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Non-wood forest products in Europe – A quantitative overview

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ABSTRACT

Mushrooms, berries and other Non-Wood Forest Products (NWFPs) are an important part of forest recreation, rural income and of cultural heritage. Due to poor data on their collection and use, they are often ignored in forest policy and management decisions, which could impair those livelihoods that depend on NWFPs as an income source. We conducted a survey involving 17,346 respondents from 28 European countries to estimate which and how much of these products are collected. Our results show that 26% of European households collect NWFPs and that collection rates and quantities increase from Western to Eastern Europe. Previous studies focused mainly on marketed NWFPs, but our findings suggest that marketed NWFPs represent only a small share and that 86% of the collected weight is self-consumed. The total value of NWFPs collected each year amounts to 71% of the value of annual roundwood production, much more than previously estimated. Our results point to the need to consider co-production of wood and NWFPs, especially in Central Europe where their value per hectare is the highest.

1. Introduction

Alongside wood-based products, forests also produce Non-Wood Forest Products (NWFPs), such as berries, mushrooms, aromatic, medicinal and decorative plant material, nuts, saps and resins. In the global context, especially for low-income households, NWFPs can represent 10–60% of household income (Asfaw et al., 2013; Babulo et al., 2009; Qureshi and Kumar, 1998), an important subsistence source (Belcher et al., 2005, Kar and Jacobson, 2012, Mahapatra et al., 2005., Heubach et al., 2011, Ambrose-Oji, 2003), provide food security by off-setting seasonality of other food sources and can play an important cultural and spiritual role (Shackleton and Pandey, 2014). About 2.8 billion people use traditional herbs and medicines, many of which is sourced from forests (World Health Organization, 2002). In Europe, collecting NWFPs is an important part of cultural heritage (Pardo-de-Santayana et al., 2007; Seeland and Staniszewski, 2007) and are closely linked to the recreational function of forests (Kangas and Markkanen, 2001; Sievänen, 2004; de Aragón et al., 2011). Moreover, NWFPs are important for the profitability of many small and medium forest-based enterprises (Pettenella et al., 2007). Nevertheless, their perceived economic importance in Europe is low. This disregard is manifested in international statistics on NWFPs; for example, the reported value of marketed NWFPs in Europe was 1.1 billion € in 1995 (UNECE-FAO, 2000), 870 million € in 2005 (FOREST EUROPE, 2007), 2.1 billion € in 2010 (FOREST EUROPE, UNECE and FAO, 2011) and 1.7 billion € in 2014 (FOREST EUROPE, 2015). These fluctuations do not represent trends in the value of NWFPs, but rather trends in the quality of national-level data (FOREST EUROPE, UNECE and FAO, 2011; FOREST EUROPE, 2015). The available information on the economic importance of NWFPs is mostly incomplete, scattered or not comparable among countries (Vantomme, 2003). Furthermore, these estimates refer mainly to formally marketed NWFPs, and do not take into account informally marketed and those removed from the forest that are used for self-consumption. No primary data on the self-consumption of NWFPs exist at the international level for Europe, but its value is estimated to be two to three times higher than the value of marketed NWFPs (Wahlén, 2017).

A lack of systematic data on NWFPs leads to a lack of awareness of their importance, which leaves them not being fully considered in rural development, forest and land-use related plans and policies (FAO, 2014; Sills et al., 2011). This is especially important in the context of a developing bioeconomy, in which forests are expected to play an important role (Koukios et al., 2017; Lainez et al., 2017; Scarlat et al., 2015). If forest management is geared towards optimizing only wood production, this may lead to sub-optimal solutions as this typically involves different management decisions than co-production of wood and of NWFPs (Palahi et al., 2009; Miina et al., 2010; Miina et al., 2016; De-Miguel et al., 2014; Kurttila et al., 2018). In this study, we assess the collection and value of marketed and non-marketed NWFPs in Europe. Specifically, we try to answer the questions (I) which NWFPs are

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collected and where, (II) what quantity of NWFPs are collected in terms of weight and economic value, and (III) to what extent do NWFPs enter markets? We conducted a household survey involving 17,346 respondents representing households from 28 European countries. The survey's respondents were asked to state (I) which products they collected, (II) what quantities they collected, (III) how much they sold and finally (IV) whether or not this activity represents an income contribution (see Materials and Methods). The survey was designed to account for one year of NWFP removals in Europe.

2. Materials and methods

2.1. Questionnaire preparation

Data sources for the design of the questionnaire include a supply-chain study of NWFPs (Da Re et al., 2015) and a data base on usage of NWFPs (Wong and Chapman, 2019) that has 39 variables and 1962 data entries. Both data sources were derived from the StarTree project and focused on 14 regions from 12 countries in Europe with a wide geographical spread. This data base was used to identify the most commonly collected NWFPs as reported by 265 forestry professionals and NWFP experts from 12 countries. The questionnaire reported in this study stated that its questions are aimed to address the respondents' NWFP collection activity in the year prior to its distribution. Respondents were then asked to choose which groups of NWFPs they collected in the previous year. For each of the selected groups, another page opened where they were asked which of the species/products within the group they collected, to indicate collected weight (in kg) and what percentage of what they collected was sold. Respondents had the option to specify the collected quantity in other units of weight or in other measures. Besides choosing from a list of individual NWFPs, respondents had the option to input additional products. Individual products were listed with both the local and Latin name, while both product groups and individual products were illustrated with images. Respondents were also asked to state if the collection of NWFPs had contributed to their household income or not. If it did, the respondents had three further response options to specify the level of income contribution: (I) more than 50% of income, (II) between 11% and 50% of income and (III) 10% or less of income. The draft questionnaire was pre-tested twice, firstly with an international group of 11 experts on NWFPs and secondly with 100 respondents from the UK using the online layout of the questionnaire. The purpose of the pre-testing (Collins, 2003) was to account for shared understanding of the questionnaires' text, respondent fatigue, and possible missing response categories. Pre-testing was performed from August to October 2015. The questionnaire had many other questions, more than could be presented here. This paper is a companion to Lovrić et al., 2020b, which looks at NWFP consumption data, classification of NWFP collectors and provides guidance on how to conduct cost-effective national-level surveys of this kind in the future, with a goal of improving the deficiencies in international reporting on the topic.

2.2. Data collection

Twenty-eight countries were included in the sample, namely the European part of Russia, Serbia and Turkey, and all EU members except Cyprus, Malta and Luxembourg (see Fig. 1 A–C). The household was selected as the basic unit of analysis because it is the unit of analysis used in internationally comparable food consumption data in Europe (Lagiou and Trichopoulou, 2001), because the collection of NWFPs is an activity predominantly practiced for household consumption (FAO, 2010), and because it recommended as most appropriate way to capture this type of data (Sorrenti, 2017). The questionnaire was translated to all the languages covered by the sample by native speakers, who are also experts in NWFPs and, mostly, are members of the NWFP COST Action FP1203. The questionnaire was designed as a dynamic format suitable for multiple platforms (personal computer, tablet, smartphone). The questionnaire was distributed by the polling agency Demetra opinion.net S.R.L., where the sampling frame included those households where the respondents are over 18 years old, have access to internet, are aware of household consumption habits and are registered to the panel. Data collection lasted from June to November 2016. Targeted statistical parameters of the sample were 95% confidence level and 5% confidence interval at the national level. As it was a paid survey (i.e. members of the polling panel who have answered the questionnaire were paid to do so), there was no nonresponse; however, 2482 responses were deleted and re-collected to replace responses that were characterized as outliers, non-valid and possibly fraudulent. The criteria for exclusion was filling in the questionnaire in less than three minutes if they stated that they have collected NWFPs, filling in a certain page of the questionnaire in less than ten seconds, providing illogical answers, or stating high outlier values (e.g. collecting 1000 tons of blueberries). The survey closed with 17,346 valid responses. The mean confidence interval at the national level was 4.21%, while for the overall sample it was 0.74%. The distribution of the number of households among the sampled countries was used for post-stratification.

2.3. Data preparation and analysis

Weight reported in different units (dkg, g) was converted to kilograms, and the same was done for volume (AVCalc, 2018). In all, 1.9% respondents reported that they picked a certain NWFP, but reported no weight or entered a non-numeric answer (quantitates with non-standard ‘units’ such as bag, piece, basket, handful, etc.). In these cases, we used the median collected weight for that NWFP instead. The quantity of ornamental products (cones, fresh and dry branches, mosses, flowers and leaves) could not be calculated as respondents reported quantities in different non-standard units that could not be converted into weight (e.g. handful, bucket, bag, etc.). The collected weight of NWFPs for European countries out of the sample was estimated based on the coverage of forests and other wooded land (FOREST EUROPE, 2015; Schuck et al., 2002). For these countries, we assumed that the collected weight of a given NWFP per hectare of forest is the same as that calculated for in the closest neighboring sampled countries (e.g. values for Bosnia and Herzegovina are based on mean values for Croatia and Serbia). Iceland was excluded from the calculations, as we considered no country has similar conditions. By this procedure, we used questionnaire responses from 28 countries to estimate the economic importance of NWFPs for 16 countries. NWFPs collected in these 16 countries represent 7.9% of overall collected weight of NWFPs in Europe.

First-placement prices (€/kg) were gathered from 23 contacts from 18 countries, representing both NWFP scientists and industry experts. The prices refer to payments made to collectors of NWFPs. Prices that were not gained directly were estimated. The price estimation is based on official EU data on food price level index (Eurostat, 2018), and for Russia based on price level index data by Organisation for Economic Co-operation and Development (2018). Prices for NWFP's in the ‘other’ category are average prices for that NWFP group, while price for ‘other’ group of NWFP is the average price across all NWFPs. In all 52.8% of prices in sampled countries were estimated in this way, corresponding to 20.0% of the value of NWFPs in sampled countries. For countries out of the sample, price estimates were based on official EU data on food price level index (Eurostat, 2018). If no appropriate data were found there, the second data source was the consumer price index by World Bank (2018). A total of 36.4% of European prices per product have been estimated in this way, corresponding to 6.9% of total value of NWFPs in Europe. Prices of ornamental products have not been estimated due to the high diversity in product usage and prices.

Analysis was performed in R statistical environment (R Core Team, 2017). Country-level collected weight per NWFP product was subjected

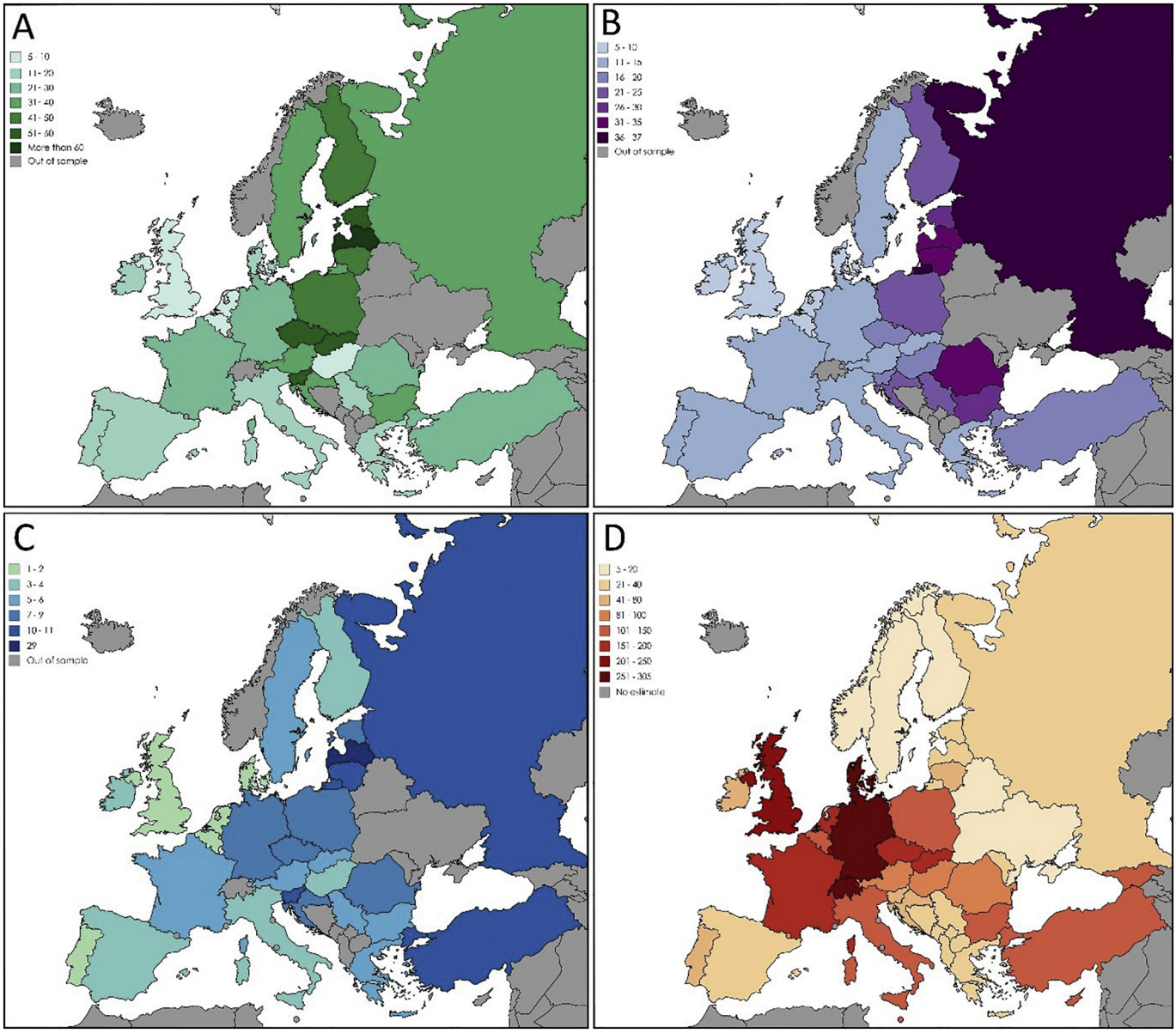

Fig. 1. Spatial distribution of (A) Share of households that collect NWFPs (%), (B) Median collected weight for households that collect NWFPs (kg · household^{-1} · yr^{-1}), (C) Share of households for which NWFPs represent an income contribution (%) and (D) Value of collected NWFPs (€ · ha^{-1} · yr^{-1}).

to hierarchical clustering with *p*-values via multi-scale bootstrapping (Suzuki and Shimodaira, 2013), where the distance matrix is based on correlation and Ward's method was used for clustering with ten thousand bootstrap replications. Products labelled as 'other' are not included as different individual species fell within these variables across sampled countries. Same clustering procedure was repeated with data on collected weight by NWFP product per country (i.e. transposed matrix of data on collected weight by country per NWFP product). These procedures identified clusters of countries with similar collection patterns of NWFPs and clusters of NWFPs with similar collection patterns across European countries. The cluster selection criteria of approximately unbiased p-value $< .05$ (two tailed) was used. The same input data (scaled from 0 to 1 on the product level) was used in Multiple Factor Analysis (Pagès, 2014) in order to analyze the association between country and product-level data. Decorative NWFPs (branches, leaves, etc.) are not included as their weights were not reported reliably and these products are not linked to individual species as is the case with the other NWFPs.

3. Results

3.1. Country-level results

All the results depicted here display the NWFP collection patterns in a single year, based on the recollection of respondents on what did they collect in the year before the survey was distributed. Results show that more than a quarter of households (26%) in 28 European countries collect NWFPs. We find an increase in collection rates from Western to Eastern Europe (Fig. 1A); it is lowest in the Netherlands (5% of households) and the United Kingdom (8%) and the highest in Latvia (68%), the Czech Republic (58%) and Slovenia (54%).

The mean weight of NWFPs collected per household that engage in this activity is 60.2 kg per year with a median of 20 kg. The distribution is more uneven than the central tendency measures indicate, as the S90/S10 ratio (mean collected NWFP weight by the 10% of the collectors with the highest collected NWFP weights divided by mean collected NWFP weight by the 10% of the collectors with the lowest collected NWFP weights) is 216.5 and the standard deviation is 185.3 kg.

The median collected weight increases from Western to Eastern Europe (Fig. 1B), and is smallest in Denmark (5 kg · household^{-1} · yr^{-1}) and Ireland (5.5 kg · household^{-1} · yr^{-1}), and largest in Lithuania (34 kg · household^{-1} · yr^{-1}) and Russia (37 kg · household^{-1} · yr^{-1}). The mean number of collected products per household follows the same geographical gradient; it is lowest in the United Kingdom (5.3) and is highest in Romania (11.5). For 0.6% of all households, NWFPs represent a main income source. For 1.5% of households they represent between 11 and 50% of income and for 4.4% of households they represent 10% or less of household income. When these three response groups are combined and disseminated on national levels, a difference between Western and Eastern European countries can be observed (Fig. 1C); we find the lowest share of households for which NWFPs represent a part of their income is in the Netherlands (1.0%) and Denmark (1.5%) and that the highest are shares in Turkey (10.9%) and Latvia (28.7%). NWFPs represent 10% or less of household income for vast majority (85.3%) of Latvian households that sell them, mirroring the overall results for income generation.

In terms of economic importance, our results indicate that collected NWFPs represent a total economic value of 23.3 billion € per year in Europe, which amounts to 20.5 € per hectare of forest and other wooded land. Excluding the European part of Russia, the value of NWFPs is 19.5 billion € with value per hectare rising to 77.8 €. In absolute amounts, NWFPs have the largest economic importance in Russia, with 3.7 billion € per year (Fig. 2), followed by France, Germany and Turkey (3.4, 3.2 and 2.5 billion € per year, resp.). The lowest total NWFP value is reported for Ireland (37.7 million €), the Netherlands (65.9 million €) and Estonia (89.5 million €). For the economic value of NWFPs per hectare of forest (Fig. 1D), the highest rates are found in Switzerland (304.6 € · ha^{-1} · yr^{-1}), followed by Denmark (297.1 € · ha^{-1} · yr^{-1}) and Germany (278. € · ha^{-1} · yr^{-1}); the lowest values are found in Russia (4.2 € · ha^{-1} · yr^{-1}), Sweden (5.9 € · ha^{-1} · yr^{-1}), Finland (17.9 € · ha^{-1} · yr^{-1}) and Ukraine (18.8 € · ha^{-1} · yr^{-1}).

3.2. Product-level results

Wild berries are collected by the largest share of households (20.7%) among all groups of NWFPs (Fig. 3), followed by wild mushrooms (19.7%), forest nuts (14.2%), wild medicinal and aromatic herbs (12.6%) and decorative products (11.6%). On the level of individual products, the largest share of households collects penny buns (*Boletus edulis*; 15.8% of households), followed by chanterelles (*Cantharellus cibarius*; 12.8%), blackberries (*Rubus fruticosus*; 11.5%), wild raspberries (*Rubus idaeus*; 10.7%), bilberries (*Vaccinium myrtillus*; 10.4%) and wild strawberries (*Fragaria vesca*; 10.0%). Flowers and cones are collected by the largest share of households (9.6% and 8.6%) within the groups of decorative NWFPs, while in the group of forest nuts same can be stated for walnuts (*Juglans regia*; 9.2%) and sweet chestnut (*Castanea sativa*; 7.3%). The high collection rates for these products is reflected in the economic value they represent (Fig. 4); wild berries have the highest economic importance (7.8 billion € · yr^{-1} or 33.5% of total value of all NWFPs), followed by forest nuts (5.1 billion € · yr^{-1}), wild mushrooms (5.0 billion € · yr^{-1}), truffles (3.1 billion € · yr^{-1}) and wild medicinal and aromatic herbs (1.4 billion € · yr^{-1}).

A total of 86.1% of the collected weight of NWFPs is used for self-consumption, while the rest is sold. Truffles are the product group with highest share of collected weight being sold (28.9%) followed by forest nuts (20.0%), saps and resins (15.4%), wild berries (13.8%), mushrooms (11.7%) and wild medicinal and aromatic herbs (7.9%). The total value of sold NWFPs in Europe is estimated at 3.5 billion € per year, representing 15.2% of their total economic value. The highest proportion of value of sold NWFPs is made up of truffles (1.2 billion € · yr^{-1}), followed by forest nuts (775 million € · yr^{-1}), wild berries (685 million € · yr^{-1}), wild mushrooms (518 million € · yr^{-1}), other products (232 million € · yr^{-1}), wild medicinal and aromatic herbs (82 million € · yr^{-1}) and saps and resins (42 million € · yr^{-1}).

3.3. Combined country and product level results

In order to combine data on collected NWFP weight by country and per product, a Multiple Factor Analysis (MFA, Fig. 5) was performed. MFA aims to show association of input data in a n-dimensional space, usually 2 (rectangle, as in Fig. 5) or 3-dimensional space (cube), where each added dimension is characterized by diminishing explanatory power (i.e. explaining smaller and smaller share of variability in the data). Thus, the association of data (i.e. physical proximity of products

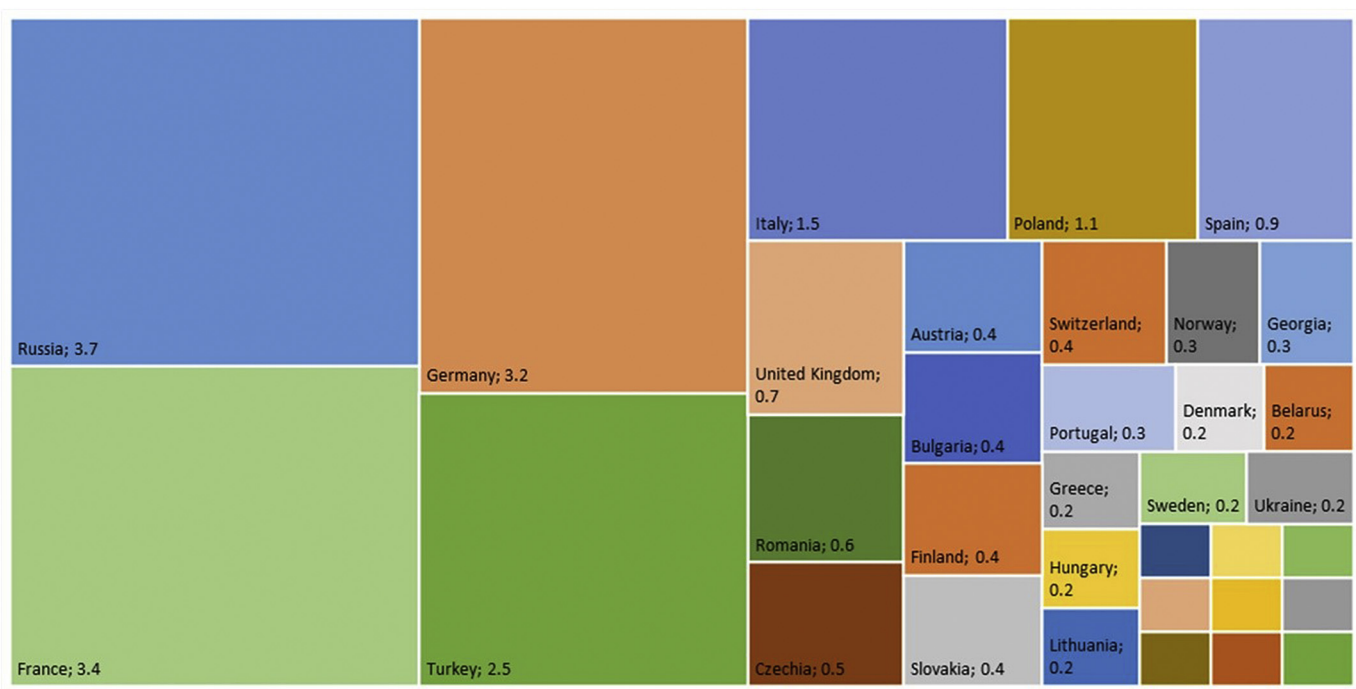

Fig. 2. Value of collected NWFPs by country (in billion €).

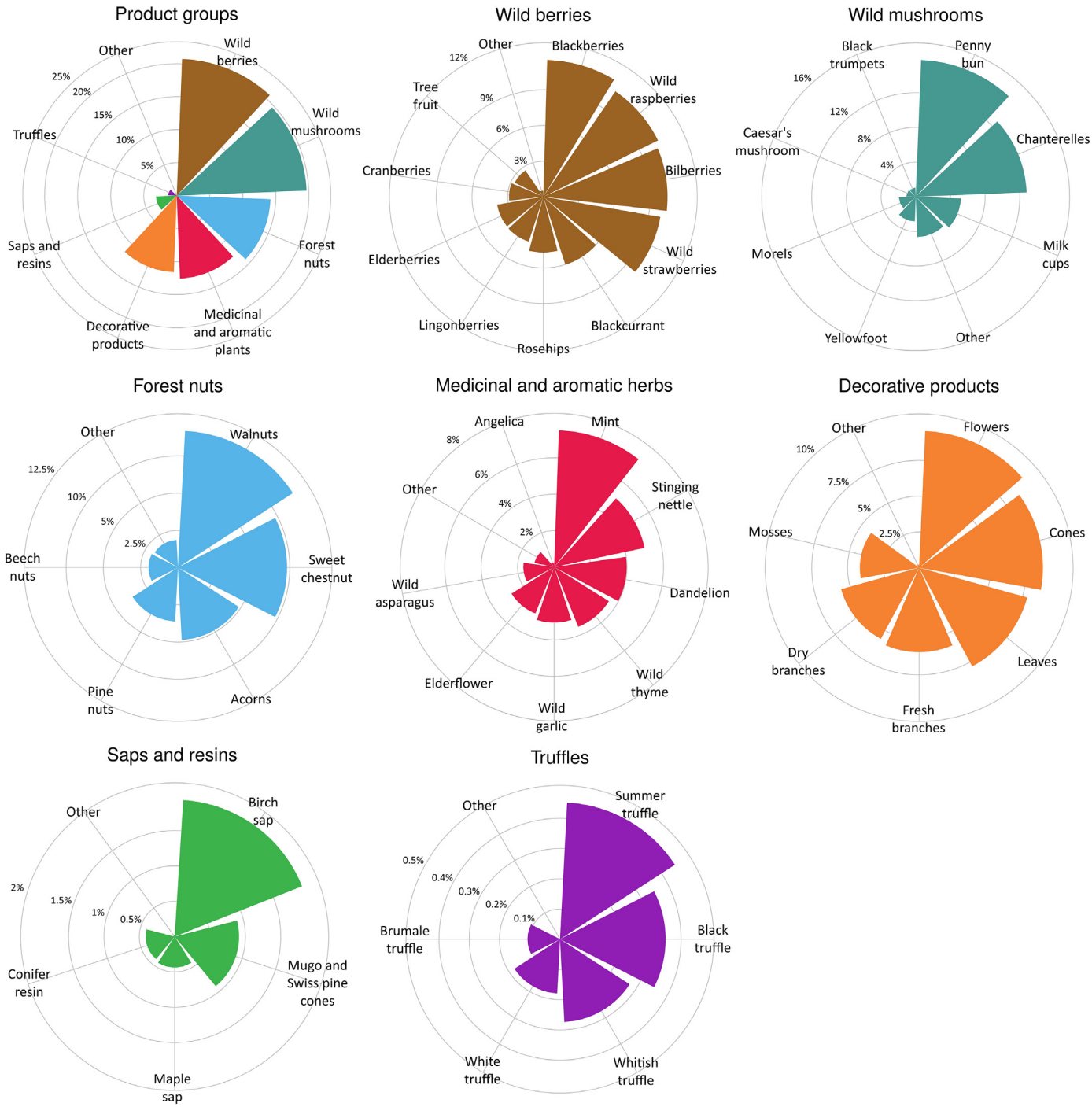

Fig. 3. Share of households that collect individual NWFPs

and countries in Fig. 5) has varying validity in each dimension – for example, fist dimension (labelled Dim.1 in Fig. 5) explains 30.2% of variability in the data on collection of NWFPs by country and thus is more explanatory than the second dimension (Dim.2), which explains 17.1% of the data variability. Decorative products were not used in our MFA as they are not associated to individual species with a distinct geographical area; products labelled 'other' were also not included as they contain different species in different countries.

The main two MFA dimensions explain 47.3% of the NWFP collection variability across sampled countries. Western and Southern European Countries have quite similar NWFP collection patterns, although they are not associated to a statistically significant cluster. In terms of total annual collected weight, this cluster is dominated by Turkey ($444 \cdot 10^6$ kg) and France ($379 \cdot 10^6$ kg). Although Germany ($368 \cdot 10^6$ kg) is clustered together with Eastern European countries, its collection patterns are quite similar to that of Western European countries. However, they are all much smaller than the weight of collected NWFPs in the European part of Russia ($1173 \cdot 10^6$ kg). The collection of truffles is predominantly associated with Italy, France, Spain and Turkey, while all other NWFPs are collected much more widely across Europe. Walnuts ($458 \cdot 10^6$ kg) and blackberries ($224 \cdot 10^6$ kg) are the main representatives of a cluster of products predominantly collected in Eastern Europe, while sweet chestnut ($258 \cdot 10^6$ kg) and yellowfoot (*Cantharellus lutescens*; $55 \cdot 10^6$ kg) are dominant representatives of a cluster of NWFPs that are mostly collected in Central and Western Europe. The cluster of products predominantly collected in

Fig. 4. Value of individual NWPFs (in billion €· yr^{-1}).

the European part of Russia and the Nordic and Baltic countries can be clearly split into three sub-clusters: one dominated by lingonberries (*Vaccinium vitis-idaea*; 125 · 10^6 kg) and cranberries (*Vaccinium oxycoccos*; 89 · 10^6 kg), the second one dominated by bilberries (231 · 10^6 kg) and chanterelles (188 · 10^6 kg), and a third one dominated by penny buns (393 · 10^6 kg) and wild raspberries (232 · 10^6 kg).

4. Discussion and conclusions

In this study, we conducted a household survey involving 17,346 respondents representing households from 28 European countries. In terms of economic importance, we estimate that collected NWFPs represent a total economic value of 23.3 billion € per year in Europe, which amounts to 20.5 € per hectare of forest and other wooded land, and represents an economic value that is comparable to 70.7% of annual roundwood removals value in Europe (FOREST EUROPE, 2015). Previous estimates of the economic value of NWFPs suggest values up to 2.1 billion € per year (FOREST EUROPE, 2007; FOREST EUROPE, UNECE and FAO, 2011; FOREST EUROPE, 2015). However, they do not account for self-consumed NWFPs, which in our study represent 86.1% of collected weight. We also find that for 0.6% of all households NWFPs represent a majority of income, and for 5.9% of households they have a minor share. However, the interpretation of results also has to take into account the limitations of the study, of which the most important ones are: (I) that this study accounts for vast majority but not all NWFPs that are collected in Europe (Schulp et al., 2014), (II) that due to higher number of responses, results for more frequently collected products and for larger countries are more valid than results for less frequently

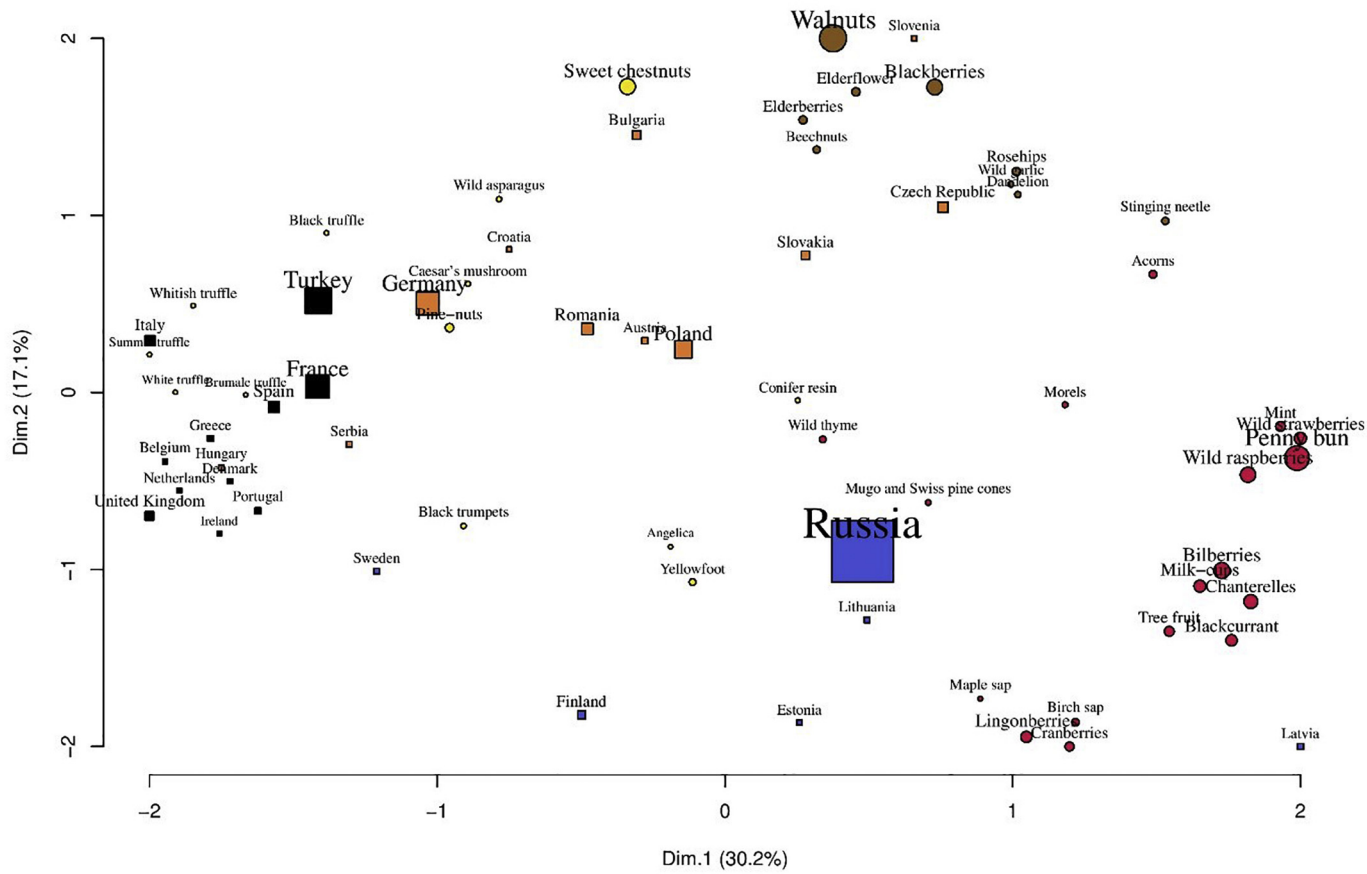

Fig. 5. Scatter plot of the first two dimensions of the Multiple Factor Analysis based on collected NWFP weight by country per product. Squares represent countries, circles NWFPs products. Size of the symbols represents collected weight. Black color represents non-statistically significant cluster; other colors represent statistically significant clusters ($p < .05$).

collected products and for smaller countries and (III) that both NWFP yield and collection vary from year to year (Calma et al., 2010). For a thorough discussion on construct, internal and external validity, please see Supplementary material.

Our results suggest an east-west gradient, where Eastern Europe is characterized by higher collected weights and a larger diversity of collected products than in other European regions. These results highlight that NWFPs are not only important in Southern Europe as previously contended (FOREST EUROPE, UNECE and FAO, 2011; Merlo and Croitoru, 2005; Croitoru, 2007), but also in Eastern Europe. Results show that collection rates and commercial collection are highest in Eastern Europe, confirming previous findings that NWFPs in Eastern Europe are more linked to subsistence and seen as an income source (Stryamets et al., 2015). The collected NWFPs in Eastern Europe that are marketed are generally consumed in Western European countries, where most of the added-value is generated. This is the most important international supply chain of formally marketed NWFPs in Europe (Da Re et al., 2015). It is more difficult to restrict commercial picking of NWFPs from forests in the Eastern Europe than in the Western. This is due to complex and restrictive NWFP harvesting rules found in Eastern Europe which are not strongly enforced (Wolfslehner et al., 2019; Schulp et al., 2014), and thus encourage the informal and suppress the formal market. Informal markets have shorter supply chains, lower added-value and more of a local character than the formal market of NWFPs (Da Re et al., 2016). These findings show that relatively high share of sold NWFPs in Eastern Europe actually represents a low contribution to rural development.

From the side of pickers, the situation could be improved by developing practical knowledge about commercializing NWFPs on the local level and by raising awareness on the multitude of NWFPs and their economic potential, as entrepreneurs are focused only on a few main products (Da Re et al., 2015). NWFPs are not perceived as 'belonging' to any sector, which is why they receive very little attention from rural development, agriculture or forestry agencies (Wolfslehner et al., 2019). From the side of policy, the situation could be improved with changes in property rights and tax regulation; but no single approach can tackle the multitude of local contexts. What is universally true in Europe is that action in these areas is seldom taken, as relevant experts and policy-makers consider NWFPs to be a low-priority topic due to their perceived low economic importance (Wolfslehner et al., 2019); our study refutes the basis for such perception. Results of this study show that 26% of European households collects NWFPs. Such a high share can be explained with outdoor recreation being an important motive behind their collection; and this is seen throughout Europe (Schulp et al., 2014). With low diversity, low average collected weight and low share of sold NWFPs, it can be assumed that recreation is the predominant motivation for their collection in Western Europe.

The results of this study can serve as an impetus for the development of national-level household surveys to be used for improving the official, statistical reporting on the value of NWFPs. Once reliable data is available NWFPs can be entered into national commodity classifications (Vantomme, 2003). Good data is a precondition for raising the importance of NWFPs in national policy contexts (Shackleton and Pandey, 2014). In terms of recognizing marketed NWFPs, the tracking of internationally traded NWFPs within multiple countries could lead to a joint proposal for introducing new NWFP codes in the international commodity classifications, which would then lead to strengthening their role in national and international policy discourses (Shackleton and Pandey, 2014; Vantomme, 2003). An example would be separating fresh truffles as a category from fresh or chilled mushrooms and truffles

(other than of the genus *Agaricus*) presented in 070959 HS (Harmonized Commodity Description and Coding System) code, to which they were joined in 2007 (Pettenella et al., 2014). The World Customs Organization that governs the HS system requires a reported annual trading volume of more than 45 million € globally in order to accept amendments to the system; it is very likely that much more than that figure is traded, as the annual value of marketed truffles in Europe (Pettenella et al., 2014) is 1.2 billion €. Economic importance of NWFPs is also higher in other regions of the world than in Europe, for example in Asia and Oceania (FAO, 2014) and in Africa (Vira et al., 2015). As these estimates were based on same methodologies as previous estimates for Europe, the findings of this study point to need for global reassessment of NWFP value.

NWFPs' lack of prominence in the policy sphere is reflected in the lack of knowledge on the interactions between their production and the production of other forest ecosystem services (Shackleton and Pandey, 2014), although there are some co-production models (Kurttila et al., 2018; Kurttila and Tahvanainen, 2016; Kilpeläinen et al., 2016; Vauhkonen and Ruotsalainen, 2017). There is already some evidence that joint production of wood and non-wood products may be complementary (Clason et al., 2008; Nybakken et al., 2013), or that they might even have synergetic effects (De-Miguel et al., 2014; Pohjanmies et al., 2017), but many of the silvicultural interactions between product types are still largely unknown (Tomao et al., 2017). In the example of three forest stand types typical for Nordic forests, Miina et al. (2016) show that forest soil expectation value doubles when berries are taken into account. In this study we identify small groups of products that are frequency collected together, mostly in Eastern and Northern Europe. It would be important to demonstrate the practical forest management interactions between multiple NWFPs that belong to different groups and are frequently collected together (e.g. penny bun, mint, wild raspberries and wild strawberries; see Fig. 5).

Current discourses in European forest-related policy centers around the bioeconomy (European Commission, 2018), a strategic orientation towards an economic development that emphasizes reliance on biological resources in order to address global and local challenges such as climate change and sustainable development. The bioeconomy includes agriculture, forestry, fisheries, food and pulp and paper production as well as parts of the chemical, biotechnological and energy industries. It is characterized by the lowering of sectoral boundaries, the cascading of biological resource use and the development of added-value bio-based products such as bioplastics and biopharmaceuticals, intended to decrease reliance on fossil fuels. NWFPs have yet to enter mainstream bioeconomy discussions (Watson, 2015), their added-value chains are not recognized in forecasting forest-based bioeconomy development (Hurmekoski et al., 2019), and as a topic they receive the lowest level of funding compared to all other research topics in the field (Lovrić et al., 2020a). The role of forestry within the bioeconomy discourse, so far, has been two-fold: as a supply-side sector that provides wood to an economy which seeks sustainability through technological advances (Overbeek et al., 2016; Hetemäki, 2014), and as an ecosystem segment that defines its ecological boundaries (European Commission, 2018). This study points to a third role: the provision of non-wood forest products consumed directly and entering markets. To guide policy-making, several studies (Scarlat et al., 2015; Ronzon and M'Barek, 2018) try to quantify the economic importance of forestry and other primary sectors (agriculture, fisheries). Our results indicate that the importance of the European forestry sector is underestimated and that its annual value should also contain 23.3 billion € stemming from collection of NWFPs. Our study shows that a regional-level approach to NWFPs is warranted; i.e. collecting NWFPs represents a contribution to livelihood in the East of Europe, while in the West it is more a component of recreation. If policies aiming to further the development of the bioeconomy lead to forest management practices geared to maximizing wood production, this might impair those livelihoods that depend on NWFPs as a source of or as a complement to their income. Our results also show that silvicultural co-production models and subsequent practical forest management considerations are most appropriate in Central Europe, where their value per hectare is highest.

Declaration of Competing Interest

None

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.forpol.2020.102175.

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