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Analysis

Wild food in Europe: A synthesis of knowledge and data of terrestrial wild food as an ecosystem service

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ABSTRACT

Wild food is an iconic ecosystem service that receives little attention in quantifying, valuating and mapping studies, due to the perceived low importance or due to lack of data. Here, we synthesize available data on the importance of wild food as ecosystem service, its spatial distribution and relations between supply, demand and benefits in the European Union (EU), covering all terrestrial wild food groups.

A wide variety of game (38 species), mushrooms (27 species) and vascular plants (81 species) is collected and consumed throughout the EU. Income, age, gender, possibilities for collecting, and cultural factors explain the importance of wild food. While the economic and nutritional values of wild food comprise a few thousands of the GDP or total consumption, over 100 million EU citizens consume wild food. Collecting wild food is an appreciated recreational activity; collecting and consuming wild food provide important cultural ecosystem services, including recreation and sense of place. Because of these benefits, wild food should be included in EU ecosystem service assessments. Better estimates could be made if better data on wild food abundance and production are available and by systematic inventories of participation in wild food collecting.

1. Introduction

The availability of wild food is commonly included as a provisioning service in ecosystem service classifications, like the MA and TEEB assessments (De Groot et al., 2010b; MA, 2005). However, despite the on-going progress in mapping of ecosystem services at multiple scales, including the European scale (Maes et al., 2012a), wild food is hardly included in mapping of ecosystem services. Possible reasons for the limited attention are the perceived low importance of this service (Egoh et al., 2008; Maes et al., 2012b), or the absence of data to quantify this service (Maes et al., 2011).

A considerable part of wild food collecting is done for home-consumption or informal marketing. Therefore, statistics on the quantities of wild food collected hardly exist and literature that attempts to quantify wild food collecting is scarce and scattered. For mushrooms and vascular plants only scattered case studies are available that address the species that are collected and the motives for collecting and consuming wild food, e.g. Pardo-de-Santayana et al. (2007) and Pieroni et al. (2002). Hunting is a more regulated wild food collecting activity. Because most countries require a hunting license and have hunting quota (FACE, 2012), more statistical data exist. However, hunting statistics commonly do not indicate if species are hunted for consumption, pest control or other motives. Attribution of these statistics to wild food provisioning is therefore not straightforward.

While mapping ecosystem services has become a key activity in many countries to quantify and assess the distribution of multiple ecosystem services to support environmental policy, wild food provisioning is often lacking in these considerations. This paper aims to synthesize the available information on the importance of wild food as an ecosystem service in the European Union (EU). We chose the EU scale since many relevant policies that influence land use, biodiversity and ecosystem services are developed and usually act on EU scale, including the Common Agricultural Policy and the Biodiversity Strategy to 2020. The EU accommodates a wide variety of landscapes and cultures, which are expected to show differences in supply, demand and benefits of the ecosystem service wild food provisioning. Insights in these spatial patterns at a European scale are thus important to evaluate consequences of EU-scale policies.

We quantify the supply, demand and benefits, map the spatial distribution of supply and demand, and evaluate the relations between supply, demand and benefits of this service. Section 2 provides an overview of the conceptual framework used to structure our synthesis, followed by a description of the methods and data used (Section 3). Section 4 presents both descriptive results as well as an overview of the quantitative data. All available information is brought together in maps to illustrate the spatial variability of availability and demand for terrestrial wild food. The paper concludes with a discussion of the importance of this

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service in the European context and possible ways forward to further include these surveys in ecosystem service mapping.

2. Conceptual Framework

We define the ecosystem service wild food as plants, berries, fruit, nuts, mushrooms and game that are collected in the wild, to be consumed as food or drink (Maes et al., 2013). We focus on wild food species living in terrestrial environments and other use of these species than consumption (e.g., medical or ritual) is disregarded. This agrees with most classification systems for ecosystem services where wild food is a subcategory of provisioning services (De Groot et al., 2010b; MA, 2005; Maes et al., 2013).

Several conceptual frameworks for assessing ecosystem services exist, among others the capacity–pressure–demand–flow framework (Villamagna et al., 2013) and the cascade approach first introduced by Haines-Young (2009) and adopted by The Economics of Ecosystems and Biodiversity (TEEB). We follow the cascade framework in this study because it makes an explicit distinction between properties and functions. This clearly follows landscape and ecological processes, and makes the role of land management more explicit. Fig. 1 shows how this cascade applies to the ecosystem service wild food. In this framework, *ecosystem properties* are defined as the ecological conditions that determine whether an ecosystem service can be provided. For wild food, this is the production of wild edible species. *Ecosystem functions* are the capacity of the ecosystem to provide a service (De Groot et al., 2010a; Van Oudenhoven et al., 2012), which is the availability of specific species that are relevant for food provision. Ecosystem properties and functions can be jointly described as the supply of the ecosystem service. The *ecosystem service* can be defined as the actual use of the function by humans (Schulp et al., 2012) or the contribution to societal benefits or well-being (Van Zanten et al., 2013). The ecosystem service is here defined as the wild food actually collected. We consider both the *flow* (the process of collecting) and the *demand* (Schröter et al., 2014; Villamagna et al., 2013). The collected food provides *benefits* to the collectors and other consumers, including food, income and cultural services. Collecting wild food can trigger *landscape management* that influences the ecosystem functions and properties. For example, overexploitation and extermination of species, or conservation of ancient woodland forests as hunting grounds for the nobility (Emanuelsson, 2009).

3. Methods

To synthesize and map the ecosystem service wild food a variety of data sources and methods were used. Table 1 and Section 3.1 provide an overview of the data sources. The following sections describe the methods for analyzing and mapping the different elements of the conceptual framework (Fig. 1): Ecosystem properties and functions (Section 3.2); Ecosystem services (Section 3.3); and Benefits (Section 3.4).

3.1. Data Collection

The synthesis of the availability and use of wild food in Europe builds on literature, statistics and spatial data (Table 1).

3.1.1. Literature

We collected scientific literature on the production, collection and use of edible game, mushrooms and vascular plants by querying Google Scholar. For game, we used the query "population [species] Europe" to collect population data of the most commonly hunted species. The most commonly hunted species were identified based on analysis of statistical data, as described below. For mushrooms, we queried for "wild edible mushroom", and "wild mushroom collect*" OR "wild mushroom picking". For vascular plants, the query "wild food plant" was used. Next, the set of literature was narrowed down to studies that provide a list of species, reporting on European countries. Gray literature was collected using similar Google Scholar searches. Additional literature was found using a snowball search. Literature collection was done in December 2012 and updated in March 2013. For mushrooms and vascular plants, data on production was collected from the surveyed literature. Most of the literature describes the species collected, the participation level and motivations for wild food collecting and consumption. The literature was therefore used for synthesis of the ecosystem function, service as well as benefits.

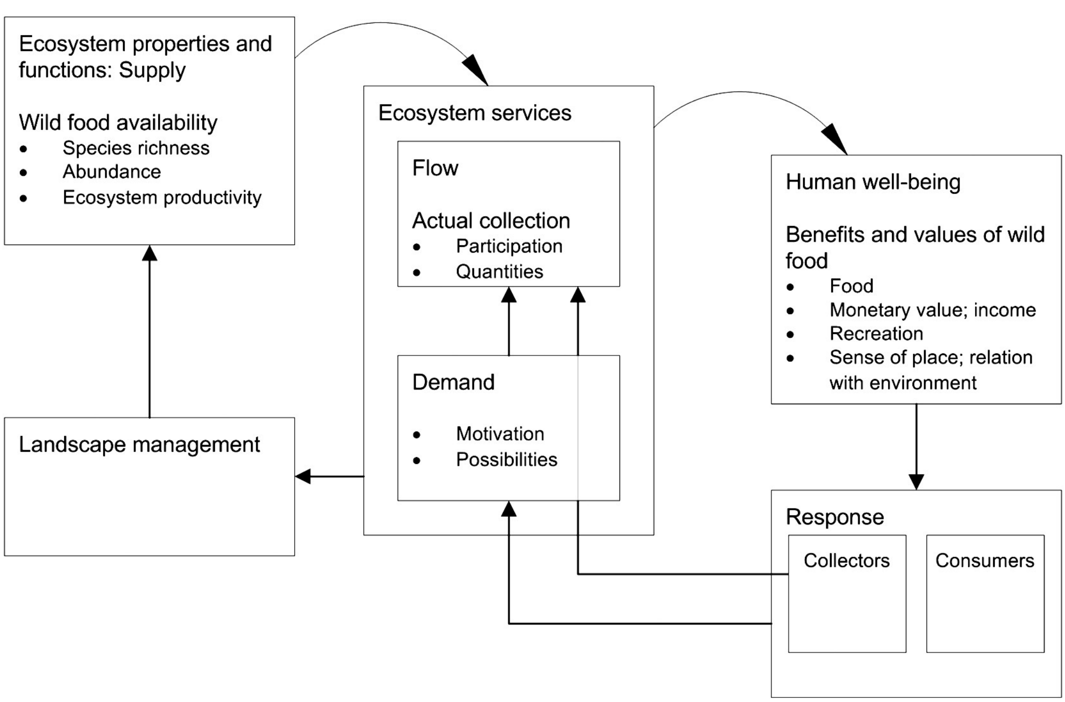

Fig. 1. Conceptual framework of the relations between wild food supply, demand and benefits.

Table 1
Overview of the data sources and the type of information extracted from each data source.

Data category	Compartment of the ecosystem service cascade		
	Ecosystem properties and functions	Ecosystem service flow and demand	Benefits
1. Literature			
a. Review of scientific papers and technical reports	Abundance, production	Game harvest[a,b,c]	Traditional cuisine descriptions, consumption quantities[d]
b. Cookbooks	Selection of actually consumed species	Inventory of the use of wild food in traditional cuisines throughout the EU	
c. Additional internet search: wikipedia, newspapers, regulations overviews		Inventory of forest access regulations, wild food collecting regulations, additional information on cuisines.	Role of wild food in cuisine, data on hunting benefits[a,b]
2. Statistical databases	Country-level hunting statistics[b]	Quantities marketed[c]	Economic value of wild food[c], consumption quantities[d]
3. Spatial data			
a. Species distribution maps	Occurrence data[e]		
b. Maps of socio-economic conditions		Spatial data on factors explaining participation in wild food collecting, motives for wild food collecting (Table 4)	

References:
[a] Data from hunting associations, (FACE, 2012).
[b] National statistical offices.
[c] State of Europe's Forests (MCPFE et al., 2007).
[d] FAOSTAT (FAO, 2012).
[e] Global Biodiversity Information Facility (GBIF, 2007), Atlas Flora Europaea (Lahti and Lampinen, 1999), IUCN (IUCN, 2012), European Bird Atlas (Birdlife International and NatureServe, 2012).

To link provision of wild food with the benefits, cookbooks that give an overview of cuisines throughout Europe were used (Dominé et al., 2000; Montagné, 2011). Additional Internet searches were done to collect information on nature access regulations and information on traditional cuisine.

3.1.2. Statistical Data

Statistical datasets providing data on wild food included game bag statistics from 17 countries from national statistical offices, hunter's associations and the European Hunter's association (FACE, 2012). Game bag statistics contain data on population, the harvested species and harvested quantities. The State of Europe's forests (MCPFE et al., 2007) summarizes commercially harvested wild food quantities and values for several mainly Eastern-European countries. Finally, consumption statistics from FAOSTAT (FAO, 2012) were collected.

3.1.3. Spatial Data

To illustrate spatial patterns of game species richness, data from the IUCN (2012) and Birdlife International and NatureServe (2012) were used that provide broad distribution patterns. For mushroom availability, occurrence data from the GBIF (GBIF) (2007) were used. For vascular plants, if available, distribution data from the Atlas Flora Europaea (Lahti and Lampinen, 1999) were used. Otherwise, occurrence data from GBIF were used (see below for details on the mapping methods). To map the spatial patterns of the demand for wild food, we used data on socio-economic factors at NUTS2 level. The socio-economic factors that explain the demand for wild food were identified based on the literature review and were acquired from Eurostat (European Commission, 2012a).

3.2. Ecosystem Properties and Functions: Wild Food Availability

We made a synthesis of the availability of wild food by making an inventory of the consumed wild food species and their production, and by mapping their species richness and abundance. This was done based on the literature survey and hunting statistics described in Section 3.1 (Fig. 2, left panel). If possible, only species that recently have been used for consumption were included in the inventory. For game, the species hunted for consumption were selected based on Murray and Simcox (2003) and Montagné (2011).

Maps of the species richness and occurrence density of the most commonly consumed wild species were constructed based on spatial distribution data and land cover data (Fig. 2, lower left panel). The distribution data have a coarse resolution: 50 × 50 km for the plant data, large polygons for the mammal and bird data and scattered occurrence data from GBIF. To refine the accuracy of the species distribution maps, they were downscaled with land cover data (Fig. 2, lower left panel). For each species, we assessed the likeliness for occurrence in each CORINE level 3 land cover type based on the BIOSCORE database (Louette et al., 2010) and Soortenbank (ETI Bioinformatics, 2013). By combining the broad distribution patterns with the likeliness of occurrence based on the CORINE map (EEA, 2012), we obtained a downscaled 250 m resolution presence/absence map for each species. For the species where no distribution maps were available, the probability of occurrence was estimated using species distribution models (Guissan and Tuiller, 2005) within the biomod2 platform (Thuiller et al., 2009). Biomod2 uses an ensemble modeling approach that relates species' occurrences to selected influential environmental variables and enables examination of species-environment relations throughout a wide range of modeling techniques (Thuiller et al., 2009). The output is a consensus probability map ranging from 0 to 1. The probability of occurrence was here modeled in function of isothermality, temperature seasonality, temperature annual range, mean temperature of the coldest quarter and annual precipitation from WorldClim (Hijmans et al., 2005) and land cover fractions of arable land, pasture, forest and other natures from CORINE Land Cover 2006, a comprehensive and homogenize mapping of land cover across the European Union at 250 m resolution (EEA, 2012). Occurrence probability maps were then converted into binary presence–absence maps using a threshold maximizing the predictive accuracy of the models. Finally, for each species group, the presence/absence maps for all species were added up, resulting in maps indicating the species richness of wild food species.

Besides the distribution of occurrence of wild food species, also the abundance of these species is important for wild food provision. Therefore, an attempt was made to map the occurrence density for a small set of wild species that is consumed throughout Europe, based on occurrence data from GBIF (GBIF, 2007). Although there is well-known bias in using these data for mapping occurrence density (Yesson et al., 2007) it is the best available proxy for getting an overview of occurrence density. Data was obtained in July 2013. Records of actual observations were selected, records based on specimen or fossils were excluded as well as records with a collection date before 1990. Using the latitude and longitude data, occurrence records were mapped. An overall occurrence density in a radius of 25 km was calculated for the occurrences of the main edible game, mushroom and vascular plant species (Fig. 2, lower left panel).

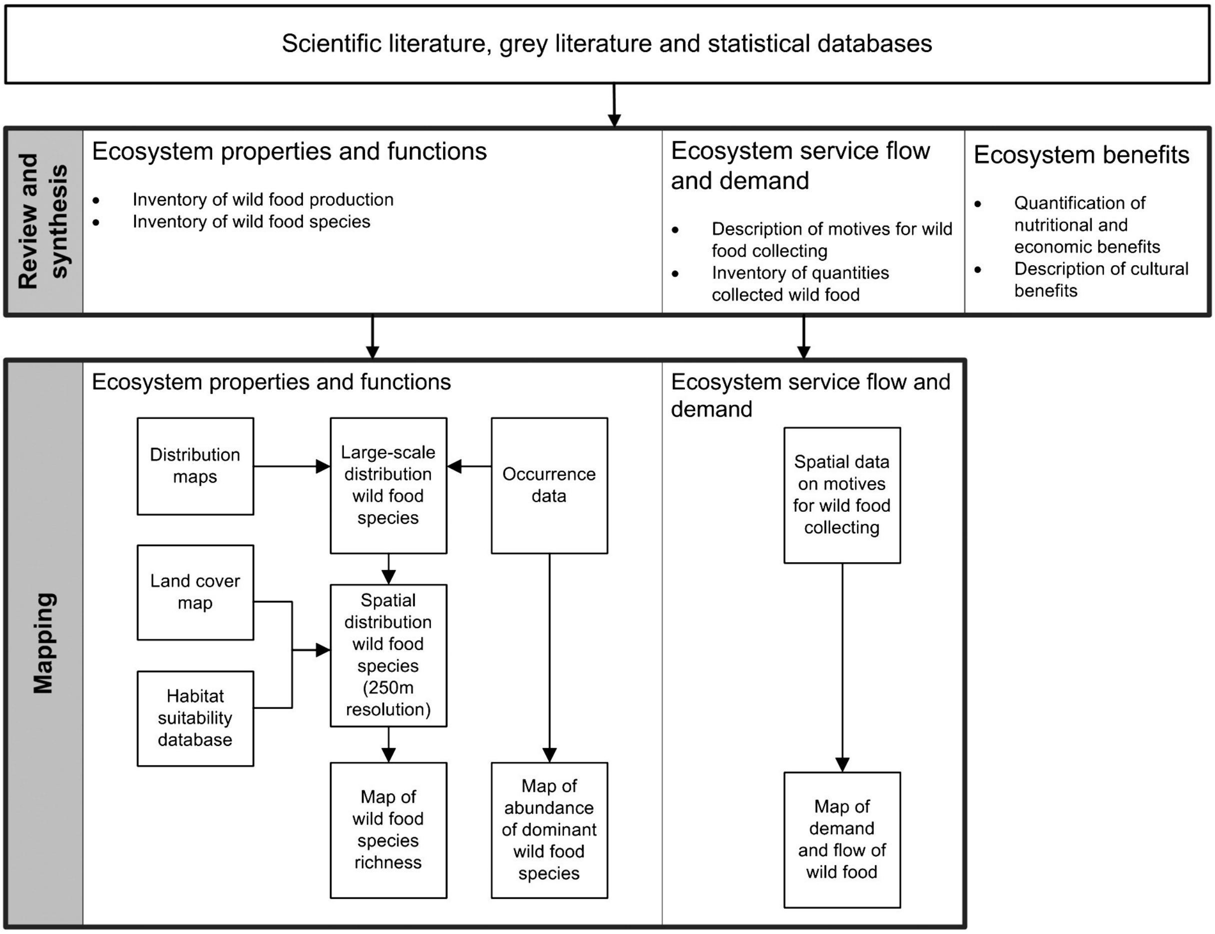

Fig. 2. Flowchart of methods used for synthesizing wild food supply, demand and benefits.

3.3. Ecosystem Service Flow and Demand: Wild Food Gathering

Using the literature and data survey (Section 3.1), we made an inventory of socio-economic, cultural and spatial conditions and motivations for collecting wild food, and summarized how these factors influence participation in wild food collecting (flow) and demand for wild food (Fig. 2, top central panel). This inventory is presented in Section 4.2.2. Secondly, we made an overview of the quantities of wild food collected based on the literature and data survey (Fig. 2, top central panel).

We mapped the spatial variation in flow and demand of wild food collecting throughout the EU based on the spatial distribution of the factors explaining wild food collecting (Fig. 2, lower central panel). For each explanatory factor, a spatial dataset was obtained and normalized using a min–max normalization. The sum of these maps provides a semi-quantitative proxy for the spatial variation in wild food flow and demand. This was done for vascular plants, mushrooms and vertebrates separately.

3.4. Benefits of Wild Food

Wild food can provide nutritional, economic and cultural benefits. The nutritional benefits were quantified using consumption data from national statistical offices and from the literature survey (Section 3.1). To quantify the economic benefits, the collected literature was searched for the percentage of wild food collected, traded or given away. We calculated the monetary value of game collecting based on the quantities of game collected (Section 3.3) and game meat prices from the German Hunters Association (Deutscher Jagdschutzverband, 1997–2014).

The cultural benefits comprise wild food collecting as a recreational activity and the importance of wild food in tradition. Due to lack of data, these benefits are synthesized in a descriptive way only. A synthesis of the importance of wild food collecting as a recreational activity was made based on the collected literature (Fig. 2, right panel). The role of wild food in tradition and cuisine was quantified using cookbooks as these provide very useful indicators for the use of wild food. Three consistent data sources were used that describe all EU cuisines at country level (Dominé et al., 2000; Montagné, 2011; Wikipedia, 2011). We reviewed descriptions of the traditional cuisine for each EU country and recipes from the traditional cuisine. We checked the descriptions and recipes for the use of wild mushrooms, berries, game and vascular plants and rated this into five categories:

- Very low: no mentioning of wild ingredients, or specific mentioning that the cuisine is based on agriculture.
- Low: little mentioning of wild ingredients.
- Moderate: several wild ingredients are mentioned, but only the more common species (fruit, game) and the importance of wild food is not explicitly mentioned.
- High: importance of wild food in traditional recipes is explicitly mentioned. Variety of wild food is not too abundant.

- Very high: many wild ingredients used, game, plants as well as mushrooms. Wide variety of species mentioned in descriptions and recipes.

4. Results

4.1. Ecosystem Properties and Functions

4.1.1. Game

We identified 97 species that are hunted in the EU. Part of these 97 species (26 bird species and 12 mammals) are consumed in the EU. An overview of edible game species is provided in Appendix A. The five main food game species are *Cervus elaphus* (Red Deer), *Capreolus capreolus* (Roe Deer), *Lepus europaeus* (Hare), *Phasianus colchicus* (Pheasant) and *Sus scrofa* (Wild Boar). These are hunted in all countries and have the largest harvest numbers.

The highest species richness of edible game species is observed in Central Europe, Southern Scandinavia and the Baltic countries. Lower species richness is seen in parts of the Spanish inlands and elsewhere in Southern Europe (Fig. 3a). The occurrence density map of the five main species (Fig. 3b) shows a strong bias due to observation intensity, but seven countries (Fig. 3b) have sufficient data availability. Within these countries, the highest occurrence densities are seen in the south of Scandinavia and parts of the UK.

Spring populations of the five main game species are summarized in Table 2. The differences between occurrence densities at country level (Fig. 3) reasonably match the data from literature and statistics (Table 2). High Red deer densities are seen in Eastern and Central European countries and in the UK while Roe deer densities were highest in Luxembourg and Denmark. The highest Wild boar density was seen in Germany. Densities of hares are highest in the Netherlands. Differences with other countries are very large, most likely due to the extensive grassland cover in the Netherlands. The highest Pheasant density was observed in France.

Table 2
Densities of the most important game species (#/1000 ha land area). For the empty cells, no data were available.

Country	Red deer[a]	Roe deer[b]	Wild boar[c,d]	European hare[d]	Pheasant[d]
Austria	18.19	9.10			
Belgium	3.22	12.97			
Bulgaria	1.50	6.54			
Cyprus					
Czech Republic	3.24	38.19	7.38	42.31	36.72
Denmark	3.54	94.30			
Estonia	0.40	12.97	5.53	5.78	
Finland		0.49			
France	1.82	21.81	16.00	18.18	63.62
Germany	4.73	86.02	26.00	10.32	5.73
Greece	0.01				
Hungary	7.72	34.69	10.67	11.61	44.95
Ireland	0.58		0.00	0.01	0.90
Italy	1.67	10.56	20.40		
Latvia	5.02	20.80	10.79	5.59	
Lithuania	2.30	13.78	8.00		
Luxembourg	12.32	92.56			
Malta					
Netherlands	0.89	14.76	0.59	147.58	17.71
Poland	4.80	22.59	6.92	17.37	13.48
Portugal					
Romania	1.44	6.52			
Slovakia	8.26	17.70	6.09	42.23	39.56
Slovenia	5.96	40.96			
Spain	5.51		6.00		0.02
Sweden	0.49	14.62			
United Kingdom	14.66	20.66			32.99

[a] Burbaitė and Csányi, 2010.
[b] Burbaitė and Csányi, 2009.
[c] ELO et al., 2012.
[d] Hunter's associations and national statistical offices.

4.1.2. Mushrooms

We found 31 papers on mushroom collecting and consumption, describing studies from 13 countries. These papers mentioned 152 species and 12 genera that are collected. While most species were only mentioned in one paper, 27 species are reported in three or more countries (list of species in Appendix B). The consumption of *Cantharellus cibarius* (Chanterelle), *Pleurotus ostreatus* (Oyster mushroom), *Lactarius deliciosus* (Saffron milk cap) and *Boletus edulis* (Cep) is widespread (collected and consumed in >7 of the 13 countries). Most mushroom species depend on trees as a host while a smaller number of mushrooms occur in grasslands. Consequently, the species richness (Fig. 4a) is high in forested areas like Scandinavia and mountainous areas and low in arable lands in e.g. England and the Netherlands.

Four countries have a suitable occurrence dataset (Fig. 4b). Of these countries, occurrence densities are the lowest in Denmark, most likely

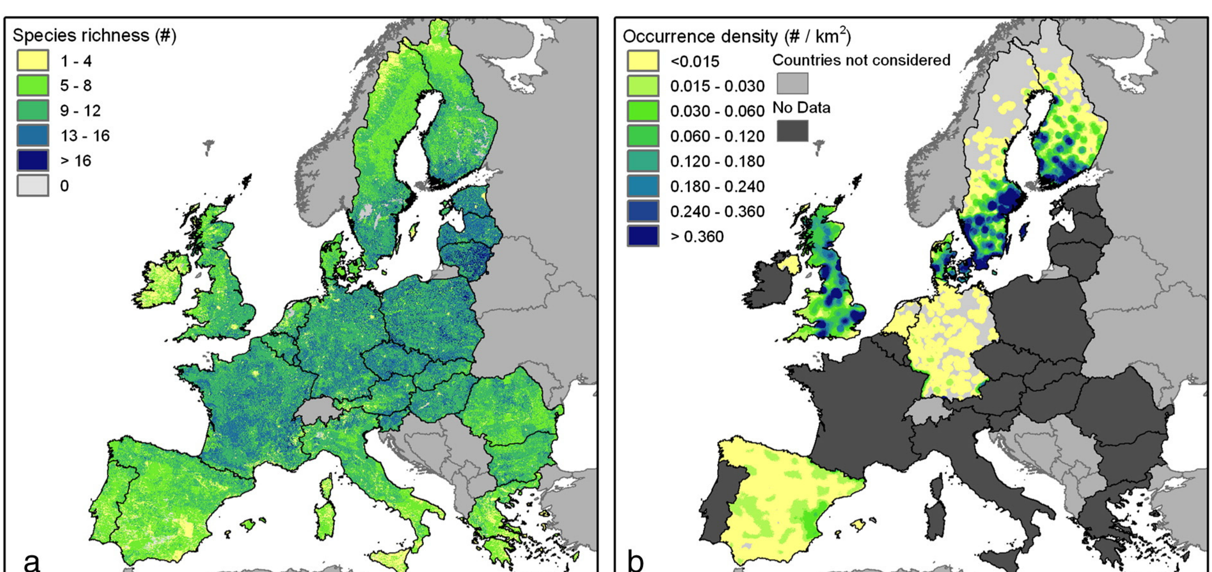

Fig. 3. (a) Species richness of the 38 common EU food game species; (b) occurrence density of the five most important food game species.

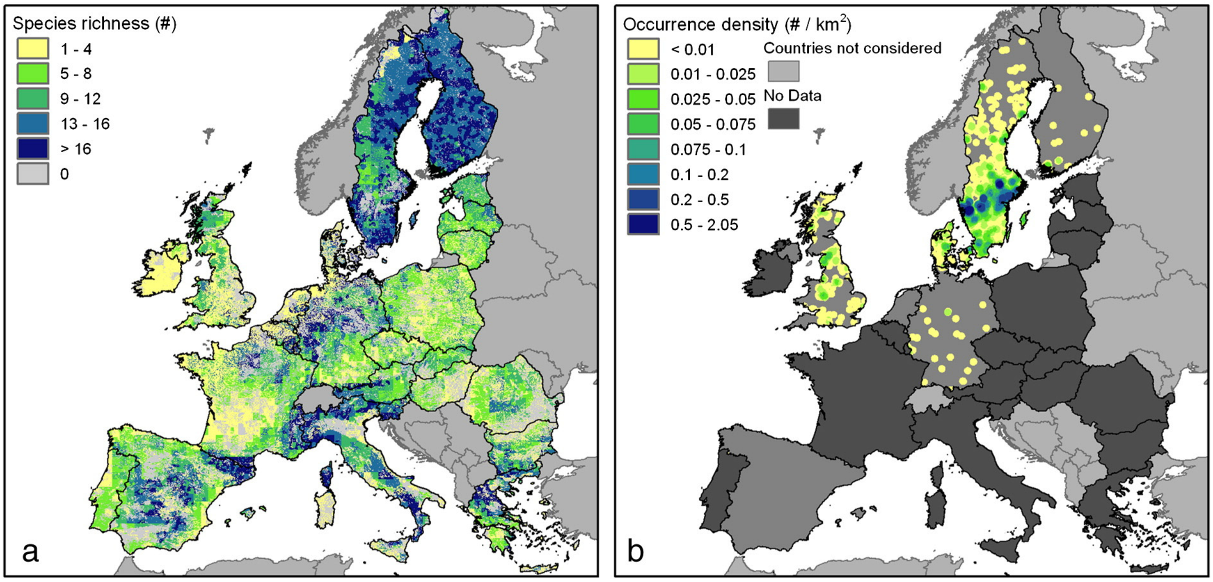

Fig. 4. (a) Species richness of the 27 common EU food mushroom species and (b) occurrence density of the four most important mushroom species.

because of the low forest cover in the country. Three out of the four mushrooms occur preferentially in conifer forests with poor sandy soils, explaining the high densities in Central Sweden.

Data on the production of wild mushrooms is very scarce. In Catalonia, Martínez de Aragón et al. (2007, 2011) report an average annual production of 41 kg/ha. Production varies between 2 and 124 kg/ha, with generally highest production in *Pinus sylvestris* stands. Bergius and Danell (2000) inventoried Matsutake densities in Swedish forests and report a density of 31–200 mushrooms/ha, corresponding to 1.5–10 kg/ha. Unless the wide variation in these two estimates, they are in the same order of magnitude.

4.1.3. Vascular Plants

We found 33 studies on collecting wild vascular plants that report on 17 countries. 592 edible species from 305 genera were identified. Most species were reported in one or two countries only, while 81 species are used in 4 or more countries (Appendix C presents a list of species). The most widely collected species were *Allium ursinum* (Wild garlic), *Bunium bulbocastanum* (Cumin), *Cirsium arvense* (Creeping thistle), *Cornus mas* (European Cornel), *Fragaria vesca* (wild strawberry), *Humulus lupulus* (hop), *Lathryrus tuberosus* (*Tuberous pea*), *Prunus virginiana* (bitter-berry), *Rubus idaeus* (raspberry) and undefined *Rubus* species, undefined *Ribes* (berry) species, *Urtica dioica* (common nettle) and *Vaccinium myrtillus* (European blueberry).

The highest species richness is found in hilly or mountainous areas in Central Europe, and in the south of Europe (Fig. 5a). Low species richness is found in agricultural areas like the Po delta, and in parts of Eastern and North-western Europe.

For the most commonly collected species, occurrence data was available for seven countries (Fig. 5b). There are several cases where the species richness is low while the occurrence density is high, especially in the Eastern UK and the southern part of Sweden. This suggests that in these locations there is supply of wild food, in spite of the lower species richness.

Only for fruit and berries in Sweden we found data on the production, however, dating from 1979 and possibly not representative for

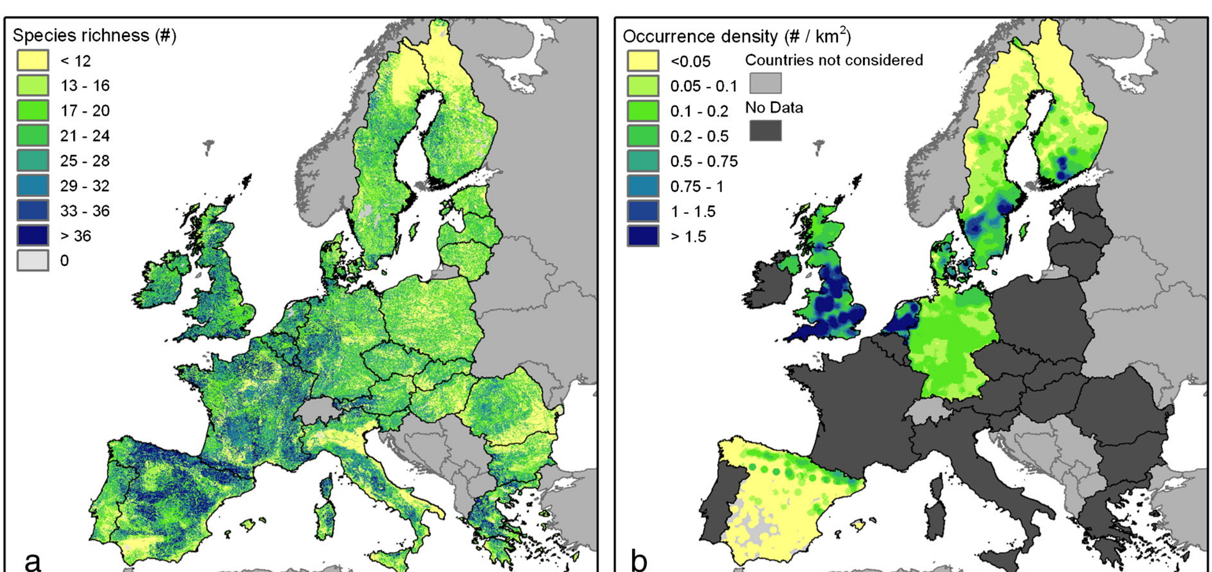

Fig. 5. (a) Species richness of the 81 common EU wild food vascular plant species (left) and (b) occurrence density of 8 most important species (right).

the current situation. The production of berries reported for Swedish forests was 250,000 ton blueberries, 155,000 ton lingonberries and 70,000–90,000 ton cloudberries per year in 1979 (Jonsson and Uddstal, 2002).

4.2. Ecosystem Service Flow and Demand

4.2.1. Flow: Participation in Wild Food Collecting

Between 0.17% (Netherlands) and 12.4% (Italy) of the population in EU countries was active as a hunter in 2010 (Deutscher Jagdschutzverband, 1997–2014). Other sources give different numbers and participation varies within countries. In Germany, participation rates between 0.02 and 0.63% were reported (Deutscher Jagdschutzverband, 1997–2014) with the highest numbers in Mecklenburg-Vorpommern. In Estonia participation varies between 0.43% and 3.1% (Statistics Estonia, 2011). For Scotland, highly diverging numbers of hunters are found, ranging between 1.5 and 3.8% of the Scottish population (Murray and Simcox, 2003). Hunting participation in Finland varies between 1.4% in the more urban regions in the south and 17.1% in the rural regions in the east and north (Finnish Game Fisheries Research Institute, 2012). Sievänen (2005) reports a hunting participation of 7% in Finland. The large difference with the other estimates might be due to different definitions of hunting participation.

The participation in mushroom picking varies between <3% of the population in Denmark and 38% in Finland (Sievänen, 2005). In Italy, 10% of all recreational forest visits is related to mushroom picking (Sievänen, 2005). In the Polish Carpathians, "nearly everybody" collects mushrooms (Łuczaj and Nieroda, 2011).

Data on the participation in berry collecting focus on Scandinavia. In Sweden, 56–58% of households collected berries in 1997 for domestic use while in Finland this is 55–60% (Jonsson and Uddstal, 2002; Sievänen, 2005; Stryamets et al., 2012). Regionally the participation rates in Finland are up to 90% (Kangas and Markkanen, 2001). For other countries no estimates were found.

For other vascular plants there is very little data on the level of participation. In two studies in Austria, collecting wild plants was reported as something "many" or "nearly all" people do (Grasser et al., 2012; Schunko and Vogl, 2010). In a region near Madrid, Tardío et al. (2005) observed that wild edible plants were gathered by 11–20% of people interviewed. González et al. (2011) found "low" participation rates in Central Spain.

4.2.2. Flow: Explaining Factors for Collecting Wild Food

The literature survey provides a wide range of factors influencing wild food collecting. Generally, the participation in wild food collecting is influenced by income, age, gender, opportunities for wild food collecting, and cultural factors. Table 3 summarizes country-scale data on these factors.

4.2.2.1. Game. The effect of income on participation in hunting depends on the national income. In high-income countries, hunting is considered a status symbol for the rich (Murray and Simcox, 2003) while in lower-income countries the role of private food supply is more important (Bell et al., 2007; Tsachalidis and Hadjisterkotis, 2008). Hunters are dominantly middle-aged. The 20–60 years age group makes up two-third (Ireland) to over 90% (Italy) of the hunter population (FACE, 2012). Men make up between 86% (Finnish Lapland,) and 99% (Netherlands) of the hunters (Finnish Game Fisheries Research Institute, 2012; Heberlein et al., 2002; MacMillan and Leitch, 2008; Nygård and Uthardt, 2011) although the number of female hunters is increasing (Heberlein et al., 2008).

People who have more opportunities to hunt are more likely to participate in hunting. First of all, opportunities to hunt can arise when people spend a lot of time outdoors. Farmers and other people with outdoor jobs or rural population in general are strongly overrepresented in hunter populations (FACE, 2012; Tsachalidis and Hadjisterkotis, 2008). Secondly, Heberlein et al. (2002) found a positive correlation between national level forest areas and hunter numbers, suggesting that people who have more nature available in their surroundings are more likely to go hunting. Third, countries with loose regulations for forest and nature access or wild food collecting have higher hunter percentages than countries with strict access regulations. For instance, in the Netherlands, hunting is only allowed on private hunting areas of >40 ha per hunter. Consequently, only people who are able to rent land or have access to private lands have the possibility to hunt, limiting the hunting participation. Contrary, in Scandinavian countries with less strict regulations the participation in hunting is higher.

A final factor is the traditional role of hunting, although this role is declining due to societal changes (Nygård and Uthardt, 2011). Hunting is considered an important part of rural traditions in Sweden (Ljung et al., 2012) and Greece (Bell et al., 2007; Tsachalidis and Hadjisterkotis, 2008). In Scotland and other parts of the UK, hunting is an ancient tradition that is important in defining the social status (Fischer et al., 2012; MacMillan and Leitch, 2008).

4.2.2.2. Mushrooms. Little proof of the effect of income on mushroom picking was found. Older people are overrepresented among mushroom collectors (Cai et al., 2011; Martínez de Aragón et al., 2011; Sievänen, 2005). There is little difference in participation level between genders. Sievänen (2005) found a higher probability of being a mushroom picker for women in Finland while several studies found higher participation rates for men in Poland and Italy (Łuczaj and Nieroda, 2011; Nebel et al., 2009; Pieroni et al., 2002).

The opportunities for mushroom picking are first influenced by regulations, e.g. in Finland the everyman's right is related to a widespread custom of collecting mushrooms (Cai et al., 2011). Second, people mostly collect mushrooms within 5 km from their home (Sievänen, 2005). Consequently, people living in a rural environment have a higher probability of collecting mushrooms, because mushroom picking requires knowledge of the ecosystem and ability to navigate in the forest. Such skills are difficult to obtain for people who do not visit forests regularly (Sievänen, 2005). Third, the frequency of mushroom collecting varies with the mushroom availability. The participation in mushroom collecting can be ~1.5 to 8 times higher in good mushroom seasons than in bad seasons (Cai et al., 2011; Ferreira et al., 2007; Martínez de Aragón et al., 2011; Sievänen, 2005).

Finally, mushroom collecting is seen as part of national traditions and culture, or an expression of the connection with the local environment. This applies in Finland (Sievänen, 2005), Baltic countries (Brokken, 2011), Romania (Scholten, 2011), Greece (Aloupi et al., 2012), Czech (Kalac, 2009), parts of Italy (Giannaccini et al., 2012), Catalonia (Martínez de Aragón et al., 2011) and for northern Slavic countries (Łuczaj and Nieroda, 2011).

4.2.2.3. Berries and fruit. Recreational berry picking is typically a family activity. While berry collecting was essential to get fruit 60–70 years ago, in many families a tradition of berry picking was kept over several generations and is still an important reason for berry picking (Kangas and Markkanen, 2001). In Finland participation rates for women are higher than for men (62% vs. 49%). The opportunities to collect berries are first influenced by the access rights to forests and nature. While in Denmark berry picking is an insignificant forest use, mainly because of the absence of common rights and the forest structure (Saastamoinen et al., 2000), in Finland, picking berries and mushrooms is ranked as a more important forest utilization than wood production (Kangas and Markkanen, 2001). People that have access to nature are more active berry pickers (Kangas and Markkanen, 2001). Berry picking is done within ~35 km distance from home (Kangas and Markkanen, 2001; Stryamets et al., 2012). In areas with a high abundance, participation in berry collection is higher than in areas with a low abundance and in

Table 3
Country-level overview of explaining factors for wild food collecting.

Country	Fraction forest and other wooded land[a]	Population density (pers/km^2)[a]	GDP per capita (€, 2010)[a]	Importance WF in cuisine[b]	Accessibility regulations forest & nature[c]	Regulations WF collection[c]	Hunters in 2010 (percent of 2010 population)[d]
Austria	0.48	102	29,300	Very high	Strict	Moderate	1.41
Belgium	0.23	353	27,400	Low	Strict[e]	Very strict[e]	0.21
Bulgaria	0.36	69	10,400	High	Moderate	Very loose	1.45
Cyprus	0.42	95	23,200	Moderate	Strict	Strict	5.60
Czech Republic	0.34	135	19,200	High	Strict	Moderate	1.05
Denmark	0.15	129	28,400	Low	Loose	Moderate	2.98
Estonia	0.55	32	15,000	High	Loose	Loose	1.24
Finland	0.76	18	26,600	Very high	Very loose	Very loose	5.76
France	0.32	1.14	25,400	Very high	Strict	Moderate	2.06
Germany	0.32	235	27,400	Moderate	Moderate	Very loose	0.43
Greece	0.51	87	22,100	High			2.08
Hungary	0.23	111	15,300	Low	Strict	Moderate	0.55
Ireland	0.11	67	29,800	Low			7.83
Italy	0.37	204	24,400	Very high			12.43
Latvia	0.56	36	12,200	Moderate			1.11
Lithuania	0.36	52	12,900	Very high	Very loose	Loose	0.96
Luxembourg	0.34	190	64,000	Low			0.40
Malta	0.01	1281	19,000	Low			3.62
Netherlands	0.11	492	30,800	Very low	Loose[f]	Strict[f]	0.17
Poland	0.30	124	14,300	High	Strict	Loose	0.28
Portugal	0.40	118	18,900	Moderate			2.16
Romania	0.29	92	10,900	Moderate	Moderate	Strict	0.28
Slovakia	0.40	113	17,200	Moderate	Very loose	Moderate	1.01
Slovenia	0.63	101	20,700	Very high	Loose	Very loose	1.07
Spain	0.56	91	24,300	High			2.13
Sweden	0.75	23	28,000	High	Loose	Very loose	3.10
United Kingdom	0.12	255	26,500	High	Very loose	Moderate	1.29

[a] MCPFE et al., 2007.
[b] Dominé et al., 2000; Montagné, 2011; Wikipedia, 2011.
[c] Based on expert classification of descriptions in Bauer et al. (2004) or data as indicated. An indicative description of the classes is as follows. Very strict: no free access to forest or nature, collecting wild food not allowed, or only under specific conditions. Strict: conditional access to forest or nature, wild food collecting is only allowed under specific conditions. Moderate: Acces depending on ownership, wild food collecting allowed depending on ownership. Loose: Mostly free access, wild food collecting allowed upon request to owner. Very loose: Free access to forest or nature (e.g. full right of way), wild food is considered a public good.
[d] FACE, 2012.
[e] http://natuurenbos.be/nl-BE/Natuurbeleid/Toegankelijkheid/Basisregel.aspx.
[f] http://www.volkskrant.nl/vk/nl/2844/Archief/archief/article/detail/2823347/2011/07/30/Wilde-bessen.dhtm.

a good year higher participation rates are observed than in bad years (Saastamoinen and Vaara, 2009; Sõukand and Kalle, 2012).

4.2.2.4. Other Vascular Plants. In contrast to the limited quantitative information on participation in wild vascular plant collecting, the literature survey provides ample information on motives for wild plant collecting. Many studies indicate that especially elderly people collect and use wild plants (Bonet and Valles, 2002; Cornara et al., 2009; Della et al., 2006; González et al., 2011; Idolo et al., 2010; Łuczaj and Wojciech, 2007; Mattalia et al., 2013; Nebel et al., 2009; Petkeviciute et al., 2010; Rigat et al., 2009; Sõukand and Kalle, 2012; Tardío et al., 2005; Vitalini et al., 2009). Secondly, collecting wild plants is poverty-related. Wild plant consumption is associated with times of scarcity (Pardo-de-Santayana et al., 2007) and is more common among people with a low income (Pouta et al., 2006) or in regions with a lower income (Łuczaj and Wojciech, 2007). In Bulgaria the economic value is an important reason for gathering wild plants (Grasser et al., 2012). Third, collecting wild plants is a female activity (Bonet and Valles, 2002; Di Tizio et al., 2012; Grasser et al., 2012; Petkeviciute et al., 2010; Pieroni and Gray, 2008).

In regions with strict access or collecting regulations, wild plant collecting is less common than areas where rules are less strict or not enforced (Pardo-de-Santayana et al., 2005; Turtiainen and Nuutinen, 2011). Plants are collected very near to people's homes, e.g. from crop fields, wild areas or hedgerows adjacent to the village (Della et al., 2006; González et al., 2011; Pieroni et al., 2002; Schunko and Vogl, 2010; Stryamets et al., 2012). Wild plant collecting is more common among people with outdoor jobs, like farmers or trekking guides (Hadjichambis et al., 2008; Idolo et al., 2010; Menendez-Baceta et al., 2012; Petkeviciute et al., 2010; Schunko and Vogl, 2010). Higher participation rates are seen in rural communities (Łuczaj et al., 2012). In areas with a high species richness or abundance, wild plant collecting is more common than in areas with a low species richness or abundance (Della et al., 2006; Idolo et al., 2010; Menendez-Baceta et al., 2012; Pardo-de-Santayana et al., 2007).

Classification systems for ecosystem services only account for the role of wild plants in food provision. However, the literature indicates that there are several cultural reasons for collecting wild edible plants, depending on regional traditions. There are clear differences in the type of plants used in different regions, even if there is overlap in the available species. This is e.g. seen in Italy, where clear differences are seen in the species collected between the south and the north in spite of the similarity in the available species (Ghirardini et al., 2007). In a study in Basque country, the consumption of ten taxa was observed that do occur throughout Spain. Consumption has not been observed in other regions, and is thus unique to this region (Menendez-Baceta et al., 2012). Also, often the pleasure of being outdoors and collecting edible plants can be a more important incentive than the actual nutritional value of the plants (Grasser et al., 2012). Finally, collecting wild plants is seen as part of the cultural history of a region (Seeland and Staniszewski, 2007; Schunko and Vogl, 2010). People who live in a region for a long time tend to collect wild plants more frequently; wild plant collecting is less frequently observed in regions with more immigrants (Della et al., 2006; Łuczaj and Wojciech, 2007; Rigat et al., 2009; Schunko and Vogl, 2010). Ethnic communities collect other species than autochthone locals; the species they collect are more similar to the species collected in the area where they come from (Di Tizio et al., 2012; Pieroni and Gray, 2008).

4.2.3. Importance of Wild Food

Altogether, approximately 13 million EU citizens (2.7%) do hunt. In the case studies included in the literature survey, up to 40% of the

Table 4
Inputs for mapping spatial patterns of the importance of wild food collecting.

Explanatory factor	Indicators for the importance per food group		
	Game	Mushrooms	Wild vascular plants
Age	Percent of population per NUTS2 region aged between 20 and 60[a], normalized (high = 1, low = 0).	Percent of population per NUTS2 region aged between 60 and 85[a], normalized (high = 1, low = 0).	Percent of population per NUTS2 region aged between 60 and 85[a], normalized (high = 1, low = 0).
Income	Not included	GDP per capita (€) at NUTS2 level[a], normalized (high = 0 low = 1).	GDP per capita (€) at NUTS2 level[a], normalized (high = 0 low = 1).
Land use/ cover	Percentage accessible rural land (nature, agriculture, water; excluding protected areas Cat. I and II) in a 50 km radius[b, c], normalized (high = 1, low = 0).	Percentage accessible forest or woodland (excluding protected areas Cat. I) in a 15 km radius[b, c], normalized (high = 1, low = 0).	Percentage accessible rural land (nature, agriculture; excluding protected areas Cat. I) in a radius[b, c], normalized (high = 1, low = 0).
Accessibility	Country specific accessibility and regulations level (Table 3) reclassified as very high = 1, high = 0.75, moderate = 0.5, low = 0.25, very low = 0. Not included in countries where no data is available.		
Cultural importance	Importance in cuisine (Table 3) reclassified as very high = 1, high = 0.75, moderate = 0.5, low = 0.25, very low = 0.		
Population	Mask of populated areas: areas with a population density > 10[d]		

[a] (European Commission, 2012a).
[b] (EEA, 2012).
[c] (IUCN and UNEP, 2012).
[d] (European Commission, 2012b).

respondents collect mushrooms; up to 60% of the respondents collect berries and between 10% and "nearly everybody" of the respondents collect vascular plants. We assume that in the 17 countries where case studies on wild food collecting are reported, half of the rural population is collecting wild food. Consequently, we estimate that 65 million people (14% of all EU citizens) collect wild food occasionally.

The explanatory factors denoting the wild food flow and demand collecting were mapped for the EU following the data and calculations described in Table 4 and Section 3.3. The resulting map (Fig. 6) provides an indication where these conditions coincide. The maps are no quantifications of the absolute demand for wild food, but rather an illustration of the spatial variability of both the flow and the demand, and with that of the importance of wild food collecting and consumption in society.

For game, the patterns in Fig. 6 broadly match the country-level hunter statistics (Table 3). Deviations are seen in Poland (low participation, high estimated importance) and Ireland (high participation, low estimated importance). As agricultural areas are also assumed suitable for hunting and people tend to travel substantially further to go hunting than to collect mushrooms or vascular plants, there is little small-scale variation. Low values are seen however around urban areas.

Patterns for the importance of wild mushrooms and vascular plants are similar. The importance of mushroom collecting is closely related to the forest areas because mushrooms are common in forest. Low importance is seen in the Netherlands, Belgium, Luxembourg and Denmark. These are high-income countries, with many urban or agricultural areas and a cuisine based on agriculture. Low values are also seen around urban centers like London or Paris, and in Hungary, which is a country dominated by agriculture.

High values coincide with the countries where many studies on wild food were done, i.e. Italy, Spain, Scandinavia and Greece. In the South of Spain the demand is lower than in the north, probably because the Southeastern half of the country has less natural land in the direct vicinity of urban area. High values are expected in France: the aging population, the very high importance in cuisine, and the strongly intermixed urban and rural land can explain this. For Germany the demand is lower, due to the lower importance in cuisine and the higher urbanization.

4.3. Benefits

4.3.1. Quantities Collected and Economic Value

In 2005, 26 million kg game meat was marketed in ten EU countries (Table 5), representing a value of €379 million (MCPFE et al., 2007). This quantity of marketed game is lower than the sum of the harvest densities (Table 5), because other and more countries are included and part of the harvested game included in the country-level statistics is not shot for trade or consumption goals. The monetary value of marketed game meat is also lower than the monetary value of all harvested game, for the same reason and because of the use of German price levels that are likely higher than average EU price levels. EU price levels at species level were, however, not available.

On average, hunters harvest between 0.2 (Italy) and 13.9 (Hungary) animals annually. In most countries part of this is traded. In the UK, 14% of the rabbit hunters sell their harvest and 57% give away harvest (Murray and Simcox, 2003). In Sweden, one-third of the economic value of the moose hunting is estimated to be the monetary value of the meat (Fischer et al., 2012).

In 2005, 388 million kg mushrooms were marketed in 13 EU countries (Table 5), representing a value of €169 million (MCPFE et al., 2007). However, the majority of wild mushroom harvesting is non-reported harvest for private use (Łuczaj and Nieroda, 2011), e.g. 93% of the mushroom collecting in a case study in Catalonia (Martínez de Aragón et al., 2011). In a study in Småland, 1–2 kg mushrooms per season per picker was collected (Stryamets et al., 2012). This is comparable with the estimate of 2 kg mushrooms per trip from Martínez de Aragón et al. (2011)[2]. While throughout the EU 27 mushroom species are collected, the trade is dominated by Chanterelles and Boletes (Editorial Board of the Central Statistical Office, 2012; Statistics Lithuania, 2009), suggesting that the other mushroom species are collected for private consumption. In Italy, recreational pickers sell mushrooms both on regional markets and to other parts in Italy (Pieroni, 1999). In Finland mushroom pickers market or give away their harvest (Sievänen, 2005). In Greece and Catalonia, the market for wild edible mushrooms is increasing (Ouzouni et al., 2007; Voces and Diaz-Balteiro, 2012).

In 2005, 281 million kg of wild berries and fruit was marketed in 12 EU countries (Table 5), representing a value of €342 million (MCPFE et al., 2007). Recreational berry collection in Sweden 1997 amounted 13 million kilos for domestic consumption (Jonsson and Uddstal, 2002). This corresponds to 2.5 kg per picker per year[3] and is in the same range as the estimate of Stryamets et al. (2012) for Småland (1–5 kg berries per season) or Saastamoinen et al. (2000) (19 million kilos for home use in the late 1990s). Estimates for Finland are much higher. Saastamoinen et al. (2000) report around 15 kg per picker per year for home use[4] and estimates vary between 10 and 22 kg

[2] In the study by Martinez de Aragon, <2 trips per season per person were made.
[3] Based on a population of 8.8 million (Eurostat, European Commission, 2012a) with 58% picking berries (Jonsson and Uddstal, 2002).
[4] Based on 40 million kg per year (Saastamoinen et al., 2000), a population of 5.1 million (Eurostat, European Commission, 2012a) and a participation in berry picking of 55%–60% (Jonsson and Uddstal, 2002; Sievänen, 2005).

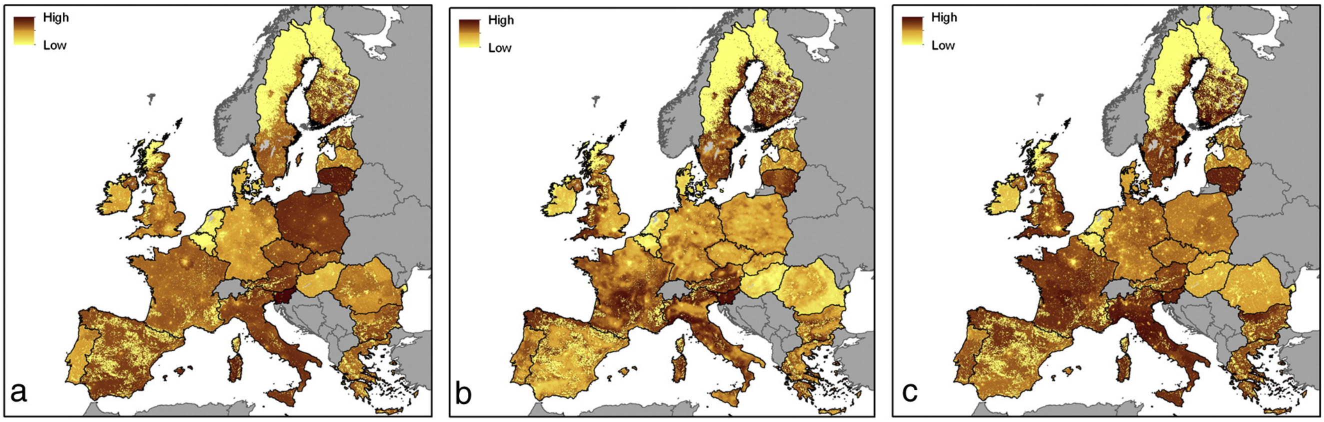

Fig. 6. Importance of game (a), mushrooms (b) and wild edible vascular plants (c) as an ecosystem service.

per picker (Kangas and Markkanen, 2001). These numbers are higher than the marketed quantities, demonstrating that non-commercial berry pickers dominantly collect berries for home use. They sell between zero and 28% (Saastamoinen and Vaara, 2009; Stryamets et al., 2012) while active pickers sell up to two-third of the berries they collect (Kangas and Markkanen, 2001).

Only Grasser et al. (2012) provides a quantitative estimate of the amount collected for vascular plants other than berries, in a case study in the Austrian Walsertal. In this case study, 40–45 kg dried plants per year is collected for tea in a 192 km^2 study area. The Walsertal has 3400 inhabitants of which "many" collect wild plants, and market "small amounts" of the collected wild plants. Rigat et al. (2009) and

Table 5
Overview of benefits of wild food.

	Harvest densities of main game species (# harvested per year/km^2 land area)[a]					Value of harvested game (million E)[b]	Wild food traded (g/capita, 2007)[c]			Game meat consumption (kg/yr pp)[d]
	Red deer	Roe deer	Wild boar	European hare	Pheasant		Game	Mushrooms	Forest Berries	
Austria	1.91		0.36	2.00	1.83	27.52	884	24	15	0.8[e]
Belgium (Flandres)		0.34		3.45	7.61		127			0.44
Bulgaria							161	1059[i]	249	0.02
Cyprus										
Czech Republic	0.25	1.48	1.19	1.03	7.45	19.32				1.1
Denmark	0.09	2.59		2.26	17.35	16.23				0.65
Estonia	0.00	0.24	0.25	0.03	0.02	1.11				0.27
Finland		0.01	0.00	0.26	0.14	4.16		80	2250	1.63
France	0.08	0.92	0.81		9.09	143.59		64		5.7[j]
Germany	0.19	3.29	1.47	1.08	0.69	91.74				0.9[f]
Greece										
Hungary	0.47	0.75	0.90	1.23	5.02	19.49	679			0.5
Ireland										0.35
Italy								5934	1932	3.8
Latvia	0.06	0.31	0.29	0.01		2.23				0.62
Lithuania	0.02	0.24	0.27	0.12	0.01	1.78	501	707	289	0.14
Luxembourg										2.7
Malta										
Netherlands	0.03	0.42	0.14	5.06	2.21	5.78	27			0.43
Poland	0.13	0.47	0.41	0.14	0.64	20.56		110	503	0.08
Portugal							245	606	5001	0.08
Romania							12	79	300	
Slovakia	0.28	0.42	0.46	0.73	2.76	5.78	194	16	75	0.56
Slovenia	0.21	1.58		0.10	1.77	1.98		49	56	0.27
Spain	0.14	0.04	0.30	1.74	0.51	77.82		83	1554	1.36[g]
Sweden	0.01	0.31	0.09	0.11		8.83				2.63
United Kingdom			0.36			11[h]	57	1	0	0.12
Total monetary value of harvested game (million E)						448				
Total wild food trade (million kg)[c]							26	388	281	

[a] National statistics, hunters associations.
[b] Game numbers from national statistics. Value per animal from (Deutscher Jagdschutzverband, 1997–2014).
[c] (MCPFE et al., 2007).
[d] (Reinken, 1998).
[e] (Paulsen et al., 2012).
[f] (Atanassova et al., 2008).
[g] (Rovira et al., 2012).
[h] 1996 (Murray and Simcox, 2003).
[i] (Department of Agriculture, 2010) reports slightly higher numbers: 1142–1677 tons.
[j] (Roth and Merz, 1997).

Tardío et al. (2005) report marketing of other vascular plants in Spain, but do not report on quantities marketed. Rigat et al. (2009) report that some people "manage to complete their revenues by selling wild herbs to restaurants" and Tardío et al. (2005) report that in regions around Madrid, "small amounts" of gathered plants are marketed.

4.3.2. Consumption

Annual game meat consumption in the EU ranges between 0.08 (Poland and Portugal) and 5.7 kg/capita (France) (Reinken, 1998) (Table 5). Other estimates are consistent with this and report values of up to 4 kg/capita per year for Italian hunter families (Paulsen et al., 2012) or up to 8.4 kg/capita per year for Andalusian hunters (Rovira et al., 2012). Compared to total meat consumption, this is between 0.04% in Bulgaria to over 6.5% in France (FAO, 2012). Seventy percent of the Swedish consume game at least once a year (Ljung et al., 2012). Which species are consumed is strongly dependent on country-level or EU-level regulations (Hopkins, 2004).

Consumption of wild berries can only be derived from the quantities collected in Sweden (max 5 kg per year pp) and Finland (max 30 kg per year per household). Compared with the annual fruit consumption, in Sweden berry pickers collect up to 4% of the average annual fruit consumption per capita (134.1 kg/capita) and in Finland up to 34% (87.3 kg/capita) (FAO, 2012). Nebel et al. (2009) indicate that wild gathered plants are consumed regularly in the season, on average 3 portions per week. For other countries and for wild mushrooms, no data were available.

4.3.3. Cultural Value

Next to providing food and income, wild food has a cultural value. In many EU countries including Greece, Poland, France and Italy wild food is important in the traditional cuisine (Table 5) (Aloupi et al., 2012; Dominé et al., 2000; Łuczaj and Nieroda, 2011; Montagné, 2011; Wikipedia, 2011). Only countries where traditional cuisine is dominantly based on agricultural products (Netherlands, Denmark, Hungary) the importance of wild food in traditional dishes is low (Dominé et al., 2000).

Second, wild food collecting and consumption are seen as part of people's identity. Wild food is considered as a mark of local and regional traditions and is an irreplaceable expression of natural and cultural heritage (Pardo-de-Santayana et al., 2005; Seeland and Staniszewski, 2007). Finally, an often-mentioned motive to collect wild food is recreational. This is seen throughout Europe, and for all groups of wild food. For game hunting, recreational motives are important for owning hunting estates in Scotland (MacMillan and Leitch, 2008). Mushroom and vascular plant collecting are the main reasons for day trips to nature in Finland (Kangas and Markkanen, 2001), Italy (Sievänen, 2005) and Spain (Martínez de Aragón et al., 2011).

5. Discussion

5.1. Interpretation of the Results

The spatial patterns of wild food species richness follow patterns of overall species richness in Europe. Species richness increases towards Southern and Central Europe, and in natural habitats a larger species variety is found than in urban and arable areas (Louette et al., 2010). For mushrooms, areas with high species richness are concentrated in forested areas. For game, the species richness shows a similar trend as vascular plants, with higher species richness in Central Europe and in natural habitats. This explains the lower species richness in parts of Italy and Hungary. In many regions, supply of edible vascular plants has decreased following general biodiversity decreases, due to scale increase of agriculture, herbicide application, nutrient inputs, fragmentation and pollution. Areas with low species richness but a high occurrence density are most common in Sweden and Finland. The high occurrence densities are mainly attributed to a few berry species or to species favoring high land use intensity, like common Nettles in the Netherlands (Fig. 5b). In most countries, the occurrence density of game is strongly controlled by hunting quota.

The participation in wild food collecting differs regionally and is controlled by income, age, gender, opportunities to collect wild food, and cultural factors. Before the rise of agriculture, hunting and gathering were the only food source (Ellis et al., 2013). Cultivation and trade gradually replaced hunting and gathering (Leonti et al., 2006; Rivera et al., 2006). Cultivation allows better quality control, a more constant supply, a higher yield, and smaller distance to food supply, leading to lower time investment to collect food. Until World War II, collecting food in the wild has been a necessity in parts of Europe, e.g. to get sufficient vitamins from fruit and proteins, especially in times of famine (Łuczaj et al., 2012). After that, due to increased agricultural production and more trade of food, the necessity to collect wild food ceased (Tardío et al., 2005).

Areas highly suitable for arable or livestock production coincided with an early rise of agriculture, and an early decrease of wild food collection, leading to an early extinction of wild food collecting and a low current participation level. This could explain the low participation in the Netherlands, Denmark and Hungary (Emanuelsson, 2009; Fresco, 2012; Weichselbaum et al., 2009). In coastal areas, fish has always been a main nutrient source and terrestrial wild food is consequently less important than in inland areas. In areas with early urbanization, people started to rely on trade for food supply. This decreased the number of people that collected food themselves. Additionally, in areas with a lot of trade, habits from elsewhere are adopted more quickly while in remote areas traditions including wild food collecting are more resistant to change (Pardo-de-Santayana et al., 2007). This could explain the low participation in Belgium and the Netherlands, and to a lesser extent in Germany. France, Italy and many Eastern European countries remained dominantly rural much longer (Fuchs et al., 2013), possibly making the need to collect wild food persists longer.

Wild food collecting is attractive in low-income regions. This can explain why wild food collecting is more common in many parts of Eastern and Southern Europe. Due to economic growth over the past decades, the necessity to collect wild food out of poverty has decreased in most of Europe.

Age might explain wild food collecting participation because elderly people are more likely to have witnessed times when collecting wild food was a necessity. Consequently, they are familiar with collecting wild food and still do it.

Traditional reasons for wild food collecting often emerge from the availability of wild food and their use in cuisine. Traditional cuisines are based on easily available products (Pieroni, 1999) and result in a high appreciation of these products. While in Northwest Europe agricultural products are more important in the cuisine, interest in wild food is low. In Central Europe, wild food products were more easily available, more important in traditional cuisine, making wild food collecting more important. In areas where a tradition of wild food has been extant until recent, it is likely to be transmitted to new generations. In areas where a tradition of wild food collecting has disappeared early, it is less likely to be re-established.

The quantities of wild food collected are small compared to total food consumption and the trade in wild food comprises a few thousandths of the GDP of the countries considered. At the same time, a considerable number of people benefit from wild food consumption. In the literature review, we found that 70–80% of the population in case studies consumes wild food. Assuming this percentage to be representative for the rural population in the countries for which data is available would suggest that at least 100 million Europeans (20% of the EU population) consume wild food. This is lower than wild food consumption outside the EU, e.g., in parts of Equatorial Africa 50% of the consumed proteins come from bushmeat (Hopkins, 2004; Wilkie and Carpenter, 1999). In Europe, the cultural benefits of wild food might be more important than the income and food benefits and more difficult to substitute.

It has been suggested that collecting wild food is decreasing and will fade out because of the aging population and increasing urbanization. Decreases of wild food collecting and as well as a declining knowledge on wild food are seen for especially vascular plants, in many parts of Europe, including Spain, Italy and Poland (González et al., 2011; Hadjichambis et al., 2008; Łuczaj, 2010; Pardo-de-Santayana et al., 2007; Seeland and Staniszewski, 2007). On the other hand, an increasing interest in wild food collecting is seen for other regions. This has mainly cultural motives. Wild food collecting and consumption are ways to express people's relation with the direct environment. The demand for wild food is believed to increase as a response to increasing industrialization and globalization (Fresco, 2012; Łuczaj et al., 2012; Menendez-Baceta et al., 2012; Pardo-de-Santayana et al., 2005; Seeland and Staniszewski, 2007) and collecting and consuming wild food are assumed to gain popularity among groups of people that were not traditionally involved, like urban professionals (Fresco, 2012).

Additionally, migration could influence the demand for wild food. Several studies show that immigrants tend to continue collecting the wild food species they are used to rather than starting to collect the wild food species common for the country they migrate to (Di Tizio et al., 2012; Pieroni and Gray, 2008). The increasing migration from the east of the EU towards the western and northern EU countries (European Commission, 2012a) could therefore increase the demand for wild food in the western and northern EU.

Wild food is collected relatively close to people's homes. Only for hunting trips, people tend to spend more than a few hours or a day (Tsachalidis and Hadjisterkotis, 2008). Consequently, wild food will be collected in areas where there is supply of wild food that is accessible to people who have a demand for collecting and consuming it. These matches between demand and supply are most likely to occur in landscapes where a variety of land cover types on one hand supports a variety of species, and where on the other hand a mix of residential, used and wilder areas enables people to access the landscape.

5.2. Evaluation of Data and Methods

In this study we summarized and applied the best data available on the supply, collecting and benefits of wild food in the first decade of the 21st century. We provide the first EU-scale estimate of the provision of this ecosystem service, and give insight in the spatial variation of the service. We cover all terrestrial wild food (game, mushrooms, plants) instead of focusing on one group only. The inventory is based on literature from 20 countries, using EU-scale data on the distribution of species. At the same time, the review of data and literature reveals several information gaps to appropriately quantify and map this ecosystem service. As wild food is often collected in an informal way, it is not part of formal economic accounts, making inventory difficult. The approach taken in this paper using a wide variety of data sources has some shortcomings.

The inventory of the ecosystem properties and functions was hampered by the nature of studies on wild food collecting and consumption. Wild plant and mushroom use is a common topic in ethnobotanical studies, but has not been studied before from an ecosystem services perspective at EU scale. Ethnobotanical studies focus on the collected species, and on countries where the use of wild plants is well-known. This causes a bias towards Mediterranean countries. Based on these sources we identified almost 600 plant species and 38 game species that are used as wild food. This is 4% (plants) and 5% (game) of the overall species richness in the EU and a credible number compared to other world regions (Turner et al., 2011).

Next to the species richness, also the abundance of wild food species is important (Łuczaj, 2010) but quantities collected are very rarely inventoried (Saastamoinen et al., 2000) and species distribution information generally only includes presence/absence data. To map a proxy for the abundance of the main wild food species, we used data from GBIF (GBIF, 2007). Although GBIF is certainly the best available data at large spatial scale, it is also relatively biased. The spatial distribution of occurrence records is unbalanced, inaccuracies in the spatial data occur and many records are not complete (Yesson et al., 2007). Occurrence data from GBIF were used to illustrate patterns of abundance and for niche modeling. In the abundance maps (Figs. 3b, 4b, 5b), consequently, spatial inaccuracies may occur although these are averaged out when calculating point densities. For niche modeling, while the spatial bias could occur, the environmental niche of species was still successful (the environmental space does not strictly follow the spatial space) and the use of an ensemble forecasting approach allows smoothing out those bias effects.

Also the literature on demand and benefits for wild food is biased towards Southern, Eastern and Northern Europe. However, the factors explaining the demands and benefits are consistent among studies on different parts of the EU. For game, distinguishing harvest for consumption from the total harvest has a high uncertainty and illegal game harvest was obviously not included while it may make a large contribution to the total harvest.

By searching literature with queries in English, we exclude data from literature in national and local languages. Many national statistical databases are however bilingual, and literature encountered in the snowball search in languages other than English was included in the survey.

A national-scale inventory of wild food as an ecosystem service could allow a stronger and more generic approach to mapping of the spatial patterns of supply and demand and the driving factors behind it. Such an approach could include a structured survey coupled with local landscape characteristics and detailed census information. Nevertheless, this would only help providing better insight in the wide variety of wild food availability and appreciation if it would be applied to all countries in Europe. Given the time commitment needed for such a study, a mapping approach based on synthesis of available data might provide more insight in the variation of impacts of European-scale policies.

6. Conclusions

Wild food is an iconic, sometimes debated, but certainly enjoyed ecosystem service. In most of Europe, there is ample availability of edible species from the wild. We estimate that at least 65 million EU citizens collect wild food and at least a 100 million consume wild food. Wild food comprises a small fraction of the total food consumption and economy in the EU, but the collecting is an appreciated recreational activity that is possibly gaining importance as a cultural service. However, ongoing concerns on the impact of wild food collecting on the populations of wild food species have triggered both prohibiting harvest of specific species but also the introduction of species, e.g. Chestnuts in forests (Emanuelsson, 2009).

A considerable part of EU citizens enjoy the ecosystem service wild food. Therefore, it should be included in the mainstream ecosystem service assessments at EU scale. It may however be rather considered as a cultural service than as a provisioning service in Europe. Wild food can provide a way to add value to ecosystems and fits the plea for multifunctional landscapes. For an easy availability of wild food, a varied landscape with easy access is important. Intensification in agriculture and forestry could be harmful for the availability and accessibility of wild food. Management and conservation of semi-natural areas could be beneficial for the supply of this service, but more research is needed on that.

Due to lack of data on the supply, demand and benefits of wild food, it is not regularly included in assessments of ecosystem services. Consequently, its many benefits – health, leisure, identity – are probably underestimated. Better estimates could be made if more and better consistent data on abundance and production of wild food were available and by an inventory of the participation in wild food collecting in more countries.

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2014.06.018.

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