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Ecosystem Services

Global Issues, Local Practices

Sander Jacobs, Nicolas Dendoncker, Hans Keune

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Global Issues, Local Practices

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CICES Going Local

Ecosystem Services Classification Adapted for a Highly Populated Country

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Chapter Outline

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1. WHY WE NEED A COMMON CLASSIFICATION SYSTEM FOR ECOSYSTEM SERVICES IN BELGIUM?

Although the concept of ecosystem services (ES) has been popularized widely since publication of the Millennium Assessment (MA) in 2005 [1], different classification schemes have been proposed by several authors, such as Costanza et al. [2], Daily [3], de Groot et al. [4], Wallace [5], and TEEB [6]. Costanza [7] argued that due to the dynamic complexity of ecosystem processes, the inherent characteristics of ecosystem services, and the diverse decision contexts, different types of classification schemes should be considered. He concludes: "Any attempt to come up with a single or 'universal' classification system should be approached with caution."

Although it is recognized that a diversity of approaches is probably necessary, the use of multiple classifications makes comparison and integration between studies and assessments more difficult. With the fast-growing number of ES assessment and valuation studies around the world, the need to design a common base that enables comparison between ES assessments at different places has become more urgent [8]. This common base should be specific enough to be operational, while remaining relevant to a multitude of objectives for which frameworks and implementation plans may be developed [9].

This need has become especially acute since the new European Biodiversity strategy requires all EU member states to map and assess the state of the ecosystems and their services in their national territory by 2014 (Target 2, Action 5). For that reason, a working group on Mapping and Assessment of Ecosystems and their Services (MAES) has been set up to support European member states in undertaking the necessary work. The MAES working group decided to apply Common International Classification for Ecosystem Services (CICES) v4.3, which will be used throughout Europe [10].

CICES was initiated by the European Environment Agency (EEA) and is coordinated by the University of Nottingham [11–13]. One advantage of the CICES approach is that it allows adjustment to local conditions. In highly populated and developed areas, such as Belgium (337 inhabitants/km^2), open space is rapidly declining and fragmenting, and the natural water cycle is getting disturbed (e.g., peak flows due to compaction, nutrient loads). In 2009, built-up areas (e.g., residential housing and transport infrastructure) covered 20% of the Belgian surface, while forest and wooded land covered only 23%. The high population density and the recent land-use changes have caused several environmental pressures, such as flooding risk, drought, air pollution, eutrophication, and loss of biodiversity. These pressures have had a negative effect on health and well-being, and are increasing the cost of environmental management measures. Consequently, the demand for specific services that can be provided by nature is increasing, while claims from different sectors often overlap or are contradicting. To adapt and fine-tune the latest CICES classification to the specific Belgian conditions, it was decided to design a Belgian version of CICES (CICES-Be).

2. CICES-BE: GOAL AND CONSULTATION APPROACH

The purpose of CICES-Be is to provide a standardized, but flexible, ES classification system that can accommodate different kinds of use in Belgium, but that can be further adapted in the future. It must be usable for the upcoming regional ecosystem services assessments for Wallonia and Flanders (respectively, for 2013 and 2014), valuation studies, payments for ecosystem services (PES) schemes, local planning exercises based on ES, and others. The aim is also for a robust list of ES that can be used as a basis for studies at different spatial scales. For example, if an ES assessment is conducted on a local scale, the CICES-Be classification can be further refined by adding another sublevel with more specific ES. For the national scale, the classification can be limited to a few broad classes (e.g., division or group level).

The initiative for CICES-Be was taken by the Research Institute for Nature and Forests (INBO) and the Université de Namur. The starting point was CICES v3 [12]. Where discrepancies with the Belgium context were found, modifications were made. Where important ES for Belgium were missing, new ES were added. In order to improve the classification from different perspectives and to increase support for the final product, the resulting CICES-Be v1 was then sent to Belgian experts who showed interest in this topic. Through iterative feedback loops, CICES-Be was further improved until consensus was reached with CICES-Be v6. The consultation lasted one year, from May 2012 until April 2013. In total, 19 experts from 11 organizations contributed to CICES-Be. The contributing experts are based at research centers, administrations, and policy-support units, have diverse disciplinary backgrounds, and come from both the Flemish and Walloon regions. The results of this Belgian consultation process were also used as an input to the international e-consultation process to improve the international CICES classification (http://cices.eu/).

3. ES DEFINITIONS AND ES CASCADE

Before we could embark on the development of CICES-Be, however, we first needed a common understanding about the framework and definitions.

3.1. What are Ecosystems Services?

The concept of ecosystem services is inherently anthropocentric. Human beings are value-expressing agents who translate basic ecological structures and processes into value-laden entities [4]. One can visualize this with a simple thought experiment: in an Earth-like planet with no humans, there could be a wide array of ecosystem structures and processes, but there would be no services [14].

CICES defines **ecosystem services** as “the contributions that ecosystems make to human well-being,” and that arise from the interaction of biotic and abiotic processes. Ecosystem services refer to the *final* outputs or products from ecological systems, which are the items directly consumed or used by people

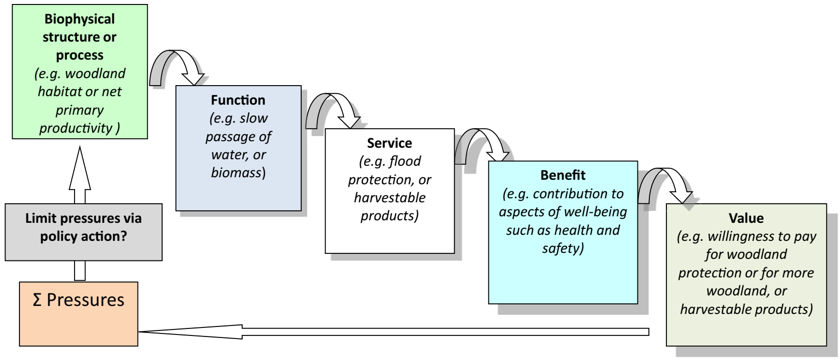

FIGURE 18-1 The ecosystem service cascade model, showing the relationship between biophysical structures and processes and benefits and values for human well-being [18].

[12]. In other words, ecosystem services are actually conceptualizations of the *useful things* ecosystems *provide* for people. As for consistency with the MA, the term *services* is generally taken to include both goods and services.

3.2. The Ecosystem Services Cascade

The definition makes it clear that ES cannot stand by themselves, but that there is something of a production chain linking ecological and biophysical structures and processes on the one hand and elements of human well-being on the other, and that there is potentially a series of intermediate stages between them. To disentangle the pathway from ecosystems and biodiversity to human well-being, a conceptual framework was proposed: the **ES cascade** structure (Figure 18-1; 12). The advantage of this construct is that it clearly demonstrates to decision makers and ecosystem service users that functional ecosystem structures and processes are required before services and benefits can be provided. In addition, the cascade adequately shows that, in order to maintain the sustainable flow of services, it requires the protection of and investment in the supporting ecosystems and biodiversity. The cascade also helps to frame a number of important questions about relationships between people and nature, such as: What are the critical levels or stocks of natural capital[1] needed to sustain the flow of ecosystem services?; Can natural capital be restored once damaged?; What are the limits to the supply of ecosystem services in different situations?; How do we value the contributions that ecosystem services provide to human well-being? The judgment made about the seriousness of these issues or pressures partly shapes policy action (= the feedback arrow in the diagram) [12].

Although the cascade model is a useful conceptual device for understanding the links between ecosystems and people, it is of course a simplification of

1. Natural capital is defined as the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future [2].

the real world [8]. For example, it should be realized that ecosystem processes and services do not always show a one-to-one correspondence: sometimes a single ecosystem service is the product of two or more processes, whereas a single process can contribute to more than one service [4]. For example, the function *wave regulation* provides services, such as flood prevention, drinking water, and recreation potential. Also, the benefits of a certain service can be manifold: for example, the provision of food has multiple benefits, such as health, employment, pleasure, and even cultural identity [15, 16]. These multiple linkages between both processes and structures on the one hand, and services and benefits on the other make the decision-making process complex [5]. The cascade model also does not really clarify the fact that ecosystems are usually not capable of generating all potential services simultaneously [8].

To make practical use of the ES cascade, all the steps need to be defined clearly:

- The actual use of goods or services provides **benefits** to humans, such as nutrition, health, and pleasure. Benefits are defined as "the gains in welfare and well-being generated by ecosystem services" [17].
- **Value** is defined as the measurement of the benefit, which can be expressed in monetary or nonmonetary terms. Metrics from various scientific disciplines can be used (e.g., economics, sociology, ecology). In economics, value is always associated with trade-offs, that is, something has (economic) value only if we are willing to give up something else to get it or enjoy it. Benefits and values are separated because the way we value these benefits is subjective: Different groups may value these gains in different ways at different times and at different places. Thus, different values can be attached to a particular benefit. When we try to measure an overall value, these different appreciations should be included [14]. Benefits are usually generated by ecosystem services in combination with human inputs, such as labor, institutions, knowledge, or equipment (e.g., hydroelectric power is dependent on water regulation services of nature, but also needs human engineering and construction materials). So attributing a value entirely to ecosystems would be misleading. Any attempt to value nature's services would have to try to disentangle the contribution that natural and human-made capital make to the benefit being considered [18].
- For many years, the terms *ecosystem function* and *ecosystem service* have been used interchangeably by some authors, creating a confusion that still exists today. **Ecosystem function** is defined as the "capacity or capability of the ecosystem to do something that is potentially useful to people" [2–4, 19, 20]. Or more specifically: "a subset of the interactions between ecosystem structure and processes that underpin the capacity of an ecosystem to provide goods and services" [6]. The capacity to deliver a service exists independently of whether anyone wants or needs that service. That capacity only becomes a service when some beneficiary can be identified. For example: The presence of ecological structures like woodlands or wetlands in a catchment area may have the capacity (function) of slowing the passage of surface water. This

function of the ecosystem becomes a service, when it modifies the intensity of flooding in downstream residential areas [8, 17].

- The building blocks of ecosystem functions are the interactions between structure and processes. **Ecosystem structure** is "the biophysical architecture of an ecosystem." The composition of species making up this architecture may vary. **Ecosystem process** is defined as "any change or reaction which occurs within ecosystems" [1]. Processes may be physical (e.g., infiltration of water, sediment movement), chemical (e.g., reduction, oxidation), or biological (e.g., photosynthesis, denitrification), whereby biodiversity is more or less involved in all of them [17]. Although there are still quite a lot of knowledge gaps about the relationship between biodiversity and ecosystem services, scientific understanding has improved over the last decade and existing knowledge has been reviewed in a few recent papers (e.g., [21–23]).

While these definitions help us further, the application of these definitions is situation-dependent. Whether or not something is called a service depends often on the perspective of the beneficiary [15, 24, 25]. For example, if someone is interested in the benefit of timber, then primary productivity is a service, but for someone who is interested in drinking water, primary production can be considered an ecosystem process.

3.3. Do Ecosystems also Produce *Disservices*?

By definition, ES refers only to the goods and services produced by biodiversity and ecosystems benefiting human well-being. However, not all impacts of nature on human well-being are positive [26, 27]. Ecosystems may also (or are perceived to) provide disservices. In urban settings, Lyytimaki and Sipila [28] argued that it may be counterproductive to frame ecosystem services only in a positive way, without paying adequate attention to the various nuisances and disservices that ecosystems inevitably produce. Consequently, they argue that green spaces in urban settings should be managed not only to generate more services and biodiversity, but also to produce fewer disservices.

As no widely agreed definition of ecosystem disservices exists, we propose the following definition: "functions of ecosystems that are (or are perceived) as negative for human well-being"[2] [28]. Ecosystem disservices can be subdivided into four categories:

- Species negatively affecting human health: Some type of biodiversity is directly deleterious for human health—for example, wetlands providing habitat for

2. Some literature uses the term *disservices* to indicate the negative effects of ecosystem degradation caused directly by human activities. For example in the context of agriculture, the term *ecological disservices* is typically understood as disturbed or missing services as the consequence of loss of biodiversity by agricultural practice, such as nutrient runoff and erosion, loss of wildlife habitat, greenhouse gas emissions, and pesticide poisoning of humans and nontarget species. As this definition of disservices covers quite a varying content, it is suggested that this second interpretation of the definition of disservices be included.

malarial mosquitoes, pathogen populations, and toxic plants. As biodiversity is a necessary component of healthy, well-functioning ecosystems, conversion of natural habitats to managed or disturbed habitats can increase the prevalence of disease. In this way, habitats can become worse for humans in terms of their disservices [29, 30].

- Species causing production damage: An example is damage to crops and livestock by pests and wild animals [31, 32].
- Discomfort caused by nature: Biodiversity elements can cause distress to human welfare. Examples are species generating nuisance [33], natural areas in urban setting that generate a feeling of fear at night [34], presence of large carnivores that cause a feeling of insecurity, and insects that cause discomfort.
- Natural disasters: Natural phenomena, such as damages caused by floods and natural occurring wildfires.

Assessing disservices can, however, be complicated: First, the same ecosystem function can be perceived as a service or disservice depending on the context or the person. The balance between disservice and service can be subtle and therefore requires a concerted effort to understand the involved species in detail [35]. Second, a certain ecosystem function that generates a positive ecosystem service can negatively affect another ES. For example, the existence of a roe deer population in a certain area can contribute to opportunities for hunting and recreation (nature experience and wildlife photography), but they can be negative for the regeneration of a tree species, thereby negatively impacting timber production; natural areas in cities are positive for recreation and quality of life, but can cause slippery roads in autumn or feelings of insecurity at night; water regulation provided by a vegetated landscape might be valued by someone who is dependent on a steady water supply, but for someone interested in using the water for boating, this vegetation can be a burden. Finally, ecosystem disservices can be perceived as a result of changes in biodiversity, or because of changes in human perceptions alone. On the other hand, adverse effects for human health can be caused by ecosystem services that are not noticed at all or are not perceived as negative. Differentiating perceived disservices from actual disservices can be challenging [28].

The issue of disservices is to a large extent a matter of positive or negative appreciation by humans. Depending on the situation and stakeholders, an ES can provide either a benefit or a liability. When it is important to look at the whole picture (for example, for a management plan of a specific region), disservices should be included as well. However, as both positive and negative impacts are part of the same continuum, they can be linked to the list of services below. We therefore have chosen not to make a separate category for disservices within CICES-Be.

4. AN ES CLASSIFICATION SYSTEM FOR BELGIUM: CICES-BE

4.1. Key Principles of CICES

The proposal for CICES was based on the requirement that any new classification has to be consistent with accepted typologies of ecosystem goods and services currently being used in the international literature, and that it should be compatible with the design of the System of Integrated Environmental and Economic Accounting (SEEA) methods and UN standard classifications (ISIC4, CPC, COICOP). In constructing CICES, three main principles were applied [11, 12]:

- Hierarchical structure: In the present one-dimensional ES listings, each time a new service is identified, the list has to be updated. Therefore, a hierarchical structure was proposed into which new and specific elements can be fitted without disrupting the general structure of the classification. A hierarchical classification also enables summaries of services' outputs at different levels of generality, a feature that is difficult to accomplish with a simple listing. At the highest level, the three usual "service themes" are listed: provisioning, regulating and maintenance, and cultural ES (called Sections). Below the Sections level, different service groups are nested (i.e., Division, Group, and Class). The labels of the classes used in CICES have been selected to be as generic as possible, so that other more specific or detailed categories can progressively be defined, according to the interests of the user or country, or the concerned scale.
- Final outputs only: CICES refers specifically to the "final" outputs or products from ecosystems. Following common usage in the ES literature, the classification recognizes these outputs to be provisioning, regulating and maintenance, and cultural services, but it does not cover the so-called supporting services originally defined in the MA. As the supporting services are only indirectly consumed or used, they are treated as part of the underlying structures, processes, and functions that characterize ecosystems. The distinction between final and intermediate products was also proposed to avoid the problem of double-counting when undertaking monetary valuation. Valuation should only be applied to the item directly consumed or used by a beneficiary because the value of the ecological structures and processes that contribute to it is already wrapped up in this estimate [24, 25, 36]. It was therefore proposed that supporting services are best dealt with in other ways in environmental accounts [11–13]. In reality, this division between final and intermediate outputs is not always clear. Some of the ES can be intermediate as well as final services, depending on the user of the service. For example, pollination is a final service for the fruit grower (as it is an essential production factor for the producer) and a supporting service for the fruit consumer. But as this is a generic classification system, this type of ES is included as long as at least one stakeholder can be identified that directly benefits from a certain ES.
- Finally, a key point of CICES is that it is a classification of services and not of benefits [13].

4.2. Role of Supporting Services and Abiotic Resources in CICES

The fact that supporting services are not included in CICES should not be taken to mean they are unimportant. Any given ES depends on a range of interacting and overlapping ecosystem functions, and one supporting service may simultaneously facilitate the delivery of many final outputs. Typical examples of supporting services are nutrient cycling, photosynthesis, water cycling, and maintenance of the gene pool. As the category supporting services comprises every function and structure that is somehow involved in sustaining service flow, providing resilience, energy, and substrate; then it will probably include nearly “all biophysical complexity. A consequence is that any attempt to seriously define the set of supporting services is likely to oversimplify the role of nature. So, every list will be necessarily incomplete and illustrative, and any valuation will be incomplete [12]. A second implication is that each plan or intervention that changes land use and its related supporting services will have profound implications for delivery of related ecosystem services. In other words, lists of desirable ES should not be goals by themselves, but a starting point to reflect on the underlying processes and functions and on how to achieve sustainable ecosystem management.

The inclusion or exclusion of **abiotic materials** (e.g., minerals, salt) and **renewable abiotic energies** (e.g., wind, hydro, solar, waves, tides, thermal energy) was quite a controversial issue within the CICES and Belgium ES communities. The most important points that were raised during the Belgian discussion are summarized below:

- The first perspective is related to the definitions. If ecosystems are defined as the interactions between living organisms and their abiotic environment, then it is argued that ecosystem services have to be traceable back to some living process, that is, be dependent on biodiversity [25]. Others argue that the ecosystem consists of biotic and abiotic processes. Many included ecosystem services, such as flood control, hydrology-related services, but also water and air purification de facto depending (partly) on abiotic structures and processes. The latter is used as an argument for including abiotic-based services in the ES classification.
- The second perspective is related to the renewability of the resource. Most authors agree that nonrenewable materials that are mined, such as fossil fuels, gold, and uranium, should not be included. For renewable natural resources, the opinions are divided. Some argue that the level of renewability could be a distinguishing feature for inclusion in CICES. This requires a consensus about the renewal period. If this period is set, for instance, at 100 years, this means that ES would include the extraction of sand in dynamic rivers and salt mines, but not the mining of fossil fuels [4]. However, defining a renewal period is always controversial. Therefore, some have suggested basing the argument on extraction rate versus delivery rate. For example, in the case of petroleum, it is the speed of extraction that makes its use unsustainable. If oil would only be extracted at the rate at which it can be replaced, it could be considered a renewable resource. This approach is consistent with the idea of sustainable resource use: Only those goods and services are included that can be used on a sustainable basis.

- The third perspective is related to abundance. Wind, solar, tidal, and other energies are abundant and nondepletable. If the ES framework is aimed to be a tool that assists society in making decisions about scarce or limited natural resources and their services, it could be argued that it is not very useful to include them in the context of an ES analysis.
- Fourth, there is the aspect of attribution. As the origin of wind and solar energy cannot be attributed to a certain ecosystem type, it is proposed to exclude them [4]. Others argue including them, based on the fact that the amount of generated energy depends on topography, orientation, and local climate.
- A final argument for inclusion is that abiotic resources play an essential role in the transition to sustainability.

For CICES v4.3, it was decided to leave the "pure" abiotic resources out of the classification system of ES [13], and for the time being, CICES-Be will follow CICES. Nevertheless, when abiotic resources and energies play an important role in the issues at stake, it makes a lot of sense to include them in mapping and planning exercises.

4.3. Modifications of CICES for the Belgian Context

When the final international CICES v4.3 was published in January 2013, it was decided to harmonize CICES-Be v5 as much as possible with CICES v4.3. The purpose of this exercise was twofold: on the one hand, to keep the classification adapted to Belgian conditions; on the other hand, to keep the system compatible with the international one, at least at the section and division level. This resulted in CICES-Be v6 with 8 divisions, 18 groups, and 41 classes. Where we felt it was relevant for Belgium, additional subclasses were defined (34 in total). All the elements of CICES-Be that differ with CICES are marked In blue colour in Table 18-1. The major differences between CICES-Be and CICES are the following:

Additional ES in CICES-Be: Where important ES for Belgium were missing, new ES were added, such as: prevention and control of fire, control of invasive species, control of nature-borne human diseases, moderation of certain diseases by exposure to nature, and some specific cultural services (see below).

Modified ES in CICES-Be:

- Biomass production for nutrition in CICES-Be is split up according their origin: terrestrial, freshwater, or marine. This is done because these ES can be associated with very distinct professional and recreational activities.
- The ES division *mediation of waste, toxics and other nuisances* in CICES is split up according to media (biota versus ecosystems) and processes (e.g., bioremediation, dilution, filtration, sequestration). For CICES-Be, we did not find this division to be practical, as in reality many of these processes interact. Therefore, it was decided to subdivide them based on the type of service they provide (soil and water quality regulation, air quality regulation, shielding). Consequently, the group "water conditions" in CICES was omitted in

TABLE 18-1 ES Classification for Belgium CICES-Be v6

Section	Division	Group	Class	Subclass for Belgium	Examples of Service Providing Units	Benefits (non exhaustive) Availability of:
Provisioning	Nutrition	Biomass	Terrestrial plants, fungi, and animals for food	Commercial crops	Cereals, vegetables, fruits	Food
				Kitchen garden crops	Vegetables, fruit	
				Land-based commercial livestock	Free-range dairy and meat cows, chickens	
				Hobby animals for food	Sheep, goat, chicken, rabbit, bees	
				Edible wild animals, plants, and fungi	Game, wild honey, mushrooms, berries, nuts, wild plants (e.g., young nettle branches)	
			Freshwater plants and animals for food	Freshwater fish and shellfish	Freshwater fish (trout, eel)	
				Cultivated freshwater fish	Carp	
				Edible water plants	Water cress	
			Marine algae and animals for food	Sea fish and shellfish	Marine fish (sea bass)	
				Cultivated seafood and shellfish	Mussel culture	
				Edible plants from salt and brackish waters	Macro and microalgae, saltwort	
		Potable water	Surface water for drinking		Rivers, lakes, reservoirs, collected precipitation	Drinking water for domestic use
			Groundwater for drinking		Springs, (nonfossil) aquifers	

Continued

TABLE 18-1 ES Classification for Belgium CICES-Be v6—cont'd

Section	Division	Group	Class	Subclass for Belgium	Examples of Service Providing Units	Benefits (non exhaustive) Availability of:
	Materials	Biomass	Fibere and other materials from plants, algae, and animals for direct use or processing	Ornamental plants and animals	Bulbs, cut flowers, decorative plants, shells, feathers, pearls	Ornamental plants & animal products
				Plant fibers and materials	Timber trees, flax, straw, herbs, resins,	Timber, paper, natural medicines, dyes, clothes
				Animal fibers and materials	Animal parts (skin, bones)	Soap, leather, gelatine, wool
			Materials from plants, algae, and animals for agricultural and aquaculture use	Organic matter for fertilization and/or soil improvement	Manure, litter, bark, algae, "plaggen"	Fertilizer for crop production, improved soil structure
				Fodder and forage	Maize, grasses	Food for animal raising
			Genetic materials from all biota		Genetic material (DNA) from wild plants, algae and animals	Medicines, breeding programs
		Nonpotable water	Surface water for nondrinking purposes		Rivers, lakes, reservoirs, collected precipitation	Water for irrigation, industrial production, cooling
			Groundwater for nondrinking purposes		Springs, (nonfossil) aquifers,	

	Energy	Biomass-based energy sources	Plant-based energy resources	Energy crops and plant residues	Yellow mustard, wheat, beetroot, straw, grass and herb residues form nature and roadside management	Energy
				Energy trees and woody residues	Fuel wood (e.g., poplar, willow trees), woody residues form nature management	
			Animal-based energy resources		Dung, fat, oils, biogas	

Section	Division	Group	Class	Sub-class for Belgium	Examples of Service Providing Units	Benefits (non exhaustive)
Regulation and maintenance	Mediation of waste, toxics and other nuisances	Soil and water quality regulation	Bioremediation of polluted soils (phyto-accumulation/degradation/stabilization)		Plants & micro-organisms	Less polluted soils
			Water purification and oxygenation		Wetlands, lagoons, molluscs	Improved water quality
			Nutrient regulation		Buffer strips, soils, water bodies, estuaries, coastal zones	Stable nutrient levels
		Air quality regulation	Capturing (fine) dust, chemicals and smells		Trees, shrubs, forests	Improved air quality
		Shielding	Mitigation of noise & visual impacts		Vegetative buffers, landscape structures	Quieter environment

Continued

TABLE 18-1 ES Classification for Belgium CICES-Be v6—cont'd

Section	Division	Group	Class	Sub-class for Belgium	Examples of Service Providing Units	Benefits (non exhaustive)
	Mediation of flows	Mass flow	Mass stabilization and control of erosion	Gravity flow protection (e.g. landslides, creep)	Land coverage, roots of large trees	Land stability
				Protection against water and wind erosion	Cover crops, buffer strips, vegetation along the hydrological network, woodlands	Mudflow protection less dredging costs, less impact of wind erosion
			Buffering and attenuation of mass flows		Rivers, lakes, sea	Transport and storage of sediment
		Liquid flow	Hydrological cycle and water flow maintenance		Permanent vegetation, land coverage	Secure navigation, drought prevention, protection against salt intrusion, hydro-power
			Flood protection	Natural flood protection & sediment regulation	Natural flood plains, wetlands	Flood safety, less dredging costs, navigation
				Coastal protection to waves, currents energy & sea level rise	Dunes, marshlands, sea grass	Coastal safety

Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination	Bees, butterflies	(Better) fruit setting
		Seed dispersal	Birds, insects and mammals	Improved tree propagation
		Maintaining nursery populations and habitats	Wetlands suitable for spawning grounds	Bigger commercial fish and shellfish population
		Prevention and control of fire	Fire resistant vegetation buffers, wetlands, wet heath'	Fire safety
		Control of (alien and/or local) invasive species	Competing plants and animal species	Reduced impact of undesirable invasive species
	Pest and disease control	Pest control	Beetle banks, hedgerows, vegetation strips, heterogeneous landscapes, agroforestry	Better health of agricultural plants and animals
		Disease control		
		Control of nature-borne human diseases	Diversity of plants and animals result in dilution of competition with vectors	Lower risk for nature-borne human diseases
		Moderation of certain diseases by exposure to nature	Trees, pollen, plants, animals, micro-organisms	Less susceptible to allergies, better resistance to infections
	Soil formation & composition	Weathering processes, decomposition and fixing processes	Green mulches, N-fixing plants, soil organisms	Fertile soils

Continued

TABLE 18-1 ES Classification for Belgium CICES-Be v6—cont'd

Section	Division	Group	Class	Sub-class for Belgium	Examples of Service Providing Units	Benefits (non exhaustive)
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations		Vegetation, soils, sediments, oceans	More stable global climate
			Micro and regional climate regulation	Regional climate regulation (e.g. maintenance of regional precipitation patterns & temperature)	Forests	More stable regional climate
				Rural micro-climatic regulation	Windbreaks, shelter belts, shading trees, droves	Buffered micro-climate, air ventilation
				Urban micro-climatic regulation	Shading trees, parks, green roofs	

Section	Division	Group	Class	Sub-class for Belgium	Examples of Service Providing Units	Benefits (non exhaustive)	Benefits for Wellbeing
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-& seascapes	Natural environment suitable for outdoor activities	Area for non-excludable outdoor activities	Green environment suitable for daily outdoor activities	Neighbourhood green, shading trees, park, natural play area, green schoolyard drove, cemetery, fallow land, dike, trail	Daily displacements by foot or bike, walking the dog, playing, local meeting	Physical, social and mental well-being, motoric and creative development of children

	Landscape for outdoor recreation	Forest, beach, agricultural landscape, river, areas with wild food, pick-nick spot in nature, sport facility	Walking, jogging, cycling, horse riding in forest, mountain biking, surfing, canoeing, skiing, motorized activities, pick-nick, collecting natural products	Physical, social and mental well-being
	Natural landscapes and species for nature experience & education	Area of outstanding natural beauty (e.g. nature reserve, natural spring, lake, river, rare species, natural smell & noises), attractive and charismatic species, area and species with educational value	Eco-tourism, bird watching, nature conservation activities, nature photographing and filming, landscape painting, spiritual activities, eco-therapy, nature education	Physical, social, mental, spiritual well-being, inspiration, cognitive development, spiritual development, nature awareness
	Landscape and biodiversity suitable for research	Ecological patterns, pollen, tree rings, genetic patterns	Understanding of natural processes, technological applications, biomimicry	Better understanding of our dependency and relationship to nature

Continued

TABLE 18-1 ES Classification for Belgium CICES-Be v6—cont'd

Section	Division	Group	Class	Sub-class for Belgium	Examples of Service Providing Units	Benefits (non exhaustive)	Benefits for Wellbeing
			Area for excludable outdoor activities	Area for land-consuming recreation	Private land: Private garden, pasture for hobby animals Areas with entrance fees: Camping site, zoo, botanical garden, safari park, golf course, horse riding school, licensed fishing areas	Relax and playing in gardens, golf, camping, riding horse, relaxation in theme park, non-consumptive angling	Physical, social, mental well-being, motoric and creative development of children
				Area for land-consuming productive activities	Farm land, pasture, kitchen garden, leased land for hunting, licensed fishing areas	Outdoor work for farming, forestry, firewood collection, vegetable growing for home consumption, hunting, consumptive angling	Physical, social and mental well-being, nature awareness

		Natural surroundings around build-up areas	Natural surroundings around buildings for living, working and studying		Green/blue views from residences, schools, offices, elderly homes	Positively influence on living, working and indoor learning (better concentration, more creative, less stress) Higher prices of real estate	Physical, social, mental well-being
			Natural surroundings around institutions for recovery and therapy		Green/blue views from hospitals, psychiatric institutes, revalidation centres	Recovering from mental or physical illness positively influenced by the green environment,	Improved mental and/or physical health
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	Landscapes and species with cultural and symbolic values		Typical cultural landscape (e.g. heath, pine forests, hedgerows), symbolic/ emblematic species (e.g. stork, sky lark, wild boar)	Cultural heritage, folklore, flagship species for promoting regional identity Hunting, fishing, photographing and observing emblematic species	Sense of place/ identity Sense of possession of skills

Note: Text in blue font indicates where CICES-Be differs from CICES v4.3.

CICES-Be because they are considered to be part of "soil and water quality regulation" in CICES-Be.

- Under the group soil formation and composition, the classes *weathering processes* and *decomposition and fixing processes* were merged in CICES-Be, as these processes are closely related to each other.
- The services under group *gaseous/air flows* in CICES are very much related to the microclimate and were therefore included under the class micro and regional climate regulation in CICES-Be.The cultural services section is conceptualized quite differently under CICES-Be:

Cultural services are primarily regarded as the "environmental settings, locations or situations that give rise to changes in the physical or mental states of people, and whose character are fundamentally dependent on living processes." Over millennia these environmental settings have been co-produced by the constant interactions between humans and nature [13, 37].

Following this logic, all cultural service classes in CICES-Be refer to a biophysical setting that provides cultural services (e.g., landscapes, individual species, and whole ecosystems). The direct benefits we derive from these cultural services are recreation, nature exploration, living in a nice environment, nature education, and others. These activities provide consequential benefits, such as physical, social, and mental well-being, and motoric and creative development for children. These benefits for well-being are mentioned in the last column of CICES-Be. This is in contrast to CICES, where benefits (e.g., use, education, entertainment, and symbolic) are categorized as ES themselves. CICES also lists bequest value (importance for future generations) and existence value (right of existence) as cultural services. They are not, however, included as ES in CICES-Be, as they are considered part of a valuation analysis.

The CICES Division Physical and Intellectual Interactions is subdivided in two groups within CICES-Be: natural environment suitable for outdoor activities and natural surroundings of built-up areas:

- For the group natural environment suitable for outdoor activities, we made a distinction between two service classes based on the concept of *excludability.* To be excludable means that "one person/party (can) keep another person/party from using a certain good or service" [14]. For CICES-Be, two classes are distinguished:
  1. *Area for nonexcludable outdoor activities*: These are public areas that everyone can use. Examples are green environment suitable for daily outdoor activities (e.g., daily stroll, cycling to work), landscape for outdoor recreation (e.g., jogging, mushroom picking), natural landscapes and species for nature experience and education (e.g., bird watching, landscape painting, and spiritual activities), and landscape and biodiversity suitable for research.
  2. *Area for excludable outdoor activities:* These are the areas where one group can exclude another group. We distinguish this as a separate

class, as some categories of this class are rapidly expanding in Belgium, and as excludability controls to a large extent how many people can benefit from them. The level of excludability can, however, vary, ranging from nonaccessible land (e.g., private gardens) to areas with restricted access (e.g., land accessible to only club members or paying visitors). We distinguish two subclasses: land that is occupied to make a certain type of recreation possible (such as private gardens or grazing land for hobby horses) and land that is used for productive activities (such as farming and kitchen-garden). The benefit of the latest type is the satisfaction and mental well-being one gets from outdoor work; the agricultural products are classified under the provisioning services.

- *Natural surroundings around built-up areas*: This is the passive use of natural settings and does not require any outdoor activity—for example, the view on green environment from residences, offices, and therapeutic institutions. This service is not included in CICES, but for Belgium it was chosen to give this a separate group in the cultural ES section. The reason is that owing to the high population pressure in Belgium, this service is becoming a more and more scarce—and therefore highly valued—resource.
- Finally, there is the Division/Group/Class that focuses on the cultural and symbolic values of landscapes and species. For this ES, it is not essential to visit these places, but the mere fact that these landscapes and species exist in people's mind is sufficient to generate a benefit for them.

5. CONCLUSION

The advantage of an inventory of ecosystem goods and services (and disservices) is that it shows in a systematic way the contributions of ecosystems to human well-being. This can assist in sensitizing policy makers, administrations, and the general public to the significance of ecosystems and enable giving suitable weight to environmental considerations within political decision making [38]. On the scientific side, the process of drawing up the classification among experts boosted discussion on definitions and conceptual assumptions regarding ecosystem services and on their application in a Belgian context..

The inventory list of CICES-Be aims to provide a complete overview of all the potential ecosystem goods and services that can be relevant in the Belgian context (summarized in Table 18-2). The hierarchical approach makes it possible to adapt the classification to more general uses (e.g., mapping on scale Belgium) or to more specific uses (e.g., sustainable management planning at the level of a municipality or a park). It is important to note that a list of (desirable) ES is not a goal by itself, but is rather a starting point to reflect on the underlying functions, processes, and structures, and on how to achieve sustainable ecosystem management.

TABLE 18-2 Summary of CICES-Be v6

Section	Division	Group
Provisioning	Nutrition	Biomass
		Potable water
	Materials	Biomass
		Nonpotable water
	Energy	Biomass-based energy sources
Regulation and maintenance	Mediation of waste, toxics, and other nuisances	Soil and water-quality regulation
		Air-quality regulation
		Shielding
	Mediation of flows	Mass flow
		Liquid flow
	Maintenance of physical, chemical, and biological conditions	Lifecycle maintenance, habitat, and gene pool protection
		Pest and disease control
		Soil formation and composition
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interactions with biota, ecosystems, and land- and seascapes	Natural environment suitable for outdoor activities
	Spiritual, symbolic, and other interactions with biota, ecosystems, and land-/seascapes	Natural surroundings of built-up areas
		Spiritual and/or emblematic

On the one hand, the link to the internationally accepted CICES classification is a great advantage for future international reporting and comparisons. On the other hand, the operationalization of CICES-Be will require further work, such as the development of proper ES indicators, integration of ES and their indicators into environmental reports, consideration of ES in specific sector reports and in debates about societal "hot" issues. It is expected that by applying the CICES-Be inventory in practical cases, additional improvements to the classification scheme will be made in the future.

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