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Collection and consumption of non-wood forest products in Europe

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Many non-wood forest products (NWFPs) such as mushrooms and berries are collected and consumed in Europe; but both national statistical and scientific data on this topic are reported only for a limited number of countries, products and case-study areas. Without an adequate quantitative basis, their importance as source of food and income, their links to recreation and cultural heritage, are all under-valued in forest-focused and forest-related policies. In this study, we aimed to address this gap by assessing the consumption and collection of NWFPs through a statistically representative survey in 28 European countries with over 17 000 respondents. Our results show that 90 per cent of households consume NWFPs and about one-quarter collects them. The consumption and collection rates, as well as the number of collected products and their contribution to household income, increase from the west to east of Europe. The vast majority of collected products are consumed fresh. Households with higher income consume a more diverse range of NWFPs, especially in Western Europe. The relation between income and collection is more ambiguous, but there is some indication that the collection rate is higher than average among higher-income households in North and Western Europe and among lower-income households in Eastern and South-Eastern Europe. Households for which NWFP collection is the main income source are predominantly located in Eastern Europe, and they focus their activities on few key products. Our results also identify recreational, hobby and professional collectors whose characteristics vary across socio-economic variables and geographical gradient. Recreational collectors in Western and Southern Europe collect 8 kg of NWFPs from five different products, while recreational collectors in Central-Eastern and North-Baltic Europe collect about four times more from 10 different products. Hobby collectors collect ∼100 kg of NWFP per year and professional collectors half a ton, where both groups focus on 8–12 different products. Professional collectors are predominantly located in Eastern and South-Eastern Europe. We end the study by pointing to future research directions and with a series of policy recommendations on how NWFPs could be addressed along the geographical, income and urban–rural gradient with respect to their role in forest recreation as a food and income source.

Introduction

Forest ecosystems supply many important products and services to society. Wood is a key forest product, but there are many other forest products (Wolfslehner *et al.*, 2019). These products are often called non-wood forest products (NWFPs) and include berries, mushrooms, aromatic and decorative plant material, saps and resins, nuts and game. Although sustainable forest management is the guiding sectoral principal, it inherently implies finding the 'optimal' balance (or trade-offs) between different societal demands on one side and supply of forest ecosystem services on another (Sotirov and Arts, 2018). On the level of practical forest management, timber production tends to be the dominant objective and NWFPs receive limited attention (Wiersum, 1995). Even within the context of ecosystem services, NWFPs so far had a minor role and have been seldom included in efforts to map ecosystem services, probably due to their perceived low importance (Maes *et al.*, 2012) and difficulty to quantify (Maes *et al.*, 2011). Wiersum *et al.* (2018) point out that NWFP perspectives in Europe are not primarily concerned with production but rather with 'fulfilling identity and belongingness needs as well as esteem and self-actualization needs for consumers'. Thus, NWFP development is part of the ongoing processes of rural adaptation to changing needs of increasingly urban and comparatively wealthy consumers, which lies outside the scope of traditional forest management.

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At international level, NWFPs are more important than previously thought as a source of food (Ickowitz *et al.*, 2014; Rowland *et al.*, 2017; Rasolofoson *et al.*, 2018) and for food security (Shackleton and Pandey, 2014) as well as in terms of income (Qureshi and Kumar, 1998; Babulo *et al.*, 2009; Asfaw *et al.*, 2013) and for medicinal use (World Health Organization, 2002). In Europe, NWFPs are especially important in the Mediterranean region and in Eastern Europe (Lovrić *et al.*, 2020), where their great diversity coupled with low wood production profitability makes them a sizable part in the total value of forest production – for instance, in Italy and Portugal, they exceed the value of industrial roundwood, while for Europe they account for 12 per cent of roundwood value (Forests Europe, 2011). The most reliable data on the economic aspects of NWFPs come from international trade statistics (Vantomme, 2003). At least, 150 NWFPs are of major significance in international trade (Millennium Ecosystem Assessment, 2005), and the global value of these during 2011 has been estimated at US$12 billion (Vidale *et al.*, 2015) excluding animal products. The European Union (EU) has a strategic role in the international market of NWFPs, accounting for 50.4 per cent of the total global export value of commodities based on raw or processed NWFPs. All of these figures are underestimates, and more important than the overall numbers is the fact that NWFPs are unevenly distributed, with higher levels of collection in forest-rich areas, and contribute to food security when other sources of food are not available (FAO, 2014a).

Changes in formal market estimates are not a full representation of the value of NWFPs but rather they indicate trends in data quality (Forest Europe, 2015, 2020), as 'statistical data are incomplete, scattered or not comparable among countries' (Vantomme, 2003). There are also pronounced inconsistencies in tracking their production, trade and consumption (Turtiainen and Nuutinen, 2012). The majority of NWFPs extracted from forests are not marketed but mostly used for self-consumption (i.e. consumed within the household) for which there are very limited primary data at the European level (Vantomme, 2003; FAO, 2010; FAO, 2014a; Sorrenti, 2017; Forests Europe, 2020). Although the scientific literature on collection of NWFPs is abundant (e.g. Seeland and Staniszewski, 2007; Barszcz and Suder, 2009; Kilchling *et al.*, 2009; Sievänen and Neuvonen, 2011; Turtiainen *et al.*, 2012; Górriz *et al.*, 2014; Kovalčík, 2014; Sisak *et al.*, 2015), it is generally focused on case-study or national-level results on nationally important products and utilizes different methodologies which makes the aggregation of findings to an international level difficult. In general, it is very difficult to collect data due to heterogeneity of the NWFP markets and the diverse local-level importance of many products (Wahlén, 2017). The lack of systematic data has a direct effect on NWFPs being generally under-represented in national statistics, development plans, forest policies and land-use planning (Sills *et al.*, 2011; FAO, 2014a) and in general in policy discourses where they have a very marginal role. The situation is complicated by the fact that specific legal competence for forestry at the European level is non-existent (Pülzl *et al.*, 2013; Aggestam and Pülzl, 2018) and that each of the sectors which takes up a part of forest policies has an inherent interest to keeping the sectoral boundaries intact (Winkel and Sotirov, 2016).

The collection of data on NWFPs also has a conceptual-level problem – the definition of NWFPs. One of the difficulties in analysing them lies in the fact that they can be classified in many ways, with a common denominator of the products being recognized as 'wild' (Kilchling *et al.*, 2009). Muir *et al.* (2020) find that NWFP/NTFP should not be used when communicating to the public or with stakeholders out of the forest sector, as they are neither widely known, nor do they have an unambiguous interpretation of what do they mean, and the authors recommend terms like wild forest products or natural forest products.

The only viable way through which data on total NWFP removals can be collected, counting products sold on formal and informal market and those used for self-consumption, is through household surveys (Sorrenti, 2017). Such an approach has been advocated for previously (FAO, 2010; Laird *et al.*, 2010; Shackleton and Pandey, 2014). As there are many hundreds of NWFPs being collected in Europe, (Schulp *et al.*, 2014), a major challenge is that surveys need to focus on a wide set of products to reveal the actual collection patterns. Although abundant, the literature of national and case-study-level studies referenced above is not sufficient to provide a European-wide overview of the most important NWFPs. Thus, to design future cost-effective national-level surveys on NWFP collection, at minimum, the following data are needed: (1) defined collection rates and weights by product and country so that survey's focus could be set and (2) defined which products are jointly collected so that the collection rates of selected key products would capture the heterogeneity and diversity of numerous other products that are collected as well. In this paper, we address this challenge by presenting the results of a survey in 28 European countries focused on the consumption and collection of NWFPs. Our study aimed to assess the consumption and collection of NWFPs across Europe. Specifically, we tried to answer the questions: (1) How many and what kind of households in Europe collect NWFPs? and (2) How much NWFPs do these households collect and consume at an annual basis? Our study contributes to having adequate quantitative data on NWFP removals in Europe with which we strive to support more appropriate inclusion of NWFPs in the respective policies and ultimately in forest- and land-use practices. This paper is a companion to Lovrić *et al.* (2020) which primarily focuses on the value of collected NWFPs (not covered here). Many more results are presented in supplementary material of both publications.

Methods

This study rests on a household-level survey distributed across Europe, with a primary goal of assessing which NWFPs are collected and consumed. Data on which NWFPs are commonly collected and how they are used are drawn from Da Re *et al.* (2015) and Wong and Chapman (2019). Based on these sources, we have identified 39 specie-level products and 7 product groups that are frequently collected and 14 product groups that are frequently consumed. As national-level collection and consumption data are typically devoid of context and thereby insufficient for informed policymaking, the guiding principle in our survey design was that it should include variables that facilitate the interpretation of collection and consumption data. The most important contextual information on NWFP is provided by the collection weight, which is a proxy for the purpose of collection, as it can be

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hypothesized (Wiersum *et al*., 2018; Weiss *et al*., 2020) that the collection of NWFPs is predominantly perceived as a cultural and recreational service in the west of Europe which is associated to smaller collection weights, and in the east, it is primary perceived as a good associated to higher collection weights. Furthermore, it can be hypothesized that the economic viability (proxied by the sale of NWFPs) is more pronounced for rural than urban households (Huber *et al*., 2019) and that self-consumption of NWFPs is much higher than what is marketed (Wahlén, 2017). It is also very important to find out what problems collectors of NWFPs face, as for example, high competition between pickers is the main perception of harm to the resource by the landowners and manager (Górriz-Mifsud *et al*., 2017), and policy and legal obstacles are the critical issue affecting the entry of NWFPs into formal markets (Mutke *et al*., 2019; Wolfslehner *et al*., 2019). To address these issues, we have also included questions on the collected weight of the products, proportion sold, use and place of collection. We also asked general socio-economic questions (urban/rural setting, household composition and income) and a series of items to ascertain the collector profiles (number of household members collecting NWFPs, forest ownership, frequency of collection, attendance to courses on the recognition of plants and fungi, constraints in collecting NWFPs and their contribution to household income). The entire questionnaire is presented in the supplementary material.

All listed NWFPs were signified by one or more names in local language, followed by the Latin name of the species (if applicable) and also by an illustrative picture. The term NWFP was not used in the questionnaire, but rather 'wild forest products' (in the introduction and at the top of each survey page), as it was considered to have an unambiguous meaning to respondents. Term 'wild' was also prominently used throughout the questionnaire to signify products that are coming from the forests and not from agricultural production. We developed the questionnaire with an online interface, which was suitable for multiple platforms (PC, tablet and laptop), and pretested it twice on a total of 111 respondents, both NWFP experts and non-experts. The final questionnaire was distributed to respondents in 28 countries comprising the European part of Russia, Serbia and Turkey and EU member states (including UK, but excluding Cyprus, Malta and Luxembourg) in all national languages spoken in these countries. The unit of analysis is a household because consumption and collection of NWFPs are generally household rather than an individual activity (FAO, 2010). A polling agency distributed the questionnaire in the period from June to November 2016 and the respondents were asked to answer the questionnaire based on their NWFP consumption and collection of the previous year. The initial discriminating variable that was used for defining valid responses was: are the respondents aware of household consumption and NWFP collection habits or not. Responses where the questionnaire was filled in below 3 min but have collected NWFPs were also disregarded, as well as filling-in individual segments of the questionnaire in less than 10 sec, providing divergent information on the household composition on two different pages of the questionnaire and stating high outliers.

To facilitate comparison of the results, we express all collection and consumption amounts in kilogrammes and converted the volume units to kilogrammes based on AVCalc (2018) conversion factors. Responses not expressed in standard units of weight and volume were replaced by the median value of collected weighs for that product and we applied the same correction when the respondents stated that they had collected a certain product but did not specify the collected weight. A total of 1.9 per cent of weight-data was changed this way. Weight of collected products for countries out of sample was estimated, where the collected weight of NWFPs per hectare of forest for a country out of the sample was equated with the mean collected weight per hectare of forest from the neighbouring countries that were sampled. Iceland data on the weight of collected NWFPs were not estimated. Forest area data were gained from Forest Europe (2015) and Schuck *et al*. (2002). Based on data from 28 sampled countries, this process was performed on 16 countries corresponding to 7.9 per cent of the NWFP collected weight in Europe. Weight for decorative products was not estimated due to the high usage of non-standard weigh and volume units.

Some compromises had to be made between accuracy and having a shared understanding of respondents of what the questions were about. One example is that we combined hedge rows, meadows and pastures all together as agricultural land. In another example, we considered bilberries (*Vaccinium myrtillus*) and blueberries (*Vaccinium corymbosum*) as a single product, as respondents in Europe collect bilberries but mostly call them blueberries. The question on household net income was provided on a scale, as during the pretesting, respondents were reluctant to write their actual income and have stated that they would be more willing to answer the question if they had to tick an income category. For that purpose, a single ordinal income scale was designed for all the sampled countries, where the borders of the category intervals were assigned with equivalent values in local currencies. To design such a scale, a third-order polynomial income curve (Oltean, 2014) was estimated for each country. Input data for the curve estimation were median net household income (European Central Bank, 2013; EUROSTAT, 2018), Gini index (World Bank, 2018) and S80/S20 ratio (Organisation for Economic Co-operation and Development, 2018). After calculating income quartiles, quintiles and sextiles for each country, they were all classed onto a 15-point ordinal scale. These data allowed us to allocate individual income responses to the percentiles of respective national household income distributions.

To build a typology of NWFP collectors, we use hierarchical clustering on respondent-level data on collected weight of NWFPs by product, where the distance matrix is based on squared Euclidian distances and with Ward's clustering method. In the first stage, 2.2 per cent of cases have been removed as outliers in the clustering algorithm, as they created very small cluster. The clustering was then repeated on the rest of the data and the number of clusters was set to the number of clusters preceding strongest relative change in the stages of agglomeration schedule, which was with a five-cluster solution. In the next step, we wanted to see if there are some significant differences or not between these clusters when it comes to additional variables such as household income or being based in a rural or urban setting. In the case of nominal variables, Chi-square test was used to test if there are significant differences between the two samples. For multiple pairwise comparisons with nominal variables, Bonferroni correction was used. In the case of interval variables, independent samples *t* test was used to test if there

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are significant differences or not between the two samples. For multiple pairwise comparisons with interval variables, One-way Analysis of Variance (ANOVA) was used. For variables where variances are not equal across sub-samples in comparison (as set by Levene's test for equality of variances), Welch's ANOVA with Games-Howell *post hoc* test was used. For variables where the homogeneity of variance is observed, Tukey's honestly significant difference test was used. Unless stated otherwise, criterion of $P < 0.05$ was used to signify a statistical significance. The final part of analysis was to define which products are jointly collected. To that end, a factor analysis was applied on the variables signifying collected weight per individual NWFP. The procedure has been applied for each country separately, as there is a great diversity in the geographical distribution of NWFPs and official reporting on their collection is performed on the national level (See Table S6). Principal component analysis was used as the factor extraction method, as it is fitting to situations when the objective of the factor analysis is reducing the number of observed variables to a smaller number where they account for most of the variance in the underlying data – and that is the case in this paper. Varimax rotation with Kaiser normalization has been applied, as this type of rotation assumes that factors are not correlated and thus produces more distinct factors – which again is the case in this paper, i.e. to produce distinct groups of NWFPs that are jointly collected. NWFPs with low collection frequency (in majority of cases, three or less) have been removed from the analysis in order to have an adequate sample, i.e. so that the Kaiser–Meyer–Olkin sampling adequacy is at least 0.6, which marks a mediocre sampling adequacy (Cerny and Kaiser, 1977). Such adequacy could not be achieved for the Belgian, Dutch and Greek sub-sample. Association of NWFPs to the components is based on the cut-off factor loading value of 0.71 (excellent association) and of 0.63 (very good association). Selection of number of components is based on the 'elbow method', i.e. the smallest increase in the percentage of explained variance with the increase in the number of components, which practically means that not all components with eigenvalue greater than 1 have been taken into account. Analysis was performed in SPSS.

The final data list had 17 346 responses. This accounts to 0.74 per cent of sample-wide confidence interval (CI) (or results' margin of error) and 4.21 per cent of mean national-level CI with 95 per cent confidence level. Confidence level of 95 per cent means that if we were to make 100 studies of this type in which the sample of European households is drawn at random, the difference between the results produced in 95 of them and the results of this study would be smaller than the above-stated CIs. These CIs can be assumed for bimodal data (e.g. consumption or collection of a certain product) but not for the collected weights as these data are not normally distributed (see Results). The distribution of collected weights is akin to an exponential distribution; out of households that collect NWFPs, most of them collect small and few collect large quantities. This makes the extrapolation of the survey's results to the population more susceptible to the changes in the parts of the sample where collection weights are high. Corresponding sensitivity analysis has been performed (see Supplementary Table S1), where the mean CI of all calculations is ±13.9 per cent. This range can be taken as a more realistic approximation of the CI for weight-based data. Before the analysis began, we needed to check to which extent is the sample representative of the population as based on socio-economic variables that are known both for the sample and the population of households. The mean income of the sub-sample that collects NWFPs is at 57.3 percentile of the national household income distributions. When the individual respondents' income from the sample is set to the mean value of the income response category, the mean difference between the country-level sub-samples' median income and the country-level median household income is €1805, which is less than the range of a single income response category (in percentiles, the difference is 4.2 per cent of population). The income at 25th percentile of the sample is higher by €2942 than the actual one; this is equivalent to a range of an entire category in the ordinal income scale (which has 15 points). This also means that the income at the 25th percentile in the sample is equal to the income at the 34.4 percentile of the actual population, i.e. the difference is 14.4 per cent. This indicates that households in the first quartile of income distribution are under-represented in the sample. The same difference in the third quartile (i.e. 75th percentile) is €657, meaning that only the respondents falling within the first quartile of the national income distributions are under-represented in the sample. Income of the third quartile falls onto 73.4 percentile of the actual income distribution. Rural households are under-represented, as in the sample, their share is 20.3 per cent compared with the actual 25.2 per cent share – but this difference is not significant (as based on *t* test for independent samples).

Results

NWFP consumption

According to our results, the vast majority (89.8 per cent) of households in sampled countries consumed NWFPs. The consumption rate (Figure 1) is highest in Italy, Turkey, Romania, Croatia, Bulgaria, Poland, Estonia and Latvia (all >95 per cent), and it is the lowest in Netherlands, UK and Denmark (all <80 per cent). All of the results present 1 year's NWFP consumption and collection activity.

Fresh or dried nuts are the NWFPs consumed by highest share of households (70.8 per cent), followed by fresh berries (59.5 per cent) and dried, frozen and prepared wild berries (45.7 per cent; Figure 2). The consumption rates for both frozen or prepared truffles and fresh truffles are the smallest out of listed products (11.4 and 6.8 per cent).

Most households (84.6 per cent) purchased NWFPs from a shop, a quarter (25.6 per cent) collected themselves, followed by purchase from a collector or a harvester (22.3 per cent) and receiving them as a gift (15.0 per cent). The percentage of households whose members did not consume NWFPs is significantly larger in the rural environment (15.1 per cent) than in the urban environment (9.7 per cent). However, there is no significant difference in consumption of individual NWFPs between rural and urban households. There is positive and significant correlation (Spearman's $r = 0.14$) between the number of consumed NWFPs and the income category that the household occupies. The same type of positive and significant relation was found in sub-samples of 20 out of the 28 countries included in our study, which implies that in most countries, more affluent households consume larger

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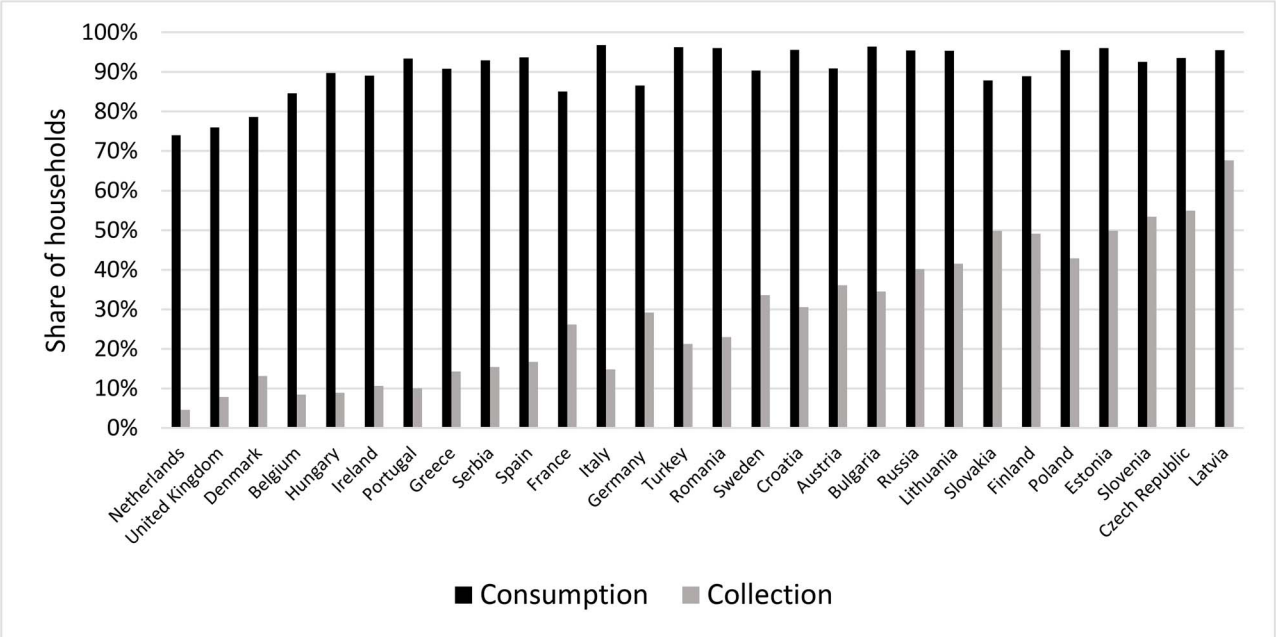

Figure 1 NWFP consumption and collection rates by household per country. Data on collection from Lovrić *et al.*, 2020. Order is set by summing up the consumption and collection rates by country and then ordering them from smallest to the largest rate.

diversity of NWFP products. The correlation coefficient is the highest in Russia (0.35), Germany (0.30) and Belgium (0.26). If we look just at the relation between number of consumed NWFPs between households above and below the mean income – then there is no significant difference between these two sub-samples. However, some significant differences exist if the test is repeated on the sub-samples of individual countries. They are most pronounced in Germany, Netherlands, Belgium and UK (above-median household consumption rates are higher by 20.8, 17.8, 16.0 and 14.1 per cent, respectively).

Univariate NWFP collection results

Our overall results show that 25.6 per cent of households collect NWFPs across all countries in our study and, as it can be seen in Figure 1, in general, it increases from Western Europe to Eastern Europe, with the lowest in the Netherlands and the highest in Latvia. The collection rates of NWFP product groups and individual products (Lovrić *et al.*, 2020) mirror their overall collected weights (Figure 3), with the highest being for berries, mushrooms and nuts out of the product groups and the highest for chanterelles (*Cantharellus cibarius*), blackberries (*Rubus fruticosus*), bilberries (*V. myrtillus*) and wild raspberries (*Rubus idaeus*) out of the individual products. All other NWFPs are less frequently collected, where individual collection rates, their most frequent and second most frequent usage (for the part which is not sold) are displayed in Supplementary Table S2. Eighty per cent of individual products are primary consumed fresh, while the most frequent secondary use is to preserve them (frozen, dried or candied; 76 per cent). A total of 62.6 per cent of the collected NWFP weight was collected in the forest, followed by agricultural land (27.9 per cent), urban area (5.5 per cent) and category 'other' (4.0 per cent), which predominantly means in the respondent's backyard. Only wild medicinal and aromatic plants are predominantly collected on the agricultural land and not in the forest (57.6 and 29.2 per cent, respectively), while all other groups of products were mostly collected in the forest (see Supplementary Table S3 for more details).

In terms of collected weight, wild berries are mostly collected ($1463 \cdot 10^6$ kg year^{-1}), followed by wild mushrooms ($1017 \cdot 10^6$ kg year^{-1}) and forest nuts ($962 \cdot 10^6$ kg year^{-1}). Collected weights by product and product group can be seen in Figure 3 and in the supplementary material. A total of 13.9 per cent of collected NWFP weight is sold. However, a closer inspection of the distribution of sold products (Supplementary Table S4) shows that the majority of those who sell them still self-consume some part of the collected NWFPs. The median share of households that exclusively sell the NWFPs that they collect across all product groups is 1.5 per cent of the households that collect, whereas that share grows to 77 per cent for those who completely consume the collected products. The only divergence from such distribution can be found for truffles, where 48.8 per cent of those who collect them completely self-consume them and 5.4 per cent of those who collect them do so for the sole purpose of selling them. NWFPs are predominantly (52.3 per cent of cases) collected for 3–12 times a year. In 26.6 per cent of cases, they were collected for less than three times a year, while in 12.8 per cent of cases, they were collected between 13 and 24 times a year, in 6.8 per cent of cases, they were collected for more than 24 times a year, and 1.5 per cent of households that collect NWFPs did not collect them in the year before the questionnaire was distributed (see Supplementary Table S4). The mean value for the number of household members that collect NWFPs is 2.2. For 0.5 per cent of all households, NWFPs are the primary source of income, for

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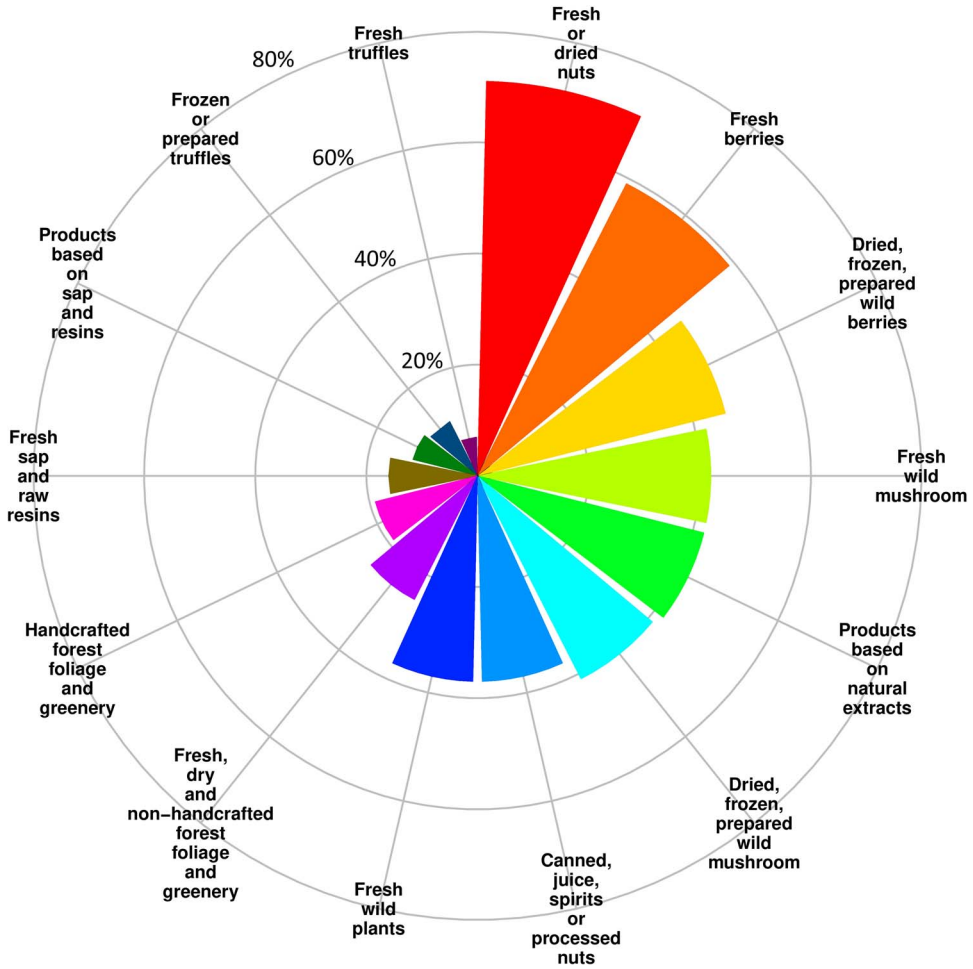

Figure 2 NWFP consumption rates expressed as shares of households in sampled countries.

1.5 per cent of households, they contribute between 11 and 50 per cent of the income, and for 4.2 per cent of households, they contribute to below 10 per cent of the income. When looking at the distribution of households that gain most of their income by collecting NWFPs per country, their share is largest in Turkey (1.28 per cent of all households), Lithuania (0.81 per cent) and Russia (0.74 per cent). Members of one-third (i.e. 35.3 per cent) of these NWFP-dependent households have attended some course on the recognition of plants and fungi, and most frequently, they have done so through private courses (in 20.6 per cent of cases), followed by school- (15.1 per cent) and university-organized courses (5.6 per cent). When asked what constraint they may have encountered during the collection of NWFPs, slightly more than half (50.8 per cent) of respondents stated that they did not encounter any problems. The most frequent problem was bad weather (23.4 per cent), followed by too much competition from other pickers (15.4 per cent), poor yield (13.7 per cent), difficult access to forest (13.0 per cent), and lastly, legal constraints (4.9 per cent; predominantly related to collection rights and taxation). The majority (53.1 per cent) of households that collect NWFPs also own a forest.

Multivariate NWFP collection results

We found no significant relation between the number of collected NWFP species and the income category to which the household belongs to. However, a significant relationship did exist for three individual countries: Czech Republic (Spearman's $r = -0.129$), Russia (-0.147) and Denmark (0.230), all three with $P < 0.05$. Although the NWFP collection rate is 6.9 per cent higher for households above the median income, the difference between them is not significant (test statistics, P-value). However, significant relationships do exist for individual countries, as the share of households that collect NWFPs is higher for above-median households than for the ones below it in Estonia (+29 per cent) and Finland (+26 per cent), while the opposite statement is true for Croatia (−15 per cent) and Romania (−5 per cent). NWFP collection rate is significantly higher for rural NWFPs than for urban ones (30.2 vs. 23.9 per cent). When taking a closer look on the relation between household income and income generated from the collection of NWFPs (Supplementary Figure S1), it can be seen that households for which NWFPs represent more than 10 per cent of the income are distributed evenly across all household income categories and that for those households where NWFPs

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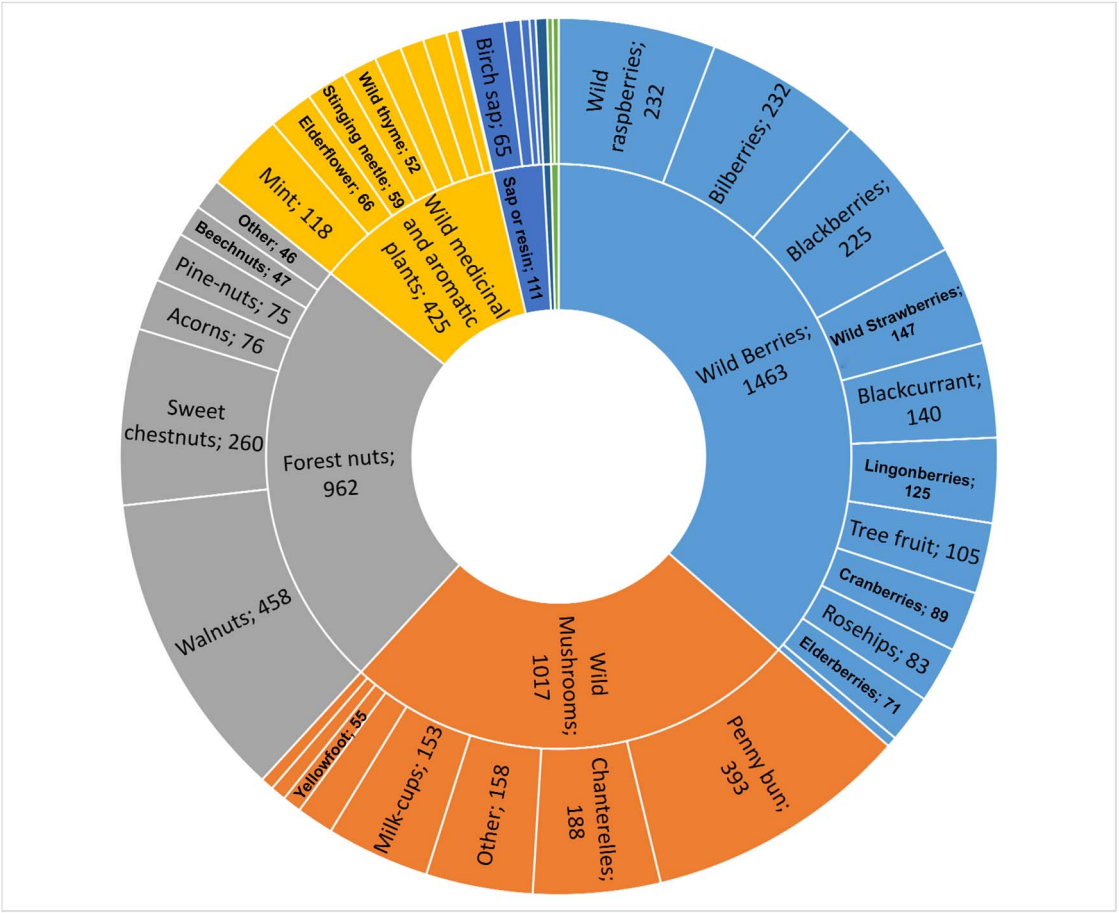

Figure 3 Collected weight by product and product group (10^6 kg) in one year.

represent 10 per cent or less of income and no income at all tend to be in the upper part of the household income distribution (the share of households in the individual bottom three deciles for these groups is two times smaller than its share in the rest of the individual deciles).

There is no significant difference when it comes to the share of rural households between the sub-samples that are economically NWFP-dependent and the ones that are not. Households that depend on NWFPs for their income purchase NWFPs significantly less frequently from the shop compared with households that do not rely on NWFP income (58.7 vs. 84.6 per cent). They also received them as a gift three times more frequently (43.7 vs. 15.0 per cent) and have purchased them from a collector or a harvester two times more frequently than the non NWFP-dependent households (43.6 vs. 22.3 per cent). The products for which the collection rate is at least double in the case of NWFP-dependent households are: beech nuts (2.8 times), morels (*Morchella* sp., 2.1), black trumpets (*Craterellus cornucopioides*, 2.2), tree fruit (2.2), wild garlic (*Allium ursinum*; 2.5) and angelica (*Aneglica officinalis*, 3.2). NWFP-dependent households are significantly less frequently forest owners than households that are not (24 vs. 53.1 per cent). They have also much more frequently attended courses for the recognition of plants and fungi (72.7 vs. 34.3 per cent), have rarely perceived poor yield to be a problem (2.3 vs. 13.7 per cent) but have more frequently faced legal constraints (9.4 vs. 4.9 per cent).

In a next step, we attempted to cluster the respondents based on the collected NWFP weight per product to investigate if significant differences exist between households that collect NWFPs (Table 1). We identified six clusters and almost half (49.1 per cent) of the respondents belong to a cluster 1, predominantly located in Western and Southern Europe, who on median collect 8 kg from five different products. Clusters 2 and 3 can be seen as the counterparts of recreational collectors in cluster 1 for Central-Eastern and Nordic and Baltic Europe, respectively. On average, they collect twice the number of products and about four times the amount compared with cluster 1 members. Clusters 4 and 5 can be labelled as hobby NWFP collectors. Clusters 2 and 4 have a very similar geographical focus, and the same can be stated for clusters 3 and 5. Although these hobby collectors collect on average at least three times more weight than recreational collectors, the diversity of collected products does not change. Cluster 6 represents outliers in the distribution of collected weight – professional collectors mostly located in Eastern Europe who collect on median 521 kg of NWFPs per year. Looking at the distribution of the collected weight and number of collected products across all clusters with respect to their geographical focus, it can be seen that both figures increase from the west to

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the east of Europe (as also shown in Figure 1). The same trend can be observed for the contribution of NWFPs to household income, share of sold NWFPs, for share of households whose members have attended courses for the recognition of plants and fungi, for household size and for share of forest ownership. The share of rural households is very similar across all clusters, and none of shares significantly differ from expected values (as based on Chi-square test with Bonferroni correction). The same can be said for the mean household income percentile. Competition with other pickers was not a pronounced problem in cluster 1, but it was in clusters 3 and 5 (both focused on North and Eastern Europe). Difficult access to forest was less frequent than the expected problem for cluster 1 but was more than the expected problem for cluster 4 (predominantly in Central and Eastern Europe). Same pattern can be observed for legal constraints related to the collection of NWFPs, which were also encountered more than expected by cluster 4. Bad weather was a problem only for cluster 4 more frequently than expected, whereas respondents for all clusters have quite similarly (14.7–18.0 per cent) experienced poor yield of NWFPs. The final step of analysis was to provide guidance to future similar studies – by identifying key products per country and finding out which products are jointly collected through factor analysis. This information is located in Supplementary Table S5.

Discussion and conclusions

In this study, we investigated the consumption and collection of NWFPs through a survey involving over 17 000 respondents from 28 European countries. Our results show that 89.8 per cent of households in Europe consume NWFPs and that a quarter collects them. This is much higher than previously estimated. For example, Schulp *et al.* (2014) estimated that 20 per cent of the European population consumes NWFPs and that 14 per cent collects them. Berries and mushrooms are both highly consumed and collected NWFPs, while forest nuts are the most consumed but not so frequently collected products. In line with previous studies (e.g. Wahlén, 2017; Huber *et al.*, 2019), we found that rural households engage more actively in the collection of NWFPs than urban households do, but they consume a smaller number of NWFPs compared with urban households. If we look at the geographical distribution of NWFP-based income from the clustering of respondents in Table 1, it can be stated that NWFPs represent a meaningful (>11 per cent) income contribution to ∼4 per cent of households in the west of Europe and to ∼8 per cent of households in the east of Europe. With some deviations, there is an overall trend of increase in the consumption and collection rates from the west to the east of Europe. Based on secondary data, Wiersum *et al.* (2018) assess that the collection rates, collected volume and economic significance are smallest in North-Atlantic Europe and also stipulate high collection rates for self-consumption and for income generation in South-Eastern Europe. In general, our results show alignment to these findings, especially when observing that the most represented countries in cluster 6 in Table 1 are from South-Eastern Europe.

Our results indicate that more affluent households collect more in Northern Europe, and less affluent ones collect more in South-Eastern Europe. As in absolute terms, incomes are lower in South-Eastern than in Northern Europe; these findings are in-line with the findings of Asfaw *et al.* (2013), Cavendish (2000) and Shackleton and Shackleton (2006) that, in less-developed regions, NWFP collection is more closely related to the household income. By contrast, more affluent households consume more NWFPs than the less affluent ones – especially in Western Europe. For more affluent households, NWFPs do not represent a significant income source. For 0.5 per cent of Europe's households, NWFPs represent the main income source, and for 1.5 per cent, they represent between 11 and 50 per cent of income. Although direct comparison cannot be made, these figures are not so different to share of the forestry sector to GDP (FAO, 2014b; for 0.8 per cent for Western and 1.2 per cent for Eastern Europe). All of the above point to a dichotomization of NWFPs' socio-economic importance. In the West, their recreation-linked collection and their consumption are externalizations of the urban affluent class taste (Bourdieu, 1984). In the East, they are especially important for rural population who focus on a smaller number of products to supplement their income. This is the primary underlying contextual setting within which all policy-level actions to address NWFPs should be embedded in.

As with the income levels, other variables to the NWFP have to be contextualized with respect to the geographical distribution of the clusters. This especially goes for the collection rates, as they tend to be lower in countries with lower forest cover and higher in countries with higher forest cover (Forest Europe, 2015). As this is the first study of its kind, it can only be compared at country level against other national-level findings. However, such comparisons are not straightforward, as every study has its own different methodological approach. Turtiainen *et al.* (2012) report that, in Finland, 23–47 per cent of households collect altogether between 15 and 16 million kg mushrooms per year, while our results suggest that 37 per cent of Finnish households collect 15 million kg of mushrooms. Kovalčík (2014) estimates that Slovakian households annually collect 29 million kg of berries and 27 million kg mushrooms and that 66 per cent of citizens collect *Boletus* spp.; these results are also similar to our findings that Slovakian households annually collect 30 million kg of berries, 20 million kg of mushrooms and that 41.8 per cent of households collect *Boletus* spp. For Poland, Barszcz and Suder (2009) show that 50 per cent of households collect NWFPs, while our data show 44.5 per cent. These comparisons indicate general agreement between our findings and those of other country-level studies. In terms of how representative the used sample is of the population – the overall and national-level sub-samples fall within standard validity thresholds (i.e. 95 per cent confidence level and 5 per cent CI), and the Methods section has shown that there is no pronounced deviation of the sample from the population in several socio-economic variables. However, as the distribution of the collected weights is not normally distributed, a more conservative approach to the interpretation of weight-based results is warranted, where readers are advised to first review the sensitivity analysis displayed in Supplementary Table S1 before forming conclusions (i.e. results are more robust for more frequently collected products and for larger countries).

We observed that there are distinct types of NWFP collectors, including recreational, hobby and professional NWFP collectors. Each of the collector groups are embedded in different

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Table 1 Clustering of households that collect NWFPs.

Cluster no.	1	2	3	4	5	6
Percentage of respondents (%)	49.1	19.7	14.0	11.3	3.8	2.2
Collected weight						
MED	8	28	39	64	127	521
IQR	11	28	39	69	160	775
No. of collected products						
MED	5	11	8	12	12	11
IQR	5	8	7	8	8	11
Dominant region of the cluster	Western and Southern Europe	Central-Eastern Europe	North-Baltic Europe	Central and South-Eastern Europe	North-Eastern	Eastern and South-Eastern Europe
Most represented countries (top five)[1]	Belgium (84%) Denmark (77%) Ireland (76%) UK (74%) Netherlands (72%)	Romania (39%) Slovenia (35%) Bulgaria (31%) Croatia (28%) Czech Republic (27%)	Russia (35%) Finland (33%) Latvia (29%) Lithuania (25%) Estonia (25%)	Turkey (32%) Bulgaria (26%) Serbia (24%) Croatia (23%) Hungary (22%)	Latvia (21%) Lithuania (16%) Estonia (13%) Russia (6%) Netherlands (3%)	Turkey (6%) Bulgaria (5%) Serbia (5%) Belgium (4%) Romania (4%)
Percentage of households that collect individual products (top five)	Penny bun (49%) Chanterelles (43%) Bilberries (41%) Wild raspberries (36%) Wild strawberries (35%)	Blackberries (60%) Penny bun (60%) Wild raspberries (55%) Wild strawberries (53%) Bilberries (50%)	Penny bun (81%) Chanterelles (74%) Bilberries (64%) Wild strawberries (49%) Wild raspberries (48%)	Walnuts (71%) Blackberries (59%) Penny bun (58%) Wild raspberries (55%) Wild strawberries (55%)	Penny bun (79%) Chanterelles (75%) Bilberries (72%) Birch sap (72%) Wild strawberries (63%)	Blackberries (64%) Penny bun (60%) Wild strawberries (56%) Walnuts (56%) Wild raspberries (54%)
COVERIATES[2]						
Rural households						
%[3]	25.9%	29.4%	26.2%	29.8%	31.5%	30.4%
Household size						
$\bar{x}$	3.0	3.2	3.2	3.5	3.7	3.7
s.d.	1.4	1.4	1.4	1.5	1.7	1.9
Diff[4]	Lower value for clusters 1–3 than for clusters 4 and 5. Lower value for clusters 1 and 3 than for cluster 6					
Forest ownership %	18.0% (↓)	25.4%	22.7%	36.7% (↑)	38.8% (↑)	37.3% (↑)
Income percentile						
$\bar{x}$	56.7	57.8	57.3	59.6	56.3	56.0
s.d.	25.9	26.0	24.7	25.5	25.1	24.4
Diff	No significant differences					
NWFPs contribute to household income by more than 11% %	4.4% (↓)	5.0%	5.6%	8.9% (↑)	8.4%	31.4% (↑)
Percentage of sold NWFP weight						
$\bar{x}$	3.4	4.9	4.9	9.6	6.9	19.5
s.d.	11.6	13.1	13.7	17.7	17.5	27.8
Diff	Lower value for clusters 1–3 than for clusters 4 and 6. Lower value for cluster 5 than for cluster 6. Higher value for cluster 6 than for all other clusters					

(Continued)

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Table 1 Continued.

Cluster no.	1	2	3	4	5	6
Number of consumed products						
$\bar{x}$	5.4	6.5	5.7	7.1	6.0	6.5
s.d.	2.9	2.9	3.1	3.2	3.1	3.2
Diff	Lower value for cluster 1 than for clusters 2, 4 and 6. Higher value for cluster 2 than for clusters 1 and 3; lower value than for cluster 4. Lower value for cluster 3 than for clusters 2 and 4. Higher value for cluster 4 than for clusters 1, 2, 3 and 5					
Attendance to courses on recognition of plants and fungi						
%	26.3% (↓)	36.2%	33.2%	45.8% (↑)	41.0%	55.9% (↑)
Experienced too much competition with other pickers						
%	12.9% (↓)	14.1%	18.9% (↑)	15.3%	20.2% (↑)	10.8%
Experienced difficult access to forest						
%	11.1% (↓)	14.2%	12.0%	20.7% (↑)	15.2%	11.8%
Experienced legal constraints related to collection of NWFPs						
%	4.9% (↓)	8.2% (↑)	5.2%	9.4% (↑)	6.2%	8.8%
Experienced bad weather while collecting NWFPs						
%	20.9%	22.7%	23.2%	29.4% (↑)	23.6%	19.6%
Poor yield of NWFPs						
%	15.2%	15.7%	18.0%	14.7%	18.0%	15.7%

[1]Shares signify number of respondents per country belonging to a cluster divided by total number of respondents from that country – counting only respondents that collect NWFPs [2]Underlined variables reflect their small size effect (Cohen, 2013) as based on Phi value for binary and η^2 for interval variables. External variables that are not underlined have very small effect size. [3]Percentage of cases at which the binary variable is present. Arrow up (↑) and down (↓) represent statistically significant (s.d.) ($P < 0.05$) higher or lower percentage than expected, as based on Chi-square test with Bonferroni correction. [4]Presence of significant ($P < 0.05$) differences in means across clusters as based on one-way ANOVA. MED, Median; IQR, Interquartile range.

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socio-economic contexts for whom a differential approach is warranted in different regions of Europe. Recreational collectors predominantly in Western and Southern Europe had lower-than-expected between-collector competition and lower-than-expected attendance on courses on the recognition of plants and fungi. This indicates that the capacity to use forests for recreational NWFP collection could be increased, and one possible way to do it could be by increasing the information dissemination level on this activity. In Central, Eastern and South-Eastern Europe, legislation governing the NWFP collection is a prominent issue flagged by respondents. This is in-line with the findings of Vidale *et al.* (2015), who find the same parts of Europe being marred with complicated and difficult to enforce NWFP collection and taxation rules. The general guidance that they provide is to simplify the collection rules and to adopt a taxation system which exempts collectors (both in terms of VAT and income taxes) and focuses on those who first place them on the market, or by incorporating it into the permit costs issued for a specific area. These are some of the possible policy solutions.

As it can be assumed that a significant part of the professional NWFP collection is conducted by members of marginalized rural households (Stryamets *et al.*, 2020), our research design, which rests on responses elicited through the internet, might not be appropriate to address these households. A more targeted research design such as embedded case-study design is warranted. Application of our research design to settings elsewhere might be marred with the same type of low-representability problems. For this type of context, a production-to-consumption system approach (Belcher, 1998) could be better suited, as it was, for example, applied in a wide-scale by Belcher *et al.* (2005).

About 85 per cent of the collected weight of NWFPs is used for consumption within the household and NWFPs are predominantly consumed fresh, which indicates their low added-value. Coupled with high consumption rates across Europe, our results clearly point to the existence of an underutilized economic potential of NWFPs. Truffles are clearly a group of products that is much more frequently sold than any other, but most collectors who sell NWFPs, partly do so for their own self-consumption as well. The NWFP-dependent households are primarily located in Eastern Europe. These 'professional' collectors did not just collect NWFPs but also frequently received them as a gift and purchased them from another collector. These professional collectors focus their activities on few key products and are knowledgeable on what they are collecting. Unlike the general population of collectors, they tend not to be forest owners and do not have problems with poor yield but have faced legal constraints quite often.

As with any other study involving large surveys, there are many threats to the validity of its findings. Firstly, not all products we considered are (solely) collected in forests. The FAO (2015) definition of forests was provided in the introduction to the questionnaire, but respondents may not have read it carefully as it was not in the main block of text. The dominant meaning of forest found in the pretesting is a forest with a full canopy cover, while the FAO definition is more than 10 per cent of canopy cover. Also some hedge rows, meadows and pastures subsumed under category of agricultural land may actually be registered under forest land use. Secondly, it could be argued that the list of products is not reflective of what the important NWFPs in Europe are, as at least 600 mushroom and plant species are collected in Europe (Schulp *et al.*, 2014). Every NWFP category had the option of respondents to input some new product which was not already listed, and the combined weight of these 'other' products is 6.8 per cent of the total. Thirdly, this study focused on plant-based NWFPs and has excluded animal-based products. These products are not just foodstuffs such as game meat and honey but also include non-food items (e.g. trophies, hides, fur, feather and bones). It also has to be stated that they are rarely included in NWFP-focused publications, the reason for which can be traced back to the long-standing demarcation between forest and game management in terms of research, education and governance (Vacik *et al.*, 2020). The latest available data (Forest Europe, 2020) show that animal-based NWFPs represent 30 per cent of the value of marketed NWFPs. The main reason for excluding game lies in the fact that adequate unit of analysis for gathering data on game meat are individuals (hunters), while for collection of NWFPs, they are households. Making a single survey that would representatively work with two units of analysis (i.e. hunters and households) would not be possible. Fourthly, another issue is that the cross-tabulation of collection rates by country is not uniform – i.e. bigger countries and more frequently collected products have bigger sub-sample sizes. This may be problematic for the extrapolation of the results from the sample to the population – as one or several data inputs may have a strong effect on the overall figures. On the general level of products, this is not problematic as 78 per cent of the product-level data has been estimated on the sample data that have three or more entries in the top-decile of the weight distributions. On the level of groups of products, truffles have only 4 per cent entries with at least three data collection points in the top decile per country, representing 16 per cent of their total weight. For other groups of products, the situation is much better; forest nuts with 65 per cent of entries representing 94 per cent of weight, wild mushrooms with 60 per cent of entries representing 96 per cent of weight, wild berries with 67 per cent of entries representing 95 per cent of weight, wild medicinal and aromatic herbs with 59 per cent of entries representing 93 per cent of weight, and saps and resins with 44 per cent of entries representing 76 per cent of weight. When the same measurements are reviewed for countries, product-level data with at least three collection points in top decile account for 86 per cent of collected weight. Three countries have less than 60 per cent of the weight accounted for by entries with more than three collection points in the top decile. They are Denmark (44 per cent), Ireland (45 per cent) and Netherlands (54 per cent).

In this study, we followed the line of thought that NWFP term should be replaced by some other more 'approachable' wording when communicating with non-experts, and we have used the term 'wild forest products' in the questionnaire (Kilchling *et al.*, 2009; Muir *et al.*, 2020). Combined with the fact that game is excluded from this study and that the term itself was not used in the distribution of the questionnaire, one should interpret the data as reflecting the products listed in the paper and not as a direct equivalent of all NWFPs in Europe. Closely linked issues are that we have included the option of collecting products from agricultural land (as NWFPs by definition subsume agroforestry practices) and that some of the 'wild forest products' that respondents said they were consuming may actually have come from agricultural production – as they might have been misinformed on its origin. Thus, we cannot exclude that some of the products that we looked into come from agricultural production. However, it also has to be stated that the dichotomy between 'wild' and

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'domesticated' is often artificial, as the analysis of local farming systems in the forested areas worldwide show a continuum from subsistence foraging to commercial agriculture (FAO, 1995). We tried to minimize this bias by repeatedly use the words 'wild' and 'forest' in the title of the questionnaire, in its introduction, next to the names of groups of products and to the names of individual products. It can also be assumed that repeated use of these words has caused some 'semi-wild' NWFPs being under-reported, such as chestnuts. Another data bias could be that the respondents were not completely aware of all the NWFP collection and consumption done by the members of their household (even though they said that they are knowledgeable on these activities), an issue for which this this study provides no verification.

The immediate practical relevance of this study is the insights it provides which could be used to design future country-level surveys in a representative and cost-effective manner. With sufficient quantitative data, forestry-focused and forestry-related policies will be able to better recognize and regulate NWFPs, as regulating them on their own in the given fragmented policy landscape is futile (Liard *et al*., 2010). Sheppard *et al*. (2020) propose a co-production management system embedded in a wider governance structure with strong local-level cooperation networks, while stressing that the functioning of such a system is preconditioned by a strong knowledge. Similar arguments are made by Vacik *et al*. (2020), who also stress that 'in many cases the production of NWFP can be increased without causing major losses in timber production' (p. 403). Such co-production propositions warrant field tests. The immediate scientific relevance of this study is that it has supported on an international level what was already indicated in many national or sub-national studies: NWFPs are widely collected and consumed products, where the purpose of collection ranges from recreation and prestige of more affluent households in the West to subsistence and a source of income in the East.

Data and materials availability

All data needed to evaluate the conclusions in the paper are present in the paper and/or the supplementary material. Additional data related to this paper may be requested from the authors.

Supplementary data

Supplementary data are available at *Forestry* online.

Authors' contributions

R.M. and D.P. developed the initial idea of the survey. M.L., R.D.R, E.V., I.P., J.W., D.P. and R.M. designed the questionnaire. M.L. controlled the data collection. M.L., R.D.R and E.V. performed the analysis. M.L. wrote the first draft of the manuscript. All authors contributed to the discussions and the writing of the manuscript.

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