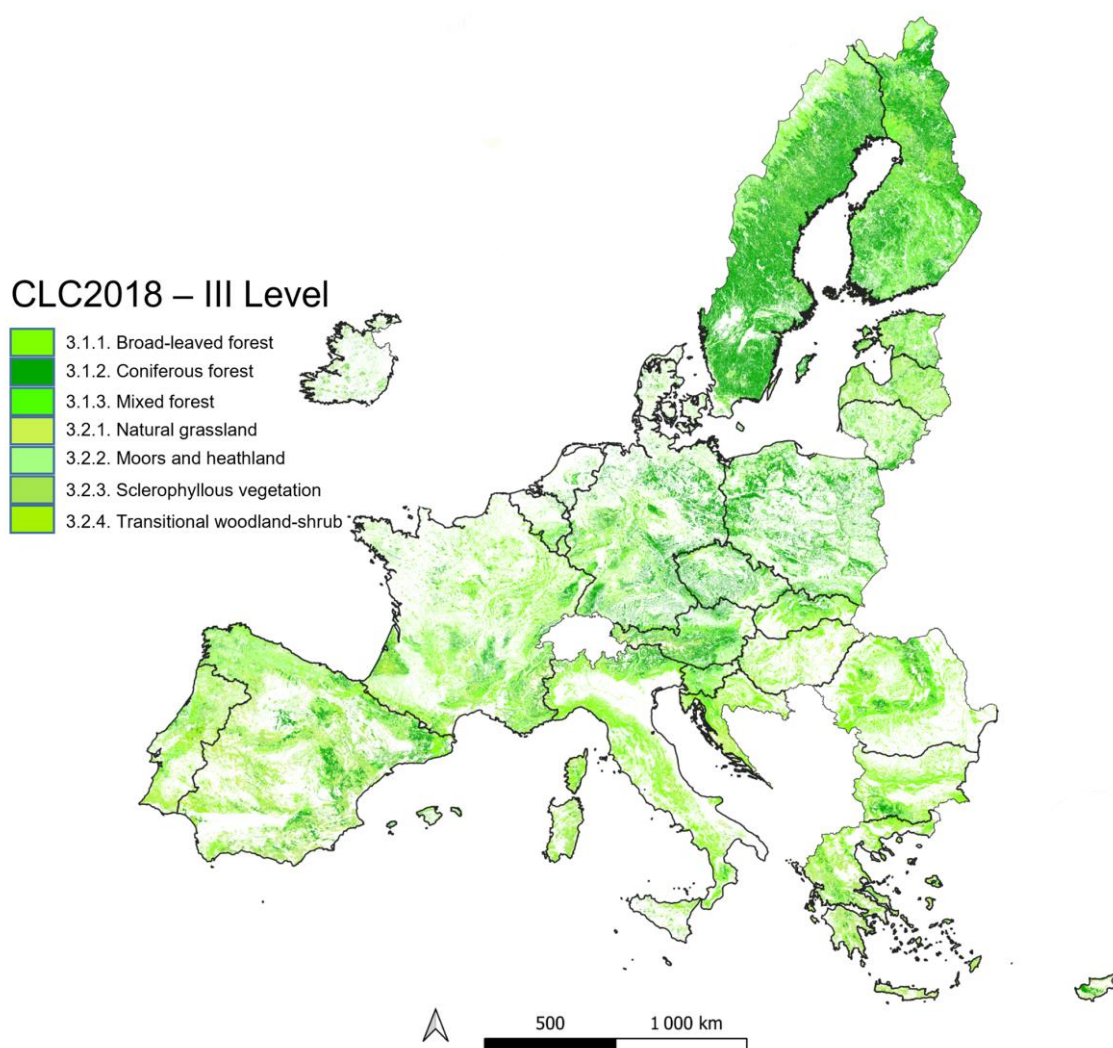


Figure 1. Forest and seminatural classes according to the Corine Land Cover (CLC) 2018—III Level—for the 27 European Union (EU) countries.

On the other hand, the main trends of future climate indicate an increase in temperature and a decrease of precipitation in most of European ecoregions and this will happen at a faster rate with respect to the rest of world (see <https://unric.org/en/climate-europe-warming-faster-than-rest-of-world-ipcc/>, accessed on 13 June 2023) under the forcing of an inescapable urbanization by 2050, about 84% of the European population will live in urban areas [101] with notable impacts on air/soil quality and, thus, on the health of European citizens, especially young and elderly people [102]. One of the most adopted strategy to mitigate the combination of climate change and urbanization is the development of urban forestation projects: a massive increase in planting, especially through the so-called Nature-Based Solutions (NBS), that helps to alleviate the micro-climate and air quality of urban areas by capturing CO₂ and reducing the impact of sun and rain on the soil [103].

All the natural areas located in urban environments, encompassing a large variety of green covers (woodlands, urban parks, gardens, street tree and square plantations, botanical gardens and also cemeteries, to which building envelop greening has also recently been added), provide key ecosystem services and goods [104], that are not limited to the supply of material but also the provisioning of habitat quality, the regulation of air, water, soil and climate [105] and the cultural ecosystem services consisting in the physical use and benefit of restoration, aesthetics and contact with nature [106].

Moreover, urban forests, especially in the advanced economies, can play a decisive role in addressing the conflicts between forest privatization and public demand originating from the resource conflicts as a typical feature of contemporary globalization [107] consisting in the dichotomy between industrial priorities and ecological and cultural needs [108].

Finally, the distributional features of forests remain a tricky issue in Europe because no official map covering large spatial scales can be considered appropriate in addressing this point [109]. Only a fine integration of land-use maps (e.g., Corine Land Cover, Copernicus HRLs) and official statistics (agricultural censuses at a fine scale, geo-spatial information from forest inventories) may specifically answer this point.

3. Environmental Effects of Forestry

Forest resources and services could be damaged or destroyed by inadequate forest management. Forestry practices are still one of the main causes of an unfavorable conservation status of forest habitats and species [110,111]. In this sense, forestry practices vary substantially across Europe, from the absence of management due to abandonment, to exclusive management for protectionist purposes, to intensive short rotation forestry aimed at power biomass production [112–120]. In any case, those management regimes that are similar to natural disturbances can effectively influence stand structure, and this could increase biodiversity over time [121] while aiming at minimizing forest changes [110,122]. Generally, when compared to agriculture practices, forestry has an overall lower impact on biodiversity due to a (very) limited use of fertilizers, adopted only for weeding before reforestation plans or to favor conifer over broadleaved regeneration, with possible impact on plant diversity and wildlife [123]. Also the case of biocides is very uncommon in forestry thus, in summary, managed forests have a much lower intensity and frequency of use of these product with respect to agricultural systems [124]. However, biodiversity in managed forests is often much lower than that observed in natural forests, because of the lack of tree species diversity, heterogeneity of tree age and peculiar habitats (e.g., deadwood, see [124]). Being stand age a pivotal element in the provision of forest ecosystem services (see e.g., Ref. [125]), it can be considered a further “victim” of the modern forestry, because restricting stand ages by clearcutting medium-aged and old stands can decrease quality and number of forest function [126].

Intensive forestry can impact also old growth forests resulting in an effective (temporary) extinction of these natural milestones [127]. Unfortunately, the biomass loss from European intact primary and old-growth forests is currently ongoing [128] mainly for economic purposes causing a typical pattern of forest degradation consisting in the shift of these environments in secondary forests [129] with a loss of specialist species depending on old trees or deadwood [130]. Lastly, forestry activities can facilitate the introduction and spread of alien invasive species through forest utilization practices (extraction of non-timber products, timber harvesting, building of roads and facilities, conversion of natural forests to plantations) and the deliberate introduction of species for commercial (agro)forestry uses (see [131], <https://www.fao.org/3/j6854e/J6854E04.htm>, accessed on 13 June 2023).

4. The Economic Use of Forest Resources and the Wood-Furniture Supply Chain

A forest area stable over time does not necessarily mean that European forests have not been subject to important changes in recent years. Forest ecosystems respond, in fact, both to human activities—with particular reference to the withdrawal of biomass—and to ecological maturation or other natural dynamics [44,132–135]. In this regard, national statistics provide information documenting a picture of lights and shadows in the economic use of forests, which can be considered intensive only in some regional contexts, despite a more general trend towards extensification and resource under-use at the community level [136,137]. In recent years, the average rate of forest utilization (the ratio between the average annual volume felled and the annual growth volume of the stock of live trees), in fact, has remained well below 1 everywhere in Europe [138]. This indicates that, although it varied from country to country, timber production has remained highly sustainable

and, in many contexts, there are opportunities for increased harvests. This assumption is conceived at an aggregate spatial scale, considering a comparison of net growth and consumption at the national scale, making use of data with different standards across countries. At the regional level, some restricted districts could be not so sustainable, with logging exerted at a very high rate [139,140]. Overexploitation of forest resources in specific areas of Europe (especially restricted contexts in Eastern Europe) may be a problem still nowadays [141–143]. Clearly, if we look at an even more disaggregated level (prefectures, municipalities), the situation could be even more complex, but usually the available data, even in the most economically-advanced countries, cannot exactly document this pattern at a so refined spatial scale.

Specifically, in 2020, wood stock in forests in the EU-27 member states amounted to approximately 27.6 billion cubic metres (bcm). With almost 3.7 billion cubic meters (13.3% of the EU-27 total), Sweden and Germany had the highest timber stocks among member states. Also France (3.1 bcm, 11.1%), Poland (2.7 bcm, 9.9%), Finland (2.5 bcm, 8.9%) and Romania (2.4 billion cubic meters, 8.5%) boasted significant stocks of timber [93]. These data suggest that, despite current problems, the forestry sector in Europe still has significant economic potential, playing a role in the long-term development of many rural regions [144,145].

Within the EU, there are approximately 16 million private forest owners and the traditional forestry sector (forest management, logging, sawmilling, wood products, cork, among others) has employed more than 2 million people in recent years, generating a gross added value well above 100 million euro [146]. The ownership structure of forests varies greatly from small family farms, through publicly owned forests to large estates that are owned by investors [147]. About 60% of the forest area is, however, in private hands [148]. Many farms also own forests which ensure economic diversification by combining agricultural and forestry production [149]. In 2017, the gross value added of forestry in the EU-27 was 26.2 billion euros, marking an increase (+1.5%) on the level recorded in the previous year and forestry represented 0.2% of total EU gross value added [150]. Just over half of the total value added came from four member states: Finland, Sweden, France, and Germany. Each of them recorded a value between 3.2 billion euros and 3.8 billion euros. Forestry contributed less than 0.3% of total gross value added in around half (13) of the Member States. This share was higher than 1.0% in Estonia (1.2%), Latvia (1.7%) and Finland (1.9%) [93].

In recent years, just over half a million people in Europe have been employed in forestry activities, providing the basis for diversified economic activities in rural areas—from close forest management to timber industries, from tourism to hunting [67,151]. However, labor intensity of forestry and logging activities varies considerably between Member States. In this context, an important factor is the potential for efficient use of forest mechanization, which reflects (at least to some extent) the structure and characteristics of each forest, the tree density, the species affected by the cuts and the landscape topography [152,153]. The largest workforce was recorded in Poland (73,000 employed), Romania (48,000 employed), Sweden (41,000 employed) and Germany (40,000 employed) [154]. Between 2008 and 2018, jobs in forestry activities decreased moderately (−0.2%) in the EU [97]. A growing level of employment in some member states on the Eastern side was recently recorded, e.g., in Hungary (+50%, with around 7000 more employees) and Poland (which boasted the largest absolute increase, with more than 11,000 additional jobs, corresponding to +18% over the last decade). On the contrary, the most significant employment drop in the forestry sector was recorded in Croatia (−55%, corresponding to −17,000 employees on a ten-year basis) [67,151].

Industrial roundwood—a primary product of forestry together with firewood—is an important resource for the timber industries, being the basis for sawn wood and veneers. Europe is one of the largest producers of roundwood in the world [155]. Timber manufacturing industries form a key part of the manufacturing sector in the EU-27 member state [156]. In 2018, the 397,000 companies active in the wood industry, corresponding to almost a fifth

of the total for the entire manufacturing sector, employed 3.1 million people (equivalent to 10.5% of those employed in the manufacturing sector), while they generated 138.6 billion euro of added value. As such, manufacturing of wood products accounted for almost one in five firms (19.6%) across the EU manufacturing sector in 2018 [97]. Comparing this figure with the share of value added (7.1%) makes clear how small and medium enterprises—with fewer than 250 people employed—dominate the wood production chain [157].

Roundwood production in Europe has increased steadily in the last decades, decreasing temporarily in 2007–2008 due to the financial crisis, and showing important signs of recovery from 2010 onwards and since 2013 production completely recovered to pre-crisis levels (458 million cubic meters) [158]. More recently, production was estimated at 490 million cubic meters in 2018, having grown (+5.5%) compared with the previous year and being significantly higher (+21.2%) compared with 2000 [159]. This production proved to be substantially stable for hardwoods and more volatile for conifers, which represent three-fifths of the total roundwood production (60.4%, corresponding to 296 million cubic meters, [97]). In 2018, Sweden produced 75.1 million cubic meters of roundwood, a slight increase (+1.1%) compared with the previous year. Together with Sweden, Germany (71.8 million cubic meters), Finland (68.3 million cubic meters), France (48.2 million cubic meters) and Poland (46.7 million cubic meters) account for almost two third (63.3%) of the roundwood produced in the EU. The total production of sawn wood in the EU was estimated at 109 million cubic meters in 2018, increasing (+11.7%) in respect with ten years earlier. Germany and Sweden were again the main producers of sawn wood in the EU (respectively 21.9% and 16.9% of total EU-27 production). Finland was the only other EU member state to record a double-digit share (10.9%) in total wood production. Between 2008 and 2018, the increasing level of sawn wood production in the EU was mainly driven by production increases in Germany (+4.6 million cubic meters, corresponding to an increase of +23.7% in relative terms), Finland (+2.0 million cubic meters, +19.8%) and Romania (+1.3 million cubic meters, +35.6%). If, in general, the production of roundwood was significantly higher than that of firewood in almost all European countries, some significant exceptions have been observed in Denmark (54% of the timber produced is represented by firewood), Italy (63%), Greece (70%), the Netherlands (76%), and Cyprus (81%).

Despite the vitality of the wood-furniture supply chain testified by the economic data reported above, the drop in employment in the manufacturing sector, particularly evident between 2000 and 2019 (−9.6%), was more than proportionally reflected in the European wood industry [160]. Indeed, the number of workers employed in furniture production and wood product manufacturing decreased by about a quarter (−26.3% and −24.9%, respectively), with an increasingly male-dominated workforce [97]. If, in 2019, more than four out of five members of the workforce in the forestry sector were men (86.1%), only a slightly lower percentage (83.4%) was observed in the manufacturing of wood and its derivatives (83.4%), while the share of male employment was still slightly lower for furniture manufacturing (77.3%) [97].

5. The Framework of European Policies and Recent Innovations in Forest Planning

Assuming a systematic reduction of forest cover and woody resources in many parts of the world due to deforestation [161], the European Commission pursues the strengthening of regulatory actions to protect forest heritage, through the promotion of global value chains that do not determine deforestation and forest degradation (Stepping up EU Action to protect and restore the world's forests. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions) [162]. From 1980 onwards, the EU has implemented guidelines and action programs for the forestry sector, which have been sometimes implemented in the Common Agricultural Policy (CAP), particularly in rural development policies [163–165]. In the 1990s, forestry evolved from a marginal support of the CAP to a transversal instrument of European policies for sustainable development, moving to the approval of the Forest Strategy of the European Union in 1998 [166,167]. This was the

first reference framework including guidelines for action in the Member States according with the principles of Sustainable Forest Management [168]. The 2005 Forest Action Plan (FAP), aimed at ‘enhancing the forest heritage of the Union, maintaining and strengthening the multifunctional role of forests through active and aware management of the forests’ was the main implementing tool of the Strategy [169]. In 2013, with the new European Forest Strategy, and its revisions afterwards, the role of forests in climate mitigation and adaptation policies was strengthened, with the aim of stimulating a supply of renewable and environmentally compatible raw materials [170].

The forest strategy has also provided a coherent framework for community policies and a fine tuning of the forest policies of individual Member States, promoting the concept of sustainable forest management in the light of an efficient use of resources [30,171]. Strongly anchored to the Green Deal and the biodiversity strategy for the 2030 Agenda target, the new community strategy recognizes the central role of forests and the contribution of the entire value chain of this sector in creating, by 2050, a sustainable and climate-neutral economy, while ensuring the recovery, resilience, and adequate protection of all ecosystems—not just those dominated by forests [172]. Given that greenhouse gas emissions and removals by forests will play a crucial role in achieving the EU target of net removal of 310 million tons of CO₂ equivalents, these measures aimed at strengthening the protection and recovery of forest stocks, improving its sustainable management, and enhancing its monitoring and the effectiveness of decentralized planning, in order to allow these ecosystems to play a multifunctional role [173].

In order to further support a sustainable forest bio-economy for a zero-climate impact future, the strategy also proposes measures for the innovation and promotion of new materials and products capable of replacing their counterparts of fossil origin and to boost a non-timber-based forest economy [174–178]. This included ecotourism on the basis of the new strategy published in July 2021 and replacing the EU Forest Strategy adopted in 2013 and evaluated in 2018 (COM (2018) 811 Final) [162]. Finally, the strategy focused on sustainable reforestation (and afforestation) was accompanied by a roadmap for the planting of at least three billion new trees in the EU by 2030 [179].

This strategy was structurally associated with (and benefits from the operational interventions of) the CAP, which supports the vitality and economic profitability of rural areas through the Rural Development Plans (RDPs) [180]. These measures also represent the main source of economic support for the protection and sustainable management of community forests by promoting multifunctional forestry and sustainable forest management, combined with other development measures (advice and services, training, investments, cooperation) that respond to specific regional needs [181]. These actions also support forest expansion through reforestation and the renewal of agroforestry systems, providing operational and economic tools for the prevention of wildfires and natural disasters, restoration after damage, investments for mitigation and adaptation to climate change, as well as compensatory economic mechanisms and incentives for improving the economic value of forests and pre-industrial wood products [162,182,183].

In a particularly dynamic context like the current one, the European Commission has based the response to the crisis produced by the pandemic with the Next Generation EU, articulating it on three pillars: social cohesion, green economy, and digital transition [184,185]. In this perspective, the Carbon Border Adjustment Mechanism intends to protect its production from less ecological ones that arrive from outside the borders of the Union (see e.g., Ref. [186]). With the “Fit for 55” package, the continent is now called to achieve carbon neutrality by 2050, with an intermediate goal of 2030 (−55% emissions, see [187]).

Supported by economic resources, the member countries will also have to reach a target for the supply of critical raw materials, being regarded as fundamental (and constantly rising) inputs in the transition and development of renewables. In the furniture sector, the possible benefits of the circular economy are estimated in the EU at 160,000 additional jobs, 3.3–5.7 tons of additional reused and/or recycled materials, 3.3 to 5.7 mt of CO₂ equivalent avoided, and an increase of 4.9 billion euros in community added value [188,189]. The

challenge for the wood supply chain and for the furniture industry is therefore to fully and rapidly seize the opportunities of a truly sustainable development [190]. However, these policies are founded on the hypothesis that biomass combustion (including wood) can be categorized as emission-free energy source, as affirmed by EPA (Environmental Protection Agency) in 2018 (see <https://www.smithsonianmag.com/smart-news/epa-declares-burning-wood-carbon-neutral-180968880/>, accessed on 17 June 2023). Despite the lack of scientific evidence [191], this underlying statement continues to drive global strategies on climate change. On the contrary, most scholars have indicated a clear worsening of climate and a threat for forests in the case of a return to firewood as energy source [192,193].

Secondary, this political orientation will have a negative impact on the accessibility to wood resources contributing to the problems for companies of high-quality wood products such as furniture factories.

6. Discussion

The empirical evidence collected in our study documents the complexity of the ecological-economic nexus underlying forestry and the forest sector at large. From the ecological perspective, a better knowledge of forest ecosystems is a key information requirement to satisfy a competitive strategy for the supply chain that guarantees environmental protection objectives and full satisfaction of climate and energy targets in the context of Sustainable Development Goals adopted by all countries as part of the United Nations 2030 Agenda [75,194–196]. Currently, the information available on forest management practices in Europe still seem not extensive enough to provide a representative overview of ecosystem conditions, their economic value, and their biodiversity [197–200]. Furthermore, some national statistics may not be fully comprehensive, since they do not include all logging activities, some of which appear to be aimed at basic (and mostly informal) needs such as home heating [201,202]. Accurate quantification of forest land-use and related changes, and more accurate information on forest management practices and their impact on forest resources are urgently needed [203]. In this sense, remote methodologies will provide better information on changes in forest area and forest management [204–213]. This will include regular updates of land monitoring services under the Copernicus-Land initiative of Global Monitoring and Environmental Surveillance (GMES) system adopted by European Environment Agency (EEA), which will provide high-resolution forest information such as tree cover density, forest type and small woody tree characteristics [214–216]. All this information is necessary for an accurate monetary quantification of resource stock, which is still incomplete today [217].

From the economic perspective, if the production of wood and other products remains stable in Europe, the number of sawmills and infrastructures for forest uses are slowly decreasing. On the contrary, forest area and volumes have progressively increased in recent decades together with the carbon storage capacity of the forests. This is good news in itself, which however has a downside, as our forests are increasingly vulnerable, threatened by natural phenomena (climate change, floods, landslide) and by agricultural abandonment, which can generate economic instability and environmental degradation especially in disadvantaged and marginal districts (see e.g., Refs. [218–220]). Evaluating the forest stock, mainly in terms of high-quality timber for the furniture industry chain, represents a challenge for official statistics, which should offer the aggregate user with a broad information of recent economic and environmental trends, stimulating improvements in data completeness, indicator reliability, and timeliness updating.

A closer collaboration between member countries and regional authorities, will contribute to harmonizing information that increase the quality of economic assessments, with a view to rational and sustainable exploitation of forest resources [221]. Being intrinsically multi-disciplinary, issues dealing with forest supply chains are difficult to monitor exclusively through official statistics [222]. At the same time, our report confirms how the economic analysis needs a broader interpretation of the various organizational dimensions which include the issue of assessing environmental resources. For instance, this dimension

is still today characterized by partial statistics, methodological definitions that are not always coherent, and limited spatial detail.

Sector operators seem to have increased awareness of the importance of investments at company level, in favor of truly significant actions in the direction of circular economy, preserving the value of products, components, and materials within the economic system as long as possible [223]. Requiring a change of corporate, territorial and individual vision, rethinking the way of producing and consuming at the root, these actions should direct the production and consumption systems towards more efficient paths, thanks to continuous and regenerative cycles, allowing for a reduction in the consumption of raw materials and energy, the generation of waste, and emissions in production processes [224,225]. Circular approaches guaranteeing medium-term environmental sustainability are now widespread in the industrial strategies of all sectors, with circular principles advancing above all within companies that produce furniture, the most dynamic dimension of the supply chain [226,227].

In the wood supply chain, most materials appear destined for landfill or combustion. Usually, dead branches, barks, ashes and processing waste are considered only as elements to get rid of. Although labeled as by-products, these materials can enjoy a different epilogue in which to find a reuse of value and a good positioning within the market [225,228]. Most of the mulch products that are on the market come from very distant areas. This makes the recovery of the discarded bark interesting. Generally, barks and dead branches are used for low-cost thermoelectric combustion, while these materials can have a great nutritional value and can play a considerable role in soil protection. Ashes can be a high carbon fertilizer capable of complementing peat and other soil conditioners (see for example the best practices implemented by ProBest project at <https://www.goprobest.it/>, accessed on 13 June 2023).

In a circular forest management, the use of the so-called “cascade” wood should be favored. It consists in assigning priority to the recovery of materials rather than to the wood combustion for energy uses. Applying this concept helps the short supply chain of wood and the economy of communities living especially in marginal areas located in the vicinity of forests [226]. With this approach, a tree trunk is considered as a raw material to be used for as long as possible through its valorisation in construction, furnishing, recycling and reuse in the paper industry, or even in the textile sector.

The use of “cascade” wood is generally an excellent exercise for conceiving forests as multifunctional resources that provide essential services for the planet and for human activities [229].

In this perspective, interventions on the labor market in the wood-furniture supply chain should include efficient information campaigns and capillary structures throughout the territory, understood as fundamental principles of information and dissemination of knowledge and practices—also with reference to environmental sustainability and the energy transition in a broad sense [230,231]. Awareness of the importance of energy and climate issues, and the urgency of policy responses to ecological issues, is already a documented prerogative of supply chain companies [232,233]. The possibility of economically supporting and encouraging active companies from the point of view of good environmental practices, but also of technological innovation, ensures a just transition—economic, ecological and informational—towards new production scenarios sustainable in the long term and resilient to rapid global changes in societies and ecosystems [234–237].

7. Concluding Remarks

This work has discussed how forestry fulfills multiple functions and provides socio-economic benefits, including new jobs, growth opportunities in rural areas, and recreational functions that contribute to the physical and mental health of citizens [238–240]. In addition to the economic benefits directly generated by forestry, wood is a vital downstream input in the timber industry, also maintaining a significant use as an energy source. Social awareness of ecosystem services deriving from sustainable forest management is also

increasing [241,242]. In this context of lights and shadows, the regulatory and institutional framework is very heterogeneous and not always effective in forest sustainable management and protection. The introduction of technical and product innovations, as well as the adoption of innovative regulatory and programmatic instruments in the coming years, is highly recommended.

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