CULTURAL ECOSYSTEM SERVICES PROVIDED BY THE BIODIVERSITY OF FOREST SOILS: A EUROPEAN REVIEW

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Abstract

Soil is one of the most species-rich habitats and plays a crucial role in the functioning of terrestrial ecosystems. It is acknowledged that soils and their biota deliver many ecosystem services. However, up to now, cultural ecosystem services (CES) provided by soil biodiversity remained virtually unknown. Here we present a multilingual and multisubject literature review on cultural benefits provided by belowground biota in European forests. We found 226 papers mentioning impact of soil biota on the cultural aspects of human life. According to the reviewed literature, soil organisms contribute to all CES. Impact on CES, as reflected in literature, was highest for fungi and lowest for microorganisms and mesofauna. Cultural benefits provided by soil biota clearly prevailed in the total of the reviewed references, but there were also negative effects mentioned in six CES. The same organism groups or even individual species may have negative impacts within one CES and at the same time act as an ecosystem service provider for another CES. The CES were found to be supported at several levels of ecosystem service provision: from single species to two or more functional/taxonomical groups and in some cases morphological diversity acted as a surrogate for species diversity. Impact of soil biota on CES may be both direct – by providing the benefits (or dis-benefits) and indirect – through the use of the products or services obtained from these benefits. The CES from soil biota interacted among themselves and with other ES, but more than often, they did not create bundles, because there exist temporal fluctuations in value of CES and a time lag between direct and indirect benefits. Strong regionality was noted for most of CES underpinned by soil biota: the same organism group or species may have strong impact on CES (positive, negative or both) in some regions while no, minor or opposite effects in others. Contrarily to the CES based on landscapes, in the CES provided by soil biota distance between the ecosystem and its CES benefiting area is shorter (CES based on landscapes are used less by local people and more by visitors, meanwhile CES based on species or organism groups are used mainly by local people). Our review revealed the existence of a considerable amount of spatially fragmented and semantically rich information highlighting cultural values provided by forest soil biota in Europe.

Key words: soil biota; forests; soil ecosystem services; Europe

Highlights

Contributes to the understanding of cultural significance of forest soils

Spatial distribution and temporal variations of CES of soil biota has been analyzed.

Highlights use of biodiversity data in soil CES studies

1. INTRODUCTION

The idea of ecosystem services (ES) was originally coined to quantify the benefits that natural ecosystems generate for human society (Westman, 1977). The aim of this effort was to raise the public awareness for the value of biodiversity and conservation of ecosystems. The Millennium Ecosystem Assessment (MEA, 2005) defined four main categories of ES: Supporting, Provisioning, Regulating and Cultural. Of these four, cultural ES probably raise the biggest controversy. Cultural ES (CES) are defined by MEA as "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences". CES are inherently difficult to identify, evaluate and employ in environmental management and decision making (de Groot et al., 2005), as their benefits are intangible and have "non-use values" for most of them (Burkhard et al., 2014). However, Satterfield et al. (2013) and Fish et al. (2016) emphasized that many cultural phenomena, such as artistic media, architecture, clothes, etc., are not immaterial or intangible and admitted thus that many CES are in principle marketable. Even though CES are not considered an initial driver of political or management decisions (Milcu et al., 2013), many researchers recognize them as one of the most potent arguments for ecosystem conservation (Hernández-Morcillo et al., 2013).

The greatest hindrances in identification of CES and their subsequent employment in management plans are difficulties in the identification of ecosystem elements underpinning CES, identification of beneficiaries of CES, the valuation of the benefits delivered and variation of CES in time and space (Blicharska et al., 2017). Therefore, research on CES mapping and evaluation often employs only the "safest", that is, marketable service groups like recreation and ecotourism (e.g., Maes et al., 2012, 2013). An additional difficulty in CES evaluation is variability of beneficiaries' attitudes towards the same CES depending upon their "mental filter" which is defined by education (Braat, 2014), cultural/societal position (Satterfield et al., 2013) or different national traditions (Daniel et al., 2012). Furthermore, CES categories overlap with each other (Daniel et al., 2012) and with other ES, for example provisioning and regulating services may in many cases also be perceived as cultural (Chan et al., 2012; Schulp et al., 2014). This may strengthen the value of CES (their importance to the beneficiaries), on the other hand, it can complicate the evaluation as double counting could occur. Temporal and spatial changes can further complicate the picture as shown for the use of fish in Swedish mountains (Blicharska et al., 2017), or the uses of wild plants for food and medicine in Eastern and Northern Europe (Luczaj et al., 2012; Stryamets et al., 2015), where the primarily provisioning ES changed in time to largely recreation and ecotourism CES.

Soil is a fundamental component of any terrestrial ecosystem and by itself it hosts a huge biodiversity, both in terms of species richness and functionality. It is estimated that about 25 % of the species on Earth live in the soil (Jeffery et al., 2010). Soils have played an important role in human life by predetermining societal and cultural development even since pre-agricultural societies (e.g., Mortensen et al., 2014) and they contribute to human welfare far beyond food production. Although they undoubtedly provide a number of ES, soils and soil biodiversity are often neglected in mapping and evaluating ES, largely because belowground biodiversity has received insufficient attention for a long time (Pulleman et al., 2012). The lack of appropriate methods to study belowground biodiversity and processes, as well as the cost and complexity of such studies is the main reason for this neglect. We also lack tools to evaluate biodiversity

components and CES derived from these components. Noteworthy is how little we understand of CES provided by soils and the biota belowground. Even the most recent papers that review ES provided by soils, state the lack of studies pertaining CES from soils. Iconic or attractive landscapes that are underpinned by different soil types were shown as the only example of CES of soils in the review of Dominati (2013). In other reviews, Dominati et al. (2010), Jónsson and Davíðsdóttir (2016) and Robinson et al. (2009) mentioned soils that are archives of archaeological heritage and spiritual-religious meanings of soils (mostly extra-European examples). Adhikari and Hartemink (2016) demonstrated very generalised CES (human wellbeing) as secondary, derived from another ES provided by soils. However, often CES are neither elaborated or mentioned at all, e.g. in reviews by Lavelle et al. (2006) and Pulleman et al. (2012). Lavelle et al. (2006) even stated that “Soils ... contribute to cultural services although to a rather minor degree...”. Thus, perception of CES from soils is rather biased towards abiotic structures and processes contrary to the usual classification and assessment of ES where biota play the main role as a service provider (Van der Meulen et al., 2016). The direct cultural benefits from soil biota are only casually mentioned in the few reviews on soil fauna (e.g., Anderson, 2009; Decaëns et al., 2006; Del Toro et al., 2012) and cultural significance of soils is often attributed to agriculture and agricultural landscapes. Even the iconic cultural symbol, a "handful of dirt" generally refers to agricultural soil. Understanding of CES provided by forest soils as opposed to agricultural soils is particularly unclear.

The aims of the present study were to i) identify the CES of European forest soil biota, ii) highlight the importance of belowground diversity on human culture and well-being, iii) outline the geographical scope of beneficiaries of these CES, iv) contribute to the understanding of temporal changes of CES and their interrelations with other ES. Our findings are intended to ensure more exhaustive evaluations and mapping of ES (including CES) that are provided by forests.

2. METHODS

To compose a list of CES, we used the framework of the Millennium Ecosystem Assessment (MEA, 2005). More than often understanding of different CES overlaps and the same benefits can be attributed to more than one CES (e.g., to spiritual and aesthetic values) (Cooper et al., 2016). Therefore, we added here descriptors to the CES, which we followed when searching for references, so that we could attribute each source to a distinct CES.

Cultural diversity, according to the Universal Declaration on the Cultural Diversity (UNESCO, 2002) includes diversity of languages, traditions, folklore and other national heritage.

For *Spiritual and religious values* we followed definition by De Groot et al. (2002), as use of nature for religious purposes.

Knowledge systems encompass traditional and formal knowledge. According to Karvonen and Brand (2013), formal knowledge is characterised by impersonal and often quantitative precision with a concern for explanation and verification. Meanwhile traditional knowledge is "experimental, local or tacit knowledge arising from personal experience and explorations outside the confines of educational institutions and without strict adherence to the scientific methods" (Karvonen and Brand, 2013).

Educational values can be provided for formal, non-formal and informal education. For further understanding of the education types we followed Dib (1988).

Following De Groot et al. (2002), *Inspiration* derived from ecosystems is defined as cultural and artistic information where nature is employed as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.

Aesthetic values are the interaction of humans with the environment based on human perceptions and resulting in aesthetic and affective reactions and judgments. According to Cooper et al. (2016), in aesthetic evaluations humans are assessors of natural beauty, rather than recipients of products or benefits.

Sense of place is usually characterised as the emotional bonds formed by people with places, their values, meanings and symbols (Williams and Stewart, 1998), however, lifestyle and

traditional use of natural resources also make a part of sense of place, as was shown by Urquhart and Acott (2013).

For *Heritage values* we followed the definition by ICOMOS (Brooks, 2002): "cultural heritage is an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values".

Social relations and human interactions are influenced by ecosystems found in a particular place. Social interdependences connected to ecosystems and their biodiversity may come in various levels (Barnaud et al., 2018).

Recreation and ecotourism encompass opportunities for recreation and tourism that stem from ecosystems and are termed as "free services" of natural capital in providing infrastructure for recreational activities (Clough, 2013).

For definition of *Health and wellbeing* we followed the statement by Sandifer et al. (2015) that apart from the absence of disease, human health is defined as a state of physical, mental and social wellbeing.

Based on these CES types, we evaluated six groups of belowground biota. Many references have demonstrated that cultural significance of organisms and their reflection in human life and perception does not always coincide with biological values or grouping of biota. Therefore we did not strictly follow the usual biotic groupings, as in, e.g., Jeffery et al. (2010) or Briones (2014), though our grouping comes close to that suggested by Orgiazzi et al. (2016). We grouped soil biota as follows:

- *Roots* (in a broad sense) included all belowground parts of vascular plants;
- *Fungi* encompassed all trophic groups (mycorrhizal, saprotrophs and pathogens). We included all references mentioning belowground mycelium and fruit bodies of macromycetes (encompassing sequestrate and semi-sequestrate (truly belowground) and emergent (above-ground) fruit bodies);
- *Microorganisms* included bacteria, protozoa and algae;
- *Mesofauna* included nematodes, collembolas and acari;

- *Macrofauna* included earthworms and burrowing macroarthropods;
- *Megafauna* included burrowing mammals (we restricted to the true burrowers only).

To avoid analysis of too extensive material, we limited search only to Europe and its forests. However, based on our search principles, methods and the keywords employed, similar reviews can be carried out in any part of the world.

For the literature analysis, we conducted a reference search at two levels. Firstly, we performed a comprehensive search of Clarivate Analytics Web of Knowledge using the search terms Cultural ecosystem service × organism group or subgroup, for example, recreation × fungi or recreation × mycorrhizal in the title, key words and abstract. The search was conducted from December 2015 until April 2016. After the screening of results for subject relevance, the search was finalized with 41 articles that were identified as relating to forest soil biota and CES in Europe. Moreover, the major part (29) of these papers dealt with only one group of organisms (fungi). As a second step, we made queries based on a system of better adapted keywords for each case, e. g. "roots + ethnography", (full keyword list provided in Supplementary material 1) in English, French, German, Dutch, Spanish, Italian, Czech, Slovenian, Slovak, Norwegian, Polish, Russian and Lithuanian languages. Thus, wider reference range in ethnobotany, ethnozoology, ethnology, mycology, toxicology, archaeology, palaeontology, literature and art research, linguistics, sociology and medicine, was covered. The queries were performed using Google Scholar, in September, 2016 – February, 2017.

This procedure was necessary as Milcu et al. (2013) noted that a large part of the CES research is published in non-peer-reviewed journals. Moreover, Harrison et al. (2014) indicated that, using a relatively new term "ecosystem service" as a keyword, will lead to inadequate numbers of relevant papers, which is especially consequential for culture-related issues, because many papers were published before the term came into wide use. In addition, a large part of data is found either in publications of non-ecological research with the CES term not mentioned (Braat, 2014) or a significant portion of information on biodiversity and human culture interactions is found in "grey literature" and in the sources published in national languages.

Additional literature and, in some cases, examples from other sources (internet sites, movies, fiction books, etc.) were found by snowball search (tracking down cited references within sources examined for their content) and expert suggestions (other sources suggested through discussions with fellow scientists at meetings during the process of the study).

For each publication, we checked element (organism group), spatial range of the benefit/service and temporal scale, type of impact on CES (direct, indirect, positive, negative or unclear (controversial or mentioning both positive and negative impacts)) and, possible beneficiaries and interaction with other CES or ES. As the collected data could not be quantified, the analysis is largely descriptive. In the text below, when the references are cited as examples of a benefit, in cases where there were more than three papers dealing with the benefit in question, only the number of references is indicated instead of a full citation.

3. RESULTS AND DISCUSSION

3.1. General results of literature analysis

The combination of both searches resulted in 226 papers (peer-reviewed and non-peer reviewed articles, conference abstracts, thesis, book chapters and books) which were further reviewed. The list of all reviewed references is provided in Supplementary material 2. It has to be noted that sometimes it was impossible to identify whether given organism or organism group was exclusively related to forest soils (i.e., some burrowing mammals, earthworms, etc. are able to inhabit both forest and non-forest habitats).

Table.1 Numbers of references found for cultural ecosystem service (CES)/organism group, the observed relationships of the organism group and the CES. Abbreviations: T – total number of references, + references mentioning positive effect, – negative effect, +/– neutral or controversial effect (also the cases when positive and negative effects both were mentioned).

CES	Roots				Fungi				Microorganisms				Mesofauna				Macrofauna				Megafauna			
	Number of references																							
	T	+	–	+/–	T	+	–	+/–	T	+	–	+/–	T	+	–	+/–	T	+	–	+/–	T	+	–	+/–
Cultural diversity	30	30			49	49											12	12			17	17		
Spiritual and religious values	8	8			18	17	1						1	1			4	4			8	8		
Knowledge systems (traditional and formal)	12	12			41	37	1	3	5	5			5	5			3	3			6	6		
Educational values	1	1			7	7			1	1			1	1			5	5			1	1		
Inspiration	5	5			20	20											6	6			6	6		
Aesthetic values					5	5											3	1	1	1				
Social relations	2	2			28	25	2	1									2	2			2	2		

Sense of place					9	9																
Cultural heritage values	11	10	1		16	16			1		1					5	4	1		9	7	2	
Recreation and ecotourism	1	1			10	10						1	1			4	4			8	8		
Health and wellbeing	17	14	2	1	33	9	23	1	1	1						3	2	1		6	1	4	**1**

The number of references found for the soil organism group contributing to the analysed CES and the type of impact of organism group on CES are presented in Table 1. The detailed results of the reference analyses are presented in Supplementary material 3. In a number of cases one paper covered more than one organism group or more than one CES, or both, therefore total numbers of references in Table 1 and Supplementary material 3 is higher than in Supplementary material 2. Of the total of analysed papers, 61 were pertaining all (or almost all) European countries, or had universal cultural significance. The rest of the references could be identified to the relevant country. The resulting distribution of the found references showed spatial unevenness across Europe, the western Mediterranean region providing the largest amount of available literature data (Fig. 1).

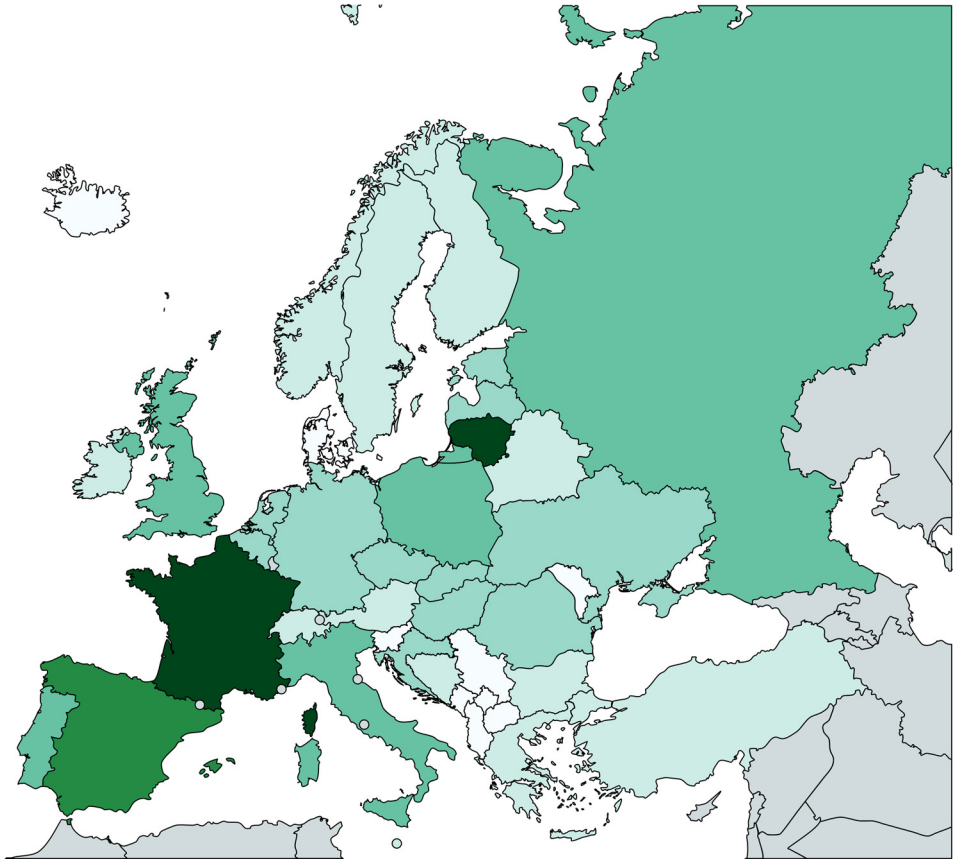
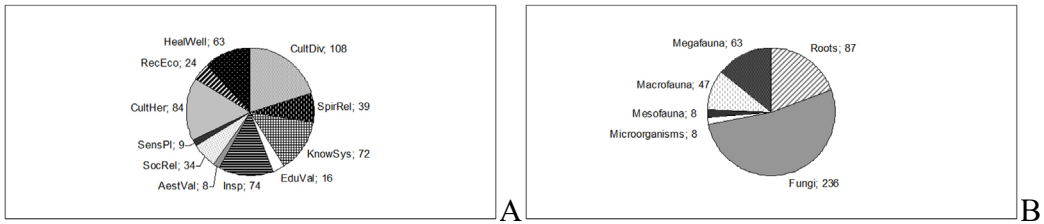


Fig. 1. Reference-based importance of forest soil biota for cultural ecosystem services. Intensity of colour refers to the number of relevant references we have found: darkest shade – over 20 references, lightest shade – no literature data. References pertaining to all European countries, or dealing with universal cultural significance of soil biota were not included

Soil organisms contributed to all CES, although their weight (expressed as numbers of references found) differed for individual CES and individual organism groups (Fig. 2). Based on reviewed literature, the highest impact was found for cultural diversity (in total 108 references, 24 % of all references) and the lowest for aesthetic values (in total 8 references, 1.8 % of all references) (Fig 2a). Of all soil organisms, fungi had the highest impact on CES, while microorganisms and mesofauna had the lowest (Fig 2b). Inadequacy between the different organism groups ("smaller" organisms versus vertebrates in their case) on CES in comparison to the impact on most other ES was demonstrated by Norris et al. (2011, table 4.2). In their study, vertebrates were shown to play a significantly higher role in CES provision than the rest of the biota. These "cultural divisions" found by Norris et al. (2011) and in our review as well, can be largely explained by the fact that the major part of the CES is based on folk perception of nature, ethnobiology and folk taxonomy, i.e., cultural recognition of biological taxa. Cultural recognition of biota is governed by the salience of different taxa, which was classified by Hunn (1999) into phenotypic, perceptual, cultural, and ecological. Following this grouping, folk recognition of organisms is based on: i) economical salience (economically important species or species used in everyday life); ii) morphological/behavioural salience (species with outstanding morphological and/or behavioural traits, often culturally important species); iii) ecological/geographical salience (species encountered in the area and the more frequent species); iv) size salience (larger species, notwithstanding organism group – microscopic species are „invisible" and therefore non-existent). Size was also recognized by Harrison et al. (2014) as an important attribute affecting species-based CES provision (recreation in their case).



A B

Fig. 2. Distribution of references according to (a) cultural ecosystem services (CES) and (b) organism groups. Acronyms of CES are as follows: CultDiv – Cultural diversity, SpirRel – Spiritual and religious values, KnowSys – Knowledge systems, EduVal – Educational values, Insp – Inspiration, AestVal – Aesthetic values, SocRel – Social relations, SensPl – Sense of place, CultHer – Cultural heritage values, RecEc – Recreation and ecotourism, HealWell – Health and wellbeing

3.2. Cultural ecosystem services and disservices provided by soil biota

3.2.1. Cultural diversity

According to the references, benefits to cultural diversity were shown to be provided by four groups of the reviewed organisms (roots, fungi, macrofauna and megafauna) (Table 1). The largest part of relevant references (75) dealt with local or national traditions of use (medicinal, edible and other) and traditional attitude towards target groups of soil biota, a benefit that supplies a base for other benefits related to cultural diversity. In many European languages, linguistic diversity is reflected by vernacular names, idioms and language forms for plant roots, fungi, and, to lesser extent, for soil fauna (25 references). Notably,

linguistic diversity related to fungi was mainly reported in the references from eastern and southern Europe (Estonian, Hungarian, Lithuanian, Romanian, Spanish and Slavic languages), while only few references (Haga, 2001; Molitoris, 2002; Rätch, 1998; Yamin-Pasternak, 2011) mentioned several folk names for fungi in German, English and Friesian languages. This imbalance of information on linguistics related to fungi between different parts of Europe was well explained by Casebeer's (2002) admission that "...mushrooms play no significant role in many Western lives, which is why most of us have no folk biological knowledge of their different varieties...". Folklore based on belowground biota is mentioned in 19 references. As in most of CES, references mentioning fungi also prevailed for Cultural diversity (Table 1). This can be explained by two reasons. Firstly, the history of using fungi is long (Dugan, 2008) and secondly, the attitudes towards fungi differ greatly among various countries, regions and nations of Europe (Hawksworth, 1996; Wasson and Wasson, 1957). This attitude difference influences many cultural phenomena. Only in the references on folklore, the number of papers referring to invertebrate fauna and roots was equal to the number referring to fungi (6 references each). Geographically, the reviewed references included most of Europe, except for the plant roots in folklore where they were limited to France, Lithuania and the Mediterranean area in general. Similarly, references that describe the tradition of use of vertebrate megafauna, were all (except one) related to European rabbit (*Oryctolagus cuniculus*) and were largely limited to the Mediterranean region.

3.2.2. Spiritual and religious values

Impact of belowground biota on spiritual and religious aspects of human life originates from the World Tree or Cosmic tree, an ancient Indo-European archetype present in many myths and religions of Indo-Europeans. Plant (especially tree) roots, burrowing mammals and earthworms are attributed to the chthonic world, or roots of World Tree (Gamkrelidze and Ivanov, 1995; Vėlius, 1987) which is reflected in various manifestations of spirituality. We found 30

relevant references where plant roots, fungi, invertebrate macrofauna (earthworms and ants) and megafauna made the base of a considerable number of beliefs, taboos, superstitions, rituals, symbols and mythology of various countries and nations which largely, at least in some forms, exist to the present time as a part of spiritual life in Europe. Sailors' beliefs connected to rabbits (Houseman, 1990) are an example of such still surviving spiritual tradition. Ivancheva and Stantcheva (2000) mentioned rituals employed by local healers to strengthen the impact of medicinal plants. Referowska-Chodak (2015) and Džekčioriūtė-Medeišienė (2016) showed superstitions connected to mushrooms that still exist in Poland and Lithuania: pregnant women shouldn't collect mushrooms and that it is dangerous for humans to see how a mushroom grows.

Jürgenson (2000, 2005) and Yamin-Pasternak (2011) showed that the attitude towards fungi may be connected to the professed religion. Intrinsic values of every species are mentioned by Decaëns et al. (2006) (soil fauna in their case), as giving a base to ethical consideration of nature conservation and moral obligation of humans to protect nature.

3.2.3. Knowledge systems

In total, 69 references were found related to the CES knowledge system, and majority of them showed that biodiversity in soil has a positive effect on the establishment of new knowledge. Data obtained from all groups of soil organisms contributed to the formal knowledge in wide fields, such as general ecology, soil science, ecotoxicology, evolutionary science, paleoecology, archaeology, ethnology and forensic science. In traditional knowledge, only roots, fungi and invertebrate macrofauna were reflected in the relevant references as a source of folk medicinal (medicinal and poisonous plants and fungi), food and non-food everyday uses, as well as folk phenology (23 references). Soil organisms were also a source of controversial formal knowledge, such as use of fungi as

bioindicators. Egli (2011), for example questioned use of fruit bodies of mycorrhizal fungi as indicators of tree health by demonstrating that decrease of ectomycorrhizal mushroom production not necessarily coincide with visibly deteriorating tree health. Meanwhile, Halme et al. (2017) analysed limitations of a widely used conservation concept of fungi as biodiversity surrogates. Steup (1915) and Referowska-Chodak (2015) showed persistent erroneous traditional knowledge concerning poisonous fungi which may have adverse effects on human health. Two papers demonstrated the connection between traditional and formal knowledge: Vogl et al. (2013) described the use of traditional Austrian medicinal plants (including roots) in formal pharmacology, while Money (2016) analysed diverse mushroom species, used in traditional medicine, and questioned their medicinal values.

3.2.4. Educational values

We found 11 references showing that all groups of soil organisms are used or proposed to be used in formal, non-formal or informal educational activities for various ages and professional levels. Earthworms and fungi can be considered as good tools to stimulate general interest in natural and environmental sciences (Blouin et al., 2013; Halme et al., 2017). Anderson (2009) demonstrated the intrinsic educational values of soil fauna as a tool to stimulate children‘s interest in natural studies. Picot (2013) gave examples of education programs for children and adults, which employ plant roots. There are many websites which employ belowground organisms as educational objects: roots (McNear Jr., 2013), badgers (Badgerland, http://www.badgerland.co.uk/education/education.html) and earthworms (L’Observatoire Participatif des Vers de Terre, https://ecobiosoil.univ-rennes1.fr/OPVT_accueil.php), etc. Decaëns et al. (2006) also cited an educational website which introduced children to soil biodiversity. Mushroom exhibitions can be used as tools of public education (Jürgenson 2005). Importance of public education was discussed by Eren et al. (2010) who stated that teaching about mushrooms is essential both for general public and medical

personnel in order to decrease the mortality from mushroom poisoning. Ramesh (2016) discussed uses of fungi to attract students to mycological studies. Belowground biota were also employed for general educational purposes: Stonkuvienė (2000) mentioned ants used as an example of moral education of children and Brink (1990) showed the use of fungi from *Amanita* genus in teaching children arithmetics.

3.2.5. Inspiration

The majority of the reviewed soil organisms – roots, fungi, macro- and megafauna are popular objects depicted in art, literature, cinematography, post stamps, crafts etc., as was shown in 34 references. In eastern and central Europe, fungi and mushroom gathering was a common topic in adult and children's literature, especially in classical prose and poetry, such as short stories by Alexander Pushkin (Russia) or poems by Adam Mickiewicz "Sir Thaddeus" (Poland) and Antanas Baranauskas "The Forest of Anykščiai" (Lithuania). Earthworms, ants and burrowing mammals are commonly depicted in children's literature. Representatives of burrowing fauna are characters of the worldwide-famous Kenneth Grahame's "The wind in the willows" and Hans Christian Andersen's "Thumbelina". Furthermore, fungi, mushroom gathering, invertebrate soil macrofauna, rabbits and their hunting, fishing with earthworms as a bait are depicted in many popular movies, such as "Lord of the Rings", "Lady Hawk", "Alice in Wonderland" and "Midsomer murders".

3.2.6. Aesthetic values

Only eight references, all related to invertebrate macrofauna and fungi, discussed the organisms from an aesthetical point of view. Some fiction literature directly described aesthetic values of fungi, such as the above-mentioned poems by A. Mickiewicz and A. Baranauskas. Similarly, aesthetic values of burrowing vertebrates are indirectly reflected by illustrations for children's books (e.g., Woodland folk series by Tony Wolf). In the reviewed references, aesthetic values of fungi vary. They may be positive, perceived as an addition to the aesthetic perception of forest (Meiresonne and Turkelboom, 2012) or even as the "flowers of forest" (Lubienė, 2015). In a negative perception, fungi are seen as monsters or as a metaphor of death and decay (Kiernan, 2010). Meanwhile, earthworms are perceived as aesthetically controversial or negative: either as symbols for Victorian aesthetics of death and decay (Sax, 2001) or outright as the objects of disgust (Cooper et al., 2012).

3.2.7. Sense of place

Fungi were the only group contributing to patrimonial values: mushrooms and mushroom picking being an important part of lifestyle mainly in Eastern Europe (9 references). Cultural identity (sense of place) in literature pertaining CES (also CES from soil) is usually associated with landscapes (e.g., Dominati 2013), but in case of fungi, benefits provided by mushroom picking shape cultural heritage, identity, social life and, subsequently, the sense of place similar to the cultural and patrimonial contribution of fish and fishing in coastal communities shown by Urquhart and Acott (2013).

3.2.8. Heritage values

Soil biota have an impact on cultural heritage, both intangible and tangible, as was shown by 35 references. The influence of soil organisms on tangible heritage can be direct or indirect. Indirect impact is provided by the depiction of fungi and megafauna in heritage artefacts (5 references). Direct effect on tangible heritage is the impact of soil biota on archaeological objects. Soils are termed to be an archive of archaeological heritage (Robinson et al., 2009), and a positive impact of soil fauna has been registered: for example earthworms bury artefacts and, thus, conserve them (Blouin et al., 2013). However, there are more reports on damage of archaeological layers caused by bacterial and earthworm decomposition or earthworm-induced bioturbation of organic archaeological layers, both directly by their own activity and indirectly, as a prey to wild boars and moles which turn over soil and stones and thus assist root penetration into the organic layers (Louwagie et al., 2005). Badgers have been known to reveal hidden artefacts (Killgrove, 2016) but they also damage archaeological sites (Mallye, 2007). On the other hand, the impact of soil biota (earthworms, burrowing mammals, fungi and plant roots) on intangible heritage was positive in all cases: they underpin national folklore, tradition and crafts. Fungi are important in traditional cuisine of "mycophilous" nations (7 references), while rabbits are widely used in traditional cuisine of southern Europe (Amaral et al., 2014; González Redondo et al., 2007).

3.2.9. CES Social relations

We found 34 references demonstrating that belowground biodiversity influenced social relations at various society levels: from family and local community to the state level. Gathering of fungi and plant roots include common activities with family members and generates knowledge transfer (13 references). At a community level, the impact of plant root and mushroom gathering may be positive (socio-economic) (Sisak et al., 2016; Stryamets et al., 2015) but also negative, in case of conflicts between the gatherers (Boa, 2004; Karvelytė and Motiekaitytė, 2013; de Román et al., 2006). Fungi, vertebrate burrowers and

invertebrate macrofauna function as an incentive for activities of various interest groups, for example mycological societies, insect gatherers, nature photographers, public scientists and conservation movements (7 references). Laws which specifically regulate gathering of plants (including roots) (Picot, 2013) and mushrooms (Peintner et al., 2013; de Román et al., 2006; Wright, 2010) and rabbit hunting (Ricci, 2008; Rödel and Dekker, 2012) function in many countries. Four references mentioned existing or potential conflicts with law in the case of mushroom gathering.

3.2.10. Recreation and ecotourism

A total of 23 references showed impact of belowground biodiversity on recreation and ecotourism, and the impact may both be indirect or direct. Indirectly, mesofauna and fungi may aid in the maintenance of the quality of recreational areas when used as monitoring tools (Barico et al., 2012, Blasi et al., 2013). Niemi et al. (2014) showed a case where forest soil and its fungi aided in faster conversion of landfill sites into urban green spaces. Direct benefits are provided by plant (roots) and especially by mushroom gathering, which is a popular recreational activity in many countries (9 references). Burrowers (predominantly rabbits) are objects in recreational hunting (6 references), earthworms are used as a bait for fishing (Blouin et al., 2013; Tripodi et al., 2012; Ulicsni et al., 2016) and are important as food for game (Decaëns et al., 2006), while burrowing mammals are common objects for nature observation and photography (Macmillan and Phillip, 2008).

3.2.11. Health and wellbeing

We found 55 references showing that soil biota influence human health and wellbeing in different ways. Plant roots and fungi had highest number of references (13 and 7 accordingly) showing their positive effect on human health, mainly as medicinal sources or healthy food. Use of fauna – earthworms and badgers in folk medicine was also mentioned (4 references). Bere and Westersjo (2013) and Stryamets et al. (2015) demonstrated that activity of mushroom and wild plant (including roots) gathering helps to fight obesity and improves the general health. Temraleeva et al. (2011) showed that soil algae diversity can be used as indicator of soil pollution that may be hazardous for health. However, 25 references indicated negative impacts of fungi and plant roots on human health: toxicity to humans and their pets was described in 16 references and high contents of trace elements in edible mushrooms as a hazard to health was indicated in 9 references. Marfenina et al. (2011) mentioned that presence of opportunistic fungi in urban forests may have adverse effects on human health as a source of potential pathogens and allergens. Tripodi et al. (2002) described a rare case of allergy caused by earthworms used as bait. Effects of vertebrate fauna on human health were shown as largely negative: five references dealt with burrowers as vectors and sources of known and emerging zoonotic diseases.

3.2.12. Disservices

Cultural benefits provided by soil biota clearly prevailed in the total of the reviewed references, but there were also negative effects mentioned in six CES for all organism groups, except mesofauna (Table 1). Highest number of references indicating negative effects were noted for Health and wellbeing CES, largely through plant roots and fungi (adverse effect of use) and megafauna (as vectors of zoonotic diseases), and for Cultural heritage CES (damage to archaeological sites caused by various soil organisms). The largest controversy was found on the effect of vertebrate fauna, especially its diversity, on human health. Woolhouse et al. (2012) stated that "…biodiversity probably has little net effect on most human infectious diseases but, when it does have an effect,

observation and basic logic suggest that biodiversity will be more likely to increase rather than decrease infectious disease risk…". This statement was, however, contradicted by Levi et al. (2015), Morand et al. (2014) and Salkeld et al. (2013) who opposed that even if biodiversity were a source of pathogens, general biodiversity loss in ecosystems but not the richness of ecosystem biota may be associated to an increase in zoonotic and vector-borne disease outbreaks. A review by Sandifer et al. (2015) demonstrated that this controversy has no unambiguous answer and requires further research on a case-by-case basis.

Fungi were the only organism group which provided benefits to all CES, but also the one that provided disservices in most of the CES. Their disservices for Spiritual and religious, Knowledge systems, Social relations and Health and wellbeing CES are discussed in corresponding subchapters.

The same organism groups or even individual species may have negative impacts within one CES and at the same time act as an ecosystem service provider (ESP) (fide Kremen, 2005) for another CES: e.g., toxic plant roots and poisonous fungi impact negatively on Health and wellbeing CES but positively on Inspiration CES when used by the authors of fiction literature and movies, as in the examples provided by Iwicka (2015) and Trestrail III (2000).

3.3. Organism groups, species diversity and key species as providers of CES

The CES were found to be supported at several levels of ESP: single species, two or more species, a single functional/taxonomical group, two or more functional/taxonomical groups. Mostly, the providers for CES were entire taxonomic/functional groups, such as collembolas (e.g., Urbanovičová et al., 2014), ants (e.g., Del Toro et al., 2012), earthworms (e.g., Blouin et al., 2013), plant roots (e.g., Picot, 2013) or fungi (e.g., Gyozo, 2010). In some cases, CES were facilitated by one or several species: roots of mandrake (primarily *Mandragora officinarum* s. lat.) (e.g., Carter, 2003), European badger (*Meles meles*) (e.g., Griffiths and Thomas, 1997), fly agaric (*Amanita muscaria*) (e.g., Brink, 1990), several species of a fungal genus *Psilocybe* with psychotrophic properties (e. g.,

Stamets, 1996). Tradition of collecting wild food and the CES related to this tradition was based on two functional groups – fungi and plant roots (e.g., Łuczaj et al., 2013, 2015). None of the CES were found to be supported by only one-level service providers, with the exception of hunting-based recreation and tourism CES which was mainly facilitated by the population of one species, European rabbit (e.g., Delibes-Mateos et al., 2009). In the cases of taxonomic/functional groups as ESP, the importance of species diversity varied: e.g., in most papers earthworms are treated as one entity, due to the fact that earthworm species are usually not recognised in folk taxonomy. According to Sax (2001) in human understanding, "…With facial features that are difficult to see, earthworms are hard to distinguish from one another…", therefore, their species diversity does not play any role in folk taxonomy-based CES. In the case of fungi and plant roots, diversity of the species involved as ESP varied depending on regions and countries, and the involvement was determined not only by presence/absence of the species but rather by local tradition (Schulp et al. 2014). As an example, mandrake roots provide direct cultural benefits in Western Europe and the Mediterranean where the plant grows naturally or has been introduced (Carter, 2003; Picot, 2013). Meanwhile, the widespread species of the fungal genus *Suillus* are traditionally used in Eastern Europe but not in Spain, even though they are common in this country (Blanco et al., 2012).

In CES such as Inspiration, Aesthetic or Heritage values, morphological diversity often acts as a surrogate for species diversity: i.e., root motifs based on form but not the species are depicted in paintings, artefacts, children's books and cinema (e.g., book by Sybille von Olfers "Etwas von den Wurzelkindern", artwork by Walter Williams, Vincent van Gogh, Caspar David Friedrich, Akseli Gallen-Kallela, etc.).

Regardless of how many species function as ESPs in a single taxonomic group, the reviewed contributions suggest that the general richness of biota is important when it comes to cultural benefits and their diversity. People have to encounter different organisms considerably frequently in order to gain cultural benefits through their use or observation. However, human activity in forests has already led to a significant decline in biodiversity and its homogenisation (Newbold et al., 2015; Van der Plas et al., 2016) thereby restricting the encounter of humans with many species, including the biota living in soil. Climate

change also affects biodiversity and has a negative impact on the CES it provides, as the example of fungi and mycotourism in Spain has shown (Büntgen et al., 2017).

3.4. Impact of soil biota on CES – direct and indirect

Previous reviews referring to CES provided by soils considered them as derived from the soil as a whole, that is, a mixture of abiotic and biotic parts. Therefore, cultural benefits rendered by soil were either generalised (soils as an archive for archaeology) or only indirectly related to the soils per se (Robinson et al. 2009, Dominati et al. 2010, Adhikari & Hartemink 2016). Our review shows that the impact of biota-based CES from soils may be both direct – by providing the benefits (or dis-benefits) and indirect – through the use of the products (i. e., folklore, books, artefacts) or services (monitoring of environment with the help of soil organisms, use of earthworms as a bait in fishing-based recreation, etc.) obtained from these benefits (Supplementary material 3). Indirect impact may be shown as transition of the intangible CES (Cultural Diversity, Inspiration, Heritage values, Knowledge systems) into tangible CES by bringing revenue from e.g., tourism (folklore festivals, mushroom picking festivals, ecotourism with local tradition included, restaurants serving local cuisine that uses wild food, thematic souvenirs, etc.) or cultural consumption, i.e., books, cinema and art. Indirect impact may also be created by a cascade of benefits: e.g., the iconic book by K. Grahame “Wind in the willows”, largely inspired by burrowing mammals, has led to the foundation of the book fans’ society and to the creation of the tourist attraction Henley River and Rowing Museum (Kenneth Grahame Society, https://www.facebook.com/Kenneth-Grahame-Society-320770334685402/). In an on-going discussion what is to be evaluated as CES, Daniel et al. (2012) stated that some historical cultural values (historical buildings, paintings, etc.) have little dependence on ecosystems, and Blicharska et al. (2017) proposed to disaggregate ecosystems into biotic, abiotic and

anthropogenic objects. Our review, however, indicates that a number of artefacts were created under inspiration provided by soil organisms, and impact of these art objects on humans has a connection to the present biodiversity – through educational and aesthetic values related to recognition of the depicted natural objects.

3.5. Interactions of CES provided by soil biodiversity

Given that ecosystems are multifunctional, they provide multiple ES which often appear together in time and space, thus creating ES supply bundles (Berry et al., 2016). In the case of CES provided by soil biota, almost all of them interact with at least one other CES; in 27 cases with Provisional ES, in two cases with regulating ES and three cases with supporting ES (Supplementary material 3). However, not all cases can be regarded as bundling, because of the temporal value fluctuations in CES and a time lag between direct and indirect benefits. For example, mushroom gathering activity in eastern and southern Europe has developed from primarily provisional ES (losing its value in the course of time) to largely recreational CES (gaining value in the course of time). Hence, the provisioning service of food evolved to CES such as cultural heritage (cuisine, traditions, folklore), which, in turn, further cascaded into recreation and ecotourism CES, knowledge systems (traditional knowledge), sense of place and social relations. However, mushroom gathering had an element of recreation even when being mostly provisional ES (as shown for instance in the above mentioned poem by A. Mickiewicz) and thus these two ES make a bundle together with Cultural heritage and Knowledge (traditional) systems CES. Time-lags between value changes and cascading services make the bundling definition complicated.

3.6. Beneficiaries of CES

Individual beneficiaries of ES (including CES) understand and value the benefits they receive from ecosystems in different and subjective ways (Braat, 2014; Fish et al., 2016). Therefore, for valuation, all possible beneficiaries have to be identified for any specific service provided. For example, a study in the Sierra Nevada showed that farmers and tourists attributed highest values to different groups of ES provided by the same landscape (Iniesta-Arandia et al., 2014). For example, collecting mushrooms or plant roots and the CES related to these activities are influenced by income, age, gender and cultural factors (Schulp et al., 2014, and the literature cited therein) which indicates that beneficiaries belonging to the same society may put different values on the same CES. Plieninger et al. (2013) have shown that one person's cultural benefit provided by an ecosystem may be a dis-benefit for another person. The references we have reviewed showed similar results, for example, Sisak et al. (2016) showed that increase in mushroom picking-based recreation may lead to legislative restrictions for forest owners. Moreover, it is obvious that a benefit may turn into a dis-benefit to the same person in changed societal conditions, as was demonstrated by an example of mushroom picking by Lithuanian immigrants (recreation and patrimonial values benefit) that resulted in a clash with British law (Džekčioriūtė-Medeišienė, 2016).

In identifying beneficiaries, distances between the ecosystem with its ecosystem service providers (ESP) and the beneficiaries of ES are important. In previous reviews pertaining soil, CES were mostly viewed from a landscape scale and, thus, the beneficiaries were seen largely as users of aesthetic values, recreation and ecotourism CES. This fact has obviously led to the statement by Burkhard et al. (2014) that for CES there is a strong spatial discrepancy between ESP and ecosystem service benefiting areas. However, when CES is provided by organisms (soil biota in our case), the benefits, especially the direct ones, are

primarily used by local inhabitants, as shown by the examples of the wild food use tradition (Schulp et al., 2014), that is, immediate benefiting areas are mainly situated close to the occurrence of ESP's.

Accessibility and quality of forests and their biodiversity in the soil are part of the CES supply to the beneficiaries. Forest area in Europe accounts for about 50% of theland area, which varies from 1.9 % (Iceland) to 75.7 % (Finland) (FOREST EUROPE/UNECE/FAO enquiry on pan-European quantitative indicators, https://www.foresteurope.org/docs/SoeF2015/OUTPUTTABLES.pdf). However, many of them are managed forests with low biodiversity, while only 6.3% of European forests currently serve to protect biodiversity (Halkka and Lappalainen, 2001). Gray et al. (2016) has shown that species richness and abundance within protected areas were higher than outside, meaning that visiting a managed local forest means less frequent encounters with biota and less diversified forest. Specific surveys on forest soil biota do not exist, but surveys dealing with the demand of cultural benefits provided by forests generally show that a large proportion of the population frequently visits forests for recreation , harvesting forest products andand observing nature. In Slovenia, for example, almost 100% of the population visited forests, the frequency of visits varied from daily (16% of the interviewed persons) to 1–2 times a month (27.7%). Recreation, relaxation and well-being, nature observation and forest product picking were identified as main reasons of the visits by Slovenians (Bogataj, 2009; Žižek and Pirnat, 2011). In Iceland, where forests occupy a negligible part of the country's area, 78.3% of the interviewed population visited forests on average 14.7 times per month (Curl and Jóhannesdóttir, 2005). The reasons for the visits were categorized as purely cultural: recreation (52.2%), enjoyment of nature (13.4%), well-being and relaxation (11 %), etc. A small percentage (1.8%) of the interviewed persons in Iceland were involved in collecting forest products (mushrooms and berries). When asked about the importance of the forest, the Icelandic interviewees put the highest values of the cultural benefits as well: recreation (91.8% of the interviewed persons), knowledge production (research) (88.3%) and education (84.7%). However, targeted interviews and surveys should be carried out in order to identify beneficiaries' attitudes and values to forest soil biota (CES demand).

3.7. CES values, their temporal and geographical scale

According to the classical Maslow's pyramid of needs, whose basis, notwithstanding wide critique of the concept itself, largely remains unchanged (Kenrick et al., 2010), spiritual and cultural benefits increase in value only after physiological, safety and security needs are fulfilled. Following Guo et al. (2010), human dependence on CES increases along with economic development of the society, while dependence on substitutable provisioning ES decreases. The increased value of CES relative to provisional ES is also due to the fact that the increase in provisional services is achieved at the expense of decreases in regulating and cultural services (Carpenter et al., 2009), cultural benefits from ecosystems becoming rarer and more valuable commodity. Hence, value of CES is generally considered to be highest in richer societies (Satterfield et al., 2013), as can be seen in the increase of interest in wild food in many regions of Europe which is considered mainly as a cultural phenomenon (Schulp et al., 2014). Poorer societies or society members use more provisional ES from forests in the form of wild food and source of pharmaceuticals or as a secondary source of income (e.g., Boa, 2004; Karvelytė and Motiekaitytė, 2013; Łuczaj et al., 2012; Stryamets et al., 2015), making them more closely associated to nature and the CES from biota of forests and their soils, such as traditional knowledge, cultural heritage, etc. This is in contrast to modern industrial societies where the mental distance between humans and nature is increasing (Braat, 2014).

Even with economic development of rural societies or in the cases when the members of these societies migrate to richer countries, tradition of picking wild plants and mushrooms is maintained as a form of sense of place or "birth right" (e.g., case of Lithuanian immigrant explaining her right and need to pick mushrooms in UK, shown by Džekčioriūtė-Medeišienė (2016)). Tipping points between rural and industrial societies may be especially difficult periods for valuation of CES connected to wild foods and pharmaceuticals because in some cases their value may decrease, while increasing for others (Stryamets et al.,

2015). Besides, access to the benefits (including the cultural ones) provided by ecosystems in communal ownership or use (and forests are mostly such) is more important to the poorer societies or society members than to the rich (Carpenter et al., 2009). Notwithstanding economic power of the society, some provisional ES have already become entirely cultural with time: e.g., historical sites of tar production from pine roots and stumps became archaeological heritage (Hjulström et al., 2006), former commercial collection of ant eggs in Slovenia became a source of inspiration and is reproduced in literature (short story by A. Ingolič "Collectors of ant eggs" (Slovenia)). When it comes to the values of indirect cultural benefits provided by soil biota, a time-lag exists between a product of Inspiration CES and Recreation and ecotourism CES which has cascaded from it (see the examples in the subchapter 3.4 (K. Grahame's book "Wind in the willows") and 3.5 (mushroom picking). Therefore, the time aspect is important when it comes to CES valuation.

Spatially, the values of reviewed CES varied: for most part, the benefits provided by soil biota were similar throughout Europe (Supplementary material 3). However, even in these continent-wide cases, regional differences between the species that were ecosystem service providers (ESP) were obvious, or the strength of CES values differed from region to region. For example, tradition of mushroom picking and use involved different sets of species in individual countries or regions (examples in Gyozo, 2010; Łuczaj et al., 2013; 2015; Stryamets et al., 2015; etc.). Collecting wild plants and especially mushrooms in different countries of Europe varies from less than 3 % of population to "nearly everybody", according to Schulp et al. (2014). Consequently, such CES as Health and wellbeing, Recreation and ecotourism, Knowledge systems (traditional knowledge) that are provided by fungi or plant roots will have higher value in the countries where higher percentage of the society keeps to this tradition. Some ESP's and their benefits were strictly regional: e.g., wild rabbits are providers of various CES only in the areas of their natural occurrence or introduction, that is they will have little or no value in northern and eastern areas of Europe where they are not found. Meanwhile indirect benefits (literature, cinema and art inspired by soil biota) may influence a wider geographical area than the actual distribution range of the species. While evaluating the CES provided by soil biota, in both temporal and spatial perspective, human migration must

also be accounted for. Interaction of migrants and local inhabitants in exchanging knowledge and traditions is known since the time of Roman Imperium (e.g., see Allen and Hatfield, 2004). Likewise, historical interchange of traditions by European migrants and indigenous people in North America (Turner and von Aderkas, 2012) or Northern Asia (Yamin-Pasternak, 2007) is well documented. Studies of recent migrations within Europe have shown that the usage intensity of wild food and pharmaceuticals, traditional knowledge, attitude and species selection flows rather from migrants to the local inhabitants. Di Tizio et al. (2012) and Pieroni and Gray (2008) stated that migrants tend to collect the species they are used to gather in their home countries more than the species common in the country they immigrated to. Blanco et al. (2012) and Yamin-Pasternak (2011) indicated that immigrants also transfer knowledge on edibility and uses of previously ignored mushroom species to the local residents. In any case, immigration tends to increase CES values provided by soil biota, plant roots and mushrooms in particular.

4. Conclusions

The provision of CES is essential for human wellbeing as shown by an incredible wealth of literature. However, CES as any other ES are in danger of decreasing due to the impoverishment of natural ecosystems. In particular, soils are under considerable threat: they are degraded by human activities such as urbanization, pollution, industrial and development activities, unsustainable agriculture and forestry and overexploitation by tourism. To prevent the loss of the soil's natural capital, valuation of ES provided by soils has been undertaken (Jónsson and Davíðsdóttir, 2016) and even an attempt to define the value of soil biodiversity in providing ES (Pascual et al., 2015). None of these included CES due to the missing studies on the cultural value of soils. Not only are such studies non-existent for soils, but studies on CES in general are largely based on landscapes or ecosystems as a whole. Harrison et al. (2014) has shown that of

the two cultural services they have found in the references they reviewed, the first (Aesthetic values) was provided at the community/landscape level and the second one (Recreation) was at the species level, due to species-based recreation (salmon fishing in their case). Although Milcu et al. (2009) have noted the importance of other sciences (economics, social, humanities) in the study of CES and that a significant proportion of the data is published in non-peer-reviewed papers, still most of the reviews are limited to the Web of Science publications, with very few exceptions such as Schulp et al. (2014). Large parts of information pertaining organism groups and their links to various cultural aspects are published in non-English references. Our combined search through multilingual and multi-subject literature (ethnobiology, ethnology, mycology, toxicology, archaeology, palaeontology, literature and art research, linguistics, sociology and medicine) revealed the existence of a considerable amount of information showing cultural values provided by soil biota just in one type of ecosystem, forests. However, we admit that even our extensive search did not cover all existing literature in all European languages. In some European countries, we found a deficiency of literature that allows a link between ecosystems (in our case, forest soils) and human culture (Fig. 1). Therefore, spatially explicit information across Europe is problematic. It is rather fragmented and has the character of a scientific artifact, depending on the search methods we used, the availability of references as Internet resources, but also research activities, research policy, subjects studied in different countries, etc. This lack of existing or widely available data can also become an obstacle to communication with local stakeholders in those countries where relevant research is lacking, as the impacts of soil biodiversity on CES may not be well documented or at least systematic.

To summarize our findings on CES provided by forest soil species or species groups the following should be highlighted:

1) Information pertaining to CES provided by forest soil biota in Europe is considerable, though spatially fragmented.

2) For CES in general, there are many overlaps between individual CES and other ES provided by soil biota.

3) Especially strong spatial and temporal fluctuations were recorded in biota-based CES.

4) We show clearly expressed regionality of CES: a same organism group or species may have a strong impact on CES (positive, negative or both) in some regions while no, minor or opposite effects in others.

5) Contrary to the CES based on landscapes, in the CES provided by soil biota, the distance between the ecosystem and its CES benefiting area is shorter. Landscape-based CES is less used by locals and more by visitors, while CES based on species or groups of organisms is mainly used by locals.

6) When CES are based on species/organism groups, there is no danger that benefits provided by the objects of anthropogenic origin (e.g., buildings in the cases of aesthetic landscapes) or objects of abiotic origin will be included in CES valuation. Species may be depicted in artefacts or appear in objects of tangible and intangible heritage, but in these cases not the artefact itself is included in CES but the species impact on creation of the object and subsequent appreciation by the public.

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Žižek, L., Pirnat, J., 2011. Odnos javnosti do gozdov v mestih na primerih Rožnika in Golovca v Ljubljani [Public Attitude towards Urban Forests – Case Studies of Rožnik and Golovec in Ljubljana]. Gozdarski vestnik 69(2): 91–98, 115–118.

Supplementary material 1

Full list of keywords and keyword combinations used for reference search in Google Scholar (also equivalents in French, German, Dutch, Spanish, Italian, Czech, Slovenian, Slovak, Norwegian, Polish, Russian and Lithuanian languages were employed)

Archaeological artefacts+ plant roots

Archaeological artefacts+earthworms

Archaeological artefacts+fungi

Dyeing + plant roots

Dyeing+ mushrooms

Earthworm + name

Earthworm + symbol

Ethnoentomology

Ethnography (ethnographic) + earthworms (or worms)

Ethnography (ethnographic) + plant roots

Ethnography (ethnographic) +mushrooms

Ethnomycology

Etymology + earthworms (or worms)

Etymology + mushrooms

Etymology + plant roots

Folklore + earthworms (or worms)

Folklore + mushrooms

Folklore + plant roots

Heritage + plant roots

Heritage +earthworms

Heritage +fungi/mushrooms

Mushroom + name

Mushroom + symbol

Mythology + plant roots

Mythology + earthworms (or worms)

Mythology + mushrooms

Novel/poem/children book + earthworms (or worms)

Novel/poem/children book+ mushrooms

Novel/poem/children book+ plant roots

Painting/graphics/textile/art/decorative + earthworms (or worms)

Painting/graphics/textile/art/decorative + mushrooms

Painting/graphics/textile/art/decorative + plant roots

Plant root + name

Plant roots + symbol

Proverbs/fairy tales/legends/songs + earthworms (or worms)

Proverbs/fairy tales/legends/songs + mushrooms

Proverbs/fairy tales/legends/songs+ plant roots

Recreation + mushrooms

Religion + earthworms (or worms)

Religion + mushrooms

Religion + plant roots

Tradition + berry gathering

Tradition + cuisine + plant roots

Tradition + earthworms (or worms)

Tradition + herb gathering

Tradition + mushroom gathering

Tradition + mushrooms

Tradition + plant roots

Tradition + root gathering

Tradition +cuisine + mushrooms

Tradition+ regional + mushrooms

Tradition+ regional + plant roots

Traditional crafts + earthworms (or worms)

Traditional crafts + mushrooms

Traditional crafts + plant roots

Traditional medicine + earthworms (or worms)

Traditional medicine + earthworms + folklore

Traditional medicine + mushrooms

Traditional medicine + mushrooms + folklore

Traditional medicine + plant roots

Traditional medicine + plant roots + folklore

Vacation+ mushrooms

Supplementary material 2. Full list of analysed references with indication which organism goup(s), cultural ecosystem service(s) and benefit(s) are mentioned.

References	Organism groups	CES/benefits

Abraham, C.K., 1963. Myth and Symbol: The Rabbit in Medieval France. Stud. Philol. 60, 589–597.	Megafauna	Spiritual and religious values/French beliefs connected to rabbits
Akers, B.P., Ruiz, J.F., Piper, A., Ruck, C.A.P., 2011. A Prehistoric Mural in Spain Depicting Neurotropic Psilocybe Mushrooms? Econ. Bot. 65: 121–128. https://doi.org/10.1007/s12231-011-9152-5.	Fungi	Inspiration/mushrooms in prehistoric paintings
	Fungi	Cultural heritage value/fungi depicted in heritage objects
Allen, D.E., Hatfield, G., 2004. Medicinal plants in folk tradition. An Ethnobotany of Britain and Ireland. Timber Press, Portland, Cambridge.	Fungi	Cultural diversity/historical traditions of mushroom use
	Roots	Cultural diversity/historical traditions of plant root use
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
Amaral, J.S., Santos, C.G., Melo, V.S., Oliveira, M.B.P.P., Mafra, I., 2014. Authentication of a traditional game meat sausage (Alheira) by species-specific PCR assays to detect hare, rabbit, red deer, pork and cow meats. Food Res. Int. 60: 140–145. http://doi.org/10.1016/j.foodres.2013.11.003.	Megafauna	Cultural diversity/Tradition of rabbit use
	Megafauna	Cultural Heritage values/Rabbit in national cuisine
Anonymous, 1907. Editorial. Leipziger-Bienenzeitung 1907. (cited in https://library.wur.nl/ojs/index.php/bijenhouden/article/view/4220/3723) (Accessed 26 April 2018)	Fungi	Knowledge systems/Traditional knowledge of Bovista mushrooms in apiculture
Anonymous, 1915. Onze Mycologische Excursie in 1914. De Levende Natur 19, 374–376.	Fungi	Social relations/Interest groups (Mycological societies)
Anonymous, 1917. Mrówki jako środek przeciw wszom [Ants as an anti-lice agent]. Dziennik Poznański (03.06.1917): http://www.wycinki.olejow.pl/?p=7404 (Accessed 26 April 2018)	Macrofauna	Knowledge systems/ traditional knowledge how to use ants for lice control
	Fungi	Knowledge systems/Use of fungi in environmental monitoring

Azul, A.M., Nunes, J., Ferreira, I., Coelho, A.S., Verissimo, P., Trovao, J., Campos, A., Castro, P., Freitas, H., 2014. Valuing native ectomycorrhizal fungi as a Mediterranean forestry component for sustainable and innovative solutions. Botany-Botanique 92, 161–171. doi: 10.1139/cjb-2013-0170.	Fungi	Recreation and ecotourism/Mushroom picking as recreation
	Fungi	Health and wellbeing/potential of mushrooms as pharmaceuticals
Bagladi, O., 2011. Magyar gombanevek nyelvészeti elemzése [Linguistic Analysis of Hungarian Fungus Names]. PhD Dissertation, University of Pannonia, Veszprem.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Hungary
Baier, I., 1981. Houby v kuchyních světa [Mushrooms in word cuisines]. Práce, Praha.	Fungi	Cultural diversity/ attitudes towards mushrooms, linguistics connected to mushrooms
	Fungi	Cultural heritage values/mushrooms in traditional cuisines
Baltėnas, A., Drobelienė, O., 2009. Šilų dzūkai [Forest Dwellers of Dzūkija]. R. Paknio leidykla, Vilnius.	Fungi	Knowledge systems/Traditional knowledge concerning mushrooms and mushroom picking
	Fungi	Social relations/various social relations connected to mushroom picking
	Fungi	Sense of place/patrimonial values of mushroom picking
Bardou-Castanier, V., 1995. Le champignon: une approche ethnographique en Lozère [The mushroom: an ethnographic approach in Lozère (France)]. Bulletin du Centre d'études et de recherches littéraires et scientifiques de Mende 15, 36–62.	Fungi	Spiritual and religious values/superstitions connected to mushrooms
	Fungi	Knowledge systems/ Traditional knowledge of mushrooms
	Fungi	Social relations/various social relations connected to mushroom picking

Barrico, L., Azul, A.M., Morais, M.C., Coutinho, A.P., Freitas, H., Castro, P., 2012. Biodiversity in urban ecosystems: Plants and macromycetes as indicators for conservation planning in the city of Coimbra (Portugal). Landscape Urban Plan. 106, 88-102. doi:10.1016/j.landurbplan.2012.02.011.	Fungi	Knowledge systems/Use of fungi in environmental monitoring,
	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Barros, L., Calhelha, R.C., Vaz, J.A., Ferreira, I. C. F.R., Baptista P., Estevinho L.M., 2007. Antimicrobial activity and bioactive compounds of Portuguese wild edible mushrooms methanolic extracts. Eur. Food. Res. Technol. 225, 151–156. https://doi.org/10.1007/s00217-006-0394-x.	Fungi	Health and wellbeing/potential of mushrooms as pharmaceuticals
Bartnicka-Dąbkowska, B., 1964. Polskie ludowe nazwy grzybów [Polish folk names of fungi]. Prace językoznawcze PAN nr 42. Wyd. Zakład Narodowy im. Ossolińskich, Wrocław-Warszawa-Kraków.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Poland
Bedry, R., Baudrimont, I., Deffieux, G., Creppy, E.E., Pomies, J.-P., Ragnaud, J.-M., Dupon, M., Neau, D., Gabinski, C., De Witte, S., Chapalain, J.-C., Beylot, J., Godeau, P., 2001. Wild Mushroom Intoxication as a Cause of Rhabdomyolysis. New Engl. J. Med. 345, 798-802. doi: 10.1056/NEJMoa010581.	Fungi	Health and wellbeing/poisoning with mushrooms
Beranská, V., Uherek, Z., 2016. Obranné strategie obyvatelstva českého a ukrajinského původu na Ukrajině vyvolané následky černobylské nukleární havárie [The Defensive Strategies of Czech and Ukrainian Residents in the Ukraine against the Effects of the Chernobyl Nuclear Accident]. Český Lid 103(1), 103-118. doi: 10.21104/CL.2016.1.06.	Macrofauna	Cultural diversity/Traditions of use of earthworms for medical purposes
Bere, E., Westersjo, J.H., 2013. Nature trips and traditional methods for food procurement in relation to weight status. Scand. J. Public Health 41, 180-184. doi: 10.1177/1403494812471446.	Fungi	Health and wellbeing/mushrooms picking helps to fight obesity
Blanco, D., Fajardo, J., Verde, A., Rodríguez, C.A., 2012. Etnomicología de los hongos del género Suillus, una visión global. Bol. Soc. Micol. 36, 175–186. http://www.abengibre.net/uploads/media/ETNOMICOLOGIA-DE-LOS-HONGOS-SUILLUS.pdf (Accessed 27 April 2018).	Fungi	Cultural diversity/ linguistics connected to mushrooms
	Fungi	Social relations/immigrants transfering mushroom-related knowledge to local people
Blasi, S., Menta, C., Balducci, L., Conti, F.D., Petrini, E., Piovesan, G., 2013. Soil microarthropod communities from Mediterranean forest ecosystems in Central Italy under different disturbances. Environ. Monit. Assess. 185,1637-1655. https://doi: 10.1007/s10661-012-2657-2.	Mesofauna	Knowledge systems/use as environmental monitoring tools
	Mesofauna	Recreation and ecotourism/monitoring

		environmental quality of urban forests
Blouin, M., Hodson, M.E., Delgado, E.A., Baker, G., Brussaard, L., Butt, K.R., Dai, J., Dendooven, L., Peres, G., Tondoh, J.E., Cluzeau, D., Brun, J.-J., 2013. A review of earthworm impact on soil function and ecosystem services. Eur. J. Soil Sci, 64, 161-182. DOI: 10.1111/ejss.12025.	Macrofauna	Educational values/Earthworms as tools for environmental education
	Macrofauna	Recreation and ecotourism/earthworms as bait for fishing
Boa, E., 2004. Wild edible fungi: a global overview of their use and importance to people. Non-wood forest products 17. FAO**,** Rome. http://www.fao.org/3/a-y5489e.pdf (accessed 27 April 2018).	Fungi	Social relations/various social relations connected to mushroom picking
Bremt, P. van dem, 2005. Enkele aspecten omtrent de cultuurgeschiedenis van de inheemse en ingeburgerde houtige gewassen van Vlaanderen: resultaten van een historisch-botanische verkenning (deel 1: Acer-Castanea). Relicta, Archeologie, Monumenten- en Landschapsonderzoek in Vlaanderen 1, 237–254.	Roots	Cultural heritage values/Use of woody roots to make artefacts
Brink, F.J. van den, 1990. Realistisch rekenonderwijs aan jonge kinderen onderzocht. Kanttekeningen bij inhoud en methode. Tijdschrift voor Didactiek der 6-wetenschappen 8, 100–120.	Fungi	Educational values/Use of Amanita fungi for teaching children arithmetics
Burns, R.G., DeForest, J.L., Marxsen, J., Sinsabaugh R.L., Stromberger M.E., Wallenstein, M.D., Weintraub, M.N., Zoppini, A., 2013. Soil enzymes in a changing environment: current knowledge and future directions. Soil. Biol. Biochem. 58, 216–234. https://doi.org/10.1016/j.soilbio.2012.11.009.	Fungi	Knowledge systems/Use of fungi in soil sciences
	Microorganisms	Knowledge systems /use of soil bacteria in soil sciences
Carter, A.J., 2003. Myths and mandrakes. J. R. Soc. Med. 96, 144–147. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC539425/	Roots	Cultural diversity/attitude towards mandrake roots
	Roots	Inspiration/mandrake roots in literature and art
Carvalho, M.L., Pimentel, A.C., Fernandes, B., 2005. Study of heavy metals in wild edible mushrooms under different pollution conditions by X-ray fluorescence spectrometry. Anal. Sci. 21, 747–750. doi: 10.2116/analsci.21.747	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms

Cassidy, N., Duggan, E., Tracey, J.A., 2011. Mushroom poisoning in Ireland: the collaboration between the National Poisons Information Centre and expert mycologists. Clin. Toxicol. 49, 171–176. doi:10.3109/15563650.2011.560854.	Fungi	Knowledge systems/Importance of mycological knowledge in medicinal toxicology
	Fungi	Health and wellbeing/poisoning with mushrooms
Cocchi, L., Vescovi, L., Petrini, L.E., Petrini, O., 2006. Heavy metals in edible mushrooms in Italy. Food Chem. 84. https://doi.org/10.1016/j.foodchem.2005.05.068.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Cool, C., 1911. Paddestoelen Eten. De Levende Natur 15(24), 494–495.	Fungi	Cultural diversity/Way of life connected to mushrooms and mushroom picking
Cooper, E.L., Balamurugan, M., Huang, C.-Y., Tsao, C.R., Heredia, J., Tommaseo-Ponzetta, M., Paoletti, M.G., 2012. Earthworms Dilong: Ancient, Inexpensive, Noncontroversial Models May Help Clarify Approaches to Integrated Medicine Emphasizing Neuroimmune Systems. Evidence-Based Complementary and Alternative Medicine. Volume 2012, Article ID 164152, http://dx.doi.org/10.1155/2012/164152.	Macrofauna	Cultural diversity/Traditions of use of earthworms for medical purposes
	Macrofauna	Knowledge systems/ use of earthworms in medical research
	Macrofauna	Aesthetic values/ earthworms as an object of disgust
	Macrofauna	Health and wellbeing/Use of earthworms for medical purposes
Corcobado, T., Moreno, G., Azul, A.M., Solla, A., 2015. Seasonal variations of ectomycorrhizal communities in declining Quercus ilex forests: interactions with topography, tree health status and Phytophthora cinnamomi infections. Forestry 88, 257–266. doi:10.1093/forestry/cpu056.	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health
	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health
Cugny, C., Mazier, F., Galop, D. 2011. Modern and fossil non-pollen palynomorphs from the Basque mountains (western Pyrenees, France): the use of coprophilous fungi to reconstruct pastoral activity. Veg. Hist. Archaeobot. 19, 391–408. doi 10.1007/s00334-010-0242.	Fungi	Knowledge systems/Use of fungi in archaeology
De Kesel, A., Vanholen, B., 2000. Een woud vol paddestoelen aan de rand van Brussel. De Levende Natur 101, 207–208.	Fungi	Health and wellbeing/mushrooms as healthy food

de Román, M., Boa, E., Woodward, S., 2006. Wild-gathered fungi for health and rural livelihoods. Proceedings of the Nutrition Society 65, 190–197. DOI:10.1079/PNS2006491.	Fungi — Cultural diversity/attitudes towards fungi
	Fungi — Social relations/legislation related to mushroom picking
	Fungi — Recreation and ecotourism/Mushroom picking as recreation
Decaëns, T., Jiménez, J.J., Gioia, C., Measey, G.J., Lavelle, P., 2006. The values of soil animals for conservation biology. Eur. Soil Biol. 42, Suppl. 1, S23–S38. https://doi.org/10.1016/j.ejsobi.2006.07.001.	All groups — Educational values of soil biota
	All groups — Spiritual and religious values/intrinsic value of every species
	Macrofauna — Recreation and ecotourism/earthworms as food for game
	Macrofauna — Knowledge systems/ants in knowledge systems
	Macrofauna — Aesthetic values/Collection of insect pupae for aesthecic decoration purposes
	Macrofauna — Social relations/Groups of collectors of insects (including soil species)
Dekker, K., 1998. Drie Rhenense pottenbakkers. Oud Rhenen 1: 38–48.	Fungi — Inspiration/Use of mushroom symbols
Del Toro, I., Ribbons, R.R., Pelini, S.L., 2012. The little things that run the world revisited: A review of ant-mediated ecosystem services and disservices (Hymenoptera: Formicidae). Myrmecol. News 17, 133−146.	Macrofauna — Inspiration/Ants in literature and art
	Macrofauna — Spiritual and religious values/ants in religious texts and beliefs

Delibes-Mateos, M., Delibes, M., Ferreras, P., Villafuerte, R., 2008. Key role of European rabbits in the conservation of the Western Mediterranean basin hotspot. Conserv. Biol. 22, 1106–1117. https://doi.org/10.1111/j.1523-1739.2008.00993.x.

Delibes-Mateos, M., Farfán, M.Á., Olivero, J., Márquez, A. L., Vargas, J.M., 2009. Long-Term Changes in Game Species Over a Long Period of Transformation in the Iberian Mediterranean Landscape Environ. Manage. 43, 1256–1268. https://doi.org/10.1007/s00267-009-9297-5.

Delibes-Mateos, M., Ferreras, P., Villafuerte, R., 2008. Rabbit populations and game management: the situation after 15 years of rabbit haemorrhagic disease in central-southern Spain. Biodivers. Conserv. 17(3), 559–574. https://doi.org/10.1007/s10531-007-9272-5.

Delibes-Mateos, M., Redpath, S.M., Angulo, E., Ferreras, P., Villafuerte, R., 2007. Rabbits as a keystone species in southern Europe. Biol. Conserv. 137, 149-156. http://dx.doi.org/10.1016/j.biocon.2007.01.024.

Dénes, A., Papp, N., Babai, D., Czúcz, B., Molnár, Z., 2012. Wild plants used for food by Hungarian ethnic groups living in the Carpathian Basin. Acta Soc. Bot. Pol. 81, 381–396. doi: 10.5586/asbp.2012.040.

Dolivo, A., 2003. Confusions lors de cueillettes de plantes médicinales. Bulletin du Cercle Vaudois de Botanique 32, 17-22. https://doc.rero.ch/record/27742/files/32-06.pdf (Accessed 27 April 2018).

Dugan, F.M., 2008a. Fungi in the Ancient World: How Mushrooms, Mildews, Molds and Yeast Shaped the Early Civilizations of Europe, the Mediterranean and the Near East. APS Press, St. Paul.

Megafauna	Knowledge systems/Impact of rabbits on ecological research
Megafauna	Cultural diversity/Tradition of rabbit hunt in Spain
Megafauna	Recreation and ecotourism/Rabbit hunting as recreation
Megafauna	Cultural diversity/Tradition of rabbit hunt in Spain
Megafauna	Recreation and ecotourism/Rabbit hunting as recreation
Megafauna	Knowledge systems/Impact of rabbits on ecological research
Fungi	Cultural diversity/Traditionally collected plant roots in Hungary
Roots	Health and wellbeing/poisoning with plants, including roots
Fungi	Spiritual and religious values/beliefs and mythology connected to fungi
Fungi	Knowledge systems/Use of fungi in arhaeology and palaeonthology
Fungi	Inspiration/Fungi in ancient art
Fungi	Cultural heritage values/Fungi in history, folklore, ancient texts, artefacts, in archaeological sites
Fungi	Cultural diversity/ fungi in folklore
Fungi	Spiritual and religious values/Beliefs connceted to fungi

Fungi	Inspiration/Fungi in literature and art
Fungi	Cultural heritage values/fungi in folklore
Fungi	Cultural diversity/ fungi in folklore
Fungi	Spiritual and religious values/Beliefs connceted to fungi
Fungi	Inspiration/Fungi in literature and art
Fungi	Cultural heritage values/fungi in folklore
Fungi	Cultural diversity/different traditions of mushroom picking, attitudes towards mushrooms, linguistics connected to mushrooms
Fungi	Spiritual and religious values/superstitions connected to mushrooms
Fungi	Cultural heritage values/mushrooms in traditional cuisines
Fungi	Health and wellbeing/poisoning with mushrooms
Fungi	Spiritual and religious values/beliefs and mythology connected to mushrooms and mushroom picking
Fungi	*Cultural diversity/attitudes towards fungi, folklore and*

Dugan, F.M., 2008b. Fungi, folkways and fairy tales: mushrooms & mildews in stories, remedies & rituals, from Oberon to the Internet. N. Am. Fungi 3(7): 23-72.

Duhart, F., 2012. Contribution à l'anthropologie de la consommation de champignons à partir du cas du sud-ouest de la France (XVIe-XXIe siècles). Revue d'ethnoécologie [En ligne], 2 | 2012, mis en ligne le 12 novembre 2013, consulté le 30 septembre 2016. DOI :10.4000/ethnoecologie.917

Dundulienė, P., 1990. Senovės lietuvių mitologija ir religija [Mythology and religion of ancient Lithuanians]. Mokslas, Vilnius.

Džekčioriūtė-Medeišienė, V., 2016. Mitinė grybų samprata lietuvių kultūroje [Mythical notion of mushrooms in Lithuanian culture]. Tautosakos darbai 52, 119–144. http://www.llti.lt/failai/TD52_visas_internetui-119-144.pdf (accessed 27 April 2018).		*linguistics connected to mushrooms in Lithuania*
	Fungi	Spiritual and religious values/beliefs and mythology connected to mushrooms and mushroom picking
	Fungi	Inspiration/Fungi in Lithuanian literature and folklore
	Fungi	Aesthetic values/Aesthetic values of fungi in Lithuanian folk attitude
	Fungi	Social relations/immigrants comming to clash with law due to mushroom foraging
	Fungi	Sense of place/immigrants bringing mushroom picking tradition as sense of home
	Fungi	Cultural heritage values/fungi in folklore
Egli, S., 2011. Mycorrhizal mushroom diversity and productivity-an indicator of forest health? Ann. For. Sci. 68, 81–88. doi: 10.1007/s13595-010-0009-3.	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor forest health is questioned
Eren, S.H., Demirel, Y., Ugurlu, S., Korkmaz, I., Aktas, C., Guven, F.M., 2010. Mushroom poisoning: retrospective analysis of 294 cases. Clinics 65, 491–496. doi:10.1590/S1807-59322010000500006.	Fungi	Educational values/Public education concerning poisonous fungi
	Fungi	Health and wellbeing/poisoning with mushrooms
Eriksson, L., Nordlund, A.M., Olsson, O., Westin, K., 2012. Recreation in Different Forest Settings: A Scene Preference Study. Forests 3, 923–943. doi:10.3390/f3040923.	Fungi	Recreation and ecotourism/Mushroom picking as recreation

Faure, N., Jesu, J., Garnier, S., 2014. Connaissances médicales utiles autour de la consommation du champignon Boletus edulis en 2014 : une revue de la littérature. Cah. Nutr. Diét. 49, 225–230. http://dx.doi.org/10.1016/j.cnd.2014.06.001.	Fungi	Health and wellbeing/poisoning with mushrooms
Ferreira C., Paupério J., Alves, P.C., 2010. The usefulness of field data and hunting statistics in the assessment of wild rabbit (Oryctolagus cuniculus) conservation status in Portugal. Wildlife. Res. 37(3), 223–229. https://doi.org/10.1071/WR09137.	Megafauna	Cultural diversity/Tradition of rabbit hunt in Portugal
	Megafauna	Recreation and ecotourism/Rabbit hunting as recreation
Ferreira, I.C.F.R., Barros, L., Abreu, R.M.V., 2009. Antioxidant in wild mushrooms. Curr. Med. Chem. 16, 1543–1560. doi: 10.2174/092986709787909587.	Fungi	Health and wellbeing/mushrooms as a source for antioxidants
Ferrier, J., Saciragic, L., Trakić, S., Chen, E.C.H., Gendron, R.L., Cuerrier, A., Balick, M.J., Redžić, S., Alikadić, E., Arnason, J.T., 2015. An ethnobotany of the Lukomir Highlanders of Bosnia & Herzegovina. J. Ethnobiol. Ethnomed. 11, 81. doi: 10.1186/s13002-015-0068-5.	Roots	Cultural diversity/Traditionally collected plant roots in Bosnia & Herzegovina
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
	Roots	Health and wellbeing/Use of medicinal plants (including roots)
Finlay, R.G., 2008.Ecological aspects of mycorrhizal symbiosis: with special emphasis on the functional diversity of interactions involving the extraradical mycelium. J. Exp. Bot. 59, 1115–1126. doi: https://doi.org/10.1093/jxb/ern059.	Fungi	Knowledge systems/Importance of mycorrhiza in ecological research
Fornasaro, F., 2003. Plantes et recettes médicinales d'apres l'herbier illustré de Joseph Jakob von Plenck. Mengés, Paris.	Roots	Cultural diversity/different traditions of collecting and use of plant roots, linguistics connected to roots
	Roots	Health and wellbeing/plant roots in medicine
Frey-Klett, P., Garbaye, J., Tarkka, M., 2007. The mycorrhiza helper bacteria revisited. New Phytol. 176, 22–36. http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2007.02191.x/full.	Microorganisms	Knowledge systems /use of soil bacteria in soil sciences

Fresquet, J.L., Aguirre, C., Baguena, M.J., Lopez, M.L., Tronchoni J.A., 1996. Plantes médicinales d'usage populaire dans le région de la Ribera Alta (Valencia, Espagne), in: Schröder, E., Balansard, G., Cabalion, P., Fleurentin, J., Mazars, G. (Eds.), Médicaments et aliments : approche ethnopharmacologique [Medicines and foods : ethnopharmacological approach]. Paris (FRA) ; Metz : ORSTOM ; SFE, pp. 207-214. (Colloques et Séminaires). Colloque Européen d'Ethnopharmacologie = European Symposium on Ethnopharmacology; Conférence Internationale d'Ethnomédecine = International Conference on Ethnomedicine, 2.; 11., Heidelberg (DEU), 1993/03/24-27. ISBN 2-7099-1320-8 (http://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_6/colloques2/010005511.pdf) (Accessed 26 April 2018)	Roots	Cultural diversity/different traditions of collecting and use of plant roots
	Roots	Health and wellbeing/plant roots in medicine
Gálvez-Bravo, L., Belliure, J., Rebollo, S., 2009. European rabbits as ecosystem engineers: warrens increase lizard density and diversity. Biodivers. Conserv. 18, 869–885. doi: 10.1007/s10531-008-9438-9.	Megafauna	Knowledge systems/Impact of rabbits on ecological research
Gamkrelidze, T.V., Ivanov, V.V., 1995. Indo-European and the Indo-Europeans: A Reconstruction and Historical Analysis of a Proto-Language and Proto-Culture. Parts I and II. Trends in Linguistics: Studies and Monographs 80. Mouton de Gruyter, Berlin and New York.	Macrofauna	Cultural diversity/folklore, linguistic diversity connected to earthworms
	Macrofauna	Cultural heritage values/earthworms in mythology
	Megafauna	Cultural diversity/folklore, linguistic diversity connected to burrowers
	Megafauna	Cultural heritage values/folklore connected to burrowers
Garibay-Orijel, R., Ramírez-Terrazo, A., Ordaz-Velázqez, M., 2012. Women Care about Local Knowledge, Experiences from Ethnomycology. J. Ethnobiol. Ethnomed. 8, 1–12. doi**:** 10.1186/1746-4269-8-25.	Fungi	Knowledge systems/Traditional knowledge concerning mushrooms and mushroom picking
	Fungi	Social relations/various social relations connected to mushroom picking
George, P.B.L., Lindo, Z., 2015. Application of body size spectra to nematode trait-index analyses. Soil Biol. Biochem. 84, 15–20. http://www.sciencedirect.com/science/article/pii/S0038071715000528.	Mesofauna	Knowledge systems/use as environmental monitoring tools

González Redondo, P., Payá López, R., Delgado Núñez, A., 2007. Comparación de los hábitos de consumo de carne de conejo entre consumidores jóvenes y compradores tradicionales de Sevilla. Proceedings IV Jornadas ibéricas de razas autóctonas y sus productos tradicionales: innovación, seguridad y cultura alimentaria. Nov. 30 - Dec. 1, Seville, Spain, 2007,p 275-281. DOI: http://hdl.handle.net/11441/53349.	Megafauna	Cultural diversity/Tradition of rabbit (including wild) consumption in Spain
	Megafauna	Cultural heritage values/Rabbits (including wild) in traditional Spanish cuisine
Gottlieb, O.R., de Borin, M.R.M.B., 1999. Bioconnectivity: a blueprint for biodiversity? Pure Appl. Chem. 71, 1635–1642. http://dx.doi.org/10.1351/pac199971091635.	Fungi	Knowledge systems/Importance of mycorrhiza in phytochemical research
Goudi, M., 2011. Etude motivationnelle de la zoonymie dialectale dans les variétés linguistique de l'ile de Lesbos (Grèce). Linguistique. Université de Grenoble, 2011. Français. https://tel.archives-ouvertes.fr/tel-00807006/document (Accessed 26 April 2018).	Macrofauna	Cultural diversity/Linguistic diversity connected to soil arthropods
Grabowski, D., Muszynski, W., Petrykowska, M., Rubel, B., Smagala, G., Lada, W., 1994. Activity of cesium-134 and cesium-137 in game and mushrooms in Poland. Sci. Tot. Environ. 157, 227–229. https://doi.org/10.1016/0048-9697(94)90583-5	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Greimas A.J., 1977. Aušrinė ir Laima I. Gyvenimo ir mirties, likimo ir laimės samprata lietuvių mitologijoje [Aušrinė and Laima I. Conception life and death, fate and fortune in Lithuanian mythology]. Metmenys 33, 95–132.	Macrofauna	Cultural diversity/ants in Lithuanian folklore
	Macrofauna	Inspiration/ants in Lithuanian folklore
Griffiths, H.I., Thomas, D.H. (Eds.), 1997. The Conservation and Management of the European Badger (Meles Meles). Nature and Environment no. 90, Council of Europe Publishing, Strasbourg.	Megafauna	Cultural diversity/Tradition of economical use of badgers
	Megafauna	Health and wellbeing/badgers as vectors of rabies and use of badgers for medicinal purposes
Grzywacz, A., 2015. Tradycje zbiorów grzybów leśnych w Polsce [Traditions of mushroom picking in poland]. Studia i Materiały CEPL w Rogowie 44, 189–199. cepl.sggw.pl/sim/pdf/sim44_pdf/Grzywacz_1.pdf	Fungi	Cultural diversity/Traditionally collected mushrooms in Poland
Gyozo, Z., 2010. The meanings and functions of mushrooms as food in Hungarian folk tradition. Acta Ethnogr. Hung. 55(1), 115–138. http://dx.doi.org/10.1556/AEthn.55.2010.1.8.	Fungi	Cultural diversity/Traditionally collected mushrooms, their use

		and linguistics connected to mushrooms in Hungary
	Fungi	Social relations/various social relations connected to mushroom picking
Haga, G., 2001. De Reuzenbovist: de voetbal van 5 miljard. Twirre 12(5), 180-181.	Fungi	Cultural diversity/linguistics connected to mushrooms
	Fungi	Social relations/Interest groups (Mycological societies)
Halme, P., Holec, J., Heilman-Clausen, J., 2017. The history and future of fungi as biodiversity surrogates in forests. Fungal Ecol. 27, 193–201. http://dx.doi.org/10.1016/j.funeco.2016.10.005.	Fungi	Knowledge systems/Use of fungi biodiversity indicators: pros and cons
	Fungi	Educational values/Fungi as tools for environmental education
Härkönen, M., 1998. Uses of mushrooms by Finns and Karelians. Int. J. Circumpol. Heal. 57(1), 40–55.	Fungi	Cultural diversity/attitudes towards fungi
	Fungi	Sense of place/immigrants bringing mushroom picking tradition as sense of home
Hawksworth, D.L., 1996. Mycophobia and Mycophilia. Nature 379, 503–504.	Fungi	Cultural diversity/attitudes towards fungi
Heger, T.J., Edgcomb, V.P., Kim, E., Lukeš, J., Leander, B.S., Yubuki, N., 2014. A Resurgence in Field Research is Essential to Better Understand the Diversity, Ecology, and Evolution of Microbial Eukaryotes. J. Eukaryot. Microbiol. 61, 214–223. doi:10.1111/jeu.12095.	Microorganisms	Knowledge systems /use of protozoans in ecological research
Heinrich, G., 1992. Uptake and transfer factors of ^{137}Cs by mushrooms. Radiat. Environ. Bioph. 31, 39–49. doi: 10.1007/BF01211511.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Heleno, S.A., Barros, L., Sousa, M.J., Martins, A., Ferreira, I.C.F.R., 2010. Tocopherols composition of Portuguese wild mushrooms with antioxidant capacity. Food Chem. 119, 1443–1450. https://doi.org/10.1016/j.foodchem.2009.09.025	Fungi	Health and wellbeing/mushrooms as a source for antioxidants

Hjulström, B., Isaksson, S., Hennius, A., 2006. Organic geochemical evidence for pine tar production in middle Eastern Sweden during the Roman Iron Age. J. Archaeol. Sci. 33, 283–294. doi:10.1016/j.jas.2005.06.017.	Roots	Cultural heritage values/Historical use of pine roots for tar and heritage sites connected to tar making
Hnízdo, J., 2005. Otrava želvy ostruhaté (Geochelone sulcata) muskarinem po pozření vláknice patouillardové (Inocybe patouillardii) [Case of muscarin poisoning by African spurred tortoise (Geochelone sulcata) after consuming Inocybe patouillardii]. Veterinární klinika 3, 54–56.	Fungi	Health and wellbeing/poisoning with mushrooms of house pets
Houseman, M., 1990. Le tabou du lapin chez les marins: Une spéculation structurale. Ethnologie française 20, 125–142.	Megafauna	Spiritual and religious values/Taboos and beliefs connected to rabbits
Ivancheva, S., Stantcheva, B., 2000. Ethnobotanical inventory of medicinal plants in Bulgaria. J. Ethnopharmacol 69, 165–172. http://dx.doi.org/10.1016/S0378-8741(99)00129-4.	Roots	Cultural diversity/Traditionally collected plant roots in Bulgaria
	Roots	Spiritual and religious values/Rituals connected to medicinal plants (including roots)
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
	Roots	Cultural heritage values/way of life related to medicinal plants (including roots)
	Roots	Health and wellbeing/Use of medicinal plants (including roots)
Iwicka, R., 2015. Użycie roślin w telewizyjnych serialach fantastycznych [Herbs in television fantasy series]. Maska 2, 159–169. http://www.maska.psc.uj.edu.pl/documents/40768330/ac52e9f1-505b-4193-8b2b-0a1ecc8974e0/ (Accessed 28 April 2018).	Roots	Inspiration/Plants (including roots) in TV series
Jasiūnaitė, B., 2010. Šventieji ir nelabieji frazeologijoje ir liaudies kultūroje [Saints and devils in phraseology and folk culture]. Vilniaus universiteto leidykla, Vilnius.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Lithuania and in Slavic languages
	Fungi	Spiritual and religious values/beliefs and mythology

Jones, C.J., Lawton, J.H., Shachak, M., 1994. Organisms as ecosystem engineers. Oikos, 69: 373–386.

Jürgenson, A., 2000. Otnoshenije estoncev k gribam [The attitude of Estonians to mushrooms]. Etnograficheskoje obozrenije 2, 115–127.

Jürgenson, A., 2005. Seened kultuuriloos [Mushrooms and Culture]. Argo, Tallinn.

	connected to mushrooms and mushroom picking
Roots	Cultural diversity/ linguistics related to plant roots
Roots	Spiritual and religious values/beliefs and mythology connected to plant roots
Roots	Cultural heritage values/folklore related to roots
Megafauna	Knowledge systems/Impact of rabbits on ecological research
Fungi	Cultural diversity/attitudes towards mushrooms, linguistics and folklore connected to mushrooms in Estonia
Fungi	Spiritual and religious values/Beliefs and mythology connected to mushrooms and mushroom picking, attitude towards mushrooms by different religious confessions
Fungi	Inspiration/Mushrooms in folklore
Fungi	Social relations/various social aspects of mushroom picking
Fungi	Cultural heritage values/mushrooms in traditional cuisines and folklore
Fungi	Cultural diversity/attitudes towards mushrooms, linguistics and folklore connected to mushrooms in Estonia

	Fungi	Spiritual and religious values/Beliefs and mythology connected to mushrooms and mushroom picking, attitude towards mushrooms by different religious confessions
	Fungi	Educational values/Mushroom exhibitions as tool for public education
	Fungi	Inspiration/Mushrooms in folklore
	Fungi	Cultural heritage values/mushrooms in traditional cuisines and folklore
Kalač, P., 2001. A review of edible mushroom radioactivity. Food Chem. 75, 29–35. DOI: 10.1016/S0308-8146(01)00171-6.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Kalač, P., 2010. Trace element contents in European species of wild growing edible mushrooms: A review for the period 2000–2009. Food Chem. 122, 2–15. https://doi.org/10.1016/j.foodchem.2010.02.045.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Kalle, R., Sõukand, R., 2012. Historical ethnobotanical review of wild edible plants of Estonia (1770s–1960s). Acta. Soc. Bot. Pol. 81, 271–281. doi: 10.5586/asbp.2012.033.	Roots	Cultural diversity/Traditionally collected plant roots in Estonia
Karvelytė, A., Motiekaitytė, V., 2013. Laukinių grybų ir uogų, vaistažolių rinkimo veiklos įvertinimas pagal ekonominius, socialinius ir gamtosauginius kriterijus [Gathering of wild mushroom, berries and medicinal herbs, its evaluation following criteria of economical, social and conservational criteria]. Jaunųjų mokslininkų darbai 1(39), 101–110.	Fungi	Social relations/social conflicts related to mushroom foraging
Kasper-Pakosz, R., Pietras, M., Łuczaj, L., 2016. Wild and native plants and mushrooms sold in the open-air markets of south-eastern Poland. J. Ethnobiol. Ethnomed. 12, 45. doi: 10.1186/s13002-016-0117-8.	Fungi	Cultural diversity/Traditionally collected mushrooms in south eastern Poland
Kemp, K., 2002. Heavy metals in edible mushrooms. Int. J. PIXE 12, 117–124. doi: http://dx.doi.org/10.1142/S0129083502000214.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms

Kiernan, G., 2010. Fungal monsters in Science fiction, in: Boddy, L., Coleman, M. (Eds.), From another kingdom. The amazing world of fungi. RBG, Edinburgh. pp. 105–120.	Fungi	Inspiration/Fungi in literature, cinema and art
	Fungi	Aesthetic values/general aesthetic attitude towards fungi
Killgrove, K., 2016. 6 Archaeological Finds Made by Badgers. http://mentalfloss.com/article/77119/6-archaeological-finds-made-badgers/ (accessed 25 April 2018).	Megafauna	Cultural heritage values/ archaeological artefacts unearthed by badgers
Kolosova, V.B., 2009. Leksika i simvolika slavyanskoi narodnoi botaniki. Etnolingvisticheskij aspekt [Lexis and symbolics of Slavonian folk botany. Ethnolinguistic aspect]. Indrik, Moscow.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Slavic languages
	Roots	Cultural diversity/ linguistics related to plant roots in Slavic languages
Kovalčík, M., 2014. Value of forest berries and mushrooms picking in Slovakia's forests. Beskydy 7, 39–46. https://doi.org/10.11118/beskyd201407010039.	Fungi	Cultural diversity/Traditionally collected mushrooms in Slovakia
Kreisel, H., 2002. Bekannte Personlichkeiten als Pilzliebhaber. Z. Mykol. 68(1), 3–30.	Fungi	Cultural diversity/attitudes towards fungi
	Fungi	Spiritual and religious values/beliefs connected to mushrooms, symbolism of fungi
	Fungi	Inspiration/Fungi in art, literature and cinema
Læssøe, T., Spooner, B., 1994. The uses of 'Gasteromycetes'. Mycologist 8(4), 154-159. http://dx.doi.org/10.1016/S0269-915X(09)80179-1.	Fungi	Cultural diversity/ tradition of uses of fungi
	Fungi	Health and wellbeing/poisoning with mushrooms
Lancellotti, E., Franceschini, A., 2013. Studies on the ectomycorrhizal community in a declining Quercus suber L. stand. Mycorrhiza 23, 533–542. doi: 10.1007/s00572-013-0493-z.	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health
Larrère, R., 2004. Champignons sauvages : initiations et savoirs. Ethnologie française 34(3), 463–470. DOI : 10.3917/ethn.043.0463.	Fungi	Cultural diversity/attitudes towards fungi

Lees, A.C., Bell, D.J., 2008. A conservation paradox for the 21st century: the European wild rabbit Oryctolagus cuniculus, an invasive alien and an endangered native species. Mammal Rev. 38, 304–320. doi: 10.1111/j.1365-2907.2008.00116.	Megafauna	Knowledge systems/Impact of rabbits on ecological research
Lehmann, H., 2013. Le médicament à base de plantes en Europe : statut, enregistrement, contrôles. Thèse Présentée en vue de l'obtention du grade de Docteur de l'Université de Strasbourg. Vol. 1, 1–324. https://tel.archives-ouvertes.fr/tel-00936734/document (Accessed 30 April 2018).	Roots	Health and wellbeing/Use of medicinal plants (including roots)
Lek, H.A.A. van der, 1913a. Dieren en Paddestoelen. De Levende Natur 18(11), 245–249.	Fungi	Cultural diversity/Traditional negative attitude towards fungi in the Netherlands
Lek, H.A.A. van der, 1913b. De Paddestoelententoonstelling der Nederlandsche Mycologische Vereeniging. Arnhem, 21—23 September. De Levende Natur 17(19): 448–454.	Fungi	Social relations/Interest groups (Mycological societies)
Leporatti, M.L., Ivancheva, S., 2003. Preliminary comparative analysis of medicinal plants used in the traditional medicine of Bulgaria and Italy. J. Ethnopharmacol. 87, 123–142. http://dx.doi.org/10.1016/S0378-8741(03)00047-3.	Roots	Cultural diversity/Traditionally collected plant roots in Bulgaria and Italy
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
	Roots	Health and wellbeing/Use of medicinal plants (including roots)
Lévi-Strauss, C., 2008. Dis-moi quels champignons... La lettre du Collège de France Hors-série 2. Claude Lévi-Strauss, centième anniversaire 38–40. http://lettre-cdf.revues.org/222	Fungi	Cultural diversity/attitudes towards fungi
	Fungi	Inspiration/Fungi in literature
Louwagie, G., Noens, G., Devos, Y., 2005. Onderzoek van het bodemmilieu in functie van het fysisch-chemisch kwantificeren van de effecten van grondgebruik en beheer op archeologische bodemsporen in Vlaanderen. Eindrapport: Unpublished report Universiteit Gent. https://www.vlm.be/nl/SiteCollectionDocuments/Beheerovereenkomsten/060303_studie_arch_bodemsporen/Eindrapport.pdf (Accessed 26 April 2018)	Macrofauna	Cultural heritage values/Bioturbation of archaeological sites by earthworms
	Megafauna	Cultural heritage values/decomposition and

	bioturbation of organic archaeological layers by moles
Microorganisms	Cultural heritage values/decomposition of organic archaeological layers by bacteria
Roots	Cultural heritage values/Roots penetrating and damaging organic archaeological layers
Fungi	Cultural diversity/ linguistics connected to mushrooms in Lithuania
Fungi	Cultural diversity/ linguistics connected to mushrooms in Lithuania
Fungi	Cultural diversity/ linguistics connected to mushrooms in Lithuania, fungi in Lithuanian folklore
Fungi	Spiritual and religious values/Beliefs connceted to fungi
Fungi	Knowledge systems/traditional knowledge connected to mushrooms and mushroom picking, folk phenology concerning mushrooms
Fungi	Aesthetic values/Aesthetic folk perception of mushrooms in Lithuania
Fungi	Cultural heritage values/fungi in folklore

Lubienė, J., 2008. Grybų pavadinimų motyvacija pagal išorinius arba vidinius grybo požymius [Motivation of fungal names according to their external and internal characters]. Res humanitariae 4, 173–192.

Lubienė, J., 2009. Lietuvių kalbos liaudiški grybų pavadinimai su grybų augimo motyvaciniais požymiais [Lithuanian folk names according to motivational characters of growth]. Res humanitariae 6, 180–203.

Lubienė, J., 2015. Lietuvių kalbos mikonimai: nominacija ir motyvacija [Lithuanian folk names of fungi - nomination and motivation]. Klaipėdos universiteto leidykla, Klaipėda.

Łuczaj Ł., Szymański W.M., 2007. Wild vascular plants gathered for consumption in the Polish countryside: a review. J. of Ethnobiol. Ethnomedic. 3, 17 https://ethnobiomed.biomedcentral.com/articles/10.1186/1746-4269-3-17.	Roots	Cultural diversity/Traditionally collected plant roots in Poland
Łuczaj, Ł., 2011a. Dziko rosnące rośliny jadalne użytkowane w Polsce od połowy XIX w. do czasów współczesnych [Wild food plants used in Poland from the mid-19th century to the present]. Etnobiologia Polska 1, 57–125.	Roots	Cultural diversity/Traditionally collected plant roots in Poland
Łuczaj, Ł., 2011b. Kulturowe różnice we florze przedstawionej w ilustracjach dziecięcych bajek Wielkiej Brytanii i Polski [Cultural differences between flora depicted in British and Polish children's books]. Ethnobiologia Polska 1, 21–29.	Fungi	Inspiration/Fungi in children literature
Łuczaj, Ł., 2012. Ethnobotanical review of wild edible plants of Slovakia. Acta Soc. Bot. Pol. 81, 245–255. doi: 10.5586/asbp.2012.030.	Roots	Cultural diversity/Traditionally collected plant roots in Slovakia
Łuczaj, Ł., Fressel, N., Perković, S., 2013. Wild food plants used in the villages of the Lake Vrana Nature Park (northern Dalmatia, Croatia). Acta Soc. Bot. Pol. 82,275–281. http://dx.doi.org/10.5586/asbp.2013.036.	Fungi	Cultural diversity/Traditionally collected mushrooms in Dalmatia
	Roots	Cultural diversity/Traditionally collected plant roots in Dalmatia
Łuczaj, Ł., Nieroda, Z., 2011. Collecting and learning to identify edible fungi in Southeastern Poland: age and gender differences. Ecol. Food Nutr. 50, 319–336. doi: 10.1080/03670244.2011.586314.	Fungi	Knowledge systems/Traditional knowledge concerning mushrooms and mushroom picking
	Fungi	Social relations/various social relations connected to mushroom picking
Łuczaj, Ł., Stawarczyk, K., Kosiek, T., Pietras, M., Kujawa, A., 2015. Wild food plants and fungi used by Ukrainians in the western part of the Maramureş region in Romania. Acta Soc. Bot. Pol. 84, 339–346. https://doi.org/10.5586/asbp.2015.029.	Fungi	Cultural diversity/Traditionally collected mishrooms by Ukrainian minority in Romania
	Roots	Cultural diversity/Traditionally collected plant roots by Ukrainian minority in Romania
Luoma, D.L., Eberhart, J.L., 2014. Relationships between Swiss needle cast and ectomycorrhizal fungus diversity. Mycologia 106, 666–675. doi:10.3852/12-180.	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health

MacMillan, D.C., Phillip, S., 2008. Consumptive and non-consumptive values of wild mammals in Britain. Mammal Rev. 38: 189–204. https://doi.org/10.1111/j.1365-2907.2008.00124.x.	Megafauna	Social relations/Public awareness towards conservation through observing some burrowers
	Megafauna	Recreation and ecotourism/Rabbit hunting as recreation, observation and photography of burrowers
Majtánová, M.,1977. Z kultúrnej histórie húb. (Etnomykologické poznámky) [Of the cultural history of fungi (Ethnomycological notes)]. Slovenský národopis 25, 415–422.	Fungi	Cultural diversity/attitudes towards fungi, linguistics connected to mushrooms
	Fungi	Cultural heritage values/mushrooms in traditional slavic cuisines
Mallye, J.-B., 2007. Les restes de Blaireau en contexte archéologique: taphonomie, archéozoologie et éléments de discussion des séquences préhistoriques, Ph.D. Thesis, Université de Bordeaux 1, ex. multigraph.https://tel.archives-ouvertes.fr/tel-00394204/PDF/Mallye_PhD_light.pdf (Accessed 26.04.2018)	Megafauna	Cultural heritage values/ bioturbation of archaeological sites by badgers
Marcinkevičienė, N., 2009. Grybai, miško uogos – Dzievo rasa [Mushrooms, forest berries – God‘s dew]. Šiaurės Atėnai 953.	Fungi	Cultural diversity/Way of life connected to mushrooms and mushroom picking
	Fungi	Knowledge systems/Traditional knowledge of mushrooms and mushroom picking
	Fungi	Social relations/Social relaations connected to mushroom picking
Marfenina, O.E., Makarova, N.V., Ivanova, A.E., 2011. Opportunistic Fungi in Soils and Surface Air of a Megalopolis (for the Tushino Region, Moscow). Microbiology 80, 870–876.	Fungi	Health and wellbeing/negative effects of presence of opportunistic fungi

Markowitz, M., 2015. Rabbits and hares in ancient coins. https://s3.amazonaws.com/academia.edu.documents/40892673/Bunny_Money_Rabbits_and_Hares_on_Ancient_Coins.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1519502051&Signature=JVMjzJFl533PXsJ6EwS6RKB0xxc%3D&response-content-disposition=inline%3B%20filename%3DBunny_Money_Rabbits_and_Hares_on_Ancient.pdf (accessed 26.04.2018)	Megafauna	Inspiration/Rabbits depicted in coins
	Megafauna	Cultutral heritage values/Rabbits depicted in artefacts
Martin, J., 2010. The wild rabbit: plague, polices and pestilence in England and Wales, 1931–1955. Agr. Hist. Rev. 58, 255–276.	Megafauna	Cultural diversity/Tradition of rabbit hunt in UK
Massart, F., 2003. Le Tricholome doré Tricholoma auratum [Fr.] Gillet au banc des accusés. Les documents mycologiques 126, 17–20.	Fungi	Health and wellbeing/poisoning with mushrooms
Meiresonne, L., Turkelboom F., 2012. Biodiversiteit als basis voor ecosysteemdiensten in regio Vlaanderen. Mededelingen van het Instituut voor Natuur- en Bosonderzoek 2012 (1). Instituut voor Natuur- en Bosonderzoek, Brussel.	Fungi	Cultural diversity/Traditionally collected mushrooms in Flanders
	Fungi	Aesthetic values/Fungi add to aesthetic values of forests
	Roots	Cultural diversity/Traditionally collected plant roots in Flanders
Merkienė, R.I., (Ed.) 2007. Šiokiadienių ir šventadienių etnografija [Ethnography of workdays and holidays]. Versmė, Vilnius.	Fungi	Cultural diversity/Way of life connected to mushrooms and mushroom picking
	Fungi	Knowledge systems/Use of fungi in ethnological research
	Fungi	Cultural heritage values/Ethnographic heritage connected to mushrooms and mushroom picking
Minter, D., 2010. Safeguarding the future, in: Boddy, L., Coleman, M. (Eds.), From another kingdom. The amazing world of fungi. ,RBG Edinburgh. pp. 143–154.	Fungi	Social relations/Interest groups (Mycological societies)

Mitchell, E.A.D., Belbahri, L., Job, D., Pawlowski, D., Lara, E., 2011. Exploring the Terra incognita of unknown eukaryotic diversity in Soils - A major challenge we now have the tools to tackle! Bulletin BGS 32(1), 57–62.	Microorganisms	Knowledge systems /use of protist communities in evolutionary sciences
	Fungi	Knowledge systems /use of fungal communities in evolutionary sciences
Mizaras, S., Kavaliauskas, M., Činga, G., Mizaraitė, D., Belova, O., 2015. Socio-Economic Aspects of Recreational Use of Forests in Lithuania. Balt. For. 21, 308–314.	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Mleczek, M., Siwulski, M., Stuper-Szablewska, K., Rissmann, I., Sobieralski, K., Goliński, P., 2013. Accumulation of elements by edible mushroom species: Part I. Problem of trace element toxicity in mushrooms. J. Environ. Sci. Heal. B 48, 69–81. https://doi.org/10.1080/03601234.2012.716733.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Molitoris, H.P., 2002. Pilze in Medizin, Folklore und Religion. Feddes Repertorium 113, 165–182.	Fungi	Cultural diversity/ linguistics connected to mushrooms
	Fungi	Spiritual and religious values/beliefs aconnected to fungi
	Fungi	Inspiration/Fungi in literature and artware
	Fungi	Health and wellbeing/Fungi used in medicine
Money, N.M., 2016. Are mushrooms medicinal? Fungal Biol. 120, 449–453. http://dx.doi.org/10.1016/j.funbio.2016.01.006.	Fungi	Health and wellbeing/value of fungi as a source for pharmaceuticals but questionable value of traditionally used medicinal fungi
Montes-Borrego, M., Metsis, M., Landa, B.B., 2014. Arbuscular Mycorhizal Fungi Associated with the Olive Crop across the Andalusian Landscape: Factors Driving Community Differentiation. PLOS ONE 9, e96397. doi: 10.1371/journal.pone.0096397.	Fungi	Knowledge systems/Use of myxorrhizal fungi to determine quality of traditional olive groves
Moskal-del Hoyo, M., Wachowiak, M., Blanchette, R.A., 2010. Preservation of fungi in archaeological charcoal. J. Archaeol. Sci. 37, 2106-2116. https://doi.org/10.1016/j.jas.2010.02.007	Fungi	Knowledge systems/Use of fungi in archaeology

Moss, M.O., 1998. Gasteroid basidiomycetes on postage stamps. Mycologist 12, 104–106. http://dx.doi.org/10.1016/S0269-915X(98)80005-0.	Fungi	Inspiration/Fungi on postage stamps
Moszynski, K., 1934. Kultura ludowa Słowian. Cz. 2, Kultura duchowa. [Slawonian folk culture. Vol. 2. Spiritual culture.]. Polska Akademja Umiejętności, Kraków.	Megafauna	Cultural diversity/folklore connected to burrowers
	Megafauna	Spiritual and religious values/beliefs connected to burrowers
	Megafauna	Cultural heritage values/folklore connected to burrowers
Motiejūnaitė, J., Kasparavičius, J., Kačergius, A., 2011. Boletellus projectellus - an alien mycorrhizal bolete new to Europe. Sydowia. 63 (2), 203–213.	Fungi	Social relations/Public scientists add to new fungi finds
Motiejūnaitė, J., Kutorga, E., Kasparavičius, J., Lygis, V., Norkutė, G., 2016. New records from Lithuania of fungi alien to Europe. Mycotaxon 31, 49–60. https://doi.org/10.5248/131.49	Fungi	Social relations/Public scientists add to new fungi finds
Nappi, A., 2013. Sulla presenza del coniglio selvatico, *Oryctolagus cuniculus* (Linnaeus, 1758), in provincia di Sondrio (Mammalia, Lagomorpha). Il Naturalista Valtellinese, 2013: 85–87.	Megafauna	Cultural diversity/Tradition of rabbit hunt in Italy
Navarro-Gonzalez ,N., Serrano, E., Casas-Díaz, E., Velarde, R., Marco, I., Rossi, L., Lavín, S., 2010. Game restocking and the introduction of sarcoptic mange in wild rabbit in north-eastern Spain. Anim. Conserv. 13: 586–591. DOI: 10.1111/j.1469-1795.2010.00390.x	Megafauna	Cultural diversity/Tradition of rabbit hunt in Spain
	Megafauna	Recreation and ecotourism/Rabbit hunting as recreation
Niemi, R.M., Poyry, J., Heiskanen, I., Uotinen, V., Nieminen, M., Erkomaa, K., Wallenius, K., 2014. Variability of soil enzyme activities and vegetation succession following boreal forest surface soil transfer to an artificial hill. Nat. Conserv. 8, 1–25 http://natureconservation.pensoft.net/articles.php?id=3998.	Fungi	Knowledge systems/Use of fungi in environmental research
	Fungi	Recreation and ecotourism/Use of fungi to convert landfill into recreation area
Nieminen, P., Kirsi, M., Mustonen, A.M., 2006. Suspected myotoxicity of edible wild mushrooms. Exp. Biol. Med. 31, 221–228. https://doi.org/10.1177/153537020623100213.	Fungi	Health and wellbeing/potential toxicity of mushrooms

Nissan, E., 2009. Deadly Flowers and Lethal Plants A Theme in Folklore, Fiction and Metaphoric Imagery. Fabula 50(3-4), 293–311. doi: 10.1515/FABL.2009.024.

Parlevliet, S., 2008. Hunting Reynard: How Reynard the Fox Tricked his Way into English and Dutch Children's Literature. Children's Literature in Education 39, 107–120. doi:10.1007/s10583-008-9062-z.

Peintner, U., Schwarz, S., Mešić, A., Moreau, P-A., Moreno, G., Saviuc, P., 2013. Mycophilic or Mycophobic? Legislation and Guidelines on Wild Mushroom Commerce Reveal Different Consumption Behaviour in European Countries. PLoS ONE 8(5), e63926. doi:10.1371/journal.pone.0063926

Pérez, R.M., Mendoza Almeralla, C., 2006. Los insectos en le cine. Un estudio preliminar [Insects in cinema: a preliminary study]. Boletín Sociedad Entomológica Aragonesa 38, 415−421.

Picot, G., 2013. Les racines, la face cachée des plantes. Ecologie et usages traditionnels dans le Vercors. http://apacheta.e-monsite.com/medias/files/6-les-racines.pdf (Accessed 26 April 2018).

Fungi	Inspiration/Fungi in literature and art
Megafauna	Inspiration/Badgers in literature
Fungi	Cultural diversity/attitudes towards fungi
Fungi	Social relations/fungal foraging and legislation
Macrofauna	Inspiration/Ants in cinema
Roots	Cultural diversity/different traditions of collecting and use of plant roots, linguistics and folklore connected to roots
Roots	Spiritual and religious values/Beliefs and mythology connected to roots
Roots	Educational values/Examples of children and adult education programs with roots
Roots	Inspiration/Mandrake roots in literature and art
Roots	Social relations/Legislation related to plant (root) gathering
Roots	Health and wellbeing/plant roots in medicine, poisoning with plant roots

Pieroni, A., Nebel, S., Santoro, R.F., Heinrich, M., 2005. Food for two seasons: Culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. Int. J. Food Sci. Nutr. 56, 245–272. doi:10.1080/09637480500146564	Fungi	Cultural diversity/attitudes towards fungi, tradition of use of fungi
Ponge, J.F., Gillet, S., Dubs, F., Fédoroff, E., Haese, L., Sousa, J.P., Lavelle, P., 2003. Collembolan communities as bioindicators of land use intensification. Soil Biol. Biochem. 35, 813–826. https://doi.org/10.1016/S0038-0717(03)00108-1.	Mesofauna	Knowledge systems/use as environmental monitoring tools
Qian, XM., El-Ashker, A., Kottke, I., Oberwinkler, F., 1998. Studies of pathogenic and antagonistic microfungal populations and their potential interactions in the mycorrhizoplane of Norway spruce (*Picea abies* (L.) Karst.) and beech (*Fagus sylvatica* L.) on acidified and limed plots. Plant Soil 199, 111–116 doi: 10.1023/A:1004276121413	Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health
Quave, C.L., Pieroni A., 2013. Mediterranean Zootherapy: A Historical to modern perspective, in: Alves, R.R.N., Rosa, I.L. (Eds.), Animals in Traditional Folk Medicine. Springer-Verlag, Berlin Heidelberg, pp. 303-316. doi: 10.1007/978-3-642-29026-8_14	Macrofauna	Cultural diversity/Historical tradition use of earthworms in medicine
	Megafauna	Cultural diversity/Tradition of economical use of badgers
	Megafauna	Health and wellbeing/ use of badgers for medicinal purposes
Ragusa, G.C., 2016. Superstizione, malocchio e scaramanzia differenza di percezione da parte dei giovani e degli anziani della Sicilia. International Journal of Developmental and Educational Psychology (INFAD Revista de Psicología) 2, 317–328.	Megafauna	Spiritual and religious values/Sicilian beliefs connected to rabbits (rabbit foot as talisman)
Ramesh, M.A., 2016. Inoculating curiosity in fungal biology for a new generation of students. Fungal Biol. Rev. 30, 15–23. http://dx.doi.org/10.1016/j.fbr.2016.03.001.	Fungi	Educational values/Use of fungi for teaching students
Rantalainen, M.L., Haimi, J., Fritze, H., Pennanen, T., Setala, H., 2008. Soil decomposer community as a model system in studying the effects of habitat fragmentation and habitat corridors. Soil Biol. Biochem. 40, 853–863. http://www.sciencedirect.com/science/article/pii/S0038071707004506.	Fungi	Knowledge systems/Use of fungi in environmental research

Rätch, C., 1998. Enzyklopädie der psichoaktiven Pflanzen. AT Verlag, Aarau.	Fungi	Cultural diversity/tradition of use of psychotrophic fungi, linguistics connected to fungi
	Fungi	Spiritual and religious values/beliefs and mythology connected to psychotrophic fungi
	Roots	Cultural diversity/tradition of use of psychotrophic plant roots, linguistics and folklore connected to roots
	Roots	Spiritual and religious values/Beliefs and mythology connected to psychotrophic plants (incl.roots)
	Roots	Inspiration/Poisonous and psychotrophic plants in literature
	Roots	Health and wellbeing/poisoning with plants, including roots
Referowska-Chodak, E., 2015a. Ludowe nazwy grzybów w Polsce [Folk names of fungi in Poland]. Studia i Materiały CEPL w Rogowie 44, 218–238.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Poland
	Fungi	Cultural heritage values/mushrooms in traditional cuisine
Referowska-Chodak, E., 2015b. Ludowe zwyczaje związane z grzybami w Polsce [Folk traditions connected to mushrooms in Poland]. Studia i Materiały CEPL w Rogowie 44, 200–217.	Fungi	Knowledge systems/various traditional knowledge concerning mushrooms
Reis, F., Carvalho, F., Martins da Silva, P., Mendes, S., Santos, S.A.P., Sousa, J.P., 2016. The use of a functional approach as surrogate of *Collembola* species richness in European perennial crops and forests. Ecol. Indic. 2, 676–682. https://doi.org/10.1016/j.ecolind.2015.10.019.	Mesofauna	Knowledge systems/use as environmental monitoring tools

Ricci, J.-C., 2008. Faune et chasse en région méditerranéenne: trente ans de coadaptations. Forêt Méditerranéenne 29, 479–490.	Megafauna	Cultural diversity/Tradition of rabbit hunt in Mediterranean area
	Megafauna	Social relations/Hunting (including rabbit) legislation
Rödel, H.G., Dekker, J.J.A., 2012. Influence of weather factors on population dynamics of two lagomorph species based on hunting bag records. Eur. J. Wildl. Res. 5, 923–932. doi:10.1007/s10344-012-0635-1.	Megafauna	Cultural diversity/Tradition of rabbit hunt in Germany and Netherlands
	Megafauna	Social relations/Hunting (including rabbit) legislation
Rodríguez-Hidalgo, A.J., Saladié, P., Canals, A., 2013. Following the white rabbit: a case of a small game procurement site in the Upper Palaeolithic (Sala de las Chimeneas, Maltravieso Cave, Spain). Int. J. Osteoarchaeol. 23 (1), 34–54. doi: 10.1002/oa.1238.	Megafauna	Knowledge systems/Impact of rabbits on archaeological research
Rodríguez Peinado, L., 2011. Los conejos y las liebres. Revista Digital de Iconografia Medieval 3(5), 11–21.	Megafauna	Spiritual and religious values/Symbolics of rabbits
	Megafauna	Inspiration/Rabbits in medieval art
Rutter, G., 2010. Fungi and humanity, in: Boddy L., Coleman M. (Eds.), From another kingdom. The amazing world of fungi, RBG Edinburgh, pp. 93–104.	Fungi	Knowledge systems/Traditional knowledge of uses of fungi
	Fungi	Inspiration/Fungi in literature and art
	Fungi	Aesthetic values/general aesthetic attitude towards fungi
Saviuc, P., Danel, V., 2008. New syndromes in mushroom poisoning. Toxicol. Rev. 25, 199–209. https://doi.org/10.2165/00139709-200625030-00004	Fungi	Health and wellbeing/poisoning with mushrooms
Sax, B., 2001. The mythical zoo: an encyclopedia of animals in world myth, legend, and literature – beaver, porcupine, badger, and miscellaneous rodents. ABC-CLIO, Santa Barbara.	Macrofauna	Cultural diversity/folklore, attitude connected to earthworms

Macrofauna	Spiritual and religious values/beliefs connected to earthworms
Macrofauna	Inspiration/Earthworms and ants in art and literature
Macrofauna	Aesthetic values of earthworms
Macrofauna	Cultural heritage values/earthworms in mythology and folklore
Megafauna	Cultural diversity/folklore connected to burrowers
Megafauna	Spiritual and religious values/beliefs connected to burrowers
Megafauna	Inspiration/burrowers in folklore and literature
Megafauna	Cultural heritage values/folklore connected to burrowers
Fungi	Knowledge systems/Use of mycorrhizal fungi to monitor tree health
Fungi	Knowledge systems/Use of fungi in soil sciences

Scattolin, L., Dal Maso, E., Accordi, S.M., Sella, L., Montecchio, L., 2012. Detecting asymptomatic ink-diseased chestnut trees by the composition of the ectomycorrhizal community. Forest Pathol. 42, 501–509. doi: 10.1111/j.1439-0329.2012.00784.x.

Schaeffer, A., Nannipieri, P., Kastner, M., Schmidt, B., Botterweck, J., 2015. From humic substances to soil organic matter-microbial contributions. In honour of Konrad Haider and James P. Martin for their outstanding research contribution to soil science. J. Soils Sediments 15, 1865–1881 doi: 10.1007/s11368-015-1177-4

Schenk-Jaeger, K.M., Rauber-Luthy, C., Bodmer, M., Kupferschmidt, H., Kullak-Ublick, G.A., Ceschi, A., 2012. Mushroom poisoning: a study on circumstances of exposure and patterns of toxicity. Eur. J. Intern. Med. 23, e85–e91. doi:10.1016/j.ejim.2012.03.014.	Fungi	Health and wellbeing/poisoning with mushrooms
Schmutz, M., Carron, P.N., Yersin, B., Trueb L., 2018. Mushroom poisoning: a retrospective study concerning 11-years of admissions in a Swiss Emergency Department. Intern. Emerg. Med. 13, 59–67. doi:10.1007/s11739-016-1585-5.	Fungi	Health and wellbeing/poisoning with mushrooms
Sears, M., 2010. Warrior Ants: Elite Troops in the Iliad. Classical World 103(2), 139–155.	Macrofauna	Inspiration/Ants in literature
Sébillot, P., 1984. Le Folklore de France - La Faune. Imago, Paris.	Macrofauna	Cultural diversity/Ants and mole crickets in French folklore
	Macrofauna	Inspiration/Ants and mole crickets in French folklore
	Macrofauna	Cultural Heritage values/Ants and mole crickets in French folklore
Sébillot, P., 2004. Les arbres et les plantes dans les traditions populaires. Extrait de Folklore de France. https://www.arbredor.com/ebooks/ArbresetPlantes.pdf (Accessed 28 April 2018).	Roots	Cultural diversity/Traditionally collected plant roots in France, folklore connected to roots
	Roots	Spiritual and religious values/Beliefs and mythology connected to roots
Senk-Szengelewicz, O., 2008. Naimenovanija gribov v russkom jazyke po ikh vneshnemu priznaku [Russian names of fungi according to their external characters]. Russkij jazyk za rubezhom 3, 57–63.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Russia
Senvaitytė, D., 2006. Psichotropiniai augalai lietuvių tradicijoje [Psychotropic plants in the Lithuanian tradition]. Liaudies kultūra 4, 21–25.	Fungi	Knowledge systems/Traditional knowledge of medicinal fungi
	Roots	Cultural diversity/Tradition of plant root use in Lithuania
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (including roots)

	Roots	Health and wellbeing/Use of medicinal plants
Setälä, H., McLean, M.A., 2004. Decomposition rate of organic substrates in relation to the species diversity of soil saprophytic fungi. Oecologia 139, 98-107 doi: 10.1007/s00442-003-1478-y	Fungi	Knowledge systems/Use of fungi in soil sciences
Sisak, L., Riedl, M., Dudik, R., 2016. Non-market non-timber forest products in the Czech Republic – their socio-economic effects and trends in forest land use. Land Use Policy 50, 390–398. https://doi.org/10.1016/j.landusepol.2015.10.006.	Fungi	Social relations/various social aspects of mushroom foraging
	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Slávik, M., Tóth, T., Árvay, J., Harangozo, L., Kopernická, M., 2016. The heavy metals content in wild growing mushrooms from burdened Spiš area**.** Potravinarstvo 10, 232–236. doi:10.5219/564.	Fungi	Health and wellbeing/hazardous trace elements in edible mushrooms
Spooner, B., Læssøe, T., 1994. The folklore of 'gasteromycetes'. Mycologist 8(4), 119–123. http://dx.doi.org/10.1016/S0269-915X(09)80157-2.	Fungi	Cultural diversity/ folklore connected to fungi
	Fungi	Cultural heritage values/fungi in folklore
Squire, S.J., 1996. Landscapes, places and geographic spaces: texts of Betrix Potter as cultural communication. GeoJ. 38, 75. doi:10.1007/BF00209121.	Megafauna	Inspiration/Rabbits in children's books
Stamets, P., 1996. Psilocybin mushrooms of the world. TenSpeed Press, Berkely.	Fungi	Inspiration/Fungi in art
	Fungi	Cultural heritage value/fungi depicted in heritage objects
Steup, F., 1915. Over giftigheid van Paddestoelen. De Levende Natur 20(9), 175–176.	Fungi	Spiritual and religious values/beliefs connected to mushrooms as "devil's creations".

	Fungi	Knowledge systems/erroneous traditional knowledge for determining mushroom toxicity
Stonkuvienė, I., 2000. Dorinis vaikų auklėjimas lietuvių valstiečių šeimoje XX a. pirmojoje pusėje [Moral education of children in the families of Lithuanian peasants in the first part of the 20th century]. Acta Paedagogica Vilnensia 7, 71–91.	Macrofauna	Cultural diversity/attitude towards ants in Lithuania
	Macrofauna	Educational values/ants as an example in traditional teaching
Strakova, P., Jagdmann, S., Balčiauskas, L., Balčiauskienė, L., Drewes, S., Ulrich, R.G., 2017. Puumala virus in Bank Voles, Lithuania. Emerg. Infect. Dis. 23 (1), 158–160. doi: 10.3201/eid2301.161400.	Megafauna	Health and wellbeing/burrowers as vectors of diseases
Stryamets, N., Elbakidze, M., Ceuterick, M., Angelstam, P., Axelsson, R., 2015. From economic survival to recreation: contemporary uses of wild food and medicine in rural Sweden, Ukraine and NW Russia. J. Ethnobiol. Ethnomed. 11, 53. doi: 10.1186/s13002-015-0036-0.	Fungi	Cultural diversity/different traditions of mushroom picking
	Fungi	Knowledge systems/Traditional knowledge of mushrooms
	Fungi	Social relations/various social relations connected to mushroom picking
	Fungi	Health and wellbeing/positive effects of mushroom picking on health
	Fungi	Recreation and ecotourism/Mushroom picking as recreation

	Roots	Cultural diversity/traditions of plant root use
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
	Roots	Social relations/various social relations connected to plant (including roots) gathering
	Roots	Recreation and ecotourism/Wild plant (incl. root) gathering as recreation
	Roots	Health and wellbeing/Various positive impact on health from wild plant (including roots) gathering
Svanberg, I., 2012. The use of wild plants as food in pre-industrial Sweden. Acta. Soc. Bot. Pol. 81, 317–327. doi: 10.5586/asbp.2012.039.	Roots	Cultural diversity/Traditionally collected plant roots in Sweden
Šarič-Kundalič, B., Dobeš, C., Klatte-Asselmeyer, V., Saukel, J., 2010. Ethnobotanical study on medicinal use of wild and cultivated plants in middle, south and west Bosnia and Herzegovina. J. Ethnopharmacol. 131, 33–55. doi:10.1016/j.jep.2010.05.061.	Roots	Cultural diversity/Traditionally collected plant roots in Bosnia & Herzegovina
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (incl. roots)
	Roots	Health and wellbeing/Use of medicinal plants (including roots)

Šimkutė, I., 2011. Natūraliųjų vaistingųjų medžiagų, naudotų Plungės rajone 2009–2010 m., etnofarmacinis tyrimas [Ethnopharmatic study of natural medicinal material used in Plungė district in 2009-2011]. Master thesis, Vilnius university. http://vddb.library.lt/fedora/get/LT-eLABa-0001:E.02~2011~D_20110628_151300-47090/DS.005.0.01.ETD (Accessed 30 April 2018).	Fungi	Knowledge systems/Traditional knowledge of medicinal fungi
	Roots	Cultural diversity/Tradition of plant root use in Lithuania
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (including roots)
	Roots	Health and wellbeing/Use of medicinal plants
Šurkus, J., 1973. Lietuvių liaudies medicinos tyrinėjimų apžvalga [Review of the studies on Lithuanian folk medicine]. Medicina 14, 33–46.	Fungi	Knowledge systems/Traditional knowledge of medicinal fungi
	Roots	Cultural diversity/Tradition of plant root use in Lithuania
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (including roots)
	Roots	Health and wellbeing/Use of medicinal plants
Temraleeva, A.D., Pinskii, D.L., Patova, E.N., Spirina, E.V., 2011. The use of algae-cyanobacterial communities for the assessment of lead pollution of gray forest soils. Eurasian J. Soil Sci. 44: 326–331. DOI: 10.1134/S1064229311030136.	Microorganisms	Knowledge systems /use of soil algae and cyanobacteria in ecotoxicology

	Microorganisms	Health and wellbeing/use of soil algae and cyanobacteria to monitor environmental quality
Thijse, J.P., 1931. Wetenschappelijke films. De Levende Natur 35, 312–327.	Fungi	Educational values/Educational value of film depicting fruitbody growth
Trestrail, J.H.III, 2000. Poisoning in fiction, in: Trestrail, J.H.III (Ed.), Criminal poisoning. Springer, New York. pp. 93–97.	Fungi	Inspiration/Poisonous fungi in literature
	Roots	Inspiration/Poisonous plants (including roots) in literature
Trimakas, R., 2008. Lietuvių liaudies medicina: etnografiniai ir folkloristiniai aspektai: XIX amžiaus pabaiga–XX amžiaus pirmoji pusė [Lithuanian folk medicine: ethnographic and folkloristic aspects]. Vilniaus universiteto leidykla, Vilnius.	Fungi	Knowledge systems/Traditional knowledge of medicinal fungi
	Roots	Cultural diversity/Tradition of plant root use in Lithuania
	Roots	Knowledge systems/Traditional knowledge of medicinal plants (including roots)
	Roots	Health and wellbeing/Use of medicinal plants
Trinkauskaitė-Johnson, E., 2006 Apie grybus, arba velniškas nuklydimas (A Diabolic Digression: Death Caps, Boletuses, Russulas). Liaudies kultūra 2, 10–18.	Fungi	Spiritual and religious values/beliefs and mythology connected to mushrooms and mushroom picking

	Fungi	Social relations/various social relations connected to mushrooms and mushrooming
	Fungi	Sense of place/patrimonial values of mushroom picking
	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Trinkauske, E., 2008. Seeing the swarming dead: of mushrooms, trees, and bees. Proquest, Umi Dissertation Publishing.	Fungi	Spiritual and religious values/beliefs and mythology connected to mushrooms and mushroom picking
	Fungi	Social relations/various social relations connected to mushrooms and mushrooming
	Fungi	Sense of place/patrimonial values of mushroom picking
Tripodi, S., Falagiani, P., Perinelli, T., Dell'Omo, F., Cristaldi, A., 2002. Allergy to fishing bait. Allergy 57, 653. DOI: 10.1034/j.1398-9995.2002.23736.x.	Macrofauna	Health and wellbeing/Allergy caused by earthworms
Turner, N.J., Łuczaj, Ł.J., Migliorini, P., Pieroni, A., Dreon, A.L.,Sacchetti, L.E., Paoletti, M.G., 2011. Edible and Tended Wild Plants, Traditional Ecological Knowledge and Agroecology. Crit. Rev. Plant Sci. 30, 198–225. http://dx.doi.org/10.1080/07352689.2011.554492.	Fungi	Knowledge systems/Traditional knowledge concerning mushrooms
	Roots	Knowledge systems/Traditional knowledge of wild plants (incl. roots)
	Roots	Health and wellbeing/Use of medicinal plants (including roots)
Turtiainen, M., Saastamoinen, O., Kangas, K., Vaara, M., 2012. Picking of wild edible mushrooms in Finland in 1997–1999 and 2011. Silva Fenn. 46(4), 569–581.	Fungi	Cultural diversity/attitudes towards fungi

Ulicsni, V., Svanberg, I., Molnár, Z., 2016. Folk knowledge of invertebrates in Central Europe - folk taxonomy, nomenclature, medicinal and other uses, folklore, and nature conservation. J. Ethnobiol. Ethnomed. 12, 47. https://doi.org/10.1186/s13002-016-0118-7.	Macrofauna	Cultural diversity/Folklore, linguistic diversity, attitude, tradition of use of earthworms, mole crickets, ants
	Macrofauna	Recreation and ecotourism/earthworms as bait for fishing
Urbanovičová, V., Miklisová, D., Kováč, L., 2014. Forest disturbance enhanced the activity of epedaphic collembola in windthrown stands of the High Tatra mountains. J. Mt. Sci. 11, 449–463. https://doi.org/10.1007/s11629-013-2736-z.	Mesofauna	Knowledge systems/use as environmental monitoring tools
Uzunov, B.A., Stoyneva-Gärtner, M.P., 2015. Mushrooms and Lichens in Bulgarian Ethnomycology. J. Mycol. Volume 2015, Article ID 361053, 7 pages. http://dx.doi.org/10.1155/2015/361053.	Fungi	Inspiration/mushrooms in prehistoric paintings
	Fungi	Cultural heritage value/fungi depicted in heritage objects
Vallejo, J.R., González, J.A., 2013. Las lombrices de tiera en la medicina popular española: contraste con el uso medicinal a través de la Historia [Earthworms in the Spanish popular medicine: contrast with the medicinal use through the History]. Medicina Naturista 7(2), 81–86.	Macrofauna	Cultural diversity/Traditions of use of earthworms for medical purposes
	Macrofauna	Health and wellbeing/Use of earthworms for medical purposes
Van Praag, E., 2016. Unusual rabbit happenings, celebration of the human spirit or scientific realities? www.medirabbit.com.; http://www.medirabbit.com/EN/Books/Rabbit_odd_en.pdf (accessed 27 April 2018).	Megafauna	Inspiration/Rabbits in art
Vėlius, N., 1987a. Chtoniškasis lietuvių mitologijos pasaulis [Chthonic world of Lithuanin mythology]. Vaga, Vilnius.	Roots	Cultural diversity/Lithuanian folklore related to roots
	Roots	Spiritual and religious values/Beliefs and mythology connected to plant roots
	Roots	Cultural heritage values/folklore related to roots

Vėlius, N., 1987b. Sužeistas vėjas. Lietuvių liaudies mitologinės sakmės [Injured wind. Lithuanian folk mythological tales]. Vyturys, Vilnius.

Vėlius, N., 2012. Baltų mitologija iš sakalo skrydžio [Baltic mythology from the flight of a falcon]. Aidai, Vilnius.

Macrofauna	Cultural diversity/ants in Lithuanian folklore
Fungi	Spiritual and religious values/Beliefs and mythology connected to mushrooms and mushroom picking
Roots	Cultural diversity/roots in Lithuanian folklore
Roots	Spiritual and religious values/Beliefs and mythology connected to plant roots
Roots	Cultural heritage values/folklore related to roots
Macrofauna	Spiritual and religious values/beliefs connected to earthworms
Macrofauna	Cultural heritage values/earthworms in mythology
Megafauna	Cultural diversity/folklore connected to burrowers
Megafauna	Spiritual and religious values/beliefs connected to burrowers
Roots	Cultural diversity/folklore related to roots
Roots	Spiritual and religious values/Beliefs and mythology connected to plant roots
Roots	Cultural heritage values/folklore related to roots

Virgós, E., Travaini, A., 2005. Relationship between small-game hunting and carnivore diversity in Central Spain. Biodivers. Conserv. 14, 3475. https://doi.org/10.1007/s10531-004-0823-8.	Megafauna	Cultural diversity/Tradition of rabbit hunt in Spain
	Megafauna	Recreation and ecotourism/Rabbit hunting as recreation
Vogl, S., Picker, P., Mihaly-Bison, J., Fakhrudin, N., Atanasov, A.G., Heiss, E.H., Wawrosch, C., Reznicek, G., Dirsch, V.M., Saukel, J., Kopp, B., 2013. Ethnopharmacological in vitro studies on Austria's folk medicine — an unexplored lore in vitro anti-inflammatory activities of 71 Austrian traditional herbal drugs. J. Ethnopharmacol. 149, 750–771. doi: 10.1016/j.jep.2013.06.007.	Roots	Knowledge systems/Traditional and formal knowledge of medicinal plants (including roots)
	Roots	Cultural heritage values/Traditional system of folk herbal medicine (roots included)
	Roots	Health and wellbeing/Use of medicinal plants
Vuletić, D., Krajter, S., Mrazek, M., Ćorić, A., 2009. Non wood forest products and services - are we using them enough? Šumarski List, 133, 175–184.	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Walter, C., Bispo, A., Chenu, C., Langlais-Hesse, A., Schwartz, C., 2015. Les services écosystémiques des sols: Du concept à sa valorisation, in: Demeter, C. (Ed.), Agriculture et Foncier - Concurrences entre Usages des sols et entre Usagers des sols Agricoles: La Question Foncière Renouvelée. Cahier Demeter, Paris, pp. 51–68.	Macrofauna	Educational values/collection of insect larvae and pupae for educational purposes
	Macrofauna	Social relations/Groups of collectors of insects (including soil species)
	Macrofauna	Cultural heritage values/Earthworms burying and conserving artefacts
Wasson, V.P., Wasson, R.G., 1957. Mushrooms, Russia and history. Vol.1, 2. Pantheon Books, New York.	Fungi	Cultural diversity/attitudes towards fungi

	Fungi	Inspiration/Fungi in literature and art
	Fungi	Social relations/various social relations connected to mushroom picking
	Fungi	Sense of place/patrimonial values of mushroom picking
Watling, R., 1997. Poisoning by fungi: interesting cases. Mycologist 11, 101.	Fungi	Health and wellbeing/poisoning with mushrooms
Welc-Faleciak, R., Pawelczyk, A., Radkowski, M., Pancewicz, S.A., Zajkowska, J., Sinski, E., 2015. First report of two asymptomatic cases of human infection with Babesia microti (Franca, 1910) in Poland. Ann. Agr. Environ. Med. 22, 51–54. https://doi.org/10.5604/12321966.1141394.	Megafauna	Health and wellbeing/burrowers as vectors of diseases
Wiltshire, P.E.J., 2016. Mycology in palaeoecology and forensic science. Fungal Biol. 120, 1272–1290. http://dx.doi.org/10.1016/j.funbio.2016.07.005.	Fungi	Knowledge systems/Use of fungi in palaeoecology and forensic science
Wood, C.L., Lafferty, K.D., DeLeo, G., Young, H.S., Hudson, P.J., Kuris, A.M., 2014. Does biodiversity protect humans against infectious disease? Ecology 95, 817–832 https://doi.org/10.1890/13-1041.1.	Megafauna	Health and wellbeing/burrowers as vectors of diseases
Woolhouse, M., Scott, F., Hudson, Z., Howey, R., Chase-Topping, M., 2012. Human viruses: discovery and emergence. Philos. T. Roy. Soc. B 367, 2864–2871. http://rstb.royalsocietypublishing.org/content/367/1604/2864.short.	Megafauna	Health and wellbeing/burrowers as vectors of diseases
Wright, J., 2010. The fungal forager, in: Boddy, L., Coleman, M. (Eds.), From another kingdom. The amazing world of fungi. RBG, Edinburgh. pp. 131–142.	Fungi	Social relations/fungal foraging and law in Great Britain
Wrzosek, M., Motiejūnaitė, J., Kasparavičius, J., Wilk, M., Mukins, E., Schreiner, J., Vishnevskiy, M., Gorczak, M., Okrasińska, A., Istel, L., Pawlowska, J., 2017. The progressive spread of *Aureoboletus projectellus* (Fungi, Basidiomycota) in Europe. Fungal Ecol. 27, 134–136. http://dx.doi.org/10.1016/j.funeco.2017.02.003.	Fungi	Social relations/Public scientists add to new fungi finds
Yamin-Pasternak, S., 2007. How the devils went deaf: ethnomycology, cuisine, and perception of landscape in the Russian North. University of Alaska, Fairbanks.	Fungi	Cultural diversity/Traditionally collected mushrooms, their use and attitude towards mushrooms in Russia
	Fungi	Social relations/various social relations connected to mushroom picking

	Fungi	Sense of place/patrimonial values of mushroom picking
	Fungi	Recreation and ecotourism/Mushroom picking as recreation
Yamin-Pasternak, S., 2008. A Means of Survival, a Marker of Feasts: Mushroom Cookery in the Russian Far East. Ethnology 47(2), 95–107.	Fungi	Cultural diversity/Traditionally collected mushrooms and their use in Russia
	Fungi	Cultural heritage values/mushrooms in traditional cuisine
Yamin-Pasternak, S., 2011. Ethnomycology: Fungi and mushrooms in cultural entanglements, in: Anderson, E.N., Pearsall, D., Hunn, E., Turner, N. (Eds.), Ethnobiology. Wiley-Blackwell, New Jersey, pp. 213–230.	Fungi	Cultural diversity/attitudes towards fungi, linguistics connected to mushrooms, traditions of use for food
	Fungi	Spiritual and religious values/Suspicious attitude towards mushrooms by some religions
	Fungi	Knowledge systems/Knowledge of fungi in ethnology
	Fungi	Inspiration/Fungi in art
	Fungi	Social relations/immigrants transfering mushroom-related knowledge to local people
	Fungi	Sense of place/immigrants bringing mushroom picking tradition as sense of home
Young, S.N., 2013. Single treatments that have lasting effects: some thoughts on the antidepressant effects of ketamine and botulinum toxin and the anxiolytic effect of psilocybin. J. Psychiatr. Neurosci. 38, 78–83.	Fungi	Health and wellbeing/positive effects of psilocybin from Psilocybe fungi

Zamfirescu, O., 2014. The characteristics of the Romanian common names given to lower plants. Lucrări Ştiinţifice (ser. Agronomie) 57 (1), 283–288.	Fungi	Cultural diversity/ linguistics connected to mushrooms in Romania

Supplementary material 3. Results of analysis of the references, showing organism group, benefit and cultural ecosystem service (CES) provided, number of references mentioning provision of the benefit by the organism group, spacial and temporal scale of the benefit, direct or indirect impact of the organism on the provision of the benefit, positive or negative impact and interaction of the CES with other CES and /or ES.

Element (organism group)	Benefit/CES	No of references	Spatial range of impact	Temporal scale	Type of impact	Beneficiaries	Interactions with other CES/ES
Roots	Tradition of use for food/Cultural diversity	10	All Europe (different species and their diversity)	Obsolete, to small part present	Direct, both positive and negative (poisoning)	Part of general society, wild food enthusiasts (locally, in small scale), Researchers (ethnobotanists, culture historians)	Recreation and etourism CES; Knowledge systems CES, Provisional ES
Roots	Tradition of use for folk medicine/Cultural diversity	10	All Europe (different species and their diversity)	Present in part of Europe, largely obsolete in some countries	Direct, both positive and negative (poisoning)	Part of general society, (locally in large scale), Researchers (ethnobotanists, culture historians), fiction writers	Recreation and ecotourism CES, Health and well-being CES, Inspiration CES, Knowledge systems CES, Provisional ES

Roots	Traditional attitude/Cultural diversity	1	Western and Meditteranean Europe (1 species – Mandragora)	Obsolete (creation), Present (use of tradition)	Direct and indirect (through the use of tradition)positive	General society, Researchers (ethnobotanists, culture historians), fiction writers	Inspiration CES
Roots	Linguistic diversity: vernacular names, phraseologisms/Cultural diversity	5	All Europe (different species and their diversity)	Present	Direct, positive	General society, Researchers (ethnobotanists, linguists), fiction writers	Inspiration CES, Knowledge systems CES
Roots	Folklore/Cultural diversity	6	Regional (France, Lithuania, Mediterranean area in general)	Obsolete (creation), Present (use of tradition)	Direct and indirect (through the use of folklore), positive	General society, Researchers (ethnobotanists, ethnologists), fiction writers	Inspiration CES, Knowledge systems CES, Cultural heritage values CES, Spiritual and religious values CES
Roots	Beliefs, mythology, rituals/ Spiritual and religious values	8	All Europe (different species and their diversity), sometimes roots in general	Obsolete (creation, practicing beliefs and rituals), Present (use of mythology, practicing beliefs and rituals)	Direct and indirect (through the use of mythology), positive	General society, Tourists, Researchers (ethnobotanists, ethnologists), fiction writers	Inspiration CES, Cultural diversity CES, Knowledge systems CES, Recreation and ecotourism CES
Roots	Traditional knowledge of use for food and medicine/Knowledge systems	12	All Europe (different species and their diversity), sometimes roots in general	Present in part of Europe, largely obsolete in some countries	Direct, positive	General society, Researchers (ethnobotanists, pharmacologists)	Health and well-being CES, Cultural diversity CES, Provisional ES

Roots	Educational programmes using roots/Educational values	1	Only French example (morphological and species diversity of roots)	Present	Direct (creation, indirect (use of the programs), Positive	teachers, students, schoolchildren	Knowledge systems CES
Roots	Roots and root usage depicted in art and literature/Inspiration	5	All Europe (different species and their diversity)	Present	Direct (creation), indirect (use of the art and literature), Positive	Fiction writers, movie makers, artists, General society	Cultural diversity CES, Aesthetic values CES, Provisional ES
Roots	Social relations and impacts of root gathering/Social relations	1	Regional (several countries)	Present	Direct, neutral or positive	Part of general society (locally, in small scale)	Cultural diversity CES, Provisional ES
Roots	Intangible heritage (traditions, folklore, way of life)/Cultural heritage	8	Regional (several countries)	Obsolete (in part) to present	Direct (creation), Indirect (use of tradition, folklore), positive	Part of general society (locally, in small scale), tourists, fiction writers, Researchers (ethnobotanists, ethnologists, pharmacologists)	Cultural diversity CES, Recreation and ecotourism CES, Inspiration CES, Provisional ES
Roots	Tangible heritage (artefacts, archaeological sites)/Cultural heritage	2	All Europe	Obsolete (in part) (creation), to present	Direct (creation of artefacts, impact on archaeological sites), indirect (use of artefacts), positive and negative(impact on archaeological sites)	Artesans, archaeologists, tourists	Recreation and ecotourism CES, Inspiration CES, Provisional ES

Roots	Root medicinal and food) gathering as recreation/ Recreation and ecotourism	1	Regional (several countries)	Present	Direct, positive	Part of general society, tourists, (locally, in small scale),	Cultural diversity CES, Health and well-being CES, Provisional ES
Roots	Use of roots for medicinal puposes/Health and wellbeing	17	All Europe (different species and their diversity)	Present in part of Europe, largely obsolete in some countries	Direct, both positive and negative (poisoning)	Part of general society, (locally in large scale), Researchers (pharmacologists)	Recreation and ecotourism CES,, Knowledge systems CES, Cultural diversity CES, Provisional ES
Fungi	Traditions and way of life connected to mushroom picking and use, attitude towards fungi/ Cultural diversity	34	All Europe (different species and their diversity)	Present	Direct, positive, indirect (use of traditions for films, art and literature, also for recreation	General society, tourists, Researchers (ethnobotanists, culturologists), Artists, writers, film makers	Recreation and ecotourism CES,, Inspiration CES, Knowledge systems CES, Health and well-being CES, Cultural heritage values CES, Sense of place ES, Provisional ES
Fungi	Linguistic diversity: vernacular names, phraseologisms/Cultural diversity	22	All Europe (different species and their diversity)	Present	Direct, positive	General society, Researchers (ethnobotanists, linguists), fiction writers	Inspiration CES, Knowledge systems CES, Provisional ES
Fungi	Folklore/Cultural diversity	6	All Europe (different	Obsolete (creation),	Direct and indirect (through	General society, Researchers	Inspiration CES,

			species and their diversity),	Present (use of tradition)	the use of folklore), positive	(ethnobotanists, ethnologists), fiction writers	Knowledge systems CES, Spiritual and religious values CES, Cultural heritage values CES, Provisional ES
Fungi	Beliefs, mythology, superstitions and symbolism connected to fungi and mushroom picking/Spiritual and religious values	17	All Europe (different species and their diversity)	Obsolete (creation, use (in part)), Present (use)	Direct, positive	General society, Researchers (ethnobotanists, ethnologists), fiction writers	Inspiration CES, Knowledge systems CES, Cultural heritage values CES, Provisional ES
Fungi	Attitudes towards fungi connected to religion and religious communities/Spiritual and religious values	3	Regional, mostly Eastern Europe	Present	Direct, neutral or negative	Individual religious communities, Researchers (culturologists)	Knowledge systems CES, Provisional ES
Fungi	Formal knowledge: use of fungi in various research areas/ Knowledge systems	25	All Europe	Present	Direct, positive and neutral (discussional research questions), Indirect (through the use of the research knowledge)	Researchers, General public	Cultural diversity CES, Health and wellbeing CES, Cultural heritage values CES, Provisional ES, Regulating ES, Supporting ES
Fungi	Traditional knowledge: use of fungi, mushrooming, etc./Knowledge systems	16	All Europe, more pronounced regionally ("mycophilous countries",	Present	Direct, positive and negative (erroneous knowledge)	General society, researchers (ethnologists)	Cultural diversity CES, Health and wellbeing CES, Social

			mostly Mediterranean and Eastern Europe)				relations CES, Provisional ES
Fungi	Use of fungi in various levels of formal and informal education/Educational values	7	All Europe	Present	Direct, positive	Teachers, students, general society	Health and wellbeing CES
Fungi	Mushrooms in literature, art, cinema/Inspiration	20	All Europe	Obsolete (creation, in part), Present	Direct and indirect (use of artefacts, literature, cinema), positive	General society, artists, writers, film makers, tourists	Cultural diversity CES, Recreation and ecotourism ES, Cultural heritage CES, Aesthetic values CES
Fungi	Aesthetic perception of fungi/Aesthetic values	5	All Europe	Present	Direct, positive to neutral (attitude towards aesthetics of fungi)	General society, artists, writers, film makers, tourists	Cultural diversity CES, Recreation and ecotourism CES, Inspiration CES
Fungi	Special interest groups, societies, “public scientists” connected to fungi/Social elations	7	All Europe	Present	Direct, positive	General society	Knowledge systems CES
Fungi	Social relations at various levels connected to mushrooming/Social relations	21	All Europe	Present	Direct, positive and negative	General society	Cultural diversity CES, Recreation and ecotourism CES, Sense of place CES, Provisional ES

Fungi	Sense of place connected to mushrooming/Sense of place	9	Regional (mostly Eastern Europe)	Present	Direct, positive	General society	Cultural diversity CES, Recreation and ecotourism CES, Social relations CES, Provisional ES
Fungi	Intangible heritage (traditions, folklore, cuisine, way of life)/Cultural heritage	13	All Europe	Present, part obsolete	Direct (creation, use in cuisine), Indirect (use of tradition, folklore), positive	General society, tourists, fiction writers, Researchers (ethnobotanists, ethnologists)	Cultural diversity CES, Recreation and ecotourism CES, Inspiration CES, Provisional ES
Fungi	Tangible heritage (artefacts, archaeological sites)/Cultural heritage	4	All Europe	Obsolete (creation) and present	Direct (creation of artefacts), indirect (use of artefacts), positive	archaeologists, tourists	Recreation and ecotourism CES, Knowledge systems CES
Fungi	Impact on human health and health of pets/Health and well being	31	All Europe, regional in some cases (stronger impact in "mycophilous" countries, Mediterranean and Eastern Europe)	Present	Direct, some positive, mostly negative	General society	Cultural diversity CES, Recreation and ecotourism CES, Knowledge systems CES, Provisional ES
Fungi	Mushroom picking as recreational activity/recreation and ecotourism	8	Regional ("mycophilous countries", mostly Mediterranean	Present	Direct, positive	General society, tourists	Cultural diversity CES, Health and well being

			and Eastern Europe)				CES, Provisional ES
Fungi	Use of fungi for monitoring and ameliorating recreation areas/ recreation and ecotourism	2	Regional (Portugal and Finland, but application may be universal)	Present	Indirect (through use of knowledge), positive	General society	Knowledge systems CES, Supporting ES, Regulating ES
Microorganisms	Impact on archaeological sites/Cultural heritage values	1	All Europe	Present	Direct, indirect (through use of archaeological sites), negative	Archaeologists, general society	Knowledge systems CES
Microorganisms	Formal knowledge: use of microorganisms in various research areas/ Knowledge systems	5	All Europe	Present	Direct, positive	Researchers, general public	Health and wellbeing CES, Supporting ES
Microorganisms	Use of soil microorganisms for ecotoxicological monitoring/Health and well being	1	All Europe	Present	Indirect, positive	Researchers, general public	Knowledge systems CES
Mesofauna	Use of mesofauna for environmental change indication/ Knowledge systems	5	All Europe	Present	Direct, positive	Researchers, general public	Recreation and ecotourism CES,
Mesofauna	Use of mesofauna to monitor recreation area quality/ Recreation and ecotourism	1	Regional	Present	Indirect, positive	Researchers, general public	Knowledge systems CES
Mesofauna	Use of mesofauna for children education/Educational values	1	All Europe	Present	Direct, positive	Teachers, schoolchildren	Knowledge systems CES
Invertebrate macrofauna	Folklore, attitude, linguistics/Cultural diversity	8	All Europe	Obsolete to present	Direct, positive	General society, Researchers (ethnologists, ethnozoologists)	Knowledge systems CES, Inspiration CES

Invertebrate macrofauna	Tradition of use/ Cultural diversity	4	Regional (Mediterranean, in parts Eastern Europe)	Obsolete to present	Direct, positive	General society, Researchers (ethnozoologists)	Knowledge systems CES, Health and wellbeing CES, Provisional ES
Invertebrate macrofauna	Beliefs and mythology connected to earthworms and ants/Spiritual and religious values	3	All Europe	Obsolete (creation), obsolete to present (use of the mythology)	Direct and indirect (through the use of mythology), positive	General society, Researchers (ethnologists)	Knowledge systems CES, Cultural diversity CES
Invertebrate macrofauna	Ants and earthworms in traditional knowledge and formal research/Knowledge systems	3	All Europe	Obsolete to present	Direct, positive	General society, researchers	Health and wellbeing CES, Provisional ES
Invertebrate macrofauna	Use of macrofauna at various levels of education/Educational values	5	All Europe	Present	Direct, positive	General society, educational institutions	Knowledge systems CES
Invertebrate macrofauna	Earthworms and ants in art, literature and cinema/Inspiration	6	All Europe	Present	Direct (creation) Indirect (use of art, literature and cinema), positive	General society, artists, writers	Aesthetic values CES
Invertebrate macrofauna	Aesthetic attitude towards macrofauna/Aesthetic values	3	All Europe	Present	Direct, largely negative	General society	Inspiration CES
Invertebrate macrofauna	Common interests – collectors of insects/Social relations	2	All Europe	Present	Direct, positive	General society	Knowledge systems CES
Invertebrate macrofauna	Impact on intangible heritage (folklore)/Cultural heritage values	3	All Europe	Obsolete (creation), present (use of the folklore)	Direct (creation) Indirect (use of the folklore), positive	General society, writers, researchers (ethnologists)	Knowledge systems CES, Inspiration CES
Invertebrate macrofauna	Impact on tangible heritage (archaeological	2	All Europe	Present	Direct and indirect, both	General society, archaeologists, tourists	Knowledge systems CES

	objects)/Cultural heritage values				positive and negative		
Invertebrate macrofauna	Food for game and bait for fishing/Recreation and ecotourism	3	All Europe	Present	Direct and indirect, positive	General society, tourists, hunters, fishermen	Health and wellbeing CES
Invertebrate macrofauna	Use of earthworms in folk and formal medicine/Health and wellbeing	2	Regional (Mediterranean, in parts Eastern Europe)	Present	Direct, positive	General society	Knowledge systems CES, Provisional ES
Invertebrate macrofauna	earthworms causing allergies/Health and wellbeing	1	All Europe	Present	Direct, negative	General society	Knowledge systems CES, Recreation and tourism CES
Vertebrate megafauna	Impact of burrowers on folklore and linguistic diversity/ Cultural diversity	4	All Europe	Obsolete (creation), present (use of the folklore and language)	Direct and indirect, positive	General society, writers, researchers (ethnologists)	Knowledge systems CES, Inspiration CES
Vertebrate megafauna	Traditional use of burrowers/ Cultural diversity	14	Regional (mostly Mediterranean, in parts Eastern Europe)	Present	Direct, positive	General society, tourists, hunters	Cultural heritage CES, Provisional CES
Vertebrate megafauna	Beliefs and mythology connected to burrowers/Spiritual and religious values	8	All Europe	Obsolete (creation and part of the tradition), obsolete to present (use of the mythology and beliefs)	Direct and indirect, positive	General society, researchers (ethnologists)	Knowledge systems CES
Vertebrate megafauna	Formal knowledge in ecological research/Knowledge systems	5	Regional (Southern and Western Europe)	Present	Direct and indirect (through knowledge use), positive	General society, researchers, territory managers	None
Vertebrate megafauna	Use of burrowers for children	1	All Europe	Present	Direct, positive	General society, educational institutions	Knowledge systems CES

	schooling/Educational values						
Vertebrate megafauna	Burrowers in literature, art and folklore/Inspiration	5	All Europe	Obsolete to present(creation), present (use of literature and art)	Direct and indirect, positive	General society, writers, artesans, tourists	Cultural diversity CES
Vertebrate megafauna	Hunting legislation, attitude towards conservation/Social relations	2	Regional	Present	Direct	General society, hunters	Recreation and ecotourism CES, Provisional ES
Vertebrate megafauna	Impact on intangible heritage (folklore, tradition cuisine)/Cultural heritage values	5	All Europe	Obsolete (creation), present (use of the folklore, tradition, cuisine)	Direct (creation) Indirect (folklore, tradition, cuisine), positive	General society, writers, researchers (ethnologists), tourists	Knowledge systems CES, Inspiration CES, Recreation and ecotourism CES, Provisional ES
Vertebrate megafauna	Impact on tangible heritage (artefacts, archaeological sites)/Cultural heritage values	4	All Europe	Obsolete and present	Direct and indirect, positive and negative	General society, archaeologists, tourists	Knowledge systems CES, Recreation and ecotourism CES
Vertebrate megafauna	Impact on hunting as recreation, animal observation and photography/ Recreation and ecotourism	7	Mostly regional (Southern and Western Europe)	Present	Direct, positive	General society, hunters, tourists	Knowledge systems CES, Social relations CES Provisional ES
Vertebrate megafauna	Impact of burrowers on human health/Health and well-being	10	All Europe	Present	Direct, mostly negative	General society	Knowledge systems CES
All organisms	Intrinsic value of all species	1	All Europe	Present	Direct, positive	Researchers	Knowledge systems CES