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Expert-Based Assessment of the Potential of Non-Wood Forest Products to Diversify Forest Bioeconomy in Six European Regions

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Citation: Huber, P.; Kurttila, M.; Hujala, T.; Wolfslehner, B.; Sanchez-Gonzalez, M.; Pasalodos-Tato, M.; de-Miguel, S.; Bonet, J.A.; Marques, M.; Borges, J.G.; et al. Expert-Based Assessment of the Potential of Non-Wood Forest Products to Diversify Forest Bioeconomy in Six European Regions. *Forests* **2023**, *14*, 420. https://doi.org/10.3390/f14020420

Academic Editor: Bradley B. Walters

Received: 6 December 2022
Revised: 27 January 2023
Accepted: 4 February 2023
Published: 17 February 2023

Abstract: The forest-based sector plays a significant role in supporting Europe on its pathway towards a more integrated and bio-based circular economy. Beyond the supply of timber, forest ecosystems offer a wide range of products and services beneficial to human wellbeing. Non-wood forest products (NWFPs) play an integral role in provisioning forest ecosystem services and constitute a huge portfolio of species from various taxonomic kingdoms. As diverse as the resources themselves is the list of end-products that may be derived from raw non-wood materials. Multiple value-chains of NWFPs provide benefits to actors across all stages of the supply chain. Forest management has not yet directed full attention towards NWFPs, since timber production remains the main management objective, although multi-purpose management is recognised as a key principle of the sector's sustainability paradigm. Lack of knowledge of the socio-economic relevance of NWFPs for European societies and diverse property rights frameworks increase the complexity in forest-based decision making additionally. In this study, the future potential of 38 NWFPs for diversifying the forest bioeconomy is investigated by means of multi-criteria analysis, including stakeholder interaction and expert involvement. The results for six case studies in different biogeographical zones in Europe indicate the latent opportunities NWFPs provide to forest owners who are willing to focus their management on the joint production of wood and non-wood resources as well as their value networks. This study intends to unravel perspectives for forest owners in particular, as they often represent principal decision makers in forest ecosystem management, act as main suppliers of NWFP raw materials, and thus can be understood as key stakeholders in a forest bioeconomy. Even though regional perspectives differ, due to varying socio-economic and ecological environments, there is huge potential to strengthen the economic viability of rural areas. Furthermore, sustainable co-production may foster the ecological integrity of forest ecosystems across Europe. Results show that wild mushrooms constitute the most widespread opportunity to increase additional income from forest management, but the most promising NWFPs can be found in the tree product, understorey plant and animal origin categories.

Keywords: non-timber forest products; decision support; stakeholder participation; co-production; sustainable forest management; diversification; natural resources management

1. Introduction

In recent years, the concept of sustainable forest management has shifted to a more ecosystem-based approach and redefined the understanding of the sector's sustainability paradigm, recognising the importance of biodiversity as well as interactions of neighborhood-, stand-, and landscape-level processes and considering a broader set of management objectives simultaneously [1–3]. When taking the human-centric perspective, utilising the entire portfolio of forest ecosystem services for the benefits of humankind is supposed to trigger multiple positive effects on contemporary global challenges like the mitigation of and adaptation to climate change, poverty reduction, or improving food security [4,5]. Thus, the forest-based sector is reinvigorating its diversity and opening up towards a European circular bio-based economy that builds strongly on a more holistic economic system, aiming at new modes of income generation across its multiple forest value chains [6–9]. Additionally, the EU forest strategy supports the socio-economic functions of forests for thriving rural areas and promoting non-wood forest-based bioeconomy, within sustainability boundaries [10].

Non-wood forest products (NWFP), i.e., products of biological origin other than wood derived from forests, other wooded land and trees outside forests [11], which represent a huge portfolio of resources from various taxonomic kingdoms, are expected to positively contribute to unlocking latent additional potentials of forestry production chains. They provide income to numerous forest owners who are willing to invest in the co-production of wood and non-wood resources and interested to engage in new NWFP businesses together with their value network partners in local to regional rural surroundings [12–17]. The value of marketed NWFP in Europe has been estimated at EUR 4 billion per year, nearly 20% the value of marketed roundwood [18]. Furthermore, 90% of European households regularly consume NWFP, while 26% collect some type of NWFP, at least once a year, for self-consumption or sale [19]. Since data availability on the production, management and use of NWFPs is still fragmented and scarce [20–23], it is not yet clear how far and through which governance mechanisms NWFPs may foster the economic viability of forest holdings in particular, or across actors along the entire value chain in general, and how much these opportunities may differ with regard to geographical regions, management concepts as well as forestry production systems [24]. Nevertheless, the value of NWFPs must not be neglected, but rather be taken into closer consideration, particularly when taking into account deficiencies in data quality and data availability as regards international reporting providing information on NWFPs [18,25,26].

Given the current state of knowledge regarding NWFPs in Europe, expert-based approaches can be understood as valuable concepts to unravel both the socio-economic and ecological dimensions of natural resources [24]. Knowledge-based expert tools to support forest management decision making have been successfully applied in a diverse range of research topics [27–33]; however, the transfer of knowledge from research into policy and practice is often dragging behind [34–36]. To support the development of an applicable decision support tool that has the power to inform decision and policy making at various scales (i.e., from local/regional over national to international) and is tailored towards extension service providers who give advice to forest owners, the expert model approach described in [24] was applied to foster the sustainable use of forest resources in different environmental conditions. One of the key intentions is to raise awareness among forest owners towards the sustainable co-production of wood and non-wood forest resources and thus contribute to product diversification of both small and large scale forest holdings as well as NWFP entrepreneurs and related value networks.

Recognising that NWFPs have been gaining momentum throughout Europe in recent years [13,37–40] the main objectives of this study are to investigate the potential of selected NWFPs in Europe and shed light on the diverse range of opportunities NWFPs may provide to forest owners who are willing to tailor their forest management more specifically towards the joint production of wood and non-wood goods [41,42] or focus their management on distinct NWFPs production systems (e.g., truffles, Christmas trees, aromatic and medicinal plants). The approach described in [24] is applied in six case study regions across Europe (i.e., Alentejo, Catalonia, Extremadura, North Karelia, Styria, and Transylvania), which represent different climatic, socio-economic and institutional environments and make it possible to discuss the economic, social as well as ecological potentials. Based on a harmonised approach for stakeholder participation the multiple dimensions of a portfolio of NWFPs considering various spatial and temporal scales are investigated from local to national levels. The uniqueness of individual NWFPs respectively the generalizability of the findings for categories of NWFPs are discussed on a European Union (EU) level. In this regard, the opportunities for the formulation as well as the implementation of European policies that aim to foster the further development of the (non-wood) forest-based sector across its member states towards 2030 and beyond are described.

2. Materials and Methods

2.1. Study Design and Case Description

With the aim of mirroring a diverse portfolio of ecological and socio-economic conditions, six case studies (CSs) in different biogeographical zones were set up—(a) Mediterranean (Alentejo, Extremadura, Catalonia), (b) Alpine (Catalonia, Styria, Transylvania), (c) Continental (Styria, Transylvania) and (d) Boreal (N-Karelia)—covering the major biomes (i.e., Dry, Subtropical, Temperate, Boreal) in Europe (Figure 1).

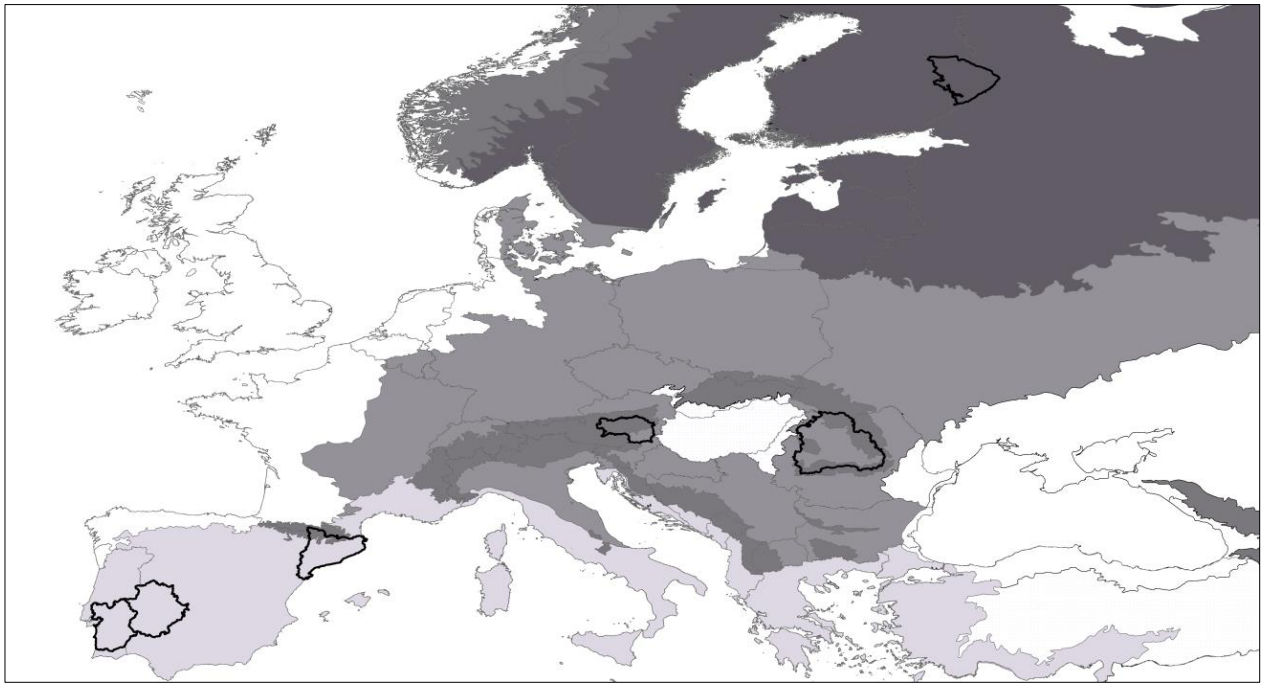

Figure 1. Overview of the case studies in Europe and related biogeographical zones.

Each CS represents a distinct geographical area with diverse ecological as well as socio-economic environments. In addition to different climatic conditions, the CSs comprise various forest ecosystems, including different regional key tree species as well as varying ownership structures (Table 1). To provide some context information for the CS comparison,

with a particular focus on the natural environment and related aspects relevant to (non-wood) forest management, each of the CSs is introduced in more detail prior to analysis.

Table 1. Ecological and socio-economic characterisation of case studies.

CS	Area (km^2)	Share of Forest Area (% of Total Land Area)	Climatic Conditions	Main Tree Species	Share of Private Forest Owners (%)
Alentejo	31,605	43.0	Mediterranean	*Quercus suber* L., *Quercus ilex* L., *Eucalyptus globulus* St.-Lag., *Pinus pinea* L.	98.0
Catalonia	32,114	64.0	(i) Mediterranean near coastal areas (ii) Continental Mediterranean central and western Catalonia (iii) Alpine northern Catalonia (Pyrenees)	*Pinus sylvestris* L., *Pinus halepensis* Mill., *Quercus ilex*, *Pinus nigra* J.F.Arnold, *Pinus uncinata* Domin, *Quercus suber*	75.4
Extremadura	41,634	65.5	Mediterranean	*Quercus ilex*, *Pinus pinaster* Ait., *Quercus suber*, *Quercus pyrenaica* Willd.	93.0
N-Karelia	21,584	89.1	Boreal	*Picea abies* L. H. Karst., *Pinus sylvestris*, *Betula pendula* Roth *and Betula pubescens* Ehrh.	55.0
Styria	16,401	61.0	Illyric, pannonian, sub-alpine	*Picea abies*, *Fagus sylvatica* L., *Larix decidua* L., *Pinus sylvestris*	55.5
Transylvania	99,837	37.0	Continental moderate	*Fagus sylvatica*, *Picea abies*, *Quercus sp.*	31.9

2.1.1. Alentejo

Continental Portugal extends over an area of 89,089 km^2 and is located in the south-western area of Europe with a temperate/mesothermal climate. According to the last Portuguese National Forest Inventory, "NFI6" [43], the forest area covers 32,000 km^2, corresponding to 35% of the country's territory. Alentejo extends over 1/3 of the country's territory. Located in Southern Portugal, it is a relatively flat region where private property predominates. Northern Alentejo is characterised by small and medium-sized properties (up to 20 ha), while the southern region is dominated by large- and very-large-scale properties (>50 ha) [44]. Cork oak (*Quercus suber*) (48%) and holm oak (*Quercus ilex*) (23%) stands represent around 71% of the Alentejo forest area, while eucalypt (*Eucalyptus globulus*) plantations and umbrella pine (*Pinus pinea*) stands extend over about 15% and 9% of the area, respectively [43]. These forest ecosystems provide wood and non-wood forest products as well as other services such as carbon sequestration, nature conservation (e.g., biodiversity, geo-monuments), tourism, and the protection of soil and water, and thus offer diverse opportunities to link domestic forest production chains to a more biobased European economy.

2.1.2. Catalonia

Catalonia is located in the north-eastern part of Spain. It is a forested region with 64% of its territory (i.e., around 2 mio ha) corresponding to forest and other wildland areas, some of them open forests, scrublands and grasslands. Most Catalan forests are privately owned, still young, and often too dense. The heterogeneity and low economic profitability together with the small extension of the forest ownerships in Catalonia (97.5% of the forest owners have less than 50 ha [45]) and other factors lead to a lack of management in most of the forests (the estimated annual increment of forest growing stock is 3.1 m^3/ha/yr, and the annual harvests remain at 0.7 m^3/ha/yr, resulting in an average harvesting intensity

ranging from 20 to 25%). Further insights into the potential of emerging forest value chains could provide additional assets for small scale forest owners and foster the development of new business networks that catalyse the species richness of their forests for a growing bioeconomy. Catalonia is characterised by a great diversity of forest species and structures, ranging from typical Mediterranean forests to other characteristic forest ecosystems of more humid conditions. A total of 60% of the forests are dominated by conifers, 20% are sclerophyllous forests, 13% are deciduous broadleaved forests and the remaining 7% are a mixture of several of these groups. Around 100 different tree species have been recorded in recent forest inventories, although the 13 most common species account for more than 90% of the total number of trees. The main tree species in Catalonia are: *Pinus halepensis*, *Pinus sylvestris*, *Quercus ilex*, *Pinus nigra*, *Quercus suber*, *Quercus humilis*, *Pinus uncinata*, *Pinus pinea* and *Fagus sylvatica*.

2.1.3. Extremadura

The region of Extremadura is located in the south-west region of Spain, bordering Portugal. With an approximate area of 41,600 km^2 it is one of the largest regions in Spain, representing 8% of the total Spanish land area. The forest area comprises almost two-thirds (65.5%) of its territory, with most of its forests being privately owned (93%). Forests in Extremadura are characterised by different climatic and environmental conditions. Zones with Mediterranean climate are the most abundant, while continental climate zones are less extended. Within each climatic zone, forest ecosystems are homogeneous and constitute mainly of *Quercus ilex* (68%). Other relevant tree species in the region are *Quercus suber* (9%), *Pinus pinaster* (7%), *Quercus pyrenaica* (5%), *Eucalyptus camaldulensis* Dehnh. (5%), *Pinus pinea* (2%) and *Castanea sativa* Mill. (0.5%) [46]. More than one-third of the forest area (37%) corresponds to open woodlands called "dehesa". Dehesas are biodiversity-rich habitats (i.e., hotspots) and priority ecoregions for global conservation [47]. They are protected under the Pan-European network "Natura 2000". Currently, the most widely accepted definition for "dehesas" is that of an agro-silvo-pastoral system consisting of an open overstorey of Mediterranean evergreen oaks, mainly holm oak and cork oak, of varying densities (20–80 trees/ha) [48]. The understorey vegetation is composed of a mosaic of croplands, grasslands and shrublands, dominated by winter annuals where cattle, sheep, pigs and goats are extensively raised. For centuries, they have been intensively managed to maximise the output of direct products in the form of grazing, browse, acorns, cork, cereals, firewood, and charcoal [49]. Given the unique environmental conditions and taking advantage of the multiplicity of natural resources available, it is necessary to better understand the opportunities related to the natural capital of the region and derive management recommendations in order to inform forest-related decision making.

2.1.4. North Karelia

Finland's forests predominantly represent a boreal forest type. North Karelia is the eastern-most region in Finland, and has a total area of 21,584 km^2, including 3821 km^2 of inland water areas. Forests cover most of the land area as the forestry land (e.g., forest land, poorly productive forest land, unproductive land, forest roads, depots, etc.) area is 15,890 km^2 (89.5%). Private non-industrial forest ownership (i.e., family forests) is the most typical form in North Karelia, representing 56% of the forest area. Additionally, companies (mainly forest industry related) and the state own good shares of the region's forests, 21% and 19%, respectively [50]. The typical tree species are Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and birch (*Betula pendula* and *Betula pubescens*). Most of the forests are managed, with the main aim being timber production. The protected forest area is 56,000 ha, of which strictly protected forests represent 42,000 ha. In forest management, the principles of even-aged management dominate, although uneven-aged forest management is also possible if owners aim for such approaches [51]. The forests, however, produce a variety of different products and services, and their use is diverse due to broad everyman's rights. In addition to roundwood cuttings which, e.g., in 2013 amounted to 5.5 mio m^3 [50],

the region's forests are actively used for berry and mushroom picking, hunting, as well as various other recreational activities [24]. Considering contemporary forest management in the region, it can be recognised that there is a shift towards ecosystem-based approaches, offering new perspectives to forest owners and their business networks that entail the sustainable exploitation of the diverse portfolio of forest resources, and hence require additional knowledge on both traditional and innovative forest value chains.

2.1.5. Styria

Austria is a predominantly alpine Central European country with an area of 83,871 km^2 situated in the Central European climatic zone (moderate, humid). Styria is the second largest province out of nine federal states in Austria, located in the south-eastern region of the country. Around 61% of the territory is forested, totalling some 1 mio ha of forest land (i.e., ~25% of the total forest area in Austria). The share of conifers is around 70%, with Norway spruce (*Picea abies*) being the dominant tree species. In recent decades, there have been massive structural changes in the agricultural and forestry sector in Austria in general (e.g., decrease in traditional family holdings, increase in sideliners/part-time farmers and "new" forest owners). In 2010, the number of forest holdings in Styria, which has been continuously decreasing since the end of the 1990s, was around 39,000, providing employment for nearly 96,000 people [52]. Timber production is the main production goal of forest enterprises, and has helped to develop a strong timber industry. NWFPs have been of high relevance, historically (e.g., resin tapping, leaf and litter collection), with some traditional uses that are still important today (e.g., hunting, fishing, gravel digging). New modes of utilisation that are often strongly related to protective and recreational forest functions and related ecosystem services are also emerging, for instance: (i) protection against natural hazards; (ii) kerbing of drinking water; (iii) horse-back riding; and (iv) mountain biking [53]. However, interest in NWFPs has been reinvigorated recently, stimulating businesses centred on both traditional as well as innovative uses of non-wood forest resources [40,54]. This holds true for small-scale forest owners as well as for bigger forest enterprises [55]. Expert-based assessments that aim to address the current forest operational environment and integrate all pillars of sustainability to holistically address the benefits forests may provide to their owners may foster a transition towards a national bioeconomy.

2.1.6. Transylvania

Transylvania is one of three historical regions in Romania located in the northwestern–central part of Romania, covering 16 counties (i.e., Alba, Arad, Bihor, Bistriţa-Năsăud, Braşov, Caraş-Severin, Cluj, Covasna, Harghita, Hunedoara, Maramureş, Mureş, Sălaj, Satu Mare, Sibiu, and Timiş), with an area of 99,837 km^2. In Transylvania, forests account for 3.67 mio ha, i.e., (i) 37% of the total land area which exceeds the share of forest area at national level (which is 29.6%), and (ii) approximately 54% of total forested land in Romania. The most common tree species in Transylvania is beech (*Fagus sylvatica*) (35%), followed by resinous species (26%), mainly Norway spruce (*Picea abies*), oak species (16%), mainly Sessile oak (*Quercus petraea* Matt. Liebl.) and other hardwood species (23%). The standing wood volume in Transylvania accounts for 54% of the total volume estimated for Romanian forests [56]. According to recent national statistics [57], this region has close to 6.75 mio inhabitants. The region was always characterised by a multi-cultural aspect, with a significant presence of Romanians, Hungarians and Germans. This can be observed, for instance, in the popular names given to some mushroom species, like "hribi" (*Boletus edulis* Bull.), with Slavonic origin, "mănătarcă" (*Boletus edulis*), with Greek origin, or "popinci" (*Armillaria mellea* (Vahl) P. Kumm), with Serbian origin [58]. From a socio-economic perspective, the most relevant NWFPs in Transylvania consist of forest fruits, edible mushrooms, game and medicinal plants. Considering the resource potential of Romanian forests and both existing as well as emerging bio-based resource markets, NWFP value chains can play a vital role in the development of regional economies.

2.2. Case Study Implementation of the Expert Model

The modelling framework designed in [24] was used to systematically evaluate both qualitative and quantitative criteria and alternatives in a multi-criteria analysis (MCA). The proposed model builds on the Analytic Hierarchy Process (AHP), an indicator-based MCA method that supports collaborative decision making based on the values and judgements of individuals [59]. The higher level of the hierarchy is decomposed into four main criteria: (a) Market potential; (b) Institutional potential; (c) Requirements; and (d) Resource potential. "Market potential" synthesises current opportunities of a certain NWFP to bring it to local, regional, national, or international markets. "Institutional potential" depicts opportunities in utilising supportive structures and organisations with regard to a single NWFP. "Requirements" highlights necessities for NWFP production and harvesting. "Resource potential" gives an estimate of the potential to successfully produce and/or harvest a single NWFP. The lower level of the hierarchy (i.e., sub-criteria) further decomposes the higher-level criteria and aims to specifically address the perceptions and interests of a single forest owner/manager in producing, harvesting and selling NWFPs [24]. Four relevant forest owner profiles on a rural–urban continuum of lifestyles [60,61] were identified, and were applied to define the individual priorities for the sub-criteria of the AHP. The profiles primarily take into account the owner's potential interest, know-how, financial assets, and time available for the required NWFP-related business activities at the individual holding level [24].

In this study, the applicability of this approach in a range of socio-economic and environmental contexts and to evaluate a suite of selected NWFP species across four defined NWFP categories was tested. The following tasks were conducted in each of the CSs iteratively: (i) nomination of the persons responsible for the CS; (ii) identification of NWFP sector experts and NWFP stakeholders; (iii) selection of regionally relevant NWFPs; (iv) selection of forest owner profiles; and (v) stakeholder and expert consultation. Table 2 provides an overview of the NWFPs selected per CS, derived from regional participatory processes with the support of various NWFP stakeholders who were identified by regional case studies responsible for the selection of NWFPs and for contributing to the expert assessments. Their expertise and knowledge of the complex relations of NWFP markets, management and policy frameworks was a prerequisite to running the AHP model and deriving regionally explicit weights, i.e., relative priorities, for defined criteria in the analytical hierarchy.

Targeting at a cross-CS comparison and following four NWFP categories—(i) Mushrooms & Truffles, (ii) Understorey plants, (iii) Tree products, and (iv) Animal origin—each CS aimed to identify at least one representative NWFP per category based on the input and support of the regional stakeholders. NWFPs were selected under the premise of social and/or economic relevance (i.e., current or potential future importance according to traditional and innovative uses) in the region, while at the same time considering the regions' current operational environment, also including future opportunities. Based on these considerations, a total of 38 NWFPs, (i.e., five in Catalonia, Extremadura and N-Karelia; seven in Alentejo; eight in both Styria and Transylvania) were chosen and subjected to the evaluation, of which there were seven in the category "Mushrooms & Truffles", seven in "Understorey plants", eleven in "Tree products" and eleven in "Animal origin" (where only game meat of individual game species was considered besides honey). Taking into account the fact that single NWFPs were selected in several CSs (e.g., Cep, Honey), and thus reduced the total portfolio of individual products, the final number of NWFPs investigated amounted to 23. Extremadura was lacking a NWFP in "Understorey plants", but possessed three products of "Animal origin" (cerdo ibérico, game meat from red deer, honey). Meanwhile, in Alentejo, "Tree products" dominated the selected NWFP portfolio (cork, pine nuts, pine resin); there is a good balance across the NWFP categories in the other CSs.

To mimic the diverging interests of forest owners in the decision analysis (i.e., by means of weighting scenarios for certain criteria), a set of four distinct forest owner profiles

on a rural-to-urban continuum was used: (i) hands-on nurturer (FO 1); (ii) part-time outsourcer (FO 2); (iii) urban value extractor with rural background (FO 3); and (iv) urban value extractor without connection to agriculture/forestry (FO 4). These profiles primarily integrate the owner's potential interest, know-how, financial assets, and time resources available to work at or manage their forest land or forest holding, and were based on the variation of lifestyles and assets of forest owners within the subsequent urban–rural continuum [60,61]. Each CS responsible had to decide upon the applicability of these profiles with respect to the prevalent regional forest owner landscape (i.e., ownership structure, owner type, management approaches) together with their NWFP experts who actively engaged in the stakeholder interactions. Table 3 indicates the forest owner types (i.e., FO 1–4) that were selected and perceived to be applicable in each CS, as well as the corresponding weights for the sub-criteria (see details in [24]).

Table 2. NWFPs (including species information as Latin names) investigated in the case study regions split into four NWFP categories. Additionally, information on the number and type of experts is included, as well as on the stakeholders involved in the evaluation process.

Region	Mushrooms & Truffles	Understorey Plants	Tree Products	Animal Origin	Involved Regional Stakeholder Groups Providing Input
Alentejo	Cep (*Boletus edulis*)	Yellow lavender (*Lavandula viridis*)	Cork (*Quercus suber*) Pine nuts (*Pinus pinea*) Pine resin (*Pinus spp.*)	Honey (*Apis mellifera*) European rabbit (*Oryctolagus cuniculus*)	Forest Owner Associations Forest owners Industrial Producers Association National Forest Authority NWFP Researchers
Catalonia	Saffron milk-cap (*Lactarius deliciosus*) Black truffle (*Tuber melanosporum*)	Yellow gentian (*Gentiana lutea*)	Cork (*Quercus suber*)	Wild boar (*Sus scrofa*)	Forest owners NWFP experts on selected products NWFP researchers Protected Forest areas representative Regional Forest service representatives
Extremadura	Cep (*Boletus edulis*)		Cork (*Quercus suber*)	*Cerdo ibérico* (*Sus scrofa domestica*) Red deer (*Cervus elaphus*) Honey (*Apis mellifera*)	Forest owner Forestry professionals NWFP yield experts NWFP researchers Regional authority representative
N-Karelia	Cep (*Boletus edulis*)	Bilberries (*Vaccinium myrtillus*)	Birch sap (*Betula pendula*) Pakuri mushroom (*Inonotus obliquus*)	Honey (*Apis mellifera*)	Forest owner NWFP entrepreneur NWFP yield expert Provincial land-use authority Provincial forest policy group NWFP researchers
Styria	Chanterelles (*Cantharellus cibarius*) Cep (*Boletus edulis*)	Bilberries (*Vaccinium myrtillus*) Wild garlic (*Allium ursinum*)	Larch resin (*Larix decidua*) Christmas trees (*Abies nordmanniana*)	Red deer (*Cervus elaphus*) Honey (*Apis mellifera*)	Forest owner Forest owner interest group NWFP association NWFP entrepreneur NWFP researchers Provincial forest authority
Transylvania	Cep (*Boletus edulis*) Chanterelles (*Cantharellus cibarius*)	Rose hips (*Rosa canina*) Bilberries (*Vaccinium myrtillus*)	Seeds (*Picea abies*) Christmas trees (*Abies alba*)	Wild boar (*Sus scrofa*) Brown hare (*Lepus europeaus*)	Forest owner Local forest authority National forest authority NWFP entrepreneur NWFP researchers

Table 3. Forest owner profiles (FO 1 = hands-on nurturer, FO 2 = part-time outsourcer, FO 3 = urban value-extractor, FO 4 = urban value-extractor without connection to forestry/agriculture) and their relative weights for the sub-criteria of the four main criteria of the decision problem.

Criteria	Subcriteria	FO 1	FO 2	FO 3	FO 4
Market potential	Competitiveness	0.2308	0.2500	0.2667	0.3333
	Current end product diversity	0.2308	0.2500	0.2667	0.2000
	Current end product value	0.3077	0.1875	0.2000	0.3333
	Low resource input for end product value	0.2308	0.3125	0.2667	0.1333
Institutional potential	Future innovation potential	0.3571	0.3333	0.3333	0.3571
	Supporting policy instruments	0.2857	0.3333	0.3333	0.3571
	Potential for cooperation	0.3571	0.3333	0.3333	0.2857
Requirements	Time needed for production	0.0833	0.2308	0.3077	0.4167
	Time needed for harvesting	0.1667	0.2308	0.2308	0.3333
	Resources (needed investments)	0.3333	0.2308	0.2308	0.1667
	Required know-how/skills	0.4167	0.3077	0.2308	0.0833
Resource potential	Low-level of threats	0.3125	0.2500	0.2500	0.1765
	Exclusion potential	0.3125	0.3125	0.3125	0.2941
	Uniqueness	0.2500	0.2500	0.1875	0.2353
	Quantity	0.1250	0.1875	0.2500	0.2941

Apart from the "Institutional potential", where forest owner preferences are homogeneously distributed across the three sub-criteria, there is a clear notion of diverging preferences for the remaining sub-criteria. The most uniform attitude towards a single criterion applies to "Exclusion potential", i.e., the ability to exclude others (third parties) from the production or harvest of a certain NWFP, while the most differentiated opinions are recorded for "Time needed for production" and "Required know-how/skills". The former refers to the time span considering the production of a certain NWFP and acknowledges temporal aspects to mirror the effects of different rotation periods (assuming that the production is initiated from bare land). The latter indicates the level of knowledge required to sustainably manage a certain NWFP. The individual weighting scenarios (FO 1–4) were implemented in the expert model and support the scenario as well as sensitivity analyses. Additionally, an "equal" scenario that assigns equal weights to all sub-criteria and criteria (i.e., all have the same relevance) and a "regional" scenario that integrates the results from the regional stakeholder interaction processes for the criteria exclusively were applied.

The software Expert Choice Desktop (v. 11.5.1683) was used to conduct the comparative judgments by means of pairwise comparisons and calculated the final results following the routine of an Analytic Hierarchy Process [59]. A Principal Component Analysis (PCA) was performed to identify potential similarities or differences of the investigated NWFPs, and extract important information from dependent variables to describe clusters of NWFPs along with the orthogonal variables called principal components (cf. [62]).

3. Results

Based on a defined participatory approach building upon (i) a single stakeholder workshop or (ii) a two-stage electronic Delphi study [24], the stakeholder perceptions towards regional NWFP sectors were identified. Apart from Styria, all CS responsibles applied the Delphi method. Table 4 indicates the outcomes of the stakeholder interaction processes as relative weights for the criteria of the decision problem that give indication on the relative importance of a single criterion within a distinct case study and allow for comparison with other case studies. Looking across CSs, the "Market potential" is the most important aspect (in four out of six regions), followed by the "Resource potential" (in two out of six regions). Both criteria appear to be of high relevance in general, though, as each of them was ranked either first or second in all six regions. "Requirements" are perceived to be very relevant as well (i.e., ranked third in all six regions), while the least

recognition is attributed to "Institutional potential" which gained the lowest priorities (i.e., weights) across all CS regions. At the individual CS level, a dominance of market potential in Alentejo and a more resource-driven attitude in N-Karelia and Transylvania can be recognised, while the most homogeneous distribution of weights applied in Catalonia.

Table 4. Regional weights for the criteria of the decision problem per case study region, with the most relevant criterion highlighted in bold letters.

Region	Market Potential	Institutional Potential	Requirements	Resource Potential
Alentejo	**0.373**	0.155	0.209	0.264
Catalonia	**0.283**	0.211	0.233	0.273
Extremadura	**0.314**	0.200	0.243	0.243
N-Karelia	0.230	0.210	0.230	**0.330**
Styria	**0.350**	0.075	0.275	0.300
Transylvania	0.300	0.100	0.200	**0.400**

The performances of the investigated NWFP alternatives were calculated based on pairwise comparisons, conducted by means of an Analytic Hierarchy Process [59], regarding each sub-criterion and using the criteria weights in each CS. The results across all regions are complete except no relevant NWFP species is given for the Understorey category in Extremadura. Table 5 gives an overview of the final results (i.e., global priorities) under several weighting scenarios. According to the results of the AHP model, the most rewarding NWFPs were spread across three categories: (i) Tree products (cork, larch resin and Christmas trees); (ii) Understorey (yellow gentian, bilberries); and (iii) Animal origin (cerdo ibérico). Apart from Styria, where larch resin performed better than Christmas trees under the FO 1 scenario, the results appear to be very robust since most relevant NWFPs perform best across all weighting scenarios in each CS. Looking at the results of NWFP alternatives on the CS level, the effect of different weightings becomes more evident. Rank reversals occur for individual scenarios, i.e., the rankings (according to the performances expressed as global priorities) of NWFP alternatives change between scenarios (equal, regional, FO 1–4). In Alentejo, cork is the dominant product, significantly outranking all other NWFPs. Pine nuts and yellow lavender are the second-most relevant NWFPs depending on the underlying scenario (i.e., pine nuts for equal, regional, FO 3 and FO 4; yellow lavender for FO 1 and FO 2). Yellow gentian performed best in Catalonia, where cork (i.e., equal, regional, FO 1) and black truffle (i.e., regional, FO 2, FO 3 and FO 4) represent the second-most suitable options. In the Extremadura region, the rankings remained the same for all scenarios, with cerdo ibérico being the most favourable NWFP, followed by cork and Cep. In N-Karelia, too, the results were stable regarding the rankings of NWFPs, with bilberries being depicted as the most auspicious option. Pakuri mushroom and honey received the same preference rating under the "equal" scenario, for all others they ranked second (Pakuri mushroom) and third (honey). In Styria, Christmas trees represent the most valuable option in general. Only under the "FO 1" scenario did larch resin perform better, the NWFP option that came in second for all other scenarios apart from "equal", where it was outranked by honey. Honey was the third-most suitable option except for in the FO 1 scenario, where Cep scored better. In Transylvania, the order of the first three NWFPs did not change across scenarios, i.e., bilberries (first), Cep (second) and rose hips (third), but for some options, rank reversals occurred under certain weighting scenarios (e.g., chanterelles vs. wild boar, seeds vs. brown hare).

Table 5. Performance (i.e., global priorities) of NWFPs in the case studies per weighting scenario, highlighting the most promising NWFP in bold letters (equal = equal weights for criteria and sub-criteria; regional = regional weights from Table 4 and equal weights for sub-criteria; FO 1–FO 4 = regional weights for criteria and the sub-criteria weights according to forest owner potential from Table 3).

CS	Category	Species	ID	Equal	Regional	FO 1	FO 2	FO 3	FO 4
Alentejo	Mushroom & Truffle	Cep	1	0.121	0.111	0.127	0.112	0.110	0.096
	Tree product	**Cork**	2	**0.263**	**0.270**	**0.261**	**0.259**	**0.265**	**0.296**
	Tree product	Pine nuts	3	0.177	0.176	0.170	0.168	0.170	0.195
	Tree product	Pine resin	4	0.102	0.106	0.111	0.119	0.112	0.089
	Understorey	Yellow lavender	5	0.163	0.168	0.175	0.174	0.168	0.137
	Animal origin	Honey	6	0.095	0.093	0.085	0.092	0.096	0.103
	Animal origin	European rabbit	7	0.080	0.076	0.071	0.075	0.078	0.084
Catalonia	Mushroom & Truffle	Saffron milk-cap	8	0.142	0.135	0.150	0.135	0.132	0.108
		Black truffle	9	0.215	0.207	0.201	0.209	0.210	0.231
	Tree product	Cork	10	0.217	0.207	0.205	0.204	0.206	0.223
	Understorey	**Yellow gentian**	11	**0.294**	**0.324**	**0.336**	**0.329**	**0.316**	**0.295**
	Animal origin	Wild boar	12	0.132	0.127	0.107	0.123	0.135	0.142
Extremadura	Mushroom & Truffle	Cep	13	0.183	0.190	0.222	0.205	0.189	0.135
	Tree product	Cork	14	0.237	0.232	0.239	0.230	0.228	0.238
	Animal origin	***Cerdo ibérico***	15	**0.368**	**0.369**	**0.356**	**0.357**	**0.366**	**0.403**
		Red deer	16	0.096	0.094	0.082	0.091	0.096	0.102
		Honey	17	0.116	0.115	0.100	0.116	0.121	0.123
N-Karelia	Mushroom & Truffle	Cep	18	0.131	0.125	0.137	0.124	0.121	0.110
	Tree product	Birch sap	19	0.153	0.166	0.163	0.168	0.171	0.169
		Pakuri mushroom (Inonotus obliquus)	20	0.219	0.230	0.232	0.234	0.227	0.234
	Understorey	**Bilberries**	21	**0.277**	**0.270**	**0.281**	**0.263**	**0.261**	**0.255**
	Animal origin	Honey	22	0.219	0.210	0.187	0.211	0.220	0.232
Styria	Mushroom & Truffle	Cep	23	0.110	0.118	0.129	0.116	0.111	0.112
		Chantherelles	24	0.108	0.114	0.121	0.113	0.108	0.107
	Understorey	Bilberries	25	0.102	0.100	0.110	0.101	0.099	0.086
		Wild garlic	26	0.113	0.114	0.117	0.112	0.112	0.106
	Tree product	**Larch resin**	27	0.142	0.151	**0.165**	0.149	0.149	0.156
		Christmas trees *(Abies Nordmanniana)*	28	**0.162**	**0.153**	0.138	**0.157**	**0.161**	**0.168**
	Animal origin	Red deer	29	0.120	0.119	0.110	0.122	0.125	0.129
		Honey	30	0.143	0.131	0.111	0.129	0.135	0.136
Transylvania	Mushroom & Truffle	Cep	31	0.167	0.155	0.157	0.150	0.148	0.163
		Chantherelles	32	0.114	0.102	0.100	0.099	0.099	0.107
	Tree product	Seeds *(Picea abies)*	33	0.079	0.077	0.082	0.079	0.078	0.078
		Christmas trees *(Abies alba)*	34	0.116	0.120	0.130	0.129	0.124	0.104
	Understorey	Rose hips	35	0.161	0.144	0.138	0.139	0.142	0.141
		Bilberries	36	**0.216**	**0.214**	**0.215**	**0.211**	**0.209**	**0.211**
	Animal origin	Wild boar	37	0.084	0.110	0.102	0.111	0.116	0.115
		Brown hare	38	0.063	0.077	0.077	0.081	0.084	0.082

When looking at the results of NWFP categories in an aggregated way (Figure 2), considering the same weighting scenario (i.e., equal) across CS to eliminate the effect of diverging weights, it can be observed that products of animal origin appear to be highly important in Extremadura (0.580), whereas in all other regions, their potential is lower (i.e., Alentejo = 0.175; Catalonia = 0.132; N-Karelia = 0.219; Styria = 0.263; Transylvania = 0.146).

Mushrooms & Truffles are of high relevance in Catalonia (0.357) and Transylvania (0.281). For other regions, they score not as high (Alentejo = 0.121; Extremadura = 0.183; N-Karelia = 0.131; Styria = 0.218). Tree products constitute an important NWFP category in all CS regions, in particular in Alentejo (0.542), but also in N-Karelia (0.372). They also perform well in Styria (0.304), while in Catalonia (0.217), Extremadura (0.237) and Transylvania (0.195) they appear to be less relevant. The results show high scores for understorey plants in Transylvania (0.377), Catalonia (0.294) and N-Karelia (0.277). Meanwhile, for Alentejo (0.163) and Styria (0.215), they also appear to be a suitable option, while their potential

for Extremadura seems not yet to be existent or is still unexplored (i.e., lacking in NWFP alternatives).

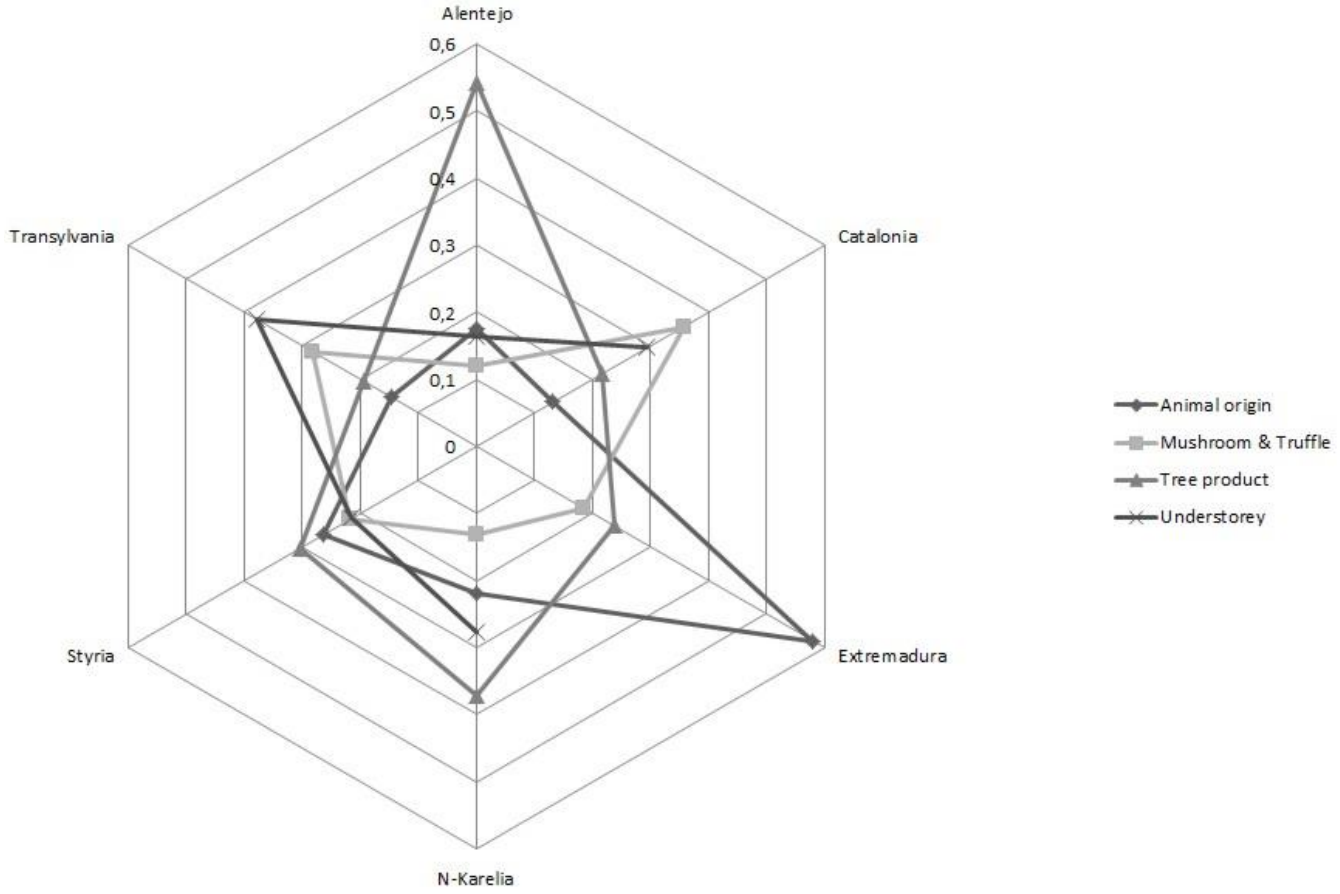

Figure 2. Cross-case study analysis of the overall performance (i.e., sum of global priorities) of the four NWFP categories under the "equal" weighting scenario.

The Principal Component Analysis (PCA), performed under the "equal" scenario, unravels patterns of NWFP groups following data reduction to a fewer number of variables, i.e., principal components. The loadings presented in Table 6—which are from a numerical point of view, equal to the coefficients of the variables—provide information about which variables give the largest contribution to the components. High values (towards 1 or −1) indicate a strong influence on the component; the sign of a loading (+ or −) indicates whether a variable and the principal component are positively or negatively related.

Current end-product value (0.880), Current end-product diversity (0.830), and Uniqueness (0.826) strongly contribute to Principal Component 1 (PC1). These parameters relate to aspects of market economies and innovation and are summarised as "market novelty". Skills/know-how (0.816), resources (0.775), and low levels of threats (0.666) particularly contribute to PC 2, and thus can be translated into "resource potential" in the following. In Figure 3, the individual NWFP alternatives are plotted according to their results (i.e., factor scores) for the two principal components. The results indicate that products of animal origin perform quite similar in all cases. Additionally, mushrooms show nearly the same results with respect to principal component loads. Among the outliers are cork, cerdo ibérico, bilberries (in N-Karelia), black truffles, and yellow gentian, as each of them scores high for at least one principal component.

Table 6. Rotated component matrix indicating the loadings of principal components 1 and 2 per criterion.

Criterion	Principal Component 1	Principal Component 2
Current end-product value	0.880	0.190
Current end-product diversity	0.830	0.276
Uniqueness	0.826	0.199
Competitiveness	0.800	−0.143
Supporting policy instruments	0.734	−0.371
Future innovation potential	0.725	0.331
Potential for cooperation	0.658	−0.475
Time needed for harvesting	0.653	−0.405
Quantity	0.217	−0.021
Skills & know-how	−0.003	0.816
Resources	0.217	0.775
Low level of threats	0.071	0.666
Exclusion potential	0.389	−0.595
Low resource input for end-product value	0.102	0.567
Time needed for production	0.053	−0.280

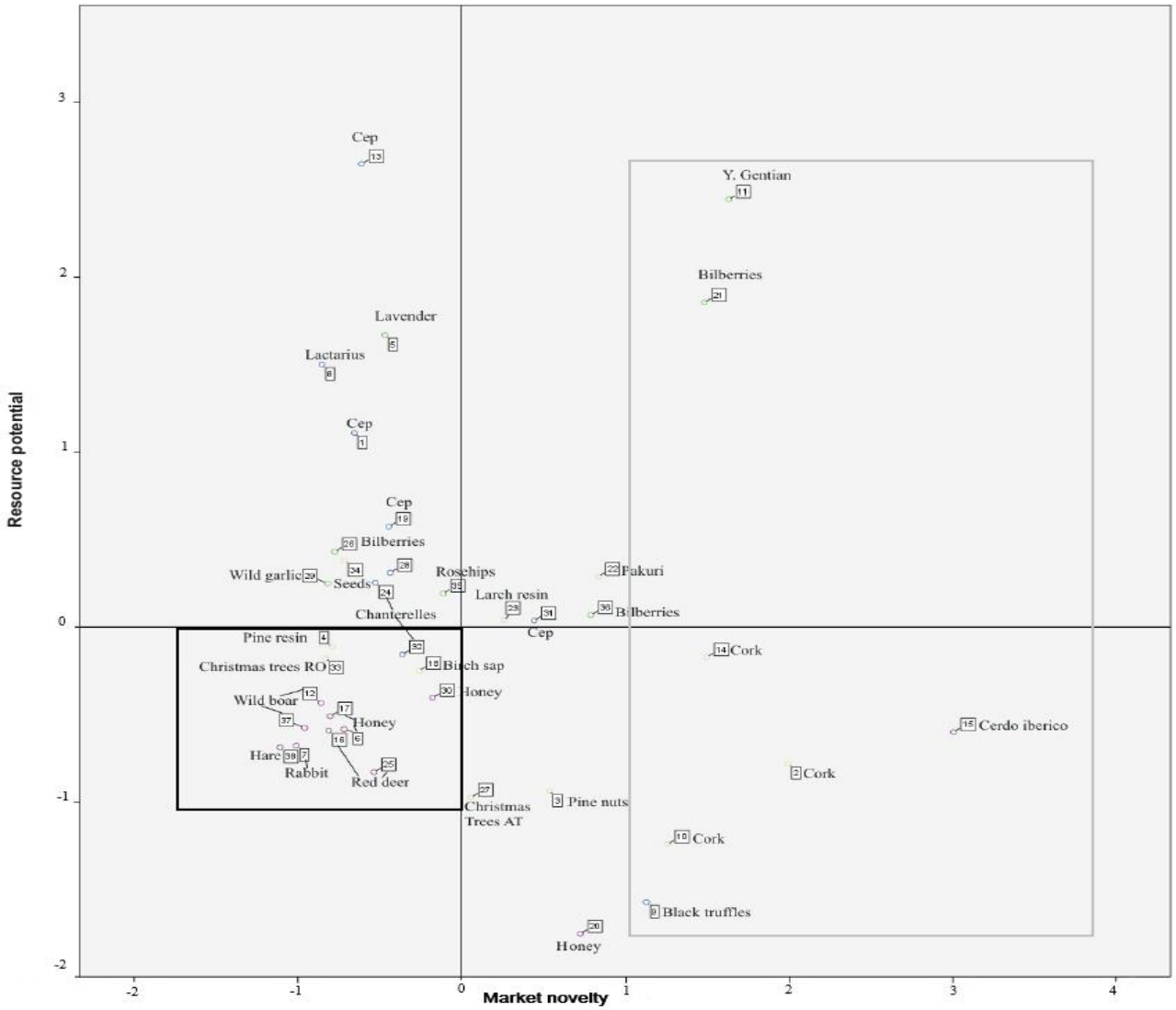

Figure 3. PCA results for NWFPs indicating factor scores of their principal components (i.e., performance on the dimensions of "market novelty" and "resource potential"). Frames indicate clusters of NWFP categories (i.e., bold frame = low-cost/low-value, grey frame = high-cost/high-value).

Principal component loads for NWFPs depict at least two "clusters" of product categories. They can be summarised as: (i) low-cost/low-value (bold frame) and (ii) high-cost/high-value (dashed frame). Under (i), NWFPs such as game species and honey can be seen that do not require high skills and know-how, nor do they require very large investments. Related resources appear to be abundant, widespread and rather quickly available. However, the added value that might be gained via marketing of related NWFPs tends to be limited. This may be due to a narrow range of less competitive, less innovative value-chains of more traditional products marketed at local to regional levels. Group (ii) pinpoints exclusive NWFPs that call for high levels of expertise as regards both management and harvesting. Resources thereof mirror some kind of uniqueness, whether in terms of endemism (e.g., cork, black truffle, cerdo ibérico) or specific attributes like chemical composition for instance (e.g., yellow gentian, North Karelian bilberries) that may contribute to the high added value of related end-products or to expanding the value chain of the respective product (e.g., more end-products). Both aspects underpin the competitiveness of (inter)nationally marketable products. Taking into consideration the classification of NWFPs beyond taxonomic kingdoms, as is also the case in this study, it appears evident that forest management and the potential for co-production of wood and non-wood resources are key drivers to supporting the further development of NWFP value networks. Adding forest owners' perspectives to the PCA, and linking it towards forest management decision making, the results support further categorisation of NWFPs into (i) spontaneous resources that are collected opportunistically and compatible with timber-centred forest management (such as wild herbs, berries, nuts, mushrooms); (ii) resources that are actively produced in forests and thus require specific management operations (like co-production of resources such as resin tapping, beekeeping, livestock grazing); and (iii) cultivated resources, often in specific (single-purpose) plantations and even on cropland (like Christmas trees, chestnuts, medicinal and aromatic plants).

4. Discussion

4.1. Comparison of NWFP Products in Europe

The NWFP performances determined according to different weighting scenarios do reflect some regional particularities, although the differences between equal weights and regionally derived weighting scenarios are relatively small (Table 5). For example, yellow gentian becomes more clearly number one in Catalonia with regional weights, and larch resin becomes nearly equal to Christmas trees and supersedes honey in Styria. In Alentejo and Extremadura, the impact of the regional weighting, however, is marginal, whereas in North Karelia the regional characteristics bring tree products (Pakuri mushroom and birch sap) as a group somewhat closer to bilberry. These observations support the argument that the results reflect true regionally relevant assets and/or the ability of participating experts to indicate those in their ratings. Nevertheless, even with the relatively small observed differences, the results may be seen as a justification for further stakeholder discussion at the regional level.

Another point to notice is that the performance differences between weights from forest owner profiles are minimal when looking at which product ranks first, but the relative performances behind that are more notable. This reflects different opportunities for a diverse forest owner landscape, as mimicked in the developed forest owner profiles. However, one may critically consider whether the forest owner weights and related performances truly reflect the differences in business potential. For this study, the forest owner weights were derived from earlier landowner behaviour studies, which may have caused the small differences between the profiles. Some more elaboration of different forest owners' entrepreneurial behaviour and practical examples of those could help in discerning such differences. Alternatively, it could also confirm the robustness of the results. When looking at the forest owner profiles applied in the weighting scenarios (FO 1–4), the PCA results reflect individual interests (Table 3) as well as scenario driven NWFP performances (Table 5), and allow for management recommendations tailored towards

diverging motivations of individual forest owners. "Hands-on nurturers" that live at or close to the farm are less limited by time constraints as well as forestry skills and know-how and may seek to harvest NWFPs opportunistically, providing a steady income with a low level of financial risks. On the other hand, "urban value extractors" without any or with scant rural background but more financial power may strive to maximise their profits. The latter are restricted by time resources and management skills, which lead to needs to outsource various tasks to third-party contractors. Thus, "high-cost/high-value" NWFPs may provide more attractive economic potential and opportunities for income generation. For that type of NWFP businesses, a more versatile value network of collaborating actors needs to be established. Additional aspects of resource intensity classes, as pinpointed in the final parts of the PCA interpretation, may create further linkages to management options as it is vital for forest owners to understand the difference when aiming at an optimisation of forestry production. Initiating new businesses from bare land in contrast to the sustainable exploitation of established forests requests for different modes of management and requires "on site" assessments of individual landowner's property (including parameters like e.g., forest area, productive/non-productive agricultural land area, Potential Natural Vegetation, Infrastructure, etc.).

When looking at the performance of individual products, it can be recognised from a Pan-European perspective that two out of all investigated NWFPs have potential in many case study regions (i.e., Cep in five regions, honey in four regions). Considering the "equal" scenario, Cep performs best in Extremadura (0.183), followed by Transylvania (0.167), N-Karelia (0.131), Alentejo (0.121) and Styria (0.110). Considering the results for Lactarius in Catalonia (0.142), it appears that there is a strong link to consumer behaviour and legal frameworks (e.g., access to forests, harvesting rights) calling for new modes of governance (e.g., [63]. In the Mediterranean region as well as in Finland and in Transylvania, it is a common practice to pick mushrooms from forests [19,37,64–66], although the motivations may differ (e.g., personal vs. commercial use), provoking conflicts in some cases [67]. In Austria, commercial mushroom picking decreased substantially over the last decades because of competition fuelled by globalisation and low-income countries. National legal frameworks in addition may on the one hand foster (e.g., res nullius) or hinder (e.g., restrictions by law) some of these practices and partially explain the results [23]. For honey, the potential appears to be highest in N-Karelia (0.219), followed by Styria (0.143) and Extremadura (0.116) with the least relevance in Alentejo (0.095). What comes as a surprise at first glance may be justified because of prevailing market aspects. Beekeeping is practised in all EU countries and is characterised by a diversity of production conditions, yields as well as beekeeping practices. While quantities are huge in Spain and Romania, attainable market prices are low. The opposite holds true for Finland and Austria [68]. However, given the diversity of resources available, and taking into account Europe's rich forest owner landscape that builds upon the interests of around 16 million private forest owners who manage approximately 60% of forests in Europe [69], latent opportunities to strengthen the economic viability of rural bio-economies with a stronger utilisation of the benefits from a joint production of NWFPs and other ecosystem services appear promising.

4.2. Regional Specifics in the Mediterranean Region

Cork oak, holm oak and umbrella pine multi-purpose forest ecosystems play a key role in the provision of the most important NWFPs in Alentejo (i.e., Amanita caesarea, Amanita ponderosa, Boletus edulis group, Cantharellus cibarius and Terfezia spp.). The importance of these NWFPs was highlighted recently by both regional [70] and landscape-level studies [71]. The economic importance of cork and pine nuts is highlighted by the fact that Alentejo was the only region in Portugal where the forest area increased (about 250 km^2), from 1995 to 2010, mainly because of the plantation of new cork oak and umbrella pine stands [43]. The results of this study further reinforce cork as the product with the greatest potential in Alentejo. Additionally, in Catalonia, particularly in acidic areas of the provinces of Girona and Barcelona, cork [72] and, to a lesser extent, pine nuts [73] represent

the most relevant NWFPs. In calcareous areas with appropriate weather conditions, truffles represent the most valuable NWFP option [74], which can also stimulate Mycotourism as an alternative income opportunity [75]. The study also very well reflected the relevance of the products from the dehesas in the Extremadura region, depicting "cerdo ibérico" and cork as the products with the highest potential from a forest bioeconomy perspective [76]. Dehesas are characterised by a high degree of anthropisation, requiring the following two concepts (i) a tree layer, and (ii) extensive livestock [77]. Among these types of agroforestry systems, cork oak and "cerdo ibérico" are the ones that appear to be most beneficial for NWFP stakeholders regarding high incomes, products with unique characteristics and a strong market associated with them [78–80]. Spain is the second-largest major cork producing nation with an annual production in 2010 of 60,736 t [46]. The "cerdo ibérico" constitutes a singular breed, strongly adapted to the ecological conditions of the dehesa ecosystem, which lead to high-quality meat products. The prize of Iberian pig fattened under free-range conditions, which is called "montanera" (fed on acorns and grass in the dehesa), has increased more than 58% from 2010 [81]. The Iberian pig is a special case of a NWFP, rooted in regional culture and the use of natural resources over centuries. It represents a unique product specific to the Extremadura region, similar to it is, for instance, the case of cork in Portugal and offers diverse opportunities for income generation across their value chains.

However, the most popular and widespread NWFPs in the Mediterranean region are mushrooms, not only in Catalonia, where in addition to the commercial aspects of wild mushrooms, mushroom picking is a long-lasting tradition. A recent official survey conducted in Catalonia with a total sample of 1600 respondents demonstrated that approximately 23% of all Catalan residents (i.e., 1.2 mio people) pick mushrooms, from which 36% go picking three or more times per season [82]. There are seven popular mushroom species, but the most preferred species is the group *Lactarius*, which are delicious, as they were identified by 89% of the people that participated in the survey [82]. Also in Alentejo, over the past two decades, mushroom picking for commercial purposes has increased considerably. Reports underline that about half of the harvested mushrooms in the Alentejo are exported [83] although mushroom picking is still mostly conducted without control mechanisms [84]. The findings of the study regarding mushrooms underline their potential for NWFP businesses as an abundant resource that might request for new management approaches to derive benefits for all actors along the value chain.

Game meat is an important good across the Iberian Peninsula, and has traditionally been considered an important product associated with dehesas, too, providing an additional income for forest owners. About 33% of the national hunting areas in Portugal are located in Alentejo [85], where a relative abundance of small game species (e.g., rabbit, thrush and partridge), and of some big game species, in particular wild boar and red deer, occurs [86]. Hunting activities are extended widely throughout all Catalonia, with the most hunted species being *Sus scrofa*, *Oryctolagus cuniculus* and *Alectoris rufa*. One surprising outcome of this study is that red deer performed worst, and were even outranked by Cep and honey in Extremadura. However, this can be explained because, on the one hand, reed deer competes with "cerdo ibérico" for acorns, and on the other, game requires fenced dehesas. These fenced areas result in a dramatic increase in wild ungulate densities [77], which threaten dehesa sustainability due to negative effects on tree regeneration [87].

Aromatic plants are one of the flagship products of Alentejo gastronomy. They contribute to the valorisation of food traditions. Medicinal plants are also important for the local community. Their use and commercialisation has increased recently [88]. According to this study, it appears that yellow lavender has a significant potential and could be seen as an opportunity for forest owners to diversify their product portfolio. This product performs almost as good as pine nuts, which is a product already exploited on a large scale in the region. However, for yellow lavender, further research needs to be undertaken, as the work about its utilisation and production is still scarce. Furthermore, aromatic and medicinal

plants represent an example of promising NWFPs in Catalonia, with high market demand (i.e., *Gentiana lutea*), but are still of minor relevance in the region.

4.3. Regional Specifics in the Boreal Region

The utilisation of various NWFPs is very common in the Boreal region. In particular, berries and mushrooms are collected for household and commercial use. Commercial utilisation includes both domestic markets and the export of rather large amounts of berries and mushrooms to foreign markets. Traditional NWFPs, which have low added value, have dominated the markets. However, although the emergence of the circular bioeconomy phenomenon mainly emphasises wood and its increased mobilisation, NWFPs have also already clearly benefitted of this trend. Furthermore, increased interest among urban consumers towards healthy diets and wild food benefits NWFPs production, collection and processing in the region. Therefore, in national and regional scales, NWFPs are receiving increased attention in policy programmes and strategies. The case study results clearly indicate that bilberry is the most prevalent individual product in North Karelia while the summed potential of birch sap and Pakuri mushroom raise tree products as the highest NWFP category. There are emerging and expanding businesses in the region, and active research and development work around these products is taking place. Characteristic of all these three products is that their production can be fairly well integrated with wood production, which is of relevance to forest owners and managers in particular who tailor their management objectives towards both ecologic and economic targets [89]. Several studies have shown that the harvesting of NWFPs can create significant additional incomes for forest owners, compared with timber production only. However, maximising the economic returns from a joint production with timber requires changes in forest management practices [90].

The position of bilberry in the results is no surprise due to its high resource potential. The relatively low figures of Cep, in turn, are a bit surprising, given the active mushroom picking and selling culture in the region, but it may be that high annual variation in crops and higher share of household use may explain those numbers. It is also notable that the Pakuri mushroom, which is a booming product, currently, is above or at least equal to honey in the assessment although its expansion potential is yet to be evidenced. The overall picture is that North Karelia, like most of the Boreal regions, is resource-rich with large forest areas and rather low population density [41]. This is also reflected in the regional weights given to the assessment criteria by NWFP stakeholders: market potential weight was lower than resource potential unlike all other case regions but Transylvania, which has some comparable characteristics. Considering the future potential of NWFPs in North Karelia, key strategy aspects are to make use of the high resource potential and invest on improving the institutional assets (i.e., innovation potential, new collaborations, and partnerships across sectoral boundaries) to enable higher international market interest and access.

4.4. Regional Specifics in the Alpine and Continental Region

The NWFP portfolio in the Alpine and Continental region provides a wide range of species from three taxonomic kingdoms, including plants, animals and fungi. Styria is one of the hotspots of NWFP production in Austria, both with regard to the ecological potential as well as market activities. Apart from forest-related services, which often act as a key driver for the marketing of NWFPs, the most relevant product categories in terms of bioeconomy are Christmas trees, honey, game meat and forest reproductive materials [55,91]. This is well reflected in the results of this study. Only the high performance of larch resin comes as a surprise, depicting the latent potentials of innovation (both at the product and process level), which can be understood as being particularly relevant in the current bioeconomy discourse [7,9]. Honey and game meat have gained momentum recently [54], and are very prominently featured in the public debate, inter alia due to upcoming trends in nutrition and gastronomy, whereas remaining NWFPs are often controversially discussed.

However, the latter play a minor role in income generation due to their "public goods" characteristics. It has to be taken into consideration that Christmas trees, which turned out to represent an interesting niche for NWFP actors, are usually grown on former agricultural land and managed as short-rotation plantations. However, benefits for individual forest owners may even increase in combination with compatible silvo-pastoral practices (e.g., livestock grazing), and thus can play a varying role in a regional forest bioeconomy in Central Europe [92,93]. A similar NWFP diversity, and thus production potential, can be recognised in Transylvania, where the most harvested forest fruits are bilberry (*Vaccinium myrtillus* L.), dog-rose (*Rosa canina* L.) and raspberry (*Rubus idaeus* L.), although recent statistics indicate that harvested quantities of forest fruits in Romania have decreased in recent years [94]. At the national level, in the period 1980–1989, 136,404 tons of forest fruit from various species were harvested [95]. With regard to mushrooms, the most harvested species in Romania are Boletus sp., *Armillaria mellea* (Vahl) P.Kumm. and *Cantharellus cibarius* Fr. where in the period 1968–1989, 68,714 tons were reported [96], and those mushroom species are predominantly present in Transylvania [97].

As regards medicinal plants, Romania, with its estimated number of 3700 species of plants with extremely curative functions, overcomes many countries with a long tradition in harvesting and processing medicinal plants in terms of numbers [98]. The largest quantities of harvested medicinal plants in the last five years were recorded in the case of common nettle (*Urtica dioica* L.), hawthorn (*Crataegus* sp.), wild garlic (*Allium ursinum* L.) and black locust (*Robinia pseudoacacia* L.) [99]. The presence of black locust in this top list is justified by the fact that this autochthonous tree species was introduced to Romania in the last two centuries thanks to its multiple uses, which include honey production [100].

The most common game species in Transylvania are wild boar (*Sus scrofa* L.) and brown hare (*Lepus europaeus* Pallas). According to the official data provided by the Ministry of Environment, Water and Forests, in 2015 there were 91,146 wild boar individuals and 1,092,531 brown hare individuals, respectively. Among them, more than half (54.8%) of wild boar individuals and around 30% of brown hare individuals were recorded in Transylvania, respectively [100]. With the relative abundance of various NWFP resources there exist latent opportunities for a bioeconomy transition in the country, although this requires not only innovative approaches to NWFP management but also institutional support and market development [92].

4.5. Methodological Constraints

This study cannot claim to represent a complete analysis of all regional NWFP sectors in Europe, as that would include several other products in different regions or the involvement of additional stakeholders. However, it can provide a comprehensive overview of the range of the regional potentials of such options. The use of different forest owner profiles for each region and all products was intended to serve as a kind of "sensitivity analysis". As the results were derived for all owner types and all categories in each region, it was possible to find out possible dominant NWFP options independently from the regional context. Similar to the study presented in [24], it was possible to utilise regional expert knowledge for the assessment of the performance of the alternatives for each criterion, where hard facts and figures were missing. On the other hand, existing data could be used by the experts in the final evaluation of the results (e.g., current end product value and end product diversity) and support a more comprehensive applicability check under various socio-economic conditions. However, the existing evaluation hierarchy of the AHP model might not be able to represent all possible legal frameworks, ownership structures, tenure as well as property rights for different NWFP products on the Pan-European level, which could be further tested in future applications and perhaps enhanced.

5. Conclusions

In this study, the approach originally introduced for two single case studies was applied under different environmental and socio-economic conditions across Europe for the first time. Even if forest ownership structures vary notably (i.e., private vs. state ownership like Alentejo vs. Transylvania), this approach was shown to be promising to support decision making regarding a joint management of NWFPs and other forest ecosystem services for a diversification of the forest bioeconomy. It has the potential to steer the mindsets of individual forest owners in Europe, who might not yet know where to focus their forest management in future or, even more importantly, it may help forest owners to choose among existing NWFP production opportunities in a multi-functional forestry. The forest owner profiles used provide room for individualised implementation, taking into account the specific region's operational environment and forest owner preferences, an asset to forestry extension service providers. The performance scores for different profiles could be elaborated towards more in-depth business consultation for starting entrepreneurs as well. Showing where an owner can achieve a competitive advantage with individual assets may foster small- and medium-sized enterprises (SME), as well as regional livelihoods.

The results reveal latent opportunities of selected NWFPs and place them in a broader context with the current state of international NWFP markets. Uncovering NWFP business potentials may offer opportunities for multi-purpose forest management strategies that could be linked with sustainable tourism. Alternatively, it may boost joint business networks across holding borders where economies of scale could be utilised to access markets with cost-efficient NWFP production. NWFP-based businesses could enable cross-sectoral collaboration in providing advice, i.e., forestry advisors and SME advisors could join forces and also learn from each other when offering new and innovative products and services in context of a more circular forest bioeconomy.

The results can help to identify the opportunities and challenges of a combined production of different NWFPs and in relation to other products and ecosystem services. This may be relevant at different spatial (stand to holding to regional to national) levels and also vary over time (taking account different rotation periods and management approaches). Not considering synergies only from an anthropocentric perspective could potentially trigger land use decisions in favour of both ecological integrity and economic viability, and thus support social equity across urban to rural regions. This would request policy support at the regional level to raise the potential of different NWFPs and foster informative campaigns or support research and development initiatives, in particular when working with innovative and boosting products (e.g., Pakuri mushrooms in North Karelia).

Even though it is not an explicit output of the analysis itself, but implicitly covered by the evaluation criteria and thus relevant for the overall performance of NWFP options, it is evident that the policy framework affects the potential of NWFPs. In Portugal for instance, cork is being fostered by policy instruments that support its production and harvesting, as well as incentives to increase the yield and planted area. In Spain, there is continuous debate on mushroom picking and policy tools that may decrease existing pressures, both on the resource as well as between landowners and pickers. Property rights, and especially access and harvesting rights (e.g., everyman's right, res nullius, res communis), govern resource use at local to regional levels and differ greatly across Europe. These varying socio-economic and legal conditions create challenges for a general policy framework within the EU, while it is evident that recognising the regional potential of NWFPs on a high policy level would boost governance and business development for diversifying bioeconomy on the regional level.

In this respect, it can be postulated that there is a need to take advantage of the multiplicity of the non-wood forest product sector, both from a regional resource as well as a stakeholder perspective, and argue for bottom-up governance approaches that respect regional/local conditions but support European policy objectives. Considering European forest-based bioeconomy developments and contemporary challenges such as climate change and demographic growth, it can be expected that NWFPs positively contribute to

the transition towards a more renewable resource-based society that is able to mobilise and use its natural capital in a more holistic way. The diversity of resources and the rich forest owner landscape with several million private forest owners managing the majority of forests in Europe, will help to strengthen the economic viability of rural bio-economies.

Author Contributions: Conceptualisation, P.H. and H.V.; methodology, P.H.; software, P.H.; validation, M.K., T.H., B.W., M.S.-G., M.P.-T., S.d.-M., J.A.B., M.M., J.G.B., C.M.E. and L.D.; formal analysis, P.H. and H.V.; writing—original draft preparation, P.H.; writing—review and editing, H.V., M.K., T.H., M.S.-G., S.d.-M., J.A.B., M.M., J.G.B. and C.M.E.; visualisation, P.H.; supervision and project administration, H.V.; funding acquisition, H.V., M.K. and J.G.B. All authors have read and agreed to the published version of the manuscript.

Funding: This study was financially supported by FP7 Project no. 311919 KBBE.2012.1.2-06 StarTree—Multipurpose trees and non-wood forest products a challenge and opportunity, and COST-Action FP1203: European non-wood forest products (NWFPs) network. Mr. S. de-Miguel was supported by the European Union's Horizon 2020 MultiFUNGtionality Marie Skłodowska-Curie (IF-EF No 655815), and Mr. J.A. Bonet benefited from a Serra-Húnter Fellowship provided by the Generalitat of Catalunya. José G. Borges and M. Marques participation was also funded by the Forest Research Centre, a research unit funded by Fundação para a Ciência e a Tecnologia I.P. (FCT), Portugal (UIDB/00239/2020). This study has been also done with affiliation to the Academy of Finland Flagship Forest-Human-Machine Interplay—Building Resilience, Redefining Value Networks and Enabling MeaningfulExperiences (UNITE) with decision number 337127.

Data Availability Statement: Not applicable.

Acknowledgments: The authors want to express their sincere gratitude to all persons who contributed to this study in the frame of stakeholder participation and expert knowledge elicitation.

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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