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Opinion piece for Trends in Ecology & Evolution

Beyond ecosystem services: valuing the invaluable

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Highlights

- Ecosystem services help itemise how we value natural places, but the concept is not robust.
- A more robust framework should focus on aspects of human appreciation of places.
- We propose an ecosystem valuing framework with 12 universal aspects of appreciation.
- This can be unambiguously complemented by ecological analyses where necessary.

Abstract

The ecosystem services framework (ESF) is advantageous and widely used for itemising and quantifying ways in which humans benefit from natural places. However, it suffers from two important problems: (i) incoherence of definitions and (ii) a narrow approach to valuation, inadequate to represent the full range of human motives for conservation and the diverse interests of different stakeholders. These shortcomings can lead to a range of problems including double-counting, blind spots and unintended consequences. Here we propose an ecosystem valuing framework (EVF) as a broader and more rigorous way to deliver the benefits currently sought from the ESF, without the conceptual problems.

The flawed genius of ecosystem services

The ecosystem services framework (ESF) is a very popular approach to incentivising nature conservation, increasingly used by conservation campaigners and policy makers around the world as well as by scientists contributing to this cause. Its genius is to facilitate a multi-dimensional analysis of the benefits that humans may derive from natural places, allowing a wide range of interests and conservation concerns to be considered and integrated with a broad view of sustainable development

and human wellbeing. As such it supports a consequentialist ethic that can be more successful than deontological approaches (see Glossary) in securing consensus and motivating action [1]. However, criticisms of the ESF as a tool for conservation raise doubts about its effectiveness and legitimacy [2, 3]. The most controversial issue is probably that of monetisation, as laid out recently by Silvertown [4]. One set of responses to such problems would continue using the ESF as a general tool for assessing habitats while recognising its multilayered structure [5], supervising it to avoid unintended consequences [6], perhaps discouraging monetisation [7], and even attempting to subjugate intrinsic value under the category of services [8]. Yet there are more profound problems with the ESF that call for a radical shift if we wish to contribute to conservation as part of a sustainable development agenda. Two outstanding issues are sufficient, in our opinion, to demand an overhaul of the ESF so radical as to require a new name. First, the definitions do not work. The fact that definitions of ‘ecosystem services’ (ES) and of specific categories are often vague, tautologous and/or at variance with the concepts actually employed is symptomatic of deep-seated problems, as we shall explain. Second, collapsing multiple human value judgments into one or a few numerical values is a form of devaluation. We unpack this claim by exploring the inescapably cultural foundation of valuation processes.

Coupling the ESF with the concern for sustainable development leads to the concept of natural capital, which is posited as underpinning (and sometimes including) ES [9]. Taken as the underlying substance that must be conserved in order to maintain delivery of ES, natural capital is prone to similar criticisms, although less susceptible to financial trading. The solution we will propose, by contrast, shifts focus from commodities to relationships between specific stakeholders and places [10].

What exactly is an ecosystem service?

Definitions of ES [11] range from “the conditions and processes through which natural ecosystems...sustain and fulfil human life” [12] through “the outputs of ecosystems from which people derive benefits” [13] to “the benefits people obtain from ecosystems” [14]; cf [15]. The variety of focal nouns in this sample of definitions (conditions, processes, outputs and benefits) reveals the difficulty of finding a logical category for things that motivate humans to protect natural habitats and places [16]. Fisher, Turner and Morling [17], affirming that ES must both be ecological and lead to human benefits, define ES as “the aspects of ecosystems utilized (actively or passively) to produce human well-being”. We find ‘aspect’ a more useful term, though not for something ‘utilized’. In fact, a minimal set of commonly-studied ES cannot logically be covered by any of the above definitions (Table 1) – and some studies [18] seem unconstrained by any of them. A definition encompassing all of these definitions would have to be very broad – something like “those ecological processes and their effects that certain humans appreciate”. But thanks to the existence of appreciative ecologists, such a definition would have unlimited scope.

Some other posited ES cannot be construed in a way that fulfils any of the above definitions. For example, animal welfare is considered in the UK National Ecosystem Assessment [13], yet its beneficiaries are not human unless we consider the satisfaction of concerned humans (in which case any ecological state of affairs that makes someone happier is an ES). Meanwhile, the biodiversity of an area [19] is sometimes considered an ES, and a subtle semantic shift from ‘biological diversity’ as an index (an intangible metric of diversity) [20] to ‘biodiversity’ being an actual aggregate (almost a synonym for ‘assemblage’) [21] allows biodiversity to be simultaneously presented as also underpinning all other ES and having ‘existence value’ [5]. The value of such concepts of biodiversity is not in question, but to construe any of them as a process, output or human benefit seems illogical.

Looking at the definitions of categories of ES, problems are multiplied. Take the four categories of the Millennium Ecosystem Assessment [22], three of which also form the basis of the Common International Classification of Ecosystem Services [23]. Perhaps ‘provisioning services’ is unproblematic – indeed a good model for ES, since beneficiaries in this case are consumers who consciously value the foodstuffs and raw materials that come under this category. ‘Regulating services’ might raise the question as to where a target value or set point for regulation can come from [24] – short of accepting something like the Gaia Hypothesis [25]. Presumably the term is simply meant to denote ecological effects that mimic the regulation that one might wish for, or that generally slow environmental change [26]. Regulating services are not clarified by the tautology engendered when the word ‘regulation’ is normally repeated within the definitions of examples – apart from pollination [22], the ‘regulatory’ sense of which remains unclear to us. ‘Supporting services’ [2] and ‘cultural services’ [27], meanwhile, are simply too broad. The former potentially includes every conceivable ecological process, since benefits for the well-being of someone can always be posited, while the latter potentially includes every positive human attitude to any element of the environment. The breadth of these categories exacerbates the risk of double-counting, while the vagueness makes a balanced audit elusive: how could one ever assess the ‘supporting disservices’ or ‘cultural disservices’ of an ecosystem? Below we argue that these last two categories of ES represent complementary but contrasting approaches to motivating nature conservation: each can ground a whole framework for analysis.

Parallel problems emerge for other concepts that might be used in a definition of ES, such as ‘processes/functions; structural components; goods; human uses; securities’ [11]. The hope is sometimes expressed that definitional problems will decline as definitions gradually improve [3]. But the problems we face are not merely about vagueness; they arise from forcing distinct concepts

into a single semantic category. The examples under ‘Valuing Ecosystems’ below suggest how they may continue fostering blind spots, unintended consequences and mistrust until the confusion is resolved.

How do humans value?

‘Value’ is a multivalent English word that can hinder logical analysis. Before advocating its use as a verb, we outline three of its divergent meanings as a noun that are highly relevant: economic, ethical and numerical. There is, firstly, an unavoidable economic aspect to nature conservation, in that some kind of prioritisation has to be made in the face of competing land-use claims. This in turn should reflect people’s values – their ethics – and need not entail monetisation, or any common currency of assessment at all. A single numerical value, therefore, cannot capture the diverse ways in which people may value a given place, important though it is to quantify these. A prominent strand of value theory (Box 1) argues for the irreducible plurality of evaluative concepts, and everyday experience shows that people both perceive and value such goods as health, utility, diversity, beauty and generosity in different ways [28]. Compressing assessments of such distinct ‘values’ onto a smaller number of axes ignores the intrinsic dimensionality of the situation and is a form of devaluation [2]. It may also produce category errors, helping to explain the definitional problems outlined above. By reducing a broad range of human motives to the category of services, the ESF reveals the influence of the rational-choice paradigm of microeconomics [29] and fails to do justice to the reality of human attitudes towards places and their conservation. This we explore in the next section.

Further complexity is added by the plurality of stakeholders. Beneficiaries are often specified on an ad-hoc basis, without regard to their socio-economic status [2] or not at all, as if everyone appreciated the same benefits equally [30]. Yet ecosystems do not produce a pool of benefits

independently of actual beneficiaries. Rather, benefits arise from particular people's interactions with particular places [31], often with technological input, communication, legal facilitation and many other cultural factors [32]. It is too easy to conceive of ES emanating from abstract classes of habitat, overlooking the uniqueness of places that can make them valuable to particular people. Yet surveys of stakeholders tend to emphasise cultural ES associated with the distinctiveness of places [33]. Only when interest groups are poorly or narrowly specified or when certain groups are excluded from the process is it possible to proceed to a summary valuation. "The current campaign to define the world as an immense collection of service commodities" [34] then allows marketisation and legislation that, one might suspect, enable owners of capital to be served as the ultimate beneficiaries [2]. The emerging discipline of political ecology is bringing important scrutiny of conservation agendas in the light of considerations of equity and power.

Valuing ecosystems

Valuation must be seen as a complex human cultural process – and not merely in assessing cultural ES [35]. Indeed, the ubiquitous yet vague 'cultural services' category probably derives from "perceptions of culture as opposed to nature, biased towards globalized Eurocentric leisure-time concepts", etc, reflecting the captivity of Western thought to a dualism of the immaterial and the subjective vs. the material and the objective [36]. It can be argued that all ES, insofar as they motivate conservation, are psycho-socio-culturally mediated [2, 34]. For example, even the provisioning of wheat by the world's major agroecosystems is an ES only in virtue of consumers' cultural conditioning to eat certain foods, and the loss of this service could, hypothetically, be accommodated by a corresponding shift in diets. Readers unconvinced about this point might instead appreciate the evolutionary psychology of valuation: how one's perceptions might reflect processes that tend to increase one's inclusive fitness [37]. In either case, contextual awareness must

remain acutely important for understanding disagreements, potential disbenefits and conflicts of interest [35].

We end our critique by mentioning some examples of conservation motivations that are difficult to capture in the ESF. Several studies have documented how people appreciate places by serving them and their constituent organisms rather than considering themselves served by an ecosystem [38] and by giving up time to protect or improve them [39, 40]. To these we add a brief example of stakeholder exclusion in conservation negotiations. Grazing on the Sinai Peninsula is said to damage scarce vegetation, and domestic grazing in the St Katherine Protectorate has been outlawed and in some areas physically prevented, despite being central to the livelihoods of people who traditionally graze their flocks in these habitats [41]. A conservation-oriented analysis of this complicated situation should recognise how the Bedouin people benefit from these arid lands in ways that are apparently disregarded by interventions focusing on the interests of other beneficiaries. It should also consider the contested ecology of the situation, where local people claim that their grazing actually improves survival in grazed species [42].

What is needed is a framework that consistently distinguishes ecological processes from human modes of appreciating them. A proper treatment should be intrinsically multi-dimensional and recognise mutual human–environment relationships [10] involving diverse stakeholders.

Beyond services: introducing the Ecosystem Valuing Framework

We suggest that conservationists should avoid the language of services altogether and adopt a framework that recognises diverse aspects of human valuation for specified people and places. To facilitate this, we here propose an ecosystem valuing framework. This explicitly recognises that

human experience provides the starting point for analysing the full range of ways in which ecosystems may be appreciated. This may be seen as a strategy of developing the ‘cultural services’ category; in closing we will briefly consider what can still be done with the popular approach of starting with ecological processes.

To understand ecosystem valuation we ideally need a comprehensive set of logically-distinct possible ways in which people may value natural places, and we find a candidate suite of axes in aspectual theory. This philosophical framework (Box 1) proposes distinct, mutually-irreducible aspects of reality that are experienced by humans (Table 2). Taking the first three of these aspects as foundational, our proposal is that the remaining 12 aspects (Fig. 1) be used to capture the range of ways in which humans may stand in evaluative relationships with natural places. These 12 dimensions collectively cover ecological, cognitive, communal and ideological aspects of valuation, and there are philosophical reasons to believe that they are both comprehensive and mutually exclusive (Box 1). For a given real place and a specified stakeholder, then, we ask how the stakeholder appreciates the place in these kinds of ways. That is, the aspects are adverbs rather than nouns. Table 2 illustrates how these aspects cover and exceed the range of the ESF.

We suggest that an ecosystem valuing framework (EVF) such as this provides the flexibility and simplicity needed for handling a complex multidimensional problem. It is designed to maintain the pragmatic, pluralistic orientation of the ESF while improving on it in important ways (Box 2).

Clearly this proposal calls for considerable inter-disciplinary collaboration and public engagement.

Fig. 1 suggests how each of the 12 aspects tends to be the focal concern of a particular group of stakeholders, and how it connects with a recognised category of value.

Outlook

There are several further reasons why the EVF should have intuitive appeal for scientists, policy-makers and practitioners. First, it has the potential to meet various recommendations previously made for implementation of the ESF, including resilience, promotion of interdisciplinary collaboration and involvement of stakeholders [11], focus on direct human encounters with ecosystems and attention to both local and off-site effects [43]. Second, the EVF should function well in non-Western cultures (often found in parts of the world of great conservation importance [38]) by downplaying the ‘humans vs. nature’ [44] and ‘cultural vs. material’ [36] dualisms typical of Western worldviews and recognising instead how people’s cultural identity and well-being may be closely bound up in relationships with the non-human world [10]. Finally, the independent philosophical foundations of the EVF should give confidence in its robustness and universal validity. Adopting the twelve aspects of valuation would provide a standard that should assist in comparison among studies, although ongoing work will be required to apply them through developing protocols and metrics (see Outstanding Questions).

In focusing on human experience, an EVF might be seen as aloof from natural science research [45]. It elicits, however, a more ecological approach as its complement. Focusing instead on a set of ecological processes such as pollination, predation and nutrient cycling, one can examine how these underlie and influence the lives of humans and other animals in diverse ways. Such ecological effects analyses, as we might call them, align with the notions of supporting services and natural capital. They would include many of the biophysical ES valuations already popular with ecologists [46], and so the question of how they should contribute to EVF assessments is clearly of pressing importance (see Outstanding Questions). But we believe that this is the correct prioritisation for the concerns of nature conservation and sustainable development, even as convergence is sought among the multiple framings of conservation [47]. An EVF should provide a more consistent and holistic starting point for most of the applications currently addressed using the ESF, as well as a rationale

for interpreting ecological effects analyses. After all, direct human perception is the foundation of scientific research as well as environmental appreciation.

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Table 1: A selection of ecosystem services and their qualification under some prominent definitions (1 = qualifies; 0 = does not; ? = may qualify in some situations). The last three rows are counterfactual test cases: phenomena that are not (to our knowledge) considered as ES yet appear to fulfil some of the definitions.

Ecosystem service	...is an ecological process/function	...is an ecological output/contribution	...is a human benefit
Insect pollination ^a	1	0	0
Climate-change reduction ^a	1	?	0
Soil formation ^a	1	1	0
Water supply	0	1	1
Food provision	0	1	1
Recreation (opportunity)	0	0	1
*Insect reproduction	1	?	0
*Photosynthetic release of oxygen ^b	1	1	1
*Profit from rising timber prices	0	?	1

^a While not themselves human benefits, these three items may lead to benefits. Yet the first two may clearly also lead to human disbenefits: some destructive species rely on insect pollination, and some people stand to benefit from climate change.

^b Our Web of Science search in July 2016 did yield 15 empirical studies (all of Chinese sites) that considered oxygen production, which was dropped from the Millennium Assessment's list of examples between [14] and [22].

Table 2. Aspects of experience, with examples for human functioning in each, correlated academic disciplines for collaboration, typical evaluative questions that should be asked concerning a natural site, and examples of specific variables to assess (drawn from the ESF where possible).

Aspect of experience	Human functioning (examples)	Academic disciplines	Typical evaluative questions (normative words in bold)	Typical questions of reflexive valuation	Examples of quantities and related ES (<i>italicised</i>), with relevant stakeholders
Foundational aspects:					
Numerical	Counting	Mathematics	Basis of quantification		
Spatial	Measuring	Geometry	Basis of geographical considerations		
Kinetic	Traversing	Classical physics	Basis of evaluating movement and change		
Ecological values (relevant to animals in general):					
Physical	Sheltering; Resource-extracting	Physics, Chemistry	How does this site protect us?		Climate/watershed regulation for those at risk. Fuel provision
Biotic	Eating	Biology, Ecology	How does it sustain us?		Food provision for consumers
Sensory	Feeling; Hearing; Seeing	Psychology, Medicine	How comfortable is it to us?		Noise regulation, Health benefits for local residents
Cognitive values (relevant to individual humans):					
Analytical	Distinguishing	Philosophy, Maths	How diverse is the vegetation to us?	How distinct are we from the site?	Biodiversity, habitat distinctiveness for naturalists

Formative	Developing; Teaching	Historical studies, Engineering, Education	How richly developed is the site?	How can we develop ourselves in it?	Educational opportunities for local people
Symbolic	Communicating; Naming	Linguistics, Cultural studies	How meaningful is the site to us?	How do we get information from it?	Information functions (e.g. on food supply) for land-based people
Communal values:					
Social	Respecting	Sociology	How socially appropriate is the site to us?	How well can we socialise at the site?	Shared recreational opportunities for locals, tourists, etc
Economic	Choosing; Trading; Optimising	Economics	How valuable is the site to us?	How do we prioritise the site? ^a	Economic opportunities for local people/investors
Aesthetic	Appreciating; Joking	Arts, Design	How beautiful is the site to us?	How do we enjoy the site?	Artistic inspiration, leisure opportunities for tourists, etc
Ideological values:					
Jural	Allocating; Doing one's duty	Law, Politics	What do we deserve from the site?	What do we owe others from the site? ^b	Benefits (climate regulation, etc) for other people
Altruistic	Caring; Loving	Ethics	How caring are we of the site?	How does it enable us to love/care ?	Conservation action by volunteers
Certitudinal	Trusting; Knowing	Religious and cultural studies	How transcendental does the site seem?	How do we know ourselves here?	Spiritual services for interested parties

^a This is one of the typical aims of a whole ecosystem valuation exercise.

^b This question should bring in concern for future generations and hence sustainability.



Figure 1: The suite of aspects for valuing ecosystems is shown as rays emanating from an ecosystem (site) of interest, with the physical (reading clockwise) and certitudinal (reading anticlockwise) as alternative foundations of interpretation (Box 2). Although written as adjectives to save space, the aspect labels should be converted to adverbs: “Physically how does stakeholder S value place P?” etc. The ecological category is indicated in green, cognitive in blue, communal in red and ideological in purple. Examples of stakeholders specialising in each kind of valuation are named in boxes, and some categories of value associated with each aspect around the periphery. An assessment ought to consider all the aspects for (i) a specific place and relevant stakeholders, or (ii) specific stakeholders and all relevant places.

Glossary

- Aspect:** In aspectual theory: a fundamental mode of being and functioning, and a limit to the process of abstraction. Each aspect (of which 14–17 are typically posited) has a core meaning that can be evoked but not defined. In human experience any object functions in all the aspects, each one providing a sphere of meaning in which things are conceptualised. Ethical norms are to be discerned in the analytical and subsequent aspects.
- Certitudinal:** In aspectual theory: describing the fundamental notion of certainty, conviction or commitment; the way in which something motivates action.
- Consequentialist:** An approach to ethics evaluating the moral rightness of choices by the consequential increase or decrease in goodness brought about by them. Different strands of consequentialism define ‘goodness’ differently: utilitarianism, for example, classically considers an aggregate of well-being summed across all persons.
- Deontological:** An approach to ethics evaluating the moral rightness of choices by their conformity with norms. Deontological ethics is arguably more concerned with right actions than with bringing about a good state of affairs.
- Formative:** In aspectual theory: describing the fundamental notion of free creative innovation; the way in which something can be historically new. Dooyeweerd saw differentiation, rather than mere innovation, as the central norm in this aspect.
- Jural:** In aspectual theory: describing the fundamental notion of what is due from one party to another; the intuitions of justice and equity that precede and ground any legislation.

Box 1: Backgrounds to aspectual theory and value theory

Aspectual theory:

Aspectual theory is a postulate of the reformational philosophical tradition, which was established in the first half of the 20th century by Herman Dooyeweerd and Dirk Vollenhoven [49] as an alternative to the dualistic thought that pervades Western culture [50]. It is a phenomenological framework to account for, among other things, how humans abstract from the integral everyday experience of reality and analyse objects or situations by abstracting selected aspects, which can be seen as fundamentally distinct modes of being and functioning [51]. Dooyeweerd and Vollenhoven identified fifteen mutually-irreducible aspects, although such a list is open to empirical revision. Aspects provide an intuitive categorisation of the diversity of meanings that can be ascribed to an object, phenomenon or situation. Reformational philosophy eschews reductionist claims about either an underlying substance ('matter') or social constructivism to explain our shared perceptions and posits instead a suite of natural laws that cause similar aspects and norms to be discernible at all times and across all cultures. Conflating the aspects is a common source of paradoxes, such as Zeno's (reducing the kinetic aspect to the spatial) and Theseus' (conflating the physical aspect with others such as the formative).

Dooyeweerd [49] found specific dependencies among the aspects. Table 2 lists them in their order of conceptual dependence (numerical as primary, certitudinal as final), but reading the table from bottom to top indicates an epistemic dependence (certitudinal as fundamental to our thinking, numerical as most peripheral [52]). Thus a comprehensive multi-aspectual assessment by a given stakeholder should have an inner coherence that is lost in combining isolated judgements about, say, the beauty or intrinsic value of a place. Also, since each aspect may be the focus of an academic discipline (Table 2), their integral coherence and mutual irreducibility cautions against attempts to seek an authoritative assessment from any single discipline. On the contrary, inter-disciplinarity is encouraged.

Value theory:

Whereas traditional ethical theorising focuses on how a person may choose the “right” course of action, value theory (related to axiology) focuses on how people attribute ‘goodness’ to different entities or situations according to their properties [53]. While this approach avoids the traditional dichotomy between consequentialist and deontological ethics, it raises its own questions about extrinsic vs intrinsic, and conditional vs unconditional, values [54]. A strand of thought aligned with our proposal sees values as context-dependent. For example, Judith Thomson [55] argues that ‘good’ is meaningless without a context: one must understand some way in which a thing X is good, such as “for purpose P” or “for the wellbeing of subject S” – so that we can understand the contrasting senses of attributions like “good for cane toads” and “good for killing cane toads”, as well as divergent forms of goodness such as generosity, justice and beauty. Accepting the fundamental multiplexity of goodness actually makes a consequentialist analysis problematic, since divergent values cannot be reduced to a common currency in order to assess the “best” course of action [56].

Aspectual theory lends itself to this view rather well. Thus the columns of examples in Table 2 may be read as ways in which a place may be good for particular people and their interests. The alleged comprehensiveness of the suite of aspects suggests that they can encompass all the possible kinds of value that might be invoked in the discourses of conservation and sustainable development.

Box 2: The Ecosystem Valuing Framework

The ecosystem valuing framework (EVF) proposed here is a set of 12 categories for a systematic analysis of how specified stakeholders value a place or ecosystem. Each category evokes a distinct aspect of the place, as outlined in Fig. 1 and Table 2. Below is a summary of the framework and some of the advantages it offers over the ESF:

- The EVF is a tool to consider the ways in which sites may be appreciated holistically, without applying the consumeristic category of services: it entails asking ‘how’ rather than ‘what’ people appreciate. The starting assumption is that any stakeholder will value any given place to varying degrees (including negatively) in each of the 12 aspects, and an evaluation therefore consists in attributing relative scores on as many as possible of these axes of valuation. They would naturally be presented graphically on a radar diagram.
- It is essential to specify at the outset which stakeholders are being considered. This necessitates consultation or at least empathy (e.g. if any non-human animals’ values are to be considered [57]). Dialogue and diplomacy may then be required for reaching a consensus for action.
- In practice, evaluations might be either site-focused (e.g. for prioritisation exercises, considering all interested stakeholders) or stakeholder-focused (e.g. for policy development, considering many sites and various spatial and temporal horizons).
- For translating between the ESF and the EVF it may be helpful to conceive of most regulating services initially in terms of the physical aspect of appreciation and of provisioning services in terms of the physical and biotic aspects. However, the EVF does not directly cover the notions of services or benefits: thus timber as a commodity or CO₂ as a disutility, for example, cannot be directly considered. Meanwhile, the ambiguity of ‘cultural services’ can be lessened by using the full suite of aspects of appreciation.

- Recognising the coherence among the aspects can help interpret the divergent perspectives of different stakeholders. For example, religious or existential convictions underlying a person's certitudinal and altruistic evaluations may shed light on their evaluations in the preceding aspects.
- The EVF intrinsically makes the normative nature of conservation explicit, facilitating the identification of negative as well as positive considerations, and “maintaining a plurality of values up to the point of decision-making” [28]. With the EVF, this “plurality of values” can be positivised as “a dozen (or more) evaluative scores”.

Outstanding Questions

1. What variables should be used to implement the axes of the EVF?

As indicated in Fig. 1, we propose that the latter 12 of the 15 commonly-accepted aspects provide comprehensive coverage of the range of fundamentally-distinct ways in which people may appreciate natural places. Some of these aspects readily evoke common assessments: the physical, biotic, sensory, analytical, social, aesthetic and economic (albeit sometimes under different names) are largely familiar from the ESF and other environmental assessment frameworks. The formative, symbolic, jural, altruistic and certitudinal aspects, however, are less often considered and will need careful consideration: how can they be quantified? Also, as indicated in Table 2, the post-ecological aspects in the list have a reflexive side: e.g. how humans not only form and develop a place, historically, but also form themselves through a place, educationally. Thus overall there could be up to 21 evaluative questions. But one might ask if some of these should be combined or downplayed.

2. How should scientific understanding of ecological processes be combined with the EVF?

Given the existence of modelling tools like InVEST [47] to quantify biophysical outputs, it would be efficient to use the analysis of “supporting services” and other ecological effects to inform EVF assessments without always consulting stakeholders directly. This is normally the only possibility if non-human species are considered; for humans it is similar to what happens when researchers model the hypothetical wellbeing of classes of people like subsistence farmers in a particular location on the basis of projected environmental factors (like climate change). Such evaluations are often restricted to the physical and biotic aspects of wellbeing, although effects in the sensitive aspect and, of course, the analytic, can also readily be modelled. But can ecological models help with any higher aspects of human experience? And how can uncertainty be accounted for, in cases where a scientific consensus is contested by key stakeholders or simply does not exist?

3. How do the axes of the EVF tie in with sustainable development goals in general?

Each of the United Nations' 17 sustainable development goals (SDGs) [57] may be characterised by one or more of the EVF aspects, and many map largely onto a single aspect (e.g. those concerning energy and climate, hunger, well-being, education, communities, justice and the various economic goals). Comprehensive assessments of natural places in terms of these aspects should therefore foster integration with the SDGs, but the best ways of combining them will require extensive exploration. True sustainability will call for a long-term perspective, with particular concern for the economic norm of frugality, while the jural norm of fairness must be applied with regard to future generations.