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PERSPECTIVE

Moving towards a multidimensional dynamic approach to nature and health: A bioavailability perspective

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Abstract

1. The benefits of exposure to nature for health and well-being have been demonstrated across multiple disciplines. Recent work has sought to establish one 'dose' or type of nature exposure that is universally beneficial, which has proven difficult.
2. We use the principles of psychopharmacology to look beyond the use of dose as a concept for prescribing nature. Instead, we posit a multidimensional model of bioavailability of nature to shift the focus beyond universal effects, and instead consider the relationship between health and nature as dynamic, changeable and heavily contextual.
3. We propose that the bioavailability of nature interactions is constructed through understanding route of administration, dose and concentration.
4. By delineating the mechanisms of health benefit derived from the type of behavioural interaction (through being, doing and living), the route of administration of nature interactions may be highly variable not just between, but also within, individuals.
5. We propose concentration as being a meeting between the subjective aspects of the individual and the subjective qualities of the nature at that specific time and place. We use a 'green equation', for mapping the processes and pathways that belie the interaction between the person and their environment. Here, the nature/health association as a dynamic interaction, and we operationalise this within a multidimensional construct of bioavailability.
6. We provide an overview of this testable model and summarise with preliminary evidence as well as a research agenda for the future.

KEYWORDS

bioavailability model, green space, health, human–nature interaction, nature connection, well-being

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1 | INTRODUCTION

Over the last 30 years, a theme in nature literature has developed and diversified to incorporate all aspects of human health and well-being (Frumkin et al., 2017). The concept of benefits from interactions with nature is one that is held both culturally and scientifically. Moreover, with the increased importance of social prescribing in healthcare, along with the increasing profile being outdoors has had during the pandemic, both engagement and targeted interventions involving contact with nature (or a 'green prescription') have become popular (Robinson & Breed, 2019). An ever-growing wealth of published systematic reviews and meta-analyses have sought to unify the data and operationalise mechanistic pathways that confer health benefits from exposure to nature. From population-level data (e.g. Mitchell & Popham, 2008) to individual empirical studies (e.g. Triguero-Mas et al., 2017), to research on environmental justice (e.g. Wolch et al., 2014) and biodiversity (e.g. Sandifer et al., 2015), nature has been associated with multiple indices of physical and mental health as indicated by measures of immunity (e.g. Böbel et al., 2018), disease (e.g. Astell-Burt et al., 2014), hormonal (e.g. Roe et al., 2013), behavioural risk factors (e.g. Jansen et al., 2017) and overall well-being (e.g. Dzhambov et al., 2018). Despite this, there is not yet conclusive evidence on what is the most optimal nature contact to improve health and well-being, and the results are inconsistent, perhaps as a result of differences in method of investigation (Neilson et al., 2020). For example, when examining attention restoration theory-driven paradigms, there are differences in measurement of restoration (Craig, 2016; Lee et al., 2015), in research design, for example, short-term or extended duration of measurement, or the use of single or repeated trials (Berto, 2005), or not at all (Cassarino et al., 2019), which makes ascertaining the necessary dimensions of nature contact difficult. Differences in measurement and research design may be, in part, due to an existing focus on consistent universal effects, or in other words, finding the best 'dose' of nature for health. While being a necessary starting point for such research, this single concept is perhaps too simplistic for a relationship between individual and environment, especially when it is subject to an array of biopsychosocial factors. To this end, deconstructing the term of 'dose' and applying it in its principal manner to inform treatment, we take learning from psychopharmacology (the study of pharmacology associated with eliciting psychological impacts from drugs) to consider *bioavailability*, a composite of concepts that speak to understanding how much of an agent is available to act at the target site once assistive and competing biological effects have taken place during its administration, absorption and transport. For this, *dose* is actually determined by a vital understanding of the various biological factors that impede or facilitate drug availability, and which are impacted by the way the drug is delivered (route of administration), and—critically—its concentration. When prescribing drugs, it is not possible to know how much or how often a drug is required without considering the complex interplay of how that drug moves around the body, and what factors are required in order for it to take effect. Only when considering how the drug physically works within the body, and what internal mechanics are required to elicit that effect, can we then consider how much to prescribe, and how often it must be taken to provide optimal impact.

Drawing from the concept of bioavailability in psychopharmacology, the present paper proposes to move beyond simple considerations of dose and stimulates a multidimensional and dynamic epistemological framework of nature interactions to refine and advance the research agenda in this broad but important area of research.[1] The proposed model provides a more integrated perspective on how nature can improve health, and includes a testable model that can be adapted to different methodological approaches to make findings more comparable and contextualised. The theory draws on the understanding of different levels of behavioural interaction with nature and natural environments, and different meanings and mindsets that individuals hold for these interactions. A view of nature dose that takes into account personal perspectives on nature underpins our position, where we argue that a multidimensional perspective is required to tailor an effective prescription for health and well-being. Our argument is that a shift is required to viewing nature as a vehicle for interaction, rather than a passive universal entity that either does or does not impart effect. By viewing the contact with nature as an interaction, this allows us to understand more about differences between people when it comes to the health and well-being effects of being in nature, but also differences within people at different times and in different contexts. Through this perspective, an understanding of how interaction can be categorised brings forward a potential framework that considers mechanism (i.e. route of administration) while also addressing the necessary relevance to the individual (i.e. concentration) that has yet to be fully explored. It is hoped that this model, attempting to eventually arrive at universality through exploring individuality, may further our understanding of how nature can be understood to support health, in what ways this may work, for whom and under what conditions.

2 | IS DOSE ENOUGH? TOWARDS A PSYCHOPHARMACOLOGY OF NATURE

A recent paper examining the impact of nature on mental health has begun the exploration of nature-as-medicine (Bratman et al., 2019). The authors point out that different ways of interacting with nature will likely elicit different effects for mental health, citing examples such as the difference between looking at water and swimming in it (Bratman et al., 2019). We build on this work to create a model of nature-as-medicine for health; and through this lens we turn to the principles of psychopharmacology. Psychopharmacology is the understanding of the dynamics of drugs to exert effect, and a relevant concept within this area is that of *bioavailability*. This refers to the dynamics of how a drug moves around the body (pharmacokinetics) and, once it has reached its target site, what it is capable of doing (pharmacodynamics), based also on the qualities of the organism's physiology. Bioavailability is influenced by the dosage of the drug (i.e. how much and how often), the route of the administration (i.e. in

what way it is taken) and the concentration (i.e. the strength of the active ingredient) of the drug (Toutain & Bousquet-Mélou, 2004). Translating this psychopharmacological perspective into nature interactions, we can see that before we can consider the duration and/or frequency of the interaction (dosage), we must also consider the way a person interacts with nature (the route of administration), and the level of engagement with nature (concentration). This bioavailability model is summarised in Figure 1.

The dosage of nature has been evaluated by some researchers already (e.g. Barton & Pretty, 2010; Cox et al., 2018; Shanahan et al., 2015), but there is little agreement as to the ideal 'dose' required to support health and well-being. The conflicting evidence that is emerging about how long or how frequently we could be engaging with nature in order to support our health indicates the potential limits of conceiving dose simply as time and frequency. A multidimensional approach to dose is required, and work from Shanahan et al. (2015), Shanahan et al. (2016) has explored the nuances of the term 'dose', unpacking it to consider the more dynamic and adaptable concepts of *intensity*, *frequency* and *duration*. Here, the understanding of dose is not limited merely to time (i.e. *duration*), but also the quality and quantity of exposure (i.e. *intensity*), as well as a consideration of the regularity of this exposure could occur (i.e. *frequency*) in order to elicit psychological, physical or social responses (Shanahan et al., 2015). This model has been tested, with a large population-based study supporting the idea that these constructs are indeed distinct, and will likely confer distinct benefits depending on the domain of interest (Shanahan et al., 2016). For our part, the understanding of dose is absolutely all of these considerations; however, there remain two other elements thus far only partially explored—the concepts of *route of administration* and *concentration*. With previous considerations of *intensity*, this was limited to understanding the quantity and quality of the nature being interacted with, with the understanding that the higher the immersion in nature, the better the outcome (Shanahan et al., 2016). Bioavailability, however, can be viewed as a potentially multidimensional construct, which might be highly individual. To be able to extend an understanding of dosage, so that 'nature' might be prescribed effectively, as is being seen in some areas of the UK through social prescribing programmes (Robinson & Breed, 2019), it would be important to further understand these multidimensional elements of bioavailability—building on work from others in the field (e.g. Bratman et al., 2019; Shanahan et al., 2015).

We add to existing work by considering the *route of administration* (i.e. the type of nature contact, and the pathway(s) by which it may confer benefit), and how these pathways will provide different, but complementary opportunities for improving health and well-being. Furthermore, we explore *concentration* as not just a conceptualisation of the type of nature being contacted, but also what the person brings to that nature contact to form an interaction, in terms of their personal expectations, motivations and perceptions of the nature they contact. The conceptualisation and importance of *route* and *concentration* are discussed in detail henceforth.

3 | ROUTE OF ADMINISTRATION: THE BEING, DOING AND LIVING

Route of administration, in psychopharmacology terms, indicates how an agent enters the body, and the necessary pathways that are required to confer the drug from point of entry to site of action. In nature terms, we can view this as the means by which nature can have a mechanistic impact on physiological processes (or ameliorate health damage via the same). Previous work synthesised by Hartig et al. (2014), Frumkin et al. (2017) and Markevych

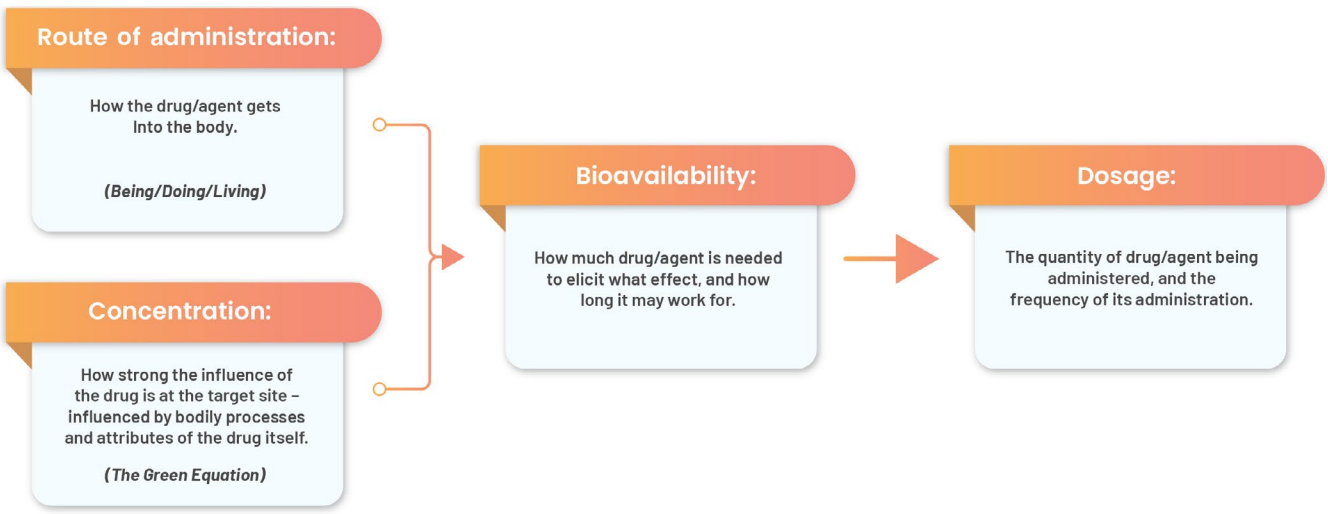


FIGURE 1 A proposed bioavailability model of nature for health and wellbeing benefit. Here, dosage can only be ascertained once we consider how the drug (nature) elicits its effects by understanding its pathways through the body (i.e. the route of administration) and the interplay between the person and the drug to determine how strong the impact may be (i.e. the concentration)

et al. (2017) outlines some of the physiological pathways by which nature can support health and well-being, and under what conditions these pathways can be accessed. To bring these together, we have grouped these pathways in accordance with behaviour, where we can see certain health pathways being impacted by levels or degrees of nature interaction. We have identified three categories of interaction that may entail either active or passive engagement (either physically or psychologically): 'being', 'doing' and 'living'. Taken together, these categories form potentially cumulative and interactive pathways, where significant health benefits are evidenced at each factor and associated mechanistic pathway. Here, distinct episodic instances ('being'), such as taking time to enjoy the scenery of a forest or a park, provide benefits through a psychobiological pathway; reducing stress, providing cognitive restoration and improving mood (Berto, 2014; Cassarino & Setti, 2015; Craig & Prescott, 2017). Natural environments can facilitate physical activity ('doing'), by providing an attractive locale to do exercise in, and thus contribute to the biobehavioural health benefits of exercise in nature (Calogiuri & Chroni, 2014; Thompson Coon et al., 2011) while also providing the acute episodic benefits of 'being' in a natural environment (Pretty et al., 2017). Finally, long-term access to natural environments ('living') has the capacity to confer biopsychosocial benefits to health across the life course. Some examples of these life course effects are by providing boosts to the microbiome in early life (Aerts et al., 2018; Böbel et al., 2018), increasing social capital and cohesion (Dzhambov et al., 2018; Groenewegen et al., 2018; Persson et al., 2018), or minimising environmental damage via pollution or environmental stress (Dzhambov & Dimitrova, 2014; Kondo et al., 2018; Twohig-Bennett & Jones, 2018). The supportive benefits provided by 'living' may be more readily accessed, as the person has easy access to episodic ('being') interactions with nature, as well as regular access to facilitative environments for the possibility of exercise and activity ('doing').

Within this conceptualisation of these pathways, 'being' would comprise the very basic (but nonetheless profound) level of benefit achievable by acute interactions with nature, which may be intentional (e.g. visiting a park or woodland) or incidental (e.g. noticing nature on your daily commute). The aspect of 'being' can co-occur with the other aspects of the framework ('doing' and 'living'), and is therefore a fundamental aspect of the process by which nature affects health. These considerations are important to understand because they will speak to the specific mechanism by which nature can confer benefit. However, it is still possible for someone to have such an acute interaction and derive no benefit at all. If the specific context were not 'right', not only might we see no benefit being achieved, but we may actually observe negative reactions to a nature interaction (Chhetri et al., 2004; Dorwart et al., 2009). For example, specific landscapes have been found to have a differential impact on stress and well-being, with those with high prospect (i.e. clear visual fields) and low refuge (i.e. places to hide) eliciting beneficial responses, whereas those with the reverse are associated with increased stress (Gatersleben & Andrews, 2013). The variation between individuals in their ability to derive restoration or relaxation from a nature interaction may also exist within individuals; with appraisals of nature interactions being dependent on a whole swathe of individual (i.e. person) and nature quality (i.e. agent) factors that may be context dependent (Root et al., 2017; Zijlema et al., 2020). Moreover, there may be dispositional factors at play, for example, psychological or emotional states that enhance or neutralise any benefit from the nature interaction (Tamir & Robinson, 2007). It is therefore imperative to understand this interaction meaning per person, per interaction; and this is what we refer to as the *concentration* element of the bioavailability framework.

4 | THE CONCENTRATION: LEWIN'S (GREEN) EQUATION

The concept of concentration provides an understanding of the implicit power and meaning of that interaction with nature to the individual *in that moment*, derived from the properties of the nature being contacted, and the particular conditions of the person at that time. It captures the essence of the contextual factors associated with the very connection itself—with the understanding that there must be an interaction between the person and the nature with which they are engaging on some level for there to be any benefit at all. This is supported by the vast amount of work that has detailed connecting with nature as a concept (e.g. Keniger et al., 2013; Kuo, 2015; Martin et al., 2020) and its associations with health and well-being. Contextual factors regarding active versus passive engagement (Duvall, 2011), actual or potential (i.e. via virtual representations, or through window views) access to nature (Korpela et al., 2017; White et al., 2018), perspectives of the purpose of the nature being interacted with (Kabisch et al., 2015; Knopf, 1983; Schilhab & Esbensen, 2019), the social circumstances and conditions that are to be met to allow meaningful engagement with nature (Seaman et al., 2010; Skår, 2010; Weimann et al., 2017), biophilia and biophobia (Gatersleben & Andrews, 2013; Ulrich, 1995), as well as the specific behavioural engagement during that interaction and the subjective intention behind it (Cox et al., 2017; Tamir & Robinson, 2007), will all likely impact the person's experience of that natural setting at the specific time of interaction. For example, an individual could visit a local park with the explicit purpose of connecting to nature, and experience various psychobiological benefits from that, yet may visit that same space another time for another purpose (e.g. a business lunch, or to remember previous fond occasions with a lost loved one, or to carry out exercise), or while that space is in a different state (e.g. during inclement weather or while it is busy with other people or during the winter when the colours and shapes of the vegetation are different), and derive a completely different benefit from that space, or none at all. With *concentration*, we posit that there is an interplay between the person and the nature being accessed, and this interplay will be reasonably subjective based on individual factors of the person, and the agent factors of the nature.

These subjective factors associated with nature contact, either in the terms of individual (person) factors or nature (agent) factors necessitate a more complex and dynamic appraisal of nature contact as

an interaction, rather than a universal unidimensional situation that will provide similar benefit to all people at all times. To understand this interaction, we consider the work of Kurt Lewin, and his formulation $B = f(P, E)$, where behaviour (B) is seen as being a function (f) of the interaction between the person (P) and their environment (E) (Lewin, 2013). This work has been shown to be highly applicable to workplace stress, where the resultant levels of stress are determined by understanding the interplay between person factors and the characteristics of their work environment (Althaus et al., 2013). We overlay this equation to instead predict health benefit (H) with the potential interplay of person and (natural) environment. The H term here being a noticeable and measurable change in health and well-being that can only be resultant from the right combination of the sum of the equation. As with the original B (behaviour) element of the equation, H can be multifaceted, measured in a variety of different ways, and be positive or negative. The Person (P) elements may be considered to be cultural, social and personal modifiers. Here, there are several potential layers of influence: the micro (e.g. perceived benefit, biophilia or affinity to nature, current mood or stress, life stage), the meso (e.g. accessibility, availability) and the macro (e.g. cultural norms of green space use, perceptions of green space function). These elements can be adaptable and applicable to a wide variety of cultural and social contexts, and allows for the engagement with nature to be on the individual's own terms. The Environment (E) elements would then be all of the considerations thus far extensively explored by the literature (e.g. type of nature, locality, quality, abundance, utility, etc.), but these factors must also be met by the individual with their own perceptions and attitudes towards the purpose of that nature, the purpose of that contact, and whether or not the current status of that nature meets those needs.

These concepts support the multidimensional perspective of bioavailability, with the BDL pathways denoting route of administration, and the green equation positing an understanding of concentration. As an example, providing an individual with 30 min of a nature walk would provide both being and doing as routes of administration (psychobiological combined with biobehavioural benefit) that would vary with concentration potential depending on the individual's current mood, affinity to nature and cultural norms of greenspace use. So, an individual who might be highly stressed, but also very drawn to nature, and who culturally sees greenspace as a relaxing and supportive environment would have a vastly different experience to another who was highly stressed, very drawn to nature, but that sees wilderness as intimidating.

5 | A PROPOSED AGENDA FOR TESTING THE BIOAVAILABILITY OF NATURE

The bioavailability framework proposed, while seemingly highly subjective and individual, is testable. The idea of concentration in this context is potentially multifaceted, but it need not be cumbersome to assess. For example, many psychobiological studies may already account for confounders with their analyses by assessing baseline levels of stress, mood or well-being (e.g. Böbel et al., 2018; Gidlow et al., 2016; Triguero-Mas et al., 2017). Similarly, controls for socioeconomic status and age are very frequently assessed in health research. What are resoundingly under-researched in the field, however, are those variables that are associated with individual appraisals of the nature interaction (such as biophilic response, affinity to nature, etc.), and how these may be variable both per individual and according to context. There are many scales available to measure an individual's affinity to nature, and while these each take a slightly different perspective in their ability to conceptualise this phenomenon, their use in such research is potentially vital. It is possible that there are more broad cultural differences in nature affiliation, which would also be important to understand in order to account for context. Research in this area is limited, and while a study using young children has suggested that there are no cultural differences between children in nature affiliation (Fränkel et al., 2019), related research with adults has shown cultural differences in aesthetic appeal of natural environments (Schetke et al., 2016).

Specific dimensions of the quality of the interaction with nature are not frequently measured, but doing so would bring nuance to understanding the benefits of nature. Interaction quality could be measured by asking participants to provide appraisals of specific components of their experience, or by using a formalised scale such as the Perceived Restorativeness Scale (PRS: Hartig et al., 1997), which provides an explicit measure of how restorative the individual feels the environment they have interacted with was for them at that time. Moreover, exploring the motivations of those that engage in interactions with nature may provide additional accounting of the variation in benefit response (Cassarino et al., 2019). For example, if individuals actively seek out nature in order to achieve restoration, this will likely engender a more active and engaged interaction (Passmore & Holder, 2017). In addition, some account for mood before experiencing their nature interaction, both as a function of motivation and a modifying factor, would be of importance.

Testing of the bioavailability framework has begun already, as outlined in Table 1. This initial investigation into the ability for the framework to provide understanding of how nature can benefit health shows the importance of accounting for variations in subjective components of nature interactions. While there is more that can be done, for example using the PRS to understand how the participants themselves felt about the ability for the interaction to restore, or their specific attitudes towards the nature interaction; this is a first step to understand the utility of this approach. Once sufficient data have been collected that examine the various factors that determine individuals' responses to natural environments and encounters, we can understand whether there are specific personal factors that are more strongly or weakly associated with the ability to gain benefit from such interactions. This will be particularly important when considering the use of nature as a social prescription (Robinson & Breed, 2019), as it may allow more detailed tailoring of interventions, or a more precise and appropriate allocation of participant to intervention.

TABLE 1 A case study of testing the bioavailability framework, where considering the concentration of nature interaction has been shown to be associated with degree of stress reduction

The bioavailability framework has recently begun to be tested on the individual level, where a recent study from our group examined the ability for a non-companion animal encounter to improve mood and reduce physiological stress (Sumner & Goodenough, 2020). Participants were taken to a walkthrough enclosure housing a variety of lemurs, who were free to roam wherever and however they wish. Concentration here was established through surveying participants' appraisal of the number of animals they saw and their proximity (i.e. whether distant in the tree canopy, or close and walking among them) as well as their nature relatedness using the Nature Relatedness Scale (Nisbet et al., 2009: to capture their individual affiliation to nature). Here, this concentration accounted for almost 40% of the variance of cortisol decrease experienced following the walk	

It is proposed that future work could incorporate the collection of data that cover both stable trait-like features and more episodic state-like features that will likely relate to the benefit received from a nature interaction. For trait-like factors, data concerning individuals' affinity to nature (as expressed by connectedness, relatedness or other conceptual metric), information on life history with nature (e.g. age and duration of times lived in or near natural environments, or living with pets or other animals), participant demographics that relate to life stage and socioeconomic status, and understanding of subjective ideas of purpose of specific natural environments. These relatively stable constructs will provide a foundation of characteristics that may impact restorativeness or salutogenesis from a nature interaction. For the more dynamic and episodic factors that will impact these outcomes, studies could seek to survey participants at least before and after any interaction, and potentially during if possible. *Before*: participants could be surveyed for current mood and level of cognitive stimulation, attitudes towards the specific environment due to be encountered, and intention for the interaction. *After*: an understanding of the subjective quality of that interaction could be ascertained, as well as subjective understanding of the benefit of that interaction, and biophilic or psychobiological response to being in that environment. *During*: while this is still an area that has been less intensely explored, it is important for studies to consider more of the dynamic experiences of a nature interaction. Nature moves. It is ever changing, with multisensory stimuli constantly fluctuating without predictability. Even if a participant is to remain motionless in their nature interaction environment, change will occur around them. Understanding how these changes of experience are received by participants will be of importance, but also how individual participants' mindsets may impact the recognition and subjective weight of these changes will be of interest to understand. It is here that qualitative work will be key, to highlight some of the salient factors to these dynamic interactions in terms of their ability to promote or restore.

In summary, in order to better understand the circumstances that can optimise the benefits of nature, further research employing mixed methods of investigation is warranted. Randomised controlled trials alongside smaller and more sensitive qualitative studies are required to plumb the depths of individual and contextual factors that may explain some of the vast variability already discovered. Building on this, it may be possible to account for those factors in order to provide generalisability, and a more targeted and effective approach to using our natural resources to support health and well-being, to finally determine a dose. Of paramount importance is that this need not be a unidirectional benefit. Indeed, it has been established that feeling affiliation with nature is strongly associated with pro-environmental behaviours (Geng et al., 2015; Kaiser et al., 2014), and so by providing more opportunity for individuals to feel connected to and improved by nature, this will likely support efforts to conserve these precious assets.

6 | CONCLUSION

By deconstructing, and subsequently reconstructing, narratives on the mechanisms of health benefits of nature interactions, we have proposed a dynamic and contextual theory as well as a conceptual framework that may guide further and future examinations of the mechanisms by which nature supports health. We provide a different perspective to support a more coherent and integrative approach to mapping the relationship of nature

with health and well-being. The principles of the present theoretical position, by attempting to provide an understanding of universality by individuality, may provide the opportunity to draw together the various strands of experience of nature regardless of the complexities of defining nature, and understanding what aspects of nature provide benefit for whom, when and how. We argue that the necessarily subjective interpretation of nature and green/blue space will assist in refocusing research by operationalising 'nature' with more precision, and reducing the obscuring and fragmenting of knowledge in the field. The need to consider a more multidimensional approach that might be offered with a lens of bioavailability provides the potential to view how nature dosage can be more accurately determined by considering route of administration (through the BDL pathways) and concentration (by using the green equation). Central to this would be understanding individuals' nature affiliation (or other concept of biophilia/nature responsiveness), and how this might relate to broader individual or cultural norms, as well as considerations for the nature context and its accessibility. By understanding more on the individual level, it may then be possible to zoom out once more and apply more reductionist principles onto research agendas to potentially find more coherence in our findings.

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CONFLICT OF INTEREST

The authors report there are no competing interests.

AUTHORS' CONTRIBUTIONS

All authors were involved in the conceptualisation, development and preparation of this work.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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ENDNOTE

[1] A full review of literature in the field informing the development of this theory can be found at: https://psyarxiv.com/knw3e/

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