Biodiversity, cultural pathways, and human health: a framework

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Biodiversity, cultural pathways, and human health: a framework☆

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Direct contact with biodiversity is culturally important in a range of contexts. Many people even join conservation organisations to protect biodiversity that they will never encounter first-hand. Despite this, we have little idea how biodiversity affects people's well-being and health through these cultural pathways. Human health is sensitive to apparently trivial psychological stimuli, negatively affected by the risk of environmental degradation, and positively affected by contact with natural spaces. This suggests that well-being and health should be affected by biodiversity change, but few studies have begun to explore these relationships. Here, we develop a framework for linking biodiversity change with human cultural values, well-being, and health. We argue that better understanding these relations might be profoundly important for biodiversity conservation and public health.

Biodiversity is culturally important

Humans have attached cultural importance to biodiversity (see Glossary) for thousands of years, over and above its utilitarian value as food, sources of material, or labour [1]. Many plants and animals have enduring symbolic significance, appearing on national emblems, in folklore legends and religious documents [2,3]. For example, lions feature on the crest of the British monarchy; peafowl are highly revered in several religions; and the resplendent quetzal is a bird of legend in Guatemala [2,4]. Such cultural importance has been recognised through global and national ecosystem assessments [5,6], which argue that the cultural meanings facilitate a pathway through which biodiversity is linked to human health. However, the significance of these processes has so far been underrepresented in ecosystem research [7,8] and we have little idea about how human health could be affected by the presence of, exposure to, and loss of biodiversity [9].

Today, the cultural value that we place on biodiversity is evident in the amount of time and money that we spend to enable us to experience nature. Some will gain pleasure from remote, vicarious experiences, such as through nature documentaries, whereas others prefer more direct encounters. Membership of environmental groups worldwide is increasing, despite the economic downturn [10],

Glossary

Biodiversity: the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. The definition we use here follows the 1993 Convention on Biological Diversity meaning of 'biological diversity', which we assume to be equivalent to 'Biodiversity' (http://www.cbd.int/convention/articles/default.shtml?a=cbd-02). We use this definition to give a general overview of the term, yet appreciate that biodiversity is likely to have different meanings to different people [58].

Cultural good: the outputs provided by biodiversity that humans place value upon because they provide some sort of well-being benefit to their lives. Goods can be use (e.g., wild bird diversity for bird watching) and non-use (e.g., wild bird diversity never to be encountered), and generally have no market price because the values placed upon them are specific to each individual; defined here using the UK National Ecosystem Assessment [6].

Cultural pathway: an indirect route by which biodiversity can affect human health. We propose that biodiversity loss will reduce opportunities to value cultural goods, thus reducing human well-being and, subsequently, human health.

Cultural value: the worth placed upon a cultural good by an individual or group or society. It is important to note that values are placed upon goods by individuals (or groups) and are vulnerable to both temporal and geographical variation, rather than each good having a fixed universal value. Values can be 'use values' (e.g., we place value on using the good, such as wild bird diversity for bird watching) or 'non-use values' (e.g., we do not directly use the good but instead place value on its existence, such as conserving rare species that we are unlikely to witness personally).

Human health: we work with the commonly accepted definition from the World Health Organization of health as being 'a complete state of physical, mental and social well-being, and not merely the absence of disease or infirmity' (http://www.who.int/about/definition/en/print.html).

Human well-being: our use of the term 'well-being' follows the highly cited definition of subjective well-being from the Stiglitz Commission stating that '(subjective) well-being encompasses different aspects - cognitive evaluations of one's life, happiness, satisfaction, positive emotions such as joy and pride, and negative emotions such as pain and worry' [63]. Here, well-being contributes to overall human health. Note that the use of this term differs from that used in the UK National Ecosystem Assessment [6], which refers to a more nebulous definition of well-being, characterised by economic, health, and shared social values.

Natural space: we work with the definition from Natural England of the natural environment, incorporating green and blue space: 'green or blue open spaces in and around towns and cities, as well as the wider countryside and coastline' [25]. Green spaces are defined as open, undeveloped land with natural vegetation (http://www.cdc.gov/healthyplaces/terminology.htm), and blue spaces as any environment, natural or urban, containing visible amounts of standing or running water [64].

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and participation in global wildlife tourism continues to rise at a rate similar to that of international tourism [11]. Public participation in biological recording through citizen science projects has also increased rapidly [12], implying that individuals value their local wildlife and want to contribute towards its conservation. For example, participation in the Great Backyard Bird Count, a joint project of the Audubon Society and the Cornell Lab of Ornithology, increased from 52 000 participants in 2005 to more than 136 000 in 2013 (http://www.birdsource.org/gbbc). The project has grown from solely recording birds in North America to a worldwide endeavour, with participants from 111 countries taking part in 2013.

Although the evidence suggests that humans care about and value biodiversity, we currently have little understanding as to how this culturally mediated value will be affected by biodiversity loss, and how this could then impact upon human well-being and health [13,14]. Current estimates of biodiversity loss place species extinction rates at 100–1000 times the natural rate [5,15], far higher than one would expect from background predictions [16]. Here, we argue that there is sufficient circumstantial evidence that biodiversity loss could affect the cultural values that we place upon biodiversity so as to cause significant repercussions for human well-being by, for example, generating anxiety, frustration, and stress. However, few studies have begun to explore the relations along these cultural pathways and we have little idea of the resulting effects upon human well-being and subsequently health. Therefore, we offer a potential framework to help researchers explore these pathways and highlight their possible importance for biodiversity conservation and public health.

Potential importance of cultural pathways for human health

Evidence from other aspects of human health research suggests that biodiversity loss might impact upon health via cultural pathways. Firstly, we know that individuals are sensitive to seemingly insignificant psychological stimuli because of cultural associations. Medical treatments provide a good illustration of this; the amount or colour of a medication taken can affect reported health outcomes for both chemically active and placebo drugs [17]. For example, tablet colour can affect our resolve in taking medication and the reported health outcomes [18]. In western societies, blue tablets are more effective as depressants, corresponding with the colour blue being culturally associated in the west with calm and quietness, and red tablets have greater efficacy as stimulants, because the colour red is culturally associated with energy and excitement. Such minor stimuli are only important because of their cultural associations, yet they are still capable of significantly affecting human health. Note that such cultural meanings display geographical and temporal variation. For example, although modern western cultures associate the colour blue with calm and quietness, in ancient times blue dye was used extensively as war paint by the Celts before battle [19].

Secondly, there is evidence that mental health is negatively affected by awareness of environmental degradation. Several studies have linked drought with increases in mental health illnesses, including higher levels of depression and self-reported distress [20,21]. These effects were still found after accounting for immediate financial and industrial impacts, and were also present in those not directly making their living from the land. Similarly, flooding has been strongly associated with elevated rates of depression, anxiety and post-traumatic stress disorder [22].

Thirdly, numerous studies provide evidence of mental and physical health being positively affected by contact with 'natural' spaces [23,24]. Individuals often seek out natural places; during 2011–2012 in the UK, the average number of visits to natural environments per adult was 65 and more than half of the population report visiting at least once per week [25]. Those who spend more time in natural spaces report fewer health problems, increased feelings of general health, lower levels of stress and faster recovery times from illness (Table 1). Although the mechanisms have yet to be uncovered, the health benefits might relate

Table 1. Health and well-being benefits found to be significantly associated with natural space experiences[a]

Type of exposure to natural space	Health or well-being measure	Refs
Percentage of local green space	Increased perceived general health	[26]
Percentage of local green space	Increased perceived general health	[27]
Proportion of local green space	Decreased levels of inequality in mortality rates (related to income deprivation)	[28]
Window view of natural space	Decreased postoperative hospital stay, negative evaluative nurse comments, and painkillers taken	[29]
Window view of natural space	Increased diverse aspects of well-being	[30]
Images of natural space	Faster recovery from stressed state, increased self-reported positive affect, and decreased self-reported anger and fear	[31]
Walk in natural space	Increased direction–attention abilities	[32]
Visits made to urban green space	Decreased stress experiences	[49]
Images of general blue space	Increased positive affect and perceived restorativeness	[64]
Proximity to the coast (blue space)	Increased self-reported general health	[65]
Window view of natural space	Increased performance on attentional measures	[66]
Proportion of local green space	Increased self-reported happiness	[67]
Walk in natural space	Increased positive affect, relaxation, and fascination, and decreased negative affect	[68]
Time spent in forest environment	Decreased stress response, blood pressure, and pulse rate, and increased well-being	[69]
Proportion of local green space	Decreased stress events	[70]

[a]A selection of results from key studies showing the variety in the natural space studied, type of exposure, and health or well-being benefit measured.

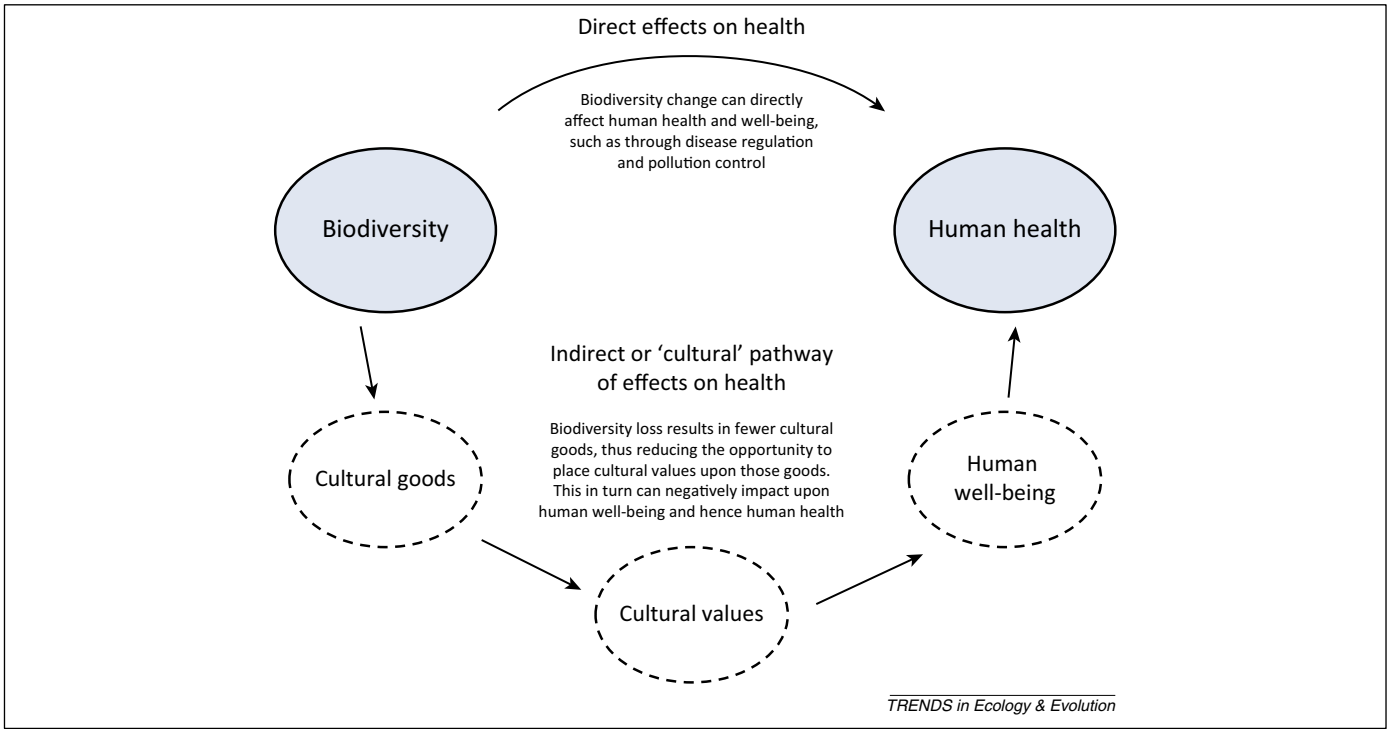

Figure 1. The direct and indirect (cultural) pathways from biodiversity to human health. Biodiversity change can directly affect human health, such as through the regulation of the emergence and transmission of diseases, or via pollution control. We propose that biodiversity change can also indirectly impact upon human health via cultural pathways; biodiversity loss affects the provision of cultural goods, which reduces our opportunity to realise the cultural value placed upon those goods and, consequently, negatively impacts upon human well-being and, therefore, health.

to the calming influence of these environments, provision of a space for exercise, or developing social connections [26–28]. The well-being and health benefits are not restricted to direct physical contact; similar gains can be achieved by viewing natural space through a window [29,30] or by examining images of natural environments [31,32]. Despite the relative wealth of such studies, most research has treated natural space as homogenous, with little or no examination of the variation in health benefits according to their environmental characteristics.

Evidence linking natural space interactions with benefits to well-being and health is rapidly becoming more robust. However, studies of the cultural pathways between biodiversity and health are lagging behind [7,8,23]. The limited evidence that does exist, much of which is centred on western, developed nations [33], suggests that exposure to biodiverse places promotes immediate psychological well-being through the cultural values associated with nature. Fuller *et al.* [34] found plant species richness to be positively linked to self-reported, current psychological state, and Lindemann-Matthies *et al.* [35] described a similar relation with aesthetic appreciation. Additionally, Dallimer *et al.* [36] reported increased general well-being in humans who perceived themselves to be in areas more diverse in birds, butterflies, and plants. A recent systematic review by Lovell *et al.* [9] indicated that exposure to, and contact with, biodiverse environments can confer some health benefit in certain populations, but agreed with other articles in highlighting a need for more research [7–9,23]. Furthermore, the existing evidence provides little information as to the pathways linking biodiversity and human well-being; neither do they allude to the possible consequences for human health.

Biodiversity, cultural pathways and health within an ecosystem assessment framework

Taking a lead from the UK National Ecosystem Assessment [6], we have structured our thinking within an ecosystem assessment framework, proposing that biodiversity can have both direct and indirect effects upon human health (Figure 1). Evidence for the direct effects of biodiversity on health is relatively abundant. Biodiversity loss can lead to the emergence and transmission of infectious diseases [37,38], and cause health defects through the loss of food or nutritional diversity [39]. In comparison, biodiversity gain can directly benefit health. For example, increasing plant abundance, such as through the use of green roofs, can help to mitigate air pollution [40] and thereby reduce incidences of respiratory and cardiovascular disease [41]. However, evidence for the indirect effects of biodiversity on health along cultural pathways is more limited and identifies a gap in what we believe is a significantly understudied area of research relevant to biodiversity conservation and public health. We propose that biodiversity indirectly affects health via several stages (Figure 1): (i) Biodiversity change affects the provision of cultural goods, which in turn (ii) affects the opportunities humans have to experiences these goods and so realise the values they place upon them; (iii) changes in these cultural values can then impact upon human well-being, which could consequently (iv) affect human health. Understanding the effect of biodiversity loss on health will require a detailed comprehension of each stage of the pathway.

Below, we discuss the methods associated with each phase and explore some of the associated issues.

Stage (i). Biodiversity loss will reduce the availability of cultural goods

Biodiversity can provide a multitude of cultural goods, from easily quantifiable items, such as wild species diversity, to less tangible goods, such as fundamental aspects of aesthetically pleasing vistas [5,6]. Biodiversity loss could severely impact the provision of these goods, although we know relatively little of these consequences because few studies have examined the mechanisms [8]. Measuring biodiversity gradients should be rather straightforward, as survey techniques are well established, and many large-scale long-term data sets already exist (e.g., [42,43]) and are ideal for analysing historical trends. However, to demonstrate causal linkages between biodiversity and health, it will be necessary to enlist experimental manipulation techniques and, potentially, collect new biodiversity data (see 'Challenges' below). Measuring the resulting cultural goods is likely to be less clear-cut. Some goods will require similar biodiversity survey techniques (e.g., wild species diversity), whereas others might call for more diverse measures. For example, quantifying recreation opportunities might require ecological surveys together with other social measures, such as ease of access or distance from settlements.

Stage (ii). Fewer cultural goods provide less opportunity to realise and place cultural values

Reductions in the availability of cultural goods could directly reduce our ability and opportunity to realise the cultural values we associate with those goods. Chan *et al.* [8] depicted the pathway from cultural ecosystem 'benefits' (i.e., goods) to cultural values, suggesting that a reduction in the former will cause a similar reaction in the latter. Although we predict that, in general, biodiversity loss will reduce the availability of cultural goods and so also the opportunities to place value upon them, this is unlikely to be a linear relation; for example, rarity could temporarily inflate the cultural value of a species as humans place greater value upon its protection. Note that these relations will be context-specific; for example, rarity will not always equate to positive value [44], and the value will not necessarily always be in favour of species conservation [45]. Measuring cultural values and the impacts of biodiversity change on people's opportunities to realise those values necessitates an interdisciplinary bridge with the social sciences. Stated preference techniques require people to state the value that they place upon a good and revealed preference methods measure a value that has already been made [46]. Both are usually described in monetary terms, primarily because this can be compared to the financial value of other goods, and conducted through quantifiable survey methods, such as questionnaires or focus groups when targeting specific sets of society. Qualitative techniques can also be used to explore personal experiences and meanings [47]; such results are often difficult to generalise and are valued less for decision making, but can be useful in 'telling a story' to policymakers and other interested parties.

Stage (iii). Having fewer opportunities to realise and place cultural values can negatively affect human well-being

Although grand-scale ecosystem assessments have recognised the importance of cultural values of biodiversity for well-being [5,6], the evidence base addressing this link is almost absent. However, as Chan *et al.* quote, these values are 'where we really get at well-being' [8]. By placing value, we are indicating the importance that we place on that good (i.e., the well-being benefit we receive from that good), otherwise we would not place the value. Measuring impacts on human well-being, and consequently health, crosses into yet another discipline: public health and epidemiology. Numerous historical data sets cover a range of relevant well-being measurements, including life satisfaction, self-esteem, and general well-being (reviewed in [48]). Such longitudinal data sets allow slow-onset or long-term well-being measures to be monitored and are more powerful at inferring causal relations than cross-sectional data. However, again it will be necessary to collect new well-being data (e.g., with questionnaires) when using experimental manipulation techniques to demonstrate causal linkages between biodiversity change and well-being (see 'Challenges' below). Specific aspects of well-being (which existing evidence indicates might be especially sensitive to biodiversity change) can be measured, such as reflection [34,36] and stress [49], as well as overall well-being measures [50].

Stage (iv). Reduced well-being can be detrimental to human health

The evidence base surrounding the final step of the framework is relatively well defined: reduced psychological well-being can negatively impact human health. For example, chronic negative mood states are associated with an increased risk of heart disease and type 2 diabetes mellitus [51,52]. Existing longitudinal data sets of health measures offer the same benefits previously discussed of long-term data and include objective measures, such as mortality rates or clinically assessed blood pressure, as well as more general self-reported measures, such as the General Health Questionnaire, which has been translated into 38 different languages and is used worldwide [53]. New health data can be collected in similar ways to well-being data when conducting biodiversity manipulation experiments.

Challenges involved in exploring the cultural pathways from biodiversity to health

Determining a causal link between biodiversity and health is a major challenge. For example, a cross-sectional study finding improved health among birdwatchers would only indicate an association between the two variables. Such a result could have been driven by a selection mechanism [26], whereby healthier people choose to spend more time bird watching. To report a causal relationship confidently, where time spent bird watching has a significant positive effect on health, selection effects would need to be controlled for (commonly by controlling for relevant demographic and socioeconomic traits [26] or by carrying out longitudinal studies [54]) and experimental techniques enlisted, where time spent bird watching would be the

manipulated variable [24]. Here, the same set of individuals would experience differing degrees of bird watching, and their well-being and health measured at each stage, while also controlling for relevant demographic and socio-economic characteristics.

Conducting social surveys, such as those to measure cultural values, well-being, or health, can bring other challenges. Participant bias can cause certain subgroups of the population to be more likely to complete the survey, and response bias occurs where people, unintentionally, fail to answer truthfully. For example, the 'Hawthorne effect' can cause subjects to modify an aspect of their behaviour (e.g., report increased well-being when experiencing higher levels of biodiversity) because they are aware of their involvement in such a study, regardless of any actual effect [55]. Other moderators that could impact on health must also be controlled for, including demographic factors, such as age, ethnicity and gender; climate; and socio-economic factors, such as crime rate and government policies [24]. Longevity and persistence are key factors to consider: for example, do certain biodiversity experiences affect us just for the short term and others for much longer? Do our childhood experiences shape the individual benefits acquired from biodiverse environments as adults [56]? Is there a threshold at which the health effects of increasing biodiversity reach an asymptote? Furthermore, researchers should be aware that, due to the slow onset of many health problems and other unobserved factors, it is possible that resulting effect sizes will be weak and too-readily dismissed when using conventional measures of significance (i.e., Type 2 errors). However, the few studies that have been conducted to date suggest that effect sizes can still be recognisable and potentially meaningful [34–36], and the use of experimental techniques in longitudinal studies will be necessary.

Studies should be somewhat comparable, so that each can contribute to the overall picture of biodiversity and health and not just be relevant to its own, possibly small and unique, study system. The large amount of variation seen in previous studies (Table 1) suggests that this could prove difficult because temporal, cultural, and geographical variation will exist. For example, Richardson *et al.* [57] unexpectedly found mortality rates to be significantly higher in American greener cities, a finding that is contrary to studies of European cities. The authors suggest that the result is partly due to the scale of their study, which is thought to be previously unstudied in this manner, or indeed a factor related to the different cultural contexts. Such culturally mediated variation in health response is plausible because impacts are likely to have varied temporally according to our changing conceptualisations of the natural environment. Focussing on comparable variables, such as general well-being measures, will allow such culture-driven context-dependence to be explored.

Crucially, studies should explicitly describe the biodiversity being considered, either when assessing one species or an entire habitat [23]. Terms such as 'urban green space', 'forest', or 'park' are sometimes used without any detailed explanation as to the biodiversity they contain. The 'Beyond Greenspace' project of the European Centre for Environment and Human Health in the UK, which aims to investigate whether different types and qualities of natural space have different consequences for human health and well-being, addresses this by examining the role of different factors related to biodiversity in the environment-health relationship (http://www.ecehh.org/publication/beyond-greenspace). Being explicit about the type of biodiversity will improve understanding of the relative importance of different aspects of nature. This could also help to combat difficulties in defining and comparing understandings of biodiversity among different groups [58].

We still lack knowledge surrounding some of the relatively better-known aspects of biodiversity and health. For example, the effect of biodiversity loss on cultural goods is unclear [8], as is the possible impact of global-scale change, such as climate change, on the direct effects of biodiversity on health [59]. Furthermore, much of what we do know is heavily biased towards developed Western societies at high latitudes [9,33], which are generally less biodiverse [60]. It is imperative that this geographical imbalance is addressed to ensure that proposed frameworks, such as ours, can represent the range of cultural values and be of global benefit.

Concluding remarks

There is emerging evidence that biodiverse natural environments have the potential to impact on human well-being and health through the indirect cultural pathways indicated in Figure 1. We now need an integrated, rigorous approach to investigate these relationships more thoroughly. This need is pressing because the potential societal health benefits of biodiversity through such cultural pathways could be significant. Mental health is a major international public health issue; globally, depression is predicted to be the leading cause of disease burden by 2030 [61]. In the UK, nearly 9 million people (14%) have mental health disorders, with many more undiagnosed or untreated, and the total cost to the economy is projected to be £88.5 billion by 2026 [62]. As a consequence, if biodiversity change has even a minor role in causing mental health disorders or in their prevention or treatment, then the economic and health benefits could be large. Therefore, better understanding the relationship between biodiversity and health along cultural pathways has the potential to further our appreciation of the value of biodiversity, provide increased support for biodiversity conservation, and contribute towards reducing the occurrence and associated costs of ill health.

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