Forest Research

Cultural ecosystem services and benefits: Indicators for forests, trees and woodlands – a review

Mark Atkinson and Liz O'Brien 2019

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1. Introduction

Functioning ecosystems deliver a broad range of benefits to humans. The ecosystem services framework has been increasingly adopted as a conceptual tool to aid decision-making, planning and management of ecosystems with respect to the multiple benefits which they provide. Of scientific interest since the 1970s, ecosystem services have become increasingly prominent in shaping environmental policy. The United Kingdom National Ecosystem Assessment (UK NEA; UK National Ecosystem Assesment, 2011) concluded that ecosystems, including trees, woodlands and forests are important to human wellbeing and economic prosperity.

Alongside provisioning, regulating and supporting services, cultural ecosystem services (CES) encapsulate a range of benefits ecosystems provide to humans. Indeed, the cultural and social benefits humans derive from ecosystems may be among the most valued of all the services that ecosystems provide. Nonetheless until relatively recently, CES were conceptually under-developed and researchers, policy makers and environmental managers faced barriers in their adequate measurement and monitoring. Underlying this problem was the widely held and frequently reiterated view that CES were by nature "intangible" and therefore intrinsically difficult to measure. Nonetheless, in recent years, research into CES has gained momentum. The UK NEA Follow-On (UK NEAFO; UK National Ecosystem Assessment, 2014) developed new frameworks in which to understand CES and to guide the development of indicators for decision and policy-making contexts.

This report identifies and critically assesses available indicators of CES for trees, woodlands and forests (TWF). CES encompass a broad set of social practices as they occur in natural environments. These practices such as walking and foraging give rise to a diverse range of benefits, which are relevant to a number of potential stakeholders, all of who may engage with the practices and environments in different ways and at different levels. This complexity of engagement and practice occasions the need for effective indicators, which capture a broad range of services and benefits. At present, the indicators which inform policy makers and decision makers do not encompass this breadth. This lack of information may impede the ability of policy, management and decision-making to effectively monitor and value particular ecosystem services and in some cases, specific environmental spaces themselves. Effective CES indicators are therefore critical in valuing nature. One example of the need to capture broader indicators of CES and their benefits is the case of substitutability of ecosystem services. Services such as timber production, carbon regulation or even physical health and wellbeing via recreation opportunities can arguably be substituted, such that they can be provided by an alternative space when diminished in another. Some CES however, may be less amenable to substitution including those providing heritage value, spiritual connections and sense of place.

Developing indicators for CES in TWF shares many of the challenges found with other natural environments. However, opportunities do exist in the context of forestry to develop useful indicators. For example, the latest cycle of the UK National Forest Inventory has collected rich data on social and recreational use as well as features in forest and woodland areas that are of cultural and heritage value. In addition, forestry has a long relationship with the arts and humanities and from this has emerged creative practices and participatory dialogues that have expressed values associated with TWF. Capturing the full range of CES is a challenge for researchers, policymakers and practitioners. In particular, the possibility of developing quantitative indicators of the kind that could be integrated with other aspects of the ecosystem services framework has been challenged. Nonetheless, a growing literature is addressing methodological, conceptual and practical difficulties with CES indicators and posing solutions and future directions. This report reviews a range of literature that has used indicators of CES relevant to TWF, in order to identify and assess these indicators as well as the data available to support the use of these indicators.

This review addresses the following specific research questions:

- What CES indicators are and could be used to capture the tangible and intangible CES provided by TWF?
- Is there existing data being collected that provides useful information on the CES provided by TWF?
- Which indicators and supporting datasets could be used to capture a wider range of ecosystem services and benefits provided by TWF?

The report will discuss the conceptual underpinnings of CES and principles / evaluation criteria for the development of effective indicators. It will then describe indicators for the supply and demand of CES, focusing on access and quality of greenspaces with trees where services can be generated via their interaction with social practices. The availability of indicators for the wide range of benefits people gain from CES will be explored. Finally, the report discusses the range of ways that people engage with TWF and barriers they may face in engaging more closely and physically with these spaces.

2. Review methods

Table 1 shows the search terms used in the literature review. Scopus, Google Scholar and Google were used to identify both academic and grey literature. Articles were imported into Mendeley and key characteristics of relevant articles were input into a spreadsheet for data analysis and review. Scopus and Google Scholar searches identified 126 peer reviewed academic articles. Of these, 89 research articles and 21 review articles were relevant and met the criteria for further review. The searches also revealed 13 "grey" literature articles, which were included as relevant to the development of CES indicators, including UK NEA and UK NEAFO and Forest Research reports.

The following inclusion and exclusion criteria were used to ensure relevant evidence was gathered:

- English language articles only
- 2005 to present
- Only include articles that address the research questions
- Search for article title, abstract and keywords
- Include grey literature where relevant as well as academic papers
- For topic areas with large amounts of evidence use articles that are reviews of evidence or meta synthesis / meta-analysis
- Include UK NEA, UK NEAFO and Forest Research reports even if they do not come up through the Scopus searches.

In addition to literature identified through the searches, a workshop was held with members of the Forest Research Land Use and Ecosystem Services group and the Social and Economic Research Group to identify further relevant work that had been undertaken on the development of indicators for CES. This identified further recent outputs under review or recently published on CES indicators, particularly in the areas of mapping supply and demand for these services, indicators from the arts and humanities, as well as the development of a health indicator for recreation.

Table 1. Indicative terms and key words used for database searches

cultural ecosystem	AND	quantitative OR qualitative OR monetary* OR economic	AND	benefit* OR value* OR service*	AND	indicator*

3. Understanding cultural ecosystem services

3.1. Conceptual basis of CES

The UK NEA recognised the importance of the social and cultural relationships, which humans have with ecosystems in the UK. CES frameworks attempt to understand the complex ways in which cultural practices and natural environments interact and how these shape and are shaped by human benefits and values. The challenge of developing conceptual frameworks to understand CES – and then guide the development of suitable indicators is also widely recognised.

A number of approaches to CES have now tried to integrate the concepts of cultural ecosystem services, benefits and values. These terms are often used interchangeably in the literature; however, some common approaches have emerged to distinguish these concepts (O'Brien, Morris and Raum, 2017). CES refer to socio-ecological processes, which generate human benefits. Ecosystem benefits are the wide range of cultural goods that emerge via these services. Finally, ecosystem values refer to core and enduring concepts of worth, which are attached to benefits. To illustrate further, forest-mountain biking is a CES consisting of the physical activity of bike riding along trails (i.e. practice) in forest and woodlands (i.e. spaces). This service gives rise to a range of benefits associated with physical and psychological health, as well as restorative benefits and connection to the space. In addition, there may be benefits to the economy via enterprise at forest mountain bike centres or social connections through clubs and meetups. Finally, these benefits are attached to cultural ecosystem values, according to enduring ideas of human worth. Health, social connections and enterprise can all be valued using a monetary framework (for example, via public savings in physical and psychological healthcare as well as direct enterprise income). Alternatively, value frames might emphasise human well-being and quality of life, or the intrinsic value of connection and relationship with the forest. Importantly for the development of indicators of CES, ecosystem values influence and define priorities for the way in which services and benefits are measured.

In general, cultural ecosystem benefits can be valued in multiple ways – although it is clear that some are more amenable to certain kinds of valuation than others are. For example, physical health benefits from green exercise can be valued economically or in terms of their contribution to global wellbeing. On the other hand, employment in environmental spaces can contribute to wellbeing, whilst also providing a monetary income. Indicators of economic benefits are frequently monetarised and this is often an appropriate metric for them (though they can still fail to encompass wellbeing benefits from economic benefits such as employment opportunities and security). On the other hand, it has been argued that in the case of for example, aesthetic and spiritual

heritage, monetary indicators may fail to encompass the value of these benefits, which are shared and often realised and identified through deliberative practices (Edwards, Collins and Goto, 2016a). The UK NEAFO elaborated on earlier work by the UK NEA, which adopted and developed these concepts to describe a framework for CES. This framework emphasised an "environmental spaces" approach and specifically, the interaction between these spaces and people (Tratalos *et al.*, 2016).This report uses the UK NEAFO framework to conceptualise CES and benefits associated with TWF, depicted in Figure 1. CES constitute geographical contexts (environmental spaces), which host human activity (cultural practices). It is this interaction between cultural practices in forests, woodlands and greenspaces with trees, which give rise to cultural ecosystem benefits for humans (O'Brien *et al.*, 2017). As depicted in Figure 1, as well as being enabled by CES, cultural ecosystem benefits can shape both cultural practice and environmental spaces. In addition, environmental spaces and cultural practices interact such that practices shape the environments, which enable the practices. This model is adopted in the subsequent discussions of CES indicators.

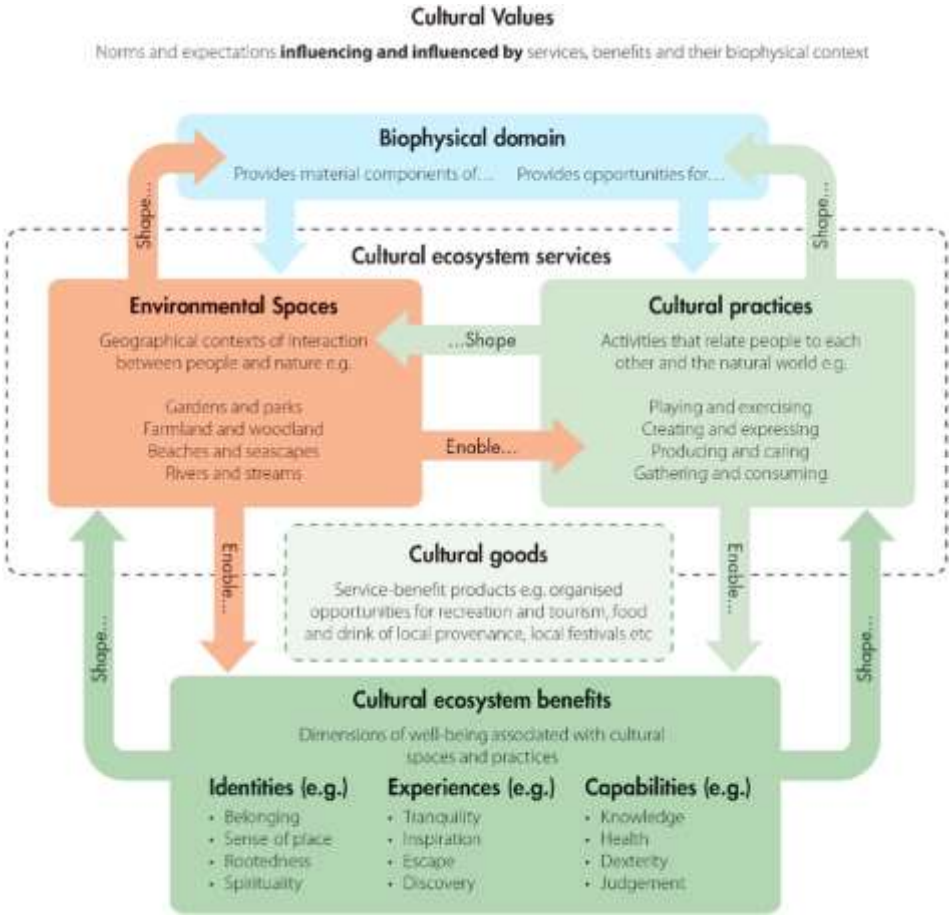

Figure 1. Cultural ecosystem services conceptualised as the interaction between environmental spaces and cultural practices that can give rise to cultural ecosystem benefits (Fish, Church & Winter., 2016).

3.2. Indicators for CES

A range of criteria now exist to guide the development of effective environmental indicators. Over 20 years of research has led to agreed internationally accepted criteria for the general development of robust environmental indicators and specifically in the context of forestry and forest management (e.g. Forest Europe, 2016; The Montreal Process, 2015; UKNEAFO, 2015). These criteria are that indicators should be:

- Simple to explain to policy-makers and public stakeholders
- Relevant to important values and serving a useful purpose in policy and decision making
- Easy to implement consistently, allowing comparison and consistency over spatial and temporal scales including ideally, international comparison
- Cost-effective, using available data where possible and not limited by budget or technical barriers
- Scientifically justified for the indicator's use and have a clear agreement of its definition and interpretation without ambiguity or need for explanation
- Used to set objectives and priorities, stimulate debate and develop community level strategies and agreements
- Used to increase awareness, partnership working and shared ownership/joint action
- Important and meaningful in their own right.

Frequently another criterion is also added; that indicators should be quantifiable. Quantifiable indicators of ecosystem services are desirable for two principle reasons:

- They can be integrated with other environmental indicators and measures for example, by being able to assess trade-offs between ecosystem services and ecosystem health
- They can be integrated with economic metrics and are amenable to monetarisation and economic valuation.

It would be fair to say that both these attributes of quantitative indicators are thought to be advantageous in policy, decision-making and management. Both integration and monetarisation are important components in assessing and communicating the relative value of different ecosystem services.

However, despite quantitative indicators having a central role in policy contexts a growing literature is emerging, which suggests that qualitative indicators are critical to effectively utilising the ecosystem services approach in policy and decision-making. For the ecosystem services framework as a whole, benefits that are derived from

provisioning, supporting and regulating services encompass, among other things human wellbeing. In the case of CES, human social and cultural practices and the interplay of these practices with environmental spaces also constitute ecosystem services themselves. Qualitative indicators, which are designed to deepen understandings of cultural practices in local contexts and require primary data collection, can be time and cost-intensive to develop. However, qualitative measures can additionally be derived from existing data. One example of this is the analysis of text and material culture, which has a long history in the arts and humanities. Some online sources of data, for example social media posts, discussion forums or reactions to the media can also be analysed qualitatively. Indicators developed from these data may in some contexts, be participatory and deliberative. Both qualitative and quantitative indicators can often be spatially represented using Geographic Information Systems (GIS) approaches.

4. Indicators of cultural ecosystem services from trees, woodlands and forests

4.1. Supply

Supply related indicators of CES focus on the measurement of environmental spaces, which support particular social and cultural practices in TWF. They can be measured through percentage cover of relevant environmental spaces (Ambrose-Oji and Pagella, 2012; Blancas *et al.*, 2013). Ideally, these will encompass a range of environmental spaces reflecting the wide degree of engagement people have with TWF and this approach was adopted by the UK NEAFO (UK National Ecosystem Assessment, 2011).

Useful datasets which inform measures of supply indicators are available for forests and woodlands, as well as rural, urban and peri-urban greenspaces and designated areas with trees (Nesbitt *et al.*, 2017; O'Brien *et al.*, 2017). The UK National Forest inventory (NFI), including the small woods survey, provides estimates of broadleaf woodland, coniferous forest and tree cover for the UK. The UK NEAFO demonstrated that supply indicators could be calculated for a number of other relevant environmental spaces. Data is available to measure presence of country parks, designated areas (which include Areas of Outstanding Natural Beauty, Special Sites of Scientific Interest, Local and National Nature Reserves, Nature Improvement Areas, Ramsar wetlands, Special Areas of Conservation and Special Protection Areas), and National Parks (UK National Ecosystem Assessment, 2014).

As with other ecosystem services, CES depend upon their accessibility as well as their socio-ecological health (quality) in order to enable their associated benefits to be realised (Morris *et al.*, 2011; O'Brien and Morris, 2013). Indeed the interaction of

cultural practices and environmental spaces depends upon social access and the spaces themselves effectively supporting socio-cultural practices. CES access and quality therefore determine their supply. In the UK, the NFI records data on a range of natural and social attributes that can be used to measure indicators of CES supply in forest and woodland areas. A number of these measures are present in European and international NFIs. Nonetheless, the present 5th cycle of NFI data collection in the UK is perhaps the most comprehensive source for the development of indicators relevant to CES in TWF (Atkinson et al., under submission). A challenge for the measurement of CES demand for TWF is comprehensively capturing the supply from trees outside of woodlands (Schnell, Kleinn and Ståhl, 2015). Many natural spaces with trees that are delivering CES, will not be encompassed by the NFI, which considers 0.5 ha, with width of 20m and with the potential to achieve 20% crown cover as the threshold definition for woodland. Alongside the NFI, the Forestry Commission administers a survey of trees outside of woodlands which can be used to estimate tree cover outside of woods and forests; however, this survey does not collect the full range of cultural and biophysical data present in the NFI. Nonetheless, indicators of culturally relevant features can be derived from Ordnance Survey GIS labels. Other datasets are available to support the presence of services such as sporting facilities and public access/rights of way.

4.1.1. Quality

Quality indicators encompass the attributes and characteristics of environmental spaces that facilitate or impede relevant cultural practices. Whilst cultural practices themselves shape and define environmental spaces and cultural value is not integral to them, a substantial body of research supports the view that social and natural features of these spaces can influence the benefits derived from them.

4.1.1.1 Size

An indicator of size for forest and woodland cover can be measured using NFI data, which reports discrete size categories for woodland areas (National Forest Inventory, 2011). In the case of greenspaces with trees outside of woodlands, discrete patches can be calculated using GIS depending on whether it is possible to move from one grid square to an adjacent where tree cover is also present. For example, this method could be used to estimate the length of walking or cycling routes with tree cover or the size of tree cover within urban and peri-urban greenspaces (Church *et al.*, 2014).

4.1.1.2 Social opportunities and facilities

The present cycle of the NFI measures the presence of a range of recreational and social facilities. Recreation specific transport features (including Public Rights of Way (PWR), mountain bike trails, formal and informal paths and bridleways). A number of recreational and social facilities are also indicated including educational facilities, camping, and furniture, signage, and visitor centres.

4.1.1.3 Natural and cultural features (including biodiversity)

The UK NFI is the most comprehensive dataset measuring the biophysical characteristics of UK forests and woodlands. These data contain measures of biodiversity, as well as species, the presence of fire damage, which can all be used to derive indicators of natural quality. The field survey takes place over a 5-year cycle period of fieldwork. A representative sample of 15,000 one-hectare plots is visited by surveyors. The most recent cycle of surveying contains data pertaining to natural and cultural features in forest areas and indicators of biodiversity such as lying deadwood, and species variability. Each NFI sample plot records the presence of veteran and heritage trees, ancient woodland, linear features of cultural value and culturally-relevant forest management practices. It is important to note that although some measures of biodiversity may function as indicators for the supply of CES, species richness may only be one of several possible natural features that predict CES benefits, alongside sensory factors such as colour and general abundance of particular plant species (Graves, Pearson and Turner, 2017).

4.1.1.4 Sensory and environmental pressures

Strategic noise maps are produced by the Department for Environment, Food and Rural Affairs (DEFRA) and spatially locate noise from road and rail sources in the UK (https://www.gov.uk/government/publications/open-data-strategic-noise-mapping). Noise from traffic or other anthropogenic sources can be a significant sensory stressor, with the potential to degrade the quality of experience in natural environments (Gramann, 1999; Mace, Bell & Loomis, 1999). Recent work in behavioural science has also indicated that features of the built environment can be a source of visual stress, when compared to natural environments (Le *et al.*, 2017). Natural environments and greenspaces, which are dominated by the visual perception of the built environment may therefore, impede tranquillity in natural spaces (e.g. De Valck *et al.*, 2016). Little work has yet addressed the development of indicators for the presence of visual stressors in natural environments or tested the impact of these features in CES supply and subsequent benefits. However the use of viewshed (computational approximations of views using GIS inputs) methods that identify views of valued natural features could be used to map visual stressors in environmental spaces (Tenerelli, Püffel and Luque, 2017; Yoshimura and Hiura, 2017).

4.1.1.5 Social pressures

Social stressors include the presence of litter or abuse, crime and anti-social behaviour or dangerous recreational activity. Again, the latest cycle of the UK NFI maps the presence of litter in forest and woodland areas, as well as any dangerous recreational activity encountered by surveyors. Crime maps are also available UK-wide, and at local authority level (https://www.police.uk) to identify areas and levels of crime activity that could be a barrier to CES.

4.1.2. Access

4.1.2.1 Population-centred approaches

Indicators of accessibility are important for understanding whether CES are available, particularly at the local level. Natural England and Natural Resources Wales (formerly the Countryside Council for Wales) (ANGSt; Natural England, 2010) criteria and methodology has been adopted to calculate access to public greenspace, across different size and criteria. The Accessible Natural Greenspace Standard (ANGSt) calculates the proportion of the population in a particular area with access distance to different class sizes of greenspace. The recommendations are:

- No person should live more than 300m from their nearest area of natural greenspace of at least 2ha in size
- At least one accessible 20ha site within 2km of home
- One accessible 100ha site within 5km of home
- One accessible 500ha site within 10km of home
- Provision of at least 1ha of Local Nature Reserve per 1,000 people

The Woodland Trust augmented the ANGSt recommendations with the Woodland Access Standard (The Woodland Trust, 2010), recommending the following with which to develop accessibility indicators:

- That no person should live more than 500m from at least one area of accessible woodland of no less than 2ha in size
- That there should also be at least one area of accessible woodland of no less than 20ha within 4km (8km round trip) of people's homes

4.1.2.2 Area-centred approaches

In addition to assessing population access to environmental spaces, accessibility indicators can be calculated across areas of woodland, forest or green places. The latest cycle of the UK NFI reports distance to the nearest built-up/urban area across the entire forest and woodland area (it is of note that the same technique has also be applied as an indicator of greenspace quality, where areas further away from settlements are higher-quality "wilderness" spaces (Schröter *et al.*, 2017). Additional NFI data which pertain to accessibility of a forest region and for which estimates can be generated across areas of UK woodland, include distance to the nearest public road, the presence of car parking and whether an area is accessible by foot (Baum, Cumming and De Vos, 2017; Nahuelhual *et al.*, 2017). Some physical and topographical features may also prohibit accessibility of forest areas such as the presence of extreme slopes and gradients. These features are further recorded in UK NFI surveying. In addition to accessibility, *access* refers to the legal rights of the public to enter woodland. The Woodland Trust published

data on this via the Space for People project (The Woodland Trust, 2010), in reference to woodland and forest sites with unrestricted open access or restrictive but permissive access (e.g. a fee must be paid or access is within fixed hours or by permission only).

4.2. Demand

Demand indicators measure the degree to which people make efforts to, or desire to access TWF. On the demand side, measurement focuses on the characteristics of the local population, travel habits and preferences for particular cultural and social practices. At the local level, questionnaires can measure CES through travel habits and preferences for particular activities and cultural practices. Willingness to pay, or actual incurred travel and access costs are sometimes suitable indicators of CES demand for TWF site visits and recreation, but can be problematic as those who travel on foot or by bicycle would not be included if demand focused only on these methods. It might also provide an inaccurate picture showing greater demand from higher socio-economic groups that are spending more to travel to sites or willing to pay more to access them.

Geotagged social media data can also be used as a proxy for visitation and therefore CES demand. In particular, the number of shared photographs in a particular area has been shown to correlate with visits to environmental spaces. In addition to social media other activities which generate global positioning system (GPS) data might also be used to measure the demand of particular sites. For example, geocaching – a worldwide outdoor game where people hide and seeks GPS located "caches", has been used to investigate recreational CES (Cord, Roeßiger and Schwarz, 2015)

Two UK datasets are particularly useful for mapping demand for CES in TWF. First Natural England, DEFRA and the Forestry Commission manage the Monitoring of Engagement with the Natural Environment (MENE; Natural England 2017). This survey collects data on respondent's visits to environmental spaces in the previous week, with around 800 surveys per week being undertaken since 2009 and with 45,000 interviews undertaken per year. This survey collects information on site visit preferences, preferred activities, transportation as well as motivations and barriers to visits. The survey is currently being reviewed and there may be some changes made to it in the future in terms of both what data are collected and how. Finally, the latest cycle of the NFI has for the first time indicators of social and recreational use across the entire inventory sample (although such use does not occur in every area). This is a promising new dataset for mapping and estimating social and recreational demand across the UK, alongside supply of CES through biophysical, recreational and cultural indicators.

While the concept of CES demand is well established (e.g. Peña, Casado-Arzuaga and Onaindia, 2015; Arbieu *et al.*, 2017; Yoshimura and Hiura, 2017), many methods of measuring demand use site visits. This can exclude groups where there may be a strong demand to visit TWF but due to lack of transport, location, accessibility, quality of spaces people are able to visit less frequently. Surveys such as MENE have value in capturing

where there is demand to visit TWF (and where doing so would give rise to cultural ecosystem benefits) but actual visits are low due to prohibitive factors. These factors are typically specific to certain groups who due to socio-economic barriers may lack the means to visit a site otherwise considered accessible and in demand (see section 6.2).

5. Indicators of cultural ecosystem benefits in trees, woodlands and forests

Indicators for cultural ecosystem benefits focus on the value and benefits arising from CES. At some level, there is considerable overlap between environmental spaces, cultural practices and their associated benefits and values. For example, the occurrences of cultural practices which take place in TWF are themselves indicators that particular practices in environmental spaces are valued. Thus, sites of cultural interest within TWF or preferences for activities in natural environments may both be indicators of the value of CES. Nonetheless, there is an interest from a broad range of stakeholders, managers and decision makers in understanding and communicating the benefits of cultural practices which occur in natural spaces. To support, there is a need to express CES by a metric of value, which is independent from the practices themselves. For example, the practice of cycling for recreation in forest areas may give rise to a range of benefits, including revenue generated in cycle hire, positive cardiovascular health outcomes, psychological benefits including increases in mood and positive affect and social benefits if the activity is undertaken with others (O'Brien and Forster, 2017)

O'Brien and Morris (2013) identified a range of goods and benefits relating to TWF and these are depicted in Table 2. Evidence suggests that priorities in policy and decision-making have favoured particular forms of valuation (see discussion in section 3.2). Few, if any studies include the full range of benefits and it is rare for indicators to be developed around benefits such as for example, sense of ownership, place or escape and freedom. The ecosystem services literature has frequently approached this issue by questioning whether the "intangible" nature of certain benefits precludes robust valuation. Against this claim, a number of studies have now demonstrated ways to produce indicators for CES benefits that are thought intangible or difficult to capture/measure, such as sense of place and well-being. A second objection to the claim of intangibility relates to other ecosystem services. Whilst provisioning and supporting services are typically thought to be more amenable to developing robust quantitative indicators including economic valuation, they do give rise to a range of benefits beyond those that can be captured in purely economic terms. For example, regulating services including forest flood mitigation can benefit wellbeing and psychological health through increased home and business security. Similar benefits arise from assurances around provisioning services, including food and timber production.

Table 2. CES benefits for TWF identified in a meta-synthesis of 31 qualitative studies (taken from O'Brien and Morris, 2013)

ES category	Value categories	Value types
Trees and woodland as important environmental spaces **i.e. destination woodlands with facilities, local woods, community woods, parks, street trees, trees as part of green infrastructure, copses etc.**	Health	Physical well-being
		Mental restoration
		Escape & freedom
		Recreation, enjoyment & fun
	Nature / landscape connections	Sensory stimulation
		Nature connectedness, biodiversity
		Landscape improvements
		Screening / Shelter
		Gathering non timber forest products
		Sense of place
	Education / Learning	Personal development
		Education / learning
	Economy	Livelihoods
		Contribution to local economy
	Social Connections	Strengthening / building existing relationships
		Building new relationships
		Participation & capacity building
	Cultural and spiritual significance	Symbolic / Cultural / Historic
		Sense of ownership
		Meaning and Identity
		Religious, spiritual, artistic inspiration

Natural Capital accounts published by Forestry Commission England for the public forest estate in England demonstrate the issue of trying to capture the full range of ecosystem benefits with a single (monetary) metric for valuation (Forest Enterprise England, 2016, 2017). The reports acknowledges that adequate methods for economic valuation for services such as flood mitigation, and a range of cultural CES have not yet been developed. In addition to methodological barriers, economic indicators for ecosystem benefits have been criticised for failing to capture ecosystem service benefits and values which are shared among people situated in particular places.

Many now argue that monetary and non-monetary quantitative measures, qualitative, deliberative and participatory approaches are essential to provide indicators for a wider range of ecosystem benefits (O'Brien, Morris and Raum, 2017). For many stakeholders managing TWF, indicators to quantify these spaces' wider cultural ecosystem benefits are not currently integrated into corporate reporting. For example, Forestry Commission England measures supply and demand measures of CES via number of visits to TWF and active (e.g. organisational and voluntary) engagement with them but wider benefits, which derive from these activities, remain unaccounted for (Forestry Commission England, 2018; Atkinson and Edwards, 2018). Employment indicators for CES encompass current employment rates, employment availability and stability as well as income. In the CES literature, these indicators measure employment linked to recreation and leisure (Liquete *et al.*, 2013; Roly *et al.*, 2017) but may also encompass employment within culturally relevant provisioning services (Mononen *et al.*, 2016). For employment rates in TWF, the ONS annual business survey measures employment in Forestry and in primary wood processing at a national level.

Property prices have also been examined to develop indicators of the local contribution of economic benefits from CES. Specifically, the hedonic price method (HPM) models property sales from characteristics and attributes that properties have in relation to relevant environmental spaces and this has been employed to value CES. Sander & Haight (2012) employ a HPM model, which includes property access to environmental and recreational spaces, tree cover and quality of environmental spaces in the quality and extent of the home's viewshed as predictors of change in home's sale prices and therefore an economic valuation of these predictors. In addition, the time properties spend on the market, rental prices and property taxations can be used as outcome variables of market value for properties in their relations to environmental spaces (Boerama et al., 2017; La Escobedo et al., 2014; Nesbitt et al., 2017; Pakzad et al., 2017).

In contrast to land value and employment rates / income, some CES benefits that are not directly economic in character as such may be amenable to economic valuation. Examples of services frequently valued in monetary terms include income from recreation, tourism and travel, as well as health benefits. However, it is of note that there is a danger with many of these benefits of "double counting" and the same benefit

being expressed by two metrics of valuation (Satz et al., 2013). This issue is however; not limited to the case of CES and indeed many provisioning and regulating services can be double counted when there are material or systemic benefits in addition to a monetary one or when there are a number of intermediary services in a process prior to the final product (Fu et al., 2010). Benefits such as social connections, cultural and spiritual significance and nature / landscape connections present a greater challenge to monetarisation. In the case of these benefits, data is not always available to measure indicators nor are there well-developed methods to attain a financial value from such data.

In these cases, research has employed deliberative methods to identify the relative value of different ecosystem services, including a broad range of CES. Nonetheless, due to barriers in the quantification and monetarisation of some of these services, they are frequently excluded from comparative assessments of ecosystem services and therefore assessments of ecosystem service trade-offs in planning and decision-making. Despite this trend, a number of studies in the literature have provided frameworks and examples of ways to integrate deliberative approaches with a range of stakeholders, alongside quantitative and economic indicators (O'Brien et al., 2017; Morris et al., 2011; Boerema, 2017). A number of studies in the literature employ revealed preference or deliberative methods, or multi-criteria analysis to value CES, where easily available quantitative indicators are not present (e.g. Barkmann *et al.*, 2008).

Indicators which measure health benefits from CES are also frequently employed in the literature. Health encompasses physical and psychological benefits, as well as more general wellbeing from outdoor activities including leisure, enjoyment and escape. Recreation from tourism and leisure visits to TWF also encompass the most widely measured quantitative indicators in the literature for CES. Enjoyment and satisfaction from recreational visits are frequently captured in site surveys of TWF, as well as larger national level datasets such as the Public Opinion of Forestry (https://www.forestry.gov.uk/forestry/infd-5zyl9w) and MENE survey.

Linked social datasets offer some promise for assessing health benefits because of access or availability of CES. In particular, nationally representative UK longitudinal datasets such as the British Birth Cohort studies and Understanding Society have been employed to identify the impacts of access to greenspace on health outcomes, including psychological wellbeing. Alcock et al., (2013) used indicators of wellbeing in Understanding Society to examine whether moves from less green to greener areas were associated with increases in psychological wellbeing benefits. A review by Nesbitt et al., (2017) of CES in North American forests revealed other indicators of physical and psychological health that may be present in national statistics or public and administrative datasets. These include for example, sick days, prescription rates, suicide rates per capita, depression and circulatory disease rates. Revealed preference methods using surveys and qualitative methods are also used in smaller, localised studies to measure indicators of subjective health and wellbeing (e.g. Biedenweg *et al.*, 2014;

Hausner, Brown and Lægreid, 2014; Sherrouse, Semmens and Clement, 2014). Revealed preference and participatory methods can also be used to capture particular benefits of the recreational experience such as a sense of freedom or escape (Bryce *et al.*, 2016) and cognitive benefits associated with restoration (Liquete *et al.*, 2013; Cabral *et al.*, 2016).

Recent work on the development of a health indicator for physical exercise recreation in woodlands has valued the health benefits in terms of quality adjusted life years, which itself has well-developed metrics for estimating financial benefits (Moseley *et al.*, 2017). Site visitor surveys and visitor experience can be used to measure indicators such as the number of people enjoying visits to TWF. All Forests monitoring surveys in Scotland (https://www.forestry.gov.uk/forestry/infd-5wcmr4) collect accurate visit numbers for specific sites in the public forest estate, as well as travel mode / times and preferences, trip duration, main recreational activity and expenditure. Indicators of CES benefits for wellbeing, fun and enjoyment in specific sites in the public forest estate are present in Quality of Experience visitor site surveys (https://www.forestry.gov.uk/forestry/infd-5wwjpt), undertaken for the Forestry Commission in England and Wales. National level data, which extends beyond Forestry Commission managed land, can be found in the Public Opinion of Forestry and across a range of environmental spaces using MENE. A number of existing datasets can be used to estimate physical health benefits emerging from TWF. Visitor and site surveys contain suitable data for estimating frequency and duration of relevant physical health recreation activities. In particular site-specific Quality of Experience surveys were employed by Moseley et al. (2017) to estimate frequency of site visits and length of physical activity. Table 3 gives examples of datasets across each of the categories of cultural ecosystem benefits.

Table 3. Example data for monetary, quantitative and qualitative valuation of the range of cultural ecosystem benefits

BENEFIT TYPE	EXAMPLE INDICATORS			
	Monetary	*Quantitative*		*Qualitative*
		Public, archived or administrative data	*Primary survey data*	
Economy	Income from environmental jobs Hedonic price method (property / assets)	Employment rates in environmental sector (All Forests) Business names (Companies House)	Perceived importance of employment / livelihood / economic security	Perceptions and emergent themes concerning economic benefits. Deliberated cultural benefits from local economy Shared cultural benefits from economy Discourses around cultural benefits from the economy. Community identity from TWF-based employment and recreation jobs Cultural value of local crafts in TFW
Education and learning	Income from educational activities Value of funded research activities	RCUK funded project repository Forest Schools administrative data Educational attainment Signage, educational activity, visitor centres (NFI data) Number of learning/education activities taking place on the PFE (via the FEE permissions system).	Education program graduate destinations Number of school-age children visiting forests (from the MENE survey) Value of TWF as places to go for learning (e.g. National Survey for Wales, Public Opinion of Forestry).	Perceptions and emergent themes around learning benefits Shared learning experiences Changes in perceptions and confidence and familiarity with TWF Deliberated perceptions of learning experiences Discourses around learning in TWF Phenomenology of learning in TWF
Health	Quality adjusted life years	Visitor survey time spent in activity (MENE; Quality of Experience; All forests monitoring; FC visitor surveys, Wales Outdoor Recreation Survey) Wellbeing scales (Understanding Society; British Birth Cohort studies) GPS fitness application data Active Forest monitoring and evaluation	Scale of perceived health and wellbeing value Subjective wellbeing (Office for National Statistics)	Shared health benefits Subjective perceptions and emergent themes around health benefits Discourses around healthy activity in TWF Phenomenology of active visits to TWF Deliberated values of active visits to TWF

BENEFIT TYPE	EXAMPLE INDICATORS			
	Monetary	*Quantitative*		*Qualitative*
		Public, archived or administrative data	*Primary survey data*	
Social connections	Monetary value of social capital	Perceived trust, fairness and cohesion (Citizenship / community life survey) Social groups during environmental visits (MENE) Number of community woodland groups.	Social capital scales Perceived trust, fairness Value of visits to TWF for bringing the community together and socialising (e.g. National Survey for Wales, Public Opinion of Forestry).	Feelings, perceptions and emergent themes around social connection and engagement Shared values of social connections Phenomenology of shared experiences in TWF Discourses around social connections environments Deliberated values of social connections
Spiritual and cultural benefits	Income for forest-based artworks, cultural experiences and sculpture trails Willingness to pay for forest based art and cultural experiences Value of sold artworks with TWF as subjects	Number of art, cultural and religious events taking place in TWF via permissions applications Number of cultural and religious monuments on TWF sites (Ordnance survey and NFI data) Number of artworks with TWF as subjects	Scale of spiritual connection to landscapes Value of TWF as places to experience culture (MENE; Public Opinion of Forestry; Quality of Experience surveys)	Subjective and perceived spiritual, aesthetic and cultural benefits from TW. Emergent themes around spiritual , cultural and aesthetic experiences. Shared values of aesthetic, spiritual and cultural experiences Phenomenology of aesthetic, cultural and spiritual experiences Discourse around aesthetic, cultural and spiritual experiences in TWF and artefacts with TWF as subjects. Deliberated values of spiritual, cultural and aesthetic value of TWF Artefacts and artworks with TWF as subjects

Note: Qualitative indicators may emerge via a number of methods, including captioned social media posts, literature, in depth interviews, workshops and focus groups, deliberative participatory processes and participatory GIS.

5.1. Education and learning

The educational benefits of a particular CES are often highly related to the biophysical domain but as with all CES, it is the presence of educational practices that gives rise to these associated benefits. Indicators of educational benefit take into account rarity or uniqueness of the biophysical domain for knowledge purposes, the presence of educational activity supported by programmes and infrastructure, as well as socio-cultural benefits that develop following educational practice (Mocior and Kruse, 2016).

A number of criteria to identify the educational benefits of CES have been identified and associated with a range of potential indicators. Quantitative indicators of educational benefits include number of visiting researchers, number of educational programmes (Valls-Donderis, Vallés and Galiana, 2015; Mocior and Kruse, 2016), graduate

destinations following educational and capacity building programmes (Smit *et al.*, 2016). Intellectual and research benefits indicators employed include the presence of long-term experiments and longitudinal data associated with an environmental space, availability or success of research funding (Boerema *et al.*, 2017) and peer reviewed publications (Chen *et al.*, 2017; Lillebø *et al.*, 2017).

Qualitative, revealed preference and deliberative approaches have also frequently used indicators of the value of knowledge systems and education as indicators of the benefits of CES. Stakeholder and expert evaluation studies have identified the relative value of sites for education (Yoskowitz et al., 2016, Darvill & Lindo, 2015). Indicators of learning and education benefits from CES also encompass traditional knowledge systems and transfer of expert knowledge, which rely on cultural practice within relevant environmental spaces (Tekken *et al.*, 2017).

5.2. Social connections

Efforts to measure CES benefits in terms of social connections in the literature have tended toward qualitative and deliberative approaches as well as revealed preference methods using surveys, rather than available quantitative indicators (e.g. Biedenweg, Scott and Scott, 2017; Rall *et al.*, 2017).

Social benefits from CES include building existing relationships and bringing community's together (bonding), as well as strengthening and generating new relationships across different groups (bridging) (Putnam, 2000). These processes can be captured by the concept of "social capital". The Citizenship and Community Life Surveys (https://www.gov.uk/government/collections/community-life-survey) contain a number of relevant quantitative indicators of both bridging and bonding social capital. In addition, they can provide information about participation and capacity building in a nationally representative sample across England and Wales. Presently however, no studies have attempted to use these indicators to map or identify social capital benefits in an ecosystem services framework.

5.3. Nature / landscape connections

Nature and landscape connections encompass the range of place-specific benefits humans derive from CES. These benefits encompass general sensory and aesthetic experiences from TWF including beautiful views, birdsong, enjoyment of flora and fauna, fresh air and smells as well as tactile experiences. Alongside sensory experiences in woodlands, landscape connections encompass other intrinsic landscape benefits that arise from CES, including foraging and gathering activities, shelter and protection, improvements to landscapes and a sense of place.

Landscape preferences have been researched extensively and this work has revealed features of forests, which predict tendencies to use these spaces for recreation (e.g. Edwards *et al.*, 2012), including forest management alternatives and stand development

stage. These studies also describe features which can be used to identify aesthetic and sensory CES supply and these are applied in the literature (Keleş, Durusoy and Çakir, 2017).

In empirical case studies, which seek to measure and map aesthetic CES benefits in a particular area, the valuation of landscape features (a direct indicator of their benefits in terms of aesthetic and sensory experience) is measured using photographic questionnaires (Casado-Arzuaga *et al.*, 2013; Peña, Casado-Arzuaga and Onaindia, 2015). Alternatively photos can be coded according to their content by experts (Richards and Friess, 2015), although these approaches are labour intensive and time consuming to apply at scale. Geotagged photographic data collected via social media (e.g. Flickr, Instagram) is also valuable as an indicator of sensory and aesthetic benefits from woodland areas. Again, photographs themselves can be assumed to be capturing beneficiary sensory experiences or alternatively, sentiment analysis of photograph captions or independent coding of images can be used to generate an indicator of value (Sherren *et al.*, 2017; Yoshimura and Hiura, 2017). Crowdsourcing images alongside text content could be used to develop indicators of visual (and other sensory) preferences over larger spatial areas.

Revealed preferences, participatory and deliberative approaches are also important for indicators of nature / landscape connections. Many of these benefits are closely linked with particular cultural practices and are therefore both group and place-specific (Adam and Kneeshaw, 2008; Tekken *et al.*, 2017). Engagement with social groups at a local level may be necessary to both reveal and understand these place-based practices and connections and their associated benefits. A number of studies in the literature have employed participatory geographical information systems tools (PGIS) to identify, map and quantify sites where landscape / nature connections are experienced (Fagerholm *et al.*, 2012; Darvill and Lindo, 2015).

A notable use of a quantitative indicator using public and administrative data to measure sense of place or cultural connections to ecosystems in the literature is the use of business names. Freitag, Hartley & Vogt (2017) used business names to identify and map areas where oysters were of high cultural value. They argue this indicator may be able to identify temporal as well as spatial changes in the distribution of this value at local as well as much larger spatial scales. It would be interesting and potentially useful for future research to develop and validate the use of a similar indicator for woodland and forest areas in the UK. Such an indicator could easily utilise publically available Companies House (https://www.gov.uk/government/organisations/companies-house) data for measurement.

5.4. Cultural and spiritual significance

There remains a clear need for a wider range of indicators for cultural and spiritual CES benefits, despite their growing presence in categories of the literature. Of particular note is cultural heritage, where Hølleland, Skrede and Holmgaard (2017) identified 53 articles referencing cultural heritage, including 12 that focused on this specific area. Tangible features of the landscape, including for example culturally relevant species or areas where spiritual and religious sites are present and which embody cultural / religious /heritage values are used as indicators in the CES literature. They can frequently be mapped and quantified using public data (the UK NFI identifies the presence of a range of cultural and heritage features in woodland and forest sites). Valuing heritage CES benefits is however, a more challenging task. Quantitative and economic indicators have been developed using tangible landscape features, typically by calculating the value these features might add for tourism or recreation. However, many have contended that heritage and other cultural / spiritual values are not amenable to monetarisation for a range of reasons. First, heritage does not merely encompass tangible aspects of the landscape but also values derived by a relationship with environmental spaces or by an interaction between human value and identifiable tangible features. Tourism and recreation practices only encompass a part of the range of these interactions. Second, cultural and heritage benefits are frequently not traded in the market place because they are plural and have shared benefits - so monetary values cannot be readily derived nor do they provide meaningful information (Irvine *et al.*, 2016).

The arts and humanities (AH) are becoming increasingly valued within ecosystem services frameworks as being able to express and indicate the cultural value of nature. A key contribution of AH approaches to the development of CES indicators has been through cultural mapping and digital/ and participatory GIS tools to spatially locate cultural value within spaces and landscapes. Forestry has a long relationship with contemporary art. In contrast to earlier traditions of landscape painting, this relationship has been characterised by situating artworks in forests and spaces with trees where they are immersed into these natural environments and the life and meaning these pieces express is embedded into these places (Cooper *et al.*, 2016; Edwards, Collins and Goto, 2016a).

Beyond the practice of placing art in forests, practices of socially engaged art seek to create transformative processes through deliberative engagement. These practices can generate new relationships between society and nature though the use of image, text and artefact, which can be experienced in both a forest setting or outside of it. In addition, critical practices of social-engaged art focus on social and cultural practice and enactment, rather than focusing on objects, which represent nature (Edwards, Collins and Goto, 2016b).

In terms of contributing to CES indicators, AH has generated and collected a wealth of material culture, through text, image, sound and practice which can be used to

understand the functioning of ecosystems in terms of social and cultural values and benefits. Some of these may be amenable to deriving quantitative indicators through for example, literature mining using software which can identify and potentially map and quantify natural areas which represent those of spiritual inspiration and artistic value. In addition, qualitative data which arises out of participatory and socially engaged arts based practice is an indicator of aesthetic and spiritual value (Church *et al.*, 2014).

In addition to functioning as indicators, i.e. data that reveal the socio-cultural health of ecosystems, AH practices can generate new forms of value. Within the more critical approaches embodied by arts based-practice, challenges emerge for the assumptions behind the ecosystem services framework. In particular, aesthetic and ethical understandings that emerge from the experience of environmental art frequently challenge the conception of TWF as being valued only for and in terms of the services and benefits they provide, favouring instead more intrinsic value for environmental spaces (Cooper *et al.*, 2016; Edwards, Collins and Goto, 2016a; Fish, Church and Winter, 2016). In addition and in line with disciplinary approaches, AH work is not typically attempting to gather data or information about the status of ecosystems and their services but rather attempting to engage people to interact with environmental spaces in a way which may generate new senses of value or rekindle those which were dormant or not explicitly articulated. Despite these difficulties, many in the literature with an interest in valuing CES have embraced the contribution of AH in understanding and valuing the full range of ecosystem services and see this critical work as a strength rather than a challenge (Bryce *et al.*, 2016).

6. Indicators of CES for whom?

6.1. Engagement with TWF

Effective indicators for CES should encompass differences in levels of engagement that people have with TWF. Levels of engagement can vary from existence knowledge and value – where TWF are not experienced directly, through virtual and real perceptual access, visits to environmental spaces, participation including decision-making and ownership, management and decision-making / setting policy. O'Brien and Morris (2013) suggest a typology of different engagement levels for TWF and this is described in Table 4.

Effective indicators need to account for these differences across stakeholder groups and although those reported in the literature for CES frequently encompass a range of engagement levels, the significance of the indicator for particular levels of engagement is rarely explicitly considered. Studies addressing indicators of supply and demand tend to focus on physical access to TWF sites or views of such sites. Nonetheless, many indicators and the data that support their measurement can target specific levels of

engagement. For example, at the level of existence value, the supply, demand, ease of access and quality of knowledge sources are suitable indicators. These could be measured using website downloads of information about sites and the coverage or availability of this information. Some studies of recreational CES have employed marketing efforts as an indicator of "discoverability" and this is also relevant for existence and virtual access of some CES (Baum, Cumming and De Vos, 2017). Whilst often used as proxies for physical engagement with environmental spaces, much of the comment and discussion surrounding images shared via social media can equally pertain to existence value and virtual access (Sherren *et al.*, 2017). These discussions could be useful indicators of a range of CES benefits which are experienced virtually, including nature / landscape connections and artistic inspiration / spiritual value.

In contrast, it is also possible to capture indicators at high levels of engagement in TWF, including the supply, quality and accessibility of woodlands for sale. For example, community created and managed woodlands have been shown to elicit a range of goods and benefits as indicated by smaller scale revealed preference surveys (Agbenyega *et al.*, 2009). UK-wide surveys among mangers, owners and agents have also been commissioned and can be used to measure indicators of benefits derived from high levels of engagement. A major source of information concerning benefits and values of TWF for owners, agents and managers is the British Woodlands Survey (https://sylva.org.uk/bws), which contains a range of indicators for highly engaged stakeholder groups at a national level.

Table 4. Range of types of engagement with TWF (taken from O'Brien and Morris, 2013)

Types of engagement	Examples of activities related to types of engagement
Existence	Knowing TWF are part of the landscape
Virtual access	Virtual or mental image, TV, computer, memory, books
Views of trees, woods, forests (TWF)	View from house, school, work, car or by walking past TWF
Using and being in TWF	Cycling, walking, picnicking, mountain biking, use of nature trail
Active 'hands on' engagement	Volunteering, Forest School, gathering non timber forest products
Participation in decision making	Involvement in decision making about creation, design, management
Ownership and or management of TWF	Responsibility for management or ownership of site/s privately or as part of a community group, social enterprise

6.2. Barriers to CES

In addition to indicators of access at the level of environmental spaces, socio-economic, cultural and personal factors shape whether CES emerge in TWF. Examples of barriers to access and engagement with TWF are given in Table 5. Whilst some socio-economic indicators such as crime rates, pertain to the supply of quality spaces themselves (e.g. O'Brien and Tabbush, 2005) others including indicators of deprivation, social norms, income and personal interest / motivation place the locus of CES barriers on personal and societal level factors (Weldon, Bailey and O'Brien, 2007).

Characteristics of environmental spaces can influence the degree to which barriers in the population limit access to CES and clearly physical / structural and socio-cultural, economic and personal factors interact to determine the degree to which barriers are present in accessing greenspace. For example, mobility may be less of a barrier to access where disabled access transport infrastructure is present.

Some indicators have been developed to identify socio-economic, cultural and personal factors which may influence engagement. Travel, accommodation or site visit costs are indicators of where a greenspace may be inaccessible to those with low incomes (Tratalos *et al.*, 2016; Baum, Cumming and De Vos, 2017). In addition, travel time is also an indicator of where access may be limited due to lack of car ownership. Currently few studies have addressed public transport infrastructure accessibility although some revealed preference surveys have attempted to measure its importance (De Valck *et al.*, 2016) and this may be an indicator of accessibility among lower-income populations. Finally demographic and population indicators of deprivation, including the Office for National Statistics index of multiple deprivation can provide information about socio-economic deprivation in specific areas. These indicators could be combined with deprivation measures to identify "coldspots" where lack of public transport, car ownership, distance to TWF and presence of areas of deprivation may combine to make the CES of a site inaccessible to a significant proportion of the population. Revealed preferences, participatory and deliberative indicators of time use, interest and motivation as well as confidence and feeling comfortable in TWF can be used to identify personal factors. Few larger quantitative datasets exist to address these issues although both Understanding Society and the Millennium Cohort Study (http://www.cls.ioe.ac.uk) employ neighbourhood surveys, which explore perceptions of respondent's local areas, including fear and discomfort concerning their local area. These data can be linked with other information within the surveys about transport habits, income and health/mobility barriers as well as respondent location.

National survey data in Great Britain is available to monitor some of the barriers to accessing woodland via MENE in England, The National Survey for Wales (Welsh Government, 2018) and the Public Opinion of Forestry for Great Britain. These datasets tend to ask participants to report barriers, which prevent them from accessing TWF. For example, POF 2015 asks participants to identify a range of factors in preventing

respondents from visiting TWF, including physical access barriers, social and psychological access barriers and disinterest in visiting. National survey data for Great Britain countries also collect demographic data, which can support indicators of systemic barriers to visiting TWF, which may be based on for example, age, gender, ethnicity or household income.

Table 5. Barriers to access and engagement with TWF, including socio-cultural, economic and personal barriers (taken from Morris *et al.*, 2011).

Barrier category	Barrier sub-category	Details / examples
Physical & structural	**General / over-arching**	Bad weather
	On-site	Lack of access points / routes Lack of facilities Poorly maintained
	Off-site	Lack of information Lack of public transport Too far away
Socio-cultural, economic and personal	**Social, cultural & economic**	Cost of visiting Deprivation Lack of cultural norm
	Personal characteristics, experience and abilities	Lack of time, interest, motivation Lack of confidence / feeling out of place Low income Restricted mobility

7. Conclusion

There is concern that indicators for CES and benefits are underdeveloped in comparison with other ecosystem services and that they are not fully accounted for in research, policy and decision-making. This report set out to review the range of indicators that are available for forest CES as well as their benefits and illustrate how these have been measured and what data is or might be available to support their measurement. It aimed to consider, current, possible and ideal indicators for capturing a broader range of ecosystem benefits provided by TWF. Critically, it also aimed to highlight the datasets that are used or could be used to support these indicators over a range of spatial scales.

The review found, consistent with previous work, that some CES benefits do not have well-established indicators, which can be applied to quantify and spatially locate services over a wide scale and/or can be valued monetarily. Participatory, deliberative and

revealed preference methods have been able to address a wider range of less frequently addressed CES and their benefits in smaller-scale studies (e.g. Martin-Lopez et al., 201; Sherrouse, Semmens and Clement, 2013), however, limitations exist in measuring these indicators at larger scales and assigning monetary values to them will not always be appropriate. An aim of this report was to identify some potential indicators as well as signpost datasets that support their use, or have the potential to do so. Nonetheless, for some CES benefits, monetarisation and even quantification may be reductive or fail to capture and communicate information about them. These challenges mean that it is possible some CES will never be captured by indicators, which can be integrated with regulating and provisioning services in a broader framework without involving a participatory and deliberative process where different types of indicators can be debated and judgements made about different types of values and benefits for guiding policy and management practice. Moreover, some CES may always be place-specific, such that in order to capture them primary data must be collected, which can focus on characteristics specific to certain socio-ecological systems (O'Brien, Morris and Raum, 2017).

This report shows that in the case of TWF, there are numerous sources of information which can be used to develop good indicators of CES and their benefits and which can be utilised in policy and decision-making. Table 6 gives examples of a range of survey, evaluation and administrative datasets for capturing supply, demand, benefits and engagement around CES at different scales. In addition Table 7 suggested improvements to the existing social forestry indicators used by Forestry Commission England (Atkinson and Edwards, 2018) and Table 8 outlines potential alternative or supplementary indicators for Forestry Commission England to capture CES and benefits. In addition to these often publically available datasets, social media platforms such as Flickr, Instagram and Twitter have increased opportunities to crowdsource information concerning CES in TWF. The present report argues that a range of datasets can be used in identifying and capturing new sources of socio-cultural information and linking these with relevant detail about environmental spaces.

This approach is consistent with a conception of CES as the interaction between people's practices and the spaces that host them (Fish, Church and Winter, 2016). Challenges remain in developing indicators, which capture CES for all sections of society and across the range of ways people engage with TWF (O'Brien and Morris, 2013). As well as developing indicators for CES, which make it easier to account for them alongside other ecosystem services, there is space for approaches which encourage creative and critical engagement with the ecosystem services framework as a whole. Policy and decision-makers will need to engage with the range of ways in which people value nature and therefore collaborate with scientists of all kinds to develop methods to apply appropriate measurement and valuation of all ecosystem services.

Table 6. Example datasets available for developing cultural ecosystem service indicators for TWF at different scales (see also Atkinson and Edwards, 2018 for list of data sets)

BENEFIT TYPE	Example dataset		
	Great Britain	***National***	***Local and multi - site***
Supply	National Forest Inventory Ordnance survey open greenspace Space for people UK Crime mapping CEH land cover Great Britain (LCGB) DEFRA noise maps National travel survey Neighbourhood survey European Quality of Life Survey	Scottish Crime and Justice Survey National Survey for Wales National travel survey	Local authority greenspace data
Demand	National Forest Inventory Grow Wild Evaluation RSPB connection to nature indicators (8 – 12 years age)	National Survey for Wales Scottish People and Nature Survey Scottish Household Survey Monitoring of Engagement with Natural Environment (MENE)	Active Forests Evaluation All Forests Monitoring Quality of Experience Surveys Visitor Surveys
Benefits	Understanding Society British Birth Cohort Studies Public Opinion of Forestry Grow Wild Evaluation RSPB connection to nature indicators (8 – 12 years age) British Social Attitudes Survey Neighbourhood survey ONS Opinions survey	National Survey for Wales / Living in Wales Welsh Health Survey Scottish Household Survey Monitoring of Engagement with Natural Environment (MENE) Scottish People and Nature Survey Health Survey for England (HSE) English Longitudinal Study of Aging (ELSA) Scottish Health Survey Scottish Social Attitudes Survey Citizenship / community life surveys Taking Part (the National Survey of Culture, Leisure and Sport) Active Lives What About Youth National Travel Survey	Active Forests Evaluation All Forests Monitoring Quality of Experience Surveys Visitor Surveys Avon Longitudinal Study of Parents and Children
Barriers and engagement	British Woodland Survey Grow Wild Evaluation Index of multiple deprivation Crime mapping RSPB connection to nature indicators (8 – 12 years age) Farm Business Survey Neighbourhood survey	National Survey for Wales Scottish Household Survey Monitoring of Engagement with Natural Environment (MENE) Scottish Social Attitudes Survey Citizenship / community life surveys	Active Forests Evaluation All Forests Monitoring Quality of Experience Surveys Visitor Surveys Avon Longitudinal Study of Parents and Children

Table 7. Suggested potential improvements to the current 6 corporate social forestry indicators used by Forestry Commission England (taken from Atkinson and Edwards, 2018)

Forest Services England:

1. ***Percentage of people in Priority Places close to accessible woodland other than that on the Public Forest Estate (PFE):*** Additional analysis to determine whether trends over time are due to changes to level and distribution of a) deprivation or b) accessible woodland (which is more relevant to FCE intervention).
2. ***Number of visits to woodland from Natural England's Monitor of Engagement with the Natural Environment survey (MENE):*** Inclusion of error bars to show whether changes are significant. Additional analysis to determine the extent to which changes are due to the weather as opposed to shifts in attitudes to forest recreation.
3. ***Percentage of people actively engaged in woodland:*** The Public Opinion of Forestry (POF) survey sample size is too small to capture significant trends. The MENE survey would probably offer the best alternative, although an additional question would need to be added to the questionnaire.

Forest Enterprise England:

4. ***Percentage of people in Priority Places close to Public Forest Estate accessible woodland:*** Similar to '1' above.
5. ***Number of people engaged in permitted locally led events and activities on the PFE****:* Further description would aid interpretability. The indicator is likely to be measuring changes to, and/or uptake of, the permissions system, rather than changes in public engagement. This could be highlighted in the commentary.
6. ***Number of households in the Discovery Pass Scheme for the PFE:*** Similarly, this indicator is likely to be measuring uptake of the scheme rather than public engagement with the PFE. This could be highlighted in the commentary.

Table 8. Potential alternatives to Forestry Commission England social forestry corporate indicators to capture CES and benefits (taken from Atkinson and Edwards, 2018)

1. ***Abuse/misuse of forests:*** NFI data could be used to report the area of forest with evidence of fly tipping, vandalism, contractor waste, etc.
2. ***Area-based recreational use:*** NFI data could be used to report the area of forest with evidence of recreational use. The evidence combines direct observation and recreational infrastructure (e.g. informal and formal paths).
3. ***Benefits of forests and woodlands:*** The POF survey could be used to report the proportion of the population who recognise one or more benefits of forest, either personal benefits or (by revising the questionnaire) public benefits.
4. ***Physical health and recreation:*** The existing corporate indicator reporting visit numbers could be developed into a metric for health benefits, e.g. Quality Adjusted Life Years (QALYs), using MENE data and additional work published by FR colleagues.
5. ***Inequalities and diversity – demographics:*** MENE data on visit numbers could be broken down to report forest engagement by children less than 16 years; people over 65 years visiting woodland as part of a group could be reported to address policy concerns with social isolation among old aged people.
6. ***Inequalities and diversity – barriers to access:*** POF data on 14 barriers to access could be used to report reasons for not visiting forests more often, or at all.
7. ***Wellbeing:*** MENE data on visit numbers could be developed to measure changes to an index of wellbeing (e.g. life satisfaction, happiness and anxiety) as a result of engagement with forest and woodland. This proposal would need additional research.
8. ***Social connections:*** MENE data on the composition of social groups during forest visits could be used to report the level of social contact that results from engagement with forest and woodland In the future, impacts on loneliness will potentially be supported by MENE data. Alternatively, POF data could be used to report the proportion of the population who recognise one or more social benefits.
9. **Education:** NFI data could be used to report area of forest with educational infrastructure, although this would not capture informal learning. The number of educational visits could be reported using FEE permissions data, or the MENE or POF data (both would require a new question to be added).

It should be noted that NFI data are only available on a five-year cycle and it can distinguish PFE from non-PFE. MENE runs annually and POF runs on a two-year cycle. It is not possible to report figures for the PFE using POF data, although with additional analysis this could be done for MENE data. We note the reliance on the POF and MENE surveys to provide the necessary datasets, and the need to ensure that these continue to be resourced and developed.

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Forest Research

Alice Holt Lodge
Farnham
Surrey GU10 4LH, UK

Tel: 0300 067 5600

Fax: 01420 23653

Email:research.info@forestry.gsi.gov.uk

www.forestry.gov.uk/forestresearch

Northern Research Station
Roslin
Midlothian EH25 9SY, UK

Tel: 0300 067 5900

Fax: 0 131 445 5124

Forest Research in Wales
Edward Llwyd Building
Penglais Campus
Aberystwyth
Ceredigion
SY23 3DA

Tel: 01970 621559

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