Observations on CICES-based classification of ecosystem services in Finland

Olli Saastamoinen

School of Forest Sciences, University of Eastern Finland

Abstract

Some aspects of past development are outlined in regard to the identification and classification of nature's benefits nowadays conceptualized as ecosystem services. The knowledge about the multitude and diversity of the useful benefits has grown tremendously and yet a large part of biodiversity is still unknown. The conclusion is that the variety and complexity of ecosystem goods and services can only be properly categorized and managed by using hierarchical classifications. The Common International Classification of Ecosystem Services (CICES) represents the most concentrated effort to develop hierarchic, systematic and multipurpose classification for ecosystem services. CICES has been applied for the classification of the services of major inland ecosystems of Finland: forests, agricultural fields, peatland and freshwaters. The major observations has been that the flexibility, which the hierarchic system provides for moving towards more detailed classification levels is really a needed advantage and was used in the classifications done. Sample examples from the expanded classification are given besides other observations. The results of the classification efforts, which are reported elsewhere, are first applications of CICES in the boreal ecosystems.

Introduction

As a concept ecosystem services is relatively new but its substance is very old. If thinking the common interpretation of ecosystem services as "benefits people obtain from ecosystems" (MA 2005), it is clear that almost all past categorizations of the tangible goods (products) of biological nature can be seen as classifications of provisioning services of ecosystems. Early observations on the adverse impacts of bad land management such as soil erosion and flooding or loss of aesthetic values have seldom been presented systematically but both are inverse identifications of what now are named as regulation and maintenance as well as cultural services of ecosystems.

In regard to forests, H. C. von Carlowitz (1713) in his "Sylvicultura oeconomica" gives a long list of forest benefits, from "the usefulness of wood at the start and end of life and mankind in general" to "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". This is only a part of his list but one can see that provisioning, regulation and cultural ecosystem services are already there, although not in the form of the systematic classification.

Along the development of agriculture, forestry and other sectors using renewable natural resources the classification systems have become more detailed and systematic. Growing involvement of sciences not only reflected the utilitarian needs for nature's products but also intellectual aims to bring order into the biological richness of nature and its evolution.

Nobody has brought more order into the taxonomy of plants and animals as Carolus Linnaeus (Carl von Linné, 1707 -1778). He studied medicine at Uppsala but devoted his work on botany, an essential part of studies as doctors often prepared medicines from plants. *Genera plantarum* (1737) was not well taken first. The head of Botanical Garden in Oxford stated that Linnaeus had brought "the whole botany in disorder" although later agreed with him (Petrusson 2014)

The Linnaean biological classification system of plants has been used since 1758 only with some modifications. In this system, species and genera are further grouped into a hierarchical system of higher taxonomic categories: families, orders, classes, phyla and kingdoms (Purves et al 2006). Most significant changes have been the number of kingdoms and most recently the preferred organization of three domains above kingdoms: Eukarya (all higher organisms), Eubacteria and Archaea (anaerobic bacteria). The latter two domains reflect increased microbiological and genetic knowledge. In all, the underground and microscopic organisms play an important role in the ecosystems contributing among other things to many regulation and maintenance services.

It has been told, that due to intensive writing and sitting with the two volumes of *Species plantarum* (1753) Linnaeus got pain in his right side. This was cured by his cure-all medicine, wild strawberries (Petrusson 2014).

While the take off from nature's products medicin has been the long-term trend in the development of modern medicine, the nomenclatures of medicinal plants show an increasing trend of their identification.

The classical "*Material medica*" from 1st century included c. 600 medicinal plants (Lavrenov and Lavrenova 1999). In Russia the handbook covers c. 2000 wild and cultivated medicinal plants (Lavrenov and Lavrenova 1999)

The modern biochemistry has enlargened the nomenclature of the products of medicinal and other useful plants and animals (e.g. insects, carbivores, herbivores, fish) into more specific elements - chemical compounds. In the Dictionary of Natural Products (htpp://dnp.chemnetbase.com/intro) these are grouped into c. 40,000 entries. Examples from 15 major entry classes are *Aliphatic natural products, Simple aromatic natural products, Flavonoids, Tannins, Lignans, Polycyclic aromatic natural products and Terpenoid*s. These are keys for the identification of medical, nutritional and other useful functions of plants and other organisms and play role in the formation of related ecosystem goods.

The above highlights on medicinal and other useful plants and organisms indicate that the multitude of identified natural products already in this very specific part is extensive.

Biodiversity has often been recognized to be in the core of ecosystem services (MA 2005, TEEB 2010) . The entire biodiversity of the world has sometimes been divided into three groups: 1) what we know; 2) what we know that we do not know and c) what we do not know that we do not know. Quite a lot of biodiversity of the world still belongs to the 2nd group and the potential of 3rd group can be assumed to be large. However, even the huge variety of the 1st one gives support to a statement that "it is virtually impossible to list all the ecosystem services let alone the natural products that people directly consume" (Sekercioglu 2010).

The conclusion from the above examples is clear: it is not possible to bring order into the multitude of tangible and non-tangible ecosystem services by adopting simple and pragmatic classification schemes. The variety and complexity of ecosystem goods and services can only be properly categorized and managed by using hierarchic classifications.

The aim of this paper is to present some observations and experiences found in the application of the Common International Classification of Ecosystem Services (CICES) for identification and organization of the goods and services of major inland ecosystems in Finland: forests, agricultural fields, peatland and aquatic ecosystems[7].

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[7] This work is part of the project "Integrated and policy relevant valuation of forest, agro-, peatland and aquatic ecosystem services in Finland". Besides identification and classification, the project focused on concepts, history, indicators, valuation (methodological orientation) and policies related to the ecosystem services in Finland. The study was funded by The Maj and Tor Nessling Foundation and carried out by the University of Eastern Finland and Pellervo Economic Research PTT, supported by many voluntary individual researchers from other research organisations. Available reports can be found in electronic publications of the University of Eastern Finland, Pellervo Economic Research PTT and the Finnish Environment Institute.

Observations on the CICES

Several classification schemes for ecosystem services have been developed before and after the Millenium Ecosystem Assessment. The former include Daily (1997) and de Groot et al (2002) and the latter TEEB (2010), UK NEA (2011) and the versions of CICES (Haines-Young and Potchin (2010, 2012 and 2013). Kettunen (2012) is a modified combination of MA (2005) and TEEB (2010) categories in the Nordic context. Haines-Young and Potchin (2012) and Maynard and Cork (2011) have cross-referenced or compared several ecosystem service classification frameworks.

Among the alternatives, the Common International Classification of Ecosystem Services (CICES) represents the widest and most concentrated effort to develop universal and hierarchic taxonomy of ecosystem services (Haines-Young and Potchin 2011, 2012, 2013, Maes et al 2013, Saastamoinen et al 2013, Turkelboom et al 2013).

The hierarchical structure allows the users to *go down to the most appropriate level of detail required by their application (italics* OS), and then group or combine results to making wider comparisons or generalised reports (Haines-Young and Potchin 2012, 2013, Maes et al 2013, Turkelboom et al 2013). The first draft of CICES appeared in 2009, within the context of the European Environmental Agency's (EEA) work on land and ecosystem accounts (Haines-Young & Potschin 2010). Since that it has been under continuous development, reported in different versions (Haynes-Young and Potchin 2011, 2012), the latest (January 2013) being version V4.3 (Haynes-Young and Potchin 2013). Changes has been due interactive considerations between the developer-coordinators and voluntary scientists interested in the CICES development and EEA.

Discussions and revisions have not concerned only structure but also the boundaries of ecosystem services and consequently what is and what is not regarded as an ecosystem service.

For example, water is included as drinking water and for non-drinking agricultural, domestic and industrial uses but from CICES version 4 onwards not any more as a source of hydropower, because abiotic services were excluded (Haynes-Young and Potchin 2012). From the point of view of Finland with her abundance of aquatic ecosystems (lakes, rivers and ponds) this boundary did not seem as crystal clear and has been discussed (Saastamoinen et al 2013). Anyway, in the context of the CICES Version 4.3. satellite account has been developed for all abiotic services (Haynes-Young and Potchin 2013).

CICES was first designed for economic accounting and had the focus on final services. Therefore it was important to exclude intermediate ecosystem services from final ones to avoid double counting (Haines-Young and Potchin 2012, 2013). However, sometimes the difference is drawn into water. Supporting services (often included into intermediate services) such as photosynthesis, water and nutrient cycles have been seen as a primary separate category, which are embedded into all three categories. For example, all primary biomass production is generated in photosynthesis. Similarly, the important role of water cycle can be seen already in the title of the Class (see next paragraph) "Hydrological cycle and water flow maintenance" being a part of Group "Regulation of flows" in the Maintenance and regulation services (Table 1a).

For a purpose to serve ecosystem service mapping and assessment, CICES adopted an additional fifth level. The levels of hierarchic structure are now Section, Division, Group, Class and Class type. Categories at each level are meant to be non-overlapping and without redundancy (Haines-Young and

Potschin 2013). Like MA 2005 and most other suggested classifications also CICES is framed around human needs.

CICES is meant to be multifunctional classification. It has even noted that “there is nothing on the design of CICES that would prevent it supporting social, moral and aesthetic forms of assessments” or to be used for physical accounting (Haines-Young & Potschin 2012, 2013).

Observations on the CICES-based classification of forest-, agro-, peatland- and freshwater ecosystem services

In this study the goods and services of each of the four ecosystem (forests, agricultural fields, peatlands and inland waters) were classified separately. In the beginning CICES version 4 was the current one and was followed in the classification of water ecosystem services (Alahuhta et al 2013) and agroecosystem services (Arovuori and Saastamoinen 2013) as well as in making first drafts for forest and peatland ecosystem services. When CICES version 4.3 was published, forest classification was drafted again using the new version (Saastamoinen et al 2014 b, in process). For the synthesis report of the study (Saastamoinen et al 2014 a), a less detailed integrated synthesis classification was done so that all services included were brought into CICES version 4.3.

The borders between the ecosystems are seldom clear-cut in the nature, as the transitions are smooth. One exception is the border between aquatic (lakes and rivers) and terrestrial ecosystems. Also agricultural fields as an intensively managed ecosystem differ easily from others, although some marginal lands can be in a transition stage towards forests. However, the only conceptual problem was the boundary between forests and peatlands (including mires). That can be drawn in different ways although as such the differences have only marginal impacts on classification.

The common forest definition, which includes all forested mires and peatland classified as productive or poorly productive forest land into forests, gives forest area to be as much as 76% of the land area. In this case the peatland ecosystems cover only open peatlands and makes not more than 7 % of land area. However, if only drained and transformed forest land mires are included into the concept of forest, it brings forest share down to 59 % and peatlands and mires up to 20% of land area. Finally, if all peatland and mires on (productive) forest land and poorly productive forest lands are added into peatland category it makes 29% and for forests consequently 50% (Saastamoinen et al 2013). Originally, before agricultural expansion and large scale drainage of peatlands for forestry, one third of Finland was covered by peatlands and mires.

Major part of agricultural lands are former forests. Agricultural areas cover now roughly 9 % and built up areas about 5 % of land area. The rest of land use is mainly composed of open (treeless) mineral fell areas and other specific areas (under an old title of “waste land of forestry”) mostly located in the northern part of the country. The open fells and other northern open areas compose their own distinct ecosystems. Their ecosystem services are numerous, and include, for example, reindeer forage, berries, game, open landscape, tourism, recreation and habitat for biota. These services demonstrate that the old title “waste land of forestry” is discriminating and needs to be renamed.

This Finnish experiment of adopting CICES confirmed that the fifth classification level (class type) brought by Version 4 was really needed. In fact, this study found that even an additional level (called here as *sub-class type*) would be instrumental. Some sample examples of this additional levels can be found in Tables 1a, 1b and 2). In the separated classification of the provisioning services of forests (Saastamoinen et al 2014b) this additional level allowed to organize wood and non-wood goods into hierarchic structures which makes the entities easier to govern. The aim of CICES to provide logical generic and hierarchic structure actually means, that the first three levels (section, division, group) are quite general and it is the fourth *class* level which in principle is the starting point to bring the identified ecosystem services into the system. This is also the recommendation given by CICES (Haynes-Young and Potchin 2013). Therefore additional levels help to make the classification more concrete and functional.

How CICES, for example, captures medicinal plants into its structures? One can see that (Table 1a) it is here found as one of the picked sub-class type examples in the Class (9) Fibres and materials from plants and animals (biota) for direct use and processing. In the original forest ecosystem service classification (Saastamoinen et al 2014b) the Class type carries the title Fibres and other materials from other forest plants (i.e. other than trees) and Medicinal plants is one of the five additional Sub-class types. Although it is located at the lowest level of an expanded CICES classification it still carries a collective title without offering room to the wild strawberries of Carl von Linné or any other species of medicinal plants. Detailed specifications must be connected in other ways.

On the other hand, this sub-class type of medicinal plants already is specific in the sense it concerns only forest plants, and is separate from medicinal substance found from trees (which are included into Sub-class types of 'e Tree extracts' and 'd Other materials from trees'). Medicinal compounds and substances are also found from mushrooms and from animals. Class *Genetic materials from all biota* include material for pharmaceutical processes. Niches for medicinal plants and materials can also be located in the classifications of other ecosystems.

Table 1a. Examples of an expanded CICES –classification of ecosystem services in Finland: Provisioning and regulation & maintenance services (Saastamoinen et al 2014 a). Class numbers are used here to connect class-types and sub-class types to classes

SEC-TION	DIVI-SION	GROUP	CLASS	CLASS TYPE (*Sub-class type = expa-nsion*) EXAMPLES! A=Agricultural F=Forest P=Peatland W=Water es.
Pro-visio-ning	Nutri-tion	Biomass	1 Cultivated plants 2 Domestic animals &outputs 3 Wild plants & mushrooms 4 Wild animals & outputs 5 Plants, algae in situ aquaculture 6 Animals from in situ aquaculture	A: 1 Grains Fruits *(Apples) 2* :Meat production *(Cattle)* W: 4 Wild fish 6 Aquaculture sp.*(Rainbow* trout*)* F: 3 Wild berries 4 Deer *(Moose)* 3 Mushrooms *(Boletus)* P: 3 Peatland berries *(Cloudberry)*
		Water	7 Surface water –drinking 8 Ground water –drinking	W:7 Lakes Rivers F: 8 Groundwater *(Eskers)* Springs
	Mate-rials	Biomass, Fibres	9 Fibres and materials from plants and animals for direct use and processing. 10 Materials from plants, algae and animals for agricultural use 11 Genetic materials from all biota	F: 9 Wood *(Industrial)* Other plants *(Medicinal)* 11 Tree genetics *(Birch genetics)* A: 9 Cultivated fibres Fodder Wool P: 10 Growth peat
		Water	12 Surface water non-drinking 13 Ground water non-drinking	W:12 Lakes Rivers Ponds *(Agriculture)* F: 13 Ground water *(Industry)*
	Energy	Biomass-based energy sources	14 Plant-based resources 15 Animal based resources	F: 14 Energy wood *(Stumps)* P: 14 Peat A: Agricultural residuals
		Mechanical energy	16 Animal based energy	A: 16 Physical labor provided by animals *(A: Horse A/F: Reindeer)*
Regu-lation & main-te-nanc e	Mediati-on of was te, toxics and other nuisan-ces	Mediation by biota	17 Bio-remediation by biota 18 Filtration, sequestration, storage, accumulation by biota	F: 17 Trees (*Willow)* Other plants W: 18 Plants and animals of lakes and rivers
		Mediation by ecosystems	19 Filtration/sequestration /storage /accumulation of harmful materials by ecosystems 20 Dilution by atmosphere, freshwater and marine eco-systems 21 Mediation of smell/ noise/visual impacts	F: 19 Filtration and absorption of impurities of atmosphere *(Trees)* W: 20 Dilution of effluents in waters (*Water plants and micro-organisms*) F: 21 Shelter zones *(Industrial areas)*
	Mediatio n of flows	Mass flows	22 Mass stabilization and control of erosion 23 Buffering and attenuation of mass flows	F: 22 Water erosion *(Forest vegetation)* 23 Forest buffer against mass flows
		Liquid flows	24 Hydrological cycle and water flow maintenance 25 Flood protection	F/W/P: 24 Effects of forests and other ecosystems (*Water storage and evaporation)* F: 25 Forests equalize water flow (Slow snow melting)

		Gaseous / air flows	26 Storm protection 27 Ventilation and transpiration	F: 26 Coastal and archipelago protection F:27 Control of ventilation and temperature differences
	Maintena nce of physical, chemi-cal and biologi-cal con-ditiions	Lifecycle maintenance, habitat and gene pool protection	28 Pollination and seed dispersal 29 Maintaining nursery populations and habitats	F/P/A: 28 Pollinator populations 29 Distribution and linkages of ecosystems *(Forest corridors)*
		Pest and disease control	30 Pest control 31 Disease control	F: 30 Biological prevention of forest pests *(parasites)*
		Soil formation and composition	32 Weathering processes 33 Decomposition and fixing processes	F:33 Nitrogen fixing (*Alder)*
		Water conditions	34 Chemical conditions of freshwaters 35 Chemical conditions of salt waters	W: 34 Oxidation of waters *(micro-organisms in lakes)*
		Atmospheric composition and climate regulation	36 Global climate regulation by reduc-tion of greenhouse gas concentrations 37 Micro and regional climate regulation	F: 36 Carbon binding *(Trees)* 37 Micro climate regulation (Forests)

Table 1b. Examples on the expanded CICES –classification of the ecosystem services in Finland: Cultural services (Saastamoinen et al 2014 a,b)

SECT-ION	DIVI-SION	GROUP	CLASS	CLASS-TYPE (*Sub-class-type* = *exp-ansion*) EXAMPLES! A=Agricultural F=Forest P=Peatland W=Water ecosystems
Cul-tural ser-vices	Physical and intel-lectual interact-tions with ecosys-tems and land/sea-scapes [environ-mental settings]	Physical and expe-riential inter-actions	38 Physical recreational use of ecosystems and environments 39 Experiential use of plants, animals, ecosystems and environments in-situ	F: 38 Weekend recreation *(Hiking)* P:39 Observation of birds and animals *(Bird towers in peatlands)*
		Intellec-tual and represen-tational inter-actions	40 Scientific 42 Heritage, cultural 44 Aesthetic	F/A/P:40 Experimental areas F: 41 School forests F: 42 National historic places *(Archeological)* F:43 Nature films (*Forest focus)* F/W: National landscapes *(Forest-water combination)*
	Spiritual, symbolic & other interacti-ons with ecosyst-ems and land/sea-scapes	Spiritual and/or emble-matic	45 Symbolic religious	W/P: 45 Symbolic animals *(Swan)* F: 46 Places *(forest graveyard)*
		Other cultural outputs	47 Existence 4	W: 47 Endangered animals *(Saimaa ringed sea)* F/P/W : 48 Nature conservation areas *(Strict nature reserves)*

Examples of cultural services are found in Table 1b. These concise examples of Class types and Sub-class types doe not make justice to CICES, which offers very wide scope into the cultural ecosystem services. Nearly everything under the extensive concept 'culture' which is related to the meanings and values of living nature can be included into these broad classes.

This is related to the important features of CICES of having generic approach and hierarchical structures, which allow several ways to identify systematically and without leakages all ecosystem goods and services – those already known and identified and those yet to be discovered. The approach illustrated in these examples to apply CICES is not the only possible. Experiences from experimental classifications will guide to find the best practices.

It has not been possible to present any of the full tables of integrated ecosystem services classificationa here but only demonstrate the general structure of the CICES and share some examples and experiences how it has been applied in the boreal context of Finland.
The decision to apply CICES as the classification framework seems to be a right one. Although CICES – based ecosystem service classifications at national level have so far published only in Belgium (Turkelboom et al 2013) it has been recommended that the countries of the European Union should use it in their national development of ecosystem service accounts (Maes et al 2013).

The observations done here are related to the attempt to bring first time in Finland the services of four major ecosystem into an integrated classification. It is also first time when CICES has been applied to the boreal ecosystem services.

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