Non-Wood Forest Products in Europe

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Ecology and Management of mushrooms,
tree products, understory plants and animal products

Outcomes of the COST Action FP1203 on
European NWFPs

Edited by
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Content

1. Introduction

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1.1 Non-wood forest products

In Europe the multifunctional sustainable forest management paradigm is generally accepted. It aims at optimizing the provision of multiple goods and services which are demanded by society, while maintaining the equilibrium of the forest ecosystem. The need for meeting multifunctional demands as well as increasing the potential for commercialising a large set of different products and services has been recognised by the European Forest-Based Sector Technology Platform. In order to optimise the production of a range of products and services forest management requires tools to quantify the production possibilities of wood and various non-wood forest products and the impacts of forest management and changing environmental conditions (including climate-induced and emerging biotic and abiotic threats) in their provision. The provision of such information will facilitate the transition from timber oriented to multifunctional forest management. However, within European forest research, development and innovation have mainly focussed on timber production. While there is a lack of detailed information in Europe about the ecology or economics of non-wood forest products so it is not possible to model or devise management systems to promote a specialized treatment and production of selected products (e.g. truffles, resin, nuts, Christmas trees) and a sustainable co-production of non-wood forest products, timber and ecosystem services in the context of climate change. In several countries, statistics on NWFP and models are available but this knowledge is poorly utilized and disseminated and is not readily accessible across Europe.

According to the FAO definition (FAO, 1999) non-wood forest products (NWFP) are of "biological origin other than wood derived from forests, other wooded land and trees outside forests". NWFP can be derived from trees, understory plants, fungi or animals. They are collected from natural forests, or produced in plantations and agroforestry systems. Examples of NWFP include mushrooms, truffles, bark (e. g. cork), nuts, acorns and other tree fruits, resin, understory berries, medicinal and aromatic plants, fodder and litter for livestock, honey and game. A similar term often used for such products is non-timber forest products (NTFP). The main difference between them is that NWFP exclude all wood and NTFPs do not exclude wood other than timber such as fuel-wood, artisanal use of wood, charcoal or, more recently, value-added chemicals from biomass (bioenergy concept). There are also other terms used such as "wild collected products" as applied by the International Trade Centre UNCTAD/WTO (2007) for use in organic certification and is defined as "mainly products with a food, cosmetic or medicinal use that are collected in the wild". As shown in Figure 1.1 there is a large degree of overlap between NTFP and NWFP and they are largely treated as synonyms.

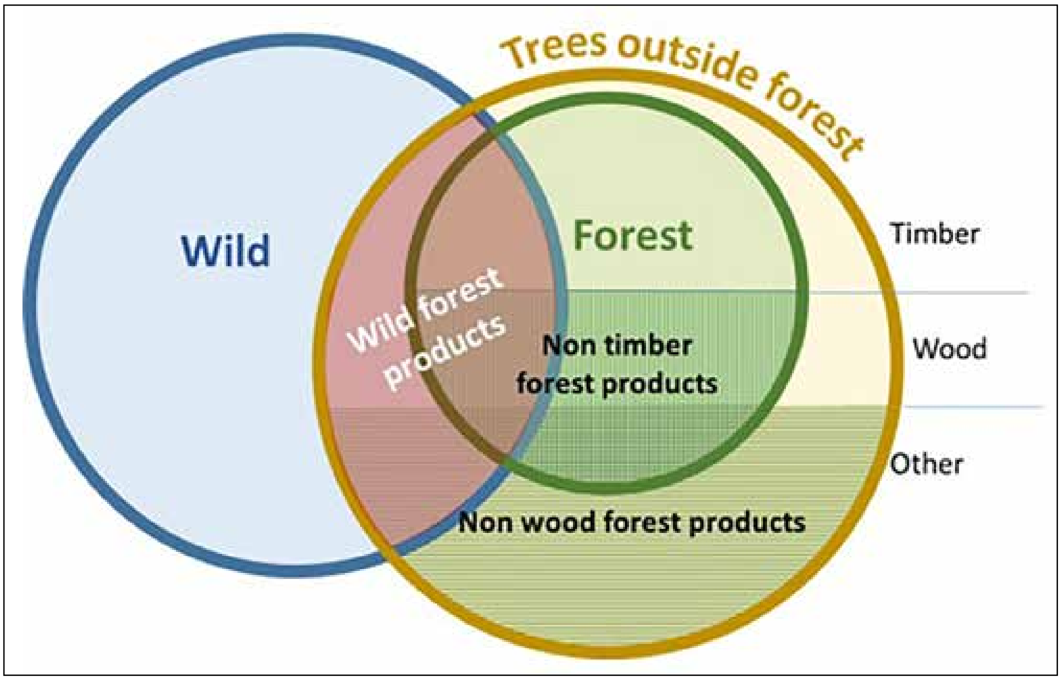

Figure 1.1: *Classification of non-wood forest products*

Both exclude timber (structural use of wood), fuelwood, charcoal and other industrial uses of wood such as paper pulp. There is some disagreement on the inclusion of 'other wood' which is generally interpreted as small sized wood for craft or subsistence uses. Tree products outside forest are usually included if they are not highly domesticated and so considered as agricultural or horticultural products (e.g. apples, palm oil). But species incorporated into agroforestry systems or cultivated in semi-natural habitats can be included (e.g. chestnuts in Turkey). Products which arose in the forest but have recently been moved into cultivation are likewise often included even though definitions exclude them as they are not tree products (Figure 1.1). “Wild forest products” (WFP) has been proposed as a term with greater relevance to the market than NWFP but apparently intended to incorporate elements of NWFP (include cultivated or semi-cultivated products) and NTFP (exclude non-forest land uses). However, the use of the term “wild” should properly only be used for animals and plants where production is spontaneous without human interference. The problem with the term „wild“ is that is not always easily to define the border between “wild”, “semi-wild”, “semi-domesticated” and “cultivated” (or “cropped”) products; the process of domestication as the opposite one of re-wilding are defining seamless categories, as represented in Figure 1.2. By the way, this is a problem well reflected by the similar problems of defining the borders between primary (untouched, virgin) forests, semi-natural forests, agroforestry-systems, plantations, orchards, and farmland. From these perspectives it seems evident that the terms WFP, NTFP and NWFP should not be treated as synonyms but as defining distinct, albeit overlapping, domains. In this book, we will refer to the term NWFP only, to support the reader in an easy interpretation of the information presented in various contexts.

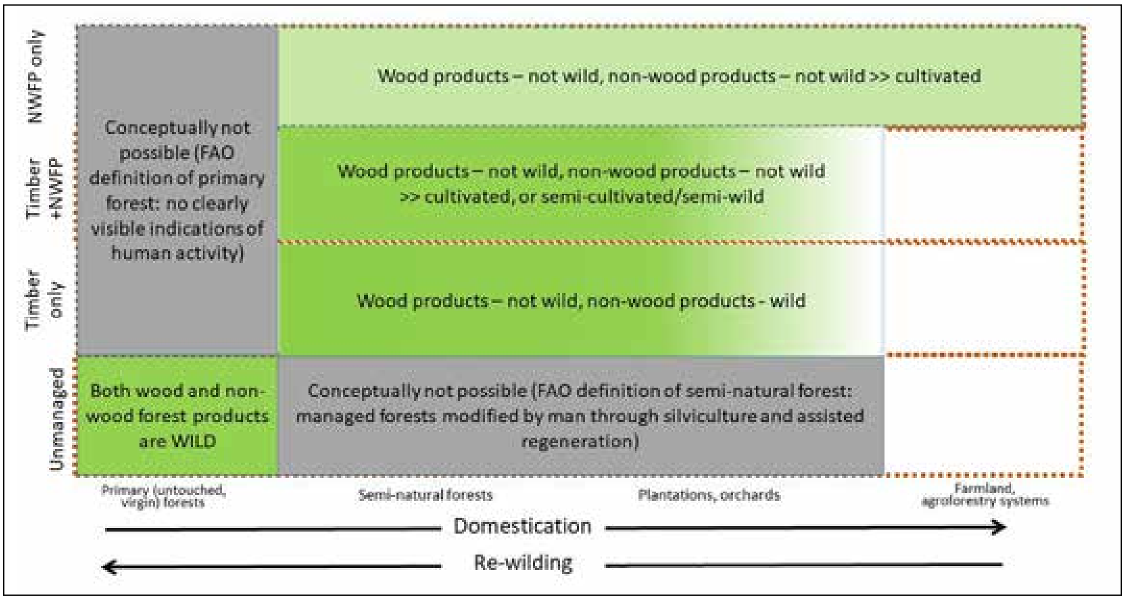

Figure 1.2: *Management and Production of non-wood forest products*

Due to the variety of NWFP products there exists a great diversity in management practices as well. Controlled harvesting of NWFP, conservation and enhancement of naturally growing species, cultivation of NWFP producing species and co-production of NWFP and wood production are common approaches. In response to the ongoing socio-cultural changes new management practices are evolving as well, which focus on rewilding food plants such as fruit and nut species. Those had been taken out of the forests to be cultivated as horticultural crops earlier, but are actively reintroduced in forests to stimulate new forms of forest food production now (Figure 1.2).

1.2 Providing evidence for NWFP collection and usage within Europe

NWFP importance differs between countries, therefore a comprehensive view on all their types across Europe is difficult to obtain. Examples of important NWFP in Boreal and temperate forests are Christmas trees, berries, mushrooms and game. Concerning Mediterranean forests examples of important NWFP are cork, pine nuts and mushrooms. Christmas trees, fruits, berries, edible nuts and cork represented, in 2010, 83 percent of the total value of marketed NWFP in the FOREST EUROPE region. The total reported value of marketed NWFP is approximately EUR 2.7 billion and has almost tripled since the State of European Forests 2007 assessment. In European countries where information is available the total value of marketed NWFP represented 15 % of the round-wood value (FOREST EUROPE, UNECE and FAO 2011). However, it is important to stress that these values are considered underestimated by authors of the reports and the quality of the existing statistical data (production/harvesting/collection) has been worsening in most European countries in the last decades.

Within the FP1203 COST Action: European non-wood forest products (NWFPs) network (http://www.nwfps.eu/) a common survey was initiated to provide a snapshot of the state of the art of NWFP collection and usage within Europe (see list of countries and MC members at http://www.cost.eu/COST_Actions/fps/FP1203?management). The identification of NWFP species and their derivative products was undertaken by means of an expert survey. Members of the FP1203 COST Action were asked to provide data for 20 important NWFP within their respective country. Questionnaires were distributed requiring respondents to nominate five important species within each designated product group, namely '**mushrooms and truffles**' thus encompassing all fungal products, **'tree products**' which includes tree fruits, leaves, flowers, sap and barks, '**understory plants**' (i.e. non woody plantlife) and finally NWFP derived from an '**animal origin**' which may include, but not exclusively meat, horn, bone, pelts, glands, feathers or honey products.

By taking an expert opinion approach a large quantity of data could be collected spanning the European continent in order to define important NWFP by identifying common species and the potential demands laid upon them. The data collection methodology can be considered subjective, yet the derived results collected within this survey provide a functional snapshot of NWFP use and production on a pan-European scale. Disseminated survey questions are given in appendix A.

Responses were received from representatives from 24 countries (23 European countries plus Morocco representing a near-neighbour country within the COST framework, see Figure 1.3). Data received represented a spread between northern counties such as Iceland and Finland to the southern Mediterranean regions. Central Europe is well represented within the dataset.

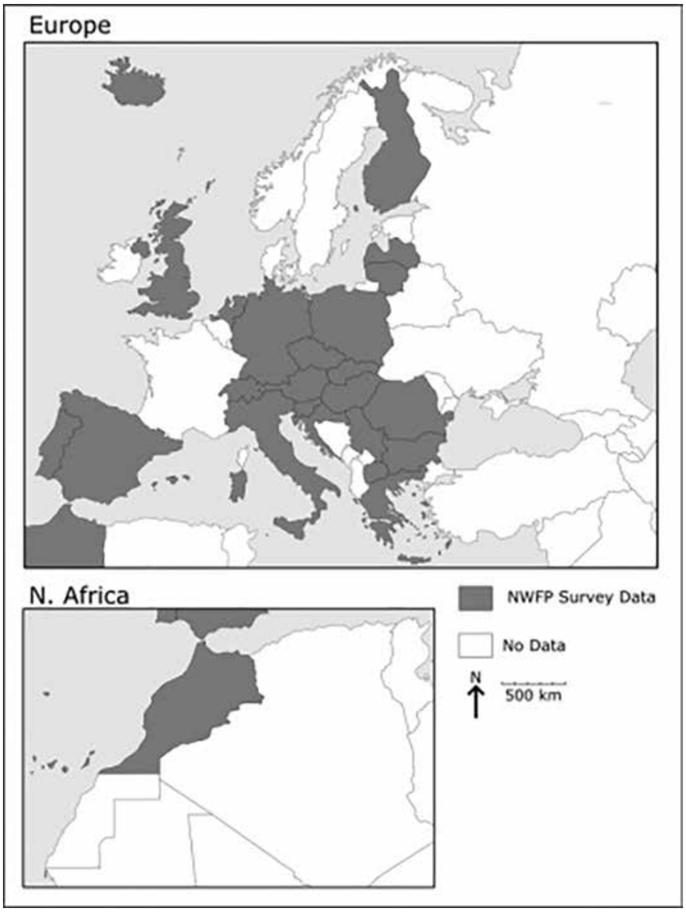

Figure 1.3: *Country responses for TF1 in COST FP1203 common survey*

1.3 Outline of the book

The FP1203 COST Action joined efforts at European level to gather existing information, reviewing it, and disseminating information to support the sustainable management of NWFP. This book presents the outcomes of this endeavour. The current state of knowledge regarding the ecology of NWFP (chapter 2), existing approaches in data collection, inventory techniques and available datasets (chapter 3) focusing on non-wood forest production across Europe will be presented.

Modelling NWFP in respect to their possible production systems (from plantations to natural forests) is a challenge due to the large differences compared to traditional modelling for timber production. Difficulties might arise for many reasons, singly or together such as: annual variability (masting), large and small-scale spatial variability, non-normality, lack of correlation with traditional forest site quality measures, little known autecology and lack of systematic data on production. Chapter 3 will provide an overview about the state of the art in modelling of non-wood forest products production across Europe with the aim of identifying and describing the existing models and predictive tools for NWFP.

Often NWFP are freely collected under open access regimes to be used directly by the collectors or sold in informal markets. Therefore a comparison of property rights regimes for NWFP across Europe is necessary as it forms the basis for understanding opportunities for improved NWFP management and production in the future. For forest management planning and decision support purposes, it is important to develop models that show how the characteristics of the forest and the management operations that change these characteristics affect the yields of NWFP. Management of NWFP requires knowledge of their ecology and an understanding of their role in different types of forest or silvopastoral systems as well as its economics, markets and legal regulations addressed by specific focused policies. Optimizing NWFP management and use can in some cases require adjustments to forest management that might not be compatible with maximizing timber yield. Therefore managing NWFP might require the implementation of strategies to support a truly integrated MSFM which takes into account the benefits of complementary product and services and the possible trade-offs between conflicting interests. The most recent findings on the production and management of NWFP are therefore compiled in chapter 4.

NWFP production in several regions is a significant source of income from forests. Valuing NWFP might be easy and straightforward in some of these cases (e. g chestnuts from northern Italy) but difficult in others (e. g wild edible mushrooms from the UK). This is due to the fact that only few NWFP are officially included in formal forest statistics and when statistical data are collected and published; its quality is often questionable. Additionally there is a growing interest of third parties to commercialize the collection of NWFP and decrease the potential income of private forest owners in bypassing their property rights. The traditional household-level collection and use seems to be decreasing and it is partly replaced by “professional like” berry and mushrooms pickers. This change has resulted in early-stage conflicts due to feeling that commercial utilization of natural resources is not in line with traditional habits and prevailing everyman’s rights. Chapter 5 will provide a representative picture of the topics under discussion when dealing with the problems and potentials of NWFP in the forestry sector, a branch that can effectively contribute to strengthening the role of forest resources in the new bio-based European economy.

The ecology of NWFP is diverse as they represent a wide range of products from not only non-woody parts of trees (e.g. resins, fruit) and understory plants but also from other taxonomic kingdoms such as animals and fungi. Since abiotic factors that shape the ecology and dynamics of forests vary from temperature limitations in boreal and high mountain areas, to water limitations in the continental and Mediterranean regions, it might be expected that climate change will have a wide range of effects on NWFP across Europe. European forestry is seeking to evolve beyond forest management regimes focusing on wood products. Alternatives go beyond new wood-based products as reactions to oversupply, important opportunities are on the production of "new" NWFP for answering the goals arising from shift to bioeconomies. Selected case studies will therefore provide an overview about the specifics of mushrooms and truffles (chapter 6), tree products (chapter 7), NWFP from the understorey (chapter 8) and animal products (chapter 9).

Throughout the whole book there are several "boxes" placed in the chapters, which highlight specific products and case studies from a variety of contexts.

A glossary of related terms supports the reader in the understanding of the underlying concepts, and definitions.

1.4 References

FAO, 1999. Towards a harmonized definition of non-wood forest products. Unasylva, 50 (1999/3)

FOREST EUROPE, UNECE and FAO 2011: State of Europe's Forests 2011. Status and Trends in Sustainable Forest Management in Europe. Ministerial Conference on the Protection of Forests in Europe. FOREST EUROPE Liaison Unit Oslo, Norway.

2. Identification and Ecology of NWFP species

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2.1 Introduction

Non-wood forest products (NWFP) are an integral share of good that are provided by forests. The trend within forest policy within Europe is increasingly moving towards a focus of multi-functionality, where alongside protective forest functions and services, a wide range of products can be derived in conjunction with timber production. NWFP are often used on a personal level to enrich a person's diet, their collection is frequently utilised as a form of recreation and social interaction or as an opportunity to generate income. NWFP are also utilised on a small and medium enterprise level but can also frequently be found as internationally established mass market products. The identification and ecology of NWFP concerns the recognition of a species, its use as a NWFP, and the specific conditions that the resource requires within the forested environment in order to flourish. Over past decades the increased utilisation and production of mushrooms and truffles have ensured that forest fungi represents one of the principal NWFP groups within European forests, this is in part due to their high economic, social and ecological value. With the exception of cork and similar products as special cases, tree derived NWFP such as fruits and nuts, but also barks, resins and leaves, although abundantly present within the forest are often confined to commercial plantations as their management and production within the forest is largely disparate with timber orientated silvicultural goals, a degree of compromise between production goals has been recognised for the successful culture and co-production of NWFP (Sheppard *et al.* 2016). Wild-harvested understory plants are widely utilised both privately and commercially, however, information remains scarce regarding population dynamics, sustainable production and harvest from a European standpoint. Similarly the use of products that are derived from an animal origin can be considered a key NWFP group; hunting as a form of recreation or as a means of species population control is widespread, with traditional roots throughout Europe, but is often considered parallel to forest management goals rather than as a direct objective.

A multitude of terms have been proposed to describe the derivation of products exclusive of wood and timber products from the forest, these include minor forest products, non wood goods and benefits, secondary forest products and so forth (FAO 1999, Belcher 2003). The established terminology for such products has been harmonised to describe such products as NWFP, a description which is generally accepted to encompass all tangible goods of biological origin (with the exception of wood products) that are derived from forests and wooded land, and also from trees outside the forest (FAO 1999). The term non-timber forest products (NTFP) is often used as a synonym although some definitions make further distinctions between wood and timber, by including small and fuel wood within the definition. Importantly forest services and benefits are excluded from the definition (FAO 1999)[1] . NWFP can be subdivided into two groups dependent on derived origin: a direct NWFP describes a product that is directly derived from a particular species i.e. cherries or walnuts from *Prunus avium* or *Juglans regia* respectively, whereas an indirect NWFP describes species that co-exist with trees when provided with certain site conditions that the overstory bestow, for example mushroom and truffle species. Such species representing sought-after NWFP are often not part of a predetermined forestry production goal but coincidentally co-exist due to particular site conditions, possibly induced or influenced by a pre-existing silvicultural regime.

NWFP have traditionally played an important role sustaining rural livelihoods all over Europe, especially in times of hunger (for example at the end of the First World War). Forest fruits, nuts and wild mushrooms were essentially gathered for food, tree barks for resin production or leather tanning, while acorns and leaves were used as fodder for domestic animals (Killmann 2009). Over time, numerous forest sites across the whole of Europe, became progressively subject to nutrient imbalances due to excess grazing and/or litter extraction, and as forest productivity and quality gradually decreased, the utilisation of NWFP became marginalised as management objectives shifted towards wood production. Nowadays, the socio-economic contribution of forests to livelihoods and the impact of their use on the environment are essential components of modern concepts for sustainable forest management and as a result, the value of non-wood forest products is being rediscovered. However, the estimated value of NWFP varies widely across countries, as most of them are site-specific, dependent on spatial distribution and may have only local importance, rendering it difficult to obtain an overview and comparable data for all types of NWFP across Europe (Forest Europe 2015).

Nevertheless, according to the latest data brought forward by the Ministe-

1 Further discussion on the definition of NWFP is given in Chapter 1.1 and Belcher (2003).

rial Conference on the Protection of Forests in Europe in 2015, the estimated total value of marketed NWFP in Europe amounts to 2,277 million EUR. Of this sum, 73% corresponded to marketed plant products and 27% to marketed animal products. The highest value generated by NWFP was reported by Central-West (1,054 million EUR), followed by South-West (EUR 807 million) and North European (EUR 246 million) regions. The lowest value was reported for the South-East (EUR 103 million) and Central-East (EUR 66 million) European regions. Data obtained from that report also show that ornamental plants (47%), food (here mushrooms are also included; 29%) and other plant derived products (21%) represented more than 97% of the total value of European marketed NWFP originating from/related to plants. Likewise, wild meat (51%) and wild honey and bee-wax (45%) also accounted for 96% of the total value of European marketed NWFP originating from animals (Forest Europe 2015).

Utilisation of NWFP varies widely across European countries. In several Northern and Eastern European countries, temperate and boreal forests are a traditional source of not only wood but also many other products that are extracted from forests, including resin, tannin, fodder, litter, medicinal and aromatic plants, fruits, nuts, roots, mushrooms, seeds, honey, ornamentals and exudates. Most of these products may be collected freely, while, a large proportion of the NWFP collection is actually intended for personal consumption, whereas only a small fraction of some of these goods (e.g. mushrooms, berries, herbs) is destined for commercial markets (both domestic and export). As an example, a study on the importance of the collection and use of NWFP for the inhabitants of the Czech Republic between 1998 and 2005, clearly showed that, the proportion of households consuming relevant amounts of collected NWFP in the Czech Republic was very high. For instance, mushrooms were collected by 90%, bilberries by 70%, raspberries by 43%, blackberries by 35%, cowberries by 12% and elderberries by 40% of respondent households. The main reason for NWFP collection was self-consumption in respective households (47%), followed by recreation and relaxation (41%) and last of all, in order to increase the family income (12%) (Šišák 2006). In contrast, in some Western European countries where private ownership is dominant in many forest areas, large quantities of NWFP are marketed and captured by official statistics as they play a key role in national economies. Firewood and fodder for grazing represent the two major NWFP groups in Mediterranean forests accounting for (27%) of total NWFP value each, closely followed by cork and other NWFP such as chestnuts, berries, acorns, and medicinal plants (Croitoru 2007).

CASE 2.1: Custodian of a regulated resource

A number of NWFP species may be identified as desirable and of interest for cultivation or collection; however, the collection of some species may by legally restricted, often for conservation purposes. One such product is the British bluebell (*Hyacinthoides non-scripta*) a native species in the UK, protected under international laws such as CITES (1973) and the EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora). The bluebell is often an indicator of ancient woodland due to its inherent longevity but vulnerable due to its slow growth and maturation. It can also be found in treeless landscapes in western Britain in areas of high humidity with bracken (*Pteridium aquilinum*) 'overstory'. This plant is both desirable for private gardens and interesting to the medical field due to certain compounds contained throughout the plant. Commercial cultivation from seed is time consuming from planting to harvest, and therefore, can often be considered uneconomical. Vera Bluebell Ltd. (www.verabluebell.co.uk) a company located in north Wales, harvests bluebells under licence. The sensitive harvesting of the resource within the terms of the licence enables the company to harvest and sell mature bluebells to the open market as a form of NWFP.

Figure 2.1: *Bluebell enclosure from which wild bluebells are harvested legally under license, North Wales. (Photo Credit: V. Thoss)*

Restrictions may also be placed upon collection of a resource concerning end use. For example the collection of mushrooms is an everyman's right within German forests, yet collection is limited to 2 kg per day per person and restricted to personal consumption. Nevertheless, a freedom to roam and a right of access is not a universal right within Europe. Many countries engage a system of trespass on private land; products, either wild or cultivated that are derived from that land are considered to be the property of the land owner, are restricted from sale and are the property owners sole right unless an agreement with a third party is reached.

Game are defined as harvested wild animals (hunted or live trapped), for whom a defined hunting season is laid out by law. Game embodies animals, covered by the valid legal acts, which have been hunted previously, are hunted presently or could be hunted in the future. The products derived from an animal origin can be considered a NWFP encompassing meat, horns/antlers, pelts, glands and bones from the harvested animal. Once again restrictions and regulation are frequently enforced to ensure the health and long term well-being of the game population. NWFP derived from game animals plays indispensable roles in the maintenance of complex, healthy ecosystems; as these ecosystems are indispensable to human well-being, the role of wildlife is also key. The greatest ecological values of game products are provided by a largely intact, healthy ecosystem – one that is capable of supporting significant populations of game animals and particularly large vertebrates.

Considering game animals, land or forest owners or hunters may be obliged to hunt species to negate damage caused to saplings/trees within the forest or to agricultural crops on the edges of forested areas. Today, game management is oriented to sustainable use and conservation of wildlife resources including the system of arrangements and economic measures to protect wildlife and their habitat, and improve habitat carrying capacity. Game management combines entitlements and obligations of involved parties. The main objects of game management are game and their habitats. It aims to regulate the use of wildlife resources managing their populations qualitatively, quantitatively and territorially, maintaining diverse and healthy wildlife populations and decrease damage caused by game to forest and other lands. Game management has to be compatible with the needs of wildlife considering complex forestry, agriculture and environment protection interests.

Figure 2.2: *Roe Deer (Capreolus capreolus L.) hunted on a driven hunt in southern Germany (Photo Credit: J Sheppard)*

The multipurpose use of trees in Europe might be regarded as less common than the level of utilisation in the tropics (Boland 1989; Hines and Eckman 1993). Important knowledge and guidance regarding silvicultural management, aiming for the dual production goals of both, timber and NWFP, is lacking. Current research in Europe on multipurpose land-use systems has been carried out particularly on agroforestry systems in the temperate (Dupraz 2005; Spiecker 2010; Morhart *et al.* 2014) and Mediterranean regions (Borges *et al.* 2009; Bugalho *et al.* 2009; Stara *et al.* 2015), but generally does not focus on multipurpose single-tree utilisation possibilities. While there is not enough distinct knowledge about specific growth parameter relations for all valuable European species, management tools, grounded on growth models, considering both, timber and NWFP production, (n many areas of Europe) would represent an absolute novelty to achieve an innovative and efficient tree use management, which is both economically viable and ecologically sustainable. Nevertheless, research is striving towards such a goal and in recent years such combined growth models are emerging (see for example Miina *et al.* 2010; Liu *et al.* 2016; Sheppard *et al.* 2016)

The ecology of NWFP is diverse as they represent a wide range of products from not only non-woody parts of trees (e.g. resins, fruit) and understory plants, but also from other taxonomic kingdoms such as fungi and animals. Due to this large diversity, lack of systematically collected data and, the traditional timber production dominated approach in forest management, their production possibilities are often poorly understood. Despite increased interest (both commercial and research orientated) within the field of NWFP at all levels, the production and usage of NWFP within Europe can be considered varied, disjointed and to date, under documented. This chapter aims to collate information regarding the importance of resource species and how they are applied within modern society, highlighting deficiencies, success and innovation within the field. We present the main problems and issues concerned with the identification and ecology of NWFP species within Europe and provide discussion and responses to the topic in order to become a reference point for future work in the field.

2.2 The identification of NWFP in Europe

The COST action FP1203 common survey[2] nominated a total of 174 unique species[3], this was derived from a total of 110 genera across all product types (Q 1-3)[4]. An overview is presented in the Figure 2.3a. The most commonly nominated genera for the NWFP type mushrooms and truffles were *Boletus /Xerocomus* spp. (n=27) largely representing ceps and other boletes, *Cantharellus* spp., consisting mostly of *C. cibarius* (chanterelle; n=21), and *Tuber* spp. and *Terfezia* spp. encompassing a wide variety of truffle species (*Tuber aestivum* n=7, *T. magnatum*

2 See Chapter 1.2 for any details concerning the methodology of the survey
3 A comprehensive list of all nominated species is given in the Appendix – Chapter 11.3
4 Survey questions can be found in Appendix – Chapter 11.2

n=3, *T. melanosporum* n=2 and *Terfezia arenaria* n=1) from central and southern Europe, additionally the desert truffles *Terfezia* and *Tirmania* spp (n=3) were also reported within Morocco. Three coniferous species were the most commonly reported tree genera associated with NWFP production, namely *Pinus* spp. (n=26), *Picea* spp. (n=18) and *Abies* spp. (n=16), these three genera were largely connected with the use of Christmas trees and as decorative branches. However, the derivation of resin, pine nuts (*Pinus cembra* and *P. pinea*) and medicinal products derived from buds (*Pinus sylvestris* and *Picea abies*) was also reported. Deciduous trees were also reported, the genera *Quercus* (n=12), *Castanea* (n=11) and *Betula* (n=10) were also frequently noted. *Quercus* spp. includes *Q. robur* and *Q. petraea* used for the production of acorns and as a source of tannin from within the bark. Notably reported by Mediterranean countries was the use of *Q. suber* as a source of cork (n=4). A widespread response was made for the *Vaccinium* genera throughout Europe (n=26), most commonly reported was *V. myrtillus* (bilberry, n=18) and *V. vitis-idaea* (cowberry/ lingonberry, n=7). *Rubus* spp. was also commonly reported, encompassing a wide number of understory berry species, most frequently blackberries and raspberries. Aside from forest berries *Allium ursinum* (wild garlic/ ramsons) was the third most frequently reported understory plant (n=7), especially nominated by central European countries. Large European game species were the most frequently reported concerning NWFP derived from an animal origin, namely *Sus scrofa* (wild boar, n=19), *Cervus elaphus* (red deer, n=19) and *Capreolus capreolus* (roe deer, n=15). The honey bee (*Apis mellifera*) was also frequently cited across Europe (n=15).

The concept of importance was explored within the common survey data (Q4), results are displayed in Figure 2.3b. Respondents from each country placed the greatest importance of NWFP on economy and thus the monetary value placed upon the derived NWFP. Recreation and diet was also reported to play a large role in the value of NWFP. Lesser roles were cultural heritage and products that were of a research interest. The most frequent miscellaneous importance placed upon NWFP was for game animals where a requirement for regulation of population was suggested a number of times. Few responses placed an importance of NWFP due to threatened production methods.

Usage (Q5) statistics are shown in Figure 2.3c wherein, mushrooms and truffles have been reported to be used almost exclusively as a source of food in Europe (99% of total responses), medicinal usage was also suggested (1%) e.g. *Ganoderma* spp. Similarly NWFP derived from an animal origin also demonstrated a high percentage of usage as a source of food (96%), smaller proportions were suggested to be used for decorative purposes (horn, skin and as trophies, 3%) and for reproductive material (1%). Understory plants encompassing herbs and fruits also demonstrated the highest proportion as a source of food and beverages (69% and 6% respectively). A higher usage proportion was seen to be from a medicinal usage as a source of pharmaceuticals (e.g. *Arctostaphylos uva-ursi*; bearberry or *Lycopodium clavatum*; stag's horn clubmoss) or directly used as

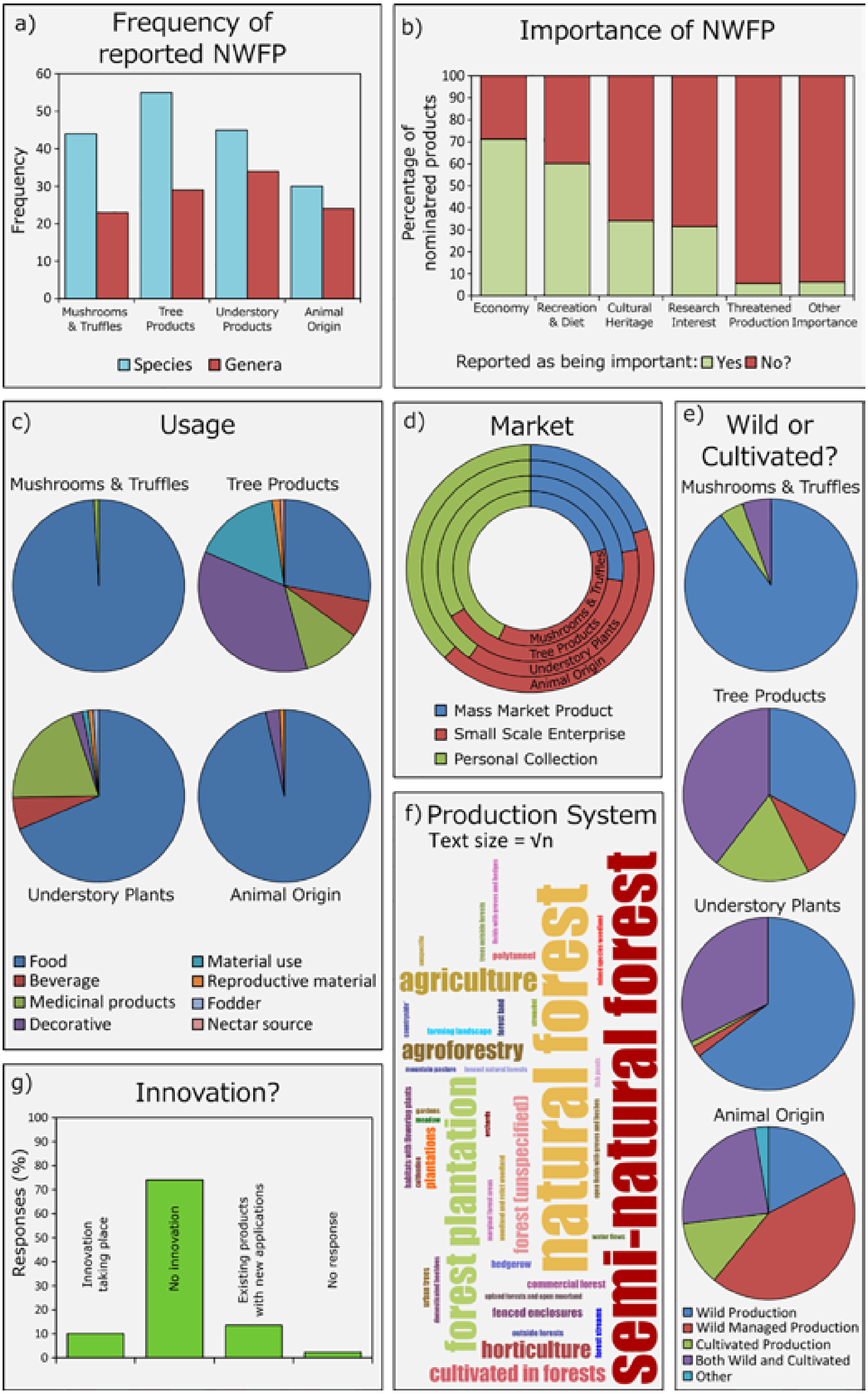

Figure 2.3: *Summarised results for importance, usage and production techniques of NWFPs*
(Source: COST Action FP1203 common survey)

medicinal herbs (e.g. *Urtica dioica*; common nettle, *Hypericum perforatum*; St John's wort or *Valeriana celtica*; alpine valerian). *Hyacinthoides non-scripta*, bluebell was nominated as a source of reproductive material, harvest of bulbs for sale and for research purposes investigating the chemical composition of the plant; for example this species is protected by law in the United Kingdom, its removal from the forest is only permitted under licence. The survey highlighted one company established in Wales[5] which markets certified native British bluebells seeds and bulbs under licence by Natural Resources Wales and the Welsh Government; this underlines the diversity of NWFP procurement and trade. Fodder was also cited as a minority use of grass species (e.g. *Dactylis glomerata*; cock's foot) grown within the forest. NWFP tree products reported a majority usage within the decorative product category (36%), this can be attributed to the use of whole trees as Christmas trees. A combined total for food and beverage use follows closely behind (35%) utilising the numerous nuts and fruits produced by tree species yet also including sap (largely *Betula* spp.; birch), flowers (e.g. *Tilia* spp.; lime and *Sambucus nigra*; elder) and extracts from bark with nutraceutical usages (e.g. *Pinus sylvestris*; Scots pine). Material use represents a proportion of direct NWFP usage, nominations include resin (n=9) derived from a number of pine species (*Pinus* spp.) and also Norway spruce *Picea abies* and *Pistachia lentiscus* var *Chia*, which is specifically used in the production of mastic gum. *Salix* spp. (willow, n=3) were also mentioned through their usage for basket making. Considering product type, respondents were asked to classify each nominated product using a pre-populated list (Q6). The group mushrooms and truffles consisted of 79% wild mushrooms and 15% truffles with only 2% and 4% designated for medicinal mushrooms and other product types respectively. Tree products were represented by a large proportion of tree fruits and nuts (31%) and use as Christmas trees (24%), 16 further product categories were utilised each totalling between 1% and 7%. Forest berries provided the largest response concerning understory plants, this was followed by culinary herbs with 10% of the total share of responses within this product type. Products derived from game animals and birds encompassed 78% of animal origin responses, broken down to 66% for game meats, 12% game birds and 1% horn. Bee products also gave a larger response, with 11% attributed to honey and 1% to beeswax.

Respondents were asked how they would classify a product's use and market within their country (Q7), three categories were assigned: mass market products, i.e. those that are widely traded nationally but also including international trade, small scale enterprises at a local scale, and personal collection where NWFP is collected and utilised on a non-commercial basis. Figure 2.3d provides an overview of the results collected within the survey divided between product categories. There is little difference between product category in terms of product type and spread between market types can be considered

5 Vera Bluebell Ltd (www.verabluebell.co.uk); see also Case 2.1

approximately even, each commanding approximately a third of the total share within the dataset.

Differences between product groups concerning cultivation (Q8) are visualised within Figure 2.3e. Respondents were asked whether individual products were 1) wild harvested, 2) harvested from wild managed populations, 3) cultivated, 4) could be derived from both wild and from cultivated sources or 5) whether a further method was apparent. Differences between product categories could be seen. The majority of mushrooms and truffle NWFP are wild harvested (90%), 5% are cultivated and a further 5% are from both wild and cultivated sources. Similarly, the majority of understory plants are also wild harvested (65%), yet a larger proportion is also derived from a combination of wild harvesting and cultivation (32%). The broad range of products available directly from trees shows the largest proportion obtained from both wild and cultivated stocks (39%), only 33% were reported within the survey to be derived from truly wild sources, a percentage that may by some be considered to be too high in general practice. NWFP derived from an animal origin shows differences from the first three product categories, the largest proportion (44%) is derived from wild managed stocks with few NWFP derived from animals come from truly wild stocks in Europe (17%). An example of other derivations is as a by-product of the timber industry, examples were reported of bark used as bark mulch from coniferous species.

Figure 2.3f demonstrates responses where experts were asked about the type of production system (Q9) that nominated NWFP were derived from. The reader should note that the text size within this figure is proportional to $\sqrt{n}$ (n=810). Natural (n=273) and semi-natural forests (n=258) were most frequently nominated as a source of NWFP. Forest plantations were also frequently cited as a source of NWFP. Agriculture, agroforestry and horticulture were also nominated multiple times. Combined results from all product types (Q10, n=466) showed that 38% of nominated products are derived from mixed species forests, 25% from single species forests, but a further 29% could be found in both mixed and single species stands. Furthermore, when considering species mixture (Q11) within such forest stands, approximately one quarter of responses showed preference for broadleaves stands, a further quarter for coniferous stands, 30% of responses suggested that there was no preference and NWFP could be found equally in broadleaved or coniferous forests.

Respondents were polled to ascertain the level of innovation found within NWFP (Q12). Experts were simply asked whether nominated products could be considered innovative or not or whether there were cases where existing products are utilised under new applications, results are outlined in Figure 2.3g. The large majority of responses reported no innovation (74%), while 10% of responses suggested that innovation is taking place. An example for an economical and innovative utilisation of a NWFP is that of Pap(p)illon GmbH in Germany[6]. The

6 Pap(p)illon GmbH (www.pappillon.de)

company produces and sells pillows and duvets stuffed with poplar seed fibres mixed with wool. The thin and hollow fibres are harvested by tree climbers. The collection of seed fibres also provides a service to urban environments removing the nuisance poplar 'fluff' and utilising them as a commercial commodity. Likewise, the Austrian company TrüffelGarten Urban&Pla OG[7] is a company specialising in the production of controlled mycorrhized seedlings and provides consultation for truffle plantation establishment and management; this displays innovation concerning the culture of truffle species for the gourmet market.

CASE 2.2: *Balancing the utilisation of a resource*

Archaeological findings show that during Neolithic ages, hunting was a dominant activity and food source: for example for Baltic tribes on the territory that is now considered present-day Lithuania. Game bones comprise more than 90% of osteological fossil record from this period in this region. Findings, folklore, folk art and Baltic mythology show that hunting was a matrix in which material and spiritual culture has spread. Today 70 species of mammals are found in Lithuania comprised of species of Central European broadleaved forests and East European taiga. Presently the hunting of 18 mammal and 16 bird species is permitted, for several decades; hunting policy has focused most on ungulates. The main ungulate game species are European Elk (idem moose) (*Alces alces*), red deer (*Cervus elaphu*s), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). Considered hunting policy allows for the mitigation of the effects of ungulates on forested ecosystems and concurrently maintains a healthy level of biodiversity. This upholds a need to consider local habitat conditions and species ecological requirements which emphasises the need to create and maintain a balance between forest/land vegetation and ungulate game animals.

Other mammals such as Eurasian beaver (*Castor fiber*) are considered a keystone species, but nonetheless, can presently be hunted and/or trapped as a game species in Lithuania. Despite a previous decline, almost to the point of extinction due to over-hunting, continuing human-induced landscape transformation and habitat loss in much of the species range, the Eurasian beaver has made a remarkable recovery due to the legal protection and targeted conservation measures. Such measures include hunting/trapping restrictions, reintroductions and translocations, natural recolonisation, land/water protection and habitat restoration.

7 TrüffelGarten Urban&Pla OG (www.trueffelgarten.at) – see also box 6.5 in Chapter 6

The species is still under special protection across Europe by a number of international legal acts as EC Habitat Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora) and Annexes II and IVa as species of "Community interest", of the Bern Convention (Appendix III). Harvesting of protected species is strictly controlled and, in general, is limited in most EU countries. Some countries have derogation for beaver management contrasting with the strict protection set out in the Directive. Beaver can presently be hunted and/or trapped as a game species throughout much of Eurasia including EU member states such as Sweden, Finland, Latvia, Lithuania and Estonia as listed in Annex V of the Directive. Considering its status, inherent damage caused to forests and agricultural land due to an increase in abundance, the beaver's role as a game animal has once again increased.

Other species such as the wolf (*Canis lupus*) has highly regulated hunting seasons for species protection where a hunting limit is set for this species. Abundant populations of some carnivore species as fox (*Vulpes vulpes*) and alien species such as Racoon dog (*Nyctereutes procyonoides*), American mink (*Neovison vison*) and others are hunted year-round. An appropriate trade-off between the advantages and disadvantages of hunting game species precedes the sustainable management of their populations and a reliable assessment of the environmental effects of their activities.

When comparing the derived results with the published figures from Forest Europe (2015) major differences can be seen between the two outputs. For plant derived NWFP decorative, craft and construction use totalled 19% (Forest Europe 47%) while food (including beverages) totalled 71% (Forest Europe 29%), a large disparity to the Forest Europe statistics, finally medicinal products totalled 10% of the total where the Forest Europe suggests a value of 1.5%. For animal derived products once again differences can be seen: 78% can be attributed to wild meats (including game birds) with 11% attributed to honey and 3% for decorative products, whereas 51%, 46% and 3% are attributed within the Forest Europe statistics respectively.

2.3 The importance of the NWFP resource

The qualification of NWFP importance is complex and different actors within the NWFP chain place varied importance upon the derived products. Importance is often coupled with local demands and other stimulus such as import and export demands which can shape collection and/or production where applicable. Within the Cost Action FP1203 common survey respondents were asked to categorise the importance of nominated NWFP[8]. Suggested categories within the survey included: 1) economic importance, 2) an importance for recreation and diet, 3) an importance due to threatened production by an external influence, 4) an importance as an object of research, and finally 5) that there is importance stemming from cultural heritage. As outlined within the results derived from the common survey suggest that the majority of NWFP have an economical importance, often overshadowing other reasons for collection or cultivation. This may simply be explained by the need for reimbursement for effort expended. Despite this observation Corona *et al.* (2016) suggest that estimating the economic value of NWFP is a complex issue, partly due to the fact that NWFP harvest and usage statistics are rarely reported to national statistics agencies in many countries. Furthermore, due to laws limiting the sale of collected goods in some countries, NWFP may have an economic value, but such currency value is restricted to the informal market (Šišák 2006). Economic value as a measure of the importance of a NWFP has the potential to mask its true value. Economic value is a measure of the amount that a specific actor is willing to pay in exchange for the goods in question, inflated value may be caused by rarity of the resource which in turn may be a function of growth conditions within a specific year, the lack (or abundance) of suitable habitat or the amount of consumer demand placed upon such a product (i.e. its desirability). The economic importance of a NWFP to the producer or harvester may be temporal but is a direct stimulus for the continued cultivation or collection of the NWFP. Economic importance can reach further than the value of the goods alone. Pettenella *et al*. (2007) suggested that the sale of recreational services (for example the issue of mushroom collection permits, myco-tourism, and guided collecting tours) may be a more relevant source of income than timber in some areas.

The common right to collect and use fruits from the forests may have an impact on the recreational function of forests. The possibility to collect mushrooms, chestnuts or walnuts for example can influence the recreational value of a forest stand. Therefore, tree species with a non-timber use, planted along forest paths and roads could provide an additional service for local citizens. Forests near to urban areas can be promoted and enhanced by producing NWFP for collection by the local people.

2.3.1 One species with many products

The use of one species as a source of NWFP is often not limited to one product. There are multiple species that provide desirable NWFP from different parts of the plant or animal. However, such multipurpose use trees are frequently

8 See also Chapter 1.2 for an overview about the applied methodology

not used for all products simultaneously. Within the COST FP1203 survey a number of examples were highlighted where such a multipurpose use was evident. These include for example:

- Willow — Salicylic acid (derived from sap), basket material
- Birch — Sap, bark, leaves and wood, also chaga (aka pakuri) fungus
- Rubus spp. — Fruit, leaves
- Game — Meat, trophies
- Cork oak — Cork, pannage, firewood

Furthermore, it is evident that in a number of cases a derivative from a plant part is used in multiple ways, for example the sap from birch is tapped and is frequently utilised as a beverage, either pure or further processed to produce sparkling beverages. There are also reported cases where the same raw product is further refined to obtain cosmetic ingredients, pharmaceutical or nutraceutical products. This for example can also be applied to birch sap, from which betulin can be derived. Betulin can be refined to obtain the more readily bioavailable betulinic acid as a pharmaceutical product. Such multipurpose use drives innovation, a readily available and unthreatened resource is desirable for the NWFP industry, likewise, the opportunity for the forester or land owner to capitalise on a resource is highly desirable.

2.3.2 One product with many species

Some products do not rely on one particular species for their production; many can be utilised for the same overarching NWFP. Such multiple source NWFP may arise from customer choice, i.e. outward appearance of the product, availability within a particular region and between cultural differences between one area and another. One prominent example is the use of Christmas trees. Used as a form of decoration during Christian Christmas festivities, it is traditional to bring a small conifer tree into the house and dress it with coloured decorations and lights. *Abies nordmanniana* is suggested to be the most frequently marketed Christmas tree in Europe (Frampton and McKinley 1999). The FP1203 common survey suggested that 14 species are utilised throughout Europe for this purpose, see Table 2.1. Similar trends can also be seen for other decorative items including those that are related to annual festivities including products such as conifer cones and decorative branches while bracket mushrooms, e.g. *Trametes versicolor*, are often used in floristics.

Table 2.1: Species utilised as Christmas Trees in Europe, data derived from the FP1203 common survey.

Fir species	Spruce species	Pine species
Abies alba	*Picea abies*	*Pinus contorta*
Abies fraseri	*Picea glauca*	*Pinus nigra*
Abies koreana	*Picea omorica*	*Pinus sylvestris*
Abies lasiocarpa	*Picea parryana*	
Abies nobilis	*Picea pungens*	
Abies nordmanniana		

Christmas trees can be considered the most important type of NWFP in Germany. In 2002, the economic volume of Christmas trees sold in Germany was about 500 million €. That equates to about 15% of the total volume of the German forest industry at that time (Weber 2006). 7-8 million trees were imported each year between 2000 and 2003. Most imported from Denmark, while approximately 1 million trees were then further exported to France, Austria, Switzerland and Poland (Weber 2006). The area on which Christmas trees are cultivated in Germany is hard to estimate. The Federal Statistical Office of Germany groups the culture of Christmas trees together with tree nurseries and short rotation plantations. It has been suggested that Christmas tree cultures in Germany amount to 50,000 to 75,000 hectares (Weber 2006). 95% of this land area is cultivated on agricultural areas or within special areas in the forest (Wegmann 2008), only about 5% of the Christmas trees sold in Germany are trees derived from forested land.

2.3.3 One product with many identities

Wild products carry an associated culture that conceptualises them differently in different contexts. These conceptualisations create different identities that very often are mirrored in species local names. Within the COST FP1203 surveys we studied mushroom local names aiming to examine the diversity and coherence of European mushroom cultures. We focused on the names of two ubiquitous, wild mycorrhizal mushrooms commonly used across Europe; the cep (*Boletus edulis*) and the chanterelle (*Cantharellus cibarius*) and species culturally significant within countries. Our results from 28 countries gave us more than 1,400 names for 45 species, almost all edible. Both the chanterelle and the cep proved to be commonly used across Europe, being representing with more than 400 and 300 local names respectively. Chanterelle's local names mostly liken the species with forest animals like deer, doe deer, hares and foxes, farm animals like goats, rabbits, gooses, hens, chickens and chicks, refer to the colour of the species that is described as the yellow of the egg yolk, the orange- yellow of the fire or the bright colour of a lighthouse. Following a different pattern the cep is mostly referred with the generic name "mushroom" or "good mushroom" that differentiate edible from similar non-edible look alike "bad" species of the same genus and confirms its highly appreciated value as safe to eat species. Other less referred cep's local names give us information about species texture, size, odour, biotope, harvesting time or value for money, while few liken the species with large animals such as calves, brown bears or little pigs (Stara et al. 2016).

Identities are not stable and can change completely through cultures or generations. The best example to show the ways different societies conceptualize natural products is mushrooms edibility. Edibility is not inherent in a species, but on the contrary is determined by culture and it can be defined by cookery, methods of processing and preservation, quantities of ingestion, as well as symbolic associations (Yamin-Pasrernak 2011), i.e. fly agarics (*Amanita muscaria*) or false morels (*Gyromitra esculenta*) are species perceived as "magic" or poisonous in some cultures and edible in others. However a new trend that advertize mushrooms as "wild food", imagined as coming from pristine forests, supremely natural, organic and ethical and opposite to the industrial food system is so sweeping that surpasses past dichotomies of mycophilic (mushroom-loving) and mycophobic (mushroom-fearing) cultures highlighting mycophagy from past famine food to a modern luxury.

CASE 2.3: *Falling from favour – the need to diversify*

NWFP like all other marketable commodities are vulnerable to market pressures and customer demands. Some trends are short lived where the importance of a particular NWFP is upmost for a short period following a trend for the use of a specified product. Other market fluctuations are longer term. Portugal has established itself as the world's largest supplier of cork, the main cork product is the production of cork bottle stoppers for the wine and Champagne industries. Wine producers are increasingly using synthetic and screw top bottle closures as it is suggested this ensures a more consistent product and may provide economic savings. Consequently, the cork industry faces a fall in demand for cork bottle stoppers and must diversify products in order to survive. Trade in NWFP like all other industries must make economic sense, the collection of wild sourced NWFP may prove expensive in terms of time invested in collection. This is justified when the price of the consumer product is sufficiently high to rationalise such costs, but must be carefully balanced when the market price is lower and production costs remain high.

2.4 Ecological requirements

The ecological requirements of NWFP are as broad as the variety found between species. This is reflected by the diversity of forested ecosystems within Europe. A large variety of species are utilised for the promotion of varied products, some demanding distinct ecological requirements for growth, while others have a more generalist strategy.

Under natural conditions the ecological requirements of a NWFP producing species can be broadly suggested to be influenced by tree species mixture and density, stand age (also influenced by even or uneven aged stands), site aspect, slope, soil composition and external influences such as applied management (or lack of) or disturbance events, such requirements are summarised in Figure 2.4[9]. Within these reports it was confirmed that NWFP in Europe present broad requirements for growth and are often highly specialised for the region that they are derived. Sheppard *et al.* (2016) explored management options for the increased production of selected NWFP, much of this work encompasses the acknowledgement of specific ecological requirements of NWFP in order to attain an end product.

The targeted production of one product may adversely or positively affect the growth of another by modifying the ecological conditions within a forest stand. The most marked conflict is often between the production of wood products and NWFP. Silvicultural treatments focused on the production of a wood product may dramatically modify the overstory, thus the ecological conditions of the understory. Likewise, careful consideration must be made towards how the production and collection of NWFP affects the ecology of cohabiting species, i.e. whether the action of production and collection modifies the ecology of the forest stand, a degree of compromise is required during forest planning operations.

When broken into two groups: direct and indirect products; indirect products, i.e. those not derived directly from forest trees in addition to the specific requirements of the trees within the canopy are also dependent on the microclimate brought about by the presence of trees or even their presence alone. Many mushroom and truffle species enjoy a symbiotic relationship with trees, others employ a saproxylic life strategy, thus depending on a source of deadwood; both strategies are dependent on the presence of trees. Similar to fungi, understory plants as an indirect NWFP in part (but not always) are dependent on the microclimatic conditions that the overstory bestows and are thus heavily influenced by the composition and structural variation within a stand.

The production of tree fruits (direct NWFP; including nuts, pomes, stone fruit etc.) is highly dependent on the position and health of the tree. Much research has been carried out within orchard systems, particularly involving

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9 The ecological requirements of selected NWFP species across Europe were introduced and discussed within the FP7 Startree project reports (Tomé and Faias 2014; Sheppard *et al.* 2016).

the culture of domesticated fruits such as apples, pears or stone fruits such as cherries or plums. Conversely limited research has been applied within a forested ecosystem, nevertheless, similarities and inferences can be drawn and applied. Selection of suitable geno- and ideotypes is common practice for fruit production within orchard systems. Genetics can control the size and quality of the harvested fruits, while the choice of ideotype (Donald 1968) allow a degree of manipulation regarding tree form. Furthermore, a suitable choice of provenance will ensure that the individual flourishes where established given the distinct set of ecological conditions it is presented with.

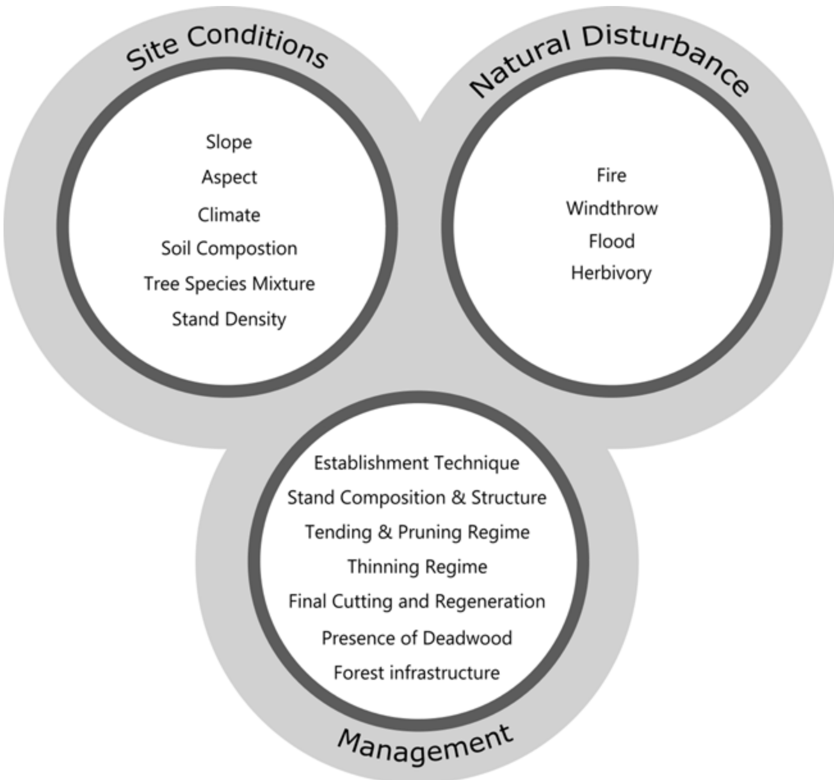

Figure 2.4: *Influencing factors effecting the growth and production of non-animal NWFP species*

A healthy tree of appropriate age in an ideal location will bear fruit, this is most often dependent on a strong well developed branch structure hanging upon sufficient supply of nutrient, water and light. Many of these factors are influenced by neighbouring trees and vegetation. Increased competition from other individuals may adjust the balance in available nutrient, water or light and thus may negatively affect a single tree's ability to produce the maximal amount of fruit. The abundant bearing of fruit is negatively linked with the production of biomass, plants experiencing high growth rates may not bear large volumes of fruit due to the simple allocation of resources within the organism (Jackson 2003; Kelc *et al.* 2007). This may present itself as a regular and natural event, referred to as biennial bearing, where a plant produces many seeds in one year at the expense of vegetative growth and vice-versa in alternate years. Biennial bearing may be a natural occurrence caused by excessive cropping in one year and less in the following (Jackson 2003), but may also be initiated by a climatic or other external factor. Such a phenomenon is common for example within walnut (*Juglans regia*) plantations. Single tree or stand level silvicultural treatments which alter the balance of nutrient, water or light availability may temporarily influence fruit production, for example by accelerating vegetative growth due to the release of an individual or by a pruning treatment that encourages new shoot growth. Orchard production techniques have endeavoured to reduce this effect to ensure a more uniform annual production, methods such as fruit thinning and targeted pruning are often applied, nevertheless, such management treatments are seldom employed within the forest

Individual climate events also present a large influence over fructification. External influences may affect fruit development at different times, namely: 1) flowering, 2) fruit set and 3) fruit growth. The development of fruit is highly susceptible to inclement climatic effects and other external factors. This may take the form of frost events (late frosts are of the highest risk when bud supercooling mechanisms are absent), high rainfall (thus promoting excess fungal infection), drought, high temperature, direct solar radiation (causing sunburn to fruits) or a lack of, or abundance of nutrient in the latter case causing excessive vegetative growth and thus adverse effect on flower formation due to self-shading (Jackson 2003). Ecological requirements also define the pollination of species, which often has a direct impact of the production of fruit. Dependent on pollination strategy (i.e. wind or reliance on insects) an absence of a clear pollination vector or an absence of compatible species will present a large influence on fructification. Considering indirect NWFP such as mushrooms and truffles, the influence of temperature and precipitation may be especially crucial for the formation and appearance of fungal fruiting bodies.

The management of forest trees has an impacting effect on the production of NWFP by the modification of stand conditions[10]. The application of a silvicultural treatment will alter forest floor conditions in terms of light, temperature and moisture, these variables are affected by the degree of canopy cover, harvest intensity, slash disposal approach and timber extraction method and can be influenced by the rate of consequent understory growth. The modification of currently applied silvicultural practice may provide the opportunity for increased NWFP production. Current research suggests that silvicultural practices can be applied to increase indirect NWFP provided by managemental synergies. The application of a thinning treatment is applied to increase the rate of growth (dimensions) and quality of the timber crop and often to stimulate natural regeneration. It has been suggested that ectomycorrhizal fruiting body production is linked to the growth and health of associated host trees. In research carried out by Egli *et al.* (2010) an increase of beech (*Fagus sylvatica*)

10 See also Chapter 4

associated ectomycorrhizal fungi was observed coupled with the rapid growth of released individuals. A similar outcome was reported by Bonet *et al.* (2004) and Liu *et al.* (2016) where the application of thinning treatments was used to decrease the density of older stands to order to enhance saffron milk cap (*Lactarius* group *deliciosus*) production.

NWFP may rely on disturbance events to flourish; this may include fire, soil disturbance, windthrow, flood, which may positively change the microclimate, light availability or nutrient status within the locality. Management of stands should note such requirements in order to increase production. For example *Vaccinium* spp. can be observed to benefit from both wild and prescribed fires, productivity increases after fire disturbance until a point where the forest canopy shades out the plant (Titus *et al.* 2004). This suggests that a level of disturbance resulting in removal of the overstory can be beneficial to the NWFP. Prescribed thinning regimes will also sufficiently alter the light regime at the forest floor boosting the opportunity for ground flora such as berry NWFP producing species (Miina *et al.* 2010), both the growth and reproduction of bilberry (*Vaccinium myrtillus*) are limited by light within dense forests, especially in dense spruce forests (Miina *et al.* 2009). Contrariwise, excessive cutting (for example during tree harvesting operations) may result in a reduction of bilberry cover (Atlegrim and Sjöberg, 1996; Bergstedt and Milberg 2001).

Indirect products may be present in forests since land disturbance for agricultural or other uses has means that forests provide a refuge. Likewise, such understory plants may be present on unforested land or within relic woodland holdings with little or no change in cover as a remnant of a previous ecosystem or land use.

The ecological conditions required for NWFP derived from an animal origin are somewhat different to other product categories; this is largely due to the fact that animals are mobile and will have differing temporal requirements either on an annual or seasonal basis. Animals are also generally adaptable to their environment and are often broad generalists, meaning that given the abundance of one foodstuff and not another will not result in the absence of the resource. Meanwhile, the presence of animal based NWFP also encompasses a further dimension of access and habitat availability. Human interaction and activity within forested ecosystems can greatly influence the suitability of a given area, either by increasing desirable food plants or providing suitable cover or alternatively by dissuading animal species from using, possibly by erecting boundaries and barriers, creating an absence of food stuff or simply by human presence. Meanwhile, the management and control of an animal population through hunting is also intrinsically linked to the harvest of the NWFP resource.

2.5 Conclusions

NWFP is a broad and extremely varied term describing a group of products derived from mushrooms and truffles, understory plants to tree products in many forms, but also including animals and animal products that are sourced from the forest. These diverse products in turn require a distinct set of ecological conditions for successful growth, conditions that can be modified by natural and man-made processes. Many of these products are naturally occurring and wild harvested, many can be encouraged and some are artificially cultivated within the forest utilising targeted silvicultural treatments for their promotion.

We have explored how one NWFP across Europe may possess a number of identities, based on how differing cultures conceptualise each product differently, we see that one species may provide a multitude of products, each derived from a different part of the source species or processed in alternative ways to produce further commodities. Finally we have shown that one product may be an assemblage of many similar species, that the minor differences between species are irrelevant to the final use of the product, this has been shown to be of particular significance for decorative items where aesthetics, individual choice and local availability play large roles.

The identification of NWFP involves the assessment of importance of particular products, the most important NWFP within Europe were nominated, the predominant perspective of European experts is that of economic importance, but within Europe this is often not equally applicable between countries due to differences in regulation and demand of distinct products. NWFP can also be important for recreational or dietary reasons or due to cultural heritage. We have also presented how products have an importance placed on them due to under- or over-exploitation, where either a product falls from favour is replaced by alternative technology and therefore the habitat or production system is threatened resulting in the loss of jobs or habitat or alternatively where a species has in the past been in high demand with limited regulation resulting in legislation to protect the resource from further damage. We report that innovation within the field is present but not dominant, innovation is evident where new products can be brought to market that utilise by-products or substitute a synthetic material or where species are regulated due to a protected status.

NWFP have been suggested to be predominantly sourced from natural and semi-natural forests but also from within forest plantations and alternative production systems aiming for combined production goals such as agroforestry. The range of required site conditions and natural and non-natural disturbances are as wide as the products themselves, with large disparities between direct (i.e. tree borne) NWFP and indirect derived products, further separated between plant and fungal kingdoms, that are somewhat static and reliant on consistent optimal conditions and the animal domain where a temporal dimension is required when considering ecological suitability. In conclusion there are vast differences in ecological requirements of NWFP, attributed to the life strategy of the derivative species. We have explored the differences between product groups and the critical differences between them. Ultimately for the successful growth and culture of desired NWFP an appropriate set of conditions must be present for individual species; this may hang on wider location or more specific microsite conditions, but may also be modifiable through management activities targeting the forest canopy or understory.

2.6 References

Atlegrim, O., Sjöberg, K., 1996. Response of bilberry (*Vaccinium myrtillus*) to clear-cutting and single-tree selection harvests in uneven-aged boreal Picea abies forests. For. Ecol. Manag. 86(1–3), 39–50. http://doi:10.1016/S0378-1127(96)03794-2

Belcher, B.M., 2003. What isn't an NTFP? Int. For. Rev. 5(2), 161-168. https://doi.org/10.1505/IFOR.5.2.161.17408

Bergstedt, J., Milberg, P., 2001. The impact of logging intensity on field-layer vegetation in Swedish boreal forests. For. Ecol. Manag. 154(1–2), 105–115. http://doi:10.1016/S0378-1127(00)00642-3

Boland, D.J., (Ed.) 1989. Trees for the tropics. Growing Australian multipurpose trees and shrubs in Developing Countries, ACIAR Monograph No. 10, Canberra.

Bonet, J.A., Fischer, C.R., Colinas, C., 2004. The relationship between forest age and aspect on the production of sporocarps of ectomycorrhizal fungi in *Pinus sylvestris* forests of the central Pyrenees. For. Ecol. Manag. 203(1-3), 157–175. http://doi:10.1016/j.foreco.2004.07.063

Borges, P.J., Marques, S., Borges, J.G., Tomé, M., 2009. Scenario Analysis Applied to Cork and Holm Oak Forest Ecosystems in Southern Portugal, in: Palahi, M., Birot, Y., Bravo, F., Gorriz, E., (Eds), Modelling, Valuing and Managing Mediterranean Forest Ecosystems for Non-Timber Goods and Services. Vol. 57. EFI Proceedings, Finland, pp. 49-56.

Bugalho, M.N., Plieninger, T., Aronson, J., Ellatifi, M., Crespo, D.G., 2009. Open Woodlands: A Diversity of Uses (and Overuses). in: Aronson, J., Pereira, J.S., Pausas, J.G., (Eds), Cork Oak Woodlands on the Edge: Ecology, Adaptive Management and Restoration. Island Press, Washington, pp. 33-45.

Corona, P., Cutini, A., Chiavetta, U., Paoletti, E., 2016. Forest-food nexus: a topical opportunity for human well-being and silviculture. Ann. Silvic. 40(1), 1-10. http://dx.doi.org/10.12899/asr-1181

Croitoru, L., 2007. Valuing the non-timber forest products in the Mediterranean region. Ecol. Econ. 63, 768–775. http://dx.doi.org/10.1016/j.ecolecon.2007.01.014

Donald, C.M., 1968. The breeding of crop ideotypes. Euphytica 17(3), 385–403. http://doi:10.1007/BF00056241

Dupraz, C., 2005. From silvopastoral to silvoarable systems in Europe: sharing concepts, unifying policies. In Silvopastoralism and Sustainable Land Management. Mosquera-Losada, M.R., McAdam, J., Rigueiro-Rodríguez, A., (Eds), CAB International, Wallingford, pp. 376-379.

Egli, S., Ayer, F., Peter, M., Eilmann, B., Rigling, A., 2010. Is forest mushroom productivity driven by tree growth? Results from a thinning experiment. Ann. For. Sci. 67(5), 509-509. http://doi:10.1051/forest/2010011

FAO, 1999. FAO forestry – towards a harmonized definition of non-wood forest products. Unasylva. 198(50).

Forest Europe, 2015. State of Europe's Forests. Ministerial Conference on the Protection of Forests in Europe. FOREST EUROPE, Madrid.

Frampton, J., McKinley, C., 1999. Christmas Trees and Greenery in Denmark, Production and Tree Improvement. Am. Christmas Tree J. 43(2), 4-11.

Hines, D.A., Eckman, K. 1993. Indigenous multipurpose trees of Tanzania: uses and economic benefits for people. Cultural Survival Canada, Ottawa.

Jackson, J.E., 2003. Biology of apples and pears. Biology of horticultural crops. Cambridge University Press, Cambridge.

Kelc, D., Štampar, F., Solar, A., 2007. Fruiting behaviour of walnut trees influences the relationship between the morphometric traits of the parent wood and nut weight. J. Hortic. Sci. Biotechnol. 82(3), 439-445. http://dx.doi.org/10.1080/14620316.2007.11512256

Killmann, W., 2009. Non–wood Forest Products for Livelihoods and Sustainable Development. In: Spathelf P. Sustainable forestry management in a changing world: a European perspective. Managing Forest Ecosystems 19. Springer, Dordrecht, 83-91.

Liu, B., Bonet, J.A., Fischer, C.R., Martínez de Aragón, J., Bassie, L., Colinas, C., 2016. *Lactarius deliciosus* Fr. soil extraradical mycelium correlates with stand fruitbody productivity and is increased by forest thinning. For. Ecol. Manag. 380, 196-201. https://doi.org/10.1016/j.foreco.2016.08.053 Miina, J., Pukkala, T., Hotanen, J.P., Salo, K., 2010. Optimizing the joint production of timber and bilberries. For. Ecol. Manag. 259(10), 2065–2071. http://doi:10.1016/j.foreco.2010.02.017

Morhart, C.D., Douglas, G.C., Dupraz, C., Graves, A.R., Nahm, M., Paris, P., Sauter, U.H., Sheppard, J., Spiecker, H., 2014. Alley coppice—a new system with ancient roots. Ann. For. Sci. 71(5), 527-542. http://doi:10.1007/s13595-014-0373-5

Pettenella, D., Secco, L., Maso, D., 2007. NWFP&S Marketing: Lessons Learned and New Development Paths from Case Studies in Some European Countries. Small-scale For. 6(4), 373–390. http://doi:10.1007/s11842-007-9032-0

Šišák, L., 2006. Importance of non-wood forest product collection and use for inhabitants in the Czech Republic. J. For. Sci. 52(9), 417 – 426.

Sheppard, J., Mangold, L., Spiecker, H., (Eds.) 2016. Revised silvicultural guidelines for selected MPT and NWFP. StarTree Deliverable 2.3. FP7 Project no 311919 KBBE.2012.1.2-06, European Commission.

Spiecker H (2010) Valuable wood production – An option for the future? For. Ideas. 16(1), 11–18.

Stara, K., Bonet, J.A., Wong, J., *et al.* 2016. Non Timber Forest products linguistic diversity. The case of mushrooms. Wild Forest Products in Europe, Barcelona, Spain. 13-14 October 2016.

Stara K, Tsiakiris R, Wong JLG. 2015. Valuing trees in a changing landscape: A case study from Northwestern Greece. Human Ecology 43: 153-167.

Titus, B., Kerns, B., Cocksedge, W., Winder, R., Pilz, D., Kauffman, G., *et al.* 2004. Compatible (or co-) management of forests for timber and non-timber values. in. One forest under two flags – Une Foret Sous Deux Drapeaux. Edmonton, AB, Canada. CD of proceedings of Canadian Institute of Forestry/Institut forestier du Canada and the Society of American Foresters Joint Annual General Meeting and Convention.

Tomé, M., Faias, S.P., 2014. State of the art, review of silviculture, models and decision support tools for multipurpose trees (MPT) and non-wood forest products (NWFP). Deliverable 2.1 of the StarTree project no. 311919 KBBE.2012.1.2-06, European Commission.

Weber, K., 2006. Christbaumhändler schauen zuversichtlich in die kommende Saison: Weihnachtsbäume in Bayern und Deutschland. LWF aktuell, 13, 8–9.

Wegmann, U., 2008. Das Ziel: so gross und fast so schön wie Marylin Monroe. Erfolgreich Christbäume im Wald produzieren. Wald Holz, 28–31.

Yamin-Pasrernak, S., 2011. Ethnomycology: Fungi and Mushrooms in Cultural Entanglements. In: Anderson EN, Pearsall D, Hunn E, Turn N. Ethnobiology. Wiley – Blackwell, New Jersey, 231-230.

3. Data & models: importance of assessing and forecasting non-wood forest products in Europe

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3.1 Assessing and forecasting NWFP as a tool for sustainable forest management

Non-wood forest products (NWFP) like cork, edible mushrooms, pine nuts, berries, acorns, resins, medicinal plants or hunting, among others, provide important recreational uses, cultural heritage and commercial incomes in the rural forested areas of Europe, being in certain regions more profitable than traditional timber harvesting. Due to the importance of these products, and based on the widely accepted focus on sustainability and multifunctionality in the European forests, non-wood forest production should be considered in the forest management and planning methods in Europe (Calama *et al.* 2010). Under the principles of Sustainable Forest Management (SFM), optimal management of NWFP requires reliable information about the availability, current stocking and spatiotemporal distribution of the subject resource at different operational scales. SFM related topics that require good quality information on the assessment of a given resource include a wide range of issues acting at different spatial scales (Wong *et al.* 2001):

- Monitoring the state of the resource and setting harvesting quotas at forest scale
- Demonstrating sustainability of a given harvesting practice
- Zoning areas for harvesting at local scale
- Planning of supply of raw material to resource-based industries at regional scale
- National level strategic and policy planning for these resources
- Global forest resource assessment

The accurate and unbiased assessment of the total amount of a given resource requires the application of scientifically sound methods for monitoring the resource at the forest, industry, household or trade-market levels. Good quality information for a specific resource can be obtained by means of biometric inventories, where the stock of the resource at the corresponding spatial scale is approached using statistical techniques as sampling (van Laar and Akça 2007).

Statistically sound assessment of timber and woody forest resources has received much attention in the scientific literature since the beginning of 20th century (Graves 1906; Bruce and Schumacher 1950; Spurr 1952). Continuously new techniques and more complex methods are developed to obtain better information of the current stocking of timber volume / biomass of the forests. Timber oriented inventories cover from forest-local scale demands to National Forest Inventories or International Assessments of forest resources. On the contrary, despite the importance of non-wood forest production, forest management planning in Europe has traditionally been wood oriented, leading to a lack of both reliable data and practical tools focusing on NWFP assessment and management. Scientific-based NWFP assessment has been described as a complex task due to different reasons (Wong *et al.* 2001):

- While timber and fuelwood are mainly obtained from trees, NWFP resource species include a wide diversity of life-forms, as trees, understory plants, shrubs, lianas, epiphytes, herbs. Additionally, non-vegetal resources are also considered: fungal communities, lichens, vertebrates as mammals or birds) and invertebrates such as insects

- Timber is obtained from the stem of the trees, while NWFP are located in a wide variety of plant (flowers, fruits, seeds, barks, leaves, branches, roots) or animal (meat, trophy, skin) parts
- NWFP include seasonal products, mainly of them perishable, thus assessment should be carried on specific dates. Moreover, while small interannual differences on timber stocking are detected (uniquely due to annual increment), large interannual variability is observed on many NWFP (e.g. masting), requiring continuous monitoring.
- NWFP include very rare or scarce products, not easily assessed by traditional sampling schedules, where only a few plots will contain the resource of interest
- Clumped distributions, with NWFP occurring in relatively dense patches within the landscape (Wong 2000)

Additionally, quantifying the production of some NWFP is also a complex issue since it often relies on cumbersome data collection methods, including the complete destructive harvesting of the resource. Think, for instance, of the time and resources required for identifying, collecting and classifying a number of mushrooms species collected from many stands in order to further measure them for their green and dry weight or number of sporocarps. On the other hand, measuring trees for assessing growth and timber production is a relatively simple task that, in addition, has traditionally benefited from technological developments and tools to ease data collection. Previous limitations result in very little information on both current and expected yield of NWFP included in inventories and managing plans at different operational scales. Surprisingly, more information is available from developing countries (for further information check regional publications on NWFP (FAO 2017) than from more developed nations, as is the case of European countries.

Assessing the availability of NWFP, where direct inventory is a difficult and time-consuming task, can be dealt by means of model-assisted estimation procedures (Mandallaz 2008). In this case, an external model relating NWFP yield to an easily measurable variable (e.g. tree diameter at breast height) is fitted and subsequently used to predict the dependent variable using data from common forest inventories.

Forest growth and yield models are mathematical and statistical tools whose aim is to contribute to understanding forests ecosystem dynamics, as well as to estimating current and future provisioning of a broad array of forest ecosystem services (Vanclay 1994). Therefore, they can be used for multiple purposes. On one hand, they allow researchers to gain insight into ecosystem functioning and, on the other hand, they can support science-based decision-making in forest management planning and policy-making. Thus, growth and yield models are often used to assess the provisioning of different forest products and services (including NWFP), as a response to changing environmental and social scenarios, under alternative management options and silvicultural schedules (Burkhart and Tomé 2012).

Historically, growth and yield models have mostly focused on those forest attributes more directly related to tree and stand dynamics, and their impact on wood production. This has been largely driven by the fact that, for decades, traditional forestry has seen the forest as a source of timber and woody biomass only. However, nowadays there is an increasing awareness from society and the forest sector that forest ecosystems provide multiple goods and services other than wood (Carpenter *et al.* 2009), and that NWFP are also of critical importance in sustaining and improving human livelihoods (as a source of food, economic income and recreation), and to further understand forest ecosystem functioning and dynamics. As a consequence of such broader recognition of the multifunctionality of forest ecosystems, there has been an increasing interest towards the development of models that explicitly consider NWFP such as wild mushrooms and fruits, resins, cork, or many other, which has further contributed to understanding the trade-offs and synergies between the provisioning of different wood and NWFP under alternative management schemes. As different recent examples see Sánchez-González *et al.* (2015) for a wide overview on NWFP models, de-Miguel *et al.* (2014) for recent mushroom models, Calama *et al.* (2016) for pine cones, Turtiainen et al. (2016) for wild berries and Tomé *et al.* (2015) for cork.

However, as in the case of assessing resources, developing models for different NWFP is not an easy task, and often proves much more difficult than traditional model only focused on tree growth and wood production (Calama *et al.* 2010). The main reason for such complexity arises from the difficulty to get appropriate, good-quality data concerning the provision of relevant NWFP to feed model development. Indeed, the quality and utility of growth and yield models highly relies on the quality of the data used to build them. The quantity and the quality of data for modelling purposes will largely determine the precision and accuracy of model-based estimates and predictions, their range of applicability and, in the end, their ability to simulate real forest conditions and dynamics. Unlike measuring wood production, which may be sometimes even estimated based on temporary plots (one single measurement of the trees based on tree-ring analysis), data collection from most NWFP requires the establishment of permanent sample plots in order to be able to monitor the provision of a given NWFP over time. This is because many NWFP such as tree nuts, wild berries or mushrooms are produced only once a year during a given time window according to the phenology of the species involved. Furthermore, NWFP production is often largely influenced by environmental factors and their fluctuation (e.g., changes in annual weather conditions), which force researchers to measure such effects during many years. What is more, some NWFP such as edible mushrooms are very ephemeral (i.e., they may last only for a few days before they are discomposed or consumed by wild animals or humans), which thus requires frequent, intensive monitoring to prevent missing valuable information.

The main objective of this chapter is to review the current state of the art on NWFP data acquisition and NWFP modelling (chapter 3.2), as well as on presenting datasets and predictive models nowadays available at a European scale (chapter 3.3), also considering near neighbouring countries. The review will focus on identifying gaps in geographical regions (chapter 3.4), analysed subject products or potential end users of the tools. Innovative proposals, as the use of model-assisted based inventories or approaches relying on expert-based knowledge, will be presented as alternatives to traditional methods. Finally, we will present guidelines and recommendations for improving and homogenizing NWFP data collection and modelling in Europe (chapter 3.5).

3.2 An overview over current data on NWFP at European-level

This chapter focus on the state of the art on data collection, inventory techniques and available datasets focusing on non-wood forest production across Europe and neighbouring countries. We aimed to include any group of data on NWFP collected with the main aim of forest/product management, national/regional estimates of production, and supply to industry. To deal with this we used the responses from the common survey questionnaire presented in chapter 1.

3.2.1 Analysis of the geographical areas and the type of products more commonly inventoried or included in data sets

Questionnaire was disseminated to 29 COST involved countries, of whom twenty-three countries responded (see ch. Three countries – Germany, Netherlands and Bosnia-Herzegovina – reported no information on existing data sets or inventories for NWFP. The remaining twenty countries reported 238 answers. In a first filtering process, we eliminated those responses uniquely including information on the introduction chapter, but not supplying additional information on inventory or dataset sections, resulting in 215 available answers (Table 3.1). At a country level, the number of valid responses ranged from one – Latvia – to twenty-two – Spain – with twelve countries providing ten or more answers. Eight countries reported information on datasets and inventories in the four main categories of NWFP types, while four countries only provided responses in a single category.

Concerning the main type of products, 60 responses on datasets and inventories corresponded to WG4 – animal origin – products, while 59 were included in WG1 – mushrooms & truffles – and 48 in each of WG2 (tree products) and WG3 (understory plants) categories. A more detailed analysis of the type of products involved (table 3.2) reveals that the type of products where more information is available are wild mushrooms (51 records from 14 countries), game meat and trophy (44 records from 16 countries), forest berries (31 records from 10 countries), tree edible fruits&nuts (21 records from 9 countries) and medicinal&culinary herbs (14 records from 7 countries).

At genus/species level, the products largely represented in the data sets focusing on NWFP at European level are ceps (mushrooms from *Boletus edulis* and closely related spp.), with 15 records from 13 different countries; berries from the genus *Vaccinium* sp., with 14 records from 10 countries; red deer (*Cervus elaphus*), 13 records from 13 countries, and wild boar (*Sus scrofa*), with 11 records in 11 countries. Apart from these products showing a widespread distribution across Europe, there are some very important NWFP with a restricted geographical distribution, but which are intensively surveyed in the countries where are present. As an example, cork from *Quercus suber* and pine nuts from *Pinus pinea*, where we find datasets on annual production from Spain, Portugal, Morocco and Italy, the main countries where the species grow in the territory, or truffles (*Tuber* spp.), widely surveyed on the Mediterranean region. On the contrary, some very interesting products with a wide distribution and production across Europe, as chestnut from *Castanea sativa* or Christmas trees are uniquely monitored in a few countries.

Table 3.1: Valid records per country and NWFP type in existing datasets and models (Source: COST Action FP1203 common survey)

		NWFP General Type				
	COUNTRY	**Mushrooms & truffles**	**Tree products**	**Understory plants**	**Animal origin**	**Total**
DATA SETS & INVENTORIES	Austria		4	2	4	10
	Bulgaria	5	6	4	3	18
	Croatia				5	5
	Czech Republic	1		5		6
	Finland	3	1	2	1	7
	North Macedonia	5	1	4		10
	Greece	5		5	5	15
	Iceland		3			3
	Italy	5	5		5	15
	Latvia				1	1
	Lithuania	3	3	4	5	15
	Morocco	5	4	3	4	16
	Poland	5	6	4	4	19
	Portugal	5	4		5	14
	Romania	4	1	6	5	16
	Slovakia	4	3	4	2	13
	Spain	6	6	4	6	22
	Switzerland	2			1	3
	United Kingdom				4	4
	Turkey	1	1	1		3
	TOTAL DATASETS	**59**	**48**	**48**	**60**	**215**
MODELS	Finland	4		5	2	11
	Greece				5	5
	Lithuania	3	2	4	5	14
	Poland			1		1
	Portugal		2			2
	Spain	4	9	1	2	16
	United Kingdom				3	3
	TOTAL MODELS	**11**	**13**	**11**	**17**	**52**

3.2.2 Aim and spatiotemporal extent of the inventories

The main part of the information concerning production of NWFP in Europe is collected at national or Regional scale, with the main aim of including it into the National/Regional Forestry Statistics (89 records up to 215, table 3.3). The objective of these forestry statistics is to provide annual information a regional or national scale on production, harvesting and trade statistics for forest products. Apart, general information on such topics as woodland area; annual planting activity; employment, finance & prices, etc. is also provided. While the main part of the statistics relies on timber and roundwood production and trade, many countries are including nowadays information on NWFP (see for example MAGRAMA 2013). In our survey, thirteen countries reported to have information on NWFP production published in these statistics, covering the whole range of NWFP. The largely represented products are those from animal origin (mainly game), with almost 50% of the records presented in these type of statistics, while only 30% of data concerning mushroom and truffle production are presented under this format. Information compiled on Forestry Statistics reflects the production harvested / collected / marketed from the forests. In this sense, data on production is collected after the harvesting process by the national/regional agencies with an annual frequency.

National Forest Inventories (NFI), widely extended in European countries, are ongoing programs aiming to provide continuous information about the stocking, size, distribution, composition and condition of forest and woodlands at national/regional scale, as well as on the changes takin place in the forests through time (Tomppo *et al.* 2010). NFI relies on a net of permanent plots where sampling inventories are carried on a regular frequency ranging from 1 – 10 years. Unlike forest statistics, NFI focuses of the total stock growing on the forests, thus providing information on potential productivity of forests. Given the frequency and sampling techniques used in NFI, only a few NWFP are considered into NFI (see table 3.3). NFI plots are visited once during an inventory cycle covering several years, at not fixed dates, so it is not possible to obtain accurate sampling estimates of those seasonal, perishable products with different collection periods, as is the case of mushrooms of berries. However, largely represented products in NFI are tree-origin products, what seems logical as inventory focuses on trees, and in general cases, are products collected with annual (e.g. fruits) or multiannual (e.g. cork, see Case 3.1) frequency, so at any date it is possible to make estimates on total production. Another alternative is the use of indirect methods – as models – permitting extrapolation of NWFP from the NFI estimates of tree stocking. Finally, game is largely represented in this category, but due to the existence on some countries of specific national inventories on hunting is independent of NFI.

Table 3.2: Valid records per type of products in existing datasets and models (Source: COST Action FP1203 common survey)

NWFP general type	Category	Datasets	Models
Mushrooms & Truffles	Truffles	8	
	Wild mushrooms	51	11
Tree products	Christmas trees	6	
	Cork & Barks	7	4
	Edible fruits & nuts	21	7
	Flower & wildgreens	4	
	Reproductive material	4	1
	Resins & exudates	4	1
	Tree sap	2	
Understorey plants	Flower & others	3	1
	Forest berries & edible fruits	31	8
	Medicinal, Culinary & Others	14	2
Animal origin	Game birds	9	4
	Game meat	41	12
	Honey	4	
	Other	3	1
	Trophy & recreation	3	
	TOTAL GENERAL	**215**	**52**

A third source of information at national scale is that defined as other country-level inventories, where we have included all the national initiatives aiming to provide an overview or a *still photograph* on the potential production of a given product for a given region/country. This approach has been used mainly to obtain estimates at national level on products as mushrooms and berries. In this type of inventory, collection of data is only performed once, commonly by means of questionnaires to collectors and enterprises.

At lower spatial scales, not aiming to provide general information at national or regional level, we find a main source of information on NWFP in the specific inventories collected within the framework of research projects.

These datasets are used for different objectives, which include identification of main factors affecting production, model building, interannual variability, management guidelines, value chain analysis. As an example, an important part of the information related with mushroom and truffles production derives from these kind of research initiatives. Spatial and temporal extent of these databases cover the research timeline, although on some occasions go beyond these limits, conforming an interesting source of permanent information (e.g. see Calama *et al.* 2016). In addition, the detailed information required in research projects provides information at very restricted temporal scales, as are weekly estimates for mushrooms and even daily collection of data for birch sap, although on many occasions inventories for research are not carried on a regular basis.

The final source of information on NWFP production are the inventories for management at forest management unit. The main aim of these inventories is to provide information on the current and expected future yield of a given NWFP in a specific management unit, in order to consider the collection and trade of the product in the forest management planning. These inventories are carried out by local forest services and forest owners. Spatial scale is restricted to the management unit, and frequency of data acquisition is defined by the validity of the forest management plan (commonly 10 years). However, for some products, as mushrooms or game, management plans are updated every year with yearly collected information.

Table 3.3: Type of inventory / data set according to the general category of NWFP monitored

	NWFP general type				
TYPE OF INVENTORY	**Mushrooms & truffles**	**Tree products**	**Understory plants**	**Animal origin**	**Total**
National/Regional Forest Statistics	18	20	22	29	89
National/Regional Forest Inventory	2	15	3	11	31
Other country-level inventory	5	2	6	7	20
Other (e.g. project databases)	22	5	9	2	38
Management inventory	12	6	8	11	37
Total	**59**	**48**	**48**	**60**	**215**

3.2.3 Data collection techniques

The technique for collecting data will depend, firstly, on the spatial scale and aim of the inventory, and secondly, on the type of NWFP product (table 3.4). Information included on National/Regional Forest Statistics is mainly collected by means of post-harvesting estimates, as post-crop visual estimates, mandatory weighing of production out of the forests, declaration by collectors, number of issued harvesting licenses, etc. Dissemination of questionnaires to owners, collectors and sellers as well as collection of data from purchase centres are complimentary techniques largely used. Local forest services or specific research institutes collect and compile the information and then send it to the national agency in charge of harmonizing, processing and publishing the information. Despite the huge differences, methodology for collecting and processing information for national forest statistics is quite homogenous among type of products and countries.

Table 3.4: Data collection technique according to type of inventory / data set

	Management inventory	National / Regional Forest Inventory	National / Regional Forest Statistics	Other (e.g. specific databases)	Other country-level inventory
Sampling inventory	13	13	10	7	4
Expert estimation	21	5	0	1	1
Questionnaires to owners/sellers	0	0	13	11	0
Questionnaires to collectors	0	2	11	4	15
Post-harvesting estimation	1	6	34	1	0
Markets / Income	1	1	14	1	0
Combining methods	1	0	0	10	0
Indirect methods	0	4	0	0	0

On the other hand, both NFIs and management inventories, which focus on the current existing stocking of the product within the forest, requires accurate pre-crop estimates of NWFP. Pre-crop estimates require the quantification of the amount of a given product that can be obtained at a given area of forest. While estimates covering the whole study area can be carried out by means of complete censuses, product assessment is commonly carried by means of either quantitative sampling inventories of the product in the forest, or giving estimates provided by experts.

CASE 3.1. *Improved assessment of the production of cork in Spanish National Forest Inventory*

Cork production is the most important source of revenue in cork oak stands (Borges *et al.* 1997), and it is considered the key element in the preservation of these systems (Campos *et al.* 2008). The importance of the cork oak and cork in Europe is reflected by the fact that the most extensive forests are concentrated in the Iberian Peninsula, located in the south of Europe and it is made up of Portugal and Spain, representing 34% and 27% of the world cork oak forests, respectively (Sierra-Pérez *et al.* 2015). The production of cork is also located mainly in the Iberian Peninsula which hosts the highest rates of global extraction of cork, more than 80% (Sierra-Pérez *et al.* 2015). Given the importance of the cork sector, it is important to have accurate estimations of the cork production at the regional and the national level not only for accomplishing international reporting requirements, but also in order to provide this information to the industrial sector. Within this framework, it seems logical to use the information given by the National Forest Inventories, whenever it would be possible. The correct assessment of the debarked area produced by a cork oak requires, at least, two variables to be recorded: cork thickness and the debarked height. In Spain, these variables were recorded in the second Spanish National Forest Inventories (SNFI) and accurate estimations of the debarked area in Spain at the National level could be obtained. Since in the 3SNFI the inventory methodology changed and the cork thickness was not measured, it is not possible to properly assess the cork production using the available data from that inventory. In order to amend this situation, the 4SNFI has been improved recently, since September 2016 additional data are being collected for estimating the cork production in both quantity and quality.

Figure 3.1: *Extracting cork samples in Spanish National Forest Inventory*

The cork data that collected in all trees in the plot are cork thickness, total debarked length and the number of debarked branches. These variables will allow the accurate calculation of cork production quantity but also allows monitoring the trends in management in terms of debarking pressure. In addition, cork samples of 5 cm of diameter are being taken in four cork trees per plot (figure 3.1). These cork samples will provide the following data:

- Cork age, i.e. years since the last debarking, which gives information about in which stage of the debarking period the cork oak forest was in the moment of the inventory and about the cork quality in terms of cork thickness growth

- Cork density, which jointly with the debarked area, provide the weight of cork
- Annual growth of cork, which can be link the growth of cork with climate
- Cork porosity and the presence of anomalies that besides cork thickness complete the information about cork quality

With this information, the Spanish National Forest Inventory will provide valuable information to fulfil the objective of quantifying accurately the production of cork in Spain at the regional and national level.

Sampling techniques include collection, counting or visual estimation of the product in the whole study area (censuses), or more commonly, in quadrats, permanent plots or lineal transects (Wong *et al.* 2001). Units to be sampled can be selected by means of either random, systematic, stratified or multi-stage (e.g. trees are measured in plots, and fruits are collected in a subsample of trees). The yield of plant origin products – as mushrooms, berries, cork or tree fruits – is commonly assessed by cropping, counting and/or weighting on permanent plots or transect-line plots (e.g. Sánchez-González *et al.* 2006). In the case of mushrooms, understory plants or berries it is common to sample subplots or quadrats (Miina *et al.* 2009), while for fruits and berries subsampling is performed on selected trees, plants, or even branches (Calama *et al.* 2011). An alternative, scarcely applied, is based on indirect model-assisted methods, where sampling inventory is applied to estimate an easily measurable attribute – e.g. cover of a given berry species of interest – and a predeveloped model permits estimating the yield of the NWFP of interest (see Case 3.2).

Unlike plant origin products, animals are in continuous movement, thus sampling methods consists of visual surveys on line transects, random walks or even, complete censuses within a unit. Indirect methods include identification of animal indicators such as excrement or footprints. Main advantage of sampling methods comes from the inferential power associated with the statistical analysis of the data.

Expert-based estimates (Oliver *et al.* 2002) are an interesting alternative to sampling in products as mushrooms or berries, which share some characteristics: are perishable, production can extend over a long period within the season, are commonly freely collected in the forests and inventory is highly expensive (see Case 3.3). Estimates usually rely on pre-crop questionnaires to experts (normally collectors), which provide either a quantitative (weight) or a categorical (ordinal scale) estimate of the product in a given location (e.g. plot). Locations are either visited or presented to the experts by means of representative photos. Robust inference on total production depends on the accuracy of the experts, the total number of experts, and the correct selection of the areas to analyse by the experts.

Finally, when the main aim of the inventory is to collect data for research projects on NWFP, collection is carried by either quantitative sampling techniques and/or post-crop questionnaires. It is noteworthy to mention how expert based methods are not usually considered in this type of inventories, except if combined with other methods.

3.2.4 Database information: length, units and availability

In the main part of the occasions where data on NWFP production are collected repeatedly, the information is processed and added to a permanent database. This is a quite common practice for National/Forest Regional statistics, NFI and research project inventories. The older series on NWFP have been uninterruptedly maintained since the 1950s. Series of data on different NWFP from Switzerland, Poland, Italy, Bulgaria, Spain, Latvia or United Kingdom cover more than 50 years of continuous monitoring (table 3.5). For some products, as wild mushrooms, forest berries and game meat long series are present for many countries, which could facilitate joint estimation of production, harmonization and research at European level. Additionally, units characterizing production are largely homogeneous across Europe, with production of mushrooms, tree products and understory plants commonly expressed in weight (either for the whole country or per ha) while game meat is generally measured in number of animals.

A final topic of interest concerning the currently existing datasets on NWFP is related with their public availability (Figure 3.2). While National Forest Statistics and National forest Inventories are public information commonly available online, the rest of the information – mainly from research projects and management inventories – show a much more restricted use, which limits their potential. Another problem is that the main part of the information is published in the original language of each country, which limits the availability and dissemination of the information.

Table 3.5: Length (years) of the larger data series recorded per country and type of NWFP monitored

Country	Truffles	Wild Mushrooms	Christmas trees	Cork & Barks	Edible fruits & nuts	Forest berries	Medicinal Culinary & Others	Game birds	Game meat	Honey
Austria					49	1		30	30	18
Bulgaria		52	11	11	11	11				
Czech Republic		21				21				
Finland		12				18			27	
North Macedonia		4			4	4				
Greece							11	20	20	
Italy	61	61		61	61					
Latvia									54	
Lithuania		16		15		16	15		47	
Morocco				10				19	19	
Poland		64	64	1	64	64	64		34	
Portugal								14	14	
Romania		47				47		9	9	
Slovakia		6	14		6	6			14	
Spain	14	14		23	52			58	58	12
Switzerland		67							67	
Turkey	15						1			
United Kingdom									53	

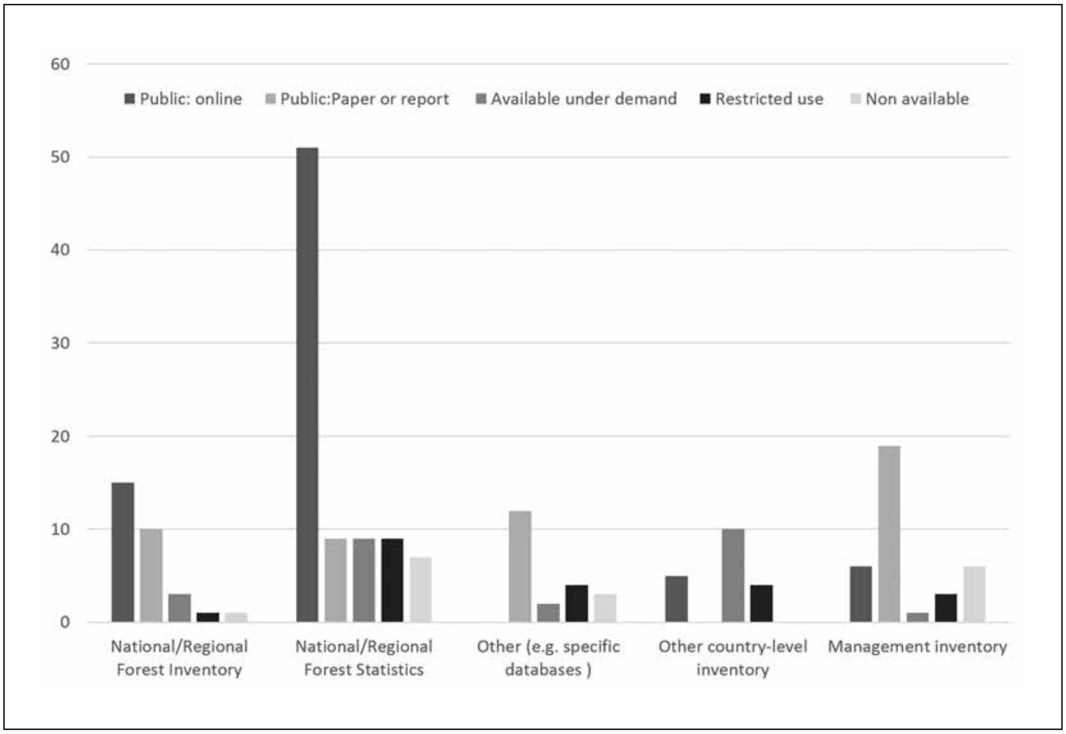

Figure 3.2: *Public availability of the existing data sets on NWFP according to the type of inventory*

CASE 3.2. *A model-based approach for annual pre-crop estimation of cone production at forest scale*

Early and accurate estimates of annual yield in forest fruit species, as cone and pine nuts from *Pinus pinea* L., are a basic requirement for the sustainable management of this production. Prompt knowledge of annual production permits harvesting enterprises to design campaigns, compute collection costs and fix selling prices. Similarly, processing industrials can properly plan in advance supply of raw material to the factories. Finally, forest managers and owners need to quantify annual cone production to propose initial prices for the public auctions of fruit, compute expected incomes, or valuate the economic losses due to a fire or illegal collection.

Given the large interannual variability of cone production, an accurate assessment of annual cone production would require monitoring fruit every year. Apart from this, large spatial variability among stands and among trees within a stand is detected, thus a wide sampling intensity would be required. Additionally, fruits are uniquely easily visible a few weeks during the beginning of the summer when cones are maturing, thus sampling should be done in this restricted period. Currently, the annual estimate of cone production at forest scale is made during the summer before collection visually by forest rangers, with no specific sampling scheme, but by means of a subjective estimation after visiting different areas of the forest. In order to define an objective protocol for carrying out accurate and homogeneous annual pre-crop estimates of cone production, INIA-CIFOR and Forest Service from Junta de Castilla y León are collaborating to develop a tool combining (i) the spatiotemporal model for annual cone production at tree scale by Calama *et al*. (2011) (ii) the information included in the periodical inventories for forest management carried out by the regional forest services and (iii) the updated climate data from the Spanish Metrological Agency (www.aemet.es).

Calama *et al*. (2011, 2016) proposed a bietapic model for predicting annual production of cones in a single tree. The model is composed of two submodels: the first oriented to predict the probability for the tree of bearing cones in a given year, the second predicting the expected weight of cones in the tree, conditional to having a non-null crop. Model assumes a zero inflated distribution of the response variable – the weight of cones in the tree in a given year – and enters as predictors attributes at age, density, mean squared diameter, site index or tree diameter, together with climate variables.

Forest management inventories are carried with a 10 year periodicity, following a systematic sampling scheme where 15 m fixed radius plots are installed in the knots of a 200 m x 200 m grid. At each plot, diameter is recorded for every tree, while height and age is measured in the dominant tree within the plot. The main subjacent idea is using the model to predict annual cone production for each *Pinus pinea* in the plot, using updated climate data from the closest to each forest meteorological station. Tree estimates are therefore upscaled to plot estimates. From the annual estimates at plot level, estimates at block and forest scale are made using sampling inferential statistics.

The routine has been implemented in an .xla complement, programmed under Visual Basic, which imports the data from forest inventories and meteorological stations, resulting in estimates of cone production at block, forest and regional scale. As the last meteorological event entering the model is the precipitation between February and May of the maturation year, the tool permits to obtain estimates much earlier than previous visual estimates. Additionally, as the main climatic factors ruling production are related with precipitation occurring two and three years before cone maturation, it is possible to make an approximate estimate of future cone crops.

This tool has been under validation since 2012, and in the 2015-2016 campaign, it was used for first time to estimate cone production for different public forests in the province of Valladolid, covering more than 10,000 ha.

CASE 3.3. *DigiMasi – improved forecasts for wild berries using citizen science*

The berry yield inventory network Masi has been established to forecast bilberry and cowberry yields in Finland (Salo 1999). The Finnish name Masi literally means berry (marja) and mushroom (sieni) information system. In the inventory, flowers and berries are counted in forest stands found to be potential growing sites for bilberry and cowberry. Annual berry yield forecasts are developed based on the Masi database. The original aim was to boost household berry picking by publishing press releases on timing of berry ripening and expected yield levels. During the recent years, commercial berry picking has increased, and thus temporally and geographically more accurate berry yield forecasts are needed. Berry yield forecasts could be improved using citizen science by observing the flowering and ripening of berries in more stands which are more evenly distributed throughout the country than currently. Since the establishment of the network in 1997, the number of stands has varied annually being about 200 stands on average. Stands are visited up to three times per season at the time of flowering and/or ripening of berries. The stands are different for bilberry and cowberry. In each stand, there are five 1 m2 permanent quadrats on which the numbers of flowers, unripe and ripe berries are counted (Figure 3.3.). Increasing the number of stands visited by Luke's staff is not feasible due to travelling and personal costs. A solution is to guide citizens interested in berry picking and phenology to establish quadrats, count flowers and berries and digitally send the records to a new DigiMasi system maintained by Luke. Citizens' records would be validated based on the data collected by Luke. Luke would be in charge of analysing the data and publishing the results as earlier.

Counting the number of flowers and berries is time consuming, and thus an automated method should be developed. Citizens could take images on the quadrats using their phone cameras and send the images to the DigiMasi system, where computer vision detecting would be applied to count the flowers and berries. Detecting the flowers and even ripe berries may not be an easy task, and possibly spectral images are needed instead of conventional ones. Prevailing weather conditions greatly affect berry yields (e.g. Wallenius 1999). Especially spring frosts during the flowering period will destroy the yield. Weather affects also the success of bee pollination. Including the meteorological data into the DigiMasi system would enable the preparation of more accurate berry yield forecasts. In Finland, volunteers have successfully monitored, for example, water quality, wildlife and distribution of bird species. Similarly, citizen science would be used to collect berry yield data, and thus to aid in improving berry yield forecasts. Improved forecasts would – better than now – boost household berry picking, but especially they would serve the berry-picking companies' needs to organize the berry picking relying mainly on foreign pickers. With improved forecasts, commercial berry picking can be located and scheduled more efficiently. The system proposed for wild berries could be developed also for wild mushrooms. The Masi database has been utilised in fitting bilberry and cowberry yield models to be included in forest planning systems (Miina *et al.* 2009; Turtiainen *et al.* 2013, 2016). In the future, the berry yield and meteorological data collected into the DigiMasi system could also be used to prepare more comprehensive models for bilberry and cowberry in Finland.

Figure 3.3: *Permanent 1 m2 quadrat for monitoring bilberry production. Total production is 593 bilberries m-2*

3.3 An overview on existing models for NWFP at European level

This chapter focuses on the state of the art modelling of non-wood forest products production across Europe with the aim of identifying and describing the existing models and predictive tools for NWFP. For this purpose, we used the responses from the common survey questionnaire presented in chapter 1.

The main aim of this chapter is the presentation of the results of the questionnaire in order to update and extend the information reported in previous reviews about the modelling of NWFP in Europe (Calama *et al.* 2010; Tomé and Faias 2014; Sánchez-González *et al.* 2015).

3.3.1 Analysis of the geographical areas and the type of products more commonly modelled

As in data collection, the questionnaire was disseminated to 29 COST involved countries: seven countries responded with 52 answers and these countries were Finland, Greece, Lithuania, Poland, Portugal, Spain and United Kingdom (table 3.1). From the reported models, 17 were developed for WG4 – animal origin – products, while 13 were developed for WG2– tree products – and 11 for each of WG1 (mushrooms & truffles) and WG3 (understory plants) categories. Table 3.2 shows that the type of products with more available models are wild mushrooms (11 records from Finland, Lithuania and Spain); game meat (12 records from UK, Greece, Spain and mainly from Lithuania); forest berries (8 records from Poland, Lithuania and mainly from Finland); and tree edible fruits & nuts (7 records, one from Portugal and the rest from Spain). This was followed by cork & barks (four models from Portugal, Lithuania and Spain) and game birds (four models from Finland and Greece). The most comprehensive result from this questionnaire from a geographical point of view is the relative high number of models reported from Lithuania. Most of the models from the others countries have already been reported in previous works (Calama *et al.* 2010; Tomé and Faias 2014; Sánchez-González *et al.* 2015), however the models from Lithuania were not well known.

At genus/species level, the products with more available models are berries from the genus *Vaccinium* sp., with seven records from 3 countries; *Pinus pinea* with seven records mainly from Spain; ceps (mushrooms from *Boletus edulis* and closely related spp.) with four records from Finland and Lithuania; and *Quercus suber* with three records from Portugal and Spain. Regarding animal species, *Cervus elaphus*, *Sus scrofa*, *Tetrao urogallus* and *Alectoris* sp. have been more often modelled with two models each. As in the data sets (chapter 3.2), it should be highlighted the lack of models for products with economic importance in many countries such as chestnuts from *Castanea sativa*, or the fact that products with an increasing demand such as the resin from *Pinus pinaster*, count with a unique model in Spain developed sixteen years ago (Nanos *et al.* 2000). However the modelling of other products with a more restricted distribution but with a high economic value has advanced greatly in recent years (Calama *et al.* 2016; Tomé *et al.* 2015).

3.3.2 Description of the models and methodological aspects

Forest models can be classified in many different ways. For the purpose of description, we have selected the following classifications: modelling approach, the hierarchy of modelling and the temporal scale. Regarding the last classification, in the reported models the most usual modelled interval is one year (32 records from 52).

Regarding the modelling approach, the reported models use the following approaches: empirical models, with or without environmental covariates, expert-based models, process-based models, geostatistical models and Markov chain models (Figure 3.4). The empirical models are constructed using statistical equations derived from empirical measurements. Since they are constructed based on sample data, they are valid only for a representative population (Fabrika and Pretzsch 2013). Process-based models orientate towards modelling causal relationships. They use algorithms simulating physiological processes such as photosynthesis, respiration and allocation. Their concept is more general. Expert models are based on expert opinions; therefore, it is important to have a complete panel of experts in order to minimize inconsistencies. This approach is useful when empirical data sets are not available (Fabrika and Pretzsch 2013).

Geostatistical models are a type of spatial model that use continuous data, which can be measured at any location in space, but they are available in a limited number of sample points. These models can predict values of the attribute considered in locations where data are not available, or reconstruct a surface of the attribute (Lee 2010). The Markov chain models are widely used in successional studies, which is based on the replacement dynamics among species or successional groups (Orloci and Orloci 1988). The elements of a Markov matrix are the probabilities P_{ij} that one adult tree belonging to the jth species could be replaced in the future by a recruit of the ith species, at any single point in space. The product between the projection matrix and the initial composition vector gives the community composition predicted at time t + 1. The stable, climax state toward which succession converges (Connell and Slatyer 1977) can be numerically approached by multiple iterations of the model, or calculated analytically through the dominant right eigenvector of the Markov matrix (Baker 1989). The elements of a Markov matrix can be easily perturbed, in order to assess the effects of hypothetical disturbances or manipulations on the future stable composition (Ogden 1983).

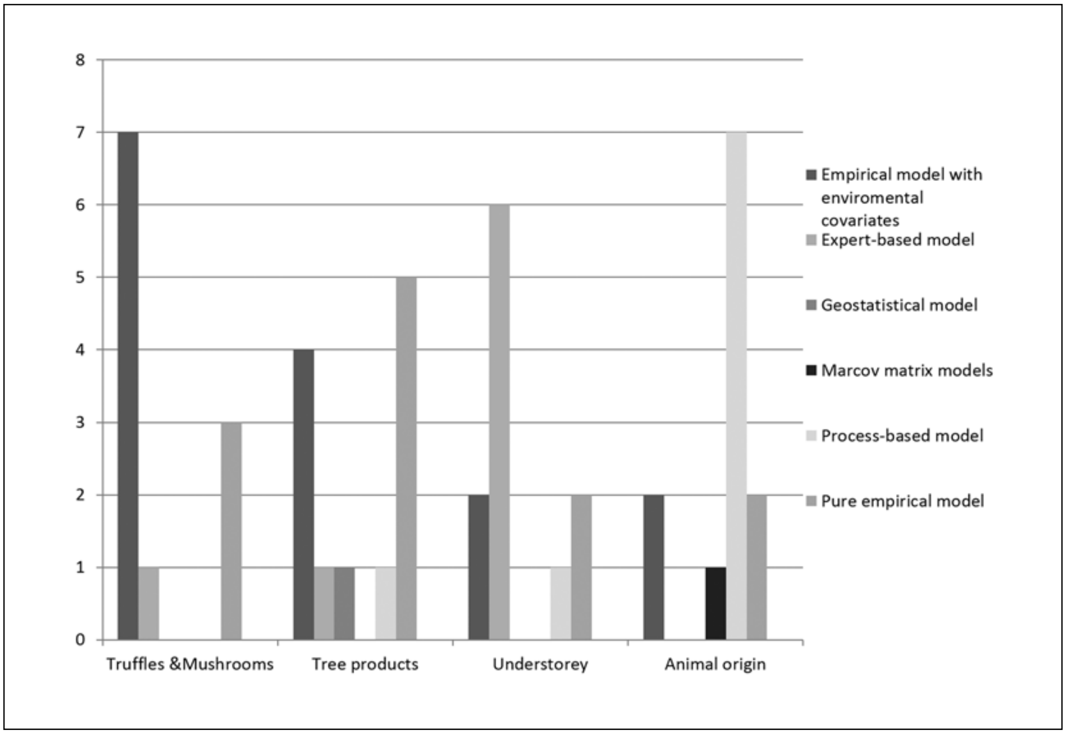

Figure 3.4: *Valid records per modelling approach and NWFP type in existing models (Source: COST Action FP1203 common survey)*

As can be seen in Figure 3.4, the modelling approach it is closely related with the type of product. In the mushrooms & truffles and in the tree products groups (WG1 and WG2 respectively), the most usual approach is the empirical one, especially including environmental covariates (see Case 3.4). While in the other two groups, these approaches rank second after the expert based models in WG3 (understory plants) and the process-based models in WG4 (animal origin). According to the questionnaire, the geostatistical approach and the Markov chain approach only have one model each, and respectively these the above mentioned models that predict resin production in Spain (geostatistical), and a model developed in UK that estimate the annual census for setting annual cull level in populations of *Capra hircus* (Markov chain approach). However, there is another model in Spain that uses the geostatistical approach for estimating cork production sampling in a cork forest in Spain (Montes *et al.* 2005).

Another way of classification is that of sorting models based on a hierarchy point of view. In this regard, we found the following hierarchical levels in the models reported in the questionnaire: landscape, regional, stand/plot, tree and organ (Figure 3.5). As in the previous classification, the hierarchical level of models depends on the type of products. The models for mushrooms & truffles (WG1) and for understory plants (WG3) are mainly developed at a stand/plot level. The developing of models for tree products mainly use data collected at tree level, while models for the fourth group (WG4, animal) consider the behaviour of the animals within a large area such as region or landscape.

When comparing these results with the review made by Calama *et al.* (2010), we found a slow trend to evolve from empirical models to process-based models attempting to enhance the knowledge about the foundations of eco-physiological processes. This evolution is related to the modelling level and to the time scale, since this evolution requires upscaling from larger to smaller detail, such us organ level, and to switch to a smaller timeframe, such us daily intervals.

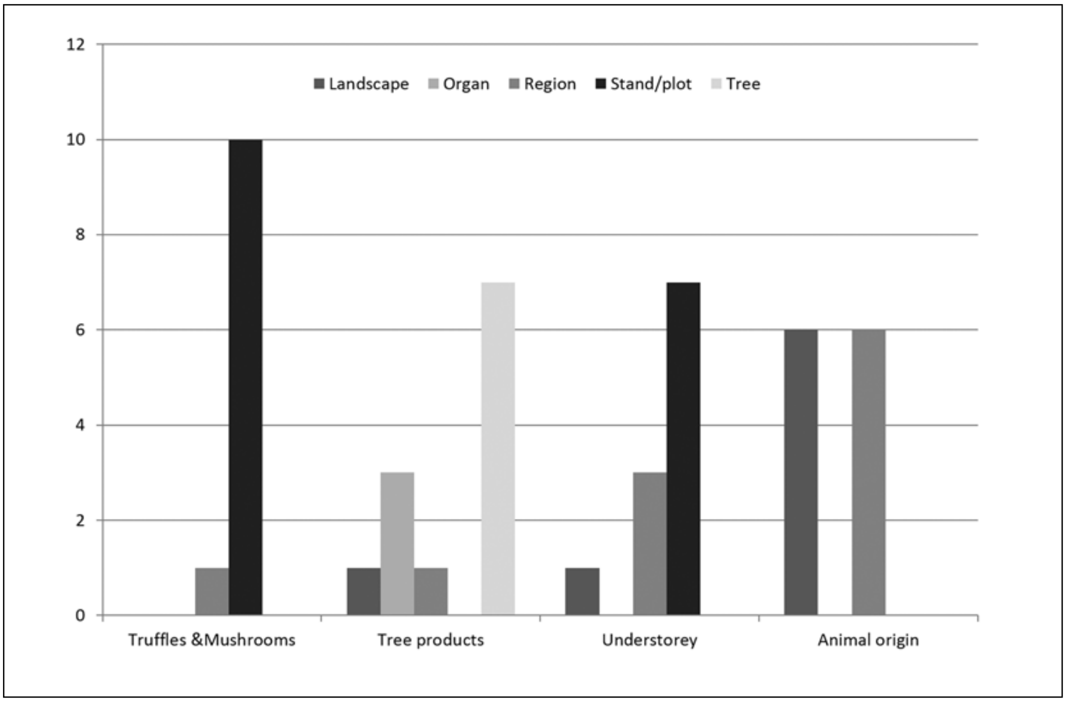

Figure 3.5: *Valid records per hierarchical level of modelling and NWFP type in existing models (Source: COST Action FP1203 common survey)*

3.3.3 Model applications in practical forest management

The application of forest models in practical forest management needs models, which are easily accessible to managers. The best way to do this is to implement models in forest simulators or decision support systems (DSS). Forest simulators are computer tools that, based on a set of forest models, make long term predictions of the status of the forests within a well-defined region, under a certain scenario of climate, forest policy or management alternatives, and in some cases taking into account the occurrence of disturbances, for instance fire or pests and diseases (Faias *et al.* 2012). DSS are computer tools providing support to solve ill-structured decision problems by integrating a user interface, simulation tool, expert rules, stakeholder preferences, database management and optimization algorithms. DSS may include simulation tools as an input for optimization and management advice to a user (Muys *et al.*, 2010).

Regarding NWFP in Europe, there are forest simulators available for different NWFP in different countries. For cork oak, there are available two stand simulators in Portugal, and another one in Spain. The SUBER model is a distance-independent individual-tree forest growth and yield model, used in Portugal to support cork oak management decision making. This model currently runs on sIMfLOR, a Portuguese platform for forest simulators (Faias *et al.* 2012), as version 5.0 (Paulo 2011), however the 6th version is under development with different improvements that can be seen in Sánchez-González *et al.* (2015). CORKFITS is a cork oak tree spatial growth simulator for cork oak woodlands (Surovy *et al.* 2011). In Spain, the ALCORNOQUE model, an integrated growth and yield model for Spanish cork oak forests (Sánchez-González *et al.* 2007), has recently been implemented in a simulator called alcornoqueWeb, which is freely available (Sánchez-González 2015). For pine nuts from *Pinus pinea*, the current version of the integrated model PINEA2 (Calama *et al.* 2007) was implemented into a stand-level simulator (Madrigal *et al.* 2009). In Portugal, Freire (2009) developed a set of equations that allow the projection of *Pinus pinea* stands either even and uneven-aged stands. These equations were implemented into the Portuguese Stand Simulator StandsSIM that projects a series of stands using pre-defined prescriptions. For mushrooms and berries, there are available stand simulators for *Pinus sylvestris* that included the production of those NWFP in Finland and Spain (see Tomé and Faias 2014 for more details) .

DSSs are useful tools in developing a feasible set of management alternatives for planning units and then supporting the decision-making situation in which the right ones are picked. In Tomé and Faias (2014), the DSSs available in Europe that include modules to deal with NWFP are analysed, while Kurtila and Tavanainen (2016) report how the existing forest DSSs have been improved and what kind of new DSSs capable for optimizing forest management that considers and combines timber production and NWFP have been developed or are under development. In this sense, recent studies as those by Palahí *et al.* (2009), Miina *et al.* (2016), Pasalodos-Tato *et al.* (2016) focused on the topic of optimizing management for joint production of timber and such NWFP as mushrooms, berries and cones respectively.

CASE 3.4. *Climate-sensitive models for Boletus edulis production in Cistus ladanifer scrublands*

Cistus species are mainly distributed around the Mediterranean basin and are typical of early successional stages in Mediterranean ecosystems (Agueda *et al.* 2008). This genus comprises several species of pyrophytic scrubs that can colonize highly degraded areas. The most abundant *Cistus* species in the Iberian Peninsula is *Cistus ladanifer* L.

Despite being traditionally considered as worthless unproductive ecosystems, *C. ladanifer* scrublands host a broad diversity of fungal species and provide high production of edible and inedible mushroom species (Oria-de-Rueda et al. 2008). The most valuable fungal species associated with this ecosystem is *Boletus edulis*, which is widely marketed in many countries (Boa 2004) reaching moderately high prices. The aim of this study was to develop a predictive climate-sensitive model for *Boletus edulis* sporocarp production in *Cistus ladanifer* scrublands. This model can be used as a tool to integrate mushroom production in the management of these areas.

The predicted variable of the mushroom yield models was the annual sporocarp production in terms of fresh biomass (kg ha-1 yr-1). The predictors included treatment (control burning vs. total clearing), time after treatment and climatic variables. The model was fitted using nonlinear regression analysis in R software (R Core Team 2013). Model was evaluated based on the following statistical criteria: (a) accordance with current scientific knowledge, (b) logical behavior of the models in extrapolations, (c) parsimony, and (d) statistical significance (p-value < 0.05). A graphic simulation was conducted as well by considering different climatic conditions.

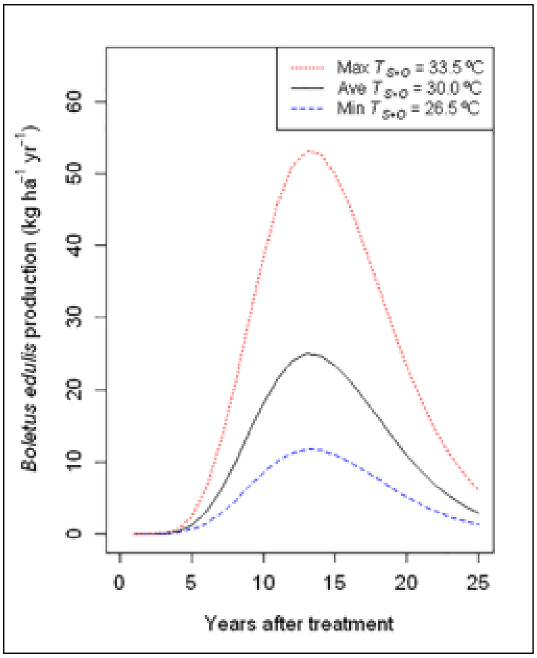

Figure 3.6: *Effect of mean temperature on September-October and time after treatment on Boletus edulis production*

The definite modes for *B. edulis* production included as predictors the sum of the mean temperatures of September and October, exerting a positive effect over annual yield of *Boletus edulis*, and the time after treatment (years), which shows a quadratic effect over annual yield (figure 3.6). The production of *B. edulis* showed a rapid increase after total clearing or burning. It is expected to start at about 5 years after treatment and the maximum production is reached at 14 years, after which it began to decrease reaching lower yields when the scrublands are senescent. *B. edulis* is usually associated with late-stage forest stands (Martín-Pinto *et al.* 2006). However, when associated with *C. ladanifer*, it can fruit very early (Hernández-Rodríguez *et al.* 2013). No significant differences were found between the two treatments.

The most influencing climatic variable for *B. edulis* production was the mean minimum temperature of September and October. Apparently, precipitation is not as limiting factor in the production of *B. edulis* in *C. ladanifer* scrublands as compared to other ecosystems. Further information can be found at Hernández-Rodríguez *et al*. (2015)

3.4 Identification of gaps in knowledge

Most of the countries responding the questionnaire – twenty out of twenty-three – reported some information on monitoring, inventorying and data storage on different NWFP. As expected, information on NWFP at national levels is referred to the more relevant products at that scale, with a clear regional pattern. In that sense, while northern countries, such as Finland or Lithuania report a large amount of information on understory products as berries, southern countries such as Spain, Portugal, Italy or Morocco are more linked with information concerning tree products as cork, pine nuts and chestnuts. However, it is noteworthy how countries with an ancient tradition on forest management for timber production and timber focused inventories, as Germany, Switzerland, United Kingdom or France, assess very little or nol information on the topic, while countries with a "theoretical" less developed forest policy reports information on products of every category.

A few products, particularly mushrooms, understory berries or game animals are widely collected or hunted throughout the whole European area, as well as in neighbouring countries, and logically are the products most likely to be represented in databases and statistics concerning NWFP, and show the longest data series, even covering 60 years. Additionally, products with a great economic importance in a given region, such as pine nuts or cork in south-western countries yield valuable information on these specific products. On the other hand, there is a paucity of information compiled on some economically valuable and widely distributed products in Europe, as honey, Christmas trees or tree sap.

Information on NWFP is commonly presented at national/regional scale through Forest Statistics, thus reporting post-crop information collected by means of questionnaires to owners, sellers, collectors and traders. A secondary source of information on NWFP is found in specific databases and inventories carried out in the framework of research projects. However, little information is reported on how to collect information on NWFP yield prior to the collection, which would be basic information to guarantee sustainable management and harvesting of the products. While sampling inventories and censuses are common in developing hunting plans, for many other products as fruits, berries or mushrooms show large interannual variability, high frequency of collection and short period of visibility. Thus methods providing early, accurate and low cost estimates of production are necessary. New techniques, such as expert opinion based inventories, joint use of inventories and models and remote sensing approaches have been postulated to fill the gaps observed in pre-crop NWFP inventories (see next chapter).

Focusing on the post-crop information included in national – regional forest statistics, while large harmonization is observed on such topics as periodicity and units, we detected a large variety of collection techniques as well as different spatial scales of collection, ranging from local to regional and national. These topics, together with the non-public availability of the information and the common use of national languages on this type of statistics currently prevents joint use in supranational studies.

Regarding models, the results of the questionnaire are in concordance with results obtained in the questionnaire gathered among professional foresters from different countries within the StarTree project (Tomé and Faias 2014). The number of countries that already count with models for estimating NWFP of any type is very low, which evidence the need to improve and enlarge the available models. The regional pattern in available models is similar to the aforementioned pattern in datasets. While northern countries, as Finland, Lithuania, Poland and UK count mainly with models on understory products and animal origin products, southern countries as Portugal and Spain are more linked with information concerning tree products as cork and pine nuts, with the exception of Greece that only count with models developed for animal origin products.

Within the StarTree project were identified the improvements already developed or that need to be developed in order to overcome the possible weaknesses of NWFP models. The NWFP treated in this project belong to the mushrooms & truffles group, to the tree products group and to the understory plants group. Sánchez-González *et al.* (2015) described the improvements made on those existing models that already present a high degree of development, such us the available models for cork oak, stone pine, mushrooms and berries in Finland, Portugal and Spain.

In that report there were also included those tasks that are being done related to the data collection that could serve as a base for future research about NWFP that, despite their importance, do not count with a yield model yet and need to be developed. This is the case of resin from maritime pine (*Pinus pinaster* Aiton), chestnut (*Castanea sativa* Mill.), walnut (*Juglans regia* L, *J. nigra* L., *J.x intermedia* Carr.), cherry (*Prunus avium* L.), sorbus (*Sorbus torminalis* L., *S. aucuparia* L., *S. domestica* L.), lime (*Tilia* spp.), bay leaves (*Laurus nobilis* L.) and pine honey.

In addition, it is noteworthy to mention how expert-based models (e.g. as those currently being developed for estimating mushrooms products in Portugal) could provide a basis for further development of models for those NWFP not currently modelled. Additionally, accuracy of existing empirically based NWFP models can be largely improved by adding expert based information (see Case 3.5).

Another very important worry concerning models, it is the level of usage by stakeholders, which it is not very high in most cases. The professional foresters questionnaires returned within the StarTree project provide evidence that most of the respondents did not know of any model for NWFP, only the responding professional foresters from Spain and Portugal knew models for NWFP. However, most of the professional foresters thought that models would be useful for any NWFP from their countries except in Austria, Germany, Latvia and UK; and most of them considered that models are useful tools for the management of NWFP in their region by supporting management decisions (Tomé and Faias 2014).

A final main gap observed in the models for NWFP relies on their dependence on empirical observations, with little knowledge on the subjacent physiological processes resulting in the production. Further research should focus on filling this main gap of knowledge, in order to construct physiological based models resulting in reliable and robust estimates under changing scenarios.

CASE 3.5. *The relevance of incorporating management objectives when modelling the distribution of game species*

There are an increasing number of works that try to predict the occurrence or abundance of plant or wild animal species on the basis of environmental characteristics, as environmental predictors can describe the potential habitat needed by the ecology of the species. This approach is carried out using models of species distributions (SDMs), also known under other names including envelope-modelling and (environmental or ecological) niche-modelling, which is a tool that is in continuous improvement with advances in statistical techniques and interpretation (Elith and Leathwick 2009).

These species distribution models are being widely applied to populations of game species to describe the environmental conditions of a species (i.e. Vargas et al. 2007) or to assess the effects of climate and land uses on game species (i.e. Acevedo et al. 2011). However, the consideration of explanatory variables related to game management is not generally explicitly considered in these approaches (some exceptions are: Delibes-Mateos et al. 2008; Sotherton et al. 2009 in small game species characterization), although wild hunting species, specially big game, are more and more frequently being managed (Mysterud 2010). The importance of considering this set of management-related variables has been stressed by Milner-Gulland (2012), and Austin *et al*. (2013), among others. In this context, the study of Martínez-Jauregui and Herruzo (2014) shows that the variables related to management objective factors describe better red deer harvest and populations in forest estates than the environmental variables, although it is the incorporation of both groups of variables which provides the best model. This indicates that variables related to management of game estates should be taken into account in any application that tries to describe the distribution or abundance of species managed, as it is the case of the hunted species. We believe that it is necessary to incorporate human aims in the resource user decision models or the study of game species trends in a geographical scale.

3.5 Proposals, guidelines and recommendations for the future

The management of the forests under the principles of sustainability and multifunctionality require sound assessment of both current and the future productivities, as well as on the response – in term of ecosystem services provision – to different management strategies under different social, economic and environmental scenarios.

While resource assessment and modelling for timber and biomass production has deserved much attention in the last decades, little is known in relation such to topics such as monitoring, data collection and modelling focusing on NWFP. At a European level, where traditional forest management has been timber oriented, this lack of knowledge is even more apparent. This issue contrasts with the wide economic and/or social importance that currently some of the products – as major game, mushrooms, berries, cork and pine nuts – merits in some European countries. In this sense it is noteworthy to mention how in some European forests regions where the income derived from NWFP overcome that from timber – e.g. Mediterranean forests –, resource assessment practices mainly still focuses on wood and biomass traits.

A thorough review on the state of art of monitoring and inventorying on NWFP in Europe reveals that the main part of the information is collected and processed at a national scale, included in National/Regional Forest Statistics and NFIs. Concerning some products, such as game, cork, pine nuts, chestnuts, truffles and mushrooms, long term series at national level – extending in some cases up to 50 years – are available for different countries, and generally are easily accessible by means of the internet. While all these issues should be seen as a main opportunity for a common and harmonized management of NWFP resources at a European scale some products prevent this potential use. There exists a severe lack of harmonization among countries in relation with data collection techniques, frequency of collection, data processing and homogenization of units, even for the same product. Policy level recommendations should focus on harmonizing the information included in these National statistics.

The collection of the information on NWFP for Forest Statistics purposes is usually based on post crop estimates, carried out by means of questionnaires to owners, collectors, managers or trade agents. However, management of the resource at the forest scale as well as the design of collection campaigns, the supply to the industry or the definition of the harvesting levels require pre crop assessment of the current availability of the resource. While for some products – such as game – scientific based sampling strategies are defined and largely used, for the main part of the European NWFP guidelines for accurate and statistically sound monitoring of the current stock are still missing. Adaptation of sampling schedules defined for assessing NWFP in tropical forests to the conditions of European forests should be a matter of future research. In addition, assessment of NWFP should be a compulsory task in the management plans at forest management unit scale. Use of techniques such as expert-based estimates and/or model assisted sampling schemes could facilitate the quantitative assessment of the resource for those products where monitoring is largely time-consuming or directly not possible (ephemeral products, exudates, etc.).

Forecasting the provision of a given Ecosystem Service – including NWFP – under current and future scenarios and management strategies is a main demand from forest managers acting at different scales – from the forest management unit to policy makers. Nowadays, several models for a few NWFP are available in Europe. However, the modelling effort does not actually reflect the relative importance of the product, with largely important products as chestnut or resin lacking of predictive tools. On the other hand, existing models present some limitations.

- For some products, as pine cones or cork, the models have an area of applicability restricted to the region. In addition, many of these regional models show different functional structures, fitting techniques, as well as the hierarchical scale of application (tree, stand or region). All of these concerns make the application of the models difficult beyond the original region and prevents common predictions at the European level. Future research effort should focus on constructing models which permit wide application at a European scale.
- A great majority of the models rely on an empirical based approach. Deep knowledge on the physiological processes resulting in non-wood forest production is largely required, as an initial basis for the construction of sound-physiological models for these products.
- While empirical based models depend on long-term series of records, expert-based models could also be seen as an interesting approach for those products where neither models nor data sets are currently available. Additionally, joint use of expert-based, physiological-based and empirical approaches could result in accurate and robust predictions.
- Available large scale information, as the data on NWFP included in the National/Regional Forest statistics, should be used to construct models working

at national / European scale. The construction of models ensuring compatible predictions at different spatial scales should be highly promoted.

A final issue of interest should focus on filling the gap between forest modellers and forest managers. End-users of the model should be considered during the model construction phase, providing feedback on topics as required inputs, expected outputs and spatiotemporal extent of applicability. In addition, the implementation of the models for NWFP into stand-level or forest-level simulators, as well as on DSS will facilitate the use of the model by the end-users. In this sense, the construction of harmonized European scale platforms for simulation, optimization and decision support should be a basis for future cooperation and research in forest modelling.

3.6 References

Acevedo, P., Farfán, M.A., Márquez, A.L., Delibes-Mateos, M., Real, R., Vargas, J.M., 2011. Past, present and future of wild ungulates in relation to changes in land use. Landsc. Ecol. 26, 19–31.

Agueda, B., Parladé, J., Fernández-Toirán, LM., Cisneros, O., de Miguel, A.M, Modrego, P., Martínez-Peña, F., Pera, J., 2008. Mycorrhizal synthesis between Boletus edulis species complex and rockroses (Cistus sp.). Mycorrhiza 18:443–449. doi: 10.1007/s00572-008-0192-3

Austin, Z., Raffaelli, D.G., White, P.C., 2013. Interactions between ecological and social drivers in determining and managing biodiversity impacts of deer. Biol. Conserv. 158, 214–222.

Baker, W.L., 1989. A review of models of landscape change. Landscape Ecology 2, 111-133.

Boa, E., 2004. Wild edible fungi. A global overview of their use and importance to people. Non-Wood Forest Products 17. FAO, Rome.

Borges, J.G., Oliveira, A.C., Costa, M.A., 1997. A quantitative approach to cork oak forest management. For. Ecol. Manage. 97, 223-229.

Bruce, D., Schumacher, F.X., 1950. Forest mensuration, 3rd edition. McGraw-Hill, New York.

Burkhart, H.E., Tomé, M., 2012. Modelling Forest Trees and Stands. Springer, New York.

Calama, R., Garriga, E., Bachiller, A., Gordo, J., Finat, L., Montero, G., 2007. PINEA2: un modelo integrado para la gestión de las masas regulares de Pinus pinea L. en la Meseta Norte. Cuadernos SECF 23, 127-132 (in Spanish).

Calama, R., Tome, M., Sánchez-González, M., Miina, J., Spanos, K., Palahi, M., 2010. Modelling non-wood forest products in Europe: a review. Forest Systems 19, 69-85.

Calama, R., Gordo, J., Madrigal, G., Mutke, S., Conde, M., Montero, G., Pardos, M., 2016. Enhanced tools for predicting annual stone pine (Pinus pinea L.)

cone production at tree and forest scale in Inner Spain. Forest Systems 25(3), e079.

Campos, P., Ovando, P., Montero, G., 2008. Does private income support sustainable agroforestry in Spanish dehesa? Land Use Policy 25, 510-522.

Carpenter, S.R., Mooney, H.A., Agard, J., Capistrano, D., DeFries, R.S., Diaz, S., Dietz, T., Duraiappah, A.K., Oteng-Yeboah, A., Pereira H.M., Perrings, C., Reid, W.V., Sarukhan, J., Scholes, R.J., Whyte, A., 2009. Science for managing ecosystem services: beyond the Millennium Ecosystem Assessment. Proc. Natl. Acad. Sci. U.S.A. 106, 1305–1312.

Connell, J.H., Slatyer, R.O., 1977. Mechanism of successions in natural communities and their role in community stability and organization. Am. Nat. 111, 1119–1144.

De Miguel, S., Bonet, J.A., Pukkala, T., Martínez de Aragón, J., 2014. Impact of forest management intensity on landscape-level mushroom productivity: a regional model-based scenario analysis. For. Ecol. Manage. 330, 218-227. http://dx.doi.org/10.1016/j.foreco.2014.07.014

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, 559–574.

Elith, J., Leathwick, J.R., 2009. Species distribution models: ecological explanation and prediction across space and time. Ann. Rev. Ecol. Evol. Syst. 40(1), 677-697.

Fabrika, M., Pretzsch, H., 2013. Forest ecosystem analysis and modelling. Technical University Zvolen, Bratislava.

Faias, S.P., Palma, J.H.N., Barreiro, S.M., Paulo, J.A., Tomé, M., 2012. sIMfLOR – platform for the Portuguese forest simulators. Forest Systems 21, 543-548.

Graves, H.S., 1906. Forest Mensuration. John Wiley and Sons, New York.

Hernández-Rodríguez, M., Oria-de-Rueda, J.A., Martín-Pinto, P., 2013. Postfire fungal succession in a Mediterranean ecosystem dominated by Cistus ladanifer L. For. Ecol. Manage. 289, 48–57. doi: 10.1016/j.foreco.2012.10.009

Hernández-Rodríguez, M., de-Miguel, S., Pukkala, T., Oria-Rueda, J.A., Martín-Pinto, P., 2015. Climate-sensitive models for mushroom yields and diversity in Cistus ladanifer scrublands. Agric. For. Meteorol. 213, 173–182. doi: 10.1016/j.agrformet.2015.07.001

Kurttila, M., Tahvanainen, V., 2016. Description of new decision support tools for optimization of MPT and NWFP management. D2.4 of the StarTree project FP7 Project no. 311919 KBBE.2012.1.2-06, European Commission.

Lee, D.J., 2010. Smoothing mixed model for spatial and spatio-temporal data. PhD thesis. Department of Statistics. Universidad Carlos III, Madrid.

Madrigal, G., Gordo, J., Montero, G., Calama, R., 2009. PINEA2 v1.0: aplicación informática para la gestión de las masas regulares de Pinus pinea L. en la Meseta Norte. In proceedings 5º Congreso Forestal Español. Ávila. (In Spanish)

MAGRAMA, 2013. Anuario de Estadística Forestal. Available online: http://

www.magrama.gob.es/es/desarrollo-rural/estadisticas/forestal_produccion_2013.aspx)
Martínez-Jauregui, M., Herruzo, A.C., 2014. A note on the effectiveness of incorporating management objectives with ecological variables when modeling red deer abundance. Eur. J. Wild. Res. 60, 511-517.
Martín-Pinto, P., Vaquerizo, H., Peñalver, F., Olaizola, J., Oria-de-Rueda, J.A., 2006. Early effects of a wildfire on the diversity and production of fungal communities in Mediterranean vegetation types dominated by Cistus ladanifer and Pinus pinaster in Spain. For. Ecol. Manage. 225, 296–305. doi: 10.1016/j.foreco.2006.01.006
Miina, J., Pukkala, T., Kurttila, M., 2016. Optimal multi-product management of stands producing timber and wild berries. Eur. J. For. Res. 135(4), 781–794. http://dx.doi.org/10.1007/s10342–016–0972–9.
Miina, J., Hotanen, J.P., Salo, K., 2009. Modelling the abundance and temporal variation in the production of bilberry (Vaccinium myrtillus L.) in Finnish mineral soil forests. Silva Fennica 43, 577-593.
Milner-Gulland, E.J., 2012. Interactions between human behaviour and ecological systems. Philos. Trans. R. Soc. B. 367, 270–278.
Montes, F., Hernández, M.J., Cañellas, I., 2005. A geostatistical approach to cork production sampling estimation in Quercus suber forests. Can. J. For. Res. 35, 2787-2796.
Muys, B., Hynynen, J., Palahi, M., Lexer, M.J., Fabrika, M., Pretzsch, H., Gillet, F., Briceno, E., Nabuurs, G.J., Kint, V., 2010. Simulation tools for decision support to adaptive forest management in Europe. Forest Systems 19, 86-99.
Mysterud, A., 2010. Still walking on the wild side? Management actions as steps towards 'semi-domestication' of hunted ungulates. J. Appl. Ecol. 47, 920–925.
Nanos, N., Tadesse, W., Montero, G., Gil, L., Alia, R., 2000. Modelling resin production distributions for Pinus pinaster Ait using two probability functions. Ann. For. Sci. 57, 369-377.
Ogden, J., 1983. Community matrix model predictions of future composition at Russell state forest. N. Z. J. Ecol. 6, 71–77.
Oliver, I., 2002. An expert panel-based approach to the assessment of vegetation condition within the context of biodiversity conservation Stage 1: the identification of condition indicators. Ecological Indicators 2, 223–237
Oria-de-Rueda, J.A., Martín-Pinto, P., Olaizola, J., 2008. Bolete productivity of cistaceous scrublands in northwestern Spain. Econ. Bot. 62, 323–330. doi: 10.1007/s12231-008-9031-x
Orloci, L., Orloci, M., 1988. On recovery, Markov chains, and canonical analysis. Ecology 69, 1260–1265.
Palahí, M., Pukkala, T., Bonet, J.A., Colinas C., Fischer, C.R., Martinez de Aragón, J.R., 2009., Effect of the inclusion of mushroom values on the optimal management of even-aged pine stands of Catalonia. Forest Science 55(6), 503–511
Pasalodos-Tato, M., Pukkala, T., Calama, R., Cañellas, I., Sánchez-González, M.O.,

2016. Optimal management of Pinus pinea stands when cone and timber production are considered. Eur. J. For. Res. DOI: 10.1007/s10342-016-0958-7

Paulo, J.A., 2011. Desenvolvimento de um sistema para apoio à gestão sustentável de montados de sobro. Universidade Técnica de Lisboa, Lisboa.

R Core Team, 2013. R: A language and environment for statistical computing.

Salo, K., 1999. Principles and design of a prognosis system for an annual forecast of non-wood forest products. In: Niskanen, A., Demidova, N. (eds.). Research approaches to support non-wood forest products sector development: case of Arkhangelsk Region, Russia. EFI Proceedings 29, p. 35-44.

Sánchez-González, M., 2015. Alcornoque 1.0. Simulador de crecimiento y producción para masas densas de alcornoque (Quercus suber L.). Available on line: http://wwwx.inia.es/alcornoqueWeb/

Sánchez-González, M., Calama, R., Cañellas, I., Montero, G., 2007. Management oriented growth models for multifunctional Mediterranean forests: the case of cork oak (Quercus suber L.). EFI Proceedings 56, 71-84.

Sánchez-González, M., Pasalodos-Tato, M., Cañellas, I., 2015. Description of the improvements in the models for multipurpose trees (MPT) and non-wood forest products (NWFP). D2.2 of the StarTree project FP7 Project no. 311919 KBBE.2012.1.2-06, European Commission.

Sierra-Pérez, J., Boschmonart-Rives, J., Gabarrell, X., 2015. World trade analysis of cork products in the Iberian Peninsula: an economic characterization of a forestry industry. Resources, Conservation and Recycling 98, 55-66.

Sotherton, N., Tapper, S., Smith, A., 2009. Hen harriers and red grouse: economic aspects of red grouse shooting and the implications for moorland conservation. J. Appl. Ecol. 46, 955–960.

Spurr, S.H., 1952. Forest Inventory. Ronald Press, New York

Surovy, P., Vones, P., Ribeiro, N., 2011. Software development for forest growth models and management: CORKFITS web-based growth simulator. Formath 10, 279-293.

Tomé, M., Faias, S., 2014. State of the art, review of silviculture, models and decision support tools for multipurpose trees (MPT) and non-wood forest products (NWFP). Deliverable 2.1 of the StarTree project FP7 Project no. 311919 KBBE.2012.1.2-06, European Commission.

Tomé, M., Paulo, J.A., Faias, S., 2015. SUBER model version 5. Structure, equations and computer interfaces. Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa.

Tomppo, E., Gschwantner, Th., Lawrence, M., McRoberts, R.E., 2010. National Forest Inventories. Pathways for Common Reporting. Springer.

Turtiainen, M., Miina, J., Salo, K., Hotanen, J.P., 2013. Empirical prediction models for the coverage and yields of cowberry in Finland. Silva Fennica 47(3), 22

Turtiainen, M., Miina, J., Salo, K., Hotanen, J.P., 2016. Modelling the coverage and annual variation in bilberry yield in Finland. Silva Fennica 50(4), 1573. http://dx.doi.org/10.14214/sf.1573.

Van Laar, A., Akça, A., 2007. Forest Mensuration. Springer, Dordrecht.

Vanclay, J.K. 1994. Modelling forest growth and yield. Applications to Mixed Tropical Forests. CAB Interantional, Wallingford.

Vargas, J.M., Farfán, M.A., Guerrero, J.C., Barbosa, A.M., Real, R., 2007. Geographical and environmental correlates of big and small game in Andalusia (southern Spain). Wildl. Res. 34, 498–506.

Wallenius, T.H. 1999. Yield variations of some common wild berries in Finland in 1956–1996. Annales Botanici Fennici 36, 299-314

Wong, J.L.G., 2000. The biometrics of non-timber forest product resource assessment: A review of current methodology. Forest Research Programme of the United Kingdom Department for International Development.

Wong, J.L.G., Thornber, K., Baker, N., 2001. Resource assessment of non-wood forest products: Experience and biometric principles. NWFP Series 13. FAO, Rome. Biometrics and NTFP inventory. Available from: https://www.researchgate.net/publication/228494354_Biometrics_and_NTFP_inventory [accessed Dec 9, 2016].

4. Considering NWFP in multi-purpose forest management

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4.1 Introduction to management concepts

The objectives and the approaches in forest management have constantly changed throughout history. The availability of wood as timber and fuelwood was a prerequisite for the expansion and development of all the early civilisations (Perlin 1991). Throughout history forests provided many non-wood forest products ranging from foodstuffs for local use such as chestnuts, walnuts, pine nuts, acorns, berries, mushrooms, game or medicinal herbs to industrial resources such as tannins from oak bark, ink from galls, lichens for dye, resins from pines and cork as well as withies and bark for baskets. With growing global populations and industrialisation, the demands placed upon forest resources increased, and the supply of both wood and non-wood products from the forest became crucial for a continuous development of human populations (Farrell *et al.* 2000). By the 18th and early 19th centuries, timber began to dominate in European forest management and the forest was increasingly no longer seen as a multiple use resource for the needs of local population but as a means of turning "wood into silver" (Ernst 1998) with a clear emphasis on timber production. Due to overexploitation of timber, adequate regulations and guidelines were needed to secure a sustainable supply of timber. In Europe forestry schools were established in the late 18th century together with the origins of classical approaches to growth and yield regulation in even-aged forests (e.g. Carlowitz 1713 in Hausrath 1982). From this time the forest was seen as a resource to be exploited in a controlled manner (Farrell *et al.* 2000).

The contribution of commercial forestry to the national income and the provision of employment especially in rural areas through timber production, were the major expectations of society in the first half of the last century, and in some countries (e.g. the UK) for much of the century (Mather 2003). It was recognised then that the success of forestry largely depends on "getting the right trees in the right places for the right reasons" (Warren 2002). Gradually, the non-wood values of forests emerged as an important issue for the environment as well as people and during the last century forestry passed through a considerable change of its socio-cultural acceptance and public perception (Koch and Kennedy 1991; Kennedy *et al.* 1998). The complexity of societal demands increased and foresters were facing more and more the challenge to integrate manifold and often conflicting demands into forest management planning (Fürst *et al.* 2009).

The World Forestry Congress of 1950 heralded the concept of multipurpose forestry. Such multipurpose forestry does not only focus on provisioning services in the form of wood, but also at the co-production of wood, other products and livestock grazing, and the optimisation of recreational and watershed services. In the 1980s the concept was further extended by also including the conservation of ecosystems and biodiversity within the model of multi-purpose forestry. A shift towards the acceptance and operationalization of this concept had different patterns in different countries and pace of the 'transition' varied (Mather 2003; Mather *et al.* 2006). Also, whereas in some regions the practice of multiple-use management was mainly focused on a biocentric ecosystem-based approach, in other countries it is more strongly focused on an anthropocentric management paradigm (Farrell *et al.* 2000).

The notion of multi-functional forestry is reflected in the system approach to forest management. For example, it acknowledges that in many cases biodiversity conservation or the enhancement of carbon benefits can be compatible with the efficient growing of wood for fuel or with NWFP production (Nijnik *et al.*, 2014). Recent afforestation programmes and enlargement of forest growing stock initiatives, supported in many European countries, often focus on new opportunities to supply wood, while promoting forest multiple benefits (Nijnik *et* *al*. 2012; Nijnik *et al*. 2016). The co-production is certainly context specific. It is diverse in content, scale and time dimensions. It usually entails both synergies and trade-offs between quantity and quality of forest goods and services, which are determined by the demand side and the cost of silvicultural interventions to enhance their quantity or/and quality (Nijnik and Miller 2014).

A shift of policy context from the production of primarily a single good (e.g. wood) or service (e.g. biodiversity) towards multiple perspectives of simultaneously benefiting the economy, environment and society is consistent with sustainable development considerations. A multi-functionality strategy is theoretically capable of meeting the increasing private and public demand on forest (Schmithüsen, 2007). The term has become a political concept, particularly as Natura 2000 promoted an integrated approach to managing European forests for multiple purposes (Wilson 2001). The EU has been active in combining multiple considerations in policy design (Brouwer and van der Bergh 2002). The reform of the Common Agricultural Policy (CAP) has demonstrated an increased priority for delivering multiple objectives. Multi-purpose forestry is increasingly being 'institutionalized' in policies and rests on the principle of forest management for provision of multiple ecosystem services. Within this context NWFP are mostly considered as forest components offering both provisioning and cultural services (Kaljonen *et al*. 2007).

Maier and Shobayashi (2001) identify two key elements in multi-purpose forestry: (i) joint production of commodity and non-commodity outputs, and (ii) the nature of the non-commodity outputs as predominantly public goods. The joint production gives rise to questions of scale and geography. Should multi-functionality be interpreted as the need that each field or forest stand fulfils two or more functions, or can it be used to describe a pattern of diversity in which different units of land are dedicated to different functions? Dana (1943) implied a 'vertical' interpretation of forest multi-functionality. Pearson's (1994) view was of its 'horizontality': 'effective multiple use is merely organized and coordinated specialization' (p. 248). The former view was dominant in the last part of the 20th century, arguably the origins of 'forest ecosystem management'. However, the latter still has its advocates (e.g. Vincent and Binkley 1993; Sedjo 2004). We argue that whether forest multi-functionality is to be considered in its vertical or horizontal sense depends on the case, scale of observation and on the issue in question. It is case, scale and context specific (Nijnik and Miller 2014). The heterogeneity in actors' capabilities, preferences and beliefs play a role in this consideration (Nijnik *et al*. 2010) bringing in a challenge of finding optimal solutions for different stakeholders (Ostrom 2009).

Since the 19th century forest management has also been guided by the concept of sustainability in addition to the concept of multi-purpose (or multi-use, multi-functional, post-productive) forestry. In the 20th century this concept became gradually extended from a rather narrow focus concerning the maintenance of yields of useful forest goods and services for human benefit to also include the maintenance of forest ecological characteristics and the sustenance of social and cultural services for human societies (Wiersum 1995). In the wake of the United Nations Conference on Environment and Development (UNCED) in 1992 the concept of sustainability became an issue of public interest worldwide. In Europe, this trend has led to a series of Ministerial Conferences on the Protection of Forests in Europe (MCPFE) which in 1993 in Helsinki led to the adoption of a Pan-European framework for sustainable forest management at politically binding level (MCPFE 2003). In parallel to these policy-driven top-down approaches to foster sustainable forest management market-based certification schemes were established (e.g. FSC-Forest Stewardship Council and PEFC-Programme for the Endorsement of Forest Certification) to promote environmentally friendly and socially responsible management of forest resources as an instrument to achieve competitive advantage.

According to these paradigms of sustainable forest management, forests serve multiple interests and are able and should provide a multitude of goods, and services. Nowadays concepts on how to attain the resilient provision of ecosystem services by social-ecological systems (Sarkki *et al.* in press) and how to manage forests in a sustainable manner to deliver the various goods, services, and benefits include ecosystem management (Kohm and Franklin 1997), the ecosystem approach of the Convention on Biological Diversity (Smith and Maltby 2003), and sustainable forest management (Lindenmayer *et al.* 2000). However, the practical applications of such integrated approaches towards forest management differ between ecosystem conditions and countries. In many areas, also top-down approaches and related policies (such as Natura 2000) have often shaped practical forest management. Another important factor is the degree of forest land and the ownership conditions ranging from public forest estates and lands of conservation agencies to small- and medium scale private forest owners. Thus, the local conditions, forest management strategies (such as even-aged management, close-to-nature forest management) and particularly the forest management goals and management tools of forest owners affect, to great extent, what our forests actually produce.

The recent international policy developments fostering a European bio-economy is gradually increasing the forest owners awareness of the potential of non-wood goods. This potential is related to the multiplicity of resources available and a huge portfolio of potential industrial products that can be derived out of them (Wolfslehner *et al.* 2014). Even though the traditional NWFP such as tannin, resin and cork have partly been substituted by chemical products from mineral resources, there is a growing interest in natural products as ingredients for cosmetic, pharmaceutical and food products. On the other hand, there is a growing public interest in collecting and using NWFP as part of recreational activities. This provides opportunities for the management of NWFP as part of the recreational infrastructure of forests. Thus the interest in NWFP is growing throughout Europe in recent years (Voces *et al.* 2012; Keca 2013; Vacik *et al.* 2014a) and forest owner´s motivation to engage in related businesses is gaining momentum (Rametsteiner *et al.* 2005; Weiss *et al.* 2011).

However, the interests of stakeholders such as forest owners, users and local communities or wider communities of interest such as governments, authorities and NGOs may differ. Sometimes policy-makers and forest managers on the ground operate within dissimilar realities (Nie, 2003). Also, notions of sustainable provision of NWFP become less precise and more subjective when viewed from the different human perspectives. The joint production of multiple forest goods and services may result in conflicts of stakeholder interests (Vogel and Lowham, 2007), and it is therefore important to reduce the scope or resolve possible conflicts. For this reason, stakeholder engagement has recently gained increasing attention in forest policy and management (Vacik *et al.* 2014b). A deeper understanding of stakeholder perceptions is essential (Nijnik and Mather, 2008) for implementing forest practices (including those regarding the management of NWFP) and influencing a policy design focusing on multi-purpose forest management (Nijnik *et al.*, 2010). Stakeholder engagement is thus becoming an important instrument for targeting towards a sustainable management of NWFP (compare also chapter 9 regarding animal conflicts). Moreover, sustainable provision of intrinsic and socially constructed values of nature and creating opportunities for people to enjoy forests necessitates vertical and horizontal collaboration (Kaljonen *et al.*, 2007), and leads to co-management arrangements across stakeholders.

Social innovation and participatory and multilevel governance, in a continuous process of adaptation, is needed to take account of opinions and behavioural patterns of stakeholders who drive forestry change and respond to it. This raises a number of questions: How are forestry institutions changing and what is their new role in facilitating the provision of forest ecosystem goods and services, including of NWFP? What are the key challenges of integrating NWFP into multi-purpose forest management? What are the prospects for social innovation, and why are some responses to forestry changes are more successful than others?

In addressing these questions, innovative cross-sectoral means of stakeholder engagement can provide an informed basis for promising approaches of sustainable multi-purpose forestry and the delivery of forest goods and services at a landscape level (von Gadow and Pukkala 2008; Sarkki *et al.* 2016). Such stakeholder collaboration involves a wider and very broad range of stakeholders actively in decision-making processes. For instance, in respect of NWFP production different stakeholders (including users) may be involved depending on whether NWFP take the form of industrial resources or as region-specific products for local niche markets (see chapter 5). Its application in forest multi-functionality, therefore, leads to new relationships and collaborations, as well as to the development of new forms of governance with stakeholders acting together. This chapter provides an overview about the different management concepts regarding the production and harvesting of NWFP on forest lands and on putting these concepts into forestry practice. First the diversity in management activities and the related diversity in regulatory systems is discussed (chapter 4.2). Next, the different types of management practices in respect of both management systems and different NWFP types is elaborated (chapter 4.3). In the last chapter (4.4) the relation of NWFP management to multi-purpose forestry is further explored.

4.2 Current situation regarding management and regulation of NWFP in Europe

Non-wood forest products should be seen as an integral part of forest management concepts in Europe as multi-purpose management is becoming a key in the provision of multiple ecosystem services. Provisioning services, forest management and planning methods in Europe have been traditionally tailored towards wood and wood-based products, *inter alia* due to their economic importance and competitive value chains (e.g. timber products, pulp and paper, bioenergy). However, NWFP also have a relevant place in the multi-purpose sustainable forest management paradigm, being the main source of income from forests in several regions. This is of special relevance considering the large share of private forest ownership in Europe. The private forests often form an important component of multipurpose rural landscapes in which the, often small, private forests provide different ecosystem services, wood and non-wood forest products that contribute significantly to rural development (Chernyavskyy *et al*., 2011, Vacik *et al*. 2014a).

Notwithstanding this significance of NWFP, the silvicultural systems for managing forests within Europe are generally timber oriented. They are often focused on a single wood production goal, whereby the full production potential of individual stands is often not utilized. Throughout Europe the majority of management operations are conducted for the increase and improvement in quality of timber products (Tomé and Faias 2014). In many countries with timber production having strong position, NWFP are a side-product and they are not considered at all in forest management decision making. In some countries, the production of NWFP is more established and they are to some degree considered in forest management. However, there are only a few cases where silvicultural management is adapted for the production of a new or additional production goal focusing on NWFP. So although NWFP are abundantly present within European forests, they are often derived from specific commercial plantations as their management and production within the forest is largely disparate with established timber orientated silvicultural methods. However, modern silvicultural concepts take into account many aspects of multipurpose forestry (e.g. risk reduction, diversification of wood products, considering various ecosystem services, adaptation to climate change, biodiversity….), which increase the options for synergies in the production of NWFP. Nevertheless, the landowners generally do not integrate the production of NWFP into the management goals. The collection of NWFP is often considered as a ‘minor’ forest product that is in several cases collected by other people than the forest owner.

Due to the large NWFP products ranging from tree products to products from understory plants, mushrooms and animal products, there exists a great diversity in NWFP management practices. In general, four types of specific activities may be identified (adapted from Wiersum, 1997): i) controlled harvesting of wild resources, ii) conservation and enhancement of naturally growing species, iii) cultivation of NWFP producing species and iv) co-production of NWFP and wood production. In the next chapter it will be elaborated how the nature and intensity of forest management differs for these different types of activities. The four types of management activities may also be related to different regulatory systems. The first category of controlled harvesting is related to the fact that harvesting of essentially wild resources (e.g. berries, game) is regulated. This might be done with provisions by the landowner or in the case of game, the owner of the hunting rights. Although this collection is often under the control of forest owners, this is not always the case. Many NWFP are public goods that may be collected freely (e.g. berries or mushrooms). Other NWFP, e.g. those derived from wildlife, are subject to formal governmental regulations (see also chapter 2). Mostly there are no active measures undertaken by the forest owner to promote the production of certain NWFP. The second and third category relate to the fact that although several NWFP are collected as wild products that are more or less spontaneously growing in forests, others are harvested from species that are consciously enhanced by the forest owner by limiting competition by other species and stimulating production capacity (e.g. fruits, nuts or seeds), or are cultivated in adapted (agro)forestry systems (e.g. truffles, Christmas trees, cork, medicinal herbs). In this category the management intensity is increased with the aim to enhance the quality and/or quantity of NWFP. The fourth category of management practices is related to the fact that NWFP production is often combined with wood production. The co-production of NWFP and timber allows the landowner to utilize synergies in the production and enhancing the overall income from the forests (e.g. resin, birch sap, game).

The variety of NWFP production systems ranging from wild NWFP as public goods that can be collected on the basis of common law to explicitly cultivated NWFP as natural resource that are managed in line with either agricultural or forestry regulations complicates the options for improving NWFP management. The diversity of s the regulations on NWFP use is illustrated by the results of the common survey among the 23 COST countries (see also chapter 1). This survey provided the following basic information regarding the production and management, harvesting and collection of NWFP in Europe (Figure 4.1):

- **Who are the holders of property rights regarding NWFP?** A large variety of NWFP are produced in Europe; these are in this book classified into four groups, products derived from: trees, understorey plants, mushrooms and animals. The production of these NWFP takes place in both public and private forest areas. Some products, especially mushrooms, are often collected under common rights and are freely available. Other products, notably tree products and understorey plants, are often the legal property of forest owners and can only be harvested for commercial use with the permission of the owner. On average 51% of the NWFP in all surveyed countries were collected from private forest lands with the owner having property rights (Figure 4.1a). Property rights for animals are rather more complex and vary according to the type of product, the size of land holding and legal provisions. It may be related to either land ownership or tenureship (e.g. beekeepers renting space for beehives on forest lands or livestock keepers with grazing rights on forest lands). In many countries game is a public good. The right to hunt is usually attached to the land but can also be held separate from land ownership. Hunting rights can be private or state owned and are usually organised into hunting grounds of an appropriate size to cover game population ranges.

- **Who are the collectors of NWFP?** The majority of NWFP such as aromatic and medicinal plants, nuts, berries and mushrooms are harvested manually. Such collection may be done by either the forest owner or by external harvesters who collect NWFP depending on personal or commercial use on the basis of either a formal contract, permission of the forest owner, or under everyman's rights as a free public good (Figure 4.1b). Notably in respect of animal products a large variety of harvesting arrangements exist, whereas the way of who gives the licenses varies. Although there are many interests regarding the products it seems that animal products have a larger number of different interested parties, besides the landowners, hunters associations or bee keepers are mentioned. For the other categories it is often a third party contractor or the private forest/land owner who has interest to collect the NWFP. In the context of tree products it is quite evident, that the private forest/land owner has the highest share regarding the potential collection of NWFP, where for instance the cutting of cork requires a high level of skill and pine nut harvesting is carried out by using mechanised tree shakers in Spain and Portugal. Dogs are employed in the hunt for truffles both within and beyond plantations.

- **Which regulations are in place for NWFP?** All countries have defined several laws, regulations and practices defined in order to protect at least the most vulnerable NWFP against unsustainable harvesting and use. Very often the forest law provides sufficient restrictions to control harvesting of plants and fungi while game and fisheries have their own legislation which often provides a higher number of regulations including those to control the ownership and use of lethal weapons such as guns (Figure 4.1c). To some extent environmental and nature conservation laws also restrict harvests particularly of species which are listed as being of conservation concern (i.e. Article 17 of the Habitats Directive). In this context in some countries the public has the general right to use NWFP, but land owners may restrict or prohibit the use of certain products (e.g. Austria, Romania) or may charge fees for their collection (e.g. Italy, Spain). In a few countries harvesting is generally free of restriction (e.g. Finland) but in most there are restrictions on harvesting for commercial purposes (e.g. Germany).

- **Who is able to control harvest and use?** Considering the authority that is able to control the harvesting and sustainable use of NWFP it becomes evident that private forest/land owners are most relevant. They have besides forest, conservation and wildlife authorities the opportunity to restrict the access or the use (Figure 4.1d). Regarding animals, there is a broader range including hunter and hunter associations as well as bee keepers and contractors.

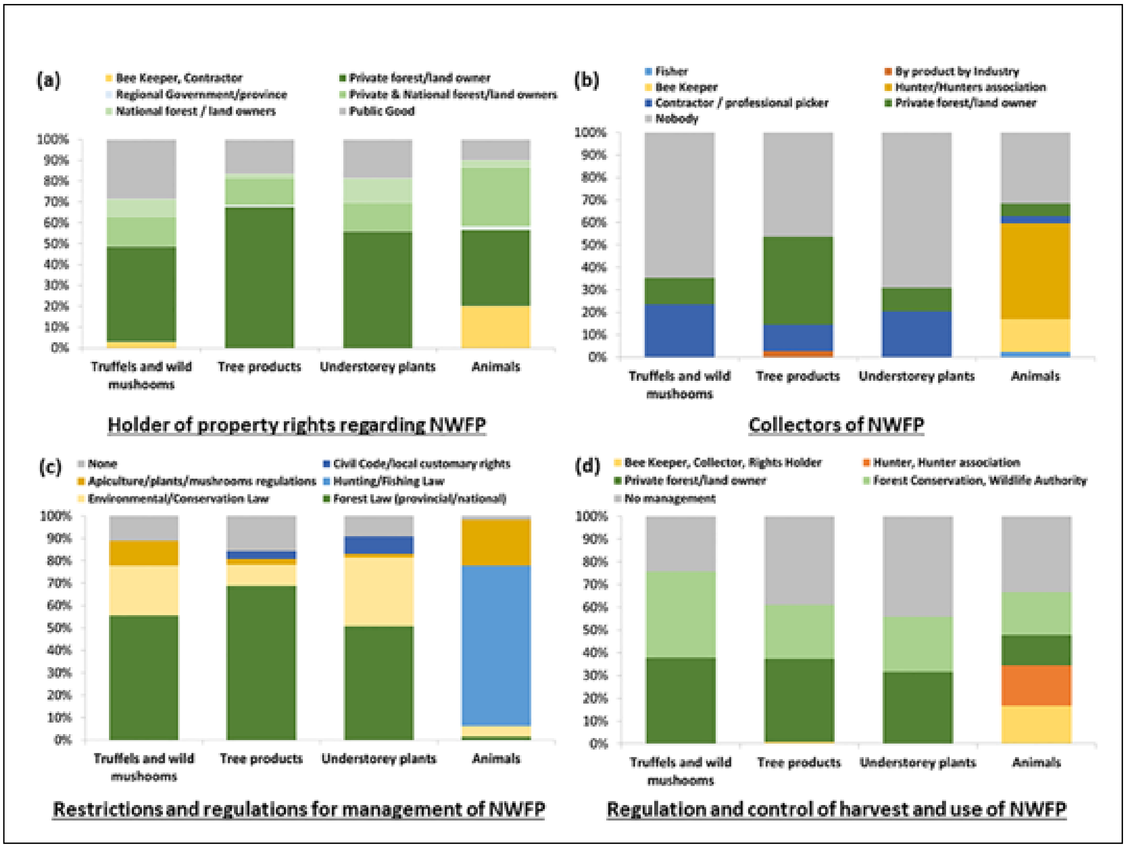

Figure 4.1: *Property rights and regulations regarding the collection and harvest of NWFP (Source: COST Action FP1203 common survey)*

4.3 Current status of NWFP management in Europe

This chapter addresses how NWFP in Europe are currently being managed as a biological resource. First, the general management approaches towards producing NWFP in a variety of production systems as well as the variety in information systems (expert based or model based) that have been developed to support management decisions. Next, it elaborates the specific management practices for four categories of NWFP and specifies their management on the basis of case-studies from selected NWFP.

4.3.1 General management approaches

NWFP are most frequently produced within natural and semi natural managed forests (see chapter 2, Figure 2.3), although in several cases forest and horticultural plantations and agroforestry systems are the key systems for their production. In a recent report Sheppard *et al.* (2016) have argued that in the case of NWFP production in (semi)natural forests a degree of compromise is required for the successful culture and co-production of NWFP. An appropriate set of ecological conditions is paramount for the successful growth and culture of desired NWFP species as introduced and discussed in chapter 2. Such circumstances are dependent on specific site conditions, but may be modified through management activities that specifically target the forest canopy or understory.

NWFP species can be wild harvested, harvested from wild managed populations and/or cultivated under controlled conditions. It has been shown that the proportion of wild vs. cultivated production is related to the product category, for example, a larger proportion of mushrooms are wild harvested (≈90%, e.g. see chapter 2 in this book, Figure 2.3e) than tree derived NWFP, many common survey respondents consider the culture of Christmas trees as a cultivated product (encompassing 14 nominated species; see chapter 2, Table 2.1). Christmas trees are a major NWFP business in Europe, the large majority of Christmas tree production is carried out in dedicated plantations, largely outside the forest (Wegmann 2008), where the single purpose management treatments are focused purely on the production of Christmas trees. Meanwhile, *Rubus* spp. (*R. fruticosus*, *R. hirtus* and *R. idaeus*) or *Vaccinium* spp. (*V. myrtillus*, *V. vitis-idaea*) were frequently suggested to be derived from both wild and cultivated sources based on the responses of the COST survey. Nevertheless, the use of silvicultural treatments has frequently been cited as a method of influencing the production of NWFP within the forest (e.g. Bonet *et al.* 2004; Liu *et al.* 2016 in the case of mushrooms or in Miina *et al.* 2010 concerning understory berries, while Sheppard *et al.* 2016 make further silvicultural recommendations for a wide spectrum of European species). Chapter 6 highlights an example of truffle cultivation utilising inoculated trees in Austria (see box 1.5). Yet large scale applications of such treatments are less commonplace.

The production of NWFP in agroforestry systems provides another example of the compromises in co-production of wood and NWFP. These systems provide the means for combining two or more production goals within one land parcel, usually a combination of trees with an annual or perennial intercrop but timber may not always be the primary goal. In the case of Silvopastural agroforestry systems the trees are combined with animal grazing for example Portuguese "Montado" and Spanish "Dehesa" utilise widely spaced cork oaks; *Quercus suber* within pasture for the production of cork. Management of individual elements considers the needs of the whole system. Low density agroforestry sits at the fringe of the definition of forest, yet may be integral for the successful production of NWFP in Europe as in practiced elsewhere in the world.

Yet another type of compromise needs to be considered in the case of NWFP production in the form of game. Forest management may also extend to the management of game animals (e.g. *Capreolus capreolus*, n=11; *Cervus elaphus*, n=10 and *Sus scrofa*, n=10) which were most frequently nominated within the common survey. Bauhus and Scherbeck (2010) suggest that habitat quality (i.e. for game animals) is likely to partly depend on the structural diversity of forest stands which in turn is highly influenced by forest management. Meanwhile, there is often a requirement that direct management of game animals within forests is carried out in order to regulate the health and size of a population and to counteract damage inflicted upon forest trees (or to agricultural crops on the periphery of forested areas) by such animals. Forests themselves are often not managed solely for game animals (with the exception of specialized hunting estates where hunting is of the upmost priority, i.e. the creation of shooting vistas and areas of game cover), however defined forest management may take into account measures needed in order to protect trees against damage caused by animals, for example the installation of fences to protect natural regeneration of stands and other protection measures.

There are different options available to enhance the yield of NWFP. Silvicultural treatments alter the micro-climatic conditions concerning light, temperature and moisture availability, as these parameters are directly influenced by the degree of canopy cover and other characteristics of the stand structure, composition, tree age, harvest intensities, as well as the methods for slash disposal and timber extraction. The presence of NWFP species can be both positively and negatively influenced by these factors as they also affect the understory growth conditions and other environmental conditions. In this context different instruments and techniques are used by forest managers to support forest management planning: among the four categories of NWFP besides monitoring systems, forest management plans and guidelines are mostly used. More sophisticated growth and yield models or decision support systems are rarely used to support managers although research has developed a number of tools to address the demands of alternative management approaches (Figure 4.2). Recent development in forest management planning has been the increased availability of NWFP yield models (see chapter 3 of this book). Even though traditional knowledge and management recommendations derived from this kind of knowledge can also be used to give recommendations to forest owners on how to manage their forest stands for increased NWFP yields, quantitative models greatly facilitate these efforts in providing substantial recommendations. With these models integrated in forest planning system, it is for example possible to perform trade-off evaluations: managers can analyse how much a certain kind of forest management increases the yield of NWFP and what effects of this alternative management approach on timber production. In Finland, NWFP-oriented holding-level forest planning is taking its first steps within the project "New products from forests" that commenced in 2016 (Luke 2017).

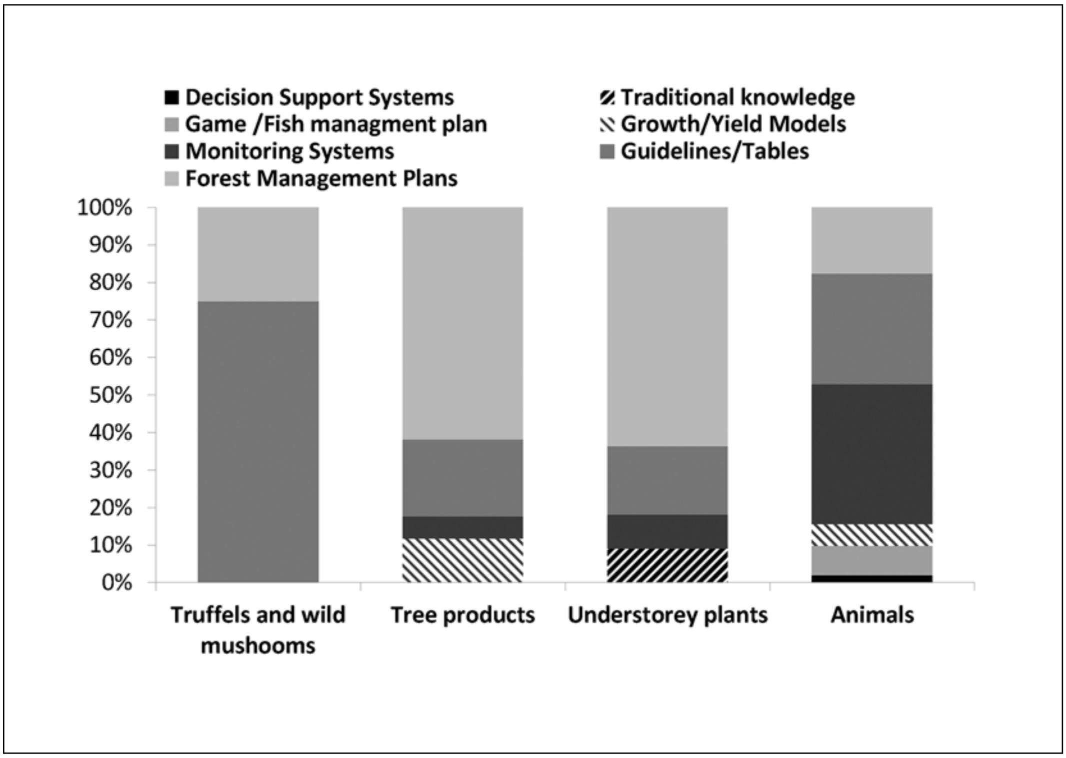

Figure 4.2: *Options to support the management of NWFP*
(Source: COST Action FP1203 common survey)

However, there are fewer examples where silvicultural practices are purposefully modified to enhance the yield of NWFP. The existing property rights are often a limiting factor for an intensified forest management. If there is a common right to harvest NWFP, then managers and private forest/land owners have less interest to increase the yields, if they can't utilize the economic benefits (Tomé and Faias 2014). Exploring the options to improve the production and the yield of NWFP it seems that there is at least some potential seen in silvicultural practices. Thinning operations (including crown thinning, selective thinning and regeneration cuts) are listed for all four NWFP categories as an important measure to influence the production (Figure 4.3). Conservation management activities have been mentioned as beneficial to improve the habitat for deer and other game species. The use of chemical/fertilizers treatments are seen as only of minor relevance. However, Christmas tree production has a larger relevance in Europe and here the use of fertilizer and pesticides are quite common, but the production of Christmas trees does not play such a prominent role in all European countries.

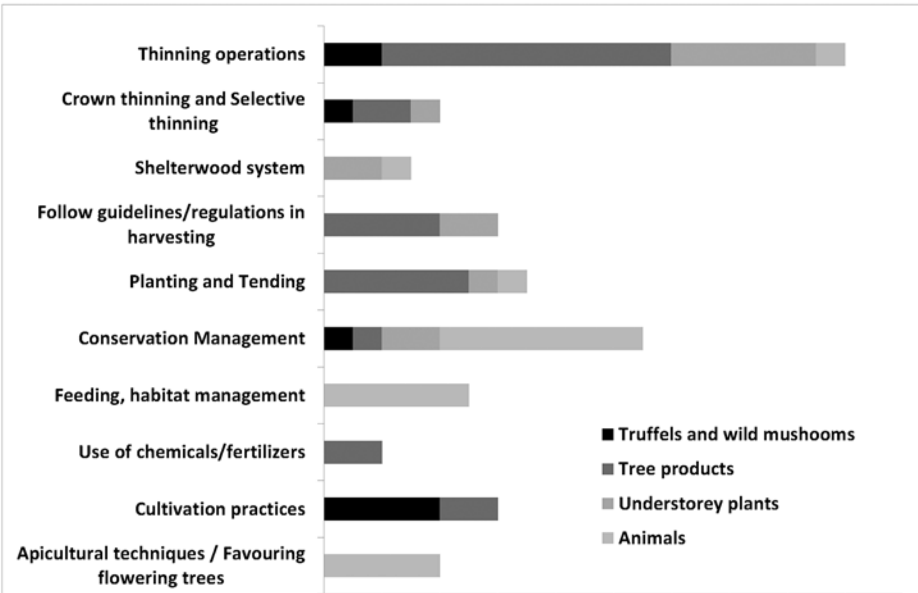

Figure 4.3: *The effect of forest management operations on the production of NWFP (Source: COST Action FP1203 common survey)*

4.3.2 Management for mushrooms and truffles

Mushrooms and truffles are economically important NWFP. In some areas where timber-oriented forestry is characterized by a low economic profitability, the commercial value of mushrooms and truffles can be much higher than the economic profit obtained from wood assortments (Alexander *et al.*, 2002; Palahí *et al.*, 2009). Even in typically profitable forest systems, such as plantations in boreal regions intensively managed for timber production, the net present value of edible, marketed mushrooms can represent 25% of the total net present income (Tahvanainen *et al.*, 2016). The increasing importance of edible mushrooms and truffles in the local and global markets, as well as their relevant contribution to the provision of cultural ecosystems services (e.g., mushroom picking as a leisure activity and a source of tourism), is increasing the interest toward suitable ways of managing and enhancing mushroom yields in forest ecosystems (Pilz and Molina, 2002). Since forest fungi are tightly connected to forest trees, for instance through the mycorrhizal symbiosis, forest management and silvicultural operations are likely to influence fungal dynamics and yield (see chapter 6). Indeed, although weather and site conditions highly determine the occurrence and productivity of mushrooms and truffles in forests and agroforestry systems, only those variables related to the stand structure and composition can be actually modified by managers via multi-purpose forest management operations aiming at enhancing the joint productivity of edible fungi and timber over large scales.

The effect of different silvicultural treatments on the productivity of mushrooms and truffles has been studied during the last decades (see chapter 6.4.1 for further details). Beyond the diverse impacts of different silvicultural operations on different fungal species and forest ecosystems, it seems clear that certain stand structures are more suitable than others when it comes to enhancing mushroom productivity in forests from northern and southern Europe. However, it must be also noted that considerable differences between stands also exists: stands with similar characteristics can give very different mushroom yields, which cannot be explained with models. Optimal stand characteristics are generally described by a range of optimal stand basal areas at which mushroom yield tends to be maximized. For instance, several studies on mushroom yield modelling found that, on average, a stand basal area around 20 m2/ha seems to be optimal for mushroom productivity in the Mediterranean area, ranging from approximately 10 to 40 m2/ha depending on the forest ecosystem and site characteristics (Figure 4.4; Bonet *et al.* 2010; Martínez-Peña *et al.* 2012; de-Miguel *et al.* 2014). Similarly, Tahvanainen *et al.* (2016) found maximum yields of edible mushrooms at stand basal areas of 25 m2/ha in Norway spruce plantations.

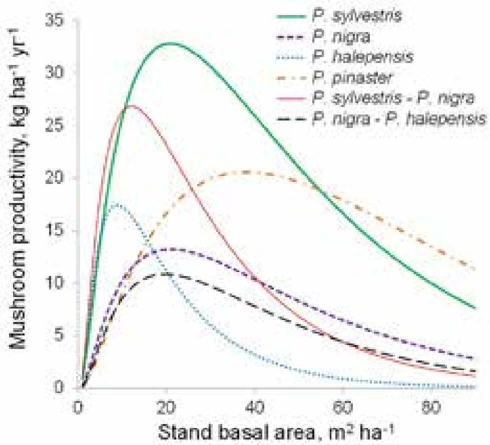

Figure 4.4: *Effect of stand basal area on edible, marketed mushroom yield in different Mediterranean forest ecosystems (modified from de-Miguel et al. 2014).*

Palahí *et al.* (2009) combined such effect of stand structure on mushroom yield with economic parameters in stand-level forest management optimization aiming at the joint production of mushrooms and timber in Mediterranean forests. They found that such multi-purpose forest management can be more profitable. For instance, thinning operations, which are often unprofitable in those areas in timber-oriented forestry, were included in the optimal management schedules when their expected positive long-term effect on edible mushroom yield was considered. As a result of combining wood and non-wood forest products in forest management planning, the rotation length tended to be longer when edible mushroom prices were high and/or when site characteristics were more favorable for edible mushroom production. Another study on the regional-level effect of forest management intensity on mushroom productivity conducted by de-Miguel *et al.* (2014) showed that, within the context of increasing abandonment of forestry activities in Mediterranean areas (due to the low profitability of timber-oriented forestry), increasing forest management intensity could mitigate and even revert the associated mushroom productivity loss. Furthermore, forest management for mushroom production tends to promote stand structures which are also beneficial in relation to the provision of other ecosystem services in Mediterranean forests. Indeed, the stand structures required for enhancing mushroom productivity, would contribute also to decreasing fire risk at the same time as they would also contribute to increasing both tree growth and water use efficiency (Gracia *et al.*, 2014).

4.3.3 Management for tree products

Whilst animals, mushrooms or understory plants have been often collected by third parties, non-wood forest products from trees are among the NWFP with the longest history of management by forest administrations or owners themselves, given their clear linkage with the trees and the implicit property rights over them. Their exploitation can be more or less compatible, complementary or competitive with optimisation of timber yield as main management goal, and may be done by the forest owner himself, or be leased or licensed for certain forest management unit and time, often annually. The co-production for timber and NWFP can require a multipurpose planning for conciliating of all considered forest goods and services, leading frequently to adaptions in species composition, stand structure, rotation length, or thinning regimes.

Studies considering the modelling and optimisation of berry or mushroom production have only recently been undertaken, while studies investigating cork and pine nuts from Mediterranean forests build upon several decades of research (see chapter 2). Conceptually, there are three major groups of NWFP to be considered in the management of tree species: i) fruits, nuts, flowers or leaves (chestnuts, walnuts, pine nuts, acorns, wild cherries, rowan, service and checker tree berries, lime flowers, bay leaves, including also the special case of certified forest reproductive material (seeds or fruits), ii) cork or tanning barks (obtained by bark stripping), iii) gums, resins or oils (tapping for extraction). Another noteworthy case is the production of Christmas trees and ornamental tree materials, these are often the object of cultivation in specific plantations outside the forest (see chapter 7).

Outputs of optimisation processes for the co-production of timber and NWFP will strongly depend on market prices assumed for different products and interest rate applied, which implies that generally optimal silvicultural guidelines cannot be obtained, the climate-dependant variability of many productions aside (Montero and Cañellas, 2003; Calama *et al*, 2010; Mutke, 2013; Pasalodos *et al*., 2015; Perreira *et al*., 2015; Rodríguez-García *et al*., 2015). Finally, the choice of the best genetic material must be considered as crucial, in terms of yield and quality, as well as a need for adaptation to current and forecasted growth conditions under ongoing climate change.

The various management options for co-production of timber and other tree products may be illustrated by the following examples.

4.3.4 Multi-purpose management of cork oak

Cork oak (*Quercus suber*) stands are usually managed as multi-purpose agroforestry systems for the production of cork combined with cattle or sheep grazing, acorns production for swine mast, firewood, hunting, and mushrooms picking, or occasional shifting cultivation under trees. In the southwestern Iberian peninsula, cork oak forms open woodlands (20-50 trees/hectare), pure or mixed with holm oak, an ancient cultural landscape called Montado in Portuguese, Dehesa in Spanish. Those traditional oak woodlands are also valued for their ecological role for wildlife, water regulation and erosion control. Most of the existing cork oak stands originated from natural regeneration or gradual clearing of previous denser oak forests, and in many cases, natural regeneration of old-grown stands is virtually nil, due to persistent grazing, acorn consumption for swine feeding, and regular understory clearing. Even when those traditional ground management practices are abandoned, regeneration is often hindered by appearance of dense understory instead, formed by *Cistus* or by *broom* species. Tree management in existing old woodlands is often limited by over-pruning for firewood and felling of single dead trees, as the harvesting activities are not always complemented with replacement planting.

New cork oak plantations are relatively recent and have seen a large increase since the 1990s, favoured by EU C.A.P. farmland set aside incentives for afforestation. More than one hundred thousand hectares have been established with cork oaks, mainly in Portugal and Spain, and to a lesser extent in Italy and France. Such newly established cork oak plantations, with higher stocking (initially 300-600 trees/ha) than many old-growth stands and with regular stem forms thanks to plastic protectors and formation pruning, will exceed diameters of 20 cm at breast height (DBH), and hence, will start cork production at approximately 25-30 years of age. Future selective thinning of trees with less-than average cork quantity or quality (e.g. thickness) will reduce stand density to finally 180-200 trees per hectare, or less, if acorn co-production and grazing is targeted.

4.3.5 Management of Mediterranean stone pine

Traditionally, Mediterranean stone pine (*Pinus pinea*) stands are managed for the joint production of timber, fuelwood and cone production; these cones provide valuable pine seeds. The pine stands traditionally originated from natural regeneration or plantation, the latter often aimed for soil protection and forest restoration and had been managed following a shelterwood system for achieving natural regeneration, underplanting, or, more often, sowing for accomplishing adequate stocking of regeneration under shelter. After removing remaining shelter trees in the final felling (rotation length 80-120 years), the density of the new stand was regulated with 2 or 3 thinnings applied during the first half of rotation (e.g. at age 10, 20 and 40), and simultaneous pruning of remaining trees. During the second half of rotation, the final stand density before regeneration felling was about 150-200 trees per hectare, combining low but significant timber and firewood yields (0.5-3 m3/ha/yr) with sustained cone harvests from age 20-25 upwards.

In the last decades, individual tree performance at early stand ages has improved considerably, due to better quality of the regeneration materials (selected genetic materials, selected quality from nurseries), as well as due to abandonment of former over-grazing by sheep or cattle. Therefore, less posterior selection is required among saplings, allowing for lower initial stand densities considered nowadays adequate, from formerly 1,000-1,600 seedlings per hectare to 500-800 or even less, especially in new plantations oriented towards cone production, in the absence of slopes or erosion risks, and with active control of ground vegetation. Also the final stand density, if natural regeneration is not prescriptive, can be reduced to less than 50 open-grown trees per hectare, similarly to the open Montado woodlands in the Portuguese Alentejo, maximising individual tree cone production.

On the other hand, natural forests or long-established protective plantations with stone pine, where soil protection, wildlife habitats, amenity landscaping and other non-market ecosystem services predominate over cone production as main management goal, higher stocking density is maintained, and they are still managed following the traditional, extensive schedule (Montero *et al.*, 2008; Tomé and Faias,. 2014).

4.3.6 Management of Maritime pine

Also the management practices for maritime pine (Pinus pinaster) is commonly focused on co-production. In this case the co-production concerns timber, wood biomass and resin. The management of the pine stands is in addition also conditioned by their protective role in respect to soil, watershed, landscape, and wildlife. During 18th-20th centuries, maritime pine was one of the major species used for forestation and forest restoration in the Mediterranean and the SW-European Atlantic coastlands. Several million hectares of maritime pine forests are managed timber- or resin-oriented, following an even-aged forest management system.

In the case of Mediterranean (*P. pinaster*) forest with reduced timber yields, co-production with resin had been paradigm for this multipurpose tree, and nowadays, after twenty to thirty years of abandonment, resin tapping activities are recovering since 2010 (Tomé and Faias, 2014). The silvicultural scheme applied is based on natural regeneration, planting or sawing for maintaining ordered series of even-aged, pure stands, balanced at Forest Management Unit scale, that allow organising and concentration of resin yielding in time and space, tapping all trees of a given stand in the same adequate size and age class, e.g. 40-65 years (DBH exceeding 25 or 30 cm). Initial stand density about 1,000 saplings/ha, after natural regeneration even exceeding 2,000/ha, will be reduced by early heavy thinnings to 150-300 trees per hectare to reaching this minimum diameter for tapping as soon as possible.

CASE 4.1: *Forest seeds harvesting in Romania*

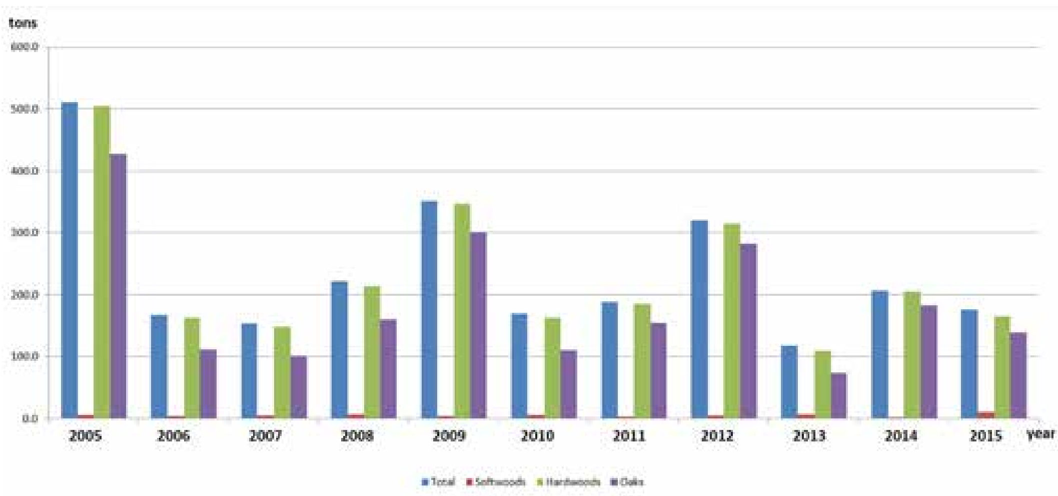

Figure 4.5: *Havested quantities [tons] of hard-, softwood and oak seeds (2005 – 2015) in Romania*

In Romania, NWFP are mainly represented by forest fruits, truffles and wild mushrooms, game, medicinal plants and forest seeds. Regarding the latter category, in the period 2005-2015, an average of 235 tons were harvested, with a minimum in 2013 and a maximum in 2005. There are more than 40 000 ha of seed stands across the country (Pârnuţă *et al.* 2012), from which the seeds are mainly harvested. There are more than 40 species of interest (Dobre 2011), but the main ones are the representatives of genus *Quercus*, especially sessile oak (*Quercus petraea*) and pedunculate oak (*Quercus robur*) that account for approximately three quarters of the harvested quantities of forest seeds in the period 2005-2015 (Figure 4.5). In the case of the softwood species, Norway spruce (*Picea abies*) is the most important, followed by fir (*Abies alba*), Scots pine (*Pinus sylvestris*) and Douglas-fir (*Pseudotsuga menziesii*).

Quantities of harvested forest seeds of main groups of species (MEWF 2016) Since the fructification of tree species is influenced by several abiotic and biotic factors, the sustainable management of the seed stands and seed storage plays an important role for forest management. In Romania the storage of the seeds is successfully carried out in the centre of Marin Drăcea National Institute for Research and Development in Forestry from Brașov. The total storage capacity of the centre is 30 tons of seeds (Budeanu *et al.* 2014), and allows to store seeds up to 10 years.

4.3.7 Resin production in Greece

In Greece, two types of resin are produced, mastic and resin. Although resin tapping of Aleppo pine (*Pinus halepensis*) forests has been an important economic activity in Greece, during the last 20–30 years annual production has dropped dramatically due to socio-economic reasons (Papagianooulos 1997). The aromatic, ivory-coloured resin, also known as mastic, is harvested as a spice from the cultivated mastic trees (*Pistacia lentiscus* var chia) (Figure 4.6) grown in the south of the Greek island of Chios in the Aegean Sea, for the last 2400 years, which export the resin and mastic-based products worldwide. It is a slow-growing sensitive species that grows in limestone soil (Ciesla 2002).

Figure 4.6: *Trees of Pistacia lentiscus var Chia.*

The resin is collected by tapping of the trees that are at least five years old. This is done in the form of small cuts made in the bark of the main branches, which allows the sap to drip onto the specially prepared ground below. The ground is previously thoroughly levelled and cleared (swept) of all branches and leaves in order to facilitate easier harvesting. After that, white soil (calcium carbonate powder) is spread on this area in order to facilitate gathering without altering its chemical composition (Masticulture 2016). Harvesting starts in the summer (June or July) and ends at the beginning of October. After the mastic is collected, it is washed manually and is set aside to dry, away from the sun, as it will start melting again. Cleaning is a very tedious process and can last throughout winter during which full time employment of the mastic producers is required. Annual production amounts to 118,000 metric tonnes, of which 88% are exported (Chios Mastiha Growers Association 2015) to more than 50 countries. Resin extraction is performed by removing a slice of the bark (about 1.5 × 8–10 cm in size) of living trees without wounding the actual wood (Spanos *et al.* 2010). In order to increase resin flow, a mixture of sulphuric acid, water and kaolin is used (Tsoumis 1991). Resin tapping is repeated every 10–15 days in the period April – October, and is mainly applied on trees with a diameter at breast height (DBH) over 25 cm. Only one tapping area is allowed when the diameter ranges from 25 – 32 cm and two tapping areas are possible if DBH is ≥ 32 cm whereas the horizontal distance between the tapping areas should exceed 7 cm. Resin collectors usually open wounds that are 11–12 cm wide, while each tapping area is extended upwards, reaching mean heights of 2.0–2.2 m above ground (Spanos *et al.* 2010). Several factors influencing resin production have been reported such as soil, climate, applied chemicals, tree age, silvicultural regime, and genetics of trees (Tsoumis 1991).

Mastic gum is principally used either as a flavouring or for its gum properties, as in mastic chewing gum. It is also included in many traditional recipes, such as Greek festival breads (e.g. the egg-enriched sweet bread tsoureki of the Easter period and the traditional New Year's cake vasilopita). Furthermore, mastic is also used for religious purposes, as it is essential to Myron, the holy oil used for chrismation by the Orthodox Christian Churches. Except from its culinary uses, mastic is also used for its medicinal properties (Dabosa *et al.* 2010, Huwez *et al.* 1998) and production of cosmetics. Efforts are made so that the volume of mastic resin is increased whereas resin from pine tapping is constantly decreasing due to socio-economic reasons. The Chios population depends upon the international promotion of mastic resin, while pine-based resin production is decreasing, due to the low income possibilities of the forest workers in most areas of Greece (Tsioras 2010). Nevertheless, an increase resin production, could support the income for rural populations and contribute through its multiplier effect to the national economy.

4.3.8 Management of understory plants

Forest management has a strong effect on the composition and diversity of understory plants (Battles *et al.* 2001) and can affect the production of NWFP originating from the understory (see chapter 8). Management and post-harvest practices alter the environmental conditions and competitive interactions among the plants of the understory and ultimately their growth and productivity (Crow *et al.* 2002; Nauertz *et al.* 2004).

Bilberry (*Vaccinium myrtillus* L.) and cowberry (*Vaccinium vitis-idaea* L.) are typical and abundant understory plants in conifer-dominated forests of medium and poor-fertility in northern Europe. Both species are economically important wild berry species, since they are widely collected for both household consumption and sale. Consumers' interests also towards berry products have been increasing globally emphasizing nutritional and health aspects of food.

The coverage and yield of bilberry and cowberry are primarily affected by site conditions, but also forest management in suitable sites clearly affects the berry yields. Regeneration fellings have clear long-term negative effects on bilberry yields. It is sparse also in seedling and sapling stands as well as in too dense and shaded young thinning stands as a moderate supply of light is needed for good bilberry yields.

Cowberry is well adapted to grow under a tree canopy of Scots pine, but a good supply of light is needed for good cowberry yields. As a result, the highest cowberry yields can be found from stands that are in the beginning of their rotation, i.e. in seed-tree and small seedling stands. The cowberry yields are low in dense and shaded thinning stands, but towards the end of the rotation, sparse pine stands are again suitable for cowberry. Thus, at the end of rotation, good bilberry and cowberry yields can be obtained even from same stands (Miina *et al.* 2016).

In Finland, berry models prepared for bilberry (Miina *et al.* 2009) and cowberry (Turtiainen *et al.* 2013) were included in a stand growth simulator and the berry production was predicted along with stand development by Miina *et al.* (2016). In their study, the aim was to optimise the multi-product management of stands growing on sites most suitable for bilberry and/or cowberry. The simulation-optimisation system maximised the soil expectation value (SEV) with 3% discounting rate. All costs of and incomes from both timber and berry production (e.g. berry-picking costs and berry prices) were included in calculations.

With the current market price of bilberries (2.4 €/kg), heavier thinnings and 25 years longer rotation are recommended for the joint production when compared to the optimal management schedules without considering income from bilberry (Figure 4.7). In sparse, mature pine stands, applying a longer rotation results in a higher mean annual bilberry harvest during the rotation due to the fact that the highest bilberry harvests are obtained in the end of the rotation.

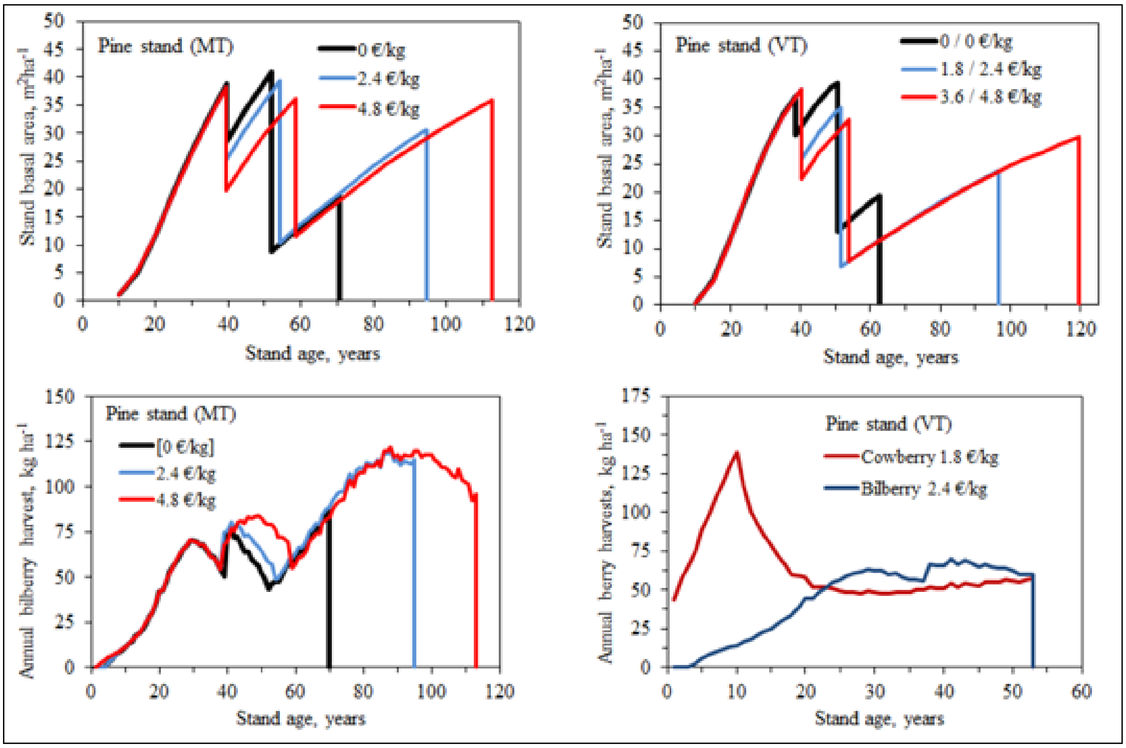

Figure 4.7: *Effect of berry prices on the optimal management schedules of Scots pine stands (above) and predicted berry harvests (below). Left: Only bilberries are harvested on medium fertility (Myrtillus type) site and valued 0–4.8 €/kg. Right: Both cowberries and bilberries are harvested on poor-fertility (Vaccinium type) site and valued 0–3.6 €/kg and 0–4.8 €/kg, respectively.*

In Norway spruce stands, it is not profitable to modify the even-aged management schedules to promote bilberry production. In management of uneven-aged spruce stands, the stand basal area would be constantly at a level that enables good bilberry yields and thus the potential bilberry yields would be higher than under the current even-aged management system (Pukkala *et al.* 2010).

Valuing cowberries with the current market price does not affect the optimal management of Scots pine growing on *Vaccinium* sites. This is due to the fact that according to the cowberry yield model applied, the highest cowberry yields are obtained in the beginning of the rotation and thinnings do not markedly affect the cowberry yields later during the rotation.

In a Scots pine stand which is suitable for bilberry and cowberry, heavier thinnings would reduce canopy shading to a level that is more favourable for both berry species (Figure 4.7). In addition, seed-tree cutting done to promote natural regeneration for pine and longer rotation lengths would be applied to promote berry yields in the end of the rotation.

The forest understory can be a source of forage for livestock and wildlife. It is well substantiated that forest management is an important factor that strongly influences forage availability for domesticated and wild ungulates (Edenius *et al.* 2014). However, as grazing is considered as a serious threat to forest ecosystems (Humphrey *et al.* 1998; Mayer *et al.* 2006), traditional European forest management has not adapted measures that can increase forage production. Although herbivorous grazing is included in multi-purpose forest management, there are still limited implications of measures that can improve understory forage production and quality. Thinning and pruning, fertilization, seeding of the appropriate herbaceous species and populations, as well as planting of fodder shrubs have been suggested as forest management tools to increase forage production and nutritive value (Papanastasis 2009; Kyriazopoulos *et al.* 2013; Abraham *et al.* 2014) but these are of limited application in the majority of European countries. Management of Dehesa on the Iberian Peninsula is an essential exception of this trend, as a variety of measures has been applied in order to sustain the productivity of these traditional agroforestry systems (Pinto-Correria and Mascarenhas 1999).

The legal framework of grazing in forested areas is highly variable among the European countries. In cases that grazing is permitted in forested areas, an important issue is the application of the appropriate grazing management. Unfortunately, this is not very easy as grazing capacity of European forests have not been evaluated in most cases (Papanastasis 2009). Moreover, a sustainable forest grazing management should take into account farmers' as well as other stakeholders' opinions in order to be successful.

4.3.9 Management of game, bird and wild animals

The management of animals in the forest has a different legal basis and hence regulatory framework than other forest products. Animals are not rooted in the ground, are free roaming and are generally not the property of the owner of land while alive (see chapter 9 for further details of legal tenure of wild animals and hunting rights). Legally, they are rendered into the possession of the hunter when they are killed. It is therefore the right to hunt that is the dominant issue when considering management of wild animals. There are lots of nuances in law between and within countries but the general situation is that rights to hunt are owned by the landowner. However, since animals range over large areas which can cross ownership boundaries there are often restrictions on the use of these rights according to the size of land holding. So, for example, in Germany landowners can only exercise their full rights to wild animals if their landholding is larger than 75 ha, owners of small landholdings are obliged to join a hunting cooperative of neighbouring owners to form hunting grounds of at least 250 ha in extent. In some countries hunting rights are owned by the state who can distribute them to hunting associations who take responsibility for game management for a specific hunting ground (e.g. in Hungary the hunting rights as well as game belong to the state, hunting clubs have the opportunity to rent hunting territories for a certain period). Management of wild animals conforms to the concept of controlled harvesting designed to ensure sustainability of the game populations and to keep related damage to forest or agricultural crops within acceptable limits. The interests of hunters and foresters are often antagonistic, in any case if both responsibilities are not managed by the same person, and the setting of acceptable population levels (and hence culling quotas) of individual game species are often a matter of societal choice. The most elaborate management provisions (based on inventory and models) are usually made for large game (i.e. deer, boar etc.) with lower levels of sophistication for more populous small game such as rabbits.

Conservation of threatened species and enhancement by re-introduction or re-wilding is also an important aspect of forest management involving animals. In this case the animals may be feral – escaped or released domestic cattle, ponies, sheep or goats or extirpated wild animals such as beaver or wolf. These animals are often hunted to control populations. Conservation programmes can also require the removal of invasive exotic species such as signal crayfish which can provide an abundant – if not ultimately sustainable – source of commercial products which can potentially be used to defray the cost of management.

Game birds such as pheasant and quail are often raised in pens with artificial feeding for release for sport shooting. The birds are raised in woodland but shooting can take place over open land or fields adjacent to the woodland. Such activities depend upon shooting income rather than the value of the birds as meat and can often generate more income for the landowner than timber sales. Bees are also European native species which are intensively managed for production of honey and other products. Incomes from beekeeping can be significant at national and individual level but usually accrue to beekeepers who rent land on which to place beehives from forest owners. The bees themselves forage across the forest taking nectar from wild flowers as well as plantation trees (e.g. pine) – the honey is then often marketed as wild or forest honey. Beekeeping is often the responsibility of the agriculture department (this is the case at EU level where national apiculture programmes are included as a distinct honey market sector of the CAP (European Commission 2016). Therefore forest honey production is not so often considered in forest management plans.

Large estates often combine game and forest management in a way which conforms to the principle of co-management. However, since game and forest management are regulated independently of each other the integration is often at the level of the holding rather than stand (see chapter 9).

As a particular management approach for animal products, game farming and game ranching are applied across Europe to fulfil several objectives simultaneously: i) managing game to prevent damage to forests, ii) production of game meat to supply markets, iii) breeding of wildlife species for re-wildering or restocking, and iv) address agro-tourism as well as recreational hunting demands. Over the last decades the number of game farms increased rapidly in Europe, due to increasing consumer demands for venison and short returns on investment.

4.4 Options for multi-purpose management – managing NWFP with other products

4.4.1 Relation of NWFP management to multi-purpose forest management

In order to better understand the various options for combining the production of NWFP with wood production and/or the provision of other goods and services of forest, in this chapter, we will further specify how this provision relates to multi-purpose forest management, and therefore, how it may be possible to optimise the joint production of forest multiple goods and services, where the non-wood forest production is a part.

An important question here is whether forest multi-functionality is considered in the vertical sense (Dana, 1943), with each forest stand fulfilling two or more functions, or in the horizontal sense (Pearson, 1944), describing a pattern of diversity with different areas dedicated to different functions (Sedjo, 2004). The vertical vision of multi-purpose forestry was dominant in the last part of the 20th century, although the horizontal interpretation also has its advocates (Vincent and Binkley, 1993). Bowes and Krutilla (1989) argue that forests are capable of successfully produce a range of desired and complementary outputs (e.g. of wood and NWFP; of NWFP and biodiversity).

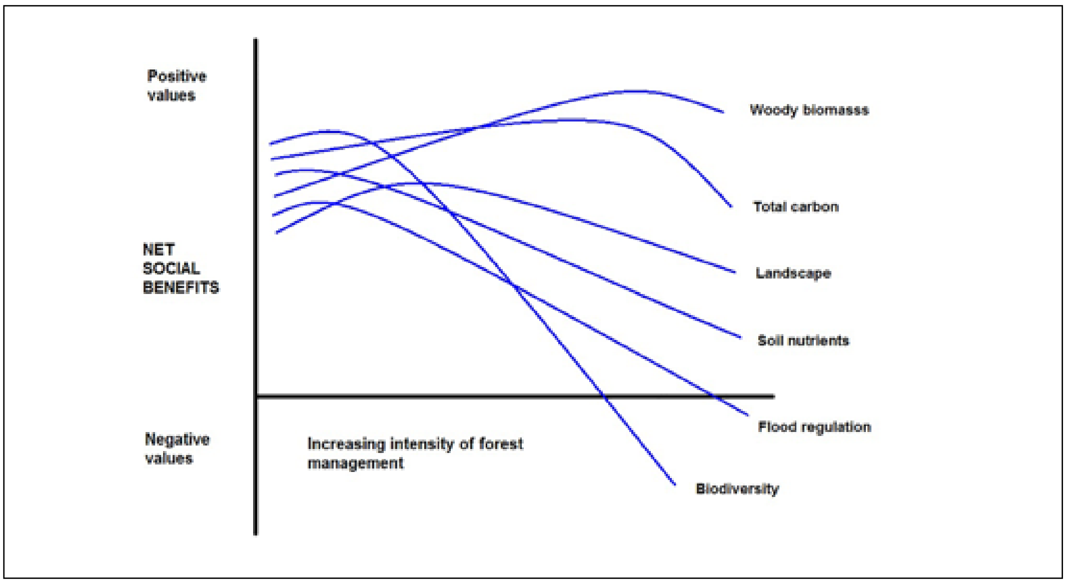

Figure 4.8: *Management intensity and forest ecosystem services delivery: a schematic, generalised relationship (Nijnik et al., 2016).*

A co-production significantly depends on the intensity of management and the related management goals. If a forest is managed for increasing biodiversity, it can be assumed that with higher management intensity biodiversity is increasing, or if a forest is managed for the beauty of landscape, the landscape will likely improve as a consequence. It is indisputable that high intensity forest management in association with wood biomass production may well achieve this particular goal, but may cause a diminution in value of other ecosystem services. The delivery of most ecosystem goods and services is likely increasing as forest management intensity for biomass increases (from passive to high intensity) up to a point, followed by a decline (Figure 4.8).

Duncker *et al.* (2012) differentiated by their degree of intervention into natural processes (for conditions of Central European forest ecosystems in a humid-temperate climate with acidic soils) the following forest management alternatives (FMA): FMA 1: unmanaged forest nature reserve; FMA 2: close-to-nature forestry; FMA 3: combined-objective forestry; FMA 4: even-aged forestry and FMA 5: wood biomass production. In relation to some services, such as landscape and biodiversity, the level of intensity at which the value starts declining may be quite low (Figure 4.8). This observation is along with the results of Duncker *et al.* (2012) who illustrate that maximizing the rates of biomass production (and carbon sequestration, which are synergetic) may conflict with biodiversity values. Concerning non-wood forest production, its dependence on the intensity of forest management for biomass is deemed to be very case and context specific, and be very different for different types of NWFP (e.g. for fungi and game). Further, different species, for instance of fungi, may be associated with different curves.

The relationship shown in Figure 4.8 is very schematic. We make an assumption that a production system, including the one representing the woody biomass curve, increases to a certain point, but doesn't increase or even sustain forever; and we also don't consider a possible collapse of a system because of unpredictable events. The actual shape and location of the impact curves will vary over space, and from one forest to another. Anthropogenic values of ecosystem services are case and context specific, and the generalised curve above will need adapting to specific locations and conditions. Temporal and scale considerations are to be accounted for, with synergies and trade-offs considered. However, the general point is that an increased intensity of management towards one single aim is often associated with a diminution of multiple forest values.

In practice, different elements of the mix of forest ecosystem goods and services are influenced by the preferences of the forest owner, by markets and/or policies; and some forest goods and services, whilst having high public good values, may not be rewarded at all by markets or policies. Therefore, forest management practices and the suite of forest products provided by private landowners who live from forestry cannot be expected to fulfil all demands of the society in view of the personal interest of the owner, market and policy failures, or blunt regulatory structures.

Particular attention should be given to synergies and trade-offs from a combined production in order, if/where possible, to find win-win solutions.

Environmental conditions (including climate change and emerging biotic and abiotic threats) and management instructions enhancing NWFP productions have to be taken into account. Existing management concepts (e.g. single tree oriented management systems, age class systems, close to nature management systems) can support a combined production of NWFP and timber in various manners. The identification of trade-offs between wood production and NWFP production is essential for a sustainable forest management, which aims at optimising the provision of multiple goods and services.

Multi Criteria Decision Making (MCDM) techniques can enable resource managers to select the most preferred choice of action in a context where several objectives have to be fulfilled simultaneously (Keeney and Raiffa 1976). In a rational decision making environment, the most preferred choice is generally bounded by the management objectives, and the constraints that limit the choices and the achievement of the objectives (Mendoza and Prabhu, 2000). Ranking or rating techniques have been commonly applied for preference elicitation (Schmoldt *et al.* 2001), and the Q method has proven to be helpful in this regard (Nijnik et. al., 2010; Nijnik *et al.*, 2016). Also, the Analytical Hierarchy Process (AHP) is a MCDM method, which allows the pairwise comparison of management alternatives with respect to single decision criteria based on a ratio scale. Nowadays the AHP is applied in a wide array of decision problem related to multi-objective forest management (Mendoza and Prabhu, 2000; Wolfslehner *et al.*, 2004). Recent applications in the evaluation of the trade-offs between wood production and NWFP production applying MCDM techniques are described by Huber *et al.* (2017). Also an economic analysis of forest management for multiple-purposes has been elaborated, with Nijnik *et al.* (2012), for instance, applying a methodology combining econometric analysis, simulation modelling, and linear programming to analyse the costs and benefits of afforestation in Ukraine for timber production, erosion prevention, and climate change mitigation.

To date, there is limited information about the effect of management practices on NWFP besides berries and mushrooms and their interaction with wood production. Obviously, the management of stands for wood production affects the production of berries. In this respect, trade-offs between tree biomass production and V. *myrtillus* were observed generally for forests in Sweden excluding those of *Pinus sylvestris* (Gamfeldt *et al.* 2013). The average performance of V. *myrtillus* was favoured after clear-cutting, while was decreased as the stand maturity increased in an intensively managed boreal forest in southeast Norway (Nielsen *et al.* 2007). The production of *Empetrum nigrum* L. in Finland was higher in stands with low density of trees (Ihalainen *et al.* 2002).

Based on the feedback provided to us by country representatives in the common survey all over Europe, it was possible to derive an expert opinion regarding the magnitude of various influences on the production of NWFP (Figure 4.9). From this evaluation it became evident, that some NWFP and services seem to have a high influence on the production of other goods and services, while others don't have it. Bees seem to have the highest positive influence through the pollination, while Christmas trees were evaluated to have the highest negative influence on the provision of other goods and services.

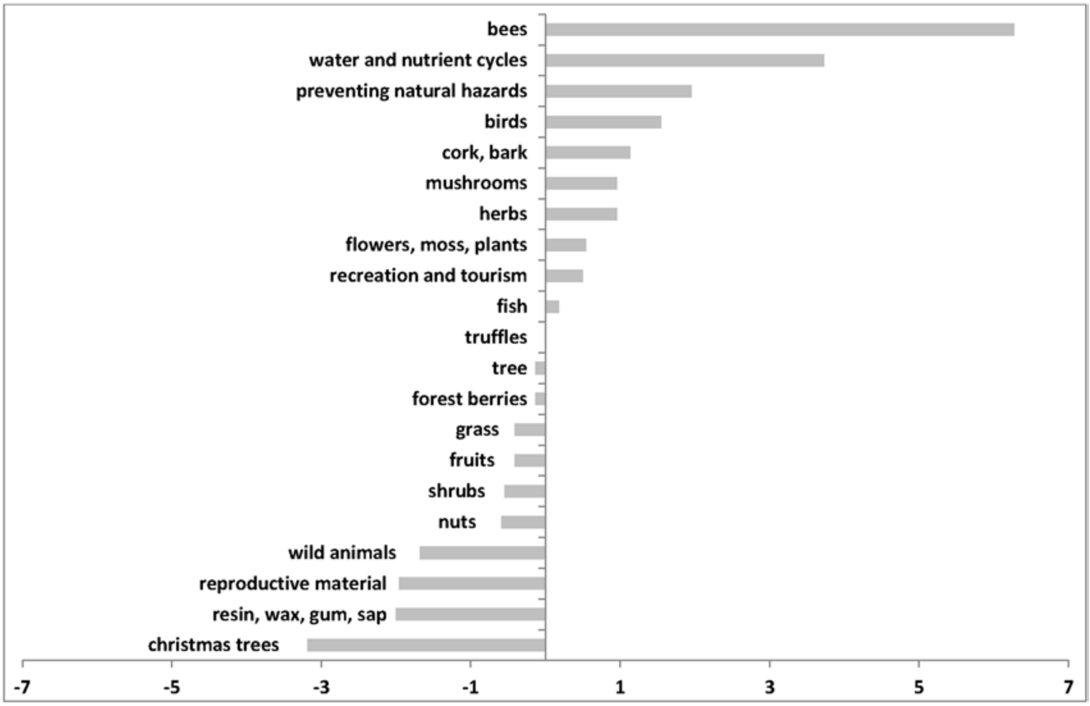

Figure 4.9: *Expert opinion regarding the magnitude of influences on the production of NWFP (Source: n=22 country representatives of COST FP1203).*

In order to apply these basic considerations on co-production of NWFP and other forest products and services several issues require further attention. These include spatial and temporal scales of co-production. Its benefits and dis-benefits (e.g. synergies/trade-offs and side effects) require consideration, along with the varying demand on NWFP for different types of consumers. As discussed in chapter 1.1, the interest in NWFP is greatly influenced by the socio-cultural acceptance and public perception of these products. Within this context it is important not only to relate NWFP demand to the traditional socio-economic conditions of rural areas, but also to the impacts of the ongoing processes of rural transformation and development of new consumer interests. Social innovation in forestry, with the increasing focus on NWFP at a community level (especially of forest dependent communities in Southern, South-Eastern and Eastern Europe, Melnykovych *et al.*, 2017) is worth exploration. Each of these issues is illustrated by the following case-studies from different parts of Europe.

4.4.2 Multi-purpose forest management planning at different spatial levels in Catalonia

In forest management planning context, the planning situations can be classified based on e.g. spatial and temporal scales, i.e. geographical coverage and time horizon (Kangas *et al.* 2015). Regarding the spatial scale, two levels may be distinguished, i.e. the stand level and the Forest Management Unit (FMU) level. Typically, in stand-level planning situations the treatment schedule of one stand for one rotation is defined (e.g. Kangas *et al.* 2015). The results from the stand level planning are primarily targeted to be utilized by forest managers as they provide them direct recommendations on how to manage certain forest stands and what amounts of outputs (both NWFP and other goods and services) can be expected. In FMU and region level planning situations, the planning area is larger and it consists of several forests stands or inventory plots which may have very different forest structures. The FMU-level planning should be most beneficial for forest owners of FMUs as the owner directly receives information on production possibilities from whole forest property. The regional level results may serve particularly for forest policy formulation and preparation of regional activities (e.g. forestry programs) and in setting their targets and developing their actions.

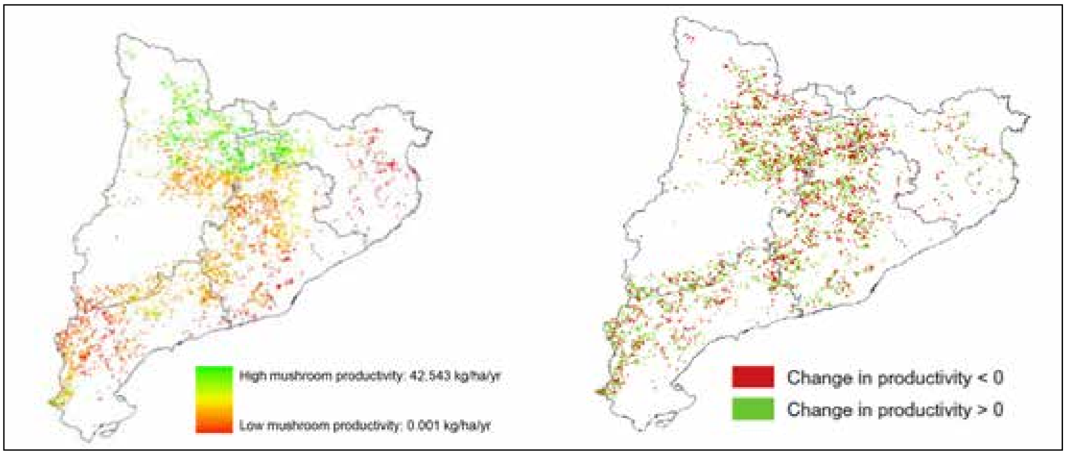

Figure 4.10: *Mushroom productivity in Catalonia region (northeastern Iberian Peninsula. Left: Predicted current productivity (i.e., year 2013) of edible, marketed mushrooms growing in pine forest ecosystems. Right: Mushroom productivity thirty years later (i.e., year 2043) as predicted when simulating a regional-level forest felling rate equal to 65% (modified from de-Miguel et al. 2014).*

The practical FMU-level activities are taking their first steps in different countries and they are based on the use of both expert evaluations and on NWFP yield models and use of multi-purpose forest planning systems. The development is also active in regional level as large-scale forest planning systems are tailored to better meet the challenges of multi-purpose forest management and in particular also NWFP that are relevant in respective regions. For example, de-Miguel *et al.* (2014) adopted the scenario approach in which the mushroom production possibilities in different cutting scenarios were estimated for Catalonia (Figure 4.10). As the inventory plots from region were used in calculations, it was possible to illustrate the results through maps and thus show how the mushroom yields in different sub-areas of Catalonia could be affected. Such felling rates are similar to the current average timber harvesting intensity in Europe, as represented by the ratio between annual harvested volume and annual forest growth.

4.4.3 Managing optimal co-production over temporal scales in Mediterranean forests

The importance of the temporal scales of management may be illustrated by the temporal scales in the joint management of Eastern Mediterranean pine stands for honey and timber. Pine honey is an important wild forest product from eastern Mediterranean coastal pine forests (i.e., Greece and Turkey), where timber production is also relevant. Pine honey, which can reach high prices in the international markets and represents the main source of income for thousands of people living in rural areas, is produced by bees that feed on the honeydew secretions of *Marchalina hellenica*, a scale insect that feeds on pine sap, especially of *Pinus brutia* trees. As a result, stands affected by this insect may experience a decrease in forest growth and yield. Therefore, there are clear trade-offs between the provision of alternative valuable ecosystem services (i.e., honey and timber) that need to be considered within the framework of the multi-purpose management of these pine ecosystems. So far, previous research on this topic has been based on simulation and optimization studies where a number of assumptions and sensitivity analyses had to be made concerning the interactions between M. *hellenica*, honeybees and pine trees due to the lack of data and models regarding such a complex system (de-Miguel *et al.*, 2014). However, this has been so far the main scientific contribution aiming at optimizing multi-purpose forest management for the joint production of pine honey and timber, by maximizing the soil expectation value of pine stands. Pine stand dynamics and timber production were simulated using individual-tree growth and yield models (de-Miguel *et al.* 2010, 2012a, 2012b) and accounting for the negative effect of M. *hellenica* on tree growth (Yeşil *et al.* 2005). The results suggest that, at least in stands growing on medium and poor sites, multi-purpose forest management considering the joint production of honey and wood assortments can be more profitable than forestry oriented toward timber production only (Figure 4.11). Thus, pine stands growing on medium and poor sites where M. *hellenica* is present should be managed using rather long rotations in order to take advantage of the joint production of pine honey and timber, whereas stands growing on very good sites may be devoted to timber production if honey yield is low, or to the joint production of honey and timber if honey yield is high enough. Pine honey represents an opportunity to increase the value and economic profitability of pine forests, and further contribute to sustaining livelihoods and the development of rural communities in some areas of the eastern Mediterranean region.

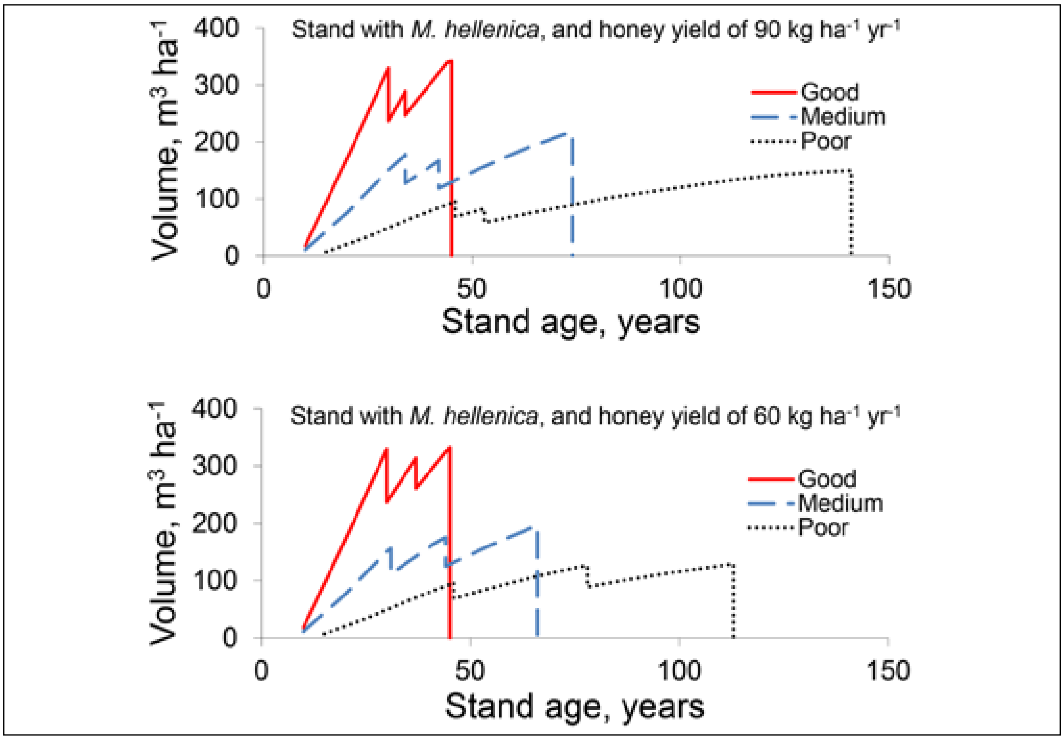

Figure 4.11: *Optimized multi-purpose forest management schedules for the joint production of honey and timber in Pinus brutia stands characterized by different site qualities and three alternative scenarios of annual pine honey production (30, 60 and 90 kg ha-1 year-1) in the presence of M. hellenica (modified from de-Miguel et al. 2014).*

4.4.4 NWFP in multi-purpose forest management in the Ukrainian Carpathians

Historically, NWFP contributed significantly to the livelihoods of rural people by providing both basic household resources and cash resources as well as emergence goods in times of crop failure. Although in many rural areas in Europe this dependency has decreased as a result of rural development, there are still several regions in Europe where NWFP are important for forest dependent rural communities and where forest management has to address this dependency. This is the case, for example, in the Ukraine (Stryamets *et al.*, 2015). In Ukrainian forests (forest cover 15.9%, with 53.5% in the Carpathian Mountains), communities living in remote forested rural areas where the well-being is usually lower than in accessible regions or than in urban areas, have used various

NWFP for centuries (Melnykovych et. al., 2016). They use NWFP as food, for income generation, as well as for fulfilling a range of social, cultural and religious purposes. Communities primarily collect and use wild berries and mushrooms but also utilize medical herbs, wild honey, birch juice, fresh grass, as well as conduct grazing in the mountains. The findings from a recent study (Chernyavskyy *et al.*, 2011) indicate that local communities are very much dependent upon the supporting forest ecosystem services (e.g., flood regulation, climate change mitigation) and sustainable forest management practices. Conservation of forests can also contribute to the sense of identity of many communities' members and NWFP in combination with recreation facilities is indicated as very important for many representatives (see Figure 4.12).

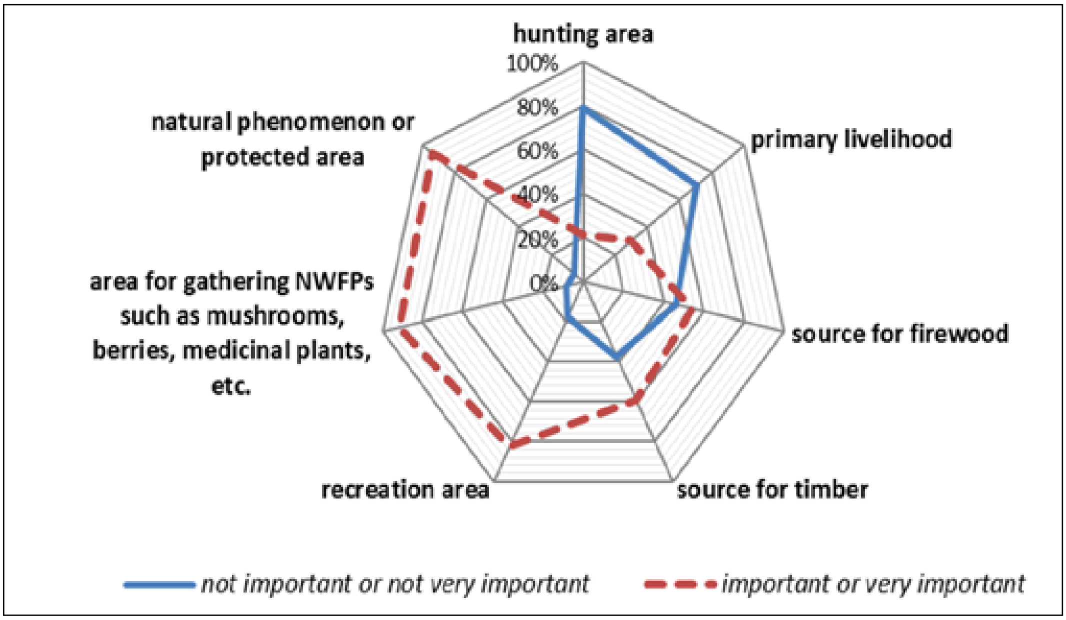

Figure 4.12: *Relevance of forests for local communities.*

The contribution of NWFP to the well-being of forest-dependent communities in Ukraine is critically especially in this transition period, accompanied by political and economic crises. Many people in forest-dependent communities revised their traditional subsistence farming and forest use to maintain their local traditions; thus NWFP continue to be a part of their livelihood. NWFP provide also tangible economic and social benefits to rural communities, and from socio-cultural perspective, the use of NWFP has a long tradition in the region, reflecting the local knowledge and social practices. To promote sustainability and multi-functionality of forest and woodlands on national as well as regional level, Ukraine has joined the process of developing and implementing sustainable forest management (SFM) principles. The strategic objectives of the Ukrainian national forest legislation are oriented towards sustained yield forestry, maintenance of forest biodiversity and socio-cultural values of forests (Forest Code 2006). Recognizing the value of NWFP and their role in supporting well-being, attention is given in Forest Stewardships Council (FSC) national standards of the Ukraine, where certification of NWFP is foreseen as a future step in marketing. Specific attention is therefore paid on social issues of SFM and a more active stakeholder engagement in the decision-making to combine industrial timber production with multiple uses of forests (FSC 2015).

Nevertheless, including NWFP in forest management planning protects the interests of forest dependent communities and fosters SFM and multiple-purpose forest management, ensuring that timber and NWFP are managed in a complementary manner with the promotion of value-added processing of NWFP in the region. Therefore, the State Forest Agency (responsible for managing 73% of the forests of Ukraine) are promoting multi-functionality through close-to-nature forestry (Krynytskyy 2016), which is currently tested in several parts in the Ukrainian Carpathians. This management is seen as especially important for enhancing ecosystem resilience in the region under climate change conditions, increasing tree/NWFP species richness, increasing structural diversity, reducing the vulnerability of high-risk stands and average growing stocks, improving forest regeneration and restoration of mixed uneven-aged forest stands in the long term. Close-to-nature forest management practices involves local communities throughout the whole management process and enables policy actors to identify the interests of local communities' and assist in managing communities' preferences related to forestry, including NWFP uses.

4.4.5 Rewilding NWFP production in the Netherlands

In contrast to the still important role of NWFP for forest dependent people in some European regions, in other regions the demands for these products are primarily related to the emerging new interests of modernized societies. For instance, in response to the socio-cultural dynamics involving a change from rural areas to peri-urbanized areas as well as a change from a production economy focused on manufacturing to a service economy focused on delivering both social and ecological services in the Netherlands new interests in NWFP are emerging (Wiersum, 2016). These interests are expressed in new forms of experiencing forests as natural cum cultural heritage providing both environmental conservation, extensive forms of food production and new forms of active interaction with nature (e.g. in the form of personal collection of natural products) rather than only enjoying its amenity functions. In response to these socio-cultural transformations new management practices for rewilding forest food production are emerging in the form of (i) nature meat from grazing animals reintroduced into the forests to stimulate naturalistic grazing, and (ii) rewilded food plants such as fruit and nut species which earlier had been taken out of the forests to be cultivated as horticultural crops that are actively reintroduced in forests to stimulate new forms of forest food production (Wiersum, 2017).

The first category of 'wild' faunal products is mainly ecologically motivated and involves the rewilding of forested landscapes. The introduction of naturalistic grazing systems had originally as objective to increase trophic levels and spontaneous processes of habitat differentiation and seed dispersal in forests woodlands. For these purposes back-bred forefathers of domesticated livestock such as auroch were introduced in several conservation and forests areas. Alternatively, also the reintroduction of ancient livestock varieties such as Scottish Highlands, Heck cattle and Exmoor pony that are considered to most closely resemble the wild ancestors of domestic stock and regional breeds of sheep and forest pigs is propagated. The historic use of these species has resulted in half-natural landscapes that are at present highly valued as nature areas. Consequently, the reintroduction of these species reflects traditional agrobiodiversity and cultural heritage values. Notwithstanding their rewilded status in biological sense, the reintroduced grazing species are still 'civilized' in the sense of being subject to several institutional arrangements for livestock keeping. Rather than legally being considered as wild species, feral populations of domesticated species are subject to animal welfare and health control regulations. The reintroduction of feral stock has also resulted in intensive discussions between conservationists and animal welfare proponents about the management of these animals. The institutionalisation of the naturalistic grazers is reflected in the increase in the production and marketing of their meat. Due to their growth in popularity the herds have increased in size and require culling to prevent overgrazing. The meat products are often branded as nature or wilderness products and marketed as niche-market products using specialized marketing arrangements in the form of sale to members of nature conservation organisations or marketing by cooperatives of nature conservation organisations.

The second category of 'wild' plant products is mainly culturally motivated. It involves new interests in forest products that derive from more naturalistic areas reflecting natural or cultural heritage values. This category of wild forest products is related to the growing consumer demands for natural and health products as well as for actively experiencing forests through gathering and tasting of wild forest products. These new consumer interests are reflected in the publication of quickly growing number of recipe books on natural food collection and preparation, the introduction of foodwalks in forest/nature areas and the organisation of forest food fairs, and inclusion of wild food related activities by the growing bushcraft movement. It is also reflected in the development of new foods gathering forests with fruit and nut species. Historically many fruit and nut species were taken out of the forest and cultivated in specialized horticultural systems. Within the context of urban transition programmes aiming at the stimulation of nature services in urban environments new types of fruit collection and food forests are being developed. These new forest types are managed to provide forest recreational experiences in the form of collection of natural and traditional forest food products. The forest vegetation is enhanced either by native fruit or nut-producing species or by the reintroduction of old varieties of horticulturalized fruit species such as traditional cultivars of apples and pears. Their 'civilized' institutional nature is illustrated by their specific management arrangements involving active participation by community and non-governmental organisations.

4.5 Conclusions on NWFP management

Multi-purpose forest management implies that objectives of all relevant stakeholders are incorporated into an adaptive and participatory planning process, so that ecosystem services and products of forest can be enhanced spatially (e.g. across the landscape) and across scales (Weiss, 2004). An adaptive forest management system is a suitable approach for the integration of information, models and methods required for solving complex multi-purpose forestry problems (Borges *et al.*, 2009; Reynolds *et al.*, 2006), where NWFP are increasingly becoming an important component. Most forest management approaches developed by forest owners in Europe so far have not considered NWFP explicitly in formulating silvicultural prescriptions or designing management strategies. In case that forest owners focus on income generation, the classical silvicultural concepts are mainly oriented towards timber production. However, modern silviculture takes into account many aspects of multipurpose forestry (e.g. risk reduction, diversification of wood products, considering various ecosystem services, adaptation to climate change, maintaining biodiversity) which would allow to incorporate NWFP more explicitly in forest management goals and strategies.

It has been shown, that for the combined production of NWFP with other products and services several options can be identified. However, the knowledge about how to stimulate NWFP with efficient management activities is still rather limited. The exploitation of tree products in general can be compatible, complementary or competitive with regard to timber production as main management goal. The co-production of timber and NWFP therefore requires adaptions in stand composition, structure, rotation length, or thinning regimes. On the contrary the commercial value of mushrooms and truffles can be much higher than the economic profit obtained from wood assortments in low productive forests. Studies on mushroom yield modelling found a stand basal area around 20 m^2/ha to be optimal for mushroom productivity in the Mediterranean area. However, stands with similar characteristics can still give very different mushroom yields. The consideration of NWFP from understory plants can lead to changes in forest management depending on the species considered as well. While in sparse, mature pine stands, longer rotation results in a higher mean annual bilberry harvest during the rotation, the uneven-aged management of spruce stands would enable higher bilberry yields compared to even-aged management systems. In the context of game management large estates often combine game and forest management in a way which follows the principle of co-management. Managing game allows preventing damage to the forests, the production of game meat can supply the local markets, and the breeding of wildlife species can help to address agro-tourism as well as recreational hunting demands. These examples demonstrate that there is a need to consider ecological, socio-economic and technical aspects in designing multi-purpose forest management strategies. The key lessons learned so far on the impacts of NWFP on the multiple ecosystem services' (cf. Nijnik *et al.*, 2014) outputs of forestry are: (i) great caution has to be made with generalisations, (ii) local social, economic and biophysical contexts have to be considered when NWFP and services are integrated in decision making, and (iii) opportunities and threats to forest ecosystem services may be uncertain, diverse in content, scale and time dimensions.

Besides these challenges, some general principles can be formulated for forest management and policy planning to enhance the opportunities for multi-purpose forestry (Nijnik and Slee, 2008; Nijnik and Miller, 2014):

Follow a systematic and comprehensive management approach: Each forest is considered as a subsystem of units higher in the forest hierarchy; all elements of multi-purpose forestry (e.g. economic, ecological/environmental and social, and their interaction) are to be considered for each level of forest policy development focusing on local, regional and national aspects. In this context priority objectives have to be defined and addressed for each level as well. For the integration of NWFP in forest management, specifically, along with other forest goods and services, a vertical and horizontal (e.g. cross-sectoral) co-operation between stakeholders, as well as a spatial (e.g. landscape or ecosystem level) approach to multi-purpose forestry is required. Although these recommendations are theoretically sound, they are very demanding in forest practice and need therefore careful consideration in forest management planning.

Consider sustainability and carrying capacity: The rates at which NWFP are used must be less than the available flows. The resources must not be driven to extinction – a safe minimum standard of conservation (Ciriacy-Wantrup, 1968) is to prevail. The long-term socially beneficial interests should be a major target. This necessitates analysing various drivers and pressures on forest ecosystems, forest transition patterns, with dynamic optimisation of social-ecological systems (cf. Ostrom, 2009). Although different business oriented decisions might be made by landowners in context of the management of NWFP an intensive level of stakeholder input and consultation is needed to receive general support. Multiple benefits arising from forestry are likely to be impacted when more intensive exploitation of one, or some of its natural assets (e.g. hunting, maintaining biodiversity) is undertaken. Increasing as well as decreasing the extraction of wood raw material from European forests will almost certainly impact on other ecosystem services and these impacts need to be assessed thoroughly.

Securing sustainable provision of other ecosystem services can increase the acceptability of demands to extract more wood from the forests as well.

Monitor ethical and precautionary measures: A more equitable distribution in space and time of all major costs and benefits of a forestry related activity should be ensured by the beneficiaries and the providers of multiple services. Increasing empowerment of stakeholders in determining forest use is a trend currently observed across Europe (Nijnik and Miller, 2014; Sarkki *et al.*, 2016). Strengthening partnerships of science, policy and practice will assist forest management to maintain and improve key forest goods and services, including NWFP, and enhance support of local communities that rely on forestry. However, the utilisation of NWFP as public good has to be properly addressed in the context of a “fair use” approach. It can be stated that ‘full scientific proof of a possible adverse environmental impact is not required before action is taken to prevent that impact’ (Scottish Natural Heritage, 1993). Whilst the evidence of needs for a multi-purpose perspective for forestry is compelling, the evidence as to whether this perspective can inform practice in a formal way, without spatially informed economics is questionable. When public money is limited, obtaining value for money from forests will be essential (Slee, 2011). However, economic valuation may not be necessary and feasible particularly when public goods are concerned. In case that only economic value are seen as appropriate, the source and robustness of these values should be tested, when wider consultation with stakeholders may enable a consensus to be reached.

Implementing multiple forestry objectives, where NWFP are to be part, can be possible with social innovation, with close co-operation of relevant stakeholders, mutual learning, and a continual development of institutional capabilities (Hajer and Wagenaar, 2003). Such capabilities include knowledge resources and skills, social and relational resources (including building of trust), as well as mobilization of manifold capabilities towards sustainable forestry objectives, with NWFP as one target besides other targets (cf. Healey, 2003; Kaljonen *et al.*, 2007). A better understanding of the motivation of stakeholders to handle nature in a certain way, the context within which people operate, and the conflicts that could arise (in order to avoid or to resolve and manage them) can help in capacity development. Here the develop of new management tools and methods and their proper combination in order to map, analyse/ assess and value NWFP, along with other forest goods and services, will enhance their sustainable management and use.

4.6 References

Abraham, E.M., Kyriazopoulos, A.P., Parissi, Z.M., Kostopoulou, P., Karatassiou, M., Anjalanidou, K., Katsouta, C., 2014. Growth, dry matter production, phenotypic plasticity, and nutritive value of three natural populations of *Dactylis glomerata* L. under various shading treatments. Agroforestry Systems 88 (2): 287-299.

Alexander, S.J., Pilz, D., Weber, N.S., Brown, E., Rockwell, V.A., 2002. Mushrooms, trees and money. Value estimates of commercial mushrooms and timber in the Pacific Northwest. Environ. Manage. 30: 129-141.

Battles, J.J., Shlisky, A.J., Reginald, H.B., Henld, R.C., Allen-Diaz, B.H., 2001. The effects of management on plant species diversity in a Sierran conifer forest. For. Ecol. Manag. 146:211-222.

Bauhus, J., Schmerbeck, J., 2010. Silvicultural options to enhance and use forest plantation biodiversity. In: Bauhus, J., van der Meer, P., Kanninen, M. (eds.). Ecosystem goods and services from plantation forests. Earthscan, London, UK, pp. 96–139.

Bonet, J.A., Fischer, C.R., Colinas, C., 2004. The relationship between forest age and aspect on the production of sporocarps of ectomycorrhizal fungi in Pinus sylvestris forests of the central Pyrenees. For. Ecol. Manag. 203 (1-3), pp. 157–175.

Bonet, J.A., Palahí, M., Colinas, C., Pukkala, T., Fischer, C.R., Miina, J., Martínez de Aragón, J., 2010. Modelling the production and species richness of wild mushrooms in pine forests of Central Pyrenees in north-eastern Spain. Can. J. For. Res. 40, 347–356.

Borges, P.J., Fragoso, R., Garcia-Gonzalo, J., Borges, J.G., Marques, S., Lucas, M.R., 2009. Assessing impacts of Common Agricultural Policy changes on regional land use patterns with a decision support system. An application in Southern Portugal. For. Pol. Econ. 12: 111-120.

Bowes M.D., Krutilla J.V., 1989. The Multiple-Use Economics of Public Forest Lands. Resources for the Future. Washigton DC. 357p.

Brouwer, F.J.C., van der Bergh, B., 2002. Sustainable Agriculture and Rural Environment: Governance, Policy and Multifunctionality. Advance in Ecological Economics. Elgar Publishing.

Budeanu, M., Șerban, T., Lupu, G., 2014. Preservation of Norway spruce seeds. Revista de Silvicultură și Cinegetică 34: 26-31.

Chernyavskyy M., Soloviy I., Henyk Y., Kaspruk O., Henyk O., Melnykovych M., Herasym H., Savka V. 2011. Problems of legal assess of local population to forest resources and illegal logging in forests of the Carpathians and the Western Polissya. – Liga Press, 2011. 256 p.

Ciriacy-Wantrup, S., 1968. Resource Conservation Economics and Policies. Berkeley.

Crow, T.R., Buckley, D.S., Nauertz, E.A., Zasada, J.C., 2002. Effects of management on the composition and structure of northern hardwood forests in upper Michigan. For. Sci. 48, 129–145.

Dana, S.T., 1943. Multiple use, biology and economics. Journal of Forestry 41: 625-627.
de-Miguel, S., Mehtätalo, L., Shater, Z., Kraid, B., Pukkala, T., 2012a. Evaluating marginal and conditional predictions of taper models in the absence of calibration data. Can. J. For. Res. 42(7):1383–1394.
de-Miguel, S., Pukkala, T., Assaf, N., Bonet, J.A., 2012b. Even-aged or uneven-aged modelling approach? A case for *Pinus brutia*. Ann. For. Sci. 69(4):455–465.
de-Miguel, S., Pukkala, T., Shater, Z., Assaf, N., Kraid, B., Palahí, M., 2010. Models for simulating the development of even-aged *Pinus brutia* stands in Middle East. For. Syst. 19:449–457.
de-Miguel, S., Pukkala, T., Yeşil, A., 2014. Integrating pine honeydew honey production into forest management optimization. Eur. J. Forest Res. 133:423–432.
de-Miguel, S., Bonet, J.A., Pukkala, T., Martínez de Aragón, J. 2014. Impact of forest management intensity on landscape-level mushroom productivity: a regional model-based scenario analysis. For. Ecol. Manage. 330: 218-227.
Dobre, T., 2011. Romsilva a recoltat 145 tone de semințe, de la 40 de specii. Revista Lumea Satului 5: 1-15.
Duncker, P.S., Raulund-Rasmussen, K., Gundersen, P., Katzensteiner, K., De Jong, J., Ravn, H.P., Smith, M., Eckmüllner, O., Spiecker. H., 2012. How forest management affects ecosystem services, including timber production and economic return: synergies and trade-offs. Ecology and Society 17(4): 50.
Edenius, L., Roberge, J.M., Månsson J., Ericsson, G., 2014. Ungulate-adapted forest management: effects of slash treatment at harvest on forage availability and use. Eur. J. Forest Res. 133: 191-198.
Ernst, C., 1998. An ecological revolution? The Schlagwaldwirtschaft in western Germany in the 18th and 19th centuries. In: Watkins, C. (Ed.), European Woods and Forests. CAB International, pp. 83–92.
European Commission, 2016. Report from the Commission to the European Parliament and the Council on the implementation of the measures concerning the apiculture sector of Regulation (EU) No 1308/2013 of the European Parliament and of the Council establishing a common organisation of the markets in agricultural products, Brussels, 7.12.2016, COM(2016) 776 final.
Farrell, E.P., Führer, E., Ryan, D., Andersson, F., Hüttl, R., Piussi, P., 2000. European forest ecosystems: building the future on the legacy of the past. For. Ecol. Manag., 132 (1): 5-20.
Forest Code of Ukraine, 2006. Lisovyi kodeks Ykrainy. [Forest Code of Ukraine from 08.02.2006]. Kiev.
FSC, 2015. International Generic Indicators, FSC-STD-60-004 V1-0 EN. Forest Stewardship Council, Bonn. Available at: https://ca.fsc.org/preview.fsc-std-60-004-international-generic-indicators.a-1011.pdf.
Fürst, C., Lorz, C., Vacik, H., Potočić, N., 2009. How to Support Forest Management in a World of Change: Results of Some Regional Studies, J. Environ. Manag., 1-12.
Gamfeldt, L., Snäll, T., Bagchi, R., Jonsson, M., Gustafsson, L., Kjellander, P., Ruiz-

Jaen, M.C., Fröberg, M., Stendahl, J., Philipson, C.D., Mikusiński, G., Andersson, E., Westerlund, B., Andrén, H., Moberg, F., Moen, J., Bengtsson, J., 2013. Higher levels of multiple ecosystem services are found in forests with more tree species. Nature Comunications. 4:1340.

Gracia, C., de-Miguel, S., Sabaté, S., Martínez de Aragón, J., Bonet, J.A., 2014. Optimizing Pinus sylvestris management for the provision of multiple goods and ecosystem services under fire risk in a Mediterranean context.

Hajer, M.A., Wagenaar, H., 2003. Deliberative Policy Analysis: Understanding Governance in the Network Society. Cambridge: Cambridge University Press.

Hausrath, H., 1982. Die Geschichte des deutschen Waldbaus. Von seinen Anfängen bis 1850. Hochschulverlag, Freiburg/Brg. 416 pp. [in German].

Healey, P., 2003. The New Institutionalism and the Transformative Goals of Planning. In: Verma, N., (ed.) *Institutions and Planning*. New Brunswick, NJ: Center for Urban Policy Research.

Huber, P., Hujala, T., Kurttila, M., Wolfslehner, B., Vacik, H., 2017. Application of Multi Criteria Analysis Methods for a participatory assessment of non-wood forest products in two European case studies. For. Pol. Econ.

Humphrey, J., Gill, R., Claridge, J., 1998. Grazing as a Management Tool in European. Forest Ecosystems, Forestry Commission Technical Paper 25, Forestry Commission, Edinburgh.

Ihalainen, M., Salo, K., Pukkala, T., 2002. Empirical Prediction Models for *Vaccinium myrtillus* and V. *vitis-idaea* Berry Yields in North Karelia, Finland. Silva Fennica 37(1):95-108.

Kaljonen, M., Primmer, E., De Blust, G., Nijnik, M., Kulvik, M., 2007. Multifunctionality and biodiversity conservation – institutional challenges. In: Chmelievski, T., (ed.), Nature Conservation Management: from Idea to Practical Issues, Lublin-Lodz-Helsinki-Aarhus, 53-69.

Kangas, A., Kurttila, M., Hujala, T., Eyvindson, K., Kangas, J., 2015. Decision support for forest management. 2nd Edition. Managing forest ecosystems vol. 30. Springer. 307 p.

Keca, L., Keca, N., Rekola, M., 2013. Value chains of Serbian non-wood forest products. International Forestry Review, 15(3), pp. 315–335.

Kennedy, J.J., Dombeck, M.P., Koch, N.E., 1998. Values, beliefs and management of public forests in the Western world at the close of the twentieth century. Unasylva 49 (192): 16-26.

Keeney, RL., Raiffa, H., 1976. Decisions with Multiple Objectives: Performances and Value Trade-Offs, Wiley, New York.

Koch, N.E., Kennedy, J.J., 1991. Multiple use forestry for social values. Ambio 20 (7):330-333.

Kohm, K.A., Franklin, J.F., 1997. Creating a forestry for the 21st century. The science of ecosystem management. Island Press, Washington D.C. 475pp.

Krynytskyy, H., Chernyavskyy, M., 2016. The future of forest ecosystems. Conceptual basics for implementation of close to nature forestry in Ukraine. –

Forestry and hunting management. №2. 12-15. Assessed at: http://www.ekoinform.com.ua.

Kyriazopoulos, A.P., Abraham, E.M., Parissi, Z.M., Koukoura, Z., Nastis, A.S., 2013. Forage production and nutritive value of *Dactylis glomerata* and *Trifolium subterraneum* mixtures under different shading treatments. Grass and Forage Science 68 (1): 72-82.

Lindenmayer, D.B., Margules, C.R., Botkin, D.B., 2000. Indicators of Biodiversity for Ecologically Sustainable Forest Management. Conservation Biology, 14: 941–950.

Liu, B., Bonet, J.A., Fischer, C.R., Martínez de Aragón, J., Bassie, L., Colinas, C., 2016. *Lactarius deliciosus* Fr. soil extraradical mycelium correlates with stand fruitbody productivity and is increased by forest thinning. For. Ecol. Manag. 380: 196-201.

Luke, 2017. Information about ERDF project "New products from forests" https://www.luke.fi/projektit/metsan-tuotteet-paaprojekti/ (in finish)

Maier, L., Shobayashi, M., 2001. Multifunctionality: Towards the analytical framework. OECD, Paris, France.

Mayer, A.C., Stockli, V., Konold, W., Kreuzer, M. 2006. Influence of cattle stocking rate on browsing of Norway spruce in subalpine wood pastures. Agroforestry Systems. 66:143–149.

Mather, A., 2003. The future, in: Smout, T. C. (ed.), People and woods in Scotland: a history. Edinburgh University Press.

Mather, A., Hill, G., Nijnik, M., 2006. Post-productivism and rural land use: cul de sac or challenge for theorization? Journal of Rural Studies 22: 441-455.

Martínez-Peña, F., de-Miguel, S., Pukkala, T., Bonet, J.A., Ortega-Martínez, P., Aldea, J., Martínez de Aragón, J., 2012. Yield models for ectomycorrhizal mushrooms in *Pinus sylvestris* forests with special focus on *Boletus edulis* and *Lactarius group deliciosus*. For. Ecol. Manage. 282: 63-69.

MCPFE, 2003. Ministerial Conference on the Protection of Forests in Europe. Improved pan-European indicators for sustainable forest management as adopted by the MCPFE Expert Level Meeting 7-8 October 2002, Vienna, Austria. Liason Unit Vienna.

Melnykovych, M., Nijnik, M., Nijnik, A., Soloviy, I., 2016. Forest ecosystem services and the well-being of communities: a case of non-wood forest products in remote areas of the highlands in Scotland and the Ukrainian Carpathians. Proceedings of the the 4h Forum Carpaticum: Future of the Carpathians: Smart, Sustainable, Inclusive, Bucharest, Romania, 28 – 30 September, 2016.

Mendoza, G.A., Prabhu, R., 2000. Multiple criteria decision-making approaches to assessing forest sustainability using criteria and indicators: a case study. For. Ecol. Manag. 131: 107–126.

Ministry of Environment, Waters and Forests (MEWF), 2016. Report on the state of Romanian's forests 2005-2015. Document available at: http://mmediu.ro/app/webroot/uploads/files/2016-12-16_Raport_Starea_padurilor_2015.pdf, Accessed on 26th of March 2017.

Miina, J., Hotanen, J.-P., Salo, K., 2009. Modelling the abundance and temporal variation in the production of bilberry (*Vaccinium myrtillus* L.) in Finnish mineral soil forests. Silva Fennica 43: 577-593.

Miina, J., Pukkala, T., Hotanen, J.P., Salo, K., 2010. Optimizing the joint production of timber and bilberries. For. Ecol. Manag. 259 (10), pp. 2065–2071.

Miina, J., Pukkala, T. , Kurttila, M., 2016. Optimal multi-product management of stands producing timber and wild berries. European Journal of Forest Research 135 (4),): 781-794.

Nauertz, E.A., Crow, T.R., Zasada, J.C., Teclaw, R.M., 2004. Microclimatic variation between managed and unmanaged northern hardwood forests in Upper Michigan, USA. United States Department of Agriculture, North Central Research Station, General Technical Report NC-236.

Nie, M., 2003. Drivers of natural resource-based political conflict. Policy Sciences 36: 307-341.

Nielsen, A., Totland, Ø., Ohlson, M., 2007. The effect of forest management operations on population performance of *Vaccinium myrtillus* on a landscape-scale. Basic and Applied Ecology 8: 231—241

Nijnik, M., Mather, A., 2008. Analysing public preferences for woodland development in rural landscapes in Scotland. Landscape and Urban Planning 86: 267-275

Nijnik, M., Nijnik, A., Brown, I., 2016. Exploring the linkages between multi-functional forestry goals and the legacy of spruce plantations in Scotland. Can. J. For. Res. 46: 1247–1254

Nijnik, M., Miller, D., 2014. Targeting sustainable provision of forest ecosystem services with special focus on carbon sequestration. In R Matyssek, N Clarke, P Cudlin, T Mikkelsen, J-P Tuovinen, G Wiesser, E Paoletti (eds.): Climate Change, Air Pollution and Global Challenges: Understanding and Perspectives from Forest Research, Elsevier: 547-565.

Nijnik, M., Nijnik, A., Lundin, L., Staszewski, T., Postolache, C., 2010. Stakeholder attitudes to multi-functional forests in Europe. Forests, Trees and Livelihoods 19 (4): 341-358.

Nijnik, M., Slee, B., Nijnik, A., 2014. Biomass production: impacts on other ecosystem services. In: Forest Biomass for Europe – What Science Can Tell Us? 'Think Forest': 82-90 http://www.efi.int/files/attachments/publications/efi_wsctu_4_net.pdf

Nijnik, M., Oskam, A., Nijnik, A., 2012. Afforestation for the provision of multiple ecosystem services: A Ukrainian Case Study. International journal of forestry research Vol. (2012): 1-12.

Nijnik, M., Slee, B. 2008. Towards sustainable development of Scottish woodlands. In T.J. Chmielewski (eds): Nature Conservation Management: from Idea to Practical Results. PWZN Print, Lublin, Poland. Pp 113-132.

Ostrom, E., 2009. A general framework for analyzing sustainability of social-ecological systems. *Science* 325:419–422.

Palahí, M., Pukkala, T., Bonet, J.A., Colinas, C., Fischer, C.R., Martínez de Aragón, J., 2009. Effect of the inclusion of mushroom values on the optimal management of even-aged pine stands of Catalonia. Forest Science, 55(6): 503-511.

Papanastasis, V.P., 2009. Grazing value of Mediterranean forests. In: Palahi, M., Birot, Y., Bravo, F., Goniz, E., (Eds.). Modelling, Valuing and Managing Mediterranean Forest Ecosystems for Non-Timber Goods and Services. EFI Proceedings: Joensuu, Finland, pp.7-17.

Pârnuţă, G., Budeanu, M., Stuparu, E., Scărlătescu, V., Cheşnoiu, E.N., Tudoroiu, M., Filat, M., Nica, M.S., Teodosiu, M., Lorenţ, A., Daia, M., Dinu, C., 2012. Catalogul Naţional al materialelor de bază pentru producerea materialelor forestiere de reproducere din România. Editura Silvică, Bucureşti, 304 p.

Pearson, P., 1994. Energy, Externalities and Environmental Quality: Will Development Cure the Ills it Creates? Energy Studies Review 6(3):199-216.

Perlin, J., 1991. A Forest Journey — The Role of Wood in the Development of Civilisation. Harvard Press, 445 pp.

Pilz, D., Molina, R., 2002. Commercial harvests of edible mushrooms from the forests of the Pacific Northwest United States: issues, management, and monitoring for sustainability. For. Ecol. Manage. 155, 3-16.

Pinto-Correia, T., Mascarenhas, J., 1999. Contribution to the extensification/intensification debate: new trends in the Portuguese montado”. Landscape and Urban Planning 46: 125-131.

Pukkala, T., Lähde, E., Laiho, O., Salo, K., Hotanen, J.-P., 2011. A multifunctional comparison of even-aged and uneven-aged forest management in a boreal region. Can. J. For. Res. 41: 851–862.

Rametsteiner, E., Weiss, G., Kubeczko, K., 2005. Innovation and entrepreneurship in forestry in central Europe. EFI Research Report 19, European Forest Institute, Joensuu, Finland. 2005.

Reynolds, K.M., Gordon, S.N., Johnson, K.N., 2008. Using logic to evaluate forest ecosystem sustainability. Forest criteria and indicators analytical framework and report workshop, 18–21 May, Joensuu, Finland.

Sarkki, S., Ficko, A., Wielgolaski, F., Abraham, E., Bratanova-Doncheva, S., Grunewald, K., Hofgaard, A., Holtmeier, F-K., Kyriazopoulos, A., Broll, G., Nijnik, M., Sutinen, M-L., (in press) Assessing the resilient provision of ecosystem services by social-ecological systems: introduction and theory, Climate Research

Sarkki, S., Ficko, A., Grunewald, K., Nijnik, M., 2016. Benefits from and threats to European treeline ecosystem services: An exploratory study of stakeholders and governance. Regional Environmental Change 16(7), 2019-2032

Schmithüsen, F., 2007. Multifunctional forestry practices as a land use strategy to meet increasing private and public demands in modern societies. Journal of Forest Science 53(6): 290-298.

Sedjo, R.A., 2004. Transgenic trees and trade problems on the horizon. Resources 155: 9-13.

Schmoldt, D., Kangas, J., Mendoza, G., Pesonen, M., 2001. The Analytic Hierarchy Process in Natural Resource and Environmental Decision Making, Vol.

3 in the series Managing Forest Ecosystems, Dordrecht, Boston, London: Kluwer.

Scottish Natural Heritage (SNH), 1993. Sustainable development and the natural heritage: the SNH approach. Perth: SNH.

Sheppard, J., Mangold, L., Spiecker, H., 2016. Revised silvicultural guidelines for selected MPT and NWFP. StarTree Deliverable 2.3. FP7 Project no 311919 KBBE.2012.1.2-06, European Commission, 113 p.

Slee, B., 2011. Innovation in forest-related territorial goods and services: an introduction. In: Weiss, G., Pettenella, D., Ollonqvist, P., Slee, B. (Eds.). Innovation in Forestry Territorial and Value Chain Approaches. CABI Publications, Wallingford. Chapter 8: 118-130.

Smith, R.D., Maltby, E., 2003. Using the ecosystem approach to implement the convention on Biological diversity: key issues and case studies. IUCN: Gland, Switzerland and Cambridge, UK. 118 p.

Stryamets N., Elbakidze M., Ceuterick M., Angelstam P and Axelsson R. (2015) From economic survival to recreation: contemporary uses of wild food and medicine in rural Sweden, Ukraine and NW Russia. *Journal of Ethnobotany and Ethnomedicine* **11**:53. DOI 10.1186/s13002-015-0036-0

Tahvanainen, V., Miina, J., Kurttila, M., Salo, K., 2016. Modelling the yields of marketed mushrooms in Picea abies stands in eastern Finland. For. Ecol. Manage. 362, 79-88.

Tomé, M., Faias, S.P., 2014. State of the art, review of silviculture, models and decision support tools for multipurpose trees (MPT) and non-wood forest products (NWFP). StarTree Deliverable 2.1. FP7 Project no 311919 KBBE.2012.1.2-06, European Commission, 176 p.

Turtiainen, M., Miina, J., Salo, K., Hotanen, J.P., 2013. Empirical prediction models for the coverage and yields of cowberry in Finland. Silva Fennica 47(3). 22 p.

Vacik, H., Wolfslehner, B., Huber, P., Ruprecht, H., 2014a. Analysis of Non Wood Forest Products and Forest Services in Sustainable Forest Management. Austrian J. For. Sci. 131(3): 147-169.

Vacik, H., Kurttila, M., Hujala, T., Khadka, C., Haara, A., Pykalainen, J., Honkakoski, P., Wolfslehner, B., Tikkanen, J., 2014b. Evaluating collaborative planning methods supporting programme-based planning in natural resource management. J. Environ. Manage. 144: 304-315.

Vincent, J.R., Binkley, C.S., 1993. Efficient multiple-use forestry may require land-use specialization. Land Economics 69: 370-376.

Voces, R., Diaz-Balteiro, L., Alfranca, Ó., 2012. Demand for wild edible mushrooms. The case of *Lactarius deliciosus* in Barcelona (Spain). J. For. Econ. 18(1), pp.47–60.

Vogel, J., Lowham, E., 2007. Building consensus for constructive action: a study of perspectives on natural resource management. J. Forestry 105(1): 20-27.

von Gadow, K., Pukkala, T., 2008. Designing Green Landscapes (Managing Forest Ecosystems). Springer Publishing: 290pp.

Warren, C., 2002. Managing Scotland's environment. University Press, Edinburgh.

Wegmann, U., 2008. Das Ziel: so gross und fast so schön wie Marylin Monroe. Erfolgreich Christbäume im Wald produzieren. Wald Holz, 28–31.

Weiss, G., 2004. The political practice of mountain restoration – comparing restoration concepts in four European countries. For. Ecol. Manag. 195(1-2): 1-13.

Weiss, G., Pettenella, D., Ollonqvist, P., Slee, B. 2011. Innovation in forestry: territorial and value chain relationships. CABI, Wallingford, Oxfordshire, UK.

Wiersum, K.F., 1995. 200 years of sustainability in forestry: lessons from history. Environmental Management 19(3): 321-329.

Wiersum, K.F., 1997. From natural forest to tree crops, co-domestication of forests and tree species, an overview. Netherlands Journal of Agricultural Science 45(4): 425-438.

Wiersum, K.F., 2016. Wild forest products between domestication and rewilding. Paper presented at Conference on wild forest products, Barcelona, October 2016.

Wiersum, K.F., 2017. Rewilding forest food production. Reforesting Scotland 56: 36-37.

Wilson, G.A., 2001. From productivism to post-productivism … and back again? Exploring the (un)changed natural and mental landscapes of European agriculture. Transactions of the Institute of British Geographers NS 26:77-102.

Wolfslehner, B., Vacik, H., Lexer, M.J., 2005. Application of the analytic network process in multi-criteria analysis of sustainable forest management. For. Ecol. Manag. 207: 157–171.

Wolfslehner, B., Huber, P., Sheppard, J., Pettenella, D., Prokofieva, I., Weiss, G. Mavsar, R., 2013. StarTree conceptual paper on multi-purpose trees and NWFP in Europe. Deliverable D6.3. FP7 Project no. 311919, KBBE.2012.1.2-06, European Commission, 30 p.

Yeşil, A., Gürkan, B., Saraçoğlu, Ö., Zengin, H., 2005. Effect of the pest Marchalina hellenica Gennadius (Homoptera, Margarodidae) on the growth parameters of Pinus brutia Ten. in Muğla region (Turkey). Pol. J. Ecol. 53(3):451–458.

5. *Economics, marketing and policies of NWFP*

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5.1 Introduction

From an economic and policy perspective Non-Wood Forest Products (NWFP) are a fascinating area of work, both for scientists and practitioners. They include a large variety of products: from those used in mass markets (cork, chestnut, Christmas trees), to specialties (truffles) and various products for niche markets (e.g., *P. pinea* seeds). Looking at their economic life cycle, and therefore to their market development, some are old, declining products (spontaneous aromatic plants that tend to de domesticated), but others are new, emerging products like those deriving from the development of new sap drinks or new (at least for the European market) edible plants and insects. Changing market conditions are re-opening opportunities for old, recently almost abandoned products, like resin and chestnut tannin. Wild medicinal plants still represent a relevant source of genetic material for the development of the pharmaceutic, chemical, cosmetic and food industries.

Two opposite trends are in place in the same time and even for the same categories of products: from one side there is a trend towards domestication, like in the case of berries and nuts. In many European countries these products are taking advantage of the image of "forest products" but they are cultivated as the most intensive farm products (strawberries, hazelnuts, ...). From the other side there is an interesting trend towards re-wilding, in search of products more "natural", tasty, rich of some micro-elements and/or more socially and environmentally acceptable products in terms, for example, of animal care standards and non-polluted sources of production. This is the case of re-wilding of game, aromatic herbs or plants to be used in cosmetics. Part of this trend is the search for old products connected with the traditional knowledge in the use of forest products still present in many remote rural areas in Europe (use of bark, chestnut beer, chaga birch tea).

Networking with the use of social media and e-marketing techniques, development of standards and the connected process and products certification activities, labelling and brand development, supported by the growth of sales in the specialized distribution channels are all relevant aspect in the development of new markets.

All these changes are having effects on the role of NWFP in rural development in terms of direct and indirect effects of income generation, far away from the needs of self-consumption and subsistence income. Short value chains and direct sales of NWFP products can represent good opportunities for diversification of income sources and seasonal employment. In marginal, inner, mountain areas an indirect economic role is played when NWFP are used as imago products in territorial marketing initiatives for branding a geographic area and networking its actors (e.g. the "chestnut road", the "valley of the blueberries", "the truffle way"). In these cases, the economic role of NWFP is more connected to social innovation, i.e. to coordinating all actors under the same vison and rules to promote a local development strategy.

However, in the developing the NWFP economy, relevant constraints and structural limitations have to be faced: the already mentioned issues of seasonality in NWFP availability is reducing the opportunities for economic specialization. The difficulties in creating a continuous flow of fresh products do not allow reaching a minimum and stable critical mass of products to enter some markets. The problem of the reduced amount of products is exacerbated by the difficulties connected to the supply aggregation through the creation of consortia, cooperatives and associations; vertical and horizontal integration among the actors of the value chain is a common reality in rural marginal areas. This is one of the reasons why many NWFP are sold fresh by individuals to middlemen. Collectors are normally price takers with a low market power and thus unable to take advantage of the potential value added creation process along the value chain. Sometimes, NWFP property rights are not designed for actively and easily promoting commercial value chains (e.g. in Greece all NWFP are owned by the State; in many regions of Spain mushrooms can be collected for free). Small-scale activities frequently based on individual pickers are associated to informal market, i.e. to markets where transactions and actors are not registered, tax evasion is a common practice, minimum standards for products storage and health care are not considered (e.g.: fresh wild mushroom in many Balkan countries).

These quite common conditions have many direct negative effects: the market is not transparent, statistics are not collected or they are unreliable, public authorities tend to underestimate the economic and social role of the sector, the social perception of the importance of NWFP is misunderstood and, at the very end, the sector is kept in a marginal position in terms of decision makers' initiatives for defining regulations and providing incentives. It is worth mentioning that in Europe there is evidence of financial activities connected to NWFP trade involving organized criminal activities (money laundering).

The second direct effect is on the sector itself: in a context based on informal rules, with frequent cases of illegal behaviour, professional operators face problems in consolidating their market position, in investing in supply chain organization; in one simple concept: in modernizing the sectoral economy. An associated issue is the one of the tracking the products from their origin to the final consumers: when transactions are not transparent and property rights and fiscal regulations are not implemented, traceability of the products is not possible. This represents an effective constraint in developing the market of some NWFP, especially in the case of food products.

Finally, there is another relevant effect that should be considered: when compared with wood products, NWFP as a branch of the forest economy is underestimated and, as a consequence, not adequately investigated and underfinanced. In many contexts NWFP were until recently considered "secondary" forest products, products for which the "Kielwasser Theory"[11] was considered

11 The "Kielwasser Theory" or "Wake Theory" is based on the assumption that "the growth of biomass is a primary value to be properly managed, whilst all other functions are secondary values, depending on the former" (Rupf 1960).

a guiding principle in forest management. But still few managers realize that in a pedunculate oak forest the annual production of a couple of hectograms of white truffles per hectare potentially generates a much higher income than wood production and that forest management practices could be adapted to optimize truffle growing, more than the annual increment of wood.

These are some of the conceptual assumptions that frame this chapter on the economics of NWFP. The chapter proceeds as follows: after this introduction, the first chapter (5.2) deals with the issue of data collection, a pre-requisite for making any serious analysis and for any political decision. One of the best examples of a stable, long running system of data collection on NWFP collection and consumption is presented: that one set down since 1994 in the Czech Republic. Chapter 5.3 provides a comparative analysis of the NWFP economy in the countries of South Eastern Europe, a region characterized by extremely high richness of species, among them mushrooms, medicinal herbs, berries and honey stand out as of particular importance, both in terms of subsistence value and for the potential of generating cash income in rural areas. Hereafter an overview of international trade patterns of NWFP that are growing in Europe and traded globally, based on the UN-Comtrade database, is given in chapter 5.4. The survey based on the recently concluded Startree project (www.star-tree.eu) provides insights into the increasing role played by international trade in meeting the growing demand for NWFP in Europe. In the following chapter 5.5 the role of innovation is discussed and in chapter 5.6 the focus is on branding, standard definition and certification as innovative marketing tools. After a comparative analysis of standards and certification schemes, the needs for improving the general traceability of the products and the transparency of the value chain are discussed. In chapter 5.7 a relevant example of a traditional NWFP of large economic relevance is presented through a comparative analysis of the value chain of wild boar meat, outlining the framework in which the product is made available to different consumers in Romania and Italy. Finally, in chapter 5.8 we summarize and discuss the main conclusions related to NWFP economics and marketing activities.

This chapter has not the ambition to give a complete evidence of the rich set of issues connected with the European NWFP economy; however, it provides a representative picture of the topics under discussion when dealing with the problems and potentials of this branch of the forestry sector, a branch that can effectively contribute to strengthening the role of forest resources in the new bio-based European economy.

5.2 NWFP production and consumption monitoring: a model example

Forest ecosystems provide a lot of services and products satisfying needs of a society as well as individuals. Multifunctional forestry is a generally supported guideline in forestland management. Besides wood, forests offer other products like mushrooms or forest berries on whose collection people have always been dependent. In terms of production, however, the attention has historically focused on market wood production while NWFP have been rather neglected. To this day, many countries still do not treat them as an important commodity. Belonging to the category of so-called private goods, the timber production can be relatively easily sold and measured. On the contrary, NWFP mostly do not belong to the category of private goods. Speaking of mushrooms and forest berries, it is obvious that their collection is closely related to frequency and intensity in which people visit forests and to recreational and health-hygienic functions of the forests. In this context, there arise many questions such as: What are the main reasons for visiting the forest? How much NWFP do people collect? What is the value of collected NWFP? What are the trends in NWFP consumption? Quite common are also the inquiries about the possibility of payments for forest environmental services (Gatto *et al.* 2009) and many more.

The answers to these questions are not only important to forest owners but also to other entrepreneurs who run businesses connected with NWFP collection and consumption as is for example tourism and gastronomy. In addition, NWFP are of significance to decision-makers at the government level because they make right decisions, formulate forest policy anticipating the needs of the society as well as forest visitors, and encourage desirable activities of forest owners by subsidies, law and other instruments. Finally yet importantly, they safeguard protection of plants and nature, all based on the principle of sustainability. So the interests of policy makers in the development of rural areas, through the support of new economic activities including subsidies (Jarský and Pulkrab 2013), should be extended in order to include the investigation of socio-economic importance of NWFP.

For long term, planning and decision making all those pieces of information are necessary, including the knowledge on how those pieces of information are accurate, representative and valid and how reliable the conclusions based on them actually are.

However, conventional national inventories usually do not provide any economic indicators of the importance of NWFP. Therefore, neither the measurement of NWFP value and importance nor the comparison of individual states on an EU level is possible.

In this chapter, we will use the case study of the Czech Republic where the systematic research of selected NWFP has been running for more than 20 years. Such research is unique and exceptional even in the European context. Thus, the history and experience with the research of NWFP and its outcomes can be instructive for other countries.

5.2.1 Forestry and the research on NWFP in the Czech Republic

In selecting the research method, the following factors were taken into consideration:

- The research method was supposed to estimate the quantity and value of the collected NWFP products and the intensity of forest visits.
- The form of research should be sufficiently accurate and allow for the generalizations of the results for the whole country, or even the comparison of different regions.
- All these results should be achieved at acceptable costs.
- In the early 90s, the network of traditional phone lines was relatively low in the Czech Republic. Mobile phones and modern communication technologies were not available at that time.

After careful consideration of all factors mentioned above, a household was selected as a basic statistical unit. The investigation was regularly done in November each year when the picking period was over and people could still remember the information about volumes and prices of NWFP in the particular season. A face-to-face technique (F2F) – a personal interview – was used from the very beginning of the research process due to the following reasons:

- Since 1994 the same research technique and the same basic set of questions have been maintained for the consistency of data.
- The advantage of personal interviews is an even coverage of the whole target population, in contrast to for instance internet polling, where the oldest groups have under-proportional representation.
- Personal interviews provide substantially higher response rate. In our particular case, the response rate is around 50% because the interviewer has the opportunity to explain the reasons for querying and personally convince respondents unlike in a phone interview, which is often considered as a breach of privacy in the CZ. Moreover, during a telephone conversation the time pressure can affect inaccuracies of answers (amount of NWFP). In the presence of the interviewer the respondent feels that he or she has more time to think through the answers.
- The interviewer can observe respondents during personal interviews and the respondents have generally more time for reflection and the interviewer has an opportunity to avoid the misreading of issues and explain (specify) what was meant.

The results of the 1994 research were published in the Report on the Forestry of the Czech Republic[12], attracting much attention. Since then, several institutions

12 The Reports ("Zpráva O Stavu Lesa A Lesního Hospodářství České Republiky V Roce"), all in Czech language, can be download in the web site http://www.uhul.cz/ke-stazeni/informace-o-lese/zelene-zpravy-mze

such as the Grant Agency of the CZ, National Agency for Agricultural Research, the Ministry of Agriculture – Forestry Branch, and the Ministry of Youth, Sports and Education, have supported the research projects dealing with the NWFP topic. 1994 can be considered the starting point of the systematic research into NWFP collection. Since 1994, the data concerning the collection and use of NWFP in the CZ have been systematically analysed every year. Thus, a unique time series has been obtained even at a European level. The 23 surveys from 1994 -2016 were performed in close collaboration with the institutes engaged in the investigation of public opinion (Amasia, Institute of Public Opinion Research, Centre for Public Opinion Research, and STEMMARK). The sample size in these surveys ranges between 1,000 and 1,100 respondents.

Since 2008, the survey has been organised by the STEMMARK research agency as a part of omnibus research. Questioning has been conducted using CAPI (Computer Aided Personal Interview) on a representative group of over 1,000 respondents (1,008 respondents in 2016) selected on the basis of gender, age, education, size of municipality and county of residence (the so-called quota sample). The network of approximately 250 trained interviewers enabled achieving the desired representativeness of the research sample using the original standardised questionnaire.

Main factors supporting the decision of the omnibus research method are as follows:

- A sufficiently large sample (number of respondents over 1,000 people) improves accuracy to a sufficient level.
- Omnibus ensures representativeness of respondents regarding their age, gender, county of residence, and education. This enables data analysis using some advanced statistical techniques. (Sisak *et al.* 2016).
- Omnibus is an economical solution. If you have a few questions only – too few full-fledged projects, you can enter into the omnibus regularly and share costs of data collection with other clients of a research agency.
- Data collection is checked against ESOMAR standards by the STEMMARK research agency. Supervisors oversee the fieldwork of the inquirers and 20% of the interviews are controlled.
- The interviews are checked using universal listening session records. (Part of the conversation is always recorded for control purposes).
- A posterior check on telephone contacts obtained during an interview with a respondent. Checking the consistency of the interview (its length, unusual answers, etc.)
- Regular training of interviewers enables sharing the common experience of all completed projects by the processor of the data.
- At extremely high or low values, data are monitored for control on other questions with the same respondent to guess whether to avoid confusion, e.g. comparing intensity of forest visits and volume of NWFP collected. If so, the data is adjusted before processing.

The data analysis was performed every year from 1994 until 2016 by a single institution, the Department of Forestry and Wood Economics in the Faculty of Forestry and Wood Sciences, the Czech University of Life Sciences Prague, with the main aims to identify and analyse the socio-economic importance of NWFP collection for the Czech population. Thus, the research has established the tradition of monitoring NWFP in the Czech Republic, which annually continues to this day, mainly thanks to the following reasons:

- Increasing interest in NWFP within the forestry sector of National Forestry Plan including the interest of the mass media such as television and national newspapers. The value of collected NWFP has exceeded 20% of the timber harvest value in recent years.
- Tracking trends and completing time series.
- Traditional publishing the results in the Report on the Forestry of the Czech Republic including certain inertia of the state bureaucracy.
- Jöbstl (2009) stressed the need to include NWFP into accounts and economic statistics, which is also one of the NWFP long-term investigation purposes in the CZ.
- The data obtained in these studies aim to improve the quality of the state forestry policy focused on the optimum use of NWFP, enhancement of incomes from forests, support of NWFP commercial production and raising a forest conservation level.

5.2.2 Outputs of the survey and their quality

Free collection of NWFP is allowed on 2.475 mil. ha (forest area accessible to public – i.e. not in military forests and strongly protected natural preserves and zones of national parks) of the total forest land area 2.637 mil. ha of forest land (or 2.580 mil. ha of forest stand areas). Other investigations inform us that bilberries cover 194 thousand ha of total forest land in the CR (8%), raspberries cover 79.5 thousand ha, blackberries 51.5 thousand ha, elderberries 61 thousand and cowberries 11 thousand ha but various species of mushrooms grow, and can be collected, over the entire forest area of 2.475 mil. ha accessible to public. The basic data, obtained from forest management plans and questionnaire investigations among results from investigations in 1994–2016, are presented in the following tables and figures. The areas stayed basically the same during the analysed period.

There are considerable differences in the intensity of NWFP collection per area unit between individual regions in the CR. The differences are caused by the percentage of forest cover in respective regions, number of households per one forestland unit, and productivity of the forest for the main NWFP being collected.

The intensity of NWFP collection in different regions is also substantially influenced by the citizens of Prague. The majority of them report collecting

NWFP up to 50 km out of Prague, which is within the Central Bohemian Region surrounding Prague. Therefore, considerably higher amounts of NWFP were collected in the Central Bohemian Region – on average more than two times higher – compared to other regions (see Figure 5.1).

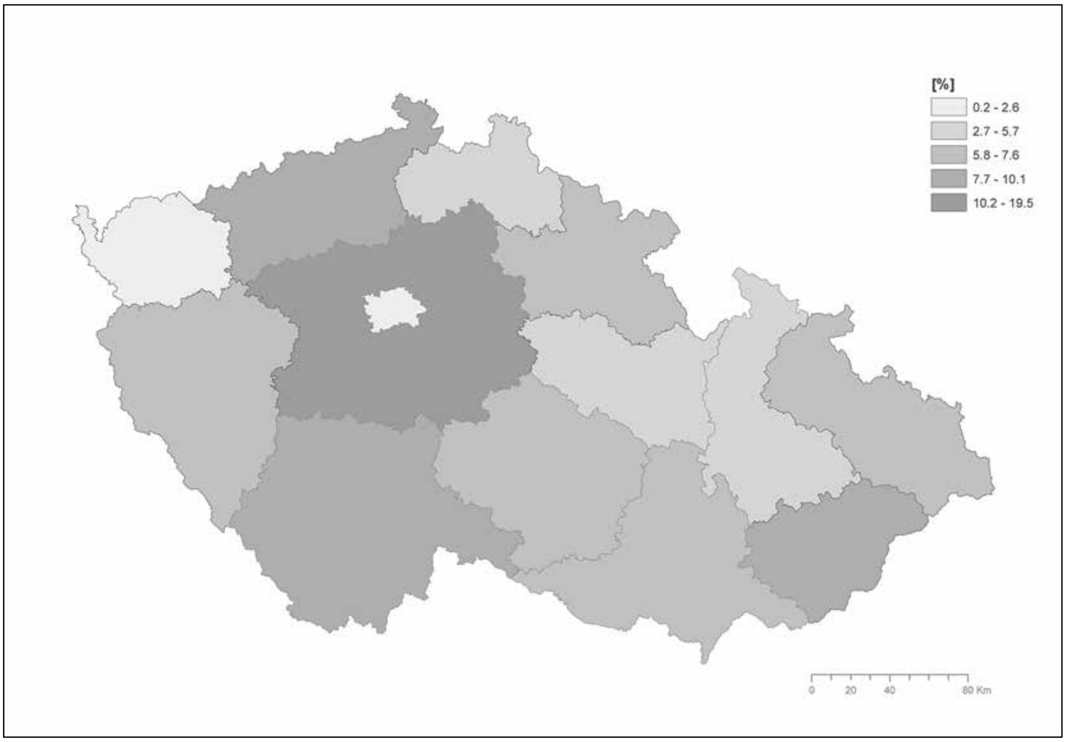

Figure 5.1: *Share of the regions in the total collection of forest fruits in the Czech Republic*

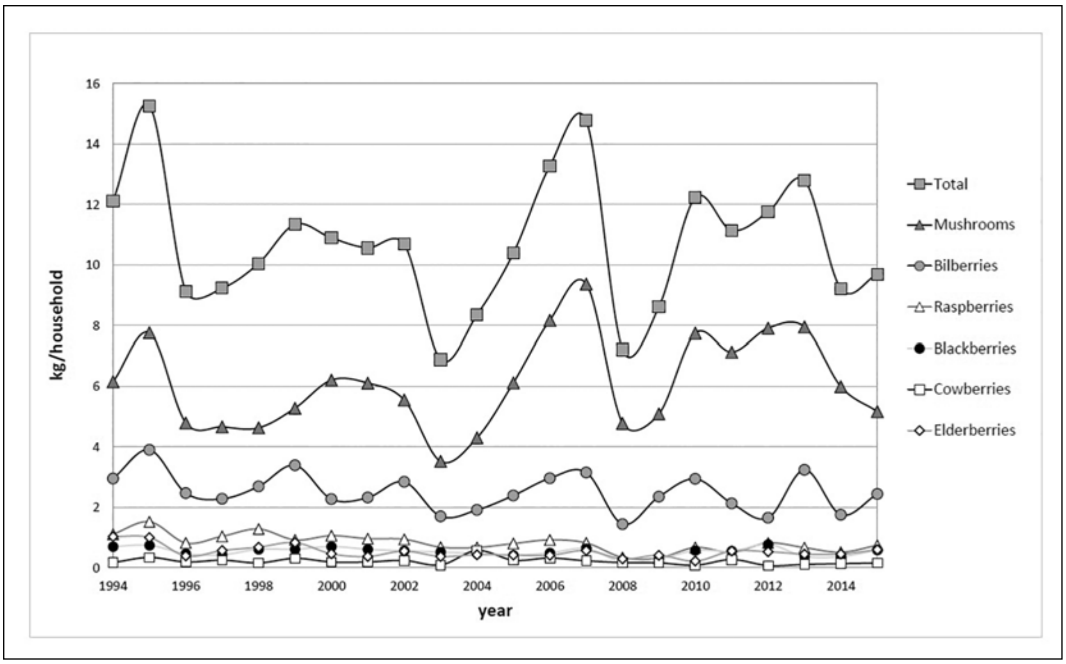

Figure 5.2: *Total amount of NWFP collected in the CZ per household*

The amounts of the main collected NWFP in the CR (kg/household) in the period 1994-2016 are shown in Figure 5.2. The total amounts of NWFP collected are in mil. kg and presented in Table 5.1. The importance of the NNWFP collection is also expressed in economic terms based on market prices of NWFP in respective years in mil. Czech Crowns (CZK) in CR and Euro (Table 5.2).

The fluctuations in the collected quantities of NWFP, as they are shown in the respective tables and figures, are most likely explained by both the socio-economic conditions (such as the level of unemployment, income and prices) and by the weather fluctuations (temperature and precipitations regime in respective years and regions) including random disasters – natural calamities of various extent. Generally speaking, the mixture of factors influencing the NWFP production and their amount collected in individual regions from 1994 until 2016 is extremely diverse. The relationships between the individual aspects and trends of the NWFP production and collection are very complex and have not been investigated yet.

The results of the long-term research covering a period of 23 years between 1994 and 2016 demonstrate the importance of the non-market NWFP collection for the CZ population not only as a recreational activity, but also in terms of socio-economic value. The importance particularly lies in the material value of collected mushrooms and berries, which, on average, was equivalent to more than 5,060 mil CZK in 2016 (see Table 5.2). However, the value of NWFP is actually higher as the main collected commodities – mushrooms and five major berries – were included in the long-term investigations only. The value is further enhanced by the collection of commodities that have not yet been reliably embraced by the investigators, such as medicinal and ornamental plants.

The economic importance of NWFP collection is still underestimated in official statistical data compared to market (mainly timber) production. Nevertheless, NWFP collection is considered to be a very important recreational activity among the Czech population. Visiting the forest and NWFP collection is an important and sensitive issue for the public as it directly affects more than 80% of population who profit from the recreational and also material benefits. Short-term recreation (relaxation) and forest fruit and mushroom picking are the two principal reasons for visiting a forest, followed by sport, nature-seeking and hunting. The data proves a considerable influence of non-market non-timber forest functions in society, and, by extension, their influence over the people's view of the whole forestry sector including forestry policy.

Table 5.1: Total amount of NWFP collected in CZ (mil. kg) between 1994 and 2016

Year	Mush-rooms	Bil-berries	Rasp-berries	Black-berries	Cow-berries	Elder-berries	Total
1994	23.6	11.3	4.2	2.7	0.7	3.9	46.4
1995	29.7	15	5.8	2.8	1.3	3.9	58.5
1996	18.4	9.4	3.1	1.8	0.7	1.5	34.9
1997	17.8	8.7	4.0	1.7	0.9	2.2	35.3
1998	17.7	10.3	4.9	2.3	0.6	2.6	38.4
1999	20.2	13.0	3.5	2.3	1.2	3.2	43.4
2000	23.8	8.7	4.1	2.7	0.7	1.8	41.8
2001	23.4	8.9	3.7	2.3	0.7	1.4	40.4
2002	21.2	10.9	3.6	2.1	0.9	2.1	40.8
2003	13.5	6.5	2.6	2.0	0.4	1.4	26.4
2004	13.7	6.1	2.1	1.5	1.8	1.4	26.6
2005	19.5	7.6	2.6	1.3	0.8	1.3	33.1
2006	26.0	9.4	2.9	1.5	1.0	1.3	42.1
2007	29.8	10	2.6	2.0	0.7	1.8	46.9
2008	15.2	4.6	1.1	0.6	0.5	0.9	22.9
2009	16.2	7.5	1.0	0.9	0.5	1.3	27.4
2010	24.7	9.4	2.1	1.8	0.3	0.7	39
2011	29.6	8.9	2.1	2.3	1.1	2.3	46.2
2012	32.8	6.8	3.4	3.2	0.3	2.2	48.8
2013	33.0	13.4	2.8	1.6	0.4	1.9	53.1
2014	24.9	7.3	2.1	1.5	0.6	1.9	38.2
2015	21.4	10.1	3.1	2.4	0.6	2.5	40.2
2016	21,9	7,2	1,6	1,6	0,4	1,0	33,8
Average	22,5	9,2	3,0	2,0	0,7	1,9	39,3
STD*	5,6	2,4	1,1	0,6	0,4	0,8	8,6

**) STD – Standard Deviation (STD)*

Table 5.2: Amount of NWFP collected in CZ (mil. CZK, mil. Euro) in 2016

	mil. CZK	mil. Euro
Mushrooms	3,589	132.9
Bilberries	851	31.5
Raspberries	237	8.8
Blackberries	219	8.1
Cowberries	64	2.4
Elderberries	101	3.8
Total	5,060	187.4

5.3 Comparative analysis of NWFP value chain in South East Europe region

The forests in South East Europe (SEE) region are characterized by extremely high richness of species. Among the NWFP of SEE region, mushrooms, medicinal herbs, berries and honey stand out as of particular importance – both in terms of subsistence value and the potential for generating cash income at the village level (Nedeljković *et al.* 2015). The forest area is the smallest in the Republic of North Macedonia (RNM), about 905,650 ha and the largest in Bosnia and Herzegovina (B&H) – 2,709,769 ha. The forestry management of these countries is still traditionally oriented and it is more focused on timber. The main income sources of forest companies originate from the fuel and technical wood. The forestry contributes to the national GDP with 0.2% in Serbia (Keča *et al.* 2013), 0.3% in North Macedonia and 1% in Croatia. Local, regional, national, and international trade of NWFP can significantly contribute both to the community and household economies in this region. As a result, marketable NWFP can provide an important means for economic growth and sustainable forest management in local communities. However, little is known about NWFP collection, utilization, and marketing in the region, irrespective of their great potential to positively affect both communities and households. Available data for NWFP are mainly from the custom services about the quantity of imported/exported NWFP and data available from some processors and traders of NWFP. Despite the availability of the species distribution data in most countries, "the actual collection or use distribution in a given country is almost unknown" (Vidale *et al.* 2015).

Depending on the number of economic actors involved in delivering the final product to the end-user, NWFP market may be simple or complex. The simple NWFP market involves only a producer and a consumer, but there are more complex markets that rely on a number of "economic actors competing or collaborating one with each other for supplying the demanded products" (Vidale *et al.* 2015), and they often form *a value chain*.

A value chain is an alliance of enterprises collaborating vertically to achieve a more rewarding position in the market (Barnes 2004). According to Porter (1996), primary activities include: input supply, production, marketing and sale, and service delivery. Support activities include input procurement, research and development of new products and services, human resource management, administration and infrastructure. Margin shown in the value chain is a difference between the total value and total costs of performing the primary and support activities (Porter 1996).

The main economic actors of the NWFP value chain may be grouped in four main categories; pickers (producers), processor, wholesalers and retailers (Vidale *et al.* 2015). Producers are "the key economic actors that physically insert the NWFP in the value chain" (Vidale *et al.* 2015). Pickers usually perform the initial (basic) drying and cleaning, and only rarely cutting the plant material, before selling it. Farmers usually cultivate medicinal plants on the basis of a contract made with a known buyer. This refers particularly to organic production, where farmers must be registered and must document the entire production process (in accordance with the standards of organic production). Production is usually limited to drying, cutting and extraction of essential oils. In most cases, activities of producers and processors include further processing, packing, product design and development, sale, market linking (they own drying facilities and equipment) (Posavec *et al.* 2014). Other actors (processors, wholesalers and retailers) are “normal business categories, which are dealing with transformation of NWFP into its final products, distribution and selling of NWFP or products based on NWFP” (Vidale *et al.* 2015).

The legal regulations on forestry in some countries of SEE region prescribe that the subjects responsible for managing the forest (both private and state forestry) should predict the places and times where and when it possible to collect NWFP. In some countries, local populations have the permission to collect NWFP only for their personal use, without a precisely predicted or allowed amount (1 kg, 2 kg, etc.). This can indirectly lead to overharvesting and harvesting in an unsustainable way (collection out of the season, without the use of adequate tools such as a comb, knife, or scissors, etc.) (Nedeljković *et al.* 2013).

The specific objective of the following pages was to analyse the organization and co-operation within the value chain of NWFP`s and their commercialization in the SEE region. The institutions involved in this project were Croatian Forest Research Institute and the Faculty of Forestry at the University of Zagreb, Croatia; the Faculty of Forestry, University of Belgrade, Serbia; the Faculty of Forestry at the University of Banja Luka, Bosnia and Herzegovina; and the Faculty of Forestry at the University of Skopje, in the Republic of North Macedonia, from year 2010 to 2012.

5.3.1 The collection of primary data

The collection of primary data was conducted through a survey with two different semi-structured questionnaires for the different actors of the value chain, one for the companies involved in the field of NWFP (buyers, processors and traders) and one for the pickers (harvesters) in the field. The survey was door-to-door and face-to-face in the field on neutral ground (Nedeljković *et al.* 2013, Nedanovska 2012). After designing the questionnaires, a pre-testing was performed in order to check the respondents’ understanding. The required data was collected in two to three months, starting from May until September 2012.

The collected primary data was quantitatively analysed with Statistical Package for Social Sciences (SPSS) version 18, summarized by frequency distribution, the selected measures of location and dispersion (mean and standard deviation) and used to present the findings.

Using a door-to-door survey technique, primary data was collected from 29 companies from B&H, 27 from Croatia, 36 from North Macedonia and 91 from Serbia. Primary data from NWFP pickers (239 in total) was collected through a face-to face survey as follows; B&H 30, Croatia 50 Macedonia 138 and 49 from Serbia. The survey was a part of the "Forest Policy and Economics Education and Research" (FOPER II) project and Collaborative Regional Research Teams (CRRTs) topic "Entrepreneurship, Markets and Marketing of Non-Timber Forest Products in SEE Region". Due to the lack of repository system with a list of companies in the NWFP-based sector in the researched countries, the sample size was determined according to the list of registered companies collected from governmental institutions and from the companies willing to participate in this research. Therefore, the sample size was not the same for each participating country. Considering that there is no official register of NWFP pickers in selected SEE countries, a snowball sample was used Nedanovska 2012).

The questionnaire for companies consisted of 51 questions, grouped into six topics (Nedeljković *et al.* 2013, Stojanovska *et al.* 2012), while the questionnaire for the pickers had 41 questions, divided into 5 groups (Nedanovska 2012).

5.3.2 Research results

The average age of the picker respondents in all the countries was slightly below 50 years old (50 years old in the Republic of North Macedonia, 50 in B&H and 47 years old in Croatia and the highest number, 26.5% of respondents in Serbia are in the age group 26-35). Male respondents dominated in North Macedonia and Serbia (59% in Croatia and 79.6% in Serbia), whilst female population was predominant in B&H, standing at 51%.

Table 5.3: Basic characteristics of NWFP picking.

Characteristics of NWFP picking		B&H	Croatia	North Macedonia	Serbia
Collected NWFP (%)	Mushrooms	26.6	66.2	82.6	87.8
	Medicinal and aromatic plants	33,3	35.2	52.2	10.2
	Berries and other fruits	33.3	54.9	41.3	42.9
Place of collection (%)	Forest near the village	70.0	62.0	95.7	55.1
	High forest	40.0	67.6	37.0	61.2
	Pasture	63.6	38.0	37.0	28.6
	Meadow	66.7	53.5	37.0	24.5
Change the location where collect NWFP (%)		86.6	77.4	97.8	77.6
The average distance from the residence to the place of collection (km)		6	16	18	9

Characteristics of NWFP picking			B&H	Croatia	North Macedonia	Serbia
Quantity of collected NWFP (kg)		Per day	7	4	14	10
		Per season	307	114	462	150
Use of collected NWFP (%)	Mushrooms	Personal consumption	20.0	76.0	86.0	8.3
		Selling	80.0	14.0	14	91.7
	Medicinal and aromatic plants	Personal consumption	34.0	59.0	86.0	50
		Selling	66.0	41.0	14.0	50
	Berries and other fruits	Personal consumption	10.0	82.0	41.0	36.7
		Selling	90	18.0	59.0	63.3
Selling of collected NWFP (%)		Raw	60.0	85.7	90.5	91.4
		Processed	40.0	14.3	9.5	8.6
Price per kg (€/kg)		Mushrooms	3.0	6.0	2.0	2.4
		Medicinal and aromatic plants	2.4	5.4	1.5	1.8
		Berries and other fruits	3.0	3.0	1.0	2.2

Pickers in all countries, except in B&H, are mainly engaged in the harvesting of mushrooms (Table 5.3). In B&H, a very small number of pickers is harvesting medicinal and aromatic plants. On the other hand, in the Republic of North Macedonia (RNM), around half of them are engaged in this activity. The difference among countries can also be seen in harvesting of berries and other fruits, because only in Croatia, more than half of the pickers are collecting those NWFP. These differences are understandable if one takes into account the natural characteristics of vegetation on these countries.

There are the differences among countries in the most common place of NWFP picking. For example, in Croatia and Serbia, the biggest number of respondents collect NWFP in the forests that are distant from their place of residence (67.6% and 61.2%, namely). This is different in B&H and North Macedonia where the majority of pickers (70% and 95.7%, respectively), harvest NWFP in the forest near their place of residence.

More than three-quarters of respondents in all countries indicate they change the location where collect NWFP and the average distance from the residence to the place of collection is less than 20 km. Change of this location is very important in terms of biodiversity conservation because over-harvesting in one place could threaten the survival of these species in the area. During the season, a picker, on average, collects 114 kg of NWFP in Croatia up to 462 kg in North Macedonia, i.e. 4-14 kg for 1 day.

In Croatia and North Macedonia, pickers usually use harvested mushrooms for personal consumption, which is opposite to B&H and Serbia, where they usually sell collected mushrooms. Medicinal and aromatic plants are usually used for personal consumption in Croatia and North Macedonia. Pickers from Croatia also differ in terms of the use of collected berries and other fruits, because, unlike in the other countries, here they rather consume those NWFP and less than 20% is selling it.

The majority of pickers in all countries sell raw NWFP. Although the average prices of 1 kg of NWFP vary in selected countries, certain regularity can be observed. Thus, in Croatia, all NWFP have the highest price and they are lowest in Macedonia.

The largest percentage of the companies located in the cities was found in North Macedonia (78%), whilst the highest percentage of the companies located in the villages was in Croatia (41%). The highest percentage of the companies located in both places (the city and the village) was in Serbia and B&H (27%). The average number of employees per company was the highest in Croatia (11 employees), followed by B&H with 9 employees. Since the companies analysed in North Macedonia were mainly family businesses, the average number of employees per company was 4. This sector primarily depends on weather conditions. Therefore most business activities are seasonal activities and companies have lists of seasonal workers. The average number of seasonal workers was the lowest in Serbia (10), followed by Croatia (13), and North Macedonia where the average number of seasonal workers stood at 26. B&H had the highest average number of seasonal workers per company (27).

The percentage of companies involved in NWFP showed differences amongst the analysed countries (Table 5.4). Most of the companies in North Macedonia (45%) and Serbia (62.2%) were involved in mushrooms. On the other hand, in B&H (43%) and Croatia (39%), the biggest number of companies were involved in processing aromatic and medicinal herbs.

Table 5.4: The share of NWFP used by processors

Country	Processors use of NWFP (%)		
	Mushrooms	Medicinal and aromatic	Berries & other fruits
B&H	24	43	33
North Macedonia	45	19	36
Croatia	23	39	38
Serbia*	62.2	35.2	62.2

** some companies are using two or three types NWFP, so the total percentage is more than 100.*

In order to provide a deeper insight into the main reasons for co-operation between the processors and the pickers, the processors were asked to evaluate several statements. A long tradition in co-operation was evaluated as important according to more than 60% of the respondents in all the countries. They agreed and strongly agreed with this statement. The reason for buying from pickers primarily because they provided a payment period of 1 month and even longer was strongly disagreed and disagreed by over 60% of the respondents in all the countries.

The highest average price for buying and selling in all the countries analysed was achieved by mushrooms (Figure 5.3).

"*The price of mushrooms mainly depends on the season and the global market*" was most frequently provided and emphasized answer when companies' representatives were asked about the average price of buying/selling mushrooms. There are big differences in prices depending on the time of harvest, whether it is a spring mushroom harvest or autumn harvest of mushrooms and certainly also depending on the quality that mushrooms have been associated with during the time of the mushroom harvest. The mushrooms harvested in autumn are more expensive compared with the mushrooms harvested in spring. The Republic of North Macedonia has the lowest average purchase and selling prices of all types of NWFP (except of selling price of medicinal and aromatic plants). On the other hand, Croatia has the highest average purchase and selling prices of all types of NWFP.

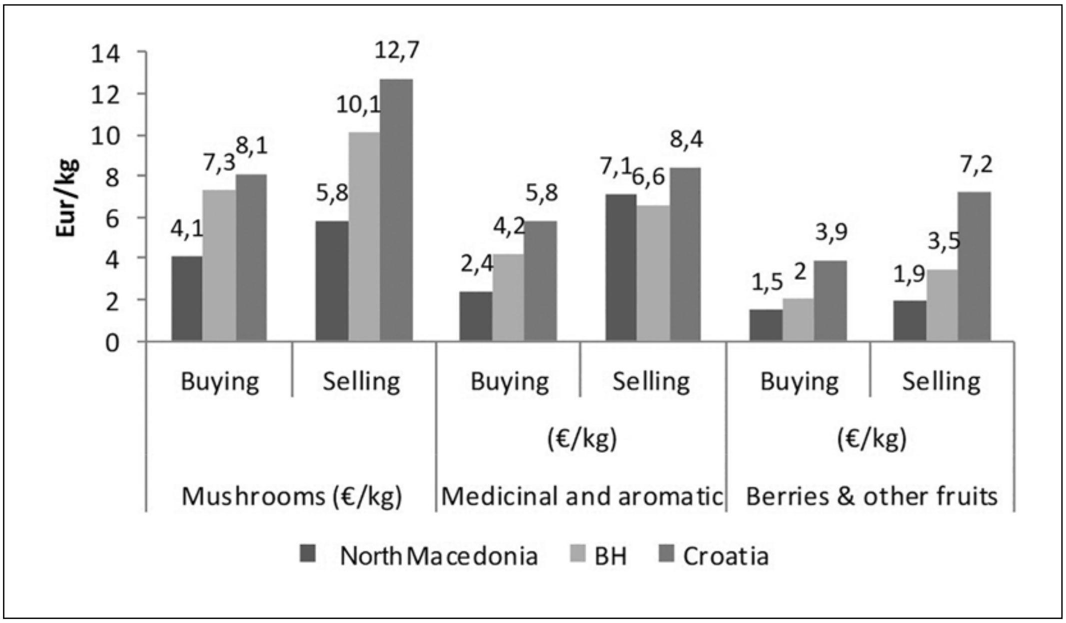

Figure 5.3: *The average buying and selling price for processors of NWFP*

According to the results, operations following the purchase of NWFP primarily accounted as follows: selling (97%), drying (94%) and processing (83%) in the Republic of North Macedonia. In B&H operations following the purchase of NWFP in highest percentage were: drying (59%), packaging (55%) and selling (48%). In Croatia, the highest share of operations following the purchase of NWFP was in packaging (85%), whilst drying and brining achieved an equal share, 59%. In Serbia, the highest percentage of operations following the purchase of NWFP was as follows: drying (74%), freezing standing at 68%, whilst the share of packaging stood at 57%. In selected countries of SEE different forms of organizing the selling of NWFP are present (Figure 5.4).

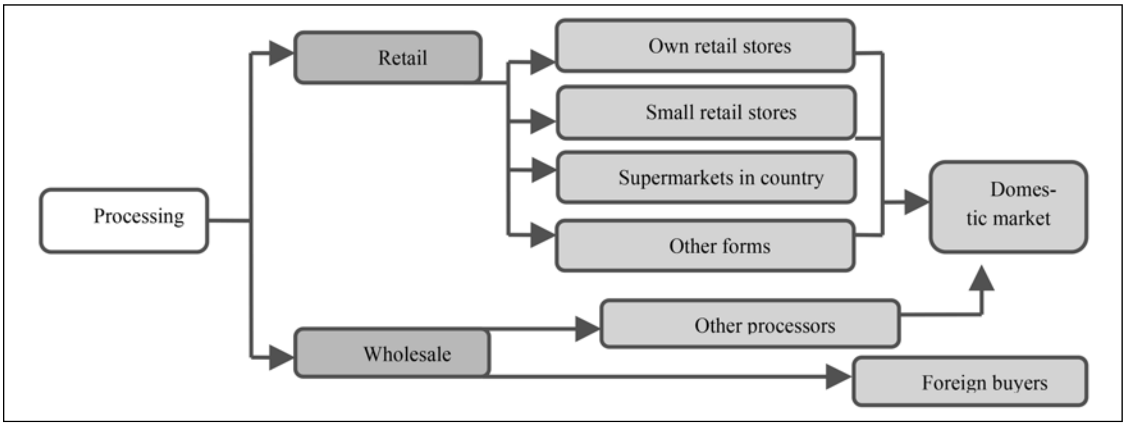

Figure 5.4: *Forms of organizing NWFP selling in selected countries (source: Nonić et al. 2014)*

Retail can be organized through own retail stores, small retail stores, supermarkets in country, other forms. Wholesale is done in two ways: foreign buyers and other processors (Nonić *et al.* 2014).

Selling on foreign markets can be organized differently (sale agents, offices abroad, etc.). Most often, the sale on foreign markets is organized in cooperation with regular customers, with whom they have direct contact and long-term cooperation (Nonić *et al.* 2014).

The countries to which the mushrooms are primarily exported were Italy, France and Germany, accounting for 92% of the total export of mushrooms. On the other hand, aromatic and medicinal plants were primarily exported to USA, the Balkan region and Russia (76%). Furthermore, the export of berries and other fruits was on a par throughout all the countries, i.e. the exports of berries and other fruits did not show differences throughout various countries. 99% of berries and other fruits were exported to Italy, Germany. Other non-wood forest products, which often included juniper, dog rose, and blackberries, were exported to Germany and Italy, accounting for 85% of the total quantity of other NWFP.

Companies in North Macedonia reported the highest average purchase of mushrooms per year (Figure 5.5). On the contrary, companies in Croatia reported the lowest average purchase of mushrooms per year. Companies in B&H have the highest average purchase of medicinal and aromatic plants, and those from Serbia[13] the lowest. The highest average purchase of berries and other fruits is in Serbia, and the lowest is in Croatia. Figure 2 shows that Croatian companies reported the lowest average purchase in general, while companies

13 Presented data for Serbia are not related solely to sample, but to all companies in central Serbia, who reported purchase of NWFP in 2010

from North Macedonia reported the highest. These results are in line with the statements of pickers (Table 5.3). One of the possible reasons for such results in Croatia is that pickers said they use most of the collected NWFP for personal consumption (Table 5.3).

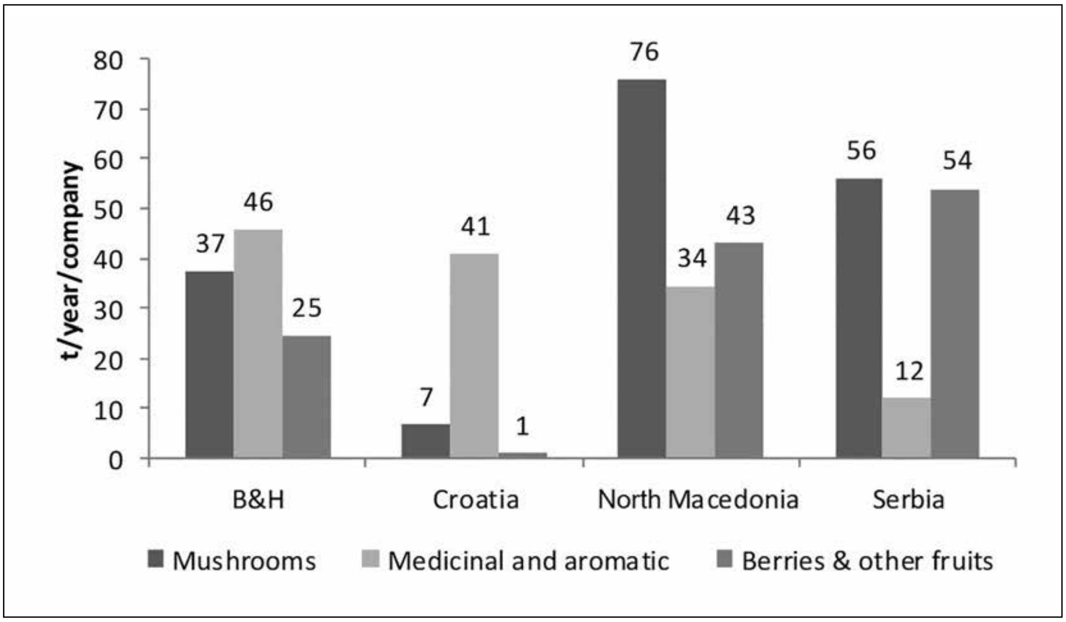

Figure 5.5: *The average use of NWFP for processing per year*

The main problems encountered by the companies involved in NWFP in the SEE region pointed out by the respondents included unfair competition (89% in B&H, 86% in North Macedonia, 60% in Serbia, 41% in Croatia), underdeveloped national market, labour shortage and payment issues. There was a large number of unregistered companies/people which/who were competitive and yet they did not pay any taxes to the state, which contributed to decreasing the market price (Posavec 2013). On the other hand, companies disagreed with the current legal framework which they deemed inappropriate (92% in North Macedonia, 72% in B&H, 71% in Serbia). As opposed to them, the respondents from Croatia and a small percentage of them (11%) strongly agreed and agreed concerning the previously mentioned issue.

The results showed that the highest percentage of companies in North Macedonia (69%) from other countries agreed that the equipment available was outdated. In B&H 48% of the respondents agreed with this statement, as opposed to 37% in Croatia and 15% in Serbia. The average distance from the companies to the buying points of NWFP, where companies could purchase NWFP, was 35 km in Serbia, around 60 km in B&H and Croatia and 105 km in North Macedonia.

Positive opinion was expressed on the assessment of the importance of marketing tools in NWFP sector (Table 5.5). In other words, the opinion on the importance of developed channels of distribution and related products/name (brand) was positive, whilst the opinion on the importance of advertising was neither positive nor negative. The use of marketing tools: PR, advertising and branding for promotion of the companies were very rarely used in the sector of NWFP (Stojanovska *et al.* 2015).

Table 5.5: The average importance of marketing tools evaluated by processors

Country	Number of samples	Public Relations	Advertising	Branding
BH	29	2.65	2.96	2.28
Croatia	27	2.62	2.37	2.76
North Macedonia	36	1.58	1.58	1.30
Serbia	91	n.d.	2.76	3.70
scale 1-5, 1-very unimportant, 5-very important				

The results showed that 40% of the companies in North Macedonia co-operated with the Ministry of Agriculture Forestry and Water Economy (MAFWE), yet most of them (60%) evaluated this co-operation as weak and very weak. The assessed co-operation between the companies and the Ministry of Environment and Physical Planning (MoEPP) did differ significantly from the co-operation of the companies with the MAFWE. The co-operation between companies and MoEPP was assessed as strong and very strong co-operation (39%) and most of the companies (89%) co-operated with MoEPP. The situation was very similar in Serbia. 49.5% of Serbian companies co-operated with the Ministry of Agriculture and Environmental Protection (MAEP) and 56% of them evaluated this co-operation as weak and very weak. All the companies in Serbia co-operated with MAEP, yet half of them (51.7%) assessed this co-operation as strong and very strong. The situation was different in the other two countries. Over half of companies in Croatia co-operated with the Ministry of Agriculture and 73% of them evaluated this co-operation as strong and very strong. A third of the companies in Croatia co-operated with the Ministry of Environment and Energy and the same percentage of them assessed this co-operation as strong and very strong. The co-operation of companies in B&H with MAFWM was similar as in Croatia. 69% of the companies co-operated with MAFWM and about 55% evaluated it as strong and very strong. The lowest percentage of companies (13.8%) in B&H co-operated with MoEPP and about 25% stated the co-operation was strong.

Table 5.6: The average number of people/companies that co-operated with the processors whilst purchasing NWFP

Country	Number of samples	Number of co-operatives
BH	29	169
Croatia	27	55
North Macedonia	36	122
Serbia	91	50

Table 5.6 shows the number of co-operatives per each country. From representative data it is clear that more people in engaged in NWFP harvesting in North Macedonia and B&H. On the other hand, companies in Croatia and Serbia have similar number of co-operatives, which is far fewer than in other countries.

Concerning the issue about the need for investment, the respondents stated that they would invest in equipment (freezing tunnels, channels), promotion (branding, advertising), and improvement of quality, cultivation and plantation of NWFP, in purchase points. The reason they provided for investment in this segment was because they wanted to secure their business for a long term, and also higher demand means higher profit, as well as to meet market requirements, to provide opportunities to sell the products when the price is higher etc.

Moreover, the respondents from all the countries pointed out the importance of the advanced stage of processing, retail, branded products, providing better education for pickers, informing the public, providing companies with appropriate equipment, establishing associations, regulating the issue of permissions, subsidies, grants, boosting absorption of IPA funds, soft loans can be granted and used for development of SMEs in NWFP sector in the SEE Region.

5.3.3 NWFP value chain analysis: the lessons learnt

In order to provide a deeper insight into the issues regarding picking and processing of NWFP, as well as into their trade, it is important to analyse policy framework (legal environment) and its implementation in order to avoid potential obstacles and ensure better use of these products. NWFP are in connection with the final buyers through value chains (Posavec *et al.* 2014).

In North Macedonia and Croatia NWFP quantities that could be used for personal purpose were clearly defined, yet this was not the case in Serbia (Nedeljković *et al.* 2011). The quantities allowed were 1 kg per person in North Macedonia (2009) and up to 2 kg of above-ground mushroom species, or up to 0.1 kg of underground species in Croatia (2002).

The common goal of all strategic documents in analysed countries is support for use of NWFP through integrated forest resource management, based on sustainable management rules. These documents in Croatia and the North Macedonia, as well as Strategy of biological diversity in Serbia, mention National Forest Inventory as a need for better estimation of possibilities both for harvesting and processing of NWFP and in order to secure long term ecological sustainability of attractive species (Živojinović *et al.* 2017, Nedeljković *et al.* 2015, Nedeljković *et al.* 2013).

Furthermore, the endangered species are protected from extensive use and by the Ministry of Environment who are responsible through the issue of control picking licenses. There is a need to involve other interest groups and educate pickers through agricultural and forestry advisory services. Regarding the issue of entrepreneurship support, only Strategy of sustainable forest development in North Macedonia mentions small and medium-sized forest enterprises as having potential for employment and income growth in rural areas (2006).

Following research results, it was confirmed that local, regional, national, and international trade of NWFP can significantly contribute both to community and household economies in this region. Marketable NWFP can provide important means for economic growth and sustainable forest management in local communities. However, there is insufficient information about NWFP harvest, utilization and entrepreneurship in the country despite their great potential and positive effects exerted both on communities and households. An increasing pressure was placed on forestry administrators when countries started searching for economic benefits from their natural resources. Timber productivity, as the most important income, was studied extensively, yet NWFP were not studied despite their evidently high value and diversity. This research has shown that many amendments need to be implemented in this area due to the presence of rich biodiversity in this region, yet the policy concerning NWFP needs to be improved by providing training for the harvesters. Education is very important for the NWFP collection, because sustainable collecting, in accordance with legal requirements and need for conservation of the natural plant resources, can be achieved through proper training and skills development. It is necessary to prepare a more comprehensive, practical guides and workshops for collectors, in order to train them before obtaining permits for the collection of NWFP. Concerns about sustainability of natural resources mean long-term strategy that can provide better position of collectors, as important but also marginalized group in the supply chain, and that can ensure implementation of laws and standards in accordance with EU regulations. Moreover, a network of harvesters needs to be established and strengthened and international funds (especially IPARD) need to be utilized for the purchase of equipment and development of SMEs. The harvesting, processing and trade of NWFP need to encourage rural populations to use their traditional knowledge to help preserve the existing forests and implement sustainable management of NWFP. Nevertheless, majority of population in rural areas still has poor access to markets, insufficient capital for investment in order to improve their livelihoods, as well as little or no bargaining power when selling their products on the markets.

5.4 An analysis of trade patterns for selected NWFP

In the recently concluded Startree project (www.star-tree.eu) a Europe-wide survey based on 17,346 questionnaires has found that nearly 25% of European households are collecting NWFP and 89.6% are buying them at least once a year (Vidale *et al.* 2015). Aside from the informal and non-market activities contributing to the well-being and the rural small-scale economies, NWFP have an important role in the domestic and international formal markets, a role that has been increasing due to a growing demand for these products in the more advanced economies. In this chapter we explore the role of NWFP in trade focusing on the role of the European market.

While industrial trade of wood products is commonly monitored by international organization like FAO, ITTO, UNECE, trade patterns of NWFP, due to the multitude of commodities falling into this definition, have been rarely analysed (Sorrenti 2017). This is also due to the complexity and variety of the value chains and final use sectors associated to NWFP processing and consumption. For instance, tannins may be considered products of the forestry sector as raw material, but once they are extracted from the tree, they are classified as chemical products, or after several processes of refining also food products. Another example might refer to berries, both collected as forest food or used as raw material for the chemical and cosmetic industries.

Beside the path a product may follow from the forest to the end user, trade analysis also provides some other evidences of the NWFP complexity, such as the effect of NWFP substitution. An example of substitution is the case of chestnuts and oak tannins, which have been almost completely substituted with tannins extracted from other species in the southern hemisphere (quebracho[14] or wattle[15]). Another example of such dynamics is the effect of market specialization that pushed NWFP producing countries, in the past supplier of rough material for other countries, to become net exporters of processed products, as has occurred for Chinese wild mushrooms or for US cranberries.

After presenting a general overview of the NWFP trade patterns, we analyse some leading products in order to highlight the main problems and potentials in developing NWFP markets in Europe.

5.4.1 The European NWFP trade: an overall view

Using the UN Comtrade database and a rather wide range of non-wood forest commodities, including all the major categories of products consumed in Europe (nuts, mushrooms, berries tannins, cork, foliage and honey), the estimated value of international trade amounted to 12 billion USD in 2011 (Table 5.7). However, part of the considered commodities that compose this value are cultivated (e.g. nuts and berries that in many European countries, even if cultivated, are considered as components of the forestry sector). Accounting for commodities coming only from forests a more prudential estimation would decrease the value to 4.69 billion US$ (Pettenella *et al.* 2014) while the rest predominantly comes from agricultural production.

14 Quebracho is a common name for several species used to extract tannins; among the most important one there are *Aspidosperma quebracho-blanco*, *Schinopsis lorentzii*, *Schinopsis balansae* and other minor species.

15 Wattle is a name used for *Acacia* species used for tannin extraction like *Acacia. pycnantha*, *Acacia decurrens*, *Acacia dealbata* and *Acacia mearnsii*; these trees grow mainly in South Africa.

Table 5.7: *Global EU trade values of selected commodities which include NWFP in the year 2011 (million USD)*

		Trade values in 2011 [USD Millions]				
Code	**Product**	**World**	**EU-Exp.**	**EU-Imp.**	**Bal.**	**%***
040900	Honey	1906	616	1019	-403	32.34
060410	Mosses	58	33	37	-4	55.98
060491	Fresh foliage	1210	729	887	-157	60.29
060499	Dry foliage	367	170	231	-61	46.33
070951	**Fresh Agaricus**	1302	1102	972	129	84.63
070959	Fresh mushrooms	785	414	480	-66	52.69
071151	**Preserved Agaricus**	101	32	53	-21	32.07
071159	Preserved mushrooms	119	17	85	-68	14.45
071231	**Dried Agaricus**	116	41	58	-17	35.52
071232	Dried Auricularia	196	4	16	-12	1.95
071233	Dried Tremella	55	1	2	0	2.30
071239	Dried mushrooms	1370	71	170	-100	5.17
200310	**Prepared Agaricus**	1179	572	568	4	48.48
200320	Prepared truffles	29	24	17	6	82.02
200390	Prepared mushrooms	228	84	87	-3	36.77
080221	**Hazelnuts**	180	25	41	-17	13.61
080222	**Shelled hazelnuts**	1782	296	1342	-1046	16.60
080231	**Walnuts**	987	164	308	-144	16.61
080232	**Shelled walnuts**	1545	219	678	-459	14.15
080240	Chestnuts	299	153	121	31	51.05
080250	**Pistachios**	3013	524	1287	-763	17.38
081010	**Fresh strawberries**	2579	1604	1533	71	62.18
081020	**Fresh raspberry**	1173	410	442	-32	34.97
081030	**Fresh currants**					
081040	Fresh cranberries	1428	345	488	-143	24.14
081090	**Fresh other**	2948	713	914	-201	24.19
081110	**Frozen strawberries**	1090	479	706	-227	43.95
081120	**Frozen Raspberries**	951	416	694	-278	43.72
081190	Frozen fruits and nuts	2530	1033	1484	-451	40.82
320110	Quebracho	85	7	32	-25	8.27
320120	Wattle	130	4	24	-19	3.37
320190	Other tannins	195	92	57	35	47.05
450110	Natural Cork	147	140	132	8	94.88
450190	Cork in pieces	93	79	69	10	84.94
450200	Cork squared	72	63	42	21	87.82
450310	Cork Stopper	743	705	406	299	94.92

Notes: The World-EU28 percentage is calculated as fraction of EU28's export with regards the global trade in 2011. The export and import values consider also the intra EU trade. Commodities marked in bold are mostly generated from agricultural land. (Source: Pettenella et al. 2014)

The EU has a strategic role in the international NWFP market, accounting for 50.4% of the total export value of commodities based on raw or processed NWFP. Europe is a global leader in the supply of cork, cork based products, truffles, chestnuts, vegetable tannins and wild mushrooms. Apart from these products, the EU is a net importer of NWFP and it accounts for almost half of the total global NWFP import.

In the following chapters we report the main outputs of the international trade analysis for cork, mushrooms, nuts and berries, four groups of commodities selected in order to provide evidence of the large varieties of trade patterns, either in terms of economic value or quantity, and of the role of the top traders. This analysis can be used to provide evidence of the potentialities connected to an in

creased role of European producers in satisfying internal demand through an increased domestic production and intra-European countries trade.

5.4.2 Cork trade

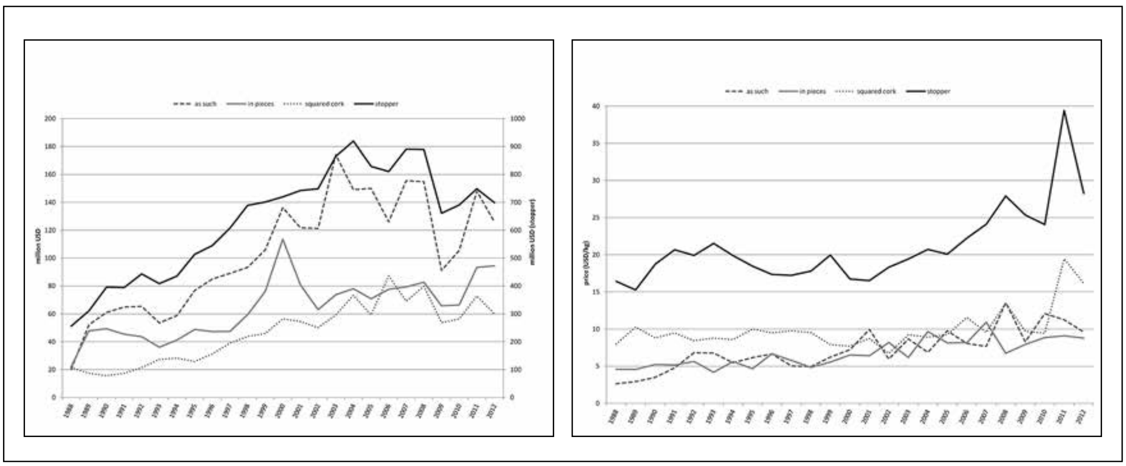

Figure 5.6 *Global cork trade by commodity (a) from 1988 to 2012 (million USD) and global cork price by commodity (b) from 1988 to 2012 (price on large quantities, above 100 metric tons)*

Cork trade data can be found in seven commodities groups; among these categories, we considered three related to rough materials (cork as harvested, pieces of cork and squared cork) and cork stoppers as final product. In 2012, the total traded rough cork accounted for 0.159 M tons (metric), a value approximately near the peak of global trade in the year 2000. The steep increase in terms of traded quantity may be understood as a new re-launch of the sector in the last three years. Nonetheless, the economic value of the rough cork is only the 28.5% of the total traded value, while the higher added value of the cork supply chain is generated from cork trade, despite the negative trend of cork stoppers (Figure 5.6a). The negative trend is most likely related to the high competition of plastic and metal stoppers, which are more frequently used (especially for cheap wines) to decrease the cost of wine bottles. The price of cork stoppers has increased by 60% in the last decade, but by relevant fluctuations probably linked to the presence of new competing raw materials (Figure 5.6b). On the contrary, prices of raw or semi-processed cork material have remained stable in the same period. Higher price instability of cork can be explained due to the very long and rigid production cycle.

Table 5.8: Global export and import top 5 countries of cork stoppers in million USD and number of trade partnerships

Exports (million USD)							
2000		2005		2010		2012	
Portugal	502	Portugal	592,1	Portugal	483,1	Portugal	524,0
Spain	58,6	Spain	79	Spain	81,6	Spain	87,7
France	53,7	France	38	France	33,2	France	27,9
Italy	28,5	Italy	29,3	Italy	29,1	USA	17,5
Germany	16,2	Germany	18,9	USA	13,5	Germany	9,4
Imports (million USD)							
2000		**2005**		**2010**		**2012**	
France	192,7	France	205,3	France	189,5	France	181,3
USA	115,6	USA	146,1	USA	137,4	USA	150,1
Australia	58,8	Spain	73,1	Spain	49,7	Spain	47,0
Spain	55,4	Australia	55,5	Italy	46,3	Italy	44,8
Germany	52,1	Italy	45,1	Chile	30	Portugal	38,0

Portugal is the main international cork stopper exporter and it covers also a relevant role as processor and producer of cork stoppers, followed by Spain, France and Italy, though this last disappeared from the top 5, due likely to the internal demand of cost stopper for the wine sector (Table 5.8). The main importers are France and US, and they have held their positions despite the growing importance of the Spanish and Italian markets.

Cork stoppers are the most valuable cork product exported from EU28. They account for 94.7% of the global export of cork of which 55% is traded within EU (Figure 5.7). The import value of cork stoppers accounted for 54.4%, of which the 95% is supplied from EU28. The monopolistic role of European forests in cork supply could allow a generation of new added value with innovative products based on cork. The EU28 trade balance accounts for 300 M US$, a value quite stable over time (Figure 5.7). The limited profitability from cork forest management is however imposing a strong constraint to increase the cork supply[16].

16 Cork oaks were planted in California, Chile, China, RSA and Australia but plantations in all these countries failed so far to produce bottle stoppers of good commercial quality. Only Morocco, Algeria and Tunisia have natural cork oak stands where cork production could be increased, however this is not happening at a significant scale.

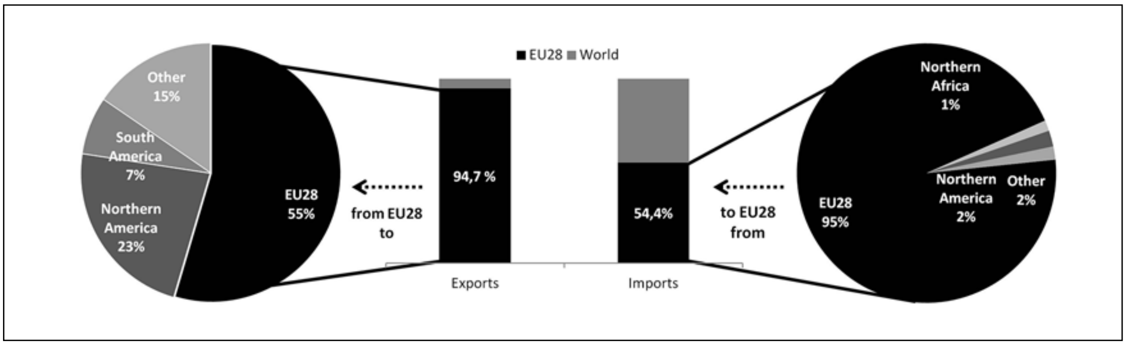

Figure 5.7: *EU28 imports and exports' partners for stoppers in 2011 with respect to global trade (percentage based on USD)*

5.4.3 Mushrooms trade

The global mushroom trade shows a continuous increase in the trade volume and value (Figure 5.8). Wild mushrooms cover the 26.4% of the total traded volume and 45.6% of the total value (4.98 billion US$ in 2011). The proportion of quantity and value was also confirmed in 2012, though the global trade decreased to 4.52 billion US$. Among all wild mushroom categories, fresh and chilled mushrooms have a relatively stable increment rate of 37.6 M US$ per year since 2002, accounting nine year later for 0.8 billion US$, a value confirmed also in 2012 (0.77 billion US$), when the trend broke its linearity.

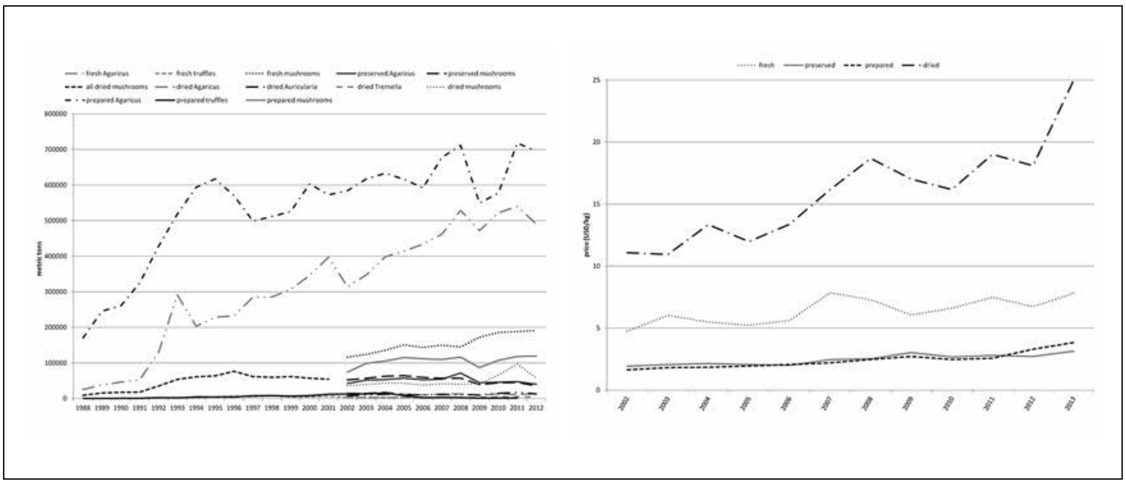

Figure 5.8: *Global mushrooms trade by commodity (a) from 1988 to 2012 (metric tons) and wild mushrooms prices (b) from 2002 to 2011 (price on large traded quantities)*

Dry mushrooms had a slower increment as preserved mushrooms, accounting respectively for 28.4 M US$ of average annual growth from 2002 till 2009 and 14.6 M US$ from 2002 till 2012. The total value of wild mushrooms trade was 2.08 billion US$ in 2012; however, the trade value is affected by Chinese export of dry shiitake and other cultivated mushrooms that can be assessed around 0.25 billion US$. This was an indicative estimation based on data comparison and information analysis, which can be calculated through more detailed data, which is available only for some countries. Prices of wild mushrooms had a positive trend in the last decade (Figure 5.8b) with the exception of cultivated mushroom.

Table 5.9: *Global export and import top 5 countries of fresh mushrooms in million USD.*

Exports (million USD)					
2005		2010		2012	
China	139,1	China	145,1	China	163,7
Netherlands	48,0	Netherlands	77,5	Poland	93,8
Poland	44,5	Poland	75,5	Netherlands	69,4
Romania	25,0	Italy	49,6	Italy	54,4
Russian Fed.	24,3	R. of Korea	44,7	R. of Korea	37,9
Imports (million USD)					
2005		**2010**		**2012**	
Japan	152,9	Japan	99,1	Germany	100,1
Germany	75,4	Germany	95,4	Japan	97,8
Italy	61,8	France	83,8	France	90,9
France	51,7	Italy	61,2	Italy	51,9
UK	34,5	UK	58,7	USA	51,1

China is undoubtedly the largest fresh wild mushrooms exporter in the world, both in terms of quantity and economic value (Table 5.9). Alone, it accounted for the 21.2% of the export value in 2012. The Netherlands and Poland cover an important role in the wild mushroom trade as main suppliers of the European market; the two counties represent also the main gates of EU28's market, though the role of The Netherlands is influenced by the presence of shiitake and king oyster mushrooms inside the commodity code. The trade traceability within the EU is generally underreported due to the custom declaration exemption for small quantities, hence the export or import values are affected by statistical bias. On the import side, the top 4 importers in terms of economic value have been the same from 2005, with a predominant role of Germany and Japan followed by France and Italy. The market structure shows a core role of EU28 as larger global importer, while the majority of the production moved to cheap labour countries where wild mushrooms are collected. As previously mentioned, outputs are affected by shiitake and oyster mushroom trade.

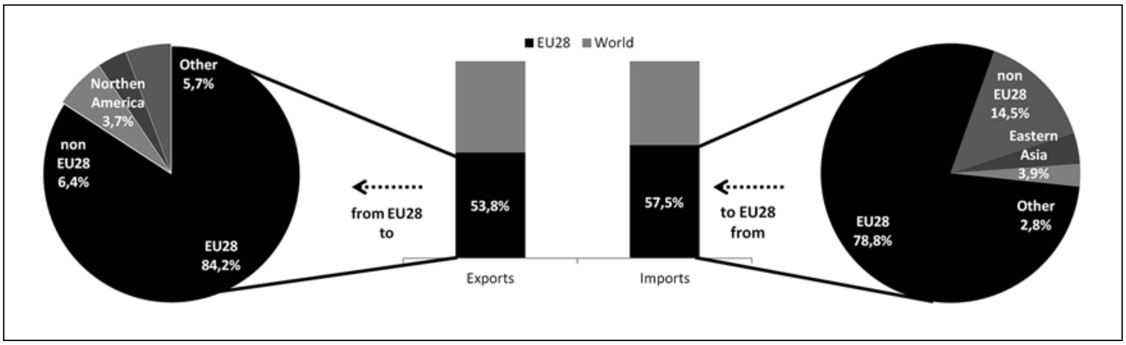

Figure 5.9: *EU28 imports and exports' partners for fresh mushrooms in 2012 with respect to global trade (percentage based on USD dollars)*

The high level of imports with regard to the exports led to a negative trade balance within the considered period (Figure 5.9). Nonetheless, the deficit has slightly decreased in absolute value from 82.2 M US$ in 2004, to 58.2 M US$ in 2013, while in general the level of import and export increased. Still a large amount of intra-EU28-trade does exist (Figure 5.10). Europe is a net consumer of wild mushrooms, but the decreasing trade balance shows a potential return to a positive side since Chinese welfare enhancement might raise the production costs and domestic demand, hence causing the EU internal production to be competitive even for industrial purposes.

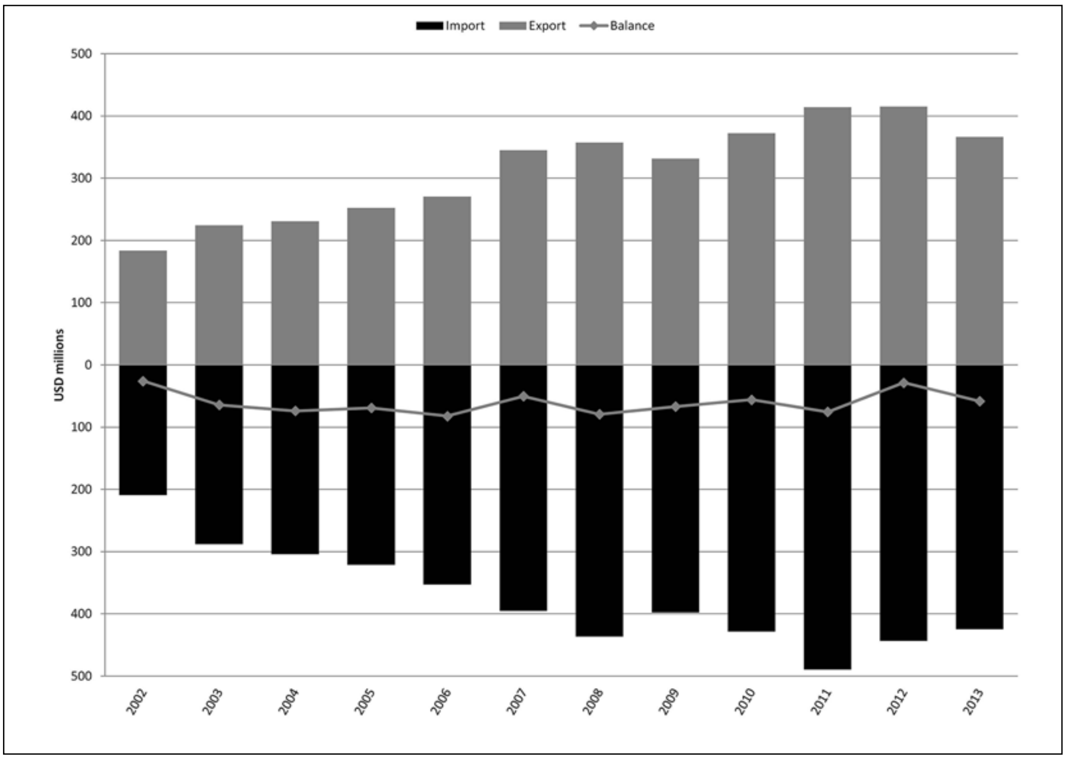

Figure 5.10: *EU28 total imports, exports and trade balance for fresh mushrooms (USD millions) in 2011.*

5.4.4 Nuts trade

Nuts are divided into two commodity families: the first considers coconuts, Brazilian nuts and cashew nuts, while the second gather all the other nuts. We looked at some nuts within the second group, such as hazelnuts, walnuts, chestnuts and pistachio, while we excluded pine nuts because the referred code considers also other tropical nuts. Among the traded nuts, only a minor part comes from forestlands, like chestnuts and minor part of traded pistachio. According to our results (Figure 5.11), the most important traded nuts are pistachios, which accounted for 3.28 billion US$ in 2011, on a total value of 8.2 billion US$ of traded nuts. The trade of hazelnuts, walnuts, chestnuts and pistachio has increased on almost constant basis by half billion US$ since 2001, a year in which trade value accounted for 2.35 billion US$. Shelled nuts have been the commodity that most impacted the global trade, both in terms of value and number of international trade partners. The food industry and large retailers prefer to trade shelled nuts, a choice that pushed the global nut trade. In general, the nuts' prices has doubled since 2001, except for chestnuts, whose price increased by 68%, stopping at 2.53 US$/kg in 2011. The shelling process on average doubles the commodity price per kg, though in some years (from 2005 to 2008) the price differences reached three times that of the raw hazelnuts. Large shelling plants and the introduction of new technologies or cultivars are the factors which have kept the price proportion quite stable over time, regardless of the market trends.

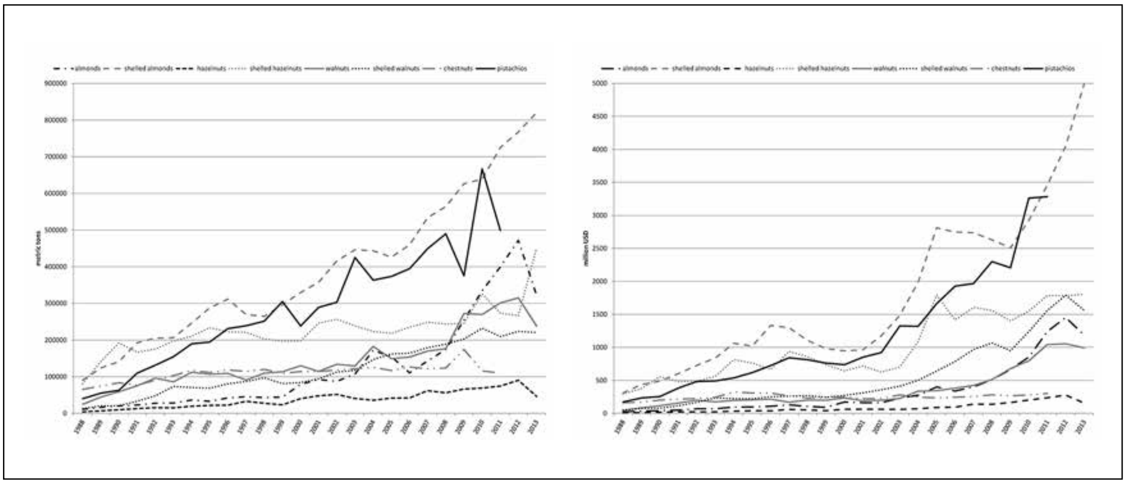

Figure 5.11: *Global nuts trade flows by commodity (a) from 1988 to 2012 (metric tons) and global nuts trade flows by commodity (b) from 1988 to 2012 (million dollars)*

Table 5.10: *Global export and import top 5 countries, only for chestnuts, in millions of USD and links*

Exports (million USD)							
2000		2005		2010		2011	
China	85,4	China	66,5	Italy	73,2	Italy	79,7
R. of Korea	84,3	Italy	64,1	China	70,1	China	78,4
Italy	40,2	R. of Korea	53,0	R. of Korea	45,4	R. of Korea	48,1
Portugal	13,1	Portugal	11,8	Portugal	22,5	Portugal	25,8
Spain	9,0	Turkey	9,4	Spain	16,6	Spain	20,0
Imports (million USD)							
2000		**2005**		**2010**		**2011**	
Japan	149,6	Japan	72,5	Japan	54,4	Japan	59,0
France	13,8	China	21,9	China	23,1	France	28,6
USA	11,5	USA	16,0	France	21,7	Italy	24,2
Asia, nes	9,8	France	13,9	USA	19,9	Switzerland	19,5
Switzerland	6,8	Switzerland	10,9	Germany	17,8	China	19,1

Among nuts commodity groups, we focus on chestnuts trade, because they are mainly supplied from forestlands, and still a key NWFP in the South European countries. Despite the constant position of China as the main global chestnut exporter, European countries were able to erode position of China and Korea in terms of economic value (Table 5.10), which have decreased their export share from the 67% in 2000 to 42% in 2011 (total trade value 0.28 billion US$). In the same period Italy, Portugal and Spain have increased their share of the export value from the 25% to 42%, probably as a combined effect of the EU Common Agriculture Policy implementation together with the consolidated EU know-how in processing and marketing. Anyhow, Eastern Asia continues to hold a leading role in the market.

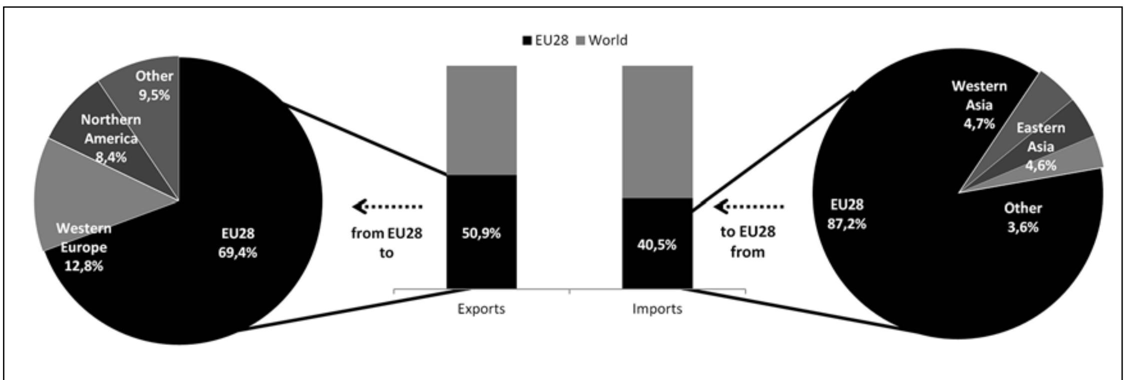

Figure 5.12: *EU28 imports and exports' partners for chestnuts in 2011 with respect to global trade (percentage based on USD dollars).*

The EU28 trade balance has been positive since 1988, oscillating around 30 M US$ in the last three years. EU28 was covering 40.5% of global import in 2011, mainly generated within the European Union (Figure 5.12). Moreover, EU28 supplied over 50% of the global export value, though almost 70% does not leave EU28 countries. Despite the increasing export trend, there is also an increasing dependency from the international trade, since the trade balance has been quite stable in the last decades (Figure 5.13). An explanation of this stable trend is surely the static dimensions of the chestnut forests (supply) combined with several pests that have limited the chestnut production (i.e. "chestnut gall wasp" and chestnut blight).

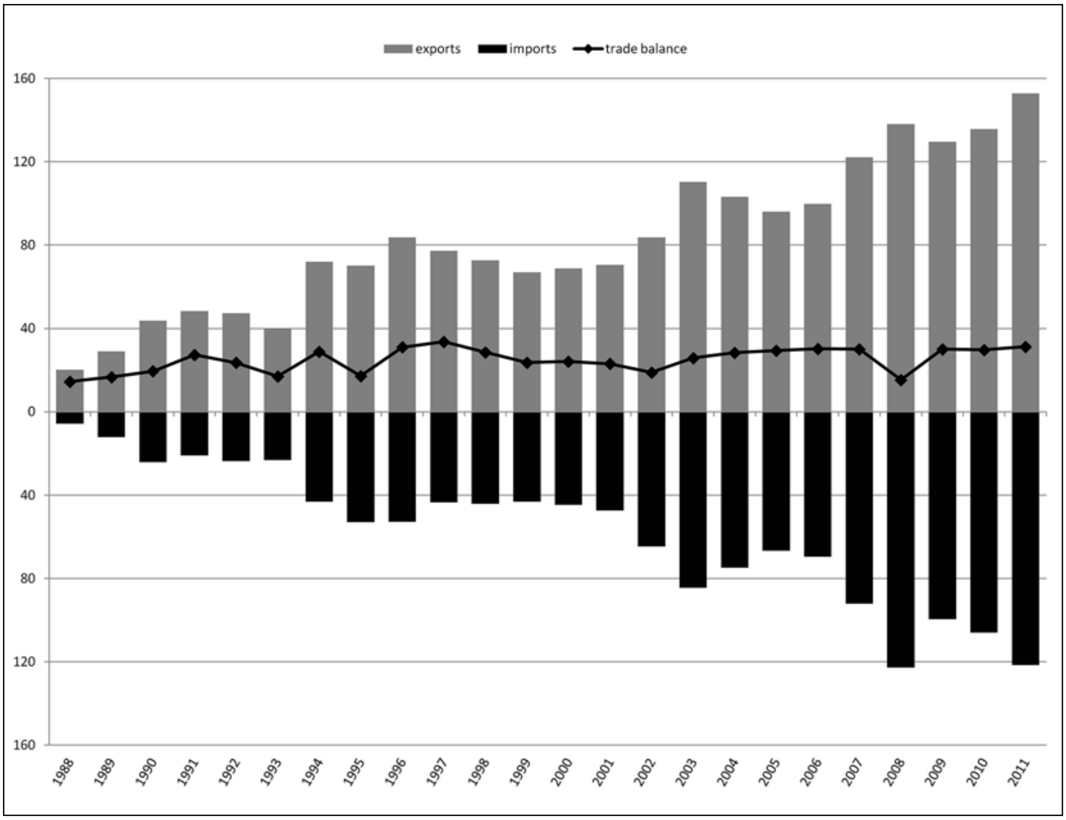

Figure 5.13: *EU28 total imports, exports and trade balance for chestnuts (million dollars) in 2011*

5.4.5 *Berries trade*

Berries are the most important NWFP category and the most valuable commercial commodity group accounting alone 7.5 M tons (metric) in 2013 (Figure 5.14a) or 14.34 billion US$ (Figure 5.14b). Berries are the most domesticated group of NWFP analysed in this survey; the wild harvest component in the international trade is a small proportion compared to the overall quantity. Wild berries harvesting activities cannot respond to the increasing global demand; the berries market is increasing both in terms of global trade partners and prices. The berry sector has had 0.989 billion US$ of average annual increment from 2003 onwards, which clearly shows an increasing global demand for forest fruits. Despite the consumer perception on berries, still considered a wild harvest production, the berry cultivation is today widespread everywhere with a huge investment on cultivars selection that adapt to the different global climates. It might be argued whether or not to consider in the present document the entire sector, but among the fresh and frozen commodities, there is a commodity group that is worthy of analysis for the historical role it had in the forest sector. Cranberries (*Vaccinium macrocarpon*, V. *oxycoccos*, V. *vitis-idaea*) represent the best example of NWFP domestication in the last two decades.

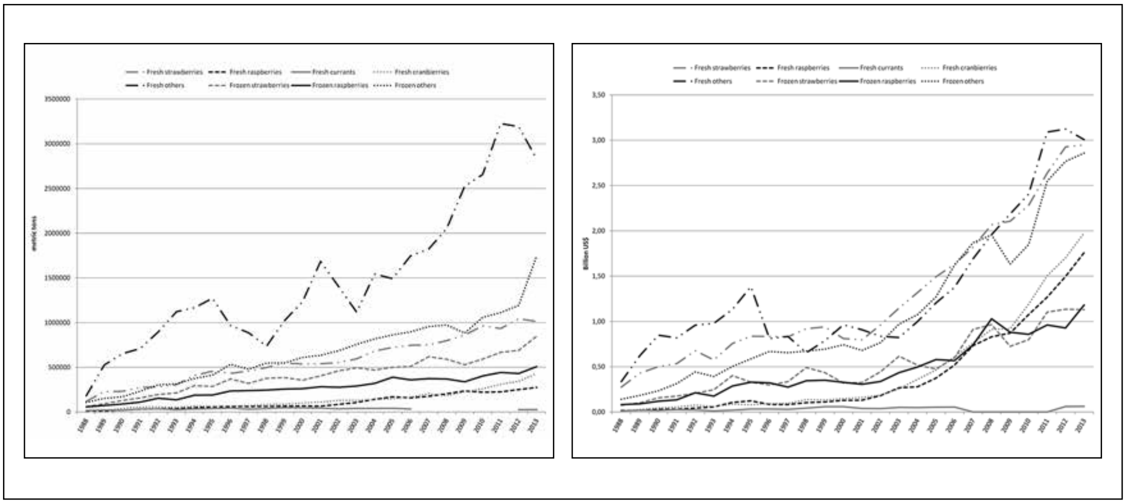

Figure 5.14: *Global berries trade flows by commodity (a) from 1988 to 2012 (metric tons) and global berries trade flows by commodity (b) from 1988 to 2012 (billions of dollars)*

Cranberries were a typical wild production of the northern hemisphere in the late ‘80s, period in which there had been a large investment on cranberry industrialization. The selection of cranberry cultivars in all the crop fields took almost a decade, which was pushed by the international demand willing to pay higher and higher prices (Figure 5.14). For instance, the specialization on fresh cranberries production let Chile, Argentina or Spain to become international players in cultivation that was not linked to their traditional crops (Table 5.11), or at the same time let Canada, US and Poland specialize in supply of frozen cranberry. The consequence of the industrialization of cranberries was also the creation of a stiff market structure in a triangular form among South America, EU and North America, the largest markets of cranberries at global scale (Figure 5.15).

Table 5.11: Global export and import top 5 countries, for Fresh cranberries, bilberries, similar fruits (81040) and Fresh other berries (81090), in million USD

Fresh cranberries, bilberries, similar fruits (81040)							
Exports (million USD)							
2005		**2010**		**2011**		**2012**	
Chile	118	Chile	363	Chile	476	Chile	468
USA	89	USA	241	USA	303	USA	321
Canada	88	ARG	131	ARG	144	Canada	189
ARG	31	Canada	115	Canada	142	ARG	157
Spain	23	Spain	75	Spain	108	Spain	133
Imports (million USD)							
2005		**2010**		**2011**		**2012**	
USA	191	USA	430	USA	532	USA	570
Canada	71	Canada	268	Canada	336	Canada	342
UK	63	UK	149	UK	181	UK	202
Japan	21	Germany	53	NL	80	NL	97
NL	18	NL	53	Germany	70	Germany	89

Fresh other berries (81090),							
Exports (million USD)							
2005		**2010**		**2011**		**2012**	
Canada	192	Canada	218	Canada	322	Canada	377
Poland	120	Poland	158	Poland	198	Poland	287
USA	78	USA	133	USA	167	USA	200
China	69	China	111	NL	157	NL	157
NL	57	NL	92	Chile	137	Chile	145
Imports (million USD)							
2005		**2010**		**2011**		**2012**	
Germany	238	Germany	283	Germany	368	USA	452
USA	177	USA	244	USA	341	Germany	367
Japan	112	France	150	NL	194	France	200
France	98	NL	139	France	188	NL	192
Netherland	91	Japan	99	Japan	130	Canada	169

ARG: Argentina; NL: The Netherlands

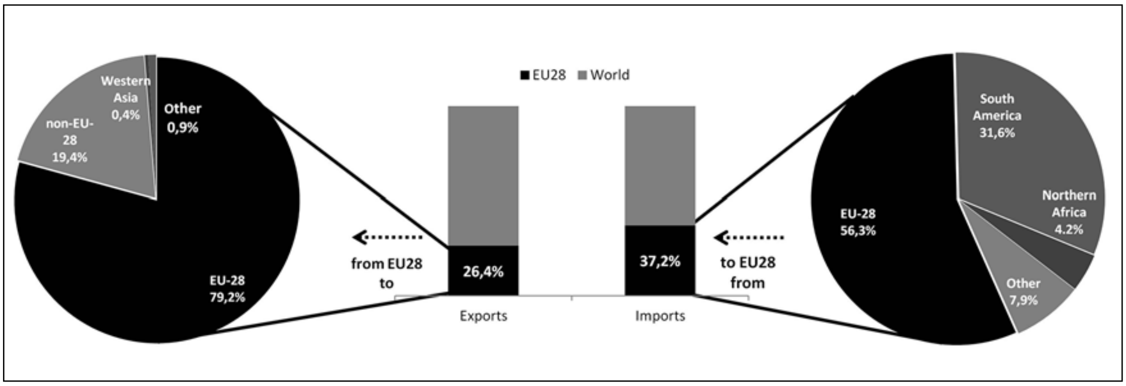

Figure 5.15: *EU28 imports and exports' partners for cranberries (081040) in 2011 with respect to global trade (percentage based on USD dollars)*

The EU28 represents one third of the international cranberries trade (37.2% in terms of import and 26.4% in terms of export). The 56% of the imported value is self-generated within the EU28 but 31% supplied by Chile (Figure 5.15). The most important market effect of domestication and international demand is represented in Figure 5.16, in which there is a clear increment of economic value, not only related to the increment in production, but mostly to the price increment due to the high demand in the market after 2001. Among the European players, only Spain and Poland have been able to obtain a strong position in the international market, while traditional producers such as Finland, Sweden and Russia are far behind the top traders, because they are still relying on wild production, with low productivity and high costs of production and logistics.

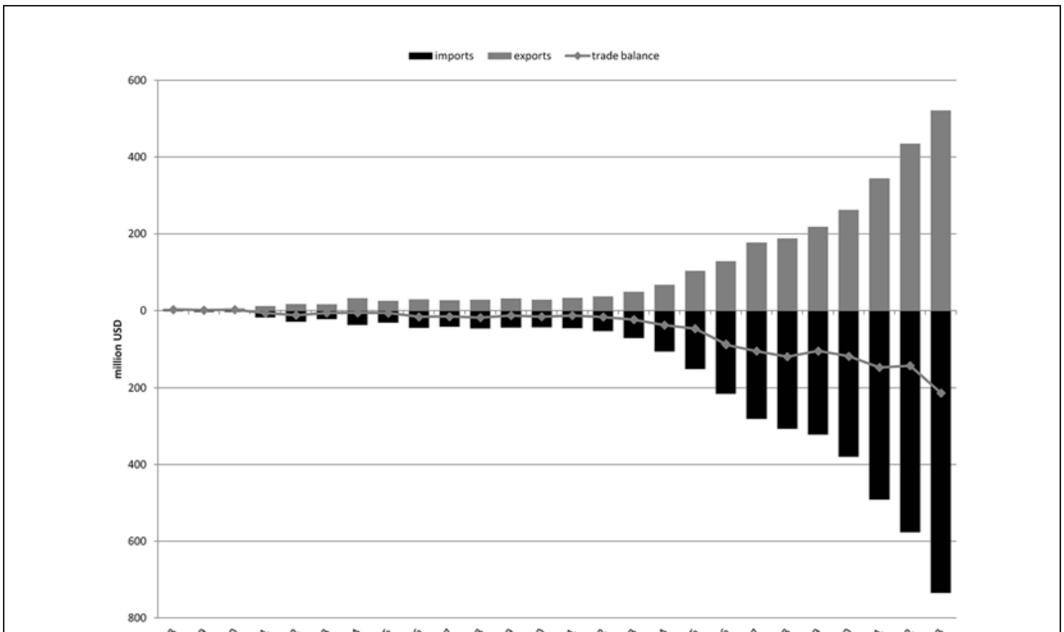

Figure 5.16: *EU28 total imports, exports and trade balance for cranberries, from 1988 to 2012 (million dollars).*

5.4.6 Trade dependence: a problem and an opportunity

The high internal demand and the EU's strong position on international markets for several NWFP represent a significant opportunity for European bioeconomy and offer a chance to enhance internal NWFP supply and maintain industrial processing as well as local and traditional know-how of NWFP value addition. While it is unrealistic to supply the internal EU demand for all NWFP from European forests, the enhancement of production of NWFP could be a key aspect of future forest policies in order to reduce dependency on international trade and re-establish economic bridges between largely urban NWFP consumers and producers located in remote rural areas; according to Da Re *et al.* (2016), the bridges between EU's NWFP and EU citizen may enhance the rural development without the use of public subsidies. The EU's support on the design of a common governance on NWFP supply chain may play a crucial role on the design of circular economy based on forest products.

Furthermore, the high dependence on international trade for most of the wild forest products, and especially for mushrooms and nuts, should make the policy makers think about the role that quality standards may play in the future competition among regional producers and exporters from outside the EU. The European food and environmental standards have already been translated into a higher quality of the imported commodities, but the competitive emerging markets with standards lower than of European Union may induce a shortage of raw materials on the international market, while demand is increasing, with impacts on raising prices. While it is unrealistic to cover the demand for all the NWFP from European forests, more attention should be given to the enhancement of the standards and overall quality of the internal supply, in order to differentiate the market and to cover at least the high-quality segments (i.e. higher prices). This target can be reached with an increase in innovation in production techniques (see chapter 5.5), in standard setting, certification and labelling (see chapter 5.6) and marketing in general with and more advanced entrepreneurship by NWFP internal producers and processors.

5.5 Developing NWFP: the role of innovation

Innovation is key to unleash the potential of NWFP for fostering rural economies. We see the role of innovation not only as a necessary answer to a growing price pressure from competing global markets, to increasing domestic labour costs and to growing quality and social standards in the production process. We also see new societal values and demands offering new – and renewed – marketing potentials for forest products such as natural, organic or wild goods and foods or related recreational, educational or experiential services.

New combinations of urban and rural skills and values in producing and marketing NWFP may contribute to a countryside renewal in Europe, however, important challenges remain: How to bridge rural and urban values? How to integrate diverse sectors such as forestry, food industries or experiential and tourism services? In this chapter we want to characterise the role of a few central elements for innovation in NWFP – entrepreneurship, institutions and social change – before we sketch typical current innovation patterns in NWFP in Europe and discuss possible support strategies.

5.5.1 Innovations in NWFP

Our understanding of innovation in this chapter goes back to Schumpeter who sees innovation as "the doing of new things or the doing of things in a new way" and characterizes innovation as "a process by which new products and techniques are introduced into the economic system" (Schumpeter 1947). This process takes place within a system of institutions and actors among which the companies are the central elements but, however, do not act independently on their own but interconnected with these innovation system elements (Edquist 1997). When looking at innovations not from a company but from a societal or national economic perspective, it becomes clear that not only the absolute new innovations are relevant (radical innovations) but all smaller improvements of our technologies or products (incremental innovations), and that we need to look not only at the development of novelties but their implementation and diffusion across the market just as much (Rogers 1995).

In such a comprehensive or systemic view, OECD classifies innovations into product, process, marketing and organisational. In addition, also institutional or policy innovations may be needed (Weiss 2011) as well as social innovations (Franz *et al.* 2012). It is not only new products but any type of innovation that may be the crucial factor for developing NWFP businesses further (Table 5.12). In practice, it is often a combination of different types of innovation, for instance, when a cooperative is created for the joint production and marketing or an association is formed in order to lobby for research, legal recognition or any other institutional support for a new product.

In this chapter, we take an innovation system perspective and focus on various qualities of innovation processes. This appears purposeful since such a cross-cutting view across all different NWFP may lead to insights on how innovations in this field may be supported by institutional level actors and policies (Rametsteiner *et al.* 2005, Rametsteiner and Weiss 2006). Besides of the companies or entrepreneurs who have a central role in the innovation process, we have to consider their interplay with the research, industry and governance systems (triple helix perspective, Etzkowitz and Leydesdorff 2000) as well as society as a whole (quadruple helix, Carayannis and Campbell 2009).

Table 5.12: Types of innovation with NWFP examples (source: Weiss et al.).

Type of innovation	**Example from NWFP**
Product innovation	New uses for the traditional material cork, for instance, for clothing; medicinal or pharmaceutical products from wood, bark, fruits, leaves or the broad range of forest plants; experiential services such as foraging or mushroom collection tours, wild fruits cooking courses or manufacturing workshops.
Process innovation	Specific forest management (lighten up the forest to enhance production of mushrooms or berries, selection of tree species such as nuts or fruit trees, agroforestry systems such as the Portuguese *montado* system, or plantation of wild or grafted fruit trees or shrubs such as chestnuts, hazelnuts, elder, sea buckthorn); new harvesting methods to reduce costs; improved processing to improve the product quality – for instance, the natural ingredients or the shelf life of the products.
Organisational innovation	Horizontal cooperation of small producers under a common brand allowing for a joint marketing; vertical integration or cooperation to secure a higher value added for the primary producer (farmers' direct marketing) or to allow for a traceability of the product chain (e.g., high quality game meat or other products from natural production).
Marketing innovation	New marketing to address new costumer groups through different design, packaging, advertising or distribution channels; internet platforms and social media networks for small producers to reach distant clients; regional or quality certification schemes for local, natural, organic or "from the wild" qualities of the products.
Policy innovation	New or adapted regulatory frameworks in the field of the products (e.g. official recognition as a forest or agricultural product; license systems for collection) or in innovation support (e.g. the European Union LEADER instrument).
Institutional innovation	New certification schemes, regional marketing approaches or the creation of new lobbying organisations for public awareness raising or for research, education and training programmes, or other political-institutional support.
Social innovation	New lifestyle trends such as foraging and bush craft activities, survival training or the rediscovery of old skills and traditions; the redefinition of traditional wild food products such as chestnuts, mushrooms, forest herbs, juices, etc. from being seen as a poor people's food to a healthy and stylish gourmet food.

NWFP have specific qualities which have a bearing on the opportunities and limitations for doing business and which define the preconditions for any innovation activities and any innovation support. First, NWFP are often characterised as “territorial goods and services” (Slee 2011) which means that they are bound to a specific place of production. This implies two qualities which may act as limitations and assets at the same time: (i) territorial goods and services can be produced only in that very place. A good illustration are certain services which are defined by the place where they are produced and consumed at the same time. Examples are the protection function of forests against avalanches or rock-fall or amenity services such as the beauty of a characteristic landscape. In the case of goods, they may be transported but only produced in certain climatic areas or on certain soils where the natural conditions are suitable (e.g., boreal or alpine berries, etc.); (ii) territorial goods and services carry the locality of production as a specific characteristic with them which can be used in marketing (Pettenella *et al.* 2007). In the case of landscape amenities, it would mean that the place is marketed for visitors to come. In the case of transportable goods, the local character may be apparent (when knowing that boreal or alpine berries can only come from those areas) or may be indicated as their origin (in terms of a region, country, producer, production method, etc.). With regard to the production method, the wild origin or an organic production may be relevant for NWFP. Marketing methods specifically for the geographic locality may be territorial/regional marketing or labels of origin, for instance, the EU regulated schemes of Protected Designation of Origin, Protected Geographical Indication and Traditional Speciality Guaranteed (see chapter 5.6 on branding, standards and certification).

Figure 5.17: *The logo of the regional marketing association “Chestnuts of Castione” in Italy (Picture: Associazione Tutela Marroni di Castione).*

Second, NWFP have often public good characteristics which limit their marketability, be it by natural characteristics or institutionally defined (Mantau *et al.* 2001, Mavsar *et al.* 2008). NWFP are often not cultivated but wild and governments have therefore often decided to grant the public free access to these products, particularly in more northern countries where forests and their products are more abundant. In situations of specific production potentials, such as with the historical resin production, focused production systems and related regulations have been developed (Prokofieva *et al.*).

In a situation when NWFP are seen as side-, by-, or minor products, innovation efforts are also lacking or occur only erratically by single entrepreneurs and activities through which their full development potentials are not realized. NWFP are not in the focus of any innovation system – also forestry actors and policies do support them only in exceptional cases (Buttoud *et al.* 2011, Kubeczko *et al.* 2006, Weiss 2013) and – if there is any support at all – they are rather supported by rural development or start-up support programmes (Ludvig *et al.* 2016a and 2016b, Zivojinovic *et al.* 2017, Weiss *et al.* 2017). One indication for the widespread ignorance of these products is the fact that statistical information is very limited. In fact, it is a quite unknown sector. It is, however, bigger than usually perceived (Vacik *et al.*, 2014) – a fact, which is shown at several places in this book.

The described conditions explain why innovations are rare in the sector and often conducted by single companies for their own or in smaller networks but with very limited institutional support, hampered diffusion processes and a lacking upscaling to industrial levels (Ludvig *et al.* 2016-a and –b, Zivojinovic *et al.* 2017). In the following, we aim to characterise the innovations in NWFP in Europe, the innovation processes how they occur in practice, and how they are supported by the institutional systems. On this basis we derive innovation patterns that are characteristic for NWFP in Europe.

5.5.2 The role of entrepreneurship

In the field of NWFP, the companies are very often SMEs, a fact, which gives a special role to the company owners or entrepreneurs (Lunnan *et al.* 2006, Niskanen *et al.* 2007). There are different notions of entrepreneurship which are all relevant for our topic: The term entrepreneur may name a personal trait (being an entrepreneurial person), or may simply mean starting up or running a business (owning a company). Under the first notion, entrepreneurs have what Schumpeter called the “entrepreneurial spirit” to innovate, pursue opportunity without regard to alienable resources currently control (Hart *et al.* 1995) and over and above are described as risk-takers (Knight 1921, Drucker 1985). This relates entrepreneurship strongly to innovativeness, but also responsibility – expressed in the often used definition of an entrepreneur being a person who undertakes and operates a new enterprise or venture, and assumes some accountability for the inherent risks.

When we look at entrepreneurs in practice, these two notions may come together, but we will find that company owners are not always what we would understand as being entrepreneurial. This is probably best explained by putting the simple question, how people come to be entrepreneurs: They may be driven by the urge to “undertake” something and “pursue new opportunities” (opportunity-driven entrepreneurs, Reynolds *et al.* 2002), but they may be simply the heirs of a business, may be forced into entrepreneurship because they have no other job options (necessity-driven entrepreneurs), or may be motivated most of all for being independent, as Hessels *et al.* put it, “hardly anybody starts a business in order to achieve innovation, job creation, or economic growth at the national level” but rather for their personal desire for profit and autonomy (Hessels *et al.* 2008).

So if in practice people may have varying histories and motivations for doing business with NWFP – what would be important qualities for successful entrepreneurship in this market? In frame of the StarTree project, we carried out a workshop with NWFP experts and entrepreneurs on this question (http://star-tree.eu/), resulting in "three P's of doing business in NWFP": Passion, Patience and Practice (in this very order). If one would want to start-up an NWFP business, these would be the recommendations: Passion seems to be the first precondition to be successful with a company: You need to be personally attached to your business. In the words of one entrepreneur: "I'm the entrepreneurial person, you know. I like the alchemistic part of doing business. You need to follow your bliss. You need passion!" Passion is the driver to create quality products, but it is also needed to cope with failures and set-backs and to keep you going – even if all takes longer than you had expected. Second, patience is needed also to do necessary but boring or even annoying stuff such as all the bureaucracy. In the workshop, it was described as "building stone-on-stone". Any business will need a lot of learning, experimenting, and trial and error to refine the product and to do it efficiently. According to the "seed-first model" you should think first about the quality of your product and not about the marketing. And in the end, one needs practice (i.e., the practical knowledge) on both making and selling the product. You will need to have the "best" product but you will also need to become interested in things you were not very excited about originally, such as how to advertise, how to keep accounts, how to get official approvals, etc.

5.5.3 The role of political-institutional frameworks

For the development of businesses and innovations, institutional frameworks are important – with more direct roles when they offer advisory services or innovation and start-up funds, or with indirect roles in the form of research, education and training, regulatory and administrative systems, etc. (Porter 1998, Rametsteiner and Weiss 2006).

Unfortunately, the institutional frameworks for supporting innovations in forestry in general, and for NWFP specifically, are relatively weak (Lawrence 2003, Rametsteiner and Weiss 2006, Weiss 2013). Since the field of NWFP is not developed as a distinguished sector, specific support structures on the public and private sides are largely missing (Weiss *et al.*). From the public side, statistical data or any other information, research, education and training services are very limited. From the private side, only weak support exists, since the established interest groups of forestry or agriculture do not have NWFP in their focus. Forest owners' interest groups tend not to support those products because the benefits are often not with the landowners (Weiss *et al.* 2017). Only rarely, specific interest groups have been founded for NWFP as such or for a range of such products. An example would be the Scottish Wild Harvests

Association (http://www.scottishwildharvests.org.uk/). Interest groups for specific NWFP usually develop only once a certain economic significance is reached (e.g., for truffles or cork in Mediterranean countries). The formation of producers' associations is often an important step for fostering the production knowhow, spreading product knowledge to consumers, or lobbying for favourable regulatory provisions.

The critical phase, however, is before that – in the earliest phase of a new product. A number of documented innovation case studies from the StarTree project[17] show that in that phase, companies have to rely on more general support structures and have to be very pro-active in searching for the relevant information, networks or funding possibilities. It is mostly not the forestry sector but actors and programmes from agriculture (e.g., agricultural direct marketing associations and vocational schools in Austria), rural, regional or business development (e.g., LEADER regions in Austria and Wales; regional development in Finland; start -up grants from national support programmes in Serbia and Slovenia) or even nature conservation (e.g., the Reforesting Scotland association; Austrian Nature Parks Association) that provide support (Ludvig *et al.* 2016-a and –b, Weiss *et al.* 2017, Zivojinovic *et al.* 2017).

In order to make an economic impact, innovations must spread and be adopted by other companies (diffusion). For this process, the formation of associations is highly useful – an institutional innovation which benefits itself from institutional support or from prior social capital (Ludvig *et al.* 2016-a).

From the 20 innovation case studies from the StarTree project, we learnt that institutional frameworks that are relevant for NWFP businesses are not the same across the European regions. We found that a special attention on (specific) NWFP does exist in Mediterranean countries (Italy, Spain, Portugal) where some of these products have a strong tradition and economic significance, e.g., cork, pine kernels, pine resin, truffles or mushrooms. We furthermore found relatively strong general framework conditions for rural or regional development in northern, western and central European countries (Finland, UK, Austria). In comparison with the western countries, the institutional structures for business support in rural areas in the former socialist countries in east and south-east Europe are not so strongly developed yet.

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17 Innovation case studies in NWFP in Europe from the StarTree research project: "Cairn O´Mohr" (wine from oak-leaves and elderberries, UK, Scotland), "Fine Pluck" (hand-plucked tea UK, Wales), "Nature Park Specialities" (wild food specialities, AT), "Xeis Edelwild" (marketing of game meat, AT), "Wild vom Förster" (marketing of game meat, DE), "Resinas naturals" (natural resin, ES), "Servizio di raccolte resine" (natural resin, IT), "LEADER Region Zirbenland" (pine products, AT), "Out to Learn Willow" (willow weaving courses, UK, Wales), "Vale die Castione" (chestnut association and events, IT), "Wild Pickings" (foraging products and tours, UK, Wales), „Woodland Skills Center" (teaching woodland management, UK, Wales), "Christmas Tree Marketing" (cut your own tree, AT), "The Monegal Mushroom Hotel" (mushroom tourism, ES, Catalonia), "Del Monte de Tabuyo" (gourmet products from mushrooms, ES), "Adonis company" (tea spoon shaped tea bags, SRB), Finnish Gift Firm (luxory gift packages, FI), Birch Sap Company (birch sap with longer shelf life, FI), Trentino Firm (domesticating mushrooms, IT), Wooden Knots for Climbing Walls (wooden climbing wall holds, SLO).

By use of the case studies, we analysed what support is actually given by the institutional system and how. From the mentioned 20 cases, only two were supported from forestry, the rest either from rural development or non-sectorial business support. The programmes apparently work quite strictly according to sectoral logics: The forestry support was for the only pure forestry case (Christmas trees marketing) and for a cross-sectoral one (game meat marketing). Rural development support was mostly given for cross-sectoral projects (e.g., EU LEADER support for links between food and tourism or gastronomy) and hardly for entrepreneurs that were originally from outside agriculture or forestry. The non-sectorial support was for the benefit of a few cross-sectoral cases (e.g., an Italian municipality to support turpentine production, a Finish start-up support for a gifts producer), but more for cases from outside (e.g., for a Welsh forager or for a Serbian herbal tea company).

In most cases, the support came from local-regional programmes (e.g., by a county council in Wales, or regional associations in Austria) or through regional administrations of national or EU programmes (e.g., the EU LEADER regions, or the local implementation of Finish start-up funds). We classified the provided support into three typical support functions of innovation systems: the provision of information, funding, and co-ordination or networking support. In one case, we found an additional function in form of an adaptation of the regulatory framework (Italian turpentine production). In almost all projects, financing was given, although very often only a small sum (a few thousand Euro) and often in combination with other support such as information. Information was relevant in the majority, co-ordination in half of the cases. When asked about which kind of support was the most important, the entrepreneurs mostly name the information in the first place, co-ordination in the second, and financing in the third. An important lesson, however, is that very often a combination of different support instruments is purposeful, and that the best help is provided if the support service has the whole portfolio of instruments and has the ability to provide tailor-made support. The best examples of support structures are therefore easy accessible, regional-level agencies that can offer advice and funding such as the LEADER regions, cluster organisations or similar (a Spanish pine resin case was purposefully supported by a regional, cross-sectoral co-ordination platform). Our best case examples correspond to the ideal form of regional support structures (Figure 5.18 and Figure 5.19) where local activities are connected to a supportive institutional environment, so-called “regionally networked innovation systems” (Asheim 1998).

Figure 5.18: *The EU LEADER programme offered "top-down support for bottom-up initiatives" for developing new products from Swiss mountain pine in Austria (picture: Patrick Huber).*

Figure. 5.19: *The Austrian direct marketing label "Genußregionen" (Regions of Delight) was used for several wild forest products, including chestnuts (picture: Patrick Huber).*

The reasons for low levels of utilization of public support by the companies may be in fact be seen on both sides: Entrepreneurs are often characterized by strong willingness to be independent and autonomous. On the other hand, the content and mechanisms of support programmes are frequently standardized, which makes it less useful with regard to the specific requirements of small companies (Boter and Lundström 2005, Zivojinovic *et al.* 2017). Therefore, companies benefit from previous development activities in the region that built up a certain social capital and they benefit from institutional structures such as regional development agencies or sectoral associations. At the same time, that should be the aim of support programmes – to build regional social capital and networks (Böcher 2008, Mary George *et al.* 2016, Maso *et al.* 2011, Micheels and Nolan 2016, Nybakk *et al.* 2008).

What can be learnt from the case study analyses is that the best examples for support structures have in common that they operate at the regional level and are open and flexible enough to adapt to the companies' needs when offering their support. This model for innovation support could be termed "top-down support for bottom-up innovations" (Weiss *et al.* 2017).

5.5.4 The role of social change

The analysed NWFP innovation cases picture a fundamental social change in rural areas: While NWFP in former times were part of the traditional agricultural land uses, farm structures and subsistence needs of the rural population, they are today more connected to new urban demands. NWFP formerly were either collected for personal consumption (e.g., nuts, berries, mushrooms or herbs as wild food sources) or specific industrial markets (e.g., pine resin collection). Although the wild collection sometimes appears like a sports activity today ("mushroom hunting"), the overall picture is that with the modern urbanised lifestyle the old knowledge gets lost and so is the time that people have available for collecting from the wild for everyday food. At the same time, the traditional products from forest collection are not competitive any more on international markets and against production from plantations (Wong *et al.*). Those developments, however, are factors in a revival of those products, although in a new context and with new qualities: They are, for example, marketed with specific or higher quality standards, as local, traditional or "wild" specialities, or in combination with embedded recreational or educational services. The new qualities for marketing NWFP are as follows:

i. Natural quality: New marketing possibilities for NWFP are often connected with their natural, non-industrial production. The revived production of Spanish pine resin is connected with the high and reliable quality and the absence of artificial additives. The new demand for green, environmentally friendly, healthy, fair or sustainable products is connected to a new urban lifestyle known as lifestyle of health and sustainability ("LOHAS", Ray and Anderson 2000).

ii. Retro quality: Traditional, home-made and hand-manufactured food or drinks, handicraft items or one-of-a-kind artisanal products are marketed as special value products in high-price segments. They are often marketed with their local culture or old traditions. The value of the products lies besides of the use value of the products itself also in the immaterial, symbolic qualities. It provides not only basic nutritional or use functions but also an "experience".
iii. Experiential quality: Our wealthy societies allow growing demands for entertainment and "experiences" for which our economy has been described as being on the way to an "experience economy" (Pine and Gilmore 1999). Besides their functionality, products are more and more marketed by appealing to costumer's fantasies, feelings, and fun. As described, NWFP often contain those qualities with their historical features, but in other cases, the products are even more closely combined with experiential services, for instance, in the cases of foraging or mushroom hunting tours, wild fruits cooking courses or do-it-yourself workshops (Figure 5.20) to learn traditional skills ("weave your own basketry", "make your own wild herbal salt", "cut your own Christmas tree"). Sometimes, the services are marketed in the first place and the products are only add-ons, such as in rural tourism, cultural events, etc. where local products are marketed on the farm holiday premises, on farmers' markets or in nature park shops, etc.).

Figure 5.20 *Do-it-yourself course for herbal smoothies: wild – natural – traditional – and experiential (picture: Ivana Zivojinovic).*

According to the described developments, the ideas and initiatives behind the analysed innovation projects come often from urban backgrounds: In one third of the cases, the projects were initiated purely by urban actors and with urban knowledge, for instance, when the entrepreneurs grew up in the city and had urban professions and skills such as in the IT sector, marketing or creative industries. In another third, this was combined with rural backgrounds when project partners had rural socialisation or professions, when the entrepreneurs had grown up on the countryside but moved to the city later on, or when they moved from the city in order to become landowners. In many innovative cases, a confrontation of urban and rural values and skills were most fruitful for getting the original idea or for the success of the product, for instance, through an appropriate modern design and marketing.

The fact that people from the cities discover the country as a good place to live has been termed "counter urbanization" (Bosworth 2010) or "countryside renewal" (Slee 2005) and is seen as an important source for new development impulses in rural areas. The new populations that are often modern, highly educated, urban people, are a resource to renew rural regions as being not only new costumers for NWFP but often as being the new producers. By connecting old and new values, rural and urban knowledge, they are sometimes particularly innovative, create new products or find new marketing channels.

5.5.5 Innovation patterns in European NWFP

Many of the analysed innovation projects were horizontal or vertical co-operations between companies. In about half of the cases, the projects were carried by one company – that was often the case with micro enterprises. The other examples were co-operation projects between several companies (in the form of joint production or marketing, or along the value chains) or innovations initiated by institutional actors or networks such as rural development agencies (LEADER region) or associations (e.g., Austrian Nature Parks, Italian chestnut association). This means that co-operation is not only crucial in the form of loose relations among companies or within an innovation network or innovation system (interrelations with relevant public or private actors such as authorities, neighbours, interest groups, research, etc.) but that the projects themselves are often carried by more than one company or by institutional actors. Here, a co-operation across sectors is often fundamental or in fact the character of the project itself, for instance, between forest holdings and game meat or resin processors, nature conservation or tourism. As described above, only one was a pure forestry initiative and only six were purely rural – most projects were cross-sectoral and had urban ideas and knowledge included.

We found a very broad range of innovation types. The projects were not only characterised by the generic innovation types (product, process, marketing, organisational and institutional innovation) but we found innovations that are particularly relevant in the NWFP field: the revival of historical technologies or products (pine resin, chestnuts, etc.) and products embedded in or combined with services (in rural tourism or social innovations such as green care or educational projects). Institutional or policy innovations are of specific relevance in order to foster the companies' capacities in terms of joint production, marketing, research or lobbying for official recognition of the product or non-discriminatory regulations. A so-called "policy entrepreneurship" appeared relevant for resin production, chestnuts, social innovations as well as touristic projects such as the mushrooms hotel (access regulation to the forest).

The example of policy innovations illustrate that innovation projects very often contain several innovation types. Institutional innovations are often connected with new marketing approaches: the creation of an official label was in the centre of game marketing, chestnuts, nature park products and domestic Christmas trees. New products often require new production technologies, co-operations or marketing approaches.

In summary, we found a remarkable diversity of ideas, companies and co-operations. We summarise the observed innovation patterns in the following list:

Forest company-driven: When innovations are carried by larger forest holdings, in-house capacities exist for investments, technical or legal advice, etc. (examples of game marketing by public forest holdings in Austria and Germany). The companies apply classical innovation management and are able to apply for R&D funds or to undertake other more bureaucratic activities by use of their own resources.

Forest owner-driven: Those innovations are often conducted by traditional forest farmers for whom the forests are an important resource and when they are open-minded entrepreneurial persons (e.g., Christmas tree marketing in Austria). They create cross-sectoral links by themselves but would benefit from various institutional support, including information, financing and networking services.

Entrepreneurial-driven: These entrepreneurs come from outside forestry (e.g., foraging or producing drinks and food specialities, soaps, etc. from wild collection in many countries). They may be from urban backgrounds and often bring in new views on rural assets, being either new land owners or even without owning land themselves. Similar to the small-scale forest owners, they can benefit a lot from broad and systemic support services.

Industry-driven: Industrial-size companies are ready for bigger investments (e.g., revived pine resin production in Spain). With their investment resources they might look for public co-funding or approach R&D programmes in a professional manner. In order to realize innovation projects, they may depend on regional cross-sectoral networking or trust-building.

Social enterprise-driven: Socially oriented entrepreneurs or organisations invest a lot of voluntary work and enthusiasm but are short on monetary resources and need monetary and non-monetary public support for the institutionalisation of their projects and long-term survival (examples of social enterprises for traditional forest management or bush-craft skills in UK). They often depend on open-minded and flexible public bodies since their ideas – even if charity or socially oriented – often do not fit into established structures, regulations or ways of thinking.

Regional development-driven: Such innovations are carried by public or semi-public organisations or programmes with a broad rural or regional development orientation (e.g., EU LEADER regions and regional development or territorial marketing initiatives in Austria, Italy or Spain). They have the specific purpose to support entrepreneurship and innovation and bring support instruments with them. Their drawbacks, however, may be inflexible structures or regulations, bureaucratic procedures, or lacking local specific knowledge and connections. Openness and adaptability of the programme framework and the persons in charge are important for successful projects, in order to pick up existing initiatives and resources instead of a top-down implementation of external ideas and support measures.

5.5.6 Support strategies for innovations in NWFP

What we can conclude is that small-scale innovations and entrepreneurship dominate in NWFP and entrepreneurs do pursue their ideas and businesses often without much institutional support. There is no "one" innovation system supporting NWFP but support is rare and is coming from various sources. For none of them, "non-wood forest products" are central and thus the offered support measures often do not easily connect to the innovation projects or needs of the innovating companies.

Break-through innovations and scaling-up, however, needs a stronger institutionalisation and systemic support, i.e. through multiple support instruments such as networking, advisory services, R&D, awareness raising, regulatory adaptations, etc. A strong general innovation and business support in rural areas is therefore crucial with support structures and instruments flexible enough to adapt to local situations and company needs.

Since the innovation patterns are very diverse, also the support needs are manifold. With regard to the provision of relevant information, they include a broad range of topics which span technical and business knowhow as well as cross-sectoral knowledge and links. Depending on the companies and projects, required financing support may be small, un-bureaucratic start-up funds for entrepreneurs on the one hand, but also large-scale R&D funds for industrial scale investments on the other. Co-ordination may be needed for all this and further purposes: for information, funding, business co-operation, conflict resolution, regulatory adaptions, or public awareness.

Effective strategies to provide policy support may include the following two different directions:

i. to develop explicit sectoral innovation policies in forestry which explicitly include the NWFP and non-topical purposes. In a systemic approach, such innovation policies should particularly provide for information measures, cross-sectoral networking and risk-oriented innovation funds (seed money);

ii. to provide for rural development agencies which offer comprehensive and systemic support for local projects, including informational, financing and networking for tailor-made support. Examples for such structures include LEADER regions, regional cluster organisations, and cross-sectoral platforms with a triple (or quadruple) helix approach which includes industry, research and governments (and possibly civil society actors).

5.6 Promoting NWFP: branding, standards and certification

To promote the use and consume of NWFP, a set of business practices and market based instruments can be adopted. These can help in building effective customer relationships, but also in improving sustainability in NWFP systems and transparency in commercialization.

The communication of NWFP characteristics and the assurance of quality pass through the use of brands, standards and certification. Branding refers to the process of creating a name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of others. As for any other product, NWFP can benefit from being associated to a special and unique brand that helps in differentiating from mass products and in gaining consumers' trust. Standards and certification schemes aim instead at ensuring the quality of the product. Certification is a market based instrument used to improve the quality, safety or management of products against the requirement of a standard, through a third party auditing (Bass *et al.* 2001).

The first part of this chapter presents some examples of branding and branding tools for NWFP. In the second part, the main standards and certification schemes that can be applied to NWFP are described, including the presentation of a comparative analysis. In the conclusions, the role of these instruments is stressed, not only for the marketing process, but also for improving the general traceability of the products and the transparency of the value chain.

5.6.1 Branding of NWFP

The creation of an effective brand for NWFP encompasses several elements, such as the identification of the target customers and the definition of a brand position and identity. The elaboration of a list of attributes and benefits associated with the marketed NWFP assumes a strategic importance as well. In Table 5.13 a list of attributes that are intrinsically linked to NWFP (and processed products made with NWFP) which have the potential of attract consumers is presented. Indeed, in the market there are several examples of NWFP commercialised with these attributes.

Table 5.13 Attributes linked to NWFP that can be used for an effective branding, per class

Class of attributes	Attributes
The place where NWFP grow	The forest, the mountain, an untamed place, local, indigenous
How NWFP grow	Wildly, semi-wildly, naturally, organically, without pesticides, respecting people/environment
How NWFP are prepared	Traditionally, innovatively, respecting people/environment
The benefits that NWFP provide	Healthy, energising, purifying

A brand is typically developed and used by a single enterprise or organization. However, it can also be shared among several entities, becoming a collective brand. In this latter case, a number of organizations share costs and benefits under the light of common reputational values and joint marketing strategies. When this is built with a synergic effort of promotion of a territory, it takes the name of territorial or regional branding. The brand of a region, or even of a country, if properly designed, can be conducted as a strategic spatial planning instrument. Territorial branding and marketing can generate social and economic development, by creating a positive image among both internal and external public, by igniting innovation and investment attractiveness and by arranging conditions for activation of enterprises and human resources (Anholt 2004, Kalieva 2015). This process implies a concrete vision, a coherent, coordinated and long term logic, an effective process of governance, as well as a dynamic and creative plan (da Silva Oliveira 2016). Especially in rural regions, the territorial marketing passes through the promotion of products and services that are linked with the local context and tradition. NWFP are good candidates for becoming "imago products" of a territory, because they are a natural produce and their collection and preparation are, in many cases, connected with traditional practices and local culture. Together with the imago product, in the territorial marketing other connected products and services are offered, typically those of the eno-gastronomic culture. The link between products and services is often materialized in the "road concept": roads, paths, trails become the tools for connecting different actors in the territory. Several examples of chestnuts roads, mushrooms trails, truffles paths exist. Case 5.1 illustrates the example of Castilla y León, Spain, which pivots on wild mushrooms as fundamental element of the territorial branding.

5.6.2 Main standards and certification schemes applicable to NWFP

Despite branding and branding tools have the potential of creating several positive effects, sometimes problems may occur. For example, Santini *et al.* (2013) showed that, in the European Union, there are several products branded with the "mountain" message, which have only partial mountain origin and others that are completely foreign to mountain food supply chains. Analogously, concepts such as "wild", "natural" and "forest" messages are widely used to commercialise products, but they do not always assure a product's connection to these origins. To avoid misleading messages, a system of assurance provided by standards and certification can be adopted.

Several studies show that opportunities exist to promote NWFP management, trade and use through certification (Shanley *et al.* 2002, Vantomme and Walter 2003, Burgener and Walter 2007, Shanley *et al.* 2008). The benefits provided are manifold. These encompass social benefits, with the strengthening of harvesting rights and broadly the empowerment of local actors; economic benefits, because certification can create additional value and price premium, improve market access and increase efficiency and transparency of the market processes; environmental benefits, conserving habitats and species. As Pierce *et al.* (2003) suggested, the creation of a certification standard for NWFP may create virtuous effects among producers, people involved in the commercialization, consumers and policy makers by laying the foundations of a sustainable management of NWFP. However, the process of certification of NWFP is often a not simple issue. As Shanley *et al.* (2002) and Burgener and Walter (2007) noted, these products are a more difficult group of products to certify than timber, due to an array of factors, including their diverse and peculiar nature and social and ecological complexity. Basic legal factors such as unsecure harvesting rights can limit from the beginning the applicability of certification to NWFP (Pierce *et al.* 2003). Economic barriers can hinder the process as well. This may happen because harvesting in the wild often requires high labour inputs for low values and for this reason NWFP suffer from diseconomies of scales (Pierce *et al.* 2008). In addition, the production of many NWFP is also strongly affected by seasonality, which creates discontinuity. Moreover, NWFP are often traded on small and local scales and trade systems are not efficiently structured. Ecological and technical challenges for certification exist as well. In particular, for some species, the definition of the sustainable harvesting rate represents a difficult assessment (Walter 2006). Finally, the end-uses of NWFP are very wide, comprising food and food additives, cosmetics, pharmaceuticals components and handcrafts.

Despite the several challenges revealed by these studies, in many cases the problems have been overcome and today several examples of standards and certification schemes that can be applied to NWFP exist in the market.

CASE 5.1: *Wild mushrooms as an element of territorial branding: the case of Castilla y León*

The autonomous community of Castilla y León, in north-western Spain counts 2,700 species of wild mush-rooms. This great ecological diversity, combined with the culinary tradition, gave Castilla y León the opportunity to develop a territorial branding based on mushrooms. The community developed strategic and innovative pro-grams and events that today make it one of the leader in mycotourism and mycological production in Spain. This passes through an organised system of picking permits and a data management system for the production and use. Data are communicated to the public through the website www.micocyl.es. The programme is active in about 950 municipalities, covering almost 47% of Castilla y León's area. For the gathering and sale of mush-rooms the Management Units (MU) were created, which are groups of places with common rules for the differ-ent picking permits, subjected to mycological regulatory bodies. For every MU, together with collection rules and information on picking permits, information such as the list of habitats, and an interactive map with mushrooms forecasts are daily shown. The model is based on sustainability: for every MU, the annual average production and the maximum number of collection permits is calculated. Figure 5.4.2 shows some of the information for one of the MU, Gredos (Ávila).

A quality brand, "Setas de Castilla y León", has been developed for the commercialization of mushrooms. This assures that mushrooms are of wild origin and come from the region, where both the management of forests and gathering are done under the criteria of sustainability. Moreover, the label assures that stringent requirements of quality are met. This label allows promoting companies that sell local mushrooms and the official website pro-vides a list of all the sale points.

The program includes the promotion of mycological guides, and the promotion of the local cuisine.:. A large network of food and beverage facilities benefits from the presence of people that are attracted to the territory, with over 5 000 restaurants.

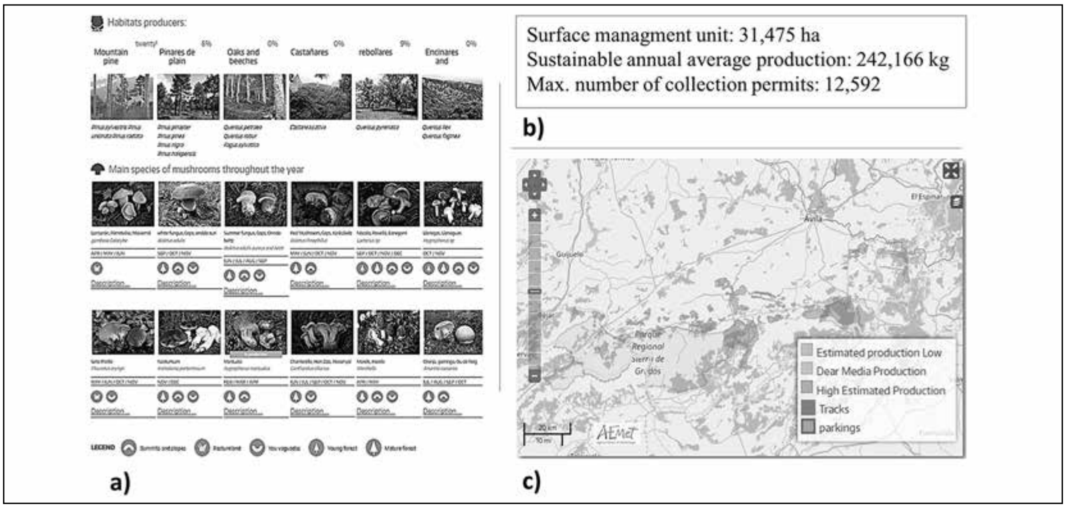

Figure 5.21: Information of the mushroom picking area of the Managment Unit of Gredos (Ávila) – a) list of habitats and the main species; b) information of sustainable rate of collec-tion; c) interactive map with information of mushrooms presence, daily updated (Source: da-ta from www.micocyl.es)

The Gastronomic Days of the Mushrooms, and the International Congress of Mycology (Soria Gastronomi-ca) are events that attracts leading figures from the Spanish and international culinary scene. The recently created Pinar Grande mycology park in Soria is a tourism resource that is part of the European Micosylva+ network.

Source: www.micocyl.es, Siglo Foundation for Tourism and the Arts in Castilla y León Junta de Castilla y León (2015)

a. Sustainable Forest Management certification

Responding to the global issue of forest degradation, forest certification was created at the beginning of the 1990s for encouraging sustainable forest management (SFM). Today more than 50 sustainable forest management certification standards exist, with national, regional or global scope. The two largest certification schemes are the Forest Stewardship Council (FSC) and the Programme for the Endorsement of the Forest Certification (PEFC). Both FSC and PEFC certificate NWFP (called "Non Timber Forest Products – NTFP" in the standards) with regards to the forest where NWFP grow and with regards to the value chain that NWFP undertake, i.e. from the forest to the sale point.

FSC was the first global forest certification programme to be established, in 1993, and discussions for incorporating NWFP into the standards began few years later. FSC developed a system in which every FSC endorsed organization, such as certification bodies, could create and implement its own NWFP standard, to be enclosed to the general standard, rather than basing on a unique, central standard. Each of these annexes includes specific requirements and ecological specifications such as the need to keep track of recruiting rates of reproductive individuals and death rates of the target specie (i.e. Brazil nut in Bolivia) (FSC 2001), or the maximum harvesting intensity per forest management unit (i.e. set at 35% of the mature bamboo in Colombia) (FSC 2006).

Chicle-gum from Mexico was the first FSC certified NWFP in June 1999. After that, several NWFP have been certified all around the world, like cork in Portugal, Spain, Oregon and Italy, maple syrup in USA, resin in Belarus and Spain, essential oils in Nepal and Brazil, venison in UK and mushrooms in Poland.

NEPCon, a FSC certification body, recently developed a NWFP annex applicable on a global scale for the evaluation of forest management enterprises that require certification of NWFP and where national or product specific NWFP standards have not been developed. This annex shall be used in conjunction with FSC accredited regional standards or NEPCon interim regional or national standards (NEPCon 2014). The annex indicates that population size of a species, structure of the population, harvesting rates, growth and regeneration rates have to be recorded and monitored through specific indicators for the different NWFP types such as plant exudates, vegetative structures (apical buds, bark, roots, leaves), reproductive structures (fruits, seeds) and for all the other NWFP categories.

b. Wild certification

The FairWild foundation developed a standard that targets the wild collection. This not only for assessing the wild origin of the product, but also for assuring that the collection is sustainably performed. The FairWild Foundation standard and certification system is based both on ecological and social aspects. The ecological part bases on the International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants. It defines guidelines and provides tools for harvesters, producers and other stakeholders for the creation of a sustainable resource management system based on the Good Agricultural and Collection Practices.

In this certification scheme, plants and fungi that grow naturally should be collected in a way that i) *plant populations do not decrease*, ii) *the species survive in the long-term*, iii) *their surroundings are not damaged*, iv) *no other plants or animals are disturbed*.

Probably because FairWild certification requires the endorsement of species on a case-by-case basis, at March 2017 a relatively few number (17) of species have been certified under FairWild (Table 5.14). Only 10 companies have applied for the FairWild certification (Fair Wild Foundations 2017)

Table 5.14 Fair Wild certified ingredients and species from which they derive (Source: FairWild Foundations (2017))

Scientific name	**Pharmacopoeial name**
Achillea millefolium	Millefolii herba (flower and leaf)
Adansonia digitata	Millefolii herba (roots and seeds)
Glycyrrhiza glabra	Liquiritiae radix (root)
Glycyrrhiza uralensis	Liquiritiae radix (root)
Juniperus communis	Juniperi pseudo-fructus (ripe cone berry)
Malus sylvestris	Mali sylvestris fructus (fruit)
Rosa canina *(R. rubiginosa / R. villosa)*	Rosae pseudo-fructus (receptacle and the remains of the dried sepals)
Rubus idaeus	Rubi idaei folium (leaf)
Rubus fruticosus	Rubi fruticosi folium (leaf)
Sambucus nigra	Sambuci flos (flower) Sambuci fructus (fruit)
Taraxacum officinale	Taraxaci officinalis radix (root)
Terminalia bellirica	Terminaliae belliricae fructus (fruit)
Terminalia chebula	Chebulae fructus (fruit)
Tilia cordata	Tiliae flos (flower) Tiliae folium (leaf)
Tilia platyphyllos	Tiliae flos (flower)
Tilia tomentosa (syn. *Tilia argentea*)	Tiliae flos (flower) Tiliae folium(leaf)
Urtica dioica	Urticae folium (leaf) Urticae radix (root)

c. Organic certification

Organic agriculture is "*a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved*" (IFOAM 2008).

Today, hundreds of organic standards and certifications programmes exist in the world. Most of the standards consider as organic both wild collected and semi-domesticated NWFP (such as chestnuts, hazelnuts, pine nuts, and certain berries). For the International Federation of Organic Agriculture Movements (IFOAM), the only international umbrella organization of the organic world, wild harvested products follow the principle and requirements presented in Table 5.15.

The EU organic framework (European Union 2007) considers wild collection an action for obtaining the organic certification as well. This occurs if: i) *the plants have grown naturally in natural areas, forests and agricultural areas*, ii) *in those areas have not, for a period of at least three years before the collection, received treatment with products other than those authorised for use in organic production* [...], and iii) *the collection does not affect the stability of the natural habitat or the maintenance of the species in the collection area.*

Organic certification does not specifically focus on forests, but rather concentrates on the quality of the land in which the product is sourced, like not contaminated areas.

According to Willer and Lernoud (2016), worldwide the wild collection area (including beekeeping) covers a considerable surface and it is increasing, reaching in 2014 a surface of 37.4 million ha. This corresponds to more the 85% of the total land that is classified as organic. Europe leads with a surface exceeding 16 Mha (Figure 5.22). The countries with the largest area are Finland (mainly berries), Zambia (beekeeping) and India. Medicinal and aromatic plants, apiculture, oil plants, berries, as well as shea nuts in Africa and Brazil nuts in Latin America cover the most important roles (Table 5.16).

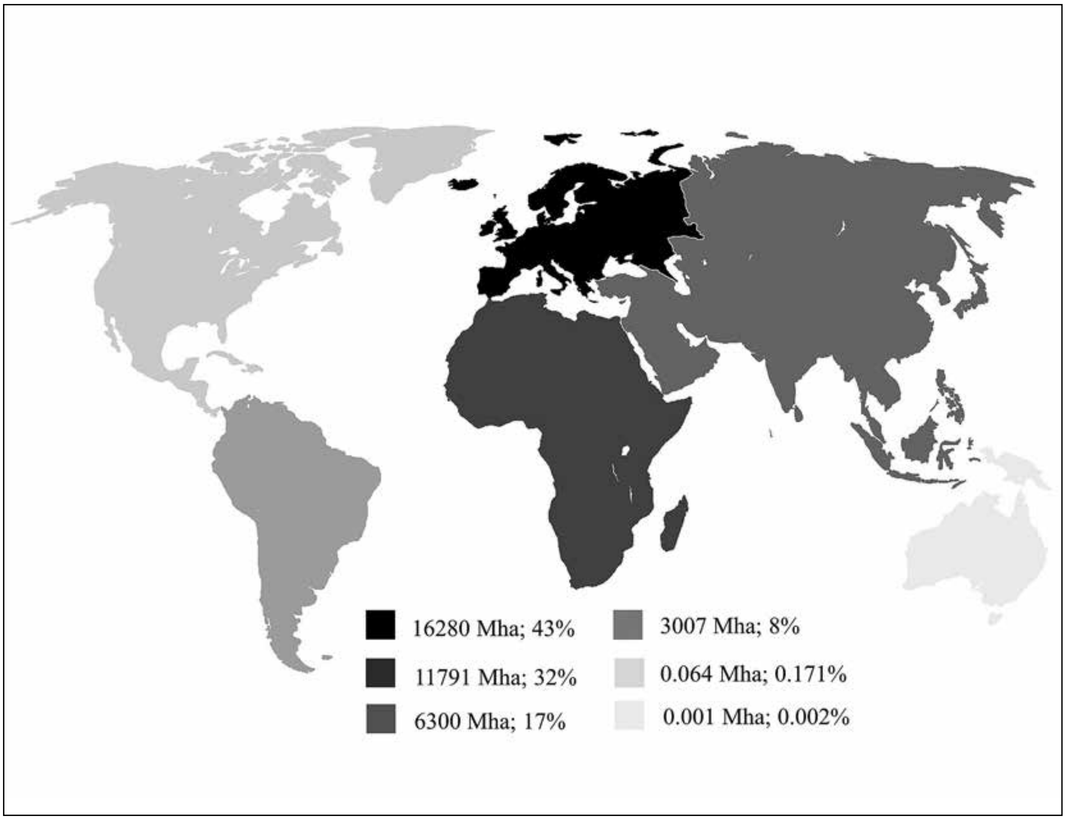

Figure 5.22: *Distribution of wild collection and beekeeping areas under organic schemes, per continent (Mha and percentage over the total area) – Source: data from Willer and Lernoud (2016)*

Table 5.15: Principles and requirements for wild harvested products being certified as organic according to IFOAM (Source: IFOAM (2014))

General principle	Organic management sustains and prevents degradation of common biotic and abiotic resources, including areas used for rangeland, fisheries, forests, and forage for bees, as well as neighbouring land, air and water
Requirements	Wild harvested products shall only be derived from a sustainable growing environment. Products shall not be harvested at a rate that exceeds the sustainable yield of the ecosystem, or threatens the existence of plant, fungal or animal species, including those not directly exploited
	Operators shall harvest products only from a clearly defined area where prohibited substances have not been applied
	The collection or harvest area shall be at an appropriate distance from conventional farming or other pollution sources in order to avoid contamination
	The operator who manages the harvesting or gathering of common resource products shall be familiar with the defined collecting or harvesting area, including the impacts of collectors not involved in the organic scheme
	Operators shall take measures to ensure that wild, sedentary aquatic species are collected only from areas where the water is not contaminated by substances prohibited in these standards

d. Environmental performance certification

Environmental performance certification aims at lowering the environmental impact of products, in a life cycle perspective. It does not specifically target NWFP, but still it can award NWFP that respect environmental performance criteria. "Ecolabels" are a sub-group of environmental labels, they are third party certified and respond to special criteria of comprehensiveness, independence and reliability (UNOPS 2009). The European Union Ecolabel[18] is an example of a regional ecolabelling scheme, coming from public initiative. EU Ecolabel has been applied to some NWFP, namely cork and cork products, such as coverings and panels.

18 Introduced by the Regulation (EC) No 880/92 and amended by Regulation (EC) No 1980/2000 and Regulation (EC) No 66/2010 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:co0012

Table 5.16: *Wild collection and beekeeping area in the world under organic schemes, per product (2014) – Source: adapted from Willer and Lernoud (2016)*

NWFP for which the land is used	Area (ha)
Beekeeping	6 707 330
Berries, wild	41 576
Forest honey	360 000
Fruits, wild	440 297
Medicinal and aromatic plant, wild	3 718 957
Mushrooms, wild	92 558
Nuts, wild	1 192 792
Oil plants, wild	1 416 229
Palm sugar	1 431
Palmito, wild	63 867
Rose hips, wild	60 028
Seaweed	200 032
Wild collection, no details	22 652 071
Wild collection, other	495 128
Total	**37 442 296**

e. Quality and food safety certification

Quality control and food safety certifications aim to assure that products that enter in the market are properly prepared, in compliance with legal requirements and with specific high quality parameters. The International Standard Organization (ISO) develops the most important standards in this sector. In particular ISO 9001 family addresses aspects of quality management and the ISO 22000 family addresses food safety management along the entire supply chain. Quality and food safety certifications do not directly target NWFP, and do not use a terminology neither for NWFP nor for wild collection; however, it can be applied on edible NWFP.

A special type of quality certification is based on the Good Agricultural and Collection Practices (GACP) guidelines, published by the World Health Organization (WHO). WHO developed these technical guidelines for sustainable harvesting of plants. This model can be adapted at national and regional level (WHO 2003). Similarly, to GACP, there are also certifications based on Good manufacturing practices guidelines for facilities, personnel and processing procedures for herbal medicines and wildcrafter guidelines (Shanley *et al.* 2008).

f. Certification of socio-economic aspects

Socio-economic certification refers to the schemes that have social and economic focus. One of these schemes is based on the Fairtrade standard. It aims at ensuring fair prices and empowering producers in the poorest countries of the world. Standards include requirements for environmentally friendly agricultural practices, such as safe use of agrochemicals, waste management, maintenance of soil fertility and water resources (Fairtrade Labelling Organizations International 2011).

The Fairtrade does not specifically target NWFP. However, several NWFP and products containing NWFP have been certified, such as herbs, herbal teas, spices, juices, honey. For each category of product, a specific standard was developed.

g. Origin, geographical indications and traditional specialties certification

Table 5.17: NWFP certified under the EU geographical indications and traditional specialties scheme in Italy

Name	Description	Category of product and N°	Product name
Protected Designation of Origin – PDO	Covers agricultural products and foodstuffs which are produced, processed and prepared in a given geographical area using recognised know-how	Honeys (3)	Miele Varesino, Miele delle Dolomiti Bellunesi, Miele della Lunigiana
		Chestnuts and chestnuts flour (5)	Marrone di Caprese Michelangelo, Marrone di San Zeno, Castagna di Vallerano, Farina di castagne della Lunigiana, Farina di Neccio della Garfagnana
		Pistachios (1)	Pistacchio Verde di Bronte
		Hazelnuts (1)	Nocciola Romana
Protected Geographical Indication – PGI	Covers agricultural products and foodstuffs closely linked to the geographical area. At least one of the stages of production, processing or preparation takes place in the area	Chestnuts (11)	Marroni del Monfenera, Marrone del Mugello, Marrone di Serino, Marrone di Combai, Marrone della Valle di Susa, Marrone di Roccadaspide, Castagna Cuneo, Castagna del Monte Amiata, Marrone del Mugello, Castagna di Montella, Marrone di Castel del Rio
		Hazelnuts (2)	Nocciola del Piemonte
			Nocciola di Giffoni
		Mushroom (1)	Fungo di Borgotaro
Traditional Speciality Guaranteed – TSG	Highlights traditional character, either in the composition or means of production	–	–

Notes: the listed products are both registered products and products candidates for registration. Products with a high degree of domestication, such as hazelnuts, were included as well. Source: European Union Door Database, accessed on 20.03.2017

Some standards and certification schemes apply to products with a recognizable traditional identity. In the EU, an example of such certification scheme comes from public initiative. According to the EU Regulation 509/2006, three EU schemes promote and protect names of quality agricultural products and foods: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Speciality Guaranteed (TSG) (EU 2006). This type of certification does not target in specific neither NWFP nor wild collection. However, there are several cases of NWFP labelled with this type of certification. Although the framework is common for all EU countries, some countries more than others use this type of scheme. For example, Italy totally counts a large number of registered (or under registration) products, 318. Of these, several are NWFP or products made with NWFP, as illustrated in Table 5.17.

h. Other certification schemes of interest for NWFP

In countries where genetically modified organisms (GMO) are produced and consumed, there are also discussions over their harmful potential. In North America operates the Non-GMO project, a non-profit organization committed at providing verified non-GMO choices. The Non-GMO label on a product indicates that the product is verified as containing less than 0.9% of GMO. Non-GMO certification does not specifically target NWFP, rather all the edible products. Products such as berries, herbs, spices and honey have been third-party verified by Non-GMO project.

Another certification that can be applied to some NWFP focuses on non-use of animal ingredients as in the case of the vegetarian and vegan certification, such as VegeCert, Vegan Action, and on animal testing, that mainly apply on cosmetics products.

5.6.3 A comparative analysis

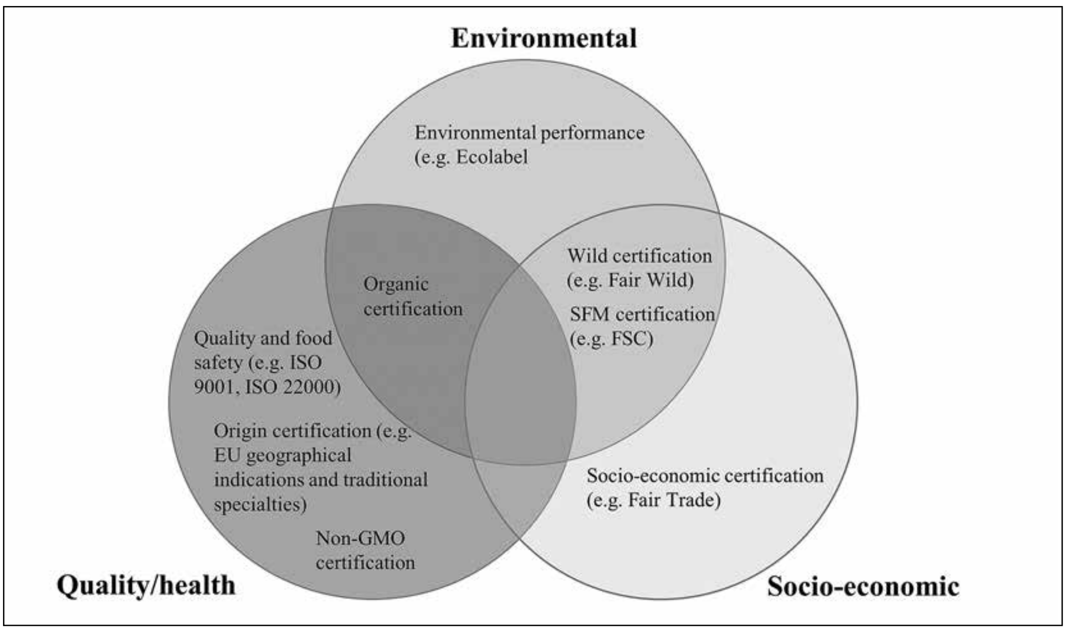

Figure 5.23: *Sustainability spheres to which NWFP certification schemes and standards belong to, according to their main scopes*

The illustrated standards and certifications schemes have different scopes, which can be comprised under the spheres of socio-economic, environmental sustainability and of assurance of quality and health benefits (Figure 5.23). They also target different segments of the value chain. The application of these certifications can provide numerous benefits, such as market visibility and premium price for economic actors, together with the benefits for consumers and society related to the specific objectives of the standards.

Only some certification schemes specifically target NWFP or wild collection. Indeed, most schemes only peripherally target NWFP, being applicable on a vast range of products. On the contrary, schemes such as sustainable forest management certification, wild certification and organic certification look at the harvesting stage of supply chain and also include ecological specifications for sustainable harvesting (detailed specifications in the cases of sustainable forest management certification and wild certification and only general specifications in the case of organic certification). Only in these cases, the economic actors give signals that the ecological impact of the NWFP harvesting is positive, or at least not negative. Table 5.6.5 summarizes the main scope of each certification type, whether each certification directly targets NWFP or wild collection, and the presence of ecological specifications in the standards.

5.6.4 Concluding considerations

The promotion of NWFP can pass through major business practices and market based instruments such as branding, standards and certification.

Many recent developments of NWFP markets, as in the cases of mushrooms, truffles, berries, chestnuts, foliage, aromatic and medicinal herbs are associated to “Lifestyles of Health and Sustainability” (LOHAS) consumers. In their purchasing policy, LOHAS consumers have ethical values associated to “clean” economic activities, often based on organic agro-forestry techniques, to healthy food and feed, to the need of re-discovering and protecting old local traditions. To describe such producers and consumers some authors are making reference to the idea of “innovative nostalgia” to define an economy that is trying to put together traditional products with new attributes of NWFP such as labelling systems based on rigorous standards, third-party certification systems associated to modern packaging, high level of information to consumers or web-marketing.

Table 5.18: Direct target to NWFP or wild collection and presence of ecological specifications, according to the certification schemes and standards

Certification type		Main scope	Specificity to NWFP or wild collection		Presence of ecological specifications for sustainable harvesting in the standard
			To NWFP	To wild collection	
SFM (in the FSC example)		Assessment of Sustainable Forest Management	Yes	-	Yes
Wild certification (in the Fair Wild example)		Assessment of sustainable wild harvesting	-	Yes	Yes
Organic (in most of the standards)		Insurance of organic production (e.g. no use of pesticides, not contaminated areas)	-	Yes	Only general specifications
Environmental performance	In the EU Ecolabel example	Assessment of low environmental impact	No		No
Quality and food safety	In the ISO example	Assessment of quality of the products	No		No
	In the WHO GAPC example	Assurance of use of good agricultural and harvesting technical guidelines	No (but some NWFP)		General specifications
Fair Trade		Assurance of fair prices and empowerment of producers	No (but some NWFP)		No
Origin, geographical indications and traditional specialties	In the EU example	Assessment of the origin and the traditional know-how	No		No
Non-GMO		Assurance that the product contains less than 0,9% of GMO	No		No
Vegan		Assurance that the product does not contain animal ingredients	No		No

Among the certification schemes, only some specifically target NWFP and/or wild collection, aiming at providing value to these wild and semi-wild products. Among the assessed standards only two, sustainable forest management and wild certification, include detailed ecological specifications for sustainable harvesting, while organic certification includes general specifications (Table 5.18).

By the assessment of the standards, an element clearly emerges: the terms Non-Wood Forest Products/Non-Timber Forest Products are exclusively used by forest standards. The other certification schemes and the market in general do not adopt it, showing a preference for the term "wild". Therefore, for promoting these products coming from forest it could be more beneficial.

Branding and certification of NWFP towards sustainability, special quality, and specific origin are a major instrument not only to differentiate against industrial mass products; they are essential tools also for tracing products. This can help in providing more transparency along the supply chain through the use of high quality standards and independent systems of control, supporting NWFP harvesting and exploitation done in a legal manner. It would ensure healthy employment conditions of the people involved in all the processes while respecting traditional use rights of local populations.

5.7 Wild game meat markets: the wild boar case in Italy and Romania from a value chain perspective

In European countries, game is one of the most important non-timber resource derived from forests. According to FAO figures[19] (2012) game meat consumption in Europe accounts for 131 million tons (metric), the wild boar being one of the most important ungulate species for hunting activities. With respect to consumers' behaviour, a recent investigation (Ghione *et al.* 2013) shows that almost 50% of European respondents occasionally eat game meat.

On the other hand, nowadays the growing interests in wild fauna preservation and a widespread ecological sensibility tend to relegate hunting activities to a marginal position, despite the fact that hunting has been a traditional activity in many countries.

At the European level, a scattered picture emerges regarding hunting activities, figures, and legal aspects related to wild game meat consumption, but other aspects emerge as shown by the increasing flow of foreign hunters that move attracted by the species' diversity, the hunting sites' wilderness, and the somewhat weaker legal restrictions. According to ENALCACCIA[20], Croatia and Scotland host, yearly, 60% and respectively 20% of the hunting tourists, followed by Romania while the Italian hunting tourism accounts for a total of approx. 30,000 people per year.

In many European Countries, the wild boar numbers have been increasing consistently during past decades (Feichtner 1998, Klein *et al.* 2007, Milner *et al.* 2006, Saez-Royuela and Telleria 1986, Toigo *et al.* 2008, Carnevali *et al.* 2009) somewhere up to the occurrence of overabundance, causing conflict between wild fauna and human activities (Côté *et al.* 2004). A similar trend is recorded

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19 Report from the commission to the European Parliament and the Council regarding the mandatory indication of the country of origin or place of provenance for milk, milk used as an ingredient in dairy products and types of meat other than beef, swine, sheep, goat and poultry meat, 2015.

20 National association of hunting, fishing and shooting sport activities: http://www.enalcaccianazionale.it/index.php?option=com_content&view=article&id=99:a-caccia-nel-mondo&catid=18:caccia-allestero&Itemid=52

for wild large herbivores and their adverse effects on forests and agriculture (Schultze *et al.* 2014)

The implications of wild game overpopulation are manifold: i) the sanitary risk of an increase in diseases, which is proportional to the number of heads, ii) the potential quality depletion of meat for human consumption[21], ii) the depletion of forests as result of browsing damages to young trees and bark peeling , iv) an increase of the wild predator attacks against backyard breedings, v) the intensification of conflicts with agricultural activities as a result of the increased occurrence of damages to cultivations/breeding, which result in an increased compensation budget to be allocated by local public authorities, vi) an increased risk for ordinary citizens' lives due to the unintentional contacts between humans and wild animals (car accidents, attacks, etc.) (Primi *et al.* 2009) vii) a threat to the conservation of biological diversity (Giménez-Anaya *et al.* 2008), viii) the formation of so-called refuge areas (Amici *et al.* 2012b).

Damages to agriculture, livestock and other economic activities catch the farmers' attention and that of the local communities (Schon 2013, Thurfjell *et al.* 2009, Morelle and Lejeune 2015, Schley and Roper 2003, Schley *et al.* 2008) which are asked to reimburse a greater amount of money year after year. Damages are intensifying due to the increase in the number of heads and the process of rural decline, in addition the resources devoted to compensating cultivated crops are being decreased. Therefore, more and more fields (marginal areas often are severely damaged by wild fauna) are left uncultivated, allowing a deeper penetration of the wild animals in the cultivated fields (Calenge *et al.* 2004). It is worthwhile to mention the case of protected areas where management rules don't allow hunting activities, letting wild species to grow uncontrolled (Tomei 2014): field crops, orchards as well as livestock fodder are an excellent food source easily available to wild fauna whilst farmers have poor chances of an effective defensive strategy[22].

Therefore, an increase in hunting permits is often advocated. In this case, an increased amount of meat made available is likely to occur as well as an increased presence on the market of raw products, by-products and ready to consume products. From an economic point of view, however, literature does not provide any information regarding the value created by the game meat consumption chain. While in the past game meat was traditionally consumed by hunters and their families, nowadays it is available also for consumers far from the forest activities and often even far from the rural life too. Therefore, game meat is offered along the food chain (typical meals, restaurants, cured meats, etc.) arising relevant questions related to its quality and economic impact. At

21 The risk of zoonoses associated with consumption of wild ungulate meats cannot be excluded but generally is considered as being low, especially if compared with that from other game species (Ramanzin *et al.* 2010)

22 Because of the legislation on natural protected areas the hunting activities are banned (national and regional parks, etc.).

this moment, little is known on the share of the meat consumption between official and informal markets.

5.7.1 Methods for the value chain analysis of the meat markets

In order to better clarify the value chain linked to the introduction of game products in the food market, a tailor-made empirical investigation was carried out in two different countries: Italy and Romania. The first with severe problems caused by the overabundance of wild boar, the second being characterized by a higher level of heads harvested. The study addressed the wild boar (*Sus scrofa*) as this is the greatest source of meat for human consumption in several countries, outlining the framework in which the product is made available to different consumers.

In order to identify the structure of the value chain for wild boar meat market, the empirical investigation has been carried out, at two levels: i) at the level of the hunting administrators/hunting groups and ii) at the level of restaurants.

With respect to hunting administrators and hunting groups, the data collection relies on interviews providing information on i) the number of heads harvested and the number of heads sold to internal and external members of associations, ii) the profile of the external buyers and the existence of contractual agreements with restaurants, hotels; iii) the meat's selling price; and iv) the existence of facilities to process and freeze the wild boar meat.

For the Romanian case, the interviews have been conducted by phone in June 2015 and all the managers of the 18 hunting association from Suceava Department have been approached. Out of these, 14 managers have provided answers to the questions, thus, a rate of response of 77% has been assured. The rest have considered that the information asked in the questionnaire are confidential. The Italian case study was carried out in a similar way, eight groups of hunters, operating in different areas of Central Italy were approached.

In order to identify the presence of the wild boar meat in restaurants, a sample has been compiled based on the answers from hunters and on desktop internet research. In the restaurant sample, prices of courses based on wild boar meat were recorded.

5.7.2 Meat consumption and chain value: the Italian case study

In Italy, wild boar is the most important species of ungulate with respect to hunting activities, in terms of number of heads hunted as well as meat available for human consumption (Ramanzin *et al.* 2010).

Statistics of the phenomenon are difficult to collect, first of all because of the administrative organization of hunting activities, that are managed by local public authorities that allocate the allowed areas and the hunting season.

Wild boar hunting is mainly organized on a collective basis. Hunters are organized in groups with or without dogs and they are supposed to report to local authorities the number of heads that have been shot at the end of each hunting season. This makes it difficult to aggregate information, and often hunter groups make a strategic use of the reports to local authorities (with a clear free rider behaviour) to be allowed to shoot year after year a higher number of heads. Also selective culling is sometimes adopted, both for hunting and containment programs, but this is mainly in the north of Italy and northern Apennines.

In Italy, the only publicly available data are provided by Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) in the so-called BDU (*Banca Dati Ungulati*) which is edited every few years (Carnevali *et al.* 2009, Pedrotti *et al.* 2001). Nonetheless, this data is not regularly updated and the number of boars is often largely underestimated. Data are expressed on the basis of four macro-regions as proposed by ISPRA: 1) Eastern Alps: Trentino-Alto Adige, Veneto, Friuli Venezia Giulia; 2) Western Alps: Piedmont, Val d'Aosta, Lombardy; 3) Northern Apennines: Liguria, Emilia Romagna, Toscana, Marche, Umbria; 4) Southern Apennines and Islands: Abruzzo, Molise, Lazio, Campania, Puglia, Basilicata, Calabria, Sicily, Sardine.

The existing studies show that game meat is often consumed by hunters and their families (Danieli *et al.* 2012) without the standard vet inspection to certify the sanitary conditions of the animal, required by ordinary procedures for other sources of meat used for human consumption (Ramanzin *et al.* 2010).

This implies difficulties in assessing the quality and hygienic safety of game meat along the food chain up to the final consumers. The legal framework allows self-consumption and the sale by hunters to the final consumer of a limited amount of meat (with respect to wild boar each hunter is allowed to sell 1 head x (person x season)-1) being requested the sole respect of the Reg. (CE) 178/2002. This Regulation imposes the animal inspection by a trained person able to assess abnormal behaviour in the live animal, pathological changes caused by diseases, environmental contamination and other factors which can affect the consumers' health (Ramanzin *et al.* 2010).

When exceeding the mentioned quantities, hunters and management authorities are responsible for meat safety and traceability according to standard EU regulations for meat slaughtering and sale which imply vet inspection and chemical analyses, if necessary.

Unfortunately, the threshold is often trespassed by hunters who hide the real amount thanks to the difficulty for control authorities to assess the amount traded due to the absence of fiscal and sanitary documents. Accordingly, a consistent amount of meat is estimated to be sold to restaurants or consumers without a proper safety risk assessment (vet. inspection). For this purpose, the Toscana Region provided guidelines to sell directly to the consumer the game meat acquired in that region.

The phenomenon pushed in the last couple of years has been for the tax policy authorities to sanction restaurants that were unable to show fiscal and sanitary documents certifying the origin of hunted meat offered to clients. A supply chain for game meat is provided by a very limited number of large slaughtering plants in Italy, therefore a dedicated slaughterhouses net is experimentally provided by Pistoia Province.

The amount of wild game meat available for Italian consumers is very difficult to estimate. A raw approximation is possible if we consider the reported data (ungulates) and some data from import (ISTAT). Despite the absence of official data, Italian estimates during the 2009/2010 hunting season, instead, reveal figures for each single species that show a total amount of wild boars harvested in Italy of 153,594 heads (Table 5.7.1), corresponding to 5,222 t of meat[23]. That amount accounts for around 0.7% of the Italian total consumption of pork meat[24]. This figure concerning ungulates is incomplete because data collection from local authorities is partial and poaching is not measurable (Riga 2015 pers. com.).

Table 5.19 Wild boar harvested in 2010 in Italy, expressed as number of heads and carcasses (metric tons). The value “0” indicate that the species is non-present or not harvested in the Region (ISPRA 2015 – unpublished data from BDU).

Area*	Heads	Carcass (tons)
Eastern Alps	3865	131.4
Western Alps	23386	795.1
Northern Apennines	121397	4127.5
Southern Apennines Islands	4946	168.2
Overall	153594	5222.2

** assuming an average carcass weight of 34 kg for wild boar (Ramanzin et al. 2010).*

Evidence shows that buyers are divided into two groups: end users and restaurants, while the products traded are non processed meat and cured meats (Figure 5.24). The latter is sold mainly to end users.

Hunters sell to restaurants unprocessed meat parts, generally hindquarters or half carcasses at an average price of 3-5 €/kg. The same portions are sold to the end users at a higher price, on average 10-20 €/kg. Higher prices depend on the cutting level and the piece (shoulder, back, round, etc.). Cured meat – with a different range of ageing – shows a price with a high variability depending on the specific product (sausages, ham, salami, dried/in oil products, etc.).

These products are mainly sold to end users due to “home-made” processing with neither control by official inspection nor hygienic authorization regarding sanitary requirements in terms of workrooms, workers and processes. Therefore, these products do not have legal access to the ordinary food market chain

23 The average carcass weight of wild boar is estimated by the authors to be 34 kg.

24 In the same period pork meat consumption accounted for 1.834 million metric tons: 730,000 t of fresh meat and 1,103,000 t of pork cured meat, respectively 12.6 and 19.1 kg/person.

and are sold on a sort of black market directly to end users, word-of-mouth style. Prices vary in a range of 30-80 €/kg.

Restaurants buy wild boar meat during the hunting season, and then cut and store the meat in freezers to have the raw material available for cooking all year round. Any kind of contract, either oral or written has been recorded due to the difficulties to forecast the number of heads and the pertaining available meat amount to be sold.

Seasonality is due to administrative time restrictions of gaming activities, and given the unlikelihood for hunters to use adequate refrigerating rooms the sale of the meat takes place within a limited time after the shooting,

In regards of wild boar meat courses the prices at which they are offered in restaurants vary widely. Data processing of course prices[25] has led to an interval stretched between 45 and 125 €/kg. Price variability obviously reflects also the restaurant's exclusiveness (market positioning) and service quality level.

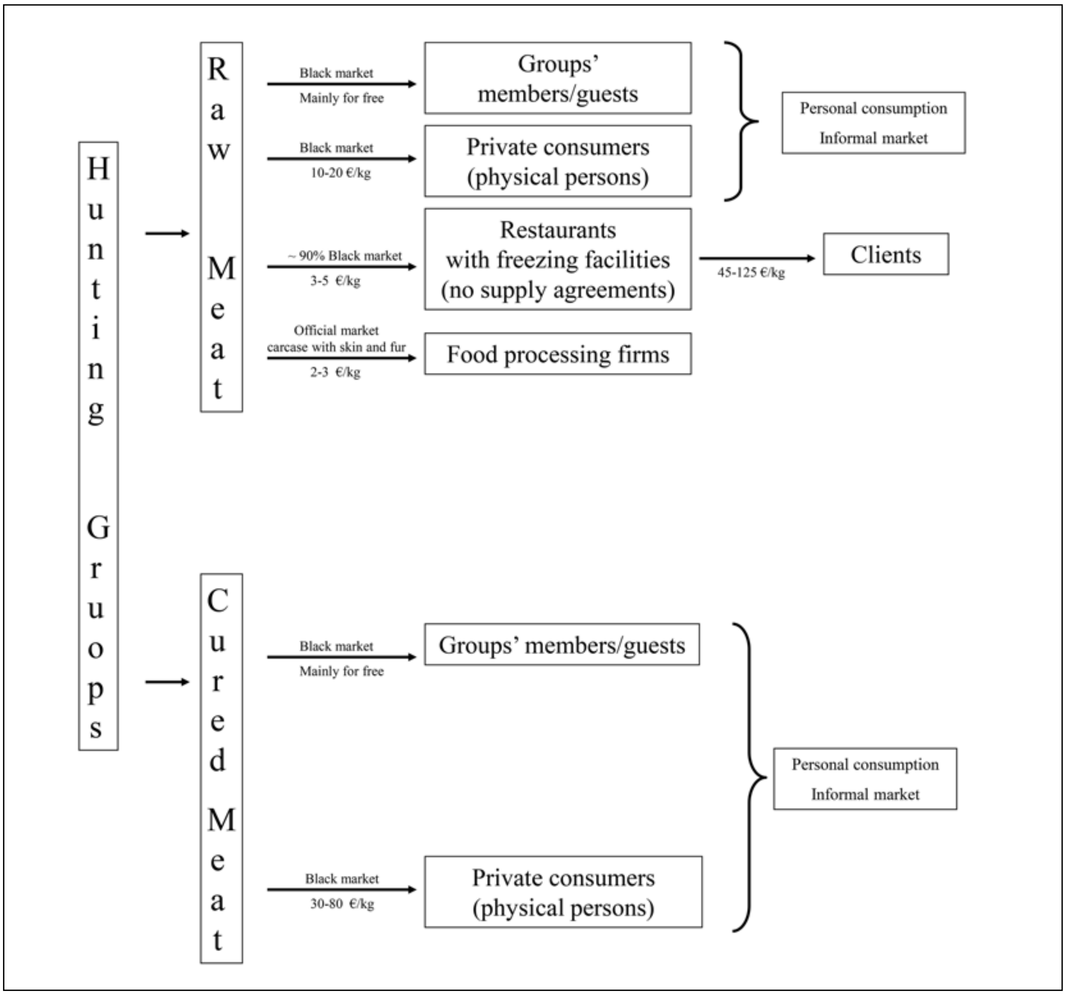

Figure 5.24 *The structure of the supply for the wild boar venison in Central Italy*

25 The figures are obtained on a basis of 2/3 of the course cost to be accounted by fixed costs (e.g. labour, amortisation and management of structures) and a proportion of 2/3 of wild boar meat and 1/3 of other ingredients (in value).

5.7.3 Meat consumption and chain value: the Romanian case study

Hunting has been a traditional activity in Romania and has increased in importance during the communist times. Therefore, hunting activities have been well organized and heavily controlled. At the European level Romania is known as an important hunting resource, especially for large carnivores, and holds some records in hunting trophies. Nowadays hunting activities are also important especially because of foreign hunters attracted by the species diversity and the vast wilderness they can still find in the Carpathian Mountains. The hunting activities have also grown in importance among rich Romanian citizens, this being perceived as a recognition of their social status.

Among different sites, Suceava County (north-east) is one of the most popular for hunting activities. It covers 855 thousand hectares (4% of the Romanian territory) and has various landforms, from mountains (55%) to hilly regions (30%) and plains (15%). The hunting area is divided in 71 hunting ranges (with an average area of 10000 ha/range), the hunting range being the physical level at which the hunting activities are administrated.

According to the Romanian Hunting Law (407/2006) the hunting ranges can be managed by "consecrated hunting associations" (existing during the communist times) or by newly created forest associations. Part of the hunting ranges are offered to the consecrated associations without an auction process while the rest are offered in administration to private associations based on an auction process granting rights for a 10 years administration contract. For the Suceava region, previous to 2011 the management of the hunting ranges was assured only by 5 hunting associations – Hunters and Sport Fishermen County Association (AJVPS), National Forest Administration (NFA), the University, the Forestry High School and only one private hunting association. With the auction taking place in 2011 the structure of the hunting administration has changed and currently there are 18 hunting associations, 15 of these being private. The National Forest Administration has 24 hunting ranges (34%), AJVPS has 23 hunting ranges (23%) and the University together with the Forestry High School have 5 hunting grounds.

The public agency named Forestry and Hunting Guard (GF) is in charge with annual authorization of the quota. GF also monitors that the hunting season deadlines are respected. Hunting associations have to have specialized rangers that will assure the protection of the wild game inside the hunting ranges against poachers and to carry investments in order to assure the wild animals don't lack food, especially in the winter.

The wild boar is one of the main hunted species in the region even though large carnivores (bears, wolves) and the red deer are more important in terms of trophy. Considering the productive characteristics of the hunting ranges it is considered that the wild boar population has a density of 5 heads / 1000 hectares. At the level the wild boar population in 2015 was estimated at 3450 heads, an increase of 3% compared with 2014 (Ministry of Environment 2015). The optimum density for wild boar at the level of Suceava Department is established at 1937 heads so it is considered that the current population is 57% higher than the optimum one.

According to the statistical data provided by the Ministry of Environment for the 2014-2015 hunting season, a number of 519 heads were extracted in Suceava County, representing 15% of the population evaluated in 2014. Out of these, 471 heads (90%) were hunted by the hunting associations responding to the questionnaire.

In 11 hunting associations out of the 14 interviewed, the wild boar meat is sold entirely to the members of the association and to the guests taking part at the hunt (Figure 5.25). None of these 11 associations have contracts with restaurants or with external buyers. The main argument provided is that it is simpler to sell to their members as they accept the price and there is no need to have special facilities to assure the selling to the restaurants.

In the other 3 hunting associations the situation is almost similar, 95% of the heads being sold to their members. Two of these associations (NFA and AJVPS) represent the consecrated hunting administrators and therefore they have better facilities and more contacts. The National Forest Administration has built a freezing facility where the wild boar meat from their 24 hunting ranges is stored in order to be sold. Each season about 6 metric tons of wild boar meat is stored and sold. The manager of the facility has declared that the buyers are people and that they have no commercial contracts with restaurants. AJVPS has no clear strategy as to assure the selling of the meat outside their associations. They have informal contracts with guesthouses and restaurants which sometime buy wild boars but the total share is up to 5%. The managers of the hunting range belonging to the University from Iasi sells 5-10% of what they harvest to a group of firms.

None of the 14 interviewed managers of the hunting associations has mentioned the existence of a commercial contract with a restaurant or other commercial buyers.

In all cases the hunted wild boards are eviscerated directly on the field by the hunting rangers which have to have special skills and an authorization from the Health Department. Samples of blood and meat are taken and send to the laboratory to test the meat for pests and trichinella and the buyers have to wait the results before consuming the meat.

Except the NFA, which can store 6 metric tons in their freezing facilities, the rest of the hunting associations have none or smaller freezing capacities and generally they do not store the meat for longer than 1-2 days (until the results from the laboratory arrive).

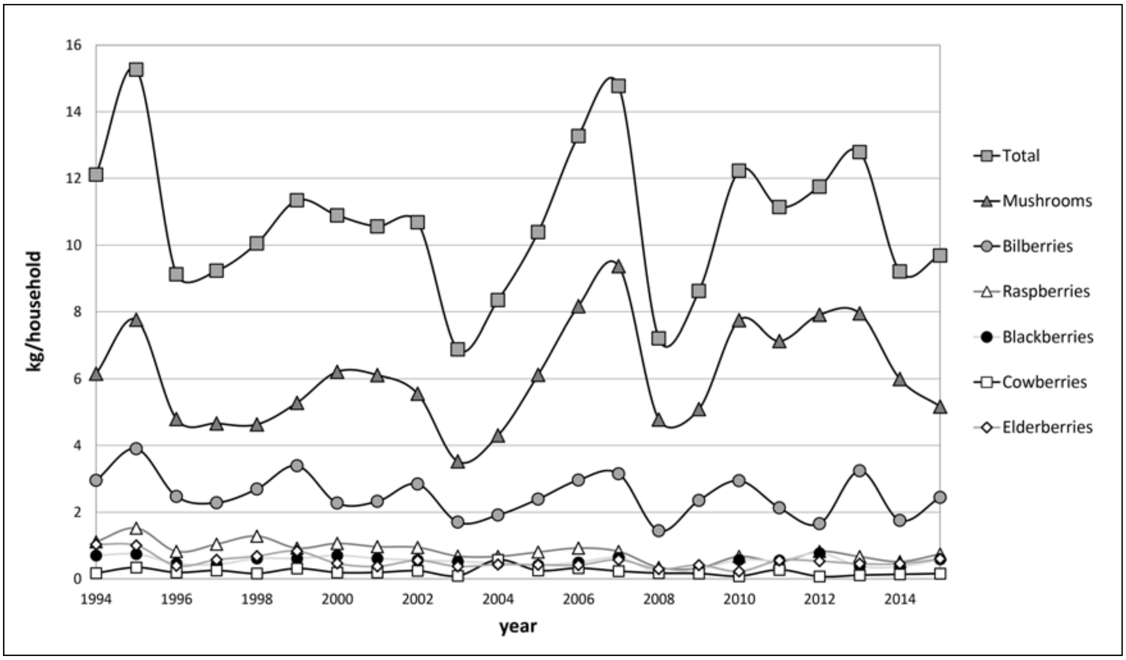

Figure 5.25: *The structure of the supply for the wild boar venison in Suceava Department*

Regarding the selling price, the study has identified three pricing policies:

(1) Selling the entire piece at a flat price of 800-1000 lei (180-230 €/piece) especially for wild boar specimens which are older than 3 years or are also valuable for the trophy. Some private associations can increase this price with 50-100% for members from outside the association;
(2) Selling the meat at a rate of 10 lei/kg (2.3 €/kg) after the animal has been eviscerated, practiced especially for younger wild boar individuals;
(3) Free for the members of the associations – four private associations have stated that the members which pay their membership fees can get the meat free of charge based on an internal agreement.

From the list of courses identified in the five restaurants and the discussions with the owners the following structured of price has been derived:

- Raw meat: wild boar loin and shoulders (boneless) – 47-53 lei/kg (11-12 €/kg) and wild boar tenderloin 70 lei/kg (16 €/kg);
- Processed meat: Salami 32 lei/kg (7.2 €/Kg), Homemade sausage 61 lei/kg (14 €/kg) and Smoked jerky 94 lei/kg (21 €/kg).

5.7.4 Wild game meat market is largely informal

The official side of the distribution of game meat traditionally did not receive much attention, being a limited amount with respect to the total of meat consumption. In addition, the presence of game meat along the food chain has always been considered similar to self-consumption (referred to hunters and their families) from a sanitary and food safety perspective.

However, it is not infrequent to find typical restaurants, in many European countries, that offer courses supposedly made from wild boar meat, despite the fact that wild boar breeding farms are very limited in number and it is hard to believe that they can account for the total demand disclosed by restaurants.

This is acknowledged by recent changes in labelling regulation that focuses the attention of the public authorities on food safety and traceability in order to comply with EU regulations. These pose a great attention to consumers' health protection from food hazards, to prevent any health problem derived from allergy and intolerance to specific ingredients, and the transmission of diseases from meat consumption. Those rules, however, apply mainly for breeding farms and the meat chain does not appear to be easily controlled in the hunting sector due to its fuzzy nature and specific administrative norms.

An exact figure of wild boar harvesting in Europe is not available, although some attempts to estimate wild animals as source of food for humans are mentionable (NWFP COST action 1203 – http://www.NWFP.eu/). Depending on the institutional context, figures on wild species hunted may be difficult to find, first of all because they are based on self-statements by local hunter groups, and monitoring activities are principally devoted to the definition of wild species' populations and their sustainability in the environment, the official economic aspect being neglected.

In the presented case studies, both countries, despite having a long tradition in wild boar hunting, seem to evidence a non-structured chain for the use of game meat.

The main constraint to a structured market in Italy refers to the legal framework that obligates a sanitary inspection of the carcass. This implies the presence of structures and skilled personnel (veterinarians, butchers, etc.). The present organization of the supply chain allows the fitting of the regulation only for large slaughterhouses receiving a high number of animals (game farms, etc.). An interesting attempt to face the problem of structure was performed by the Toscana Region and Pistoia province, which financed a network of wild ungulates mini-slaughterhouses to carry out pre-inspection procedures. The absence of sanitary rules compliant procedures and refrigerating facilities imply that the majority of the meat consumed is traded in informal markets.

A similar picture emerges in Romania, despite somewhere the presence of special infrastructure could facilitate the official meat provision to restaurants. The sole presence of the equipment, however, doesn't allow the development of a structured market, the formal supply agreements and contracts between hunters and restaurants being neglected. This could potentially increase the hunters' profit due to the restaurants' preference for a stable meat supply in all seasons.

At European level available figures show average prices (referred to the whole set of hunted species in western regions[26] – Forest Europe 2011) spread in a range between 5.15 and 56.66 €/kg[27]. Given the described character of the meat consumption market, limited to a narrow local market, in which a few actors operate and interact often in informal ways, the official price ranges often reflect the market power of the actors and the information's asymmetry.

5.8 Conclusions

As mentioned in Wolfslehner *et al.* (2016), NWFP "*can help to bring about the necessary shift to a sustainable, smart and inclusive bio-based economy, a bioeconomy. They cover both the dimension of natural resources and materials, as well as being strongly connoted to the provision of ecosystem services, conservation, issues, traditional knowledge, cultural values, and the complex of drivers in the context of rural development*". In the past NWFP were a matter of concern and policy action mainly in developing countries, while in the last decades forest policy in Europe has also highlighted the importance of NWFP as a component of the total value of forests: Resolutions approved under the Forest Europe Ministerial Conferences in Helsinki (H1 and H2) and the Lisbon (L1 and L2) stated that the promotion of use of NWFP and services are an integral part of socio-economic aspects of sustainable forest management (Glück 2000, Pettenella *et al.* 2006, Cai *et al.* 2011, Steele *et al.* 2015). Any national policy framework in Europe should therefore enable the sustainable use of NWFP (Buttoud 2000, Vuletić *et al.* 2011, Riera *et al.* 2012, Živojinović *et al.* 2017).

As a matter of fact, we have demonstrated (chapter 5.3) that, starting from Eastern Europe, in many rural areas NWFP can contribute to the livelihoods of local communities (Marshall *et al.* 2003, Ahenkan and Boon 2010), with special regards in those marginal and remote areas where no many alternatives in agriculture and tourism are available (Saxena 2003).

NWFP can not only support household food security and nutrition (Clark and Sunderland 2004) but also generate additional employment and income (Andel 2000, Marshall *et al.* 2005) and provide opportunities for NWFP-based enterprises (Shackleton and Shackleton 2004). Moreover, an increased NWFP European supply can contribute to reduce the dependence for imports (Andel 2000, Shiva and Verma 2002), a growing trend for many NTWP consumed in Europe (chapter 5.4).

NWFP can be harvested with relatively little impact on the forest environment (Neumann and Hirsch 2000), but the growing demand for some NWFP is creating problems of scarcity in some European countries; this problem should be solved through information, education, licencing and new property right regulations (chapters 5.2 and 5.7). Legislation regulating NWFP needs therefore

26 Central-West Europe and South-West Europe.

27 The average price for the aggregate meat obtained from hunting activities in Europe 27 (Russia excluded) is 3.75 euro/kg.

some revision as the existing regulations in many European countries are not always able to find the right balance between the rights of the land owners, the need to create a physical basis for the development of professional harvesting activities and the related NWFP-based enterprises, and the demand (and rights) of public access to forest resources, with the connected positive economic impacts of tourism. Moreover, the marketing and processing of many NWFP have to be legislatively regulated in line with the general rules related to food, medicinal, cosmetic products.

Most of the European consumers of NWFP have high standard of life and relatively high willingness for pay for natural, safe and healthy products. Considering this demand characteristics, NWFP have the potential to be branded and marketed as environmentally friendly products, healthy foods, and also as traditional products that can help in sustaining local rural development (chapter 5.6).

A relevant innovative aspect connected to the recent development of NWFP market in Europe is connected to the use of some products to differentiate and promote local economies (chapter 5.5), to link external consumers (tourists and other buyers of local products and services) to the local economies: many NWFP are used as imago products ("*genius loci*") in territorial marketing initiatives for branding a specific (a valley, a group of villages, …) and networking its local actors (the "blueberry valley", the "chestnut trial", the "Boletus roads"). These types of value chains are fruitfully developed mainly in Mediterranean regions and can be considered one of the few important options to keep these regions socially alive, maintaining the full basket of environmental services associated to forests.

Several studies show that opportunities exist to promote NWFP collection, trade and use through certification (chapter 5.6). Today in the market several certification schemes and standards applicable to NWFP exist. Some of them are applicable to a general range of products, some others more specifically target NWFP. Only a few of these certification schemes include detailed ecological specifications for sustainable harvesting. Being the entire NWFP supply chain indissolubly connected to the availability of raw material, these specifications are of particular importance. Branding and certification do not only represent innovative tools to differentiate NWFP from industrial mass products, but they are also important instruments for tracing products. Tracing products and consumption patterns are important to understand the organization of the value chains, to protect consumers, to create a fair fiscal system for all the actors in the value chain and, at the end, to support the supply of healthy and valuable products.

In conclusion, the above-mentioned the European NWFP economy has many elements of interest and call for further research into the socio-economic aspects of NWFP production, harvesting, processing and consumption.

5.9 References

Ahenkan, A., Boon, E., 2010. Non-Timber Forest Products (NTFPs): Clearing the Confusion in Semantics. Journal of Human Ecology, 331, 1-9.

Amici, A., Serrani, F., Rossi, C.M., Primi, R., 2012. Increase in crop damage caused by wild boar (Sus scrofa L.): the "refuge effect". Agronomy for Sustainable Development, 32,683–692.

Andel, T.R. van, 2000. Non-Timber Forest Products of the North-West District of Guyana Part II, A Field Guide. Tropenbos-Guyana Series 8,12-81

Anholt, S., 2004. Branding places and nations. In: Clinton, R., Simmons, J., Ahmed, S. (eds.). Brands and Brandind, 2nd ed, Bloomberg Press. Princeton, NJ, USA, 213-226.

Asheim, B.T. (1998): Territoriality and Economics: on the Substantial Contribution of Economic Geography. Economic Geography in Transition. The Swedish Geographical Yearbook 74. O. Jonsson and L.-O. Olander. Lund.

Bass, T., Markopoulos, R., Grah, G., 2001. Certification's impacts on forests, stakeholders and supply chain instruments for sustainable private sector. Forestry Series, International Institute for Environment and Development, London, UK.

Böcher, M. (2008). "Regional Governance and Rural Development in Germany: The Implementation of LEADER+." Sociologia Ruralis 48(4): 372-388.

Boter, H., Lundström, A. 2005. SME perspectives on business support services: The role of company size, industry and location. Journal of Small Business and Enterprise Development 12(2), 244 – 258, http://dx.doi.org/10.1108/14626000510594638

Burgener, M., Walter, S., 2007. Trade measures – tools to promote the sustainable use of NWFP? An assessment of trade related instruments influencing the international trade in Non-Wood Forest Products and associated management and livelihood strategies. Non-Wood Forest Products Working Document (6), FAO, Rome, Italy.

Buttoud G., Kouplevatskaya-Buttoud, I., Slee, B., Weiss G., 2011. Barriers to institutional learning and innovations in the forest sector in Europe: Markets, policies and stakeholders. Forest Policy and Economics 13, 124–131.

Buttoud, G., 2000. How Can Policy Take into Consideration the "Full Value" of Forests? Land Use Policy, 17, 169-175

Cai, M., Pettenella, D., Vidale, E., 2011. Income Generation from Wild Mushrooms in Marginal Rural Areas. Forest Policy and Economics 13 (3), 221-226.

Calenge, C., Maillard, D., Fournier, P., Fouque, C., 2004. Efficiency of spreading maize in the garrigues to reduce wild boar (Sus scrofa) damage to Mediterranean vineyards. European Journal of Wildlife Resources, 50, 112–120.

Carayannis, E. G., Campbell, D.F.J. 2009. 'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem. International Journal of Technology Management, 46(3), 201-234.

Carnevali, L., Pedrotti, L., Riga, F., Toso, S., 2009. Banca Dati Ungulati: Status, distribuzione, consistenza, gestione e prelievo venatorio delle popolazioni di Ungulati in Italia. Rapporto 2001-2005. Biologia e Conservazione della Fauna, 117,1-168.

Clark, L.E., Sunderland, T.C.H., 2004. The Key Non-Timber Forest Products of Central Africa. State of the Knowledge. USAID Office of Sustainable Development, Bureau for Africa, Washington D.C., Technical Paper (122).

Côté, S.D., Rooney, T.P., Tremblay, J-P., Dussault, C., Waller, D.M., 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution, and Systematics 35, 113–47.

Da Re, E., Vidale, E., Corradini, G., Pettenella, D., 2016. Rural development and SME: the bridge between natural capital and NWFP economy. Project deliverable D3.4. StarTree project (EU project 311919). Padova, Italy.

da Silva Oliveira, E. H., 2016. Place branding in strategic spatial planning: an analysis at the regional scale with special reference to Northern Portugal. University of Groningen, Groningen, The Netherlands.

Danieli, P.P., Serrani, F., Primi, R., Ponzetta, M.P., Ronchi, B., Amici, A., 2012. Cadmium, Lead and Chromium in Large Game: A Local-Scale Exposure Assessment for Hunters Consuming Meat and Liver of Wild Boar. Archives of Environmental Contamination and Toxicology, 63 (4), 612-627.

Drucker, P.F.,1985. Innovation and Entrepreneurship. Practice and Principles. Heinemann: London.

Edquist, C. (1997). Systems of Innovation Approaches – Their Emergence and Characteristics. Systems of Innovation. Technologies, Institutions and Organizations. C. Edquist. London, Pinter.

Etzkowitz, H., Leydesdorff, L. 2000. The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university-industry-government relations. Research Policy, 29 (2).

European Commission, 2015. Report from the Commission to the European Parliament and the Council regarding the mandatory indication of the country of origin or place of provenance for milk, milk used as an ingredient in dairy products and types of meat other than beef, swine, sheep, goat and poultry meat. European Commission, COM (2015) 205 final, Brussels.

European Union Door Database, 2017 http://ec.europa.eu/agriculture/quality/door/list.html

European Union, 2006. Council Regulation (EC) No 509/2006 of 20 March 2006 on agricultural products and foodstuffs as traditional specialities guaranteed.

European Union, 2007. Council Regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91.

Fairtrade Labelling Organization International, 2011. Fairtrade Standard for Herbs, Herbal Teas & Spices for Small Producer Organizations. Fairtrade Labelling Organization International, Bonn, Germany.

FairWild Foundation, 2017. FairWild certified ingredients under production. Fair Wild Foundation, Switzerland.

FAO FRA, 2010. Global Forest Resources Assessment 2010. Food and Agriculture Organization of the United Nation, Rome, Italy.

FAO, 1999. Towards a harmonized definition of non-wood forest product, Unasylva 198 (50), 63-64

Feichtner B., 1998. Ursachen der Streckenschwankungen beim Schwarzwild im Saarland. Z Jagdwiss, 44, 140–150.

Forest Europe, 2015. State of Europe's Forests. Food and Agriculture Organization of the United Nations, European Forestry Institute, Forest Europe Liaison Unit Madrid, Madrid, Spain.

Forest Europe, UNECE, FAO, 2011. State of Europe's Forests 2011. Status and trends in sustainable forest management in Europe. Forest Europe Liaison Unit Oslo, Oslo, Norway.

Franz, H.W., Hochgerner, J., Howaldt, J., 2012. Challenge Social Innovation. Potentials for Business, Social Entrepreneurship, Welfare and Civil Society, Springer, Heidelberg, 215-237.

FSC, 2001. Bolivian Standards for the forest certification of the Brazil Nut (Bertholletia excelsa). FSC Work Group in Bolivia, Riberalta, Beni, Bolivia.

FSC, 2006. Estándares para la certificación forestal voluntaria de guaduales en Colombia bajo el esquema del FSC. Forest Stewardship Council Colombia, Santiago de Cali, Colombia.

Gatto, P., Pettenella, D., Secco, L., 2009. Payments for forest environmental services: organisational models and related experiences in Italy. iForest Biogeosciences and Forestry, 2(1),133-139.

Ghione J., Matarrese A.M., Ponzio R., Sardo P. (a cura di), 2013, Sondaggio sui consumi di carne e sul benessere animale rivolto ai soci Slow Food europei, Slow Food, Fondazione Slow Food per la Biodiversità ONLUS.

Giménez-Anaya, A., Herrero, J., Rosell, C., Couto, S, García-Serrano, A., 2008. Food habits of wild boars (Sus scrofa) in a Mediterranean coastal wetland. Wetlands 28, 197–203

Glück, P., 2000. Policy Means for Ensuring the Full Value of Forests to Society. Land Use Policy, 17 (3), 177-185.

Hart, M., Stevenson, H., Dial., J., 1995. Entrepreneurship: a definition revisited. Frontiers of Entrepreneurship Research Paper; Babson College, MA.

Hessels, J., van Gelderen, M., Thurik, E., 2008. Entrepreneurial aspirations, motivations, and their drivers. Small Business Economics 31, 323-339. DOI: 10.1007/s11187-008-9134-x

IFOAM, 2008. Definition of Organic Agriculture in English, as approved by the IFOAM General Assembly in Vignola, Italy in June 2008. International Foundation for Organic Agriculture, Bonn, Germany.

IFOAM, 2014. The IFOAM norms for Organic Production and Processing Version 2014. International Foundation for Organic Agriculture, Bonn, Germany.

Kalieva, O., 2015. Development of Territory Brand Image: The Marketing Aspect. Review of European Studies, 7(2).

Karasová, K., 2007. The Czech names of mushrooms – etymological and formal analysis (in Czech).

Keča Lj., N. Keča, M. Rekola, 2013. Value Chains of Serbian Non-Wood Forest Products. International Forestry Review, 15 (3), 315–335.

Klein F., Baubet E., Toigo C., Leduc D., Saint-Andrieux C., Saïd S., Fréchard C., Vallance M., 2007, La gestion du sanglier. Des pistes et des outils pour réduire les populations, chasse et de la faune sauvage. Office national de la chasse et de la faune sauvage. Paris, Auffargis, Bar-le-Duc, France.

Knight, F., 1921. Risk, uncertainty and profit. Houghton Mifflin, New York.

Kubeczko, K., Rametsteiner, E. and G. Weiss (2006): The Role of Sectoral and Regional Innovation Systems in Supporting Innovations in Forestry. In: Forest Policy and Economics 8/7, 704-715.

Lawrence, A. (2003): No forest without timber? International Forestry Review 5 (2), pp 87-96.

Ludvig, A., Corradini, G., Asamer-Handler, M., Pettenella, D., Verdejo, V., Martínez, S. and G. Weiss (2016): The practice of innovation: The role of institutions in support of Non-Wood Forest Products. BioProducts Business 1(6), pp. 73-84.

Ludvig, A., Tahvanainen, V., Dickson, A., Evard, C., Kurttila, M., Cosovic, M., Chapman, E., Wilding, M. and G. Weiss (2016): The Practice of Entrepreneurship in the non-wood forest products sector: Support for innovation on private forest land, in: Forest Policy and Economics, Vol 28, pp 31-37.

Lunnan, A., Nybakk, E., & Vennesland, B. (2006). Entrepreneurial attitudes and probability for start-ups—an investigation of Norwegian non-industrial private forest owners. Forest policy and Economics, 8(7), 683-690.

Mantau, U., Merlo, M., Sekot, W., and B. Welcker (2001): Recreational and environmental markets for forest enterprises: a new approach towards marketability of public goods. CABI Pub, Wallingford, Oxon, UK.

Marshall, E., Newton, A.C., Schreckenberg, K., 2005. Commercialisation of non-timber forest products: first steps in analysing the factors influencing success. International Forest Review, 5 (2), 128-137.

Mary George, N., Parida, V., Lahti, T., Wincent J. 2016. A systematic literature review of entrepreneurial opportunity recognition: insights on influencing factors. International Entrepreneurship and Management Journal 12 (2), 309-350. DOI: 10.1007/s11365-014-0347-y

Maso, D., Matilainen, A., Pettenella, D. 2011. The Role of Networks in Non-wood Forest Products and Services Market Development. In: Weiss, G., Pettenella, D., Ollonqvist, P., Slee, B. (Eds.), Innovation in Forestry: Territorial and Value Chain Relationships. CABI, 154-168.

Mavsar, R., S. Ramcilovic, M. Palahi, G. Weiss, E. Rametsteiner, S. Tykkä, R. v. Apeldoorn, J. Vreke, M. v. Wijk and G. Janse (2008): Study on the Development and Marketing of Non-Market Forest Products and Services (FORVALUE). Study Report for DG AGRI, Study Contract No. 30-CE-0162979/00-21.

Micheels, E.T., Nolan, J.F. 2016. Examining the effects of absorptive capacity and social capital on the adoption of agricultural innovations: A Canadian Prairie case study, Agricultural Systems 145, 127–138, http://dx.doi.org/10.1016/j.agsy.2016.03.010

Milner, J.M., Bonenfant, C., Mysterud, A., Gaillard, J-M., Csányi, S., Stenseth, N.C., 2006. Temporal and spatial development of red deer harvesting in Europe: biological and cultural factors. Journal of Applied Ecology, 43, 721-734.

Morelle, K., Lejeune, P., 2015. Seasonal variations of wild boar Sus scrofa distribution in agricultural landscapes: a species distribution modelling approach. European Journal of Wildlife Research, 61, (1), 45-56.

Nedeljković, J., Lovrić, M., Nonić, D., Stojanovska, M., Nedanovska, V., Lovrić, N., Stojanovski, V., 2013. Utjecaj političkih instrumenata na poslovanje s nedrvnim šumskih proizvodima u Hrvatskoj, Makedoniji i Srbiji, Šumarski list, 9-10, 473-486.

Nedeljković, J., Nonić, D., Keča, Lj., Ranković, N., 2011. Legal framework of non-wood forest products in Western Balkan countries. In: Ristić R., Medarević M., Popović Z. (eds.) Proceedings "First Serbian Forestry Congress: Future with Forests". Faculty of Forestry, University of Belgrade, Belgrade, Serbia, 446-455.

Nedeljković, J., Nonić, D., Ranković, N., Nonić, M., 2015. Održivo sakupljanje nedrvnih šumskih proizvoda: karakteristike i stavovi sakupljača na području Kopaonika i Beljanice, Šumarstvo 1-2, 135-150.

NEPCon, 2014. NEPCon FSC Global Non Timber Forest Product Certification Addendum. NEPCon, Copenhagen, Denmark.

Neumann, R.P., Hirsch, E., 2000. Commercialisation of Non-Timber Forest Products: Reviews and Analysis of Research. Centre for International Forestry Research, Bogor, Indonesia.

Niskanen, A., Slee, B., Ollonqvist, P, Pattenella, D., Bouriand, L., Rametsteiner, E. 2007. Entrepreneurship in the forest sector in Europe, University of Joensuu, Faculty of Forestry, Silva Carelica 52, 73-102.

Nonić, D., Avdibegović, M., Nedeljković, J., 2014. Organization of non-wood forest products selling in small and medium enterprises in central Serbia, In: Marković A., Barjaktarović Rakočević S. (eds.): Proc. XIV International symposium SymOrg2014 "New Business Models and Sustainable Competitiveness", Faculty of Organizational Sciences, Belgrade, Serbia, 526-534.

Nybakk, E., Crespell, P., Hansen, E., Lunnan, A., 2009. Antecedents to forest owner innovativeness: An investigation of the non-timber forest products and services sector. Forest Ecology and Management 257, 608–618.

Nybakk, E., Vennesland, B., Hansen, E., Lunnan, A. 2008. Networking, innovation and performance in Norwegian nature-based recreation services industry, Journal of Forest Products Business 5 (4), 1-26.

Pedrotti, L., Dupré, E., Preatoni, D., Toso, S., 2001. Banca Dati Ungulati: status, distribuzione, consistenza, gestione, prelievo venatorio e potenzialità delle popolazioni di Ungulati in Italia. Biologia e Conservazione della Fauna, 109, 1-132.

Pettenella, D., Ciccarese, L., Dragoi, S., Hegedus, A., Hingston, A., Klöhn, S., Matilainen, A., Posavec, S., Thorfinnsson, T., 2006. NWFP&S marketing: Lessons Learned from Case Studies in Europe. In: Niskanen, A. (ed.). Issues Affecting Enterprise Development in the Forest Sector in Europe. University of Joensuu, Faculty of Forestry, Joensuu. Research Notes 169, 367–403.

Pettenella, D., Secco, L., Maso, D., 2007. WFP&S Marketing: Lessons learned and new development paths from case studies in some European countries. Small-scale Forestry 6: 373–390.

Pettenella, D., Vidale, E., Da Re, R., Lovric, M., 2014. NWFP in the international market: current situation and trends. StarTree Project Deliverable 3.1. Padova, Italy.

Pierce, A., Shanley, P., Laird, S.A., 2003. Certification of non-timber forest products: Limitations and implications of a market-based conservation tool. Paper presented at The International Conference on Rural Livelihoods, Forests and Biodiversity 19-23, May 2003. Bonn, Germany.

Pierce, A.R., Shanley, P., Laird, S.A., 2008. Non Timber Forest products and certification: strange bedfellows. Forests, Trees and Livelihoods, 18(1), 23-35.

Pine, J.B. and Gilmore, J.H., 1999. The Experience Economy, Boston (Harvard Business School)

Porter, M.E. 1998. Clusters and the new economics of competition, Harvard Business Review, 76:6, 77-90.

Posavec, S., 2013. Green Tax Influence on Croatian forestry, Forêt Méditerranéenne. 34(4), 319-322.

Posavec, S., Beljan, K., Fornažar, A., 2014. Entrepreneurship Development of Non-Timber Forest Products in the Republic of Croatia, Adaptation in Forest Management Under Changing Framework Conditions. Schiberna, E., Stark, M. (eds.), Sopron, Hungary, IUFRO, 189-199.

Primi, R., Pelorosso, R., Ripa M. N., Amici, A. (2009). A statistical GIs-based analysis of Wild boar (Sus scrofa) traffic collisions in a Mediterranean area. Italian Journal of Animal Science 8, 649-651

Prokofieva, I., Bouriaud, L., Corradini, G., Gorriz, E., Buttoud-Kouplevatskaya I., Nichiforel, L., Towards a new policy framework for NWFP – demands and barriers. In: Wolfslehner, B et al. (Eds.), Non-Wood Forest Products in Europe – Seeing the Forest Around the Trees. What Science Can Tell Us series, European Forest Institute.

Provincia di Pistoia (2014). Progetto sperimentale per il trattamento e la commercializzazione delle carni di fauna selvatica di cui alla misura F.1.8 Az. A) del PFAF, Regione Toscana. Determinazione (512) 15.05.2014.

Ramanzin, M., Amici, A., Casoli, C., Esposito, L., Lupi, P., Marsico, G., Mattiello, S., Olivieri, O., Pinzetta, M.P., Russo, C., Trabalza Marinucci, M., 2010. Meat from wild ungulates: ensuring quality and hygiene of an increasing resource. Italian Journal of Animal Science 9(e61), 318-331.

Rametsteiner, E., Weiss, G., Kubeczko, K. 2005. Innovation and entrepreneurship in forestry in central Europe. EFI Research Report 19, European Forest Institute, Joensuu, Finland.

Ray, P.H. and Anderson S.R., 2000. The Cultural Creatives: How 50 Million People are Changing the World. Three Rivers Press, New York.

Riedl, M., 2010. Marketingový pohled na výsledky výzkumu vnímání lesů a lesnictví. The Results of Forestry Public Opinion Survey from a Marketing Point of View, Zprávy lesnického výzkumu, 1-9.

Riedl, M., Sisak, L., 2013. Analysis of the perceived condition of forests in the Czech Republic, Journal of Forest Science, 59 (9), 514–519.

Riera, P., Signorello, G., Thiene, M., Mahieu, P.-A., Navrud, S., Kaval, P., Rulleau, B., Mavsar, R., Madureira, L., Meyerhoff, J., Elsasser, P., Notaro, S., De Salvo, M., Giergiczny, M., Dragoi, S. (2012): Non-Market Valuation of Forest Goods and Services: Good Practice Guidelines, Journal of Forest Economics, 18 (4), 259–270.

Rupf H. (1960). Wald und Mensch im Geschehen der Gegenwart. Allgemeine Forstzeitschrift, 38: 545552.

Saez-Royuela, C., Telleria, J.L., 1986. The increased population of wild boar (Sus scrofa L.) in Europe. Mammal Review, 16 (2), 97-101.

Santini, F., Fatmir, G., Gomez y Paloma, S., 2013. Labelling of agricultural and food products of mountain farming. JRC Scientific and policy report, European Commission, Joint Research Centre, Institute for Prospective Technological Studies, Seville, Spain.

Saxena, N.C., 2003. Livelihood Diversification and Non-Timber Forest Products in Orissa: Wider Lessons on the Scope for Policy Change? Overseas Development Institute. London, UK. ODI Working Paper (223).

Schley, L., Dufrêne, M., Krier, A., Frantz A.C., 2008. Patterns of crop damage by wild boar (Sus scrofa) in Luxembourg over a 10-year period. European Journal of Wildlife Research, 54, 589–599.

Schley, L., Roper, T.J., 2003. Diet of wild boar Sus scrofa in Western Europe, with particular reference to consumption of agricultural crops. Mammal Review, 33, 43-56.

Schon, T., 2013. The cost of having wild boar: Damage to agriculture in South-Southeast Sweden, Swedish University of agricultural studies, Department of Wildlife, Fish, and Environmental Studies.

Schulze, E.D., O. Bouriaud, J. Wäldchen, N. Eisenhauer, H. Walentowski, C. Seele, E. Heinze, U. Pruschitzki, G. Danila, G. Marin, D. Hessenmöller, L. Bouriaud, M. Teodosiu, 2014. Ungulate browsing causes species loss in deciduous forests independent of community dynamics and silvicultural management in Central and Southeastern Europe. Ann. For. Res. 57(2):2014. http://www.afrjournal.org/index.php/afr/article/viewFile/273/339

Shackleton, C.M., Shackleton, S.E., 2004. The Importance of Non-Timber Forest Products in Rural Livelihood Security and as Safety Nets: A Review of Evidence from South Africa. South African Journal of Science, 100, 658-664.

Shanley, P., Pierce, A.R., Guillén, A., Laird, S.A., 2002. Tapping the green market: Certification and Management of Non-Timber Forest Products. Earthscan, London, UK.
Shanley, P., Pierce, A.R., Laird, S.A., Robinson, D., 2008. Beyond timber: certification and management of non-timber forest products. CIFOR, Bogor, Indonesia.
Shiva, M.P., Verma, S.K., 2002. Approaches to Sustainable Forest Management and Biodiversity Conservation: With Pivotal Role of Non-timber Forest Products. Dehra Dun: Centre for Minor Forest Products, Valley Offset Printers.
Siglo Foundation for Tourism and the Arts in Castilla y León Junta de Castilla y León, 2015. Wine tourism and gastronomy in Castilla y León. Siglo Foundation for Tourism and the Arts in Castilla y León Junta de Castilla y León, León, Spain.
Sisak, L., 2006. Importance of non-wood forest product collection and use for inhabitants in the Czech Republic. Journal of Forest Science, 52(9), 417–426.
Sisak, L., 2011. Forest visitors' opinions on the importance of forest operations, forest functions and sources of their financing. Journal of Forest Science, 57, 266–270.
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.
Slee, B. 2011. Innovation in Forest-related Territorial Goods and Services: an Introduction. In: Weiss, Gerhard, Davide Pettenella, Pekka Ollonqvist and Bill Slee (Eds.): Innovation in Forestry: Territorial and Value Chain Relationships, CABI International, Oxfordshire; 118-130 (ISBN 978-1-84593-689-1).
Slee, R.W. 2005. From countrysides of production to countrysides of consumption? Journal of Agricultural Science (2005), 143, 255–265. Cambridge University Press. doi:10.1017/S002185960500496X
Sorrenti, S., 2017. Non-wood forest products in international statistical systems. Non-wood Forest Products Series (22). FAO, Rome, Italy.
Steele, M.Z., Shackleton, C.M., Shaanker, R.U., Ganeshaiah, K.N., Radloff, S., 2015. The Influence of Livelihood Dependency, Local Ecological Knowledge and Market Proximity on the Ecological Impacts of Harvesting Non-Timber Forest Products. Forest Policy and Economics, 50, 285–291.
Stojanovska, M., Nonić, D., Baumgartner, J., Nedeljković, J., Stojanovski, V., Nedanovska, V., Posavec, S., 2015. Challenges and Opportunities in the Use of Marketing Tools and the Promotion of Non Wood Forest Products-Based Small and Medium Enterprises in the South East Europe. South-East European Forestry, 6 (1), 97-106.
Swiergosz R., Perzanowski K., Makosz U., Bitek I., 1993. The incidence of heavy metals and other toxic elements in big game tissues. Science of the Total Environment, Supplement (1), 225-231.
Thurfjell H., Ball JP., Åhlén PA., Kornacher P., Dettki H., Sjöberg K., 2009, Habitat

use and spatial patterns of wild boar Sus scrofa (L.): agricultural fields and edges. European Journal of Wildlife Research, 55, 517–523.

Toıgo, C., Servanty, S., Gaillard, J.M., Brandt, S., Baubet, E., 2008. Survival patterns in an intensively hunted wild boar population: disentangling natural from hunting mortality. Journal of Wildlife Management, 72, 1532–1539.

Tomei, G., 2014. Danni da fauna selvatica nelle aree protette: Il caso del Parco Regionale dell'Appia Antica. Final dissertation, supervisor A. Coletta. Università degli Studi della Tuscia, DAFNE Department.

UHUL, 2014. Online Statistics Education: An Interactive Multimedia Course of Study. Available at:

UNOPS, 2009. A guide to environmental labels – for Procurement Practitioners of the United Nations System. United Nations Office for Project Services, Copenhagen, Denmark.

Vacik, H., Wolfslehner, B., Huber, P. and H. Ruprecht (2014): Estimation of the value of non-timber forest products and services in Austria. In: Parrotta, J.A., Moser, C.F., Scherzer, A.J., Koerth, N.E., Lederle, D.R. (eds.): Sustaining Forests, Sustaining People: The Role of Research. XXIV IUFRO World Congress, The International Forestry Review, Vol. 16 (5).

Vantomme P., Walter, S., 2003. Opportunities and challenges of non-wood forest products certification. Paper submitted to the World Forestry Congress, Quebec, 21-28 September, Rome, Italy.

Vidale, E., Da Re, R., Corradini, G., Pettenella, D., 2015. The regional markets of NWFP: current situation and effect on SME. Project deliverable D3.2. StarTree project (EU project 311919).

Vidale, E., Da Re, R., Pettenella, D., 2015. Trends, rural impacts and future developments of regional WFP market. Project deliverable D3.3. StarTree project (EU project 311919). Padova, Italy.

Vuletić D., Krajter, S., Vlanić, O., 2011. Pregled stavova lokalnog stanovništva i korisnika o nedrvnim proizvodima i uslugama šuma. Šumarski list br. 13, 222–229.

Walter, S., 2006. Certification of Non-Wood Forest Products: Relevant Standards, Preliminary Experiences and Lessons-Learnt. Paper presented at the 1st International Conference on Wild Organic Production Teslic, Bosnia Herzegovina, 3-4 May 2006, 3–4.

Weiss, G. 2011. Theoretical approaches for the analysis of innovation processes and policies in the forest sector. In: Weiss, Gerhard, Davide Pettenella, Pekka Ollonqvist and Bill Slee (eds.): Innovation in Forestry: Territorial and Value Chain Relationships. Innovation in Forestry: Territorial and Value Chain Relationships, CABI International, Oxfordshire; 10-33 (ISBN 978-1-84593-689-1).

Weiss, G. 2013. Innovation in Forestry: New Values and Challenges for Traditional Sector. In: Carayannis E.G. (ed.): Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship, 964-971.

Weiss, G., Ludvig, A., Asamer-Handler, M., Fischer, C., Vacik, H., Zivojinovic, I., Bringing innovation into non-wood forest products. In: Wolfslehner, B et al.

(Eds.), Non-Wood Forest Products in Europe – Seeing the Forest Around the Trees. What Science Can Tell Us series, European Forest Institute.

Weiss, G., Ludvig, A., Zivojinovic, I., Asamer-Handler, M., Huber P., 2017. Non-timber innovations: How to innovate in side-activities of forestry – Case study Styria, Austria. In: Austrian Journal of Forest Science (in print).

Weiss, G., Ollonqvist, P., Slee, B. 2011. How to Support Innovations in the Forest Sector: Summary and Conclusions. In: Weiss, Gerhard, Davide Pettenella, Pekka Ollonqvist and Bill Slee (eds. 2011): Innovation in Forestry: Territorial and Value Chain Relationships, CABI International, Oxfordshire; 303-319 (ISBN 978-1-84593-689-1).

WHO, 2003. WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. Geneva, Switzerland.

Willer, H., Lernoud, J. (eds.) 2016. The world of organic agriculture. Statistics and emerging trends 2016. Reserch Institute of Organic Agriculture (FiBL), and IFOAL-Organics International, Bonn, Germany.

Wolfslehner, B., Prokofieva, I. and Mavsar, R. (eds), 2016. Wild Forest Products in Europe: Seeing the forest around the trees – What Science Can Tell Us. EFI, Joensuu.

Wong, J. and Wiersum, F. A spotlight on NWFP in Europe. In: Wolfslehner, B et al. (Eds.), Non-Wood Forest Products in Europe – Seeing the Forest Around the Trees. What Science Can Tell Us series, European Forest Institute.

Wong, J. et al. in this book.

Živojinović I., Nedeljković J., Stojanovski V., Japelj A., Nonić D., Weiss G., Ludvig A. (2017). Non-timber forest products in transition economies: Innovation cases in selected SEE countries, Forest Policy and Economics.

6. Mushrooms & truffles

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6.1 Introduction

Fungi are one of the most diverse groups worldwide (Tedersoo *et al.* 2014), playing a key role in the ecosystem functioning. Their relevance is not exclusively restricted to their ecological role, but also to the economic potential mainly as a food source of their fruit bodies. Wild forest mushrooms are among the most important non-timber forest products and they have been collected and used by humans worldwide for thousands of years. They have been valued as food, traditional source of natural bioactive compounds, medicine, tinder, handicrafts, cloths, ritual praxis, spiritual enlightenment, recreation and a number of other purposes ranging from insecticides to soil fertilizers (Wu et al. 2016; Yamin-Pasternak 2011; Peintner and Pöder 2000). Archaeological findings also suggest that mushrooms have been used in religious ceremonies in many ancient cultures. Their sudden appearance after rain and thunderstorms, short life, polysemy and marginal place between the pure and the dangerous are the main reasons for connecting them with the supernatural and the spirits world. One of the most recognizable and widely encountered mushrooms in popular culture is the magic red mushroom with the white warts, which illustrates children books, the fly agaric (*Amanita muscaria*). It has been claimed to be the basic component of *soma*, the good narcotic of ancient India, and is also known for its hallucinogenic and magico-religious use by the Siberian shamans, the Mayas, the Aztec Indians, the modern inhabitants of Mesoamerica, while it is well known worldwide in modern times for its psychoactive properties (Schultes *et al.* 1992; Lowy 1974) together with other psychoactive magic mushrooms, e.g. *Psilocybe spp.*

Fungi play also an important role in our life as a food. Yeasts are essential for the making of wine, bread and beer, molds are important for cheese and sausage production, as well as for fermentation (Miso, Tempeh, Sufu, Soja-Sauce) while mushrooms are known to be used as food from archaeological records that associate edible mushrooms with people who lived in Chile 13 000 years ago (Boa 2004). According to Boa (2004) there are over 200 mushroom genera, which contain species of use to people worldwide, of which 46% (a total of 1154 species recorded from 85 countries) are used as food, 20% have medicinal properties and almost 10% have at present other uses (e.g. ceremonial, as tinder, as natural dyes).

Nowadays, wild edible mushrooms are collected and traded in more than 80 countries worldwide Furthermore, there is a growing awareness that mushrooms make up a vast, and generally untapped, source of new pharmaceutical products (Wu *et al.* 2016; Boa 2004). In Africa, almost half of the countries have some tradition of wild edible mushroom collection, particularly, in central and southern regions, where mushrooms provide a notable contribution to diets during the months of the year when the food supply is extremely low. Moreover, nearly 15% also export small quantities of wild edible mushrooms (e.g. cep, desert truffles, matsutake), mainly to European countries, such as Italy but also to China and Japan. Likewise, 45% of Asian countries also possess traditions of wild edible mushroom picking and consumption, mainly China and Russia and surrounding countries. Also, near 20% of Asian countries export morels to nearby countries and/or matsutake to Japan, a major importer of this mushroom species. China stands out as the world leading producer, user and exporter, mainly of matsutake and other medicinal mushrooms used in traditional Chinese medicine. Regarding America, only few countries have strong traditions of collecting and consuming wild edible fungi, such as Mexico, Guatemala and Honduras. In the United States of America (USA) and Canada, wild mushroom collection is much lower than that suggested by the vast mycological knowledge available and mostly centred in the Pacific Northwest, yet, both are major exporters of matsutake to Japan. In more than 50% of all the South American countries, no information on wild edible mushroom picking and consumption is available. A few countries (e.g. Brazil and Ecuador) do export small quantities of edible mushrooms like *Agaricus blazei* (to Japan) and pine bolete (to USA), whereas Argentina and Chile have a localized consumption of morels and/or *Cyttaria* spp. As for Oceania, with the exception of Australia, where useful accounts of aboriginal use do exist, from the great majority of countries we do not have information about collection and consumption of wild edible mushroom or only have weak traditions (e.g. Fiji, New Zealand and Papua New Guinea). However, New Zealand has a recognized production of *Agaricus* spp. and *Tuber* spp. (Boa 2004).

In Europe, there is a long tradition of collecting wild edible mushrooms, mainly for self-consumption. This fact is well documented since Roman times, but recent archaeological findings (e.g. the "Red Lady" of Cantabria) revealed that the consumption of wild edible mushrooms in Europe is older, dating back to the Palaeolithic (Power *et al.* 2015). Nowadays, it is clear that most of the European countries value their mycological resources and more than 50% have some sort of legislation or guidelines for mushroom harvesting, consumption and commercialization (Peintner *et al.* 2013). Generally, countries fall into two categories: first, nations with weak economies, usually with a significant local tradition of using wild edible mushrooms; second, wealthier countries that import but may not have a strong tradition of collecting. Romania is an example of the first group and the Netherlands an example of the second. Southwestern and Central European populations reveal a mycophilic attitude and have strong traditions related to the consumption of many different species of edible mushrooms. For instance, edible mushroom *taxa* listed to be commercialized in France (122), Switzerland (114), Spain (93), Austria (92) and Italy (73) are much higher than in Croatia (27), Bosnia and Herzegovina (18) and Serbia (15). The overall diversity of edible mushrooms authorized to be commercialized in Europe is very high (268, 60 of which can be cultivated). Remarkably, only two fungal *taxa* are on all the lists: Cep (*Boletus edulis* complex), and chanterelle (*Cantharellus cibarius*) (Peintner *et al.* 2013).

The mycophilic or mycolatrous (mushroom-loving) versus mycophobic (mushroom-fearing) dichotomy is based on the work of Wasson and Wasson (1957) who created a scale of mycophilia and mycophobia syndromes and attempted to place on this scale different countries around the world based on their own studies. This dichotomy was criticized for overgeneralization, polarization and for giving little room for specific communities or individuals differentiations (Yamin-Pasternak 2011; Letcher 2007). Detailed studies of mushroom lore and the linguistic diversity of mushroom local names suggest that even mushrooms are understudied because of their role as occasional or famine food of the poor people have had their place in many local cultures and gastronomies (Stara *et al.* 2016; Vrachionidou 2007).

Wild edible mushrooms represent a significant growing dietary supplement for many European populations and an important marketable product for rural economies in many countries. Some populations have a strong tradition of wild edible fungi collection and consumption, given that mushrooms constitute a necessary portion of their diets. Moreover, selling mushrooms is a very common occupation which constitutes an extra income, often tax free, among the impoverished populations or/and in countries with weakened economies. Selling mushrooms seems a widespread tradition in Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Macedonia, Poland and Russia among others. Contrary, in e.g. Austria, Denmark, Germany, Norway, Sweden, and Switzerland, picking mushrooms is rather a recreational activity mostly for personal consumption. Here mycophilic people are often organized in mycological societies or local scientific groups for exchanging and sharing taxonomic knowledge on mushrooms and organizing mushroom forays (Information about different mycological societies in Europe may be found on the homepage of the European Mycological Association (EMA 2017)). In some countries (e.g. Finland, Italy, France, Spain and Portugal) there are clear distinct local behaviours among the populations: in some districts people are afraid and refuse to eat wild mushroom because of fear, while in others people love eating mushrooms. There are case studies (e. g. France, Spain, Finland, Switzerland, Czech Republic) that show the economic importance of wild edible mushroom exploitation in rural areas. For instance, Sisak *et al.* (2016) demonstrates that the material value of collected mushrooms could surpass 12% of the average annual value (per hectare) of the intensive forestry timber production and hence that forest management for timber production can be smoothly combined with edible mushroom exploitation.

The expansion in commercial harvesting in some countries and international trade has led to an increase of harvesting pressure and concerns about overharvesting and damage to fungal resources (Boa 2004). Some countries or regions have introduced legal restrictions on the harvesting of edible fungi in natural habitats because they fear that the removal of fruit bodies from the forest, often before spore dispersal, might impair their reproduction. However, experimental studies on the effect of harvesting have revealed that long-term and systematic harvesting reduces neither the future yields of fruit bodies nor the species richness of wild forest fungi, irrespective of whether the harvesting technique was picking or cutting (Egli *et al.* 2006; Norvell 1995; Pilz *et al.* 2003). However, after mass removal of fruit bodies, on a local fine scale establishment of new mycelia maybe slower due to competition with other fungi, because local mass spore deposition from fruit bodies may compensate for the low probability that a single spore will germinate and establish a new mycelium (Heegaard *et al*. 2016).

Albeit poisonous mushrooms only represent a very small fraction of all wild mushrooms, some of them are deadly poisonous, and ingestion of those may result in serious intoxication, including death. The death cap (*Amanita phalloides*) and related Amatoxin-containing *Amanita* species cause deadly intoxication worldwide every year. In Poland, for example, 54 persons died between 1953–1962 as a consequence of the consumption of *A. phalloides* (Grzymala 1965). Some countries have established information/consulting services, giving the opportunity to private mushroom harvesters to present their harvests to trained mushroom advisers sorting out the poisonous mushrooms. Such services exist for example in Finland, in Norway ('svamp police'), or in Switzerland where a network of about 300 mushroom checkpoints all over Switzerland exists.

CASE 6.1: *The most appreciated mushrooms and truffles species in Europe*

There is a huge variability of mushroom preferences within European countries, and even between regions in the same country. Based on the work of Peintner *et al*. (2013) that lists the edible mushrooms authorized for trade in 27 European countries, we may consider the most relevant mushrooms and truffles those which are authorized in at least 7 countries. The list includes 27 genera with a total of 59 species:

Figure 6.1: *Marketed mushroom species. From left to right: Cantharellus cibarius (Photo credit: Željko Zgrablić), Boletus edulis (Photo credit: Irmgard Krisai-Greilhuber), Lactarius deliciosus (Photo credit: Friedrich Reinwald), Tuber aestivum (Photo credit: Irmgard Krisai-Greilhuber), Tuber melanosporum (Photo credit: Daniel Oliach).*

Agaricus arvensis, A. bisporus, A. bitorquis, A. campestris, A. silvaticus, A. silvicola, Agrocybe cylindracea, Amanita caesarea, Armillaria mellea, Auricularia ssp., *Boletus aereus, B. badius, B. edulis, B. pinophilus, B. reticulatus, Calocybe gambosa, Calvatia gigantea, Cantharellus cibarius, Coprinus comatus, Cortinarius caperatus, Craterellus cornucopioides, C. lutescens, C. tubaeformis, Hydnum repandum, H. rufescens, Kuehneromyces mutabilis, Lactarius deliciosus, L. deterrimus, L. salmonicolor, L. sanguifluus, L. semisanguifluus, L. volemus, Leccinum aurantiacum, L. scabrum, L. versipelle, Lentinula edodes, Lepista nuda, Macrolepiota procera, Marasmius oreades, Morchella conica, M. elata, M. esculenta, M. gigas, Pleurotus cornucopiae, P. eryngii, P. ostreatus, Russula cyanoxantha, R. vesca, R. virescens, Suillus granulatus, S. grevillei, S. luteus, S. variegatus, Tricholoma portentosum, Tuber aestivum, T. brumale, T. magnatum, T. melanosporum, Xerocomus subtomentosus.*

CASE 6.2: *Mushrooms also cause poisonings*

The Public National Poisons Information Centres provide an advisory service in case of suspected poisonings. The Swiss National Poisons Information Centre, Tox Info Suisse, for example, registered since its establishment in 1966 over 12,000 mushroom-related calls (Schenk-Jäger *et al*. 2016). Despite the highly developed and effective mushroom control system in Switzerland, 32 mushroom-related *A. phalloides* – or amatoxin-intoxications by related species were registered from 1995-2009, 5 of them with fatal outcome (Schenk-Jäger *et al.* 2012).

Between 2010 and 2015 in Munich, the Giftnotruf München registered 2 661 cases of real and/or assumed mushroom intoxications. They can be subdivided in 56 cases of abuse (intentional consumption), 25 commercial accidents, 2 255 household accidents, 11 suicide attempts and 314 others (Bettina Haberl and Rudi Pfab, unpubl. pers. comm.).

According to Arif *et al.* (2016) in Austria in 19 years (1996-2014) the Poison Information Centre had 1,072 inquiries regarding mushroom ingestion in children (1-14 years old). In 68% fungal parts were ingested raw (within these cases *Amanita phalloides* was verified in 1.6%). In 32% of the cases, mushrooms were consumed cooked and *Amanita phalloides* was verified in 3.5% of these cases. Three children developed serious symptoms (2 cases to liver transplantation, one child deceased). In 2016, the mushroom counselling service of the municipality of Vienna altogether gave advice 401 times, with 2 samples of deadly poisonous, 30 poisonous, 132 inedible, and 237 edible species.

Even nowadays new, unusual fatal mushroom poisonings occur which are due to hitherto unnoticed toxic species. For instance, it is not well known that sometimes morels can cause neurological symptoms similar to drunkenness (one case in Austria in spring 2016). *Echinoderma aspera* may cause alcohol abuse syndromes; *Russula subnigricans* caused fatal rhabdomyolysis in Japan while in China the "Yunnan Sudden Unexplained Death-Syndrome" generated by *Trogia venenata* caused hundreds of deaths. Further toxic species are *Pleurocybella porrigens*, *Scleroderma* spp., *Omphalotus olearius* and *Clitocybe amoenolens*, which recently have also been found in Central Europe. A very dangerous and new phenomenon is confusion of highly valued medicinal fungi with toxic ones, e.g. *Ganoderma lucidum* with *Ganoderma neojaponicum* or with *Podostroma cornu–damae*, the latter is by far the most poisonous mushroom existing (Berndt 2016).

Figure 6.2: *Potential confusion within fungal species. Russula heterophylla (left) is an edible species while Amanita phalloides (right) is poisonous (Photo credit: Irmgard Krisai-Greilhuber). Amanita verna, commonly known as the fool's mushroom, is a deadly poisonous basidiomycete, one of many in the genus Amanita (Photo credit: Simon Egli).*

Fungi are more and more recognized internationally as organisms which are in need of concern for conservation measures, especially habitat protection, as is the case with animals and plants. Several international societies were founded dealing with conservation of fungi. For instance, the International Society for Fungal Conservation (ISFC) promotes conservation of fungi globally (http://www.fungal-conservation.org/). On their homepage it is stated that one of the main aims is to be a Global Federation for Fungal Conservation Groups, supporting regional or national and local bodies in fungal conservation activities.

The Global Fungal Red List Initiative (http://iucn.ekoo.se/en/iucn/welcome) was started and finally led to the inclusion of fungi in the IUCN Red List of Threatened Species. There are Red Lists in many European countries either on a local or national scale, e.g. Switzerland (Senn-Irlet *et al.* 2007), Czech Republic (Holec and Beran 2006), Poland (Wojewoda and Lawrynowicz 2004), the Netherlands (Arnolds and Veerkamp 2008), Sweden (Gärdenfors 2005), Germany (Bundesamt für Naturschutz 2017), or Austria (Dämon and Krisai-Greilhuber 2017). In Europe finally in 2013 the Bern Convention (Council of Europe) has created a Charter for Fungi-Gathering and Biodiversity (Brainerd and Doornbos 2013), see Union for the Conservation of Nature (www.iucn.org); which also includes a Code of Conduct for mushroom picking in nature.

This chapter will provide a characterisation of fungal communities and the different approaches to study fruit body production (chapter 6.2). The ecology of mushroom and truffle species is introduced in chapter 6.3 and the necessary requirements for a fungal oriented forest management are discussed in chapter 6.4. The role of trade as the main driver of the wild mushrooms economy and other socio-economic aspects are described in chapter 6.5.

6.2 Characterization of fungal communities and fungal diversity

The great temporal and spatial variation in mushroom and truffle yields between and within years (Alday *et al.* 2017) makes the fine characterization of fungal communities difficult. The study of the presence/emergence of mushrooms has been traditionally based on the collection of fruit bodies from permanent plots or transects, which are systematically sampled once per week (Bonet *et al.* 2012; Martínez de Aragón *et al.* 2007; Egli *et al.* 2006; Dahlberg 1991). This data is very valuable since, like any other forest resource, forest management plans demand first the estimation and evaluation of the marketable resources in quantifiable terms (Díaz-Balteiro *et al.* 2003; Palahi *et al.* 2009).

Despite the relevance of obtaining potential mushroom productions, an extensive sampling approach has to be conducted for several years if the final objective is to obtain representative data (Martínez de Aragón *et al.* 2007; Büntgen *et al.* 2013). This long-term sampling is followed together with measurement of the environmental characteristics of the plots, especially to understand the causal factors affecting mushroom production (Vogt *et al.* 1992). Similarly, the sampling scheme will depend on the previously established objectives. For instance, measuring fruit body species richness requires as large sampling plots or as long transects as possible (Martínez de Aragón *et al.* 2007), whereas the use of smaller sampling plots or transects (100 m^2) is advisable if the aim is to estimate fruit body productivity (Dighton *et al.* 1986; Hintikka 1988; Smith *et al.* 2002; Martínez de Aragón *et al.* 2007). Due to the high sampling frequency in these plots, caution is advised with the use of heavy equipment or any other factors such as trampling of the forest floor causing soil disturbance, which can negatively affect mushroom production (Wästerlund 1989; Egli *et al.* 2006). In addition, any silvicultural treatment, such as thinning, also needs to be taken in account, since it has been shown that forest management has an effect on the mushroom production and diversity (Bonet *et al.* 2012; de-Miguel *et al.* 2014, Egli *et al.* 2010). Finally, to avoid losing data, temporal organization of samplings will be important, e.g. sampling at the end of week in order to reduce the probability of mushroom hunting by other pickers (Martínez de Aragón *et al.* 2007). In addition, if the objective is the use of a non-destructive sampling approach (i.e. fruit bodies are only counted *in situ*), fruit bodies might be marked with a colour stain to avoid double counting one week later (Egli *et al.* 2006).

If the sampling approach is based on fruit body counts and weight measurement, samples are brought to the laboratory after sampling for fresh weight measurement and fruit body count (Martínez de Aragón *et al.* 2007). Moreover, since fresh weight is biased by the actual weather conditions determining the water content of the fruit body, fruit bodies should be dried in air-vented oven at 35-40 °C and weighed (Väre *et al.* 1996). A classification of the mushrooms is necessary, especially if we are focused in understanding their commercial status (e.g. edible non-marketed, marketed) together with the measurement of all of the environmental factors of the plot, which will be later used to design the forest management plans to optimize mushroom production, according to any specific tree species (Martínez-Peña *et al.* 2012).

Despite the need of conducting fruit body samplings for future commercial purposes but also to better understand the ecology of these species, the current methodology used to estimate fungal productivity is very limited when it comes to hypogeous species such as truffles, or ephemeral species with a very short lifespan of their fruit bodies, as well as species which fruit very rarely and not every year (Vogt *et al.* 1992). In addition, due to the high costs associated with these sampling approaches, there is a need to improve the tools to detect and quantify mushroom yields. In the next subchapters, we will present some new promising approaches that may help estimating or predicting the mushroom production and approximate its diversity both at ground level but also belowground by using molecular techniques.

6.2.1 The use of belowground communities to study fruit body production

Fruit body-forming fungi in forest soils are supported by a vegetative system which involves two main structures; the fungal mycelia and the mycorrhizas. However, these structures have been very difficult to study, since fungal species living in soil are highly diverse (Buée *et al.* 2009) and, in the case of fungal mycelia, it is often not visible to the human eye. The use of novel molecular techniques to study fungal communities living belowground has answered several ecological questions such as seasonality of soil mycelia (De la Varga *et al.* 2012; Jumpponen *et al.* 2010) and is allowing the identification of the fungal species living in soils (Nilsson *et al.* 2006; 2012; 2013). Other techniques such as qPCR have also been developed with the aim to quantify the specific fungal species living in soils, e.g. *Lactarius vinosus* (Castaño *et al.* 2016), *Boletus edulis* (De la Varga *et al.* 2013) and *Tuber melanosporum* (Liu *et al.* 2014; Parladé *et al.* 2013; Suz *et al.* 2006). The use of soil mycelia (also referred as extramatrical mycelia) has the advantage with respect to fruit bodies that it is much more stable across years, within the year, has much higher diversity (Buée *et al.* 2009) and shows many other species not forming or only forming inconspicuous fruit bodies. However, molecular methods have to be developed, so we can to differentiate between productive viable mycelia and other fungal DNA sources, such as propagules, very young mycelia, inactive or dead mycelia (Simmel 2016; Bässler *et al.* 2016).

It is apparent that the fungal community shows much higher diversity belowground (mycorrhizas and mycelia) than above ground evidence (fruit bodies) (Dahlberg *et al.* 1997; Gardes and Bruns 1996; Koide *et al.* 2005), but community studies focused on understanding more specifically to what extent the soil fungal mycelia can predict or estimate the potential mushroom production are missing. Thus, to date only few examples report correlations between fungal mycelia (Suz *et al.* 2008; Liu *et al.* 2016) or mycorrhizas (De la Varga *et al.* 2012; Parladé *et al.* 2007) and their fruit body production. Therefore, it's needed to understand if there is such relationship, and if this may depend on the fungal species or the spatial scale considered, as well as whether they may be affected by the seasonality of the fungal mycelia (De la Varga *et al.* 2013) or the sampling design (e.g. plot size) (Martínez de Aragón *et al.* 2007). The potential use of soil samples or mycorrhizas to estimate mushroom production will be hopefully soon clarified with the optimization of such methodological questions together with the optimization of high-throughput sequencing technique approaches and the interpretation of such data.

6.2.2 The use of spore traps to study fruit body production

Fungal spores or fungal propagules could be also used to estimate potential fruit body production as an alternative to the use of mycorrhizas of fungal mycelia, yet no evidence of the feasibility of this approach has been presented so far. However, despite few, recent studies have provided new insights in such relationship (see discussion in Peay and Bruns 2014) and there is also new evidence that it is possible to detect fruit body emergence using spore traps together with molecular techniques (Castaño et al. 2017 unpublished).

The use of spore traps to detect and quantify fungal spores and use such data as a proxy for the colonization potential of fungal inoculum has been mostly restricted to plant pathology (Jackson and Bayliss 2011). Literature in this field has provided evidence that spore trap samples used with molecular techniques are useful to quantify the spore inocula of specific fungal pathogens such as *Fusarium circinatum* (Schweigkofler and Garbelotto 2004) or *Hymenoscyphus fraxineus* (Chandelier *et al.* 2014). An important aspect concerning the use of these spore traps is that they should be easy to handle and easy to replace, since they will be most likely located in forests, where accessibility is not always easy. In this sense, both passive funnel and filter traps were shown to have fungal spores (Chandelier *et al.* 2014; Peay and Bruns 2014) (See Figure 6.3), which are most likely derived from the biological activity of these organisms nearby. One of the disadvantages of using these devices is that sporulation is very species-specific in terms of the quantity of released spores and many basidiomycetes (especially ectomycorrhizal) seem to disperse less abundantly and dispersal is often restricted to a very short period in the year (Galante *et al.* 2011; Kivlin *et al.* 2014; Li 2005). Furthermore, the traditional identification approaches, e.g. microscopy techniques, are almost prohibitive under this context and would be very time-consuming (West *et al.* 2008). Here, the use of next generation sequencing represents another promising opportunity to characterize these communities. Again, apart from the technical considerations when using molecular techniques (see a review in Lindahl *et al.* 2013), other factors such as precipitation events, wind direction or specific traits (Oliveira *et al.* 2009; Burch and Levetin 2002; Troutt and Levetin 2001; di Giorgio *et al.* 1996) will most likely affect any hypothetical relationship between spores and fruit body yields and therefore should be studied and taken in account in future.

Figure 6.3: *Example of a passive spore traps or funnel spore trap (Left) and an active (Burkard) spore trap (Right) using a solar panel as a source of energy supply (Photo credits: Carles Castaño).*

6.3 *Ecology of mushroom and truffle species*

Fungi exhibit a high variability in their nutrition approaches and the related ecology. Pathogenic fungi feed on their hosts that they attack, usually causing tree diseases and potential landscape-level disturbances in forests. Not many pathogenic fungi are considered commercial as opposed to saprotrophic or mycorrhizal fungi. As degraders of the recalcitrant organic matter needed for nutrient cycling and the forest soil development, many mushroom-forming saprotrophic fungi are easily cultivated and sold. Frequently cultivated genera are *Agaricus*, *Pleurotus*, *Ganoderma*, *Volvariella* and *Lentinus*. The cultivated mushrooms are not regarded as wild mushrooms. Among commonly recognized non-wood forest products (e.g. wild edible mushrooms) we consider in this context only species and genera that grow in ectomycorrhizal symbiosis with living trees and shrubs or are saprotrophic species in natural habitats.

6.3.1 *Distribution patterns and productivity*

A wide range of biotic and abiotic factors influences fruit body productivity. These factors are commonly classified into three main groups: (a) meteorological variables, e.g., precipitation, temperature (Alonso Ponce *et al.* 2011; Wollan *et al.* 2008); (b) local site characteristics, e.g., soil, altitude, slope aspect (de-Miguel *et al.* 2014; Bonet *et al.* 2004); (c) forest stand structure, e.g., tree species, stand density, stand age (Bonet *et al.* 2008; North and Greenberg 1998). This subchapter will describe the main ecological factors affecting the presence of mushrooms and truffles, focusing on target species such as *Boletus edulis*, *Lactarius* spp. and *Tuber* spp. (see management of such species in chapter 6.4).

Precipitation and temperature are the main ecological factors affecting fungal distribution and fruit body production on a global scale (Sato *et al.* 2012; Straatsma *et al.* 2001; Wardle and Lindhal 2014; Wollan *et al.* 2008). Fungal yields vary strongly between years (Alday *et al.* 2017), depending on water availability and temperature, but these factors alone do not explain the whole extent of this variation (Egli 2011). Thus, increased precipitation directly causes the fungal yield to increase (Heegaard *et al.* 2016), but conditioned by other variables such as wind or temperature. Temperature is another crucial variable that determines the start of fruit body production during yearly cycles (Wollan *et al.* 2008). Certain fungal species, as widely appreciated *Amanita caesarea* and *Boletus aereus*, are thermophilic and thus their distribution is restricted to warmer habitats of southern and central Europe (Breitenbach and Kränzlin 1995; Papetti *et al.* 2011).

Even for fungal species that show cosmopolitan distribution patterns, soil properties are often a crucial factor that influences fruit body production. The *Boletus edulis* group is distributed worldwide (Águeda *et al.* 2006; Hall *et al.* 1998a), but in certain habitats specific ecological conditions are required. In

Cistus ladanifer shrublands in Spain, fruit bodies from this group are produced only in strongly acidic soils with very narrow textural range (Alonso Ponce *et al.* 2011). *Tuber magnatum* is another example of a species whose occurrence is also linked with specific soil conditions, as described by Bragato *et al.* (2004; 2010) in Istria (Croatia), and by Hall *et al.* (1988b). *Tuber melanosporum* is limited to alkaline soils (pH 7.5-8.5; Colinas *et al.* 2007), while *Tuber aestivum* is adapted to a broader range of ecological conditions, and can be found in almost every European country (Stobbe *et al.* 2013). A result from Bonet *et al.* (2004) and more recently by de-Miguel *et al.* (2014) in the Spanish Pyrenees suggests that slope, aspect and geographic exposition are a significant factor for fungal yield: northern aspects are found to be more productive for some fungal species in respect to southern, drier aspects. Fungal productivity varies along a range of altitudes. Depending on the latitude, we may observe a variation of fungal yields in altitudes that also relates with climatic conditions. The general trend is an increase of mushroom collection once we increase the altitude with a usual decrease at higher altitudes associated with low temperatures (Jang and Kim 2015; de-Miguel *et al.* 2014). In general, we may confirm that fungi are distributed over a wide range of altitudes, mostly depending on geographical position.

Numerous ectomycorrhizal fungi are species-specific towards host trees. Distribution of such species is often limited by the distribution of the corresponding host plants. As an example, *Lactarius deliciosus* group is mycorrhizal with *Pinus* sp. (Consiglio and Papetti 2009; Heilmann-Clausen 2000) and its distribution coincides with the host tree distribution. In contrast, *Boletus edulis* group species and *Cantharellus cibarius* have a broader association (Danell 1994; Hall *et al.* 1998a; Knudsen and Vesterholt 2012), linked with broadleaved and coniferous host trees. Stand density can affect ectomycorrhizal fruit body production in natural and managed conditions. *Tuber melanosporum* requires low density habitats while *T. magnatum* and *T. aestivum* fructify in stands with full canopy closure. Fungal species often follow different stages of forest succession, showing preferences towards either young, mature or old forest stands (North and Greenberg 1998). Some species fructify regularly in all forest types in respect to age classes, as Bonet *et al.* (2004) outline for the *Lactarius deliciosus* group.

6.3.2 Impact of global change on diversity, productivity and distribution patterns

The current awareness of the global environmental trends and climate change scenarios has finally reached the political ranks, due to the growing concerns on our ability to contain the decline of life-supporting resources (Rockström *et al.* 2009). According to the European Environmental Agency (EEA), both climate change and human activity are major drivers of losses in European natural resources such as biodiversity, soil, water and land (EEA 2015). In order to understand the real costs linked to such losses, integrating economic tools for the evaluation of ecosystem services, such as those developed by TEEB (TEEB 2017), is essential. They should help policy makers decide for the conservation of NWFP such as mushrooms, both in the management of human activity and in adaptation to climate change (Pedrono *et al.* 2016; Schulp *et al.* 2014).

Mushroom productivity can be affected by climate change at two levels: more immediately, through phenological shifts; and ultimately, through habitat replacement. The former can be assessed through contemporary and retrospective studies, and several reports have provided compelling evidence of such shifts (see review of Boddy *et al.* 2014). Thus, the comparison with historical records has revealed, for the summer-autumn fruiting season, a significant increase of its duration for many mushroom species (but not for all), with an average fruiting time later in the year, correlated with a delay in frosting and thus an extended vegetation season (Gange *et al.* 2007; Kauserud *et al.* 2012; Andrew *et al.* 2017). Due to the dependence of fungi on vegetation resources, it seems clear that climate warming affects mushroom phenologies indirectly (Sato *et al.* 2012; Kauserud *et al.* 2012; Gange *et al.* 2013), but climate warming may also drive a concomitant increase in mushroom productivity directly, especially for saprobic species (Büntgen *et al.* 2013). A similar study for spring-fruiting species indicated a slight tendency for earlier fruiting, correlated with elevated temperatures in winter and the earlier onset of spring (Kauserud *et al.* 2010). Due to land use changes and climate change a considerable shift in species composition over time may also take place, as e.g. seen in the studies of Simmel (2016b) and Stulik (2016) where a species numbers were quite similar but species composition had changed over time, resulting in a loss of rare and red listed species and an uprise of ubiquitous species. Such shifts, while overshadowed in the shorter term by the unpredictability of meteorological patterns related to phenomena such as the North Atlantic Oscillation (CPC 2017), spell a progressive change in the management and utilization of forest resources (de-Miguel *et al.* 2014). Thus, short-term policy responses should be directed at the mitigation of climate impacts, which is much wiser than staying inactive and hoping for the best (Pedrono *et al.* 2016).

Modelling species distributions (Hijmans and Elith 2016) according to relevant environmental variables provides potential geographical distributions for each species, and examples of this approach for mushrooms have highlighted the role of temperature in the present (Wollan *et al.* 2008) and determined potential refugia in the past (Sánchez-Ramírez *et al.* 2015). Future geographical displacements of species due to climate change can also be predicted with this approach, under current assumptions of climate trends, with compelling, albeit speculative, results. Thus, one simulation of the potential forest cover in Europe predicts that, by 2070–2100, most of France will be not be fit for central European oaks or beech, but rather for Mediterranean oaks, and Germany will lose Norway spruce and Scots pine, just to name two examples (Hanewinkel *et al.* 2013). The economic losses calculated for Europe in that study refer to wood production, but similar efforts could be undertaken (in spite of all uncertainties) for mushrooms and other NWFP: on one hand, to estimate the impacts of habitat replacement (negative as well as positive) and the costs of transition, and on the other to assess the consequences of abandonment of forest-based economic activities.

One obvious outcome of such long-term predictions is to prompt the question of what can be done today, given the relatively slow responses by forest ecosystems, to ensure an efficient transition in forest cover — and, with it, of mushroom production. The installation of prospectively more adapted forests must rely not only on climate and soil characteristics, but also on the below-ground connectivity with other ectomycorrhizal hosts (Perry *et al.* 1990; Büntgen and Egli 2014; Tubay *et al.* 2015; Lavorel *et al.* 2015). Once settled, such new plantations have a good prospect for maintaining soil health and mushroom diversity (Oria-de-Rueda *et al.* 2010). However, in spite of the overall good scores by European countries, regarding the ND-GAIN index (ND-GAIN 2017), one study has detected a lack of attention, in the European policies for adaptation to climate change, to species interactions (van Teeffelen *et al.* 2014).

6.4 Towards mycosilviculture: fungal oriented forest management and planning

The increasing importance of the edible mushrooms and truffles in the local and global markets is also increasing the interest toward suitable ways of managing and enhancing mushroom yields in forest ecosystems (Pilz and Molina 2002). Contrary to the so-called 'direct' NWFP, which are obtained directly from a particular tree species (e.g., tree fruits, cork), mushrooms are typically considered as indirect wild forest products that coexist with trees and whose provision is modulated by an array of site and stand conditions. Such 'indirect' wild forest products have been usually considered as side-products of a given silvicultural regime and not part of a predefined production goal within the framework of traditional timber-oriented forestry. Since forest fungi are tightly connected to the main element that characterize forest ecosystems (i.e., the trees), forest management and silvicultural operations are likely to influence fungal and mushroom dynamics (Egli 2011).

Silviculture has been defined as the array of treatments that may be applied to forest stands to maintain and enhance their utility for any purpose (Smith 1986), including benefits derived either directly or indirectly from the trees themselves, other plants, water, wildlife and minerals found in forested areas (Nyland 2002). Therefore, silviculture has been always regarded as the instrument for managers to retrieve multiple ecosystem services from forest systems. Within this context, mycosilviculture may be defined as the array of silvicultural treatments and operations aiming at enhancing the provision of mushrooms and truffles in order to integrate these products into multifunctional forest management planning. Indeed, previous research has shown that mushrooms can result in higher economic profit than timber in Mediterranean areas characterized by a reduced profitability of timber harvesting (Palahí *et al.* 2009), and can also represent a considerable proportion of the whole forest value even in regions where timber-oriented forestry is profitable (Tahvanainen *et al.* 2016).

Although weather and site conditions highly determine the occurrence and productivity of mushrooms and truffles in forests and agroforestry systems (see chapter 6.2), only those variables related to the stand structure and composition can be modified through mycosilvicultural operations in order to propose fungal-oriented management recommendations in large-scale forested landscapes. An exception to this are the intensively managed, cultivated systems for truffle production where irrigation may constitute an additional management tool, therefore modifying the micro-site moisture conditions. Thus, managers and landowners can mainly affect certain ecosystem attributes such as stand age, stand density, tree species composition and forest cover. Accordingly, the modification of the rotation length, stand basal area or tree species composition through forest management is expected to have an impact on fungal dynamics. Similarly, differences in fungal productivity may arise from applying either even-aged or uneven-aged forest management methods. In addition, the degree of mechanization and associated soil disturbance from timber thinning and harvesting operations may have an impact on the amount of mushrooms produced in a given forest area (see chapter 4.3).

A set of silvicultural procedures covering, among other operations, tending, thinning, pruning, harvesting and re-establishment of forest stands is referred to as a silvicultural system, which can be conducted on a continuum of forest management intensity ranging from extensive to intensive management schedules (Duncker *et al.* 2012): from rather passive systems such as unmanaged forests or nature reserves, through semi-natural systems of medium management intensity, to intensively managed cultivated agroforestry systems (Table 6.1). However, the observed pattern of occurrence of mushrooms in a certain forest ecosystem for total, edible and/or marketed productions may not be the same for individual target species since fungal species have different ecological strategies. Thus, the literature reflects very contradictory effects of silvicultural treatments on the individual species (e.g., Kardell and Eriksson 1987; Ohenoja 1988; Shubin 1988; Kropp and Abee 1996; Kranabetter and Kroeger 2001; Egli et al. 2010, Bonet et al. 2012). Additionally, most of the studies are very local or regional, and consequently between-region differences in terms of site characteristics, weather and forest structure prevent adopting general recommendations, and further in-depth analysis focusing on individual fungal species is recommended. Furthermore, the large amount of potential variables related to mushroom productivity and their interdependence makes it difficult to give clear recommendations for managing mushroom yields. Since both positive and negative effects of silvicultural operations on mushroom yield are theoretically possible, the main dilemma when considering mushroom and truffle production within the framework of mycosilviculture may be summarized as follows: i) how can silvicultural treatments enhance the provision of edible fungi, and ii) how can silvicultural guidelines be modified and adapted to increase the production of target fungal species.

Table 6.1: Silvicultural systems associated to typical forest types producing mushrooms or truffles. Management intensity refers to the periodicity of the interventions.

Forest type	Silvicultural regime	Silvicultural operations	Management intensity
Natural	Unmanaged forest / reserve	Isolated interventions	Passive
Semi-natural	Continuous cover forestry	Selective cuttings, thinning from above	Low – Medium
	Even-aged forestry	Shelter-wood methods, thinning from below	Medium
Plantation	Intensive even-aged forestry	Final felling, replanting, thinning from below, pruning	High
	Agroforestry / cultivation	Final felling, planting, fertilization, weed and shrub control, irrigation	Intensive

6.4.1 Silvicultural treatments and their impact on mushroom yields

Silvicultural operations can affect the occurrence, productivity and reproduction of mushrooms. Understanding the ecology of ectomycorrhizal fungi and the effect of forest management practices such as forest thinning, pruning, shrub and weed control or regeneration methods may contribute to improving natural mushroom production in forest ecosystems. In this chapter, we review the current state of the art of forest management practices that can contribute to enhancing mushrooms and truffles productivity and evaluate the potential of mycosilviculture.

6.4.1.1 Thinning

Forest thinning aims to manage the competition among trees by removing some individuals in order to favour the growth of the remaining trees. After tree removal, the remaining trees can increase their photosynthetic activity and allocate more carbohydrates to their root system, which benefits mycorrhizal fungal species. Other factors such as microclimatic changes in the soil layer and soil disturbance arising from forestry operations may also affect both productivity and composition of fungal species (Bonet *et al.* 2012).

While some studies have reported higher mushroom productivity in thinned stands (Kirsi and Oinonen 1981; Shubin 1988; Ohenoja 1988; Egli *et al.* 2010; Bonet *et al.* 2012), other authors have not found such trends (Kardell and Eriksson 1987). A remarkable post-thinning increase in diversity and productivity of mycorrhizal fungi has been reported by Egli *et al.* (2010) in a Swiss forest, and Bonet *et al.* (2012) found an immediate positive effect of thinning on the yield of *Lactarius* group *delicious* (Figure 6.4). Similarly, thinning of *Cistus ladanifer* scrublands can enhance the production of some valuable species such as *Boletus edulis*, *Leccinum corsicum* or *Lyophyllum decastes* (Hernández-Rodríguez *et al.* 2015). On the other hand, other studies have observed an initial negative thinning reaction on mushroom yield with a subsequent recovery of the productivity after 3 to 6 years (Pilz *et al.* 2006; Egli *et al.* 2010). This apparent contradiction may probably arise from differences in soil disturbance caused by forest harvesting operations, which was minimal, e.g., in the experiment conducted by Bonet *et al.* (2012). Therefore, low-impact timber harvesting procedures (i.e., with limited soil disturbance and compaction associated to mechanization of forestry works) may also contribute to diminishing potential negative impacts of thinning operations on mushroom yields and/or to further enhancing any positive thinning effects on fungal fructification.

Thinning intensity also seems to affect the subsequent production of mushrooms. In this regard, light to moderate thinning seems to enhance the productivity of certain mush-rooms, including important marketable species such as the *Lactarius deliciosus* group, whereas heavy thinning seems to reduce the fructification of target fungal species (Bonet *et al.* 2012).

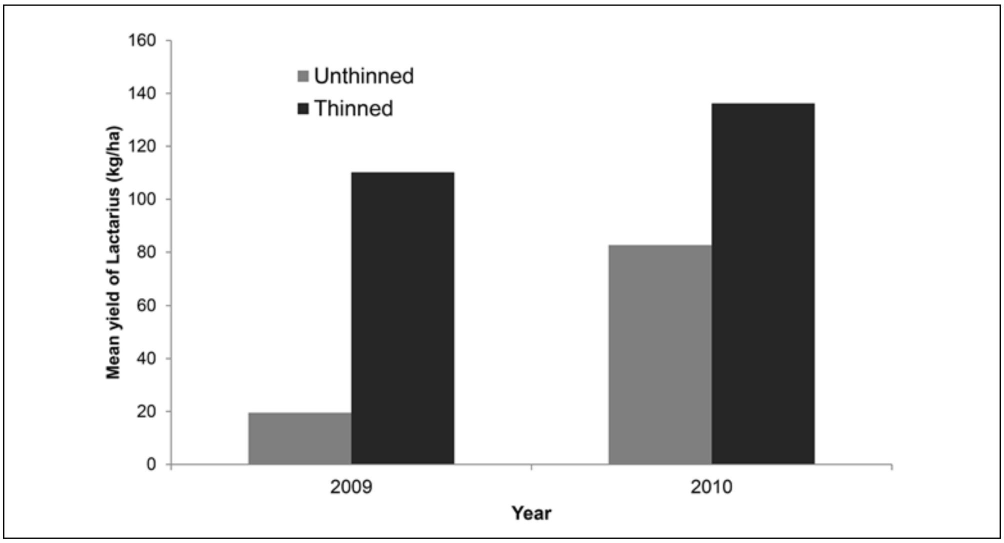

Figure 6.4: *Immediate effect of thinning on Lactarius deliciosus group yield in North-Eastern Iberian Peninsula. Thinning treatments were conducted in August 2009, right before the start of the autumn season, when Lactarius sp. fructifies (Bonet et al. 2012).*

6.4.1.2 Regeneration methods

The main regeneration methods may be summarized in the following concepts: clearcutting, shelterwood methods and selective cutting. Clearcuts and shelter-wood methods are typical of even-aged forestry, sometimes characterized by thinnings from below during the rotation period and final fellings at the end of the rotation, which implies the removal of tree cover. Although shelter-wood methods may be also regarded as transient states toward uneven-aged forestry, selective cutting is the typical regeneration method (that also comprises tending, thinning and final cutting) in continuous cover forestry, where tree cover is always maintained. Differences in colonization strategies, use of the available water and nutrients, and competitive abilities of different fungi contribute to explaining that, generally, the number of fungal species increases with stand age with a peak around canopy closure of the forest stand and the fungal community composition stabilizes at the stand reinitiation stage (Dahlberg 2001; Twieg *et al.* 2007). Some fungi are able to rapidly colonize a site after disturbance by spores or resistant propagules, whereas others need an intact mycorrhizal network that connects them to another tree for colonization. After operations such as clear-cuts, these patterns are most pronounced when no stumps and living roots from which mycorrhizal fungi could recolonize new roots are left over (Peter *et al.* 2013). Thus, negative effects of clear-cutting on mushroom productivity (at least on the productivity of mycorrhizal fungi) have been reported in previous research (Kardell and Eriksson 1987; Ohenoja 1988). However, the potential inoculum in the soil of a clearcut area may be rather similar to the adjacent forest area (Harvey *et al.* 1980; Dahlberg and Stenstrom 1991; Le Tacon 1997). At the development stage of young regenerated stands, mushroom productivity has been found to be recovered (Hintikka 1988). When vigorous adult trees are left in the stand, as in the case of shelter-wood or retention tree methods (which may be also regarded as high intensity forest thinning), the mycorrhizal fungal diversity is much higher than in clearcut stands (Peter *et al.* 2013), since the remnant trees act as fungal reservoirs allowing fungi to colonize the new offspring. Similar observations were made after windthrow, that should be considered as a natural clearcut. Ten years after a heavy windthrow event, the number of infective ectomycorrhizal fungi was significantly reduced, but the soil still contained enough mycorrhizal fungi to fully colonize ongrowing seedlings, even 10 years after the event (Egli *et al.* 2002).

In general, in an even-aged forestry framework, the integration of mushroom production into forest management planning will result in longer rotation lengths so that the forest cover allows for mushroom production over a longer period (Palahí *et al.* 2009; Bonet *et al.* 2012). In this regard, selective cutting of different intensities within the framework of continuous cover forestry may avoid temporal gaps without mushroom production inasmuch as the forest cover (of host trees) remains over time (de-Miguel *et al.* 2014).

6.4.1.3 *Pruning*

In principle, pruning may have an impact on mushroom productivity if the removal of living branches affects significantly the overall photosynthetic activity of the tree, which may further affect the allocation of carbohydrates to the root system and mycorrhizal fungi. However, such an assumption is just based on theoretical considerations, since no experiments have been carried out so far. In this regard, the only group of fungi for which pruning of host trees is recommended is represented by the genus *Tuber* in cultivated and intensively managed agroforestry systems, being the main tree hosts *Quercus sp.* and *Coryllus avellana*. Thus, during the first years after plantation establishment, pruning is carried out primarily for correcting structural defects of the host trees (Sourzat 2002) and favouring the desirable tree form associated with suitable conditions for truffle fructification (Ricard 2003). Such formation pruning or early training aims at attaining a tree crown with the shape of an oval or an inverted cone by eliminating lower branches and basal sprouts. Formation pruning may begin in the third year depending on the vigour of the plant and should be of low intensity (Bonet *et al.* 2009). This pruning procedure may influence positively *Tuber*, aiming at increasing the amount of light that reaches the ground providing additional space for installing irrigation systems, which may further increase both truffle productivity and the efficiency of truffle collection in the future (Reyna 2012).

6.4.1.4 *Weed and shrub control*

Weed and shrub control is only considered as a normal practice in intensively managed truffle plantations or agroforestry systems. During the first 2 to 4 years after plantation establishment, the area around each tree should be kept free of weeds by using manual hoes (Bonet *et al.* 2009) or mulches (Olivera *et al.* 2014b). This is supposed to increase the survival rate of the host trees by eliminating competition for water and nutrients while increasing the proliferation of mycelium. In the rows between each tree, the land should be cultivated with suitable tools allowing shallow treatments reaching a soil depth not greater than 15 to 20 cm (Reyna 2012). Once the typical ‘burnt’ area provoked by the truffle’s allelopathic activity appears, some landowners further suppress weed development by means of mechanical tools, i.e., with depth-control tines reaching a soil depth not greater than 10 cm, which also contributes to soil aeration.

6.4.1.5 *Fertilization*

Previous research has observed a positive effect of sporadic fertilization on mushroom dynamics (Hora 1959; Kutafyeva 1975), although other studies have reported a decrease in mycorrhizal productivity and diversity in the third or fourth year after the continuous application of fertilizers (Termorshuizen 1993; Ohenoja 1989; Cox *et al.* 2010; Lilleskov *et al.* 2011). Since ectomycorrhizal symbiosis is generally regarded as an adaptation to conditions of nitrogen (N) scarcity, when N availability increases, trees allocate less carbon to the roots and mycorrhizal symbionts, and more to the aboveground biomass (Peter *et al.* 2013). Based on these assumptions, fertilization of black truffle plantations has been recommended only if the soil has an exceptionally low concentration of a particular nutrient in order to compensate for such deficit (Olivier *et al.* 2012). However, a common practice in areas with acidic soils is to gradually add slow-release calcareous corrections with $CaCO_3$ before cultivating the land. It is worth highlighting that these procedures are generally carried out in intensively managed systems and not in natural forest stands.

6.4.1.6 Irrigation

Irrigation is not a common practice in forest stands, although a positive effect on mushroom yield might be expected (e.g. Wiklund *et al.* 1995; Sarjala *et al.* 2005). In black truffle plantations, regular watering is recommended during the first years until the root system is well established and, later on, in the productive phase in order to stabilize the annual fluctuations in truffle yield caused by interannual changes in the meteorological conditions (Olivier *et al.* 2012). However, similar to the above-described effect of fertilization, excess water could also cause a decrease in the amount of black truffle production (Bonet *et al.* 2006; Olivera *et al.* 2011). Recent studies (Olivera *et al.* 2014a) highlighted the need for introducing moderate irrigation doses in order to increase the presence of *Tuber melanosporum*. Accordingly, they recommend complementing natural precipitation up to 50% of the evapotranspiration during the first half of the growing season, and allowing for some slight water stress before the autumn rains.

6.4.1.7 Prescribed burning

As alternativ to thinning, vegetation may be also managed by means of prescribed burning. Depending on the characteristics and intensity of a given burning prescription, a considerable post-fire increase in soil pH can occur, and negative impacts can be caused to upper roots and mycorrhizas (Certini 2005). This effect could be especially severe in the presence of great amounts of fuel load (i.e., vegetation biomass) as well as in the particular case that fire spreads slowly throughout the target area to be managed. This could even entail the total destruction of the rhizosphere system whose restoration could take many years. In a study on the short-term effects of wildfire on fungal communities in Mediterranean ecosystems in north-western Spain, dominated by *Pinus pinaster* and *Cistus ladanifer*, Martin-Pinto *et al.* (2006) found a decrease in total fungal dry weight in burned plots along with a significantly lower richness, and diversity of mycorrhizal species and lower production of edible fungi. However, although controlled burning needs to be applied with caution to avoid undesirable ecological and economic effects, some fire-prone pyrophytic or pioneer taxa of edible fungi such as the genus *Morchella* can be favoured immediately after fire events (e.g., Larson *et al.* 2016). Fernández de Ana (2000) also observed an increase in the production of *Tricholoma equestre*, *T. portentosum*, *Lactarius deliciosus* or chanterelles mushrooms after prescribed burning in *Pinus pinaster* forests of north-western Spain, using fire as management tool so that the tree root systems were maintained alive after the prescribed burning. The benefits of prescribed burning for promoting the yield of certain mushroom species may be more suitable in areas where the soil pH is very low since burning may not modify drastically the conditions of such acidic soils, especially if the fuel load is small. On the other hand, where the burning bush is thick and there is little fuel load, then the fire effect can be similar to a slashing, in the sense that no significant alterations in the ecosystem occur.

6.4.2 Important edible commercial wild forest mushrooms

Other than black truffle (*Tuber melanosporum*) yields, which have been the object of much research due to its high economic value and the progressive shift of its production from natural forests to cultivated agroforestry systems, the edible commercial fungal species most studied from a silvicultural perspective so far have been the *Boletus edulis* group and *Lactarius delicious* group. Cep (*Boletus edulis*) represent one of the most valuable and traded mushroom species worldwide, and *Lactarius deliciosus* group mushrooms are also highly appreciated in some countries and regions.

CASE 6.3: *Silvicultural recommendations for Boletus edulis production*

Martínez-Peña *et al.* (2012) reported that the optimal stand basal area that seems to maximize *B. edulis* production in *Pinus sylvestris* forests of central Spain is around 40-45 m2/ha (Figure 6.5). The influence of forest stand conditions was also observed in Italy, where Salerni and Perini (2004) found the greatest number of *B. edulis* fruit bodies in thinned stands with moderate thinning intensity, whereas very low production was found in the stands subjected to heavy thinning. The authors concluded that this species does not need a dense canopy in mixed forests (i.e., *Abies alba*, with a minor presence of *Picea abies*, *P. nigra* and *Acer monspessulanum* in that study), but an open and sunny habitat for maximizing their yields. The influence of clearing and the burning of the vegetation on *B. edulis* production in *Cistus ladanifer* scrubland ecosystems in Western Spain has been studied by Hernández-Rodríguez *et al.* (2015). *Cistus* scrublands are a source of highly appreciated boletes, which normally appear after a disturbance, namely clearing or fire. The authors observed that the production of *B. edulis* sporocarps is expected to start at about 5 years after treatment, whereas the maximum production, which can achieve more than 50 kg/ha/yr is reached at 14 years. According to this study, *B. edulis* production starts when the mean height of the scrubland reaches one metre, and achieves its maximum at a mean height of 1.5 metres. The highest production was associated with a shrub canopy cover of 80 %, which is reached already at early ages (before 10 years) and maintained during the rest of the life cycle of *C. ladanifer*, which also matches with the findings of the aforesaid research conducted by Salerni and Perini (2004) in a very different ecosystem.

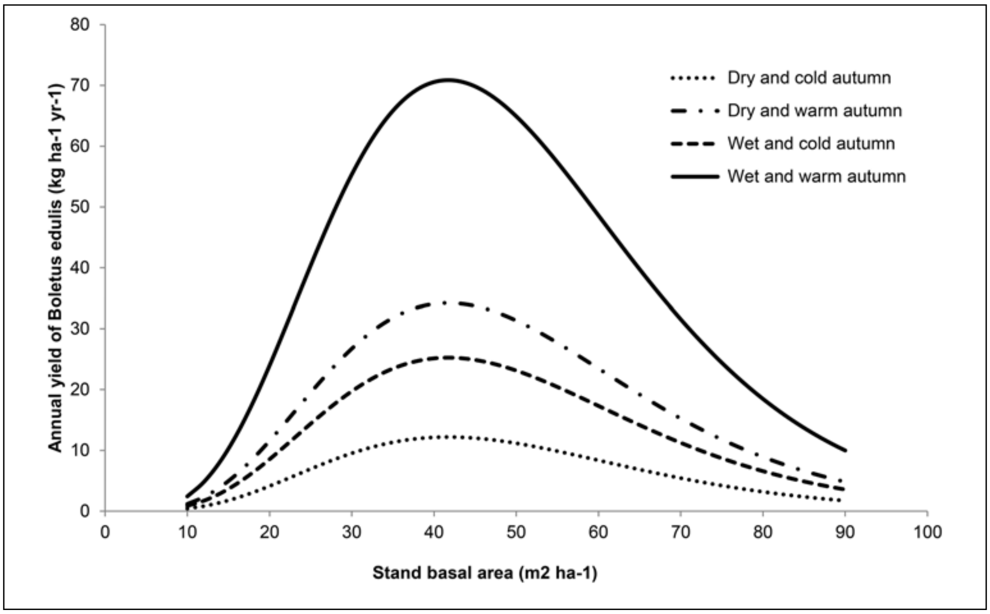

Figure 6.5. *Relationship between annual yield of B. edulis and stand basal area in Pinus sylvestris stands (Martínez-Peña et al. 2012).*

Under boreal conditions, Tahvanainen *et al.* (2016) found that *B. edulis* yields increased along with stand age until a certain point (30 years), after which the yields started to decline. They also reported that thinning can improve *B. edulis* yields, although only slightly. According to the simulation results, advanced thinning (i.e. five years earlier than recommended for timber production) was the most suitable schedule for *B. edulis* production. On the other hand, they also realized that *B. edulis,* as an ectomycorrhizal fungal species, suffers from regeneration cuttings of spruce stands. In such forest systems, *B. edulis* production increases along with stand development so that the highest yields are obtained just before the first commercial thinning (at the age of 25-30 years and stand basal area of 25 m2/ha). The yields of *B. edulis* increases after the first thinning and also after the second thinning but to a lesser extent. Thinning opens up the canopy and rainfall is more likely to wet the forest floor, which may promote mushroom yields after thinning.

CASE 6.4: *Silvicultural recommendations for Lactarius group deliciosus production*

Saffron milk caps (*L. deliciosus*) have been described as an early colonizer of plantations (early-stage fungi), and found in greatest abundance in young stands (Fernandez-Toirán *et al.* 2006). Martínez-Peña (2009) observed two peaks of production in Scots pine (*P. sylvestris*) forests of different age classes, the first peak occurring at the age of 16-30 years and the second one at the age of 70 years. However, Bonet *et al*. (2004) found saffron milk caps along all age classes and on all aspects of *Pinus sylvestris* plantations in North-east Spain. Such an apparent contradiction may be explained by the fact that open forest conditions with relatively low basal areas typical of the early stage of natural forest succession (before canopy closure), but that can be found also within mature stands, are favourable for saffron milk cap production. Thus, the use of silvicultural treatments to decrease the density of older stands may contribute to enhancing *L. deliciosus* production, assuming that forest stand structure is more relevant to saffron milk cap productions than stand age.

The empirical models for *L.* group *delicious* developed by Bonet *et al.* (2008) and Martínez-Peña *et al.* (2012) further supported the importance of stand basal area as the most relevant predictor, in terms of the silviculture and forest management for *Lactarius* yields. Bonet *et al.* (2012) found that light to moderate thinning treatments (i.e., around 10 m2/ha of basal area removal) affected positively *Lactarius* yields during the first two years after the forest thinning, whereas heavy thinning (i.e. beyond 35 m2/ha of removed basal area) would result in a reduction of fungal yields as compared with unthinned plots (Figure 6.6). Preliminary results based on the continuous inventory of mushrooms during the years 2011-2015 suggest that the thinning effect on the production of *L. deliciosus* group may fade away after two or three years after thinning. This suggests that *L. deliciosus* group has a high adaptive ability to different stand structures partly due to the particular and diverse habitat preferences of the individual species included in the group *deliciosus* (*Lactarius deliciosus*, *L. vinosus* and *L. sanguifluus*). This also contributes to the idea that the *L. deliciosus* group prefers growing in relatively open forest conditions and when stand age is close to the period of highest tree growth. This coincidence sounds reasonable from the ecological point of view since saffron milk caps are ectomycorrhizal fungi that grow in symbiosis with forest trees. Based on that, one could expect that the maximum mushroom productivity matches with the maximum tree growth due to the high quantity of carbohydrates produced by the trees and shared with the mycorrhizal fungal communities. However, the analysis of such relationships conducted so far have shown no clear temporal synchronization between annual mushroom yields and seasonal wood formation, except for some pine stands growing on quite xeric sites (Primicia *et al.* 2016).

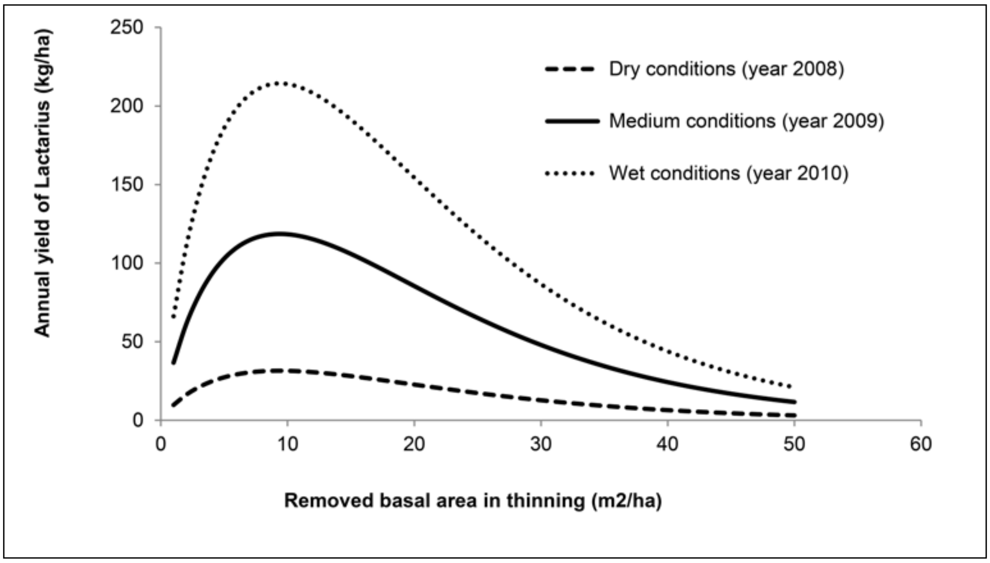

Figure 6.6: *Relationship between the annual yield of Lactarius group deliciosus and removed basal area in thinning in the years of study (Bonet et al. 2012).*

6.5 Socieconomy linked to mushrooms and truffles in rural areas

Wild mushrooms have been used and traded as food or medicinal products practically everywhere in the world (Boa 2004). Each country has regulated the harvesting rights differently, with direct impacts on the socio-economic values created through the wild mushroom uses. Wild mushrooms may be commercialized as products for the international or niche markets, or as recreational service, in which a picker purchases a picking permit for collecting wild mushrooms. The economic performance may be very different according to the targets of policy makers. This subchapter reports a set of case studies through which we may understand the complexity and the potential value of European forest if proper policies are offered. Moving from the case of export-oriented countries like Serbia, we will describe the strategic effect of wild mushroom trade on the remote rural areas in Romania that are the key suppliers for Spain and Italy, countries where the commercialization of wild mushrooms is still an important activity for the local niche markets, while a new form of income is generated with the commercialization of picking permits or with the new establishment of truffle production in a country.

Trade is the main engine of the wild mushrooms economy that has had a positive growth in terms of volumes and values recently at a global scale (Pettenella *et al.* 2014). A general overview of European trade of wild mushrooms gives an understanding of the scale of the market and the implications that trade might have on the trans-boundary effects of national policy with regard the market. The trade balance of EU28 (external and internal EU28trade) has been negative for the fresh and frozen mushrooms (Figure 6.7) according UN-Comtrade data, while only after 2012, the trade of dried and preserved mushrooms moved to a positive net balance, due to the increment of prices of Chinese supply (Figures 6.8 and 6.9).

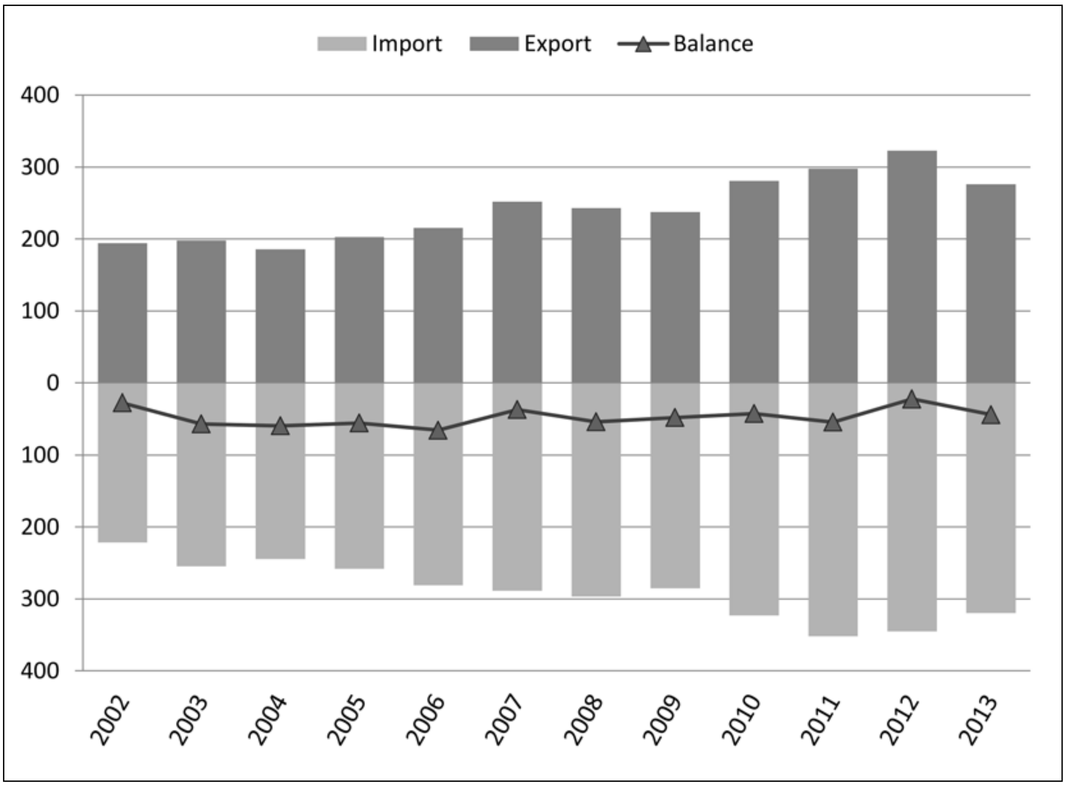

Figure 6.7: *EU28 trade balance for fresh and frozen mushrooms other than Agaricus species in million € (HS-070959)*

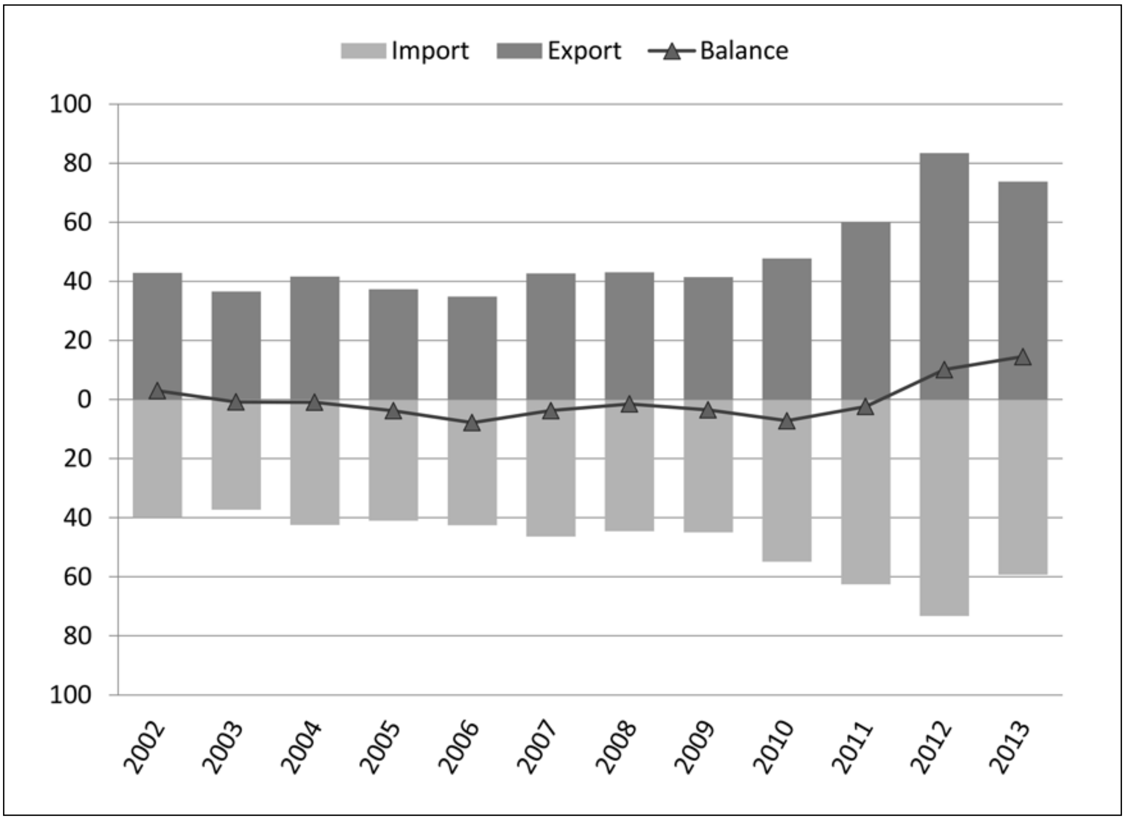

Figure 6.8: *EU28 trade balance for dried mushrooms other than Agaricus species in million € (HS-071239)*

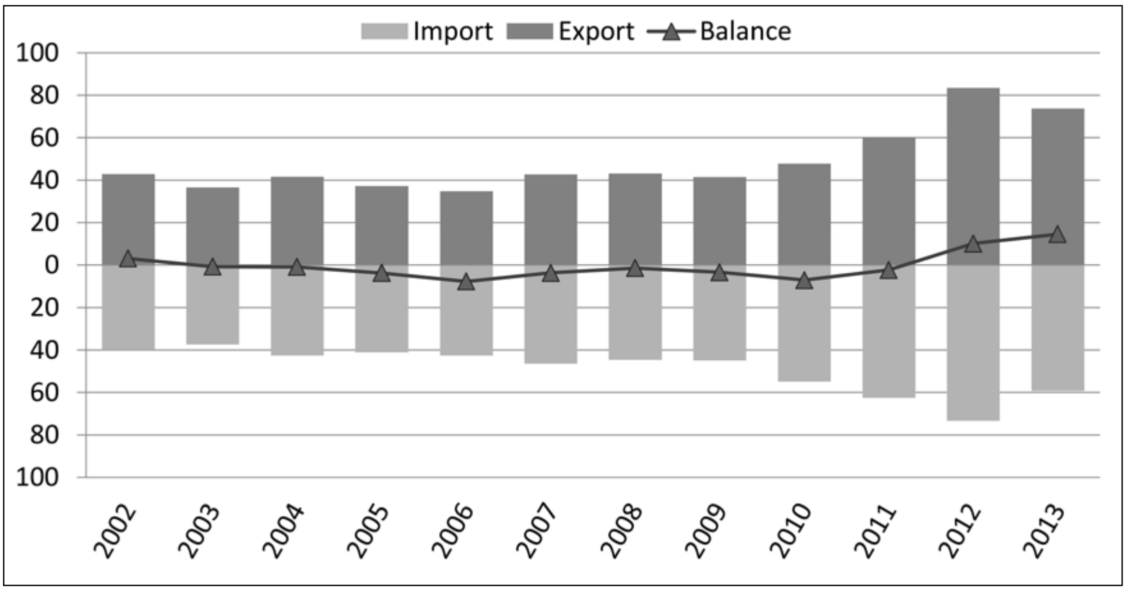

Figure 6.9: *EU28 trade balance for preserved mushrooms other than Agaricus species in million € (HS-200390)*

The estimations cannot be precise because a specific overview of wild mushroom trade would need higher resolution data, which may be only available in some countries through their official statistics. Anyhow, the UN-Comtrade database represents a key data source for studying the global overview of a commodity traded internationally. A precise trade overview can be done only for specific commodities like truffles, clearly with a positive net balance both as fresh and frozen product as well as final product (see Figures 6.10 and 6.11), thanks for the natural availability of truffles in Europe and the limited capacity of truffle plantation outside Europe.

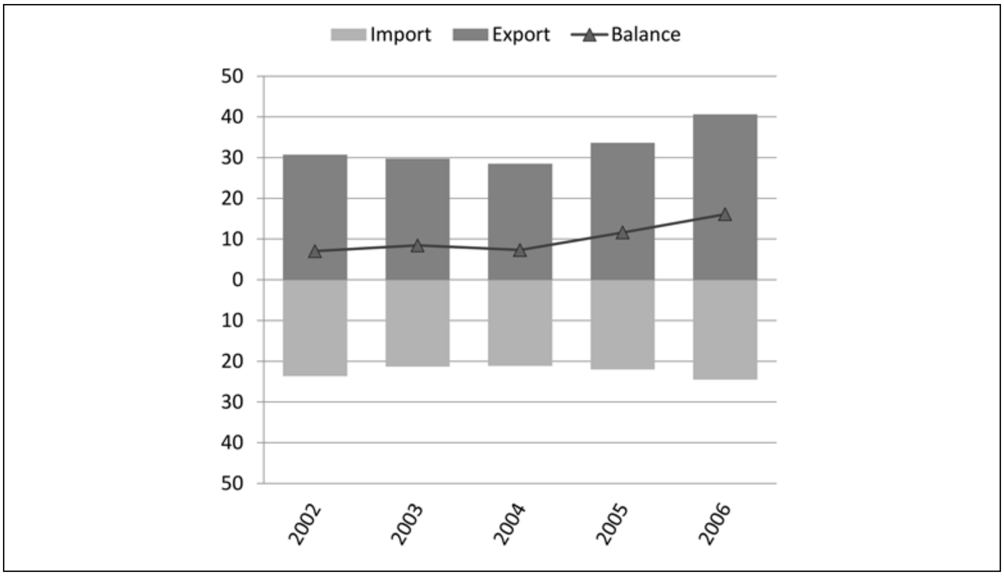

Figure 6.10: *EU28trade balance for fresh and frozen truffles in million € (HS-070952)*

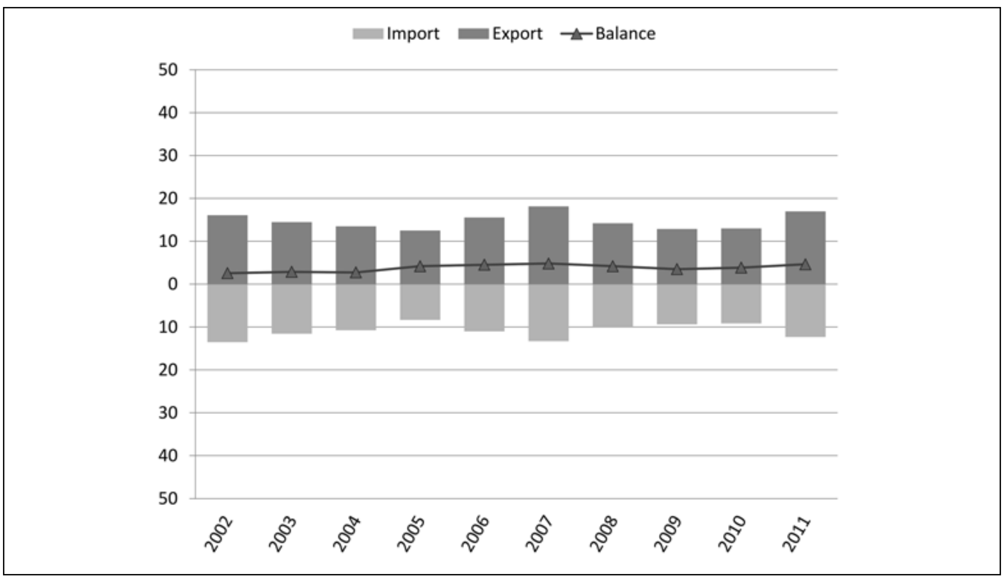

Figure 6.11: *EU28trade balance for preserved truffles in million € (HS-200320)*

International trade is affected by national policies that may stimulate or inhibit wild mushroom production and export. For instance, the Western Balkans, as well as Serbia, are known for a rich spectrum of wild mushrooms that facilitates a large scale use. Thanks to the increasing of European demand, Serbia has enabled companies to become more oriented towards export of wild mushrooms (Keča *et al.* 2014); in 2007, Serbia exported a little over 7 million € worth of fresh (chilled) forest mushrooms to the EU. In second place was the export of dried forest mushrooms, at about 6.2 million €, followed by preserved forest mushrooms at 2.6 million €. The collection and export of mushrooms is a highly regulated activity and the government establishes an annual quota for the collection of wild mushrooms, limiting the total quantity available for exports for the stimulation of products with added value (Keča *et al.* 2015). The production of wild mushrooms is very inconsistent due to the variability of the climatic conditions; consequently, the supplied quantity in the market follows the wild mushroom availability in the forest (Figure 6.12).

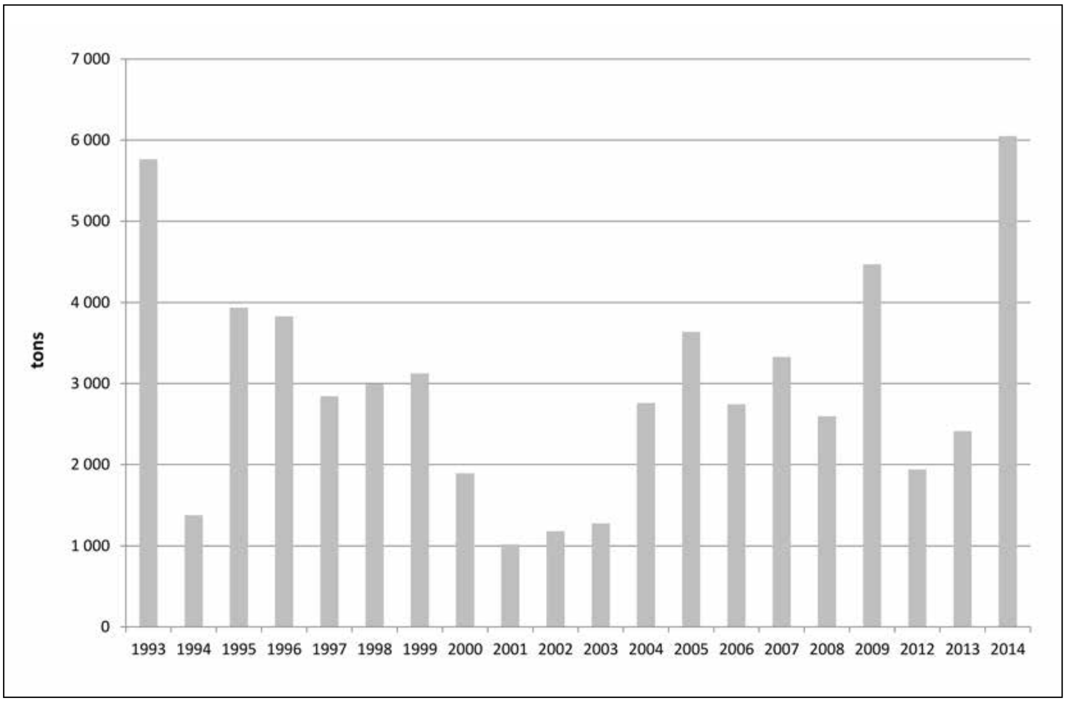

Figure 6.12: *Production of wild mushrooms in Serbia (in tons) (Source: Keča et al. 2015).*

Important species such as Boletus edulis, Cantharellus cibarius, Craterellus cornucopioides, Lactarius deliciosus, Marasmius oreades, Tuber aestivum and T. magnatum are collected by an estimated 125 000 individuals in rural areas (Keča et al. 2015). The forest productivity is around the 21.5 kg of wild mushrooms per hectare (Keča et al. 2013), a quantity that may be translated in terms of economic value that ranges approximately between the 40 and 60 €/ha considering the cep price. In general, wild mushrooms pickers sell their harvest to the “purchase stations”, which are usually located near the wild mushroom companies. The pickers are a crucial element of the supply chain because they represent the suppliers for the 152 registered companies dealing with NWFP (Ministry of Agriculture and Environmental Protection, Internal document, 2015), among which 51 of them deal with mushrooms. A survey carried out on 43 wild mushroom companies showed that each company has on average more than 10 permanent workers, with an annual supply capacity of over 50 tonnes of mushrooms both for domestic and foreign markets (Keča et al., 2015). Moreover, the survey highlighted that the companies are generally involved in buying and processing of raw and semi-processed wild mushrooms, though they are moving quite fast on the commercialization of final products. Wild mushroom prices depend on the balance of supply and demand through the year (see Table 6.2). The price usually covers the main supply costs like the fee costs for the purchasing facilities, costs of raw materials, followed by the cost of cleaning, processing, packaging, transportation, as well as the costs of promotion and the time of year when mushrooms are harvested. Almost all enterprises indicated that the price at which they sold was decided on a "cost plus" basis, or in other words, a price set up multiplying the total cost by a factor that corresponds to the net profit the seller wants to have.

Table 6.2: Average prices of forest mushrooms in Serbia (Source: Keča *et al.* 2015)

Product	**Average price (€/kg)**
Dry Chanterelles	12.25-53.9
Dry Bolete	9.3-49.1
Fresh Chanterelles	3.43-16.38
Brined Chanterelles	2.25-12.26
Brined Bolete	2.25-11.77
Deep frozen mushrooms	5.40
Fresh Bolete	2.21-2.94

Another case of an export-oriented country is Romania, in which the wild mushroom trade allows the transfer of a consistent flow of money to remote rural areas. Well recognized for the richness of its forests, Suceava is an administrative unit located in North-East Romania with good natural conditions for mushroom production. Mushroom collection is traditionally practiced by household members for personal consumption and by poor segments of the rural population to supply local markets. For almost ten years, there has been an intensive trading of mushrooms and berries along the main road crossing the region. Alongside this, an export-oriented mushroom business is flourishing, with collection points all around the Suceava county. This facilitates the transfer of the harvest to a large processing centre in Western Romania. The official production sold every year by the national forest administration in Suceava region accounts on average for 150 tonnes, though specific studies seem to indicate a production of 50 tonnes sold on the informal market (Bouriaud *et al.* 2015a). The mushroom business in the region is based on an estimated number of 600 to 700 pickers. Less than 100 of them are selling the mushrooms directly at the roadside or in the farmers' markets, and some 500 to 600 sell the collected mushrooms to the trading firms or intermediaries. In Suceava, there are in total ten firms legally registered, which rely also on an undefined number of intermediaries acting on behalf of other firms located in Suceava or other surrounding regions. For instance, the study conducted by Bouriaud *et al.* (2015a) indicates at least seven firms in this semi-legal situation, but the real number may be substantially higher.

Pickers can generate an important income from wild mushroom collection. This is done on a family or a group network basis with an average number of four persons in case of families or eight in case of larger networks organized during the season (May to September). For most of the pickers, the income from mushroom selling represents the only or a substantial part of the family income (Bouriaud *et al.* 2015b). In a good season, they can sell between 10 to 60 kg of mushrooms per day (usually cep and chanterelle, but also *Armillaria* spp. at the end of the season). The quantities unsold at the end of the day will be consumed by the household. At a price of 2,5 €/kg (cep, end of 2014 season), and a number of 30 working days, the monthly income varies between 750 € and 4,500 € in the case when mushrooms are sold directly in the farmers' market or next to the road. The income is shared amongst the collectors, that means on average four people (family) or eight (larger pickers' networks), which means that the income may reach up to 2,500 € for a family with one or two children. This data is confirmed in another study published in a German newspaper (Cadenbach 2015), which quotes a 22 € income per day per person from mushroom picking by Roma people in Western Romania. All these results do not consider the pickers' costs for transportation that varies between 10 and 100 km to reach the collecting places by train or car. When the production is sold to intermediaries, the estimated income is less than half of this figure (one family may get between 500 to 1,000 € income per season) meaning that pickers earn more when selling the harvest directly to the final customer along the road than when selling to the firms. This is due to the fact they do not pay any tax and they do not pay any fee for the right to collect the mushroom in the forests, a right which is normally reserved to the forest owner, but rarely enforced. The income generated by wild mushroom picking is used for immediate consumption like food, firewood, sometimes something for the home (e.g. a TV) or for paying school-related items (the school is free of tax, but some social categories cannot afford to pay appropriate shoes and clothes for sending children to school). Almost all the pickers are entitled and receive social assistance from local government, as they belong to a very poor social category. For this reason, some of the people interviewed were reluctant to speak about their mushroom-related income. On the other hand, in the rural areas where the pickers live, there are scarce employment opportunities. For instance, a municipality of 5,000 inhabitants may have only 240 employed people. In general, the active population in rural area is occupied with subsistence agriculture. However, most of the pickers do not own land. They sell therefore their traditional knowledge on mushroom picking, getting an income critically needed for family welfare.

The two examples of Serbia and Romania show how important the economy of wild mushroom business is for rural development; especially the case of Romania demonstrates the crucial importance on household welfare were the state often fails to support economically poor segments of the rural society. Despite the fact that many authors bind NWFP with poverty (Marshall *et al.* 2006), the wild mushroom economy may be an important source of income for the forest managers in the industrialized countries even if the wild mushrooms are sold more as a service rather than a product. One example of how edible mushrooms can impact in a rural development is the case of Castilla y León region in Spain. The region has more than 4.5 million productive hectares, of which 1.5 million hectares are forests with great capacity for the production of edible wild mushrooms with a high market value. These include species recognized around the world as the black truffle (*Tuber melanosporum*), cep (*Boletus edulis* group), saffron milk caps (*Lactarius deliciosus* group), chanterelles (*Cantharellus cibarius*), St. George's mushrooms (*Calocybe gambosa*), morels (*Morchella* spp.), and more than 50 other wild edible species. Castilla y León also has centuries-old forests and a high level of use and management of mycological resources that, although still very much emerging, is one of the most developed in Spain (Martínez-Peña *et al.* 2012). It is estimated that every year the rural environment of Castilla y León receives an average of 251,029 mushroom tourists from the urban areas of different Spanish regions including from Castilla y León. These harvesters (tourists and day-trippers) spend money in the rural areas during their harvesting visits. The region also attracts other tourists and day-trippers every year for mycological culture or food, who are not necessarily harvesters (Latorre 2014). It is estimated that the mycological sector of Castilla y León can, in a good year, generate up to 65 million €, of which 20% is direct income from harvesters selling mushrooms, 40% is value added by the agro-food industry, 39% is value added by mycotourism and 1% is ownership right (Martínez Peña *et al.* 2015). The same source also calculated that approximately 50% of restaurants in the region serve wild mushrooms, thus generating added value of greater than 9 million € /year. Average yearly costs for a mycotourist was estimated of 130.6 € /year; nevertheless the estimation may be higher or lower if we consider that a mycotourists in Castilla y León who stayed overnight spent 214.7 € per person per year or day-trippers that spend approximately 72.8 € a per person per year. Applying this value to the total number of mycotourists estimated above, the total average spending of mycotourists in Castilla y León is estimated at 32.7 million € (Latorre 2014). After more than ten years of consolidation of the program of mycology of Castilla y León and around 8.5 million € invested in the regional government and provincial councils (52%), the European Union (38%) and the Spanish State (10%), Castilla y León is a region recognised internationally[28] . The system currently runs without a public subsidy thanks to the average annual income of 0.5 € per hectare generated by the sale of harvesting permits, which guarantees the control of mushroom use and respects their ownership rights, while also allowing locals and visitors to collect mushrooms. In June 2016, the program accounted 408,893 hectares of public forests in Castilla y León where mushroom harvesting was regulated through the issue of permits.

CASE 6.5: *Truffle cultivation in Austria – domestication of an ectomycorrhizal gourmet fungus?*

In Austria, local truffling was almost forgotten, and truffle cultivation had not yet been established. The legal status of harvesting wild truffles in Austria is complex (nine different federal laws regulating nature protection and fungi collection. A project (1998-2002; Austrian Research Promotion Agency co-funded), laid the foundation for documenting truffling in Austria (e.g. Urban and Mader 2003), for the discovery of previously not reported truffle species (e.g. *T. brumale*; Urban and Pla, unpubl.), and for research on truffle cultivation. The project resulted in the foundation of TrüffelGarten (supported by INITS, an incubator for academic spin-offs), a company producing controlled mycorrhized seedlings and providing consultation for truffle plantation establish- and management. The initiators of truffle cultivation in Austria did not promote harvesting of wild truffles and, specifically, the training of truffle hunting dogs, to avoid conflicts with stakeholders and nature conservation. Wild truffle populations are primarily considered as a valuable genetic resource for truffle cultivation (Urban and Pla 2009).

The main Tuber species currently cultivated in Austria as a NWFP is *T. aestivum* f. *uncinatum*, the Burgundy truffle. The different eco- and genotypes of *Tuber aestivum* s.l. (Molinier *et al.* 2016) cover a wide amplitude of ecological conditions and habitat characteristics. Its cultivation has a large potential in Austria (Chevalier 2012), but truffle orchard management is less studied, compared to the Périgord truffle (*Tuber melanosporum*). The Tuber *aestivum/uncinatum* European Scientific Group (TAUESG) promotes research and exchange on this species on a European scale. In Austria, most habitats currently known are in planar, colline and submontane zones, typically on lime-rich soils, suggesting that this species is limited by colder climates and the more acidic soils prevailing at higher elevations.

28 See for instance the three main Projects related to mycotourism developed by Castilla y Leon: www.micocyl.es, www.micosylva.com, www.mercasetas.es

Since the foundation of TrüffelGarten in 2003, many plantations have been established in Austria and in other European countries, by private initiative and investment. This resulted in a multitude of experiments with little scientific monitoring, due to a lack of funding. Since the first harvest of a cultivated Burgundy truffle in October 2008, the results are increasingly promising, however, due to a lack of irrigation facilities in most plantations, highly dependent on climatic conditions. In 2016, after abundant precipitation in spring and summer, the season provided a major harvest by July (Figure 6.13) in a plantation first established in 2004. In several other plantations, first harvests were recorded (http://www.trueffelgarten.at/aktuell/).

Truffle cultivation in Central Europe opens up many possibilities for gastronomy, tourism, rural economy and sustainable development. More funded research is needed to optimize plantations making yields more reliable and amplifying the success of truffle cultivation as a NWFP.

Figure 6.13: *Truffle production in Austria (Photo credits: A. Urban)*

The brief descriptions of the above-mentioned case studies shows the real possibility to develop a wider income portfolio from the forest sector. Achieving this with wild mushrooms is not easy but potentially wild mushrooms can readily contribute to household incomes and welfare in remote rural areas. Commonly policy makers pay little attention to the economy that can be generated from wild mushrooms and other NWFP, but there is a clear need from companies and citizens to promote a slow change toward a greener economy. In a recent study (Vidale *et al.* 2016), it was highlighted that the future policies on wild mushroom collection should go far beyond the harvest limitations in terms of quantity. They also should consider these new professional activities of the forest sector within a fiscal system that takes into account the high-risk annual weather conditions on yields, as in the described Serbian case.

6.6 Conclusions

Forest fungi play a key role in forest ecosystem functioning by contributing to nutrient turnover from litter and wood, tree nutrition and carbon sequestration. Fungi are also an important piece of the biodiversity puzzle. Approximately 12,500 fungal species of macrofungi alone grow in Europe, which means that fungal species richness is higher than in the case of animals or plants. In addition, wild edible fungi are also considered a valuable NWFP throughout the world. Fungal fruit bodies have been traditionally used by different civilizations up to the point that more than 1,100 fungal species are consumed worldwide as food or medicine (the number rises to 2,800 species if uses such as cosmetics or toxicology are also considered). However, the knowledge on mushrooms and the species used vary among different regions of the world. For instance, 268 fungal species are authorized for trade in all the European countries with relevant differences between countries. In spite of the growing interest in mushrooms and truffles in Europe, little is known about fungal productivity as well as about the different factors influencing the presence of the fungal fruit bodies in different forest ecosystems. This is mainly due to the short above-ground appearance of those species which implies conducting long-term monitoring and repetitive inventories in order to properly characterize fungal communities in target ecosystems. The consequence is the scarce scientific information on fungal ecology and productivity throughout Europe. This also implies that forest managers who wish to optimize forest conditions for enhancing mushroom production do not have sufficient site-specific or species-specific information available for developing a suitable fungal-oriented forest management by means of the so-called mycosilviculture. This chapter aimed to compile the scattered available information on fungal ecology, productivity and socioeconomics, summarizing the suitable techniques and tools for enhancing mushroom and truffle production within the context of the multifunctionality of European forest ecosystems.

In spite of the growing interest on the forest mushrooms and the consequent increase of research efforts, gaps of knowledge still exists. As a conclusion of the chapter, the authors identified the needs of further research in the next key points:

- There is an unbalanced knowledge about fungi in Europe. Therefore, there is a need for increasing research efforts towards developing the missing national red checklists of endangered fungi species.
- The factors affecting mushroom emergence need to be further understood. Besides the effects of site, stand and weather variables on mushroom yields, also the interactions of these variables also needs to be clarified.

- Scenarios for landscape change associated with global change are needed and how this may affect the fungal communities.
- Long-term effects of forest management practices need to be monitored and analyzed. Forest management practices which favour mushroom yields need to be identified.
- Besides *Tuber* species, (semi)cultivation with other ectomycorrhizal species need to be studied.
- More research on fungal communities is needed with broadleaves species, rather than coniferous species.
- There is a need to carry out long-term studies on the dynamics of fungal communities.
- There is a need to estimate the economic impact of the global climate change on mushroom fruiting and thus trading possibilities at different scales (from local to global).
- There is a need to highlight the real value of the mushroom market (informal market) and their contribution to the rural economies and especially to low income groups.
- Harmonization of policies at European scale (for example: toxicology. – i.e.: *Tricholoma equestre*) are necessary.

6.7 References

Águeda, B.; Parladé, J.; de Miguel, A. M.; Martínez-Peña, F. 2006. Characterization and identification of field ectomycorrhizae of *Boletus edulis* and *Cistus ladanifer. Mycologia*, 98(1): 23-30.

Alday, J.G.; Bonet, J.A.; Oria-de-Rueda, J.A.; Martínez de Aragón, J.; Aldea, J.; Martín-Pinto, P.; de-Miguel, S.; Hernández-Rodríguez, M.; Martínez-Peña, F. 2017. Record breaking mushroom yields in Spain. Fungal Ecology, 26: 144-146.

Alonso Ponce, R.; Águeda, B.; Agreda, T.; Modrego, M. P.; Aldea, J.; Fernández-Toirán, L. M., Martinez-Peña, F. 2011. Rockroses and *Boletus edulis* ectomycorrhizal association: realized niche and climatic suitability in Spain. *Fungal Ecology*, 4(3): 224-232.

Andrew, C.; Heegaard, E.; Kirk, P.M.; Bässler, C.; Heilmann-Clausen, J.; Krisai-Greilhuber, I.; Kuyper, T.; Senn, B.; Büntgen, U.; Diez, J.; Egli, S.; Gange, A C; Halvorsen, R.; Høiland, K.; Nordén, J.; Rustøen, F.; Boddy, L.; Kauserud, H. 2017. Big data integration: pan-European fungal species observations as assembled in the ClimFun meta-database opens for addressing questions in fungal ecology and global change biology. *Frontiers in Ecology and the Environment* (submitted).

Arif, T.; Schiel, H.; Bartecka-Mino, K. 2016. *Amanita phalloides* ingestion in children in Austria, 1996 to 2014. Poster Abstract 300. 36th Congress of the European Association of Poisons Centres and Clinical Toxicologists. 24-27 May 2016. Madrid.

Arnolds, E.; Veerkamp, M. 2008. Basisrapport Rode Lijst Paddenstoelen. – Nederlandse Mycologische Vereniging, Utrecht.

Bässler, C., J.; Müller, M. W.; Cadotte, C.; Heibl, J. H.; Bradtka, S.; Thorn, S.; Halbwachs, H. 2016. Functional response of lignicolous fungal guilds to bark beetle deforestation. *Ecological Indicators* 65:149-160.

Berndt, S. 2016. Aktuelles aus der Mykologie: wenig bekannte Pilzvergiftungen. Biologie in unserer Zeit 3/2016(46): 170-176.

Boa E. 2004. Wild edible fungi: A global overview of their use and importance to people. Non-Wood Forest Products report nº 17. Rome: FAO, ISBN 9251051577. http://www.fao.org/docrep/007/y5489e/y5489e00.htm.

Boddy, L.; Büntgen, U.; Egli, S.; Gange, A.C.; Heegaard, E.; Kirk, P.M.; Mohammad, A.; Kauserud, H. 2014. Climate variation effects on fungal fruiting. *Fungal Ecology*, 10: 20–33.

Bonet, J. A.; De-Miguel, S.; Martínez de Aragón, J.; Pukkala, T.; Palahí, M. 2012. Immediate effect of thinning on the yield of *Lactarius* group *deliciosus* in *Pinus pinaster* forests in North-Eastern Spain. *Forest Ecology and Management*, 265: 211-217.

Bonet, J.A.; Fischer, C.R.; Colinas, C. 2006. Cultivation of black truffle to promote reforestation and land-use stability. *Agronomy*, 26: 69-76.

Bonet, J. A.; Fischer, C. R.; Colinas, C. 2004. The relationship between forest age and aspect on the production of sporocarps of ectomycorrhizal fungi in *Pinus sylvestris* forests of the central Pyrenees. *Forest ecology and management*, 203(1) : 157-175.

Bonet, J.A.; Oliach, D.; Fischer, C.R.; Olivera, A.; Martínez de Aragón, J.; Colinas, C. 2009. Cultivation methods of the black truffle, the most profitable Mediterranean non-wood Forest product: a state of the art review. *EFI proceedings*, 57: "Modelling, valuing and managing Mediterranean forest ecosystems for non-timber goods and services". Pp: 57-71.

Bonet, J.A. ; Pukkala, T. ; Fischer, C.R. ; Palahí, M.; Martínez de Aragón, J.; Colinas, C. 2008. Empirical models for predicting the production of wild mushrooms in Scots pine (*Pinus sylvestris* L.) forests in the Central Pyrenees. *Annals of Forest Sciences*, 65: 1-8.

Bouriaud, L.; Nichiforel, L.; Jitariuc, I.; Nastase, C.; Ursache, I.; Ipsilat, I.; Cârciu, C.; Luchian, L. 2015a. Regional state of NWFP. *Project deliverable StarTree (EU project 311919) D1.3 Regional state of the* NWFP *sector report: Suceava region.*

Bouriaud, L. ; Nichiforel, L. ; Moyer, A.; Jitariuc, I. 2015b. Non wood forest products supply chain in Suceava county, Romania. Presentation to *7th StarTree project meeting*, Hamburg, Germany, 11th – 13th November, 2015.

Bragato, G.; Sladonja, B.; Peršurić, Đ. 2004. The soil environment for *Tuber magnatum* growth in Motovun forest, Istria. *Natura Croatica*, 13(2): 171-185.

Bragato, G.; Vignozzi, N.; Pellegrini, S.; Sladonja, B. 2010. Physical characteristics of the soil environment suitable for *Tuber magnatum* production in fluvial landscapes. *Plant and soil*, 329(1-2): 51-63.

Brainerd, S.; Doornbos, S. 2013. European charter on fungi-gathering and biodiversity. (https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=2515600&SecMode=1&DocId=2037384&Usage=2) (accessed: 21.03.2017).

Breitenbach, J.; Kränzlin, F. 1995: Fungi of Switzerland. Vol. 4. *Mykologia Luzern*, Luzern.

Buée, M.; Reich, M.; Murat, C.; Morin, E.; Nilsson, RH.; Uroz, S.; Martín, F. 2009. 454 Pyrosequencing analysis of forest soils reveal an unexpectedly high fungal diversity. *New Phytologist*, 184(2): 449-456.

Bundesamt für Naturschutz, 2017. Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands, Bd. 8: Pilze (Teil 1) – Großpilze. Naturschutz und Biologische Vielfalt 70/8, *Landwirtschaftsverlag*, Bonn-Bad Godesberg.

Büntgen, U.; Egli S. 2014. Breaking new ground at the interface of dendroecology and mycology. *Trends Plant Sci*. 19: 613 – 614

Büntgen, U.; Peter, M.; Kauserud, H.; Egli, S. 2013. Unraveling environmental drivers of a recent increase in Swiss fungi fruiting. *Glob. Change Biol*. 19: 2785.2794.

Burch, M.; Levetin, E. 2002. Effects of meteorological conditions on spore plumes. *International Journal of Biometeorology*, 46: 107-117.

Cadenbach, C. 2015. Guter Stiel. Seite 2: Sie haben bereits ein wenig Aroma verloren, gewinnen nun aber umso mehr Wert. *Süddeutsche Zeitung Magazin* 43/2015.

Castaño, C.; Parladé, J.; Pera, J.; Martínez de Aragón, J.; Alday, J.G.; Bonet, J.A. 2016. Soil drying procedure affects the DNA quantification of *Lactarius vinosus* but does not change the fungal community composition. *Mycorrhiza*, 26(8): 799-808.

Castaño, C.; Oliva, J.; Martínez de Aragón, J.; Alday, J.G.; Parladé, J.; Pera, J.; Bonet, J.A. 2017. Mushroom emergence can be detected by combining spore trapping with molecular techniques. *Applied and environmental microbiology* (In review).

Certini, G. 2005. Effects of fire on properties of forest soils: a review. Oecologia, 143: 1-10.

Chandelier, A.; Helson, H.; Dvorak, M.; Gischer, F. 2014. Detection and quantification of airborne inoculum of *Hymenoscyphus pseudoalbidus* using real-time PCR assays. *Plant Pathology*, 95: 220.

Chevalier, G. 2012. Europe, a continent with high potential for the cultivation of the Burgundy truffle (*Tuber aestivum/uncinatum*). *Acta Mycologica*, 47 (2): 127–132.

CPC (Climate Prediction Centre) 2017. http://www.cpc.ncep.noaa.gov/data/teledoc/telecontents.shtml (accessed 21.03.2017).

Colinas, C.; Capdevila, J. M.; Oliach, D.; Fischer, C.; Bonet, J. A. 2007. Mapa de aptitud para el cultivo de trufa negra (*Tuber melanosporum* Vitt.) en Cataluña. Ed. Centre Tecnologic Forestal de Catalunya, Solsona, 134 p.

Consiglio, G.; Papetti, C. 2009. Atlante fotografico dei fungi d'Italia. Vol 3. A.M.B. *Centro Studi Micologici*, Vicenza.

Cox, F.; Barsoum, N.; Lilleskov, E.A. ; Bidartondo, M.I. 2010. Nitrogen availability is a primary determinant of conifer mycorrhizas across complex environmental gradients. *Ecology Letters*, 13: 1103-1113.

Dämon, W.; Krisai-Greilhuber, I. 2017. Die Pilze Österreichs. Verzeichnis und Rote Liste 2016. Teil Makromyzeten. *Austrian Mycological Society*, Wien (in press).

Dahlberg, A. 1991. Dynamics of ectomycorrhizal fungi in a Swedish coniferous forest: a five year survey of epigeous sporocarps. Swedish Univ. Agricultural Science, Dep. Forest Mycology and Pathology. Uppsala. 23 pp.

Dahlberg, A. 2001. Community ecology of ectomycorrhizal fungi: an advancing interdisciplinary field. *New Phytologist*, 150: 555-562.

Dahlberg, A.; Jonssen, L.; Nylund, J. 1997. Species diversity and distribution of biomass above and below ground among ectomycorrhizal fungi in an old-growth Norway spruce forest in south Sweden. *Canadian Journal of Botany*, 75: 1323-1335.

Dahlberg, A.; Stenström, E. 1991. Dynamic changes in nursery and indigenous mycorrhiza of *Pinus sylvestris* seedlings planted out in forest and clearcuts. *Plant and Soil*, 136(1): 73-86.

Danell, E. 1994. Formation and growth of the ectomycorrhiza of *Cantharellus cibarius*. *Mycorrhiza*, 5(2), 89-97.

De la Varga, H.; Águeda, B.; Ágreda, T.; Martínez-Peña, F.; Parladé, J.; Pera, J. 2013. Seasonal dynamics of Boletus edulis and *Lactarius deliciosus* extraradical mycelium in pine forests of central Spain. *Mycorrhiza*, 23: 391-402.

De la Varga, H.; Águeda, B.; Martínez-Peña, F.; Parladé, J.; Pera, J. 2012. Quantification of extraradical soil mycelium and ectomycorrhizas of *Boletus edulis* in a Scots pine forest with variable sporocarp productivity. *Mycorrhiza*, 22: 59-68.

De-Miguel, S.; Bonet, J.A.; Pukkala, T.; Martínez de Aragón, J. 2014. Impact of forest management intensity on landscape-level mushroom productivity: a regional model-based scenario analysis. *Forest, Ecology and Management*, 330: 218-227.

Di Giorgio, C.; Krempff, A.; Guiraud, H.; Binder, P.; Tiret, C.; Dumenil, G. 1996. Atmospheric pollution by airborne microorganisms in the city of Marseilles. Atmospheric Environment, 30: 155-160.

Díaz-Balteiro, L.; Álvarez, A.; Oria de Rueda, J.A. 2003. Integración de la producción fúngica en la gestión forestal. Aplicación al monte "Urcido" (Zamora). Investigación Agraria. Sistemas y Recursos Forestales, 12: 5-19.

Dighton, J.; Poskitt, J.M.; Howard, D.M. 1986. Changes in occurrence of basidiomycete fruit bodies during forest stand development with specific reference to mycorrhizal species. Trans. Br. Mycol. Soc., 87(1): 163-171.

Duncker, P.S..; Barreiro, S.M.; Hengeveld, G.M.; Lind, T.; Mason, W.L.; Ambrozy, S.; Spiecker, H. 2012. Classification of forest management approaches: a new conceptual framework and its applicability to European Forestry. *Ecology and Society*, 17(4): 51.

EEA (European Environment Agency) 2015. http://www.eea.europa.eu/soer-2015/europe/climate-change-impacts-and-adaptation (accessed 21.03.2017).

Egli, S. 2011. Mycorrhizal mushroom diversity and productivity—an indicator of forest health? *Annals of forest science*, 68(1), 81-88.

Egli, S.; Ayer, F.; Peter, M; Eilmann, B.; Rigling, A. 2010: Is forest mushroom productivity driven by tree growth? Results from a thinning experiment. *Ann. For. Sc.*, 67: 509

Egli, S.; Peter, M.; Buser, C.; Stahel, W.; Ayer, F. 2006. Mushroom picking does not impair future harvests – results of a long term study in Switzerland. *Biol. Conserv.*, 129: 271-276.

Egli, S.; Peter, M.; Falcato, S. 2002. Dynamics of ectomycorrhizal fungi after windthrow. *For. Snow Landsc. Research* 77, 1/2: 81-88.

EMA, 2017. European Mycological Association. http://www.euromould.org/links/socs.htm (accessed 21.03.17).

Fernandez de Ana, F.J. 2000. El fuego y los hongos del suelo. Cuadernos de la Sociedad Española de Ciencias Forestales, 9: 101-107.

Fernández Toirán, L. M.; Ágreda, T.; Olano, J.M. 2006. Stand age and sampling year effect on the Fungal fruit body community in *Pinus pinaster* forests in central Spain. *Can. J. Bot*, 84: 1249-1258.

Galante, T.E.; Horton, T.E.; Swaney, D.P. 2011. 95% of basidiospores fall within 1 m. of the cap: a field- and modelling-based study. *Mycologia*, 103: 1175-1183.

Gange, A.C.; Mohammad, A. B.; Damialis, A. ; Gange, E.G. 2013. Mushroom phenological changes: A role for resource availability? *Proc. Natl. Acad. Sci.* USA 110: E333-E334.

Gange, A. C.; Gange, E. G.; Sparks, T. H.; Boddy, L. 2007. Rapid and recent changes in fungal fruiting patterns. *Science*: 316(5821): 71-71.

Gärdenfors, U. (ed.). 2005. The 2005 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala. 496 pp.

Gardes, M.; Bruns, T.D. 1996. Community structure of ectomycorrhizal fungi in a Pinus muricata forest: above- and below-ground views. *Canadian Journal of Botany*, 74: 1572-1583.

Grzymala, S. 1965. Les recherches sur la frequence des intoxications par les champignons. *Bull. Med. Legale*, 8(2), 200-210

Hall, I. R.; Lyon, A. J.; Wang, Y.; Sinclair, L. 1998a. Ectomycorrhizal fungi with edible fruiting bodies 2. *Boletus edulis*. *Economic botany*, 52(1): 44-56.

Hall, I. R.; Zambonelli, A.; Primavera, F. 1998b. Ectomycorrhizal fungi with edible fruiting bodies 3. *Tuber magnatum*, *Tuberaceae*. *Economic Botany*, 52(2): 192-200.

Hanewinkel, M.; Cullmann, D.A.; Schelhaas, M.J.; Nabuurs, G.J.; Zimmermann N.E. 2013. Climate change may cause severe loss in the economic value of European forest land. *Nature Climate Change*, 3: 203-207

Harvey, A.E.; Jurgensen, M.F.; Larsen, M.J. 1980. Clearcut harvesting and ectomycorrhizae: survival of activity on residual roots and influence on a bordering forest stand in western Montana. Canadian Journal of Forest Research, 10(3): 300-303.

Heegaard, E.; Boddy, L.; Diez, J. M.; Halvorsen, R.; Kauserud, H.; Kuyper, T. W.; Bässler, C.; Büntgen, U.; Gange, A. C.; Krisai-Greilhuber, I.; Andrew, C. J.; Ayer, F.; Høiland, K.; Kirk, P.; Egli, S. 2016. Fine-scale spatiotemporal dynamics of fungal fruiting: prevalence, amplitude, range and continuity. *Ecography*. Accepted.

Heilmann-Clausen, J.; Verbeken, A.; Vesterholt, J. 2000. The genus *Lactarius*. Fungi of Northern Europe – Vol. 2. Svampetryk, *Danish Mycological Society*. 287 pp.

Hernández-Rodríguez, M.; Oria de Rueda, J.A.; Pando, V.; Martín-Pinto, P. 2015. Impact of fuel reduction treatments on Fungal sporocarp production and diversity associated with *Cistus ladanifer* L. ecosystems. *Forest, Ecology and Management*, 353: 10-20.

Hijmans, R.J.; Elith, J. 2016. http://rspatial.org/sdm/ (accessed 21.03.2017).

Hintikka, V. 1988. On the macromycete flora in oligotrophic pine forests of different ages in south Finland. Acta Botanica Fennica, 136: 89-94.

Holec, J.; Beran, M., (Herausg.) 2006. Red list of fungi (macromycetes) of the Czech Republic. – Príroda, Praha, 24: 1-282.

Hora, F. G. 1959. Quantitative experiments on toadstool production in woods. *Trans. Brit. Mycol.* 1-14.

Jackson, S.L.; Bayliss, K.L. 2011. Spore traps need improvement to fulfil plant biosecurity requirements. Plant Pathology, 60: 801-810.

Jang, S. K. ; Kim, S. W. 2015. Relationship between Ectomycorrhizal Fruiting Bodies and Climatic and Environmental Factors in Naejangsan National Park. *Mycobiology*, 43(2), 122-130.

Jumpponen, A.; Jones, K.L. ; Mattox, J.D.; Yaege, C.; Mattox, J.D.; Yaege, C. 2010. Massively parallel 454-sequencing of fungal communities in Quercus spp. Ectomycorrhizas indicates seasonal dynamics in urban and rural sites. Molecular Ecology, 19(Suppl 1): 41-53.

Kardell, l. ; Eriksson, L. 1987. Kremlor, riskor, soppar. Skogsbrukmetodernas inverkan pa produktionen av matsvampar. Sveriges Skogsvardsforbunds Fidskrift 2 (87): 3-24.

Kauserud, H.; Heegaard, E.; Semenov, M.A.; Boddy, L.; Halvorsen, R.; Stige, L.C.; Sparks, T.H.; Gange, A.C.; Stenseth N.C. 2010. Climate change and spring-fruiting fungi. *Proc. R. Soc. B.*, 277: 1169-1177.

Kauserud, H.; Heegaard, E.; Büntgen, U.; Halvorsen, R.; Egli, S.; Senn-Irlet, B.; Krisai-Greilhuber, I.; Damonf, W.; Sparks, T.; Nordena, J.; Hoilanda, K.; Kirk, P.; Semenov, M.; Boddy, L.; Stenseth, N.C. 2012. Warming-induced shift in European mushroom fruiting phenology. *Proceedings of the National Academy of Sciences*, 109(36), 14488-14493.

Keča, L.; Keča, N.; Marčeta, M. 2015. Non-wood forest products, Socio-economic and ecological aspects. *University of Belgrade, Faculty of Forestry Press.*, 262.

Keča, L.; Keča, N.; Rekola, M. 2013. Value chains of Serbian non-wood forest products. *International Forestry Review*, 15(3): 315–335.

Keča, L.; Marčeta, M.; Keča, N. 2014. Value chain analysis of forest mushrooms in Serbia. Proceedings of II International Congress "Food Technology, Quality and Safety", Novi Sad.

Kirsi, M.; Oinonen, P. 1981. Mushroom yields in 10-year-old coppice after spraying with MCPA. *Karstenia*, 21: 1-8.

Kivlin, S.N.; Winston, G.C. ; Goulden, M.L.; Treseder, K.K. 2014. Environmental filtering affects soil fungal community composition more than dispersal limitation at regional scales. *Fungal Ecology*, 12: 14-25.

Knudsen, H.; Vesterholt, J. 2012. Funga Nordica: agaricoid, boletoid and cyphelloid genera. Nordsvamp, Copenhagen, Denmark.

Koide, R.X; Xu, B.; Sharda, J. 2005. Contrasting below-ground views of an ectomycorrhizal fungal community. *New Phytologist*, 166: 251-262.

Kranabetter, J.M.; Kroeger, P. 2001. Ectomycorrhizal mushroom response to partial cutting in a western hemlock-western redcedar forest. Can. J. For. Res., 31: 978-987.

Kropp, B. R.; Albee, S. 1996. The effects of silvicultural treatments on occurrence of mycorrhizal sporocarps in a *Pinus contorta* forest: a preliminary study. Biological conservation, 78(3): 313-318.

Kutafyeva, N.P. 1975. Vlijanie udobrenii na urozai gribov v sosnjakah srednego Priangarja. (Summary: Effects of fertilizers on mushroom yield in pine forest along the middle Angara). *Mikol. Fitopatol.*, 9, 288-293.

Larson, A. J., C. A. Cansler, S. G. Cowdery, S. Hiebert, T. J. Furniss, M. E. Swanson, and J. A. Lutz. 2016. Post-fire morel (*Morchella*) mushroom production, spatial structure, and harvest sustainability. *Forest Ecology and Management*, 377: 16-25.

Latorre, J. 2014. Diagnóstico e innovación aplicada a la gestión y valorización del micoturismo en Castilla y León. Universidad Católica San Antonio de Murcia.

Lavorel, S.; Colloff, M.J.; Mcintyre, S.; Doherty, M.D.; Murphy, H.T.; Metcalfe, D.J.; Dunlop, M.; Williams, R.J.; Wise, R.M.; Williams, K.J. 2015. Ecological mechanisms underpinning climate adaptation services. *Glob. Change Biol.* 21: 12-31.

Le Tacon, F. 1997. Vers une meilleure prise en compte des champignons mycorhiziens dans la gestion forestière. *Revue Forestière Française*, XLIX : 245-255

Letcher, A. 2007. Shroom: a cultural history of the magic mushroom. Ecco, New York.

Li, D.W. 2005. Release and dispersal of basidiospores from Amanita muscaria var. alba and their infiltration into a residence. Mycological Research, 109: 1235-1242.

Lilleskov, E.A.; Hobbie, E.A. ; Horton, T.R. 2011. Conservation of ectomycorrhizal fungi: exploring the linkages between functional and taxonomic responses to anthropogenic N deposition. Fungal Ecology, 4: 174–183.

Lindahl, BD.; Nilsson, RH. ; Tedersoo, L. ; Abarenkov, K. ; Carlsen, T. ; Kjøller, R. ; Kõljalg, U. ; Pennanen, T. ; Rosendahl, S. ; Stenlid, J. ; Kåuserud, H. 2013. Fungal community analysis by high-throughput sequencing of amplified markers – user's guide. *New Phytologist*, 199: 288-299.

Liu, B. ; Fischer, C. ; Bonet, J.A. ; Olivera, A. ; Inchusta, A.; Colinas C. 2014. Pattern of *Tuber melanosporum* extramatrical mycelium expansion over a 20-year chronosequence in *Quercus ilex*-truffle orchards. *Mycorrhiza*, 24 (1) supplement: 47-54.

Liu, B.; Bonet, J.A.; Fischer, C.R.; Martínez de Aragón, J.; Bassie, L.; Colinas, C. 2016. *Lactarius deliciosus* Fr. Soil extraradical mycelium is more resilient to forest thinning than mushroom fruiting and can be used to estimate potential stand fruitbody productivity. *Forest, Ecology and Management*, 380: 196-201.

Lowy, B. 1974. *Amanita muscaria* and the Thunderbolt legend in Guatemala and Mexico. *Mycologia* 66:189-191.

Marshall, E.; Schreckenberg, K.; Newton, A. C. 2006. Commercialization of Non-timber Forest Products: Factors Influencing Success. Lessons Learned from Mexico and Bolivia and Policy Implications for Decision-makers. Book, Cambridge, UK: Traffic International.

Martínez de Aragón, J.; Bonet J.A.; Fischer C.R.; Colinas C. 2007. Productivity of ectomycorrhizal and selected edible saprotrophic fungi in pine forests of the pre-Pyrenees mountains, Spain: Predictive equations for forest management of mycological resources. *Forest, Ecology and Management*, 252: 239-256.

Martínez-Peña, F.; de-Miguel, S.; Pukkala, T.; Bonet, J. A.; Ortega-Martínez, P.; Aldea, J.; Martínez de Aragón, J. 2012. Yield models for ectomycorrhizal mushrooms in *Pinus sylvestris* forests with special focus on *Boletus edulis* and *Lactarius group deliciosus*. *Forest Ecology and Management*, 282(0), 63–69.

Martínez Peña, F.; Picardo, A.; Redondo, C.; Latorre, J. 2015. Micocyl.es: El programa de micología de Castilla y León. *Boletín Micológico de FAMCAL*, 10, 1–149.

Martínez-Peña, F. 2009. Producción de carpóforos macromicetos epígeos en masas ordenadas de *Pinus sylvestris*. L. Disseration, ETSI Montes. Universidad Politécnica de Madrid.

Martín-Pinto, P.; Vaquerizo, H.; Peñalver, F.; Olaizola, J.; Oria-de-Rueda, J.A. 2006. Early effects of a wildfire on the diversity and production of fungal communities in Mediterranean vegetation types dominated by *Cistus ladanifer* and *Pinus pinaster* in Spain. *Forest Ecology and Management* 225 (2006) 296–305.

Molinier, V.; Murat, C.; Peter, M. et al., 2016: SSR-based identification of genetic groups within European populations of *Tuber aestivum* Vittad. *Mycorrhiza* 26: 99.

ND-GAIN 2017. http://index.gain.org/ranking (accessed 21.03.2017).

Nilsson, R.H. ; Ryber, M. ; Kristiansson, E. ; Abarenkov, K. Larsson, K.H. ; Kõljalg, U. 2006. Taxonomic reliability of DNA sequences in public sequence databases : a fungal perspective. PLoS One, 1: e59.

Nilsson, R.H. ; Taylor, A.F.S. ; Bates, S.T. ; Thomas, D. ; Bengtsson-Palme, J. ; Callaghan, T.M. ; Douglas, B. ; Griffith, G.W. ; Ucking, R.L. Suija, A.V.E. ; Taylor, D.L.E.E. ; Teresa, M. ; Kõljalg, U. ; Abarenkov, K. ; Tedersoo, L. ; Bahram, M. ; Bruns, T.D. ; Drenkhan, T. ; Eberhardt, U. ; Dueñas, M. ; Grebenc, T. ; Hartmann, M. ; Kirk, P.M. ; Kohout, P. ; Larsson, E. ; Lindahl, BD. ; Lücking, R. ; Martín, M.P. ; Matheny, P.B. ; Nguyen, N.H.; Niskanen, T. ; Oja, J. ; Peay, K.G. ; Peintner, U. ; Peterson, M. ; Põldmaa, K. ; Saag, L. ; Saar, I. ; Schüßler, A. ; Scott, J.A. ; Senés, C. ; Smith, M.E. ; Telleria, M.T. ; Weiss, M. ; Larsson, K.H. 2013. Towards a unified paradigm for sequence-based identification of fungi. *Molecular Ecology*, 22, 5271–7.

Nilsson, H. ; Tedersoo, L.; Abarenkow, K.; Ryberg, M. Kristiansson, E.; Hartmann, M.; Schoch, C.; Nylander, J.; Bergsten, J.; Porter, T.; Jumpponen, A.;, Vaishampayan, P.; Ovaskainen, O.; Hallenberg, N.; Bengtsson, J.; Eriksson, M.; Larsson, K.H.; Larsson, E.; Koljalg, U. 2012. Five simple guidelines for establishing basic authenticity and reliability of newly generated fungal ITS sequences. *MycoKeys*, 4: 37–63.

North, M.; Greenberg, J. 1998. Stand conditions associated with truffle abundance in western hemlock/Douglas-fir forests. *Forest Ecology and Management*, *112*(1), 55-66.

Norvell, L. 1995. Loving the chanterelle to death? The 10 year chanterelle project. *McIlvanea* 12, 6–25.

Nyland, R.D. 2002 Silviculture: Concepts and Applications, 2nd Edition. The McGraw-Hill Companies, Inc. New York. 704 pp.

Ohenoja, E. 1988. Effect of forest management procedures on fungal fruit body production in Finland. Acta Bot. Fennica, 136: 81-84.

Ohenoja, E. 1989. Forest fertilization and fruiting body production in fungi. Atti del Centro Studi per la Flora Mediterranea, 7: 233-252.

Oliveira, M.; Ribeiro, H.; Delgado, J.L.; Abreu, I. 2009. The effects of meteorological factor son airborne Fungal spore concentration in two areas differing in urbanisation level. International Journal of Biometeorology, 53: 61-73.

Olivera, A.; Bonet, J.A.; Oliach, D.; Colinas, C. 2014a. Time and dose of irrigation impact *Tuber melanosporum* proliferation and growth of *Quercus ilex* seedling hosts in Young black truffle orchards. *Mycorrhiza*, 24 (1) supplement: 73-78.

Olivera, A.; Bonet, J.A. ; Palacio, L.; Colinas, C. 2014b. Adequate weed suppression strategies can promote *T. melanosporum* mycelial expansion and seedling growth in newly established black truffle plantations. *Annals of Forest Sciences*, 71(4): 495-504.

Olivera, C.; Fischer, C.R.; Bonet, J.A.; Martínez de Aragón, J.; Colinas, C. 2011. Weed management and irrigation are key treatments in emerging black truffle (*Tuber melanosporum*) cultivation. New Forests, 42 (2): 227-239.

Olivier, J.M.; Savignac, J.C. ; Sourzat, P. 2012. Truffe et Trufficulture. Ed. Fanlac. París.

Oria-de-Rueda, J.A.; Hernández-Rodríguez, M.; Martín-Pinto, P.; Pando, V.; Olaizola, J. 2010. Could artificial reforestations provide as much production and diversity of fungal species as natural forest stands in marginal Mediterranean areas?. *Forest, Ecology and Management*, 260: 171-180.

Palahí, M.; Pukkala, T.; Bonet, J.A.; Colinas, C.; Fischer, C.R.; Martínez de Aragón, J. 2009. Effect of the inclusion of mushroom values on the optimal management of even-aged pine stands of Catalonia. *Forest Science*, 55 (6): 503-511.

Papetti, C.; Consiglio, G.; Simonini, G. 2011. Atlante fotografico dei fungi d'Italia. Vol. 1, A.M.B. *Centro Studi Micologici*, Vicenza.

Parladé, J.; de-la-Varga, H. ; de-Miguel, A.M. ; Sáez, R. ; Pera, J. 2013. Quantification of extraradical mycelium of *Tuber melanosporum* in soils from truffle orchards in northern Spain. Mycorrhiza, 23: 99-106.

Parladé, J.; Hortal, S.; Pera, J.; Galipienso, L. 2007. Quantitative detection of *Lactarius deliciosus* extraradical soil mycelium by real-time PCR and its application in the study of fungal persistence and interspecific competition. *Journal of Biotechnology*, 128: 14-23.

Peay, K.G.; Bruns, T.D. 2014. Spore dispersal of basidiomycete fungi at the landscape scale is driven by stochastic and deterministic processes and generates variability in plant-fungal interactions. New Phytologist, 204: 180-191.

Pedrono, M.; Locatelli, B.; Ezzine-de-Blas, D.; Pesche, D.; Morand, S.; Binot, A. 2016. Impact of Climate Change on Ecosystem Services. in: E. Torquebiau (ed.), Climate Change and Agriculture Worldwide, Springer, Netherlands. Ch. 19, pp: 251-261.

Peintner, U.; Pöder, R. 2000. Ethnomycological remarks on the Iceman's fungi. *In: Bortenschlager S, Oeggl K (eds) The Iceman and his natural environment*. Springer, Vienna. Pp: 143-150.

Peintner, U.; Schwarz, S.; Mesic´, 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.

Perry, D.A.; Borchers, J.G.; Borchers, S.L.; Amaranthus M.P. 1990. Species Migrations and Ecosystem Stability During Climate Change: The Belowground Connection. *Conservation Biology*, 4: 266-274.

Peter, M.; Buée, M.; Egli, S. 2013: Biodiversity of mycorrhizal fungi as a crucial player in forest ecosystem functioning. In: Kraus D., Krumm F. (eds.) Integrative approaches as an opportunity for the conservation of forest biodiversity. *European Forest Institute*. pp. 170-179.

Pettenella, D.; Vidale, E.; Da Re, R.; Lovric, M. 2014. NWFP in the international market: current situation and trends. *Project deliverable D3.1. StarTree project (EU project 311919)*. Legnaro (Padova), Italy.

Pilz, D.; Norvell, L.; Danell, E.; Molina, R. 2003. Ecology and Management of Commercially Harvested Chanterelle Mushrooms. Gen. Tech. Rep. PNW-

GTR-576. Portland OR: Department of Agriculture, Forest Service, Pacific Northwest Research Station, pp. 1–83.

Pilz, D.; Molina R. 2002. Commercial harvests of edible mushrooms from the forests of the Pacific Northwest United States: issues, management, and monitoring for sustainability. Forest, Ecology and Management, 155(1): 3-16.

Pilz, D.; Molina, R.; Mayo, J. 2006. Effects of thinning Young forests on chanterelle mushroom production. Journal of Forestry, 104(1): 9-14.

Power, R.; Salazar-García, D.; Straus, L.; Morales, M.; Henry, A. 2015. Microremains from El Mirón Cave human dental calculus suggest a mixed plant-animal subsistence economy during the Magdalenian in Northern Iberia. *Journal of Archaeological* Science, 60: 39-46.

Primicia, I.; Camarero, J.J.; Martínez de Aragón, J.; de-Miguel, S.; Bonet, J.A. 2016. Linkages between climate, seasonal wood formation and mycorrhizal mushroom yields. *Agricultural and Forest Meteorology*, 228: 339-348.

Reyna, S. 2012. Truficultura. Fundamentos y técnicas. Ed. Mundiprensa. Madrid. 720 pp.

Ricard, J.M. 2003. La truffe. Guide technique de trufficulture. Centre technique interprofessionnel des fruits et légumes. Paris. 268 pp.

Rockström, J.; Steffen, W.; Noone K., Persson Å., Chapin, III F.S., Lambin E.F., Lenton T.M., Scheffer M., Folke C., Schellnhuber H.J., Nykvist B., de Wit C.A., Hughes T., van der Leeuw S., Rodhe H., Sörlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R.W., Fabry V.J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., Foley J.A. 2009. A safe operating space for humanity. *Nature* 461: 472-475.

Salerni, E.; Perini, C. 2004. Experimental study for increasing productivity of *Boletus edulis* s.l. in Italy. *Forest, Ecology and Management*, 201(2): 161-170.

Sánchez-Ramírez, S.; Tulloss, R.E.; Guzmán-Davalos, L.; Cifuentes-Blanco, J.; Valenzuela, R.; Estrada-Torres, A.; Ruán-Soto, F.; Díaz-Moreno, R.; Hernandez-Rico, N.; Torres-Gómez, M.; León, H.; Moncalvo, J.-M. 2015. In and out of refugia: historical patterns of diversity and demography in the North American Caesar's mushroom species complex. *Molec. Ecol.* 24: 5938-5956.

Sarjala, T.; Savonen, E.-M. ; Potila, H. 2005. Effect of irrigation on fruitbody production of mushrooms in a Finnish Scots pine forest. Abstract book of the IV International Workshop Edible Mycorrhizal Mushrooms. Murcia, Spain. Pp: 113.

Sato, H.; Morimoto, S.; Hattori, T. 2012. A thirty-year survey reveals that ecosystem function of fungi predicts phenology of mushroom fruiting. *PloS one*, 7(11), e49777.

Schenk-Jäger, K.M.; Rauber-Lüthy, C.; Bodmer, M.; Kupferschmidt, H.; Kullack-Ublick, G.A.; Ceschi, A. 2012. Mushroom poisoning: a study on circumstances of exposure and patterns of toxicity. *European Journal of Internal Medicine* 23: e85-e91.

Schenk-Jäger, K.M.; Egli, S.; Hanimann, D.; Senn-Irlet, B.; Kupferschmidt, H.; Büntgen, U. 2016. Introducing mushroom fruiting patterns from the Swiss National Poisons Information Centre. *PLoS ONE* 11: e0162314.

Schulp, C.J.E.; Thuiller, W.; Verburg P.H. 2014. Wild food in Europe: A synthesis of knowledge and data of terrestrial wild food as an ecosystem service. *Ecological Economics*, 105: 292-305.

Schultes, R.E.; Hofmann, A. ; Rätsch, C. 1992. Plants of the Gods. Their sacred, healing and hallucinogenic powers. Healing Arts Press, Rochester-Vermont.

Schweigkofler, W.; O'Donell, K.; Garbelotto, M. 2004. Detection and quantification of airborne conidia of *Fusarium circinatum*, the causal agent of pine pitch canker, from two California sites by using a real-time PCR approach combined with a simple spore trapping method. *App. Environ. Microbiol.*, 70(6): 3512-20.

Senn-Irlet, B.; Heilmann-Clausen, J.; Genney, D.; Dahlberg, A. 2007. Guidance for Conservation of Macrofungi in Europe. Document prepared for The Directorate of Culture and Cultural and Natural Heritage Council of Europe, Strasbourg. – The European Council for Conservation of Fungi (ECCF) within the European Mycological Association (EMA).

Shubin, V.I. 1988. Influence of fertilizers on the fruiting of forest mushrooms. Acta Bot. Fennica, 136: 85-87.

Simmel J. 2016a. Chapter 7 – conclusions and perspectives. In Simmel J.: Cryptogams as indicator organisms in ecology and conservation biology. 79-82. – Dissertation University of Regensburg.

Simmel J. 2016b: Chapter 6 – shifts in species composition of macromycete assemblages in the nature reserve „Sippenauer Moor"– an assessment using species identities, Ellenberg indicator values, and functional traits. pp. 68-78. Dissertation University of Regensburg.

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.

Smith, J.E.; Molina, R.; Huso, M. M.; Luoma, D.L.; McKay, D.; Castellano, M.A.; Valachovic, Y. 2002. Species richness, abundance and composition of hypogeous and epigeous ectomycorrhizal fungal sporocarps in young, rotation-age, and old-0growth stands of Douglas-fir (*Pseudotsuga menziesii*) in the Cascade Range of Oregon, USA. *Canadian Journal of Botany*, 80(2): 186-204.

Smith, D.M. 1986. The practice of silviculture. 8th ed. John Wiley & Sons, New York.

Sourzat, P. 2002. Guide pratique de trufficulture. Ed. Station d'expérimentations sur la truffe. Le Montat. France. 119 pp.

Stara, K., Bonet, J.A. ; Wong, J. ; Avdibegović, M. ; Barstad, J. ; Bouriaud, L. ; Danut Chira, D. ; Dickinson, B. ; Egli, S. ; Ehrlich, P. ; Karpavičienė, B. ; Grebenc, T. ; Hale, M. ; Kadlec, J. ; Karadžić, D. ; Kasparavičius, J. ; Keča, L. ; Keča, N. ; Korjus, H. ; Kovalcik, M. ; Krisai-Greilhuber, I. ; Kušan, I. ; Dinca, L. ; Magnúsdóttir, L. ; Martín-Pinto, P. ; Martínez de Aragón, J. ; Molinier, V. ; Kängsepp, V. ; Korjus, H. ; Mumcu Küçüker, D. ; Nahm, M. ; Nedanovska, V. ; Nedelin, T. ; Oria-de-Rueda, J.A. ; Rasztovits, E. ; Riedl, M. ; Salo, K. ; Santos e Silva, C. ; Sheppard, J. ; Sitta, N. ; Staniszewski, P. ; Stoyanova, M. T. ; Suriano,

E. ; Tomao, A. ; Toscani, P. ; Zalitis, T. ; Zgrablić, Ž. 2016. Non Timber Forest products linguistic diversity. The case of mushrooms. *Conference Wild Forest Products in Europe*, Star Tree, 13-14 October 2016.

Stobbe, U.; Egli, S.; Tegel, W.; Peter, M.; Sproll, L.; Büntgen, U. 2013. Potential and limitations of Burgundy truffle cultivation. *Applied microbiology and biotechnology*, 97(12): 5215-5224.

Straatsma, G.; Ayer, F.; Egli, S. 2001. Species richness, abundance, and phenology of fungal fruit bodies over 21 years in a Swiss forest plot. *Mycological Research*, 105(05): 515-523.

Stulik, M. 2016. Die Fruktifikation der Makromyceten auf Probeflächen in der Lobau im zweiten Halbjahr 2015 im Vergleich mit den Jahren 1980 – 1994. – Diploma-Thesis University of Vienna.

Suz, L. M.; Martín, M.P.; Colinas, C. 2006. Detection of *Tuber melanosporum* DNA in soil. *FEMS Microbiol Lett*, 254(2): 251-257.

Suz, L.M.; Martín, M.P.; Oliach, D.; Fischer, C.R.; Colinas, C. 2008. Mycelial abundance and other factors related to truffle productivity in *Tuber melanosporum-Quercus ilex* orchards. *FEMS Microbiol. Lett*, 285(1): 72-78.

Tahvanainen, V.; Miina, J.; Kurttila, M.; Salo, K. 2016. Modelling the yields of marketed mushrooms in *Picea abies* stands in Eastern Finland. *Forest, Ecology and Management*, 362: 79-88

Tedersoo, L.; Bahram, M.; Põlme, S.; Kõljalg, U. and other 54 coauthors. Global diversity and geography of soil fungi. *Science*, 346 (6213).

TEEB (The Economics of Ecosystems & Biodiversity). 2017. http://www.teebweb.org/resources/ecosystem-services/ (accessed 21.03.2017)

Termorshuizen, A. J. 1993. The influence of nitrogen fertilisers on ectomycorrhizas and their fungal carpophores in young stands of *Pinus sylvestris*. *For. Ecol. Manag*., 57, 179-189.

Troutt, C.; Levetin, E. 2001. Correlation of spring spore concentrations and meteorological conditions in Tulsa, Oklahoma. International Journal of Biometeorology, 45: 64-74.

Tubay, J.M.; Suzuki, K.; Uehara, T.; Kakishima, S.; Ito, H.; Ishida, A.; Yoshida, K.; Mori S., Rabajante J.F., Morita S., Yokozawa M., Yoshimura J. 2015. Microhabitat locality allows multi-species coexistence in terrestrial plant communities. *Scientific Reports* 5: 15376.

Twieg, B.D.; Durall, D.M.; Simard, S.W. 2007. Ectomycorrhizal fungal succession in mixed temperate forests. New Phytologist, 176(2): 437-447

Urban, A.; Mader, A. 2003: Über Trüffelvorkommen (*Tuber aestivum*) im südlichen Niederösterreich: Einfluss des Niederschlags auf die Fundmenge. *Österr. Z. Pilzk*. 12: 193-204.

Urban, A.; Pla T. 2009: Conservation strategies for *Tuber aestivum*. *Österr. Z. Pilzk*. 19: 273-279.

van Teeffelen, A.; Meller, L.; van Minnen, J.; Vermaat, J.; Cabeza, M. 2014. How climate proof is the European Union's biodiversity policy? *Reg. Environ. Change*, 15: 997-1010.

Väre, H.; Ohenoja, E.; Ohtonen, R. 1996. Macrofungi of oligotrophic Scots pine forests in northern Finland. Karstenia, 36: 1-18.

Vidale, E.; Da Re, R.; Pettenella, D. M. 2016. Trends, rural impacts and future developments of regional

WFP market. Legnaro (Padova), Italy.

Vogt, K.A.; Bloomfield, J.; Ammirati, J.F.; Ammirati, S.R. 1992. Sporocarp production by basidiomycetes with emphasis on forest ecosystems. In: Carol, G.C., Wicklow, D.T. (Eds). The Fungal Community. M. Decker, New Yor. Pp: 563-579.

Vrachionidou, M. 2007. Cultural and social value of mushrooms. Unpublished PhD thesis. Universtiy of Ioannina, Ioannina – Greece (in Greek).

Wardle, D. A.; Lindahl, B. D. 2014. Disentangling global soil fungal diversity. *Science*, 346(6213), 1052-1053.

Wasson, V.; Wasson, R.G. 1957. Mushrooms, Russia, and history. Volume II. Pantheon Books, New York.

Wästerlund, I. 1989. How is the occurrence of mushroom fruitbodies influenced by the silvicultural treatments?. *Svens Bot. Tidskr.*, 83: 103-12 (in Swedish with English Summary).

West, J.S.; Atkins, S.D. ; Emberlin, J. ; Fitt, B.D.L. 2008. PCR to predict risk of airborne disease. Trends in Microbiology, 16: 380-387.

Wicklund, K.; Nilsson, L.O. ; Jacobsson, S. 1995. Effect of irrigation, fertilization and artificial drought on basidioma production in a Norway spruce stand. *Canadian Journal of Botany*, 73(2): 200-208

Wojewoda, W.;Lawrynowicz, M. 2004. Red list of threatened macrofungi in Poland (3rd edn)[Czerwona lista grzyböw wielkoowocnikowych zagrozonychwPolsce (wyd. 3)]. – In Zarzycki,K., Mirek Z.(Herausg.): List of slime moulds, algae, macrofungi, mosses, liverworts and plants threatened in Poland.-Krakow: Inst. Bot. Pol. Acad.Sci.

Wollan, A. K.; Bakkestuen, V.; Kauserud, H.; Gulden, G.; Halvorsen, R. 2008. Modelling and predicting fungal distribution patterns using herbarium data. *Journal of Biogeography*, 35(12), 2298-2310.

Wu, Y.; Choi, M-H.; Li, J.; Yang, H. ; Shin, H-J. 2016. Mushroom Cosmetics: The Present and Future. *Cosmetics*, 3(3): 22-35.

Yamin-Pasrernak, S. 2011. Ethnomycology: Fungi and Mushrooms in Cultural Entanglements. In: Anderson, EN, Pearsall, D.; Hunn, E.; Turn, N. *Ethnobiology*. Wiley-Blackwell, New Jersey. Pp: 230-231.

7. Non-wood tree products in Europe

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7.1 Introduction

Prior to the industrial revolution man used forests at a moderate rate to meet multiple demands (e.g. game, wood for fuel and construction, honey, berries) as needed to satisfy basic needs, thus suggesting a traditional multiple usage of forests. More recently, population growth and a rapid industrial growth led to the clearing of large forest areas for agriculture and to an increased use of wood for construction of boats, buildings, for mining and as fuel. As a consequence, wood production has been, during the last centuries, the main purpose of forest management, and therefore, optimizing wood production and wood products has been the main objective. However, multifunctional management of the forest has been gaining relevance as well as the knowledge of the value of some non-wood tree products. At present it is important to analyse the opportunity to manage the forest so that diverse products can be obtained. In this chapter the most relevant non-wood tree products are identified based on a survey carried out under the scope of the COST Action FP1203 (chapter 7.2). Based on this survey, selected non-wood tree products were characterized in more detail (chapter 7.3), where the required information was available. A brief description of the history (including social and cultural relevance), species and production area, silviculture and silvicultural systems (if relevant), associated products services and economic importance is given. Along with the description of the seven examples relevant literature has been identified and final conclusions (chapter 7.4) are given.

7.2 Identification of non-wood tree products relevant for Europe

The COST Action FP1203 conducted a survey through the Management Committee (MC) representatives of the 29 member countries of the Action, to which 24 countries replied (see also chapter 1, for detail concerning methodology used in the survey). As part of this survey, the most relevant NWFP in each country were identified. Table 7.1 shows the results of the survey for the non-wood tree products. Evaluating the relevance of each product by the number of countries that selected this product as relevant, Christmas trees are by far the most relevant product in the largest number of countries, closely followed by chestnuts. Resin, pine nuts, birch sap and acorns were identified as relevant by four countries and cork by three. Table 7.2 summarizes other non-wood tree products also identified in the survey.

7.3 In-depth analysis of the most relevant non-wood tree species

This chapter characterizes the NWFP that were selected as relevant because of their economic or social importance at regional/national level.

7.3.1 Christmas trees

History

The use of evergreen trees within Christmas celebrations has more than a 500 years history in Europe and, some 200 years ago, the Christmas tree was connected to Christian festivities by an English monk. Many believe that the first decorated Christmas tree dates back to Riga, Latvia, in 1510, but some claim that the tradition goes even further back in time, suggesting that Egyptians brought green palm branches into their homes as a symbol of life's triumph over death. The Romans adorned their homes with evergreen foliage during Saturnalia, a winter festival in honour of Saturnus, their god of agriculture. Druid priests decorated oak trees with golden apples for the winter solstice (Ciesla 1998).

Species and area

Christmas trees are produced by approximately 15,000 growers on some 120,000 ha in Europe resulting in an annual production of approximately 75 million Christmas trees. True firs make up for 50 million trees each year with Nordmann fir (*Abies nordmanniana*) being the most important species. Spruces make up for 20 million trees each year with Norway spruce (*Picea abies*) and blue spruce (*Picea pungens*) as most commonly used. Finally pine makes up for 5 million trees sold each year with Scots pine (*Pinus sylvestris*) and black pine (*Pinus nigra*) as the most common.

Originally trees were harvested in natural forests and later from managed timber producing stands of fir and spruce trees. In more recent years dedicated Christmas tree plantations have been widely established on former farmland.

Table 7.1: Most relevant non-wood tree products, the respective tree species and countries in which they are relevant

Product	Number of		Tree species1	Countries1
	species	countries		
Christmas trees	19	28	*Abies alba* Mill., *Abies fraseri* (Pursh) Poir, *Abies koreana* E.H.Wilson, *Abies lasiocarpa* (Hooker) Nuttall, *Abies nobilis* (Douglas ex D.Don) Lindl., *Abies nordmanniana* (Steven) Spach, *Abies bornmülleriana* Mattf., *Abies procera* Rehder, *Abies cephalonica* Loudon, *Abies borissi-regis* Mattf., *Picea abies* (L.) H. Karst., *Picea glauca* (Moench) Voss, *Picea omorica* (Pančić) Purk., *Picea pungens* Engelm., *Picea sitchensis* (Bong.) Carrière, *Pinus contorta* Douglas ex Loudon 1838, *Pinus nigra* J. F. Arnold, *Pinus sylvestris* L., *Juniperus spp.*	Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Great Britain, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland
Chestnut	1	11	*Castanea sativa* Mill.	Austria, Croatia, North Macedonia, Germany, Greece, Italy, Netherlands, Portugal, Slovenia, Spain, Switzerland, Turkey
Resin	5	5	*Larix decidua* Mill., *Picea abies* (L.) H. Karst. *Pinus halepensis* Mill., *Pinus nigra* J. F. Arnold, *Pinus pinaster* Aiton., , *Pinus pinea* L.*Pinus sylvestris* L.	Finland, Greece, Hungary, Italy, Portugal, Spain
Pine nuts	1	5	*Pinus pinea* L.	Greece, Italy, Portugal, Spain, Turkey
Birch sap	1	4	*Betula pendula* Roth	Finland, Germany, Lithuania, Poland
Acorns	4	4	*Quercus ilex* subsp. *ilex* L., *Quercus robur* L., *Quercus suber* L., *Quercus rotundifolia* Lam.	Croatia, Hungary, Lithuania, Portugal, Spain
Cork	1	3	*Quercus suber* L.	Italy, Portugal, Spain

1 Underlined countries and tree species were not identified during the survey but added by the authors, based on their expertise, due to its relevance for the respective NWFP

Table 7.2: Other non-wood tree products identified during the survey, according to their use

Product use	Products	Tree species
Decorative products	Birch bark, fir branches, holly berries and holly sprigs, larch bark, ornamental shoots, resinous cones	*Abies alba* Mill., *Betula pendula* Roth, , *Ilex aquifolium* L., *Larix decidua* Mill., *Picea abies* (L.) H. Karst., other *Picea* sp., *Pinus strobus* L., *Pinus sylvestris* L., other *Pinus* sp., *Pseudotsuga menziesii* (Mirb.) Franco
Medicinal products	Abigenol, Alder buckthorn, Birch buds, Birch leaves, Birch Sap, Lime flowers, Pine buds, Quercus bark, Spruce resign ointment, Pakuri/Chaga (*Inonotus obliquus* (Ach. ex Pers.) Pilát (1942)) extract, Pine bark extract	*Abies alba* Mill., *Betula pendula* Roth, *Betula pubescens* Ehrh., *Frangula alnus* Mill., *Picea abies* (L.) H. Karst., , *Pinus sylvestris* L., *Quercus* sp., *Sambucus nigra* L., *Tilia argentea* DC., *Tilia cordata* Mill., *Tilia platyphyllos* Scop., *Tilia rubra* DC., *Tilia tomentosa* Moench
Craft and construction	Common osier, cork, osier, Poplar Seed Fibres	*Quecus suber* L., *Populus sp.*, *Salix viminalis* L., other *Salix* sp
Food	Tree fruits, tree nuts, mastic resin	*Ceratonia síliqua* L., *Corylus avellana* L., *Juglans regia* L., other *Juglans sp.*, *Pinus cembra* L., *Pistachia lentiscus* L. var *Chia*, *Prunus dulcis* (Mill.) D. A. Webb, *Sambucus nigra* L., *Sorbus aucuparia* L., *Sorbus torminalis* (L.) Crantz

Production

The statistics for Christmas tree production in Europe are difficult to estimate since no Europe-wide report system is in place. Therefore, overall figures for production are based upon national reports and these figures can be variable due to Christmas trees being considered as either forest or agricultural enterprises between reporting countries (Talgø & Fløistad 2015).

The Christmas tree tradition in Europe is strong, approximately 70 % of all households display a natural Christmas tree. This indicates a total market for natural Christmas trees of around 100 million trees. However, only 75 million are considered to be sold on the commercial market since 25 million are sold in barter deals.

Most countries in Europe have some kind of established Christmas tree production system, but Germany has the largest production in Europe producing approximately 22 million trees of all Christmas tree species each year. Denmark is the second largest producer of Christmas trees and the biggest exporting country for Christmas trees in Europe with 9 million trees labelled for export each year.

Economic importance

Figure 7.1 shows the evolution of average prices for sale to Danish wholesalers, considering all quality gradings and heights.

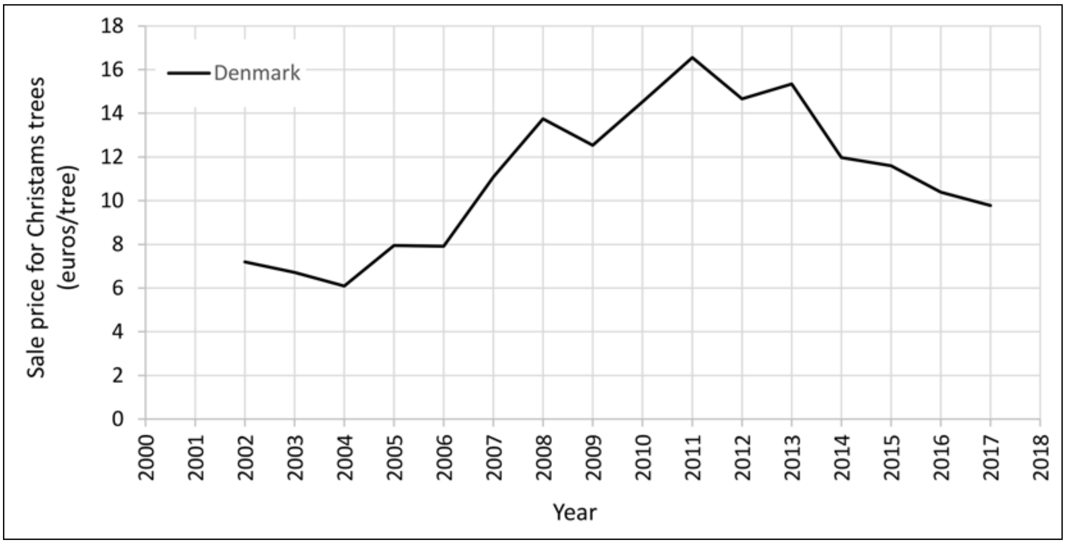

Figure 7.1: *Average prices for sale to Danish wholesalers, all quality grades and heights (data from Danish Christmas Tree Association)*

7.3.2 Chestnut

History

The European chestnut is native to southern Europe from Spain to Iran and extending northwards to Hungary, and is also present in North Africa. Nowadays the species is extensively planted and naturalized throughout Europe. The sweet chestnut is considered part of European culture; timber and nut production in silvo-pastoral and silvo-arable production systems started with the Greeks and the Romans who expanded chestnut cultivation to the whole of central and southern Europe.

Species and area

The four main chestnut species established for the production of edible chestnuts include: the European chestnut (*Castanea sativa*), the most relevant species for chestnut production in Europe and for this reason will be the main focus of this chapter; the American chestnut (*Castanea dentata* (Marsh.) Borkh.), a species native to USA; the Chinese chestnut (*Castanea mollissima* Blume), from northern China; the Japanese chestnut (*Castanea crenata* Siebold & Zucc.), native to Japan and also frequently grown for timber in southern Europe.

European chestnut is estimated to cover a total of 2.5 million hectares, of which 2.2 million hectares are chestnut dominated forests and the remaining

0.31 million hectares classified as mixed forests with chestnut. 79% of the area ascribed to chestnut forest or mixed forest with chestnut is devoted to timber production (1.75 million ha) (Conedera and Krebs 2010). The total area devoted to worldwide nut production amounts to approximately 0.6 million hectares (Table 7.3). European chestnut production area has remained reasonably constant over the past 20 years (increasing by ca. 42,000 ha); the greatest increase in production area has been seen in Asia, amounting to 0.22 million ha (FAO 2018).

Silviculture and silvicultural systems

"Sativa" literally means "cultivated", possibly a reference to the widespread historical cultivation of the chestnut tree by civilisation. A wide range of varieties have been bred for nut production in southern Europe. Grafted chestnut cultivars have been traditionally propagated utilising three or four year old rootstocks often of interspecific origin. Grafted plants are more expensive to produce but their use creates a more consistent product than when using non-grafted varieties. Three main management practices can be found in Europe concerning the cultivation of chestnut: high forest, coppice and orchards (Pereira Lorenzo et al. 2010) Nevertheless, dual-purpose chestnut varieties for both fruit and timber production are suggested to be quite common in some European regions (Conedera and Krebs 2010). The combination of timber and chestnut production (see chapter 4 in this book) allows for greater product diversity and income generation, an aspect especially important for small scale land owners and managers. In the Bragança region in Portugal a system called soutos is practiced, widely spaced chestnut trees are dispersed on pasture for the grazing of sheep (Castro 2009); this is similar to the dual use Streuobst system in central Europe (Lucke et al. 1992; Herzog 1998), which is widespread throughout western, central and eastern Europe. Trees are dispersed amongst pasture, cropland or meadow at low density (ca. 20 to 100 trees ha-1). Other dual systems such as that commonly utilised on the Iberian Peninsula require the grafting of desirable chestnut cultivars on top of a straight branch free stem at a height of 2 m (Conedera and Krebs 2010), similar to practices carried out in mono-use C. sativa production systems. Stocking is closer than that found within chestnut orchards, allowing for increased interspecific competition that creates a better stem form (Pereira Lorenzo et al. 2010). Short rotation biomass crops such as willow (Salix spp.) and poplar (Populus spp.) or other intercrops can also be grown between the rows as a form of agroforestry system (Morhart et al. 2014); within such a system chestnut can be managed for both timber and non-wood products.

Associated products and services

Chestnut is historically known as the "bread tree" producing edible nuts which are a good source of dietary carbohydrates, fibre and essential minerals. The nuts, leaves, flowers and bark of chestnut have also been extensively used in the cosmetics industry, in natural and homeopathic medicine, and in the nutraceutical sector (Abrudan et al. 2010; Di Renzo et al. 2010). Furthermore, the shell and leaves can be utilised as a source of natural antioxidants and phenolic compounds (Calliste et al. 2005; Vázquez et al. 2008; Vasconcelos et al. 2010). The residues resulting from the processing of nuts contain compounds that have anti-diabetic, antitumor, antioxidant, antimicrobial and anti-malarial properties (Abrudan et al. 2010; Di Renzo et al. 2010), and have even been proposed as a means of absorbing heavy metals (Vázquez et al. 2009). Tannins extracted from wood and bark of Chestnut have been used in the leather processing (Braden and Russell 2001) and cosmetic industries. Chestnut tannins can be used to improve the stability of wines, as antioxidant compounds, and as an animal feed (Fioravanti et al. 2010). Tannins can also be added to fibre panels to improve bonding. Other NWFP that can be associated with the culture of chestnut including honey and edible wild mushrooms such as *Boletus* spp. and *Amanita cesarea* (Scop.) Pers. which commonly grow underneath the crown (Bellini and Vannacci 2010). In particular, chestnut orchards are a favourable habitat for the growth of the edible and highly valuable mushroom *Boletus edulis* Bull. (1782) (Ciesla 2002). Chestnut wood, although susceptible to devaluing "ring shake", is used for veneer, wine barrels, construction, poles and stakes for vineyards, furniture, door and window frames, medium/high density fibreboard (MDF and HDF) and many outdoor products due to its inherent durability (Pereira Lorenzo et al. 2010; Fioravanti et al. 2010).

Production

Table 7.3 reports the harvested area and production in the countries relevant for chestnut production and Figure 7.2 demonstrates official annual production data since 1961, reported by the current top five chestnut producing countries in Europe.

Table 7.3: Global and European production figures for chestnut (just countries with an area >1000 ha are individualized, Source: FAO database (FAO 2018).)

Country	Harvested area 2017		Annual production 2017		Exports 2016	
	(ha)	%world	(tonnes)	%world	Thousand euros	%world
Turkey	39,580	6.6	62,904	2.7	22,302	7.2
Portugal	36,759	6.1	52,356	2.2	50,165	16.1
Spain	35,241	5.8	36,000	1.5	46,274	14.8
Italy	21,627	3.6	29,875	1.3	57,042	18.3
Greece	9,200	1.5	15,623	0.7	8,005	2.6
France	7,686	1.3	8,406	0.4	15,492	5.0
Albania	2,306	0.4	6,226	0.3	7,459	2.4
Other Europe	2,133	0.4	3,418	0.1	14,715	4.7
TOTAL Europe	154,532	25.6	214,808	9.2	221,454	71.0

Country	Harvested area 2017		Annual production 2017		Exports 2016	
	(ha)	%world	(tonnes)	%world	Thousand euros	%world
China	335,904	55.7	1,939,719	83.3	68,914	22.1
Bolivia	57,161	9.5	85,047	3.7		0.0
South Korea	30,204	5	52,764	2.3	15,186	4.9
Japan	18,800	3.1	18,700	0.8	2,504	0.8
North Korea	5,122	0.8	12,540	0.5		0.0
Chile	1,114	0.2	2,583	0.1	1,250	0.4
Other world	240	0	1,335	0.1	2,449	0.8
TOTAL World	603,077	100	2,327,496	100	311,757	100

World production figures are dominated by Asia (all edible varieties) with Europe estimated at producing nearly 10 % of world supply (FAO 2018). Marron varieties have been traditionally cultivated in Italy and in a few areas in France, within pure stands, which account for nearly 80% of European chestnut cultivation. Spain, Portugal, and Switzerland provide a further 10% (Conedera and Krebs 2010). Turkey is Europe's largest producer where official data suggests that nearly 60,000 tonnes are produced annually (10 year average, FAO 2018).

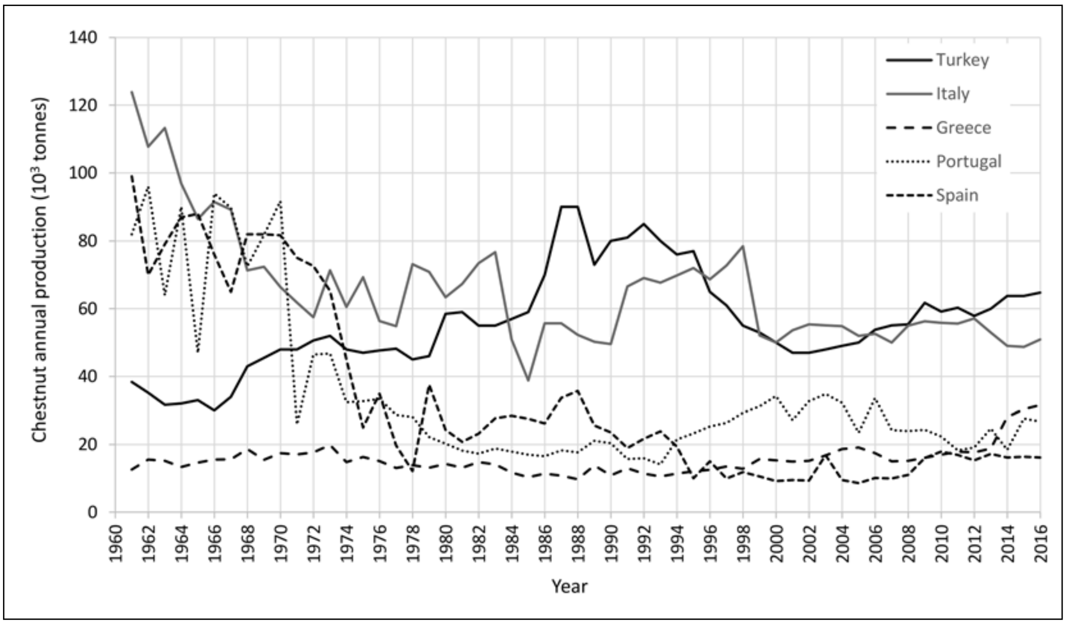

Figure 7.2: *Annual production of edible chestnuts from the current top five European producing countries. Data from FAOSTAT Database (FAO 2018)*

Economic importance

Chestnut is an important revenue in the rural areas of the countries where it is cultivated. Figure 7.3 shows the evolution of chestnut prices for the most important countries. An increasing tendency can be seen since the year 2000 for all the countries. Table 7.3 shows the exports (in thousand euros), showing that Europe is responsible for 71% of the total world exports of chestnuts.

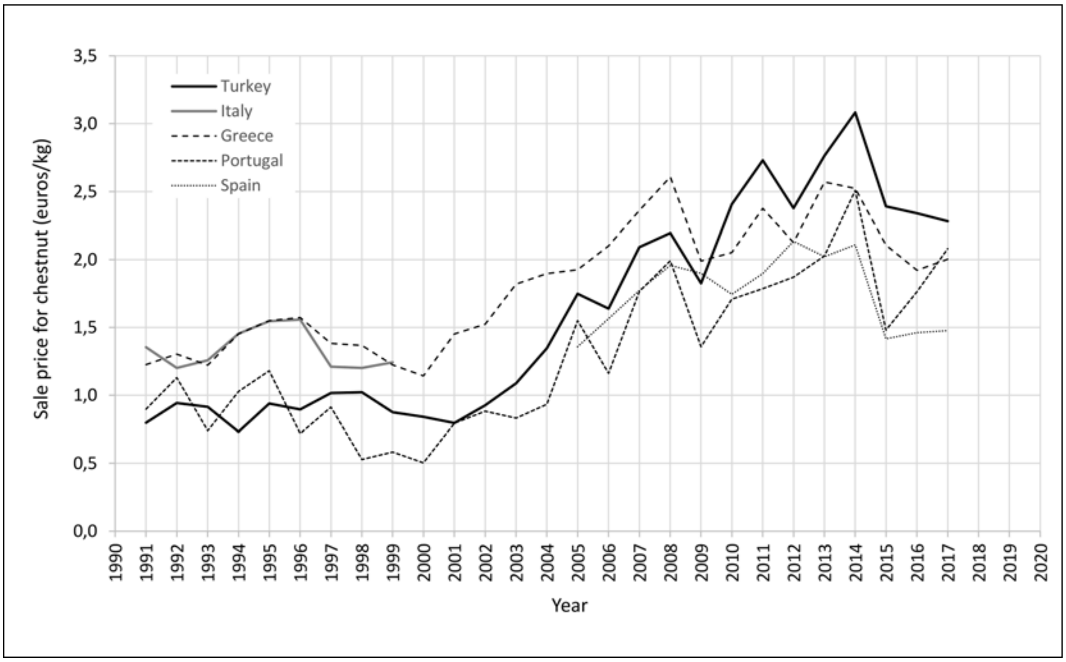

Figure 7.3: *Evolution of chestnut sales price in the countries with higher chestnut production (FAO 2018)*

7.3.3 Resin

History

The resin, harvested from various species of *Pinus*, may be considered the oldest and most important non-wood product from conifers (Ciesla 1998). This author mentions that pine resin has been an important commodity at least since biblical times, as attested by the story of Noah receiving instructions from God to "pitch the ark within and out with pitch" and by the reference of the Roman poet Ausonius about tapping of pines for resin in Aquitania in the south-eastern part of France.

Species and area

While most living pines are capable of yielding resin on tapping, it is only economically viable to do so if the quantity obtained is sufficient and its quality acceptable. Historically the most relevant pine species in Europe tapped for resin has been *Pinus pinaster* in southwest Europe, *P. nigra* and *P. sylvestris* in Central-Eastern Europe and *P. halepensis* in Greece (Themudo and Carneiro 1958; Coppen and Hone 1995). In Southwest Europe, maritime pine (*P. pinaster*) is the main resin tree species and produces resin of high quality that, when distilled, yields rosin and turpentine, the basis for a wide range of industrial products. Stone pine (*Pinus pinea*), mainly used for pine nuts production, is also often tapped for resin in Portugal.

Associated products and services

The resin exploitation is associated to many social and economic benefits, providing employment and income opportunities for people in rural areas, and improving the profitability of primary forest activities by co-production of this NWFP. There is no consensus on the negative effects of resin tapping on tree diameter growth and wood quality (Gomes 1954, Figueiredo and Filho 1991, Palma 2007, Rodríguez-Garcia et al. 2015, Silva et al. 2018).

In Portugal, and since the 19th century, resin tapping has been a traditional forest use with great importance for rural economy, and it has been maintained until the 1980's (Santos 2013). After that time, resin tapping revealed some limitations due to international market competition especially from China (utilizing *P. massoniana* Lamb. and *P. kesiya* Royle ex Gordon) and Brazil (with *P. elliottii* Engelm.), changes in rural structure, human desertification of rural areas, lack and price of labour, and deforestation of maritime pine areas (Anastácio and Carvalho 2008). However, the resin production supremacy projected by China has changed in recent years as the result of overly aggressive pine tree tapping for resin, and increased labour costs, further triggered by the prevalence of Pine Wilt Disease that has been causing Masson pine mortality (Gao et al. 2015; Wei et al. 2016).

Resin salve from *Picea abies* is traditionally and widely used in folk medicine to heal various skin infections and wounds in Finland (Sipponen 2013). No statistics are available in Finland, but approximately 1,000 kg of resin is annually used in several spruce resin-based products for medical treatments. Similarly, in Italy, about 1,200 kg resin from Larch (*Larix decidua*) is tapped each year for cosmetic or medicinal uses (Corradini 2015).

Silviculture and silvicultural systems

In Portugal and Spain resin yield is mainly obtained by tapping maritime pine trees in natural or artificially regenerated stands that occupy, according to the last national inventories, 714,445 ha (ICNF 2013) and 691,000 ha (CESEFOR 2009), respectively. In Europe, there are no pine plantations managed only to produce resin, thus the management objective is a combination of timber and resin as the main productions (Baskent et al. 2014), combined with associated ecosystem services (soil protection, carbon sequestration, landscape value). Stands can be pure or mixed but single species stands are recommended for resin extraction purposes (Tomé and Faias 2014). Resin tappers move from tree to tree, to tap the trees and collect the resin. The resin is collected with small hand-cars and the topographic characteristics (e.g., excessive slopes) and the density of understory can be limiting for profitable resin exploitation.

Resin flow from pine can be induced after local bark stripping, mechanically by cutting grooves in the underlying wood or chemically by applying stimulants, often acid. The resin is collected in pots fixed beneath on the stem. In Portugal, the gum resin activity has been regulated by specific legislation since 1957 (DL 41033, 18/3). More recently, the Decree-Law nº 181/2015 defines the legal regime for the resin activity and circulation of pine resin. The minimum tree diameter at breast height (dbh) size, the number of wounds per tree, and the distance between tapping faces of the same tree are defined. Some of these rules are function of the resin extraction system adopted: to death - trees tapped in the 4 years immediately preceding the harvest (thinning or final cut); to life – the incisions extend over several years. The minimum dbh for a tree to be tapped to life is 20 cm (63 cm of perimeter). Until 2015, the period for resin harvesting was restricted to the period between 1st March to 30th November, but after 2016 trees can be tapped any time during the year. In Spain the minimum dbh is around 30 cm, but it depends on the number of consecutive tapping faces that shall be opened on the tree, normally four or five, each of which will last during five consecutive years of resin production (Mutke et al. 2013).

Breeding programs and new silvicultural management systems for managing maritime pine stands for co-production of wood and resin, combined with the development of new tools to resin tapping, extraction methods and business models are of importance for this NWFP (Morris 2015).

Production

Mean annual resin yield is about 2-3.5 kg per tree (CESEFOR 2009; ICNF 2015). However, resin yield of 7.4 kg/tree has been referred by Palma et al. (2016) in central Portugal. Tadesse et al. (2001) referred values up to 25.1 kg/tree in selected high resin yielding trees in central Spain. In temperate climate zones, peak resin flows usually occur during summer (Themudo and Carneiro 1958; Rodriguez-García et al. 2014, 2015). Tree resin yield is influenced by natural factors and technological factors (tapping techniques) (Palma 2007). Natural factors explaining variation in resin production are: genetic variability; individual tree size variables; inter and intraspecific competition; site quality; and climate conditions (Palma 2007, Rodríguez-Garcia et al. 2015, Palma et al. 2016, Rodríguez-Garcia 2016, Silva et al. 2018).

In Portugal, gum resin production reached 108,000 tonnes in 1986 (CESE 1998) and reduced drastically to 63,000 in 1990 and 5,000 after 2004 (INE 2016). After 2011, a slight increase in production has been observed with 8,003 tonnes in 2017 (INE 2018) with higher prices at the point of processing. A similar trend has been observed in Spain: the maximum resin production was 55,000 tonnes in 1961, decreasing slowly to 40,000 in 1971-75 (MARM 2008). After 1990, and during more than two decades, resin output was lower than 5,000 tonnes per year achieving 1,443 in 2008 (MARM 2013). The global economic crisis, which reduced wages and increased unemployment, led to the coming back of labour to rural areas, allowing for a renaissance of resin tapping activities in Spain (Picardo and Pinillos 2013). Data available from Greece show a similar pattern. Figure 7.4 summarizes the data series on production for these countries.

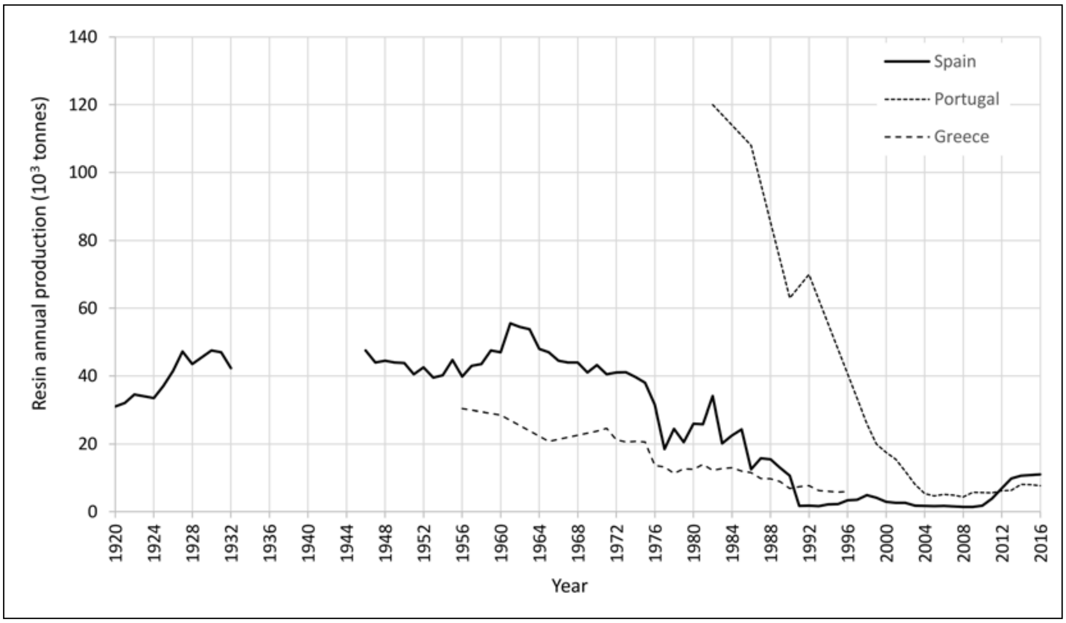

Figure 7.4: *Annual production of resin from the top three European producing countries (data from several sources – Spain: MAPAMA 2015; Portugal: INE 2017, in http://resipinus.pt/resinagem/resinagem-em-Portugal-e-no-mundo/); Greece: Koutsiriba 1998)*

Figure 7.5: *Evolution of resin sales price in Portugal and Spain (data from several sources – Spain: MAPAMA 2015; Portugal: INE, in http://resipinus.pt/resinagem/resinagem-em-portugal-e-no-mundo/)*

Economic importance

As mentioned before, the economic importance of resin in the rural areas economy has steadily increased in south Europe, namely Portugal and Spain, in recent years. Figure 7.5 shows the evolution of sales price for resin in Portugal and Spain where the increase in price, consequence of the renaissance of this activity in the Mediterranean region.

7.3.4 Mediterranean pine nuts

History

Mediterranean pine nuts kernels, obtained from cones of stone pine (*Pinus pinea*), have been consumed by man in the Mediterranean region since antiquity. Today, Mediterranean pine nuts are a cultural heritage, a Mediterranean food with excellent dietetic values (Evaristo et al. 2010) and singular flavour, and one of the most expensive and emblematic nuts in the world. The high price paid for pine nut kernels increases the revenues for forest owners from cone, exceeding the amount obtained for any other primary product, including timber (Mutke et al., 2000, Ovando et al. 2010; Mutke et al. 2012; Pasalodos et al. 2015; Pereira et al. 2015).

Stone pine is not very relevant in terms of area but it can be locally relevant. Emblematic pinewood regions are namely Valladolid, Catalonia or Huelva in Spain, the Coastal region of Alentejo in Portugal, Kozak/Bergama and Koçarli/Aydin in Aegean Turkey, Tyrrhenian coastal areas of Italy (e.g., in Tuscany and Sardinia) or Metn and Jezzine on Mount Lebanon, where the activity of cone picking is embedded in a general appreciation of that ancient cultural forest landscape, highly esteemed by local dweller and visitors for its scenic amenity and relevant for recreation and rural tourism. Even the character of being a cultural tree species associated with anthropic landscapes does not diminish, but increases, the esteem of stone pine as genuine Mediterranean element that contrasts with surrounding endless cereal-dominated plains in inner Spain or with crowded urban areas along the Mediterranean coastal plains.

Species and area

At national scale, pure or mixed native stone pine forests are rare in all Mediterranean countries, normally limited locally to poor sandy or rocky soils where no other forest types can prosper. Due to this boundedness to restrictive environments stone pine is not a prevailing forest species at national scale; mixed or pure stone pine forests represent about 6% of national forest area in Portugal, 5% in Lebanon, 4% in Spain, 1.7% in Tunisia, and less than 1% in Turkey, Italy, France, Greece, Morocco and Israel, summing up about 960,000 ha in the whole Mediterranean area (Mutke 2013; Hamade 2016; Mutke et al. 2017).

In Portugal, stone pine occupies 175,742 hectares (ICNF 2013) representing over 20% of this species global distribution area. About 38% of the Portuguese area is found on agricultural farms (INE 2017). Productive stands are often uneven-aged. Even aged stands are typically young because, since 1992, a part of the EU forest funds have been used to promote stone pine plantations (Carrasquinho et al. 2010).

In the last decades, private landowners have been investing for establishing new areas of this tree as agronomic crop, due to the perspective of a lasting world demand for pine nuts exceeding the limited supply of wild-harvested from pine forests (Calado 2012; Kilci et al. 2014). Both in Portugal and in Turkey, new plantations have multiplied the area devoted to stone pine nearly fourfold in the last 40 years, offering an alternative to widely cultivated species such as maritime pine, which is severely affected by fatal pine wilt nematode outbreaks and less tolerant to drought.

Associated products and services

Other relevant ecosystem services derived from pine forests are soil and watershed protection, these are paramount forest functions of Mediterranean woodlands, as well as wildlife conservation, landscape or recreational uses, especially in public forests. But even taking into account all forest goods and services, pine nut production is locally still an outstanding economic, social and even cultural value of several Spanish, Portuguese, Turkish or Lebanese stone pine districts.

Production

The same as in many other NWFP, overall production of pine nuts can only be estimated approximately, given the actual lack of traceability of the supply chain. A great number of small familiar enterprises or autonomous cone pickers are involved in collection and extraction; and local or informal markets for cones and pine nuts prevail in most regions. The perfect durability of pine nuts in shell allows for storing stocks among years, and there are huge (and not always declared) export-imports of unprocessed cones among countries. Table 7.4 presents some estimates for current mean productions of Mediterranean pine nuts in the main producing countries and Figure 7.6 shows time series of production for the same countries. Annual variation due to masting is important, country time series showing values ranging from about 0.25-2.5 times their average, regional yield series varying even more. In the 21st century, increasing frequency of drought events in the Mediterranean has been reducing per-hectare yields (Mutke et al. 2005; Calama et al. 2008, 2011, 2016). In some years of the present decade, pine nut production from forests has been drastically diminished by the incidence of an invasive exotic pest, *Leptoglossus occidentalis*, whose predation can abort the seeds or whole cones (Bracalini et al. 2013; Lesieur et al. 2014). The impact of this pest is a serious threat for the pine nuts production in the future.

Silviculture and silvicultural systems

Traditionally pine nuts have been collected from existing stands, most of which are naturally regenerated and often mixed with other Mediterranean tree species. In recent years, the income that the landowners can take from this non-wood product lead to an increase of new planted stands that are managed as even-aged stands, and there are several running trials in order to find the best management approach in terms of pruning and stand density.

Increasing kernel production is one of the purposes of stone pine improvement programs in Portugal and Spain. Cone crop production, assessed through the number and weight of the produced cones, has been the main criterion for selecting plus trees (Mutke et al. 2000, 2012). Carneiro (2005) reported a high genetic correlation between cone weight and seed weight per cone, kernel weight and the weight of a hundred seeds.

Recently (starting from 2009), grafting has been used to establish orchards for pine nuts production. This technique has important advantages for producers such as: to reduce the juvenile period of the tree with no flower production, to propagate the most productive trees (plus trees), to standardize crops, and to facilitate cultural interventions (Mutke et al. 2000; Carneiro et al. 2007). However, to assure the species sustainability, genetic variability must be guaranteed by selecting a representative number of plus trees. In fact, the recent register of elite stone pine clones with superior cone production in Spain and plus clones in Portugal allows their release for use in grafted plantations on farmland, offering higher yields than from forests (Guadaño and Mutke 2016).

Table 7.4: Average current in-shell pine nuts production for the most important countries

Country	In-shell pine nuts [tonnes]	Source
Spain	5,000	Vallejo et al. 2010
Portugal	4,500	Costa and Evaristo 2008.
Turkey	5,000	Sülüşoğlu 2004; OGM 2015
Italy	1,000	Mariano et al. 2010
Lebanon	4,000	Hamade 2016
TOTAL	16-20,000	INC 2012

Using the average of mean annual productions of the data in Figure 7.6 for the period 2006-2016, the production of (in-shell) pine nut is 4,714 tonnes for Spain, 4,669 for Turkey, 4,003 for Lebanon, 2,488 for Portugal and 542 for Italy.

The global pine nut production is expected to increase greatly in the near future, when 200,000 ha of new planted stone pine orchards in Portugal, Spain and Turkey will reach full production (Mutke et al. 2017).

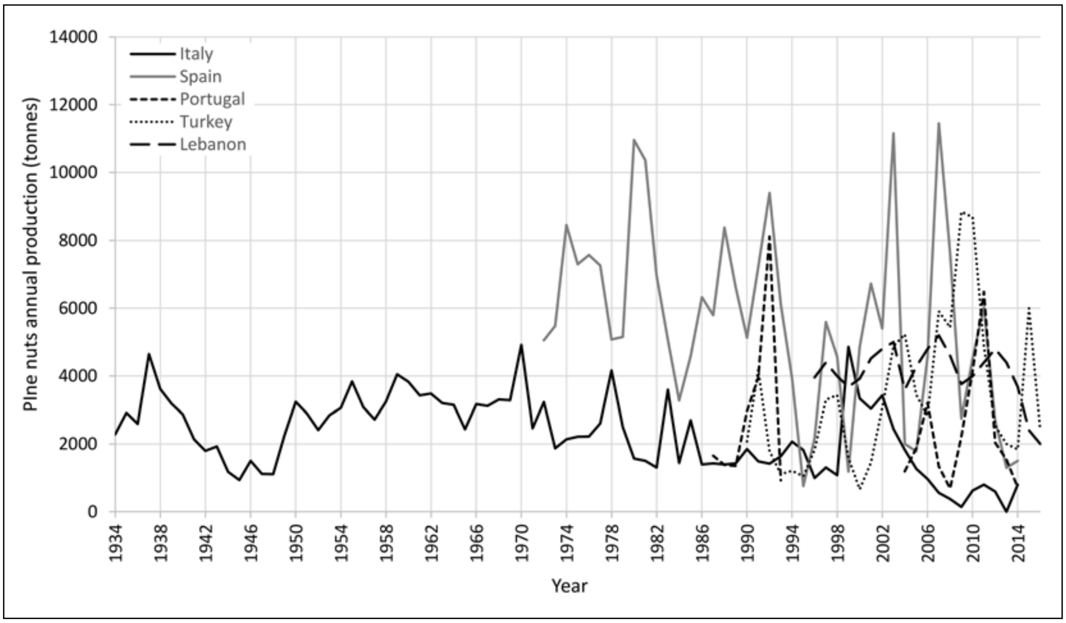

Figure 7.6: *Annual production of in shell pine nuts from the top producing countries (data from several sources – Spain: MAPAMA 2015; Portugal: Oliveira 1995; Agri-Ciência 2014; INE 2014, 2016; Italy: ISTAT 2018; Turkey (exports only) – Açar et al. 2010, Pastor 2014, Kilci et al 2014, Can 2016, Lebanon – Sattout and Faour 2017)*

Economic importance

In Spain, the value of mean annual (in-shell) pine nut production amounts to approximately 24 million euros, this total is only 2.1% of all income derived from forest products comprising timber, firewood and biomass (65%), cork, chestnuts, acorns, mushrooms, truffles, resin, acorns or forest beekeeping (Vallejo et al. 2010). Considering regional analyses for stone pine forest districts, such figures are dramatically different. In the Spanish province of Valladolid, stone pine is the primary forest species occupying 42% of total forest area, and cone harvesting yielded as much as 43% of total income for public forests, with timber amounting only to 33% (Gordo et al. 2016).

For the owner of stone pine forest holdings, cone yield is often more profitable than timber (mean annual stem growth often not exceeding 1.5-2 m^3/ha/year) or other uses. In the case of public forests in Valladolid the returns are: 25 euros/ha/year for cones harvesting rights; 20 euros/ha/year for timber and firewood; 5 euros/ha/year for grazing rights and 2 euros/ha/year for hunting rights (Gordo et al. 2016). It must be noted that these values refer to one of the coldest, driest and less productive stone pine growth regions in the world, where mean cone yields are low and a strong masting habit reduces the average (Mutke et al. 2005; Calama et al. 2011). But the conclusion of higher revenues summing annual cone yields than from final clearcutting at the end of stand rotation would be similar in other conditions, given the long rotation length of stone pine and the low technological value of its timber that cannot compete with Scots pine, radiata pine or other imported conifers.

Official data are available still only for the years before full incidence of Leptoglossus, when annual production of shelled pine nut kernels could be estimated in 4,000-4,500 tonnes from Mediterranean stone pine forests, i.e. about euros 300 million market value, while production of other Asiatic pine nuts obtained from different species, such as *P. koraiensis*, *P. sibirica* or *P. gerardiana*, exceeds 30,000 tonnes, nearly euros 1 billion in retail. Genuine Mediterranean pine nut kernels obtain, however, the highest market price (over 100 euros /kg in retail). The lack of sufficient supply from natural pine forests for which contribute climate restrictions and the seed pests, as well as frequent deficiencies in labelling of different species and geographic origins in retail (not even distinguishing Mediterranean from other cheaper Asiatic pine nuts), hampers its prevalence in the European nut market. The resulting shortage on pine nut markets has driven prices up for several years (Figure 7.7).

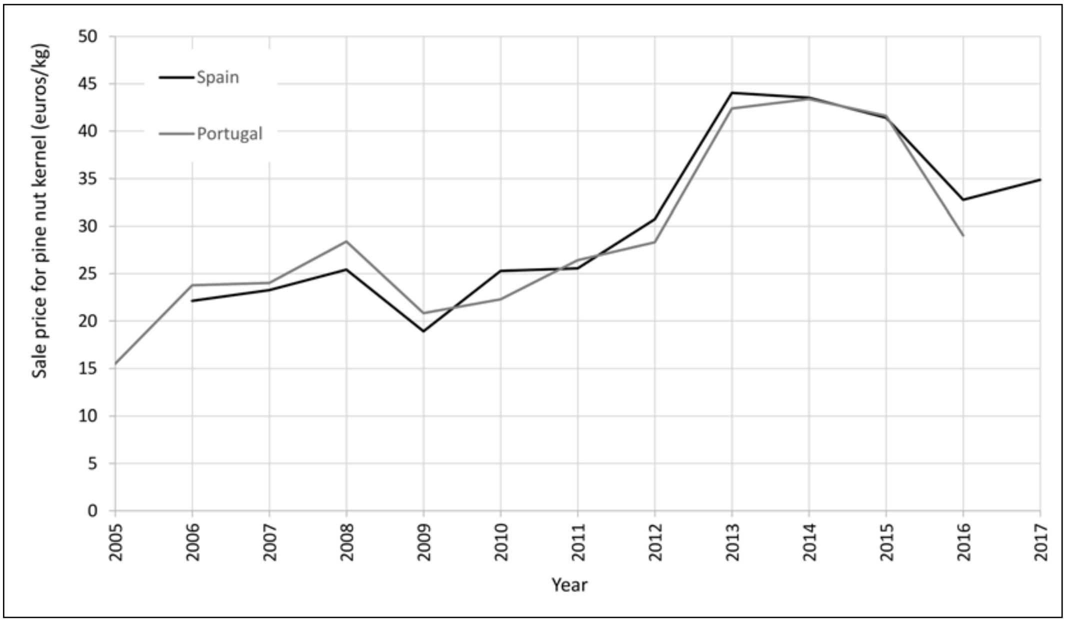

Figure 7.7: *Wholesale price for Mediterranean pine nut kernel. Spain: at Reus, the Spanish reference auction for nuts (*http://www.llotjadereus.org/*); Portugal: GPP, Sistema de Informação de Mercados Agrícolas (*http://www.gpp.pt/index.php/sima/sima-2018 *)*

7.3.5 Birch products in Finland

History

'Koivu', birch, is deeply entwined within Finnish culture and livelihood. A poem from the Finnish epic 'Kalevala' aptly depicts the importance of birch to Finnish people. Therein, the hero of Kalevala, Väinämöinen hears the sorrow of a weeping birch. The birch sadly describes his terribly destiny in the edge of summery joy; people cut wounds to its belly to drain spring fresh sap 'mahla' and in summer cut off its branches to make 'vasta' (a birch bath whisk used in sauna) to bring health and smell of summer, how people tear off its skin, the bark, to make shoes, bags, call horns, and mugs, and finally how people towards winter make firewood out of birch. To this Väinämöinen replies: praising the birch on how it brings life and joy to people. To pronounce his words, he calls the birch a mother tree and from its curly heartwood he will carve the finest 'kantele' (Finnish traditional instrument) ever made, to bring the joy of music to people.

Species and area

The birch species with relevance for NWFP are mainly *Betula pendula* Roth but also *B. pubescens* Ehrh. They are the most common deciduous trees in Finland. Birch typically occurs as minor tree species in forests dominated by spruces and pines. However, also birch dominated stands exist particularly in situations where birch seedlings have been planted after regeneration cut or when reforesting former agricultural lands. According to Finnish National Forest Inventory, birch predominates on about 10% of forest land and the birch volume is almost 17% of the total volume of trees in Finnish forests.

Associated products and services

Many of the forms of use described above still exist today. Many commodities have and are being made of birch. Besides its timber for veneer, furniture, building, pulpwood and firewood, birch is a vast source of NWFP. Finland is ideal for wild forest products due to its pure nature (Peltola & Sarala 2012) and high levels of technology, infrastructure and innovation. Xylitol, a healthy sugar alternative, and alcohol being just some of the treasures birch presents.

Though traditional uses have prevailed, new innovations derived from birch are increasingly evident as well as from species living on it. Great interest has been focussed especially in respect to the nutra and pharmaceutical properties of birch and other wild forest commodities it supports. In traditional medicine birch leaf tea has been used as diuretic remedy (Shikov et al. 2014)

Sadly the tradition of making utensils out of birch bark is slowly disappearing and can be found only in select souvenir stores, but new innovations from birch bark have been generated. Birch bark has indicated the capability to solve health problems caused by diet. In traditional medicine birch bark extracts have been used as remedy for various inflammatory diseases including dermatological inflammations, arthritis and rheumatism (Rastogi et al. 2015). Betulin and its derivatives which give the white colour to birch bark have shown a wide spectrum of biological functions including antiviral, antibacterial, antitumor, anti-inflammatory, and hypolipidemic activities (the ability to lower bad cholesterol) and antiatherosclerotic activities and intensive research concentrated on the extraction of betulin from bark gained as a side stream of veneer production (Alakurtti et al. 2006, Tang et al. 2011). By applying feasible extraction methods a new value chain from bark could be created.

Besides the tree itself, commodities that grow and live on birch trees have also attracted the interest of both researchers and forest owners. Birch stems and stumps accommodate, for example, valuable edible and specialty mushrooms. At its best the cultivation of these mushrooms can be integrated into current forestry practices, or utilize set-aside birch stands in cultivation. Pakuri, (chaga in English; *Inonotus obliquus*) and sheathed woodtuft (*Kuehneromyces mutabilis* (Schaeff.) Singer & A.H.Sm. (1946)) are the species where most of the research and development is focussed. Pakuri is a pathogen living on broadleaved trees. In Finland, it occurs mainly on birch (*Betula* sp.) infecting trees that are damaged by frost or mechanical injury. Pakuri is able to produce many interesting metabolites with biological activities including β-glucan, triterpenoids and sterols (Du et al., 2011, Rhee et al., 2008, Zhang et al., 2015). Furthermore, Pakuri converts birch betulin to betulinic acid which appears to have much higher pharmaceutical activity than betulin itself (Chen et al., 2009). Pakuri is used as tea made out of a sterile conk which pakuri forms on a tree. Water and ethanol extracts of pakuri have been used as part of traditional medicine especially in Asia. In test animal trials these extracts have been shown to correct various metabolic problems due to unhealthy Western style diets. These effects include e.g. amelioration of chronic and acute inflammation (Shikov et al. 2014) and distorted lipid metabolism in obese rats (Wu et al. 2015), antihyperglycemic and antidiabetic (Wang et al. 2017, Diao et al. 2014) as well as hepatoprotective effcts (Wang et al. 2017, Wu et al. 2015). Currently interest on pakuri tea as health promoting product is growing also in Europe

Sheathed woodtuft is an edible decomposer mushroom which grows on birch stumps and other dead wood, and thus not infecting living trees as pakuri. So far, harvesting the species has relied on natural production of conks or fruiting bodies (wild harvesting). For viable value chains of these products, a higher and more stable supply of raw materials is needed. A growing demand for raw materials could be fulfilled by systematic and organized cultivation of the species (Vanhanen et al. 2014, Issakainen 2015).

Silviculture and silvicultural systems

Birch has both a traditional importance and as yet an un-harnessed potential to Finns. The emerging new business opportunities call for forest management, which better enables the joint production of timber and non-wood forest products. In the management and utilization of birch, novel approaches must be applied to generate new value chains that are not solely dependent on high-quality timber, but also on extracts and commodities derived from birch.

Production

One of the traditional NWFP uses mentioned in Kalevala that thrives extensively today is birch sap tapping. Finland harbours one of the biggest producers of tree waters in the world. This tree water is solely sap tapped from birch growing in organic certified forests and over 90% of the birch water is exported. The abundance of birch in Finland makes birch sap production almost infinitely scalable. One birch at its best can give a yield of approximately 250 litres of sap during spring, but the season is limited to some weeks during early spring. Sap flow begins when temperatures rise above +4 °C, usually in April, and ends at bud break.

Economic importance

Currently, birch trees are used mainly in forest industry and based on statistics of Natural Resources Institute Finland (https://stat.luke.fi/en/) in 2018 the birch roundwood harvesting exceeded 9 mill. m^3.

Although important regarding the traditional use and for rural population, the economic importance of NWFPs from birch has not been evaluated. However, recent global trends related to health promoting diets and healthy lifestyles have promoted the production of NWFPs products from birch forests. Special mushroom cultivation, e.g. Pakuri (*Inonotus obliquus*) and birch sap tapping have increased considerably during last years (Ristioja 2018). In addition, these products are more and more often collected and sold onwards with organic certificates. The annual birch sap deliveries to birch sap companies in Finland can be estimated to approach 2 mill. litres. In addition, there exist several hundreds of forest owners, who have started to cultivate specialty mushrooms. Currently the yearly purchase amounts for one specialty mushroom, Pakuri vary from 3 to 20 tonnes.

7.3.6 Acorns

History

Acorn domestication can be found during previous millennia (Fonseca 2003). Archaeological data and Roman and Greek literature sources show that acorns were an important component of the human (Mediterranean) diet. Pais (1996) reports archaeological findings of acorns from the XI century in South Portugal (Mértola), under a context similar to wheat (to produce flour), while acorn usage references can go back 5000 years to the Bronze Age (Mattoso 1993).

Nowadays, acorns are mainly considered as animal feedstock, an important energetic complement between Mid-Autumn and Mid-Winter. In terms of human consumption, eating acorns, apart from the tannin removal, has a “psychological barrier”. During the last century, or even earlier, only those suffering extreme economic difficulties would eat acorns. Acorns are traditionally linked to pig-feeding and it is not uncommon to hear comments nowadays such as “acorns are for pigs”.

However, recent studies have shown the potential of acorns for human consumption and evidence of acorn usage potential is somewhat clear. Sooner or later, acorns will once again become more frequent in our diet as the conscience of human diet diversification prevails. Often acorns are divided into two “types” (sweet and bitter), but all acorns are edible if the tannins are removed or neutralized.

Acorns can produce gluten-free flour, with polyunsaturated lipids, high in phenolic compounds, high in protein and fibre, anti-mutagenic, highly anti-oxidant, and anti-microbial. Products based on acorn flour pass taste/flavour tests compared to current market products and can provide viable alternatives to products from which there are intolerances (Pintado 2015). The benefits of acorn for human consumption needs to foster attention to further assessments to release its potential, in particular those that could help overcome the psychological barrier while establishing a new market for an overlooked native non wood food product.

Species and area

Although typically attributed to common oak (*Quercus robur*), holm oak (*Q. rotundifolia* and *Q. ilex*) or cork oak (*Q. suber*), acorns are the fruit of more than 800 oak species worldwide (Manos 1999). Oaks are one of the most abundant broadleaves in the world, reason why is not surprising to find acorn domestication so long ago.

Associated products and services

Acorns are associated with the grazing under the oak trees managed as agro-pastoral systems. In particular, the high quality Iberian ham, in order to be certified as such, requires the pigs to browse for 40 days, eating about 10 kg of acorns per day (Lopez-Bote 2000).

Other types of services, difficult to measure, are associated with oak trees as they are part of landscapes with high natural and cultural values, linked to different types of activities (e.g. tourism, hunting, hiking, cycling). Clearly, further studies should be taken to improve our knowledge in terms of management of such *Quercus* systems under an ecosystem approach. The tree element comes from a highly hybridized genus, with high variability amongst individuals in fruit productivity (e.g. Garcia-Mozo et al. 2012), while being a pivot for agriculture (soil improvement), livestock (energy from acorns and improved welfare from shade), wildlife and tourism (including hunting).

Production

In spite of acorn use having started so long ago, data on acorn production are rare. According to ISTAT (2018) time series, acorn production in Italy has decreased markedly over the past decades, from 13,000 (1991-2000) to 410 tonnes (2001-2010).

Economic importance

A brief exploratory economic analysis of this potential is given by Sottomayor (2015). An attempt for a national figure for acorn production based on the Portuguese Forest Inventory (IFN5) estimates that there are about 400,000 tonnes of acorns from oaks (*Q. rotundifolia* (118,948 tonnes), *Q. suber* (185,827 tonnes), and other oak species (96,800 tonnes)). Current “active” use of the acorn is about

85,000 tonnes for pig browsing, another 3% for other livestock species and 1% for flour production. An estimate of the "passive" use by wildlife of about 20% leaves 54% of acorns "unused". Sottomayor (2015) concludes that the current use of acorns is worth a conservative 6.3 Million euros; however, if considering the unused acorns, and taking into account 1) 50% use, 2) harvesting costs, 3) processing costs, and 4) the current price of acorns at farm-door, the value increases to 13 Million euros (i.e. about double the current value of acorns).

7.3.7 Cork

History

Cork, the bark layer from cork oak (*Quercus suber* L.), has been extracted and utilized for a large range of uses in the Mediterranean since antiquity, as a consequence of the ability of the tree to regenerate a new cork after its removal, and due to the physical and chemical properties of this noteworthy material (Pereira 2015).

As a curiosity, cork has been the first tissue that was observed at the microscope and the first to be described, by Robert Hook in 1665 (Natividade 1959). A great step for the generalized use of cork was due to the French monk Dom Pierre Pérignon (1639-1715) that used the first cork stoppers for champagne bottles (Oliveira and Oliveira 2000).

Cork is a cellular natural material, very versatile, very light in weight, elastic, flexible, impermeable to gases or liquids, and good electric insulator, as well as a thermal, sound and vibration insulator and also a dielectric material. Its unique properties arise from its closed cell structure (Gil 2015). It has been used in applications that go from very simple ones like handicraft or the currently most common use as natural cork stoppers, to new products and applications such as bioabsorbents of heavy metals in aqueous solutions, composite materials, thermal, acoustic or vibration insulation, architecture, clothing or furniture (e.g. Pereira 2007; Gil 2015). Despite this innovative scenario concerning cork products, in 2016 natural cork stoppers were still responsible for 44% of the Portuguese cork sales (exports), followed by 28% from other types of stoppers. Other products were responsible for 28% of the exports (APCOR 2016).

Species and area

Although *Quercus suber* L. is not the only species able to produce and regenerate a bark layer with a significant amount of suberine, it is by far the only one that produces the thickest cork layer, with larger amount of suberine, and with less percentage of woody incrustations (Leite and Pereira 2017).

The world area of cork oak (Table 7.6), a species restricted to the Mediterranean basin, is estimated in 2.245 million hectares, with 73% of this area in Europe (Portugal, Spain, Italy and France) and the rest of the area in North Africa (Morocco, Algeria and Tunisia). However, the most part of the cork oak is located in Portugal and Spain, with 32.8 and 25.8% of the total world area, respectively.

Associated products and services

Today, cork is also a product associated to cultural heritage, in particular in regions where large areas of *montado* or *dehesas* exist, in Portugal and Spain respectively (Plieninger *et al.* 2015; den Herder *et al.* 2017), or in the Gallura district of Sardinia (Italy). These systems are recognized for important ecosystem services such as carbon sequestration (Coelho *et al.* 2012; Palma *et al.* 2014), soil and watershed protection (e.g. Guerra and Correia 2016), wildlife and biodiversity conservation (e.g. Godinho et al 2010; Santos-Silva *et* al 2011; Curveira-Santos *et al.* 2017), landscape or recreational uses (Pinto-Correia and Vos 2004, Barroso et al 2012).

Cork contributes towards fixing carbon dioxide, specifically for every tonne of cork transformed into products 14.3 t of CO_2 are fixed (Rives 2011). The fixation of CO_2 is increased by cork extraction because the periodic cork harvesting generates 250-400% more cork that would be produced if were not extracted (Gil 2015).

Silviculture and silvicultural systems

Most cork oak stands have been naturally regenerated or originated from broadcast seeding and are managed as agro-silvopastoral systems called *montados* in Portugal and *dehesas* in Spain. In these systems cork oaks are maintained at low density and low crown cover in order to combine cork production with agriculture or grazing. In most countries where the species grows well, there is a reasonable area of new plantations that took advantage of the European Union policies and incentives for afforestation of set-aside agricultural lands. Most of these plantations were established mainly for cork production purposes, and consequently with higher stand density than traditional agroforestry systems. For instance in Portugal, plantation rates in the periods 1990–1994 and 1995–2000 were 24,000 and 60,000 ha (Pereira et al. 2009), corresponding to annual afforestation rates of 4800 and 10,000 ha year^{-1}.

The extraction techniques and processes are mostly the same since centuries, passed to young generations during the debarking campaigns. Debarking is carried out, traditionally and most of the times, manually by a group of rural workers that annually undertake this seasonal activity (*rancho* in Portuguese), under hard summer conditions with air temperatures easily reaching more than 35°C. Inside the group each person plays a different role: woman are responsible for painting the year of extraction on the trees, transporting the extracted cork from the tree to the tractor with the help of young man; young man learn the techniques by practicing in smaller trees; more experienced man carry out the debarking of larger trees, many times in high branches with the help of ladders. Payment is made on a daily basis, with more experienced man being paid more in recognition of their skills. This social and social-ecological heritage entails valuable insights for the conservation of these Mediterranean landscapes (Otero *et al.* 2013). Although some machine prototypes have been produced in the last decades attempting the mechanization of the debarking operations, its feasibility is still surrounded by much controversy and its effective usage in the field to date has still not occurred. Even under a mechanised scenario, the expertise, training and formation of the debarking operator will still be crucial for the success of the operation, mainly for the minimisation of wounds made during the cork extraction that ultimately affect the tree life and future production.

Production

The amount of cork extracted from a tree is quite variable even among trees of the same size and located near to each other on the same stand. It depends on: tree size, cork thickness, debarking height, tree shape (namely height to the stem bifurcation and number of main branches) and, ultimately, on tree genetic variability. Table 7.5 presents average values of cork dry weight extracted per tree in relation to tree diameter at breast height under cork (data from Paulo and Tomé 2010).

Table 7.5: Values of cork dry weight extracted per tree in relation to tree diameter at breast height under cork

du class	n	mean	sdv
15	516	5.89	1.18
20	68	8.16	2.34
25	121	12.05	4.40
30	136	19.03	7.80
35	120	22.60	7.88
40	105	29.25	11.61
45	70	40.98	14.38
50	46	56.32	21.64
55	28	56.38	22.34
60	17	72.81	25.15
65	11	77.20	38.62
70	5	104.87	-
75	9	102.33	-
80	2	147.95	-
85	2	157.11	-
90	2	174.11	-
95	4	139.98	-

du – diameter at breast height measured under cork; n – number of observations per class; mean – mean value of tree cork production (kg); sdv – standard deviation of tree cork production; data from: Paulo and Tomé 2010

Concerning the world cork production, Portugal and Spain are the main producers. Table 7.6 shows the raw cork production in Europe and the world for 2010. Estimates for 2015 in Portugal and Spain amount to 127,500 tonnes (APCOR 2016). Data on the evolution of cork production in Portugal, Spain and Italy can be seen on Figure 7.8.

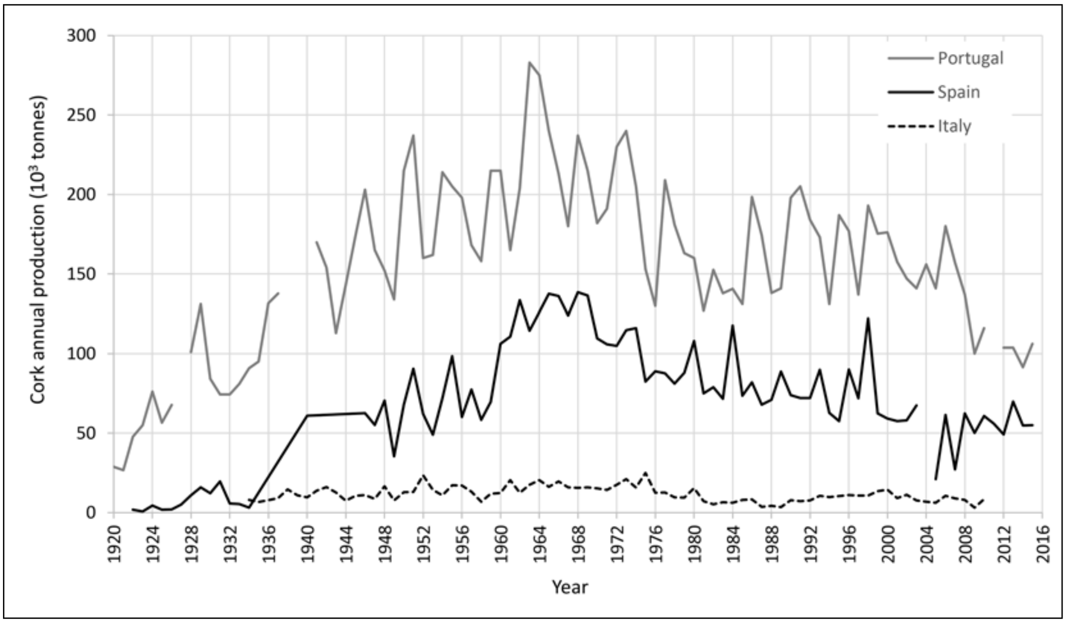

Figure 7.8: *Annual production of cork (total production, including mature and virgin cork). Data sources – Portugal: till 2010, as presented by Mendes (2002) using the Portuguese Statistics (Estatísticas Agrícolas) as source, from 2011 http://www.filcork.pt (with own estimation of virgin cork); Spain: MAPA 1922-1971, MAPA 1972-2004, MAPA 2005-2015; Italy: ISTAT 2018.*

Table 7.6: Global and European production for cork oak and cork

Country	Area		Annual production[8]		Exports 2017[9]	
	(ha)	%	(tons)	%	Million euros	%
Portugal	736,7751	32.8	100,000	49.6	985.2	61.6
Spain	578,9962	25.8	61,504	30.5	292.8	18.3
France	157,0003	7.0	5,200	2.6	81.4	5.1
Italy	168,6024	7.5	6,161	3.1	41.8	2.6
Germany	-	-	-	-	29.7	1.9
Other Europe	-	-	-	-	44.8	2.8
TOTAL Europe	1,549.601	73.1	172,865	85.8	1,475.7	92.3
Morocco	293,5005	13.1	11,686	5.8	14.2	0.9
Algeria	220,0006	9.8	9,915	4.9	4.1	0.3
Tunisia	90,4237	4.0	6,962	3.5	5.3	0.3
EUA	-	-	-	-	21.9	1.4

Country	Area		Annual production[8]		Exports 2017[9]	
	(ha)	%	(tons)	%	Million euros	%
China	-	-	-	-	19.7	1.2
Chile	-	-	-	-	9.6	0.6
Other world	-	-	-	-	94.0	5.9
TOTAL World	2,245,296	100.0	201,428	100.0	1,403.8	100.0

Sources: 1ICNF 2013; 2MAPA 2016; 3French NFI, Antoine Colin, personal communication, 2019; 4Gasparini and Tabacchi 2011; 5FAO 2010; 6Dehane et al. 2013, 2009; 7Direction Générale des Forêts 2005; 8FAO 2010; 9ITC 2018 (cork and cork products).

Economic importance

In *montado* and *dehesa* systems, cork is most of the times one of the main revenues, together with grazing, game, agriculture production and wild products picking (Campos *et al*. 2007). Despite its multifunctional management, common agricultural policy subsidies are increasingly determinant for the financial sustainability and income of the farms, and ultimately for the *montado* and *dehesa* ecosystems (Campos *et al* 2008; Fragoso *et al*. 2011). For this reason, cork price is a critical issue that many times determines the farm profitability (Paulo and Tomé 2017). Two features are important when defining the value of the cork for the industry of cork stoppers: the thickness of the cork plank and the cork mass quality. The latter concerns the cork porosity and the presence of cork defects and leads to the classification of cork into seven classes: from quality class 1 (best quality used for natural cork stoppers) to quality class 7 or refuse (worst quality used for other types of cork stopper, floor, wall coverings, insulation, and other cork products). In the stand, and regarding the cork price establishment, an average price is established for the harvested cork. It is recommended that this price is established between buyer and seller after a cork sampling is carried out, following the sampling procedures for cork forest inventory proposed by Almeida and Tomé (2010). The set price is later multiplied by the amount of extracted cork for the determination of the cork revenue. The amount of cork extracted can be determined before or after the cork extraction. Before, by means of local visual assessment or estimation using cork weight models such as that suggested by Paulo and Tomé (2010). After cork extraction, by the effective weighing of the extracted cork after a period of drying usually carried out in the field during 21 days, in a cork pile, as described by Costa and Pereira (2013). Limited by geographic proximity between farms and industries, in some regions, extracted cork is daily delivered and weighted at the industry, with humidity discounts in the negotiation agreement. These, and other recommendations regarding cork extraction and commercialization, are presented by UNAC (2010).

In the years between 2000 and 2010, cork price structure – expressed by the prices for each combination of cork thickness class X cork quality – experienced considerable fluctuations, generally showing a significant decrease in the value for most of the cork quality classes, namely in cork classified as poor and medium quality classes. In the present decade the prices for some best cork quality classes have increased and have been more stable. The 2015 harvest campaign saw a trend towards a wider price range, with an increase in value among the best quality corks (APCOR 2016). At that time, some farmers decided to postpone the debarking operation from nine years (minimum allowed by the Portuguese and Spanish law) to ten or more years, as farmers hoped to get an increase of cork average price as a result of an increase of cork thickness when cork debarking is postponed. Paulo and Tomé (2017) studied the consequences, at the medium and long term income, of this option at the farm level. They concluded that for some stands (high to average productivity sites and/or high to medium cork quality stands), a delay in the debarking may result in a significant increase of cork thickness and, as a result, of cork price. In recent years, however, the increase in cork prices (see Figure 7.9) led again to a reduction in the cork rotation, showing the dynamism of forest owners that take into account also the annual cork price in the decision to extract or postpone the cork debarking, being the postponing less frequent when price conditions are increasing.

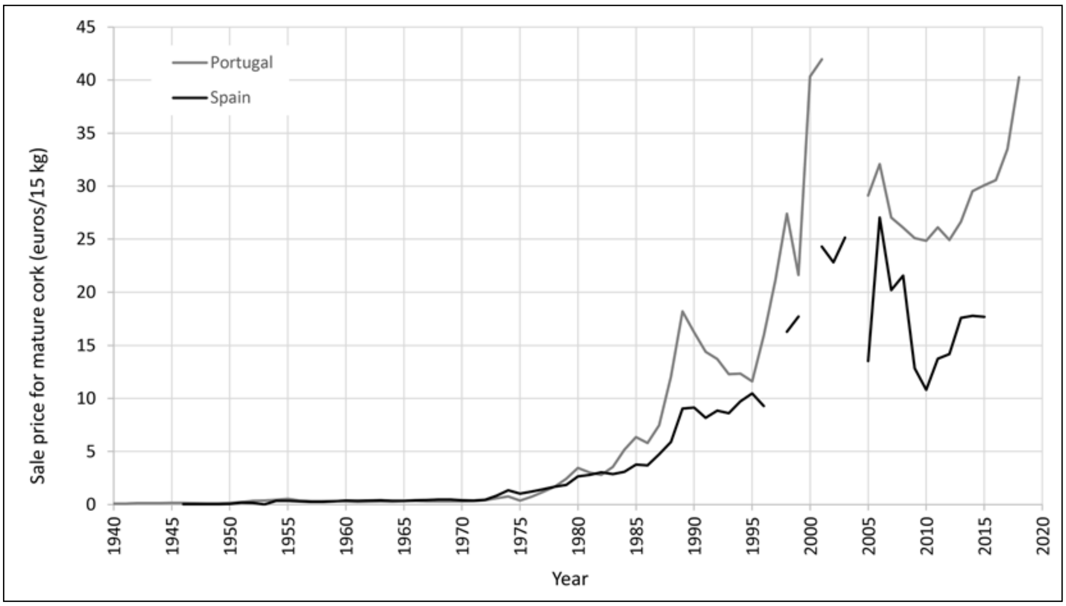

Figure 7.9: *Wholesale price for cork in Portugal and Spain. Sources – Portugal: till 2001 as presented by Mendes (2002), between 2001 and 2009 ICNF (2017), from 2009 UNAC (2019); Spain: MAPA 1922-1971, MAPA 1972-2004, MAPA 2005-2015.*

Cork is the basis for the work of 670 companies operating in Portugal, which produce roughly 40 million cork stoppers per day and employ around nine thousand workers (APCOR 2016), and 200 in Spain. Iberian countries increased gradually after the crisis (2008-2009) the quantity of imported raw cork, whereas other countries (e.g. Italy) started the trend to increase the export of it, which is still continuing up to now. This can be considered as a clear sign of the crisis of the Italian transformation industry: of the 217 companies operating in the cork sector in Italy in 2011, with almost to 2,000 workers, only 126 companies employing 1,400 workers were left in 2016.

Portugal is the world leader in the cork sector in terms of exports. In 2017, its share was 61.6%, followed by Spain with 18.3%. Total world cork exports reached 1,598.7 million euros in 2017, showing an increase compared to 2014 by around 16.7%, which is equivalent to 228.7 million euros.

7.4 Conclusions

The relevance of selected non-wood tree products for Europe was assessed according to several indicators: economic importance at regional/national level; production (quantity); social relevance (employment, etc.); cultural relevance; other relevant issues (e.g. level of domestication, identification of relevant innovative cases). The Action FP1203 survey highlighted the relevance of seven products for a large number of countries: Christmas trees, chestnut, resin, pine nuts, birch products, acorns and cork. The importance of the non-wood tree products is strongly related to the region: Christmas trees are relevant in a large number of countries but with a particular relevance in central Europe. Several countries selected chestnut among the products that are relevant, however an in-depth analysis showed that the European production comes mainly from four south western countries (Italy, Greece, Portugal, Spain), being also highly relevant in Turkey (at present the country with the largest production). Birch products are important for northern Europe and, to a certain extent, in central Europe. However, pine nuts, cork and resin are typical Mediterranean products, although the last is also important for Hungary.

The information available is quite variable among products and depends a lot on the economic importance of the product and on the existence of a well-established chain, from the landowner to the industry and final consumer (e.g. cork). For instance, non-wood products are very often economically more important than wood in Mediterranean regions (e.g. cork and pine nuts) but this is not the case for non-wood products in other European regions (e.g. chestnut or birch sap). Generally, there is a lack of national statistics on non-wood tree products (either in production or in economic value). One of the reasons is because in many NWFP, overall production can only be estimated approximately, given the actual lack of traceability of the supply chain. In what concerns forest management, different systems are used, from systems that have as objective the optimization of the NWFP to systems that are managed with the focus on wood with the co-production of some NWFP. This is an additional difficulty for the estimation of the national production of some NWFP as it is not directly related to the area that the species occupies. One problem that was detected is the decrease of information available in FRA from FRA2010 to FRA2015. National reports in 2010 were much richer than those in 2015 in what concerns the information on NWFP. A recommendation from this chapter is that the NWFP statistics be given more importance in this and other world statistics data bases.

In spite of the lack of official information, the importance of non-wood tree products for the landowner income and/or for the national and European economy is unquestionable. Europe is the main producer of cork with a share of 72% of the area and 86% of the production. The value of cork exports is 1,599 million euros and the cork industry employs around 9,000 employees. The total production of pine nuts is estimated to be between 4,000 and 4,500 tonnes with a value that amounts to 300 million euros. Europe is responsible for 9% of the world production of chestnut with a production of 214,808 tonnes. In what concerns Christmas trees, 75 million trees are sold on the commercial market. Resin production has decreased in the past but recently it has begun to increase, although still much lower than the past values. Birch products are highly relevant in Finland. Acorns are mainly used as animal feedstock but estimations made in Portugal point for a high potential of this NWFP.

7.5 References

Abrudan, I.V., Fellini, F., Bellini, E., 2010. Multi-functionality of European Chestnut Trees, in: Bellini, E., Vannacci, G. (Eds.). Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept. – 1st Oct. 2010, pp. 13–17.

Açar, B.C., Bilgin, F., Boza, A., Altun, Z.G., Çoşgun, S., Saribaşak, H., Gülbaba, G., Tüfekçi, S., 2010. Fıstıçamı (*Pinus pinea* L.) origin denemesi [Results of provenance trials of stone pine (*Pinus pinea* L.) at the 10 year]. Teknik Bülten 45, Ege Forestry Research Institute, İzmir, 52 p.

Agri-Ciência, 2014. Estudo sobre a cadeia de valor da fileira Pinha/Pinhão (*Pinus pinea* L.) [Value chain study for Mediterranean stone pine cones and nuts]. União da Floresta Mediterrânica, Lisboa, 119 p.

Alakurtti, S., Mäkelä, T., Koskimies, S. & Yli-Kauhaluoma, J. 2006. Pharmacological properties of the ubiquitous natural product betulin. European Journal of Pharmaceutical Sciences 29(1):1-13.

Almeida, A., Tomé. M., 2010. Field sampling of cork value before extraction in Portuguese 'montados'. Agroforestry Systems 79: 419–430. http://dx.doi.org/10.1007/s10457-009-9260-8

Anastácio D., Carvalho J.B., 2008. Sector dos resinosos em Portugal; evolução e análise. Direção Geral dos Recursos Florestais, Lisboa, Portugal.

APCOR, 2016. APCOR's Cork Yearbook 2016. Associação Portuguesa da cortiça. 104 pp. Available in: http://www.apcor.pt/wp-content/uploads/2016/09/Boletim-estatistico-2016.pdf (accessed 19.03.2017.

Barroso, F.L., Pinto-Correia, T., Ramos, I.L., Surová, D., Menezes, H., 2012. Dealing with landscape fuzziness in user preference studies: Photo-based questionnaires in the Mediterranean context. Landscape and Urban Planning 104: 329-342. http://dx.doi.org/10.1016/j.landurbplan.2011.11.005~

Baskent, E.Z., Küçüker, D.M., Cañellas, I., Bonet, J.A., Paulo, J.A., Guerra, J.G., Miina, J., Sheppard, J., Salo, K., Fontes, L., Kurttila, M, Sánchez-González, M., Tomé, M., Soares, P., De Miguel, S., Mutke, S., 2014. Description of existing silvicultural systems for some selected MPTs and NWFP, in: Tomé, M., Faias, S.P. (Eds.), State of the art, review of silviculture, models and decision support tools for multipurpose trees (MPT) and non-wood forest products (NWFP). Deliverable 2.1 of the StarTree project, 176 pp.

Bellini, E., Vannacci, G., 2010. Chestnut (*Castanea sativa*): a multipurpose European Tree. Discussion paper, in: Bellini, E., Vannacci, G. (Eds.). Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept. – 1st Oct. 2010, pp. 72–87.

Bracalini, M., Benedettelli, S., Croci, F., Terreni, P., Tiberi, R., Panzavolta, T., 2013. Cone and seed pests of *Pinus pinea*: Assessment and characterization of Damage. J. Econ. Entomol. 106(1):229–234.

Braden, N., Russell, K., 2001. Chestnut in the United Kingdom: Forest area, management and utilisation as timber. Forest Snow and Landscape Research 76 (3): 505–510.

Calado, N., 2012. Fileira da pinha/pinhão: necessidades de informação e conhecimento. Seminá-rio UNAC de Valorização da Fileira da Pinha/Pinhão, Alcácer do Sal, September 18, 2012.

Calama, R., Gordo, J., Madrigal, G., Mutke, S., Conde, M., Montero, G., Pardos, M., 2016. Enhanced tools for predicting annual stone pine (*Pinus pinea* L.) cone production at tree and forest scale in Inner Spain. Forest Systems 25(3), e079, doi:10.5424/fs/2016253-09671

Calama, R., Gordo, J., Mutke, S., Montero, G., 2008. An empirical ecological-type model for predicting stone pine (*Pinus pinea* L.) cone production in the Northern Plateau (Spain). Forest Ecology and Management 255(3/4):660–673.

Calama, R., Mutke, S., Tomé, J., Gordo, J., Montero, G., Tomé, M., 2011. Modelling spatial and temporal variability in a zero-inflated variable: the case of stone pine (*Pinus pinea* L.) cone production. Ecological Modelling 222(3):606–618

Calliste, C.A., Trouillas, P., Allais, D.P., Duroux, J.L., 2005. *Castanea sativa* Mill. Leaves as New Sources of Natural Antioxidant: An Electronic Spin Resonance Study. J. Agric. Food Chem. 53 (2): 282–288.

Campos, P., Bonnieux, F., Caparrós, A., 2007. Measuring total sustainable incomes from multifunctional management of Corsican Maritime Pine and Andalusian Cork oak Mediterranean forests. Journal of Environmental Planning and Management 50 (1): 65-85. http://dx.doi.org/10.1080/09640560601048424

Campos, P., Ovando, P., Montero, G., 2008. Does private income support sustainable agroforestry in Spanish dehesa? Land Use Policy 25 (4): 510–522. http://dx.doi.org/10.1016/j.landusepol.2007.11.005

Can, T., 2016. Fıstıkçamı ormanlarında verimi etkileyen faktörlerin belirlenmesi ve çözüm önerileri. Ege Forestry Research Institute, İzmir, 140 p.

Carneiro, A.N., 2005. Ganhos genéticos na seleção de características biométricas das pinhas e semente de pinheiro manso. Livro de Atas do V Congresso Florestal Nacional, Sociedade Portuguesa de Ciências Florestais, 16-19 Maio 2005; Viseu.

Carneiro, A.N., Alpuim, M., Vacas-Carvalho, M.A., Pessoa, J., Carrasquinho, I., 2007. Manual Ilustrado de Enxertia de Pinheiro manso. Editor Estação Florestal Nacional, Oeiras, 30 pp. ISBN 978-972-95736-9-9.

Carrasquinho, I., Freire, J., Rodrigues, A., Tomé, M., 2010. Selection of *Pinus pinea* L. plus trees candidates for cone production. Annals of Forest Science, 67: 814. DOI: 10.1051/forest/2010050

Castro, M., 2009. Silvopastoral systems in Portugal: Current status and future prospects, in: Rigueiro-Rodríguez, A., McAdam, J., Mosquera-Losada, M.R. (Eds.). Agroforestry in Europe. Current status and future prospects. Dordrecht: Springer (Advances in Agroforestry, 6), pp. 111–126.

CESE, 1998. Livro verde da Cooperação do Ensino Superior-Empresa. Centro de Estudos Superiores Especializados, Portugal.

CESEFOR, 2009. La resina: herramienta de conservación de nuestros pinares. CESEFOR, Soria, Spain.

Chen, Q.-H., Liu, J., Zhang, H.-F., He, G.-Q. & Fu, M.-L. 2009. The betulinic acid production from betulin through biotransformation by fungi. Enzyme and Microbial Technology 45: 175-180.

Ciesla, W.M., 1998. Non-wood forest products from conifers. FAO series on Non-Wood Forest Products, n 12. Food and Agriculture Organization of the United Nations, Rome, 140 pp.

Ciesla, W.M., 2002. Non-wood forest products from temperate broad-leaved trees. FAO series on Non-Wood Forest Products 15, FAO, Rome, Italy. http://www.fao.org/3/y4351e/y4351e00.htm (accessed 12.01.2018)

Coelho, M.B., Paulo, J.A., Palma, J.H.N., Tomé, M., 2012. Contribution of cork oak plantations installed after 1990 in Portugal to the Kyoto commitments and to the landowners economy. Forest Policy and Economics 17: 59 – 68. http://dx.doi.org/10.1016/j.forpol.2011.10.005

Conedera, M., Krebs, P., 2010. *Castanea sativa*: the European tree, in: Bellini, E., Vannacci, G. (Eds.), Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept.-1st Oct. 2010, pp. 8–12.

Coppen, J.J.W., Hone, G.A., 1995. Gum naval stores: turpentine and rosin from pine resin. FAO.

Corradini, G., 2015. WP5 Report on additional case-study. Turpentine of larch, a re-discovered activity. Internal report of the EU research project StarTree: Multipurpose trees and non-wood forest products: a challenge and opportunity, grant agreement 311919, 5 pp.

Costa, A., Pereira, H., 2013. Drying kinetics of cork planks in a cork pile in the field. Food and Processing 91(1): 14–22. http://dx.doi.org/10.1016/j.fbp.2012.08.002

Costa, R., Evaristo, I. (Eds.), 2008. Condução de Povoamentos de Pinheiro Manso e Características Nutricionais do Pinhão. INRB, Oeiras. 48 pp. ISBN 978-989-95658-3-8.

Curveira-Santos, G., Marques, T.A., Björklund, M., Santos-Reis, M., 2017. Mediterranean mesocarnivores in spatially structured managed landscapes: community organisation in time and space. Agriculture, Ecosystems & Environment 237: 280-289. http://dx.doi.org/10.1016/j.agee.2016.12.037

Dehane, B., Bouhraoua, R., Latifa, B., Hamani, F.Z., 2013. La filière liège algérienne, entre passé et présent. Forêt Méditerranéenne, XXXIV(2): 143-152.

den Herder, M., Moreno, G., Mosquera-Losada, R., Palma, J. H. N, Sidiropoulou, A., Freijanes, J. J. S., Crous-Duran, J., Paulo, J.A., Tomé, M., Pantera, A., Papanastasis, V. P., Mantzanas, K., Pachana, P., Papadopoulos, A., Plieninger, T., Burgess, P.J., 2017. Current extent and stratification of agroforestry in the European Union. Agriculture, Ecosystems and Environment 241: 121-132. https://doi.org/10.1016/j.agee.2017.03.005

Di Renzo, L., Bianchi, A., Lorenzo, A., 2010. Quality and Nutraceutical Assessment of Chestnut Fruit, in: Bellini, E., Vannacci, G. (Eds.), Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept. – 1st Oct. 2010, pp. 58–69.

Diao, B.-Z., Jin, W.-R & Yu, X.-J. 2014. Protective effect of polysaccharides from *Inonotus oblicuus* on streptozocin-induced diabetic symptoms and their potential mechanisms in rats. Evidence-based Complementary and Alternative Medicine 2014:1-5. Article ID 841496.

Direction Générale des Forêts, 2005. Deuxième Inventaire National Forestier et Pastoral: Résultats de l'Inventaire Forestier sur l'échelon de Jendouba (Gouvernorats de Jendouba, Béja et Bizerte). Direction Générale des Forêts (Tunisie), 2005, 129 pp.

Du, D., Zhu, F., Chen, X., Ju, X., Feng, Y., Qi, L.-W. & Jiang, J. 2011. Rapid isolation and purification of inotodiol and trametenolic acid from *Inonotus obliquus* by high-speed counter-current chromatography with evaporative light scatting detection. Phytochemical Analysis 22: 419-423.

Evaristo, I., Batista, D., Correia, I., Correia, P., Costa, R., 2010. Chemical profiling of Portuguese *Pinus pinea* L. Nuts. Journal of the Science of Food Agriculture, 90: 1041-1049.

FAO, 2010. Evaluation des Ressources Forestières Mondiales 2010. Rapports National Algeria, France, Italy, Maroc, Portugal, Spain and Tunisia. FAO, Rome, Italy. (available at http://www.fao.org/3/a-az281f.pdf).

FAO, 2013. State of the Mediterranean Forests. FAO, Rome, Italy (available at www.fao.org/publications).

FAO, 2018. FAOSTAT Database. Rome, Italy: Food and Agriculture Organization of the United Nations, FAO. http://www.fao.org/faostat/ (accessed 22.12.2018).

Filho, A.F., 1991. Influência da resinagem no crescimento de Pinus elliottii var. elliottii e a sua avaliação económica. Tese de Doutoramento, Universidade Federal do Paraná, Brasil.

Fioravanti, M., Lemaire, J., Togni, M., 2010. Enhancement of Timber Production, in: Bellini, E., Vannacci, G. (Eds.), Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept. – 1st Oct. 2010, pp. 44–57.

Fonseca, A., 2003. O montado da baixa idade média ao fim da época moderna, Master thesis, University of Évora.

Fragoso, R., Marques, C., Lucas, M.R., Martins, M.B., Jorge, R., 2011. The economic effects of common agricultural policy on Mediterranean montado/dehesa ecosystem. Journal of Policy Modeling 33 (2): 311–327. http://dx.doi.org/10.1016/j.jpolmod.2010.12.007

Gao, R., Shi, J., Huang, R., Wang, Z., Luo, Y., 2015. Effects of pine wilt disease invasion on soil properties and Masson pine forest communities in the Three Gorges reservoir region, China. Ecology and Evolution 5(8):1702–1716.

García-Mozo, H., Dominguez-Vilches, E., Galán, C., 2012. A model to account for variations in production in southern Spain. Annals of Agricultural and Environmental Medicine 19:403–408.

Gasparini, P., Tabacchi, G., 2011. L'Inventario Nazionale delle Foreste e dei serbatoi forestali di Carbonio INFC 2005. Secondo inventario forestale nazionale italiano. Metodi e risultati. Ministero delle Politiche Agricole, Alimentari e Forestali, Corpo Forestale dello Stato. Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Unità di ricerca per il Monitoraggio e la Pianificazione Forestale. Edagricole, Milano.

Gil, L., 2015. New Cork-Based Materials and Applications. Materials 8: 625-637. http://dx.doi.org/10.3390/ma8020625

Godinho, S., Santos, A.P., Sá-Sousa, P., 2010. Montado management effects on the abundance and conservation of reptiles in Alentejo, Southern Portugal. Agroforestry Systems 82 (2): 197-207. http://dx.doi.org/10.1007/s10457-010-9346-3~

Gordo, J., González, A., Hernández, J., Finat, F., Martínez, C., Cubero, D., del Río, J., Feliz, J.M., Peláez, H., Sandonis, F., Morán, F., 2016. Análisis de los aprovechamientos en los montes públicos de la provincia de Valladolid. Periodo 2002-2013. Jornada final proyecto PROPINEA. Pedrajas de San Esteban, February 29, 2016.

Gomes, A.M.A., 1954. Sobre a influência da resinagem no crescimento do pinheiro bravo, I. crescimento em diâmetro. Ministério da Economia, DGSFA, Estudos e Informação, nº 43-E3, Lisboa, Portugal.

Guadaño, C., Mutke, S. (Eds.) 2016. Establecimiento de plantaciones clonales de Pinus pinea para la producción de piñón mediterráneo. Monografías INIA: Serie Forestal Nº 28. INIA, Madrid, 79 p.

Guerra, C., Pinto-Correia, T., 2016. Linking farm management and ecosystem service provision: Challenges and opportunities for soil erosion prevention in Mediterranean silvo-pastoral systems. Land Use Policy 51: 54–65 http://dx.doi.org/10.1016/j.landusepol.2015.10.028

Hamade, K., 2016. Non-Wood Forest Product Value Chains in Lebanon. FAO, Beirut, 46 pp.

Herzog, F., 1998. Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. Agroforestry Systems 42 (1): 61–80. doi: 10.1023/A:1006152127824.

ICNF, 2013. IFN6 – Áreas dos usos do solo e das espécies florestais de Portugal continental em 1995, 2005 e 2010. Resultados preliminares. [pdf], 33 pp, Instituto da Conservação da Natureza e das Florestas. Lisboa.

ICNF, 2015. Estratégia Nacional para as Florestas (ENF). Resolução do Conselho de Ministros n.º 6-B/2015, Diário da República n.º 24/2015, 1º Suplemento, Série I de 2015-02-04, Portugal.

ICNF, 2017. Informação estatística sobre o sector florestal e sobre as fileiras florestais (2000 a 2016). In http://www2.icnf.pt/portal/florestas/fileiras/econ.

INC, 2012. Nuts and Dried Fruits. Global Statistical Review. International Nut and Dried Fruit Council, Reus.

INC, 2016. Nuts & Dried Fruits. Global Statistical Review 2015/2016. International Nut & Dried Fruit Council, Reus.

INE, 2014. Estatísticas agrícolas 2014. Instituto Nacional de Estatística, Lisboa, Portugal.

INE, 2016. Estatísticas agrícolas 2016. Instituto Nacional de Estatística, Lisboa, Portugal.

INE, 2017. Inquérito à Estrutura das Explorações Agrícolas 2016. Editor Instituto Nacional de Estatística, I.P., Lisboa. 50pp. ISBN 978-989-25-0429-2.

Issakainen, J. 2015. Herkkuruokaa puusta – syötävien lahottajasienten viljely maatalouden sivuelinkeinona. Turun ammattikorkeakoulun raportteja 216. 192 p.

ISTAT, 2018. Time series on removals of NWFP. http://seriestoriche.istat.it (accessed 31.07.2018)

ITC, 2018. International Trade Center (https://www.trademap.org/tradestat/index.aspx, accessed 22.12.2018)

Kilci, M., Akbin, G., Sayman, M. (Eds.), 2014. Fıstık çamı (*Pinus pinea* L.). Müdürlük Yayın No: 74, Ege Forestry Research Institute, İzmir, 229 pp.

Koutsiriba, E., 1998. The socio-economic and the environmental point of view. Primer Simposio de aprovechamiento de resinas naturales, Segovia, 5,6, 7 de febrero de 1998. Actas Científicas.

Leite, C., Pereira, H., 2017. Cork-Containing barks – a review. Frontiers in Materials 3: 63. http://dx.doi.org/10.3389/fmats.2016.00063

Lesieur, V., Yart, A., Guilbon, S., Lorme, P., Auger-Rozenberg, M.A., Roques, A., 2014. The invasive *Leptoglossus* seed bug, a threat for commercial seed crops, but for conifer diversity? Biol In-vasions 16:1833–1849.

Lopez-Bote, C.L., Fructuoso, G., Mateos, G.G., 2000. Sistemas de producción porcina y calidad de la carne. El Cerdo Ibérico. XVI Curso Espec. FEDNA.

Lucke, R., Silbereisen, R., Herzberger, E., 1992. Obstbäume in der Landschaft. Stuttgart: Ulmer (Ulmer-Fachbuch Obstbau und Landespflege).

Manos, P.S., Doyle, J.J., Nixon, K.C., 1999. Phylogeny, biogeography, and processes of molecular differentiation in *Quercus* subgenus *Quercus* (*Fagaceae*). Molecular Phylogenetics and Evolution 12, 333–349.

MAPA, 1922-1971. Estadística Forestal de España, (Spanish Forestry Statistics). In. Ministerio de Agricultura, Pesca y Alimentación (Spanish Ministry of Agriculture, Fisheries and Food).

MAPA, 1972-2004. Anuario de Estadística Agraria, (Yearbook of Spanish Agricultural Statistics). In. Ministerio de Agricultura, Pesca y Alimentación (Spanish Ministry of Agriculture, Fisheries and Food).

MAPA, 2005-2015. Anuario de Estadística Forestal (Spanish Forestry Statistical Yearbook). In. Ministerio de Agricultura, Pesca y Alimentación (Spanish Ministry of Agriculture, Fisheries and Food).

MAPA, 2016. Anuario de Estadística Forestal (Spanish Forestry Statistical Yearbook). In. Ministerio de Agricultura, Pesca y Alimentación (Spanish Ministry of Agriculture, Fisheries and Food)

MAPAMA, 2015, Anuario de Estadística Forestal. Ministerio de Agricultura, Pesca, Alimentación y Medio Ambiente, Madrid.

Mariano, A., Gasparini, P., De Natale, F., Colletti, L., Macrì, A., Pompei, E., Romano, R., Sambucini, V., Visentin, R., Vitullo, M., 2010. FRA 2010 Country Report Italy. Global Forest Resources Assessment 2010. FRA2010/101. FAO, Rome, 66 pp.

MARM, 2008. Anuario de Estadística Forestal. Ministerio de Medio Ambiente, Medio Rural y Marino, Spain.

MARM, 2013. Anuario de Estadística Forestal. Ministerio de Medio Ambiente, Medio Rural y Marino, Spain.

Mattoso. J, 1993. “1096- 1325”, in: Mattoso, J. (Ed.), História de Portugal, Vol. 2: 10- 3 19 .Círculo dos Leitores, Portugal.

Mendes, A., 2002. A economia do sector da cortiça em Portugal. Evolução das actividades de produção e de transformação ao longo dos séculos XIX e XX. Conference paper: XII Encontro da Associação Portuguesa de História Económica e Social, Universidade de Aveiro, Aveiro, Portugal. (available at https://www.researchgate.net/publication/299704427)

Morhart, C., Douglas, G., Dupraz, C., Graves, A., Nahm, M., Paris, P., Sauter, U., Sheppard, J. & Spiecker, H., 2014. Alley-coppice – A new system with ancient roots. Annals of Forest Science 71: 527-542. doi:10.1007/s13595-014-0373-5.

Morris, C., 2015. From Forests to Factories, Innovation Drives Pine Chemicals Industry. IFEAT World July 2015: 3.

Mutke, S., 2013. Stone pine in Mediterranean forests, in: Besacier, C., Briens, M., Duclercq, M., Garavaglia, V. (Eds.). State of Mediterranean Forests 2013 (SoMF 2013). FAO, Rome. p. 83–87.

Mutke, S., Calama, R., González-Martínez, S.C., Montero, G., Gordo, J., Bono, D., Gil, L., 2012. Mediterranean Stone Pine: Botany and Horticulture. Horticultural Reviews 39: John Wiley & Sons, Inc., Hoboken, New Jersey: 153–201.

Mutke, S., García del Barrio, J.M., Martínez-Jauregui, M., Soliño, M., de Miguel, J., Justes, A., Ruíz-Peinado, R., del Río, M., Alía, R., Chambel, R., Herruzo, C., Sánchez de Ron, D., Alonso, C., 2013. Bases para buenas prácticas en la gestión del aprovechamiento resinero. INIA, Madrid, Spain.

Mutke, S., Gordo, J., Gil, L., 2000. The Stone Pine (*Pinus pinea* L.) Breeding Programme in Castile-Leon (Central Spain). FAO-CIHEAM Nucis-Newsletter 9:50–55.

Mutke, S., Gordo, J., Gil, L., 2005. Variability of Mediterranean Stone pine cone yield: yield loss as response to climate change. Agricultural and Forest Meteorology 132:263–272

Mutke, S., Vendramin, G.G., Fady, B., González-Martínez, S.C., (in press). Genetic diversity in *Pinus pinea*, in: Nandwani D. (Ed.). Genetic Diversity in Horticultural Plants, Springer, Switzerland.

OGM, 2015. Ormancilik İstatistikleri (Forestry Statistics). Orman ve Su İşleri Bakanlığı, Ankara.

Oliveira, A.C., 1995. Present situation and perspectives of *Pinus pinea* in Portugal. I Reunión de la Red de frutos secos de la FAO sobre el pino piñonero, Madrid, 24-25 noviembre 1995. INIA, Madrid:39-46.

Oliveira, M.A., Oliveira, L., 2000. A cortiça. Corticeira Amorim S.G.P.S., Portugal, 175 pp.

Otero, I., Boadaa, M., Tàbaraa, J.D., 2013. Social–ecological heritage and the conservation of Mediterranean landscapes under global change. A case study in Olzinelles (Catalonia). Land Use Policy 30 (1): 25–37. http://dx.doi.org/10.1016/j.landusepol.2012.02.005

Ovando, P., Campos, P., Calama, R., Montero, G., 2010. Landowner net benefit from Stone pine (*Pinus pinea* L.) afforestation of dry-land cereal fields in Valladolid, Spain. Journal of Forest Economics 16(2):83–100.

Pais, J., 1996. "Paleoetnobotânica (finais séc. XI e séc. XIII/XIV) do Sul de Portugal – Setúbal, Mértola e Silves". in: Arqueologia Medieval: Campo Arqueológico de Mértola, nº4, pp.277-280.

Palma, A., 2007. Capacidade produtiva de resina de pinheiro bravo. Breve panorâmica do sector resineiro em Portugal. Dissertação para Investigador Auxiliar, INRB, Oeiras.

Palma, A., Pereira, J.M., Soares, P., 2016. Resin tapping activity as a contribution to the management of maritime pine forest. Forest Systems, 25(2), eSC11, 5 pages. http://dx.doi.org/10.5424/fs/2016252-08925.

Palma, J.H.N., Paulo, J.A., Tomé, M., 2014. Carbon sequestration of modern *Quercus suber* L. silvoarable agroforestry systems in Portugal: a YieldSAFE-based estimation. Agroforestry Systems. 88(5): 791-801 http://dx.doi.org/10.1007/s10457-014-9725-2

Pasalodos-Tato, M., Pukkala, T., Calama, R., Cañellas, I., Sánchez-González, M., 2015. Optimal management of *Pinus pinea* stands when cone and timber production are considered. European Journal of Forest Research 135:607–619.

Pastor, A., 2014. Mercado mundial del piñón [Pine nut world market]. Seminário UNAC Programa de Valorização da Fileira da Pinha/Pinhão, Alcácer do Sal, March 28, 2014.

Paulo, J.A. Tomé, M., 2017. Using the SUBER model for assessing the impact of cork debarking rotation on equivalent annual annuity in Portuguese stands. Forest systems 26(1), e008, 11 pages. https://doi.org/10.5424/fs/2017261-09931

Paulo, J.A., Tomé, M., 2010. Predicting mature cork biomass with t years of growth based in one measurement taken at any other age. Forest Ecology and Management 259: 1993-2005. http://dx.doi.org/10.1016/j.foreco.2010.02.010

Peltola, R. & Sarala, P. 2012. The clean nature of the north. Acta Lapponica Fenniae 24. The Research Society of Lapland.

Pereira, H. 2015. The Rationale behind Cork Properties: A Review of Structure and Chemistry. BioResources 10 (3): 1-23.

Pereira, H., 2007. Cork: biology, production and uses. Elsevier, Lisbon, 336 pp.

Pereira, L.S., Werner, M., Bouffier, V., Segatz, E., 2010. Sustainable Orchards/Chestnut Forest Mangement, in: Bellini, E., Vannacci, G. (Eds.), Chestnut (*Castanea sativa*): a multipurpose European Tree. Brussels, 30 Sept. – 1st Oct. 2010, pp. 28–34.

Pereira, S., Prieto, A., Calama, R., Díaz-Balteiro, L., 2015. Optimal management in *Pinus pinea* L. stands combining silvicultural schedules for timber and cone production. Silva Fennica 49(3):1226.

Pereira, T.C., Seabra, T., Maciel, H., Torres, P., 2009. Portuguese National Inventory Report on Greenhouse Gases, 1990–2007 Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Portuguese Environmental Agency, Amadora, 614 pp.

Picardo, A., Pinillos, F., 2013. La resinación en España y en el mundo en 2013: situación y perspectivas. Atas do II Simposio Internacional de Resinas Naturales, 16-18 abril 2013, Coca – Segovia, Ministerio de Agricultura, Alimentación y Medio Ambiente, Spain.

Pintado, M., 2015. As características nutricionais e funcionais da bolota para consumo humano., Symposium Bolota: o futuro de um alimento com passado, Herdade Freixo do Meio, Montemor-o-Novo, Portugal (personal communication).

Pinto-Correia T., Vos, W., 2004. Multifunctionality in Mediterranean landscapes – past and future, in: Jongman, R. (Ed). The new dimension of the European landscapes. Wageningen FRONTIS Series. Springer, Dordrecht, pp 135–164

Plieninger, T., Hartel, T., Martín-López, B., Beaufoy, G., Bergmeier, E., Kirby, K., Montero, M.J., Moreno, G., Oteros-Rozas, E. and Van Uytvanck, J., 2015. Wood-pastures of Europe: Geographic coverage, social–ecological values, conservation management, and policy implications, Biological Conservation 190, 70-79. http://dx.doi.org/10.1016/j.biocon.2015.05.014.

Rastogi, S., Pandey, M.M. & Rawat, A.K.S. 2015. Medicinal plants of the genus *Betula* -Traditional uses and a phytochemical-pharmacological review. Journal of Ethnopharmacology 159:62-83.

Rhee, S.K., Cho, S.Y., Kim, K.M., Cha, D.-S. & Park, H.-J. 2008. A comparative study of analytical methods for alkali-soluble medicinal mushroom, Chaga (*Inonotus obliquus*). LWT 41: 545-549.

Ristioja, A. 2018. Natural products as business – report on the natural products sector. Ministry of Economic Affairs and Employment. Sector Reports 2/2018. 48 p.

Rives, J., 2011. Enviromental evaluation of the cork sector in Southern Europe (Catalonia). Universidad Autonoma de Barcelona. PhD Thesis.

Rodriguez-Garcia, A., Lopez, R., Martin, J.A., Pinillos, F., Gil, L., 2014. Resin yield in *Pinus pinaster* is related to tree dendrometry, stand density and tapping-induced systemic changes in xylem anatomy. Forest Ecology and Management 313:47-54.

Rodriguez-Garcia, A., Martin, J.A., Lopez, R., Mutke, S., Pinillos, F., Gil, L., 2015. Influence of climate variables on resin yield and secretory structures in tapped *Pinus pinaster* Ait. in central Spain. Agricultural and Forest Meteorology 202:83-93.

Santos, C., 2013. Resinagem em Portugal, situação atual e perspetivas futuras. Atas do II Simposio Internacional de Resinas Naturales, 16-18 abril 2013, Coca – Segovia, Ministerio de Agricultura, Alimentación y Medio Ambiente, Spain.

Santos-Silva, C., Gonçalves, A., Louro, R., 2011. Canopy cover influence on macrofungal richness and sporocarp production in Montado ecosystems. Agroforestry Systems. http://dx.doi.org/10.1007/s10457-011-9374-7

Sattout, E., Faour, G., 2017. Insights on the value chain and management practices of stone pine forests in Lebanon. Options Méditerraneenes 122, 119-124.

Shikov, A.N., Pozharitskaya, O.N., Makarov, V.G.,, Wagner, H., Verpoorte, R. & Heinrich, M. 2014. Medicinal plants of the Russian Pharmacopeia; their history and applications. Journal of Ethnopharmacology 154:481-536.

Silva, M.E., Gaspar, M.J,, Pires, J., Ribeiro, M., Loureiro, C., Coutinho, J.P., Santos, E., Carvalho, A., Brito, J.L., Salgueiro, A., Lousada, J.L., 2018. Resimprove – Contribuição para a melhoria da eficiência, racionalização e expansão da atividade de resinagem. UTAD – Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.

Sipponen, A., 2013. Coniferous resin salve, ancient and effective treatment for chronic wounds – laboratory and clinical studies. Doctoral dissertation. The Medical Faculty of the University of Helsinki.

Sottomayor, 2015. Potencial Económico da Bolota em Portugal: Análise Exploratória., Symposium Bolota: o futuro de um alimento com passado, Herdade Freixo do Meio, Montemor-o-Novo, Portugal (personal communication).

Sülüşoğlu, M., 2004. The Management of Villagers owned Stone Pine (*Pinus Pinea* L.) Plantations in Kozak Region, Turkey: A Case Study. FAO Working paper. FAO, Rome, 56 pp.

Tadesse, W., Nanos, N., Aufion, F.J., Alía, R., Gil, L., 2001. Evaluation of high resin yielders of *Pinus pinaster* Ait.. Forest Genetics, 8(4): 271-278.

Talgø, V. & Fløistad, I.S. (Eds.), 2015. The 12th International Christmas Tree Research and Extension Conference, NIBIO BOOK Vol 1 nr 1 2015, ISBN: 978-82-17-01453-9, ISSN ISSN 2464-1189.

Tang, J.J., Li, J.G., Qi, W., Qiu, W.W., Li, P.S., Li, B.L. & Song, B.L. 2011. Inhibition of SREBP by a small molecule, betulin, improves hyperlipidemia and insulin resistance and reduces atherosclerotic plaques. Cell Metabolism 5:13(1):44-56.

Themudo, J.C.F., Carneiro, A.E., 1958. A resinagem. Suas vantagens e inconvenientes. Aspectos técnicos e económicos. Ministério da Economia, Junta Nacional dos Resinosos.

Tomé, M. and Faias, S.P. (Eds.), 2014. State of the art, review of silviculture, models and decision support tools for multipurpose trees (MPT) and non-wood forest products (NWFP). Deliverable 2.1 of the StarTree project, 176 pp.

UNAC, 2010. Recomendações Técnicas para o Processo de Extração e Comercialização de Cortiça. União da Floresta Mediterrânica. 34 pp. Available in: http://www.unac.pt/attachments/082_RECOMENDA%C3%87%C3%95ES%20TECNICAS%20CORTI%C3%87A_Campanha%202010.pdf. (accessed 19.03.2017)

UNAC, 2019. Boletim do mercado da cortiça, campanha de 2018, Unac, Portugal, 18 pp.

Vallejo, R., Fernández-Centeno, G., Viejo-Téllez, C., 2010. FRA 2010 Country Report Spain. Global Forest Resources Assessment 2010. FRA2010/196. FAO, Rome, 63 pp.

Vanhanen, H., Peltola, R., Ahtikoski, A. & Pappinen, A. 2014. Cultivation of Pakuri (Inonotus obliquus) – potential for new income source for forest owners. The 10th International Mycological Congress (IMC10), Bangkok, Thailand, 3-8.8.2014. In: IMC 10 Organizing Committee (Ed.), Book of Abstracts, p. 418.

Vanhanen, H., Peltola, R., Ahtikoski, A. & Pappinen, A. 2014. Cultivation of Pakuri (*Inonotus obliquus*) – potential for new income source for forest owners. The 10th International Mycological Congress (IMC10), Bangkok, Thailand, 3-8.8.2014. In: IMC 10 Organizing Committee (Ed.), Book of Abstracts, p. 418.

Vasconcelos, M.C. B.M, Bennett, R.N., Quideau, S., Jacquet, R., Rosa, E.A.S., Ferreira-Cardoso, J.V., 2010. Evaluating the potential of chestnut (*Castanea sativa* Mill.) fruit pericarp and integument as a source of tocopherols, pigments and polyphenols. Industrial Crops and Products 31 (2): 301–311.

Vázquez, G., Calvo, M., Freire, M.S., González-Alvarez, J., Antorrena, G., 2009. Chestnut shell as heavy metal adsorbent: Optimization study of lead, copper and zinc cations removal. Journal of Hazardous Materials 172 (2–3): 1402–1414.

Vázquez, G., Fontenla, E., Santos, J., Freire, M.S., González-Álvarez, J., Antorrena, G., 2008. Antioxidant activity and phenolic content of chestnut (*Castanea* *sativa*) shell and eucalyptus (*Eucalyptus globulus*) bark extracts. Industrial Crops and Products 28 (3): 279–285.

Wang, C., Chen, Z., Pan, Y., Gao, X. & Chen, H. 2017. Anti-diabetic effects of *Inonotus obliquus* polysaccharide-chromium (III) complex in type 2 diabetic mice and its sub-acute toxicity evaluation in mice. Food and Chemical Toxicity 108:498-509.

Wei, Y., Liu, Q., Dong, H., Zhou, Z., Hao, Y., Chen, X., Xu, L. 2016. Selection of Reference Genes for Real-Time Quantitative PCR in *Pinus massoniana* Post Nematode Inoculation. PLoS ONE 11(1):e0147224.

Wu, T., Shu, Q., Yang, K., Xie, X., Wang, X., Wang, Y., Guo, A., Yuan, N., Zhao, B., Chi, B., Wu, Q. & Fu, Z. 2015.Ameliorating effects of Inonotus obliquus on high fat diet-induced obese rats. Acta Biochim. Biophys. Sin. 47:755-757.

Zhao, F., Mai, Q., Ma, J., Xu, M., Wang, X., Tiantian, C., Feng, Q. & Han, G. 2015. Triterpenoids from *Inonotus obliquus* and their antitumor activities. Fitoterapia 101: 34-40.

8 NWFP from Understory Plants in Europe

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8.1 Introduction

The understory plant species are an important structural and functional component of forests. These species usually represent a wide variety of growth forms and functional groups. Understory plants are considered as all the plant species below the canopy. However, in some cases, the term "understory" is used only for species of shrub size or smaller (Antos, 2009). This approach is used in order to present the NWFP of understory plants in this chapter.

A wide range of products and goods can derive from the understory plant species. Examples of NWFP from the understory include products that are used as food and food additives (herbs, spices and condiments, aromatic plants), fibres (used in construction, furniture, clothing or utensils), for medicinal, cosmetic or cultural purposes. The 76% of the recorded taxa in an oak forest in Northern Greece (Abraham *et al.* 2015) was classified in one or more categories in relation to its use (edible, medicinal etc). Regarding food, there is evidence that 81 species of vascular plants are collected and consumed throughout the EU (Schulp *et al.* 2014) with nutritional, economic and cultural benefits. For example, picking wild herbs and berries (Molina *et al.* 2011) is a common recreational and sometimes profitable activity in many European countries.

Medicinal and aromatic plants species with their particular chemical profiles were important elements of religious and therapeutic practices in early cultures worldwide (Samuelsson 2004). European countries have a long tradition in herbal medicine since Greek and Roman times (Gurib-Fakim 2006). Nowadays medicinal and aromatic plants have a wide range of applications in pharmaceutical, cosmetic, food industry, sanitary, agriculture and animal feeding. Regarding pharmaceutical use, the 11% of the basic drugs are exclusively of plant origin according to World Health Organization (WHO 1992). Furthermore, there is a continuously growing interest in alternative therapies and therapeutic use of products derived from plants (Rates 2001). Finally, natural products isolated from medicinal plants can be an essential component in the search for new medicines (Balunas and Kinghorn 2005).

The NWFP of the understory may be gathered from the wild, or produced in forest plantations and agroforestry schemes. The products usually are gathered by local people of rural areas either for their own use or for commercial purposes. Data about the wild berry trade in several European countries was reviewed by Schulp *et al.* (2014). However, in many cases there is lack of official data about the trade of these products, as this activity in some cases is illegal. The commercialization of these products may provide local populations with additional income and employment, contributing directly to rural development (Abraham *et al.* 2015). On the other hand, the commercialization increases the gathering intensity threatening the natural populations of these species.

The understory plants provide forage to wildlife and livestock. In some cases, grazing in forested areas by large herbivores (wildlife and livestock) is considered as an efficient management tool to increase species and landscape diversity, to reduce fire hazards and fire risks. Moreover, grazing could positively affect soil properties, the nutrient cycling within the system, the ratio of green to dead material of herbage (Bernues *et al.* 2005) and the competition between understory vegetation and trees for nutrients and water. In this respect, grazing could enhance the environmental and recreational value of forests (Casasus *et al.* 2007). On the other hand, grazing by livestock (especially goats in forests) in some cases has negative impact, mainly on forest regeneration.

Regulating the use and protecting NWFP of understory plants is important for the development of rural areas, their protection from over-exploitation, reduction of stocks and protection of biodiversity. In this chapter the variety of benefits derived from understory plants and the possibilities for harvesting and processing is presented (chapter 8.2). The chapter will also focus on the economic importance of the understory plants in European countries (chapter 8.3) and discuss the implications of forest grazing (chapter 8.4). Additionally, case studies from countries with a long tradition in the use and production of NWFP from the understory will be presented in illustrative boxes and final conclusions will be given (chapter 8.5).

8.2 NWFP of understory plants in European countries

8.2.1 The importance and the uses of understory plants in European countries

The uses of the wild understory plants and their products is referred in the following categories: 1) Edible: food and food additives, beverages provided by plants' leaves, fruits, seeds, roots; 2) Medicinal and aromatic: traditional medicine, pharmaceutical industry, essential oils, cosmetic and food industry; 4) Forage: Herbaceous vegetation that is available for livestock and wildlife; 5) Dyeing and tanning: plant materials that used as colorants and other that provide tannins; 6) Construction, handicrafts, ornamental. A total of 32 taxa was cited as important NWFP from the understory plants by the respondents from 23 European countries (Table 8.1).

Forest berries were the most popular category among the edible plant species representing the 50% in Northern and Southern Europe (Case 8.1). *Vaccinium myrtillus* L. (Bilberries), *Vaccinium vitis-idaea* L. (Cowberries/Foxberries), *Rubus* sp. (Blackberries) and *Fragaria vesca* L. (Wild strawberry) were recorded as important products for the majority of the respondents (Table 8.1) in all geographic areas, while *Empetrum nigrum* L. was only reported in the North. On the other hand, *Arbutus unedo* L. was reported only in Southern countries. Indeed, *Arbutus unedo* is traditionally used in the Iberian Peninsula and other Mediterranean regions (Redzic 2006; Hadjichambis *et al.* 2008). The berries are consumed fresh or are used for jams, liqueurs, jelly, dessert topping, pie filling, ice cream, yoghurt and other desserts. Consumers perceive berries as healthy food and due to the promotion of health benefits over the last years, their use has been significantly grown. They are characterized by high nutritional value. All plant parts of *Vaccinium* sp. are considered potential sources of phenolic compounds for use either as food or by the pharmaceutical industry (Riihinen *et al.* 2008). Similarly, the fruits of *A. unedo* contain a wide range of antioxidants including vitamin C and E, carotenoids and polyphenolic compounds (Barros *et al.* 2010).

Other taxa that were reported as important edible NWFP in Northern and Central European countries were *Allium ursinum* L. (wild garlic) and *Galium odoratum* (L). Scop. The wild garlic has a long tradition of edible and medicinal use due to its antimicrobial, cytotoxic, antioxidant, and cardioprotective properties (Sobolewska *et al.* 2015). Its leaves, stems and flowers are consumed raw or cooked. Additionally, *Asparagus aqutifolius* L., *Hyppophae rhamnoides* L., *Origanum vulgare* L., *Thymus* sp. and *Urtica dioica* L. have been reported in Southern and Central European countries (Table 8.1). *Asparagus aqutifolius* has been gathered since ancient times (Molina et al. 2012), it is popular in the Mediterranean countries (Chauvet 2001; Ertug 2004; Ghirardini *et al.* 2007; Hadjichambis *et al.* 2008; Molina *et al.* 2012) and it is of higher nutritive value than that of cultivated *Asparagus officinalis* (Ferrara et al. 2011). Oregano and

Thyme are both important culinary and medicinal herbs. They are used for the flavour of their leaves fresh or dried. Stinging nettle (*Urtica dioica* L.) can be used not only for food and medicine but also for dyeing, textile and energy (Dreyer and Müssing 2000).

A great number of plant species from the understory have been reported with medicinal use depending on the ethnomedicine of each country (Case 8.2). For example, the 21% of all the known 4102 species listed on the territory of Bulgaria have medicinal uses (Zahariev *et al.* 2015). According to González-Tejero *et al.* (2007) 406 taxa with medicinal uses have been recorded in the Mediterranean basin. According to Hanlidou *et al.* (2004), among 172 taxa with medicinal uses found in the market of Thessaloniki, 93 of them were mentioned by Dioscorides. The knowledge of harvesting and uses of medicinal plant species is usually kept by older people and nowadays the number of professional harvesters is decreasing as they are getting older. The lack of people's knowledge on botanical identification, habitats and uses of medicinal plant species limits the harvesting and use of many medicinal plants. However, a number of them are still known to be gathered or cultivated and used in the pharmaceutical and cosmetics industries. For example, *Hypericum perforatum* has many medicinal applications such as skin wounds, depression treatment (Di Carlo *et al.* 2001), antioxidant properties (Silva *et al.* 2005) and could be used either as pharmaceutical preparations or included in food products.

Table 8.1: The most important NWFP from the understory plants according to the respondents from 23 European countries. (Source: COST Action FP1203 common survey)

	Uses			Geographic area			Resource	
Species	**E**	**M&A**	**O**	**N**	**C**	**S**	**Wild**	**Cultivated**
Allium ursinum L.	√	√		√	√		√	
Arbutus unedo L.	√					√	√	
Arctostaphylos uva-ursi (L.) Spreng.		√				√	√	
Asparagus aqutifolius L.	√	√			√	√	√	
Cistus ladanifer L.			√[1]			√	√	
Convallaria majalis L.			√[2]	√			√	
Empetrum nigrum L.	√	√		√			√	
Filipendula ulmaria (L.) Maxim.		√		√			√	
Fragaria vesca L.	√	√			√	√	√	√
Frangula alnus Mill.				√			√	
Galium odoratum (L) Scop.	√			√			√	√
Gentiana lutea L.		√				√	√	
Geranium sylvaticum L.		√		√			√	
Hypericum perforatum L.		√				√	√	

	Uses			Geographic area			Resource	
Species	**E**	**M&A**	**O**	**N**	**C**	**S**	**Wild**	**Cultivated**
Hyppophae rhamnoides L.	√	√			√		√	
Ilex aquifolium L.			√[3]			√	√	√
Juniperus communis L.		√		√	√	√	√	
Origanum vulgare L.	√	√				√	√	√
Ribes spicatum Robson, Downy Currant.	√	√		√				√
Rosa canina L.	√	√			√	√	√	√
Rubus chamaemorus L.	√			√			√	
Rubus fruticosus L.	√			√	√	√	√	√
Rubus hirtus L.	√			√	√		√	
Rubus idaeus L.	√	√		√	√		√	√
Sideritis sp.		√				√	√	√
Stipa tenacissima L.			√[4]			√	√	
Thymus sp.	√	√				√	√	√
Urtica dioica L.	√	√			√	√	√	
Vaccinium myrtillus L.	√	√		√	√	√	√	√
Vaccinium oxycoccos L.	√	√		√			√	
Vaccinium vitis idaea L.	√	√		√	√	√	√	
Valeriana celtica L.		√			√		√	

Uses: E (Edible), M&A (Medicinal and aromatic), O (Other); Geographic areas: N (North Europe), C (Central), S (South); Other uses: [1]perfumes and paints (Spain), [2]Decorative (Poland), [3] Decorative (Greece), [4] Craft and construction (Spain)

CASE 8.1. *Edible plant species from the understory*

A great number of plant species from the forest understory are edible. Particularly 59 taxa were classified into this category belonging in 40 genera. The most popular genera were *Ribes*, *Rubus* and *Vaccinium* with 4, 7 and 6 taxa respectively.

Edible plant species are: *Alliaria petiolata* (M.Bieb.) Cavara & Grande, *Allium ursinum* L., *Arbutus andrachne* L., *A. Unedo* L., *Asphodeline lutea* (L.) Rchb., *Asparagus acutifolius* L., *Bellis perennis* L., *Berberis vulgaris* L., *Centaurea cyanus* L., *Cichorium intybus* L., *Cirsium oleraceum* (L.) Scop., *Cistus* sp., *Cornus mas* L. *Crataegus monogyna* Jacq., *C. pentagyna* W.K., *Crocus* sp, *Empetrum nigrum* L., *Fragaria vesca* L., *Galium aparine* L. *Galium odoratum* (L.) Scop., *Heracleum sphondylium* L. ssp. *ternatum* (Velen.) Brummit, *Hippophae rhamnoides* L., *Lapsana communis* L., *Levisticum officinale*

(Hill), *Mespilus germanica* L., *Origanum* sp., *Oxalis acetosella* L., *Pistacia terebinthus* L., *Rhus coriaria* L., *Ribes grossularia* L., *R. nigrum* L., *R. spicatum* Robson, *Ribes uva-crispa* L., *Rosmarinus officinalis* L., *Rosa cannina* L., *Rubus caesius* L., *R. canescens* DC., *R. chamaemorus* L., *R. fruticosus* L. *R. idaeus* L., *R. sancus* L., *R. saxatilis* L., *Satureja cuneiforlia* L., *S. montana* L., *S. thymbra* L., *Silene vulgaris* (Moench) Garcke, *Sisymbrium officinale* (L.) Scop., *Taraxacum officinale* Weber., *Thymus* sp., *Urtica dioica* L., *Vaccinium arctostaphyllos* L., *V. microcarpon* Aiton, *V. myrtillus* L., *V. oxycoccos* L., *V. uliginosum* L., *V. vitis-idaea* L., *Verbena officinalis* L., *Veronica officinalis* L., *Viola odorata* L., *V. tricolor* L.

Figure 8.1: *From right to left: Lingonberry (Vaccinium vitis-idaea L.) highly important understory plant, Bearberry (Arctostaphylos uva-ursi (L.) Spreng.) one of the most commercialized species in the pharmaceutical market in Lithuania (Photos credit: Jolita Radušienė)*

8.2.2 The importance and use of understory plants in Lithuania

According to the data of State Forest Survey Service (2014) forest in Lithuania covered 33.3 % of country's territory. Coniferous stands covered 56.1 % of the forest area, mainly in dry and mesic habitats, which are dominated by cowberry and bilberry pine and pine-spruce forests. In more humid areas a mixed-wood species dominated by Scots pine (*Pinus sylvestris*), spruce (*Picea abies*), downy birch (*Betula pubescens*) and black alder (*Alnus glutinosa*). The distribution of wild plant species and their biological yield estimation was inventoried at the Institute of Botany (currently Nature Research Centre) from 1979 to 1990. Harvesting rates and return periods were established for some species and were declared in acts and regulations that followed the Law of Wild Vegetation (1999). Big changes are observed nowadays in relation to the changing natural environment and human activities.

The understory vegetation is dominated by ericaceous dwarf shrubs, mosses, lycophytes, lichens, and various herbaceous species. The most important category of understory plants is wild berries which mainly situated in coniferous forests in southeast and east parts of Lithuania. Large areas are occupied by bilberries (*Vaccinium myrtillus*) – 19.3 thousand ha, lingonberries (*Vaccinium vitis-idaea*) – 5.0 thousand ha and cranberries (*Vaccinium oxycoccos*) – 3.5 thousand ha. The raspberries (*Rubus idaeus* (about 6.9 thousand ha) and wild strawberries (*Fragaria vesca)* are common at the forest edges and cuttings all over the country.

The second important category of understory plants comprises of medicinal plants used as alternative medicines. The biggest resources of medicinal plants are found in south and the north-east Lithuania. There were inventoried 16.6 thousand ha of medicinal plants. Huge areas are occupied by common juniper (*Juniperus communis*) (3363 ha), marsh tea (*Ledum palustre*) (3207 ha), common nettle (*Urtica dioica*) (2446 ha), club mosses (*Lycopodium* spp.) (250 ha), and lily of the valley (*Convallaria majalis*) (196 ha) (compare Figure 8.1). According to the knowledge of plants usage assembled from published and unpublished original sources, about 180 understory plant species are considered as medicinal plants[1]. Most species are collected in very few quantities for specific therapeutic purposes, in general for household consumption. However, quite often these volumes are commercialized in local markets. Medicinal plants mainly used to treat colds, alimentary disorders and urinary tract ailments. Herbs generally consumed for teas within a food context as "healthy" drinks to enhance immunity. The overall favourite and widely used medicinal plants are common species, as: *Achillea millefolium* L., *Arctium* spp., *Artemisia absinthium* L., *Alchemilla* spp., *Arctostaphylos uva-ursi* (L.) Spreng., *Crataegus* spp., *Fragaria vesca* L., *Filipendula ulmaria* (L.) Maxim., *Hypericum* spp., *Epilobium angustifolium* L., *Origanum vulgare* L., *Mentha* spp., *Potentilla erecta* Uspenski ex Ledeb., *Rubus idaeus* L., *Thymus serpyllum* L., *Tussilago farfara* L., *Urtica dioica* L., *Vaccinium myrtillus* L., *Vaccinium vitis-idea* L., etc.

Eating wild products is becoming fashionable, however, harvesting and use of understory plants for food, except wild berries, is not common[29]. Only some plants have long traditions of usage, like *Juniperus communis* whose sprigs are used to flavour smoked meat and berry-like cones used as spice for game meat or in some beverages. *Hierochloe* spp. and *Galium odoratum* are used to flavour spirits, while wild hop (*Humulus lupulus*) has old traditions in brewing beer. Only a few plants are used as a spice, mostly the herbs *Origanum vulgare* and *Thymus spp*. Leaves of *Aegopodium podagraria*, *Taraxacum officinale* are picked as culinary herbs. Young plants of *Urtica dioica* and *Rumex acetosa* are commonly used to make spring season soups. Leaves of *Allium ursinum* are known as a favourite culinary herb. However, this species is included in Red Data Book which strictly prohibits any wild harvesting. According to the extensive research of plant distribution and biology, viable populations of *Allium ursinum*

29 Original information for the use of plants was collected by students (A. Šulskienė and P. Šarka) while preparing her master's thesis under the supervisor J. Radušienė.

formed large stands, mainly prevailing in deciduous forest of central and western lowlands of Lithuania (Karpavičienė 2003; 2006). The further use of natural populations of this plant highly impacts on the survival of plant populations in their natural habitats. On the other hand, the plant could be bred and cultivated in favored forest habitats to supply raw herb material.

Understory plants used for decorative purposes: home decoration, grown as ornamentals in gardens, used for religious feasts decorations, especially for Easter. Willow (*Salix caprea*) and juniper twigs bouquets are traditionally used for blessing during Palm Sunday. In the Vilnius area are distinct "Vilnius Palms" which are created using about 40 different dried wild plants, including mosses, lichens, clubmosses, sprigs of lingonberries and many flowering forest and meadow species. The wild flowers and greenery are collected for market and sold in the biggest cities. The most popular plants for bouquets are: *Convallaria majalis*, *Hepatica nobilis*, *Primula veris*, *Pulsatilla* spp., *Pulmonaria obscura*, *Aquilegia vulgaris*, *Anemone ranunculoides* and *A. nemorosa*, *Campanula trachelium*, *Salix caprea*, *Viola* sp., *Calluna vulgaris*. Forest visitors collect flowers also for their own home decoration. However, collection and sale of some species, including: leaves and flowers of *Convallaria majalis* (except for medicinal raw material), flowers of *Primula veris*, *Pulsatilla* spp., *Lilium martagon* and *Anemone sylvestris*, is prohibited by national legal regulations on sustainable use of wild flora issued by the Ministry of Environment and follows the Law on Wild Flora. Destruction of *Lycopodium clavatum* plants and *Cetraria islandica* thallus is prohibited according CITES Convention ratified in 2001.
Forest plants are grown in home gardens as decorative plants; the most commonly grown species are: *Antennaria dioica*, *Daphne mezereum*, *Juniperus communis*, *Aquilegia vulgaris*, *Anemone sylvestris*, *Convallaria majalis*, *Hepatica nobilis*, *Primula veris*, *Polygonatum* spp., *Viola odorata*.

Figure 8.2: *From right to left: Juniper (Juniperus communis L.) cornes used as spice for game or beverages (Photo credit: Kristina Ložienė), Ramsons (Allium ursinum L.) stands in deciduous forest (Photo credit: Birutė Karpavičienė). Club mosses (Lycopodium sp.) spores are used in pharmaceutics (Photo credit: Jolita Radušienė)*

8.2.3 The importance and use of understory plants in Bulgaria

According to data from Forest Administration during the period 2000-2015 berries (blueberries, blackberries, raspberries, sloe, etc.), rose hips and herbs are collected from forests (Figure 8.3). Their quantities vary from year to year, which is associated with seed bearing, the status of habitats, dynamics of the climate impacts and work organization. Among the above products, the greatest demand in Bulgaria and internationally is for rose hips. The plants can be grouped into the following categories in relation to the parts used:

- Radix-V*aleriana officinalis* L., *Urtica dioica* L., O*nonis spinosa* L., *Levisticum officinale* W.D.J.Koch, *Symphytum officanale* L., *Althaea officinalis* L., , *Petasites hybridus* (L.) G.Gaertn., B.Mey. &Scherb., *Chenopodium* sp. etc.
- Flowers: *Lavandula officinalis* L., *Matricaria chamomilla* L., *Achillea millefolium* L., *Spiraea ulmaria (Filipendula ulmaria)* (L.) Maxim, *Primula officinalis* L. etc.
- Herbs: *Veronica officinalis* L., *Verbena officinalis* L., *Stellaria media* L., *Tanacetum vulgare* L., *Taraxacum officinalis* L., *Galium verum* L., *Galega officinalis* L., *Solidago virgaurea* L., *Arctostaphylos uva-ursi* (L.) Spreng., *Chelidonium majus* L., *Herniaria glabra* L., *Viscum album* L., *Hypericum perforatum* L., *Centaurium erythraea* Rafn., *Achillea millefolium* L., *Thymus serpyllum* L., *Capsella bursa-pastoris* L., *Euphrasia officinalis* L. , *Artemisia absinthium* L., *Teucrium chamaedrys* L, *Melissa officinalis* L., *Origanum vulgare* L., *Fumaria officinalis* L., *Agrimonia eupatoria* L., *Satureja Montana* L., *Equisetum arvense* L., *Hieracium pilosella* L., *Viola tricolor* L., *Betonica officinalis* L.
- Foliage: *Hedera helix* L., *Plantago major* L., *Plantago lanceolata* L., *Rubus idaeus* L., *Rubus fruticosus* L., *Urtica dioica* L., *Corylus avellana* L., *Atropa belladonna* L., L *Mentha sp.*, *Melissa officinalis* L., *Tussilago farfara* L., *Symphytum officinale* L.
- Fruits: *Juniperus communis* L., *Crataegus* sp., *Rosa canina* L., *Sambucus nigra* L., *Prunus spinosa* L., *Coriandrum sativum* L., *Foeniculum vulgare* Mill, *Silybum marianum* L.
- Berries: *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L., *Rubus idaeus* L., *Rubus fruticosus* L., *Fragaria vesca* L.

Bulgaria has a long tradition in ethnomedicine. Hardalova *et al.* (1994) reported that the use of resources of medicinal and forest plants in Bulgaria to produce industrial quantities of raw materials began after World War I, mainly due to demand from Germany. After 1930 this activity developed increasingly as the main factor that influences the dynamics (number, type and quantities) is the export of herbal medicinal raw materials. Strong demand for raw materials of medicinal plants leads to the creation of the Law on Medicinal Plants in Bulgaria in 1941, which was revised in 2000. The purpose of this law is to ensure and regulate sustainable management, use and conservation of medicinal plants in Bulgaria. According to the Law on Medicinal Plants (2000), 770 species (19% of all plants in the country) have healing properties. Most of them (about 760 species) are wild. About 250 of these species are used in large quantities for trading and processing. Others are not subjected to economic interest for now, but scientific data and practical evidence exists regarding their effectiveness. Export of medicinal herbs from Bulgaria ranges between 8-th and 10-th place in the world, but the reported quantities that are harvested from forests are very small (between 300 and 700 t) compared with the total exported quantities (between 7690 and 12294 t) (Stoyanov and Stoyanova 2013).

Foliage includes needles and leaves of shrub species together with twigs with thickness of up to 8 mm. This is the vital part of shrubs that is rich in biologically active substances, such as vitamins, chlorophyll, ferments, trace elements, essential oils and other substances, which are useful for humans and animals. Besides the direct use of foliage as fodder for livestock, it can also be utilized for the production of essential oils, vitamin conifer flour, chlorophyll-carotene paste, etc. The raw material for these productions is obtained from needles with twigs of coniferous shrubs (mainly from Juniper). Small twigs and shoots from different shrub species, and stems of bulrush and reeds are used for manufacturing of agricultural and household vessels. Woven baskets, hand baskets and mats are among the earliest devices produced by humans. Now, besides basket articles, furniture and knitted garments are used in the household as objects of artistic crafts. The most widely used materials are willow branches. They can be derived from natural stands or from especially established plantations.

Use of medicinal and forest-fruit plants from the forest until now was done without taking into account the ability of their resource base, due to absence of inventory for them, which does not allow their rational use together with conservation and enrichment of the habitats (Stoyanova and Stoyanov 2007). Thus, some years' acquisition exceeds the capacity of the habitats, which leads to reduction of their stock. Utilization now is carried out under the Biological Diversity Act, Forestry Act, the Law on Medicinal Plants and the Law on Environmental Protection. In these regulations, medicinal and forest-fruit species, depending on the status of their stocks, are related to the following groups-*Species prohibited for collection* by the Biological Diversity Act (BDA); *Species in special mode of utilization* by the Medicinal Plants Act (MPA); *Widespread species*, whose national stock is of interest to be collected for commercial purposes. Use is subject to certain rules. A serious problem that arises as a result of increasing demand for non-wood forest products is overexploitation. When organizing the use of non-wood forest products, each forest owner must first be familiar with the provisions on this matter laid down in legislation on forests. The use of non-wood forest products as an economic activity, regardless of ownership of forests and forest lands shall be authorized by the State Forestry Enterprise or by the Municipality by issuing a written permit against paying a fee for its issuance and they are carried out under the terms and conditions set out therein. For the use of non-wood forest products from forest – owned by individuals or legal entities, the permit is issued based on a written application by the owner and paid fee for issuance. The owners do not pay a fee for the object type and volume of the non-wood forest products. There are also rare and endangered species that are subjected to protection (70 species are included in the Red Book of Bulgaria (2015), 43 species are under protection of CITES, there are 12 medicinal plant species in Bulgaria that are characterized as endangered at European level).

Figure 8.3: *From right to left, Hypericum perforatum L., Rosa canina L., Leucojum aestivum L. (Photos credit: Nickola Stoyanov and Maria Stoyanova).*

8.2.4 Threats, exploitation and prospects of Greek Mountain Tea (Sideritis sp.) in Greece

Greek Mountain tea is a group of different species, indigenous to Greece, of the genus *Sideritis* of the Lamiaceae family. The genus *Sideritis* includes about 140 species. Ten species are annual and the rest of them are perennial. In the Mountain Flora of Greece (Baden 1991) the following *Sideritis* taxa, belonging to the sect. Empedoclia (Rafin) Bentham, have been recorded:

- S. *syriaca* L. ssp. *syriaca* (endemic to Crete),
- S. *raeseri* ssp. *raeseri* (Boiss. & Heldr.), S. *raeseri* ssp. *attica* (Heldr.), endemic, included in the Red Data Book of Rare and Threatened Plants of Greece (VU)
- S. *scardica* Griseb.
- S. *clandestina* ssp. *clandestina* and S. *clandestina* ssp. *peloponnesiaca* (Boiss & Heldr) endemic to southern Greece – Peloponnese
- S. *euboea* Heldr., endemic to Evia island – included in the Red Data Book of Rare and Threatened Plants of Greece (EN),
- S. *perfoliata* ssp. *perfoliata*, S. *perfoliata* ssp. *athoa* (Papanic. & Kokkini)
- S. *sipylea* Boiss, included in the Red Data Book of Rare and Threatened Plants of Greece (EN)

Mountain tea is used traditionally as a popular infusion, widely consumed and established as food or medicine. In folk medicine, various *Sideritis* species are used as antioxidant, antiinflammatory, antispasmodic, analgesic, carminative etc. Plant extracts are known to be biologically active; essential oils, diterpenes, phenolics, flavonoids, are the main bioactive compounds and there is an increasing interest on *Sideritis* antioxidant activities. Several studies have been reported in the last decades on the pharmacological properties of *Sideritis* sp., such as antimicrobial, antiulcerative, anti-inflammatory, spasmoytic, antiproliferative etc. Recent studies have also shown that *Sideritis* extracts from some native to Greece species may be used in phytotherapy for preventing anxiety related behaviors, to promote the mineral density and strength of bones, and for the prevention and treatment of neurobehavioral diseases.

Sideritis species grow mainly in stony or rocky places at high altitudes and they are collected from natural resources, strictly distributed in mountainous areas. *Sideritis* plants are grown mostly in sandy loam soils, within a wide pH range (6.75-8) and minimal requirements in soil nutrients. In recent years, due to the increasing demand, *Sideritis* species have experienced a dramatic decline in the number of populations, due to overexploitation and destructive harvesting and the remaining populations are frequently small and isolated from each other. Additionally, grazing by animals has a significant effect on *Sideritis* natural populations. In particular, S. *raeseri* ssp. *attica*, S. *syriaca* ssp. *syriaca*, and hardly S. *scardica* are the most affected species. Nowadays, *Sideritis* populations are also threatened, due to alteration of plant habitats caused by human activities, such as fires, tourism activities and increased accessibility to natural plantations, enabled by forest roads, or recreational development of certain mountainous areas which are close to urban centers, the agricultural intensification etc. Moreover, climate change consequences and mainly reduction of precipitation, is seriously affecting *Sideritis* species, having habitats on sunny slopes of alpine or sub-alpine zones.

Collection of wild *Sideritis* plants is carried out either by rural people for whom it provides a supplementary income, or even by tourists. Nevertheless, *Sideritis* is among the most traded medicinal plants in Greece. Harvesting is done either with or without prior contractual agreement with a trader and it is usually traded in dried form of whole inflorescences. Personal communications, experiences from plant collection missions conducted by different Institutes, data from relevant Authorities and articles in press have reported that over harvesting and unsustainable collection practices, i.e use of inappropriate tools, uprooting plants, or collection before seed formation, etc, pose a serious threat to *Sideritis* natural stands and consequently its biodiversity.

Unfortunately, so far conservation measures for a species have only begun once it has already become endangered. Besides that, there is an effective legislation on protection of endangered medicinal and aromatic plant species in Greece. The Forest services issue regularly specific provisions, regulating or prohibiting the collection of wild *Sideritis* species, in several areas. So, the collection is illegal without prior authorization. Nevertheless, these measures are not adequate and the development of conservation strategies still remains crucial, especially for species traditionally used and facing potentially threats of genetic erosion, such as *Sideritis*. There are three main conservation strategies of medicinal and aromatic plants: in situ (protection of their habitats), ex situ (conservation at species and germplasm level through field collections and gene banks) and introduction into cultivation (domestication). By introducing the most demanded species into cultivation, the pressure on natural populations is eliminating and the efficient supply of raw material is assured (Figure 8.4).

S. *raeseri* is the most widespread species in Greece, and it has been firstly introduced into cultivation, in areas of Mount Othrys (Thessaly). Nowadays, *Sideritis* cultivation, and mostly the taxa S. *scardica*, S. *raeseri* and S. *syriaca*, has been expanded in several mountainous and semi mountainous areas of Greece. Due to the specific ecological requirements, the selection of the appropriate agro-ecological conditions for cultivation is crucial. The plantations should be established at high altitudes, where the environmental conditions are similar, as much as possible, to those to *Sideritis* natural habitats. Growing *Sideritis* at lower altitudes, abiotic (climate conditions) and biotic stress (pest attacks and weeds occurrence) are more intensive, leading to measures and treatments for their eradication. *Sideritis* organic cultivation is simple and effective. Usually, the only needed treatments are weed control and applying of some organic fertilizers. Plant protection treatments are limited and where they are necessary, organic preparations are usually available. During the 1st year of cultivation, limited flowering occurs. The most intensive stem growth and formation of above ground biomass is observed after the 2nd year of vegetation, when the number of flowering stems increasing considerably, accompanied with intensive branching. Specifically, after the second year, the herbage yield in approximately 1500 kg/ha dry plant material (flowering stems).

Sideritis wild populations present a great variability in morphological, physiological and qualitative features. Significant differences have been recorded, regarding the morphological characteristics, within populations of the same species and even within a population, associated frequently with phytochemical diversity. Therefore, selection and breeding might be useful tools for achieving high biomass yield, plant uniformity and enhanced desired constituents that can satisfy consumers' preferences and adjusting them to the industry demands and the standardization of the final product.

Figure 8.4: *Natural population and cultivated Sideritis sp. (Photo credit: Paschalina Chatzopoulou).*

CASE 8.2: Understory plants, meadowsweet and its use in Iceland

Iceland is an island in the Atlantic Ocean and lies just south of the Arctic Circle. It was settled in the 9th century by Vikings from Norway who started farming in the new country. At the time of settlement 25 – 30% of the land area (about 103.000 km2) was believed to be forested (Eysteinsson 2013). The forest consisted mainly of birch and was used for charcoal production and for the grazing of sheep, consequently the forest area quickly declined and by the mid-20th century the forest cover of Iceland was as low as 1%. The Iceland Forest Service was established in 1907 with an initial remit of preserving the remaining birch forests. Later new forests were planted in order to increase the forest cover, nevertheless, in 2015 the forest cover is only up to 1.8% but as the planting of new forests continues, forest area will expand.

Due to the degradation of forests in Iceland many species of understory plants have either disappeared or can be found outside of forested areas. One of the plants with long tradition of use in Iceland is meadowsweet (*Filipendula ulmaria*) which can be found both in forests and outside forested areas. As the planted forests grow and expand, the meadowsweet has found shelter in the new forests and thrives very well in aspen forests (for example in the southern part of Iceland).

Meadowsweet is known for its healing abilities especially noted for stomach and digestive disorders but the name comes from using the herb for making mead, originally in Celtic culture (Róbertsdóttir 2011). In Iceland, the herb has been known and used for its healing power through the centuries and is still used for remedies and teas by herbalists in Iceland. It has also been used for dyeing wool and is known for a long lasting color and good quality as a dyeing herb (Helgadóttir and Hlöðversdóttir 2010).

The meadowsweet grows best in rich, slightly humid soil and is mostly found in the southern and western area of Iceland though it can be found elsewhere if the conditions are good and it is also cultivated in gardens (Kristinsson 2013). The meadowsweet is favored by sheep and is only found with small leaves and no flowers where grazing is common. As the planted forests are usually free from grazing the meadowsweet grows very well there.

Meadowsweet is picked wild and used fresh or dried depending on the interests of the user. It is used by herbalists for its healing abilities and sold as remedies or as an ingredient in herb teas. Owners of land where the meadowsweet grows can either allow people to pick the herb or pick and sell themselves but organized marketing of the herb itself is not available as far as known to the authors. Using of wild herbs is gaining interest in Iceland and small companies driven by entrepreneurs are being established, producing products and selling in local markets or through websites. The market for meadowsweet and other products containing herbs and forest products is growing and will hopefully continue to do so in the near future.

8.3 Commercial status of NWFP from the understory

8.3.1 Commercial status of wild harvested and cultivated NWFP from the understory

Wild berries are the most important market for understory plants in European countries. In general Poland, Serbia, Spain, the Netherlands and Belgium are the main producers of berries in Europe and the total European imports of fresh berries in 2015 were about 70 thousand tons with a value of €413 million (https://www.cbi.eu/node/2074/pdf/).

Medicinal and aromatic plants (MAPs) are an important market, too. About 200 Bulgarian herbs are exported, mainly to Germany (65%), Spain (10%), Italy (5%), France (5%) or other countries (15%). Over 85% percent of harvested medicinal plants in Bulgaria are exported in dried form for further processing abroad. Bulgaria and Bulgarian businesses lost much of the potential revenue of these exported medicinal plants. Besides the collection of herbal raw materials, extraction of the healing power of plants through processing and production of final products containing herbal extracts, Bulgaria can be a successful destination for specialized tourism and culinary services related to herbs (Case 8.3).

The most commercialized plant species used in the pharmaceutical market in Lithuania are leaves of raspberries (*Rubus idaeus*), common nettles (*Urtica dioica*), bearberries (*Arctostaphylos uva-ursi*) and lingonberries (*Vaccinium vitis-idaea*), herb of wild thyme (*Thymus serpyllum*) and St. John's wort (*Hypericum perforatum*), spores of clubmoss (*Lycopodium clavatum*) and thallus of Iceland moss (*Cetraria islandica*) 2. Commercial amounts of medicinal plant raw material continuously decreased from the late 90s, from 80-90 t/year to around 20 t in 2010. However, in the case of *Hypericum* spp., *Urtica dioica*, *Vaccinium vitis-idaea* and *Rubus idaeus* the raw material purchase increased in the last accounting year. Manufacturers and wholesalers demand for large quantities of raw material and prices paid to harvesters are low, as herb material and products have high competition with those imported from other countries. Therefore, the harvesters often sold the dry herb material directly in fairs or markets.

Most of the raw material used for the production of herbal teas was sold into the pharmaceutical market, spores of clubmoss used as a special powder. Extracts from nettles and common juniper are produced for phytomedicines and cosmetics. There are around 20 enterprises dealing with MAPs wild harvesting in Lithuania. The most important are: "Švenčionių vaistažolės", "Mėta", "Acorus calamus" which are located in the northeast part of the country.

The majority of the NWFP of the understory are wild harvest (gathering) from the forests and only few of them are cultivated (Case 8.4). According to Hanlidou *et al.* (2004) among 131 medicinal taxa with Greek origin that were recorded in the market of Thessaloniki, 80 were gathered exclusively from the wild, 31 were exclusively cultivated and 20 were both wild and cultivated. These products, mainly edible and medicinal, were collected either for personal use or for sale. The urbanization and the economic development has resulted in a decline of gathering NWFP for food and medicine (Łuczaj *et al.* 2012; Schulp *et al.* 2014). However, increased public awareness on healthy diet has renewed interest in these products. Thus, NWFP for food and medicine are becoming fashionable and gathering a recreational activity mainly in financially strong European countries (Łuczaj *et al.* 2012). On the other hand, the gathering and consuming of these products has an economic role in financially less strong countries and in many cases, is an important resource for local livelihoods as they sell their products on local markets mainly to the people of urban areas (Stryamets *et al.* 2015). Gathering of understory plants for sale usually is a seasonal subsistence activity of the unemployed and elderly people.

The increasing wild harvest of these products has an ecological impact on the plants' population dynamic. As a result, many of these species are threatened due to overharvesting. The legal framework regarding wild harvesting of non-wood forest products is usually in reflection of the importance of these resources in the country, both for commercial and non-commercial purposes. In this respect, wild berries and other understory plants are freely available resources for everyone to use in the state and private forests of Lithuania. The national legislative framework for conservation and regulation on sustainable use of wild resources included: *Law on Environmental Protection* (1992), *Law on protected animal, plant and fungi species and communities* (1997, amended in 2001 & 2010), *Red Data Book of Lithuania* (1981, 1992, and 2007), and *Law on Wild Vegetation* (1999). Ministry of Environment maintains administration of legal regulations. Although most of the normative acts are adopted by harvesters, some of them are not yet well known or are partly left out. Permission for wild harvesting is required for any legal person using wild harvested resources for trade and permits are only valid for 1 year. Permits are issued by staff inspectors of local agencies in eight territorial Environmental Protection Departments.

Cultivation of these products could be an expedient for reducing the over-harvesting (Lubbe and Verpoorte 2011). However, only few of the most important NWFP from the plants of the understory are cultivated (Table 8.1) such as V.

myrtillus, *Rubus idaeus*, *R. fruticosus*, *Ribes* sp., *Origanum* etc. Nevertheless, some species could be used as crops of multiple uses in low input agriculture. For example, stinging nettle (*Urtica dioica* L.), a perennial low-requirement crop, can be cultivated for the production of textile fibre, numerous active compounds for application in food, medicinal and cosmetic industries and finally as energy crop (Di Virgilio *et al.* 2015).

Besides food and food additives, many of these plant species are sources of fine chemicals/industrial products that broadly used in pharmaceutical, cosmetic and food industry (Lubbe and Verpoorte 2011). Some of the most important industrial crops in European countries are chamomile (*Matricaria chamomilla* L.), lemon balm (*Melissa officinalis* L.), oregano (*Origanum* sp.), St. John's wort (*Hypericum perforatum*), common sage (*Salvia officinalis*) and valerian (*Valeriana officinalis*) (Honermeier *et al.* 2013; Stefanou *et al.* 2014). Notwithstanding, the main source of raw materials for medicinal and cosmetic industries in European countries is still the wild harvesting (Vines 2004). The main reasons for this are related to technical problems of cultivation such as the plants' slow growing rates, low seed germination etc (Schippmann *et al.* 2006), that increase the cost of cultivation and, as a consequent, the price of the final product. Additionally, the consumers consider the cultivated products inferior in quality compared to wild harvested (Schippmann *et al.* 2006). On the other hand, the advantage of cultivation is the easier control of quality and quantity of production especial in case that improved cultivars are used (Schippmann *et al.* 2006).

CASE 8.3: *Innovative NWFP from the understory – case study of Bulgaria*

The interest in use of wild and cultivated medicinal herbs is growing up. One of the most favorable and prospective herb in use is Immortelle (*Helichrysum arenarium* (L.) Moench). Immortelle is the new hit among oil-bearing crops. Immortelle is also known as the Stone Flower, yellow milling and dry flower. In the past, this herb was used to treat foot-and-mouth disease, so call it even foot-and-mouth diseases herb. According to experts Immortelle is characterized by exceptional healing properties and is used today in many pharmaceutical and perfume industries. It is used to remove scars after surgery, rheumatism, jaundice, stones and sand in the gallbladder, inflammation of the kidneys and bladder, neuralgia, low blood pressure, gynecological, skin diseases and others. Immortelle is the new hit among essential oil plantations. At the moment it is produced mainly in Corsica and Bosnia and Herzegovina. 650 kg of green mass produce one kg oil and 1 kg oil of immortelle is traded on world markets for €1500 -€1800.

Cultivation of medicinal and aromatic crops also is a new innovative activity. The country has about 39 thousand ha of cultivated medicinal plants, according to agricultural statistics. The creation of plantations and cultivation of healing and aromatic plants is a great achievement for the country's economy and for the preservation of the natural resources of these species. For example, rose (*Rosa canina* L.) plantations are created with the following developed and implemented varieties: Plovdiv -1, Nectar; Svetla, Vebetsina-115 and others. For plantations of *Melissa officinalis* L. varieties are: Standard, Quedlinburger Niederliegende and Citronella and for *Hyssopus officinalis* L.-White Nectar, Blue Nectar and Napoletano.

Among cultivated medicinal plants economically important species are *Lavandula spica* L., *Mentha spicata* L., *Valeriana officinalis* L., *Coriandrum sativum* L., *Foeniculum vulgare* Mill., *Pimpinella anisum* L., *Silybum marianum* (L.) Gaertn., *Sideritis scardica* Griseb., *Leucojum aestivum* L., *Salvia officinalis* L.

Mountain tea (*Sideritis scardica* Griseb) is Balkan endemic. In Bulgaria it was distributed in Middle and South Pirin, Mursal part of Rodopa Mountains, the mountain Rzhana and mountain Slavyanka (Alibotush) at an altitude of 1400 to 2200 m. It occurs more in some mountains in Greece, North Macedonia and Albania. Since the mountain tea is not a common species in the country, it is included in the Red Book of Bulgaria and from 1942 to 2002 is in the list of protected species under the Nature Protection Act. After its successful cultivation in the country, mountain tea is excluded from the Act and is included in the list of species under special management regime and its collection from natural habitats for industrial and commercial use is prohibited. Thanks to the cultivation of the mountain tea in recent years, it can be found in pharmacies and other stores in the country.

The largest market share has coriander and sale of essential oil from rose oil. Significant funds are received from the sale of hips, fennel and lavender. Analysis of farms in the country shows that the lowest income per hectare was received by growing mallow, marigold, thyme and white oregano. Medium scale is reported in the savory, valerian, sage, wild rose and basil. The largest yields occurred from fennel, coriander, lavender, rose oil, mint, lemon balm and milk thistle.

CASE 8.4: *The production of forest berries in Lithuania and Romania*

Bilberries (*Vaccinium myrtillus* L.), lingonberries *(V. vitis-idaea L.),* cranberries *(V. oxycoccos L., V. microcarpum (Turcz. ex Rupr.) Schmalh.)*, strawberries (*Fragaria vesca* L., *F. viridis* Weston, *F. moschata* (Duchesne) Duchesne) and, partly, sea buckthorns (*Elaeagnus rhamnoides* (L.) A.Nelson) are those of commercial importance as wild harvested plants in Lithuania. The latter was introduced in the middle of 20th century and, later on, used for recultivation of sand and gravel pits, to fight erosion on embankments and elsewhere, mostly on sandy soils, and naturalized quite well. The most abundant resources are those of bilberries, lingonberries and cranberries, which also are the most popular among wild berry pickers. According to the official statistics (Statistics Lithuania, 2013), the purchase of bilberries in 2011 and 2012 amounted to 1,169,647 and 1,494,352 kg, lingonberries – 446,409 and 141,951 kg, and sea buckthorns – 349,685 and 577 kg, respectively. A huge variation in the amounts purchased could be attributed to a complex of factors, including those influencing biological yields, like climatic conditions and species-specific properties, as well as socio-economic conditions, like reduction of population due to emigration, price policy, etc. Unfortunately, no official statistics on berry purchase is available since 2012.

Blackberries (*Rubus hirtus*) and rosehip (*Rosa canina*) are the main forest berries of commercial importance in Romania. The total harvested amounts of forest berries in 2009, 2010 2011 were 4600 t, 5775 t and 5785 t respectively (www.recolta.eu). The wild berries quantity that was estimated to be harvested in 2016, is a smaller compared with the quantities that were harvested in latest years, around to 3169 t. This is because some forest areas have returned to the former owners and are no longer managed by National Forest Administration and on the other hand due to the drought that affected southeast regions of the country.

8.3.2 Commercialization of medicinal and aromatic plants in Serbia

A large number of medicinal plants of outstanding properties, valued in the market (Keča et al., 2012a) are derived from forest ecosystems. Medicinal and aromatic plants in Serbia are traditionally used for medicinal purposes and as food. In addition, they are often used as a raw material in pharmaceutical industry, chemical industry, etc. The main regions of collection of wild medicinal and aromatic plants in Serbia are situated in the southeast. On the other hand, in the territory of Vojvodina cultivated species are dominated. In this research were included 22 enterprises from the 4 statistical regions in Serbia. The largest number of analyzed enterprises is situated in the territory of Vojvodina. The criterion for the selection of enterprises was their market significance in different parts of Serbia (Marčeta *et al.* 2014). The primary method of study was modeling while the statistical technique was trend analysis, with regression and correlation analyses. For the verification of obtained regression models trend correlation coefficient (R), *t-statistics* derived estimates of parameters and F-*statistics* were used (Keča and Marčeta 2015). In the study a questionnaire combined with personal interviews was used.

Purchase of medicinal and aromatic plants

In Serbia, the collection of non-wood forest products (NWFP) in nature is performing by the "quota" system, given by working group of representatives from the Institute for Nature Conservation of Serbia and the relevant Ministry of Agriculture and Environmental Protection (Keča *et al.* 2015). Medicinal plants are mostly purchased from southeast Serbia (Paraćin, Svrljig), then from the territory of Vojvodina (Pećinci, Perlez, Padej, Bavarište, Pančevo), and from the rural parts of Belgrade. Purchase of plants with multiple sites, despite the spatial distance is justified by the favorable terms of purchase certain raw materials (Keča and Marčeta 2015). In all cases the correlation coefficient and parameters were statistically significant at the level of error of 5%.

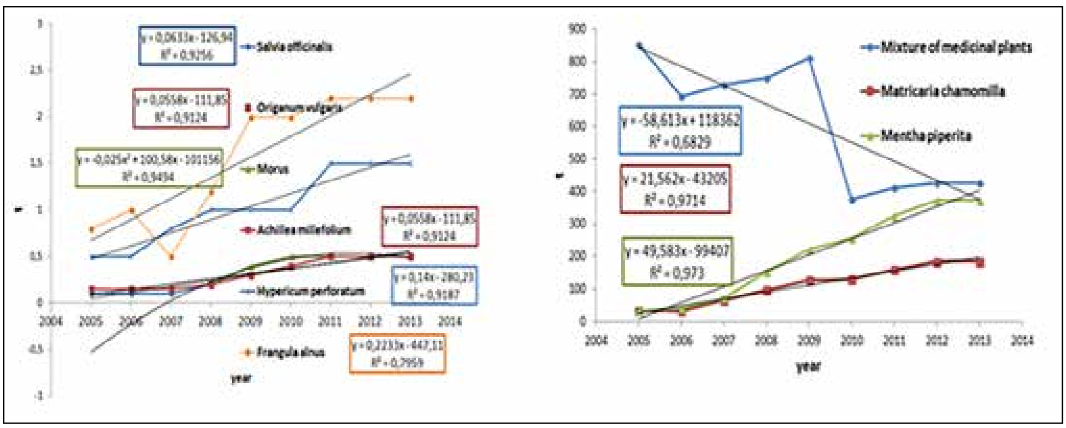

Figure 8.5: *Trend of purchase for selected medicinal and aromatic plants*

All analyzed species showed increased purchase for the period 2005-2013 with *Frangula alnus* (Figure 8.5) showing the largest quantity. Mixtures of medicinal and aromatic plants had periods of growth and stagnation of purchase in the period 2005-2013 (Figure 8.5). For *Matricaria chamomilla* and *Mentha piperita* the trend increased over the same time interval also.

Placement of medicinal and aromatic plants (domestic market)

In assortment of enterprises, various types of teas in filter bags and in bulk packaging dominate. Placement of filter teas on the domestic market showed a positive trend until 2009, followed by a decline (Figure 8.6). The other species had sub-periods of growth and stagnation. According to the quantity sold on the domestic market the dominant products were spices. Correlation in the case of filter teas was at the middle level although the correlation coefficients were not statistically significant. The dry extracts of *Mentha piperita* and *Althaea officinalis* had a strong correlation relationship while the rest of products (Figure 8.6) had a weak one.

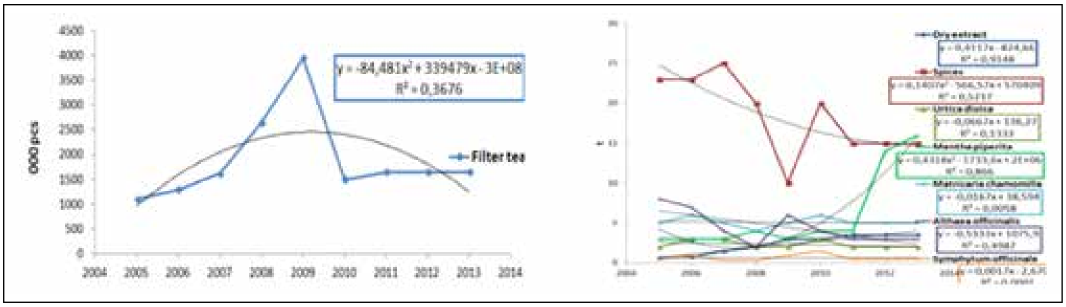

Figure 8.6: *Trend of placement medicinal and aromatic plants on the domestic market*

Export of medicinal and aromatic plants

The analyzed enterprises were mainly oriented to the domestic market. The only products which were placed on the international market were "Mixture of medicinal plants" and "Spices". Both of the analyzed categories (Mixture of medicinal plants and Spices) had negative trend in exports for the period 2005-2013 (Figure 8.7). The export of Mixtures of medicinal plants showed a strong correlation and significance of the correlation coefficient and parameters. On the other hand, this was not the case in the export of Spices.

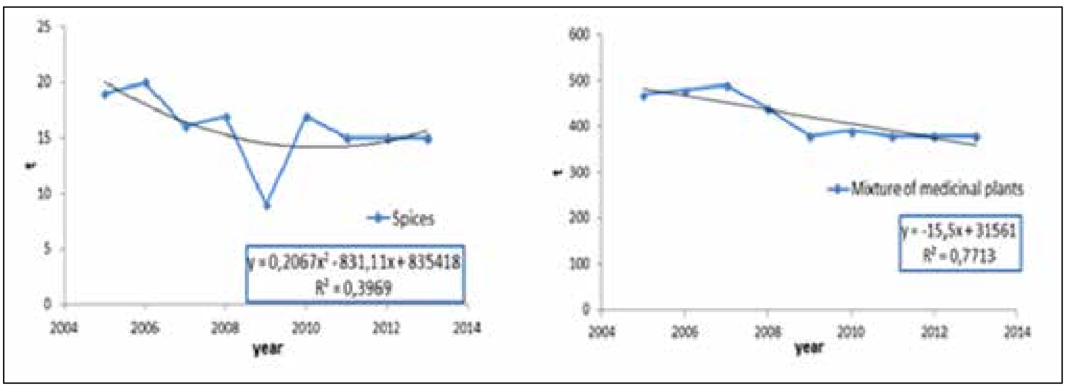

Figure 8.7: *Trend of export for medicinal plants and spices*

For foreign market entry, the NWFP enterprises must fulfil a number of import-export conditions. Usually those are: standards, phytosanitary regulations, license and tax payments, etc. These factors create barriers to small producers, who are predominantly addressed in this study, to perform and develop their products outside the country (Marčeta and Keča 2014).

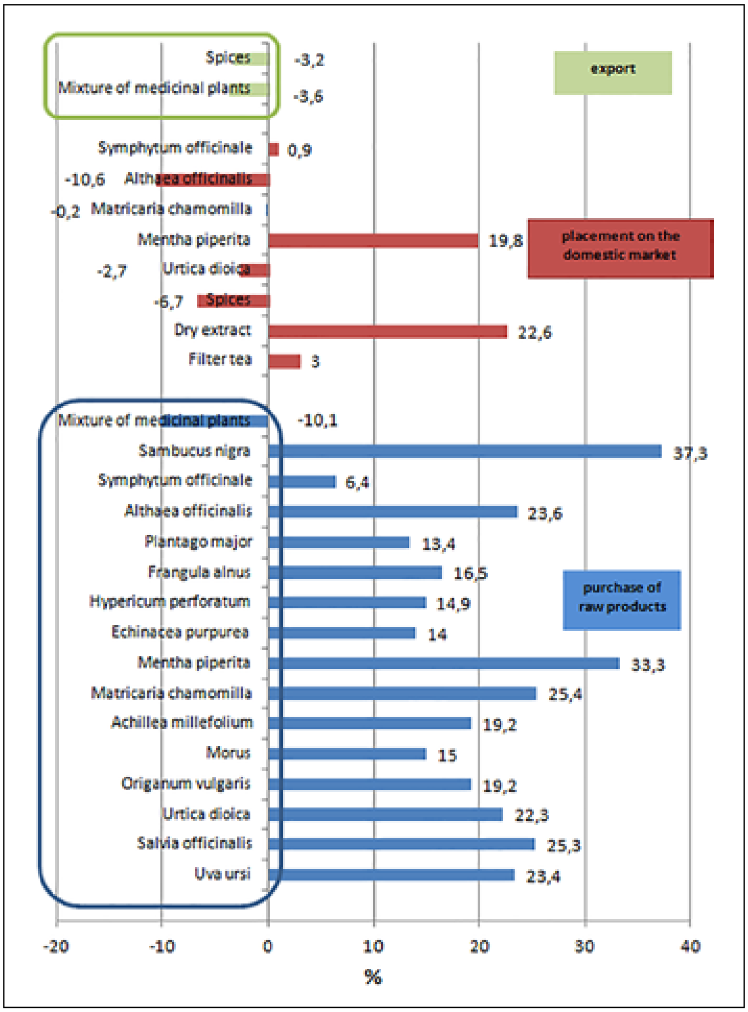

Figure 8.8: *Average annual growth rates in purchase of raw products, placement on the domestic market and export*

In the purchase of all kinds of medicinal and aromatic plants positive growth rates were recorded (Fig 8.8). The only exception constitutes the Mixtures of plants, which showed a decline (-10.1%). The most significant growth rate was recorded in the purchase of *Sambucus nigra* (37.3%) and *Mentha piperita* (33.3%). The highest growth in placement on the domestic market was recorded for Dry extracts (22.6%). A slightly lower growth of 19.8% was recorded in the case of *Mentha piperita*. The export of both species was recorded as decreases – Mixture of medicinal plants (-3.6%) and Spices (-3.2%). Unlike the situation in the whole of Serbia positive growth rates in the purchase and sale on the domestic market of all categories of medicinal and aromatic plants were realized in Vojvodina (northern Serbia) (Keča *et al.* 2012b).

Value chain of medicinal and aromatic plants

Purchase of raw materials enterprises is performed at several locations in Serbia, while some quantities are imported from Bosnia and Herzegovina, North Macedonia, Albania and Croatia. A part of raw material enterprises purchases is in the dry state, while some enterprises purchase raw plants and perform drying in their own drying facilities, which is also the most common method of preservation of plants (Keča and Marčeta 2015). For the transport of raw materials to the processing capacities the enterprises use their own vehicles. In storage, strictly controlled conditions such as optimal temperature and air humidity are provided. In the next step, raw materials are subjected to quality control (by accredited institution or internally within their own laboratory). After quality control, the raw materials are transported to the processing plant and finally the end products are stored (Fig 8.9).

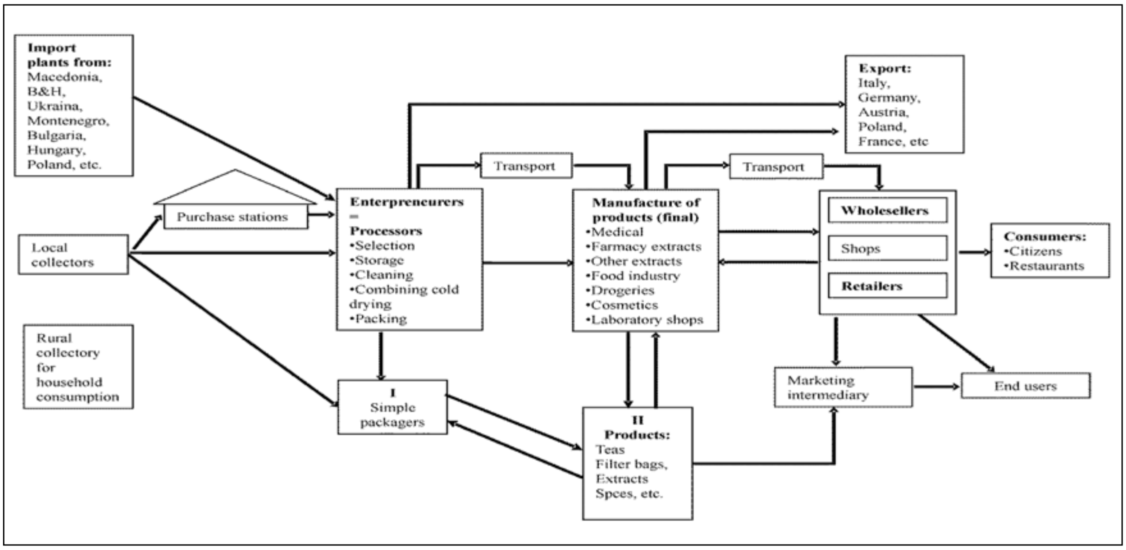

Figure 8.9: *Value chain for medicinal and aromatic plants in Serbia (Source: Keča et al., 2013)*

Enterprises covered by this research sell their products via wholesale chains, retail outlets, small pharmaceutical companies or directly on the industrial market. Export destinations for medicinal and aromatic plants are EU countries (France, Italy, Germany, Austria) and USA (51%) and CEFTA countries (45%), but also the countries of the Western Balkans (Keča *et al.* 2015).

In Serbia there are three major associations in the field of medicinal plants. Association "Dr Jovan Tucakov" brings together enterprises and individuals, both professionals and amateurs who deal with medicinal, aromatic, spicy and similar plants and forest fruits. This includes growers, pickers, processors of medicinal plants, as well as enthusiasts. Their primary goal is to improve the protection of the interests of people who are involved in growing, harvesting, producing, promoting and selling various medicinal plants. In addition, they promote a healthier life and preservation of the environment and carry out education about ecology and conservation of natural resources.

The second one is “Srboflora” – The National Association of processors and exporters of medicinal and aromatic plants was founded with the support of USAID Agribusiness Project. It is consisted of eight leading Serbian companies, which together hold over 50% of the Serbian market products based on medicinal and aromatic plants. The Association aims at improving the processing and placement of products based on medicinal and aromatic plants on domestic and international markets.

Association “Producers of herbal raw materials and herbal products “Herbal PharmaNet” is a non-profit, non-governmental business association of private companies, institutions and individuals from the field of herbal raw materials and products, with a particular interest in the production of herbal medicines, dietary supplements and cosmetics. Association “Herbal PharmaNet” was established in order to better exploit the potential of herbal sector of Serbia and stimulate market-oriented cooperation and strengthen mutual links among the collectors and growers of medicinal and aromatic plants, processors and manufacturers of herbal products, and educational and scientific institutions.

Serbia has significant natural resources in the area of medicinal and aromatic plants. There is a long tradition of collecting wild plants. However, cultivation has been increased, especially in the northern part of the country. So, it tends to reduce the pressure on natural resources and ensure a uniform level of quality of plants. In order to improve this, it is necessary to make better connection between manufacturing and processing industries.

General problem in Serbia is the lack of information about the possibilities of their collection, processing technologies and marketing, the commercial importance of NWFP, as well as informing the population of potential users of these products. A problem faced by the enterprises is the sale of products at a low level of processing. Therefore, there is no additional value and income is significantly lower than that potentially possible. In that sense, future efforts should be directed towards the closure of the entire production process to the final products (starting from manufacturing, through small laboratories and small processing enterprises, to making appropriate preparations and salves, and their sales in the domestic and foreign markets) (Keča and Marčeta 2015).

8.4 Forest grazing by livestock

Forage is often considered as NWFP according to many classifications (e.g. FAO, 2002). Indeed, woody and herbaceous vegetation from the understory is used as a feed for livestock since at least the Neolithic era (Luick 2009), while woodland grazing is an important part of the European cultural and ecological heritage (Bergmeier *et al.* 2010; Hartel and Plieninger 2014). Due to several land-use changes occurring in the last 70 years, traditional forest grazing has been reduced in many parts of Europe, but it is still practiced in Fennoscandia, the

Mediterranean region and mountainous areas in central Europe (Humphrey *et al.* 1998; Mayer *et al.* 2006).

Forest grazing has been debated in Europe and elsewhere as grazing herbivores are considered to pose a serious threat on the biodiversity, regenerative capacity of woody species, social and economic value of multi-purpose forests (Figure 8.10). On the other hand, the livestock and wild herbivores are an important economic asset to many rural communities. Moreover, grazing in forests can be used as an essential tool to reduce wildfire risk in the Mediterranean region (Lovreglio *et al.* 2014). It has to be noted that legal status of livestock grazing in forests differs among European countries, from total prohibition to allowable under certain conditions (Case 8.5).

Forest grazing causes tree damages through trampling (Mayer *et al.* 2006; Vandenberghe *et al.* 2007) and can lead to loss of species richness and diversity (Fleischner 1994). Moreover, forest grazing is often considered as negative to natural regeneration of broadleaved tree species especially (Van Ijssel 1990). However, there are findings suggesting that despite livestock impacts to saplings, damage levels were insufficient to alter tree regeneration (Buffum *et al.* 2009; Kaufmann *et al.* 2014). Many authors argue that livestock and forest production can be achieved under controlled grazing intensity (Pollock *et al.* 2005; Mayer and Huovinen 2007). Forest grazing can enhance tree growth as reducing the biomass of herbaceous and shrubby vegetation that outcompete tree seedlings (Darabant *et al.* 2007). Grazing has also been reported to promote biodiversity (Mountford and Peterken 2003; Mosquera-Losada *et al.* 2009). Lempesi *et al.* (2013) reported results regarding a grazed oak woodland in northern Greece confirmed the moderate grazing hypothesis (Noy Meyer 1995; Tilman, 1997) that light and moderate grazing increase biodiversity, whereas at high grazing pressures or at absence of grazing some species become dominant, hence diversity reduces (Willoughby and Alexander 2007).

Forest grazing has been reported to have negative impacts on forest soil properties (Belsky and Blumenthal 1997; Barnes *et al.* 1998). Besides the direct effect of trampling, livestock can indirectly change soil properties by consuming vegetation, thus altering plant community structure (Beukes and Cowling 2003), that would otherwise contribute to soil organic matter available to support soil microfauna and by reducing the amount and extent of fine roots that open new soil channels and contribute nutrients that support the soil rhizosphere. However, grazing effects on soil properties are not the same for all vegetation types. Smit and Kooijman (2001) for example, have reported less impact of grazing in the case of forests where tree litter is only slightly affected by herbivores. Thus, Blinkley *et al.* (2003) suggested that the effects of grazing on forest soils are important indicators of long term determination of the sustainability of the ecosystem. Nevertheless, stocking rate, kind of grazer and grazing management are important factors that can alter grazing effects on soil functions.

Grazing is often accused of decreasing soil quality, especially due to increased soil compaction (Zhao *et al.* 2007). Soil compaction is a process of densification.

Soil becomes compacted mainly through livestock trampling. In compacted soils soil strength is increased, while porosity and permeability are reduced and water infiltration alters. Increased soil compaction can have a negative effect on plant productivity, vegetation cover and the growth of young tree seedlings (Xie and Wittig 2004). Compaction affects in turn soil bulk density at different rates depending on the amount of available plant biomass left on the ground (da Silva *et al.* 2003). Bulk density and porosity affect water and aeration status of the soil, as well as root penetration and development. Soil compaction varies with kind of grazer, stocking rate, grazing system, vegetation type and age, soil type, soil water content and time of compaction (da Silva *et al.* 2003; Tom *et al.* 2006). Grazing intensity is another important factor regarding soil compaction. Generally, light to moderate livestock grazing on well drained soils (Greenwood and McKenzie 2001) has limited impact on overall soil compaction as measured by soil bulk density or water infiltration rate. In contrast, heavy grazing (Mapfumo *et al.* 1999) or grazing on wet soils (McNabb *et al.* 2001) reduces water infiltration rates and air-filled porosity, and increases bulk density.

The reduction of the incorporation of plant residues into the soil due to livestock grazing (Bilotta *et al.* 2007) alters the cycle of nutrients in ecosystems and consequently the nutrient contents in soil. Additionally, grazing affects the plants' photosynthetic rate and allocation patterns and consequently the chemistry of plant tissue among species (Scogings *et al.* 2004). Therefore, the impact of grazing on plant nutrient contents has to be taken into account as it affects nutrient recycling. On the other hand, the faeces and urine can provide essential amounts of soluble N and promote soil organic matter mineralization rates (McNaughton *et al.* 1997). There are contrasting results in literature regarding the impact of grazing on soil nutrient contents (Liu *et al.* 2011; Barger *et al.* 2004; Steffens *et al.* 2008). These differences could be attributed to differences in climate, soil nutrients, plant composition, and grazing intensity (Li *et al.* 2011). The majority of the research about the impact of grazing on soil nutrient contents has been performed in grassland or pasture ecosystems. However, the impact of grazing on soil nutrient content in forests is more complicated. Tree litter input in forests is slightly affected by herbivores and consequently there is generally less reduction in total litter input compared to grassland or pasture ecosystems (Smit and Kooijman 2001).

Besides direct grazing, forage from forest can be used by livestock after harvesting. From the traditional forestry point of view this procedure is more acceptable, but it must be done very carefully with respect to the preservation of existing undergrowth. Suitable for harvesting are non-regenerated burnt out areas and clearings. Additionally, fruits and seeds such as oak and beech acorns, can be used for feeding domestic livestock. Fruits and seeds of *Robinia pseudoacacia* L. and *Gleditsia triacanthos* L. can be used for fodder mixtures due to their high content of proteins and fats. The use of branches and leaves for making a foliar fodder is still practiced in many European countries, especially in the Balkan peninsula to provide roughages for livestock in winter. Foliage fodder is mainly made from various oak species, but hornbeam, black locust, poplar, aspen, willows, lime-tree, ash, maple and others are also suitable.

Figure 8.10: *Grazing by goats in an open oak forest in Northern Greece (Photos credit: Eleni Abraham)*

CASE 8.5: *Fodder and grazing of livestock in Bulgaria*

Usage of fodder is realized through harvesting of hay, fruits and seeds; yield of foliage and branches from tree and shrub species; grazing of livestock.

The grazing of livestock is permitted after paying the price for the calendar year in state and municipal forest of Bulgaria. The price is determined by the Ministry of Agriculture and Food for state forests and by the decision of the municipal council – for municipal ones. For a determined price a document is issued, indicating the type and number of animals, which will be grazed. Grazing of farm animals in forest areas of private property and property of legal entities is made upon written consent with the owner.

In Bulgaria, according to Forest Law (2011) grazing is prohibited in forest areas of livestock without a shepherd, in torrential and eroded forest areas, in dendrariums, approved and registered sources for the production of forest reproductive material in forest nurseries, in forest plantations and young stands of seed origin and coppice plantations until they reach a height of 3 m, in forest areas, which have started or are likely to start regeneration and also at night in forest areas.

8.5 Conclusions

The understory vegetation is a source of variable NWFP. The most important regarding to their use are included to the categories of edible, medicinal and aromatic. The forest berries were the most common edible product of the understory. In particular, *Vaccinium myrtillus* is consumed in all European countries, while other species such *Empetrum nigrum* and *Arbutus unedo* only in north and south Europe respectively. The category of medicinal and aromatic plants includes a great number of species mainly depending on the ethnomedicinal tradition of each country. However, the knowledge about the identification and use of many of them tend to be lost as they are harvested and used only by the old people in rural areas. The plant species for other uses such as decorative, craft and construction are more specific for each country.

The importance of these products is highly related to socioeconomic factors. In less economically favorable rural areas can be a source of income, while in economically favorable regions a recreational activity for stress-reducing. However, their economically importance could be also a threat. Most of them are wild harvested and in many cases, are overharvested. This could threaten both the population of the collected species and the biodiversity of the habitats. The impact is difficult defined for each case, because of the plethora of plant species/products, the harvesting practices and the legal status for each country. The pressure on the natural resources could be reduced by their cultivation. However, the cultivation is limited only in few species and the use of cultivated materials is still lower compared to the wild harvested.

Forage for livestock is also a NWFP of the understory vegetation. The impact of livestock grazing on biodiversity of the understory and regeneration of forest trees is highly depended on the intensity. Under moderate grazing intensity both biodiversity and regeneration are promoted. On the other hand, grazing can negatively affect some soil properties. Nevertheless, this negative effect can be altered by grazing management and the proper stocking rate. Finally, grazing in forest understory affects the cycle of nutrients in ecosystems. The effect is depending on climate of the area, soil nutrients plant composition, and grazing intensity.

It can be concluded that the NWFP of the understory could essentially contribute to the livelihood of people in rural areas. However, it is important their harvesting is consistent with their conservation. This can be achieved through to a legal framework that is strictly implemented but also through the awareness of local people, especially. Additionally, it is necessary that the people of the local communities are aware of the commercial importance of their harvested products. Marketing of dried materials reduces their potential income if they are further processed elsewhere for higher return. In this respect, added value products would increase the income and profits for local communities. Finally, a number of these species are potential industrial crops with multiple uses especially for the less favorable areas.

8.6 REFERENCES

Abraham, E.M., Theodoropoulos, K., Eleftheriadou, E., Ragkos, A., Kyriazopoulos, A.P., Parissi, Z.M., Arabatzis, G., Soutsas, K., 2015. Non-wood forest products from the understory and implications for rural development: The case study of a broadleaf deciduous oak forest (*Quercus frainetto* Ten) in Chalkidiki, Greece. J ENVIRON PROT ECOL. 16(3), 1024-1032.

Antos, J.A., 2009. Understory Plants in Temperate Forests, In: John N. Owens, H. Gyde Lund (Eds.) FORESTS AND FOREST PLANTS, Vol. I , ©Encyclopedia of Life Support Systems (EOLSS),

Baden, C., 1991. Mountain flora of Greece Vol. 2 | Sideritis L., in: Strid A, Tan K, (Eds.), Edinburgh University Press, Edinburgh, UK. pp. 84-91.

Balunas, M. J., Kinghorn, A. D., 2005. Drug discovery from medicinal plants. Life Sciences 78, 431 – 441.

Barger, N.N., Ojima, D.S., Belnap, J., Wang, S.P., Wang, Y.F., Chen, Z.Z., 2004. Changes in plant functional groups, litter quality, and soil carbon and nitrogen mineralization with sheep grazing in an Inner Mongolian Grassland. J. Range Manage. 57 (6), 613–619.

Barnes, B.V., Zak DR, Denton, S.R., Spurr, S.H., 1998. Forest Ecology. 4th edition. Wiley New York.

Barros, L., Carvalho, A., Morais, J. S., Ferreira, I. C. F. R., 2010. Strawberry-tree, Blackthorn and Rose Fruits: Detailed Characterisation in Nutrients and Phytochemicals with Antioxidant Properties. Food Chem 120, 247-254.

Belsky, A.J., Blumenthal, D.M., 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west. Conservation Biology 11, 315–327.

Bergmeier, E., Petermann, J., Schröder, E., 2010. Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. Biodivers Conserv 19, 2995–3014.

Bernues, A., Riedel, J.L., Asensio, M.A., Blanco, M., Sanz, A., Revilla, R., Casasús, I., 2005. An integrated approach to study the role of grazing farming systems in the conservation of rangelands in a protected natural park (Sierra de Guara Spain). Livest. Prod. Sci. 96, 75–85.

Beukes, P.C., Cowling, R.M., 2003. Non-selective grazing impacts on soil-properties of the Nama Karoo. J Range Manage 56, 547-552.

Bilotta, G.S., Brazier, R.E., Haygarth, P.M., 2007. The impacts of grazing animals on the quality of soils, vegetation, and surface waters in intensively managed grasslands. Advances in Agronomy 94, 237-280.

Binkley, D., Singer F., Kaye, M., Rochelle R., 2003. Influence of elk grazing on soil properties in Rocky Mountain National Park. For. Ecol. Manage.,185, 239-247.

Buffum B., Gratzer, G., Tenzin, Y., 2009. Forest Grazing and Natural Regeneration in a Late Successional Broadleaved Community Forest in Bhutan. Mountain Research and Development, 29(1), 30-35.

Casasús, I., Bernues A., Sanz A., Villalba D., Riedel J.L., Revilla R. 2007. Vegetation

dynamics in Mediterranean forest pastures as affected by beef cattle grazing. Agriculture, Ecosystems and Environment 121: 365–370.
Chauvet, M, 2001. Inventorying food plants in France. In: Rudolf Mansfeld and Plant Genetic Resources. Proc Symposium dedicated to the 100th birthday of Rudolf Mansfeld (Knüpffer H, Oschmann J, eds.). Gatersleben, Germany. Pp. 98-107.
Darabant, A, Rai, P.B., Kenzin, K., Roder, W., Gratzer, G., 2007. Cattle grazing facilitates tree regeneration in a conifer forest with palatable bamboo understory. Forest Ecology and Management 252, 73–83.
Da Silva, A.P., Imhoff, S., Corsi, M., 2003. Evaluation of soil compaction in an irrigated short-duration grazing system. Soil & Tillage Research 70(1), 83–90.
Di Carlo, G., Borrelli, F., Ernst, E., Izzo, A. A., 2001. St John's wort: Prozac from the plant kingdom. Trends in Pharmacological Sciences, 22, 292–297.
Di Virgilio, N., Papazoglou, E.G., Jankauskiene, Z., Di Lonardo, S., Praczyk, M., Wielgusz, K., 2015. The potential of stinging nettle (Urtica dioica L.) as a crop with multiple uses. Industrial Crops and Products 68, 42–49.
Dreyer, J., Müssing, J., 2000. New horizons in natural fiber production: retting hempand nettle with enzymes. In: Proceeding of 3rd International Symposium Bioresource Hemp and Other Fibre Plants, Wolfsburg, Germany, September 13–16.
Ertug, F., 2004. Wild edible plants of the Bodrum Area (Mugla, Turkey). Turk J Bot 28, 161-174.
Eysteinsson, T., 2013. Forestry in a Treeless Land – Fourth edition. Egilsstaðir, Iceland: Iceland Forest Service.
Ferrara, L., Dosi, R., Di Maro, A., Guida, V., Cefarelli, G., Pacifico, S., Mastellone, C., Fiorentino, A., Rosati, A., Parente, A., 2011. Nutritional values, metabolic profile and radical scavenging capacities of wild asparagus (A. *acutifolius* L.). J Food Compos Anal 24(3), 326-333.
Fleischner, T.L., 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8, 629–644.
Ghirardini, M., Carli, M., del Vecchio, N., Rovati, A., Cova, O., Valigi, F., Agnetti, G., Macconi, M., Adamo, D., Traina, M.,*et al.*, 2007. The importance of a taste. A comparative study on wild food plant consumption in twenty-one local communities in Italy. J Ethnobiol Ethnomed 3(1), 22.
González-Tejero, M.R., Casares-Porcel, M.C., Sánchez-Rojas, P., Ramiro-Gutiérrez, J.M., Molero-Mesa, J., Pieroni, A., Giusti, M.E., Censorii, E., de Pasquale, C., Della, A., Paraskeva-Hadijchambi, D., Hadjichambis, A., Houmani, M., El-Demerdash, Z., El-Zayat, M., Hmamouchi, M., El-Johrig, S., 2007. Medicinal plants in the Mediterranean area: synthesis of the results of the project RUBIA. J. Ethnopharmacol. 116, 341–357.
Greenwood, K.L, McKenzie, B.M., 2001. Grazing effects on soil physical properties and consequences for pastures: a review. Aust J Exp Agric 41, 1231–1250
Gurib-Fakim, A., 2006. Medicinal plants: Traditions of yesterday and drugs of tomorrow. Molecular Aspects of Medicine 27, 1–93.

Hadjichambis, A.C., Paraskeva-Hadjichambi, D., Della, A., Giusti, M.E., De Pasquale, C., Lenzarini, C. *et al.* 2008. Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. Int. J. Food Sci. Nutr. 59, 383–414.

Hanlidou, E., Karousou, R., Kleftoygianni, V., Kokkini S.,2004. The herbal market of Thessaloniki (N Greece) and its relation to the ethnobotanical tradition. Review. Journal of Ethnopharmacology 91, 281-299.

Hardalova, R., Evstatieva L., Gusev Ch.., 1994. Characteristics of resources from wild medicinal plants in Bulgaria and recommendations for their long-term sustainable development. – In: National strategy for conservation of biological diversity (In Bulgarian) pp. 41-72.

Hartel, T., Plieninger, T., 2014. European Wood-Pastures in Transition: A Social-Ecological Approach. Earthscan Publications Ltd., Abingdon, UK.

Helgadóttir, S., Hlöðversdóttir, O., 2010. Foldarskart í ull og fat. Jurtalitun. Reykjavík.

Honermeier, B., Ali, S., Leschhorn, B., Mahmood, A., Ijaz, M., Russo, M., Shafiee-Hajiabad, M., Ullah, H., Zeller, S., 2013. Cultivation of medicinal and spice plants in Germany – A review. Int. J. Agric. Biol., 15, 1379–1388.

Humphrey, J., Gill, R., Claridge, J., 1998. Grazing as a Management Tool in European. Forest Ecosystems, Forestry Commission Technical Paper 25, Forestry Commission, Edinburgh.

Karpavičienė, B., 2006. Distribution of *Allium ursinum* L. in Lithuania. Acta Biol. Univ. Daugav., 6 (1-2), 117–121.

Karpavičienė, B., 2003. Intensity of generative and vegetative reproduction of *Allium ursinum*. Botanica Lithuanica, 9(1), 3–12.

Kaufmann, J., Bork, E.W., Alexander, M.J., Blenis, P.V., 2014. Effects of open-range cattle grazing on deciduous tree regeneration, damage, and mortality following patch logging. Canadian Journal of Forest Research, 44(7), 777-783.

Keča, Lj., Bogojević, M., Marčeta, M., 2012a. Organization marketing activities in enterprises for buying processing and selling of medical and aromatic plants in Serbia, Proceedings of the Seventh Conference on Medicinal and Aromatic Plants of Southeast European Countries – CMAPSEEC, 27-21 May, Subotica, Serbia pp. 205-213.

Keča, Lj., Marčeta, M., Bogojević, M., 2012b. Commercialisation of non-wood forest products on the territory of AP Vojvodina. Bulletin of the Faculty of Forestry 105, 99-116.

Keča, Lj., Keča, N., Rekola, M., 2013. Value chains of Serbian non-wood forest products, International Forestry Review Vol. 15 (3), 315-335.

Keča, Lj., Marčeta, M., 2015. Export as Market Component and Development Perspective of NWFP Sector in Central Serbia. Baltic Forestry 21(2), 315-325.

Keča, Lj., Keča N., Marčeta M., 2015. Nedrvni šumski proizvodi, Socio-ekonomski i ekološki aspekti, Univerzitet u Beogradu, Šumarski fakultet.

Kristinsson, H., 2013. A Guide to the Flowering Plants and Ferns of Iceland. Reykjavík, Iceland: Mál og menning.

Lempesi, A., Kyriazopoulos, A.P., Orfanoudakis, M., Korakis, G., 2013. Soil properties and plant community changes along a goat grazing intensity gradient in an open canopy oak forest. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 41 (2), 567-575.

Li, W., Huang, H.Z., Zhang, Z.N., Wu. G.L., 2011. Effects of grazing on the soil properties and C and N storage in relation to biomass allocation in an alpine meadow. J. Soil Sci. Plant Nutr. 11 (4), 27-39.

Liu, T., Nan Z., Hou F., 2011. Grazing intensity effects on soil nitrogen mineralization in semi-arid grassland on the Loess Plateau of northern China. Nutr. Cycl. Agroecosys. 91, 67–75. doi:10.1007/s10705-011-9445-1.

Lovreglio, R., Meddour-Sahar, O., Leone, V., 2014. Goat grazing as a wildfire prevention tool: a basic review. iForest 7, 260–268.

Lubbea, A., Verpoortea, R., 2011. Cultivation of medicinal and aromatic plants for specialty industrial materials. Industrial Crops and Products 34, 785– 801.

Łuczaj, Ł., Pieroni, A., Tardío, J., Pardo-de-Santayana, M., Sõukand, R., Svanberg., I, et al., 2012. Wild food plant use in 21st century Europe: the disappearance of old traditions and the search for new cuisines involving wild edibles. Acta Soc Bot Pol 81(4), 359–70.

Luick, R., 2009. Wood pastures in Germany. In: Rigueiro-Rodríguez, A., McAdam, J. and Mosquera-Losada, M.R. (eds) Agroforestry in Europe – Current Status and Future Prospects. Springer, Dordrecht, Netherlands, pp. 359–376.

Mapfumo, E., Chanasyk, D.S, Neath, M.A., Baron, V.S., 1999. Soil compaction under grazing of annual and perennial forages. Can J Soil Sci 79, 191–199.

Marčeta, M., Keča, Lj., Jelić, S., 2014. Perspectives and Possibilities for Development of Rural Areas in Vojvodina Through the Sector of Non-Wood Forest Products, Bulletin UASVM Horticulture, 71(2), 402-407.

Marčeta, M., Keča, Lj., 2014. Analysis of Sale of Non-Wood Forest Products from Northern Serbia on the Domestic and Foreign Markets. Baltic Forestry 20(1), 115-130.

Mayer, A.C., Stockli, V., Konold, W., Kreuzer, M., 2006. Influence of cattle stocking rate on browsing of Norway spruce in subalpine wood pastures. Agroforestry Systems 66, 143–149.

Mayer, A.C., Huovinen, C., 2007. Silvopastoralism in the Alps: Native plant species selection under different grazing pressure. Ecological Engineering 29, 372–381.

McNabb, D.H., Startsev, A.D., Nguyen, H., 2001. Soil wetness and traffic level effects on bulk density and air-filled porosity of compacted boreal forest soils. Soil Sci Soc Am J 65, 1238–1247.

McNaughton, S.J., Banykwa, F.F., McNaughton, M.M., 1997. Promotion of the cycling of diet-enhancing nutrients by African grazers. Science 278, 1798–1800.

Molina, M., Pardo-de-Santayana, M., García, E., Aceityno-Mata, L., Morales, R., Tardío, J., 2012. Exploring the Potential of Wild Food Resources in the Mediterranean Region: Natural Yield and Gathering Pressure of the Wild Asparagus (*Asparagus acutifolius* L.). Span J Agr Res, 10 (4), 1090.

Mosquera-Losada, M.R., Rodríguez-Barreira, S., López-Díaz, M.L., Fernández-Núnez, E., Rigueiro-Rodríguez, A., 2009. Biodiversity and silvopastoral system use change in very acid soils. Agric Ecosys Environ 131, 315–324.

Mountford, E.P., Peterken, G.F., 2003. Long-term change and implications for the management of wood-pastures: Experience over 40 years from Denny Wood, New Forest. Forestry 76, 19–43.

Noy-Meir, I., 1995. Interactive effects of fire and grazing on structure and diversity of Mediterranean grasslands. J Veg Sci 6, 701-710.

Pollock, M.L., Milner, J.M., Waterhouse, A., Holland, J.P., Legg, C.J., 2005. Impacts of livestock in regenerating upland birch woodlands in Scotland. Biological Conservation 123(4), 443–452.

Redzic, S., 2006. Wild edible plants and their traditional use in the human nutrition in Bosnia-Herzegovina. Ecol. Food Nutr. 45, 189–232.

Rates, S.M.K., 2001. Plants as source of drugs. Toxicon 39, 603–613.

Riihinen, K., Jaakola, L., Kärenlampi, S., Hohtola, A., 2008. Organ-specific distribution of phenolic compounds in bilberry (*Vaccinium myrtillus*) and 'northblue' blueberry (*Vaccinium corymbosum* x V. *angustifolium*). Food Chemistry 110, 156–160.

Róbertsdóttir, A. R., 2011. Íslenskar lækningajurtir notkun þeirra, tínsla og rannsóknir. Reykjavík, Iceland: Anna Rósa grasalæknir ehf.

Samuelsson, G., 2004. Drugs of Natural Origin: a Textbook of Pharmacognosy, 5th Swedish Pharmaceutical Press, Stockholm.

Schippmann, U., Leaman, D., Cunningham, A.B., 2006. A Comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: Bogers, R.J., Craker, L.E., Lange, D. (Eds.), Medicinal and Aromatic Plants: Agricultural, Commerical, Ecological, Legal, Pharmacological and Social Aspects. Springer, Dordrecht, pp. 75–96.

Schulp, C.J.E., Thuiller, W., Verburg, P.H., 2014. Wild food in Europe: A synthesis of knowledge and data of terrestrial wild food as an ecosystem service. Ecological Economics 105, 292–305.

Scogings, P.F., Dziba, L.E., Gordon, I.J., 2004. Leaf chemistry of woody plants in relation to season, canopy retention and goat browsing in a semiarid subtropical savanna. Austral Ecol. 29, 278–286.

Silva, B.A., Ferreres, F., Malva, J.O., Dias, A.C.P., 2005. Phytochemical and antioxidant characterization of *Hypericum perforatum* alcoholic extracts. Food Chem 90, 157–167.

Smit, A., Kooijman, A.M., 2001. Impact of grazing on the input of organic matter and nutrients to the soil in a grass-encroached Scots pine forest. For Ecol Manage 142, 99-107.

Sobolewska, D., Podolak, I., Makowska-Wąs, J., 2015. *Allium ursinum*: botanical, phytochemical and pharmacological overview. Phytochem Rev 14, 81–97.

Stefanou, P., Baloutas, D., Katsinikas, D., Abraham, E.M., Kyriazopoulos, A.P., Parissi, Z.M., Arabatzis, G.. 2014. Cultivation and production of aromatic plants in Greece: present situation, possibilities and prospects. Proceedings

8th meeting of Greek Grassland Society (Kyriazopoulos A.P., Karatasiou M., Sklavou P and Chouvardas D. eds) Thessaloniki 1-3 October pp 65-70. (In Greek, abstract in English).

Steffens, M., Kolbl, A., Totsche, K.U., Kogel-Knabner, I., 2008. Grazing effects on soil chemical and physical properties in a semiarid steppe of Inner Mongolia (PR China). Geoderma. 143, 63-72.

Stoyanova, M., Stoyanov, N., 2007. Laws and regulations relating to conservation, trade and use of non wood forest products in Bulgaria. In: IUFRO 9 th International Symposium on Legal Aspects of European Forest Sustainable Development. Armenia.

Stoyanova, M., Stoyanov, N,. 2013. Non-wood forest products in Bulgaria, Silva Balcanica, 14(1), p. 5 – 21, ISSN 1311-8706.

Stryamets, N., Elbakidze, M., Angelstam, P.μ 2012. Role of non-wood forest products for local livelihoods in countries with transition and market economies: case studies in Ukraine and Sweden. Scand J For Res. 27(1), 74–87.

Tilman, D., 1997. Community invasibility, recruitment limitation and grassland biodiversity. Ecology 78, 81-92.

Tom, N., Raman, A., Hodgkins, D.S., Nicol, H., 2006. Populations of soil organisms under continuous set stocked and high intensity-short duration rotational grazing practices in the central tablelands of New South Wales (Australia). New Zealand Journal of Agricultural Research 49, 261-272.

Vandenberghe, C., Francois, F., Moravie, M.A., Gadallah, F., Buttler, A., 2007. Short term effects of cattle browsing on tree sapling growth in mountain wooded pastures. Plant Ecology 188, 253–264.

Van Ijssel W. 1990. The effect of grazing and seedbed type on forest regeneration under two silvicultural systems in a mixed broadleaf forest, Gedu. Tsenden 3(1):32–44.

Vines, G., 2004. Herbal harvests with a future: towards sustainable sources for medicinal plants. Plantlife International.

WHO — World Health Organization, 1992. Quality control methods for medicinal plant materials, Geneva.

Willoughby, M.G., Alexander, M.J., 2007. Rangeland health for native and modified plant communities in the Rough Fescue Ecological Site of the Montane Subregion. Alberta Sustainable Resource Development, Lands Division, Edmonton, Alberta. Publication No. T/150. ISBN No. 978-0-7785-6523-9.

Xie, Y., Wittig R., 2004. The impact of grazing intensity on soil characteristics of *Stipa grandis* and *Stipa bungeana* steppe in North China (autonomous region of Ningxia). Acta Oecol 25, 197–204.

Zahariev, D., Dimitrova, J.et al. 2015. Album of medicinal plants in Bulgaria, Editor: D. Zahariev,"Himera"OOD, Shumen, ISBM 978-619-7218-18-3.

Zhao, Y., Peth, S., Krummelbein, J., Horn R., Wang, Z., Steffens, M., Hoffmann, C., Peng, X., 2007. Spatial variability of soil properties affected by grazing intensity in Inner Mongolia grassland. Ecol. Model., 205, 241-254.

9 Forest products of animal origin

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9.1 Introduction

Forests harbour a significant proportion of European fauna and conservation of faunal diversity is a key forest ecosystem service. In this chapter we are concerned with products derived from forest animals which are not often addressed in the NWFP literature. This is not so surprising, as "NWFP" is a term which originated in the forestry domain and has little currency in other domains. It is hardly likely that game managers will appreciate their charges being described as 'not wood' any more than foresters would consider trees as 'not animal'. Nevertheless, animal products are relevant to the NWFP concept and here we present an overview of the production of products derived from animals in the forest for a forestry audience.

Products derived from forest animals take the form of foodstuffs such as game meat and honey but also includes non-food items such as trophies, hides, fur, feather, bones, silk, lac, musk, castoreum etc.. Since the decline of wild fur trapping in the mid-20th century, game meat accounts for 96% of traded wild animal products in Europe though there is some use of bristle (boar) and hair (squirrel) in brushes and some manufacture of hides and leather as well as resources for medical purposes (e.g. marmot fat and deer musk). There are also animal products which are reared in the forest such as honey, game birds, fur farms and domestic livestock. Although many of these products are, according the definition, undisputedly NWFP they are seldom addressed in publications using NWFP in the title. This is perhaps because there is a long-standing three-way institutional distinction between; forest management for timber production, game management concerned with sustainable hunting and conservation. These divisions are evident in research, education, institutions, law and regulations. The basis for this separation is fundamental differences in tenure and management systems which arise from the fact that plants and fungi are rooted in the land while animals are free-ranging. This chapter is organized as follows: at the beginning chapter 9.2 provides an overview about the animal species evaluated in the COST Action and chapter 9.3 describes the conservation status of selected animals. The management of game (chapter 9.4), birds (chapter 9.5), fish (chapter 9.10), bees (chapter 9.11) and an overview about the official data sources on hunting (chapter 9.6) cover general aspects related to the management of animal species and the markets for selling the products (chapter 9.9). In chapter 9.8 the complexity of human-wildlife conflicts is described, while chapter 9.7 introduces the concept of re-wilding. The final conlusions are given in chapter 9.12.

9.2 Animals in the forest

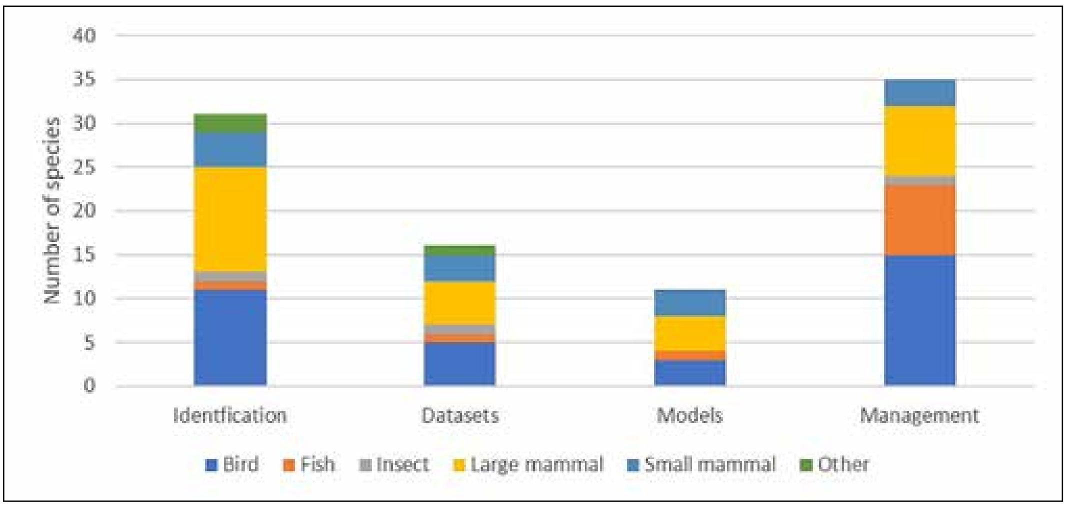

Figure 9.1: *Number of animal species reported as NWFP (Source: COST Action FP1203 Common survey)*

The FP1203 COST Action Common survey gathered information on 48 animal species (listed in Appendix 2 of this book) and asked Action members to indicate four animals of significance as NWFP in their country in relation to their identification (n= responses from 24 countries), the presence of datasets (n=11), Models (n=5) and management (n=22). Figure 9.1 indicates the types of animals reported. Despite the many caveats on these data (they are based on expert opinion, consistency of reporting between countries was very variable etc.) they serve as a basis for further investigation of animals identified (largely by foresters) as being NWFP.

The first thing to note is that large mammals – the classic large game species (especially elk, deer and wild boar) and game birds (e.g. partridge, grouse and pheasant) were most often identified as being NWFP. This is expected as hunting such game is traditionally associated with forests. Interestingly, birds were more frequently associated with forest management than large mammals – perhaps because production of birds and trees is usually synergistic while production of trees and large mammals is often antagonistic. Small mammals such as hare and rabbit are not generally associated with forest in most parts of Europe – in many countries these species are commonly hunted in fields. Insect NWFP are, in Europe, almost exclusively derived from honey bees (there are a very few exceptions, such as wood ants which are occasionally exported from Finland), which means they hardly appear in Figure 9.1 although bee-products represent a significant NWFP in most European countries (see chapter 9.7.2).

The large number of fish reported as NWFP was something of a surprise. In some countries fish, being associated with lakes and rivers would not be counted as something derived from the forest while in others fish and other aquatic resources fall under the jurisdiction of forestry authorities if the water bodies are on designated forest land. This is particularly the case in Romania where the National Forest Administration (Romsilva) is charged with controlling fisheries in mountain waters, trout farming and manages the forests and associated fisheries of the Danube Delta. The Other category identified garden snails in Bulgaria and signal crayfish in the UK.

9.2.1 Who owns animal NWFP?

Any domesticated animals (e.g. sheep, pigs, goats and cattle) are private property and by extension reared game birds, enclosed deer and wild boar and bees in hives. Thus, all products of these animals are private property; so honey belongs to the beekeeper etc.. Feral animals (i.e. escaped or released domesticated goats and cattle which are now free-ranging and wild in behaviour) are a special case and generally remain under the jurisdiction of the law on domestic animals which means they are not covered by hunting regulations and there are no prescribed closed seasons etc. though they are often hunted in the same manner as wild animals.

The ownership of free-ranging wild populations of animals whether native or non-native is somewhat more complex and varies between countries and may be differentiated for mammals, birds and fish. The animals themselves can be either owned by no-one – the *res nullius* of Roman law or by the state but importantly are never private. There are several legal forms for state ownership: *res communis* – belonging to the community in this case interpreted as meaning everyone; *res communalis* – a public form of ownership by a commune (most often in CIS countries) or *res publicae* – vested in the state on behalf of society (Bouriand & Schmithusen 2005). In many countries it is rather difficult to determine the exact status of wildlife especially the nuances of state ownership as it is rarely invoked or confused with the ownership of hunting rights which are independent of property rights. Nevertheless, as pointed out by Putman (2011) the ethical distinction of belonging to everyone or no-one strongly conditions legislation related to wild animals, the regulation of hunting and cultural attitudes towards game.

The act of killing an animal renders it into the possession of the hunter (by the first finder principle) which usually confers ownership. So, a live wild animal may belong to no-one, but the carcass becomes the property of the hunter. Thus, hunting rights strongly condition the management and use of wildlife. The allocation of hunting rights is, in most of Europe a palimpsest of historical precedents and modern conservation regulations which often do not mesh together particularly well. This is especially evident when hunting rights at national level are restricted by European–level conservation listing as shown in chapter 9.5.2.

Originating in Medieval feudalism, hunting rights to large game (hoofed animals and also large birds such as swans) were often reserved for the crown or aristocracy (noble families) with many laws to this effect dating from the 12th century. During this period, peasants were generally permitted rights to small game such as rabbits and birds on common land for subsistence use. For example, in Norway, the right to big game hunting has historically been assigned to land owning farmers while small game and predators was an Everyman's right. In most countries the exclusivity of large game hunting changed from the 18th century in response to broader socio-political processes which transferred hunting rights to either private landowners or the state which was often rapidly followed by dramatic decline or extirpation of wildlife. For example, after the 1848 revolution in Germany the rights to hunt were transferred from the nobles and clergy to landowners who were mainly farmers, who having suffered from high levels of damage from over-abundant deer proceeded to rapidly all but extirpate them. By the end of the 19th century groups of hunters and conservation-minded people started to pro-actively manage and restore ungulate populations which evolved into present forms of game management.

Wild animals range freely across the landscape and do not respect land ownership boundaries. Sustainable management of wild populations requires management plans and hunting regulations for areas commensurate with the populations and movements of the animals. In countries where the state holds the hunting rights the whole territory is generally divided into hunting grounds and the state often at provincial level prepares management plans (FI, FR, CH, LT) though this responsibility may also be delegated to Hunters associations formed of the landowners within a hunting ground (PT, RO, SI) or to non-landowning hunters (IT), or management is transferred from state to municipal government, thus introducing an element of local diversity within a national set of regulations. In countries where hunting rights belong to the landowner, the state often intervenes and requires smaller landowners to amalgamate into hunting associations to form areas sufficiently large to effectively manage the wildlife. Generally, a threshold area is defined above which the landowner has sole responsibility for management and below which landowners are required to work together (AT, BE, CZ, DE, HU, LZ, NO, LT). The threshold areas vary by country and sometimes by species within a country. For example, in Austria the threshold is 115 ha for all game while in Latvia thresholds are set by species with 200 ha for roe deer, 100 ha for wild boar, 2000 ha for red deer stags, 1000 ha for red deer hinds and calves and calves and 2500 ha for elk. In Norway, no set area size is specified, only stating the size and condition must be sufficient to sustain long term management. Where landowners hold hunting rights they can usually transfer these rights through rental, lease or sale to a third party. This alienation can be at the level of the personal transactions by individual landowners, the lease of the whole hunting ground to an external hunting club or sale[30] of licenses by the association to non-members. Where the state owns the hunting rights then they may allocated exclusively to state-employed hunters, sold as annual licenses to individual hunters or associations for a specified number of animals by species or licensing maybe delegated to hunters' associations for their hunting ground. Whatever the case there are often several licenses required to hunt legally often issued by different levels of government e.g. federal and provincial.

Generally, game management plans are required by law to cover the whole hunting territory prepared by the state or hunters' associations. The exceptions are the UK, Ireland and Sweden (excluding elk) where management co-operation between adjacent owners and management plans are entirely voluntary. In Norway, the municipalities and counties, through their right to approve individual management plans can impose a form of co-management by withholding approval for plans. In most countries with obligatory game management plans, owners are not able to withdraw their land from the plan but it is possible for owners to request their land is exempt from hunting in Portugal and Italy on the proviso that "that it does not hinder the implementation of wildlife management plans" (Cirelli 2002).

Table 9-1 illustrates some of the different distributions of ownership rights for ungulates (large game) for a selection of European countries. Although the

30 In which case hunting rights could become disassociated from the land and become private property as is the case in the UK where title to hunting rights can be registered with the Land Registry independent of the land as *profit a prendre*.

information in the table was taken mostly from sources referencing ungulates similar arrangements are often found for wild game birds and small game though definitions of hunting grounds and detailed management plans may be less formal or absent.

Table 9.1: Property rights for game animals in some European countries (COST Action FP1203 Common survey, Apollonio et al 2010, Putman (2011), Cirelli 2002, Mustin et al (undated)

Country	Ownership of		Hunting grounds	Management plan preparation
	Wild animals	Hunting rights		
Austria	*Res nullius*	Landowner	Association required for land-owners of < 115 ha	Association approved by state
Belgium (Flanders)	*Res nullius*	Landowner	Association required for landowners of < minimum area (e.g. 1000 ha for Roe deer in Flanders)	Association approved by state
Croatia	*Res nullius*	State	Association required for land-owners of < 100 ha (breeding station) < 1000 ha (hunting ground)	Association approved by state
Czech Republic	*Res nullius*	Landowner	Association required for land-owners of < 20 ha and < 5000 ha for big game	Association approved by state
Estonia	*Res nullius*	Landowner	Association required for land-owners of < 20 ha and < 5000 ha for big game	Association National plan for elk
Finland	State	Landowner	Usually based on communal or administrative boundaries	Association – State gives target densities
Germany	*Res nullius*	Landowner	Association required for landowners of < 75 ha (in some parts of country)	Association approved by state
Hungary	State: *Res communis*	Landowner	Association required for land-owners of < 3000 ha	Association approved by state
Iceland	*Res nullius*	Landowner	No	Not required
Italy	State: *Res publicae*	State	Defined by Provinces. With-drawal from HA possible.	Association approved by state
Latvia	*Res nullius*	Landowner	Association required for landowners of < min. area by species (e.g. Roe deer < 200 ha; elk < 2500 ha). Withdrawal of land from HA possible.	No plans required
Lithuania	State	Landowner	Association required for land-owners of < 1000 ha	Association approved by state
Nether-lands	*Res nullius*	State	None – culls only approved on case-by-case basis	Wild animals com-pletely protected

Country	Ownership of		Hunting grounds	Management plan preparation
	Wild animals	Hunting rights		
Norway	*Res nullius*	Landowner	Single owner or association of owners. Hunting quotas established on a mix of area size and local conditions to ensure sustainable, long term management. No fixed size limits.	Approval by municipal and/or county authorities based on a national set of management rules.
Poland	State	State	Defined by state	Association approved by state
Portugal	*Res nullius*	State	Defined by HA. Withdrawal of land from HA possible.	Association approved by state
Romania	State	State	Defined by state	State
Slovenia	State	State	Defined by state	State
Spain	*Res nullius*	Landowner	Varies across country	Association approved by state
Switzerland	State	State	Defined by Cantons	State
UK	*Res nullius*	Private – separated from landownership	No	Voluntary

9.2.2 Regulation of animal NWFP

All aspects of hunting activities are generally highly regulated. There is a degree of homogeneity in the subject of the regulations coupled with a high degree of variation in the details of rules and scale of implementation and assignment of responsibilities. This results from social, cultural and historical differences between administrations.

There are no EU-level regulations for game management in general but there is an expectation that hunting of species listed in Annex III of the Birds and Habitats Directives and in Norway, the Nature Diversity Act (2009) should be sustainable. At the other end of the supply chain there are a host of EU regulations concerned with food quality and traceability including Regulation 853(2004) covering hygiene for meat supply businesses which specifically mentions wild game which must be processed in approved game handling establishments (AGHEs). The role of these regulations in shaping game meat markets in Europe is explored in chapter 9.7.2.

Legislation governing hunting can be found among early laws in many countries e.g. the Hunting Directive of 1568 in the Czech Republic and the Lithuanian

Statutes of 1529. These antecedents can be reflected in sub-national differences in legislation and regulation as is the case in Austria's nine provinces and the 15 autonomous regions of Spain. Other countries have overarching national or federal hunting law with responsibility for administration and specific bylaws passed to sub-national regions as is the case in Italy, Switzerland and Germany. However, in most countries hunting is governed by legislation at national level. Even in countries with national legislation there can be significant variation in the number and type of laws. In a few there is a single Act which governs hunting along with wildlife management such as the Norwegian Wildlife Act (1981). The Netherlands is a special case in that the Flora and Fauna Act (2002) which puts conservation first and only permits hunting for population control on a case by case basis and only if this can be shown to be necessary for reasons of public health and safety, or to prevent damage (Van Wieren & Bruinderink 2010). Other countries separate conservation from hunting and have a specific Hunting law (e.g. as is the case for Sweden, Estonia and Latvia) while in others there are several laws which refer to game. For example, in Denmark hunting is referenced in the National Hunting Act (1993), Animal Welfare Act (1991), Nature Protection Act (1997) and the Firearms Act (1994) while in Slovakia hunting is included in Legal Codes on Hunting (1962), Game Protection (1975), List of Game Species (1975), Nature and Landscape Protection (2002) and Forests (2005). Despite this variation, there are some common features of the governance of hunting, these being:

- Registration of hunters or owners of guns – which can require specific training and passing a test
- Definition of hunting grounds
- Assignment of responsibility to monitor population numbers and kills – including requirement for professional game managers
- Assignment of management responsibility e.g. set culling levels, control of population numbers and damage – this can be the state, hunting associations or private landowners
- List of species which can be hunted
- Hunting seasons
- Type of weapon and calibre of bullet to be used for each species
- Type of hunting practices that can be used (stalking, drives etc.)
- Animal welfare – especially in the case of wounded animals
- Procedures for compensation for damage to trees and crops and who should pay
- Licencing procedures and dispersal of fees

Putman (2011) gives an overview of the governance of large game across Europe while details of legislation in 25 countries in collected in Apollonio et al (2010).

9.3 Conservation and animals NWFP

The conservation value of species is codified in listings of species considered to be at risk of extinction. Listing takes place at several scales with IUCN Red Data Book at global level, regulatory instruments such as the Habitats Directive (Council Directive 92/43/EEC) at EU level, in national legislation and at local level in biodiversity action plans. Generally, listing at any of these scales means the species is protected which usually translates into special consideration with regard to hunting. It may perhaps appear that hunting is incompatible with the conservation of biodiversity and management of rare habitats, but hunting can have positive impacts on protected sites and species if done in accordance with conservation goals. After all, the long-term interest of hunters is generally the maintenance of viable populations of game species which in turn requires that their habitats are in favourable condition.

The natural range of many animals is defined by biogeographical regions within Europe and across national boundaries. However, within its' range the actual conservation status of a species may be dramatically different – it could be considered extirpated and re-introduced in one country, critically endangered in another, while in a third, populations maybe deemed out-of-control and require culling. Case 9.1 illustrates the impact of priority species listing for brown bear as an example of a valuable NWFP species which requires a different approach to management across its' range.

CASE 9.1: Brown bear (*Ursus arctos*)

Figure 9.2: *Distribution of brown bear populations in Europe (Boitani et al. 2015)*

The brown bear is both a valuable source of NWFP and an iconic conservation species. The brown bear inhabits a wide range of habitats who's omnivorous diet includes livestock, crops and, notoriously, beehives. Current populations are estimated to reach almost 18000 individuals in Europe, with population strongholds in the Carpathians, Scandinavia and Dinaric-Pindos. Population sizes range from <50 bears in small isolated ones such as the Pyrenean or Apennine, to several thousand. Except for the Apennine and Cantabrian populations, all are transboundary i.e. span more than one country. All populations remained stable or expanded slightly since 2005 (Boitani et al. 2015). This success is mainly due to the conservation measures, as most European populations are strictly protected while some kind of bear management, action plan or bear management strategy exists in nearly all countries.

Bears are large and opportunistic with a wide range of biological needs during their life cycle what may bring them into conflict with humans (e.g. livestock depredation, attacks on humans; habitat fragmentation, den disturbance; traffic accidents). Reintroduced populations expand into areas where prevention practices do not exist, thus leading to high damage incidence. Management to minimise human conflict varies from culling quotas, payment of compensation (costing € 2.5-3 million per year) to pro-active management such as diversionary feeding can be applied. Which mechanism is used depends on the size of the population. Thus brown bear meat can be legally consumed and sold in Slovenia derived from culls prescribed by a comprehensive national management plan while in other parts of Europe consumption of bear meat is illegal. So the NWFP opportunity derived from brown bear can be as game meat or restricted to tourist viewing depending on where you are in Europe.

9.3.1 Genetic conservation of exploited species

With a few exceptions (see chapter 9.3.3) animals used as NWFP are native to Europe, most often native to the country and derived from free-living, wild populations. The genetic integrity of these populations can be threatened by selective breeding and the introduction of non-native genes through hybridisation with introduced species. For example, red deer (*Cervus elaphus*) hybridises with sika deer (*Cervus nippon*) resulting in introgression of sika and red deer genes (Bartoš 2009). Sika deer was introduced from Japan in the 19th-20th centuries and is now present across Europe. The problem is well recognised but control programmes are generally lacking, though, as in Lithuania, release of animals into the wild is generally prohibited. There is no co-ordinated European strategy to manage the risk to red deer and restrict the spread of sika deer. Both species are sources of NWFP and hunting interest in sika deer can stymie attempts to eradicate it.

CASE 9.2: Genetic conservation of the Western honey bee (*Apis mellifera*)

There is only one species of honeybee in Europe with many subspecies, each adapted to different environmental conditions and further differentiated into a great number of land races.

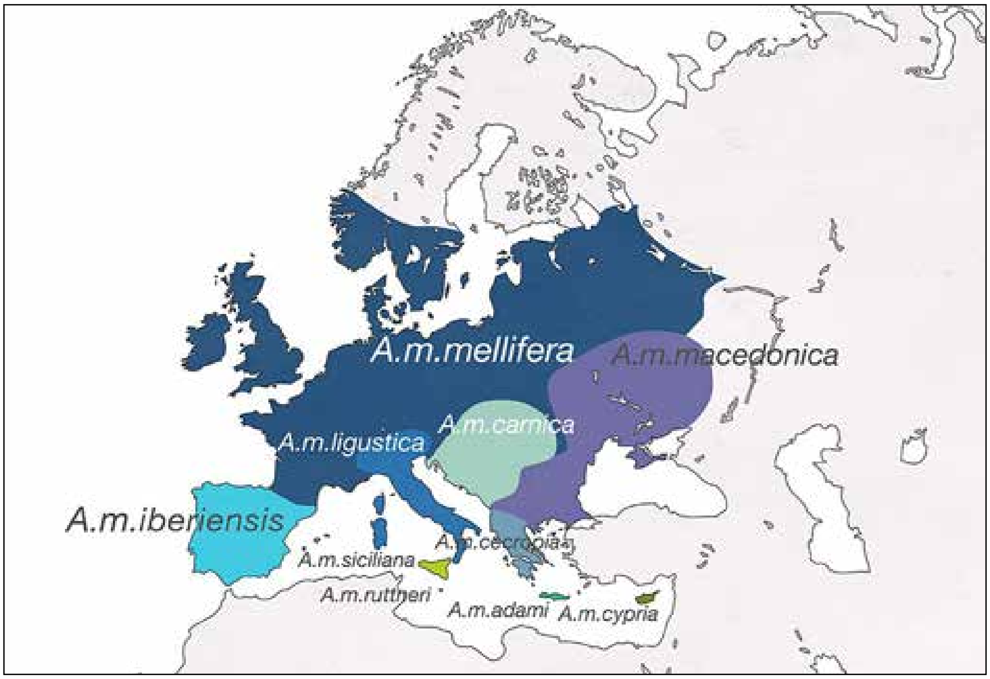

Figure 9.3: *Historical distribution of honey bee subspecies in Europe (FP7 SMARTBEES project)*

There is clear scientific evidence that the performance of honey bees is strongly dependent on local adaptation but the use of breeding lines from only two subspecies the Carniolan honey bee (*Apis mellifera carnica* and the Italian honey bee (*Apis mellifera ligustica*) results in hybridization with local populations and subsequent loss of unique genotypes. Maintenance of genetic diversity which may confer resistance to new threats such as Varroa infestation or facilitate climate adaptation is desirable.

Conservation of genetic diversity and adapted land races is best served by minimal intervention in bee breeding and the use of locally raised queens if needed. The intensity of bee breeding and importation of 'improved' queens and hybrids varies from country to country. In some, there is widespread use of bees bred for honey production and there are few remaining wild or native honey bees left (e.g. UK). In other countries bee breeding is low intensity and there is little use of imported non-native queens. For example, there were only 30 consignments of bees for breeding imported into Romania in 2014, a country which has approximately 42,000 beekeepers (EU Food and Veterinary Office 2015) and bee breeding is from within the gene pool of the native bees.

Several countries have regulations intended to conserve local sub-species; for example; Italy has laws to protect *Apis mellifera ligustica* and Slovenia protects its' *Apis mellifera carnica*.

For more information see FP7 SmartBees project (http://www.smartbees.eu/).

Another threat to genetic integrity of a wild species is the purposeful breeding to increase productivity or other desirable features of a domesticated native species. Thus the domestication of a resource as a NWFP may pose a threat to the species itself as natural variation is supressed or lost as the genetic profile is homogenised and modified to suit human interests. See Case 9.2 for the example of just such processes for European honey bees.

9.3.2 Exploitation to control invasive species

There are a number of non-native species which have been deliberately or inadvertently introduced into Europe. A few of these find themselves in favourable habitats, perhaps with few natural predators or absence of other limits to population growth and establish aggressive populations. The list of NWFP animal species reported in the Common survey included several non-native species and it is informative to consider their various roles as NWFP:

Brook trout (*Salvelinus fontinalis*) originally from North America was intentionally released into sport fisheries but has escaped and is spreading and present in 20 European countries. The fish replaces native brown trout (*Salmo trutta*) in high altitude lakes and streams and hybridises with trout at lower altitudes. It generally has a negative impact on stream fauna. Established populations are difficult and costly to control and bans on further stocking or introduction of brook trout is recommended. However, the recreational and sport fishing values of the brook trout can be socially and economically important to local communities.

Signal crayfish (*Pacifastacus leniusculus*) was introduced widely into Europe from the western seaboard of Canada since the 1960s into fish farms from which they have escaped into the wild and are now rapidly extending their range. Signal crayfish are a serious threat to native crayfish through spread of crayfish plague, competition for refuges and have a significant impact on other aquatic life as they are voracious predators. They are however, very tasty and sales of crayfish can help support control programmes.

Grey squirrel (*Sciurus carolinensis*) was introduced into the UK and Ireland from eastern United States of America from 1820s as a parkland ornamental species and to three sites in Italy between 1948 and 1994. It replaces native red squirrels, is a vector for the squirrel parapox virus and causes considerable economic damage to young broadleaf trees. It is expected to colonise France and Switzerland in the next few decades and from there spread across Europe. Squirrel control is expensive and often unpopular with the general public who appreciate the grey squirrels as a visible, attractive and entertaining wild animal. There have been several attempts to find a use for grey squirrel as game meat and as hair for paint brushes to recoup some of the costs of control. So far none have been particularly successful though there is perhaps untapped potential to supply ethnic markets who would value squirrel as 'bushmeat'.

Feral cattle and goats (i.e. formerly domestic animals) are present in relatively few locations and are generally treated as wild animals and culled along with other ungulates (see chapter 9.6.4 for an example of feral goat population control in the UK).

Ring necked pheasant (*Phasianus colchicus*) originating from India was introduced specifically to serve as a NWFP (i.e. a woodland game bird) and is closely managed as (semi-)domesticated species and is not considered to be invasive.

Wild boar (*Sus scrofa*) is, in modern times, considered an invasive species in Norway. The species was absent in Norway for 600-800 years due to hunting pressure coupled with an inhospitable climate. No domestic population of wild boar exist and any animals crossing the border from Sweden can be hunted year-round.

From these brief accounts it is clear that some non-native species are managed as NWFP resources while for others the main objective of management is reduction of an invasive population where meat and other NWFP uses can help fund or incentivise control programmes. In this way elevation of a new resource to a NWFP can be a positive contribution to conservation. This is a relatively new concept and is being explored along with harvest incentives (bounties) and citizen science in the USA (Pasko & Gioldberg 2014) along with public awareness programmes e.g. http://eattheinvaders.org/ which provide stories and recipes for a wide range of invasive species.

9.4 Managed production of game

All forests provide habitats for animals and actions related to them frequently figure in forest management plans. These can include provisions to protect endangered species, maintain biodiversity, control invasive species, reduce damage to trees and ecosystem services and to generate a sustainable supply of game. Several of these animal-focussed actions need to be combined with each other and be compatible with forest production objectives. In this way co-production of animals and timber at forest and stand level is commonplace. However, since game is often the jurisdiction of hunters while forest management is the prerogative of the forest owner the trade-offs are often negotiated between different stakeholders (see Table 9.1).

There are several reasons for the dissociation between forester and hunter. Game has long been associated with high value, high status recreational hunting and as the preserve of the aristocratic elite. For example, the New Forest in England was set aside as a Royal hunting preserve in 1079 and it was only in 1483 that formal timber production commenced, a progression which was also evident in the Czech Republic and Lithuania and likely elsewhere in Europe. Large, single-owner estates co-managed for hunting and agriculture remain a significant feature in many parts of Europe to this day while long-standing regulation of game has a legacy in regional level game management institutions which reflect historical political boundaries. The home range of animals often exceeds the extent of a single forest stand and can span across individual properties, forest management units, national borders or in the case of migratory birds, can cross several continents. Co-operation between neighbouring landowners is therefore required to effectively manage game in a way which is not usually the case for timber or other NWFP. Finally, game and timber are often viewed as antagonistic as high densities of grazing and browsing animals often increases the establishment costs of tree crops and compromises timber quality (see chapter 9.7).

The most obvious example trade-offs between timber and animal NWFP interests is when threshold damage levels to trees are set by regulatory authorities with the hunters required to pay compensation to forest owners for damage above this level which serves as an inducement for hunters to regulate game population levels. Species conservation regulation is also often used to ensure game production does not endanger rare species and biodiversity. For example, in many countries predator populations (e.g. fox) can be controlled to enhance production of game birds but this cannot result in the extirpation of the predator populations.

The need to coordinate game and hunting with other interests have been codified in principles of “wildlife management“ (Riley et al, 2002). These principles provide guidance of decision-making processes and the implementation of practices to purposefully influence the interactions among and between people, wildlife and their habitats. Among the most relevant measures for game species, are hunting and species-specific culling quotas, fenced hunting grounds, supplementary feeding and winter enclosures (as exemplified in Case 9.3 for red deer).

CASE 9.3: Red deer (*Cervus elaphus*)

Red deer (Cervus elaphus) are among the most widespread species of ungulates in Europe and has been the subject of intensive management for centuries (Apollonio et al. 2010). Only in some countries such as Norway are red deer are allowed to roam free and may occupy all areas they can inhabit, in most other European countries their ranging behaviour is controlled as regards their movement which is monitored and influenced with supplementary feeding, particularly during winter. In Austria, Germany, Slovakia, Czech Republic, Croatia, and Romania the provision of winter fodder is a legal obligation on hunters. Winter feeding is intended to stabilise population numbers and reduce mortality as well as to prevent movement into areas where human–deer conflicts are likely. This strategy has partly evolved as a response to the loss of traditional winter habitats due to expansion of agriculture and urbanization. While in the German and part of the Austrian Alps this practice evolved further to include winter enclosures where red deer are induced to return to a fenced area where food is provided during autumn and then enclosed for the winter and provided with food, preventing them from damaging surrounding forests. In Spain and Scotland, game fencing (sometimes supported with supplementary feeding) is becoming popular in order to prevent red deer from moving beyond the borders of private hunting estates. In eastern and south eastern Europe (e.g., Serbia, Macedonia, Bulgaria, Greece, Slovakia, Belarus, and Hungary) there is a growing trend to establish fenced hunting grounds. This widespread manipulation of red deer also extends into protected areas where some form of intervention (feeding, winter enclosure, or hunting) is often practiced despite these areas being primarily for conservation.

For example: in the Swiss National Park in Switzerland production forestry, agriculture and hunting were prohibited. In the 1970s the carrying capacity for red deer was surpassed (i.e. 4500 – 5500 individuals at ~ 300 km^2), causing severe damage to protection forests during summer and to agriculture during winter. High winter mortality due to high population sizes as well as a decline in roe deer and chamois due to competition called for a management concept that effectively, but sustainably reduces the number of deer in the region. Based on the results of intensive censuses (monitoring) regulation measures were implemented, involving intensive culling of young and female animals based on quotas and allowing the culling of red deer beyond the regular hunting season. Since the 1980s the red deer population has been kept stable below the carrying capacity and provides a useful NWFP. A success story that led to several positive effects on the regeneration of protection forests and other wildlife species´ populations.

In terms of management to enhance productive potential most NWFP perforce play second fiddle to timber production with the notable exception of large game and birds. The value of game for recreational hunting is the primary product in the management of large areas of land in private estates across Europe (see Case 9.4 for a case study for Portugal).

CASE 9.4: Hunting estates (Portugal)

After the Carnation revolution in 1974 the ancient shooting estates were abolished with the nationalisation of the land. In the absence of game management this led to an increase in the numbers of hunters and a strong decrease in populations of game and non-game animals. In 1986 a new Hunting Act was established which allowed the restoration of the shooting estates. The first estates under the 1986 law were established in 1988 and by the mid-1990s most of the land had been returned to its previous owners.

In 2013, there were 286,941 hunting permits (2.6% of population) and 131 651 annual licences issues with 1 137 of these being to people outside Portugal. This represents a 60% reduction on the number of hunters in the 1990s. Nevertheless, it is estimated that hunting and management of the estates contributes up to € 250 million a year to the Portuguese economy including 7 000 full time and 10 000 part-time jobs.

In 2013 there were 4 472 hunting estates in Portugal covering 7 082 200 ha, representing 79% of the land and 90% of the former hunting grounds. Much of this land has severe restrictions for farming and thus forestry, hunting and (eco-)tourism are some of the few economically viable activities in these areas with hunting often being the main activity.

Game management in Portugal includes provision of food and water, habitat management (game crops, vegetation and cover management, game population management (monitoring, predator control, density control and selection shooting) and surveillance.

Many of the estates are multi-functional landscapes which combine sustainable hunting, traditional grazing and conservation. Game animals are a small part of biodiversity; income from hunting is used to manage the whole landscape which benefits all biodiversity in a self-sustaining manner. Hunting estates are included in conservation programmes for several high profile endangered species such as the Iberian lynx and Black vulture (e.g. the Life Habitat Lince Abutre project http://habitatlinceabutre.lpn.pt/en). The Associação Nacional de Propietários Rurais (http://anpc.pt) represents the interests of the hunting estates and encourages the use of the Wildlife Estates label to recognise excellence in integrated game and wildlife management. In 2016, 18 Portuguese hunting estates with a combined area in excess of 50 000 ha were certified as Wildlife Estates.

9.5 Managing for game birds

Game birds are an important quarry for European hunters across a range of habitat types including wetlands for ducks and geese, open moorland for grouse, capercaillie and ptarmigan and woodland for pheasant, quail and partridge. We are here most concerned with woodland species and particularly with those which are actively managed as quarry for sport hunting. Such activity is variable across Europe being very common in the UK, eastern and central Europe, with some activity in northern Europe and very little direct management in southern Europe.

According to Mustin et al. (undated) there are two distinct management styles for woodland game bird management. The less intensive style is based on increasing the density of wild populations through activities such as planting of crops for food or shelter, creation of glades within forests, provision of food and water, control of predators etc.. This is usually coupled with 'walked up' hunting where a line of hunters walk through the woods with dogs to flush the birds which is favoured where game bird densities are relatively low (albeit higher than without any form of intervention). This form of management dominates in areas where game is common property, land is common property or state owned and/or where authorities can regulate quotas. This type of management is used for native species of pheasant, partridge and quail and is commonplace in much of Europe.

The more intensive 'rear, release and restock' style of management focusses on the Common pheasant (*Phasianus colchicus*) which are raised in pens at high densities and released into woodland. This is associated with the 'driven' style of hunting where hunters outside the woodland shoot at birds driven out by beaters and dogs. This style of management and hunting is intended to create high densities of birds and is exclusive to private land in countries where the right to hunt game birds and the number that can be shot reside with the landowner and hunting for 'sport' is culturally acceptable. In countries such as the UK where pheasant shoots are popular this activity offers greater economic returns than timber production and woodlands are specifically managed for this form of hunting (Robertson 1992). Since pheasant is a woodland edge species many of the management interventions are related to the creation and maintenance of features such as wide rides, shrub margins to edges and inclusion of mast and berry bearing species into the woodland. Managed well, this can increase the general biodiversity of the woodland but will degrade its timber potential. In the UK numbers associated with this activity in 2014 are large (PACEC 2014, BASC undated):

- 830,000 ha of woodland managed for sport shooting
- annual revenue of around € 1.26 billion £1 billion
- releases of 35 million Pheasant and 6.5 million Red-legged partridge
- 3,000 tonnes of game meat – 97% destined for human food chain
- game bird market € 120 mill in 2014 – € 151 mill in 2015 and projected to be € 204 mill by 2020
- supports 70,000 paid workers – many seasonal but estimated to be equivalent to 7,000 FTE
- On Exmoor game shoots generated € 31 million direct income and € 100 million of tourism in 2004 generating 1,600 jobs in the rural economy.

The economic value of game birds means that this is a growing activity in Europe with several notable exceptions i.e. it is not popular in Fenno-Scandinavia and is banned in the Netherlands.

9.6 Official data sources on hunting

To conserve and manage natural resources in a territory requires information on which to base adequate decisions and actions. Official hunting statistics are an important source of data and complement the use of other type of data to manage game resources (Soininen et al. 2016). In particular, hunting statistics help decision-makers to learn more about the economic, ecological and social situation related to recreational hunting markets and game meat trade among other non-direct market uses (Apollonio et al. 2010; Herruzo & Martínez-Jauregui, 2013). As a result, hunting statistics are essential for developing policies and effective planning and management of available hunting resources and game species in rural areas.

In 2001, the European Commission launched the EU 'Sustainable Hunting Initiative' seeking to improve the understanding of the legal and technical aspects of the Birds Directive's provisions on hunting and to develop a programme of scientific, conservation and awareness raising measures to promote sustainable hunting. Further, in 2007, the annual meeting of the Standing Committee to the Convention on the Conservation of European Wildlife and Natural Habitats, adopted the European Charter on Hunting and Biodiversity which is fully supportive of the EC's Sustainable Hunting Initiative. In 2006, the European Commission declared the importance of high quality hunting bag statistics and the need to set up a common scheme in Europe for the collection, scientific interpretation and proper use of hunting statistics.

However, there is still a lack of standardization in the definition of the variables and the methodology employed to collect hunting data differ among counties. The absence of a shared international statistical protocol for hunting makes national hunting statistical data very heterogeneous and often difficult to compare. Nevertheless, the hunting sector still has more available data than other NWFP.

In this chapter we consider challenges to the collection of comparable statistics across countries and demonstrate the value and use of good quality data for trophies in Croatia.

9.6.1 Variables and sources of hunting statistics

In order to inform the current debate on the improvement of European Hunting Statistics we compared hunting statistics in seven European countries (Austria, Germany, Lithuania, Norway, Slovenia, Spain and United Kingdom). We discovered that it was hardly possible to compare the figures provided between countries as they were all different in either content, the method of collection or veracity. This experience highlighted that an important prerequisite for international reporting is the existence of well elaborated and applicable definitions for target variables for which data is to be collected and an agreement about the methods or protocols to be used. We therefore turned our attention to the consideration of the challenges to the collection of data for the key target variables which we considered to be: the duration of the hunting season, extent of hunting ground, number of hunters, and hunting bag (numbers of animals killed). Other data are collected by different agencies e.g. trade in game meat (already gathered in international meat trade data bases), trophies (gathered in national trophy catalogues in many countries) or monitoring of the impact of wildlife on forests (already gathered in some National Forest Inventory Data) are of interest but are not considered here because they are additional information normally not gathered in the official hunting statistics.

Hunting season
Hunting seasons vary among species and from region to region even within a country. For example, in Austria, for the federal provinces of Carinthia, Lower

Austria, Salzburg and Vienna it corresponds to the calendar year, while in Burgenland the hunting season lasts from 1 February to 31 January and in the remaining four provinces from 1 April to 31 March. Another example is Lithuania, where hunting all year round is allowed for foxes, raccoon dogs, American mink, muskrat and recently for wild boar but there is a limited season for other small species and the most important migrant bird species. Variation in the length of the season might affect hunting effort and should be taken into account when comparing statistics on the number of animals harvested as well on the population characteristics of those animals (age, weight, etc.).

Hunting ground

The number and type of hunting grounds, in terms of hunting property rights, in a territory can inform about the nature of the supply curve of big game (Herruzo & Martínez-Jauregui, 2013). For example, in open access territories where anyone is entitled to hunt increases the risk of "Tragedy of the Commons" situations in game hunting and complicates game management. On the other hand, hunting areas with enforced property rights over hunting facilitate the control of harvesting level and can help secure sustainable hunting. Data on the land within hunting grounds are commonly gathered (not in UK, in Norway only for wild reindeer), however the proportion of the land which is forest is often missing. What is more, the definition of the type of the hunting grounds can change through time and space because of changes in legislation (i.e. Slovenia and Spain).

Hunters

To evaluate the abundance of wildlife species and to measure trends in wildlife populations, variables related to effort of capturing are necessary, such as for example the number of effective hunting days. However, this variable requires the collaboration of the hunters and nowadays is not commonly collected or included in official hunting statistics in European countries. A proxy to this index could be the number of hunters. The most common indicator to describe the number of hunters is the number of people holding a hunting license but there is often only a loose correlation between the number of licenses issued and active hunters. For example, in Austria and Spain, it is mandatory to obtain a hunting license but these can be issued by both the federal state and national administration. Therefore, hunters could own several licenses to hunt in particular regions. Also no data is commonly available to indicate if hunters are practicing or passive, or the type of hunting used (i.e. with or without dogs, individual hunting or in group, etc.). In other countries such as the UK, hunting licenses are not required and a rougher estimate of hunter numbers is the number of licenses for firearms commonly used in hunting. But still there is no information on whether these firearms are used for hunting or other purposes such as target shooting.

Hunting bag

From a scientific perspective live animal census data is preferred but this requires the development and use of precise protocols implemented by trained staff. However, data provided by hunters for harvested game animals (the hunting bag) is considered sufficiently reliable to serve as a good indicator of hunting activity. This is because the hunting bag it is easy to define and because with the collaboration of hunters' (i.e. Slovenia, Germany) and/or owners of hunting grounds (i.e. Lithuania, Spain) data collection can be a cost-effective way of monitoring game species. However, some correction for hunting effort should be considered alongside more powerful indicators such as the type of hunting method, the number of hunters, or the area baited during hunting. Different strategies for such corrections could be applied depending on who is responsible for data collection. For example, in Lithuania and Spain every owner requests a hunting quota before the beginning of the hunting season which is approved by the local authorities. Therefore, the final data provided could be conditioned by the previously approved quota. Also, additional information such as the gender or size/age of the animal harvested could contribute to valuable demographic information to game species management (this is already done in some countries e.g. Norway).

9.6.2 Using trophy records to track management objectives in the Republic of Croatia

In the Republic of Croatia, there has been a legislative regulation on obligatory measurement of wild ungulates and brown bear trophies since 1976. This regulation has fortunately been kept in place until today with Hunting Law 2005 and other legislation. Under these regulations, each trophy is given a unique hunting trophy certificate which gives details of its valuation according to the Conseil International de la Chasse et de la Conservation du Gibier rules. Trophies are evaluated into four medal categories according to trophy value given on the Croatian Forests Ltd price list for the year: Not deserving a medal; Bronze; Silver or Gold medal. The trophy certificates can be used as evidence in case of theft and illegal hunting. Such a long period of trophy evaluation and documentation provides a means of tracking the condition of trophy species. We show results of surveillance of big game in Croatia based on a seven-year hunting period spanning 2007 to 2013 from the official Gazette.

During the 2007-2014 hunting years, the biggest number of trophies were roe deer (38 054 trophies), wild boar (15 190 tusks) and red deer (5 749 trophies), while other big game trophies were in much smaller numbers. The fewest trophies were of chamois where numbers were also static over the observed period. Generally, trophy numbers slowly increased over the period with the numbers of all trophies in 2013 being higher than 2007. There are three species for which trophy numbers have increased by around 150%. Red deer (Figure

9.4) trophies increased continuously after 2011, because of too high red deer population density in the Forest administration branch Osijek, Baranja region (Croatian forests Ltd.) which led the game manager to increase the red deer bag. The trend for brown bear (Figure 9.4) decreased because Croatian Forests Ltd introduced lower prices after Croatia entered the EU.

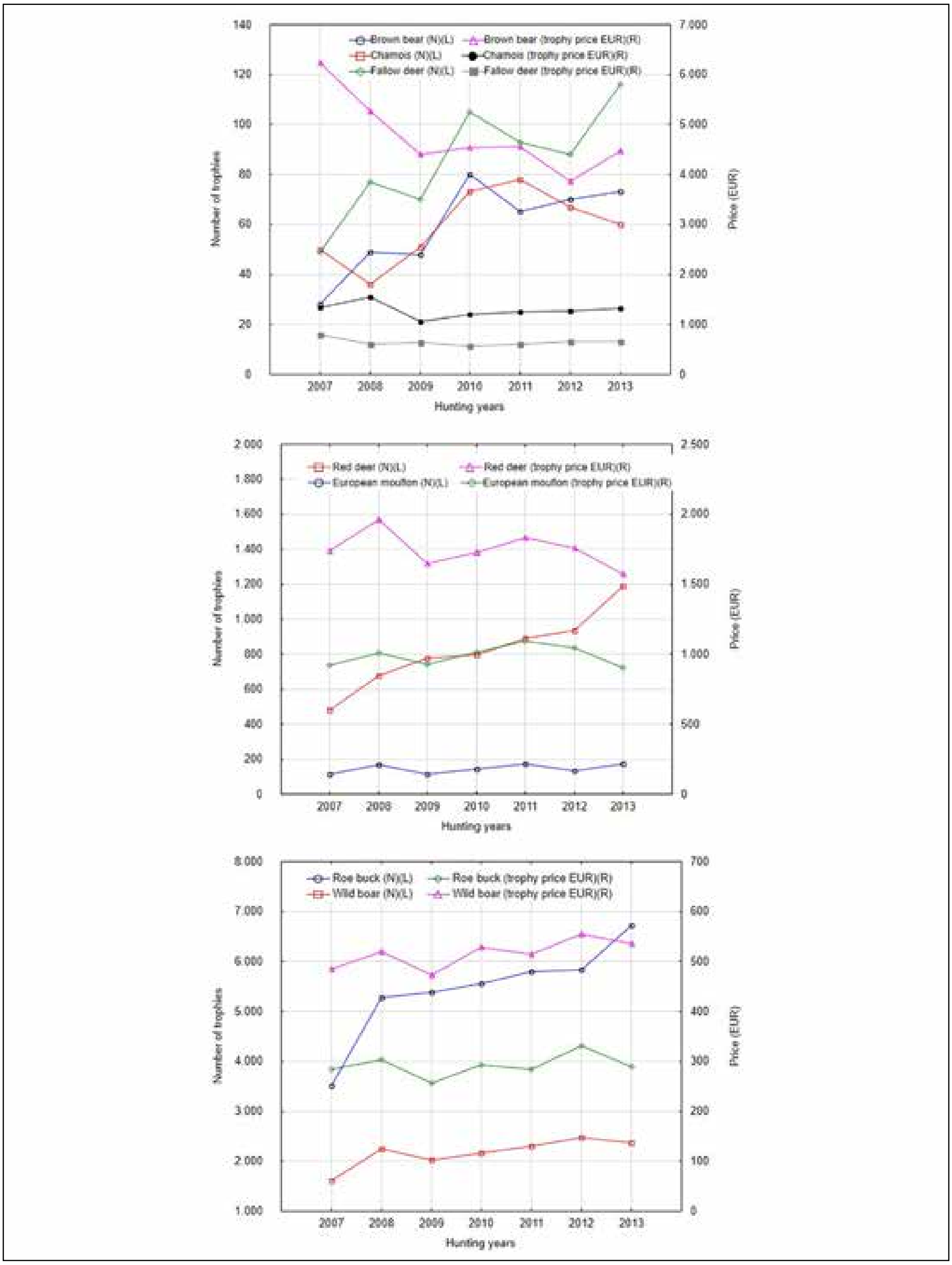

Figure 9.4: *Number of gained trophies and average trophy price (€) for seven game species in Croatia from 2007 to 2013*

The most expensive trophy was brown bear, with the average cost for the species being € 4 600, while roebuck was the cheapest (average price € 292). However, trophy values vary from year to year and are a reflection of market prices for shooting rights. On average, annual trophy sales are valued between € 3 004 828 and € 5 712 332, or an average of € 4 686 596 per year. Shooting methods vary between species. Brown bear is shot from closed shooting stands located at feeding stations that must be declared to the Ministry of Agriculture, while other species are shot using individual hunting techniques (stalking, waiting on high seats or on the ground, baiting and alluring (imitating animal calls)). The exception is wild boar that can be shot in driven hunts with dogs. For that reason, the value of tusks should be interpreted with care, as the hunting tax for drives is charged as a flat rate, but the price depends on number of shot game in other forms of hunt.

In Croatia management aims for trophy species are: realisation of general breeding guidelines; maintenance of hunting ground carrying capacity and production of high quality animal meat and trophies. The legacy of big game breeding (to improve trophy quality) has been maintained in the former socialist countries through accession into the EU countries thanks to consideration of hunting as an economic activity. Despite the downfall of the old system, there are still some traditional "hunting countries" (Hungary, Czech Republic, Slovakia, Romania, Bulgaria), that are known to produce high quality deer trophies in the past as well as in the present. Through analysis of official data on game trophies it is possible to get insight into game management methods as well as make predictive models, with the goal of sustainable game management. It is clear that a prerequisite for these analyses must be accurate records on game trophies.

9.7 Re-wilding

Re-wilding is a conservation movement which is based on restoring 'wilderness' as self-regulating ecosystems. Although there are many elements to this it is often associated with re-introduction of extirpated native species, many of these are species which can provide NWFP in the form of large grazers such as deer and bison and carnivores e.g. wolf and lynx to prey on the graziers. Re-wilding is most prominent in countries such as the Netherlands which has very little wilderness but is also evident in changing attitudes to the management of existing wilderness areas. As such, re-wilding can mean different things depending on context and there is no formal definition of the term. Rewilding Europe an EU-level NGO has proposed a working definition: "Rewilding ensures natural processes and wild species to play a much more prominent role in the land- and seascapes, meaning that after initial support, nature is allowed to take more care of itself. Rewilding helps landscapes become wilder, whilst also providing opportunities for modern society to reconnect with such wilder places for the benefit of all life." (Rewilding Europe 2017).

Re-wilding or more correctly re-introduction of animals can create new opportunities for animal NWFP. For example, Eurasian lynx (*Lynx lynx*) is listed in the Red Data Book of Lithuania as an endangered species and its' Action plan encourages the rearing and release of this species into natural habitats. However, other species are more problematic e.g. European bison (*Bison bonasus*) is also listed in the Red data book and captive breeding is successful, however, release of this species is problematic for landowners due to damage caused to their holdings. So, despite the aspiration of a hands-off approach after re-introduction it is often necessary to control i.e. hunt animals to limit damage. This coupled with the hunter's interest in large, challenging quarry means that hunting and re-wilding can work together. Thus re-wilding can be considered a NWFP production system (as described in chapter 4).

9.8 Conflict: it's not the animals – it is us!

A natural resource conflict has been defined as a situation in which the interests of two or more parties towards some aspect of biodiversity compete, and when at least one of the parties is perceived to assert its interests at the expense of another party's interests. In other words, different stakeholder groups have aspirations for a common resource that collide with each other at some level. White et al. (2009) expanded the definition of natural resource conflict further to include, not only the conflicting interests with regard to an environmental resource, but also the situation when actors have the same needs, but do not agree about the distribution of the resource, or when actors disagree about procedures for resource exploitation and distribution. In the forest context, conflicts related to game can relate to a single resource, for example one wildlife species or wildlife inflicted damage to commercial forestry, but they can also arise in a situation where land use of the same geographical area is contested and arguments concerning the existence of a wildlife species are simply a focal point for wider discussion of alternative use or cultural value of the area. This is the case, for example, when discussing the amount of red deer in Scotland (Scottish Natural Heritage 2016) and reindeer in Lapland (Dana & Åge Riseth, 2011). In Scotland, conservation interests contend that the populations of red deer are kept artificially high to favour commercial shooting such that populations exceed the natural carrying capacity of the landscape. However, deer stalking is in some areas an important source of income and rural employment. The conservation and hunting stakeholders do not agree on desirable deer stocking levels or the mode of culling. The same phenomenon can be identified in Lapland with reindeer, even though it is considered as semi-domesticated species, herds roam freely in forests. Oversized reindeer populations cause damage both to the forest as well as the natural plants and overgrazing decreases the soil microbial activity. Natural lichen species have vanished in some areas with declines of over 75% over 30 years in Northern Lapland which has prompted the importation from other parts of Finland of hundred thousands of kilograms of lichen annually to feed the reindeer. Every once and a while a discussion is raised about limits on the size of the herds as well as to the herding areas. This is, nonetheless, seen as an attack on the traditional Sami[31] culture and a way of life and causes very heated political discussions.

It has been stated that conflicts over pure environmental issues are, in fact, rare and most conflicts include a variety of issues around competing use of forests (Hellström 2001). It should be also noted that, the dimensions of conflict are not just those that concern economic or leisure interests related to a particular species, but also aspects that are related to urban-rural tensions, cultural aspects, economic development and institutional change and disparity between dominant ecological-technological expertise and subordinate forms of local knowledge (von Essen, 2015; White et al. 2009). There is a large body of literature arising from conflict situations when the local use of the resource is threatened by the changing global demands for the same resource (see e.g. Dowie, 2011). In the forest context, for example, moose hunting by using barking dogs was under threat in Finland at the beginning of 2000 century due to increased wolf populations. Wolves learned to kill the hunting dogs, who literally notified loudly of their presence. However, the EU policies stipulated wolf as a protected species and also estimated the suggested population sizes. This lead to the illegal poaching of wolf in rural areas (Pohja-Mykrä, 2016) as the hunters wanted to continue their moose hunting tradition.

In addition, it is evident that natural resource conflicts tend to vary between cultures, based on social, political, economic and resource aspects. According to Hellström (2001) "*the conflicts can be viewed as cultural phenomena from at least three perspectives: perceptions of conflicts, societal aspects of conflicts and conflict management strategies*". A concept of conflict culture has also been developed, describing a situation in which a certain society tends to create certain types of conflicts and respond to them in certain ways (Hellström 2001).

Regardless, often the suggested solutions to the natural resource conflicts focus only on evidence for impacts or management interventions and are based on the assumption that the stakeholder groups involved in the conflict will act in a rational way. In human behavioural sciences, on the contrary, there is a long history of understanding conflict as a multidimensional, even partly unconsciously produced, phenomenon. For example, one strand of research describes a conflict as a mental state due to, for example, a situation when a cognitive "knowledge" of a person about a certain issue is challenged by some social factor related to the same issue (a socio-cognitive conflict approach). This mental state is further translated into action via the conflict handling modes the person selects. It has been further found out that when there is a conflict between self-interest and concern of others, these two influence human

31 The Sami is a collective term for the indigenous peoples of the European Arctic who traditionally practice a nomadic lifestyle based on reindeer herding.

behaviour though different cognitive systems. Self-interest is often assumed to be automatic, viscerally compelling, and even unconscious, while obligations to others involves a more thoughtful process. This automatic nature of self-interest gives it often a primal power to influence judgment. It also makes it difficult for people to understand its influence on their decision making. The conflicts are also commonly recognized to include different kinds of emotions for example, anxiety, jealousy, frustration and anger. Thus, instead of viewing a conflict situation purely as consisting of disagreements or differences in opinion or as interfering or obstructing behaviour, they should be viewed as some combination of the actual differences, and the behaviour resulting from it together with a mixture of emotions.

In general, conflicts are usually seen as a negative phenomenon. Although natural resource conflicts often emerge as nonviolent, they are still destructive in nature as they impede development of the social constructions like co-operation relationships and sometimes even conservation efforts (von Essen et al., 2015; Woodroffe et al., 2005). In the worst case, failed attempts to solve natural resource conflicts may actually lead to an increase in criminality, for example illegal poaching (e.g. Pohja-Mykrä, 2016; Filteau, 2012). However, it must be also noted that sometimes the conflicts related to natural resources can have positive results. For example different NGOs have used them successfully to publicize their messages related to the conservation issues (Hellström, 2001).

We illustrate these concepts using cases of conflict from Northern parts of Europe related to game species and commercial forestry aiming to wood production as well as between game species and other, multiple use of forests.

9.8.1 Conflicts with forestry – examples from Lithuania

In many cases, the production of an animal NWFP is not the primary objective of management but is negotiated with other products – such as timber on forestry land and agricultural crops as well as conservation interests. In this chapter, using examples from Lithuanian forestry, we examine the way in which these competing interests create complexity in the management of game production. In both the case of the beaver and wild boar populations are considered by foresters and farmers to be ‘too’ high as they cause unacceptable damage to other occupiers of the land. Hunting of these species results in NWFP production in the form of meat and pelts which are marketed and used by the hunters. But hunting alone is insufficient to limit the populations to levels considered acceptable by foresters and farmers. A system of penalties and incentives has been introduced to coerce the hunters into increasing their offtake.

Maintaining a balance between Beaver hunting and other land users’ interests
The Eurasian beaver (*Castor fiber*) had extensive distributions in the northern hemisphere until the early 1800s, after which intensive hunting reduced both

their range-size and population densities. Not only direct impact on beaver populations (hunting/trapping), but also forestry activities greatly affected beaver habitats. Due to legal protection and targeted conservation measures including hunting restrictions, reintroductions and translocations, natural recolonization and habitat restoration, the beaver has made a remarkable recovery. Beaver is still under special protection in Europe according to international legal acts as the EC Habitat Directive and the Bern Convention. Harvesting of listed species is strictly controlled and, in general, is limited in the Baltic Sea countries.

Beaver is regarded as a keystone species which changes its environment in an active way that can causes damage to forests and adjacent agricultural lands. In Lithuania the beaver population reached 121 025 and was found to be causing damage to forest roads and other infrastructure due to flooding and channel digging that could extend hundreds metres into the forest. Therefore, the attitudes of landowners and foresters toward beaver are negative.

Figure 9.5: *Beaver cuts of an aspen tree and a dam in drying ditch*

What is the solution? Lithuania, as has some other member countries, has derogations for beaver management which allow landowners, forest owners, forest managers and hunters to remove beaver dams with a permit from the local Environment Protection Agency. This tool was approved both by foresters and hunters, and has been in use since 2003. Permits are zoned with approximately 50% of beaver sites included while around 10% were defined as sites of high value where no control is allowed. The removal of beaver dams depends on the level of the damage to the forest. Beaver dams are undisturbed (usually, these are old beaver sites), where damage is negligible or in the absence of damage (Figure 9.5). Selective removal of beaver dams (simultaneously cleaning drainage ditches) helps to maintain the beaver population and reduce damage caused to forests. The permit on the beaver dam removal is given to hunters who are also responsible for hunting the beaver population as required by management plans. In Lithuania, the number of harvested beavers (hunting/trapping using allowable selective traps) was 19 544 in 2015 and 21 749 in 2014. The NWFP provided by beaver is not of high value to the hunters but through the imposition of a damage penalty they are incentivised to hunt to limit populations. In a situation that a landowner would like a beaver dam removed or the numbers of beaver reduced they first make a request to the local hunters. If hunters do not reply to applicants, the landowners can apply to the municipality for compensation for the damage caused to their area, which the municipality will recover from the hunters. Thus, the hunters have not just hunting rights but responsibility for beaver management. At the moment, the situation at the national scale is in balance and the NGOs and conservationists are content with the size of the population. However, in local settings conflicts can easily arise.

Open season on Wild boar

The wild boar (*Sus scrofa*) is one of the most common and abundant game species not only in Lithuania but within much of the species range in Europe. Wild boar is an important and inherent component of the forest ecosystem of Lithuania as well as an iconic and valuable game species which produces NWFP in the form of meat, hides and hair. The high sociality and reproductive potential, adaptability, omnivory, mobility and other species-specific features enable wild boar to adapt to a wide range of environments but it causes damage to forest and agriculture. Wild boar effects forest litter and plantations and destroys protected anthills, it is found in urban environments where it damages gardens and lawns. Agricultural crop losses reach millions of tons and this is the main reason why this species is of paramount importance for hunters, landowners, foresters, authorities and scientists. Wild boar populations will quickly grow to exceed all permissible levels in the absence of natural predators and has furthermore become a vector for contagious diseases in farm animals. Moreover, humans themselves support wild boar by providing forage (supplemental feeding, suitable landscape transformation) for hunting.

Due to damage caused to forest and agricultural crops and the potential risk of zoonoses, wild boar hunting was initially allowed without special permits from 1st May to 1st March; however, harvesting was not intensive. Since 2014, following an outbreak of African swine fever (ASF) there has been a year-round open season on wild boar and Hunting Regulations were changed to allow a significant reduction of wild boar populations. This decision has been well received by farmers and landowners (rural society) but is less acceptable for hunters who wish to maintain healthy population of wild boar. The current hunting regulations prescribes hunting of all animals, including females, from certain management areas. This is very much against the unwritten rule of hunting communities, as the maintenance of a number of healthy females is a pre-requisite for future populations. Despite the economic incentive in the form of a payment from the Veterinary and Food Agency for harvested females the attitudes of hunters towards the new regulation have been negative. Nevertheless, as hunters are obliged to compensate for damage caused by the wild boar populations, they have been forced to keep the level of hunting too high for their own interests.

9.8.2 Conflicts with other non-wood uses of forests in Finland

The conflicts related to non-wood uses of forests and game can be various. Similar to conflicts with forestry the conflicting interests can be economic, game is destroying or hindering economic activities in the forest, like collection of mushrooms or nature tourism while they also represent non-wood benefits from the forests.

How many elk are enough? – conflicting views of different stakeholders

Figure 9.6: *Elk (Alces alces) is an amazing gracer*

Annually approx. 40 000 elk hunting licenses are granted by the Finnish Government. The number of licenses is decided annually based on the elk population, estimates of forest damage and traffic accident statistics. Most of these licenses are targeted to rural areas. At the same time the amount of rural hunters is dramatically decreasing due to socio-demographic changes in rural areas. In the absence of large carnivores, the elk population needs to be controlled by humans to keep the damage within acceptable limits. The licenses are granted by the Game management districts, some to the private forests, some to the State land. Typically, the licenses are allocated to local hunting clubs. Elk hunting is very time consuming and as the average age of the hunters is increasing, controlling the population can be a burden for the locals in rural areas and there are hunters who are obliged to hunt more than they would prefer. At the same time there are a lot of hunters outside of local hunting clubs and even foreign tourists who would be interested in obtaining an elk hunting license. However, the locals' attitudes are typically negative towards these kinds of activities, especially in the form of hunting tourism. In their opinion, the licenses should not be allocated to hunters outside of the region or to foreign tourists. The local hunters very strongly influence the policy making processes and legislation via hunting associations and the organization handing out the licenses. Even though the elk are a relatively plentiful resource and in some areas there would be enough licenses for both local hunters and hunting tourism companies. In their public discourse, the local hunters highlight the value of the elk meat to their domestic economics, even though considering the time, equipment and other needed materials, the elk consumed by local hunters is relatively high cost. However, the core of the conflict is not only the elk resource as such, but also the opinions that commercial hunting tourism is against the local hunting culture and the strong experienced ownership feelings towards the local game resources. The hunting tourism sector is very delicate in Finland, not so much due to the public opinions against hunting, but due to the rural lifestyle and values. Thus, it has been highlighted that the social sustainability is the most crucial issue to be taken into the consideration in the business planning as well as in stakeholder management.

Conflicts related to the use of Brown bear

In the Eastern parts of Finland, one of the latest innovations in nature tourism is watching and photographing of large carnivores. The regions of Kainuu, Kuusamo and Pohjois-Karjala are the main stronghold of the four large mammalian carnivores in Finland: brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), lynx (*Lynx lynx*) and wolverine (*Gulo gulo*). Nature tourism is centred mainly around bear-watching. The number of entrepreneurs offering watching and photographing of brown bears have increased from a few part-time actors in the early 2000s to 20 full-time actors in 2008 and at least 45 entrepreneurs in 2012. This tourism product has been recognized a specific theme and is supported by a national development project called Outdoors Finland from 2009 to 2014 and has been acknowledged in national and regional tourism strategies and programmes.

Watching and photographing brown bear depends heavily on the use of carrion in bear feeding stations. Stable carrion baiting in the watching sites ensures a regular and predictable presence of bears. This continuous carrion baiting has been central to discussion by the stakeholders related to bear-watching. Especially the local residents and hunters, but also nature conservationists argue that carrion increases bear numbers to "un-natural" densities in the area and may have an effect on feeding habits of bears. In addition, the locals state that the bears get used to the people's presence due to this activity, are not anymore afraid of people, on the contrary, and therefore, the risks of encountering a bear in the forests and the presence of the bears near houses increases significantly.

Brown bear, alongside European elk, is the most valued game species in Finland. As the highest densities of bear population as well as the highest densities of hunters occur in the same regions with bear-watching enterprises, it is in hunters' interest that this "new" and competing way of using the game resources should not interfere with the hunting tradition. Hunting bear by using carrion as bait is strictly forbidden by law, but, the hunters feel that the presence of carrion feeding steers the bears' movements in the area and makes it impossible for the hunters themselves to avoid an illegal situation where hunting dogs take up a bear scent trail from a carrion feeding station. In addition, the bear hunting season starts typically on 20th of August in Finland, which is the busiest tourism season, especially for foreign tourists.

On the other hand, the need for innovative nature tourism products as a livelihood in remote rural areas is also highlighted in the regional discussion. For the entrepreneurs the occurrence of bears is crucial for the success of the business. Their interest is to maintain high bear density in the watching areas during the whole season to guarantee the daily presence of the bears. The regularly seen bears become well known by the entrepreneurs and they have for example, given them names and raised them to the level of local celebrities. In case that one of these personally known bears has been shot during the bear hunting season, an intense public outcry has been raised.

9.8.3 Conflicts and adaptive institutions for feral goat management in Great Britain

Goats are not indigenous to the UK and it is thought they were first brought onto the islands by Neolithic farmers some 4,500 years ago. The descendants of these small, long-haired hardy animals are recognized as a landrace of *Capra aegagrus hircus* known as the "British primitive goat". Primitive goats remained a significant part of upland farming systems until the 18th century (providing milk, tallow, hair used for wigs, hides and meat) when sheep became the dominant livestock and feral goat populations were established. Although long naturalized and truly wild the feral goat has a unique status as it is considered a domestic animal in law and can legally be captured, ear tagged and sent to a livestock abattoir or sold alive by the owner of the lands over which the animals wander. As domestic animals, feral goats are not covered by game regulations (i.e. there is no closed season and culls are not reported in game bag statistics) although they are hunted in the same manner as other wild animals for population control, sport and trophies.

From being considered an inconsequential component of upland ecosystems, by the mid-1990s the feral goats were increasingly viewed as a pest especially by foresters because of the impact on restocking, conservation interests seeking to establish woodland by natural regeneration and re-wilding and residents suffering damage to gardens. Several of the conservation and forestry interests proposed the removal of the feral goats which would have eradicated local populations. These proposals drew strong objections from several quarters. Foremost amongst these was a lobby group who argued that the goat deserved protection as a threatened primitive breed. Other objections came from local people who championed the goats as a contribution to cultural heritage and as longstanding and essential features of the landscape. Animal rights activists also threatened retaliation on authorities daring to propose shooting the goats for any reason. In the absence of any formal regulation or national-level strategy concerning feral goats, meetings for the purpose of conflict resolution were often called and facilitated by leading public bodies e.g. National Park Authority, Forestry Commission, local Council (municipality). Though the absence of formal authority means the goat management groups necessarily operate by consensus.

The outcome of the conflict over the continued existence of feral goats in the landscape was that eradication of goats has generally been deemed unacceptable for most, if not all, remaining populations. In most cases the development of goat control strategies and management plans was facilitated by the informal (self-governing) goat management groups which evolved from the conflict resolution meetings. This is generally because control is only effective if applied across land ownerships (i.e. at a landscape scale) so a forum for voluntary co-operation between several landowners is needed. However, the groups also include special interest groups who are not landowners as they continue to have an interest in goat control and in some cases are instrumental in fundraising and provision of volunteers. A key question for management was then the selection of methods for population control and the acceptable population levels which would be socially acceptable. The method for controlling goat numbers proved to be the most emotive issue which often reaches the local (and national) press. The flexibility provided by the ability to treat feral goats as both a domestic and game species coupled with the freedom to create locally distinct solutions resulted in the evolution of a range of methods for controlling feral goat populations as shown in Table 9.2.

Table 9.2: Methods for control of feral goat populations used in UK

	Population control method	Cost implications for landowner
Game shoots	Sport hunting for trophy heads	Low – hunters may even pay for access to feral goats for sport hunting
Culls	Regular shoots, carcasses left as carrion, use of population models to determine cull levels	Moderate – hunter is contracted (paid) to undertake cull. No income from carcasses.
Fencing	Boundary fencing + clearance for small scale areas and large scale re-wilding projects	Large initial capital outlay
Shepherding	Shepherding with dogs to encourage hefting away from sensitive areas	Moderate
Live capture & translocation	Capture, ear-tagging and translocation to sites requiring conservation grazing, mohair farming. No use as meat.	High – requires secure locations to accept goats
Contraception	Contraceptive implants in breeding age females	High – costs reducing as new implants become available

In the UK, informality and the ability to self-organise, arise from very light regulation. But active conflict resolution only happened with acceptance by powerful interests of the validity of diverging opinions on

the value of feral goats – without this light regulation local elites would have been allowed to do as they pleased. This acceptance arose from social pressure operating on government institutions and land-owning NGOs both of which are sensitive to civil society concerns and can take on the role of facilitators or leaders in informal institutions. Such institutions promote a science-based approach to management and thus provide the monitoring and feedback required to inform adaptation by broad-based management groups. Innovation in management methods was also stimulated by the diversity of viewpoints within management groups and between sites.

Conflicts over goat damage and culls remain and bubble up whenever culls in areas frequented by the public are undertaken and consultation and public awareness campaigns remain a necessary component of goat management strategies.

9.8.4 The social element in animal NWFP production

The cases examined and the literature (e.g. White et al, 2009), highlight that game related conflicts arise from the divergent opinions and approaches of different stakeholder groups towards the game species in question. The question is often not ecological, but social. For example; in the Lithuanian beaver case the conflict is between forest managers/owners and conservation requirements of protected areas while the mode of feral goats culls in the UK is contested with a wide range of stakeholders and civil society. Often, especially in Northern Europe, local hunters are in a central and even controversial role in game related conflicts. They have the means and possibility to limit and manage the game populations, either according to the agreed regulations or illegally (see e.g. Pohja-Mykrä 2016). Sometimes they are also given the official responsibility to do so, as in the Lithuanian wild boar case. In practice, the local hunters are also by far the most cost effective way to control the populations to limit the forest damages caused European elk or wild boar. However, local hunters are also in many cases a central stakeholder group antagonistic to recreational hunting and thus cannot be seen as an objective party or simply as a tool in game management.

Traditionally in rural areas, local people often perceive natural resources as "theirs" (Matilainen & Keskinarkaus, 2010). However, as forest-based resources provide benefits at different scales (local, national, global) other people than locals increasingly feel that they have "right to enjoy" and, therefore, also "right to say" on the use of different kind of natural resources based on their own values. In other words, several interest groups have developed feelings of possession towards the natural resources. It has been argued that these experienced feelings of ownership and an appreciation of their significance can play a significant role in both successful co-operation between the different stakeholders in conflicts related to the use and management of natural resources and in fully understanding the core of the conflict situation. For example, in the Lithuanian beaver case the conservation requirements came from EU legislation and from the values that were discussed and debated during the legislation preparation and even though the compensation scheme for the damages exist, the locals can still feel their rights have been violated. Indeed, in the case of wolf conservation, the most problematic issues for the people of Eastern Finland were that the appropriate size for the wolf population was decided at EU level and not the presence of the wolf itself.

In many attempts to solve conflict in natural resource context, a typical mistake is that stakeholders are assumed to act in economically rational ways, and therefore, conflict analysis and management have been focused on disciplinary approaches (White et. al., 2009) or simply by providing objective evidence to the process. To put it in a simple example, if the people get some compensation of the damages to their forests or the people are told about the value of European beaver to the ecosystem that should solve the problem? Not likely. In the case of feral goat, on the other hand, the discussion was more on the methods, how the goat population should be managed, which highlights the importance of taking people's values into account in conflict management. The conservation interests' involvement in socially sensitive sites trigger the reactions and hunting of domestic stock seems distasteful for the public. In fact, it seems as if animal welfare and ethics is a bigger concern for civil society for a feral animal than those which are truly indigenous and wild. The cost of reducing numbers is also not so much an issue as the social acceptability of the method. Some of the actions are, in fact, funded through site-level grants or public donations with volunteer contributions.

In analysing and managing natural resource conflicts, the importance of social psychology and interdisciplinary methods in the integration of cultural and biophysical aspects is becoming increasingly recognized (White et al., 2009). It has been proposed that the origin of the conflict arises from a deep cognitive level and is linked to changing attitudes and values that are rooted in social and cultural history (Redpath et. al., 2013). These attitudes may not be fully rational and sometimes not even a conscious process. In addition, often the arguments that are used make the particular opinion acceptable are aimed at a wider audience and may not have much to do with how and why the complainant has created the opinion (s)he is defending. Sometimes the complainant him/herself may not even be fully aware of the psychological origins of his/her opinion. As in the context of hunting tourism, the arguments are concentrated on the size of moose population. Proving, via population counting, that the population is big enough to supply hunting tourism in addition to the locals' licenses, does not change the opinion of the opposing party as this is not the basis for their objections. This should also be understood in participatory management: involving the key stakeholders in the process is not enough, it is important to understand the underlying causes of conflicts. In many cases participatory management practices have been criticized as failing to take properly into consideration the emotional aspects that influence the opinions of the stakeholders. New approaches, based on human behaviour, not the behaviour of game species, should be found.

9.9 Markets for game

Considering the multiple societal demands regarding NWFP of (wild) animal origin a suite of management concepts are in place to meet the diversity of human needs. In light of recent trends in consumption (e.g. organic, biological, regional or seasonal) and increasing awareness of environmental sustainability and ecological integrity, appreciation of the “wild” or “wilderness” is gaining momentum across Europe. Thus, there is an increasing demand for the supply of NWFP derived from wild animals from the forest. In order to capitalise on these markets local producers are turning to some form of labelling to distinguish their products in the marketplace and capture a share of the new markets. There are several forms of these labels representing different organisational structures and market messages. Case 9.5 gives the example of “Genussregion Gesäuse Wild” which arose from a regional grouping of actors up the value chain established through across-sectorial dialogue resulting in a new institution with its own rules. In the UK, FSC certification of sustainable forest-based production has been adopted for use on venison by the Forestry Commission (state forest enterprise). While in other instances regional labels have also been developed by existing hunters’ associations.

CASE 9.5: Venison labelling: “Genussregion Gesäuse Wild” in Austria

This association is located in northeast of the province Styria in Austria and is composed of actors from the fields of forestry, hunting and gastronomy who decided to establish the “Genussregion Gesäuse Wild” label to sell venison, produced in the region for distribution within and outside the region. The products are raw meat and high quality processed products (e.g. sausages and terrine). The association has developed a chain of production process starting from the hunters who prepare the carcasses and sell the raw meat to the other part of the production chain such as local and regional restaurants, butchers and other private businesses. The

Styrian Provincial Forests lead the association, the hunters hunt the game within the area of the National Park “Gesäuse” with red deer, roe deer and chamois being the most hunted game. The butcher processes the meat and can sell privately if he wishes or through the Provincial Forest Service which is responsible for marketing and selling the “Gesäuse Wild” products. The “Gesäuse Wild” umbrella name is very well recognized and serves to secure market share for venison produced in Styria which would be difficult to achieve without this level of supply chain co-operation and the support of the forest authorities.

Although wild food dominates these markets not all products are edible as shown the in case of the boar bristle brushes from Latvia (Case 9.6).

CASE 9.6: Boar (*Sus scrofa*) bristle brushes from Latvia

In Latvia, hunters traditionally sold wild boar meat as a source of income, but with the introduction of new meat hygiene regulations many hunters were unable to adapt and reduced their hunts to just enough to supply family and friends. As a consequence, the numbers of wild boar increased along with damage to agricultural crops and forestry.

Figure 9.7: *wild boar bristle hair brush (Photo credit: http://www.wild-good.com)*

Daba Laba an outdoor activities company recognised the problem and wondered if there was any way to make use of boar for a non-food product and provide the company with a commercial opportunity to fill the winter off months for outdoor activity holidays. Hair brushes are traditionally made from boar bristle and the company experimented with updating the traditional boar bristle hair brush. The company concept was not to compete on the price but on quality which resulted in process and design innovations. In addition to this the company wanted to provide a new product that would be ecological, natural and with good design. With innovation funding from the EU Leader programme Daba Laba developed a wooden handled boar bristle brush made using state of the art laser cutting technology with modern shapes and strong focus on design and quality. These brushes were launched under the brand name WildGood with a webshop for international sales (http://www.wild-good.com) and sales through design shops, hair salons, eco boutiques etc (Figure 9.7).

Initially the boar hides were sourced free of charge from hunters as a waste product but once the brushes were being sold the price per hide began to rise. As production grew, Daba Laba found itself with a quantity of raw hides from which they had removed the bristles going to waste so they approached a local tannery to see if they would be interested in making wild boar leather. The tannery now takes in the hides to produce quality boar leather for a range of uses with some going back to Daba Laba for use in packaging, a range of archery items, leather bracelets and handmade boots.

The creation of a supply chain for boar hides has created a range of high value products which supports 12 jobs (many for disabled people) in WildGood, the tannery, an artisanal shoe maker and provides an income stream to hunters to support culls of wild boar. It is not known how great an impact this has had on the boar population. On the WildGood website the boar are all said to live in FSC certified natural forests of Latvia – but the FSC label is not attached to the boar products.

9.9.1 Trade in game meat

Although wild animal NWFP, particularly game meat (including wild birds), are easily found in shops and markets across Europe commercialisation of these products is actually rather poorly developed. In no country is the objective of game management the maximisation of meat production. Furthermore, hunting is a deeply embedded cultural activity in many countries (e.g. 10% of the population of Norway are listed on the official register of hunters) and in many hunting is a recreational activity rather than a contribution to income. The common survey asked respondents to indicate the perceived contribution of various uses to the national importance of NWFP with the results for game meat given in Figure 9.8. These results clearly show that the economic contribution of game meat dominates perceptions of the value of game in only a few countries (BU, PL, RS and UK) and is completely absent from others (HR and CH). It is interesting to note that countries with high numbers of hunters often require registration for which a fee is charged which is used to fund wildlife management, monitoring and research (e.g. Norway's Wildlife Fund receives around € 7.5 million per year from hunter's fees, Andersen et al 2010)) which reduces the need to generate direct income from meat sales. Whereas, in the UK where game management is the sole responsibility of the landowner, commercialisation of meat helps to offset the costs of management.

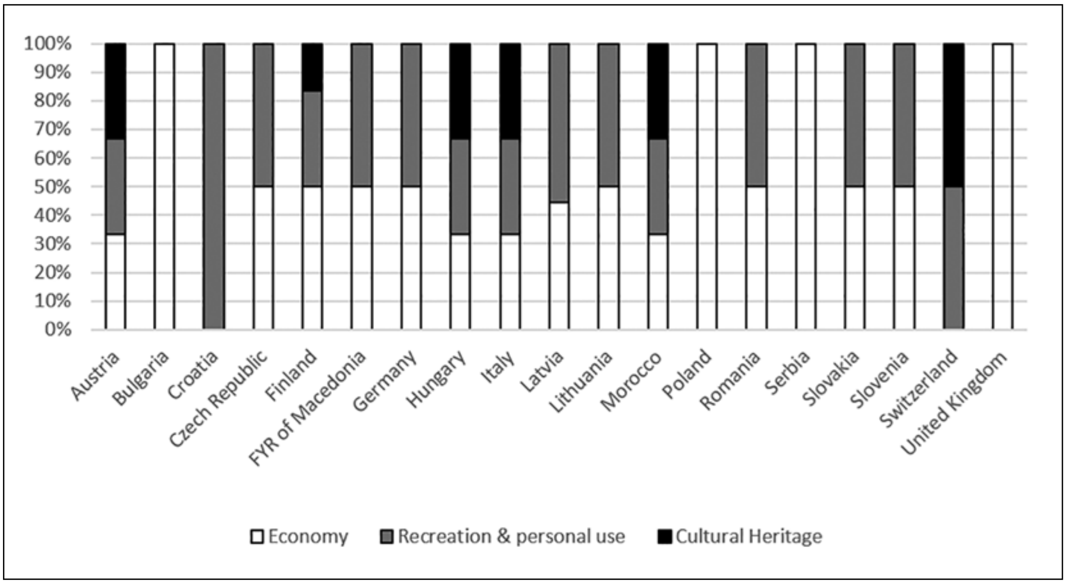

Figure 9.8: *Components of the perceived 'importance' of game meat by country (Source: COST Action FP1203 Common survey)*

In most countries game meat is a by-product of animal population control programmes which is mostly consumed by the hunters and distributed through social networks (i.e. to family and friends) rather than entering formal markets. Use and trade of game birds and fish is similar to that described above for game meat in general. The activities are mainly recreational or for personal use with only relatively small amounts entering formal trade.

Honey and bee products sit on the border between wild and domesticated products – and although the bees themselves are often wild varieties (see chapter 9.11) and they often feed on forest trees and wild flowers these products are usually included in agricultural statistics. Beekeeping can be a full-time occupation, a part-time income diversification option or a hobby pursuit. Honey sales can likewise be wholesaled, sold as a regional speciality or sold simply in local markets to friends and neighbours.

In the Common survey country respondents were asked to indicate the significance of mass markets, small scale enterprise and personal use (not marketed) for game. This indicated marked differences between countries in the way game meat and game birds are marketed as shown in Table 9.3. There are several reasons for these differences rooted in regulations, hunting culture and ability to overcome the not inconsiderable barriers to formal trade arising from food hygiene and other regulations (see chapter 9.9.2). Of course, personal consumption represents socially-orientated markets where trade is likely to be non-monetary. It is clear that small scale markets are an important form of commercialisation for game in most European countries. Relatively few countries target mass (commodity) markets for game other than for venison or wild boar meat. Although very different volumes and values are represented by the different market scales it seems that most game produced in Europe is likely to be consumed within the country and probably quite close to where the animals were hunted and thus contribute to the local food culture.

Table 9.3: Markets for national production of game meat and game birds in some European countries (Source: COST Action FP1203 Common survey)

Type of game product	Number of countries reporting markets for game			
	Total	Mass market	Small scale markets	Personal consumption
Birds	5	1	4	3
Game meat (including birds)	6	1	4	4
Game meat (not including birds)	13	8	11	9

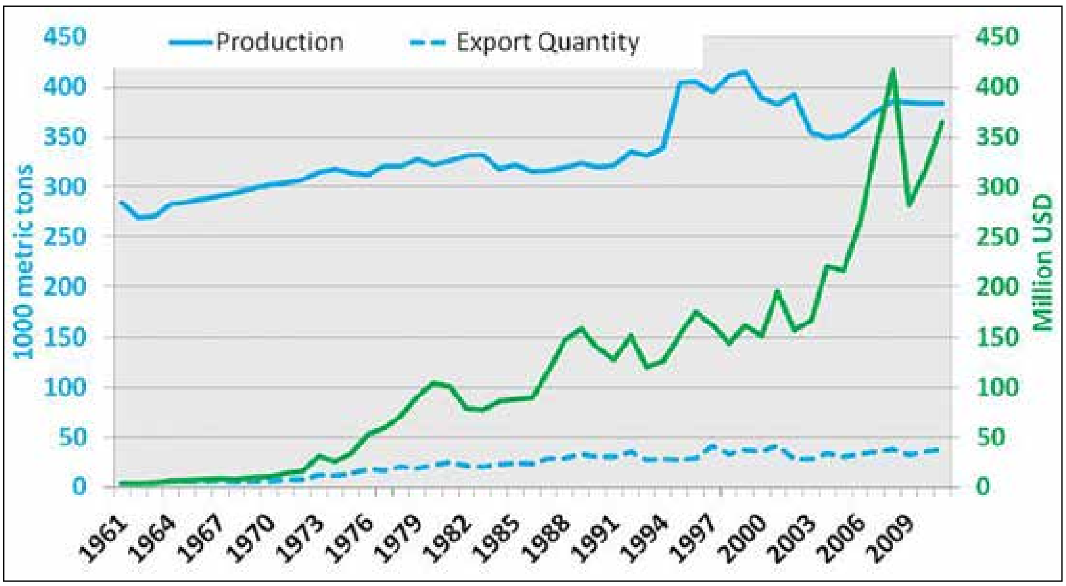

Figure 9.9: *Game meat in the UNECE (Source: Li 2014 from FAOSTAT)*

Figure 9.9 indicates some trends in game production from 1961 to 2011 based on FAOSTAT records. This reveals that although overall production is only increasing at a modest rate that there has been a gradual increase in the value of marketed game starting in the mid-1970s with a dramatic increase from 2005[32]. Only a very small fraction of this is represented by export (most likely to be mass market) which suggests most value is being added in internal markets which as shown in Table 9.3 are likely to be small scale enterprises. However, the data on game held by UNECE/FAO is acknowledged as being rather poor and a separate enquiry on wild game meat was sent to all UNECE countries in 2016.

Digging a bit deeper into available statistics details of import and export trade of game meat, mainly involving wild boar products, in EU countries for 2015, is shown in Figure 9-6[33].

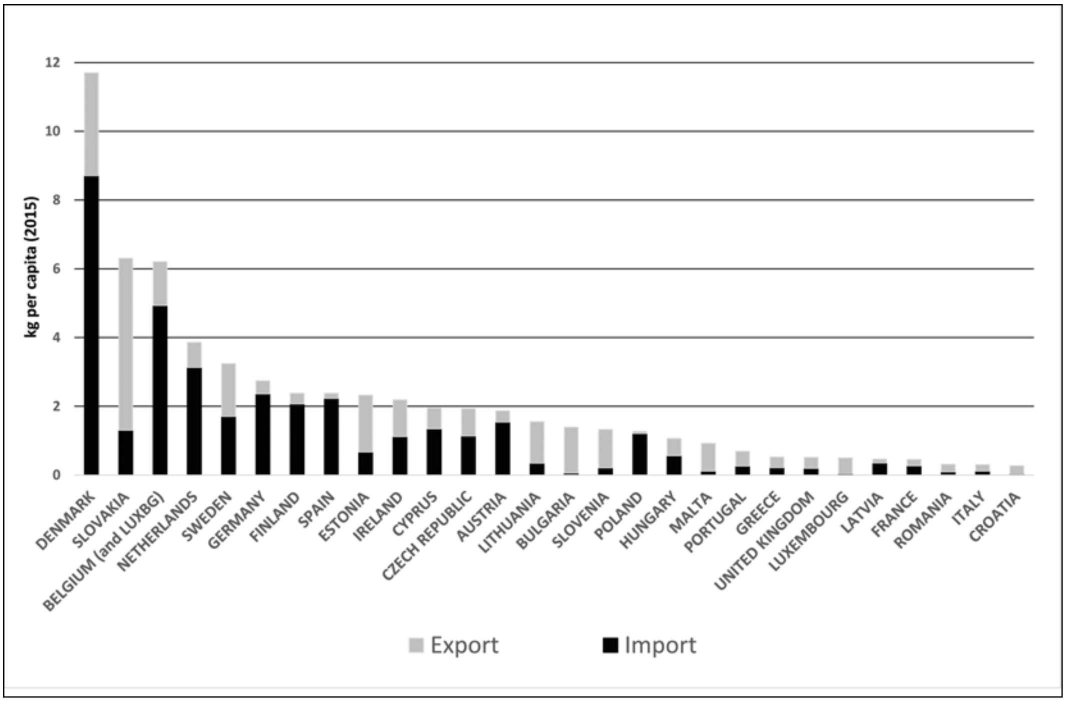

Figure 9.10: *EU country game meat import and export per capita for 2015 (Adapted from EUROSTAT statistics)*

32 See Chapter 5.7 for an intensive discussion about the wild game meat markets

33 The figures show the amount of the following products' categories: 1. frozen meat of non-domestic swine (excl. carcases and half-carcases and hams, shoulders and cuts thereof, with bone in); 2. fresh or chilled meat of non-domestic swine (excl. carcases and half-carcases, hams, shoulders and cuts thereof, with bone in); 3. meat of non-domestic swine, salted, in brine, dried or smoked (excl. hams, shoulders and cuts thereof, with bone in, and bellies and cuts thereof); 4. bellies "streaky" and cuts thereof of non-domestic swine, salted, in brine, dried or smoked; 5. fresh or chilled hams, shoulders and cuts thereof with bone in of non-domestic swine; 6. frozen hams, shoulders and cuts thereof of non-domestic swine, with bone in; 7. fresh or chilled non-domestic swine carcases and half-carcases; 8. frozen non-domestic swine carcases and half-carcases; 9. hams, shoulders and cuts thereof of non-domestic swine, salted, in brine, dried or smoked, with bone in.

The largest importer is Germany (190 000 t/year), Spain follows at distance, importing 104 000 tonnes/year, while Belgium, Denmark, The Netherlands and Poland import 50 000 tonnes/year each. What is interesting is the low level of exports from many countries with large populations of game and hunters. For example, nearly 6% of the Finnish population are hunters but export of game is very low and dwarfed by imports. This suggests that local production of game is not meeting demand or that internal supply chains for game are not well established. Several countries have net export of game and these are typically those in eastern Europe with large forests and high numbers of game and a need to provide sources of rural income (e.g. Bulgaria. Slovakia etc.). As always there are exceptions to these generalisations reflecting the scale of internal markets and cultural preferences for wild meat.

Considering domestic markets, a recent study in Austria revealed that game meat (dominated by deer) was assessed to a market value of more than € 15 million not including the recreational use of hunting which provides around € 48 million according to the Austrian hunting administration (i.e. licences, lease of hunting grounds). This accounts for 28% of the value of all NWFP goods and services and represented 8% of the value of timber production (Vacik et al, 2014).

Game meat represents only a small fraction of total meat trade in Europe but it represents a growing market opportunity with demand exceeding current supply. The shortfall is being made up of imports of farmed venison from New Zealand which is also stimulating the growth of deer farming in Europe. At the same time wild game populations and increasing and spreading across Europe are increasing and marketing of game meat could facilitate more effective control of populations. However, growth in commercial markets for wild game is sluggish and stymied by price (see Case 9.7) and trade barriers in the form of regulations such as the EU food hygiene regulations (see chapter 9.9.2).

CASE 9.7: *Developing game meat markets in Poland*

Increasing populations of wild ungulates in Poland have yielded a considerable increase in bag numbers of the three commonest large game species since 1975. In 2009-10 this yielded 12-14 thousand tonnes of venison of which 98% is exported, mainly to Germany but also to France and Italy. Consumption of venison by the Poles is very low at 0.8 kg per person per year and prices on the local market are high compared to domestic meat. There is a strong feeling within the venison supply chain that more venison should be supplied to national markets which means reducing prices and promoting venison. In 2009 the “Dziczyzna Polska” consortium led by the Polish Hunting Association and involving five meat processors and a wholesaler was established to supply Polish supermarkets and consumers with venison from its own network of 30 venison collection centres.

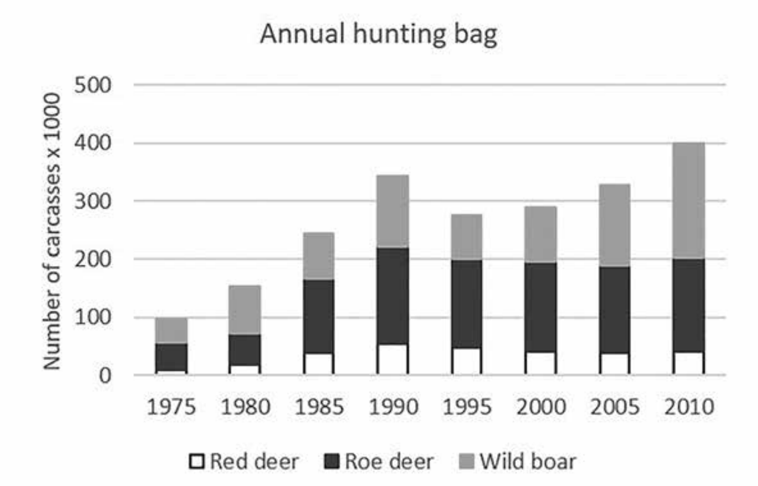

Figure 9.11: *Annual hunting bag for red deer, roe deer and wild boar in Poland (Sources: Górecka & Oksana (2012), Wawrzyniak et al (2010))*

In addition to sale of meat, the owners (could be the hunter or state) of the carcass can also make use of other products from the carcasses such as hides, bone, horn and antlers as trophies or raw materials for further processing. In addition, there are many enterprises established on the lease or rental of hunting rights to recreational hunters, both locally and also foreign tourists. The revenues from such activities alongside the multiplier in hotel and catering trades are often a significant proportion of total incomes from game-related economic activity.

9.9.2 Impact of EU meat hygiene regulations on game meat supply chains

Consumers often associate game meat from hunted wild animals with food of high quality, due to their origin from wild and natural areas. However, game meat has been recognised as a somewhat dubious source of food mainly because of the unknown sanitary condition of the animal when it is harvested, and its uncontrolled feeding. Indeed, wild fauna is estimated to be the last reservoir (mostly unknown or unquantifiable) for foodborne and emerging infective diseases (Ramanzin et. al, 2010; Membré et al., 2011). Case 9.8 gives an overview of the ways in which the hygiene of game meat can be compromised.

CASE 9.8: Sources of pathogens and contaminants in game meat

Microbial pathogens

The microbiological quality of game meat will depend on: (1) microorganisms in the digestive tract and muscles of animals; (2) circumstances in which animals are killed; and (3) the conditions under which the carcass is dressed. As a general consideration shooting should be lethal and there should be no delay in bleeding, evisceration and chilling to ensure game meat has good microbiological and hygiene standard. In addition, during storage of meat, microflora development is related to storage conditions and to biochemical characteristics of the meat.

There are several microbes which can infect meat which is poorly handled and slaughtered (e.g. *Clostridium perfringes* and *Listeria monocytogenes*, while some species are prone to parasites such as the *Trichinella spiralis* nematode in wild boar meat.

Influence of hunting practices

Hunting practices can be significant, for example the possible effect of prolonged and long-distance chases with large packs of hounds are likely to cause much greater stress in quarry animals than short-time and short-distance drives, and often delay the removal of spoil and dressing procedures. The placement of the shot wound is critical with high bacterial counts from animals shot in the digestive tract, which contaminates the carcass with faeces. Hunting methods which give a clearer shot such as the stands for deer may help reduce the incidence of this type of contamination. The risks of microbial contamination of muscle due to gut spilling also suggests stopping hunts after 1–1.5 hours to allow timely dressing of shot animals and reduce the microbiological contamination.

Heavy metal contamination

Heavy metals such as cadmium (Cd), lead (Pb), mercury (Hg) and arsenic (As) can accumulate in organs and tissue and have been found in game meat and offal above levels for tolerable intake in animals living close to mining sites or other pollution sources and feeding on contaminated mushrooms, lichens and wild plants. Lead (Pb) contamination due to the residues of bullets in the muscle area is also a risk which can be minimised by accurate trimming of the carcass around wounds and bullet pathways.

Pesticides

Organochlorine pesticides (OCs) and polychlorinated biphenyls (PCBs) are widely used in agricultural practices, and generally accumulate in fat of mammals and are considered to be endocrine disruptors and carcinogenic.

Mycotoxins

There is scarce data are available on the presence of mycotoxins in wild animal meat or the food chain.

Radiation

The Chernobyl disaster in 1986 resulted in a widespread fallout of 137Cs (caesium) which contaminates game meat in various countries in northern Europe. It is important to highlight that large part of roe deer and wild boar harvested in highly contaminated areas exceed the EU threshold for radiation in foodstuffs of 600 Bq radiocaesium per kg of fresh meat.
Main sources: Gill, 2007; Ramanzin et al., 2010; Membré et al. 2011; Sales & Kotrba 2013

Improving hunting practices across the European countries and encouraging good carcass and meat hygiene practices are the main strategies to maintain the microbiological quality of wild game meat (Membré et al., 2011). However, both quality and hygiene assurance are difficult to control from shooting in the field to final consumption. Hygiene requirements for game meat have been addressed by the European Parliament with two Regulations (EC) No. 853/2004 and No. 854/2004 which focus specifically on food of animal origin. In 2002, the European Parliament harmonised food quality standards by means of Regulation (EC) No. 178/2002 – the so-called European Food Law – which lays down the procedures in matters of food safety. Several critical points have been raised in connection with sanitary conditions with the EU Regulations mainly related to the presence of contaminants and animal diseases potentially dangerous to humans.

In order to cope with the existing regulation a few countries have established a hygiene standard compliant supply chain from the site of shooting to butchery plants, that allows the collection of relevant food safety information by means of vet inspection, and the provision of samples to be analysed if required for monitoring and control of zoonoses and residues.

The good practice suggestions may be of help in the game meat supply chain, which in many countries is still informal, and consequently uncontrolled, despite its increased importance in terms of value and quantities consumed. This trend is shown in several European countries where the number of harvested wild boar has increased by up to 100% in the last 10-15 years (Massei et al, 2015).

9.9.3 EU food safety law for meat

Regulation (EC) No. 178/2002 establishes the general principles and requirements of European food law and lays down the procedures in matters of food safety. The aim of the so called European food law is to guarantee a high level of protection of human life and health and to allow the free movement of food within the whole EU. Although game meat is considered safe, and hygienic due to its natural origin, the supply chain is often characterised by risks.

Safety standards for game meats have been specified consequently by two Regulations; EC Regulation No. 853/2004 and No. 854/2004 which focus on food from animal origin including game meat. The basic requirement is that any meat sold to a wholesaler, processing companies or direct to consumers has to be traceable to source with skilled hunters being responsible for preparation and handling (EC regulation 853/2004, annex III, Sec. IV, Ch. 1. P. 1, 2). Ideally, the wild animal should be examined while alive by a trained person able to ascertain abnormal behaviour and pathological changes caused by disease, environmental contamination or other factors, which may affect human health. The carcass must then be processed in an approved game-handling establishment (AGHE) where a veterinarian inspects it and, if relevant, further analyses may be conducted. These regulations also apply to animals hunted in wild-like conditions and to farmed wildfowl. There are two exemptions to these rules, for hunters and primary producers.

Hunter exemption: Private consumption by hunters (and their families) is legal in every country, regardless of the way the carcass is handled. Game consumed by the hunter does not require the standard vet inspection to certify the sanitary conditions of the animal, required for meat destined to human consumption. Shooting for home consumption is a strong element of traditional hunting culture in many countries and restricts the supply of game meat onto commercial markets.

Primary producer exemption: A limited amount of meat, can be sold by hunters to a final consumer, or local retailers under an exemption, however rules on traceability have to be observed according to Regulation (EC) No. 178/2002, art. 3 by both trained hunters and local retailers. This exemption was proposed by Austria, UK and Italy mainly to preserve traditional direct sale from hunters to local retailers and consumers as certifying the traceability of the game meat is quite straightforward. In some instances, specific analysis can be requested before selling the meat although at least until 2014 there were no cases of infestation reported. The “limited amount” is defined at country level, with high differences between countries. Italy for instance limits to 1 ungulate per hunter per year or 500 animals per hunter per year for other species, while Austria refers to “small enterprises” with a threshold of 5.0 tonnes of boneless meat per week. There are several initiatives to encourage hunters to access direct marketing such as the Toscana Region (Italy) which provides guidelines for

hunters to sell local game meat directly to consumers.

9.9.4 EU food hygiene compliant supply chains

As a general indication, for field harvested wild animals, the first step is to perform evisceration and bleeding as soon as possible and before the carcass is transferred to the butchering facility. The inspection by a trained person of the carcass and of any viscera removed is necessary to avoid the risk of disease. Fresh carcasses with a good microbiological quality should be correctly cooled to avoid microbiological contamination and spoilage. Skinning, butchering and processing of the carcasses should be performed in an approved game establishment (AGHE), under veterinary control and the structure should undergo Hazard Analysis and Critical Control Point (HACCP) procedures.

In general, commercial abattoirs and butchery plants meet the required standards but often are not able or willing to take in game carcasses and they are in any case often remote from the forest. This lack of a compliant supply chain from shooting site (in the forest) to butchery plants is the main barrier to accessing commercial markets for game meat in many countries. This in turn can be a disincentive for culling, or reduces returns from hunting which can have a knock on impact on culling and hence damage levels. There are a number of different approaches to tackle these problems:

Italy has a very limited number of large slaughtering plants which can take in game carcasses, though the Pistoia Province (Tuscany, Italy) is piloting a network of dedicated slaughterhouses which conform to the EC regulation 852/2004 compliant AGHEs. These AGHEs will be distributed around the Province according to the numbers of carcasses expected and will be able to take in whole carcasses and eviscerate, bleed, remove skin and to fulfil the first steps of sanitary inspection (trained person available).

In **Latvia** there are few AGHEs and the hunters are struggling to sell enough meat to generate an income and are consequently killing fewer animals which in turn generate more damage to crops and trees. As shown in Case 9.6 one response to this has been to add value to non-food parts of the carcass i.e. the bristles and hide.

The annual cull of game in **Poland** is many times higher than that for Italy with most meat flowing into supply chains intended for export. Here, the response to the need for compliant supply to AGHEs resulted in a nation-wide network of AGHE compliant butchery plants which are able to take in carcasses 24 hours a day (see Case 9.7).

In the **UK**, most game is shot in areas remote from the road, let alone near to a commercial butchery unit. Here, based on pre-existing traditions of (private) estate game larders, the approach has been to develop mobile facilities to

AGHE standards to undertake the preliminary stages of carcass preparation with chilling to regulation temperatures prior to veterinary inspection and butchery either in the mobile unit or after transport to a commercial butchery plant. Guidelines for design of a compliant game larder have been prepared by the Deer Initiative (2008) and there are several commercial suppliers of both mobile and static containerised larders offering a range of sizes suitable for one or two to 15-20 carcasses. Although of limited dimensions, these structures do comply with the EC regulations for all the main characteristics; allowing hygienic treatment of the carcasses, avoiding wastage, recovery of liquid and solid wastage, and the refrigeration of carcasses.

Some administrations and wildlife management authorities have published guidelines concerning "proper practices" in carcass dressing and butchering (e.g. Winkelmayer and Paulsen, 2008 for Austria and Food Standards Agency, 2011 for UK).

9.9.5 Consumers' attitude towards game meat

Consumer's preferences with respect to game meat seem to be spread in different directions. Large differences across countries are influenced by culture, traditions, food habits, etc.. As an example a survey into the consumption of meat found that "… the majority in Scandinavia see venison very appealing, the opposite is the case in countries like The Netherlands, Britain and Italy" (Kjærnes et al. 2009). This is certainly due to different concepts of edible species, wild species and pets in different cultures. Tickle (2016) focuses attention on the differences between rural and urban communities, with the former being more supportive of hunters because of their closer contact with natural resources and wildlife for human consumption. Often game meat is supposed to be a sort of delicacy among traditional foods.

Hungarian culture, as well, presents very old traditions in which several recipes are devoted to the game meat and widely appreciated (Bodnar et al, 2014).

The attitude toward natural resources, however, can be interpreted in different ways. Some consumers have a strong positive attitude toward game meat consumption, due to its origin from natural areas which often implies the idea of safety and uncontaminated food. Bodnar et al (2014) found that Hungarian consumers involved in their survey about 90% considered game meat as healthy and an almost organic food. Similar investigation in Finland found that the purchased amounts of minced meat and pork have declined between 1998 and 2006, however the amounts of poultry, venison and other game meat have increased (Koistinen, 2010).

Statistics rarely seem to be available on consumption of game meat, and the only available survey was conducted among the members of the Slow Food movement, which shows that 49% of people in the sample consumed wild game meat (Ghione et al., 2013). This result is probably overestimated if it applies to the rest of the population, as adherents of this association are more interested in alternative and niche products than the rest of the population.

The safety of game meat, however, is often disputed by scientific contributors because of the presence of potentially toxic elements. This is the case of pollutants such as heavy metals that can concentrate along the food chain, and the possibility of human infection by several diseases (Ramanzin et al., 2010), even if this aspect seems to be widely unknown by consumers, as reported by Bodnar (2014) who found that only 2% of the respondents in the survey carried out were aware of this.

Other consumer groups, on the contrary, are against hunting activities *tout court* mainly for wildlife preservation and animal welfare and rights considerations, and consequently do not eat venison rejecting the concept of cruelty that hunting activities may imply. This was found to be the case in some studies that investigate the importance of labelling, referring to the area of origin in food attributes and the preference for organic and animal welfare-oriented food. The opinions on the subject are not unanimous, as shown by Tickle (2016) who mentions an increase of the popularity of the game meat as a consequence of the " … rising in organic and health trend."

The picture is even more heterogeneous if other traditions are taken into account, as shown by Peterson et al. (2010) that support the idea that hunting is a sustainable form of nutrition and "cruelty free" if compared with domestic animals killed in large slaughterhouses.

An important quantity of game meat is consumed out of a market structure by hunters and their families/friends often for free. Informal markets (black market) exist and trade a consistent amount of meat due to lack of slaughtering facilities and administrative procedure for hunters who want to sell an amount of meat exceeding the "limited amount" allowed by the EU regulations. In Italy, this problem required the attention of authorities and ended in sanctions on restaurants that were unable to show fiscal and sanitary documents certifying the origin of hunted meat offered to clients.

Food hygiene regulations deeply affect trade opportunities, since only compliant traders are allowed to sell meat products in the domestic and international markets. This is why organised groups of hunters that operate in countries that have invested in infrastructures can benefit from higher market margins, while informal relationships and hunters that are unable to guarantee hygienic and sanitary standards are excluded from the effective access to the market as potential suppliers. As an example, in Slovenia figures show one of the highest exported amount per capita. However, the market is highly concentrated since the raw game meat is sold to only one large company that acts as a monopolistic buyer (monopsony) and controls access to international markets. Conversely the investment in mobile game larders may pay off and be able to dominate legal markets for game at EU level. Indeed, there is apparently no problem in finding markets for UK red deer venison which is FSC certified as well as meeting game hygiene regulations.

Several countries, despite having a long tradition in wild boar hunting, seem to evidence a non-structured chain for the use of game meat. Both markets (official and unofficial) often show market asymmetries along the value chain related mainly to seasonality in the harvesting activities and storage facilities. Seasonality is due to the imposition of hunting seasons, while lack of refrigeration limits the time available to pass on the meat after shooting. Restaurants buy wild boar meat during the hunting season, and then cut and store the meat in freezers to have the raw material available for cooking all year round. Accordingly, hunters without storage facilities are forced to sell the meat over a very short period (few days) without the possibility of seeking added value solutions. Asymmetries, of course, largely occur in black markets where the absence of any kind of supply contracts or other institutional arrangements between hunters and clients (restaurants, guesthouses, etc.) relegate hunters to a marginal role.

Free rider behaviours sometimes emerge too. Hunters, for instance, often make a strategic use of their bag reports to local authorities, registering only a part of harvested animals, in order to be allowed to shoot year after year a higher number of heads.

Although game meat is the main product from wild boar hunts there are other products which are of value – but only if there is a market for them. Case 9.6 illustrates what is possible when an innovative entrepreneur takes on a problem as a challenge.

9.10 Forests and fisheries

On the ground there is a strong association between forests and water resources but this is often not reflected in jurisdiction where streams, rivers, lakes and their contents are often not the responsibility of the forest authorities. Thus, in many countries fish and other denizens of freshwater would not be considered as NWFP while in others where all resources within an area defined as forest is the responsibility of the national forest authority and thus fish are undisputedly a forest product.

9.10.1 Tenure and rights

The habitat for freshwater fish is regulated at EU-level by the Water Framework Directive (2006).

Rights to freshwater fish are essentially distributed in the same manner as for game. So if hunting rights are state-owned then fishing rights are usually also state-owned. However, ownership of water courses is treated in a variety of different ways from country to country. Using Mitchell et al. (2012) as a source we observe that there are several scenarios for ownership of water bodies:

- Larger bodies of navigable (floatable) water such as rivers and large lakes are owned by the state e.g. the Danube in Bulgaria, navigable rivers in Belgium and the ten largest lakes in Finland with smaller rivers being privately owned. Tenure of fishing rights follow ownership.
- All water features are state owned e.g. Estonia, Greece, Hungary, Italy, Lithuania, Poland (except for lakes completely enclosed by one landowner which are private), Spain (at regional level) and Turkey. In these countries fishing rights are owned by the state (at various levels) and usually leased to commercial companies, fishing associations or to joint owners of historical rights (as a common resource).
- All fishing rights belong to state though water courses can be privately owned as in Latvia.
- Water courses and fishing rights are all privately owned. As long as national goals and regulations are the basis for local management there is little interference from the state as is the case in Norway and Sweden.

In these four scenarios, fishing rights cannot be alienated from ownership of the land but fishing rights can be dissociated from ownership of watercourses or adjacent land as is the case in the UK and also possible in Germany.

Wild fish are most often managed by fishing associations or the state in areas defined by rivers or river basin with management and licensing organised along similar lines to those for other game animals.

Fishing is most often regulated under specific Fishing laws (Bulgaria, Czech Republic., Lithuania, Spain, UK) or Water Acts (Italy, Netherlands and Poland), and is the responsibility of Ministries for Agriculture and administered by Fisheries agencies. This means that although there are strong links between forests, water courses passing through them and downstream water bodies that there is a degree of dissociation between fisheries and forestry interests as noted in chapter 9.2. However, there are countries where fisheries are considered part of forestry and under the jurisdiction of forest agencies. For example, in Romania the Danube delta and its associated commercial fisheries are managed by Romsilva, and in Slovakia fishing some rights are assigned to the state forest enterprise. In Finland, a country which is 69% forest and lands the largest volume of freshwater fish of any European country (Newman 2014) fisheries are the responsibility of the Ministry of Agriculture and Forestry. Analogous with hunting areas, fishing rights are generally exercised within defined areas within which rights are leased, licensed or owned by fishing associations. These fishing areas are usually determined in relation to the distribution of water features and thus are usually defined in terms of river catchments or significant features such large lakes, estuaries or river deltas.

Dill (1993) concluded a FAO survey of European fisheries noting "Although the role of private fishing and ownership of fishing rights is decreasing in some areas, it still plays an important part in the inland fishing, both recreational and commercial, of many European countries. There is, however, a tendency for placement of the control of the inland fisheries in the hands of the State. There is also a tendency to rely more on the new State environmental agencies rather than the older or better established fishery agencies which in many maritime nations are dominated by marine administrators." This situation hasn't changed over the past 20 years and Mitchell et al. (2012) found that many countries had little or no data on inland fish catches and besides countries with significant commercial fisheries (sea, major river or large lakes) the inland fisheries sector is largely neglected (it is not included in the Common Agricultural Policy) (Newman 2014).

A notable exception is the EU-wide management plan for the European eel (Council Regulation (EC) No 1100/2007) which requires member states to identify eel basins and prepare management plans and to requires escapement (not caught) of 40% of adult eels to the sea and that 60% (since 2013) of the catch of glass eels (immature returning eels) should be reserved for restocking within the EU (Newman 2014). Eels do spawn in forest streams and ponds so this will have an impact on the ecology of forest waters (e.g. the project restocking steams in the Forest of Dean with glass eels in UK).

9.10.2 Commercial inland fisheries

The total annual catch of freshwater fish in Europe was estimated as 35 000 tonnes in the year 2007/8 which represents 1% of all fish products (99% from the sea) (Newman 2014). Nevertheless, freshwater fish catches are significant for a small number of countries, namely; Finland (4 498 tonnes), Romania (4 284 tonnes) and Italy (3 915 tonnes). In terms of value the total EU catch is estimated to be worth 100-110 million euro at first sale in 2007/8. Interestingly the league table of the value of fish catches is topped by the Netherlands, Germany and France with Finland in fourth place and Romania in tenth. This discrepancy is due to commercial fishers targeting the more lucrative species so lower volumes result in high values in western Europe while in eastern countries, less valuable species are targeted and caught in greater volumes to supply the domestic markets (Newman 2014).

In order to relate this trade and activity to forests, it is notable that the top producers of freshwater fish are countries with high forest cover where fisheries are more closely integrated with forest land use and administration (e.g. Finland, Romania, Germany and France). What proportion of these fish are sufficiently associated with forests to merit being called NWFP is unknowable.

Dill (1993) summed up his review of European inland fisheries with the observation that commercial fisheries based on wild species are in decline. This is a consequence of shifts from fish as a source of subsistence or livelihoods to a recreational and social activity and also of increasing use of aquaculture. Newman (2014) some 20 years later suggests these processes continue to erode commercial fishing and that this is exacerbated by poor representation of commercial fishing interests with only two countries (Finland and France) having national representative bodies for inland fishermen.

9.11 Beekeeping in the forest

Although bees are not confined to forests they are strongly associated with trees and forests. This is because hives are often located on forest land even if they are not under the trees and the bees often depend on trees for forage especially in the spring (e.g. sycamore) or trees are the source of nectar for speciality honeys such as lime (*Tilia*), acacia and pine (via honeydew collected by *Marchalina hellenica* aphids) honey. Internationally honey is considered an important NWFP (Bradbear 2009) and is recognised as an important NWFP in Europe, particularly in Mediterranean countries, e.g. Turkey.

9.11.1 Legislation

Beekeeping in several countries was reported in the Common survey as being governed by specific law on apiculture (e.g. Morocco, Italy and Bulgaria). In most other European countries, beekeeping provisions are contained with agricultural legislation though in some countries such as Slovenia beekeeping is included in Forest law. Within the EU there are various pieces of legislation related to beekeeping such as Regulation (EU) No 1308/2013 of the European Parliament and of the Council establishing a common organisation of the markets in agricultural products. This particular regulation is mostly concerned with providing a basis for EU support for national apiculture programmes under the Rural Development Programme. The national apiculture programmes mainly deal with technical assistance to beekeepers, containment of Varroa (*Varroa destructor*, a parasitic mite which attacks, weakens and can infect bees with dangerous diseases), rationalisation of the seasonal movement of hives, analysis of honey, restock of hives and provisions for applied research. None of this relates to the legal status of bees as wild animals, ownership of wild bees or indeed measures to protect the genetic integrity of the indigenous bees of Europe (see Case 9-6). Past EU legislation (EU Regulation 1804/99) did encourage the use of local races of bees but this has not been carried through in a consistent manner in later legislation (De la Rúa et al 2009).

9.11.2 Beekeeping

Of the 600 bee species in Europe, only one: *Apis mellifera* has been domesticated and is reared and kept to produce products principally honey, beeswax, pollen, propolis, royal jelly etc. and to provide pollination services for a wide range of orchard and field crops. There are two aspects to the production of honey; the management of the bees themselves and the placement of hives to take advantage of different nectar sources.

Beekeeping is highly skilled and remains a largely traditional, hands-on activity with high numbers of participants across Europe. Across Europe Chauzat et al. (2013) estimated there were about 620 000 beekeepers in 2010 who between them manage some 13.8 million bee colonies (hives). The majority (76.4 %) were hobbyists with small numbers of hives (<50), 15.1 % were part-time beekeepers with 50-150 hives and only 9.3% identified as professional beekeepers though only 2% had more than 300 hives. There is significant variation in the profile of beekeepers from country to country with the UK having the largest number of hobbyists with an average of five hives each with the largest apiaries in Greece, Italy and Romania. Across Europe the average productivity per 100 colonies is 1.6 tonnes and per 100 km² is 4.8 tonnes. However, production is highly variable ranging from 0.5 to 4 tonnes per 100 colonies and 0.4 to 19.8 tonnes per 100 km² between counties both as a function of climate (it is lower in northern countries), history and current beekeeping culture.

There is some innovation in breeding controls and technology such as scanners and GPS systems to track bee activity but these are not yet in widespread use. The main concern of beekeepers is the control of pests (e.g. *Varroa*) and diseases (e.g. foulbrood and colony collapse disorder) resulting in a general decrease in the number of colonies. However, this may only partially be attributed to disease as climate will also have an impact on bee mortality while declining rural populations also have an impact on the numbers of beekeepers.

The other aspect of beekeeping is the siting of hives in areas with plentiful bee fodder. In many areas bees are moved seasonally to provide pollination services for orchards and crops such as oil seed rape. Hives may also be moved to higher altitude wild flower meadows in the spring, into the forest when the chestnut trees are flowering, onto the moors for heather and into conifer forests for pine honey. Mono-floral honey commands the highest prices and some, such as Manuka honey from New Zealand is used medicinally. Recent work in the UK (Hawkins 2015) found similar levels of antibacterial activity in honey derived from woodruff (*Galium odoratum*), bluebell (*Hyacinthoides non-scripta*) and dandelion (*Taraxacum officinale*). This is perhaps not such a surprise as honey has been used medicinally for thousands of years but it does enable the more formal use of honey in modern medicinal practice. Within Europe the most formal inclusion of beekeeping in forest management is in Turkey as illustrated in Case 9.9.

CASE 9.9: Honey forests in Turkey

Beekeeping is a traditional activity in all parts of Turkey and the country is the second largest global exporter of honey (after China). Production in 2012 was 89,162 tonnes estimated to be worth US$ 300 million. Beekeeping is a rural activity with around 150,000 households involved in honey production with 10% of these being full time beekeepers, 30% having honey as a significant part of their income and the remainder 'hobby' producers. Honey production is strongly associated with forests with 85% of hives are sited in or near open areas within forest.

Forest honey production in Turkey is from: nectar and pollen from flowering trees (e.g. lime (*Tilia* spp), chestnut (*Castanea sativa*) and *Robinia*), forest understorey shrubs (e.g. heather (*Erica arborea*), thyme (*Thymus* spp) and rock rose (*Cistus* spp)) and honeydew exuded by the sap-sucking aphid *Marchalina hellenica* on Pines (*Pinus* spp.). Pine honey accounts for 25% of honey production in Turkey and is of particular interest as this represents 92% of global pine honey exports and commands a premium price. The *Pinus brutia* forests of Mugla Province accounts for 80% of Turkish pine honey production. Specific actions to protect this production included the 2006 listing of *M. hellenica* on the European and Mediterranean Plant Protection alert list and the reservation of 13,204.5 ha of *P. brutia* forest for honey production.

Figure 9.12: *Honey Action Plan for Turkey formalises measures for beekeeping*

The significance of honey as a useful source of income for rural communities was formally recognised in 2010 with the introduction of a suite of measures designed to facilitate honey production. These measures included a waiver on charges for siting beehives in the forest on condition of a commitment to not harm the forest and the establishment of 'Honey forests' where forest management would favour honey production and programmes of education for beekeepers in bee improvement and honey production processes.

Average annual production in Turkey is 16-17 kg per hive which is somewhat lower than the global average of 20-22 kg per hive which suggests that there is scope to improve production. Bee improvement is part of this but is often equated with introduction of commercial bees but in order to protect the high diversity of wild bees in Turkey bee farmers are encouraged to breed bee species native to their region rather than commercial bees.

For the period 2013 to 2017 these actions were collected together into the Honey Action Plan (Figure 9.12) which formalises actions and sets targets. Among these actions are:

- Listing of 50+ species of bee fodder plants
- Inclusion of bee species in afforestation programmes
- Education programmes for beekeepers
- Designation of Honey forests

9.11.3 Trade in honey and bee products

Honey and bee products (pollen, propolis, royal jelly and beeswax) are treated at EU level as agricultural products (https://ec.europa.eu/agriculture/honey_en). Statistics are quoted for all apiculture and it is difficult to disentangle the component which could be termed 'forest' or 'wild' honey. However, in many of the countries with high honey production (RO, ES, HU, DE, IT, GR, FR and PL Figure 9.13) the bees are the native strains and forest cover is high so much of the honey can be assumed to be 'wild forest' honey.

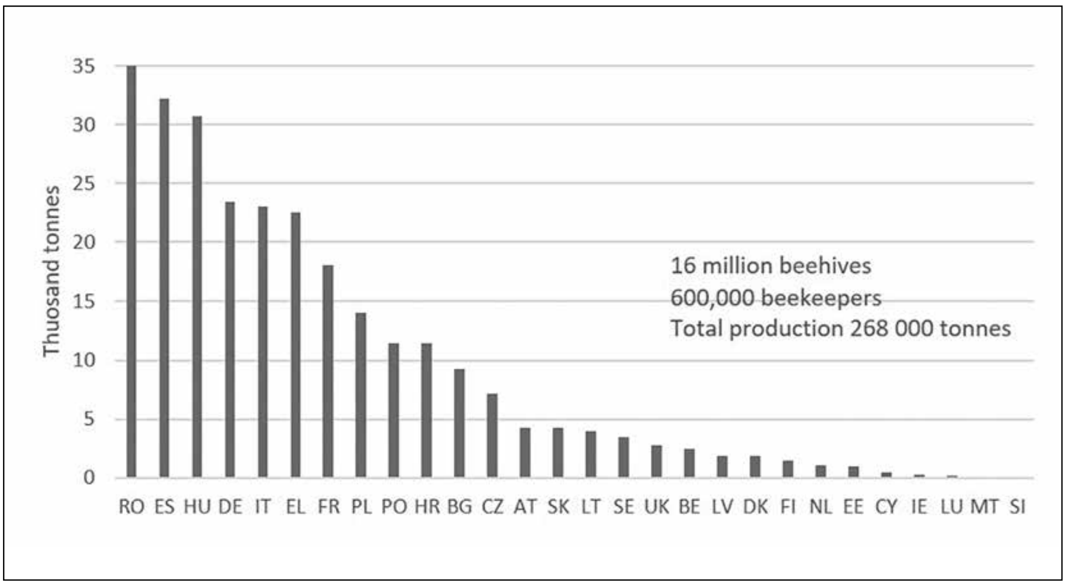

Figure 9.13: *EU honey production (Source https://ec.europa.eu/agriculture/honey_en and Member States' national apiculture programmes)*

As a block the EU is both the world's second largest honey producer and a net importer of honey mainly from China (50% of imports) but also from Ukraine and Latin America as domestic production only covers around 60% of consumption. Supply chains for honey are complex and an intimate mix of home use of small quantities by "hobby" beekeepers, small scale income diversification through local sales through markets and shops by those with a few hives (up to 20 hives) to part-time commercial enterprises (20-300 hives) large scale production by specialist beekeepers with more than 300 and up to 1000s of hives. This diversity was reflected in the Common survey responses as shown in Table 9.4.

Table 9.4: Markets for national production of honey in some European countries

Country	**Mass Market**	**Small Scale Enterprise**	**Personal consumption**
Austria			
Bulgaria			
Czech Republic			
Germany			
Hungary			
Iceland			
Italy			
Lithuania			
Morocco			
Netherlands			
Switzerland			
United Kingdom			

Honey is a highly differentiated product and there are specialities based on location and also the sources of nectar e.g. chestnut honey, pine honey, borage honey etc. Demand for local, speciality honey is high and attracts a considerable premium with a wide range in prices. EU (2016) report prices for multi-floral honey across the EU ranging from € 2.54 per kg in Poland sold in bulk to wholesalers to € 15.18 per kg for honey sold at the site of production in the United Kingdom. Even within the UK there is significant price differentiation with a 2014 survey revealing prices for local speciality honey ranging from € 12.30 per kg to € 36.70 per kg. This means that a beekeeper who can package honey to food quality standards can make a good return on sales into local markets. However, as production increases local markets can become saturated, packing by hand may no longer be efficient, branding is required etc. all of which can be barriers to scaling up incomes.

In the UK the Honey First co-operative was started in 1995 when British honey prices were so low that it was barely worth producing. Nestlé through its ownership of Gales Honey a UK packer sponsored the co-operative and bought, packaged and sold the co-operatives' honey branded as "Honey First". Among other customers Honey First used to supply the National Trust shops but when the honey market started to improve, the National Trust started to source its honey from local suppliers. Increases in prices for British honey also meant that the beekeepers found they could jar and sell their honey at a reasonable price to local markets without the need for the co-operative. With reduced volumes going through the co-operative and the loss of the supportive relationship with Gales honey when it was sold by Nestlé to Premier Foods resulted in the closure of the co-operative in 2014.

Wholesale prices are so much lower than local market prices that production for mass market needs to be on a very large scale involving hundreds of hives to generate sufficient income to make the venture profitable. This results in two rather distinct supply chains, small, local and socially orientated versus regional, large and financially orientated with relatively few links between them. The smaller enterprises also add value by offering artisanal honey-based products such as soap, candles, honey sweets etc., sale of bee equipment and offering training courses.

9.12 Understanding animal NWFP

Animals are an integral part of forests. Historically hunting, fishing and beekeeping all provided essential provisions for local people; meat, other foodstuffs, furs, medicines, wax, glue etc.. In the modern world these all provide opportunities for NWFP as 'gourmet' food products, traditional foods and crafts and as the basis for tourism and experiences.

As has been shown in this chapter, in many jurisdictions wild animals have a distinct legal status and belong to no-one or the state which puts them at risk of the 'tragedy of the commons'. These risks are mitigated through overlapping regulations derived from both EU conservation regulations and local and national hunting regulations.

Wild animals are considered as one of the dominant drivers affecting forest health in Europe (Forest Europe 2015), imposing threats to forest reproduction processes and affecting species´ composition of forest ecosystems. However, it can be argued that this is a consequence of the removal of large predators which would naturally keep herbivore numbers in check and the need for culling to replace lost predators is not the 'fault' of the game or nature but created by imbalances created by man. Nevertheless, in the absence of large predators, the main control on the population levels of wild animals is hunting which is naturally done to satisfy the hunters' demand for game meat, pelts, trophies and increasingly, recreation. In many cases, hunting levels naturally arising from market demands for these products is insufficient to keep populations levels low enough to limit wildlife damage to levels considered acceptable by other land users. There are also incidents where the operations of other land users can damage the interests of the hunters (e.g. forestry felling).

Current national official hunting statistics on hunting season, hunting grounds, hunters and hunting bags are not comparable across Europe and efforts to harmonize this information should be taken. First, a unified list of all the species effectively hunted in Europe every year is needed. Then consensuses of reference definitions of the main variables have to be reached. Also a common protocol to collect new data should be available. Finally, in order to keep a consistent, large data series in every country a bottom-up approach using existing method designs is recommended for harmonizing international reporting. Different methods and functions to transform every country variable to the reference definitions and methods should be fitted. With some effort and with every country taking care of their own statistics, there is a potential to develop harmonized hunting sector estimations in the future.

Management plans for game therefore result from an explicit or implicit trade-off between the needs of conservation to maintain protected species, hunters' desire for strong populations and high quality trophies as well as needing to balance timber and agricultural production with game populations which are antagonistic. Balancing the diverse land-use interests of an array of stakeholders is a challenging task especially concerning wild animals which roam freely across ownership boundaries. In order to meet multiple objectives across sectors and interest groups there are only a few concepts available that are applied in most European countries in line with contemporary national and international policies:

- Voluntary co-operation between multiple owners
- State control (wildlife or conservation departments)
- Arrangements whereby responsibility for game is transferred to hunters via a requirement for hunters to compensate farmers/foresters for damage caused by populations allowed to get larger than agreed population levels

How far these provisions for animal conservation and hunting are integrated into forest management depends to a large extent on the extent to which responsibility for conservation, forestry and wildlife are separated. In some countries, all three aspects are governed by a single agency (e.g. Romsilva in Romania) and integration is good. In others, responsibility is divided between agencies and integration may only be at the level of honouring statutory obligations. It is rare that authorities will be antagonistic but it is often the case that civil society in the form of NGOs, forest owners' and hunters' associations will seek to influence management plans to favour their point of view or oppose actions which they consider damaging to their interests be this conservation of an endangered species, re-introduction of a predator or increased culls for browsing animals. Negotiation between these divergent interests is a feature of animal-forest planning in many countries and trade-offs are often required. Sometimes these trade-offs are managed by national regulation e.g. requirements that damage does not exceed an agreed threshold and for others it is a matter of local debate and accommodation at site level. Unsurprisingly, stakeholders often come into conflict regarding the management and use of game. These conflicts are often multidimensional in nature and mix of social, cultural elements in addition to the optimization of co-production of timber and game. Sometimes the question is about the competing land-use alternative, however in all the cases examined in this chapter a co-existence between apparently competing production interests can be reached in ecological terms. However, the social, cultural and psychological aspects of the conflict are much more difficult to solve.

Very often the results of conflict resolution fall short of a considered approach to co-production which is perhaps best expressed by owners of forest who are also hunters as is often the case in larger private hunting estates where game production is integrated into landscape scale habitat management which usually includes at least some commercial forestry. Full integration of game into forest management is also the norm in multi-functional forests and agroforestry systems (e.g. wild boar under cork oak in Portugal and Spain).

Timber production is often seen by foresters as the primary product from a woodland but there are several examples where production of animal NWFP is of higher priority. Notable cases of this are the honey forests of Turkey and the woodlands turned over to pheasant rearing in England. However, such cases are relatively rare.

Wild meat is inherently expensive compared to domestic stock as it is difficult to reduce costs of hunting and preparing carcasses in remote forests. Nevertheless, there are problems in securing markets for wild meat which derive from both the difficulties of meeting EU food hygiene regulations, the informal nature of game markets and the cultural perception of hunting as a subsistence activity.

Entry into official markets starts with carcass processing from shooting to the butchering facility. There are guidelines and some supply chain innovation to implement “proper practices” in carcass dressing and butchering such as establishment of special facilities including mobile butchery units. From an EU perspective, the origin of the product is the first requirement of information to assess traceability, and consequently safety of food products. In the specific case of game meat, the geographic origin is an indicator of possible uptake of contaminants (from polluted areas), and the likelihood of risk of infectious and/or parasitic diseases. Regional variation in the occurrence of animal, or zoonotic diseases requires continuous monitoring of the health status of wild and domestic animals to reduce the risk of expansion of these disease.

As for European consumers’ attitude toward game meat, a wide range of different behaviours appears: in some cases game meat is a “special meal“ perceived to be elegant and refined and offered in the menus of restaurants often specialised in such kind of preparations. Others consumer groups have preference for a food that comes from natural areas and not from the intensive animal breeding; these consumers associate game meat to an idea of “natural and, accordingly, safe” making the equation: natural equates to safe.

Evidences of a non-structured chain (beside official markets) appear in several countries, even in those that have a long tradition in wild boar hunting and eating; those unstructured chains are often characterised by market asymmetries and free rider behaviour.

9.13 References

Andersen R., Lund E., Solberg E.J. & Sæther E. 2010. Ungulates and their management in Norway. Pp. 14-36 in: Apollonio M., Andersen R. & Putman R. (eds) European ungulates and their management in the 21st century. Cambridge.

Apollonio, M., Andersen, R., Putman, R., 2010. European Ungulates and their management in the 21st century. Cambridge University Press

Ayan S., Ayan Ö., Altunel T. & Yer E.N. 2015. Honey forests as an example of agroforestry practices in Turkey. Forestry ideas 20(2): 141-150.

Bartoš L. 2009. Sika deer in continental Europe. Pp 573-594 in: McCullough D.R., Takatsuki S. & Kaji K. (eds) Sika deer: Biology and management of native and introduced populations. Springer.

BASC Undated. Economic and environmental benefits of lowland game shooting in the UK. British Association for Shooting and Conservation, Wrexham, UK.

Bodnar K., Szel Hodi M., Skobrak Bodnar E. 2014. Acceptance of the meat of wild ungulates among the Hungarian consumers, Agronomy Series of Scientific Research / Lucrari Stiintifice Seria Agronomie, Vol. 57 Issue 1, p35-39

Boitani et al. 2015. Key actions for large carnivore populations in Europe. Institute of Applied Ecology (Rome, Italy). Report to DG Environment, European Commission, Bruxelles.

Bouriaud L. & Schmithüsen F. 2005. Allocation of property rights on forests through ownership reform and forest policies in Central and Eastern European countries. Schweiz. Z. Forstwes. 156(8)

Bradbear N. 2009. Bees and their role in forest livelihoods: A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products. Non wood forest products 19. FAO, Rome. http://www.fao.org/3/a-i0842e.pdf

Chauzat M.P., Cauquil L., Roy L., Franco S., Hendrikx P. & Ribière-Chabert R. 2013. Demographics of the European Apicultural Industry. PLOS One 8(11): e79018. https://doi.org/10.1371/journal.pone.0079018

Cirelli M.T. 2002. Legal trends in wildlife management. FAO legislative study 74. FAO, Rome.

Dana, L. P., & Åge Riseth, J. 2011. Reindeer herders in Finland: Pulled to community-based entrepreneurship and pushed to individualistic firms. The Polar Journal, 1(1), 108-123.

De la Rúa P., Rodolfo Jaffé R. Dall'Olio R, Muñoz I. & Serrano J. 2009. Biodiversity, conservation and current threats to European honeybees. Apidologie 40(3): 263 – 284. DOI https://doi.org/10.1051/apido/2009027

Deer Initiative 2008. Carcass larder design. England & Wales best practice guides. The Deer Initiative, Wrexham, UK. http://www.thedeerinitiative.co.uk/uploads/guides/139.pdf

Dill W.A. 1993. Inland fisheries of Europe. EIFAC Technical Paper no. 52 Suppl. FAO, Rome. http://www.fao.org/docrep/009/t0798e/T0798E00.htm#TOC

Dowie, M. 2011. Conservation refugees: The hundred-year conflict between global conservation and native peoples. MIT Press.

EU 2016. Report from the Commission to the European Parliament and the Council on the implementation of the measures concerning the apiculture sector of Regulation (EU) No 1308/2013 of the European Parliament and of the Council establishing a common organisation of the markets in agricultural products. Brussels, 7.12.2016 COM(2016) 776 final. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0776&from=EN

EU Food and Veterinary Office 2015. Final report of a mission carried out in Romania from 04 May to 08 May 2015 in order to gather information on bee health and restriction on use of certain plant protection products. Ares(2015)3692321 – 08/09/2015.

Filteau, M. 2012. Deterring Defiance: Don't Give a Poacher a Reason to Poach. Journal of Rural Criminology, 1: 236–55.

Food Standards Agency 2011. The wild game guide. A guide to the hygiene regulations for people who shoot wild game and supply in in-fur or in-feather or as small quantities of wild game meat. Food Standards Authority, UK. https://www.food.gov.uk/sites/default/files/multimedia/pdfs/wildgameguide0611.pdf

Forest Europe 2015. State of Europe's forests 2015 report.

Ghione J., Matarrese A.M., Ponzio R. & Sardo P. 2013. Meat Consumption and Animal Welfare: A Survey of European Slow Food Members. Slow Food & Slow Food Foundation for Biodiversity.

Gill, C. O. 2007. Microbiological conditions of meats from large game animals and birds. Meat Science, 77, 149–160.

Górecka J. & Oksana B. 2012. Market of venison meat in Poland. http://cyberleninka.ru/article/n/market-of-venison-meat-in-poland.pdf

Hawkins J. 2015. Investigating antibacterial plant-derived compounds from natural honey. PhD thesis, Cardiff University. http://orca.cf.ac.uk/77005/1/2015HawkinsJphd.pdf

Hellström, E. 2001. Conflict cultures: qualitative comparative analysis of environmental conflicts in forestry Silva Fennica monographs 2. Finnish Society of Forest Science, Helsinki, Finland. 109 pp.

Herruzo AC, Martínez-Jáuregui M. 2013. Trends in hunters, hunting grounds and big game harvest in Spain. Forest Systems 22 (1): 114-122.

Kjærnes U., Bock B.B., Roe E., Roex j., 2009. Consumption, Distribution and Production of farm animal Welfare, editors, Welfare Quality Reports n. 7

Köhl M, Traub B, Päivinen R. 2000. Harmonisation and standardisation in multi-national environmental statistics – mission impossible? Environ Monit Assess 63:361–380. doi:10.1023/A:1006257630216

Koistinen L., 2010. Consumers relative preferences for meat attributes and the impact of carbon footprint information on consumer choice, Aalto University – School of Economics, Master's Thesis

Li Y., 2014. Improve FAOSTAT data on NWFP: Game meat and mushroom. Presentation to UNECE/FAO Meeting of team of specialists on forest products statistics. Geneva, Switzerland, June 16th 2014. https://www.unece.org/fileadmin/DAM/timber/efsos/general/2014jwpfsem-item5a-ii-b-nwfp.pdf

Martínez-Jauregui M, Arenas C, Herruzo AC. 2011. Understanding long-term hunting statistics: the case of Spain (1972-2007). Forest Systems 20(1): 139-150

Massei G, Kindberg J, Licoppe A, Gačić D, Šprem N, Kamler J, Baubet E, Hohmann U, Monaco A, Ozoliņš J, Cellina S, Podgórski T, Fonseca C, Markov N, Pokorny B, Rosell C, Náhlik A.et al, 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. Pest Management Science 71(4): 492-500.

Matilainen, A. & Keskinarkaus, S. (eds.) 2010. The Social Sustainability of Hunting Tourism in Northern Europe. University of Helsinki, Ruralia Institute Reports 59. 111 p. 2010.

Membré, J. M., Laroche, M., & Magras, C. 2011. Assessment of levels of bacterial contamination of large wild game meat in Europe. Food Microbiology, 28, 1072-1079.

Mitchell M., Vanberg J & Sipponen M. 2012. Commercial inland fishing in member countries of the European Inland Fisheries Advisory Commission (EIFAC): Operational environments, property rights regimes and socio-economic indicators. Country profiles. FAO, Rome. http://www.fao.org/3/a-an222e.pdf

Mustin K., Newey S., Irvine J., Arroyo B. & Redpath S. Undated. Biodiversity impacts of game bird hunting and associated management practices in Europe and North America. Contract report. The James Hutton Institute. http://www.hutton.ac.uk/sites/default/files/files/RSPB_ReportFINAL_Covers.pdf

Newman S. 2014. Inland fisheries and the common fisheries policy. Note. European Parliament. IP/B/PECH/IC/2013-097. PE 514.001. http://www.ieep.eu/assets/1346/Inland_Fisheries_and_the_Common_Fisheries_Policy.pdf

PACEC 2014. The value of shooting: The economic, environmental, and social benefits of shooting sports in the UK. Public and Corporate Economic Consultants. Cambridge, UK.

Pasko S. & Goldberg J. 2014. Review of harvest incentives to control invasive species. Management of biological invasions 5(3): 263-277.

Peterson M., Hansen, H., Peterson, M. & Peterson, T., 2010. How Hunting Strengthens Social Awareness of Coupled Human -Natural Systems. Wildlife Biology in Practice [Online] Vol. 6, No. 2, p. 127 -143.

Pohja-Mykrä, M. 2016. Felony or act of justice? – Illegal killing of large carnivores as defiance of authorities, Journal of Rural Studies, Vol 44: 46-54.

Putman R. 2011. The governance of hunting and game management. Pp. 54-79 in: Putman R., Apollonio M. & Andersen R. (eds) Ungulate management in Europe: Problems and practices. Cambridge Press.

Ramanzin M., Amici A., Casoli C., Esposito L., Lupi P., Marsico G., Mattiello S., Olivieri O., Ponzetta M.P., Russo C., Trabalza Marinucci M., 2010. Meat from wild ungulates: ensuring quality and hygiene of an increasing resource, Italian Journal of Animal Science 2010; volume 9:e61

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., ... & Gutiérrez, R. J. 2013. Understanding and managing conservation conflicts. Trends in Ecology & Evolution, 28(2), 100-109.Reiger, John F. (2000) American Sportsmen and the Origins of Conservation. 3rd ed. Corvallis: Oregon State University Press.

Rewilding Europe. 2017. https://www.rewildingeurope.com/about/what-is-rewilding/

Robertson P.A. 1992. Woodland management for pheasants. Bulletin 106. Forestry Commission. Edinburgh, UK.

Sales, J., & Kotrba, R. 2013. Meat from wild boar (Sus scrofa L.): A review. Meat Science, 94, 187–201.

Scottish Natural Heritage 2016. The Deer Management in Scotland: Report to the Scottish Government from Scottish Natural Heritage 2016. http://www.snh.org.uk/pdfs/publications/corporate/DeerManReview2016.pdf

Smith J. 2010. Send a goat – are we overlooking the value of feral goats? ECOS 31(2): 49-59.

Tickle L., 2016. An Exploration of Hunting in Modern Society, Swedish University of agricultural Sciences, Department of Urban and rural Development, Master Thesis

Vacik, H; Wolfslehner, B; Huber, P & Ruprecht, H. 2014. Analysis of Non Wood Forest Products and Forest Services in Sustainable Forest Management. AUSTRIAN J FOR SCI. 2014; 131(3): 147-169.

Von Essen, E., Hansen, H. P., Källström, H. N., Peterson, M. N., & Peterson, T. R. 2015. The radicalisation of rural resistance: How hunting counterpublics in the Nordic countries contribute to illegal hunting. Journal of Rural Studies, 39, 199-209.

Wawrzyniak P., Jędrzejewski W., Jędrzejewski B. & Borowik T. 2010. Ungulates and their management in Poland. Pp. 223-242 in: Apollonio M., Andersen R. & Putman R. (eds) European ungulates and their management in the 21st century. Cambridge.

White, R. M., Fischer, A., Marshall, K., Travis, J. M., Webb, T. J., Di Falco, S., ... & Van der Wal, R. 2009. Developing an integrated conceptual framework to understand biodiversity conflicts. Land Use Policy, 26(2), 242-253.

Winkelmayer R. Paulsen P. 2008. Direct marketing of meat from wild game in Austria: A guide to good practice according to Regulations (EEC) 852 and 853/2004 Fleischwirtschaft 88 :122-125

Woodroffe, R., Thirgood, S., and Rabinowitz, A. 2005. The impact of human-wildlife conflict on natural systems. In R. Woodroffe, S. Thirgood, and A. Robinowitz (eds.). People and wildlife: Conflict or coexistence? Cambridge: Cambridge University Press.

10 Conclusions

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10.1 Conditions for NWFP management

Non-wood forest products (NWFP) are important goods provided by forests. NWFP comprise a group of products derived from mushrooms and truffles, understory plants to tree products in many forms, but also including animals and animal products that are sourced from the forest. These diverse products in turn require a distinct set of ecological conditions for successful growth, conditions that can be modified by natural and man-made processes. Many of these products are naturally occurring and wild harvested, many can be encouraged and some are artificially cultivated within the forest utilising targeted silvicultural treatments for their promotion. They are used on a personal level to enrich a person's diet, their collection is frequently utilised as a form of recreation and social interaction or as an opportunity to generate income. The trend within forest policy is increasingly moving towards multi-purpose forest management in Europe, which further encourage the production, collection and use of NWFP. The common right to collect and use NWPF from the forests plays an import role here. The possibility to collect mushrooms, chestnuts or other products can influence the recreational value of a forest. Therefore, tree species with a non-timber use, planted along forest paths and roads could provide an additional service for forest visitors.

The ecological requirements for the management of NWFP are as broad as the variety found between species. Some demand special ecological requirements for the growth, while others have a more generalist survival strategy. The conditions can be influenced by tree species mixture and density, stand age, site aspect, slope, soil composition and external influences such as applied management (or lack of) or disturbance events. The application of a silvicultural treatment will alter forest floor conditions in terms of light, temperature and moisture, these variables are affected by the degree of canopy cover, harvest intensity, slash disposal approach and timber extraction method and can be influenced by the rate of consequent understory growth. The ecological conditions required for NWFP derived from an animal origin are somewhat different as animals are mobile and will have differing requirements either on an annual or seasonal basis.

The identification of NWFP involves the assessment of particular products, but within Europe there are several differences in regulations and demands. NWFP are predominantly sourced from natural and semi-natural forests but also from forest plantations and alternative production systems aiming for combined production goals such as agroforestry. NWFP might be due to under- or over-exploitation, depending on the availability of alternative technologies and various regulations. Therefore the habitat or production system can be threatened resulting in the loss of jobs or habitat or alternatively resulting in a legislation to protect the resource from further damage.

The range of required site conditions and natural and non-natural disturbances are as wide as the products themselves, with large disparities between direct (i.e. tree borne) NWFP and indirect derived products, further separated between plant and fungal kingdoms, that are somewhat static and reliant on consistent optimal conditions and the animal domain where a temporal dimension is required when considering ecological suitability. In conclusion there are vast differences in ecological requirements of NWFP, attributed to the life strategy of the derivative species. We have explored the differences between product groups and the critical differences between them. Ultimately for the successful growth and culture of desired NWFP an appropriate set of conditions must be present for individual species; this may hang on wider location or more specific microsite conditions, but may also be modifiable through management activities targeting the forest canopy or understory.

For the combined production of NWFP with other products and services several options can be identified. The exploitation of tree products in general can be compatible, complementary or competitive with regard to timber production as main management goal. The co-production of timber and tree products therefore may require adaptions in stand composition, structure, rotation length, or thinning regimes. It is a challenge to increase total value production by additional efforts to increase production of NWFP without major losses in other forest products. For example the commercial net value of mushrooms and truffles can be much higher than the economic profit obtained from wood assortments in low productive forests.

10.2 Importance of NWFP

The importance of NWFP as commercial resources is documented by the country data on NWFP production published in the State of European Forests 2010. With an overall market value of € 785 million the ornamental plants are the most important category of NWFP, second most important category are food plants worth € 490 million and other plant products valued at 346 million Euro. The data illustrate that commercial NWFP are primarily ornamental products and forest foods rather than industrial products. This indicates that NWFP in Europe are increasingly valued for their experiential value rather than the commodity value. However, these data should be considered as indicative as they reflect differences between the countries in officially registering NWFP production in their statistics. Additionally the importance of non-wood tree products is strongly related to the regional context. Christmas trees, chestnuts, resin, pine nuts, birch products, acorns and cork can be listed as the most relevant products in Europe. Christmas trees are of particular relevance in central Europe, chestnut production is mainly enforced in Mediterranean countries (e.g. Italy, Greece, Portugal, Spain, Turkey) similar to the resin production. Birch products are important for northern Europe while pine nuts and cork are typical Mediterranean products again.

Approximately 12,500 fungal species of macrofungi grow in Europe, which means that fungal species richness is higher than in the case of animals or plants. Fungal fruit bodies have been traditionally used by man all over the world, whereas more than 1,100 fungal species are consumed as food or medicine. Wild edible mushrooms represent a significant growing dietary supplement for many European populations and an important marketable product for rural economies in many countries. Black truffle (*Tuber melanosporum*) is of high interest due to its economic value and there is a progressive shift of its production from natural forests to cultivated agroforestry systems. The edible commercial fungal species most studied from a silvicultural perspective have been the Boletus edulis group and Lactarius delicious group. They represent the most valuable and traded mushroom species worldwide.

A wide range of products and goods can be derived from understory plant species. Examples of NWFP from the understory include products that are used as food and food additives (herbs, spices and condiments, aromatic plants), fibres (used in construction, furniture, clothing or utensils), and for medicinal, cosmetic or cultural purposes. Forest berries (*Vaccinium myrtillus* L. (Bilberries), *Vaccinium vitis-idaea* L. (Cowberries/Foxberries), *Rubus* sp. (Blackberries) and *Fragaria vesca* L. (Wild strawberry)) are the most popular category among the edible plant species in Northern and Southern Europe. The majority of the NWFP of the understory are wild harvest from the forests and only few of them are cultivated. The importance of these products is highly related to socioeconomic factors. In less economically developed rural areas they can be a source of income, while in economically favourable regions they can be a recreational activity for stress-reducing.

Products derived from forest animals are game meat and honey but also includes non-food items such as trophies, hides, bones, silk or musk. Historically hunting, fishing and beekeeping provided essential provisions for local people. Nowadays game meat accounts for 96% of the traded wild animal products in Europe. Special products are bristles (boar) and hair (squirrel) in brushes, manufacture of hides and leather as well as resources for medical purposes like marmot fat and deer musk. There are several examples where the production of animal NWFP is of similar or even higher priority compared to other forest ecosystem services. Notable cases are the honey forests of Turkey, or the wild boar in agroforestry systems under cork oak in Portugal and Spain.

So the importance of NWFP differs between countries in Europe, and a comprehensive review is difficult to obtain. Relevant NWFP in Boreal and Temperate forests are Christmas trees, berries, mushrooms and game. In Mediterranean forests cork, pine nuts and mushrooms are of high relevance. These products represent also the majority of the total value of marketed NWFP in Europe, which is steadily increasing over the last years according to national and European statistics. The recent international policy developments fostering a European bio-economy is gradually increasing the forest owners awareness of the potential of non-wood goods. Even though the traditional NWFP such as tannin, resin and cork have partly been substituted by chemical products, there is a growing interest in natural products as ingredients for cosmetic, pharmaceutical and food products. Additionally there is a growing public interest in collecting and using NWFP as part of recreational activities. Innovation is evident where new products can be brought to market that utilise by-products or substitute a synthetic material or where species are regulated due to a protected status.

10.3 Supporting the management of NWFP

Most forest management approaches developed by forest owners in Europe have not considered NWFP explicitly in designing management strategies. In case that forest owners focus on income generation, the classical silvicultural concepts are mainly oriented towards timber production, because timber often provides higher income than other forest products. However, in many cases the production of NWFP can be increased without causing major losses in timber production. Modern silviculture takes into account many aspects of multipurpose forestry (e.g. risk reduction, diversification of wood products, considering various ecosystem services, adaptation to climate change, maintaining biodiversity) which would allow to incorporate NWFP more explicitly in forest management goals and strategies.

While resource assessment and modelling for timber and biomass production has deserved much attention in the last decades, little is known about how to increase the production of NWFP. This is in contrasts with the wide economic and/or social importance of some products (e.g. game, mushrooms, berries, cork and pine nuts). Topics such as monitoring, data collection and modelling focusing on NWFP need to be emphasized. The main part of the information on NWFP is collected and processed at national scale like National/Regional

Forest Statistics and NFIs. Only for selected products long term monitoring data are available. There exists a severe lack of harmonization among countries in relation with data collection techniques, frequency of collection, data processing and homogenization of units, even for the same product. In addition, the assessment of NWFP at forest management unit scale should be fostered.

Different techniques and tools are used by forest managers to support forest management planning. Besides monitoring systems, forest management plans and guidelines are mostly used. More sophisticated growth and yield models or decision support systems are rarely used to support managers although research has developed a number of tools to address the demands of alternative management approaches in Europe. However, the existing models do not always take the relative importance of the products into account, as there are knowledge gaps for chestnut or resin production. In spite of the growing interest in mushrooms and truffles in Europe, little is also known about fungal productivity and the factors influencing the presence of the fungal fruit bodies in different forest ecosystems. The application of NWFP models is generally difficult beyond their region of origin, which prevents harmonized predictions at the European level. However, knowledge and empirical data on the effect of forest management on physiological processes related to NWFP is heavily required. Besides models based on long-term monitoring, expert-based models could be therefore interesting alternative approaches.

Non-wood forest products should be seen as an integral part of forest management concepts in Europe as multi-purpose management is becoming a key in the provision of multiple ecosystem services. Developing decision support tools that help forest managers to select the best management approaches for combining a variety of ecosystem services and products is recommended. A better understanding about the synergies and trade-offs in considering the co-production of NWFP and other services will be needed to support the ongoing efforts towards forest bio-economy. It can be expected that NWFP positively contribute to a more renewable resource-based society that is able to mobilize and use its natural capital in a more holistic way. In this context the different spatial levels (stand – forest holding – regional – national) and temporal aspects (taking into account different rotation periods and management approaches) must be considered.

11 Appendix

11.1 Glossary

Aromatic plants Plants that produce and exude aromatic substances mainly volatile compounds known as essential oils that broadly used in food inductry, cosmetics, animal breeding, agriculture.

Ascomycete Fungi that, together with the Basidiomycete, form the subkingdom Dikarya of the kingdom Fungi. Ascomycete are the largest phylum of Fungi with over 64,000 species, including species of commercial interest such as morels or truffles.

Basal area Is the area of a given section of land that is occupied by the cross-section of tree trunks and stems at the base.

Basidiomycete Fungi that, together with the Ascomycete, from the subkingdom Dikarya of the kingdom Fungi. Basidiomycete includes valued species such as chantarelles or boletes.

Bioavailible The availability of chemical or compound for absorption by plant or animal tissue in a defined form or state.

Brand unique design, sign, symbol, words, or a combination of these, employed in creating an image that identifies a product and differentiates it from its competitors. Over time, this image becomes associated with a level of credibility, quality, and satisfaction in the consumer‘s mind (Source: http://www.businessdictionary.com).

Decision support system (DSS) A tool that provides support to solve decision problems by integrating user interface, simulator, expert rules, stakeholder preferences, database management and optimization algorithms.

Certification (from ISO) the provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements (standard).

Ectomycorrhiza Form of symbiotic relationship that occurs between a fungal symbiont and the roots of various plant species that acts as a host

Ectomycorrhizal The symbiotic relationship between a fungus and the tissues of various plant species.

Empirical model A model that is developed using statistical techniques and calibrated with an empirical data set measured in the field.

Epigeous fungi The fruit body of the fungi grows on or close to the ground.

Expert-based model A model that is developed using a data set of quantitative expert judgements when empirical data are not available or cannot be measured.

Explanatory variable In a modelling framework, each of the factors – continuous or categorical – that influences and causes changes over the response variable, which is the focus of the research. When the model is expressed as a mathematical equation, the explanatory variables are those whose value is given as an input of the model. Also known as independent variable or predictor.

Forest inventory Collection, summarization and processing of the information related with the stock, availability, potential use and spatial distribution of a given biological resource located in the forest

Forest model A dynamic representation of the forest and its behaviour, at whatever level of complexity, based on a set of (sub-)models or modules that together determine the behaviour of the forest as defined by the values of a set of state variables as well as the forest responses to changes in the driving variables

Forest Ownership Refers to the legal right to freely and exclusively use, control, transfer, or otherwise benefit from a forest (trees growing on land classified as forest). Ownership can be acquired through transfers such as sales, donations, and inheritance.

Forest Statistics A compilation of statistics at national or regional level providing information on production, harvesting and trade statistics for forest products. Apart, general information on such topics as woodland area, annual planting activity, forest ownership, employment, finance & prices... is also provided

Future-proof food (NWFP and wild forest products) following the definition given by the EC in the European Research & Innovation for Food & Nutrition Security report (EC, 2016) future-proof food are more sustainable, resilient, responsible, diverse, competitive, and inclusive food products:

- Sustainable: with respect to natural resource scarcity and in respect of planetary boundaries;
- Resilient: with respect to adapting to climate and global change, including extreme events and migration;
- Responsible: with respect to being ethical, transparent and accountable;
- Diverse: with respect to being open to a wide range of technologies, practices, approaches, cultures and business models;
- Competitive: with respect to providing jobs and growth;
- Inclusive: with respect to engaging all food system actors, including civil society, fighting food poverty, and providing healthy food for all.

Grazing intensity The proportion of the current season's forage production that is consumed or trampled

Growing Stock Volume over bark of all living trees with a certain minimum diameter at breast height. Includes the stem from ground level up to a top, excluding branches (but considering a limit diameter; branches > 7cm count), twigs, foliage, flowers, seeds, and roots.

Growth and yield model A set of models that predicts the structure and development (regeneration, increment and mortality) of a forest stand.

Hypogeous fungi The fruit body of the fungi grows below-ground.

Ideotype The description of the idealised appearance of a plant variety (see Donald 1968).

Informal economy system of trade or economic exchange used outside state controlled or money based transactions. Practiced by most of the world's population, it includes barter of goods and services, mutual self-help, odd jobs, street trading, and other such direct sale activities. Income generated by the informal economy is usually not recorded for taxation purposes and is often unavailable for inclusion in gross domestic product computations. (Source: http://www.businessdictionary.com).

Livestock grazing The grazing of domestic animals that are raised on a farm. In some cases, the term is referred only to the ruminants (cattle, sheep and goats).

Management Plan Supports the planning of management activities on a forest area that has a long-term management goals, which is periodically revised. The plan may refer to forest management unit level or smaller units (stands or compartments) and describes activities planned for individual operational units but may also provide general strategies planned to reach management goals.

Medicinal plants Plants that are used by humans for therapeutic, tonic, purgative, or any other health-promoting purposes. It could be used any part of the plants (leaves, roots, seeds, bark).

Model A mathematical description of the real world in a simplified way.

Multi-purpose management Forest area designated primarily for more than one purpose and where none of these alone is considered as the predominant designated purpose. Forest management might focus on provisioning services in the form of wood, but also at the co-production of other products (like non-wood forest products), livestock grazing, recreational or watershed services including the conservation of ecosystems and biodiversity.

Mycelium Vegetative part of a fungus consisting of a mass of branching, thread-like hyphae. Fungal colonies composed of mycelium are found in and on soil and many other substrates

Mycosilviculture Array of silvicultural treatments and operations aiming at enhancing the provision of mushrooms and truffles in order to integrate these products into multifunctional forest management planning.

National Forest Inventory The systematic collection of data and forest information such as, situation, property and protection regime, nature, legal status, probable evolution, production capacity, etc., of all types of forest goods at a countrywide level for making high-level policy decisions and broad-scale resource monitoring.

Non-timber forest products (NTFP) NTFP is often used as a similar term for non-wood forest products (NWFP). The main difference between NTFPs and NWFP is, that NWFP exclude all wood products and NTFPs do not exclude wood products such as fuel-wood, artisanal use of wood or charcoal.

Non-wood forest products (NWFP) All tangible goods of biological origin (with the exception of wood products) that are derived from forests and wooded land, and also from trees outside the forest (see FAO 1999 and Belcher 2003).

"Direct NWFP" are often considered as products that are directly derived from a particular tree species i.e. cherries or walnuts from *Prunus avium* or *Juglans regia* respectively. "Indirect NWFP" are often considered as species that co-exist with trees when provided with certain site conditions that the overstory bestow for example mushrooms and truffles, e.g. *Boletus edulis*.

Nutraceutical A standardised nutrient of pharmaceutical-grade.

Permanent plot Plot installed with the main aim of continuous research on the evolution, dynamics and continuous resource assessment of the forests. They are commonly established and measured at the start of an investigation and subsequently remeasured at fixed intervals over a period of a few to many years. For the period of observation, permanent plots provide points in a real growth and yield series, as opposed to artificial growth and yield series constructed from single measurements of stands subjectively selected to represent successive stages in development.

Plantation Forest predominantly composed of trees established through planting and/or deliberate seeding. Includes rubberwood, cork oak and Christmas tree plantations.

Process-based model A model that describes and simulates the behavior of a system derived from a set of functional components and their interactions with each other and the system environment, through physical and mechanistic processes occurring over time.

Production Forest Forest area designated primarily for the production of wood, fibre, bio-energy and/or non-wood forest products.

Raw materials The basic plant material from which a product is made.

Resource assessment The interpretation and evaluation of data obtained from inventory against some objective or standard, aiming to attain the optimal utilization of the resource under the constraints given in the framework of the forest management planning.

Sampling inventory A sample-based survey of the forest resource. The main aim is to quantify the abundance of a given biological resource (timber, biomass, NWFP...) in the forest using sound statistically based procedures and optimal sampling techniques.

Saproxylic Organisms that feed on dead wood.

Silviculture The combination of different forest measures (e.g. planting, tending, thinning) to ensure continuous and sustained production of a defined production goal including benefits that can be directly or indirectly derived from trees, plants, water and wildlife within forested areas.

Simulator A tool that uses mathematical models for calculation and presentation of outcomes of a set of stand management scenarios.

Stand basal area The sum of the cross-sectional areas at breast height (1.30 meters aboveground) of trees growing within a forest stand, using square meters per hectare as the typical measurement unit.

Stocking rate The relationship between the number of animals and the total area of the land that is utilized over a specified time

Traceability in supply chain traceability is the ability to identify, track and trace elements of a product as it moves along the supply chain from raw goods to finished products.

Transect Sampling technique based on making observations of the subject resource walking along a prepared trail of known length. It is widely used for monitoring wild animals, or plant species which form dense contiguous cover, e.g. ground flora

Understory plants All the plant species below the canopy. In some cases, the term "understory" used only for species of shrub size or smaller.

Value chain the set of activities for producing and marketing a product or service involving the acquisition and consumption of resources – money, labour, materials, equipment, buildings, land, administration and management.

Wild products Plant resources that are grown in natural ecosystems and are collected by humans for food, dietary supplements or medicinal proposes.

11.2 Common Survey Questions: NWFP identification

1. Please specify resource name (name that the resource is known by in English) (Text Response)

2. Please specify resource name separated by commas (the name(s) that the resource is known by in your local language(s). (Text Response)

3. What species does this resource come from?
   (Text Response – Latin Binomial)

4. Why is this NWFP important in your country?

(Choice Response) 1- Economic importance, 2- Recreation and Diet, 3- Production is threatened, 4- Research Interest, 5- Cultural heritage, 6- Other (specify)

5. What is the resource used for?

(Choice Response) 1- Food, 2- Beverage, 3- Medicinal product, 4- Craft and construc tion, 5- Reproductive materials, 6- Decorative products, 7- Fodder, 8- Other (specify)

6. How would you classify the type of product?
   (Choice Response) 1- Tree fruits, 2- Forest Berries, 3- Carob, 4- Tree nuts, 5- Wild mushrooms, 6- Truffles, 7- Game birds, 8- Game meat, 9- Honey, 10- Tree sap, 11- Flowers, 12- Culinary herbs, 13- Wild greens, 14- Medicinal herbs, 15- Medicinal mushrooms, 16- Nutraceuticals, 17- Pharmaceuticals, 18- Colourants and dyes, 19- Fibre, 20- Resins, 21- Waxes, 22- Cork, 23- Bark, 24- Moss, 25- Seeds, 26- Bulbs, 27- Wildlings, 28- Floral greens, 29- Christmas trees, 30- Grass, 31- Shrubs, 32- Other (Specify).

7. How would you classify the use of this product in your country? (Choice Response) 1- Mass Market Product, 2- Small Scale Enterprise, 3- Personal Collection

8. Please specify if resource is produced through 1- Wild Production (harvested from a population where there is no intervention to increase numbers or growth of species), 2- Wild Managed (where a wild population is managed in some way to control production) or 3- Cultivated Production (where regeneration and growth are controlled), 4- Both or 5- Other. (Choice Response)

9. Please suggest system from which this resource is harvested: (Free Text Response, for example: natural forest, forest plantation, semi-

natural forest, cultivated in forest, agriculture, agroforestry, horticulture, polytunnel, fenced enclosure, don’t know)

10. Which is the most favourable Forest Composition for this resource? (Choice Response) 1 – Mixed species forest, 2 – Single species, 3 – Both, 4 – Other, 5 – Don’t Know

11. Please identify the most relevant group of tree species associated with the occurrence the resource species.
    (Choice Response) 1- Broadleaves, 2- Conifer, or consists of several cover types 3- Mixed Forest. If the tree species cover is not important for this product choose 4- Not Applicable. If non of these choose 5- Other and provide detail.

12. COST should also look towards the future: Is this product new/ emerging, and or innovative? Or is the product well established but with new technology and applications (Choice Response: Yes/No/Both)

11.3 List of species by NWFP category type

Mushrooms and Truffles	Tree Products	Understory Plants	Animal Origin
Agaricus spp.	Abies alba	Allium ursinum	Alces alces
Albatrellus pes-caprae	Abies fraseri	Arbutus unedo	Alectoris barbara
Amanita caesarea	Abies koreana	Arctostaphylos uva-ursi	Alectoris chukar
Armillaria mellea	Abies lasiocarpa	Arnica montana	Alectoris graeca
Boletus (Xerocomus) badius	Abies nobilis	Asparagus acutifolius	Alectoris rufa
Boletus aereus	Abies nordmanniana	Cistus ladanifer	Anas platyrhynchos
Boletus aureus	Aesculus hippocastanum	Clematis vitalba	Apis mellifera (inc. subsp mellifere)
Boletus edulis	Argania Spinosa	Convallaria maialis	Capra aegagrus
Boletus mamorensis	Betula pendula	Dactylis glomerata	Capra ibex
Boletus reticulatus	Betula pubescens	Sphagnum spp.	Capreolus capreolus
Cantharellus cibarius	Carpinus betulus	Polytrichum spp.	Castor fiber
Cantharellus lutescens	Castanea sativa	Pleurozium schreberi	Cervus elaphus
Chlorophyllum rhacodes	Ceratonia siliqua	Pseudoscleropodium purum	Columba palumbus
Chlorophyllum olivieri	Cornus mas	Empetrum nigrum	Cornu aspersa
Chlorophyllum brunneum	Corylus avellana	Filipendula ulmaria	Coturnix coturnix
Craterellus cornucopioides	Fagus sylvatica	Fragaria vesca	Dama dama
Craterellus lutescens	Frangula alnus	Frangula alnus	De-domesticated cattle
Ganoderma lucidum	Ilex aquifolium	Galium odoratum	Lepus capensis
Gyromitra esculenta	Inonotus obliquus	Gentiana lutea	Lepus europaeus
Lactarius deliciosus (group deliciosus)	Juglans regia	Geranium sylvaticum	Lyrurus tetrix
Lactarius deterrimus	Juniperus communis	Hippophae rhamnoides	Marten marten
Lactarius rufus	Larix decidua	Hyacinthoides non-scripta	Odocoileus virginianus
Lactarius trivialis	Malus sylvestris	Hypericum perforatum	Oryctolagus cuniculus
Leccinum albostipitatum	Picea abies	Juniperus communis	Ovis musimon
Leccinum aurantiacum	Picea glauca	Lycopodium clavatum	Pacifastacus leniusculus
Leccinum scabrum	Picea omorica	Myrtus communis	Phasianus colchicus
Lentinula edodes	Picea parryana	Origanum compactum	Rangifer tarandus
Marasmius oreades	Picea pungens	Origanum vulgare	Rupicapra rupicapra
Mattirolomyces terfezi-doides	Pinus cembra	Ribes spicatum	Salmo trutta (inc. subsp. Fario)
Morchella conica	Pinus contorta	Rosa canina	Sus scrofa
Morchella elata	Pinus halepensis	Rosmarinus officinalis	(inc. subsp. Barbarous)
Morchella esculenta	Pinus nigra	Rubus chamaemorus	Tetrao urogallus
Morchella vulgaris	Pinus pinaster	Rubus fruticosus	
Pleurotus ostreatus	Pinus pinea	Rubus hirtus	
Russula cyanoxantha	Pinus strobus	Rubus idaeus	
Suillus grevillei	Pinus sylvestris	Sideritis spp.	
Suillus luteus	Pistachia lentiscus (inc. var. Chia)	Thymus satureioides	
Terfezia arenaria	Populus spp.	Thymus vulgaris	

Tirmania spp.	Prunus amygdalus	Thymus zygis	
Tricholoma caligatum	Prunus avium	Thymus mastichina	
Tricholoma equestre	Pseudotsuga menziesii	Urtica dioica	
Tuber aestivum	Quercus robur	Vaccinium myrtillus	
Tuber magnatum	Quercus petraea	Vaccinium oxycoccos	
Tuber melanosporum	Quercus suber	Vaccinium vitis-idaea	
	Quercus ilex	Valeriana celtica	
	Robinia pseudoacacia		
	Salix viminalis		
	Sambucus nigra		
	Sorbus aucuparia		
	Sorbus torminalis		
	Tilia cordata		
	Tilia platyphyllos		
	Tilia rubra		
	Tilia tomentosa		
	Tilia argentea		