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Do ecosystem service frameworks represent people's values?

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ABSTRACT

Since the Millennium Ecosystem Assessment was published, a plethora of ecosystem service frameworks have been developed to conceptualise the links between the natural environment and society. The intended geographic scales of application, the policy/practice context, and the scientific disciplines involved have driven variations in how the frameworks are constructed. However, the frameworks are homogenous in that they have been created predominately based on expert opinions and views of how ecosystem services are structured. Here, we use the Common International Classification of Ecosystem Services (CICES) to examine the extent to which frameworks capture people's values for British woodlands. Our findings reveal several disparities between how experts and the public conceptualise ecosystem services. The considerable refinement and specificity provided by CICES does not align with public values (e.g. some provisioning, and regulation and maintenance, services), which tend to be more generalised. We also demonstrate differences in values explained by social characteristics (e.g. ethnicity) that need to be accounted for in decision-making processes. Moving forwards, we need to consider how society views the services derived from nature and reflect this in frameworks to ensure ecosystem service approaches are effective, transparent and widely supported.

1. Introduction

The general relationship between ecosystems and human wellbeing is well recognised. However, conceptual frameworks that systematically integrate data from multiple sources to establish empirical links between the natural environment and society (Vallecillo et al., 2019) vary in the way they are constructed (La Notte et al., 2017). These variations reflect the rapidly evolving nature of approaches to knowledge creation in the field of natural capital and ecosystem services. Depending on the background of the ecosystem service (ES) framework, it will emphasise specific contexts or goals (Czúcz et al., 2018). Variation can be attributed to the different geographic scales the frameworks aim to assess, the scientific disciplines involved in their creation, and the policy and management context they are to operate in (Chaudhary et al., 2015). The Millennium Ecosystem Assessment (MA, 2005) has been a remarkably durable heuristic but, since its inception, numerous other ES frameworks have been developed. For example, the purpose of The Economics of Ecosystems and Biodiversity initiative was to provide a structured approach to mainstream the economic values of biodiversity and ES into decision-making at all levels (http://www.teebweb.org/) (Schleyer et al., 2015). The Common International Classification of Ecosystem Services (CICES; https://cices.eu/) attempted to consolidate aspects of a variety of ES frameworks for natural capital accounting purposes (Haines-Young and Potschin, 2018). In 2017, the Inter-Governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; https://ipbes.net/) was established to improve the use of ES approaches in international policy. IPBES authors went on to develop a framework to capture the closely related concept of Nature's Contributions to People (Pascual et al., 2017).

By making the value of nature's contribution to people explicit, trade-offs between services and prioritisation of management/policy options are enabled (Grêt-Regamey et al., 2017). Adopting standardised approaches can enhance the transparency and fairness of ecosystem use, and are considered integral to making fully informed decisions about our natural environment (Fisher et al., 2009; Hein et al., 2020). ES frameworks aim to be clear, robust, unambiguous and adaptable to

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different contexts (Polasky, Tallis and Reyers, 2015). Nonetheless, they are all structured slightly differently, resulting in lively discussions over the relative merits of ES frameworks (see Braat et al., 2018; Kenter, 2018; Maes et al., 2018; Faith, 2018; Peterson et al., 2018; Kadykalo et al., 2019). Indeed, the debate surrounding classifying different types of ES has led some to make the case for plurality (Peterson et al., 2018; Ainscough et al., 2019), accepting that the ES concept can be open to a variety of perspectives and worldviews, and believing this to be a strength (Schröter et al., 2014). However, with this comes the risk of reducing the usability of the ES concept by stakeholders, especially if the goal is to harmonise approaches to resource management across scales and from context-to-context. It has been argued that the plurality of ES conceptualisations creates ambiguity and inconsistencies in research and policy (La Notte et al., 2017).

For ES approaches to inform environmental decision-making, frameworks for assessment should support comparative assessments. Many frameworks achieve consistency and standardisation by using hierarchical, nested structures under broad ES categories (Czúcz et al., 2018) (e.g. CICES). However, some authors still question whether frameworks can accurately account for ES provision, with many attempts oversimplifying ES (Nahlik et al., 2012; Boerema et al., 2017). By doing so, the frameworks may fail to fully account for conceptual complexity, as well as the social and cultural particularities underpinning values (Costanza et al., 2017). Ultimately, there is a trade-off between two quite different tendencies in ES assessment and accounting, which are at the heart of debate about the scope and practical purpose of ES frameworks: the need to standardise to facilitate comparisons, and the need for flexibility and recognition of specificity.

Both the MA and IPBES are international-scale endeavours to evaluate the status and trends of different ES and their interlinkages at a global and sub-global scale. Furthermore, many governments undertake ES assessments at a national-scale (e.g. Watson et al., 2011; Albert et al., 2014; Mononen et al., 2016). CICES was developed with commonality in mind, providing a flexible framework that could be adapted to suit an array of geographic and thematic scales (Czúcz et al., 2018). Higher categories of CICES were intended to be sufficiently general to encompass all ES, with lower levels designed to be open-ended and adaptable, enabling users to include specific services relevant to them and thus providing a one-stop-shop for ES assessments. The extent to which these standardised and generalised ES frameworks can capture the nuances of ES in specific locations or contexts remains an open question.

Even though frameworks endeavour to bring a sense of unity to the ES approach, they have been constructed predominantly based on expert opinions and views of how ES are structured. Yet, ES should reflect the wants and needs of society (Small et al., 2017), meaning that the frameworks should account for the values of members of the public, not merely expert standpoints based on specialist knowledge (Costanza, 2020). The abundant literature dedicated to examining the values that people place on different ES demonstrates substantial variability between geographic locations (Ryfield et al., 2019) and, even in the same locality, individuals can have radically different ES values (Chakraborty et al., 2020). This is particularly salient for cultural ecosystem services (CES) that are interpretive and pluralistic, strongly linked to the specificities of the environmental setting and the cultural practices that construct and enable them (Fish et al., 2016).

Common frameworks designed by experts have attempted to provide standard and robust approaches for assessing ES. An increasing number of institutions and disciplines at the interface of environmental science and policy are adopting ES and natural capital approaches. For ES to be effective, transparent and widely supported, it is imperative that societal views and comprehension of ES are understood and reflected in ES frameworks. To date, no study has attempted to understand the extent to which expert views of ES capture the values of the wider public. Here we explore the extent to which ES frameworks represent people's values. We use CICES to investigate how people's understanding and values of ES aligns with that of experts. We also consider how these values change within sectors of society.

2. Method

2.1. Common international classification of ecosystem services (CICES)

We used the CICES framework (version 5.1) to understand the extent to which it can capture the ES values held by a diverse set of the public. While other frameworks have established their own unique method to conceptualise ES, CICES was developed to harmonise the ES approach by promoting the use of a single common framework. It builds on alternative frameworks, incorporating their strengths, while prioritising scientific rigour and adaptability to any geographic context (Czúcz et al., 2018). Consequently, it positions itself as a reference framework that allows the translation of information between other frameworks, like the MA and IPBES. Developed by the European Environment Agency, CICES has become the most extensive and complete ES framework available (Antognelli and Vizzari, 2016). As such, it is widely used internationally in ES research for designing indicators, mapping and valuation (Haines-Young and Potschin, 2018). CICES has been continually updated to reflect the evolution of ES, seeking to improve robustness and usability of the tool, with the most recent iteration being version 5.1 (Haines-Young and Potschin-Young, 2018). CICES provides a five-level hierarchical ('Section', 'Division', 'Group', 'Class', and 'Class type') ES structure, including those that are enabled through direct-use ('*in-situ and outdoor interactions with living systems that depend on presence in the environmental setting*') and indirect-use ('*remote, often indoor interactions with living systems that do not require presence in the environmental setting*' (Haines-Young and Potschin, 2018). At the highest level, 'Sections' represent three ES categories originally proposed by the MA (provisioning; regulation and maintenance; cultural). Subsequent levels become increasingly more specific and detailed. For example, 'Section' – '*Provisioning*'; 'Division' – '*Biomass*'; 'Group' – '*Cultivated plants*'; 'Class' – '*Cultivated plants for nutrition*'; 'Class type' – '*Cereals*'. Following recognition that only biotic processes were captured in the framework (e.g. Van Ree et al., 2017), version 5.1 was extended to cover abiotic processes. For instance, allowing users to include the cultural values of cliffs, rock formations, waterfalls, rivers, views or caves, or the mediation of waste by sequestration or filtration. The comprehensiveness of CICES, along with its ambition to be *the* ES framework adaptable to any context, makes it the ideal case study framework.

2.2. Study system

Woodlands in Britain were used as a study system to investigate the ability of an ES framework to account for people's values and understanding of ES. Woodlands were selected because they provide a myriad of ES including provisioning (e.g. fuel, fibre), regulation and maintenance (e.g. climate, flooding, air quality), and cultural (e.g. cultural heritage, recreation, tourism) services. Woodlands occur across the entire country, both inside and outside of urban areas, representing 13% of landcover (Forest Research, 2020). They are the most visited green space behind 'urban parks' and 'paths, cycleways & bridleways' in Britain (Natural England, 2019), and are considered the second most wellbeing enhancing type of environment after beaches (Harrison et al., 2014).

2.3. Questionnaire development

We designed a questionnaire that represented the 'Class'-level ES set out in CICES version 5.1. CICES classes were only excluded if they were not relevant to woodlands. Wherever feasible, the wording used for the question statements mirrored the language used in the CICES framework. Some minimal modifications were made to facilitate comprehension. For instance, three statements were developed to separate out abiotic reliant physical activities, and examples drawn from CICES were

incorporated into each statement. Additionally, spiritual CES within CICES encompass spiritual, sacred and religious activities and values. Given the growing body of literature suggesting a distinction between these three concepts (e.g. Irvine et al., 2019), these were divided into three individual statements.

In total, 47 CICES statements were used in the questionnaire (Table 1). Of these, 21 focussed on direct-use values pertaining to cultural and provisioning ES. The remaining 26 statements assessed indirect-use values across cultural, provisioning, regulation and maintenance. Both biotic and abiotic services were included. Participants were asked to respond to two stem questions (one for direct-use values, and another for indirect-use values) on a 5-point scale (direct-use values: 1 = very unlikely to 5 = very likely; indirect-use values: 1 = strongly disagree to 5 = strongly agree). The questionnaire also asked about participant's social characteristics (e.g. age, gender, ethnicity) and country of residence. The questionnaire was piloted and modifications were made to the wording to address points of ambiguity.

2.4. Implementing the questionnaire

Participants, recruited by a social research company, completed the questionnaire in an indoor setting. The participant cohort was characterised by gender balance across male and female (or people who identify as such); age balance across three brackets (18–29 years; 30–59 years; >60 years); a mix of White British and other ethnicities (at least 20%); a diversity of people from different government regions of England, plus individuals from Wales and Scotland; a mix of individuals from different social classes; and a mix of both urban and rural (at least 20%) dwellers. Using these criteria, we aimed to capture the diversity of the British public, including sectors of society who are often underrepresented in research (e.g. elderly, ethnic minorities, lower income households) (Fischer et al., 2018). Data collection was completed in October 2019. Ethical approval was gained from the University of Kent's School of Anthropology and Conservation Research Ethics Committee (Ref: 009-ST-19).

2.5. Analysis

Factor analysis is a useful tool for investigating how different variables (in this case statements) are related in complex concepts, such as ES. Factors are formed from multiple statements that have similar patterns of responses because they are all associated with a latent (i.e. not directly measured) concept. The relationship of each statement to the underlying factor is described by the 'factor loading', with higher loadings representing stronger associations. To explore how participants valued the different ES, and whether this reflected the hierarchical structure of CICES, we performed principal axis factoring with oblique rotation (oblimin with Kaiser Normalization) following Tabachnick and Fidell (2013). Statements for direct-use and indirect-use values for ES were analysed separately. Factors were constructed from statements with factor loadings of > 0.45 (Tabachnick and Fidell, 2013); those not meeting these criteria were excluded from further analysis. Cronbach's alpha was calculated to evaluate reliability of resulting factors. Following Nunnally (1967), factors with a Cronbach's alpha above 0.70 were retained. Responses for the individual statements in each factor were then averaged to create a new composite variable which was used in subsequent analysis.

To investigate how values of ES might vary within a diverse public, we examined a range of participant social characteristics considered important to understanding response variation (A.1). Gender, employment status, ethnicity, age and country of residence (England, Scotland, Wales) were modelled against ES factors using multiple regression. Four factors were included in the multiple regression analysis that explained high levels of variation and had high internal consistency. In addition, we included factors that were associated with high and low public values. Akaike Information Criterion (*AIC*) was used to compare

Table 1
Statements were developed to reflect the depth and breadth of the CICES 'Class'-level (version 5.1). Statements were divided between two stem questions to assess direct- and indirect-use values associated with British woodlands. Biotic and abiotic ecosystem services were included. Statements denoted with '*' represent both biotic and abiotic services, however were only asked once in the questionnaire. Statements were answered on a 5-point scale (direct-use values: 1 = very unlikely, 5 = very likely; indirect-use values: 1 = strongly disagree, 5 = strongly agree).

CICES Code	Questionnaire statement	
	Direct-use	Indirect-use
	Stem question: On this visit to the woodland or forest, how likely or unlikely are you to do the following? Please tick one option per statement. Remember this visit is taking place in the next couple of weeks.	Stem question: Please indicate how much you agree or disagree with each of the following statements about woodlands and forests in Wales, Scotland and England. Please tick one option per statement.
Provisioning (Biotic)		
1.1.1.2		Woodlands provide a source of timber for construction, fencing, firewood or fuel
1.1.3.1		Woodlands are not a location in which animals can be raised and used for food
1.2		Woodlands are not a source of genetic material (e.g. seeds, spores, animal, fungi, tree and plant varieties) which can be used for commercial purposes
1.1.5	Collect wood to burn	
	Collect all or parts of plants or trees or mushrooms for decoration, crafting, fencing, carving, games, enjoyment, sacred or spiritual activities, etc.	
	Collect all or parts of plants or trees (e.g. seeds, nuts, leaves, fruits, roots, stems, shoots, twigs, bark, pinecones) or mushrooms to eat or make drinks from	
1.1.6	Fish, hunt or collect animals or parts of animals (e.g. feathers, antlers, bones) for decoration, crafting, enjoyment, sacred or spiritual activities, etc.	
	Fish, hunt or collect animals to eat	
Regulation and maintenance (Biotic)		
2.1		Woodlands do not help reduce the smells, noises and visual appearance of industry, buildings, roads, etc.
		Woodlands help break down and filter waste and pollutants in the soil, water or air
2.2		Woodlands help reduce soil erosion, floods, storm surges, wind damage and landslides
		Woodlands help maintain soil quality
		Woodlands do not help maintain water quality
		Woodlands help regulate the global climate (e.g. through the removal of carbon dioxide from the atmosphere)
		Woodlands do not help reduce air temperatures in towns and cities
		Woodlands help reduce the spread of pests and diseases of plants, animals or humans
Cultural (Biotic)		
3.1.1.1	Eat (e.g. picnic, barbeque), sit or rest	
	Watch, look at, listen to, touch or smell trees, plants, fungi (e.g.	

(continued on next page)

Table 1 (*continued*)

CICES Code	Questionnaire statement	
	Direct-use	Indirect-use
	mushrooms, puffballs) or animals (including mammals, birds, butterflies and other insects)	
	Recreational fishing (not for eating or keeping), swim, paddle, kayak, canoe or other physical activities requiring water	
	Go for a walk, jog, cycle, ride horses or do other sports or physical activities not mentioned above	
3.1.2.2	Participate in research, or the generation of knowledge or data (e.g. taking part in a citizen science project, sharing observations with the scientific community) on trees, plants, fungi or animals	
	Participate in the generation, or passing down, of traditional knowledge on trees, plants, fungi or animals	
3.1.2.3	Learn more, or teach others, about trees, plants, fungi or animals	
	Visit the woodlands to experience your culture, history or heritage	
	Visit the woodlands to experience other cultures, history or heritage	
3.1.2.4	Visit the woodlands for their beauty	
	Take photographs, paint, draw or do another craft or artistic activity	
3.2.1.1		The trees, plants, fungi, animals found in woodlands do not have a cultural meaning
		The trees, plants, fungi, animals found in woodlands do not have a historical meaning
		The trees, plants, fungi, animals found in woodlands do not have a symbolic meaning
3.2.1.2	Engage in activities that have a sacred significance*	The trees, plants, fungi, animals found in woodlands have a sacred significance
	Engage in activities that have a religious significance*	The trees, plants, fungi, animals found in woodlands have a religious significance
	Engage in activities that have a spiritual significance*	The trees, plants, fungi, animals found in woodlands have a spiritual significance
3.2.1.3		Woodlands provide a setting for books, plays, paintings, drawings, TV programmes or films (e.g. horror movies, fairy tales, police dramas, nature documentaries)
3.2.2.1		Woodlands are important even if no-one visits them
3.2.2.2		Woodlands should be conserved for future generations
Cultural (Abiotic)		
6.1.1.1	Rock climb, boulder, explore caves or other physical activities requiring rock features	
	Participate in research, traditional knowledge, teach others, learn more about cliffs, rock formations, waterfalls, rivers, views or caves	
6.2.1.1		The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands do not have a cultural, meaning
		The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands do not have a historical meaning
		The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands do not have a symbolic meaning
6.2.1.2	Engage in activities that have a sacred significance*	The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a sacred significance
	Engage in activities that have a religious significance*	The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a religious significance
	Engage in activities that have a spiritual significance*	The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a spiritual significance

candidate models and identify the most parsimonious solution (Burnham et al., 2011). Models with a ΔAIC_c value of > 2 were excluded, with parameter estimates and r^2 values averaged across the $\Delta AIC_c < 2$ model set. All statistical analyses were undertaken in R (version 3.6.1) (R Core Team, 2020).

3. Results

3.1. Participant characteristics

A total of 198 participants completed the questionnaire (A.1). Participants represented both genders (53% female) and the mean age was 46 years old (range: 18–78 years). The majority of participants were White British (68%), employed (55%) and resided in England (88%).

3.2. Participant ES values

For the provisioning direct-use ES, a single factor emerged (interpretable as 'Direct Provisioning'; explaining 43% of the variation in the data) with all five statements loading (Table 2). Three factors emerged for CES direct-use values, interpreted as 'Direct Learning and Research' (19% of the variation explained), 'Direct Spiritual' (17% of the variation explained), and 'Direct Aesthetics' (12% of the variation explained). Just 10 of the 16 CES statements loaded onto these factors. Statements that did not load included those pertaining to physical activity (n = 3), visiting woodlands to experience culture, history or heritage (n = 2), and visiting to undertake artistic pursuits (n = 1). Internal consistency for all direct-use factors exceeded 0.7.

Six of the eight statements for indirect-use regulation and maintenance ES emerged as a single factor (Table 3), pertaining to 'Indirect Regulation and Maintenance' (38% of the variation explained). Neither *'Woodlands can reduce the spread of pests and disease of plants, animals or humans'* or *'Woodlands help reduce air temperatures in towns and cities'* met the loading threshold. For CES indirect-use values, three factors were apparent, interpreted as 'Indirect Spiritual' (30% of the variation), 'Indirect Symbolism' (20% of variation) and 'Other Indirect Cultural Values' (9% variation). The only CES indirect-use statement that did not load was *'Woodlands provide a setting for books, plays, paintings, drawings, TV programmes and films'*. All three indirect-use provisioning ES statements loaded onto a single factor, but it was disregarded due to low levels of internal consistency.

There were discrepancies between how people's values of different ES formed into factors compared to the structure of CICES. The

Table 2
Principal Axis Factoring with oblique rotation (oblimin with Kaiser Normalization), performed for values associated with direct-use ecosystem services. Three factors for cultural ecosystem services emerged, with a single factor for provisional ecosystem services. Statements that loaded onto each of the three factors at a cut-off loading value of > 0.45 and Cronbach's alpha of > 0.7 are included. Variation explained by each factor followed by mean reported values are shown.

CICES Section	Factor theme	% variation explained	Cronbach's alpha	Factor mean (±SE)	Statement	Loading
Provisioning	Direct Provisioning	43	0.78	1.83 (±0.06)	Fish hunt or collect animals, or parts of animals for decorations, crafting, enjoyment, sacred or spiritual activities	0.8
					Collect all or parts of plants or trees or mushrooms for decoration, crafting, fencing, carving, games, enjoyment, sacred or spiritual activities etc	0.7
					Collect all or parts of plants or trees or mushrooms to eat or make drinks from	0.7
					Collect wood to burn	0.7
					Fish, hunt or collect animals to eat	0.5
Cultural	Direct Learning and Research	19	0.86	2.62 (±0.07)	Participate in research, traditional knowledge, teach others, learn more about cliffs, rock formations, waterfalls, rivers, views or caves	0.9
					Participate in the generation, or passing down of traditional knowledge on trees, plants, fungi or animals	0.8
					Learn more or teach others about trees, plants, fungi or animals	0.7
					Participate in research or generation of knowledge or data (e.g. citizen science)	0.6
	Direct Spiritual	17	0.89	1.97 (±0.08)	Engage in activities that have religious significance	0.9
					Engage in activities that have sacred significance	0.9
					Engage in activities that have spiritual significance	0.8
	Direct Aesthetics	12	0.71	3.67 (±0.06)	Visit woodlands for their beauty	0.7
					Watch, look at, listen to, touch or smell trees, plants, fungi, or animals	0.6
					Take photographs, paint, draw or do another craft or artistic activity	0.5

Table 3
Principal Axis Factoring with oblique rotation (oblimin with Kaiser Normalization), performed for values associated with indirect-use ecosystem services. Three factors for cultural services emerged, with a single factor for regulation and maintenance services. Statements that loaded onto each of the three factors at a cut-off loading value of > 0.45 and Cronbach's alpha of > 0.7 are included. Variation explained by each factor followed by mean reported values are shown.

CICES Section	Factor theme	% variation explained	Cronbach's alpha	Factor mean (±SE)	Statement	Loading
Regulation and Maintenance	Indirect Regulation and Maintenance	38	0.81	4.29 (±0.04)	Woodlands help reduce soil erosion, floods, storm surges, wind damage and landslides	0.9
					Woodlands help maintain soil quality	0.7
					Woodlands help break down and filter waste and pollutants in the soil, water or air	0.6
					Woodlands help regulate the global climate	0.6
					Woodlands help maintain water quality	0.6
					Woodlands help reduce the smells, noises and visual appearance of industry, buildings and roads	0.5
Cultural	Indirect Spiritual	30	0.95	3.04 (±0.07)	The trees, plants, fungi and animals found in woodlands have a spiritual meaning	0.9
					The trees, plants, fungi and animals found in woodlands have a sacred meaning	0.9
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a religious meaning	0.9
					The trees, plants, fungi and animals found in woodlands have a religious meaning	0.8
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a spiritual meaning	0.8
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a sacred meaning	0.8
	Indirect Symbolism	20	0.85	3.92 (±0.05)	The trees, plants, fungi and animals found in woodlands have a historical meaning	0.7
					The trees, plants, fungi and animals found in woodlands have a symbolic meaning	0.7
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have cultural meaning	0.7
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodland have historical meaning	0.7
					The trees, plants, fungi and animals found in woodlands have a cultural meaning	0.6
					The cliffs, rock formations, waterfalls, rivers, views or caves found in woodlands have a symbolic meaning	0.6
	Other Indirect Cultural Values	9	0.73	4.65 (±0.03)	Woodlands should be conserved for future generations	0.8
					Woodlands are important even if no-one visits them	0.7

participants did not separate the ES beyond 'Division'-level for either direct-/indirect-use provisioning services, or indirect-use regulation and maintenance services. For CES, there was more refinement in the way statements loaded onto factors. The 'Direct Learning and Research' factor included statements from CICES 'Class'-level associated with education, science and heritage. This suggests that people's values reflect CICES at the 'Group'-level for '*3.1.2 - Intellectual and representative interactions with natural environment*'. However, the aesthetic component of this group loaded into the 'Direct Aesthetics' factor. 'Direct Aesthetics' also contained statements that, according to the structure of CICES, should be related to the 'Group' '*3.1.1 - Physical and experiential interactions with natural environment*'. Statements included in 'Direct Spirituality' mirrored the CICES 'Class' '*3.2.1.2 - Elements of living systems that have sacred or religious meaning*'. This continuity was also seen for 'Indirect Spirituality', although it incorporated both biotic and abiotic statements that are separated in CICES. Indeed, there was a lack of distinction between values associated with biotic and abiotic processes throughout, with these differentiated statements loading onto the same factors across all ES. The factor 'Indirect Symbolism' combined 'Class' '*3.2.1.1 - Elements of living systems that have symbolic meaning*' and '*6.2.1.1 - Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions*'. Finally, the 'Other indirect cultural values' factor included statements of both bequest and existence values, matching the CICES 'Group' '*3.2.2 Other biotic characteristics that have a non-use value*'.

We found considerable variability between the values participants held for ES factors (Tables 2 and 3). Of the direct-use values, participants were most likely to use woodlands for activities belonging to the 'Direct Aesthetics' factor (mean = 3.69, SE = 0.06). Conversely, activities in the 'Direct Provisioning' factor were least likely to be undertaken by participants (mean = 1.83, SE = 0.06). For indirect-use ES, statements relating to bequest, existence and entertainment services, falling into the 'Other Indirect Cultural Values' factor, were most highly valued (mean = 4.65, SE = 0.03). Values associated with 'Indirect Spirituality' were reported as the lowest (mean = 3.04, SE = 0.07).

3.3. Influence of participant's social characteristics on ES values

'Direct Provisioning', 'Direct Spiritual', 'Direct Leaning and Research' and 'Indirect Spiritual' were analysed as dependent variables. Across the four factors, 'Direct Spiritual' was influenced most significantly by social characteristics, with the ethnicity of participants accounting for 19% of the variation observed in the data (Table 4). Indeed, those from a White ethnic background were significantly less likely to use woodlands for activities that had spiritual, sacred or religious significance (Fig. 1). Ethnicity was also found to explain variation in 'Indirect Spiritual' (Table 5) and in 'Direct Learning and Research' activities (Table 6), although to a lesser extent (8% and 5% of the variation respectively). The likelihood of taking part in 'Direct Provisioning' activities was influenced by ethnicity and also country of residence. However, combined, these characteristics only explained 7% of the variation (Table 7).

Table 4
Multiple regression analysis identifying social characteristics explaining the variation in people's values of 'Direct Spiritual' ecosystem services. The most parsimonious candidate models with model averaged parameter estimates where $\Delta\ AIC_c < 2$, are shown. Participant's gender, employment status, ethnicity, country of residence and age were entered into the model (n = 198). Excluding age, all variables were categorical. Categorical variables were incorporated into the regression using dummy coding. A reference variable was chosen, and the significance of alternative social characteristics was calculated through comparison to the reference variable. Significant difference of social characteristics from reference characteristic is indicated for $p = 0.01$ (*); 0.001 (**); >0,001 (***). Parameter estimates are provided with standard errors.

Variable	Model			Model average
	1	2	3	
Intercept	1.76 ± 0.07	1.82 ± 0.09	1.69 ± 0.21	1.76 ± 0.12
Gender (ref: Female):				
Male	–	−0.15 ± 0.14	–	−0.15 ± 0.14
Ethnicity (ref: White):				
Any other ethnicity***	1.17 ± 0.18	1.21 ± 0.18	1.18 ± 0.18	1.19 ± 0.18
Age	–	–	0.01 ± 0.01	0.01 ± 0.01
AICc	503.31	504.29	505.29	
Akaike weight	0.38	0.23	0.14	
r^2	0.19	0.19	0.19	0.19

4. Discussion

There has been a paucity of work to understand how ES frameworks reflect public values and whether they can effectively unpick the particularities of ES values in different contexts. As national governments further adopt ES and natural capital approaches, there is a need to interrogate the ability of these generalisable frameworks to perform when we start to include public values of these ES at a sub-global level. Here we aimed to explore this using an established ES framework (CICES version 5.1) to investigate the values and understanding of a diverse public revealing some stark disparities.

Across all ES we found people's values represented higher levels in the structural hierarchy of CICES, with most mirroring the 'Group' (e.g. '*3.2 - Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting*') or 'Division'-levels (e.g. '*3.2.1 - Spiritual, symbolic and other interactions with natural environment*'), rather than the more specific 'Class'-level (e.g. '*3.2.1.1 - Elements of living systems that have symbolic meaning*'). This was particularly apparent for provisioning, and regulation and maintenance, services. This represents a difference between how the perspectives of experts align with those of the public. The high resolution of options provided using the CICES framework is considered an asset by decision-makers, allowing them to adapt the framework to a variety of contexts. From the perspective of scientific assessment, distinguishing ES into such fine-grained categories enables specificity and precision in accounting. Such refinement, however, does not appear to align with public values and understanding. This suggests that frameworks may be ill-equipped to deal with the nuance that people's values bring to the ES concept. As such, frameworks may be predicated on the wrong assumptions. An alternative argument may be that while researchers may advocate for the development of more resolved ES categories (Haines-Young and Potschin, 2018), we must recognise that, in some cases, further divisions may serve only to satisfy academic or policy/practice interest.

Complexity of values was apparent within CES, demonstrated by the number of factors needed to explain people's values. CES are conceptually complex and, as such, often considered difficult to classify and measure (Fish et al., 2016). Yet, despite being viewed as more intricate, people's values aligned relatively well to the expert-developed ES framework. This was the case with spiritual related values, which we hypothesised would divide into three distinct concepts: religious, spiritual and sacred values. Increasingly people in westernised cultures are defining themselves as spiritual but not religious (Berghuijs et al., 2013), with some authors proposing those individuals are using spirituality as a means of rejecting conventional religion (Zinnbauer et al., 1997). While some academic research centres on understanding the complexities that distinguish these services, in our study, participants interpreted them as the same. The perceived homogeneity of these services could be explained by individuals reporting low values associated with direct-use spiritual ES and consequently not recognising nuances between them.

A clear discrepancy in relation to CES was associated with physical activity. Being able to account for the values associated with natural spaces as a resource for physical activity is of interest to a range of stakeholders, including land managers (Moseley et al., 2018). This is particularly important when considering trade-offs with other services, for instance whether to prioritise conservation or recreation. CICES currently conceptualises physical activity as a single entity,

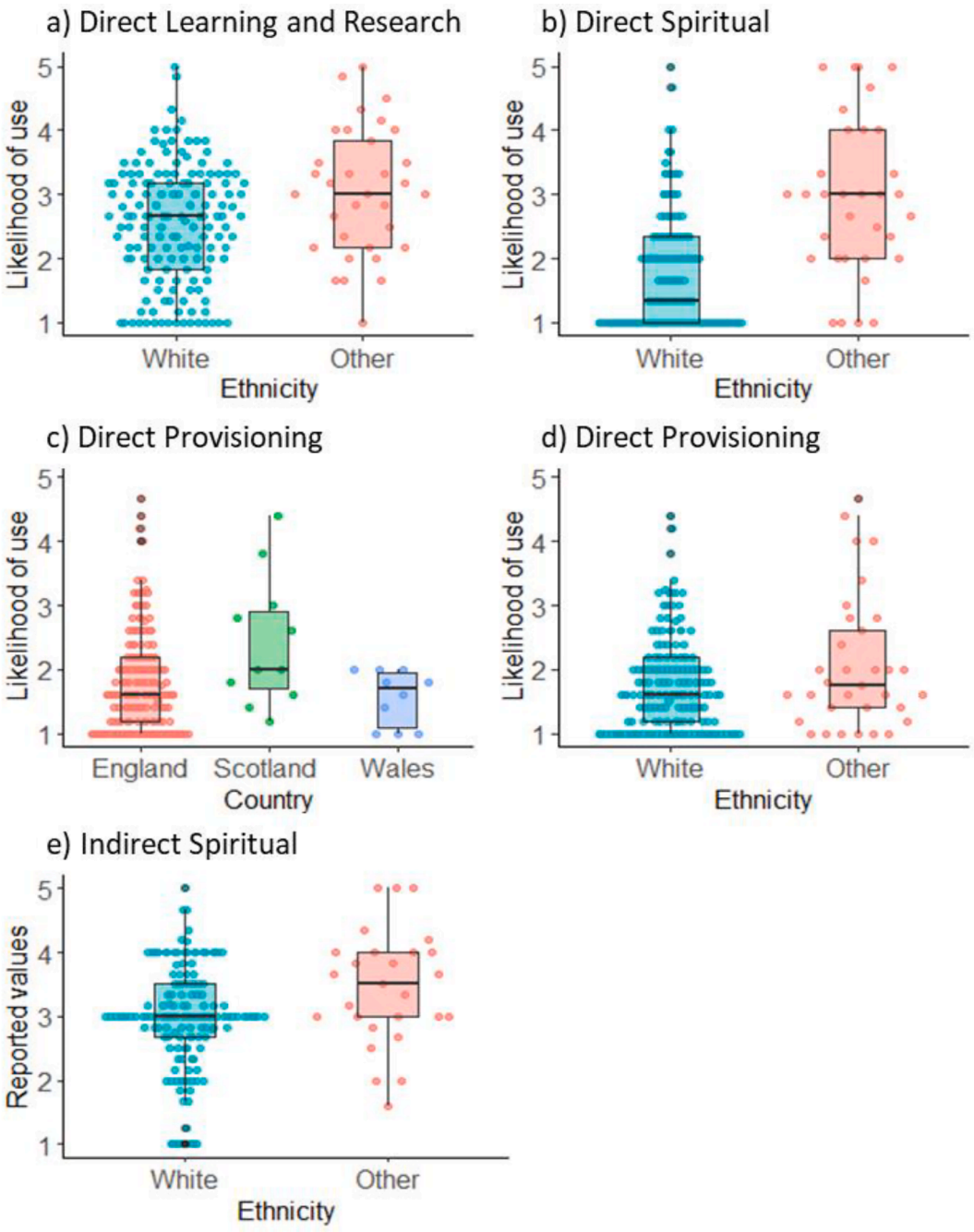

Fig. 1. Variation in values associated with ecosystem services and social characteristics. Plots depict differences between a) ethnicities for 'Direct Learning and Research', b) ethnicities for 'Direct Spiritual', c) country of residence for 'Direct Provisioning', d) ethnicities for 'Direct Provisioning', and e) ethnicities for 'Indirect Spiritual'. Box plot demonstrates the median value, inter-quartile range and upper and lower adjacent values. Kernel probability density of the data at different values is depicted, with points showing frequency of responses.

distinguished only by reliance on biotic or abiotic processes. Other ES frameworks take an analogous approach. While characterising physical activity in this way may be sufficient in some circumstances, it appears that it does not represent public values accurately. This may suggest that physical activity, although commonly considered a more straightforward CES to quantify, is multifaceted when we start to consider public values. Conversely to spiritual ES, physical activities were reported as one of the main ways people interact with the outdoors and, as such, individuals may be more likely to see differences between the categories. To accurately understand people's values about physical activity, researchers should consider expanding framework categories to provide a more nuanced framing that can capture the details of this dimension of ES. One way of doing this could be to provide a more comprehensive list of practices that more closely align with how people conceptualise physical activity. For instance, although mountain biking, cycling, walking, running and horse riding were all reported in UK woodlands, there is significant variation in the likelihood of undertaking these practices, their duration and intensity, as well as their value when measured against Quality Adjusted Life Years (Moseley et al., 2018). Likewise, practices involving wildlife, including fishing or bird watching, are viewed as distinct from human-orientated pursuits such as walking or running (Bullock et al., 2018). Evidently, this is an area of research that needs further exploration to ensure the portrayal of CES in ways that resonate with the way people understand them.

Table 5
Multiple regression analysis identifying social characteristics explaining the variation in people's values of 'Direct Learning and Research' ecosystem services. The most parsimonious candidate models with model averaged parameter estimates where $\Delta AIC_c < 2$, are shown. Participant's gender, employment status, ethnicity, country of residence and age were entered into the model (n = 198). Excluding age, all variables were categorical. Categorical variables were incorporated into the regression using dummy coding. A reference variable was chosen, and the significance of alternative social characteristics was calculated through comparison to the reference variable. Significant difference of social characteristics from reference characteristic is indicated for $p = 0.01$ (*); 0.001 (**); >0,001 (***). Parameter estimates are provided with standard errors.

Variable	Model					Model average
	1	2	3	4	5	
Intercept	2.46 ± 0.08	2.52 ± 0.08	2.42 ± 0.10	2.47 ± 0.09	2.47 ± 0.09	2.47 ± 0.09
Gender (ref: Female):						
Male	–	–	0.10 ± 0.14	0.11 ± 0.14	–	0.11 ± 0.14
Ethnicity (ref: White):						
Any other ethnicity**	0.59 ± 0.18	0.53 ± 0.18	0.57 ± 0.19	0.51 ± 0.18	0.55 ± 0.18	0.55 ± 0.18
Country (ref: England):						
Scotland	0.57 ± 0.29	–	0.57 ± 0.29	–	–	0.57 ± 0.29
Wales	0.29 ± 0.31	–	0.28 ± 0.31	–	–	0.29 ± 0.31
Age	–	–	–	–	0.01 ± 0.01	0.01 ± 0.01
AICc	501.22	501.45	502.81	502.92	503.02	
Akaike weight	0.20	0.18	0.09	0.09	0.08	
r^2	0.07	0.04	0.07	0.05	0.05	0.05

Table 6
Multiple regression analysis identifying social characteristics explaining the variation in people's values of 'Indirect Spiritual' ecosystem services. The most parsimonious candidate models with model averaged parameter estimates where $\Delta AIC_c < 2$, are shown. Participant's gender, employment status, ethnicity, country of residence and age were entered into the model (n = 198). Excluding age, all variables were categorical. Categorical variables were incorporated into the regression using dummy coding. A reference variable was chosen, and the significance of alternative social characteristics was calculated through comparison to the reference variable. Significant difference of social characteristics from reference characteristic is indicated for $p = 0.01$ (*); 0.001 (**); >0,001 (***). Parameter estimates are provided with standard errors.

Variable	Model		Model average
	1	2	
Intercept	3.39 ± 0.19	3.42 ± 0.19	3.41 ± 0.19
Gender (ref: Female)			
Male	–	−0.11 ± 0.12	−0.11 ± 0.12
Ethnicity (ref: White):			
Any other ethnicity**	0.45 ± 0.17	0.48 ± 0.17	0.47 ± 0.17
Age	−0.009 ± 0.003	−0.008 ± 0.003	−0.008 ± 0.003
AICc	418.24	419.60	
Akaike weight	0.44	0.22	
r^2	0.08	0.08	0.08

Table 7
Multiple regression analysis identifying social characteristics explaining the variation in people's values of 'Direct Provisioning' ecosystem services. The most parsimonious candidate models with model averaged parameter estimates where $\Delta AIC_c < 2$, are shown. Participant's gender, employment status, ethnicity, country of residence and age were entered into the model (n = 198). Excluding age, all variables were categorical. Categorical variables were incorporated into the regression using dummy coding. A reference variable was chosen, and the significance of alternative social characteristics was calculated through comparison to the reference variable. Significant difference of social characteristics from reference characteristic is indicated for $p = 0.01$ (*); 0.001 (**); >0,001 (***). Parameter estimates are provided with standard errors.

Variable	Model		Model average
	1	2	
Intercept	1.73 ± 0.07	1.91 ± 0.17	1.82 ± 0.12
Ethnicity (ref: White):			
Any other ethnicity*	0.33 ± 0.15	0.31 ± 0.15	0.32 ± 0.15
Country (ref: England):			
Scotland**	0.68 ± 0.25	0.74 ± 0.25	0.71 ± 0.25
Wales	−0.17 ± 0.26	−0.17 ± 0.25	−0.17 ± 0.25
Age	–	−0.01 ± 0.01	−0.01 ± 0.01
AICc	435.55	436.43	
Akaike weight	0.26	0.17	
r^2	0.06	0.07	0.07

Variation between different groups of people was predominately associated with ethnicity. A clear example of this is the values surrounding spiritual CES. We found that individuals of a White ethnic background report lower spiritual values for woodlands and are less likely to use woodlands for spiritual purposes than those from other ethnicities. ES literature is littered with examples of people holding diverse values (e.g. Kenter et al., 2015; Tadesse et al., 2014; Lau et al., 2019; Moutouama et al., 2019). Why this difference exists requires further study, but it highlights an important consideration for decision-makers. With societies becoming increasingly heterogeneous, variation in values of ES related to social characteristics must be taken into account by decision-makers to make effective choices about ES. Many ES studies are restricted by small sample sizes of very limited sectors of society (Fischer et al., 2018). Our findings reveal that this could be leading to inaccurate evaluation of ES values. It also reinforces the importance of including hard to reach groups, such as individuals from different ethnic backgrounds, in ES research. Studies where this is not feasible must be cautious of interpreting their results, especially when considering extrapolation of findings and making trade-offs between ES.

CES have been proposed to inspire "deep attachment in human communities" (Chan et al., 2011) and thus have been identified as important entry points to engage the public in environmental matters and grow support for ecosystem protection (Daniel et al., 2012). Researchers have critiqued ES frameworks for inadequately defining and poorly integrating CES, suggesting they act as a residual broad category after accounting for more tangible ES (Daniel et al., 2012). In contrast to this argument, findings from our study indicates that some services, such as spiritual CES, are well defined and mirror the public's values. Despite this, some services remain poorly captured by ES frameworks. This is most notable for CES pertaining to physical activities, which represents a significant challenge that still needs to be addressed in ES frameworks.

There is clearly a requirement for standardised and robust ES frameworks. They play a significant role in decision-making and help translate the importance of ES to a variety of different audiences. Yet, ES frameworks should not be considered static and infallible entities. Expert derived hierarchical frameworks may improve the ease of use and adaptability, but they may not account for the intricacies and particularities of people's values. Overlooking these particularities that underpin public values of ES risks incorrectly valuing services, leading to poor decision-making about natural resource management. ES frameworks like CICES are intended to be universally applicable,

generalisable approaches. However, the challenge moving forward is for ES frameworks to strike a balance between generality and specificity. The complexities of economic, cultural and social values remain seldom incorporated into decision-making processes (Costanza et al., 2017). For instance, the proposed sell-off of publicly-owned forests in the UK revealed that public values for the environment had been largely ignored by politicians responsible for the decision (Irvine et al., 2016). Similarly, private owners of woodlands often hold views regarding the provision of public goods from their property which are at odds with those of wider society, leading to mismatches between how the public might want woodlands to be managed, and their actual management (Urquhart et al., 2010). Frameworks must be able to account for the variety of views, values and contexts that govern ES valuation. Decision-makers need to recognise and be cautious of these variations and complexities when interpreting outputs and considering trade-offs. While generalised approaches are an asset to ES frameworks, particularities must not be overlooked if we are to ensure the accurate portrayal of the benefits we derive from nature.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendices

A.1. Social characteristics of questionnaire participants (n = 198).

Variable	n	%	Variable	n	%
Gender:			Employment status:		
Female	105	53	Employed	109	55.1
Male	92	46.5	Self-employed	26	13.1
Prefer not to say	1	0.5	Unemployed	9	4.5
Ethnicity:			Retired	36	18.2
White British	135	68.2	Student	14	7.1
White Other	22	11.2	Prefer not to say	4	2
Any Asian	10	5	Household income:		
Any Black	16	8.1	Under £5,199	2	1
Other	11	5.5	£5,200 - £10,399	4	2
Prefer not to say	4	2	£10,400 - £15,599	9	4.5
Country:			£15,600 - £ 19,799	12	6.1
England	175	88.4	£20,800 - £25,999	14	7.1
Scotland	13	6.6	£26,000 - £31,199	19	9.6
Wales	10	5	£31,200 - £36,399	18	9.1
			£36,400 - £51,999	29	14.6
			£52,000 and above	37	18.7
			Prefer not to say	54	27.3

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