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EASTERN FINLAND

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Authors' affiliations: Olli Saastamoinen[1], Jukka Matero[2], Paula Horne[3], Matleena Kniivilä[3] , Emmi Haltia[3] , Hannu Mannerkoski[1] & Matti Vaara[1]
[1]*University of Eastern Finland, School of Forest Sciences; School of Forest Sciences;*
[2]*University of Eastern Finland (- 30.7.2012);* [3]*Pellervo Economic Research PTT*
Contact: Olli Saastamoinen, e-mail: olli.saastamoinen@uef.fi

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Prof. Pekka Kilpeläinen, Prof. Kai Peiponen, Prof. Matti Vornanen
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ABSTRACT

The report aims to a systematic identification and classification of the boreal forest ecosystem goods and services of Finland. Forest sciences together with other sciences and professional knowledge provide a basis for that purpose. Work is based on the Common International Classification of Ecosystem Services (CICES). It is a hierarchic system potentially becoming a standard within EU. The classification of many provisioning goods of forests is more straightforward than those of the other major categories. However, the number of forest goods in Finland is large and their logical grouping was seen to benefit from adopting an additional level of hierarchy, used also in other categories. Classification of some regulation and maintenance services was less straightforward. Sometimes it was due to gaps in existing research knowledge or due to characteristics of services as multifunctional processes. Many of these services require more attention in future research. The cultural services involve a large spectrum of forest related meanings and issues for which CICES provided enough space to be applied in the specific cultural context of Finland. The outdoor recreation research in Finland offered good basis to the identification of the environmental settings of recreational activities. Apart from CICES an outlook of disservices of ecosystems is included. Some general conclusions based on this classification are given. Discussion extends the scope a bit towards considerations how ecosystem services are related to "wooden structures", which are further away from forests. As far it is known this is the first national level study which has applied CICES classification focusing only on the boreal forest ecosystem services.

Keywords: Forest ecosystem services, provisioning services, regulation and maintenance services, cultural services, CICES, disservices, boreal forests, Finland, classification

ABSTRAKTI

Raportin tarkoituksena on tunnistaa ja luokitella systemaattisesti Suomen boreaalisten metsäekosysteemien aineelliset ja aineettomat tuotteet ja palvelut. Luokittelu perustuu metsä- ja muiden tieteiden tutkimuksen ja ammatillisen tiedon pohjalle. Työ soveltaa kansainvälistä ekosysteemipalvelujen luokittelua (*Common International Classification of Ecosystem Services, CICES*), josta saattaa tulla standardi EU:n piirissä. Metsistä saatavien tuotantopalvelujen luokittelu on selväpiirteisempää kuin muiden pääluokkien palveluiden. Metsän tuotteiden moninaisuus on kuitenkin suuri ja siksi niiden looginen luokittelu edellytti yhden luokittelutason lisäämistä. Sitä sovellettiin myös muissa pääluokissa. Metsien säätely- ja ylläpitopalvelujen luokittelu on monimutkaisempaa johtuen osin tiedon aukoista ja niiden monivaikutteisten prosessien luonteesta. Kulttuurisiin ekosysteemipalveluihin kuuluu laaja kirjo metsiin liittyviä merkityksiä, joiden luokitteluun CICES tarjoaa hyvin tilaa. Suomessa tehty virkistyskäyttötutkimus tarjoaa hyvän pohjan tunnistaa metsien erilaisten virkistystoimintojen ympäristöjä. Mukana on erillinen - CICES-luokitukseen kuulumaton – katsaus metsäekosysteemien tuottamiin haittoihin. Luokitusta koskevien johtopäätösten ohella keskustellaan lyhyesti ekosysteemipalveluihin liittyviä ”rakenteita” kauempana metsästä. Tutkimus on tiettävästi ensimmäinen kansallisen tason yritys boreaalisten metsien ekosysteemipalvelujen yksityiskohtaiseksi jäsentämiseksi CICES -luokittelun mukaisesti.

Avainsanat: Metsän ekosysteemipalvelut, tuotantopalvelut, säätely- ja ylläpitopalvelut, kulttuuriset ekosysteemipalvelut, CICES, metsien tuottamat haitat, boreaaliset metsät, Suomi, luokittelu

Forward

This report is a part of the synthesis study ”Integrated and policy relevant valuation of forest, agro-, peatland and aquatic ecosystem services in Finland” funded by The Maj and Tor Nessling Foundation. The study is carried out by the University of Eastern Finland and Pellervo Economic Research PTT together with a number of voluntary contributing authors from several research institutes, universities and expert organizations. The objective of the study was to produce an up-to-date synthesis of the goods and services of forest, agro-, peatland and aquatic ecosystems in Finland to serve improved decision making, governance and public communication.

It is hoped that this report on the identification and classification of the goods and services of boreal forest ecosystems in Finland will contribute to the knowledge and further development in this field. The work is done in aspiration that it furthers understanding of the multiple roles the forests play for the well-being of the people in Finland.

It is my pleasure to thank the Maj and Tor Nessling Foundation for their initiative and funding of this study and the support of the project management group. I would like to thank the co-authors, who are not responsible for the prolonged finalization of the report.

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Olli Saastamoinen
Professor emeritus

Contents

1. Introduction

1.1 MULTITUDE OF FOREST BENEFITS

There was a time when the principal life form on earth was the tree (Westoby 1989). Trees in particular, among other plants, have profound, indirect influences on other organisms that go beyond their function in the wood web (Perry et al. 2008). One such an influence played, indirectly or directly, a fundamental role in human evolution. It was trees, which provided shelter and food for the tree-dwelling primates, the direct ancestors of a human. Later on, human evolution was not hanging that much on trees only. For example, grasses, which came later than trees were able to take advantage of any climatic changes or other disturbances, unfavorable to trees. Species in the ape/human lineage spent increasing time on the ground. The mix of sparse forest and grassland was the environmental setting favorable to the emergence of the *Homo habilis* (the gatherer), *Homo erectus* (the hunter) and finally *Homo sapiens* and *Homo sapiensis neandertalensis* (Westoby 1989).

During the co-evolution of humanity and nature, all other ecosystems similarly became important and necessary for the development. But, as Grebner et al. (2013) state, since the birth of humankind, forests have played an important role of our species.

The environmental influences of trees and forests both to maintain and improve favorable living conditions on the earth continues to be a vital element for the progress of human life in our days (Westoby 1989, Perry et al. 2008). Yet it refers to only one of the groups of benefits and products forests have been able to deliver during the co-evolution of trees and other forms of life.

Forest literature has characterized many peculiarities of forests which were thought to make forestry different from other modes of human production. The long lifetime (rotation) of trees, the production capacity and the products of trees being the one and the same, renewability of forests, site and climate dependence, a need of large areas are the most commonly mentioned. It is true that other nature based forms of production share many of the same features, but not all of them as forestry does. The rotation period – the time trees require to be mature for harvesting - commonly varying between 30 to 100 years or more (although can be only 5 to 20 years among fast growing plantation species, Bauhus et al. 2010) no doubt make the difference (e.g. Keltikangas 1971, Kauppi et al. 1983, Saastamoinen 1982, Gregory 1987, Price 1989, Perry et al. 2008, Kuuluvainen and Valsta 2009).

Sometimes the lists have forgotten to include a feature which neither is unique to forests but finds its full bloom in forests. That is the unexceptional multitude of goods and services forests are able to deliver. It can be claimed to be the other, if not the most fundamental characteristics of forests.

It can be concluded that by their very nature, forests are multiproduct and multifunctional ecosystems. As Perry et al. (2008) emphasize ”in forestry, the central unchanging reality is that forests have multiple values for humans, and focusing on one while excluding others leads to both social and biologic problems”.

1.2 PAST BENEFITS OF EUROPEAN FORESTS

In Europe, the multitude of material and non-material benefits provided by forests for people have been described ever since written[1] sources on forests have been available. Platon's (*Kritias 111b-d*) description on the erosion and other adverse

[1] Before use of wood fiber for paper was discovered, other materials of trees were used for writing. One was bass, the inner fiber containing side of bark, of which Latin word *liber* (a book) originated. The other was waxed boards, pieces of tree, called *caudex*, of which the codex (a collection of codes, a hand written book) is derived (Westoby 1989).

consequences following to the cutting of Attika's forests and the long-time deforestation in the Mediterranean region have become an inherent part of forest and environmental history (Thirgood 1981, Westoby 1989, Hughes 2009). The early critical findings did not prevent the same to be replicated elsewhere. Most of Europe's forests continued to be deforested, in accelerating pace from c. 1000 A.D. until the end of 18th and 19th century. The ever growing scarcity of trees and forests germinated the ideas towards sustainable use of forests in France and England, but most systematically in Germany.

One of the first if not the first articulation of the principle of sustainable forest management can be found from von Carlowitz (1713), a mining expert, in his "Oeconomica Sylvicultura". It also contains an early illustration of the variety of forest benefits. The examples of forest benefits were:

- the usefulness of wood at the start and end of life and mankind in general;
- especially in building work, for making utensils and handtools,
- in food making, beer brewing and wine making,
- how to get bread from tree, in dyeing and agriculture,
- for travelling on land and seas, in the production of iron and salt,
- protection of soil and roads, the usefulness of the forests as a seat of wild game, and sustenance for cattle, forests as beautiful environment for the song of birds,
- in manufacture of all kind of materials,
- the music and echo of the forests, the offers of forests for food and drink
- and their usefulness during wartime and when epidemics rage.

It is clear that all the categories of provisioning, regulating and maintenance and cultural ecosystem services already are there (Saastamoinen et al. 2013). Although the emphasis has been in provisioning services, for example the cultural services (the song of the birds, music and echo of the forests) recorded 300 years ago still sound that fresh that one may even ask whether they have been given enough attention in the current research.

Westoby (1989) include wide historic and more recent surveys and country cases about the multitude and utilization of different forest products and benefits in different parts of the world. He used an implicit division between products based on wood material, other forest products and other influences of trees. It also contains descriptions and analyses how, why and to what extent the forests and their benefits have been lost - and sometimes recovered or reconstructed - during the history in the many parts of the world, including Europe.

Schmithüsen (2008) gives an illustrating picture about the land use, population and forest dynamics related to multiple uses of the temperate forests of Central and Eastern Europe during roughly the past millennium. Local resources of forests were important. A saying that "wood and suffering grow everyday" expresses the elementary necessity of wood for daily uses. In line and addition to the list of von Carlowitz (1713) one can find, for example provisioning service such as hazelnuts, wild fruits of trees, berries and mushrooms, which helped people to survive during the bad years with low crop yields. For fattening of pigs, acorns and beech mast were used and in some regions the earnings from pig fattening in forests became larger than those from wood use. Potassium carbonate from ash for glass production, shrubby vegetation and bark for tanning and fiber, resin and tar were among forest goods. Forests provided forage and litter for livestock, land for agroforestry. Roots, leaves, bark and branches were used in the pharmacopoeia or for dyes. Collecting honey from wild and beekeeping were important activities. Leaves and needles collected from forest substituted fertilizers in small farms. Besides the traditional use of wood for construction, firewood and charcoal, mining, iron making, salt production and glass making were known as *xylophage* – wood eating industries. Naval dockyards and boat building were among these large scale users of wood serving both warfare and trade (Schmithüsen 2008).

The mixed and shifting borders of forests, pastures and agricultural lands, however, made it difficult to say what were forests and what not. This problem is evident also elsewhere when looking back into history and in some parts of the world even nowadays. The only clear distinction at that time was between intensively used areas (home gardens, plowed fields) and the common land accessible to the community. The separation between the systems of agriculture and forestry became later during the agrarian reforms and intensification of agricultural, and later forestry, production (Schmithüsen 2008). This separation and intensification brought adverse consequences to species and biotope diversity and also major changes in landscape (Schmithüsen 2008).

The earliest cultural services of the forest seem to have been hunting as an amusement – not for subsistence. In viewing a history of forest management in Europe, Adams (2008) mentions that Phillip of Macedonia (400 B.C.) maintained forests for his hunting and other recreational pursuits. The objective of royal forests in England was to protect game for the king's use and enjoyment, not to grow trees. The concept of the royal forests grew to encompass at least one fourth of England (Young 1979, cited in Adams 2008). Forest was defined as "a Certain territory of wooded grounds and fruitful pastures, privileged for wild beasts and fowls of the Forest … to rest and abide in, in the safe protection of the king, for his princely delight and pleasure" (Manwood [1615] 1976, cited in Adams 2008). The dominance of the hunting interest of the king and noblemen were evident in Germany and Denmark as well, which besides legislation was also reflected in the origin of the professional titles of foresters (Groen 1931).

1.3 PRE-INDUSTRIAL FOREST USES IN FINLAND AS ECOSYSTEM SERVICES

Compared to the Central European forest uses there are many similarities in the types of forest goods and services utilized by people during the centuries before industrialization in Finland. The major differences are largely due to the shorter history of the settlements, much smaller population densities and lesser need for permanent agricultural land. Other differences are due to the biological features of boreal forests, being less rich in species of tree and animals, yet offering abundant amounts of firewood, logs, and game to the first small population despite of harsh climate. Additionally, the sea and numerous inland lakes provided fish and seals for nutrition.

Provisioning services. The necessities of finding food and shelter dictated the life of the earliest inhabitants arriving at the grasslands and boreal forests after the last Ice Age (Helander 1949). The most important provisioning goods from forests during the long period until mid19th century were non-wood products such as berries and mushrooms collected from forests for food, meat and fur from hunting, products of slash-and-burn agriculture, fodder and bedding for cattle, firewood for food preparation and heating (Luttinen 2012). Logs and other wood were used for several purposes such as buildings, farming, infrastructure, utensils, tools and lumber for water powered sawmilling. Wood was needed also for iron industries. All kind of wood from firewood to sawn timber and wood barrels were also exported before the birth of the pulp and paper industries. However, furs from forest game were the first export product, which connected Finland to the European markets. It was followed by tar, which already by the mid 18th century became a prominent export product bringing wealth not only for merchants in coastal trading towns but also to farmers and workers involved in tar making and supply chains in inlands. When the wooden ships started to lose their dominant position in trade and warfare, and tar lost it export markets, the time for larger scale saw-milling and pulp and paper industries was entering. Industrialization became to be the engine to make changes in Finland and in its forests (Helander 1949, Kuuluvainen at al. 2004, Kuisma 2006, Vehkamäki 2006).

Maintenance and regulation services. According to Swedish studies, the postglacial mid-July temperature peaked before the beginning of late tundra climate about 11 000 years ago and had its lowest level in the beginning of the preboreal stage. It then turned to increase some 4000 years through the boreal climatic stages and stabilized at much higher level than that of the earlier peak during the warm Atlantic climate period (Mattsson and Stridsberg 1981). The successional development of forest cover after tundra vegetation apparently meant a stabilizing infrastructure to further and maintain the diversity of ecosystems, including the forests themselves. However, primarily it was the changing climate (temperature and precipitation) which has organized the moving spatial patterns of trees, related biota, and the larger vegetation formations – not the other way round (Perry et al. 2008, Kellomäki 2009).

In this larger frame, one may assume as Mattsson and Stridsberg (1981) do, that the protective roles of forests may have had a particularly important roles during the sub-Atlantic and sub-boreal climates lasting some 4 500 years, having a slow cooling trend, before again turning to slow growth during past 250-300 years.

The literature on environmental benefits of forests in Finland dates back to the times of the early development of forest science. The first forest textbook on silviculture written for Finnish conditions (Gyldén 1853) stated that in every country settlement and means of livelihood were dependent on the forests, since they controlled local climate. The forests preserved the humidity and the warmth of the soil, and protected farmed land and the soil from the cold, dehydrating winds. He concluded that the importance of forest cover is naturally the greatest in hot and cold regions.

The old literature also emphasized the shelter forests provided for the living conditions close to northern timberline areas as well as general protective role of forests in the world climate. Often studies and textbooks on silviculture and forestry included international surveys and research results related to what now could be called as "global ecological and environmental" roles of forests (Cajander 1916, 1917, Ilvessalo 1928).

The cited research indicated that forests balance temperature and humidity variation of climate, but the impact is not large and mainly inside forest and nearest environment. Forests thus decrease the cold of winter and heat of summer as well as coolness of night and high temperature of day. In the upper parts of mountains in Central Europe, forests increase rain considerably but less in lower parts and lowlands.

According to Homén (1917), forests in Finland through evaporation increase rain and thus mediate spring dryness, which could be much stronger without wide forest cover. Homén (1917) also assumed that forest destruction around the largest inland lake system of Saimaa was probably the major reason for increased floods. Forests were also seen to prevent effectively mass movements of soil and avalanches in the steep slopes of mountains. They also protect shore land banks of waters and bind "flying sand lands". Forests reduce winds and their mechanical pressures and drying or cooling effects. It is also known that forests with vitality considerably slow down paludification through the evaporation[2]. One can find, that older observations and findings around (what is now called) regulating and maintenance services of forests have been dealing with questions which are not less actual at present times.

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[2] This can be seen as a benefit in the country where mires and peatlands naturally have covered one third of the country and where drainage of peatlands for agriculture and in particular for wood production during past decades has been regarded as a vital part of economic development.

Cultural services of the past. Sihvo (1997) has found that ever since men started writing in Finnish, Finns have been portrayed as people of the forest. In The Psalter of David (1551) Agricola, the father of written Finnish, told about the idols of the Finns: "*Tapio* from the forest the game giveth, /And *Aht*i from the waters the fish bringeth" and "*Hiisi* gave a victory over the game in the forest" (Sihvo 1997).

Pentikäinen (1994) has studied the nature religion of the *Hantis*, a small Finno-Ugric group in the northernmost corners of the north-western boreal (*taiga*) forest of Siberia. The key word of people living in the wilderness was "sacred". What people regard as sacred is their religion. According to Anttonen (1994) the concept "sacred" (in Finnish *"pyhä"*) is common in naming places and in folk tradition. He regards that it meant a place where different value categories of people – food, safety, health, etc. – were bordering. Natural places having a prefix "sacred" became border places, which often were topographically different and prominent, and therefore easily to be recognized.

Finland was six centuries an eastern part of the Kingdom of Sweden but after a short war Finland in 1809 became part of the Russian Empire (Michelsen 1997). The new Grand Duchy of Finland got a large degree of political autonomy, which in the course of 20th century gave a possibility to further develop national economic and public institutions largely on the basis of legal and administrative structures inherited from Sweden.

Language is an inherent part of culture[3]. An interest in the Finnish language grew during the autonomy. The Finnish national epic *Kalevala,* compiled by Elias Lönnrot on the basis of the epic folk poems, appeared first time in 1835. According to the Finnish Literature Society (http://www.finlit.fi/) *Kalevala* marked an important turning-point for Finnish-language culture and caused a stir abroad as well. Sihvo (1997) calls *Kalevala* as

[3] According to Paasilinna (1989) "Finland has been two periods under the foreign reign and was able to survive only for the reason that ordinary people did not understand the languages of the rulers" [*An informal translation*].

the world's largest forest epic. The Finnish version of the creation in Kalevala is composed of planting different trees (and a few other plants) in the variety of sites (Sihvo 1997).

The novel "Seven brothers" by Aleksis Kivi (1870) is a landmark in Finnish literature, rich in language and deep in psychology of the characters of the ordinary people. The brothers, feeling that the society was pressing them, escape into the wilderness to build a log cabin, live by hunting, eat pine bark bread – and enjoy freedom and outdoors – until their cabin burns on ashes on Christmas Eve. On frosty night, half-naked and chased by wolves they run safety to their old farm (Sihvo 1997). Although Kivi was a poet of the forest, his work also emphasizes the national ideology of 20th century, that to live a stable life you have to clear land and cultivate fields. The harsh experiences teach the brothers to become orderly members of the agrarian society. The place of the forest cabin, *Impivaara,* is still the symbol of Finnish escapism (Sihvo 1997).

The past cultural beliefs were much instrumental in their search to safeguard the immediate needs for subsistence from nature, like success in hunting. Also in the turn of the 19th and 20th century the rural people regarded burnt, grazed and felled forests as natural and ordinary landscapes, as these were a necessary condition for living (Reunala 1997).

Economic development, urbanization and growing wealth had increased the number of people, whose living was not any more dependent on rural production landscapes. That kind of urban people began to look forests as an enjoyable landscape and environment for leisure time (Löfgren 1981, Reunala 1997). At the time of national-romanticism untouched, original natural landscapes were appreciated more than ever before. At the same time, however, forests were also influenced by straightforward commercial fellings, which spread rapidly after the regulations of saw-milling were removed and demand also for smaller wood increased due to emerging pulp and paper industries.

The well-known artists were seeking beauty, mysticism and connections to the roots of national existence from the distant wilderness. National landscapes of forests and lakes such as *Koli* and *Punkaharju* got their lasting fame at that time. But the development had also political aspects.

Around the turn of the century two periods of repression seemed to change the earlier relatively benevolent attitudes of the Russian empire to her grand duchy (Michelsen 1995), which further strengthened national spirit (Reunala 1994) and political will towards the independence. All this needed and found symbols for national identity from the representations of Finland's nature by artists, authors and composers.

Aesthetic and identity values of forests and other nature, in the context of the unabated logging, brought also nature conservation on the public agenda. Already in 1880 A. E. Nordenskiöld, the explorer of the Northern Sea Route, raised the question of the establishment of nature parks in the Nordic countries so that the future generations could "get a right picture of the land of their fathers". The discussion continued but it was not until in 1914 Metsähallitus (Finnish state forest organization) separated with its own decision the first *Mallatunturi* nature park and later other areas, including Koli and Punkaharju. At the same time in 1923 the Parliament approved the Act on Nature Conservation. The first species were protected in 1923, and the first nature reserves were designated in 1932. The first four national parks were established by law in 1938.

1.4 POLITICAL, ECONOMIC AND SOCIAL DEVELOPMENT DURING THE INDEPENDENCE

The independence was gained in 1917, in the aftermath of the Bolshevik revolution in Russia (Michelsen 1995). Unfortunately, it was not able to prevent the outburst of the growing socio-economic and political tension deriving from an uneven distribution of the fruits of development and from other social problems. Soon after the independence, in 1918, the nation was brought into tragic citizen (liberation) war. It was short but left long-lasting wounds into the human minds and the whole society.

Forests and forest industries had become the most important, although not only industries creating economic grounds for the independence through growing production, employment in forests, factories and export income. The development of agriculture since the famine in 1870 had formed a steady backbone for population growth and better nutrition, supporting food industries and many other sectors.

After the independence agriculture[4] was also promoted through land reforms. It has also been a source for export products for long times. Excluding the world depression in the early 1930s, the economy developed favorably.

After the Winter War of 1939 between Finland and Soviet Union and the Continuation war as a part of the World War II in 1941-1945 Finland was able to maintain her young independence, but with heavy human sacrifices. The resettlement of people of the ceded areas (which included 12 % of the country's forest area) and the frontline men, who were promised to receive land, the reconstruction of the economy and infrastructure in addition to the payment of war compensation to the Soviet Union were the primary tasks. Since that the economy had developed mostly well based not only the forest industries but also being diversified into mining and engineering and more recently to electronic industries. Export oriented economic development was often aided by currency devaluations. The economic growth together with the social and educational reforms, continuing with some breaks[5] almost until

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[4] The relationship between agriculture and forestry often culminates into the land allocation problem. However, besides former settlement disputes mainly in state forests, the relationship of agriculture and forestry in Finland is basically not antagonistic but rather symbiotic. Most lands are not fertile enough for agriculture. In addition it has been traditionally regarded that the northern agriculture with a short growing season does not alone provide livelihood but every farm needs a forest area much larger than the cultivated field in order to obtain sufficient livelihood and support for investments.

[5] The major exceptions were the severe depression in 1991-1993, global financial crisis in 2009, and the ongoing one 2012-.

recently, brought Finland to be one of the Nordic (Scandinavian) welfare states. This characterizes the country also now, although the industrial and economic basis, particularly in paper industries and electronics but also in other industries, has weakened during the past years due to the external and internal reasons and led into ongoing structural changes. Adjustments are seen to be needed also in the public sector. The paths and successes of these transformations are still open.

Among the numerous keywords for the future the concepts such as green economy and growth, bioeconomy and bioclusters or innovation strategies such as "Intelligently with the powers of nature" (Sitra 2009) are inclusive to the concepts and approaches of the ecosystem goods and services.

The increasing welfare during second half of the 20th century in particular was due to the more intensive production and use of wood as the major provisioning good of forests. But the rising standard of living gradually increased the importance of both cultural as well as regulation and maintenance services of forests. Increased leisure was not any more the privilege of the upper fractions of the society but a right of all people. Demand for recreation, nature-based tourism, summer cottages, biodiversity conservation and clean water increased. The mitigation of climate change and other adverse impacts of economic growth have become to be the essential parts of forest and environmental policies of the late 20th and the early 21st century in Finland as well as everywhere. However, most the new demands are additions to the early recognized multitude of the forest products and benefits. Therefore, it is useful to see how it has been conceptualized before ecosystem service approach.

1.5 CONCEPTUAL APPROACHES TOWARDS THE MULTIPLICITY OF FOREST BENEFITS IN CENTRAL EUROPE, THE NORDIC COUNTRIES AND FINLAND

In the Central Europe, in particular in the German speaking countries, the theory of forest functions was widespread. Its founder V. Dieterich (1953) defined forest function as a societal demand posed to forests such as wind protection or water retention.

Originally his ”Land area function” (*Flächen-funktion*) included the positive effects of the forest on climate, water management, erosion and landscape. These are regulatory and maintenance functions of forests. ”Primary-resource function“ (*Rohstoff-funktion*) formed the group of provisioning services. However, the original ”Working function” (*Arbeits-f.*), ”Income function” (*Einkommen-f*), and ”Asset function” (*Vermögens-f*) (Dieterich 1953) refer all to economic roles of forests, being derived from provisioning services and as such cannot be translated into ecosystem services. Rather, these “functions” can be seen as the socio-economic drivers, as the major motivations for deriving individual and public benefits from forests to gain wages, income, profits, wealth and taxes. The standard socio-economic importance of forest benefits is largely built upon and even dominated by the magnitude and distribution of these categories, although welfare and well-being as inclusive concepts (such as in UK NEA 2011) offer broader social and cultural contents and meanings of what matters in “good life”.

In an article on the theory of forest functions and ecosystem services Riegert et al. (2010) state that Dieterich intended to describe the relationship between forests and people. His aim was to present the role of forests to people’s welfare. With this function theory of 1953, he formed the doctrine although ideas were there earlier. For example, in 1807 Konrad Zwierlein published "On the great influence of forests on culture and happiness of states" (cited in Riegert et al. 2010). Later forest functions were organized into three groups: utilization (in German *Nutz)*, recreation (*Erholung)* and protection (*Schutz)*.

These formed the basis of forest management, policy and legislation in several mid-European countries.

Some considerations on forest function theory and its relationship to multiple-use can be found also in Nordic countries (e.g. Huse 1973). The term forest function as such is common in forest literature everywhere, including FAO statistics as can be seen in a country report from Denmark (Koch 1984). A function, of course, plays an important role in the ecosystem service literature. It is a bridging concept in the translation of ecosystems structures and processes into goods and services (de Groot and van der Meer 2010) and has been defined as "the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly" (de Groot 1992). Multifunctional forestry usually is an alternative expression to multiple-use, or *vice versa*. However, the Scandinavian countries adopted widely the idea and concept of the multiple-use of forests, one immediate reason being that it was the theme of the 5th World Forestry Congress held in Seattle, USA, in 1960. This conceptual approach was also made known by the Multiple-Use -Sustained Yield Act 1960, which USA adopted at the same year for the federal forests (Saastamoinen et al. 1984, Cubbage et al. 1993, Hytönen 1995).

The act listed (in alphabetical order) outdoor recreation, range, timber, watershed, and wildlife and fish as purposes of forest management "to be utilized in the combination which best meets the needs of the American people" (Cubbage et al. 1993).

In Denmark, Finland, Norway and Sweden the research on multiple-use of forests (under this explicit title, older research and discussion[6] on different uses existed earlier) started roughly at the same time, before and after the turn of 1960s and 1970s. It was focusing first on forest recreation (for example, in Denmark Koch 1974, in Norway Strand 1967, in Sweden Kardell 1972 and in Finland Saastamoinen 1972). Wider surveys on the

[6] For example in Finland, Olli Heikinheimo, professor of silviculture, during the training day for the foresters in 1936, had a presentation on tourism and forestry (Heikinheimo 1939).

development of multiple-use concept and research in the Scandinavian countries are found in Saastamoinen et al. (1984) and in particular in Hytönen (1995).

1.6 MULTIPLE-USE AND ECOSYSTEM SERVICE CLASSIFICATION

As discussed earlier, the traditional "multiple uses of forests" were prevailing until liberalization of sawmilling restrictions and the rise of pulp and paper industries from the latter part of 19th century. However, systematic accounts of the all forest benefits are rare and often related to the considerations of definitions of forestry at large (Saari 1928, Helander 1949). Alho (1968) provides a historical survey and schematic picture of the long term importance of major forest uses in North Ostrobothnia, which also illustrated the growing role of wood production and forest industries in the economy of the country.

The actual concept of multiple-use of forests was first discussed in professional papers in the 1960s (e.g. Mikola 1966, Manninen 1967). Together with the beginning of research on new forest uses, in particular that of forest recreation in the urbanizing country, it brought an interest to study and also classify the wider scope of forest uses and benefits, old and new.

In the Finnish Forest Research Institute, a "multi-disciplinary" group of researchers developed the classification of forest uses mainly for research purposes (Jaatinen and Saastamoinen 1976). It covered rather well the research planning[7] and communication needs. By dividing two forest uses (outdoor recreation into everyman's outdoor recreation and nature-based tourism; and environmental influences of forests into carbon storage and other environmental influences) one got the following list of ten forest (forestry land) uses, which provides room for further identification and has formed a part of the frame serving first

[7] In particular, when taking account that the number of researchers in the institute in this front was small during the first 10-15 years.

attempts to assess tentatively the total value of Finnish forest (Saastamoinen 1995, 1997):

a) wood production (all commercial and non-commercial wood utilization),
b) collecting berries, mushrooms and other non-wood resources (e.g. decorative lichen, forest flowers, herbs, birch sap etc.),
c) hunting and game management,
d) reindeer husbandry and other grazing,
e) landscape enjoyment and management,
f) everyman's outdoor recreation (non-commercial, based on everyman's rights),
g) nature based tourism (recreational activities based on or related to commercial tourism enterprises),
h) carbon sequestration capacity of forest,
i) other protective functions of forests (protection of soils, water resources, regulating micro and macro climate etc., and
j) nature (biodiversity) conservation and preservation.

This kind of classifications of forest uses in Finland on their part demonstrate that not a tiger’s leap but rather the deeper and more integrated ecological, economic and social re-thinking is needed to transform multiple-uses into the expanding framework of ecosystem services.

1.7 FORESTS IN THE SCIENCE OF ECOSYSTEM SERVICES

Like three centuries ago, deforestation and forest degradation has persistently kept its position as a major concern in the world of forests, although during the past 100-150 years mostly outside Europe, and most recently also at a somewhat slower rate (FAO 2012). The ever growing research evidence on the negative consequences of deforestation during the past decades has supported and promoted international and national actions and programs in their attempts to turn the tide of forest losses. In this front, research on ecosystem services of forests has become an important part, along its basic task to understand more comprehensively the relationships and interactions between people, forests, and other ecosystems. In fact, the science of ecosystem services plays nowadays a vital role in identifying unknown, poorly understood or underestimated functions and benefits of forests (and of other ecosystems), which are still in danger to be lost in the prevalence of deforestation and environmental degradation - or to be neglected due to the lack of knowledge.

As it has been implicitly shown, there are old and new research related to ecosystem services if the demarcation line is drawn according to the explicit use of the ecosystem service concept and the framework. Internationally, the "birth" of this concept and framework is related to the developments in ecological sciences and ecological economics. De Groot (1992) and de Groot et al. (2002) developed detailed analysis on ecosystem functions and first classification on ecosystems services, including those of forests. Some other pioneering work, in particular those of Costanza et al. (1997) and Daily (1997) brought the concept already more widespread in the scientific community and beyond, before the Millennium Ecosystem Assessment (MA 2005) made it known all over the world.

As forests compose the largest terrestrial ecosystems and the statistics and knowledge on forest resources and major forest products are well developed compared to many other ecosystems, it has been natural that forests have been an important field in the investigations on ecosystem goods and services both from an ecological and economic perspectives. For example, Costanza et al. (1997) in their ambitious assessment developed global economic values for 17 forest ecosystem services, separately also for tropical and temperate/boreal forests. Average annual values were much higher for tropical than temperate/boreal forests.

Taken the multiplicity of forest benefits and values it is no wonder that the Millennium Ecosystem Assessment (MA 2005) paid a lot of attention to the unique richness of forest ecosystem goods and services, which is emphasized by the scale: forests include two thirds of the world terrestrial biomass.

Among the many findings of MA (2005) were that forest and mountain ecosystems are associated with the largest amounts of fresh water - 57% and 28% of the total runoff, respectively. These systems provide renewable water supplies to at least 4 billion people, or two thirds of the global population (MA 2005). It also demonstrated that boreal forests were least threatened among the 18 major terrestrial biomes.

The Economics of Ecosystems & Biodiversity-study (TEEB 2010) used forests as a model case in a tiered approach for valuation and based its survey on economic evaluation methods of ecosystem services largely on research on forests and wetlands, which had been most often studied from that point of view.

The UK NEA (2011) has probably been the most widely cited national assessment of ecosystem services, which has also furthered methodological and conceptual discussion beyond the national borders (e.g. Haines-Young et al. 2012, Haines-Young and Potschin 2013, Kettunen et al. 2012, Saastamoinen et al. 2013). The specific chapter on "Woodlands" (Quine et al. 2011) deals with 13 major groups of ecosystem services with numerous examples of goods and benefits in the UK. For example, one of the regulating service groups 'Detoxification and Purification' is divided into 'Water quality', 'Soil quality', 'Air quality' and 'Noise reduction' with detailed examples in each group. Among the findings of the study is that timber production is an important provisioning service of woodlands but also non-timber products matter, specifically the contribution of game shooting was given. However, the social value of net carbon sequestration by UK woodlands was assessed to be at least double the market value of wood production per hectare. The woodlands of the UK are also highly valued by people for social and cultural services (Quine et al. 2011; in UK NEA 2011). The maritime influence of climate has led to cool temperate and boreal native forest types, even though the latter are now rare (Quine et al. 2011).

Niu et al. (2012) is an example of the combined national and sub-national economic assessment of forest ecosystem services in a large country (China) where the focus has been in maintenance and regulation services, water conservation alone making 40% of the total value. Barton et al. (2011) points the need of the valuation of ecosystem services from the Nordic watersheds.

So far boreal forests have not been very much present explicitly under the ecosystem service frames, although there otherwise has been long and abundant literature around boreal forests and their benefits. A recent Nordic survey (Kettunen et al. 2012) makes an exception. It surveys ecosystem goods and services of all terrestrial and aquatic ecosystems in the Nordic countries, and therefore gives quite a lot attention to forests as well (some additional featuring is found in chapter 1.7).

Ninan and Inoue (2013) reviewed over 40 studies (between 1989 and 2010), which had a focus on the valuation of intangible (non-provisioning) forest ecosystem services, such as water and soil conservation and carbon sequestration, which are more difficult to estimate. They primarily sought studies assessing multiple rather than single forest functions. Only three studies were found from the boreal forests, two from Finland and one from Sweden[8]. One of the conclusions was that four ecosystem services (watershed protection/hydrological services, soil conservation, carbon sequestration, and recreation) have received considerable attention, whereas services such as nutrient cycling, pollination, and environmental purification, have received little attention.

One may conclude that so far boreal forests have not got enough attention in the analyses using the framework of ecosystem services if taken into account the significant role of forests compared to other ecosystems in the countries locating in the boreal zone or considering the huge area boreal forests occupy.

[8] Of course, these kind of international meta-surveys most often dismiss studies that are not published in English or not easily available in web.

1.8 FOREST ECOSYSTEM SERVICES IN RECENT FINNISH FOREST LITERATURE

As discussed earlier the old Finnish forest literature includes many observations, considerations and deductive reasoning, which are relevant to the ecosystem service approach of our time. However, here only the research which has explicitly connected forests' benefits to ecosystem services is briefly mentioned. The words of ecosystem services can be found at the end of the article of Kouki and Niemelä (1997), without any comment. It has been also discussed by Naskali (1999).

The first scientific article in Finland focusing on forest ecosystem goods and services (Matero et al. 2003) was largely an application of the functional ecosystem service classification of de Groot (2002). The latter study has probably influenced many of the further classification schemes, including to some extent at least MA 2005, TEEB 2010 and CICES. Matero and Saastamoinen (2007[9]) continued the Finnish application focusing on the (marginal) economic valuation of forest ecosystem services in Finland.

Theoretical and conceptual considerations around forest ecosystem services in Finland are included in Naskali et al. (2007) but mainly it has been only during the past 3-4 years, when the general concept of ecosystem services has made a breakthrough in Finnish environmental and forest sciences. The growing number of state- of the art- and conceptual reports and collection of papers either around the general concept and approach of ecosystem services – but including forest aspects (Hiedanpää et al. 2010, Ratamäki et al. 2011, Primmer et al. 2012) - or with mere forest focus (Hytönen 2009, Kniivilä et al. 2011) have appeared in Finnish and enriched the understanding of the concepts and applications of the field.

The recent literature in English related to forest ecosystem services in Finland includes Vihervaara et al. (2010), Kettunen et al. (2012), Mashkina and Itkonen (2012). Also the general state-of

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[9] The data and calculations concerns the situation around the year 2000 as the manuscript was sent in 2003.

the-art report of this ongoing project (Saastamoinen et al. 2013) took many of its examples from forests. Primmer et al. (2012), Primmer and Furman (2012) and Saastamoinen (2012) have had a focus on forest and environmental policies related to forest ecosystem services. Policy aspects, including forest policy, have given much attention also in the main report, written in Finnish but with an extended abstract (Saastamoinen et al. 2014).

Generally speaking, the most recent forest related ecosystem service literature in Finland has mainly considered general aspects of ecosystem service approach and its significance, including those related to valuation and policy aspects. Little attention has been given to further the classification of forest ecosystem services beyond those general categories already found in MA (2005) and TEEB (2010), besides what is found in next.

The closest to the approach of this report is a Nordic study (Kettunen et al. 2012) in the context of the Economics of Ecosystems and Biodiversity (TEEB). It surveys the socio-economic importance of ecosystem services of the terrestrial and aquatic ecosystems in Denmark, Finland, Iceland, Norway and Sweden. The identification and classification of the ecosystem services was developed on the basis of classification adopted by TEEB (Kumar 2010) and the Millennium Ecosystem Assessment (MA 2005), but it was a bit extended to reflect the natural and socio-economic conditions of the Nordic countries. For example, provisioning ecosystem services typical to Nordic ecosystems (such as reindeer herding, berries and mushrooms) were given due attention. Also cultural ecosystem services were highlighted more from the same point of view. However, the study notes that "the approach adopted in the context of TEEB Nordic does not attempt to systematically identify and synthesize ecosystem services per individual ecosystems. Therefore, the list of identified ecosystem services should be considered as a generic starting point for all Nordic ecosystems, including marine areas" (Kettunen et al. 2012, 42).

Despite that, the study captures rather well also the forest ecosystem services in Finland (and other Nordic countries) and provides a lot of socio-economic information on their importance based on existing statistics, research and other information. In particular, the study produces a broad informational basis and platform for the further comparative studies within and beyond the Nordic countries, responding thus adequately to the needs of further work within the TEEB framework.

1.9 PURPOSE OF THE STUDY

The purpose of this report is to provide a coherent and systematic identification and classification of the boreal forest ecosystem goods and services in Finland. The approach is based on the still evolving Common International Classification of Ecosystem Services (CICES), as it represents the most ambitious effort to continue the development of the classification approach internationally culminated in the Millennium Ecosystem Assessment (MA 2005), in The Economics of Ecosystem and Biodiversity (TEEB 2010) and ecosystem service research these two milestones were based and further inspired.

The CICES works mainly under the umbrella of European Environmental Agency (EEA) and is coordinated by Roy Haines-Young and Marion Potschin from the Centre for Environmental Management, School of Geography, University of Nottingham (Haines-Young and Potschin 2011, Haines-Young et al. 2012).

This study is a part of the research project "Integrated and policy relevant valuation of forest, agro, aquatic and peatland ecosystems services in Finland", which aimed to "produce an up-to-date, integrated and policy relevant synthesis on the ecosystems services of forest, agro, peatland and aquatic ecosystems in Finland to serve improved decision making, governance and public communication (Research plan 30.11.2011). The focus of the whole study is in concepts and classification of the services of the four ecosystems, indicators, valuation and policies, which are reported in several publications[10].

One of the aims of the whole study is to make the concept of ecosystem services more familiar not only to the decision-makers but also other stakeholders and the public at large. Therefore, an aspect supporting communication is included in the aim to bring ecosystem services where possible "down to the earth". It is hoped, that the lowest hierarchical levels (Chapter 3.1.) would mostly be identifiable components of the Finnish forests as seen by the ordinary people in the forest.

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[10] The other published reports are: 1) Saastamoinen, O., Matero, J., Haltia, E., Horne, P., Kellomäki, S., Kniivilä, M. & Arovuori, K. 2013. Concepts and considerations for the synthesis of ecosystem goods and services in Finland. Publications of the University of Eastern Finland. Reports and Studies in Forestry and Natural Sciences. No 10. 108 p. http://epublications.uef.fi/pub/urn_isbn_978-952-61-1040; 2) Alahuhta, J., Joensuu, I., Matero, J., Vuori, K-M. & Saastamoinen, O. 2013. Freshwater ecosystem services in Finland. Reports of the Finnish Environment Institute 16/2013. 35 p. http://hdl.handle.net/10138/39076 ; 3) Kosenius, A-K., Haltia, E., Horne, P., Kniivilä, M. and Saastamoinen, O. 2013. Value of ecosystem services? Examples and experiences on forests, peatlands, agricultural lands, and freshwaters in Finland. PTT Reports 244. 102 p. http://ptt.fi/wp-content/uploads/2014/02/rap244.pdf; 4) Kniivilä, M., Arovuori, K., Auvinen, A.-P., Vihervaara, P., Haltia, E., Saastamoinen, O. ja Sievänen, T. 2013. Miten mitata ekosysteemipalveluita: olemassa olevat indikaattorit ja niiden kehittäminen Suomessa. PTT työpapereita 150. 68s http://ptt.fi/fi/prognosis/150 ; 5) Kniivilä, M. ja Saastamoinen O. 2013. Markkinat ekosysteemipalveluiden ohjaus- ja edistämiskeinona. PTT työpapereita 154. 32s. http://ptt.fi/fi/prognosis/154; 6) Arovuori, K. & Saastamoinen O. 2013. Classification of agricultural ecosystem goods and services in Finland. PTT Working Papers 155. 23 p. http://ptt.fi/fi/prognosis/155-arovuori-k-ja-saastamoinen-o 7s.; 7) Saastamoinen, O., Kniivilä, M., Arovuori, K., Kosenius, A-K., Horne, P., Otsamo, A. & Vaara, M. 2014. Yhdistävä luonto: ekosysteemipalvelut Suomessa. [Extended abstract]. Publications of the University of Eastern Finland. Reports and Studies in Forestry and Natural Sciences. No 15. 207 p. [Main report]. http://epublications.uef.fi/pub/urn_isbn_978-952-61-1426-2/. NOTE: In early communication the series number of this current forest report was mistakenly given as 16 instead of number 11 as it is here.

2. *Finland's boreal forests*

2.1 THE GLOBAL BOREAL FOREST CONTEXT

The boreal forests are a band of conifer-dominated forests which extend from Russian Far East across Siberia and Scandinavia to Northern Canada and Alaska, covering an estimated 1.7 billion hectares and over one-quarter of the planet's forest area. The boreal forests contain some 45% of the world's stock of growing timber. Their timber is globally a much valued commodity: some one quarter of global exports of forest industry products derives from the boreal forests (Vanhanen et al. 2012).

Pines and spruces, among other major coniferous species of boreal forests, have been in large scale used by forest industries. Until the 1950s the share of boreal coniferous forests was a half of the all industrial wood harvested in the world, but nowadays it is only 17%. The change was due to the development of forest industries in the tropical forests and that industrial plantation forests have been established in the temperate and tropical areas of the world. Nowadays it is the plantation forests which provide more than a one third of all industrial wood in the world, and their share is assumed to reach a half of that by 2050 (FAO 2012, Kanninen et al. 2010). While strongly focusing on fibre production, properly planned plantation forests can also produce other ecosystem services (Bauhus et al. 2010).

Even if boreal forests make the largest single forest biome in the world and they have for a long time been the major source of industrial wood from natural forests, boreal forests have not been severely threatened by deforestation (see e.g. MA 2005 and FAO 2010). The boreal forests have lowest deforestation rates among the all major forest biomes.

The reasons for the better performance vary in different parts of the boreal zone, but most evident ones are more or less the same: low population pressure, historical dependence on forests and later their economic importance, low competition from agricultural land uses and good natural regeneration capacity (Hannelius and Kuusela 1995, Vanhanen et al. 2012). In some countries, due to their high dependence on forests, the early attempts to use forest resources in a sustainable way have also borne fruit.

However, there is another major reason for the low deforestation rate which is not anymore shared by all boreal countries. A large part of boreal forest is beyond economic wood harvesting comprising 19% of closed-canopy forests in Canada, 14% in Norway, 9% in Sweden, 2% in Finland and 32% in Russia. Most of the Alaskan forests in the boreal zone proper are excluded from timber production (Vanhanen et al. 2012). However, in Russia and Canada these areas and forests are at the same time under other anthropogenic influence such as oil and gas exploration, hydropower development, mining and peat extraction.

That said one have to add that while deforestation is the main global concern it is not the whole story. Although forest degradation as such is a well-known intermediate stage in many deforestation processes, it is also an important problem of its own, given probably in the dark shadow of forest loss less attention that it earns. Degradation - which actually is a multi-faceted phenomenon not easy to define (e.g. Simula 2009) - is to some extent and in one form or another found in all boreal countries, but in larger scale in particular in Russia and Canada, which possess the largest areas. Besides the human induced impacts also pests and fires are among the reasons of degradation.

Nevertheless, these two countries possess the largest wilderness forest areas in the boreal zone and among the largest globally as well.

Boreal forests are not regarded as hottest spots of biodiversity, although forest utilization has also taken its toll as seen in the list of endangered species (MA 2005). Degradation can be defined also in the terms of biodiversity, regarded mainly as a supportive service in ecosystem service literature while some of its components are included into provisioning (genes), regulation and maintenance or cultural ecosystem services (Haines-Young and Potchin 2012, Kettunen et al. 2012).

2.2 ECOLOGICAL HISTORY AND FOREST ZONES IN FINLAND

Boreal plant communities are young compared with tropical moist forests which have changed little over at least a million years. During the last (Weichselian) glacial period in northern Europe, ice advancing from north swept away all plants, animals and soils, including peat layers and masses of loose soil parent material. In whole Eurasia, the last glacial covered the northern parts of the British Isles, Fennoscandia, and parts of Central Europe and European Russia. Similarly, almost all of the Boreal North America was covered by ice (Eyre 1968).

When the ice started to melt and retreat in central and northern Europe at the end of the last glacial period some 15 000 years ago, an inorganic surface of parent materials appeared consisting of bare rock, boulders, sand, gravel, moraine and fluvial loam and clay. The pre-glacial drainage system was destroyed. The new terrain was poorly drained and studded with ponds and lakes. Large areas were susceptible to peat forming mires (Hannelius and Kuusela 1995).

The revealing soil was colonized first by tundra vegetation, grasses, dwarf birch and so on and then by trees[11]. Tundra vegetation provided living conditions for reindeer, which was followed by its predators such as wolf and wolverine. So, already during the tundra period an ecosystem with relatively complex nutrition web was formed, to be later added by human influences (Mattsson and Stridsberg 1981). Birch and pine became the most common species in Northern Scandinavia and on poorer soils in the south. Spruce came some 4000 years ago

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[11] Colonization and further developments are usually described by serial successions of plant communities, although the description could equally well be focused on the characteristics of animal communities, microclimates or soil processes (Eyre 1968).

from Russia to Finland and continued its westward expansion to Norway and Sweden, where it advanced from south to north. It became the dominant tree species in better soils of middle and northern Scandinavia but never reached Denmark and southwest Norway by natural dispersal. Roughly at the same time, beech entered Scandinavia from the south and attained a dominant position in the broadleaved forests of southern Scandinavia, where lime and elm lost the importance received during the warmest post-glacial period. Thus, 2000 years ago, when also spruce had settled down, the present forest zones of Northern Europe were more or less established (Fritzboeger and Soendergaard 1995, Kouki and Niemelä 1997).

The same can also be said about the forest vegetation zones in Finland. Finland has the complete latitudinal cross-section of boreal forests. Only the thin southwestern seashore zone of the Baltic Sea belongs to *hemiboreal vegetation* with several broadleaved species common in the temperate zone. In the north the boreal forest borders to the sub-arctic vegetation, a mix of small birches, brushes and treeless area, which sometimes is included into the northern boreal zone (Figure 1). Rather similar sub-arctic (alpine) zone of tundra vegetation is located along the higher parts of the mountain chain bordering Sweden and Norway.

The other larger natural ecosystems of Finland – *lakes and rivers* as well as *mires and peatland* – are direct descendants of the Ice Age: the melting waters found their forms and locations in the terrains shaped by the retreating ice. Agroecosystems have mainly indirect connections to the Ice Age: they are mainly cleared from forests or peatlands, but to minor extent also by drying lakes (Saastamoinen et al. 2013). The major ecosystems and land uses form the mosaic which covers the whole country although lakes and rivers, peatlands and agricultural lands have their own regional patterns while forests are rather evenly covering the whole country (Figure 2).

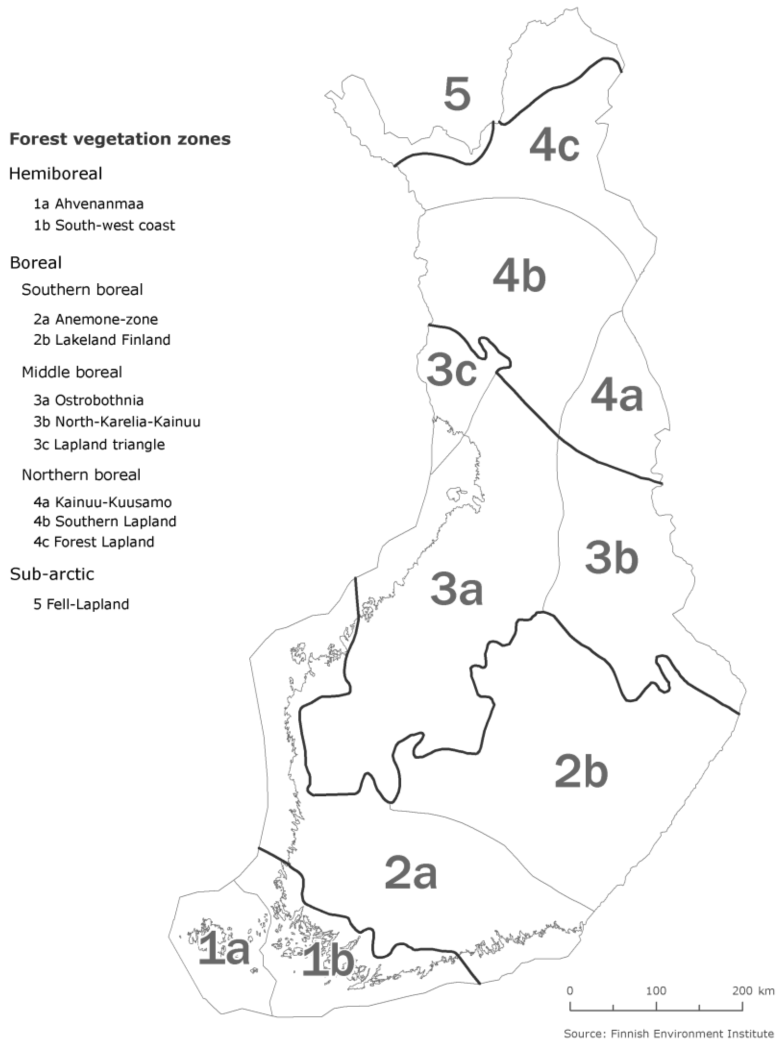

Fig. 1. *Forest vegetation zones in Finland. The sub-arctic zone (5 Fell-Lapland) is sometimes regarded as the northernmost part of Northern boreal zone.*

2.3 CURRENT LAND USE AND FOREST RESOURCES

Finland may earn the epithet of 'forest country' as 86 % or 26.2 million ha of the land area in Finland, are classified as forestry land. Fortunately, there are some further specifications, which prevent the Finns to be entirely lost in forest. Based on site productivity, forestry land is divided into forest land (20.3 mill. ha), poorly productive forest land (2.5 million ha) and unproductive land (3.2 million ha of treeless or almost treeless land)[12] (Tomppo et al. 2012, Finnish Forest Research Institute 2012[13]). If the unproductive, practically "open" forestry land is left out, forests make 68 per cent of *the total area* of Finland (without sea areas). Thus the inherent human need to experience open space can be satisfied by inland watercourses 10 per cent, agricultural lands 8 per cent, open peatlands[14] 6 per

[12] The categories of forestry land are based on the land's capability of producing volume increment. On forest land the capability is 1.0 m³/ha/year or more (as an average of the rotation period), on poorly productive forest land 0.1 m³/ha/year or more, and on unproductive land less than that. Forestry land includes also forest roads, depots and other minor areas. Unproductive and a part of poorly productive forest land are not suitable for wood production (open areas or scanty trees and brushes covered areas) but good for many other forest uses such as grazing, recreation or for providing open space. Forestry land also includes large areas which are not meant for wood production (or it is restricted) (such as several types of nature conservation or other protected areas).

[13] From 1.1.2015 the Finnish Forest Research Institute (Metla) will be a part of the Natural Resources Institute Finland (Luke) together the two other state research institutes MTT Agrifood Research Finland, the Finnish Game and Fisheries Research Institute, and the statistical services of the Information Centre of the Ministry of Agriculture and Forestry. (www.luke.fi)

[14] The concepts of forests and peatlands are partially overlapping. About half of the mires and peatlands have naturally, or due to forest drainage, a forest cover which brings them into the category of forest land or unproductive forest land. When forests are defined as the sum of forest land and unproductive forest it includes peatlands meeting the criteria of the two categories. What is left, are practically open peatlands. In Fig 2 the grey colour refers to all open lands. In the very north these are either peatlands or treeless fell areas and elsewhere mostly open peatlands. The detailed land use in respect to the whole area and land area is found in Saastamoinen et al. (2013), Table 1.

cent, open fells 3 per cent and at least a part of built-up environment and infrastructure covering 5 per cent of the total area (Saastamoinen et al. 2013). This kind of ecosystem and other land use cover can roughly be seen in Figure 2, where "open area", however, does not distinguish between most northern open fells and open peatland areas elsewhere.

Fig. 2. *Main land cover categories in Finland. Open area in the northernmost part refers mostly to open (treeless) fells and peatlands and elsewhere to open peatlands.*

Of the total forestry land (including unproductive land) in Finland, 52 % is under non-industrial, private ownership. The state owns 35 % and forest industry companies own 8 %. The remaining 5 % represents forests under municipal, parish, shared or joint ownership. State-owned forests are mainly situated in northern Finland (including extensive nature conservation and wilderness areas, most of which are located in northern parts of the country). The private forests are mostly located in southern and central Finland and also in more fertile sites due to their traditional connection to agriculture. If only (productive) forest land is taken into account, the share of private ownership, including jointly owned forests, is higher (62%) and their economic importance is further emphasized by their key role in the domestic supply of wood used by forest industries (about 80 per cent). The number of individuals owning forest (> 2 hectares) is 737 000 persons (Statistical Yerbook of Forestry 2014).

Statistics on forest resources in Finland are based on the *National Forest Inventories* (*NFIs*), which were started already in the early 1920s using statistically advanced methods from the very beginning. The inventory system has been continuously developed and broadened to include new data needs, related for example the health of the forests and their silvicultural conditions (Tomppo et al. 2008). The most recent data on forest resources is based on the field measurements obtained during the 11th National Forest Inventory performed over 2009–2012 (Tomppo et al. 2012, Statistical Yearbook of Forestry 2014). The following summarizes some results[15].

[15] The information and statistics on Finnish forests, forestry and forest industries is abundantly available in the web. The major source providing statistical and other information also in English is the Finnish Forest Research Institute (www.metla.fi). Other useful sources can be found in the Ministry of Agriculture and Forestry (www.mmm.fi), forest industries (www.forestindustries.fi), Metsähallitus (state forests)(www.metsa.fi), Finnish. Forest Association (www.smy.fi) and the Ministry of Environment (www.environement.fi) .

Since the 1970s, the standing volume has continuously risen. The growing stock volume is now more than 60 % higher than during the early 20th century. Half of the growing stock volume consists of Scots pine, 30 % of Norway spruce, and 20 % of broadleaved species (mainly birch).

The major reason for the successful development of forest resources largely dates back to the turn of the 1950s and 1960s when it was found that the strong expansion of the forest industries has led to wood harvesting volumes considerable higher than the allowable cut. It was seen endangering drastically both the current and in particular the future sustainability of forestry in the country. Several programs for intensification of silviculture and forest improvement were soon planned and implemented during the next decades, supported by the government's organizing and financial support for measures taken in private forests. Other policy measures were also taken.

For example, the construction of the large scale forest road network, the restoration of unproductive forests, the increase of the use of artificial regeneration, forest fertilization and the large scale peatland drainage were essential part of the intensification programs since late 1960s and 1970s. All these programs could be planned because the forests inventories had provided detailed information on the state of the forests and forest research was able to provide mostly adequate estimates of the growth potential of forests due to the measures. As a consequence wood production increased considerably. An important supplementary factor in achieving the balance between realized and sustainable allowable cut was also the substantial decrease of the use of fuelwood due to the emerging low cost oil energy from the early 1960s until the first oil crisis in 1974.

Afterwards, however, it was also found that ca. 15-20 % of the new peatland drainage areas did not produce the assumed outcomes. New drainage was practically finished by 1990 and restoration of many uneconomic drainage areas has been going on during past 20 years, in state forests in particular.

Taken as a whole, the draining of mires has substantially improved the growing conditions for trees on peatlands and hence the importance of growing stocks on mires is increasing. Currently 24 % of the growing stock is on peatland. Of the total growing stock volume of the country, 90 % grows in forests available for wood production. Other part of the growing stock is on forestry land allocated for nature conservation or other protection purposes (Finnish Statistical Yearbook of Forestry 2014).

The annual increment of the growing stock in Finland is 104 million m^3 (Figure 3). The annual increment began to mount up rapidly in the 1970s. Before that, it used to be approx. 60 million m^3 annually. The main contribution to the rise in increment is from pine, due to the large number of young stands at the rapid growth stage.

The growing stock volume on forest land and poorly productive forest land amounts now to 2 357 mill. solid m^3 (over bark). Since the 1970s, the standing volume has continuously risen. The growing stock volume is now nearly 60 % higher than during the 1970s, as the annual growing stock increment has been larger than the volume of removals. Half of the growing stock volume consists of Scots pine, 30 % of Norway spruce, and 20 % of broadleaved species (mainly birch) (Finnish Statistical Yearbook of Forestry 2014).

Since the 1970s, the total drain (removals + logging residuals + natural drain) has continuously remained lower than the volume increment of the growing stock. The total drain was 71 million m^3 in 2011 (Figure 3) and 79 mill m3 in 2013, highest than ever. Yet the drain amounted to only 72 % of the annual increment of the growing stock (Finnish Statistical Yearbook of Forestry 2012, Finnish Statistical Yearbook of Forestry 2014).

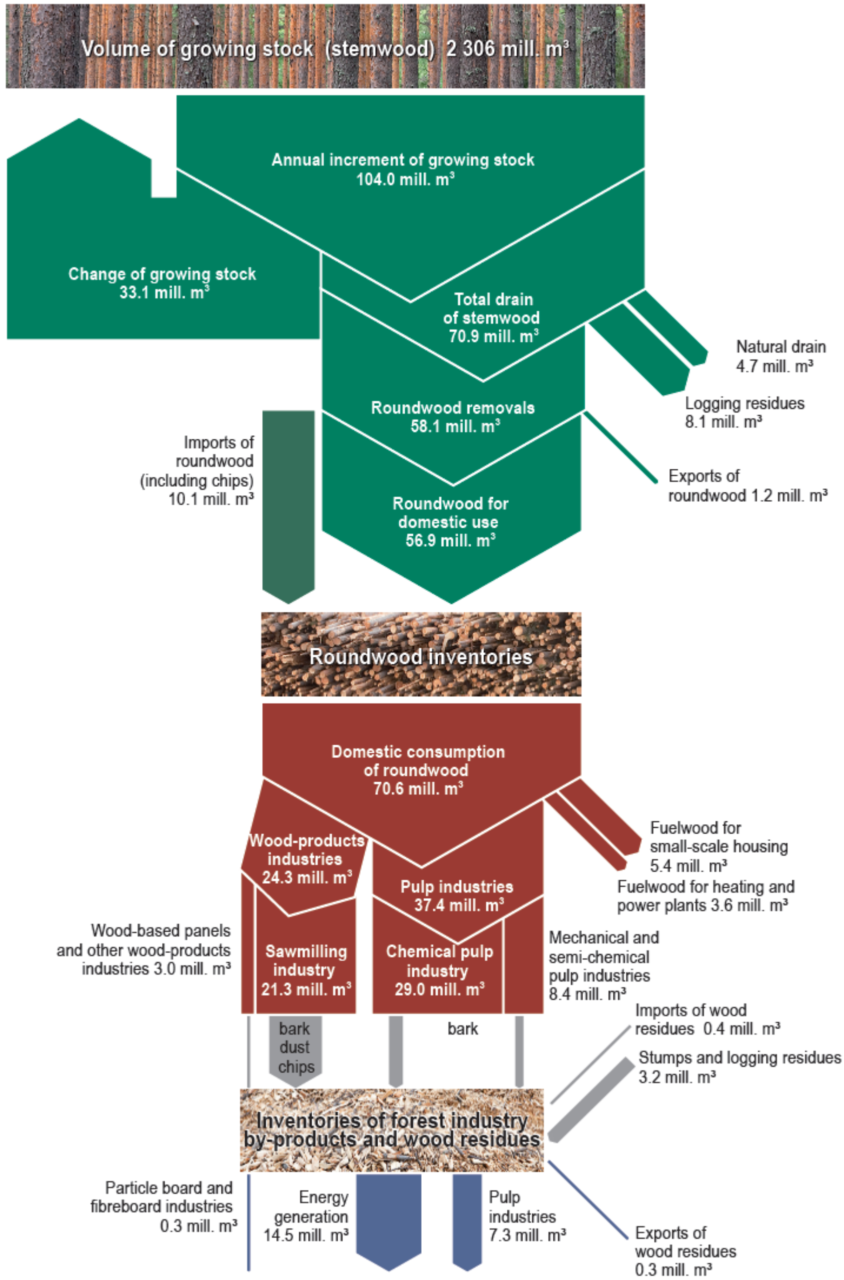

Fig. 3. *Wood flows from forest to industry products. Source: Peltola 2013, Finnish statistical yearbook of forestry 2013.*

In 2013, value added of forestry totaled EUR 2.9 billion (1.7 % of the gross value added), of which EUR 0.5 billion originated from the value of net increment of the growing stock. The value added generated by the wood products industries reached EUR 1.1 billion (0.6 %), and by the pulp and paper industries EUR 2.7 billion (1.6 %). In 2013, the share of the all forest sector was 3.6 % of Gross Domestic Product (Finnish Statistical Yearbook of Forestry 2014).

The relative importance of the forest industries in the Finnish economy has continued to decrease during the 2000s, in particular after 2007. Yet it made 20 % of the total export of goods from Finland in 2013. The new investment plans suggest that the turn upwards is in sight.

Besides the wood provided for industrial processing, export and consumption, forests provide numerous non-wood forest products and are the source for many other benefits. Traditionally these benefits have been considered under the broad concept of multiple-use of forests, as discussed earlier (Ch. 1.6 and 1.7) and nowadays in the broader framework of ecosystems services (next Ch. 3).

Another more recent but also broad concept related to the roles of forests in nature and society is biodiversity. Biodiversity in the forest signifies the abundance and versatility of various forest environment types, organism communities and ecosystems, as well as the variety of species living in forests and their genetic heredity. Protecting biodiversity in forests is one of the main goals of the Finnish forest and environmental policies. Measures to conserve forest biodiversity include establishing protected areas, protecting valuable habitats to save threatened species, and taking into consideration the goals of biodiversity in the management of commercial forests (Finnish Forest Research Institute 2012).

3. Classification of forest ecosystem goods and services in Finland using CICES

3.1 INTRODUCTION TO CICES

The Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin 2011, 2013) represents the most concentrated effort at the European and international level to continue the work of Millennium Ecosystem Assessment (2005) (later referred as MA 2005) and its economic extension study The Economics of Ecosystems and Biodiversity (TEEB 2010). The CICES works under the umbrella of European Environmental Agency (EEA) and the CICES "coordinators" are Roy Haines-Young and Marion Potschin from the Centre for Environmental Management, University of Nottingham.

The first version of CICES was published in 2010. Approximately at the same time when our Finnish study was launched, the paper for discussion of CICES Version 4, July 2012, was revealed (Haines-Young et al. 2012). The new version and categories of CICES have targets to serve: 1) ecosystem service mapping and assessment and 2) ecosystem service accounting. The V4 differs from the earlier versions in that it includes an additional "column" called "Class type", which brings the general categories to the more concrete levels.

In September 2012 CICES Version 4.1. appeared and was adopted in this study as the basis for the classification of forest ecosystem services. However, when the CICES V4.1 based classification in the Finnish context was largely drafted, but not finalized, it was noticed that already CICES V4.3 (Haines-Young and Potschin 2013) had been launched. The latest version of CICES classification system is available at http://www.cices.eu. As it seemed that the actuality and usefulness of the classification exercise if using the V4.1 (September 2012) will suffer to some extent at least, it was decided to modify it according to the most recent version. Although there certainly is much common in both versions, there were also several changes which meant that the transformation was not a straightforward one and took its time.

When CICES-format is used in the concrete national application, it needs to be decided which "entering point" into the classification hierarchy is used. It was recommended in CICES V4 that "users would ... identify the specific services that they are dealing with as 'classes' and 'class types', and use the hierarchical structure to show where the focus of their work lies" (Haines-Young and Potschin 2012). The most recent report (Haines-Young and Potschin 2013) similarly emphasized that it is at this level where users could identify whether a particular service is arising from a terrestrial, freshwater, or marine ecosystem, for example, or in the case of cultural services whether the setting is a formal (designated) or informal (non-designated) species or location.

This was also followed here in a sense that the "class" was interpreted to be "forest ecosystem class". Implicitly it means also that "Group 111 Terrestrial plants and animals for food" refers to "Forest plants and animals" and could logically be written as "Group 111 Terrestrial plants and animals for food (in forests)". However, this is not done as the title of table already gives that classification concerns forests.

The table form here is different from the large CICES Excel tables. This was necessary to make it possible to create readable tables (although divided), which within the format of the publication series gives a possibility to present each section in two to four tables.

In addition to the "class type" introduced in CICES V4, an additional column called here as "sub-class type" has been adopted to further the possibilities to go into more concrete or detailed categories, which sometimes allows introducing goods as species groups or even species levels. This is done in order to make the ecosystem goods and services more understandable also for the laymen. However, in many cases this kind of further specification is only given as a list in the tables and in the text, without further comments.

Numbering of classification categories is not used in CICES – although in a way it is in-built into the structure of the Excel format – but was adopted here to make the hierarchy of different categories more visible and also to make the identification of categories in the text easier. Numbering goes up to five digit codes. Sub-class types are identified with alphabets, but first sub-class type includes the number code of class type common to all[16].

In the following the ecosystem goods and services are presented in three major tables (divided to 2-4 sub-tables) according to the three sections of CICES. Descriptions and comments in the text try to cover systematically all the categories in the tables until class type level at least, sometimes including also the additional sub-class types if needed.

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[16] In the "numbering approach" assumed in this study for clarity purposes (the decimal classification), all forest ecosystem services are directly located under classes, as is recommended by CICES. However, if thinking about combined classification of (for example) four ecosystems (forests, agroecosystems, peatlands and freshwaters) of the whole study, it would mean that the 9 (1-9) or 10 (0-9) sub-categories are not enough). In that case the group or some other higher category should be divided to identify the four ecosystem services , a bit in a way similar to CICES V4.1 used the group "terrestrial plants and animals for food". However, whenever the classification field is conceptually broad and substantially large the possibilities of decimal classification are also limited and also any numbered category having more than 5 digits already loses their demonstration values. As seen, here alphabetics is adopted after 5 digits to point the lowest additional sub-class type category.

3.2 PROVISIONING SERVICES

Provisioning services are divided into three divisions: Nutrition, Materials and Energy (Tables 1a and 1b).

Division 11 Nutrition (Table 1a)

Wild animal and plant resources formed the basic means of prehistoric human subsistence in the deciduous and coniferous wildwood of Scandinavia (Fritzboeger and Soendergaard 1995). A recent expert assessment of stone age nutrition in Finland assumes that 25 % of nutrition came from berries, mushrooms, nuts and seeds, 45 % was meat, of which 30 % was derived from heals, beaver, moose and forest deer, 10 % from other mammals like forest hare, fox, pine marten, squirrel, common otter, bear and dog, and 5 % from birds. Fish made the rest 30 % (Mannermaa and Tallavaara 2012). All nutrition came from wild, roughly about 60 % from forests and 40 % from lakes and sea. At present only minor part of nutrition is forest based.

Group 111 Biomass

The traditional slash-and-burn agriculture based on felling and burning trees to cultivate crops could be called in modern terms as agro-forestry. Burning gave ash and space for rye and other crops.

The grazing of domestic animals in the forests was common in the past. Natural meadows and the areas left from slash-and-burn agriculture were used for grazing in summer time. Twigs and leaves of broadleaved trees were collected for winter feed. Coniferous twigs were used as bedding for cattle. The main purpose of early cattle keeping was to get dung to fertilize the burnt areas, which allowed only some subsequent crops. When milk and meat became the major products of cattle, almost every farm had some forest area for keeping cattle. When the population was small there was no shortage of forest grazing areas (Helander 1949). The winter feed was collected also from meadows. The amount of forest grazing areas was largest in mid 1950s but after that it was decisively decreasing until the 1960s. The last statistics on forest grazing area was from 1965 when it was 1.36 million hectares (Kuuluvainen et al. 2004, Pykälä 2011).

Contrary to slash-and-burn agriculture collecting nature products and hunting continued in Finland long compared to other European countries. These activities have still a bit larger role in Finland than in Sweden and Norway (Sievänen and Neuvonen 2011), as a part of household production, recreation and even commercially. However, it can be concluded from the data presented by Prättälä (2012) that the totality of products from wild nowadays may only make no more than 1-3 % of the total nutrition in Finland. Yet their role is increasingly emphasized in the public advice concerning healthy diet based on intensive research on berries in particular (e.g. Mykkänen et al. 2012, Kallio and Yang 2013).

Class 1111 Cultivated crops

There is no crop cultivation in the forests anymore.

Class 1112 Reared animals and their outputs

Class type 11121 Reindeer herding. Reindeer husbandry area covers mostly the northern forests, peatland and fell areas of the country making as much as 34 % of the terrestrial area of the country (Nieminen 2013). It forms the traditional livelihoods of indigenous Sámi people in the northernmost Lapland. Yet reindeer husbandry is practiced also by many Finnish people, often as an additional income in their farms mostly in central and southern parts of reindeer management area. That type of reindeer keeping relies nowadays very much on additional winter feeding in the farms[17]. Reindeer meat (*Sub-class type 11121 a)* is the major output, much valued low-fat product.

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[17] In the System of National Accounts (SNA) reindeer husbandry is a part of agriculture – not forestry. However, as over 95 % of the land grazed by

Table 1a. *CICES V4.3 classification of provisioning services of the boreal forest ecosystem [NOTE: The numbering of categories is not a part of CICES, but only adopted in this study. The same concerns category Sub-class type]*

CICES Section 1 PROVISIONING SERVICES		
Division 11 Nutrition		
Group 111 Biomass		
Class[18]	**Class type**	**Sub-class type**
1111 Cultivated crops [Not in forests]		
1112 Reared animals and their outputs	11121 Reindeer herding	11121a Meat b (Reindeer milk)
	11122 Grazing of livestock	11122 a Cattle b Sheep
	11123 Bees	11123 Honey
1113 Wild plants, algae and their outputs	11131 Berries	11131a Cowberry b Bilberry c Cloudberry d Other 34 species
	11132 Mushrooms	11132 a Caps b Chantarelles c Ceps d Other boletuses e Russulas f Other ca. 100 species
	11133 Herbs	11133a Birch b Spruce c Rosebay willowherb d Other ca. 220 species
1114 Wild animals and their outputs	11141 Deer	11141a European elk b White-tailed deer c Roe deer d Forest reindeer (e 3 imported species)
	11142 Grouse	11142a Black grouse b Hazel grouse c Capercaillie d Willow Grouse e Rock ptarmigan
	11143 Hares	11143a Arctic hare b European hare
	11144 Large carnivores	11144 Brown bear
	11145 Other wild animals (and their outputs)	11145a Beaver b Wild boar c Mouflon
Group 112 Water		
1121 Surface water for drinking	11211 Springs	
	11212 Upland brooks	
1122 Ground water for drinking	11221 Ground water storages	

Last decades have not been easy times for reindeer husbandry. It has suffered from the pressures of other land uses, in particular from forestry, artificial lakes, tourism and mining. The difficulties are also due to the long-term overgrazing (e.g. Akujärvi et al. 2013) and low profitability, partially explained by the increasing need of hay or other additional winter feed. However, reindeer serves also as an important tourist attraction

reindeer is forestry land, it is regarded as a forest activity in multiple use of forests.

[18] Under each **Group**, first column (4-digit) refers to **Class,** second to **Class-type,** third to the additional **Sub-class type**.

in Lapland, and tourism in many forms offers additional income opportunities for many of the altogether 4500 reindeer owners. Multiple field entrepreneurship has been seen as an alternative for traditional reindeer husbandry (Meristö et al. 2004, Nieminen 2013).

Class type 11122 Grazing of livestock. Grazing of domestic animals such as cattle (*Sub-class type 11122 a*) and sheep (*11122 b*) is nowadays based on managed fields and is in near-by marginal forest lands occasional and done for dual purposes. The forest areas once reduced by grazing were often located in most fertile forests. Therefore, these activities produced diversified biotopes later appreciated as heritage forests and cultural landscapes such as leaf fodder meadows, pasturage and forest grazing areas, which had developed their own rich biodiversity. Nowadays forest grazing is mainly promoted as a means to maintain the biodiversity and landscape values of these areas, supported by EU (Tiainen et al. 2004).

Class type 11123 Bees. Forest regeneration areas, which are richer in species bees prefer than those with dense tree cover, are to some extent used for beekeeping and honey production *(Sub-class type 11123a)*.

Class 1113 Wild plants, algae and their outputs

Class type 11131 Forest berries. Although, urbanization as such has alienated people from forests, in particular youth, the wild berries and mushrooms from forests and peatlands still have rather significant role in a Finnish way of life. It is supported by the traditional everyman's right which allows picking wild berries and mushrooms even from private forests, but also by increased leisure time and high number of summer cottages (Sievänen and Neuvonen 2011), as well as increased access to forest by dense forest road network (Saastamoinen 1997).

The Finnish forest site classification has plant ecological background (Cajander 1909, 1925) and forest site types have been categorized according to the typical ground and field floor plants. Examples such as lingonberry (*Vaccinium vitis-idae*) and bilberry (*Vaccinium myrtillus*) site types demonstrate that boreal forests in Finland are rich in wild berries, as they also are rich in lichen resources and mushrooms.

There are altogether 37 edible wild berry species in Finland and 16 are picked for human consumption (Salo 1995). In 1997 the total harvest of wild berries was 56 million kg (assumed to the highest reliably recorded), of which 73 % was directly used by households and 27 % sold to markets (Saastamoinen et al. 2000). Based on the second similar large national survey the wild berry harvest in 2011 was 35 mill. kg (Vaara et al. 2013). The annual and geographical variations of biological crops are large. Based on expert-empirical models, total average annual biological crops of the two most popular species, lingonberry *(Sub-class type 11131a***).** and bilberry *(Sub-class type 11132b*, were 257 and 184 million kg, respectively, and their harvests in a good year 1997 were estimated to be about 8 and 6 per cent, of the crop, respectively (Turtiainen et al. 2011). The precious cloudberry *(Sub-class type 11123c)* grows on forested and open peatlands is much wanted but rare**.** Altogether 58 % of Finns, aged 15-74 years, participated in berry picking (at least once a year) in 2010 (Sievänen and Neuvonen 2011). Among other 34 edible berries *(Sub-class type 11123d***)** there are wanted ones with small crops, and abundant species even with moderate nutrition values but not regarded tasty and little picked**.**

The commercial picking by ordinary Finns has been decreasing. This has created demand for foreign pickers (in particular as far as from Thailand) which have been invited by the berry companies to participate in commercial picking, following what has been going on earlier in Sweden. Nowadays it is estimated that foreign pickers supply at least 78% of the harvest bought by the organized berry trade (Vaara et al. 2013).

Class type 11132 Mushrooms. From approximately 200 edible mushrooms some 30 species are used as food. The earlier lists of commercial mushrooms, allowed to be traded, included 24 species or species groups. The most common and popular edible mushrooms are to be found among caps (*11132a*), Cantharelles *(11132 b*), Ceps *(11132c*) and other boletus species *(11132d)* as well as *Russula*s (*11132e*) and. Cantharelles and recently in particular *Boletus edulis*, due to its export markets in Italy (e.g. Cai et al. 2011), are most important among the commercial species. The highest unit price has recently had Matsutake, a rare species which is very popular in Japan. Household harvesting of all edible mushroom was 15 million kg in 2011 and 42 % of households participated in picking mushrooms. However, only ca. 1 % of households engaged in picking mushrooms for sale (Turtiainen et al. 2012).

Mushroom utilization rate is much lower than that for berries; expert estimates assume it to be 1-3 % of the total crop, which, however, is not very well known and is assumed to be high among the most popular species. It seems that interest in mushroom collection is somewhat gaining back its past popularity (Luttinen 2012). In 2000, participation rate was 38 % and in 2010 40 % (Sievänen and Neuvonen 2011).

Class type 11133 Herbs. In addition to berries, there are a number of edible wild forest plants which can be used as nutrient-rich ingredients for different foods, mostly as salads, seasonings and herbal beverages. Natural herbs can also be dried or frozen so that their flavours can be enjoyed all winter long (Moisio 2006). The following are examples of herbs from abundant forest species (www.arcticflavours.fi).

Sub-class type 11133a Birch (*Betula spp*). Dried birch leaves can be used for teas and other herbal beverages and fresh or frozen leaves for salads or soups. The leaves are also suitable for preparing green leaf powder or seasoned salt. *Sub-class type 11133b Spruce (Picea abies).* The young annual shoots can be used as a seasoning on fresh salads and bread or in soups, stews and casseroles as well as in jams, syrup and sweets. They are also suitable as a bright, attractive garnish. *Sub-class type11133c Rosebay willowherb* (*Epilobium angustifolium)* is a common and handsome perennial all-over in the country and thrives well for example in regeneration areas after mature forest has been harvested. Young shoots can be served similarly to asparagus. The finely chopped young leaves add variety to salads and vegetable dishes. However, it is best known for its use in herbal beverages. *Sub-class type11133d Other species*. Altogether there are ca. 220 edible species of natural herbs, of which about a half can be regarded having forests as their major habitats (Moisio et al. 2004, Piippo 2005).

Class 1114 Wild animals and their outputs

Class type 11141 Deer. Contrary to berries and mushrooms the game resources in the boreal forests are mainly scarce. However, some species also benefit from forestry: this is in particular true for the European elk (*Sub-class type 11141a;* (*Alces alces*) which eats the young pines growing in the forest regeneration areas with such an apetite that it has become one of the major problems of silvicultur. and partly because of that its optimal population a continuously debated. Other *artiodactyla (Sub-class type 11141b-d)* have smaller populations or all more local but increase much the variety.

While everyman's rights allow simple fishing it excludes hunting rights. The number of hunters who paid the game management fee in 2011 was 312 000. However, not all of them were active hunters. The number of hunters has slightly increased every year.

The game production and management problem is difficult biologically and technically because a part of management system (weather, natural population dynamics) is uncontrolled and partially also not very well-known (e.g. relation between forest management and game management, real size of game populations). Economically and socially, the problem is not easier. For example, how much to produce and hunt European elk, at which direct and indirect costs (game management efforts, lost timber benefits due to seedlings/young forest damage and traffic accidents)?

Non-consumptive use of game is represented by guided bear watching and photographing in the wild (see cultural services). The scale of this kind of nature tourism is small but offers as unique experiences as strictly regulated bear hunting. In principle forest nature and game population management can provide a variety of ecosystem services: coupled provisioning products (meat and fur as animal fibre) and cultural services (hunting experience, trophies and fur as recreational experiences and as symbolic cultural service).

In Finland, the amounts of harvested wild game are collected from hunters and many hunters have participated voluntary game population recording or game management activities. Hunting participation rate was in 2010 about 8 % among the whole population and 14 % among the males (Sievänen and Neuvonen 2011).

Class type 11142 Grouse. Many species of Grouse especially Black grouse (*Sub-class type 11142a*), are keenly utilized and demand for them is greater than maintained by the scanty biological production of boreal forest under the influences of forest operations

Group 112 Water

Water supply services are covered by Alahuhta et al. (2013) in the classification of ecosystem services of freshwaters. Here only forest springs and groundwater storages are included, because of their close relatedness with forests.

Class 1121 Surface water for drinking

Class type 11211 Springs. Springs are small, pool-like places, where ground (unconfined aquifers and floating groundwater) water from soils is discharged on soil surface or on peatland (Raatikainen 1989). The discharging water can form small streams and specific biota around it, which are called as spring complexes. Most springs not more than one square meter in size but also larger pond-like springs exist and largest spring complexes can consist of several hectares.

There are more than 33 000 recorded springs in Finland but the real number is assumed to be higher. Springs can be found both on mineral land forests and peatlands. Most springs are located in areas with varied topography as in northern Finland, where humid climate supports springs. Also in central and southern Finland springs can be found everywhere in particular within the esker, edge and hill moraine land forms. However, in central and southern parts of the country, in particular, human activities such drainage of peatlands, forestry and agriculture and gravel intake destroyed springs. Springs are regarded as vulnerable biotypes in the whole country and endangered in southern Finland (Raunio et al. 2008).

The groundwater outflow rates in the smallest springs are less than 0.1 liter/second but the largest can give groundwater hundreds or even one thousand liters/second. The quality of spring water is excellent and in former times it has been the most important source for potable water, one spring serving often several households in the vicinity. After the deployment of deep wells and water-intake installations based on groundwater sources or surface waters their role has decreased. However, the rise of bottled water consumption has brought new importance for larger natural spring water sources. Regardless of rural depopulation many small springs may have found new users from summer house dwellers. Väisänen (2013) emphasizes that spring waters in Lapland have a good quality and springs serve well tourists during their skiing and hiking trips around the fell resorts.

Class type 11212 Upland brooks. One might also consider that small brooks in the forestry land on the upper parts of watersheds similarly have a quality good for drinking purposes.

Class 1122 Ground water for drinking.

Class type 11221 Ground water storages. Most important potable ground water storages are found in coarse-textured sorted soils, easily permeable for water such as in eskers, delta and glacial ice marginal formations. These can be tens of meters thick. There the ground water surface is deeply located and the temporal variations of water level are small. The quality of groundwater is on the average very good (Mannerkoski 2012). According to a study of the National Institute for Health and Welfare, Finnish tap water has a better quality than bottled water, although this is mainly due to storage and warming of the bottled water (Grönholm et al. 2010).

Eskers are usually covered by pine forests. The protection of groundwater areas used to be done by the decision of the Water Courts, but nowadays more often it is based on the conservation plan (Mäyränpää and Rihkavuori 2011).

About 4.7 million (ca. 90 %) of the Finnish people belong to water supply network of 1900 waterworks that supply water to at least 50 people. In this system the share of groundwater/artificial groundwater is 61 % and surface water 39 % (Grönholm et al. 2010).

Forests play significant role in maintaining and protecting groundwater resources. However, forestry activities can have adverse impacts on their quality and quantity if appropriate care is not taken into account (Mannerkoski 2012).

Finland is implementing the common European Water framework directive, having the goal of good ecological status of all water bodies in 2015. The national Water Protection Policy Outlines from 2006 defines measures to safeguard good quantitative and qualitative state of groundwater storages. The regional industry, transportation and environmental centers (ELY) are controlling the protection of ground waters.

The environmental guidelines of Metsähallitus (state forest organization) give detailed means how to protect the quantity and quality of groundwater in the areas which are used for forestry (Hiltunen et al. 2011).

Division 12 Materials (Table 1b)

Group 121 Biomass

Forests are most well-known in history and in our times for their material benefits. In Finland the ecosystem goods derived from the growing stock of forests are of particular importance and in detail monitored (Chapter 2.2).

The dominating form of forest biomass is the biomass of trees, which can be classified in several ways: into coniferous and broadleaved forests, by biological species, by size and qualities related to the different industrial or other uses wood and so on.

The major part of forest statistics in Finland is based on the major native tree species (e.g. pine, spruce, birch, other) and their industrial or energy use (logs, pulpwood, fuelwood) but forest statistics is very detailed and many other categories can be found (Finnish Statistical Yearbook of Forestry 2012). Where appropriate, in the following the core elements of Finnish forest statistics are followed.

Class 1211 Fibres and other materials from plants, algae and animals for direct use or processing

This class is extensive and contains quite a lot of goods which are important and need to be recognized. Therefore, in the Finnish conditions, it would be useful to organize forest materials first into three logical Class types: (12111) "*Fibres and other materials from trees*", (12112) *"Fibres and other materials from other forest plants"*, and (12113) *"Fibres and other materials from forest animals"*. Otherwise the list of goods becomes too long to be governed reasonably. It means that the more concrete contents becomes visible only in the adopted additional "sub-class types". Even then the detailed contents of other material from trees, for example, (*Sub-class type 12111f) Wood extracts* can only be demonstrated in the text. However, because the sub-class types are denoted by alphabetic there is potentially much room to keep things organized.

That kind of ”congestion” problem did not exist in CICES V4.1 (September 2012). The main reason seems to be the shift in V4.3 to more generic or broad titles at the Division, Group and Class levels of provisioning services. The number of divisions in Provisioning services in V4.1 was 4 and in V4.3 it was 3 (due to the merger of Water supply-division to other categories). The number of groups in Provisioning services was reduced from 10 to 6 and that of classes from 25 to 16. In the hierarchical classification this brings more burden to the lowest category (class type) of the formal structure. Although CICES allows for more detailed categories outside its formal frame, it is important that the main frame also gives enough concrete categories to communicate clearly the ecosystem services. While in the case of Regulation and maintenance services the change was similar in divisions and small in groups (from 10 to 9) but just the opposite at the class level increasing from 11 to 21. Consequently, the direct information value of classes has grown. The present structure of provisioning services might benefit from some reconsideration, although it also needs to recognize that CICES-structure does not limit the number of any sub-categories as the numbering approach (1-9) here does. In that sense the problem may only be “made in Finland”.

Class type 12111 Fibres and other material from trees. Like in many countries, and even more in Finland, larger scale timber (logs) forms a major raw material and component of various industries. Primary processing industries such as saw-milling, plywood, log-house construction and pole production use mainly coniferous but also birch logs to produce sawn wood, plywood, carved logs (for log-house construction) and processed poles for electricity or communication poles.

As UK NEA (2011) states, arguably many wood products could also appear as in regulating services as options for reducing carbon dioxide emissions into the atmosphere through the substitution of wood for building materials such steel or concrete (with higher embedded carbon), and the substitution of woody biomass to generate heat and/or power instead of fossil fuels. This is also an important standpoint in the Finnish context.

Sawnwood goes for export or is used in domestic pre-fabricated wooden house production or as basic material for on-site wood house (other wood building) or, in other construction, indoor panels, door and window making or furniture and other production. Production in 2011 was as follows: timber 21.8 mill. m^3 and pulpwood 29.9 mill. m^3 (Finnish Statistical Yearbook of Forestry 2012). Forest industry products make ca. 20 % of the total export of Finland.

Sub-class type 12111a Unprocessed logs (and small trees), direct use. Even now trees or its parts can be used for a variety of purposes, with only cutting, trimming and barking, as in traditional log house construction. This has been facilitated by the fact that coniferous species of boreal forests, in particular pine and spruce, have by nature straight trunks and are light and more resistant than broadleaved species. Even now round barked logs can be used as such or only slightly carved from four sides for house or other building construction. Until recently, the most valued holiday houses or small/medium sized accommodation buildings were often made from natural logs, most expensive from standing, aged dry silver coloured pine snags. Although most building logs for wooden cabins or even town houses) are nowadays a bit more processed (logs are halved and glued), log house industry is still characteristically based on the use of round and solid wood in their natural forms.

Small size roundwood is used in many purposes in rural areas, in gardens and summer cottages from fences and other minor outdoor constructions to fishing rods and campsite shelters. The purpose dictates what is the size and species used. Lower priced and easily workable alder and aspen are also widely used.

Sub-class type 12111b Industrial logs (fibre for processing). Coniferous logs are mainly used for sawnwood production and birch logs for plywood, often with spruce inner layers. Sawn wood is mainly used in wood construction from single or multi-apartment residential houses but now emerging also into wooden multi-store residential houses and many public buildings. Summer cottages and accommodation in nature tourism centers are traditional home fields of wooden buildings.

In concrete building construction sawn-wood have two "opposite" roles: low quality sawnwood is used as rough short-term subsidiary material in making scaffolding and concrete castings for houses or infrastructure developments (bridges etc.).

The "middle" stage wood is used in roof frames and some other long-lasting but usually not visible construction components in all kind of buildings.

The high value end for solid wood use is in the interior and finalization of apartments (floors, ceilings and walls using already more manufactured wood products such as parquets, panels, high-quality planed sawn timber etc.) and in production of wood furniture.

Plywood industry is another major user of birch and spruce logs. Plywood is used in construction, transport vehicles and in furniture industries, formed often into value added design qualities.

Solid wood constructions and interior uses serve also long-term (from decades to hundreds of years) carbon storages being at the consumer end of climate regulation. Besides that wood construction and wooden buildings have also cultural meanings as they maintain and continue thousands of years long traditions from the times when wood was the material for almost everything (e.g. Class 3132 Heritage, Culture).

Sub-class type 12111c. Pulpwood (fibres for processing). Smaller trees, mostly from thinning and smaller parts of logs are used as pulpwood in mechanical, semi-chemical and chemical pulp industries for making different paper and paperboard qualities. In small extent, they are used also for other purposes such as dissolving pulp for the textile industry and other uses. Spruce is mainly used for mechanical pulp, pine and to lesser extent birch for chemical pulp production of higher quality paper and

Table 1b. *CICES V4.3 classification of provisioning boreal forest ecosystem services (continuation from table 1b)*

CICES Section 1 PROVISIONING GOODS AND SERVICES		
Division 12 Materials		
Group 121 Biomass		
Class	**Class type**	**Sub-class type**
1211 Fibres and other materials from plants, algae and animals for direct use or processing	12111 Fibres and other material from trees	12111a Unprocessed logs, direct use of wood b Industrial logs (for sawn wood and plywood) c Pulpwood d By-products of wood processing e Organic parts of trees f Wood extracts g "New" forest chemistry
	12112 Fibres and other materials from other forest plants	12112a Natural plant fibres b Decorative plants c Medicinal plants d Dyes e Food preserving biotic materials
	12113 Fibres and other materials from animals	12113a Reindeer b Mammals c Birds
1212 Materials from plants, algae and animals for agricultural use	12121 Wood for agricultural use	12121a Construction b Other uses
	12122 Material from other plants	12122a Forage b Bedding c Handgraft d Decorative
1213 Genetic materials from all biota	12131 Major tree species	12131a Pine b Spruce c Silver birch
	12132 Other native species	12132a Down birch b European aspen c Grey alder d Black alder e European mountain ash f Goat willow
	12133 Other wild plants	
	12134 Wild animals	
	12135 Reindeer	
Group 122 Water		
1221 Surface water for non-drinking purposes	12211 Spring waters	12211a Animal consumption
	12212 Uplands brooks and ponds	12212a Animal consumption b Washing by hikers c Fire protection
1222 Ground water for non-drinking purposes	12221 Forests maintain ground water storage	
Division 13 Energy		
Group 131 Biomass based energy sources		
1311 Forest biomass	13111 Solid wood fuel	13111a Small-diameter wood b Stumps c Cutting residuals d Process by-products
	13112 Black liquors	13112 a Black liquors b Other liquors
1312 Animal based resources		
Group 132 Mechanical energy		
1321 Animal based energy	13211 Reindeer	

paperboard. The smaller-scale dissolving pulp is made from birch and aspen. A lot of recycled paper is used in many lower quality paperboards and tissue papers.

Sub-class type 12111d Industrial wood processing by-products (other than energy). As sawn wood production is able to use only a half of the volume of the logs, the rest is mainly processed into chips. These and other wood residues of forest products go mainly for pulp and energy production. Saw-dust and chips can be used in making pulp and fibreboard. Earlier saw-dust and in particular a bit larger sized cutter was used in house isolation. Currently, only very minor flows of saw dust and chips go for other uses, mainly for making "soft" jogging and ski-trails in the recreation areas near cities[19].

Sub-class type 12111e Organic materials from trees. Many other "minor" materials from trees are also available. For example, organic parts of trees include seeds (for seedlings), cones, twigs, bark, burl, roots and some other. They are widely used for ornamental and decorative purposes.

Sub-class type 12111f. Wood extracts not used as nutrition include tar and resin, both having very small scale compared to that in past.

Due to the downturn of paper industry, but also for the needs and demands of the growing bioeconomy, there has been an increasing interest to find new sustainable materials from trees. This trend or research field can broadly be named as the *"new forest chemistry" (Sub-class type 12111g),* although it also is the continuation of the "old wood chemistry" having discovered many useful by-products used as a source of alcohol products, soaps and other cleaning products. One still very popular cleaning product, pine (tall) oil, has also widely used as biological insecticide in gardens.

Nevertheless, in the "new" forest chemistry it is seen that innovative new products and technologies that conserve energy and production resources will form a focal area for the forest industry of the future. In addition to traditional solid biofuels, new products include goods made out of microfibril cellulose

[19] In Belgium these are known as "Finntrails".

and wood-plastic composites as well as second-generation liquid biofuels, biochemicals and biopolymers that are produced by biorefineries. (http://www.forestindustries.fi/ Infokortit/ newbusiness2012/Pages/default.aspx).

For example, wood derived health promoting biochemicals could become a new source of revenue for the forest industry. Organic compounds of trees have some potential in such important fields as cancer and obesity prevention (http://fibic.fi/researcher-of-the-month/new-sources-of-income-for-the-forestry.

Class type 12112 Fibres and other materials from other (non-tree) plants of forests. While minor in size the species diversity of other plants is in its own class compared to that of the boreal trees, although it is not that high as found in temperate and tropical forest ecosystems.

Among *natural plant fibres (Sub-class type 12112a)* willow (*Salix sp*) is the major material used for basket and other weaving works and decorative things. *Cladonia alpestris* (ground lichen) is only one among the many *decorative plants (Sub-class type 12112*b) but also one exported in larger scale. Traditional *medicinal plants (Sub-class type 12112c)* are many but those having evidence supported by modern medicinal research are more limited. For example the list of medicine by Finnish Medicines Act 395/87 includes ca. 200 plants (Enkovaara 2002, Moisio 2006). *Dyes (Sub-class type 12112d)* are numerous, bilberry being one of the most common. Many *food preserving biotic materials* **(***Sub-class type 12112e)*, have often been synthesized, but have their origins in natural plants such as wild berries. For example cowberry (*Vaccinium vitis-idaea*), cranberries (*Vaccinium oxycoccos*, *Vaccinium microcarpum*) include five E-coded additives sorbic acid (E200), benzoic acid (E210), pectin (E440), carotenoid (E160a) and anthosyanin (E163).

Class type 12113 Fibres and other material from forest animals. Reindeer is the major and sheep occasional domestic animal producing also fibre besides their major nutritional importance *(Sub-class type 12113a)*. Similarly moose is hunted for its meat but also its furs (Sub-class type 12113b) are sometimes used in the interior of houses or as a sleeping pad. Same is true for the furs and skins of bear and wolf. Fibres of forest birds *(Sub-class type 12113c)* are only occasionally used.

Class 1212 Materials from plants, algae and animals for agricultural use

Class type 12121 Wood for agricultural use. CICES has its own category for materials used in agriculture. Many wood uses listed in Class 1211 are valid here, only the scale is much smaller. Trees without processing (and with minor processing only) and processed wood products are widely used in farms in Finland (in particular as almost all farms have their own forest areas) for different purposes such as fences, shelters and other production facilities.

Class type 12122 Material from other plants. *Forage (Sub-class type 12122a)* from forests is marginal for cattle but *beddings (Sub-class type 12122b)* are sometimes needed. As reindeer husbandry according to the System of National Accounts (SNA) (European Union 2009) belongs to agriculture, the forage reindeer graze in forests is relevant also here. Also, increasingly during winter time, in southern parts of reindeer management area, reindeer are brought to farms and kept in fences for hay feeding. Some lichens from forests are sometimes mixed to make it taste better.

Class 1213 Genetic materials from all biota

CICES classification refer here to genetic material (DNA) from wild plants, algae and animals which can be used for biochemical, industrial and pharmaceutical processes, such as medicines, fermentation, detoxification; and bio-prospecting activities e.g. wild species used in breeding programmes.

Class type 12131 Principal tree species In Finland the focus of forest genetics has been to ensure the preservation of genetic diversity of principal domestic tree species *(Sub-class types 12131a-c: pine, spruce and Silver birch***)** to maintain and through tree breeding develop their productive and qualitative properties (Rusanen et al. 2004).

Class type 12132 Other major native tree species. Other six major native tree species are included here (*12132 a-f)* Ultimately, the genetic diversity of trees forms the basis of forestry and related forest industries.

Class type 12133 Other wild plants. Ex-Situ Conservation of Finnish Native Plant Species (ESCAPE) –program has an aim to prevent reduction in genetic diversity in native plant populations. It is lead by the Finnish Nature Museum of the University of Helsinki. The program is needed as "the seemingly pristine large habitat areas such as boreal forests are, in fact, often fragmented to a degree that has an impact on the survival of many species. Moreover, the state of Finland is committed to the implementation of the Global Strategy for Plant Conservation (GSPC). Hence, the proportion of threatened plant taxa in ex-situ conservation should be increased from less than 20% (situation now) to 75% by 2020". (http://www.luomus.fi/en-)

Compared to trees, far less systematic attention from the instrumental (provisioning service) point of view has been given to other wild plants.

Class types 12134 Wild animals and **12135 Reindeer**
The genetic research on wild **animals** and reindeer is done in the Finnish Game and Fish Research Institute. The main example is the Wild forest reindeer which has been studied with the Karelian Research Centre of the Russian Academy of Sciences. The wild forest reindeer and semi-domesticated reindeer can produce fertile offspring. Interbreeding reduces the genetic purity of the wild forest reindeer. In order to prevent

encounters between wild forest reindeer and semi-domesticated reindeer, a 90 km long wild forest reindeer fence was built in 1993-1996 on the southern border of the reindeer herding (http://www.suomenpeura.fi/en/population-anagement/genetic-purity.html). In CICES, genetic diversity is also related from other angles to Regulation and maintenance services (Class 2312) and Cultural services (Class 3221).

Group 122 Water

Class 1221 Surface water for non-drinking purposes

Class type 12211 Spring waters. Forest surface waters such as springs and upland brooks (cf. 1121 surface water for drinking) have minor role in providing water for non-drinking purposes. Animal consumption (*Sub-class type 12211a)* by reindeer and minor livestock groups and the large variety of entire wildlife water consumers need to be mentioned.

Class type 12212 Upland brooks (small rivers) and ponds. As the quality requirements for non-drinking purposes are not strict, the contents of forest related surface waters could perhaps be seen in a bit broader sense including also upper parts of small rivers and ponds. The smaller the surface water "unit" is the more it is influenced by forests.

Besides *animal consumption* (wildlife, reindeer) *(Sub-class type 12212a)* other uses include washing by hikers and those working in forests (*Sub-class type 12212b). Sub-class type 12212c* is an occasional but important use of water for fire protection in forests.

Class 1222 Ground water for non-drinking purpose

Class type 12221 Forest maintain ground water storage. In the organized system of national water supply the share of groundwater and artificial groundwater is 61 % and surface water 39 % (Grönholm et al. 2010). The larger part of groundwater is used for other than drinking purposes in the households and industries. Forests play an important role in maintaining the storages of ground water.

One may add that all forest related water resources – besides those mentioned above – are also consumed by trees themselves and other plants, for their growth and as a part of hydrological cycle.

Division 13 Energy (Table 1b)

Group 131 Biomass-based energy sources

Class 1311 Forest biomass

Being thousands of years a major source of energy, the use of wood was first reduced by coal and then by cheap oil (since early 1960s in Finland). After the first oil crisis in 1973, wood energy got again more attention. It was required that new family houses using oil or electricity heating should have wood-burning oven as a reserve energy source. The rising oil prices, strengthening climate policies and new EU targets for increased use of bioenergy have raised the roles of wood energy, even above the high national use targets in industries and households.

In 2011 the use of wood fuels increased to 25 % of the total energy consumed (including oil in transportation) making it the most important source of energy (oil products 23 % and nuclear energy 18%). Wood fuels were the second and almost as important source, accounting for 23 % of the total consumption of energy. Wood based fuels are composed of two major components: solid wood fuels (14 %) (Class type 13111) and black and other concentrated liquors (Class type 13112) of forest industries (11 %).

Class type 13111 Solid wood fuels. Within the solid wood fuels forest chips used for heating and power plants made 4 % and bark 3 % while small-scale combustion of wood composed mainly from fuelwood of small-sized residential housing took 5 % (Finnish Statistical Yearbook of Forestry 2012). Participation rate of people (15-79 years) in collecting, cutting or chopping small wood for household use, was as high as 42 % (Sievänen and Neuvonen 2011). Based on the national time use data, Saastamoinen and Vaara (2009) found that time allocated in fuelwood production- and consumption-related activities is a large but "invisible" part of everyday life of the Finns. Transforming daily hours into annual entities resulted an estimate of 103 000 person-years in 2000. Only 8 % of that time was spent in the forest. The most time-consuming activities were splitting, shopping and storing firewood at yards, and burning wood in ovens and stoves and heating saunas (the most time consuming single activity). In all, in 2011 small-scale housing used 5.4 mill. m^3 of roundwood for these purposes. That is 1 m^3 per person and year. Firewood is also used by hikers as well as loggers and other people working in forests.

Class type 13112 Black liquors. This include wood based waste liquors of pulp and paper industries and is divided into *black liquors* (*Sub-class type 13112 a*) and *other concentrated liquors (Sub-class type 13112 b*). Their role together in energy production is 11% - close to that of solid wood fuels (14%).

Class 1312 Animal –based resources (None in forests)

Group 132 Mechanical energy

Class 1321 Animal-based energy

Class type 13211 Reindeer. Reindeer are now only marginally used as draught animals and nowadays mostly for touristic purposes. The adoption of snowmobiles since the 1960s has gradually substituted this traditional way of using animal transportation energy[20].

[20] However, in the transportation of the Christmas presents the market share of the reindeer is still nearly 100 per cent.

3.3 REGULATION AND MAINTENANCE SERVICES

Regulation and maintenance services are divided into three divisions; Mediation of waste, toxics and other nuisances, Mediation of flows, and Maintenance of physical, chemical, biological conditions (Tables 2a, 2b, 2c).

While these services include much more "new" aspects than can be found in provisioning services, this area of interest has been studied also in the early forest research in Finland.

About 85 years ago Ilvessalo (1928) stated that "traditionally, it has been thought that forests have positive effect on natural conditions, although also opposite opinions have been presented. Only during past and this century the importance of forests in the economy of nature has been revealed by specific studies more thoroughly, although not yet fully".

Forest research in Finland is extensive and it is done besides the multitude of forest sciences also in many disciplines without the 'forest'-prefix. Research covers almost all aspects related to forests, although the focus has been on silvicultural and utilization aspects of the long wood production chains feeding raw-material flows to forest industries and energy uses. Already for these purposes – and even more for biodiversity and climate agendas – silvicultural, ecological and other forest sciences have studied many phenomena, which are closely related to the regulation and maintenance services of forests. And many disciplines outside forestry (climate, hydrology) produce research results that can be applied in forestry. An extensive compilation on the climatic and hydrological influences of forests (Mannerkoski 2012) provides rich evidence on the usefulness of that kind of approach.

The above influences are a part of a larger concept and entity known as *environmental influences.* Mannerkoski (2012) defines *environment influences of forests* to mean all impacts of forest vegetation, which have effects on its own growth environment and can have impacts in the external environment outside of the forest.

The environmental influences of forests can be largely varying, such as a shade and wind protection provided by the trees of forests. Sometimes a difference between beneficial and non-beneficial influences can be found already during a cycle of a day. For example, a shade against sun provided by trees can be very useful during daytime but in the evening when sun is low it may lead to less light and warmth and be a disadvantage (Mannerkoski 2012). This is not a problem during the "nightless nights" of midsummer (Figure 4) in Finland when sun never goes down, but in the Finnish conditions may be so, already during the late summer and autumn times.

Mannerkoski (2012) makes an important distinction between *environmental and protective influences* of forests. The latter are part of the former and mean such environmental influences that protect human being and her environment (cultural environment) from different destructions, damages or disbenefits. Many of these influences are needed and useful also for other living creatures.

Mannerkoski (2012) further emphasizes that understanding of protective functions of forests and applying these in human activities requires knowing of phenomena related to the environment and factors affecting these as well as their interactions. In many cases the difference between positive and negative environmental impacts of the forests is only a matter of degree, as the shade example above illustrates. The human activities for achievement of protective influences are often balancing between beneficial and harmful effects.

An example is the shelter trees, which prevent frost (night time cold air) damages for seedlings during the growth period. A good number of shelter trees provide the protection but too many shelter trees hinder the growth of young trees. As the trade-off exists, one should evaluate the risk of frost damages and growth losses of young trees, taking into account that during the growth period frost is not an annual phenomenon and sites differ in their sensitivity for frost occurrence (Mannerkoski 2012).

Division 21 Mediation of waste, toxics and other nuisances (Table 2a)

The division deals widely with the capacities of ecosystems to meliorate the adverse impacts of industries and other human activities in nature, mediate the important material and other flows in nature and maintain or regulate the essential and favorable physical, chemical and biological conditions for all kind of the life on the earth (Haynes-Young and Potchin 2013).

Group 211 Mediation by biota

Class 2111 Bio-remediation by micro-organisms, algae, plants, and animals

Bioremediation means a possibility to destroy or render harmless contaminants using natural biological activity. By definition, bioremediation is the use of living organisms, primarily micro-organisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment (Vidali 2001). There are several forms of bioremediation. When the focus of bioremediation is on plants, one can talk about *phytoremediation.* According to the Phytoremediation Association of Canada (2012), it consists of mitigating pollutant concentrations in contaminated soils, water, or air, with plants able to contain, degrade, or eliminate metals, pesticides, solvents, explosives, salt, crude oil and its derivatives, and various other contaminants from the media that contain them. Vegetation based remediation shows potential for accumulating, immobilizing, and transforming a low level of persistent contaminants. In natural ecosystems, plants act as filters and metabolize substances generated by nature (Vidali 2001).

Class type 21111 Bioremediation by trees. Willows have sometimes been used for bioremediation of dump areas. A joint experiments in Finland and Russia are using willows (*Salix sp*) for phytoremediation of polluted mining areas (Terebova et al. 2014, www.uef.fi). Early results suggest that intake of zinc (Zn) in particular has been effective *(Sub-class type 21111a).* Also a long term experiment has been started with forest and hybrid aspen (root and in-plant bacteria) to clean contaminated soil in industrial areas (Metla 2012) *(21111b).* Experiments with Scots pine (*Pinus sylvestris, 21111c)* in symbiosis with mycorrhiza and mycorrhiza colonizing bacteria was used to clean soil contaminated with BTEX and other compounds, common in oil and gasoline, indicated that pine rhizospheres used show good potential for bioremediation (Lindström et al. 1998). An enhancement of microbial activity for the degradation of contaminants, typically around plant roots is called also as *phytostimulation*.

Class type 21112 Bioremediation by other plants, micro-organisms, and animals. As seen above, the borderline between these two class-types is flexible. Among other forest plants which have been or can be used in bioremediation most common is crowberry (*Empetrum nigrum)* but the most important and promising organism in bioremediation of contaminated soil is the *fungi* (Steffen and Tuomela 2010, Hatakka 2013). Also soil invertebrates and bacteria play a role *(21112 a–d).*

Class 2112 Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals

Class type 21121 Filtration. It means the capacity of trees mechanically to catch impurities of air pollution**.** The same concerns also forest ecosystems, basically only the scale is different.

Table 2a. *CICES V4.3-based classification of boreal forest regulation and maintenance services*

CICES Section 2 REGULATION AND MAINTENANCE SERVICES		
Division 21 Mediation of waste, toxics and other nuisances		
Group 211 Mediation by biota		
Class	**Class type**	**Sub-class type**
2111 Bio-remediation by micro-organisms, algae, plants, and animals	21111 Bioremediation by trees	21111a Willow b Aspen c Pine
	21112 Mediation by other plants, animals and micro-organisms	21112a Plants b Invertebrates c Fungi d Bacteria
2112 Filtration/ sequestration/ storage/ accumulation by micro-organisms, algae, plants and animals	21121 Mechanical filtration of atmospheric substances by trees	21121a Absorbtion and adsorbtion by foliage b Absorbtion of trunks and branches
	21122 Phytostabilisation by trees and brushes	21122a Tree roots b Brushes
	21123 Phytoaccumulation by trees and other organisms	21123a Trees b Fungi
Group 212 Mediation by ecosystems		
2121 Filtration/sequestration/ storage/accumulation by ecosystems	21211Air filtration by forests	21211a Adsorbtion and absorbtion by forests
	21212 Ground water filtration by forests	21212a Roots of trees remove toxic metals from ground water (rhizofiltration)
	21213 Sequestration and accumulation by forests	21213a Sequestration /accumulation of nutrients and pollu-tants in tree stands b.. . in organic soil sediments
	21214 Filtration of local/regional pollution sources	21214a Forests near pollution sources are damaged through take of the pollutants (phytodegradation)
2122 Dilution by atmosphere, freshwater and marine ecosystems		
2123 Mediation of smell/noise/ visual impacts	21231 Ordinary and ”left out” forests	
	21232 Planned buffer zones	
	21233 Green screens and landscaping	
	21234 Other forms of landscaping	

Class type 21122. **Phytostabilisation**. It refers to reducing the movement or transfer of substances in the environment, for example, limiting the leaching of substances of contaminated soil. Trees are able to limit leaching of substances of contaminated soil into ground and surface water.

Class type 21123. Phytoaccumulation (phytoextraction). It means uptake of substances from the environment, with storage in the plant. For example, nitrogen and sulphur oxides from the atmosphere or from local sources are accumulated in trees). If degradation is occurring within the tree it is called *phytodegradation*. For example, in Finland, there are older cases where emissions from mills have been absorbed by trees, which have been damaged or died *(Sub-class type 21121a*) but local air pollution may have marginally decreased Further on, *rhizofiltration* contains the removal of toxic metals from the ground water. The roots of trees do all the time a kind of rhizofiltration (Mannerkoski 2012) *(Sub-class type 21122a).*

UK NEA (2011) notes, that the roadside forests may prevent traffic pollution to be spread to more vulnerable ecosystems or areas. In Finland it may include waters, agricultural lands and housing areas. Also dense roadside bushes and forests may to some extent prevent contamination of non-wood forest products: safe distance recommendations for picking berries and mushrooms along roads illustrate the breadth of zone needed.

Trees are effective scavengers of pollutants from the atmosphere both through internal absorption of pollutants, and external adsorption on to leaves and bark surfaces; hence, problems may arise when the acidity scavenged finds its ways to watercourses (UK NEA 2011).

Like natural, probably also polluted litter is similarly decomposed by bacteria, fungi and invertebrates, increasing availability of N, P and S as nutrients.

Group 212 Mediation by ecosystems

Making the difference between mediation by biota (Group 211) and by ecosystems (212) is primarily the matter of scale and more complex structures of ecosystems, which make the latter be more effective and multifunctional in mediation processes.

Class 2121 Filtration/sequestration/storage/accumulation by ecosystems

Class type 21211 Air filtration by forests. All forests have some role in air and water filtration, although research on air filtration in Finland has mostly been related to urban forests. The capacity of Finnish boreal forests to filtrate particulates (air pollutants) by sedimentation, absorption and adsorption is estimated to be about 10-20 tons per hectare per year at maximum (Kellomäki and Loikkanen 1982). Forest soil processes play a critical role for the sustainable utilization of this waste disposal services as the soil is the final deposit/sink for several pollutants filtrated by the forest (Ukonmaanaho 2001).

Forests gather more air-carried substances than open fields. One reason is the reduced wind speed in the forest (Mannerkoski 2012).

Class type 21212 Ground water filtration by forests. R*hizofiltration* contains the removal of toxic metals from the ground water (Class type 21124). The roots of trees do all the time some kind of rhizofiltration (Mannerkoski 2012).

Class type 21213 Sequestration and accumulation. At the ecosystem level (Group 212), the boreal forests (Class 2121) filtrate and sequestrate the major part of the airborne nitrogen fluxes, which otherwise would leach into waters and increase their harmful nutrition loads. The efficient binding is promoted by the natural scarcity on nitrogen for the growth of trees (Finér 2015). In southern Finland, from the total deposit of nitrogen roughly 90 % was taken into soil or biomass and only about 10 % was flown to waters in 1979-1988 (Lepistö 1999). The capture of nitrogen has been assumed to deliver a potential fertilization effect on forest growth (Kauppi and Nöjd 1997).

Filtered material is mainly sequestrated into the soil in the forest ecosystem. Absorbed material first sequestrated into forest biomass ends up finally also into the soil in natural conditions. Nutrients and pollutants are also sequestrated in organic sediments *(Sub-class type 21212a, b*). The removal rates depend on the amount of air pollution and length of in-leaf season which makes difference between deciduous and coniferous trees. The heavier particles of aerosols settle out under the influence of gravity (sedimentation) (Perry et al. 2008).

Forest ecosystems with trees, plants and other organisms have a potential to carry out useful functions related to bioremediation. Research in this field needs to be increased to get a more holistic and realistic view how forests together with other ecosystems may improve the health and resilience of our ambient environment.

Class 2122 Dilution by atmosphere, freshwater and marine ecosystems [This does not concern terrestrial ecosystems]

Class 2123 Mediation of smell/noise/visual impacts

Class type 21231 Ordinary forests. Many people like forests because of their fresh smell, but forests can also be used to prevent the spread of unpleasant smell. Dump sites, for example, are surrounded by dense forest for smell and hygienic reasons but also for hiding unpleasant visual scenes. Forests reduce noise everywhere they appear.

Class type 21232 Buffer zone forests. Specific forest zones can be established to mediate noise and other nuisances of transportation. Buffer zones have sometimes been used along the roadsides to "hide" unattractive clear cut-areas. Buffer zone forests are usually multi-functional, additionally maintaining biodiversity and forming bridges connecting separate habitats, minimize soil erosion and enhance community appearance.

Class type 21233 Green screens and landscaping. These are techniques for separating land uses either by natural or human made fences of trees and shrubs that address visual, light, and sound impacts.

Class type 21234 Other forms of landscaping can serve also several purposes. Mostly these are part of rural landscaping or urban forestry (e.g. Kellomäki and Loikkanen 1982, Komulainen 1995).http://planningtoolkit.org/land_use/buffering screening_landscaping.pdf).

Division 22 Mediation of flows (Table 2b)

Group 221 Mass flows

"The greatest enemy of the mankind is soil erosion" concluded Walter Lowdermilk (1935) in his article "Man made deserts". Worldwide land degradation continues to be among the most severe international challenges. According to the consensus estimate of the extent of global land degradation, about a quarter of global land area has been degraded (Lal et al. 2012, von Braun et al. 2013). Topography (steep slopes), land cover (deforestation, land conversion), climate (dry and hot areas, strong rainstorms, erosive rainfall), soil erodibility (high silt content) are the major natural reasons to accelerate soil erosion. The social causes and drivers of erosion and land degradation are, for example, rapid population growth and weak government institutions. While soil erosion is largely a problem of the southern hemisphere and closely related to deforestation, also in Europe problems of soil erosion are found in particular in mountainous parts of central and southern Europe.

Class 2211 Mass stabilization and control of erosion rates

The land is fairly flat in large parts of Finland, and the few higher altitude areas in the central and eastern parts of the country have modest altitude (300-400 m asl). Even the larger higher altitude areas in the north mostly remain below 1000 m asl and represent smooth rather than steep topographic forms. This also is true for the highest peak bordering Norway and Sweden, which is 1300 m asl. That is why, and due to the mostly humid climate and wide original forest cover (ca. 80 %), there have been hardly any larger scale problems related to soil erosion, avalanches or landslides at national level (Ministry of Agriculture and Forestry 2011).

Class type 22111 Water erosion mediation by forests. Sheet erosion is low in vegetation covered surfaces and in forests particular. Often in northern humid forests' roots, groundfloor vegetation and litter deposits together form *a mat –like layer (*known as *kuntta* in Finnish*) Sub-class type 22111a*), which prevents effectively sheet erosion by water while trees depart the effect of rain drops. Therefore sheet erosion in general does not exist in forests regardless mountain forests under heavy rains. To the lesser this holds true also in forests growing on other sites which have good *ground floor vegetation without "kuntta" formation (22111b).*

On the other hand, forestry activities reveal mineral soil in road construction, due to logging machines, through soil scarification for forest regeneration and in peatland drainage (Mannerkoski 2012). Undisturbed natural peatland does not release particulate humus or other material but drainage and ditches on sloping areas with a shallow peat and fine-textured soil under the peat can in the worst cases lead to small-scale gully or channel erosion. Soil erosion analysis is based on the concept of the load of suspended solids (Mannerkoski 2012).

Table 2b. *CICES V4.3-based classification of boreal forest regulation and maintenance services (continued from 2a)*

CICES Section 2 REGULATION AND MAINTENANCE SERVICES

Division 22 Mediation of flows

Group 221 Mass flows

Class	**Class type**	**Sub-class type**
2211 Mass stabilisation and control of erosion rates	22111 Water erosion mediation by forests	22111a Trees, roots, litter and ground vegetation form effective mat-like structures in humid north b Trees and ground-floor elsewhere
	22112 Wind erosion mediation by forests	22112a Most fields are surrounded by forests b Coastal protection by forests c Small dune areas d Protection from snow accumulation
	22113 Mediation of gravity induced erosion and mass stabilization by forests	22113a Stabilisation of river banks, steep road sides and other sensitive steep areas b Restoration of gravel intake areas c General soil stabilization impacts
2212 Buffering and attenuation of mass flows	22121 Buffer strips along the water courses 22122 Forested surface runoff areas	
Group 222 Liquid flows		
2221 Hydrological cycle and water flow maintenance	22211 Forests maintain hydrological cycle 22212 Forests regulate water flow	
2222 Flood protection	22221 Forests balance spring floods	22221a Slow down snow melting
	22222 Run-off reduction	22222a Interception b Evapotranspiration c Infiltration
Group 223 Gaseous/ air flow regulation		
2231 Storm protection	22311 Coastal protection	22311a Coastal and archipelago forests mitigate wind and waves
	22312 Inland storm protection	22312 a Inland forests mitigate strong winds
2232 Ventilation and transpiration	22321 Forest structure and ventilation 22322 Evapotranspiration	

The largest load comes nowadays from agricultural land. In forestry there are no new peatland areas drained any more, but drainage maintenance still causes some load of suspended solids into waters. For many years the reduction of the load of suspended solids has been among the top priorities in environmental management in forestry and loads have been reduced significantly.

Only a few very sensitive areas for erosion such as open dunes can be found in Finland. The dune areas, quite common after melting of the glacial ice also in Finland, have been covered and stabilized by forests already long time ago. Minor avalanche risks exist in specific conditions on fell slopes without forest cover. Informational means are used to avoid their realization. Purposeful use of forests and trees for stabilization against mass movements of soil or snow are rare, for reasons given above. In principle, the Forest Act (1996) allows the designation of *protection zones* if the preservation of a forest needed on high slopes or steep bluffs, or to prevent landslides, calls more severe restrictions on forest use than elsewhere laid down in the Forest Act. So far, the other means of the Act have been sufficient.

Class type 22112 Wind erosion mediation. Strong winds can cause erosion and damage plants. Forests reduce wind velocity at the ground level in the forest. It also does so on the open lands bordering the forest, both on the windward side and in particular on the lee side of the forest. Forests and trees can be used for wind protection for other plants for example in agriculture, and for animals. Also human settlements are often in the need of wind protection, which given by trees can a bit reduce the need of heat energy (an important aspect in the Finnish climate) and protect planted vegetation (Mannerkoski 2012)[21]. The wind protection for agricultural crops in Finland

[21] Boreal forests may improve housing comfort by reducing wind velocity (Kellomäki 1984, Miller 1997). The reduction capacity is mainly determined by the canopy cover of the forest stand (Kellomäki and Loikkanen 1982). Urban microclimatic regulation is also important due to the abundance of trees and small forests also in urban areas in Finland, but outside the scope of this study.

does not usually need specifically planted wind protection tree belts, as the fields are most often *"naturally" surrounded by forests (Sub-class type 22112a).* The average farm usually owns larger areas covered by forests than those allocated for agricultural use.

Similarly to the case of soil erosion, the Forest Act (1996) provides a possibility to designate small protection zones in small, most vulnerable areas in regard to preservation and shelter effects, if needed for the protection of settlements or cultivated areas that are highly exposed to the wind on islands or shores along the *coast or in inland waters (22112b)*. The precondition is that more severe restrictions on forest use are needed than laid down in other sections of the act. This was already mentioned in Coastal protection. In addition forests provide some shelter also to the *minor dune areas*, being already by definition formed by wind *(22112c)*.

Trees and shrubs to some extent regulate snow accumulation and movements caused by winds. In most parts of the country the forests protect naturally roads for additional snow accumulation while in treeless sub-arctic and higher altitude areas specific wooden snow protection fences are established to prevent snow accumulation on roads. However, purposeful establishment or maintenance of forests belts against *snow movements* are not reported and may be only occasional *(22112d)*.

Class type 22113 Gravity induced erosion. Gravity is always a part of erosion processes, but plays sometimes a major role (like in landslides). The need for mediation of gravity induced erosion is local and found in special sensitive places such as *steep road sides (Sub-class type 22113a)*. In steep sides of roads planting trees is usually not sufficient alone but requires artificial constructions (including net mats of willow), where trees are complementary and also play landscaping roles. In the *restoration of gravel intake areas* planting trees is common but there landscaping is often the primary purpose and control of erosion a complementary one. Soil erosion on river banks is a result of water and gravity together and is to some extent mediated by *natural vegetation including trees and shrubs* (*(22113c)*.

Class 2212 Buffering and attenuation of mass flows

This refers to transport and storage of sediment to rivers, lakes and sea. A part of that is natural erosion from lands, which cannot be prevented, because it is small scale and occurs "everywhere". However, the loads of suspended solids and nutrients can also be a result of the insufficient erosion control or imperfect prevention of nutrient leaching in managed terrestrial ecosystems such as forestry (peatland drainage), agriculture and energy peat extraction.

Class type 22121 Buffer strips. Forests can be used in this context as buffer strips or zones along the water courses.

Class type 221212 Forested surface run-off areas. Forests can provide surface runoff areas, which gather suspended solids and nutrients.

Group 222 Liquid flows

Class 2221 Hydrological cycle and water flow maintenance

"By keeping water in circulation, forests effectively create rainfall and may affect climate regionally and globally. Forests play a vital role in regulating streamflow and water quality, though the details vary depending on environmental conditions. Deforestation has contributed to the greenhouse effect, led to decreased precipitation in some areas, and produced large accumulations of silt in rivers, lakes and estuaries", Perry et al. (2008) characterize the roles of forests in the hydrological cycle and mass flows (previous chapter).

In concordance with the MA (2005), Ojea et al. (2012) emphasize that while water cycle plays many roles in the climate, chemistry and biology of the Earth, it is difficult to define it as a distinctly supporting, regulating or provisioning service. Although ecosystems are strongly dependent on the water cycle for their very existence, at the same time they represent domains over which precipitation is processed and transferred back to the atmosphere or passed to another system. According to Futter et al. (2010) circumpolar boreal forest zone contain 60 % of world's fresh waters).

Mannerkoski (2012) contains an updated analysis of hydrological cycle and functions focusing in boreal context of Finland. The water cycle in Finnish forest terrain is demonstrated in general terms in Figure 5.

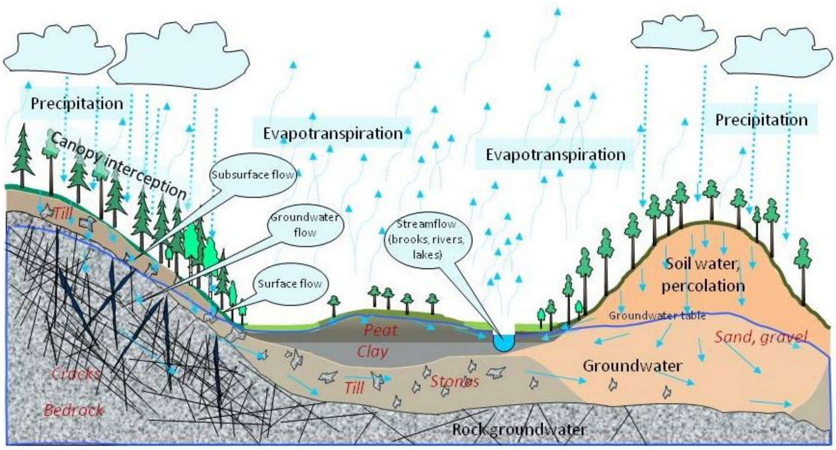

Fig. 5. *Hydrological cycle in Finnish forest landscape. Precipitation comes down everywhere and evapotranspiration comes from everywhere. Spruce and birch stands are usually found on till soils and pine stands on coarse-textured sorted soils. Peatlands are found on depressions like also water bodies. Ground water is found everywhere at least in bedrock and it is flowing down along the average slope of the terrain. Downward flowing water on and in the ground accumulates in depressions to water bodies, continues towards larger ones and finally to the seas. Blue arrows show the main direction of water flow in the ground (line) and in the atmosphere (dotted lines). Rectangular boxes indicate water flows in the atmosphere, oval boxes water flow on and in the ground and black text without boxes different stores of water. Red text describes materials in the ground (Mannerkoski 2012, slightly modified).*

Class type 22211 Forests maintain hydrological cycle. Forests form the major vegetation cover in watershed areas in Finland. Forests capture effectively precipation, promote infiltration and thus contribute to the storage of water in the soil and ground waters. Evaporation and transpiration in forests are part of the hydrological cycle (Mannerkoski 2012).

Class type 22212. Forests regulate water flow. The structure of forests, ground vegetation and soils reduce the surface run-off rates (Mannerkoski 2012). It means that water and the nurients can be better used in the ecosystem and the nutrient flow to water ecosystems is minimized. Management of forest stands and their structure as well as snow cover can be used to regulate and allocate water yield for the downstream purposes (Bales et al 2011).

Class 2222 Flood protection

Class type 22221 Forests balance spring floods. Much what has been said above concerns also the role of forests in flood protection. In Finland, mostly "moderate" floods are common on almost every spring causing problems in particular on flat areas where rivers flow to the coast of the Ostrobothnia and where there are very few lakes. Quite a large part of the lower lying flat areas of the river basins are dominated by agricultural lands.

Forests and peatlands make the major "natural" land cover in all larger watershed areas in Finland. Forests balance floods by *slowing down snow melting (22221a) in spring time* (Päivänen 2007, Finér et al. 2010, Mannerkoski 2012).

Class type 22222 Run-off reduction. Forest reduces surface flows after rainfall and slowdowns their generation, an interception evaporation being the major reason. Also transpiration evaporation is high and infiltration of rainwater into forest soils is significant due to its porosity and litter layer

(Sub-class types 22222a-c). It depends on the quality of forests, however. Compared with peatlands forests reduce spring flows which peatland tend to increase (Mannerkoski 2012) (Figure 5). According to Päivänen (2007) natural peatlands and mires form large water storage because as much as 80-97 % of the peat volume is water. However, only a small part of this water volume *participates* in annual water cycle and therefore the capacity of the natural peatlands to regulate floods is limited. Uneven relief of some mire types, however, does have minor effects in the early of development (Päivänen 2007, Päivänen and Hånell 2012). About a half of peatlands have some kind of forest cover and their capacity to attenuate floods is substantially better. However, perhaps because of the fact that there is a permanent forest cover (although composed of different age and development classes as forests are largely used for commercial forestry) the water authorities have not demanded for a more strict regulation of forest utilization in the watershed areas being exposed to more regular flooding. Probably restrictions are regarded not as cost-efficient (because of small marginal benefits and higher opportunity costs of reduced logging) or widely used engineering solutions are seen to be more advantageous. The focus of debate on forest and flooding has not been on the management of mineral land forests but rather on the impacts of peatland drainage for forestry on flooding. Matero and Saastamoinen (1995, 1998) assumed that run-off changes due to newly drained peatland forests have caused substantial additional costs in flood protection projects in late 1980s in Western Finland.

Rantakokko et al. (2002) considered that although forests are generally thought to delay and reduce flood events, in Finland it seems difficult to achieve any significant benefits in flood reduction for example by regulating hydrological flow or by restoration of drained peatlands. This was because large areas would be needed for restoration, which might cause more costs to forestry than the potential benefit in flood control. On the other hand, Finér et al. (2010) noted that in Finlands forests are not used actively for regulation of the quantity and quality of run-off. Instead, an intensive forestry is practiced.

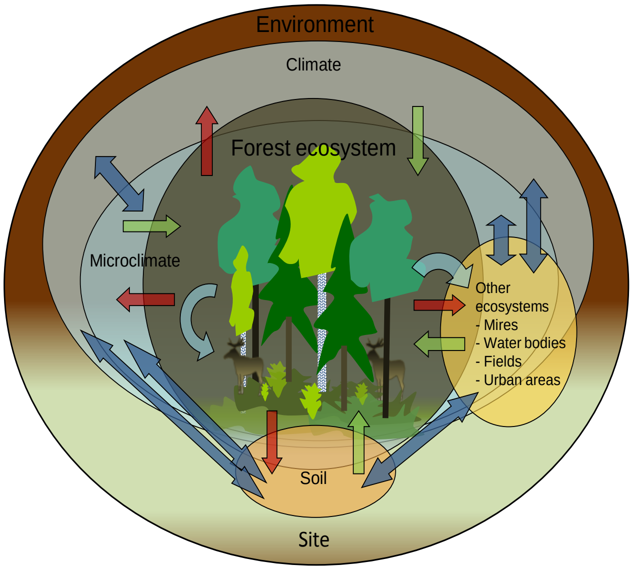

Fig. 6. *Interactions between forest and its environment. Red arrows describe the effects of forest on its environment, light green arrows the effects of environment on forest, light curved arrowse the shelter effects of forest, and two-headed arrows describe interactions between the other components of the environment (Mannerkoski 2012).*

In their study on the valuation of ecosystem services from the Nordic watersheds, Barton et al. (2012) state that valuation studies of regulating and supporting habitat services seem to be under-represented in the Nordic research. In particular, the studies on flood reduction seem to be rare. In that respect, examples of Barton et al. (2012) from the Glomma-Lågen watershed show that the value of regulating services can be indirectly derived from the valuation of property at risk. Flood damages for many hundreds of millions of Norwegian crowns[22] happen annually. They underline that the link between flood

[22] 1 € = c. 8 Norwegian crowns (*kroner*).

risk and the condition of ecosystems in the watershed is nevertheless a complex biophysical modeling task.

Group 223 Gaseous / air flows

Class 2231 Storm protection

Class type 22311 Coastal protection. The speed of the wind at the level of soil surface is always zero. If there is no vegetation on an even land, the speed of wind rises rapidly along the height level at a logarithmic scale. When there is vegetation, the wind speed rises slowly inside the vegetation canopy, and just above it starts a rapid (logarithmic) rise of wind speed (Mannerkoski 2012). Forests therefore provide an effective shelter also against strong winds and therefore also in archipelago can a bit mitigate the waves *(Sub-class type 22311a and 22312)*.

As mentioned earlier, the Forest Act (1996b) allows the establishment of small scale protective areas in areas very sensitive for winds in islands of the sea or inland lakes to protect settlements and cultivated areas. Although coastal protection by forests is recognized, so far this legislative approach are not utilized but the ordinary forest management decisions or other means are seen to be sufficient for this kind of protection needs.

Class type 22312 Inland storm protection. Similarly inland forests provide shelter against strong winds (*Sub-class type 22312a).* However, it needs to be added that forests naturally are also vulnerable to strong storms. For example, at the end of 2011, two sequential windstorms together damaged 3.5 million m3 of roundwood in western and eastern parts of Finland. Falling trees can damage houses, other property and infrastructure. Almost every year there are small storms or heavy snow loads which may fall trees causing damage to electricity lines crossing forests almost everywhere. Due to the changing climate the risk of wind damage will grow. Especially in Southern Finland the unfrozen soil period is expected to increase significantly, decreasing tree anchorage during the windiest time of year (Peltola 1995, Peltola et al. 2010).

Class 2232 Ventilation and transpiration

Class type 22321 Forest structure and ventilation. Forests influences *air* ventilation in many ways. In microclimate, wind plays an important role for mixing the air mass close to the earth's surface. The mixing transfers the heat and water vapor from soil surface into the atmosphere and enables the continuation of evaporation. On the other hand, when the surface of soil is cooling, the wind transfers heat from the atmosphere close to the soil surface (Mannerkoski 2012). The species composition, height and density of the forest is a decisive factor regulating the wind speed and therefore the circulation of air masses close to the soil surface.

Class type 22322 Evapotranspiration. The influence of forests on evapotranspiration is based on interception and long lasting transpiration during dry spells what is maintained by the deep root systems of the trees. The roots generate water to be transpired through the leaves of the trees from deeper soil layers where it otherwise would not evaporate. Deep and wide root system is a guarantee that at least a part of roots is located in the conditions where water is available. Roots can sometimes extend into the depths with capillary connection to groundwater. The precondition is good soil aeration so that the roots get enough oxygen to function. In this way the transpiration of water can continue almost at its potential level long after the rain has stopped (Mannerkoski 2012).

Although the processes related to ventilation and transpiration are much more complex than can be covered here, one may assume that the roles of forests in regard to ventilation, are beneficiary for the human life in the boreal conditions. The extent of that benefit requires specific investigations.

Division 23 Maintenance of physical, chemical, biological conditions (Table 2c and 2d)

Group 231 Lifecycle maintenance, habitat and gene pool protection

Class 2311 Pollination and seed dispersal

Class type 23112 Seed dispersal. Connected forest landscape patterns facilitate seed dispersal and contributes to natural regeneration of natural (seed trees) or artificial (sowing or planting) forest regeneration. Major class types for natural seed dispersal are by animals *(Sub-class type 23112a)* (including insects and ants) and by wind *(24122b).*

Class type 23111 Pollination. Forests provide habitat for many pollinating species. Widely connected forest landscape patterns facilitate pollination processes not only inside forests but also between forests and agroecosystems. Major class types are pollinators of forest plants *(Sub-class type 23111a)* and pollinators of agro- and other crops *(23111b).* Pollination of wild berries is in particular dependent on wild insects. In case of bilberry (*Vaccinium myrtillus*) their role is been estimated that 90%. The major group of pollinators are bumblebees (*Bombus* sp), because there are seasoned and can fly even in cool weather and rain (Heliövaara and Mannerkoski 2009). Increasing attention to pollination services can now be found also in Finland (Kettunen et al. 2012)

Class type 23112 Seed dispersal. Connected forest landscape patterns facilitate seed dispersal and contributes to natural regeneration of natural (seed trees) or artificial (sowing or planting) forest regeneration. Major class types for natural seed dispersal are by animals *(Sub-class type 23112a)* (including insects and ants) and by wind *(23112b).*

Class 2312 Maintaining nursery populations and habitats

Forests provide major habitat for "ordinary" and threatened forest species (habitat refuges). At the same time logging and silviculture, in particular earlier, have been among the reasons for threatening endangered habitats and dependent populations. Therefore, one of the new topics getting most attention during the past two decades in forestry has been the protection of habitats for endangered forest species (Päivinen et al. 2011).

Class type 23112 Seed dispersal. Connected forest landscape patterns facilitate seed dispersal and contribute to natural regeneration of natural (seed trees) or artificial (sowing or planting) forest regeneration. Major class types for natural seed dispersal are by animals *(Sub-class type 23112a)* (including insects and ants) and by wind *(23112b)*.

Class type 23121 Forest spatial pattern and connectivity. Forest spatial pattern refers to the spatial distribution of forest across the landscape. Landscape pattern and their changes are important because they impact ecological processes such as gene flow, pollination, wildlife dispersal, or pest propagation in different ways. Forest connectivity is based on forest availability and distances between patches, it refers to the degree to which the landscape facilitates or impedes the movements of species with specific dispersal capabilities (Forest Europe 2011, p. 84).

High coverage of forests (76 %) in the land area of Finland means at the general level that natural spatial pattern and forest connectivity *(Sub-class type 23121a)* support well the functions of life-cycle maintenance. However, in particular in southern parts of the country and in the smaller scale elsewhere, reconstruction of corridors (*23121 b)* has been done and further needs exist (Päivinen et al 2011).

Table 2c. *CICES V4.3-based classification of boreal forest regulation and maintenance services (continuation from table 2b)*

CICES Section 2 REGULATION AND MAINTENANCE SERVICES		
Division 23 Maintenance of physical, chemical and biological conditions		
Group 231 Lifecycle maintenance, habitat and gene pool protection		
Class	**Class type**	**Sub-class type**
2311 Pollination and seed dispersal	23111 Pollination	23111a Pollinators of forest plants b Pollinators of agro- and other crops
	23112 Seed dispersal	23112a By animals b By wind
2312 Maintaining nursery populations and habitats	23121 Forest spatial pattern and connectivity	23121a Natural ecological corridor b Rehabilitated corridors
	23122 Ordinary forests	23122a Habitats for common species b Habitats protected by Forest act
	23123 Threatened habitats and habitat refuges	23123 a Critically endangered forests b Old-growth forest reserves c Private protection forests d Forest habitats protected by Nature conservation act
	23124 Protected areas and habitats	23124 National parks b Nature reserves c Wilderness areas
	23125 Forest genetic resources	23125a In situ conservation b Ex situ conservation
Group 232 Pest and disease control		
2321 Pest control	23211 Forest plant-derived products	23211a Compensatory for synthetic pesticides b Affecting behavior of synthetic species c Birch biochar
	23212 Animals in pest controls	23212a Parasites b Competetive species c Predators
	23213 Forests as a potential pest "buffers	23213a Providing habitats for above
	23214 Alien species	23214 a Invasive alien species b Potentially or locally harmful species c Particularly harmful
2322 Disease control	23221 Mycorrhiza	*23221a Paxillus involutus*
Group 233 Soil formation and composition		
2331 Weathering processes	23311 Soil fertility	23311a Trees b Other plants c Animals
	23312 Soil structure	23312 a Roots and soil porosity b Roots and soil ventilation
2332 Decomposition and fixing processes	23321 Decomposition	*23321a* Saprophytic fungi *b* Soil micro flora *c* Nematodes d Enchytraeids e Collembolans f Macro-arthropods g Soil microbes
	23322 Fixing processes	23322a Alder b Zigzag clover c Wood vetch d Habitats for nitrogen fixers

Class type 23122 Ordinary forests. Most 'ordinary' forests provide major habitat for "common forest species and perhaps complementary space also for some threatened forest species *(Sub-class type 23122a).* As logging and silviculture have been among the reasons for threatening endangered habitats and dependent populations, since the 1990s, nature management and care of biodiversity has been extended into all forests. The main target has been to increase the amount of wood debris and retention trees to create room for endangered forest species (Päivinen et al. 2011, Tapio 2011). In addition, The Forest Act (1996, revised in 2013) contains definitions of 12 *habitats of special importance* (key biotopes) in commercial forests (private non-industrial and industrial and state owned) whose natural features must be conserved *(23122b).* These key biotopes accounted 178 000 hectares or 0.9 % of forestry land available in wood production in 2013 (Finnish Statistical Yearbook of Forestry 2014).

Class type 23123 Threatened habitats and habitat refuges. The assessment of threatened habitat types in Finland (Raunio et al. 2008) was based on the red listing of habitat types done by groups of national experts. The assessment covers all natural habitat types and traditional rural biotopes in Finland. Some reasonably well-defined and well-recognized habitat complexes were also included in the assessment. In all 368 habitat types were classified according to their risk of decline and deterioration.

The habitat types were divided into seven main groups: the Baltic Sea and its coast (53 habitat types and habitat complexes of which 53 % threatened), inland waters and shores (43 types, 40 % threatened), mires (70 types, 56 % threatened), *forests (73 types, 70 % threatened)*, rocky habitats (43 types, 21 % threatened), traditional rural biotopes (40 types, 93 % threatened) and the fell area (46 types, 15 % threatened).

It can be seen, that forests include the largest number of habitat types (70) and second highest share (70%) of threatened habitat types. However, the endangered habitat types in forests are typically small in size (State of Finland's forests 2012) and the area of critically endangered forests (CE**)** is only 1 % of total forest area and that of endangered forests (EN) is 2% (23123a). The reasons for being endangered are largely in the past. For example, herb-rich forests with favourable soils in terms of cultivation have been turned into fields. The present herb-rich stands are small and scattered remnants of original larger forests. Although they are proportionately well-protected – there are 47 herb-rich forest reserves covering 1100 hectares – they suffer from a decline in species diversity because of small size and isolation (www.environment.fi/biodiversity). There are also 90 old-growth forest reserves *(Sub-class type 23123b)* outside national parks and strict nature reserves covering 9500 hectares. Both above figures concern areas on state lands. On private lands there are also private nature reserves, protection areas, habitat and species protection areas *(Sub-class type 23123c)* – altogether 11 029 habitats areas and 135 200 hectares. The average size is 12 hectares.

Other smaller protected forest related habitats *(Sub-class type 23123d)* protected by Nature Conservation Act are 1) wild woods rich in broad-leafed deciduous species; 2) hazel woods; 3) common alder woods; 4) sandy shores in their natural state; 5) coastal meadows; 6) treeless or sparsely wooded sand dunes; 7) juniper meadows; 8) wooded meadows; and 9) prominent single trees or groups of trees in an open landscape.

Class-type 23124 Protected areas and habitats. The larger scale valuable forest habitats and refuges can be found in forests of national parks (*Sub-class type 23124a* - 38 areas, 0.806 mill. hectares), in strict nature reserves (*23124b* - 19 areas, 0.150 mill. ha) and in wilderness areas (*23124c* - 12 areas, 1.38 mill. ha) (Figure 6). The areas given include also peatlands, waters and fell areas. National parks and strict nature reserves are protected by Nature Conservation Act (1996) while wilderness areas have their own Wilderness Act (1991), which allows, some economic uses as selected forestry activities. Wilderness areas are only located in the northernmost part of the country, where also largest nature reserves can be found. Other nature reserves are better spread all over the country, although in particular in areas where state lands and waters prevail. Most of these are important bird areas (IBA) (http://www.birdlife.org/europe-and-central-asia/partners/ finland-birdlife-suomi) but providing habitat also for larger mammals and other threatened species.

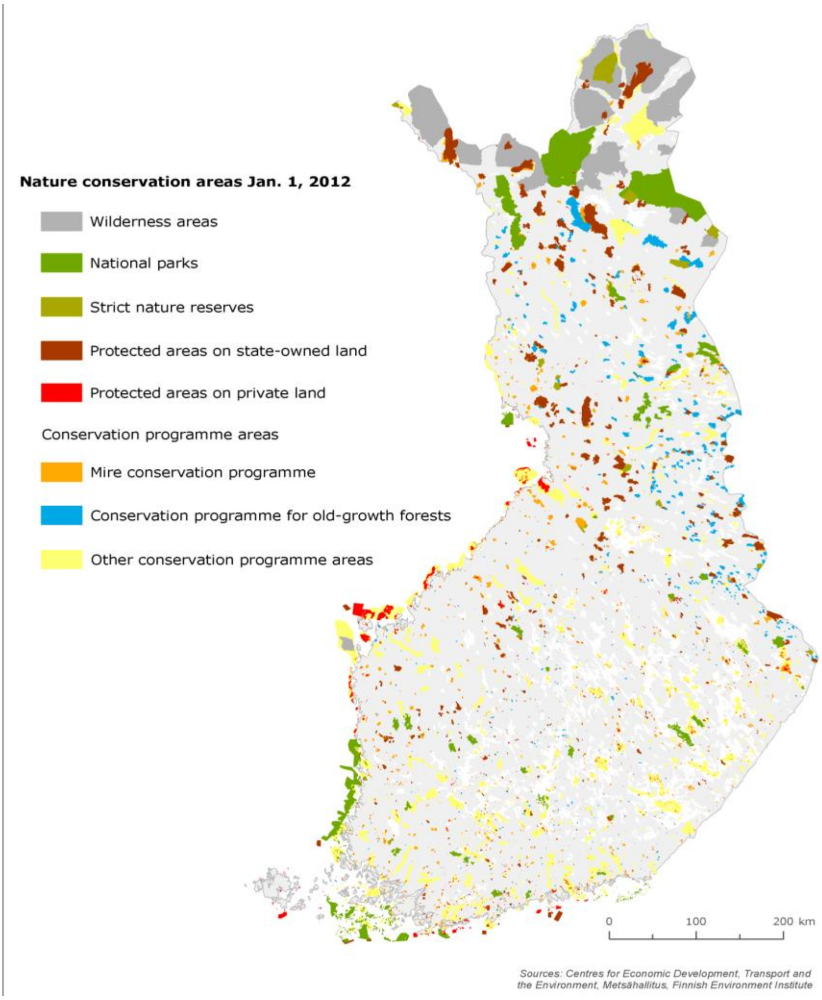

Fig. 6. *Nature conservation areas in Finland (Sources: Centres for Economic Development, Transport and the Environment, Metsähallitus, Finnish Environment Institute).*

The principal objective of national parks, nature reserves and other forested conservation areas is to preserve forests, other ecosystems and habitats thereby in their natural states, but at the same time they may serve genetic conservation. Most of the conservation areas in Finland are on state-owned land and enjoy legal protection and are meant to be permanent.

Class type 23125 Forest genetic resources. The different types of nature reserves given above are valuable also in maintaining genetic resources, but Rusanen et al. (2004) state that for genetic conservation purposes these reserves have two limitations. Firstly, their coverage and geographic location do not correspond to the needs of genetic conservation. Secondly, the protection prevents management that would be needed to promote regeneration. The regulations also restrict the utilization of genetic resources.

According to Rusanen et al. (2004) the purpose of conserving of forest genetic resources is to maintain hereditary variation in species and local populations far into the future so that their viability and adaptability would be sufficient to cope with changing environmental conditions. Environmental change could be, for example, long-term climate change or changes in ecological conditions caused by forest treatment and management practices. Methods for conserving forest genetic resources can be classified into two types according to whether the genetic resources are conserved at the original site - in situ or outside the original site - ex situ (Rusanen et al. 2004).

In situ conservation forest *(Sub-class type 23125a)* normally requires that a representative area of undisturbed, natural forest or a naturally regenerated commercial forest is set aside as a gene reserve forest. In situ gene reserve forests are used to conserve the common and widely distributed species.

Ex situ conservation *(Sub-class type 23125b)* has a focus in rare tree species. It is implemented by establishing collections of individual trees in an orchard or by storing seeds, pollen or tissue (Rusanen et al. 2004).

There are 39 gene reserve forests in Finland altogether and their combined area is about 6,700 hectares. As the network of forest stands are spread over different climate zones, a large range in adaptive traits is included (Rusanen et al. 2004). The Finnish Forest Research Institute is responsible for the conservation of forest genetic resources (Rusanen et al. 2012).

Group 232 Pest and disease control

Class 2321 Pest control

Class type 23211 Forest plant-derived products. Forest plant-derived products may have a useful role in sustainable plant protection when functioning as compensatory substances for synthetic pesticides *(Sub-class type 23211a)*, or alternatively by affecting the behaviour of synthetic pesticides in the soil *(23211b)* (Hagner 2013). The latter type is close to the Class 2111 (Bioremediation).

For example, Hagner (2013) found a strong evidence for the potential of birch (*Betula* sp.)-derived slow pyrolysis products, birch tar oil, wood vinegar and biochar, as an effective, non-costly and environmental friendly method against molluscs. Populations of the molluscs (*Arianta arbustorum* and *Arion lusitanicus*) have increased in many parts of northern Europe in recent years in home gardens. Biochar could also play a role in pesticide risk reduction, particularly in preventing contamination of the aquatic environment (Hagner 2013).

As the above, many other biological solutions are in the processes of research and development (Vartiamäki et al. 2009**)**. In Finland, more than 60 million euros are annually used to remove hardwood sprouts in forestry, under electric lines and along the road sides. In an ongoing project a *Chondrostereum purpureum* (Silver Leaf Disease) strain will be produced that will efficiently prevent sprouting of hardwood stumps. The breeding program will be composed of three processes, the outcome of which will be a fungal strain capable to prevent sprouting more efficiently than any of the natural isolates.

Class type 23212 Animals in pest control. Forest ecosystems are complex food webs at different levels and these natural relationships can be applied to some extent in biological control of pests. The relationships can represent parasitism (*Sub-class type 23212a)*, competition on resources *(23212b)* or predation *(23213c)* as the following examples indicate.

Tomicobia seitneri is an important parasitoid of bark beetles, in particular of *Ips. typographus,* which *is* major threat for young pines (Joensuu et al. 2008). The ant beetle (*Thanasimus formicarius*) is also an important predator of bark beetles. Timberman (*Acanthocinus aedilis*) is a useful beetle because it competes with resources of the detrimental *(Tomicus piniperda),* which is an important thread for pines. *Lamachus eques* and *Exenterus marginatorius* eat the larvaes, eggs and aurelia of the sawflies (*Diprion pini* and *Neidiprion sertifier*) which live in the groups and eat the needles of pine causing growth losses. Forest ants (e.g. *Formica rufa*) control also some pest insects (Uotila and Kankaanhuhta 1999, Annila et al. 1999, Heliövaara 2001, Heliövaara and Mannerkoski 2009, Kankaanhuhta 2014). However, the insects causing damages by *Tomicus*, *Neodiprion* and *Diprion* species and spruce bark beetle (*Ips. typographus*) have usually been local.

Larger scale example on predation is the wolf (*Canis lupus*), which control for example European elk (*Alces alces*) population. Moose (European elk) causes much damage to young pines in regeneration areas. However, wolf has powerful competitors among Finnish hunters, which do their best for controlling European elk in the limits of given licenses. There is an official control mechanism for wolf population, which is in the hands of the authorities as the wolf is protected.

Class type 23213 Forests as potential pest "buffers". Large forests between field areas may prevent or slow down the spread of some agricultural pests - serving in this sense as pest buffers as maintaining habitat for species harmful for pests (Tapio 2011). On the other hand, forests may increase the likelihood of crop damages caused by pest animals (like deer) dwelling in forests. The balance between the two aspects remains open here.

Class type 23214 Alien species. The number of alien species in Finland is over 600, and species are composed of mostly plants. Alien species that cause obvious harmful impacts are known as invasive alien species.

Finland's National Strategy on Invasive Alien Species (2012) aims to prevent damages and risks caused by invasive alien species (IAS) to the Finnish nature, sustainable use of natural resources, livelihoods and well-being of the society and people (Ministry of Agriculture and Forestry in Finland 2012). By 2020 a system will be established whereby the harmful impacts of invasive alien species can be controlled and the entry into Finland can be prevented. Based on international experiences, the system is based on three principles: 1) preventing and combating; 2) early detection and eradication and 3) prevention of spreading and continuous long term follow-up.

Sub-class type 23214a Invasive alien species. A total of 157 invasive alien species permanently established in Finland which cause clearly identifiable, direct or indirect damage have been identified. A significant share of these species (100 species) is alien agricultural and forestry species. Some of them may also constitute a threat to the indigenous natural environment. Of the alien species in other groups, 5 occur in the territorial waters of Finland in the Baltic Sea, 5 in inland waters, 6 are land vertebrates, 24 are plant species, and 9 are indoor pests.

*Sub-class type 23214b Potentially or locally harmful alien species***.** In addition, 123 potentially or locally harmful alien species which may cause direct or indirect damage have been identified in Finland. About a one third of these species are agricultural and forestry species. Most of the potentially or locally harmful alien species are already present in Finland, while some of these are still outside our national borders.

Sub-class type 23214c Particularly harmful alien species. Particularly harmful alien species were classified into a specific category. These include dangerous plant pests or quarantine species (37), whose import and dissemination is prohibited by a directive in all EU Member States. Hogweeds, Japanese rose, crayfish plague, Spanish slug and [American] mink have been declared particularly harmful alien species in Finland. For these species natural enemies are few, if any, and therefore immediate and systematic action must be taken to eradicate them, or at the very least to prevent their spreading and to mitigate their harmful impacts (Niemivuo-Lahti 2012). Natural enemies – species functioning as ecosystem services are few and prevention activities are mainly in the human hands.

In all harmful alien species are close to the ecosystem disservices discussed in Chapter 4.

Class 2322 Disease control

A disease is an entity that disturbs the normal function or condition of the living organism (Grebner et al. 2013). So far, the discussion on forest health has primarily focused on trees (and sometimes shrubs) and the focus of forest research has been in the prevention of diseases of trees although one should take into account the other forest plants and animals as well. It should be noted that CICES V4.3 (January 2013) examples on disease control refers to those in cultivated and natural ecosystems and human populations. Disease control "in human populations" refer to the control of risks of diseases, which people can get when being in forests or living close to forests. The latter is related, for example, to pollen allergies and the former, for example to the nuisance known as the sheep tick (*Ixodes ricinus*), which however is potentially dangerous as the transmitter of

Lyme disease[23] (borreliosis). In this application the diseases and other human health risks related to forests are compiled into an additional short review and list named as "Forest ecosystem disservices" (Chapter 5).

In regard to diseases of trees and scrubs Sinclair et al. (1987) classify their causal agents as fungi, bacteria and mollicutes, viruses, nematodes, abiotic and unknown or autogenous. Due to the focus on diseases only, damage caused by insects and vertebrates was left out.

In Finland, the occurrence of *all* damaging agents reducing stand quality in timber production in 2008 was a the following: Unknown 34%, natural competition 3%, fungi 16%, insects 1%, vertebrates 13%, abiotic 28% and human interventions 5% as identified in the National Forest Inventory by the Finnish Forest Research Institute (State of Finnish Forests 2011).

Damages necessitating regeneration were caused above all by snow, wind and moose, as well as Scleroderris canker and resintop disease. Most of the causal agents remain unidentified, however.

The most important forest diseases in Finland are caused by fungi. Resin-top disease and Scleroderris canker are commonly identified causal agents in pine-dominated forests.

Rot fungi are the most frequent causes of damage in spruce-dominated forests. They cause 80% of butt rot in spruce stand in southern Finland. Annosum root rot (*Heterobasidion* sp.) was found in almost 100 000 ha of spruce forests.

The fungi are part of normal organisms of boreal coniferous forests. Most of them are common, but can cause disastrous epidemics only when shortly variation in weather conditions appear or the forest environment changes rapidly for example after a storm. These phenomena cannot be regulated, although the risk for storm damages of forests can be reduced by

[23] Haines-Young and Potchin (2009) refer to an unpredictable consequences of biodiversity loss in ecosystems emphasized by Ostfeld and LoGiudice (2003) who based on simulation model demonstrated how different sequences of species loss from vertebrate communities might influence risk of human exposure to Lyme disease. The regulation of disease risk was considered to be a relevant ecosystem service.

appropriate silvicultural measures (Peltola 1995, Peltola et al. 2010).

However, no extensive forest damage has occurred in Finland in the last few decades. This is partly due to the strict legislation on insect and fungi damage prevention, restricting the storage of timber in the summer. Between 2004 and 2008, damages requiring immediate regeneration occurred over a total of 38,000 hectares, which makes 0,2 per cent of the forest land available for wood production (excludes nature conservation and other areas where harvesting is not allowed) (State of Finland's Forests 2012).

Diseases and other damages have impacts on forest dynamics and the types of ecosystem services that can be or are decided to be provided. Trade –offs are often available also in disease and pests control. For example, forest management which allows more natural mortality of trees by diseases due to insects and fungi, can enrich the biodiversity dependent on coarse wood, including larger populations of endangered species. That occurs at the expense of some reduction in wood production. Among the environmental targets in Finnish forestry it has been to increase the volume of coarse wood in the forests (Ministry of Agriculture and Forestry 2011).

The features and functions of forest ecosystems which would naturally reduce the risk of fungi caused diseases for trees (or othe forest benefits) should be the "entity" considered as an ecosystem service. Unlike in the case of insects and other animals, natural enemies seem to be rare.

Class type 23221 Mycorrhiza. As the symbiosis between plant roots and fungi mycorrhiza provides an example on disease control as it can establish protection for pathogen microbes. A non- edible *Paxillus involutus* mushroom (*Sub-class type 23221a*) can stop the spread of spruce root rot (*Heterobasidion parviporum*) (Heinonsalo and Lehto 2013).

Group 233 Soil formation and composition

Forests and forestry require large land areas although their capacity to compete on fertile and productive soils is weak compared to agriculture or other intensive land uses. Therefore, the importance of the available soil productivity cannot be overstated, in particular in the context of continuing land degradation and soil erosion in many areas of the world. More generally, soil is the fundamental resource of terrestrial ecosystems, which ultimately provide the sustenance for all earthly organisms. It provides a variety of critical ecosystem services, including the support and nutrients for the production of food and fiber, cleansing the water that flows through the soil medium, imparting physical support for human structures (roads, buildings, etc.), and acting as waste repositories (Perry et al. 2008). Soils thus provide *supporting services and intermediate services* for many ecosystems and directly to human beings. It also is an essential part of *geodiversity* (Mace and Bateman 2011) and similarly an important part and foundation for agricultural, forest and other ecosystems.

Class 2331 Weathering processes

Class type 23311 Soil fertility. Soil is the loose material originating from bedrock through weathering or produced by organisms on the earth surface above the bedrock. In the larger setting soil development – called *pedogenesis* – takes time tens of millions of years (Perry et al. 2008), and is influenced besides time by four other interrelated factors: organisms (trees, plants, other organisms), topography, parent material, and climate. The chemical properties of the soils are determined by the chemical composition of the parent material and the extent of weathering of this material. It can be seen as the primary source of nutrients.

The other major source of nutrients comes from the organic materials – the biological components of soil systems. Trees *(Sub-class type 23311a)*, other forest plants *(23311b)* and animals

(23311c) are the major sources of organic matter that feed soil organisms and accelerate weathering. Forest vegetation leads to the formation of certain soil types. For example, acid needle litter of conifers enhances the process of *podsolization*, which is typical to boreal forests.

Topography and climate are also important physical determinants of soil fertility. Water carries soil substances including nutrients from higher areas to lowlands. Climate determines largely what kind of vegetation and organisms thrive in given sites.

Therefore the distinction between the roles of chemical, physical, biological and climatic components in forming the nutrition storage of soils is somewhat arbitrary, and may also include human inputs as in case of agriculture and forest fertilization. Perry et al. (2008) concludes that all soil properties interact in complex to influence the characteristics of the soil.

Class type 23312 Soil structure. What has been said above holds true also for the structure of soil. In short, the soil is a multiphasic system that includes solids (mineral and organic materials), gases (air), and liquid (water).

The structure of a typical, productive soil has roughly 50 % of solids, mainly minerals and only 5 % of organic material. The other half is divided evenly by air and water, the sum of which is called as soil porosity. The diversity of pore sizes created by aggregation maintains a balance between soil and water and soil air and also provides living and hiding space for soil organisms (Perry et al. 2008). Peat soils (histosols) are also common in Finland, and they have only about 10 % solid organic material and 90 % porosity filled mainly by water.

The roots of the trees maintain *porosity (Sub-class type 23312a)* while compaction due to the use of forest machines may reduce it. However, it only occurs in logging and is marginal on mineral lands. Mechanized soil scarification has widely been used in preparing regeneration areas for planting, but nowadays more mounding is increasingly used because it does not cause that much of leaching of soil nutrients (Tapio 2011).

Class 2332 Decomposition and fixing processes

Class-type 23321 Decomposition. Properties of soils are dependent on the amount, composition and decomposition of organic matter inputs from plants to the soil. Decomposition influences nutrient cycling in various ways. In general, detrital inputs from plants to soils fuel numerous processes that produce and maintain soil fertility (Perry et al. 2008).

Forest soils are fundamentally different from agricultural soils not only because of the different plant communities (dominated by trees) they support, but also because of the presence of a *forest floor*, an organic rich layer that typically accumulates over the mineral soil (Perry et al. 2008). Most of the biological activity in soils occurs in rhizospheres (i.e. the zone around roots, e, and mycorrhizial hyphen).

A small amount of soil in hand contains a billion of organisms, the trophic relations of which are similar to those aboveground. In their role as regulators of ecosystem processes, these organisms perform several vital functions, including *decomposition*, serving as source of nutrients, acting as catalysts, interacting in gaseous processes with atmosphere and with plants and animals, synthesizing and acting as engineers of soil structure (Perry et al. 2008).

In boreal forests, microorganisms have a pivotal role in nutrient and water supply of trees as well as in litter decomposition and nutrient cycling. This reinforces the link between above-ground and below-ground communities in the context of sustainable productivity of forest ecosystems. In northern boreal forests, the diversity of microbes associated with the trees is high compared to the number of distinct tree species (Rajala 2008).

Dominant decomposers in boreal coniferous forests are saprophytic fungi *(Sub-class-type 23321a*), soil microflora *(23321b)*, nematodes (*23321c)*, enchytraeids (*23321d)*, collembolans (*23321e)* and macro-arthropods (*23321f).* Most of the nutrients in dead organic matter are finally mineralized by soil microbes (*23321g)* (Rajala 2008, Kataja-Aho et al. 2011, Steffen and Tuomela 2013).

The interactions between above-ground and below-ground communities are the basis for the stability and function of the whole forest ecosystem (Rajala 2008).

Yet one may conclude that ecosystems and their services are more than it is usually thought led from the underground headquarters.

Class-type 23322 Fixing processes. Unlike in moist tropical forests, where most nutrients are in the phytomass of trees, in boreal forests large amounts of organic matter and nutrients will accumulate on soil – even under small litter fall. In boreal conditions, the soil organic matter provides a large reserve of nutrients that can be made available for tree growth with the help of proper soil management (Kellomäki 2009).

The growth of forests everywhere in Finland is restricted by the scarcity of nitrogen, which is influenced by its slow biological setting. On the other hand there is a lot of nitrogen in the litter and humus layers of the soil, but its mineralization is very slow for reuse. In natural forests nitrogen has originally been bound from the atmosphere, but nowadays forests get much nitrogen also through the impurities of the air (Kellomäki 2005). In all cases forests keeps nitrogen circulating in the ecosystem between soil and plant biomass.

A considerable part of acid deposition comes with long-range pollution transport. Around 2000, 71 % of nitrogen deposition and 83 % of sulphur deposition measured in Finland originated abroad. However, the stability of nitrogen concentrations in the soil or their decrease over the monitoring period since 1996 implies that the current nitrogen deposition will not constitute a health risk for forests in southern Finland in the near future (Ministry of Agriculture and Forestry 2011).

The structure that develops as forests grow provides habitat for nitrogen fixers or diazotrophs and enhances atmospheric inputs through interception of dust and fog by canopies. Carbon fixed in photosynthesis provides the energy required to fix nitrogen (Perry et al. 2008).

The major nitrogen fixing tree in Finland is alder *(Sub-class type 23322a)*, which however thrives mainly in more fertile soils. Other plants include Zigzag clover (*23322b)* and Wood vetch (*23322*c). Habitats which favour nitrogen fixers increase when forests grow or for biodiversity conservation (e.g. decaying logs, rhizospheres and mycorrhizospheres, *Sub-class type 23322d*).

Fertilization of forest is less common now than some decades ago, when it was supported financially by the state. An increasing use of small-scale biomass (for energy purposes, leaving less cutting waste on the ground) is seen as a threat to nutrition balance of forest soils. Leaving more coarse wood for biodiversity purposes provides a bit more nutrients for the soil.

Group 234 Water conditions (Table 2d)

Due to the great number of inland lakes, rivers and smaller water systems in Finland, issues related to water quality have long received special attention in the forest management. A short consideration of those aspects may be useful as such and in demonstrating interaction between the management of one ecosystem to the services of the other.

Within the river basin management plans the origin and proportions of loading, for example that of forestry, imposed to Finnish watercourses are identified on total drainage basin scale. The estimates are based on registers on land use and soil properties of the basin, on models developed for material transport and leaching estimations, on material transport rates measured in different research projects and on obligatory monitoring of loading. GIS software is widely used in Finnish environmental administration. Also possibilities of land use planning in decreasing the environmental impacts of diffuse loading in lakes and rivers have been lately developed in Finland.

Table 2d. *CICES V4.3-based classification of boreal forest regulation and maintenance services (continued from tables 2a, b and c)*

CICES Section 2 REGULATION AND MAINTENANCE SERVICES (continuation from table 2a)		
Division 23 Maintenance of physical, chemical and biological conditions		
Group 234 Water conditions		
Class	**Class type**	**Sub-class type**
2341 Chemical condition of freshwater	23411 Water purification	23411a Forest shelter belts b Forested catchments c Logging and silviculture risks for water quality
2342 Chemical condition of salt waters	23421 All waters runs into the sea	
Group 235 Atmospheric composition and climate regulation		
2351 Global climate regulation by reduction of greenhouse gas concentrations	23511 Carbon sequestration 23512 Reduction of other greenhouse gases 23513 Forests and cloud formation	23511a All forests b Wood products
2352 Micro and regional climate regulation	23521 Micro and local climate regulation 23522 Climate regulation and timberline forests	23521a All forests b Forests close to settlements and urban areas 23522a Protection forest zone

The role of forestry from the total anthropogenic load into water systems is 6 % in phosphor and 4 % of nitrogen. It is less than 1/10 of the load of agriculture, although it's relative importance grows towards north (Ollikainen 2011).

Watershed analysis is a method for estimating the total load of forestry in a selected watershed. Furthermore, it is possible to assess how effectively various water protection measures can reduce this load. Watershed planning is used especially in sensitive areas in terms of water protection (Päivinen et al. 2011).

Forestry measures that may burden waterways include final felling, soil preparation, forest drainage and fertilization. Natural peatlands are no longer drained for commercial forest use in Finland. On the other hand, ditch maintenance activities periodically done in already drained peatland forests that have appropriate growth potential, still have some impacts on waters (e.g. Finér 2010). It has also been assumed that climate change will increase run-off and suspended soil loading as well as accelerate flood risks.

Class 2341 Chemical conditions of freshwaters.

Several water-related regulation services (i.e. water purification and water flow regulation) are to a large extent provided also by terrestrial forest vegetation and soil micro-organisms and invertebrates (jointly with aquatic micro-organisms and invertebrates).

Class type 23411 Water purification. Forested shelter belts (*Sub-class type 23411a*) and forested catchments (*23411b)* are effective in retaining aerial nitrogen deposition, which can exceed 10 kg per hectare per year in southern Finland. According to Lepistö (1999) 93 % of the inorganic nitrogen deposition was retained in forest soil and vegetation and only 7 % leached to water bodies during 1979-1988. Finér (2010) noted that alkalications from forest soil reduce the acidity of water areas.

The condition of freshwater systems requires continuous attention in forestry, and for this purpose water management plans, local restoration programmes and specific quidelines have been drawn up (*23411c).* Besides protective shelter belts with trees established alongside waterways in harvesting, sedimentation pools are dug during drainage reconditioning, and waters from the area are passed to open waters through an infiltration area to prevent leaching of nutrients and sludge (Ministry of Agriculture and Forestry 2011).

Matero (2004) concluded that it is possible to reduce phosphorus leaching by buffer strips in the representative private forest management with minor costs. He also suggested in this context to study positive externalities of buffer strips on biodiversity protection. That was done by Miettinen et al. (2012), who concluded that buffer zones do reduce nutrition load to watercourse although from the point social welfare optimum the buffer zones in forestry should be left most importantly for biodiversity reasons and not so much for water protection, due to low damage value of nutrition load (Ohtonen et al. 2005, Wilander et al. 2012.)

So far, monitoring of the effects of silviculture on water systems over a period of 15 years indicates that the level of water protection has improved continuously at felling sites. The level of water protection regarding harvesting and soil preparation was found to be excellent or good in over 90 % of the sites (Ministry of Agriculture and Forestry 2011). Growing environmental orientation of silviculture and logging could further reduce adverse impacts on freshwater ecosystems.

Nevertheless, due to climate change, water availability is further decreasing and the frequency of severe hydrological events, such as floods and droughts, is rising. Global problems concerning water sufficiency are having a major effect on consumer habits and industrial production in Finland. For these reasons, there is a need to achieve a better understanding of the water cycle in boreal forests, the effects of climatic factors and their temporal changes on forests and their adaptability in Finland (http://www.metla.fi/ohjelma/h2o/index-en.htm)

The ongoing 'Forests and Water Research and Development Programme' (H2O, 2013-2017)[24] is a large scale interdisciplinary project covering the key components of the terrestrial water cycle, from the physiological processes of forest trees to the water cycle at the catchment level of the Baltic Sea. (http://www.metla.fi/ohjelma/h2o/index-en.htm

[24] Programme Director is Professor Leena Finér , Finnish Forest Research Institute, Joensuu unit.

Class 2342 Chemical conditions of salt waters

As all freshwaters are finally running into the seas, and many forests are extending to the seashores, that said above is to some extent valid for the breakish seawaters of the Baltic Sea.

Group 235 Atmospheric composition and climate regulation (Table 2d)

Class 2351 Global climate regulation by reduction of greenhouse gas concentrations

Class type 23511 Carbon sequestration. While considerable uncertainty exists regarding the carbon budgets of terrestrial ecosystems, at global level forests are clearly the largest sinks and greatest storehouses on land (Perry et al. 2008).

Each country contributes to the global climate regulation in its own way and scale. The growth of Finland's forests has been larger than the total drain and therefore the forests have been net sink of carbon since 1990 when the calculations have been done. In 2010 the annual removals of carbon stocks sequestrated by the forest land came to 32.8 mill. m.t. CO_2 equivalent. It was about 30 % less than previous year of global financing crisis, due to increased roundwood fellings. National total emissions in the same year were 74.6 mill. m.t. CO_2 equivalent (Finnish Statistical yearbook of Forestry 2012). Carbon sequestrated by forests covered that year 44 % of the total emissions, of which most (81 %) were due to the energy use *(Sub-class type 23511a)*.

A longer trend can be found in smaller scale. Kauppi et al. (2010) presented results for changing stock of biomass during 93 years in a forest area of 387 km^2 in southern Finland. The growing stock more than doubled from 1.6 to 3.4 million m^3 between 1912 and 2005. Carbon sequestration was mainly a result of a long-term recovery from forest degradation, a legacy of land use in the 18th and 19th centuries.

Also the role of long-life wood products is important in carbon storing *(Sub-class type 23511b).*

Class type 23512 Reduction of other greenhouse gases. Air masses moving onto continents from the ocean carry elements contained in sea spray, primarily chlorine, sodium, potassium, and magnesium. Air moving across continental interiors picks up a wide variety of chemicals from various sources: dust and gases from surface soils, emissions from fires and volcanoes, pollen and other organic emissions from vegetation, ammonia volatilized from fertilizers and animal wastes, and a variety of chemicals (especially nitrogen, sulphur, and heavy metals) released by industry and automobiles. This produces characteristic patterns of nutrient input to temperate forests. Areas of Europe and North America affected by acid rain have especially high levels of nitrogen and sulphur in precipitation (Perry et al. 2008).

Finnish forests as a sustainable and healthy part (ca 0.5 %) of the total area of global forests have their corresponding small positive impacts on atmospheric composition by reducing besides carbon also other greenhouse gases.

Class type 23513 Forests and cloud formation. A new angle to climate regulation by forests is the way how organic compounds take part into the particle formation of the atmosphere and thus the formation of clouds. It is known that clouds have cooling impacts on earth but the scale of that phenomen is not well-known so far.

Riccobono et al (2014) regard that their experiments in the precisely controlled environment of the CLOUD chamber (at CERN) confirmed that oxidized organics are involved in the formation and growth of particles under atmospheric conditions. The results were seen as a strong confirmation of the fundamental role of emissions from forests in the very first stage of cloud formation, and that the new work may have succeeded in modeling that influence.

Class 2352 Micro and regional climate regulation

Class type 23521 Micro and local climate regulation. National forests, of course, are better to be situated in regard to their influences on climate regulation at local and regional (sub-national) levels than at global scales. However, these are not easy to define because climate interactions in particular do not recognize national borders. In Finland older studies refer to favourable but minor local climate impacts of forests (Cajander 1916, Ilvessalo 1928). Mannerkoski (2012) summarizes that the recent knowledge on climatic influences of forests are mostly applicable at microclimate (in forest and its vicinity) and local levels (*Sub-class type 23521a, b)* The processes regulating climate at micro and local levels include radiation regulation, temperature regulation, humidity and wind protection, closely related to mediation of Gaseous and air flows (Group 223 and Classes 2231 Storm protection and 2232 Ventilation and transpiration), and can be found to some extent at local level and perhaps also at regional levels as well.

Class type 23522 Climate regulation and timberline forests. Protection of timberline forests in particular has regional climatic importance due to the large size of (timberline) protection forest zone *(Sub-class type 23522a)* in the northernmost area in Lapland. The total area of timberline protection forests is 3.3 million hectares, which makes c. 12 % of the all forestry land area. State owns 91 % of the protection forest zone area. The specific legislation on protection forest zone was established already in 1922 (Veijola 1998). In the forest law reforms in 1996 (and 2014) the regulations concerning protection forest zone were included into the main forest law (Forest Act 1996, 2014). In these areas, forest should be managed and used following special cautiousness in a way to prevent the timberline from receding down (in latitude and altitude). For example, commercial felling are either forbidden or severely restricted and also wood use for household purposes can be forbidden by forest authorities. The area of commercial forests in protection forest zone is only 0.4 mill. ha. According to monitoring of forest regeneration, there has been no change in the receding of the timberline during the past decades (Ministry of Agriculture and Forestry 2011).

While being regional at a sub-national context, the Finnish timberline forests are a part of the whole Eurasian and North American northern timberline forests, constituting the transition ecosystem between 'productive' boreal forest and naturally treeless areas (tundra), referred to as the forest tundra zone, or *lesotundra*, including sub-arctic birch forests (Veijola 1998, Kankaanpää et al. 2002, Müller-Wille et al. 2002, Vlassova 2002). As these forests are stretching for more than 13 400 km all over the arctic (Vlassova 2002), they also have a global dimension.

In the longer past, one has found evidence of adverse human influences, which have decreased timberline forests. However, it is the long-term climate changes which have more substantially altered the spatial distribution of timberline forests (Veijola 1998, Kankaanpää et al. 2002). Carbon sequestration capacity of northernmost forests is limited, but the existence of forest cover may have some roles for other global aspects of climate change. In the longer term at least, the spatial changes of timberlines function as a natural indicator for climate change.

Contrary to the (assumed) marginal global climate role, the importance of timberline forests is, however, very essential for people and settlement in Finland (Veijola 1998) and elsewhere (Kankaanpää et al. 2002, Vlassova 2002). The sub-arctic birch forests provide shelter, firewood, material for households, arts and handicraft, forage for reindeer, game, berries and cultural values for the Sámi people and to the increasing amounts of hikers and other tourists (Aikio and Müller-Wille 2002). In addition to the local needs, the coniferous part of timberline forests provide also logs for construction and pulpwood for industries, although only in modest scale, as given above.

Timberline forests are another example that there are several forest functions and processes, which having impacts to the local and regional climate, may generate benefits that cannot be easily located into any single category.

3.4 CULTURAL SERVICES

Division 31 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings] (Tables 3a, 3b and 3c)

Group 311 Physical and experiental interactions/use of ecosystems (Table 3a)

Nature-based recreation is part of the Finnish way of life. Forests and forestry lands provide the largest areas and greatest variety of opportunities for recreational activities. Inland waters and seashore areas with their archipelago are also highly appreciated as recreational environments. In nature, terrestrial and aquatic ecosystems complement each other and form together the basic attractions of the recreational landscape. Agricultural lands, peatlands and treeless fells create more open space in the scenery. Also clear-cut areas in forest open up scenery, although they are not appreciated as much as the former. The combination of forests and waters as a recreational setting in Finland is canonized in the culture of summer houses and cottages, usually located at the forest edge bordering on water.

First forest-focused outdoor recreation studies investigated the use of recreation areas near population centres (Jaatinen 1975) and recreation in northern wilderness areas (Saastamoinen 1972). A study on the use of outdoor recreation trails in 1995 was based on nationwide survey (Sievänen 1995). It paved way to the first National Outdoor Recreation Demand and Supply Assessment focusing the year 2000 (Sievänen 2001). A decade later the similar national survey 2010 was done (Sievänen and Neuvonen 2011). These two large scale assessments, based on telephone and mail surveys (in 2010 also internet surveys) and several theme studies, provide an extensive overview on outdoor recreation activities in major ecosystems of Finland. The results include comprehensive statistics about the participation rates and visit frequencies of 86 outdoor recreation activities,

Table 3a. *CICES V4.3-based classification of cultural services*

CICES Section 3 CULTURAL SERVICES

Division 31 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]

Group 311 Physical and experiental interactions/use of ecosystems

Class	**Class-type**	**Sub-class type**
3111 Experiential use of plants, animals and land-/seascapes in different environmental settings	31111 Bird watching	
	31112 Nature photographing	
	31113 Watching forest sights	
	31114 Other nature observation	31114a Song of birds b Other
3112 Physical use of plants, animals and land-/seascapes in different environmental settings	31121 Close-to-home forest recreation	3112a Walking b Nordic walking c Jogging d Biking e Cross-country skiing
	31122 Forest recreation in "ordinary forests"	31122a Recreational picking activities b Hiking and picnicking c Hunting d Vehicle based activities (mountain bike, snow mobile)
	31123 Summer cottage recreation	31123a Summer time b All-the year round
	31124 Nature tourism	31124a Camping areas b Rural forest-related tourism c State hiking areas d Nature tourism (ski) resorts e National parks f Wilderness areas

their distribution seasonally and between major land use and ownership categories and regions, connected with a large number of socioeconomic factors. They also give possibility to study changes and dynamics of outdoor recreation, which sometimes can be reflected to earlier less systematic studies and observations.

Although the results of these national assessments provide an excellent basis to frame the recreational ecosystem services of forests and some other ecosystems, their interpretation is far from being a straightforward one. Major reason is given above: outdoor recreation visits and experiences often move across the borders of ecosystems. Crossing the borders is of course larger if travelling to the site is considered. Similarly, the duration of the activities in forests varies a lot: from a minimum of 15 minutes (as recorded in the national assessments) walk in near-by forest, to a week's wilderness hiking, or a month stay in a summer cottage.

The activities in nature and the nature itself are experienced physically and mentally. Activities and experiences are reflected emotionally, intellectually and spiritually in the mind of the participants, also before and after the visit. In fact, there are several levels of recreational experiences conceptualized in the recent outdoor recreation research (Tyrväinen et al. 2008). On the other hand, recreational services are also seen as welfare services provided by the society and thus recreation opportunities can be seen not only as a part of green infrastructure of the society but also in the broad context of social structures of welfare and well-being (Sievänen 2001, Sievänen and Neuvonen 2011). The traditional institution (now known as Everyman's rights) provides a free access to any forests and most non-wood forest products regardless of the form of ownership: private or public. It also concern peatlands and fell areas but excludes agricultural fields and areas close the houses (Ministry of Environment 2013). For example, picking forest berries also in private forests is allowed and free for everybody, including the tourists and other visitors from other countries.

Class 3111 Experiential use of plants, animals and land-/seascapes in different environmental settings (in forests)

As discussed above, drawing a borderline between "experiential" and "physical" use of ecosystem services is not easy. The title and examples of CICESV4.3 (2013) suggest to focus more on "intensive" observation on species or "species groups" levels. The following class types can be identified based on the second National Outdoor Recreation study in Finland (Sievänen and Neuvonen 2011): Class type 31111 Bird watching, 31112 Nature photographing[25], 31113 Watching nature sights, and 31114 Other nature observation.

[25] Includes in statistics *nature painting* (cf. 31251-31253)

The environmental settings are varying and usually involve several ecosystems. For example, bird watching occurs in archipelago, in peatlands and wetlands providing habitat for migrant species. Often there are bird watching towers constructed. Generally speaking it requires specified habitats and open landscapes. Dense forests are not ideal places but almost always make a part of the landscape and sparse trees may characterize the nearest environments even in peatland observation places. Forest landscape can be a topic of nature photographing and watching nature sights, but again the specifics objects and sites of sight may vary a lot. In fact, it is difficult to find a landscape in Finland where forests or trees do not play some role close to the site or far in the horizon, or framing the lake views.

One of the most enjoyed, yet a neglected service in the literature of forest ecosystem services (cf. von Carlowits 1713, Ch 1.2), is the song of birds (31114a). Where there are trees, shrubs or forests, there are singing birds. Free open air concerts are abundantly available in particular during spring and summer times from early morning. According to the survey of BirdLife Finland (2002)[26] most popular singing birds in Finland are the black bird (*Turdus merula*), thrush nightingale (*Luscinia luscinia*), black-throated diver (*Gavia arctica*), blyth's reed warbler (*Acrocephalus dumetorum*) and common chaffinch (*Fringilla coelebs*). Song of birds can also be seen as an essential part of the auditory dimension of wilderness experience: "the sounds of silence" (Saastamoinen 1997).

Class 3112 Physical use of land-/seascapes in different environmental settings (in forests)

[26] Birdlife Finland organized in 2002 among the bird watchers a pre-competition voting for the Birdeurovision 2002. The winner, and chosen Finnish representative in Estonia, Blackbird (*Turdus merula*), did very well in popular voting (4.), but in expert voting found the placing familiar for Finnish singers in better known Eurovision competitions. http://www.birdlife.fi /lintuharrastus/lintujen_euroviisujen_tulokset.shtml.

Class type 31121 Close-to-home forest recreation. In 2010 the total participation rate for the whole population (15-74 years) to visit nature at least once a year was 96 %, at the same level than in 2000 (Sievänen 2001, Sievänen and Neuvonen 2011). The average number of visits of those participating was 170. Close-to-home recreation was by far the most common group of recreational activities. The elderly people (age 65-74) had the largest average number of trips, 179, during the year. Almost half of trips were less than one hour but the average was two hours (Sievänen and Neuvonen 2011).

Walking for pleasure or fitness including Nordic walking is the most common activity: participation rate is 70 % and it makes a third of all close-to-home recreation trips. Walking with dogs makes 11 % of the trips and is followed by jogging, being out with children, biking and cross-country skiing. It is common that walking routes and maintained skiing tracks are illuminated *(Sub-class types 31121a-d)*. Forests were the most common close-to-home recreation environment: nine of ten trips go to the areas and routes with forests, followed by parks and waters. Most people have good possibilities to visit forest, as the average distance to the forest close-to-home is only 700 meters. A half of Finns have no more than 200 meters to the nearest forest. Nearly two thirds (63 %) of these trips occurs on municipality areas, 22 % on private areas, 9 % on own summer house and 6 % on state lands (Sievänen and Neuvonen 2011). The latter are mostly far away from urban areas.

Class type 31122 Forest recreation in "ordinary" forests. "Ordinary" refers to mainly commercial forests, owned by private persons, state or forest companies, which are mostly used for commercial wood production but are at the same time under some types of multiple uses, based on Everyman's right and forest owners' preferences. To reach these forests some travelling is required but there are no commercial recreational services related to the use of these forests, neither any recreational facilities, regardless of natural forest paths, or sometimes, organized snow-mobile routes. Forest road network, built for forestry purposes, makes an access easy and provides also opportunities for mountain biking. Hiking (27 %), bird watching (22 %) and other kinds of observing nature (51 %) are occurring also in these forests making the largest part of Finnish forests *(Sub-class types 31122a-d)* (Sievänen and Neuvonen 2011).

However, the most common outdoor recreation activities in ordinary forests are related to extractive recreational activities: picking berries (participation rate 58%) and mushrooms (40%) and hunting, which are also classified as provisioning services *(Sub-class types: 11131a Forest berries, 11131b Mushrooms, 11132 Game meat).* Only 5 % of households are picking berries for sale (Saastamoinen et al. 2000) and even less are picking mushrooms for sale. Recreational aspect and household consumption are the dominating motives for picking berries and mushrooms. Participation rate in hunting is 8 % (Sievänen and Neuvonen 2011) but its share of time use is larger (Saastamoinen and Vaara 2009). A popular activity is collecting, cutting and chopping small trees for households use (cf. provisioning service 14111) done also as leisure time recreational activity. Taking trees from a forest is not allowed in Everyman's rights, so it is available mainly for forest owners or requires the permission of the owner.

In wintertime, cross-country skiing is a traditional activity, in which 42 % of the adult population participates. It is a mixed activity: one may start in near-by forest but then can continue into ordinary commercial forests if skiing trails are there. During sunny spring days, ice and snow covered lakes attract many skiers. Driving by snow mobiles (10 %) is not allowed without permission in private forests. It is done mainly along marked trails and on ice, or in own forests.

Class type 31123 Summer cottage recreation. Many of the above activities are to some extent related to the popularity of spending time at the summer cottage (65 % of people, 38 days per year on the average). Summer cottage forest-related activities include making firewood from the trees in the cottage plot or collecting (with permission) cutting wastes or fallen dry twigs in nearby forests.

Most summer cottages are located on the lake shore and therefore water related activities like swimming, rowing (or boating with engine) and fishing are essential part of life in summer house.

Yet more and more of summer houses are built or rebuilt to serve as a second home during the whole year, in particular if they are not too far from work and home. In winter and spring time snow mobiles, skiing on ice and fishing on ice enter into the activities.

Class type 31124 Nature tourism. Known as a land of lakes, forests and four seasons, nature is regarded as a major attraction for visitors in Finland. Most travelers, of course, are domestic and the variety of forest related destinations are numerous *(Sub-class types 31124a-f).* Tourism trips during summer time may often be round trips by car and several types of listed areas can be visited. In winter, available time is shorter and trips are oriented to one destination such as the ski-resort. Whatever is a reason and season for visiting, nature and activities in nature are an essential part of what can be seen and experienced. There is wide amplitude in regard to the importance of social life between, for example, visitors of ski-resorts and those seeking wilderness experiences.

The major landscapes provided by the sea archipelago, lakes with their islands and shores, Lapland with its reindeer, wilderness and open fells, trees and forests everywhere, are also represented in the network of *national parks.* They are visited by foreign tourists besides domestic ones, as they provide the most beautiful parts of national landscapes. Because of their long and growing popularity as recreational and tourist sites, they often also provide a variety of good quality accommodation, possibilities to numerous organized or individual outdoor activities during all seasons (Hemmi 2005). Including domestic nature oriented tourism, it has been estimated with somewhat different assumptions and definitions that nature tourism may create about 25 % of the overall tourism income in Finland (Koivula and Saastamoinen 2005).

Larger wilderness (*31124f*) areas are mostly located in Lapland and other northern/eastern less inhabited areas of the country but also in national parks elsewhere. Isolation from crowded areas, silence and physically rather demanding backpacking or cross-country skiing trips, overnighting in tents , simple lean-tos or small wilderness cabins, are experiences what people are looking after. A flavor of risk is included. Climbing to the top of fells (not steep in Finland) opens rewarding landscape with no or limited signs of "civilization". Northern nature provides possibilities to test physical as well as psychological capacity when hiking alone or in a small group to experience the art of "surviving in the wild" (Hallikainen 1998). On the other hand, Lapland, the most popular target area for longer wilderness trips, has decades ago been called "the most civilized wilderness in the world"(Paavo Kallio[27]). During to-days rescue teams with snow mobiles and helicopters it is even more so. Participation rate in (roughly) this type of outdoor recreation is only 10%, but 15 % among the younger people (Sievänen and Neuvonen 2011).

Group 312 Intellectual and representative interactions

Class 3121 Scientific

Due to the economic, ecological, social and cultural importance of forests in Finland forest research is intensive and widespread. Not only forest sciences, multidisciplinary themselves, but also several other disciplines from basic and applied natural sciences, to social sciences and cultural studies have found important problems to investigate in the interactions of society and forest nature. The state of the forests mirrors the state of the society. Both a sociologist (Koskinen 1982) and a historian (Kuisma 2006) have claimed that to study forests and

[27] Professor Paavo Kallio was a well-known biologist and long time head of Kevo sub-arctic research station of the University of Turku.

forest sector means to study the core of the Finnish society. Certainly, it at least used to be so. What follows from above, that forests and their roles in the society are under scientific investigations from different disciplines and angles in all Finnish universities, at least when seen from the wide perspectives, which the classification of ecosystem services provide.

Two universities, University of Helsinki and University of Eastern Finland have their department and school of forest sciences. In addition, in forest research (and education) in both universities cooperate with other disciplines and departments of their universities.

However, most systematically Finland's forests have been under scientific investigations of the Finnish Forest Research Institute (Metla/FFRI). Its share of the public financing of forest research has been almost a half. Among its several activities,

the National Forest Inventory (NFI) has since 1921-24 been the the fundamental instrument to monitor the sustainability of forest resources. As mentioned, from 2015 it merges with agricultural research and game and fish research institutes working under the Ministry of Agriculture and Forestry into the Natural Resources Institute Finland (www.luke.fi).

There are also private research institutes such as Pellervo Economic Research and Metsäteho which specialize on particular issues in forest sector. A major international consultancy company in the field of forestry and forest industries is Finnish although its scope extends now to other fields as well. Also smaller ones are transforming research and expertice on forests into commercial services.

Altogether in the above three major research and educational institutes there are about 50 professors (professorships, not all filled). The existence of professorship is often taken as the criteria of an established discipline of science. As many institutions have professorships representing the same "basic" disciplines, although their focus can be different, the number of different disciplines is less, roughly perhaps 30 – 35.

Table 3b. CICES V4.3-based classification of cultural services (continued from 3a)

CICES Section 3 CULTURAL SERVICES		
Group 312 Intellectual and representative interactions		
Class	**Class-type**	**Sub-class type**
3121 Scientific	31211 Research forests	
	31212 Other permanent experimental plots	31212a State forests b Company forests
	31213 Ordinary forests	
	31214 Nature conservation areas	31214a Strict nature rserves b National parks
	31215 Indicator species	31215a Forest types b Air quality c Biodiversity d Geo-indicators e Soil quality
3122 Educational	31221 Close-to kindergarten /school forests	31221a Kindergarten b Basic c Secondary/Upper secondary education
	31222 Nature trails	31222 a All levels b All people
	31223 Ordinary forests	31223 a All levels
	31224 Arboretums	31224 a Higher education b All people
	31225 National parks	31225 a All levels b All people
	31226 Training forests	31226 a Vocational b Higher education c Ordinary forests
	31227 Biosphere reserves	
3123 Heritage, cultural	31231 Antiquities in forests	31231 a National b Local
	31232 Wooden heritage landscapes	31232 a Wooded pastures b Grazed forests c Wooded meadows d Old burnt-over woodlands
	31233 Wooden buildings and structures	31233 a Old logging cabins b Brook floating structures c Hunting, fishing and "reindeer" cabins d Wartime constructions
	31234 Forest museums	31234a National b Local c General
	31235 Traditional knowledge	31235 a General b Specific
3124 Entertainment	31241 In-situ	31241a Kids' everyday games b Ga-mes of youth c Other
	31242 Ex-situ	31242a TV b Movies c Internet d Computer games
3125 Aesthetic	31251 National landscapes	31251-31254 a Everybody b Artistic [a and b concern all sub-class types here]
	31252 Regional landscapes	
	31253 National parks	
	31254 Other forests	
	31255 Landscape management in forestry	31255 a Policy driven b Voluntary

On the other hand, some disciplines, which are represented by professorships in other countries, are led by other experienced researchers. International Union of Forest Research Organisations (http://www.iufro.org/science) has categorized forest research in nine larger divisions together having about 120 lower level problem areas and units. The international Forest Decimal Classification – FDC, which Seppälä (2014) applied in his study on the state of forest research in Finland, has similarly nine major categories (plus one for bibliographic and related purposes).

Each discipline has their own scientific focus, theories, methods and other intellectual ways to conceptualize important aspects of forests and forestry for the scientific purposes. Basically, forest sciences in Finland can be organized into four larger categories: ecological and silvicultural, forest measurement and planning, wood science and forest technology, and forest economics, policy and other socio-economic sciences (cf. Seppälä 2014), the latter category including most research on multiple use forests and in that sense having the wide scope closest to that of ecosystem services (Ch 1.6).

This consideration on forest disciplines is not only "an academic exercise". It can be though that the ways science is organized in investigating forests should be the essence of what has been categorized as "scientific" (Class 3121 here) as the part of "intellectual and representative interactions" (Group 312). The above views illustrates that scope in very general terms.

However, the short example of CICES V4.3 for the class Scientific (3121) outlines it more as a subject matter for research both on location and via other media. In the following, this more concrete spatial approach on categorizing forests for research is adopted.

Class type 31211 Research forests. These are specific forest areas, dedicated for research conducted mainly by the Finnish Forest Research Institute, which earlier also was the administrator of these state forests. Although now under the care of the state forest organization Metsähallitus, these forest serve the same research purposes. Altogether their area is about 33 000 hectares.

Class type 31212 Other experimental areas. These forests are also used for relatively long term research experiments but are smaller areas or plots, located either on state lands *(Sub-class type 31212a)* or in the forests of forest industries *(31212b)*, which are interested in long term research cooperation.

Class type 31213 Ordinary forests. Systematic long term forest inventory plots as a part of National Forest Inventory (NFI) are located in all forests *Sub-class type (31213a)*. Shorter term experiments and studies are also done in all kind of commercial forests in agreement with the forest owners *(31213b)* by all institutions doing forest research. Forest research is also often focused in the study and development of practical scale forestry and logging activities such as forest regeneration, other silvicultural activities and forest technology research on wood harvesting or mechanization of tree planting.

Class type 31214 Nature conservation areas. Strict nature reserves (*Sub-class type 31214a*) are in particular devoted for research as the use for other purposes is strictly limited. However, the research needs always permissions and should not change the protected areas. National parks and other types of nature conservation areas (*31214b,c*) are widely used for ecological and other (such as multiple-use) research both by forest, biological and other research institutions.

Class type 31215 Indicator species. These are typical or key plant or animal species, which are used for identification of sites, to indicate states of environmental pollution, biodiversity, soil qualities (Poikolainen 2004, Poikolainen et al. 2009), and even mineral properties of bedrock. The biological forest site type classification based on the indicator plant species (Cajander 1924) has been in use almost hundred years *(Sub-class types 31215a-d)*. For example, from ecosystem service point of view

Vaccinium forest site type means not only a site suitable for Scots pine but as the name reveals it indicates also an abundant whortleberry (*Vaccinium vitis-idaea)* crops. More recently, Pakkala (2012) found the redbreasted flycatcher (*Ficedula parva* Bechst.), the pygmy owl (*Glaucidium passerinum* L.) and the three-toed woodpecker (*Picoides tridactylus* L.) to be the most suitable candidates of multi-scale indicators for species richness of the forest birds.

Class 3122 Educational

Class type 31221 Close to kindergarten/school forest. As forests are common components of urban environment in Finland, it very often can be found in walking distance from the school. In smaller cities a forest may be found just besides the school or kindergarten yards. Although no statistics is available, one can assume that only in the centres of larger cities public transportation is needed to reach the forest in reasonable time. However, the visits to forests or other ecosystems are not necessarily part of the curricula but depends on a teacher. On the other hand, in many kindergarden a close forest is commonly used for being outdoor and learning about nature. Some UK-type Forest School (Knight 2013) elements can even be found in the Finnish pre-primary education systems.

In the obligatory basic and upper secondary education the forests emerge variably in different subjects.

Class type 31222 Nature trails are usually permanent trails in the forests where there are several nature objects or sites with information about the contents of the topic, related to the species, forest site or other landscape feature. They are close to settlements, outdoor recreation areas or part of the educational infrastructure of national parks.

Class type 31223 Ordinary forests. The Finnish Forest Association has organized programmes to support teachers of biology and related subjects to have up-dated material on forests and forestry and also have organized field trips to forests for the student groups quided by local foresters. Many of these and other educational visits occur in ordinary forests available everywhere and demonstrating the everyday forestry practices

Class type 31224 Arboretums. Arboretums are regularly visited at all levels of vocational and higher forest education (at the universities and the universities of applied sciences) but they are also open for the public. The School of Forest Sciences of the University of Eastern Finland in Joensuu has the arboretum in the walking distance from the campus. It is easily available for the citizens. Its development has taken so far three decades and requires two more. The Botanical Garden of the University of Helsinki serves also forest studies but a well-known private Mustiala arboretum locates in the distance of one hour's drive from Viikki campus, where forest education occurs.

Class type 31225 Training forests. At all levels of vocational training *(Sub-class type 31225 a*) and higher level forestry education, the institutes have forest areas available for practical training and field exercises. Most of the forest education units of the Universities of Applied Sciences were formerly technical level forest institutes and have their permanent training forests usually close to the units *(31225 b*). Forest education at the University of Helsinki has its famous Hyytiälä research station with a state forest area managed by Metsähallitus for field courses *(31225 c*). The University of Eastern Finland has not any more a permanent forest area for practical training but uses other facilities and cooperation alternatives, including the Mehtimäki forest area and arboretum just besides the university.

Class type 31226 National parks. All the national parks have well constructed Nature centres which have their own exhibitions and information about the nature and culture of the park and its surrounding areas. Among these, the Nature Services of Metsähallitus (State forest organisation) has three major nature centres: one in Nuuksio National park close to Helsinki regarded as a gate to all National parks in Finland and having a nature school, another in Rovaniemi city in Lapland called as Science centre and third in Inari representing Samí culture of the Northern Lapland. In 2013 there were altogether 860 000 visitors in the 22 Nature centres (www.metsa.fi).

Class type 31227 Biosphere reserves. These are run by internationally recognized non-profit organizations in the areas of world class environments nominated by governments and designated by the United Nations to promote and experiment a balanced relationship between the local people and nature (North Karelia Biosphere… 2013). Biosphere reserves have besides educational also action research goals.

Class 3123 Heritage, cultural

Class type 31231 Antiquities in forests. Since the National Forest Programme 2010, accepted in 1999, the concept of sustainable use of forests has included a cultural dimension, in addition to the economic, ecological and social dimensions. 'Culture' is a wide, even overarching concept, but one important aspect is maintaining what is left from the past. Under the Antiquities Act, antiquities are automatically protected. Prehistoric and historic relics must be taken into account in all land use. This requirement is also incorporated in forest certification. The National Board of Antiquities has, together with some organisations in the forest sector, produced guidelines for forest management in areas containing antiquities (State of the Finnish Forests 2012). For example, Metsähallitus (state forests organisation) has drawn up a cultural heritage strategy for its Natural Heritage Services for the period 2007–2015. Antiques in forests are by definition national values *(Sub-class type 31231a)* but at the same time have their local connections *(31231b)*.

Class type 31232 Heritage landscapes. The national inventory of heritage landscapes was conducted in 1992–1998. The inventory identified 3700 valuable heritage landscapes, which had developed as a result of traditional agricultural practices. Wooded heritage landscapes are wooded pastures *(Sub-class type 31232a)*, grazed forests *(31232b)*, wooded meadows *(31232c)*, and old burnt-over woodlands *(31232d)*. Such sites are often part of a larger milieu, which include traditional farmhouses or other structures.

The sense of place of cultural landscapes is generated from the history of land use and the caring human influence and management which can be experienced (Hiedanpää and Peltola 2011).

Class type 31233 Wooden buildings and structures. When old wooden buildings are aging, they are transformed into cultural products, in particular if they belong to some specific landscape or have some other additional cultural meaning. Some of the old logging camps and cabins have been maintained, restored and are serving nature tourism *(Sub-class type 31233a)*. Floating of timber in the past along even brooks and minor river tails was an art itself and required wooden constructions *(31233b)* like dams and tubes of which some have been maintained and restored. Some of the oldest wooden cabins still maintained in inland forests or small islands of lakes have been served the needs of hunting, fishing and reindeer herding purposes *(31233c).* So far, there is no chapter in man's history without wars. During the World War II trenches, which were supported by wood structures were built in the forests of front areas, mostly for defense purposes. Many of them are maintained as historic sites to remind on the sacrifices for the independence *(31233d)*.

Class type 31234 Forest museums. The Finnish forest museum *(Sub-class type 31234a)* "Lusto" (the name means an annual ring of tree) is located in the vicinity of the Punkaharju national landscape, Punkaharju unit of the Finnish Forest

Research Institute and its arboretum. The popular museum was opened to public in 1994 and was financed both from public and private (forestry and forest industry related) sources. It has permanent and changing exhibitions and, for example, a collection of old and new forest machines, used in harvesting of the heaviest goods among provisioning ecosystem services. Forest museum organizes the periodical "Lumberjack's cultural days". It also hosts the Association of Finnish Forest History.

First forest and forestry focused museums *(Sub-class type 31234a)* were created by private initiatives of forestry people and were maintained largely with the help of voluntary work while getting some support from forestry organizations. Some of their collections have moved to Lusto museum (see below).The only still functioning old museum, the Forest Museum of Lapland, *(31234b)* continues to be open only on demand. Several general museums, national, local and regional museums also have collections related to forest history *(31234c)*

Publications on forest history have been booming during past twenty years. Many important contributions are produced outside the academic forest sciences, which actually is lacking the chair in this important field.

Class type 31235 Traditional knowledge is a part of cultural heritage related to forests and forest uses. It can be related to any categories of ecosystem services, although mostly to provisioning services. Traditional knowledge has often primarily been related to unwritten sources. More and more can now be found in printed form in the records of forest history (e.g. Luttinen 2012). It can be general knowledge concerning forests *(31235a)* or specific related to certain forms of forest uses *(31235b)*.

Hiedanpää and Peltola (2011) note that (practical) knowledge and skills related to nature based industries such in agriculture, forestry, hunting and fishing have cultural meanings and should be included as cultural services although they are difficult to identify – unless something goes wrong.

Class 3124 Entertainment

Class type 31241 In situ. For generations, besides home yards, forests have provided the major playing grounds for children in Finland. It was only a few steps away in rural areas and not much longer from urban multi-storey houses built in "forest sub-urban areas" during the urbanization period of last five decades. Also new detached one family (or connected multi-apartment) houses are often located near forests. Only the kids in the centre of larger cities had a longer distance to forests, but most of the larger towns have wide forest parks. Forest games were many, from making animals from tree cones to constructing a shelter in the forest or from hiding to fighting. Walking and exploring nature or climbing into the trees also were basic forms of free time activities *(Sub-class type 31241a)*. The Scouts and other youth organizations have their own long tradition to organize forest games in their summer camps *(31241b)*. A new form of games in forests is the historic plays younger people have organized or the more spontaneous adventure / fighting games by teams of youth or even adults, involving old or modern weapons with paint or ball bullets *(31241c)*. Entertainment can be used also for the learning form. A common educational tool for all people is specific forest trails near settlements, and other places, where walkers can find information on trees, plants and other features of the sites.

Class type 31242 Ex situ. Television, radio, books, nature related journals and newspapers and internet are the most important media transmitting experiences from forest and other nature in form of films, photographs and written text. As everywhere, the TV's domestic nature programmes are popular, although not produced with the same resources as those being in international distribution. Nature programmes in TV are also widely directed to kids and whole families *(Sub-class type 31242a)*.

Traditionally, nature in her summer clothes, in particular agricultural, lake as well as forest landscapes have played an important role in the Finnish films *(31242b)*. Timber floating romantics was one of the popular topics until 1950s. During the rapid urbanization period from the 1960s onwards the role of rural movies decreased but has gained some room after that. There are some carefully done films on Finnish nature which have become popular and brought also to the international audience[28].

Radio maintains its position as an easy access entertainment provider and fast information source *(31242c)*. The main radio programme on forests has been for decades a weekly "Forest radio" and still continues on the demand of the audience. Nowadays even a more popular programme "Nature radio" has interactive communication in regard to all aspects of natural world in Finland. A tradition of the public Finnish Broadcasting Company (Yle) has been to send a weekly half-a minute "voice of nature" several times during the day and a week, where forest and other birds are widely represented. Forest has been a subject matter for hundreds of books targeted also to the great audience *(31242d)* [29]. Among nature related journals and newspapers *(31242e)* a weekly "Metsälehti" [Forest newspaper] has a broad audience even beyond forest owners and other forestry people. Thrice a week published newspaper "Maaseudun Tulevaisuus" [The Future of Rural Areas] discusses widely agricultural and forest issues, and has the second highest readership of all newspapers. A bi-monthly "Suomen Luonto" [Finland's Nature] represents the voice of

[28] "Story of the forest" (premier 28.12.2012) has become the most popular documentary film ever in Finland (http://www.nordiskfilm.fi/valkokangas/uutinen)

[29] Literature and arts and in particular music echoes the varieties of nature's voices and experiences of nature. Dr. Kaisa Junninen, an active environmentalist now serving Metsähallitus Parks & Wildlife Finland (an entity of State forest organization guided by the Ministry of Environment) was studying in the 1990s in Canada. During a lecture discussion she told that the wooden instrument called *Kantele* is the national musical instrument of Finland. "I thought it was the chain saw" was the comment of her professor. (With a permission of Dr. Junninen).

nature conservation also on forest matters. Daily newspapers are actively following forests, forestry and forest industries and other nature's state and events. All major forest organizations have their internet pages and much above (a-e) are found in one form or another also through internet *(31242f)*.

In the Finnish game business the Finnish nature has so far not played a larger role. Angry birds may not be endemic in Finnish forests.

Class 3125 Aesthetic

"Finland is, in the eyes of the world, a forest country, in reality and in imagination, in the past and in the present", summarizes Yrjö Sepänmaa (1997) in his article on aesthetician's view on Finnish forests. "Proper" forests make 68 % of the total area of Finland (without sea areas), inland watercourses 10 %, agricultural lands 8 %, open peatlands 6 %, open fells 3 % and built-up environment and infrastructure 5 % (Saastamoinen et al. 2013, Finnish Statistical... 2012). So, it is also true what Sepänmaa (1997) says that "Fields and waters combine with the forest to dominate the Finnish landscape". It is a variety of forests, lakes, agricultural lands, peatlands and other open areas which is the basic characteristics of the most attractive Finnish landscapes, seldom any of the single ecosystems as such although in some cases it may be also the forest alone.

In fact the word *landscape*[30], according to Raivo (2002), incorporates at least three essential features or connotations. It may be understood as referring to (1) a visual scene, (2) a geographical region, or (3) a culturally determined way of viewing or analyzing the environment. These properties are not mutually exclusive; the notion of landscape frequently subsumes all three. A landscape can thus have many faces, or in other words, one landscape has numerous new landscapes opening up within it. The most characteristic feature attached to a landscape, nevertheless, is its visuality (Raivo 2002).

[30] In ecology landscape refers to the wider area combining different ecosystems.

In the landscape-based system of regions originally proposed by geographer J.G. Granö in 1925, Finland is divided into five major landscape regions, 13 landscape provinces, and 51 landscape districts (Raivo 2002). The five major landscape regions are Southern Finland (in the forest vegetation map of Fig. 1, roughly zones 1 and western and southern coast areas of 2a), Lake Finland (rest of 2a and 2b), Ostrobothnia (roughly 3a and 3c), Wooded hill Finland (roughly 3b and 4a) and Lapland (roughly 4b,4c and 5). In all these areas forest is a dominating terrestrial land cover, but the roles of open landscapes (seashores, lakes, agricultural lands, open peatland and treeless fells) combined with topography make the distinctions.

The contrasts between two or more landscape elements (e.g. lakes and forests, fields, forests and lakes or open fell and timberline forests) together with topographic variation yield most enjoyable environments for viewers, whether residents or visitors. The typical character of Finnish landscape is also the distinct seasonal variation: summer and winter, spring and autumn all form their own colours, light and clothing for the one and same landscape (Kalliola 1981). Whatever is the main focus and contents of landscape, very often it is trees in near landscape and forests in distant landscape which frame the view.

Class type 31251 National landscapes The term 'national landscape' is used to describe the most famous cultural and natural landscapes in Finland. The origin of the concept derives back to the rising national romantics and identity development during 19th century. To commemorate the 75th Independence Day in 1992, altogether 27 areas from all around Finland were designated as national landscapes. Most of the national landscapes have the cultural core with settlements, old buildings and cultivated areas and often water as the other major element. Forests and trees are there as minor elements, as forested hills or otherwise framing the landscapes. Natural landscapes are the combinations of waters and forests. Because of the strong cultural criteria in selecting national landscapes,

Fig. 7. *Summernight. Lake and forest makes the national landscape in Finland. Photo: Antti Otsamo*

none are mainly forest focused landscapes. The other reason is that natural – and therefore forest related landscapes – have been already included into the system of national parks, which were developed much earlier **(Class type 31254)**. On the other hand, Häyrynen (1997) argues why in particular the lake landscape[31] was chosen to be the national landscape during the national romanticism: among the reasons was not only its geographic originality and picturesque variety but also the need to emphasise the Finnish (language) interior alongside coastal cultural landscapes.

Class type 31252 Other nationally valuable landscape areas. Finland has 156 smaller scale landscape areas which were identified as nationally valuable in a Government Resolution of

[31] It has been argumented here that "lake landscape" most often means lake and forests landscape, where forests (in particular island forests) bring the variety, contrasts and framing to the water surfaces making landscape in particular attractive.

1995. Key areas are vital agricultural landscapes that have remained traditional in appearance. Wooded heritage landscapes are wooded pastures, grazed forests, wooded meadows and old burnt-over woodlands. Many of these landscapes are important also for biodiversity conservation.

Class type 31253 National parks. One of the reasons to establish national parks has been to preserve unique landscapes of the country. Therefore some outstanding landscapes of the parks are all included in **Class types 31251 and 31252**. In addition, all the landscapes of national parks and strict protection areas are usually left intact, unless there are reasons to restore forests, for example by prescribed burning to make more natural habitats for biodiversity reason. Other specific landscape managements are related to the buffer zones, which may have large scale tourism accommodation and other related infrastructure. The buffer zone bordering protected areas is not a legal concept of Nature conservation act or Forest Act, but has born case by case on practical needs of tourism and nature management. No doubt, beautiful landscapes are among the major ecosystem services of national parks, other protection areas and in general forested areas important for tourism.

Class type 31254 Landscape management in forestry. In the management of "ordinary" forests landscape features can be taken into account at different spatial scales from stand (e.g. species composition) and cutting area (size, delineation) levels up to landscape levels (in larger state forests). In private forests the owner has possibilities to take landscape aspects into account largely in his/her own ways, and with considerations on the recommendations of good silviculture and paragraphs of Forest Act (1996/2013)[32] on landscape. State forests have

[32] If the site where the felling is carried out is of special importance in terms of biodiversity preservation, in respect to the landscape, multiple-use of forests or other special purpose felling can be carried out in a manner required by the special nature of the site (Forest act, 1085/2013, section 13).

possibilities for larger scale landscape management, for example, in their integrated natural resource planning, and have more detailed guidelines (Päivinen et al. 2011). It has also experimented landscape management agreements with tourism enterprises. Landscape management in forestry has long been touched in scientific and professional forest literature, but in particular so during the past two decades (e.g Komulainen 1995, Harstela 2007, Karjalainen et al. 2010). Harstela (2007) sees that landscape management is to integrate economy, aesthetics, ecology and cultural heritage.

Landscape dynamics is an important part of understanding the relationship between forestry and landscape values (Harstela 2007). During the long (say 60-120 years) rotation of forests, there is a period (5-10 years), when the aesthetic values of forests turn to zero level, if not into negative zone. That happens when the mature forest stands are clear-cut by harvester, transported by forwarder, soil prepared mechanically for planting, which so far mainly is done manually[33], with some left cutting waste and even standing broken trees left for biodiversity enrichment. This landscape is not attractive to see, neither easy to walk. But after some years, when the seedlings are growing and naturally seeded broadleaved colonize the open space, the scene is entirely different.

The perception of that kind "production landscape" is related to the concepts of 'meaning' and 'understanding'. The visitor, who knows that wood is needed for houses, furniture, paper and packing and that a clear-cut (with available restrictions) of mature forest is one of the sound methods of harvesting wood, and that the immediate planting of trees maintains forest sustainability, may look at the landscape with more reassured mind than a person who doesn't understand the whole picture. Aesthetically both may share the similar assessment but emotional and cognitive perceptions might be different.

The more experienced watcher may also look how the cutting area is demarcated in the landscape, what soil preparation

[33] However, the use of planting machines is increasing and under further development.

method is used, whether there are groups of trees or other signs of landscape details taken into account. Observations can be done also on what happens to the cutting residuals: are most taken for energy use all left to maintain the nutrients of the soil. An aesthetician may wonder the role of standing trees, some damaged or cut from half height, but the loss of landscape value might be a bit easier to tolerate if the reason behind it - biodiversity - is revealed. In commercial and multiple use forestry the cultural ecosystem services are an inseparable part of the way the provisioning services are managed and harvested.

Table 3c. *CICES V4.3-based classification of cultural services (continued from tables 3a and 3b)*

CICES Section 3 CULTURAL SERVICES		
Division 32 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]		
Group 321 Spiritual and/or emblematic		
Class	**Class type**	**Sub-class type**
3211 Symbolic	32111 Symbolic and charismatic animals	32111a Brown bear b Golden eagle c Reindeer d European elk e Capercaillie
	32113 Symbolic plants	32112a Lily of the valley b Juniper c Silver Birch d Spruce
3212 Sacred and/or religious	32121 Places	31221a Old Finnish b Sámi culture c Present attitudes on nature
	32122 Species	32122 a Rowan tree
Group 322 Other cultural outputs		
3221 Existence	32211 Endangered species 32212 Pristine forests 32213 Wilderness areas	32211 a Critically endangered b Endangered
3222 Bequest	32221 National parks	32221a Forest major vegetation b Forests minor vegetation
	32222 Strict nature reserves	32222a Forest major cover b Forest minor cover
	32223 Other conservation areas	32223 a Private forests b Other non-state owners
	32224 Nature's monuments	32224a Single trees b Tree groups
	32225 Habitats	32225a Forest habitats of Nature conservation act b Habitats of Forest act

Division 32 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [Environmental settings] (Table 3c)

During the latter half of 19^{th} century forests and other nature were sources of inspiration for the rising national arts, in particular in literature, music and painting – as envisaged in Ch. 1.3. The cultural achievements related to forests and other nature was meant to strengthen the national identity. It raised the understanding on the aesthetic values of forests and lakes. It also brought (arts and music) the country to be better known in Europe and elsewhere, which was important for the growing will of the country to become an independent nation.

Earliest claims and initiatives for nature conservation occurred at the same times. Also forest literature gave attention to the aesthetic and spiritual values of forests, including early nature conservation (Cajander 1916, Ilvessalo 1928). Similarly, the research on the earlier folk culture and traditions of the past generations were given attention increasing the understanding of the relationships of people and nature in the past.

An essential part of the Finnish culture is sauna, a place for effective bathing and mental refreshment. It is now found in all forms of housing from one –family houses to the multi-storey buildings. In the latter there are one or more sauna departments, which the dwellers may reserve their own weekly hour. Most recently, there has also been a trend to have a personal electricity sauna even in the smallest apartments. Whatever is the location of sauna, wood is its dominant interior and seating material.

In sauna human being meets almost all elements of the nature. Rural and summer house saunas are often separate small wooden cottages, built on the lakeshore. The fireplace full of stones is made very hot by burning wood. Throwing water on stones gives a high temperature steam making body to sweat and refreshing soul. A whisk made of thin twigs of Silver birch (*Betula pendula*) furthers the physical and odor impacts. After washing with water and swimming in lake or snow, a human being is fully regenerated. Sauna is the physical, mental, spiritual and symbolic experience and ritual.

When a nature movie seen at a theatre or via TV is an ex-situ experience of ecosystem service, sauna in above archetype sense may defend its place as the bundle of "ex-situ" (forest) and in-situ (water) ecosystems services. Cultural ecosystem services seem to be even more layered than provisioning and regulating services.

Group 321 Spiritual and/or emblematic

Class 3211 Symbolic

There are many symbolic values related to forest plants, animals and forests themselves. The Finns have traditionally regarded themselves as forest people. Finland is a land of "green gold" or "the green kingdom" as the book on the Finland's forest cluster was titled (Reunala et al. 1999). The slogan of the Finnish forest industries from the seventies declared that "Finland lives on her forests". After the downturn of paper industries, with massive capacity reduction and lay-offs this slogan was somewhat set aside. Yet with the rise of bioeconomy and its new products and the wider scope the ecosystem services have brought also on forest benefits, the slogan may still be justified. But it could be enlarged to cover also the other important ecosystems of the country.

Class type 32111 Symbolic and charismatic animals. Brown bear (*Ursus ursus*) is the national animal of Finland *(Sub-class type 32111a)*. The population of this sturdy king of Finnish forest is historically large for the period of last twenty years.

Golden eagle *(Aquila chrysaetos)* (*32111b)* is one of the most majestetic bird species and the symbol of wilderness lands and values in Finland. As an endangered species it has been protected since 1962, when the population was 20-50 pairs. Now it is about 310-390 pairs (http:/www.metsa.fi). The success has largely been based on the cooperation among parties facilitated by the tolerance payments to reindeer herders (Hiedanpää & Borgström 2014). Reindeer (*Rangifer tarandus*) (32111c) itself is not a wild animal but grazes a larger part of the years freely in forests, peatlands and fells and has become a symbol of Sámi culture and whole Lapland. Among the forest birds, Capercaillie (*32111e)* is the most respected inside the forests because of its size and beauty. Besides being symbolic, Golden eagle is also the charismatic species dominating the higher air space above forest lands. Inside the forests besides the brown bear another charismatic species are European elk (*Alces alces) (32111d)* as being the largest mammal.

Class type 32112 Symbolic plants. Lily of the valley (*Convallaria majalis*) is the national flower of Finland *(Sub-class type 32112a)*. Not due to its personous character but because of its modest beauty with small pearl like white flowers contrasting to very green leaves with a bit boat type forms. The poison substance was used for many diseases in traditional medicine. Juniper (*Juniperus communis*) *(32112b*) is a modest brush, only seldom in the south reaching a size of small tree, which can survive in very poor soil and water conditions. It has been used as a national metaphor for the Finns, demonstrating the ability to survive in difficult conditions by living modest life, bending but not broking. Young silver birches (*Betula verrucosa*) celebrate the Mid-Summer Eve *(32112c)* and spruce (*Picea abies*) does the same during Christmas in Finland as elsewhere *(32112d)*. In fact, several other trees have symbolic and cultural values (Pekonen 1997).

Large areas of the northernmost forests were in 1991 declared as Wilderness areas based on the Wilderness act of 1991. The act was a result of the campaign of the environmental organizations against logging activities in the state forests due to their wilderness values and importance for reindeer husbandry (Lehtinen 1991). The wilderness areas consist of forest, forest tundra and tundra areas. Soft cutting methods were allowed in some parts of the wilderness areas, which basically can be regarded more as a specific multiple use area than mere conservation area. It can be noted that wilderness areas and protected areas have many uses and values, and therefore are present in several categories of the classification.

Class 3212 Sacred and/or religious

Class type 32121 Sacred places. These are mainly related to the old spiritual and religious beliefs and habits (see Ch. 2.2) related to Finnish *(Sub-class type 32121a)* and indigenous Sámi *(32121b)* cultures, perhaps also in regard to forest uses such as hunting and reindeer husbandry. The register of prehistoric relics of the Museum authority includes 27 000 objects of which 60% are situated in forests. The latter are former settlement sites, burial places and stone constructions (Tapio 2011).

At present times one can find in formal and informal literature individual descriptions about feeling sacredness of (mainly natural) forests by people. Although it is not difficult to find evidence to the claims in public discussion that "nothing is sacred in our times", it also may be possible that the spectrum of things and ideas given much worth is only wider than earlier: from traditional national anthems, religious symbols, human rights and pristine forests to pop idols and football teams.

According to a survey study, over 40 % of Finns agree with a statement that "Forests are sacred places" (Horne et al. 2004). The group which was least inclined to agree with the statement was the young urban males. However, the present attitudes apparently support the claim that there are attitudes and feelings of sacredness related to forests even in our days *(Sub-class type 32121c).* The following more support to this statement.

There is a common saying that "the forest is a church of a Finn". A version of that, the unique wooden *Paateri* chapel in the middle of pine trees was the biggest single project by the wood sculptress Eva Ryynänen (1915-2001). The chapel located near her home was completed in 1991 and become one of the most popular tourist attractions in Lieksa municipality, Eastern Finland. Another wooden *Chapel of Silence*, found in 2012 its place in one of the busiest squares of Helsinki, being that time the design capital of the world. The chapel provides everybody an easy possibility to sit and have a silent moment inside the oval structure of the Finnish wood.

Anyway, the Lutheran church has its own environmental concerns and forests are part of the discussion. For example, Kainulainen (2013) has brought a concept of "forest's theology" which derives inspiration from forest and other nature. She believes that the forest can help the Finns to "relocate themselves in the universe" and get rid from the alienation from their home and the nature. "Forest's theology" has an environmental ethos but the concept also refers to a search of theology which is close to ordinary people and the Finnish (Fenno-ugric) way of life. Forests prevent to be lost, give solace, food and health. "The Holy Three in the forest cures soul, body and the whole planet" (Kainulainen 2013).

Sacred species (Class type 32122). Rowan tree (*Sorbus aucubaria*) is the best known sacred tree in Finland *(Sub-class type 32122a)*. According to Anttonen (1997) the early inhabitants of Finland during the critical times laid the twigs of Rowan tree above doors to protect from external threats and dangers. The white flowers and red berries have determined the growing period of crops and have been symbols promoting and protecting the fertility of women.

Group 322 Other cultural outputs

Class 3221 Existence

Existence values, the right to exist beyond any benefits to human beings is assumed to be inherent to all living nature, – concern naturally all biota but are most actual to Endangered species **(Class type 32211)**, Pristine forests **(Class type 32212)** and Wilderness areas **(Class type 32213)**. It is usually regarded that values for nature conservation are either anthropocentric or ecosentric. The studies of attitudes of the citizens reveal that there is a continuum rather than a sharp division between the supporters of the value groups. Nevertheless, people can be categorized into utility emphasizing and intangible as well as nature values supporting fractions, which have different socio-economic backgrounds (Horne et al. 2004) Enjoyment provided by wild species, wilderness and ecosystems and landscapes are no doubt real and lead to further arguments for preserving.

Northern wilderness areas are mostly located in Lapland. Isolation from people, experiences of solitude and silence and spiritual connections to nature, earth and sky are main spiritual aspects people are looking after. A flavor of risk is included. Climbing to the top of fells (not steep in Finland) opens rewarding landscape with no or limited signs of "civilization". On the other hand, as given earlier, Lapland has been called "the most civilized wilderness in the world". Northern nature provides possibilities to test physical as well as psychological capacity when hiking alone or in a small group to experience the art of "surviving in the wild" (Hallikainen 1998).

Activities related to charismatic wildlife include an organized bear watching in Kuhmo and unorganized watching of capercaillie and other larger birds. There is a possibility to see signs of bear in summer or footprints of wolf during winter in the wilderness.

Class 3222 Bequest

Bequest in CICES V4.3 refers to "willingness to preserve plants, animals, ecosystems and landscapes for the experience and use of future generations". It contains "moral/ethical perspective of belief". Basically, the major difference from existence value is the more altruistic orientation of bequest (values) towards benefits of future generations, be these generated from experiential or other motivations. However the two concepts are complementary and provide the major moral argumentation for nature conservation.

The history of nature conservation areas has been related to the initiative of A.E. Nordenskiöld in 1881 "to maintain the right picture to future generations of the land of their fathers"

(Helander 1949) while Kuusinen and Virkkala (2004) see it start from the order of tsar Alexander I in 1802 not to cut the forests of Punkaharju. The first nature conservation area on the state land was established in 1916 by the decision of Metsähallitus and Nature conservation act accepted in 1923 contained orders for nature conservation areas. However, the first four national parks and six strict nature reserves based on the act were established not until 1938.

The initiatives and suggestions to develop nature conservation area network became originally from scientific societies and Metsähallitus. Later on preparation were also done within state committees, developing nature conservation and environmental administration supported by non-governmental conservation organizations.

Finland has now one of the most developed network of forest based national parks and other protection areas, in particular in the northern part of the country. According to and European assessment, almost half of the strictly protected forests in Europe are located in Finland (Parviainen 2013).

Finland's Nature Conservation Act (1996) has biodiversity conservation as the first of many targets. The act lists nature conservation areas in the following way.

Class-type 32221 National parks. Minimum area of the National parks are 1000 ha.

Class-type 32222 Strict nature reserves. These areas have no minimum area and limited access. They can be roughly divided into areas having major forest cover *(Sub-class 32222a)* or minor forest cover *(32222b)*

Class type 32223 Other conservation areas. The latter include conservation areas in private lands *(Sub-class type 32223a)* and other conservation areas *(32223b)*.

Class type 32224 Nature's monuments. In addition the Act protects smaller objects, including remarkable single trees and tree groups *(32224a and b).*

Class type 32225 Habitats under protection. Nature conservation act places nine habitats under protection, which including four rare broad-leaved deciduous forests *(Sub-class types 32225a-d)*. The protected habitats of Forest Act (2014) include eight habitat types. These are small in size and their protection is to some extent flexible, but compulsory in all forests and altogether their area covers nearly 100 000 hectares (Statistical Yearbook of Forestry 2014).

The EU Habitats Directive lists 69 habitats found in Finland, which are protected as part of the Natura 2000 network. Many of these are protected already in the nature protection areas of the Nature Conservation Act (http://www.ymparisto.fi/en-US/Nature/Natural_habitats).

Besides biodiversity conservation Nature Conservation Act (1996, now under revision process) have four other targets: to maintain nature's beauty and landscape values, to support sustainable use of natural resources and natural environment, to strengthen knowledge on and public interest in nature, and to advance research on nature. That is a reason why nature conservation areas, habitats and species are represented in many roles in the classification of ecosystem services, as is found in this study.

4. Disservices of forest ecosystems

Forests and forest ecosystems do not only provide goods and services but also may deliver nuisances and risks, sometimes even dangerous ones, for people visiting forests or living closet to forests. Mannerkoski (2012) noted that any forest (environmental) service, when it is maintained or produced "too much" can turn into disbenefit. It is also well-known, that what is very much appreciated by many people may be felt as disbenefit for others. This is also is true in particular for the first two cases, where the component of being "a disservice" is primarily related to related to the size of the population (European elk) or the size and/or location of the population (wolf). It is reminded, that this chapter is not a part of the CICES.

European elk (*Alces alces*) is the largest mammal, and most important game species in Finland (11141a) but causes also damage to forests and society. The damages are largest in pine seedling stands, which elks regard as the best nutrition nature can provide. Forests owners see it otherwise as this significantly reduce forest growth, increase regeneration costs and have an adverse impact on the quality of future trees. Silvicultural choices can even be limited in southern Finland. Ecologically, even the species structure is changing in protected areas (Heikkilä and Härkönen 2007). Outside forests moose and smaller deer cause damage for agricultural crops, and domestic animals and gardens. Most important disservices, however are the traffic accidents caused by moose, which cross the roads, often during dark times. These economic costs are calculated to be about 100-150 mill. € per year; considerable higher than agricultural and silvicultural damages (10-20 mill. € per year) (http://www.mmm.fi/fi/index/etusivu/kalastus_riista_porot/riistatalous/riistavahingot/hirvivahingot.html). The policy measures include regulation of elk population, state compensations for damages to forest owners and farmers (paid partially from hunting fees), traffic insurances and signs and most recently coloured plastic belts along road sides to direct elks to cross the roads in places where the risks for both parties are reduced.

Wolf. Due to the aims of the EU and national biodiversity policies the wolf (*Canis lupus*) is protected in Finland as in other EU countries. The size of present wolf population was estimated to be (February 2014) 140-155 individuals, and found to be growing after a decreasing trend (Finnish Game and Fisheries Institute 2014).. The problems with the wolfes are mainly local. People leaving in primarily rural and remote areas feel insecurity for their kids, for themselves, for cattle and home animals. Threatening situations with wolves increase if the populations are growing too much or the wolfs assume intruding manners. Wolfs and their packs are sometimes also moving from place to place. European Elk is the major diet of wolf, which on its part reduce the risks discussed earlier – but also the catch of elk hunters. Hunters have also lost their dogs due to wolfs. There is a small quota for licensed hunting to keep the population limited but still viable. For many years rather heated debates around the wolf protection and the related policies have been going on, mainly between the conservationists, local people and the hunters. Policies and policy instruments are being sought to find a just balance between the different interests and perceptions. When found, the scale of the "wolf disservice" will be greatly reduced as is already practically occurred in the case of other larger mammal predators, brown bear (*Ursus ursus*), Lynx (*Lynx lynx*) and wolverine (*Gulo gulo*). Only bear is seen as a thread for human life (the risk cannot be entirely removed) while the wolverine in particular takes a toll in reindeer herds, which however is compensated.

Snake. The only poisonous snake found in Finland is an adder (*Vipera berus)*. The last time anyone died as a result of a bite from the adder was in 1994 but very often people are advised to have a specific medicine with them if moving in terrains where this small snake may appear.

Mosquitoes. If an ordinary Finn is asked about the inconveniences of forests, the most probable answer would be the mosquitoes, which are abundant in late summer and more abundant in the humid climate of Lapland. These are nuisances but not dangerous at all, making people to understand that sometimes there are no pleasures of hiking or picking berries in the forest without some cost. In Lapland the peak period of hiking is in September due to the bright colours of nature and the absence of mosquitoes which disappear after night frosts and are not found in windy higher elevations.

Indirect health risks carried by animals. Mostly, the Finnish forest provides safe opportunities for different kind of recreational and other activities. However, there are some other risks to be mentioned. The *deer ked*, or the deer louse fly (*Lipoptena cervi*), is a parasitic fly that came to southern Finland in the 1960s. The Finnish translation is "European elk fly". They cause more inconvenience in the areas they are abundant, as they may go into hairs and clothes of people, may sometimes bite and cause for some people skin problems or allergy (Laukkanen et al. 2005). However, it can cause more serious health problems as the deer ked is a potential vector of various diseases, via e.g. bacteria of *Bartonella spp*. – as found in Central Europe (Dehio et al. 2004).

A longer known nuisance has been the sheep tick (*Ixodes ricinus*), which can dig into the skin of person and is not always easily taken off. In most cases it does cause anything else, but it also is potentially dangerous as being the transmitter of Lyme disease (borreliosis) and TBE (Tick Borne Encephalitis), and, less commonly, rabbit fever, each of which can have serious consequences for the health of those infected. Earlier, the TBE cases where found only in the southernmost archipelago of Ahvenanmaa, but now also elsewhere mainly in southern Finland. It is assumed that sheep tick in Finland is increasing as a result climate change. So far, however, only a few cases are found annually.

Hemorrhagic fever (*Nefropatia epidemica*) is caused by Puumala-virus (PUUV), which belongs to Hantaviruses. Hantavirus is naturally maintained in persistently infected rodents and can be transmitted to humans via the inhalation of aerosols. In Finland it is spread by forest mole (*Myodes glareolus*), which is found through the whole country except the northernmost Lapland. The fever usually is high in the beginning and can include pains in the back, tiredness but also more serious side-effects. The death risk is low, 0.1 % and no permanent impacts remains. Once a person had suffered the fewer, it gives lifetime protection. It is not transmitted from human to human. The most probable risk group is the scientist investigating forest rodents (Brummer-Korvenkontio et al. 1982, Henttonen et al. 1996). Later another risk group has been found, as it has been noted that to the surest way to get molefever is chopping firewood in late autumn inside the wood storage building (Henttonen 2013).

According to Voutilainen (2013) forest habitats disturbed by intensive forest management were associated with a higher likelihood of PUUV infection in bank voles. This finding could be explained by the poorer quality of these habitats, leading to lower condition and higher susceptibility, and also by more favourable environmental conditions for virus survival outside the host. Despite the higher infection prevalence in voles, the total number of PUUV-infected bank voles was 46-64% lower in young, intensively managed than in undisturbed, old forests. Thus, environmental change per se does not automatically lead to relative success of species that serve as reservoirs for zoonotic pathogens, and thereby, to increased human disease risk.

Poisonous plants and mushrooms. Approximately ten species of dangerously poisonous plants are found in Finland. Edible plants eaten raw or wrongly processed may cause severe symptoms (Hoppu et al. 2011). Fatal intoxications by poisonous plants and mushrooms are, however, rare. Unitary deaths have been caused by lily of the valley (*Convallaria majalis*, cf. 32112a), Solomon's seal (*Polygonatum odoratum*) and cowbane (*Cicuta virosa*).

None of the common berries are poisonous although red berries of brush mezereon (*Daphne mezereum*) look attractive but the taste is not pleasant.

Among the mushrooms, the Finnish Mycologicl Association (http://www.funga.fi/category/myrkkysienet/) lists as deadly poisonous six species: death cap (*Amanita phalloides*), destroying angel (*Amanita virosa*), ergot fungus (*Claviceps purpurea*), *Galerina marginata* and deadly webcap (*Cortinarius rubellus*) as well as false morel (*Gyromitra esculenta*). However, false morel after several parboils in abundant water is very tasty in particular as mushroom sauce or soup. In this case, the difference between ecosystem good and ecosystem bad is drawn into boiling water. Deadly webcap has caused deaths as it can be confused with many edible mushrooms. Common roll-rim (*Paxillus involutus*) is an example of many other less poisonous mushrooms, which can easily be mixed with edibles species.

Pollen allergy. Alder (*Alnus* spp.) and birch (*Betula* spp.) pollens occur in south and mid- Finland in quantities capable of causing allergy symptoms. Except for birch pollen, allergenic pollens occur in far lower concentrations than in central Europe. In northern Lapland only birch and pine pollen concentrations are high. Pollens may occur without signs of local flowering when there are southerly winds. This finding suggests that long-distance transport is an essential contributing factor to the occurrence of pollens. Pollen allergy is rather common seasonal problem among population.

Ozone forming potential of forests. Biogenic volatile organic compounds (BVOC) emitted by terrestrial ecosystems into the atmosphere play an important role in determining atmospheric constituents including the oxidants and aerosols that control air quality and climate (Guenther 2013).

BVOCs are part of Volatile organic compounds (VOCs), which affect atmospheric chemistry and thereafter also participate in the climate change in many ways. The long-lived greenhouse gases and tropospheric ozone are the most important radiative forcing components warming the climate, while aerosols are the most important cooling component (Ruuskanen 2009).

Also VOCs can have warming effects on the climate: they participate in tropospheric ozone formation and compete for oxidants with the greenhouse gases thus, for example, lengthening the atmospheric lifetime of methane. Some VOCs, on the other hand, cool the atmosphere by taking part in the formation of aerosol particles (Ruuskanen 2009). So, VOCs of forests may not only be disservices[34].

There are hundreds of BVOCs emitted into the atmosphere, but a relatively few compounds (e.g., isoprene, methanol, α-pinene, acetone, and ethene) dominate the total flux. All BVOCs can influence atmospheric composition, if they are emitted at sufficient rates, but some BVOCs have a relatively high impact due to their reaction rates, products, ozone production potentials, organic aerosol yields, and other properties. (Guenther 2013). Accurate quantitative estimates of BVOC emissions are needed to understand the processes controlling the earth system and to develop effective air quality and climate management strategies.

In Finland the biogenic VOC emissions are estimated to be almost twofold compared to the anthropogenic emissions and

[34] In fact, when the volatile organic compounds are experienced by people inside the forests, they are found to lower blood pressure. It is also thought that many other health effects of staying in forests are due these compounds. These are widely used in traditional medicine and aromatherapy in Russia, Ukraine, China and Japan (Vasara et al. 2013)

are dominated by monoterpenes (45% of the total annual emissions of 319 kt, i.e. 0.71 t of monoterpenes/ km2 forest land), whereas the isoprene emission is only about 7% of the total (Lindfors and Laurila 2000). It is also assumed that the increased monoterpene flux due to the damages caused by herbivory could strongly increase the total amount of monoterpenes emitted into the atmosphere. Since the predicted climate change can increase the frequency of outbreaks (e.g. caused by sawfly) there is a potential to significantly increase the herbivore-induced emission of monoterpenes (Räisänen et al. 2008).

5. Conclusions

Although ecosystem services as a concept is relatively new, many of the wide array of nature's goods and processes this concept covers have been long time objects of basic and applied natural sciences. Like all research, that on ecosystem services can build upon a past and recent research.

This is valid also for the forest ecosystem goods and services of Finland. Forests have been and still are the major natural asset. Forest research has long traditions, touching problems such as forest and local climate already a century ago and including four decades of research on multiple-use of forests. This may give a reason to raise the familiar question about "old wine in a new bottle "Vatn (2010) used in the context of the payments for ecosystem services.

Since the Millenium Ecosystem Assessment (2005), one of the focuses in ecosystem service research has been in further development of the classification of ecosystem services. The major effort in this field has and is being done in the process of Common International Classification of Ecosystem Services CICES (Haines-Young et al. 2012). Therefore, the most recent CICES-classification (at that time Version 3, Haynes-Young and Potchin 2011) was adopted in the beginning of this study. The question about old wine, literally taken, was not valid in this Finnish exercise. Although the CICES-process was known to be an evolving one, it produced a new bottle of wine faster than former was "done" in Finland. The finally "full" one used here carries the label CICES V4.3.

While it was evident, that in particular the *provisioning services (goods)* of Finnish forests are well-known and have abundant statistics to build upon, their (re-)identification in the frame of ecosystem services opened also fresh insights.

One such derives from the triviality as such, that "forest-based food" found its place in the first division of CICES "Nutrition". The mere location in the frontline of CICES –

classification, makes justice to the historical role of forests as the "mother of agriculture" (e.g. early dominance of forest and water ecosystem food, "slash and burn agriculture" in forests, most agricultural fields are former forests), and connects it to the current concerns on global hunger and healthy food, the latter being of rising importance also in the affluent world.

A more technical observation on classification was related to forest materials (goods) in the provisioning services. Despite the past downturn of paper industry, the economy of Finland is still having a steady wooden leg. Wood is used in numerous industries and increasingly for bioenergy: therefore wood assortments are many. While the other materials from forests are very small in volumes, their diversity is much wider. As discussed in Chapter 3.2 (under Group 121) it led to adopt one more "clarifying" intermediate grouping at class type level, which moved further the more concrete contents to become better visible only when additional "sub-class type" level was adopted. Despite that, for example, the detailed contents of "sub-class types" (as e.g. 12111f Wood extracts) could only be demonstrated in the text[35].

Admittedly, as emphasized in the development consultation (e.g. Haines-Young and Potschin 2012), CICES is meant to flexible for the national applications and solutions can be found at national levels – as already outlined here. And if what has noted here does not reflect a general problem but only a specific (national) case, then national solutions are sufficient.

Compared to the amount of research and monitoring data available on the provisioning services of forests in Finland, *the regulation and maintenance services of forests* have been more demanding both in the process of identification and finding systematic information. Major exceptions were the services that have been long time related to specific national concerns – as the

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[35] Of course, leaving out the above three "logical" Class types , would give room for the now 14 categories listed in "sub-class types". But then the list becomes very long and in makes the conceptual governance of the entities more difficult.

questions related to the water quality – and those being important in the international agenda – in particular carbon sequestration and climate change as well as those categories (directly) related to biodiversity.

All these three categories have been studied and followed intensively in Finland, although it might be possible that in forest water-interactions there are questions which may require further studies, such as forest shelterbelts between agricultural lands and water systems and perhaps the regulation of floods as well. Even if watershed areas are defined in water management policy in Finland, the potential of holistic watershed management research (common in many countries where topography has higher variation) might need more re-thinking. This should cover the integration of all ecosystems of the watershed area. In fact, the new research program on Water and Forests (2013-2017, see Group 234 Water conditions), launched at the Finnish Forest Research Institute (note organizational change in footnote 13), seems to have adopted the holistic approach to water issues, from the hydrology of single tree to the Baltic sea, and probably will respond to that issue also.

Lesser-known species among the regulation and maintenance services of forests in Finland are 'mediation of waste, toxics and other nuisances' and this concerns both the mediation by forest biota and the mediation by forest ecosystems. Some aspects, however, have been given longer, although sporadic, attention such as nitrogen fixing by forests and mediation of noise and visual impacts. On the other hand, a lot of background information is available as a part of monitoring of forest health: for example decreasing concentration of lead and nickel in (forest) mosses has been recorded during the measurement period 1985-2010 by the Finnish Forest Research Institute. From the classification point of view the difference between bioremediation by biota and by ecosystems caused some pondering, but this distinction has its grounds on intensive (smaller polluted areas) and extensive (large ecosystems) scales of remediation. Anyway, bioremediation research related to individual species has recently increased and this will gradually improve the possibilities for more precise and detailed ecosystem assessments.

Although *cultural ecosystem services* have had a rather solid position as the third major category of the services, it has sometimes met also criticism as being, so to say, too far from the nature of ecosystems. Without going into the philosophy of the relationship between nature and humanity, one can simply confirm from the Finnish boreal point of view, that this category is as important as are the other two. Perhaps similarly to other forested countries, the culture of forests is deeply rooted into the mind and soul of the Finnish people as also are the material goods and other physical expressions of culture developed during the times[36]. Cultural meanings related to forests may matter more in Finland as elsewhere also because the other sources of culture have shorter history in Finland than in most other countries. This may be among the reasons why many cultural services of forests are rather well studied and recorded in the country, within and outside forest sciences and communities.

From that background and based on the done classification one can conclude that the CICES V4.3 has adopted a wide and open approach to cultural ecosystem services, which provides

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[36] Also critical views have been given on the claim, or the "myth", of the Finns being basically "forest people". The term sometimes includes besides close forest connections also features of being unsocial and not-talking people. The recent monthly magazine article by Ilkka Malmberg (Helsingin Sanomat Kuukausiliite 6/2013: 54-59), not meant to be scientific while borrowing some scientists, claims that "our forest relationship is the result of ideological education. In the mid 19th century Finland-minded educated classes started to build an own identity to Finland. It needed to be different from that of Sweden. Therefore field and village landscapes of Western Finland were not appropriate, although major part of the Finns lived in that kind of landscape. In the east it was different, deep forests" The view that there were ideological and political aspects to choose inland lake (and forest) landscape as a national symbol has been given e.g. by Häyrynen (1997), see also Chapter 1.3 and Class type 31251 National landscapes here). Effectively the author arguments against asociality and taciturnity of the Finns. However, an interesting discord remains: the field and village people in the west have more social activities but are even now known to be less talkative, while the eastern "forest people" are known for their talkativeness, as Malmberg emphasizes.

many opportunities to include and organize both the variety and the multitude of the cultural services of forests into its structure. The broad yet structured scope makes justice to the richness of the interactions between the ecosystems and the human society and to the ways and layers human minds, senses, ideas and institutions perceive, embrace and re-create this richness. As the cultural diversity is wide, one may anticipate that in particular in regard to the *spiritual, symbolic and other interactions with biota, ecosystems and landscapes* (Division 32) in the future national level classifications a large variety of interpretations can appear. Also in this Finnish case other choices for the contents of (lower level) cultural categories had been possible as it sometimes was envisaged.

The other conclusions concerning the classification of forest ecosystem goods and services in Finland in the CICES framework are the following.

The classification has decisively brought further evidence about the multitude of forest goods and services in boreal forests of Finland. The CICES classification was also instrumental in opening some new windows to forest ecosystems services in the fields of bioremediation in particular, and more generally within the many other categories of regulation and maintenance services.

The conceptualization of pest and disease control in the terms of ecosystem services demonstrates examples of those cases where the transformation of existing knowledge into services was not straightforward. There are certainly also other services where this classification needs to be amended and improved in further efforts.

The identification and classification has given support to the point presented in the earlier conceptual report (Saastamoinen et al 2013) that on the one hand it is important to keep the familiar concepts of goods and services in use, but understanding at the same time that the "hybrid services" exist where goods and services together make the concrete benefits people get and enjoy. This often happens in the context of regulation and maintenance services and in cultural services.

The other point which makes the difference between goods and services continuously valid, discussed also in literature, is that regulation and maintenance ecosystem services are biological and physical processes, sometimes crossing many ecosystems. Although not new, perhaps even the concept – process services – might be useful to add into the vocabulary. Many cultural ecosystem services similarly are *cognitive* processes, or *interactions* as CICES rightly name these, occurring at the same time physically and mentally when people are in the nature, but also *ex situ*.

The study, although perhaps so far less explicitly, demonstrates that the goods and services of forests (or any other ecosystems) do not always nicely stay in the categories they are classified. Many goods, for example wild berries, are involved in several categories. A ripe bilberry is a (delicious) final consumer product, when eaten in the forest (this part in particular stays outside statistics or research surveys). The common family trip for berry picking to forest may be as much a recreational experience like that for harvesting vitamins and desert berries for the winter. Bears, birds and other animals use berries for the same purposes. Sometimes these may be important features of refuge habitats protecting endangered species. When picked for commercial purposes, berries can enter to the open square city markets, food shops or for industrial uses as intermediate goods for many different purposes. Using berries in different ways is an essential part of the Finnish food culture.

National parks (and some other conservation areas) provide another example of the multifunctional and multi-layered nature of the ecosystem services. In Finland these areas are commonly thought to be “one purpose“ areas (i.e. for conservation only) but in fact the national parks can be found in the many different categories of classification. Although not present in the provisioning service categories, these areas are important for reindeer husbandry and as all forests (except strict nature reserves) can be used for picking berries – but not of course for wood production or hunting.

An observation in regard to the "fourth" major category of ecosystems services, supporting services can be done. The principle of the CICES was not to classify supporting services as their own category, because these influence to and are intangled in many ways inside all the other major categories, provisioning, regulation and maintenance and cultural services. However, it seems that quite a many of so called supporting services (for example nutrition and water cycles, soil formation) have found in one form or another a place among regulation and maintenance services.

As an additional and outside the CICES-classification the nuisances and more substantial risks related to the forests were in this study compiled into their own list (Chapter 5). The concept of disservices of ecosystems is not commonly used in the literature as such, although to some extent it is found there inversely: the characteristics of ecosystems which mediate the existing risks (like pests and diseases) are seen, and rightly so, as ecosystem services. However, as there is no paradise without a snake, it was already in the beginning decided to include disservices explicitly in this study (Saastamoinen et al. 2013), although now done only in forest classification. As mentioned earlier the disservice is often very much a relative concept, for example almost any living population growing too much, may transform from the service into disservice.

The final conclusion of the study is that through its logical and hierarchic structure the CICES provides a powerful tool to identify, investigate and classify the rich multitude and variety of ecosystem services of boreal forests in the context of Finland. The proper identification and classification of ecosystems services is the key to improve their integrated research, governance and management.

6. Discussing some wooden structures based on and related to forest ecosystem services

6.1 A STOOL

An important aspect in the assessment of the roles of ecosystem services in the society is related to the existing possibilities and further potentials of the services to be the sources of longer production and value chains and networks. The Finnish forest cluster[37] with its long production chains from forest to world export markets of sawnwood, plywood, pulp and paper, and interaction with industries providing intermediate goods and production services, has been in Finland a well-known example of forest originated industrial network.

The cluster exists, although in more modest scale than earlier. It is also trying to be more diversified and more innovative using the possibilities of "new" forest chemistry, bioenergy, biotechnology, information technology etc. and is therefore renamed collectively as a "biocluster". In addition, possibilities to expand the existing and perhaps create new forest goods and services related production chains and networks can be found at least in nature tourism, other cultural services, design products

[37] A comprehensive compilation and an analysis on the role of wood –based industries and forestry in the Finnish society at the turn of the century (Reunala et al. 1999) got a name "The Green Kingdom - the Finnish Forest Cluster". It was published also in Finnish (1998). In the terms of ecosystem services the kingdom was very much oriented in further processing of provisioning services of trees and wood but also took into account some views on cultural services related to forests and wood.

and in numerous nature products. A schematic outline for a "multi-cluster strategy" as an alternative to forest cluster had been discussed a bit also earlier (Saastamoinen 2005).

From the point of view of the economics of the ecosystem services, the existing or potential capacity of goods and services to be a source of manufacturing or primarily services -oriented chains bringing income and employment, may from the regional, national or policy points of views be as, if not more, relevant as the estimation of ecosystem service values on-site. In the functioning markets of roundwood, the stumpage prices of standing trees reflect and are dependent on the economic significance and profitability of the whole chain or the cluster. In tourism industry the "derived demand" of the aesthetic and recreational values of a landscape is reflected in land prices, which however may only inform a part of the value of the entire scenery. Nevertheless, the on-site valuation in one form or another is needed to maintain the potential from being lost.

From this larger forest and wood processing background in the following some specific wood products are taken as tools to discuss and reflect of different angles on forest ecosystem services.

To summarize the primary classification structure of the ecosystem services one can claim that it is like the three-leg wooden stool designed by Alvar Aalto[38] (Figure 8, left). The three legs represent provisioning, regulation and maintenance, and cultural services. Any leg missing, the stool cannot stand. The round seat represents the primary supporting services (photosynthesis, material and energy cycles, biodiversity) which connects all the legs, keeps them stable and able to carry out their functions.

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[38] Alvar Aalto, the most famous Finnish architect, developed the L-shaped legs' unique bending technology during the years 1932-1933. The patented design and manufacturing technology still used today is a clear representation of Functionalism. The seat and legs are comprised of solid birch veneer accented with laminate on the seat's surface. On permanent collection at The Museum of Modern Art in New York, the simplicity and innovative technology captured by this three-legged stool is timeless. Made in Finland by Artek. http://www.aalto.com/aalto-3leg-stools.html.

When several ecosystems and their services are presented in the same frame, it demonstrates strong interactions and interconnectedness between the ecosystems and their services. If taking another metaphor from the world of design, the spiral model (Figure 8, right) might have some relevance with that kind of multi-layer structures and interconnectedness, not always easily to be investigated.

Fig. 8. *The stool model of ecosystem services: (left) the supporting services (the seat) connects the three major categories of ecosystem services; (right) the ecosystems and their services form interconnected and multi-layered structures, where the functions of each ecosystems and their services are not always easily to be seen. (Photos by the permission of Artek)*

Outside the design workshop, the ecosystems services as a scientific and political concept and framework can be seen as a social construction or re-construction - the latter to the extent it builds upon the past concepts and knowledge.

Identification and classification of ecosystem services aim at a systematic, hierarchic and comprehensive records of the goods and services of nature, bringing benefits for the well-being of people. The multitude and diversity of ecosystem services brought by classification already in itself demonstrates the value of nature and its biodiversity, besides providing fields for monitoring and valuation their present states and assessing their potential. Therefore, the classification is a necessary and an inherent part of sustainable use and development of the ecosystem services and the ecosystems.

6.2 A HOUSE

The cultural ecosystem services (Class type 31233) introduced old wooden buildings and constructions in forests.

What about new wooden buildings? Is it possible that the products (round building logs, sawngoods, wooden building components) derived from the provisioning services (standing trees of forests), when used in new buildings may get some character of cultural services of forests as well? This is discussed next.

Although Finland has a long tradition in building single family wooden houses and other buildings or interiors from wood, it has been long behind many other countries in constructing multi-storey wooden houses or large public buildings from wood. But the change is going on. The Finnish Forest Research Institute, Metsähallitus and a wood product company Finnforest have been pioneering to demonstrate the way to the new wooden public and business architecture. For example, the Metla House of the forest research institute was the first large wooden, timber framed three-storey office building in Finland (Figure 9).

Located adjacent to the Joensuu campus of the University of Eastern Finland, Metla House building has attracted in eight years more than 30 000 visitors representing very different stakeholder groups interested in timber construction, from all over the country and abroad (Parviainen and Lindroos 2013, Parviainen 2013).

Fig. 9. *A carbon sink and a combination of provisioning and cultural ecosystem services: Metla House located in Joensuu is the largest wooden public building in Finland. (Architect: Antti-Matti Siikala)*

Among other topics, research on forest ecosystem services is carried out in this unique construction. But does this wooden office itself represent an ecosystem service? Certainly not in the strict sense, but in the broader meaning the answer might be a conditional "yes". It is an end product of a standing timber, a provisioning ecosystem service, and a material good when felled. This primary good has got much more human capital inputs when transported, processed and again transported to be used in the construction of the building. Finally, the construction process connects all these human, material, energy and logistical processes together following the ideas of the architect. The economic value of standing trees, received by the forest owners in the form of stumpage price is a market measure of the provisioning services of forest ecosystem but only a small part of the all construction costs. However, they are just those standing trees in their solid processed forms, all visible outside and inside of the office house, which gives the building its unique wooden character. No doubt there is a resemblance to the ecosystem services used or enjoyed by human beings, in that the goods and benefits created are jointly produced by nature and human inputs. In this special wooden building the wood material costs from all building costs[39] of 11.3 mill. € was 12 %, a bit more than 1 mill. € (Vatanen 2006). The amount of wood material used in building was 2000 m3 in terms of wooden building components and sawnwood (Vatanen 2006). Translated into roundwood it makes about 5000 m3. It can be calculated that the stumpage value of spruce logs as standing trees was c. 2 % of the above construction costs. In other words, it is in this case the value of the provisioning service in the form of standing spruce trees, representing the log-size trees (a smaller trees and minor parts of large ones goes for pulpwood and have a lower price) in several spruce dominated forests (making roughly together a clear-cut area of about 40 ha).

Another aspect – temporally closer to Class type 31233 – of this awarded wooden building needs to be emphasized. The two end fascades on both sides in front of the entrance yard (extreme left and right in Figure 9) are built from two hundred years old timber removed from old buildings. This nice and sound timber has been storage of carbon already for two centuries and is assumed to continue this climate regulating ecosystem service (Class type 23511 Carbon sequestration) computationally one century more, but in practice much longer. This binding capacity of CO_2 from the atmosphere concerns also the other wood used in construction, about 2000 m^3 or corresponding to the quantity of the standing timber more than twice of that (Parviainen and Lindroos 2013).

[39] Building costs as a total sum of building contractors, without value added tax (Vatanen 2006).

6.3 A BRIDGE

In their introductory paper to the journal *Ecosystem Services* Braat and de Groot (2012) emphasized that the ecosystem services agenda is bridging the worlds of natural science and economics, conservation and development, and public and private policy.

In the concluding chapter "Finland's bridges to the future" Saari (2013) creates his interpretation on the views of several authors contributing to the book carrying the above name. He organized the core thoughts under eight pairs of bridges such as "bridges of public power, bridges of markets", "bridges of recession, bridges of development", "bridges of past, bridges of future", and 'Europe's bridges, Finland's bridges". Conclusions include the importance of coherent environment for human well-being, ecologically sustainable social policy and rooting sustainable development into every-day policies. On the other hand, it was also recognized dangers that ecological scarcity and global threats will be capsulated by different defence mechanisms from the human and political consciousness (Saari 2013). Ecosystem services can work as a bridge to connect everyday nature products and experiences to the global environmental threats (Figure 10).

The main report on ecosystem services in Finland (Saastamoinen et al. 2014) concludes that ecosystem services is a multifunctional concept and approach being educational, capable of integrating natural resource and environmental policies by providing a common language and theoretical background, and can easily be adopted into the frame of sustainable development. It also locates in the cores of bio- and green economies. It makes nature's benefits and potential better visible and known, many of which in the institutional context of Finland are open for all citizens. By raising the appreciation of nature and the common good it can provide, it was finally thought that the consequent better care of nature and its services can even improve the social cohesion in the society (Saastamoinen et al. 2014).

Fig. 10. *Ecosystem services is a bridging concept. A wooden bridge at the Ruunaa hiking area (Photo: Sari Hiltunen/Metsähallitus)*

The last part of the concluding chapter on the bridges of Finland (Saari 2013) carries a title 'Finnish bridge builders'. It was addressed to all the actors in the policy arena but emphasize that the politicians have a last say when making institutional choices - apparently including also those concerning improvement of existing and construction of new bridges for the better future for Finland.

Nature with its ecosystems is the most fundamental bridge (or a network of bridges) between the past, present and future for any nation and the whole mankind. Maintaining and improving nature's health, productivity and diversity means to secure the solid and sustainable bridge over the troubled waters in the man's journey to the future.

While nature in this assertion means all ecosystems, organically and functionally related to their abiotic environment and the man dominated urban spaces, in particular in the boreal context one may recognize that forests have been and still are among the major sources of providing structural materials also for building the bridges of the future.

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