Forest Research

Scoping Study on Valuing Mental Health Benefits of Forests

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Final Report

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Executive Summary

This scoping study examines evidence on the valuation of the mental health benefits of forests and proposes next steps for developing monetary valuation of these benefits further.

Mental health valuation pathways

Valuation of the mental health benefits of a forest intervention or interaction involves two fundamental elements:

1. Quantifying the mental health impact using a metric, such as a self-reported mental health scale or based upon a directly observable characteristic (e.g. a biomarker such as cortisol level) or intervention (e.g. anti-depressant prescription rates), compared to an appropriate baseline. (This could either be a standardised baseline, or based upon a pre-intervention survey)
2. Monetising this mental health impact through a valuation pathway

This study focuses on methodologies for achieving this second step.

Based upon a review of recent literature, we identified three major 'direct' methodologies applicable to mental health valuation:

- QALY (Quality Adjusted Life Years):
    - Useful for comparing healthcare interventions, but less sensitive to detecting changes in mental health than in physical health.

- Wellbeing Valuation:
    - Life Satisfaction Scores: Changes can be directly monetised utilising a causal model of income as a determinant of life satisfaction, but life satisfaction is a broad measure of wellbeing which encompasses wider benefits apart from mental health.
    - Short-Warwick Edinburgh Mental Wellbeing Scores (SWEMWBS): Changes can be monetised using a simple model relating SWEMWBS to life satisfaction, although the current model's simplicity lends it more towards evaluation of local interventions rather than natural capital accounting. Further work may be required to develop this pathway, but the metric itself is a robust measure of mental health.

- Avoided Costs:
    - Mental illness drug (e.g. anti-depressant) prescriptions: Gives a very conservative estimate and conceptualises mental health as a simple binary outcome.

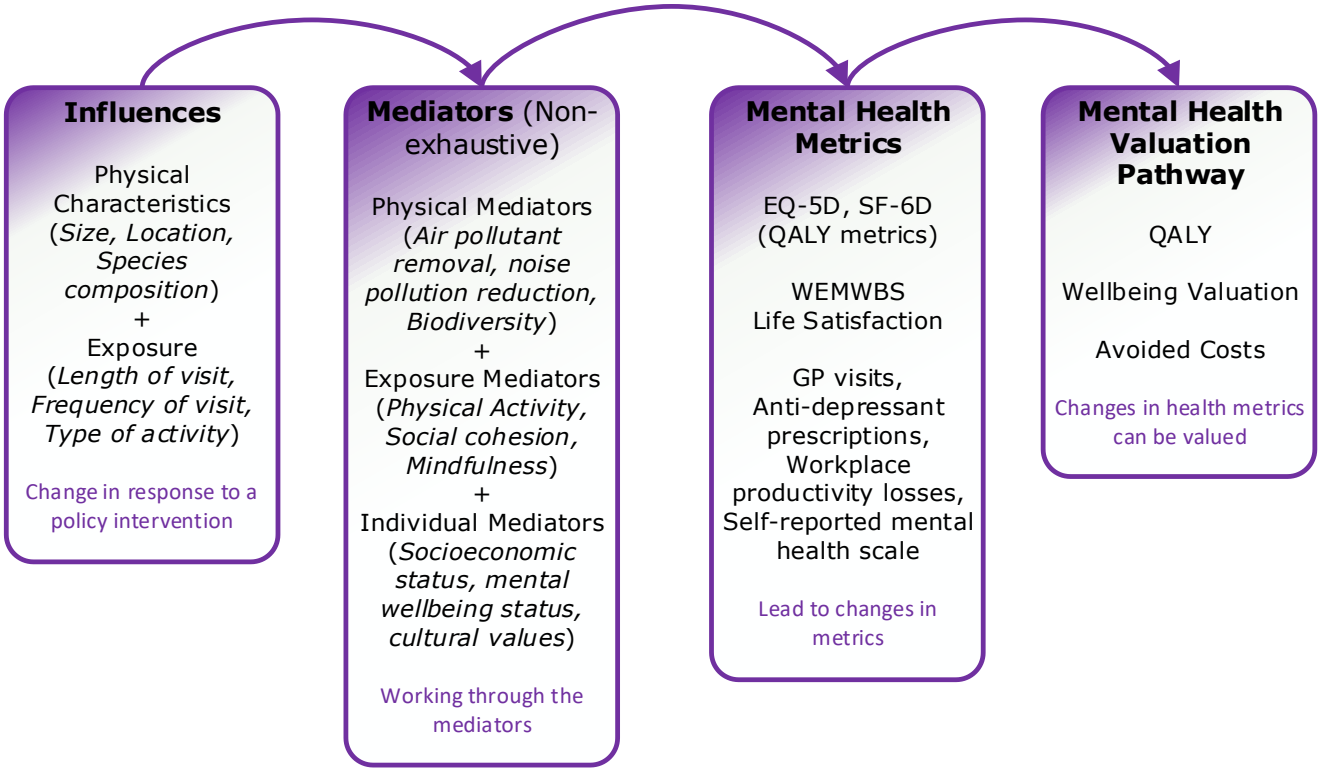
- General Practitioner (GP) Visits: Challenging to disentangle from other reasons for visiting a GP (unless NHS data can be used).
- Costs of poor mental health (productivity losses): Productivity losses from poor mental health or mental illness are difficult to estimate and quantifying underlying drivers by separating out sick leave due to mental health issues from that due to other factors is not always straight-forward.
- Costs to the National Health Service: available data on NHS spending on mental health is often utilised using a crude transfer without establishing proper attribution of the woodland's (or other greenspace's) impact and causality.
- Other cost metrics (e.g. costs of mental-health related court cases) could potentially be utilised if causality between woodland use or proximity and relevant mental health states can be established.

A major distinction between the approaches is that avoided costs and QALY approaches value the benefits associated with reductions in mental illness, whereas a wellbeing approach values improvement in positive mental health and benefits of interaction with nature for a large share of population which maintains good mental health. The value of positive mental health reflects a value to an individual, whereas the value of a reduction in mental illness is usually captured in terms of a wider societal value such as clinical cost savings or avoided productivity losses. Understanding mental health as encompassing a broad spectrum of states, valuation solely on the basis of reductions in mental illness without considering the value of maintaining good mental health is likely to significantly underestimate the value of preventative interventions.

We also identified a range of different kinds of 'mediators' of the mental health benefits of woodlands, including air pollutant removal, noise reduction and physical activity. These mediators are the drivers of the relationship between an interaction or intervention with forests and mental health benefit. Apart from external mediators, such as socioeconomic status and pre-existing mental health condition, none of the studies identified attempted to monetise the relative influences of other mediators on mental health benefits.

Logic Chain

The logic chain below summarises the over-arching framework proposed for quantifying and valuing the mental health benefits of forests, woodlands and trees (or any natural environment).



Limitations

Valuation relies upon mental health impacts being quantified robustly. There remain major challenges in achieving this. Principally, there are large number of factors that can affect the relationship between mental health and the natural environment, which can be difficult to control for without detailed studies. Factors that mediate this relationship include physical characteristics such as size, location and species composition of woodlands which influence removal of air pollutants and reduction in noise pollution. Other factors also include socioeconomic and other attributes such as age, gender and ethnicity and the extent and type of exposure to the woodland (e.g. length and frequency of visits, and activity undertaken).

Research Proposals

The feasibility of incorporating mental health benefits of woodlands into natural capital accounting will necessitate further work to reduce uncertainties currently associated with use of the valuation pathways. Given the closeness between mental health and recreation, a simple approach could be used to partition estimated recreational values based on visits associated (e.g. primarily) with mental health benefits.

To underpin more robust monetary valuation, there is a need for further longitudinal or cohort studies to explore the influence of forest interventions on mental health, with a focus on establishing causal relationships rather than associations.

The impact of some mediators can be highly influential on mental health outcomes. These include socioeconomic factors and existing mental health status. Exploring the causal nature of these relationships in greater detail is an important area for future research. This could be pursued by exploring relationships drawing upon existing datasets such as the Monitor of Engagement with the Natural Environment (MENE) or a small primary research study.

An avoided cost approach may be best suited to estimating additional mental health values that avoid double-counting issues with existing ecosystem service values such as those for recreation. Although work has been undertaken on some elements – such as in relation to new appraisal guidance being launched by the Environmental Agency on valuing the mental health benefits of flood risk management projects, existing data to support avoided cost approaches may not be readily available in most cases. Cost metrics relating to the treatment of a range of mental illnesses that forests help ameliorate could be gathered through a future study.

Ultimately however, each pathway may be more or less suitable for valuation depending on the audience aimed at and the question the analysis is aiming to address. For example, a local government interested in valuing natural capital may be more interested in wider mental wellbeing benefits of the natural environment than a NHS trust, who may be more interested in the avoided costs of mental illness. Precise estimates may be less important in some circumstances than a sense of the magnitude of impact and how the natural capital value compare to those for other ecosystem services.

Introduction

There is strong evidence supporting associations between the natural environment and improved mental health including reductions in psychological stress, anxiety, fatigue, depression and improvements in reported quality of life (Haluza, Schönbauer and Cervinka, 2014; Gong *et al.*, 2016; Lee *et al.*, 2017; Houlden *et al.*, 2018; O'Brien, Ambrose-Oji and Wheeler, 2018). For children, access to and use of the natural environment is associated with improved cognitive development and reported wellbeing, as well as reduced rates of hyperactivity and inattention (Milligan and Bingley, 2007; Jane, 2009; Corraliza, Collado and Bethelmy, 2012; Gill, 2014; Lubans *et al.*, 2016; McCracken, Allen and Gow, 2016; McCormick, 2017).

In recent years there has been an increasing awareness of the benefits that forests provide in improving peoples' mental health, with a number of studies commissioned to quantify the impacts in different parts of the world. In particular, there has been significant media interest in 'forest bathing' ('shinrin yoku') - a practice developed initially in Japan which emphasizes the health benefits of people spending time in forests (Furuyashiki *et al.*, 2019); see also https://www.theguardian.com/environment/2019/jun/08/forest-bathing-japanese-practice-in-west-wellbeing.

Despite the growing number of case studies and evidence base on the benefits of forests for mental health, there remains a significant evidence gap in estimating associated economic values (Faccioli and Bateman, 2018). Furthermore, valuations have been performed in a number of different ways in previous work. These include (i) the impact on productivity and reductions in hours worked; (ii) the avoided costs of treating mental health disorders (iii) wellbeing valuation, which utilises income equivalence models with subjective wellbeing metrics; and (iv) quality adjusted life years (QALYs) (Kessler *et al.*, 2008; Luppa *et al.*, 2008; Mann, Gilbody and Richards, 2009; Mihalopoulos *et al.*, 2011; Olesen *et al.*, 2012; Bouwmans *et al.*, 2013; Simon *et al.*, 2013; Fujiwara and Dolan, 2014; Wolf and Robbins, 2015; Mihalopoulos and Chatterton, 2015; Chisholm *et al.*, 2016; Luo *et al.*, 2017).

Valuing mental health benefits of forests is a fast-moving field of research. A review to assess the current state of the art in this field is timely in considering which approaches are best for policy appraisal and natural capital accounting purposes and in order to develop future work on the monetary valuation of the mental health benefits of forests to address existing evidence gaps.

Aims and Objectives

This scoping study examines existing evidence on the value of forests on mental health and propose next steps for providing monetary valuation of these benefits.

Specific objectives are to:

- review existing literature on the impacts and value of forests on mental health, including methodologies which currently attempt to monetise the mental health benefits of wider nature/greenspace in order to consider which methods may apply to forests specifically;
- identify methodologies for valuing forests' role in mental health; specifically highlighting relevant impact pathways/logic chains which focus upon monetary valuation of identified relationships; identify what metrics are available in the United Kingdom (UK) and internationally to measure and value mental health benefits of forests and list the pros and cons of these tools;
- interview key stakeholders as a route to access key literature and to gain expert judgement on what metrics work under which circumstances and which can have monetary value associated with them;
- develop proposals, including methodologies, for how the value of forests in the UK for mental health could be assessed, potential for their incorporation into natural capital accounting processes as well as for project and policy appraisal, including marginal benefit assessments.

Methodology

The two main strands of the study are (i) a literature review; and (ii) interviews with experts to supplement the review by highlighting additional relevant material. Two expert 'critical friends' helped in identifying materials to review and in refining the proposals made. Dr Tim Taylor, a Senior Lecturer in Environmental and Public Health Economics, European Centre for Environment & Human Health at the University of Exeter Medical School and David Pepper, a practicing mental health professional treating individuals who require treatment for acute and complex mental health issues, particularly related to anxiety, depression, and alcohol and substance misuse.

Literature review

The focus and choice of materials to review were guided in part by the project steering group, who also facilitated access to relevant materials not currently in the public domain. The choice of terms for the literature search was also guided by team members'

specialist knowledge. Findings from countries other than the UK were included in the review, focusing upon literature published in English.

The review focused initially primarily on mental health values for forests within the UK and benefits derived by UK residents. However, due to a dearth of evidence, it was subsequently broadened to valuation of the mental health benefits of greenspace and evidence on the benefits of trees as a component of these.

The study both considers values derived from forest recreation/usage and from other biophysical and psychological pathways through which mental health benefits can arise, including evidence relating to the relationship between air pollution and mental health. Interrelationships between mental health and other ecosystem service benefits of forests are also considered, including issues relating to potential double-counting of benefits.

The study considers whether and how values can vary spatially, and whether it is feasible to account for this in valuations such as, for example, between broad species type (broadleaved vs coniferous) or locality (i.e. urban, peri-urban and rural).

The review of literature was conducted in line with the Government Social Research Service (GSR) Rapid Evidence Assessment (REA) guidance (GSR, 2013). Grey literature (i.e. reports not published in peer reviewed journals) was sought through Google Scholar searches and advice of the project steering group and experts interviewed and contacted during this study.

Details of the literature search protocol are presented in the Annex 1.

Interviews with experts

Although desk-based work comprised the largest component of the project, engagement with relevant experts was also undertaken. This was considered necessary in order to take account of knowledge and insights not available in the published literature, as well as to provide a critical appraisal of the existing approaches to quantifying and valuing mental health benefits of forests, and their potential for application to natural capital accounting and policy appraisal.

Participants and design

An initial list of 12 experts to approach was included in the study proposal. Each was approached using email and invited to take part in interviews remotely using Skype or telephone. If a participant was unable to complete a Skype/telephone interview, they were invited to submit a written response to the questions. A snowball sampling strategy was used, asking the initial participants about other experts to contact. This strategy resulted in a range of participants from the fields of environmental design, psychology, medicine, health / environmental economics, informatics and clinical practice. The

experts represented both the academic and private sectors. Many had undertaken work both for academic outlets as well as policy and decision making, including impact evaluation and natural capital accounting.

In the case of Skype and telephone interviews, written consent was gained from all participants to record and transcribe the interview and to use anonymised data in reporting. Skype and telephone interviews were 30 minutes in duration and were designed as semi-structured interviews. An interview protocol was developed and this is shown in Annex 2.The protocol was designed to gather information from participants in the following areas:

- The participant's expertise in economic valuation of mental health benefits of forests / greenspace with trees
- Knowledge of monetisation approaches
- Metrics for measuring mental health benefits amenable to monetisation
- New developments in the field
- Applications of economic valuations for policy and decision making
- Overall evaluation of success in valuing mental health benefits in forests / greenspaces with trees.

The questions and overall structure of the interview protocol was adapted based on the participant's background, expertise and experience. In addition, some participants invited colleagues who had taken part in relevant work to join the interview in order to share their views. In total, 12 experts took part in the interviews. A list of those interviewed – which included the two critical friends of the project, is shown in Annex 3. List of expert stakeholder interviewees Of the final interviewees, three were private consultants, two were clinical practitioners and seven were active academic researchers.

Interview data analysis

All of the interviews were recorded using telephony software. Recordings were transcribed by a professional transcription agency and all the interview transcripts were imported into NVivo 12 (proprietary qualitative data analysis software) alongside participants who submitted written responses to the interview questions. These transcripts were analysed to identify key information by coding. Coding is an interpretive process where the data is organised according to key themes. Segments of text are identified by the researcher and assigned to one or more themes. The analysis of each interview transcript therefore assigned individual sentences, phrases or words to single or multiple codes and related themes. Codes were grouped under the following high-level themes:

- **Monetisation** approaches
- **Measurements / metrics** of mental health

- **Applications to policy and decision-making** (e.g. natural capital accounting approaches).

Within each high-level theme segment, the following codes were applied:

- **Knowledge** (e.g. description of an approach or technique)
- **Reports** (e.g. examples of methods in project evaluations, academic papers)
- **Critical appraisal** (evaluation of the high-level themes by experts).

Any literature that was highlighted by one of the experts was used to inform the literature review. No names or organisation affiliations are used in the qualitative reporting or quotations from the participants.

Results

Literature review

Through our searches, roughly 1,400 titles and abstracts were scanned. The results highlight the paucity of evidence in the current academic literature for valuing mental health benefits of forests. Ten relevant studies were identified, of which eight had robust enough valuation pathways to inform mental health valuation approaches. Details of the studies identified, including the location, type of site, the valuation approaches used, and key findings can be found in Table 8, in Annex 1.

A growing body of evidence was also found supporting trees as the most influential component of greenspaces for self-reported mental health improvements, compared to shrubs, grass or built structures (Zhang and Tan, 2019). Another study of 46,786 adults over the age of 45 found that exposure to greenspaces with over 30% tree canopy compared to greenspaces with 0-9% tree canopy was associated with 31% lower risk of psychological distress (Astell-Burt and Feng, 2019). Although this field is still emerging, it highlights how differences in the physical characteristics of a site can affect the mental health benefits delivered. These themes are discussed further in the section '*Measuring exposure-response'*. Given this relationship and limited initial search results, greenspace terms were also included in the searches, leading to an increase in additional titles.

Prior to considering the evidence and approaches to valuing the mental health benefits of woodlands, it was essential to adopt a clear conceptual framework. An essential first step was therefore to clarify what is meant by 'mental health benefits'.

Defining mental health

Mental health can be conceptualised in different ways, which ultimately inform different valuation pathways that can be taken to capture benefits. Understanding current thinking on how best to define mental health can help inform valuation.

Traditionally, mental health was seen predominantly as the absence of mental illness (Galderisi *et al.*, 2015), with mental illness defined as a type of psychological distress. This includes disorders such as substance abuse or medically diagnosable mental health conditions such as depression, anxiety or schizophrenia as well as conditions such as dementia and autism, recognisable according to the World Health Organisation (WHO) International Classification of Diseases (WHO, 2019).

The WHO now defines mental health as "a state of well-being in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community"(WHO, 2004). The definition constitutes an important shift away from the conceptualisation of mental health solely in terms of the absence of mental illness towards also recognising positive wellbeing as a key aspect of mental health, thereby increasing its relevance to every individual. This shift is reflected in the growth of 'positive mental health' and the development of new widely-adopted approaches of measuring mental health, including the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) (Tennant *et al.*, 2007). This kind of conceptualisation sees mental health and wellbeing as interchangeable terms, although potentially excludes the heavy burden of more serious mental illnesses (Galderisi *et al.*, 2015).

From this perspective, mental health can be broadly conceptualised as covering both positive and negative states, encompassing both the presence of wellbeing and the absence of mental illness. For valuation pathways, this conceptualisation of mental health benefits can reflect both an individual's wellbeing value and wider values to society associated with avoided costs to the NHS and avoided losses to organisations through impacts on workplace productivity. In each case a person's interactions with and/or proximity to woodlands can reduce the risk of mental illness and help reduce losses in economic output. Wellbeing and avoided cost components are not mutually exclusive but reflect the different types of mental health benefit that woodlands can provide.

An important complication is that mental and physical health components of overall health and wellbeing can be difficult to disentangle, with a large body of evidence supporting a strong link between physical health and mental health (Ohrnberger, Fichera and Sutton, 2017).

Mental health valuation pathways

We identified three major 'direct' methodologies that are applicable for mental health valuation. These are summarised in Table 1, along with common metrics used to measure change in mental health that can then be monetised. The associated logic chains for each of the pathways also describes their operation, and worked examples are provided for each pathway in the *'Proposals'* section.

Table 1. Mental health valuation pathways

Methodology	Overview	Common Metric
QALY	A specific questionnaire of generic health status is ranked through a QALY framework to create a unique health state profile between 0-1, relative to 1 QALY (a perfect score). There is some debate on what monetary value should be placed on QALYs (Donaldson *et al.*, 2011). The Department of Health and Social care recommends the willingness-to-pay (WTP) for a QALY at £60,000, as outlined in the latest edition of HM Treasury's Green Book (HM Treasury, 2018). The National Institute for Care and Excellence (NICE) recommend their preferred metric for Quality of Life as EQ-5D (NICE, 2019). Figure 3 shows the steps involved in QALY valuation.	EQ-5D, SF-6D or any validated QALY metric.
Wellbeing Valuation	Direct monetary valuation based upon changes in life satisfaction data has been developed by leading contributors to the Green Book on non-market valuation (HM Treasury, 2018). The approach draws upon results from a model, using longitudinal data from the British Household Panel Survey, that established a causal estimate between income and life satisfaction by examining the influence of random shocks in income, in the form of lottery wins (Fujiwara, 2014). The method estimates the monetary amount an individual would need to be compensated with per annum to keep their mental health or wellbeing levels at	Life Satisfaction and SWEMWBS

	a constant level in the absence of a particular good (such as access to a forest site). The method has been used in a variety of contexts, including for the Department of Digital, Culture Media and Sport (Fujiwara, Kudrna and Dolan, 2014), and can be considered a pioneering approach in monetising wellbeing. A statistical relationship between life satisfaction and the short Warwick Edinburgh Mental Wellbeing Scale (SWEMWBS) has also been investigated (Fujiwara *et al.*, 2017). This has produced a methodology that allows valuation of changes in SWEMWBS scores. Figure 2 describes the wellbeing valuation pathway.	
Avoided cost	Avoided costs can cover a range of different approaches. These could include looking at reduced GP visit frequency associated with an intervention or interaction (Fujiwara, Lawton and Mourato, 2015) or reduced anti-depressant prescription rates (Bratman *et al.*, 2019) or productivity losses due to mental health issues (Isham, Mair and Jackson, 2020). The approach requires specific data that isn't necessarily readily available. Of the above, only (Fujiwara, Lawton, Mourato, 2015) attempted an actual valuation. The pathway can be applied broadly based upon the costs associated with poor mental health by assuming a given percentage reduction associated with percentile changes in a relative mental health scale (Vivid Economics, 2017; Dickie *et al.*, 2018). Figure 3 conceptualises steps for an avoided cost valuation.	Self-reported GP visits, anti-depressant prescription rates, workplace absenteeism or any self-reported mental health metric. (Note – this is a non-exhaustive list.)

Pathways not included in the above table include 'indirect valuation' approaches. These can involve applying regression analysis based upon changes in self-reported mental health values from an intervention or interaction (e.g. proximity to a greenspace) and individual or household income data in order to derive a 'hypothetical' willingness-to-pay (WTP) estimate (for forests or greenspace). However, compared to multivariate regression analyses used in wellbeing valuation where the main determinants for life satisfaction are fairly well-determined (Fujiwara, 2014), the number of factors that can contribute towards higher income and living in close proximity to forests or other greenspace are far more complicated and difficult to control for. Although a few papers adopted this approach (Bertram and Rehdanz, 2015; Krekel, Kolbe and Wüstemann, 2016), a simple model such as this is unsuitable for underpinning a robust mental health valuation pathway.

Other pathways include contingent valuation and other stated preference methodologies. However, asking an individual on their WTP for perceived mental health benefits is an extremely crude approach and can be difficult to disassociate from other cultural ecosystem service benefits such as sense of home, aesthetic values or spiritual and religious values. Studies exploring broad cultural ecosystem service benefits and the value of particular natural sites often include subjective wellbeing indicators associated with access to sites to support the study (Bryce *et al.*, 2016; Kenter *et al.*, 2016). However, as valuation is derived through stated WTP preferences rather than based on subjective wellbeing, the mental health value cannot be readily isolated.

Another approach encountered involving contingent valuation included filtering people's WTP estimates based on their primary reasons for visiting parks (Henderson-Wilson *et al.*, 2017). Such an approach has the benefit of isolating those who value mental health benefits most highly amongst other values, although any WTP estimates will still be inclusive of all other values. This particular study found an overall mean annual WTP for those vising parks of $45.4 (AUD) and a mean for those visiting for relaxation and wellbeing benefits of $23.3 (AUD). The reasons for a lower than average estimate for those seeking wellbeing benefits is likely to be that wellbeing is rarely a sole driver for a visit. People may be more likely to visit for recreation, socialisation or physical activity, with mental health and wellbeing benefits gained as secondary benefits, or perhaps feel uncomfortable about reporting mental wellbeing as a primary reason due to a residual social stigma attached to mental illness. As such, this approach can lead to an underestimation of the importance of mental health benefits. Furthermore, stated preference methods are typically discouraged for valuation if their estimates are insufficiently robust (HM Treasury, 2018). Given the biases that can be present, a stated preference WTP approach would likely be unsuitable for mental health valuation.

A component not encountered in the literature as part of a valuation pathway was the mental health value associated with 'increased productivity'. We came across a single reference to evidence that exposure to natural environments, even through videos or 3-dimensional (3D) virtual reality (VR), increase creativity (Palanica *et al.*, 2019).

Productivity impacts could be characterised conceptually as sitting within a similar category to 'avoided cost' as a metric that in principle could be directly monetized, although there are likely to be major difficulties in its applicability in practice, especially in relation to positive mental health. Primarily this is due to increases in productivity neither being easily measurable nor associated with a readily available cost. In principle sick days taken due to poor mental health can be quantified and monetised, but good mental health does not produce a readily observable impact on output through increased productivity. Where the impact of good mental health on productivity is associated with business as usual and there is no loss in productivity evident currently, it is appropriate to consider the mental health value in terms of productivity losses avoided through existing interactions with and proximity to woodlands (and other greenspace).

An indirect avoided cost pathway relevant to some woodlands is the new Environment Agency (EA) guidance on valuing mental health benefits of flood risk attenuation projects (Environment Agency, 2020). This way published after the formal end of the contract for this study. The EA guidance recommends deriving the mental health benefits of flood risk mitigation projects (which can include woodland creation and other forestry measures) by estimating impacts per property based upon the number of adults per property and the severity of the flood. Drawing upon information from Public Health England on prevalence of anxiety, depression and post-traumatic stress disorder (PTSD), the mental health impacts of flooding are assumed to last on average for 2 years after a flood and involve costs that range from £1,878 to £4,136 (in 2018 prices) per adult per flood event depending on the depth of the flood.

A similar approach to the QALY is the Disability-adjusted life year (DALYs). Where QALY is suited to evaluating the impact of potentially fatal health conditions, DALYs can better evaluate the impacts of living with chronic disability, including mental health disorders (Sassi, 2006) In practice however, the use of DALYs is less common in the UK (HM Treasury, 2018) and, most importantly, is not given a readily attributable value. As the aim of the study was to explore pathways of for monetary valuation of mental health benefits, a DALY approach is not considered a suitable pathway to do this at present, despite its greater effectiveness than QALY in quantifying changes in mental health (and thus also its greater suitability in comparing the effectiveness and cost-effectiveness of mental health interventions).

Mental Health Outcomes and Double-Counting

When considering the three primary valuation pathways identified and the definition of mental health, it can be seen that the metrics used to evaluate them relate to slightly different components of mental health that are not necessarily mutually exclusive. Considering how these pathways relate to mental health outcomes can help highlight differences in the types of benefits covered and contexts in which they can be used, as well as facilitating an understanding of potential double-counting issues that can arise,

as described in Table 2. A further discussion of the themes highlighted in Table 2 can be found in the '*Pros and Cons'* section.

Table 2. Valuation pathway metrics and their relationship to different outcomes associated with mental health

Valuation Pathway & Associated Metrics	**Mental Health Outcomes from an Intervention or Interaction**	**Double Counting Issues**	**Spatial Applicability**
QALY	*Reduced Mental Illness*	-	-
All QALY Metrics	Reduced disease burden (i.e. lost quality of life associated with poor health states, including poor mental health)	QALY metrics reflect changes both in mental and in physical health. For interventions (e.g. woodland creation) that can influence both mental and physical health, the estimated QALY improvement will capture both of these elements. Separating out effects due to changes in mental health can be challenging. Double counting could arise where separate values for physical health are included.	QALY metrics can be used to evaluate any kind of intervention impacting on human health at any spatial scale. QALY improvements due to interventions such as woodland creation could be expected to be greater for accessible woodlands and for woodlands in or near urban areas.
Wellbeing Valuation	*Increased Positive Mental Health*	-	Wellbeing values may be higher for accessible and urban woodlands than for rural woodlands and ones

			without public access.
SWEMWBS	Improved feelings and functional aspects of positive mental wellbeing	To the extent that visits to woodlands are motivated by mental wellbeing benefits, double-counting with recreational values could arise. However, given the focus on functional mental health, SWEMWBS is subject to double-counting issues with recreational values to a lesser extent than is life satisfaction.	The existing SWEMWBS valuation model is simplistic (Fujiwara *et al.*, 2017) and may be less suitable for usage with large scale datasets without further development. Thus, the SWEMWBS valuation pathway is currently more suited to evaluation of local interventions.
Life Satisfaction	A balance of positive and negative emotions that contribute towards an individual's satisfaction with current life status. Essentially a form of subjective wellbeing (Krueger and Schkade, 2008).	Life satisfaction is a broad category of subjective wellbeing that could be expected to potentially overlap with recreational benefits, as wellbeing may be a motivation for visits. It may also overlap with amenity values derived using hedonic price methods to the extent that a driver for buying property close to woodlands or other greenspace	Life satisfaction valuation has been directly correlated with income (Fujiwara, 2014). As such its applicability is flexible for any context, local or large-scale and for any kind of intervention or interaction using life satisfaction as a metric.

		is the wellbeing benefits.	
Avoided Cost	*Reduced Mental Illness*	-	Avoided cost benefits may be higher for accessible and urban woodlands than for rural woodlands and ones without public access.
Self-reported GP visits	Cost-saving to the NHS from reduced GP burden	If all self-reported GP visits are used as a metric (as opposed to just mental health related ones), there would be overlap with physical health benefits, with the latter potentially being double counted if also valued separately.	Could be used at any spatial scale, data availability permitting.
Anti-depressant prescription rates	Cost-saving to the NHS from reduced prescription rates	No double-counting issues, although gives a very conservative estimate of mental health value.	Could be used at any spatial scale with self-reports, data availability permitting.
Workplace productivity losses	Cost-saving to a workplace from reduced productivity losses in the form of absenteeism and presenteeism	Calculations of workplace productivity losses associated with poor mental health are quite crude (Parsonage and Saini, 2018) and, due to difficulties separating out	Could be used at any spatial scale, data availability permitting.

		causes, could include other reasons for absence along with mental health issues, and potentially double-count associated values (e.g. those for some physical health benefits).	
Self-reported mental health metric (GHQ-12)	Changes to GHQ-12 have been associated with cost savings to the NHS's expenditure on mental health treatment (Dickie *et al.*, 2018) and overall costs of poor mental health (Vivid Economics, 2017). GHQ-12 focuses on identifying minor psychiatric disorders as hindrances to normal day-to-day processes of an individual	Various categories of avoided costs can be associated with changes in self-reported mental health. Avoided cost metrics such as savings in mental health expenditure are free of double counting issues. However, the approach is often based upon a crude transfer, which doesn't utilise an estimated relationship between an intervention or interaction and the costed elements. For metrics such as avoided costs of GP visits or productivity losses, separating out mental health and physical health related savings can be tricky, with potential overlap if a value for physical	Could be used at any spatial scale, data availability permitting.

		health benefits is included separately.	

Although discussed in Table 2, no study identified through our literature searches or expert interviews had a strong focus on how to avoid double-counting of mental health benefits for natural capital accounting purposes. Neither did any of the studies consider spatial issues of mental health benefits and how these may vary between urban and rural environments. Consideration of spatial elements as external influences is further discussed in the '*Mediators*' section.

The various pathways reflect a focus on different mental health outcomes. A major distinction is that avoided costs and QALY approaches value the benefits associated with reductions in mental illness, whereas wellbeing valuation values positive improvements in mental health (including changes not resulting in reduced mental illness).

As wellbeing benefits accrue to individuals, while avoided costs relate to reductions in the burden of mental ill-health on the NHS and employers, these cover two different components of mental health benefits and are not mutually exclusive, but complementary. A mental wellbeing valuation and an avoided costs approach could be combined to capture a more comprehensive range of mental health benefits than either of these approaches provides by itself. This combined approach to reflect total economic value (TEV) has been applied to valuation of the aggregate health and wellbeing benefits of greenspace in at least one previous study (Jump and Simetrica, 2018). A multi-method approach to valuing mental health could potentially give rise to some additional double-counting issues however and should be used cautiously. It is unlikely that QALY would be combined with other valuation pathways in this fashion, due to the unique subjectivity associated with its monetisation. A QALY approach is more often used to determine cost-effectiveness, than to value mental health benefits, and due to the uniqueness basis on which values are derived may be considered unsuitable to include within a TEV valuation.

The following diagram provides a simple summary of these considerations, illustrating how each pathway relates to different kinds of value, and how an aggregate value may rely on both.

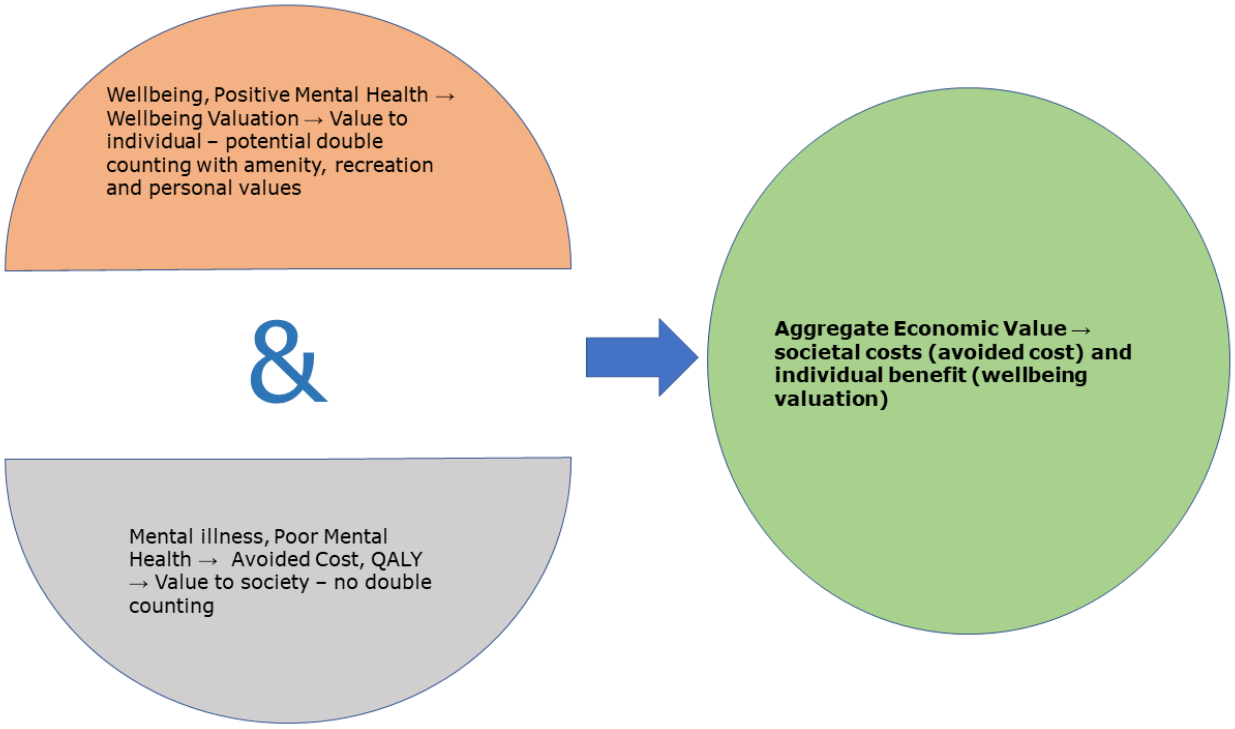


Figure 1. Relationship among various valuation pathways

To support understanding of these valuation pathways, the following figures (taken from relevant publications encountered in the literature) attempt to describe the steps involved.

The first figure is on the wellbeing valuation pathway, taken from (Trotter and Railings Adams, 2017).

- The income model relies on life satisfaction data extracted from the British Household Panel Survey (BHPS), examining the change in life satisfaction from the effect of random income, in the form of lottery wins. The model derives a coefficient for the impact of income on life satisfaction.
- Although the model is titled 'Community Investment Outcomes', the steps describe a transferrable approach of examining change to life satisfaction from an intervention or interaction, which for example could be a trip to a forest site.
- With the coefficient established for impact on life satisfaction from income, any impact on life satisfaction from a particular intervention, or interaction, can be given a monetary value.

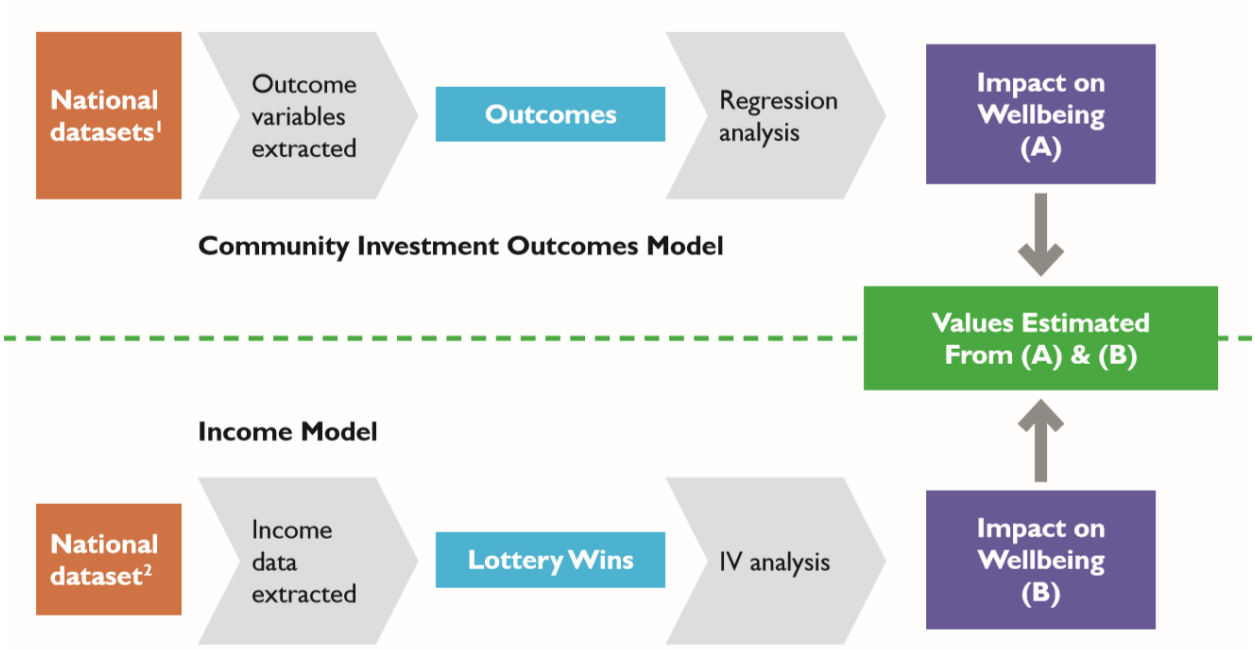


Figure 2. The wellbeing valuation pathway, taken from (Trotter and Railings Adams, 2017)

The second figure below shows the steps involved in the QALY pathway (yellow boxes) and an avoided cost pathway (red lines) in order to derive a health services value. The pathway considers mental health value predominantly from a clinical perspective, rather than in relation to a wider wellbeing benefit. Taken from (Buckley *et al.*, 2019).

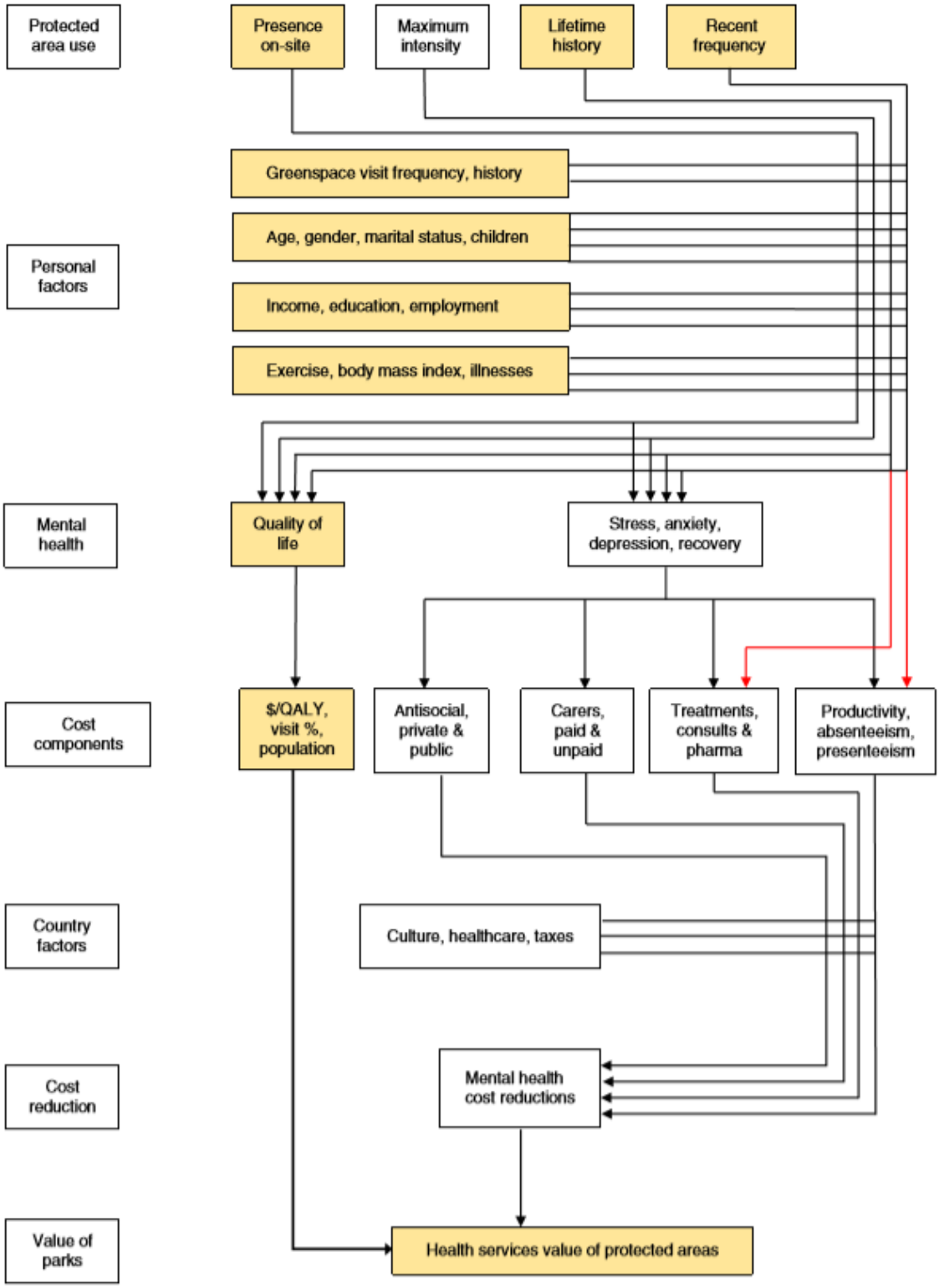


Figure 3. Flowchart of calculation pathways for health benefits values. Taken from (Buckley *et al.*, 2019)

Annex 4 includes two additional logic chains, which illustrate how interactions between mental health and nature but without considering valuation.

Pros and cons

A common characteristic of almost all valuation references we encountered was the use of self-reported mental health scales to quantify changes in mental health. Few studies were encountered that attempted to use biophysical indicators. This may be due to these currently being unsuitable for valuation. For example, cortisol levels in hair have been used as an indicator for stress and have been applied in natural environment settings (Gidlow *et al.*, 2016; Kondo *et al.*, 2018), although results have been mixed and the relationship between chronic stress, cortisol and its incorporation in hair is still not fully understood (Lee, Kim and Choi, 2015). Furthermore, there is currently no readily available valuation pathway to value associated changes in cortisol levels

Self-reporting is generally regarded as a reliable predictor of symptoms, particularly for mental health (Maske *et al.*, 2016), although this relies heavily on the quality of the metric used. A list of common mental health and wellbeing metrics used in natural environments can be found in the Valuing Nature Programme's Demystifying Health Metrics (Valuing Nature Programme, 2019). They include the Office for National Statistics subjective wellbeing questions (ONS-4), the general health questionnaire -12 (GHQ-12) and the shortened WEMWBS (SWEMWBS). Although there is no 'gold standard' for applications, the WEMWBS or SWEMWBS is often recommended (Valuing Nature Programme, 2019). The main difference between the scales is that the fewer questions within the SWEMWBS gives the scale a slightly greater focus on functioning than feeling. WEMWBS has been widely validated across different populations (Clarke *et al.*, 2011; Maheswaran *et al.*, 2012; Bartram, Sinclair and Baldwin, 2013; Taggart *et al.*, 2013; Smith *et al.*, 2017). SWEMWBS has been found to detect changes in mental health in a very similar way to WEMWBS (Haver *et al.*, 2015), with the added benefit of a lower participant burden making it a popular choice for large-scale national surveys (Ng Fat *et al.*, 2017).

Using SWEMWBS to underpin valuations has limitations, however. Although life satisfaction is the underlying basis, there is not a statistically significant relationship with life satisfaction for changes at lower end of the SWEMWBS scale (Fujiwara et al., 2017). As such the pathway cannot readily capture changes associated with very poor mental health. Furthermore, SWEMWBS has a non-linear relationship with life satisfaction, so there is no single coefficient that can describe changes within the scale. The current model also only has 12 categories applicable to valuation, despite scores being available between 7 and 35. To be able to track small changes across SWEMWBS with averaged data scores across two distinct groups, the model would require further development or major assumptions. In its current form, the model is more suitable for smaller project interventions that track SWEMWBS changes on an individual level.

Life satisfaction is a more inclusive metric than just mental health, typically reflecting the full balance of an individual's positive and negative emotions as well as a self-assessment of how their life measures up to their aspirations and goals (Kahneman and Krueger, 2006). It is considered a reliable measure of subjective wellbeing (Krueger and Schkade, 2008), and a concept that is becoming increasingly recognised as useful for social cost-benefit analysis (HMT, 2018). Due to its inclusive nature, life satisfaction may give rise to double-counting issues, as it may capture values associated with recreation, physical health and even amenity value in addition to mental health. These can give rise to inflated values (Jump and Simetrica, 2018). Nonetheless, it can be a very useful metric in considering the broad range of wellbeing benefits.

A wider issue of wellbeing valuation is the close relationship between income and other factors that improve wellbeing, such as education and health. Although the income model that underpins wellbeing valuation attempted to control for this, further longitudinal research would be necessary to understand the relationship between life satisfaction and income as accurately as possible. Wellbeing valuation is sometimes considered to give inflated estimates due to this.

Wellbeing valuation as a pathway is heavily statistically dependant, on monetary estimates of mental health benefits and can also be inflated due to influential factors that also impact directly on mental health metrics. These include the characteristics of the surrounding area - e.g. being less deprived (White *et al.*, 2013) and of existing visitors - e.g. having more free time and being more likely to be healthy (Dolan, Peasgood and White, 2008), factors which can be difficult to control for without longitudinal studies to explore these relationships. These issues of co-contributing factors on metrics are a broader issue of measuring mental health, rather than just wellbeing valuation, however.

Commonly used metrics that underpin QALY estimates include EQ-5D or SF-6D. The questions covered by these self-reported metrics relate to overall functional and physical health. Interactions such as engagement with the natural environment is highly likely to generate benefits associated with improved physical health as well as mental health, and as such these can give rise to double-counting issues if solely mental health benefits are desired. To best evaluate changes in mental health, QALY metrics may be less suitable (Brazier, 2010), with EQ-5D found to be far less sensitive to detecting changes in mental health compared to dedicated mental health scales such as WEMWBS (Johnson *et al.*, 2016).

A further limitation may be their innate undervaluation of mental health issues by design. QALY uses hypothetical preference-based frameworks to create health profiles, considering the relative negative impact of different health states against each other. Such an approach can be vulnerable to a number of preference-based biases, including a focusing illusion (Kahneman *et al.*, 2006), where mental health issues can be difficult to conceptualise relative to salient physical health conditions. When using a direct

subjective wellbeing approach to evaluate the effect of real negative health states individually, mental health issues are shown to have far greater impact on an individual relative to other dimensions of health (Powdthavee and van den Berg, 2011), compared with EQ-5D (Dolan and Metcalfe, 2012) and SF-6D (Fujiwara and Dolan, 2014). These limitations could make QALY pathways unsuitable for robust mental health valuation.

An avoided cost pathway is unique in that it can use physically observable data, although in practice there can be major difficulties in doing this, primarily as the availability of this data can be scarce and not always explicitly informative. For example, the use of anti-depressant prescription rates as a metric in relation to greenspace proximity, although readily available (Taylor *et al.*, 2015), gives a simplistic, binary outcome for mental health compared with the SWEMWBS where respondents can score anywhere between 7-35 for their mental health. As many people who experience poor mental health do not go to their GP to receive treatment (Lubian *et al.*, 2016), an avoided cost approach will tend to under-value the mental health benefits of woodlands. Due to background fluctuations in drug prices, changes in avoided costs are also not always straight-forward to interpret, as an increase (or fall) in avoided costs may be due to higher (or lower) drug prices rather than changes in mental health impacts due to an intervention or interaction and so need to be considered together with changes in prescriptions. Furthermore, a focus on avoided costs does not capture any of the positive mental health and welfare elements associated with woodland engagement, although avoided costs will avoid any potential double-counting issues with broader recreational and amenity values.

GP visits is a more inclusive metric of the range of different mental health issues than a focus on changes in costs for specific mental health conditions, and there have been attempts to utilise an average cost to the NHS per GP visit based on average consultation lengths and healthcare costs data (Fujiwara, Lawton and Mourato, 2015). Limitations of this approach however include the fact that GP visit data are often inclusive of visits for all health-related issues, including visits for physical health conditions, regular check-ups and vaccinations, as well as excluding people who have not visited their GP regarding mental health problems. Furthermore, this kind of data is typically only available at the GP-practice level in the UK, which could limit analyses and data extrapolation when making regional or national level assumptions, where there could be significant variability between practices.

Rather than use these more complicated metrics for valuation, studies adopting an avoided cost methodology for mental health valuation of natural environments have instead generally used changes in a self-reported mental health scale, such as GHQ-12, and transferred that as a percentage reduction to an associated NHS mental health spending (Dickie *et al.*, 2018) in the area. Naturally though, this approach is very simplified and does not utilise a causal relationship.

A similar study used this percentage-change approach but with a broader value associated with the costs of poor mental health (Vivid Economics, 2017), inclusive of factors such as greater social spending on disabilities and sick benefits as well as reductions in workplace productivity through presenteeism (working whilst sick, rather than recuperating), lost days and staff turnover. Establishing a causal relationship between these wider components and mental health can be extremely difficult however due to the huge number of potential contributory factors and a lack of available data. As a consequence, often large assumptions are necessary to compute comprehensive estimates of avoided costs associated with reductions in poor mental health. For example, estimates of sickness absence due to mental health problems are often working days lost as a proportion of people who have mental health problems, rather than lost days as a result of actual symptoms (Parsonage and Saini, 2018). Similar themes of difficulties in applying avoided cost approaches were echoed in our expert interviews and in comments from critical friends.

Although none were encountered through the literature searches, further NHS-related avoided costs could be utilised in future research, where observations on a clinical population with a variety of related cost elements could be made. Such an approach could be used to establish causal relationships between an intervention and changes in avoided costs more readily. However, the outcomes of this kind of approach would likely be very different depending on the kind of population sample used, and depending on the severity of pre-existing mental health conditions. Furthermore, different NHS trusts may have varying levels of costs associated with mental health treatments, which could limit the transferability of such an approach.

An important consideration to note however is that although each pathway has limitations, different end users may have preferences for different metrics and approaches to support their needs. For example, to compare cost-effectiveness against other healthcare interventions an NHS trust may still retain a preference for a QALY approach. Conversely, a local authority may have a greater preference to understand broader wellbeing impacts on its population and may be less concerned about issues of double-counting or value uncertainty. Either may prefer an avoided cost approach for a conservative estimate of mental health value. Robust valuation may be less important in some circumstances and rather a sense of scale and how this compares to other natural capital values could be highly desirable, particularly as this field is still developing. To summarise broader pros and cons associated with these metrics and the pathways themselves, Table 3 below provides an overview of the most prominent considerations and discusses the overall suitability of these valuation pathways for mental health.

Table 3. Pros and cons for QALY, Wellbeing Valuation and Avoided Cost mental health valuation pathways

Pathway	Pros	Cons	Overall Suitability
QALY	A popular, widely accepted metric for valuing health outcomes. Captures overall health impacts associated with an intervention, which may be desirable.	May undervalue the impact of mental health. Can be subject to stated preference biases. Value is rooted in evaluating clinical interventions. May be less comparable with non-health interventions and less suitable for informing broader forest policy.	Useful in comparing healthcare interventions, but may fail to capture some mental health impacts.
Wellbeing Valuation	Valuation is based on real, observable experiences and can be used in cost-benefit analysis. Broad applicability with any dataset on life satisfaction or SWEMWBS. Can capture a direct value associated with positive mental health for each and every individual.	The pathway is heavily statistically dependant, and can give inflated values without robust mental health measurement data. Changes in SWEMWBS at lower levels of the score do not have statistically significant changes on life satisfaction. The SWEMWBS valuation model requires further work to increase its feasibility for use with large datasets.	May miss some value associated with very poor mental health and tracking small changes may require major assumptions for SWEMWBS data, but is widely applicable and can generate a direct and comparable value for an intervention or interaction.
Avoided costs	Can reflect market costs, and costs to the public sector (NHS). Can capture value associated with improvements in very poor mental health, that	Data on avoided costs of poor mental health or mental illness is often sparse and very general in nature. Can be difficult to quantify impacts of poor mental health for some metrics	Can provide a conservative estimate of mental health benefits, although often requires major assumptions.

	wellbeing valuation misses. Can provide a conservative, lower-bound estimate for mental health benefits.	(GP visits, missed days at work, etc). Can be used primarily for costs associated with avoiding more serious mental health illnesses. Does not capture any impacts of improvements in good mental health.	

Interviews with experts

Results for the twelve responses from expert stakeholders are reported in the following sections. Table 4 outlines the experience of the interviewees in monetary valuations of mental and physical health as well as the use of other measurement approaches.

Table 4. Experience of monetary valuation of mental health benefits of forests and greenspace by expert interviewees

	N	**%**
Monetary valuations of mental health outcomes	6	50
Monetary valuations of other health outcomes	8	66.6%
Self-report mental health outcomes	5	50%
Biophysical mental health outcomes	4	33.3%

Measurement and valuation

Table 5 describes the principle recommendations made regarding the three valuation approaches outlined in the literature review according to the expert interviewees.

Table 5. Expert interviewees recommendations according to valuation methodology

	Policy and decision - making applications	**Future research directions and data requirements**
Wellbeing valuation	Valuations of forestry and greenspace assets Comparisons with other valued social impacts (e.g. heritage and culture)	Experimental data to determine direction and strength of effects Utilising longitudinal datasets
QALY	Comparisons with other healthcare interventions	Inclusion of appropriate instruments and biophysical data in surveys of natural environments or

	Biomarkers linked to QALYs impactful among medical / health service stakeholders (but are indirect methods)	linking these data elsewhere with small area geographies.
Avoided cost	Wider economic impacts in society e.g. in labour force	Linked administrative data Large scale studies to determine impact of exposure and engagement with forest and greenspaces on biomarkers
All methods		Environmental data including biodiversity / recreational facilities. Objective measures and perceptions of environments Experimental research assigning people to environments / activities / visit conditions to control for self-selection bias and endogeneity

Several experts expressed the view that wellbeing valuation approaches that are then monetised tend to yield higher values than QALYs or avoided cost methods. In addition, wellbeing valuation methods tend to attach higher values to mental rather than physical health conditions:

> *We found in that method that using the subjective wellbeing approach actually attaches a much higher value to mental health conditions relative to physical health conditions compared to the Quality Adjusted Life Year. (Consultancy expert)*

One reason attributed to this is that most QALY data is based on hypothetical preferences, which are not collected among those experiencing a particular condition, whereas wellbeing valuations are derived based upon relationships between wellbeing and a particular person experiencing the condition.

A second reason is that QALYs are calculated based upon symptoms of poor mental health – which may be derived from a general health or primary care measure. However, they do not take into account broader positive benefits from exposure or access to green space. These factors combined tend to lead to differences in the relative value of mental and physical health benefits and overall differences in the value of benefits derived:

> *The QALY is biased, to some extent, against mental health conditions. It's because the questions that make up a QALY mainly focus on physical health issues, things like self-care and mobility and pain, at the detriment of talking about emotional wellbeing; so, you get physical health conditions showing up much higher. (Consultancy expert)*

In using any self-reported measures, a clinical expert noted that for mental health issues, scoring can be particularly difficult when compared to for example, physical pain.

> *Mental health is a very odd concept to deal with as it deals mainly with perceptions of the sufferer which may conflict with the person managing the sufferers care. It is hard to score unlike, for example pain. (Clinical expert)*

Subjective wellbeing approaches tend to involve valuations that are an amalgamation of greenspace benefits and which may include mental, physical, aesthetic, cultural and social benefits supported by visits to or proximity to greenspace.

> *So, the values that we derive are for a bundle of benefits and goods that things like green space provide. So, we know that green space is good for peoples' wellbeing and it differs across different population groups. But we're not exactly sure within that how much of that is due to the visual amenity versus, let's say, the existence of the site versus the physical or mental health benefits. We just take values at the moment that are kind of an aggregation of all of that, as it were, but there is data out there that would allow you to look into this in a bit more detail. (Consultancy expert)*

However, in discussing recent developments, experts suggested that future work can and should separate out which proportion of an overall wellbeing impact for access or engagement with forests and greenspaces may be attributable to different benefits:

> *We could look at initially the impact of forests and green space on peoples' life satisfaction directly and get a value of that, and I'm just making this figure up, but let's say that turns out to be £800 a year or something is the value, in a separate model you could then also look at the impacts of green forests, green space on indicators of peoples' mental health, so things like the GHQ score in Understanding Society* [survey]*. (Consultancy expert)*

A further recommendation in cases where data availability – particularly on engagement with forests and woodland might be limited or whether specific sites such as the public forest estate might be of interest, is to employ primary data collection in smaller scale on-site surveys alongside previously validated work using national-level data:

> *There's a possibility to supplement [national level data] with, I think, some primary surveys. So just to give you an example, work that we did for the Natural History Museum and Tate Liverpool, we initially started with deriving values for museums in general because we have that type of data in the national datasets and then we supplemented that with primary data collected from visitors at both of those two museums, and again ran the same subjective wellbeing valuation analysis that way to get a value for the specific museums. (Consultancy expert)*

A critical perspective offered by one expert interviewee was that much of the data supporting relationships between both exposure to (e.g. proximity to) and engagement with (e.g. visits to or time spent in) natural environments was cross-sectional in nature. This made it difficult to establish precisely the components of the relationship between exposure and engagement with natural environments which is causing changes in mental health outcomes as opposed to visa-versa:

> *The question is what proportion of the variance in these more sophisticated epidemiological, econometric type approaches is really that direction versus the reversal direction and, at the moment, I don't think we've got a handle on that. (Academic expert)*

> *That is generally the challenge of working with observational, with cross-sectional data where we just conduct a survey and where we have large survey datasets like this MENE survey or something that you might know where we just have one observation for one person being interviewed, and then we have multiple measures of types of activity, where does the person live and social demographics and stuff like this, but we cannot get to the causal effect. (Academic expert)*

In view of the importance of self-report measures for both wellbeing valuation and QALY approaches to mental health valuation, one expert stressed the importance of including robust measures of wellbeing and mental health outcomes in national datasets. The inclusion of these measures was sometimes thought to contrast with the inclusion of relatively simple outcome measures for the purposes of monitoring, which some policy-making stakeholders tended to include in major surveys for the natural environment. In contrast, well-validated measures were valuable for statistical analyses of relationships between outcome measures and environmental exposure needed for econometric analyses:

> *The thing that I have noticed – the piece of information I would give you – is that quite often a lot of these organisations feed in requests for relatively simple data... often the way they want [the data] structured in the questions they ask doesn't help us make more sophisticated analyses by, for example, using response scales that we can then do factor analysis and mediation structural equation models on…They don't necessarily realise that the quality of the questioning they're asking isn't sufficient for our analytical approaches. (Academic expert)*

Another expert concurred that there is value in being able to conduct multivariate analyses, including structural equation modelling when wanting to understand a range of potential benefits (for example aesthetic benefits, social connections, reducing symptoms of depression and anxiety, physical health) on overall wellbeing. These approaches are also necessary in tackling issues of double counting.

> *I think it's a case of just being quite smart with the data and moving away potentially from just these single equation models to think about maybe a simultaneous equation model, structural equation model where you're accounting for all of the moderating and mediating factors in the model. (Consultancy expert)*

Owing to, and in part dealing with issues around double counting, another academic expert added:

> *You are always going to get issues of potential double counting – but I think there is value in looking at the orders of magnitude of the different impacts. (Academic expert).*

Another expert pointed out that some measures used for avoided cost methods can also be difficult to measure:

> *One of the challenges of productivity is that it is very difficult to measure. I think there is a World Health Organisation questionnaire on productivity, which I have and that we have used in some of our research, but actually the simplest way of assessing productivity, if you like, we've found is just to ask people how productive have you been over the last month on a scale of 0-100 (Academic expert).*

Nonetheless, there was recognition by a range of experts that data availability was improving, for example with better linkages and availability of administrative data such as prescription rates. In general experts expressed the opinion that data for all methods was becoming more available for example, with the inclusion of better measures of mental health and wellbeing in national level surveys and GIS methods, which can augment existing population level studies.

Applications of mental health valuation in policy and decision making

Expert interviewees suggested that the most appropriate approach may depend upon the overall aim of the valuation exercise and the relevant stakeholders involved. In particular, a number of stakeholders suggested that wellbeing valuation approaches tended to be more useful for making the case for the overall value of a natural environment, whereas QALY and avoided cost methods might be more appropriate if integrating 'green' interventions into a healthcare context:

> *I think because it's billed as a natural capital valuation tool where you're trying to capture as much of the value as possible and also speak to an audience of local authorities who are interested in wellbeing outcomes not just from a cost-saving perspective. Whereas if you were just interested in making the case of the value of reducing disease outcomes or reducing the burden on the healthcare system, that might not actually be as useful a metric. (Consultant expert)*

One expert defended the use of self-reported measures themselves as having good predictive power in respect of outcomes such as all-cause mortality, however they conceded that for many stakeholders in medicine, objective, biophysical measures do possess greater credibility:

> *I gather, for example, particularly in older age, the best predictor of whether you'll be alive tomorrow or dead in your sleep is how you say you feel today, and no amount of taking blood pressure or all kinds of other physiological measures actually trumps the predictive power of someone who says actually I feel okay, versus someone who says I really don't feel at all well, something's not right. (Academic expert)*

However, the expert proceeded to say:

> *Many people in medicine really like biomarkers because they are considered independent measures and are apparently more precise of certain physiological states that people are in. So, I think they are popular and if you can use them, you get the attention of medics in a different way if you use biomarkers. (Academic expert)*

However, some academic experts suggested that using biomarkers such as cortisol – or linking mental health burdens to environmental phenomena such air quality are far from "quick wins" and could be difficult to place a monetary value on. One clinical expert further underlined this perspective:

> *The outdoors in general has a calming and relaxing effect on most people, though some like the outdoors for is ability to stimulate. Let's*

> *forget the 'effect' of Cortisol, this is a bit too disputed and can lead us down a winding path, we aren't worried by endocrinology, just the general visible benefits (Clinical expert)*

Finally, in targeting valuations to areas of policy or particular stakeholders, one clinical expert suggested the benefits for those with severe and enduring mental health problems may differ from those with milder issues and policy – alongside the necessary monitoring and evidence needed to inform it will differ. Moreover, another expert agreed that targeting interventions at less severe issues, including prior to any other pharmaceutical interventions may be appropriate in the case of natural environments such as forests and greenspaces:

> *There has to be an agenda and a group with which the Commission choose to work with. The Commission has got to decide with which group they wish to engage. It may be that those with low level issues are a target group, again selection may be used to see if GP or Emergency Department visits are reduced, the potential savings of time and consequential financial benefits may be vast. (Clinical expert)*

> *Because what we're thinking is in terms of prescriptions, basically if they've got a pill, the drugs, it's too late, the green space hasn't been able to prevent them getting that condition. So, we're doing two different designs, so basically for all the routine data we're trying to update our primary mental health outcome to include everything but the pills, so trying to work up to there. (Academic expert)*

Discussion

Measuring exposure-response

Valuation of the mental health benefits of a forest intervention or interaction is essentially a two-step process, which involves:

1. Quantifying the mental health response to the intervention or interaction using a metric, such as a self-reported mental health scale or a directly observable characteristic (e.g. anti-depressant prescription rates), compared to an appropriate baseline (which could either be a standardised baseline, or based upon a pre-intervention survey)
2. Monetising the change in mental health.

This report discusses the methodologies for achieving this second step, but the process also requires a robust estimate of the mental health impact that describes the change.

Difficulty can arise in establishing a baseline to define this change. For small project interventions, these baselines often take the form of pre and post intervention surveys,

which gives greater control over the influence of subjective factors that can influence mental wellbeing. However, understanding the duration of effects for these projects can be a challenge, but is clearly important – as it is for other types of health interventions. For example, evaluation of the Branching Out project (CJC Consulting, 2016) found no evidence for benefits maintained after 3 months (CJC Consulting, 2016) and an evaluation of WIAT interventions found no benefit for mental wellbeing beyond 6 months (Ward Thompson *et al.*, 2019). Interventions potentially produce different kinds of effects (such as a greater effect spike with a sharper drop-off) compared to long-term behavioural patterns of interaction (such as a shallower but more consistent effect), and these should be taken into account when drawing conclusions and aggregating expected effects.

Large-scale datasets that collect information on engagement with the environment alongside mental health metrics are likely reflective of more consistent behavioural patterns but studies utilising these datasets are sometimes limited due to the lack of extensive, specific data to establish clear baselines and control for influential factors. Jump and Simetrica (2018) compare their findings for wellbeing benefits of greenspaces between users and non-users, with non-users defined as those who have visited their local greenspace less than once a month over the past 12 months using data from the Monitor of Engagement with the Natural Environment survey (MENE). A limitation arises in that these boundaries are inherently arbitrary and cannot control for the characteristics related to the greenspace or the quality of the interaction that takes place. Someone who travels in close proximity to greenspaces on their drive to work may gain enough passive wellbeing benefit through seeing greenery every day, so that they do not feel the need to visit greenspaces as often but would be classified as a non-user. An individual who spends hours every weekend in nature would have their benefits aggregated alongside an individual who uses their local park for an evening run every few weeks. These assumptions are somewhat unavoidable without pre-existing, quality data that has explored this relationship and can be used as a standard.

Another approach is the use of a control group. With the growing evidence base for trees as a very important feature of greenspaces for mental health improvement (Astell-Burt and Feng, 2019; Zhang and Tan, 2019), comparisons between greenspaces with predominantly grassy features and greenspaces with trees could be an important area of future research for understanding the influence of forests on mental health. However, a challenge remains in understanding the wide range of influences and drivers of the relationship between the interaction with nature and changes in mental health. Without controlling for these factors, comparisons base upon physical site characteristics could be flawed.

There have been several studies that attempted to explore the relationship between mental health and nature in greater detail. The influences within this relationship can reflect the quality and characteristics of the environment as well as the individual activity that occurs on-site, and potentially the amount of leisure time an individual has too.

Figure 4 provides an overview of these interactions in Annex 4. The quality of a greenspace can reflect elements such as the prevalence of trees (Astell-Burt and Feng, 2019), its ability to remove air pollutants (Yuan, Shin and Managi, 2018) and the types of flora and fauna present (Aerts, Honnay and Van Nieuwenhuyse, 2018). Individual activity that constitutes a 'dose of nature' can reflect site visits (Kondo *et al.*, 2020) or living in close proximity to greenspaces (White *et al.*, 2013; Houlden *et al.*, 2019) as well as reflecting the kind of activity that takes place, such as physical exercise (Dzhambov *et al.*, 2018), socialisation (De Vries *et al.*, 2013) or meditation (Park *et al.*, 2010). Of studies examining dose-responses of time spent in nature associated with mental health benefit, results can be mixed. White *et al.* (2019) found that at least 120 minutes spent in nature a week was associated with good self-reported mental health, although there was little evidence for benefit below this threshold and a plateau of benefits beyond 200-300 minutes of exposure. A slightly earlier study found a lower threshold, with lower rates of depression and high blood pressure amongst people visiting greenspaces for more than 30 minutes a week (Shanahan *et al.*, 2016). A similar study to this found that at least 10 minutes a week of greenspace activity may be able to prevent between 5-27% of depression cases and that if neighbourhood vegetation coverage is managed above 15%, this could prevent a further 5% of depression cases (Cox *et al.*, 2017). A recent scoping review of the effects of nature on college-aged adults found also found that mental health benefits can be achieved in single sessions with as little as 10-20 minutes of exposure (Meredith *et al.*, 2020). Conversely, Picavet *et al.* (2016) found the percentage of greenery around place of residence to have no effect on self-reported health, including depressive symptoms. As a consequence of the mixed results, the number of different elements to consider and the many confounding factors that can influence mental health and wellbeing, quantifying this relationship and then estimating monetary values poses significant challenges. The field is notably lacking longitudinal experimental studies to control for these different influences, a limitation highlighted by several of our interviewees. Without this, values estimated can only be associative and remain uncertain. This remains a major limitation for valuation studies.

Mediators

Valuation studies often utilise a simple regression analysis with cross-sectional data on changes in a mental health metric and exposure to the natural environment. Although lacking precision, this rough approach is necessary without longitudinal data to support investigating causal relationships. Given these limitations in the data, there has been almost no attempt to monetise the influence of the individual drivers of the relationship between greenspace and mental health. These can relate to a wide variety of factors (relationship 'mediators'), such as air pollutant removal, physical activity as well as pre-existing mental health status, which all influence the overall effect of change in mental health. Figure 6 in Annex 4 describes the influence of these mediators as drivers influencing the extent to which greenspaces provide mental health benefits. Table 6

provides a non-exhaustive list of some of these mediators and reference to studies that have explored their influence. Although there has been very little attempt to value or robustly quantify the impact of these mediators on mental health, with previous studies predominantly exploring associations rather than causal relationships with mental health, understanding what these mediators are is an important initial step in understanding the divers of mental health benefits.

Table 6. How influences that drive mental health relate to the different kinds of mediators in natural environments

Influence	Description	Mediators	Reference
Physical characteristics	Size Biodiversity/species composition Location	Air pollutant removal	(Freire *et al.*, 2010; Becerra *et al.*, 2013; Power *et al.*, 2015; Tian *et al.*, 2015; Tzivian *et al.*, 2015; Lanki *et al.*, 2017; Perera, 2017; Dzhambov *et al.*, 2018; Gascon *et al.*, 2018; Yuan, Shin and Managi, 2018)
		Noise pollution reduction & natural sounds	(Alvarsson, Wiens and Nilsson, 2010; Gould Van Praag *et al.*, 2017; Gascon *et al.*, 2018)
		Biodiversity	(De Vries *et al.*, 2013; Cox *et al.*, 2017; Aerts, Honnay and Van Nieuwenhuyse, 2018)
Exposure	Length of time spent Frequency of visits Type of Activity	Social cohesion	(De Vries *et al.*, 2013; Dzhambov *et al.*, 2018)
		Physical Activity	(De Vries *et al.*, 2013; Dzhambov *et al.*, 2018)
		Mindfulness	(Park *et al.*, 2010)
External factors	Individual attributes that affect the kind of benefit that can be received	Cultural values and upbringing	(Thompson, Aspinall and Montarzino, 2008; Hartig *et al.*, 2011)
		Mental wellbeing status	(Bagnall *et al.*, 2019)
		Socio-economic status	(O'Brien and Morris, 2014; Jump and Simetrica, 2018)

When considering the effect of external factors such as socio-economic and existing mental wellbeing status, these can be highly influential on the effectiveness of an intervention or interaction for mental health benefits (Jump and Simetrica, 2018; Bagnall *et al.*, 2019). The influence of these individual attributes is also often easier to observe than other mediators, such as those associated with the characteristics of a greenspace or the type of activity that occurs on-site, as external factors are readily categorizable and more easily controllable. Of the above studies examined, only external factor mediators had been explored for their relative influence.

- Jump and Simetrica(2018) found that lower socio-economic groups and BAME groups both placed a higher relative wellbeing value on parks and greenspaces than their counterparts.

- Bagnall *et al.*, (2019) found that people with lower mental wellbeing status in the baseline for a forestry intervention had a lower social return on investment in mental health benefit, compared to people with average to high wellbeing at the baseline.

Controlling for mental health mediators that relate to physical characteristics and on-site exposure, such as air pollutant removal, noise pollutant reduction or physical activity is a far more difficult task than controlling for external factors due to potential interactions. For example, a study exploring the effect of air pollutant removal on mental health by different tree species may inadvertently introduce the effects of biodiversity differences into people's subjective preferences for mental health benefits. Similarly, a study exploring the effects of varying levels of physical activity in nature on mental health may introduce the influence of visual, oral or other meditators often associated with 'forest-bathing' – especially amongst groups involved in less strenuous forms of physical exercise who may give more attention to diverse environmental cues. The effect of other mediators such as biodiversity may be more feasible to explore in terms of the influence of the presence of particular species. Approaches such as use of the Outdoor Recreation Valuation Tool (ORVal) have been used to value people's greenspace recreational preferences for different land covers (Day and Smith, 2017), which may in part reflect their preferences regarding associated mental health benefits. (The relationship between recreation and mental health is considered further in the 'Applicability' section). However, it is possible that mediators such as woodland sounds including birdsong could have a larger effect on mental health than on recreation benefits, although untangling the effect of different factors remains challenging.

Until there is better understanding of the range of mediators that can influence mental health benefits from woodlands, and there is a more robust understanding of the influence of woodlands on mental health, attempting to value the impacts of individual mediators could be difficult.

Research Gaps

Major gaps in the academic literature include:

- Evidence specifically on values of mental health benefits associated with UK woodlands. Few studies focused solely on mental health benefits, often including mental health as a component of wider benefits, such as cultural ecosystem services or overall health, which gives rise to double counting issues.
- Robust, quantified evidence of impacts on mental health, which can in turn be monetised. There are many factors that must be considered and controlled for which can drive the relationship between an intervention or interaction and mental health (White *et al.*, 2019). These considerations are discussed further in the section '*Measuring Exposure-Response*'. Many studies are too small-scale to be able to robustly explore impacts on mental health. There is a need for longitudinal trials and cohort studies to better explore the relationship between woodland interventions or interactions and mental health, taking these factors into account.
- A comprehensive approach that considers benefits both in terms of individual mental health and associated benefits to society such as avoided costs to the NHS, drawing upon valuation pathways for these different components of the mental health benefits of woodlands. Each of the existing mental health valuation pathways has some limitations, as discussed under the *Pros and Cons* section and Table 3: QALY pathways can be hindered through the limited ability of its metrics to detect changes in mental health, as well as the element of subjectivity around monetisation; Wellbeing valuation is unique in that it attempts to capture a welfare value associated with positive mental health at the individual level, although the current models for SWEMWBS valuation are limited and life satisfaction is a broad and often inflated metric to use in valuing solely mental health benefits; Avoided cost approaches are heavily dependent on the availability of specific data and can neglect causality and be based upon a very narrow conceptualisation of mental health benefits. A systematic approach to valuation encompassing the different components of mental health benefits is needed in order for the full value of woodlands for mental health to be recognised.

Applicability

In view of these evidence gaps and taking account of the principles of natural capital accounting (ONS, 2017), inclusion of the mental health benefits of woodlands in natural capital accounts may be premature until further work is undertaken, due to the level of

uncertainty in computing estimates associated with the current lack of robust evidence on impacts. In addition, an appropriate conceptual framework for the inclusion of mental health benefits in natural capital accounts remains to be agreed. In particular, mental health benefits might be considered to constitute ecosystem services themselves, or the ecosystem services involved might be considered to be characteristics such as 'woodland settings' for recreation and other activities providing these benefits, and 'woodland exposure' based upon views from and proximity to homes, offices, hospitals and other buildings and transport infrastructure (roads, railways, paths, etc). While the value of mental health benefits associated with ecosystem services that act as 'mediators' (air pollution absorption, noise reduction, etc) could be included within the value for these, separating out mental health benefit components could be useful for policy and appraisal purposes in comparing different options aimed at improving mental health. While valuing the mental health benefits of woodlands for inclusion in natural capital accounts is feasible in principle, establishing a robust quantitative evidence base on exposure-response relationships remains a major hurdle.

There could also be significant interactions and potential double-counting issues to address in considering how best to incorporate mental health benefits into natural capital accounting. As mental health affects human behaviour, values for other ecosystem services that depend on human behaviour are likely to be affected by it. For example, while recreational activity is generally associated with relaxation and enjoyment implying mental health and wellbeing gains, individuals with good mental health may be more likely to engage in recreational activity than those with poor mental health.

The value of recreation for visits motivated by a desire to obtain mental health benefits is an element of the overall value for recreational visits. Thus, including a separate value for the mental health benefits derived by individuals for such visits within natural capital accounts could risk an element of double-counting with recreation value – unless a method is used explicitly to partition the latter value into the element where visits are motivated by mental health benefits and that associated with other visits.

Recreation is typically valued using a travel-cost approach, using observable market interactions on components including fuel costs, public transport, parking and admission fees as well as occasionally a welfare value for travel time to act as a proxy recreational value for accessing a site (Day and Smith, 2017). The willingness of individuals and households to incur travel costs is not a pathway used to value mental health benefits in the studies reviewed, but in principle the recreational value of visits to woodlands motivated by mental health benefits could be derived separately using the same method. A question would then arise as to how best to quantify any additional mental health benefits of recreational visits to woodlands for those visiting – both for those whose visits are motivated by mental health benefits (e.g. to what extent does a travel cost approach under-estimate the magnitude of the mental health benefits visits provide?) and with respect of visits not explicitly motivated by mental health benefits. These

considerations illustrate a close alignment between some mental health and recreation values.

Untangling the influence mental health and wellbeing gains using hedonic pricing methods could be very challenging at present, as the underpinning evidence base to allow these benefits to be quantified for different types and locations of buildings and categories of residents does not exist at present. Nonetheless, a similar argument to recreation could be made for potential overlap with amenity values from hedonic price models, namely that proximity to woodland (as well as other natural environments) is likely to be a driver for purchasing property in part due to associated mental health and wellbeing benefits. As with recreation, in principle the estimated amenity value of woodlands could be partitioned on the basis of gaining mental health and wellbeing benefits is the motivation for purchasing a property – although such data is unlikely to exist for the UK at present and may be more unreliable (especially the longer the time that has elapsed since the purchase).

Once incorporated into natural capital accounts, care will be needed in interpreting any changes in mental health-related natural capital values. Akin to how a decrease in natural capital values for pollution absorption can be associated with an increase in environmental quality due to reductions in ambient air pollution, a reduction (or increase) in the mental health value may be due to an improvement (or decline) in the overall mental health status of the population.

Proposals

A number of approaches could potentially be adopted in estimating the mental health benefits of woodlands. The choice between them will depend in part on which elements of mental health benefits of forests are considered of primary interest. Just as a variety of approaches can be applied in estimating values for some other ecosystem services (e.g. flood risk attenuation), some of the approaches outlined below are complementary rather than strict alternatives in valuing the mental health benefits of woodlands.

Example 1 – Mental Health component of Recreation

The first example illustrates a simple approach to estimating the mental health component of the value of forest recreation. In this case the value for forest recreation is partitioned between a value associated with recreation visits motivated primarily, or largely, by the mental health benefits and a value for other recreational visits. These two categories of visits would need to be distinguished based upon inclusion of a question in a survey of forest visitors. For example, the question included might be along the lines of: 'Which of the following best describes your motivation for visiting this forest today: (a) to increase your psychological wellbeing (alleviate mental fatigue, reduce stress,

etc); or (b) another reason. The exact phrasing of the question could be tailored depending upon the specific forms of mental health improvement of most interest. The proportion answering (a) out of the total number of respondents (i.e. those answering (a) or (b)) could then be multiplied by the recreation value for all visits to give an estimate of the recreational value associated with mental health benefits. This relatively simple and conservative approach could be used both in option appraisal and in conjunction with natural capital accounting in cases where a rough estimate of the value of woodland recreation for mental health is needed.

The above example illustrates how existing values for forest recreation can be used with visitor survey data to provide an estimate of mental health value of recreational visits motivated by mental health benefits However, this could be expected to give a conservative estimate as there are likely to be many people who gain higher mental health benefits than the value implied based upon the underlying (e.g. travel cost) model used to derive recreational values and many visitors to woodlands could be expected to benefit even though not their purpose for visiting.

Given the above proposal, a small-scale scoping study could be undertaken that explored potential options to utilise existing data sets such as the Monitor Engagement with the Natural Environment (MENE), Quality of Experience surveys and Public Opinion of Forestry surveys to identify if these can assist in answering this question about the proportion of recreational visits that are motivated by mental wellbeing. A key limitation of MENE however is its lack of consistent socio-economic data across waves, specifically household income, which can be highly influential for driving changes in mental health. If this existing data was found not to be appropriate, then a small scale primary research study could be undertaken specifically to explore feasibility of the approach outlined above.

Example 2 – Wellbeing Valuation (vs QALY)

The second example illustrates how the mental health benefits of a forest-related intervention or interaction could be valued in a policy appraisal using a wellbeing approach. This approach treats mental health and wellbeing benefits as a separate category alongside traditional recreational benefits. If using life satisfaction as a metric, a wellbeing approach could capture some of the broader benefits beyond mental health such as enjoyment The example would require a dataset containing both self-reported metrics of mental health and environmental engagement data. For comparative purposes, QALY metrics are also included in this example, although in practice interventions aimed at delivering mental health benefits do not always deliverer significant changes in QALYs due to its insensitivity to modest changes.

1. Identify the mechanism by which the forest intervention or interaction focused upon is expected to provide mental health benefits. For the purposes of this example, we will assume that a woodland creation project is expected to increase

the number of visits to all the woodlands in an area and that an increase in visits is expected to increase the mental health of those who visit more often.

2. Estimate the extent to which the forest intervention or interaction is expected to impact the variable mediating the increase in mental health benefits (e.g. visit numbers) for each group (e.g. those who do and do not regularly visit woodlands). For example, this may be feasible using ORVal, or using the modelling outlined in step 5.

3. Identify the most appropriate valuation pathway or pathways in terms of mental health indicators and methods. For the purposes of this example, we will assume that changes in mental health are quantified using WEMWBS, life satisfaction and EQ-5D scores.

4. Establish baseline mental health levels without the forest-related intervention or interaction (e.g. for different groups of people depending whether they currently visit forests and if they do, how often). For example, if survey data is available for a simple question such as: 'How often in the last 12 months have you visited woodlands, forests or other green areas where trees are the predominant natural feature?', respondents could be divided into groups according to whether they visited woodlands or not during the past year. Those visiting less than one visit a month could then be categorized as 'non-users', and those more than once a month or more as 'users'. Users could then be subdivided according to the number of visits they made for further comparison. Alternatively, a comparison could be between users of greenspaces with grassland as the predominant feature and users of greenspaces with high percentage covers of tree canopies, if survey data were available to divide users into separate groups on the basis of type of greenspace accessed. However, establishing a control group could be a bit more tricky as many people would no doubt access both types of greenspace and more 'mediators' of mental health impacts could be involved that it would be necessary to take int account in the subsequent analysis.

5. Controlling for as many other influential variables as possible, investigate the relationships between forest visits and different levels of self-reported mental health metrics (e.g. WEMWBS, EQ-5D, life satisfaction) across different categories of forest visitors and those who do not regularly visit woodlands. To ensure a causal relationship is identified in quantifying the impact of the forest-related measure, simultaneously estimate how numbers of forest visits impacts mental health and how state of mental health impacts number of visits. For the purposes of this example, we will use changes in WEMWBS or life satisfaction scores.

6. Use the modelling results on the impact of the mediating variable (e.g. forest visits) to estimate the mental health benefits of the intervention or interaction for different groups. For example, if those not regularly visiting woodlands have an average SWEMWBS of 30, while those who do visit have an average of 31, using values derived through the SWEMWBS wellbeing valuation approach, a change in mental health from not visiting to visiting once is associated with a wellbeing equivalent gain of £376 per person per year (Fujiwara *et al.*, 2017).

   Alternatively, using the coefficient that describes change in life satisfaction, hypothetically set at 0.066, the annual value would be estimated at £974 per person (as outlined in Jump and Simetrica, 2018) using the life satisfaction wellbeing valuation approach (Fujiwara, 2014).

   Using a QALY approach based upon changes in EQ-5D, if the increase in woodland usage were associated with an increase of 0.01 QALYs, applying the £60,000 per QALY value from the Treasury Green Book (HM Treasury, 2018), would imply an estimated mental health value of £600 per person.

7. Estimate the value per visit. For example, if the average number of visits to forest sites by the user group is 50 per year, the per visit value for the forest sites would be £7.52 for SWEMWBS value, £19.48 for life satisfaction value and £12.00 for QALY value. Deriving the estimates for different mental health metrics would provide an indication of some of the uncertainties involved – although it is not directly analogous to sensitivity analysis given that different metrics are based upon different categories of mental health (and in some cases, wider) benefits.

8. Combine the per visit value estimates with site visit numbers, to estimate mental health and wellbeing values on a per site basis or national basis. For example, a hypothetical 10-hectare natural mixed-leaf woodland in central Wales with 10,000 annual visits would generate £75,200 through mental health benefit in SWEMWBS, £194,800 through life satisfaction values or £120,000 for QALY value.

Although a valuation based on QALYs is easy to implement, it can also be highly subjective and simplistic. Considering the limitations of wellbeing valuation:

- The change in SWEMWBS is more uniform and likely larger than may occur in reality. To detect smaller changes, further work may be required with the valuation pathway. In its current form, the model is more suitable for smaller interventions that track SWEMWBS changes on an individual level.

- Life satisfaction can be associated with broader benefits beyond mental health. Although this may be desirable to capture a holistic value that encompasses wider

health and other benefits, the estimates could be expected to be closely correlated with recreational values and could lead to double-counting issues unless the boundaries are not clearly defined and understood.

- The accuracy of the model is heavily dependent on controlling for wider variables that affect mental health and wellbeing, such as income and many other socio-economic characteristics. The values estimated could be inflated unless such variables are adequately controlled for. Additional data would also be necessary to explore more detailed effects of influences including different characteristics of forest sites and the effect of different kinds of on-site activities. Even with this, longitudinal experimental study is required to determine true causal effects.

Example 3 – Avoided Costs

The third example illustrates how avoided costs to the NHS from reduced GP visits associated with woodland usage could be estimated. Such an approach involves valuing mental health benefits as a separate category in a way that avoids potential double counting with any values included separately for physical health benefits. In principle it could also be combined with a wellbeing-based approach to mental health valuation. An avoided cost approach is highly dependent on the availability of specific cost data, which is not often readily available. In principle the approach might be combined with impacts quantified in QALYs by using an avoided cost per QALY of £15,000 which is used by Department of Health economists as a benchmark in purchasing decisions (DEFRA, 2020), but in this example, we assume that data on self-reported GP visits for mental health reasons and on woodland usage is used.

The same steps as outlined in the second example above are also followed in this case, the difference being that the focus is on the metric of self-reported GP visits for mental health reasons, rather than life satisfaction or SWEMWBS. The approach could utilise cost estimates in Fujiwara, Lawton and Mourato (2015), who report that each GP visit can be estimated to cost the NHS £37.00 on average. For example, GP visits for mental health issues amongst regular woodland users (more than once a month) might be found to be 0.5 times a year on average, compared with twice a year for non-users on average. If there were on average 50 visits a year by those in the user group, the annual avoided cost to the NHS associated with an intervention resulting in a non-user becoming a woodland user would be (if all other factors were equal) £55.50, equivalent (if also based upon an average of 50 woodland visits a year) to £1.11 per woodland visit.

However, even if sufficient data is available for a causal relationship between a forest intervention or interaction and self-reported GP visits for mental ill-health issues to be established, the focus on self-reported GP visits for mental health issues could be expected to significantly underestimate the associated mental health value. Some people may feel that there is a stigma associated with disclosing information on GP visits for mental health issues and be inclined to under-report these. Others may simply be

unaware of underlying mental health issues associated with visits for issues such as chronic tiredness, difficulty sleeping or stress.

Other avoided cost metrics could also be adopted, were information available, such as mental health drug prescriptions, hospital admissions and treatment plans, GP admissions and therapy sessions, and possibly also for mental ill health-related court cases. A bespoke survey, as utilised in Jump and Simetrica (2018), could explore changes in these metrics associated with engagement with woodlands or other natural environments. To use biomedical indicators, a simple transfer approach might be adopted, as in some previous avoided cost approaches, as attempted in some previous avoided cost approaches (Vivid Economics, 2017; Dickie *et al.*, 2018), although establishing a causal relationship for these metrics can be difficult.

For example, percentage changes in cortisol levels could be taken to imply percentage reductions in mental health costs. However, this is a very crude approach as previously discussed under the '*Pros and Cons*' section, and due to uncertainty around drawing conclusions associated with cortisol levels, it may be an unsuitable metric to use at this stage.

A basic transfer approach could also be used with other mental health metrics if a causal link could be established between changes in the metric and engagement with woodlands. Even rough estimates based upon somewhat crude approaches involving associations between woodlands and mental health rather than causal relationships could help give an indication of the scale of benefits, which may nonetheless be useful.

Other Research Areas

For future research, focusing on a particular group may be most useful due to the influence of external mediators on mental health. For example, the effects of an intervention or interaction with forests would likely produce very different results in a clinical setting compared to the general population, due to the influence of existing mental wellbeing status. Similarly, research on the effect of forests and greenspaces on a rural population would likely produce different results to those for an urban one, potentially due to different cultural values or a potential saturation effect (White et al., 2019), whereby high levels of existing exposure to greenspace may imply that a new intervention generates few additional mental health benefits. Relatively little attention has been devoted to understanding these differences, although preliminary studies have suggested their influence can be considerable (Jump and Simetrica, 2018; Bagnall *et al.*, 2019). As there is some emerging evidence that a mix of habitat types may provide higher recreational benefits than a single land cover such as woodlands (Colin Smyth pers., comm.), studies comparing mental health benefits of woodlands not only with other habitat types but also land cover mixes, could be useful to strengthen the underpinning evidence base.

Clinical experiments on how exposure to woodlands or other types of greenspace can improve mental health outcomes amongst patients could be an important area for future research, utilising a QALY or avoided cost approach. A cohort of patients grouped into woodland users, general outdoors users and a control group could be followed over an extended period of time to observe to what extent regular use of the natural environment improve mental health outcomes. Such research would require close collaboration with a NHS Board but could make use of novel avoided cost metrics to better evaluate changes in patient's mental health outcomes.

Another important area for future research that could usefully be linked to one of the valuation pathways (e.g. avoided costs) is longitudinal studies. Studies could follow individuals' development to estimate the extent to which childhood exposure to woodlands and other types of greenspace in forest schools, nurseries and kindergartens affects their subsequent mental health. Longitudinal studies following children are lacking in the UK but have been done elsewhere. A large scale 2019 study in Sweden following children growing up in varying proximities to greenspace found those with the lowest levels of greenspace have up to a 55% higher risk of developing a psychiatric disorder independent of other risk factors (Engemann *et al.*, 2019). In a UK context, embedding greenspace into children's regular experiences can be seen at Alder Hey Children's Hospital, designed specifically to blend into local greenspace to provide a better experience for children and to improve healthcare outcomes. Although a systematic analysis of improved mental health outcomes at this hospital has not been performed, the 'passive' mental health benefits of regular exposure to greenspace is likely to help improve recovery times (and may also help improve physical health outcomes).

Further work could also be useful on development of similar metrics to QALYs that are more inclusive of mental health and wellbeing issues, and on associated valuation pathways. QALYs have an importance place in evaluating healthcare interventions. Considering the effectiveness of the natural environment on improving mental health outcomes in clinical settings is a more specialist area of research than considering the broad impact of engagement with forests in a day-to-day setting. Previous studies have raised these issues (Johnson *et al.*, 2016), with calls for development of a wellbeing adjusted life year to compliment QALYs.

Conclusion

There have been few attempts to value the mental health benefits of forests in monetary terms. However, the valuation pathways identified show that there is potential for this in the future. All of the pathways identified involve underlying assumptions and acquiring the requisite exposure-response estimates can be challenging.

Each valuation pathway relates to a different range of mental health benefits and beneficiaries. Thus, each could have its place depending on the purpose of the valuation exercise.

QALY remains an important pathway for evaluating forest interventions as an alternative to other forms of healthcare treatment (CJC Consulting, 2016; Ward Thompson *et al.*, 2019) due to its widespread use in decision-making in the health sector, although it is limited in its applicability for measuring changes in mental health.

Wellbeing valuation can be a highly effective direct pathway to valuation that can utilise readily available data (Jump and Simetrica, 2018) and is based upon a broader conceptualisation of mental health. Wellbeing valuation is growing in popularity for natural environment valuation, forming a basis for the upcoming Greenkeeper tool from Vivid Economics, University of Exeter and Barton Willmore. Greenkeeper aims to utilise a combination of natural environment surveys, GIS and location data to understand how greenspace usage affects health and wellbeing (Vivid Economics, Barton Willmore and University of Exeter, 2020). However, as life satisfaction data underlying this approach to valuation captures a broad range of components relating to wellbeing, separating out the value of mental health benefits is difficult.

Wellbeing valuation can focus specifically on mental health benefits through monetising changes in the SWEMWBS, with the scale growing in popularity as a metric in nationally available datasets. For example, the National Survey for Wales 2016-17 includes questions on natural environment engagement alongside WEMWBS and life satisfaction data, and the Understanding Society survey also collects WEMWBS data alongside small area geographic information for proximity to forests. Valuation through SWEMWBS is more difficult than life satisfaction and may require further work, although a robust pathway for monitoring changes via this scale could provide the best outlet for valuing mental health applicable to the general public

Avoided costs can be based upon different categories of expenditures, but generally apply to wider societal costs (e.g. to the NHS or companies) rather than individuals. They provide conservative estimates (Vivid Economics, 2017; Dickie *et al.*, 2018). However, as they are based upon valuing impacts associated with reducing the burden of mental illness on wider actors, double-counting issues do not arise with other ecosystem service values (e.g. those for recreation and amenity), although separating out avoided costs due to mental health from those associated with physical health is not always easy.

For initial steps into the field of mental health valuation, an avoided cost approach may be best suited due to its conservative estimates and lack of double-counting issues. Although existing data to support this may not be readily available, costed metrics relating to the treatment of mental illnesses could be gathered through a carefully conducted study.

Ultimately however, each pathway may be more or less suitable depending on the audience aimed at for research. For example, a local government conducting a natural capital account valuation may be more interested in wider wellbeing benefits of the natural environment than an NHS trust, who may be more interested in the avoided costs of reducing poor mental health. Robust valuation may be less important in some circumstances, with a sense of scale and rough estimates to show how mental health benefits of woodlands compare to other natural capital values highly desirable.

There are also an expanding number of relevant tools and datasets that could assist further work for the field. ORVal, developed by the University of Exeter with funding from Defra acts as a predictive map-based tool that can deliver site visitation numbers from existing, modified and new greenspaces in England and Wales, utilising a large econometric model (Day and Smith, 2017). With derived values per visit for mental health benefit associated with different kinds of greenspaces, the use of a tool such as ORVal could extrapolate these values to be used to inform decision making and natural capital accounting.

The most significant research gaps remain around quantification of changes in mental health attributable to woodland interactions and interventions. Future research should make addressing these gaps a priority.

The primary findings of this study on how the mental health benefits could be monetised are illustrated in Figure 4 in terms of a logic chain. This shows how an intervention or interaction with forests (or any natural environment), defined in terms of its physical characteristics and the type of exposure, generates a change in a mental health metric to which a monetary valuation method is then applied. The extent of the change in the mental health metric depends upon a wide range of mediators, not all of which are shown. The mediators include ones that relate to the characteristics of the specific interaction or intervention and activity, the characteristics and mental health status of the individual, as well as the provision of other ecosystem services by the woodland. Changes in the mental health metric are monetised using one or more of the mental health valuation pathways, each of which ultimately reflects either the value to an individual (wellbeing valuation) or the wider society (Avoided costs), or a particular mix of both (QALY).

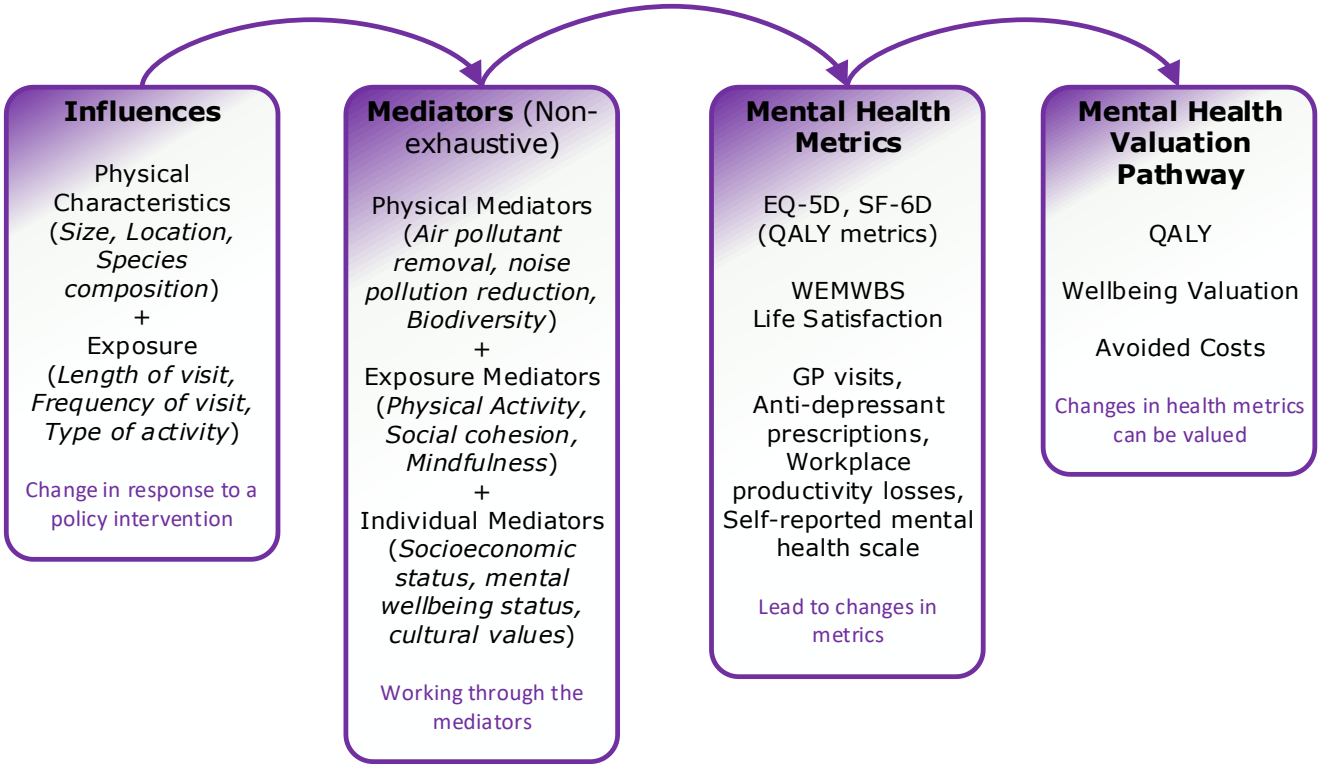


Figure 4. How the mental health benefits of woodlands can be monetised

To illustrate how the logic chain (Figure 4) can be applied, we adapt an example from Bratman *et al.*, (2019). Consider a decision maker interested in the benefits of an urban street tree planting scheme in terms of the associated reduction in antidepressant prescription rates in the local population as a crude proxy for a reduction in the prevalence of depression. The first step in the process of quantifying and valuing these benefits would be to identify 'Influences' (the first box) affecting the size of the mental health impacts, such as the location, distribution, species, and size of trees planted, and the extent to which exposure to trees is increased by the scheme based, for example, on the increase in the density of street trees in residential and other neighbourhoods. The second step (box) involves considering which mediators are that are most influential in improving mental health, which in this case might be reduced air pollution and noise, increased birdsong and improved views. The third step (box) involves quantifying the impacts based upon a specific mental health metric taking into account the influence of the mediators, and the fourth step (box) to then monetising the impact through a specific valuation approach. Choices of metrics in steps three and four (details in corresponding boxes) will be driven by the outcome sought. In this case antidepressant drug prescription levels in the locality and the avoided cost method are most suitable. Ideally the quantification of mental health impacts in step three should be based upon causal relationships rather than associations - although, unless a primary study can be

undertaken, the approach will depend on the existing evidence base, which is more likely to be for an association. In this example a previous study may have identified an association between the density of street trees and the rate of antidepressant prescribing based upon a regression analysis indicating that each additional tree per kilometre of street is associated with x fewer antidepressant prescriptions per 1000 population per year with confidence intervals estimated. Analysis of the population exposed to a new street trees scheme by various characteristics (e.g. income, age, etc.) may provide useful information on who benefits most from the intervention (although this is a further step not included explicitly in the Figure).

Appendices

Annex 1. Literature search

Table 7 below summaries the search terms and their combinations. Within each column, terms were combined with a logical Boolean "OR" operator and across columns terms were combined with "AND" operators. The full primary search string was:

("protected area*" OR trees OR pollen OR "urban green*" OR "green urban" OR "greenspace*" OR greenspace* OR forest* OR wood* OR parkl* OR parks) AND

("mental health" OR anxiety OR schizophren* OR psychosis OR depressi* OR wellbeing OR well-being OR "well being") AND

(wtp OR mwtp OR willingness-to-pay OR "willingness to pay" OR econom* OR monet* OR cost*) AND

(effect* OR support OR improve* OR better* OR *valu* OR benefit* OR impact* OR saving* OR productivity OR qaly OR cost-effective* OR cost-benefit)

A few additional searches were also performed in isolation of their category to search for specific results. Where these searches yielded >50 results, only the top 50 most cited papers were screened. These terms can be viewed in italics in the table.

Table 7. Search terms used within their component categories. Isolated searches, performed after the full string was performed, can be seen in italics

Forests	Mental health	Economic	Valuation
("protected area*" OR trees OR pollen OR "urban green*" OR "green urban" OR "green space*" OR greenspace* OR forest* OR wood* OR parkl* OR parks) *"natural environment"* *"nature"*	("mental health" OR anxiety OR schizophren* OR psychosis OR depressi* OR wellbeing OR well-being OR "well being")	(wtp OR mwtp OR willingness-to-pay OR "willingness to pay" OR econom* OR monet* OR cost*)	(effect* OR support OR improve* OR better* OR *valu* OR benefit* OR impact* OR saving* OR productivity OR qaly OR cost-effective* OR cost-benefit) *"quality of life"* *"quality-of-life"* *"daly"* *"waly"*

Databases searched: Scopus (www.scopus.com); note that Scopus content coverage includes over 95% of Medline publications as well. The search focused on newer papers published in English. Initially the search considered papers published from 2000 to the present. However, due to the volume of potentially relevant papers, , it was focused more narrowly on publications from 2010 to present after initial searches.

Of the 1,408 search results considered, the most relevant references are shown in Table 8 below, along with references identified through expert interviews and our own expert knowledge of grey literature.

Table 8. Literature Review References

Reference	Approach	Location	Mental Health (MH) Metric	Intervention or Interaction Type	Datasets for MH Δ	Key findings
(CJC Consulting, 2016)	QALY	UK (Scotland) Forests	SF-6D/SF-12	Physical and social activities	Pre and post QALY surveys	Averaged 12-week programme cost per person per QALY generated was £17,300.
(Ward Thompson *et al.*, 2019)	QALY	UK (Scotland) Forests	EQ-5D	Physical and social activities	Pre and post QALY surveys	Programme cost per person per QALY: Physical Intervention group: £157 Physical and Social Intervention group: £345
(Buckley *et al.*, 2019)	QALY	Australia National Parks	Personal Wellbeing Index (PWI) (Australian)	National Park Visits	User PWI survey compared against national averages	Δ PWI = 2.5% $/QALY = US$200,000 Health services value of national parks to Australia's adult population = US$100 billion Global estimate = $US6 trillion
(Maund *et al.*, 2019)	Wellbeing Valuation	UK (England) Wetlands	WEMWBS	Physical and social activities	Pre and post QALY surveys	6-week programme generated an

						average of £4,848 per person in mental health improvements (excluding programme costs)
(Bagnall *et al.*, 2019)	Wellbeing Valuation	UK (England) Nature-rich environments	WEMWBS	Physical and social activities	Pre and post WEMWBS surveys	12-week programme generated the following average value per person in mental health improvements (excluding programme costs). Target projects (aimed at vulnerable population with low wellbeing) = £12,929 General projects (aimed at anyone interested in volunteering) = £1,878
(Jump and Simetrica, 2018)	Wellbeing Valuation, Avoided Cost	UK (England) Greenspaces	Life Satisfaction	Greenspace usage	User greenspace usage and wellbeing survey, compared against	National aggregate values for greenspace/park users, using their park more than once a month:

					national averages (using MENE).	Wellbeing value: £34.2 billion (£8.47 per visit) NHS savings (overall health): £111 million (£3.16 per user)
(Bertram and Rehdanz, 2015)	Indirect Valuation	European Greenspaces (Berlin, Stockholm, Rotterdam and Salzburg)	Life Satisfaction	Proximity and usage of green urban areas	Comparisons within a primary survey, with a sample of 485 people.	Based on median availability of greenspace and income, implicit marginal rate of substitution is €33.51 per resident per hectare per month.
(Krekel, Kolbe and Wüstemann, 2016)	Indirect Valuation	German Greenspaces	Life satisfaction	Proximity to green urban areas	German socio-economic panel (residential wellbeing) and European Urban Atlas (land use)	Implicit willingness-to-pay for an additional hectare of green urban coverage: Per resident: €23 Average household WTP within 1km^2: €933,647
(Vivid Economics, 2017)	Avoided cost	UK (London) Greenspaces	GHQ-12	Proximity to green space	BHPS	Greenspace is associated with a 0.7 reduction in GHQ-12 within a particular density of greenspace and

						population (roughly ~2%). Taking estimated costs of mental ill health in London (£17bn), avoided costs are valued at £370 million per year.
(Dickie *et al.*, 2018)	Avoided cost	UK (Manchester) Greenspaces	GHQ-12	Proximity to green space	BHPS	Greenspace is associated with a 0.7 reduction in GHQ-12 within a particular density of greenspace and population (roughly ~2%). Extrapolating density for relevance to Greater Manchester (~4.6%) and taking mental health spending in Greater Manchester (£5.7bn), avoided costs are valued at £264 million per year.

NOTE: In accordance with the aims of this study, the table includes references identified through searches meeting three criteria: monetary valuation, forests/greenspace focus and a mental health focus. Some studies were included through recommendation and correspondence with experts and grey literature searches that may not explicitly meet this criteria but are very relevant. There may be further studies that have explored (i) mental health valuation through non-forest interventions or interactions; (ii) broad cultural services or health and wellbeing benefits of which mental health may be a component; and (iii) attempted to quantify the relationship between mental health and greenspace/forests without valuation. However, these topics was out of scope of the review.

Annex 2. Expert stakeholder interview protocol

Introduction	On behalf of Forest Research, Forestry Commission England and the Welsh Government, I would like to invite you to take part in an interview / brief questionnaire regarding economic valuations of mental health benefits in forests and other natural environments. This scoping study will examine existing evidence on the value of forests on mental health and propose next steps for providing monetary valuation of the mental health benefits of forests Scoping study objectives • Review existing literature on the impacts and value of forests on mental health, including methodologies which currently attempt to monetise mental health benefits of wider nature/greenspace • Identify methodologies for valuing forests' role in mental health • Develop proposals, for how the value of forests in the UK for mental health could be assessed, potential for their incorporation in natural capital accounting as well as for project and policy appraisal In meeting the study objectives, we would like to interview key stakeholders as a route to access key literature and to gain expert judgement on what metrics work under which circumstances and where effective monetisation can take place
Q1	Could you briefly outline your background and expertise in this area?
Q2	Do you have any experience with, or have you ever undertaken a monetary valuation exercise of mental health benefits linked to forests or other natural environment?
Q3	What do you think are important recent developments in the area of monetary values for mental health benefits?
Q4	How would you *evaluate* some of the key metrics and the methodologies in which they are used in valuation?
Q5	Which areas do you feel are priorities for future work and where are there significant evidence gaps?
Q6	Do you have suggestions for how the monetary value of the mental health benefits of woodlands could best be incorporated into national accounts?
Q7	How successful and / or useful do you feel that monetising the mental health benefits of natural environments has been?

Annex 3. List of expert stakeholder interviewees

Dr Mathew White	European Centre for Environment and Health, University of Exeter, U.K.
Prof Sarah Rodgers	Institute of Population Health Sciences, University of Liverpool, U.K.
Prof Catherine Ward-Thompson	OPENspace research centre, University of Edinburgh, U.K.
Prof Jenny Roe	School of Architecture, University of Virginia, U.S.A
Prof Marc Jones	Department of Psychology, Manchester Metropolitan University, U.K.
Dr Qing Li	Nippon Medical School, Japan
Ashley Gorst	VividEconomics, U.K.
Caroline Vexler	VividEconomics, U.K.
David Pepper	NHS Wales
Prof Timothy Taylor	European Centre for Environment and Health, University of Exeter, U.K.
Dr Tobias Borger	Department of Economics, University of Stirling, U.K.
Daniel Fujiwara	Daniel Fujiwara, Simetrica, U.K.

Annex 4. Additional Logic Chains

The following figures outline 2 additional logic chains encountered that cover how to conceptualise interactions between mental health and nature.

Figure 5 below shows how the characteristics of a natural environment, the kind of exposure and type of experience ('dose' or interaction) determine the mental health and wellbeing benefits derived by individuals and different population groups. The model illustrates the mental health and physiological wellbeing effects in terms of as stress and

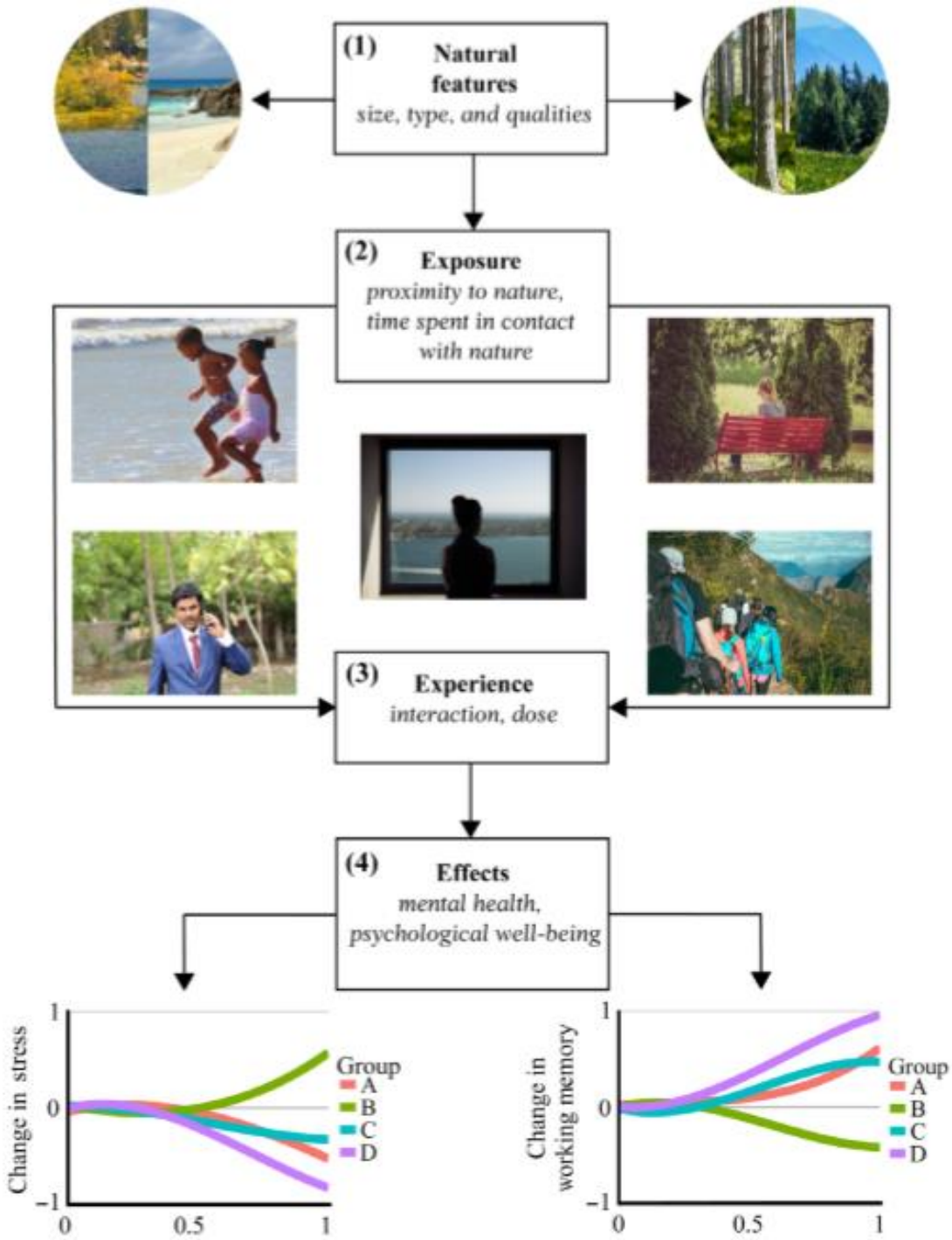


Figure 5. A conceptual model for mental health as an ecosystem service. Taken from (Bratman *et al.*, 2019)

changes in working memory, although other metrics of mental health could be used instead.

Figure 6 below shows a more detailed framework illustrating how the characteristics of a natural environment and the type of contact and activity influence overall health outcomes. The relationship between these outcomes (including mental health and wellbeing benefits) and contact with the natural environment is mediated through multiple factors that derive from the quality of the environment itself, such as the benefit of air pollutant removal and visual amenity value, as well as various socio-economic factors. These socio-economic factors can include existing health and wellbeing status or life experiences, as well as independent feelings, such as sense of place and identity. Outcomes can be sensitive to short-term and long-term impacts. Ultimately, these outcomes can also act as a behavioural driver in a feedback loop to promote usage of the natural environment.

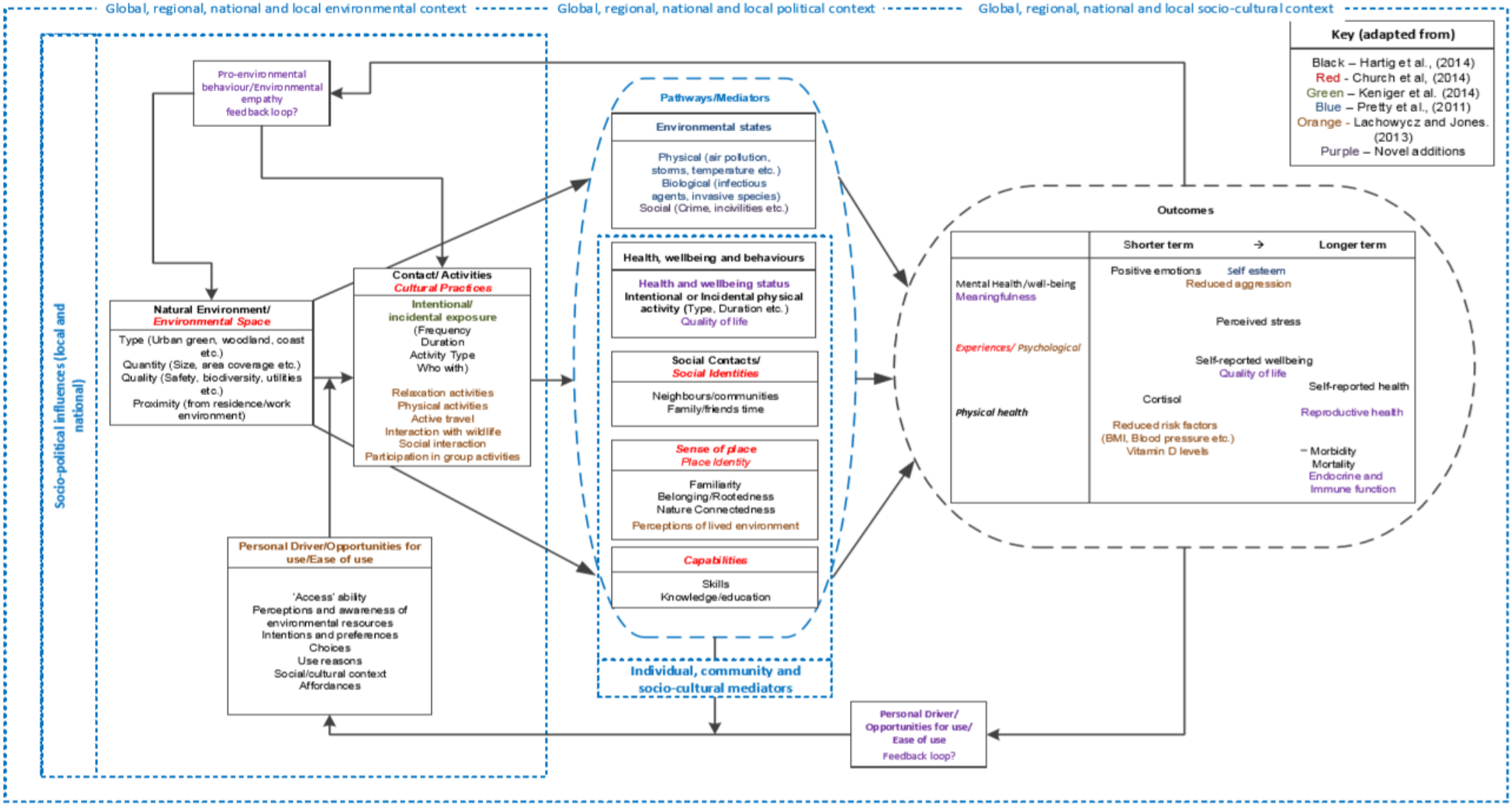


Figure 6. Synthesised framework of pathways between natural environments and health. Taken from (Lovell, Depledge and Maxwell, 2018)

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