PHILOSOPHICAL TRANSACTIONS B

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Review

**Cite this article:** McElwee P. 2021 The role of soils in learning and inspiration, physical and psychological experiences, and in supporting identities. *Phil. Trans. R. Soc. B* **376**: 20200184. https://doi.org/10.1098/rstb.2020.0184

Accepted: 10 May 2021

One contribution of 17 to a theme issue 'The role of soils in delivering Nature's Contributions to People'.

**Subject Areas:**
environmental science

**Keywords:**
ecosystem services, soil science, social benefits, Nature's contributions to people, relational values, cultural identities

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# The role of soils in learning and inspiration, physical and psychological experiences, and in supporting identities

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This paper reviews the literature on soil and nature's contributions to people (NCP) around learning and inspiration, physical and psychological experiences, and supporting identities, revealing a range of relationships to imagining, understanding and experiencing soil. Often labelled elsewhere as 'cultural ecosystem services', these NCP provide a range of benefits that are mostly non-material, non-consumptive and intangible. The review finds that NCP framings help to highlight how soils have contributed to inspiring learning and creative works, like art; to mental and physical health benefits, such as through recreation and gardening; and to cultural identities and practices, including religious practices and efforts for social justice. Overall, soils have played a large role in human creative endeavours, are the root of significant relationships to the environment and can be conceptualized through key metaphors, ideas and theory as a bridge linking culture and nature together. Yet despite the wide-ranging contributions of soils to these NCP, the literature remains uneven and much more remains to be understood, including how relational values of care and stewardship with soils can be fostered and how attention to the co-produced 'biosocial' nature of soil can help improve practices for soil health.

This article is part of the theme issue 'The role of soils in delivering Nature's Contributions to People'.

## 1. Introduction

In recent years, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has brought attention to the broad range of potential benefits from nature under the category of nature's contributions to people (NCP) [1]. NCP was suggested as an alternative framing to 'ecosystem services,' in part to engage a wider range of scholarship from the social sciences and humanities and a larger discussion of values around ecosystems, and 18 broad categories of NCP have been proposed [2]. This paper for the special issue on 'The role of soils in delivering NCP' reviews literature on three different but related NCP categories: those of NCP 15—Learning and Inspiration, NCP 16—Physical and Psychological Experiences, and NCP 17—Supporting Identities. For each case, while the use of the term 'NCP' is not yet widespread in literature discussing soils, there are in fact numerous examples of how humans have imagined, understood and experienced soil that represent the types of benefits the term NCP tries to capture. Soils have inspired art, literature and film; contributed to mental and physical health benefits from a variety of recreational and livelihood activities; and shaped cultural identities and practices.

The three NCP reviewed here are unique. NCP have been broadly divided into regulating, material and non-material categories; the non-material NCP are also labelled elsewhere as 'cultural ecosystem services' [3]. These NCP share in common an attention to the non-consumptive, intangible and immaterial benefits that people receive from nature. Table 1 presents how these NCP categories have been defined by IPBES, along with related examples from the Common International Classification of Ecosystem Services (CICES). The



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**Table 1.** Explanation of NCPs 15–17 and examples relating to the soil.

| type of NCP | definitions of NCP [4] | related class and examples from CICES [5] | examples found related to soil |
|---|---|---|---|
| NCP 15: learning and inspiration | | | |
| keywords: *art, literature, film, biomimicry, knowledge* + *'soil'* | provision, by landscapes, seascapes, habitats or organisms, of opportunities for the development of the capabilities that allow humans to prosper through education, acquisition of knowledge and development of skills for well-being, information, and inspiration for art and technological design (e.g. biomimicry) | *class*: characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge (3.1.2.1)<br>*example*: researching nature<br>*class:* characteristics of living systems that enable education and training (3.1.2.2)<br>*example*: studying nature<br>*class*: characteristics of living systems that enable aesthetic experiences (3.1.2.4).<br>*example*: the beauty of nature<br>*class*: elements of living systems used for entertainment or representation (3.2.1.3)<br>*example*: things in nature used to make films or to write books | research field of soil science<br>formal and informal education about soil<br>indigenous knowledge regarding soil<br>soils as pigments or subjects in art<br>inspiration from soil in film and literature<br>use of soil in architecture and design |
| NCP 16: physical and psychological experiences | | | |
| keywords: *physical benefits, recreation, sport, psychological benefits,* + *"soil'* | provision, by landscapes, seascapes, habitats or organisms, of opportunities for physically and psychologically beneficial activities, healing, relaxation, recreation, leisure, tourism and aesthetic enjoyment based on the close contact with nature (e.g. hiking, recreational hunting and fishing, birdwatching, snorkelling, diving, gardening) | *class:* enable activities promoting health, recuperation or enjoyment through passive or observational interactions (3.1.1.1)<br>*example*: using the environment for sport and recreation & using nature to help stay fit<br>*class:* enable activities promoting health, recuperation or enjoyment through active or immersive interactions (3.1.1.2)<br>*example:* watching plants and animals where they live & using nature to destress | recreation and sports dependent on soil<br>health benefits from being in nature/working with soil<br>soils as food<br>social, economic and other benefits from gardening<br>tourism and entertainment regarding soils |
| NCP 17: supporting identities | | | |
| keywords: *cultural identities, religious practices, cultural practices, ethics, philosophy* + *'soil'* | landscapes, seascapes, habitats or organisms being the basis for religious, spiritual, and social-cohesion experiences:<br>— provisioning of opportunities by nature for people to develop a sense of place, belonging, rootedness or connectedness, associated with different entities of the living world (e.g. cultural, sacred and heritage landscapes, sounds, scents and sights associated with childhood experiences, iconic animals, trees or flowers)<br>— basis for narratives, rituals and celebrations provided by landscapes, seascapes, habitats, species or organisms<br>— source of satisfaction derived from knowing that a particular landscape, seascape, habitat or species exists | *class:* characteristics of living systems that are resonant in terms of culture or heritage (3.1.2.3)<br>*example*: things in nature that help people identify with the history or culture of where they live or come from<br>*class:* elements of living systems that have symbolic meaning (3.2.1.1.)<br>*example*: using nature to as a national or local emblem<br>*class*: elements of living systems that have sacred or religious meaning (3.2.1.2)<br>example: things in nature that have spiritual importance for people | linguistic references to soil<br>soils in myths and metaphors<br>soil as linked to social identities<br>soils in religious ritual or cultural practices<br>managing soils to achieve symbolic meanings, such as social justice |

three reviewed NCP are often associated with the idea of 'relational values', which recognizes that people often see themselves in shared relations with nature, or that nature facilitates opportunities for extended social relationships with others [6,7]. Such relational values can be contrasted with the instrumental values often associated with ecosystem services in which a one-way relationship from ecosystems to people can be quantitatively assessed and (economically) valued [8]. The non-material NCP are also distinctive because they are constituted by interactions in specific places (i.e. are highly contextual), unlike other NCP such as regulating services, whose processes and outcomes are more universal [9].

With these key points in mind, several questions guided this review: (i) what existing research on cultural, psychological and social interactions with soil fits within NCP categorizations? (ii) How does the concept of NCP help us see soil–human contributions and interactions in new or particularly useful ways? And (iii) what gaps in research and future directions does an NCP framing reveal? For the first question, because NCP has only been in use as a term since around 2015, the direct literature on NCP and soils is just now emerging [10]. However, there is a long history of interdisciplinary work on human interactions with soil that fits with the idea of 'nature's contributions', ranging from humanities scholarship on art and soil to social science on the role of soil in shaping identities and the social and psychological benefits from nature [11], all of which are explored in §§3–5 below. More recent scholarship on relational values and human contributions to soil materiality (discussed in §6) also fits well within NCP framings.

On the second question of the usefulness of the NCP concept, unlike other authors who have used soil 'ecosystem services' concepts to explore what benefits soil can provide to humans [12,13], this review presents NCP as a way to provide a different approach to soil/society relations. Several authors have stressed that NCP do not exist *a priori* to be supplied by nature but are co-produced by interactions of humans with ecosystems [14]. An NCP approach can thus emphasize how reciprocal relations with nature can be both created by and manifested in soil [15], a framing that has implications for reconfiguring soil management practices and policies. Yet despite the wide-ranging contributions of soils to human well-being, the literature is uneven, as noted throughout the paper in answering the third question, and much more remains to be understood about how values can shape and be shaped by soil. The paper concludes with an examination of how NCP as a framing device can help expand the diversity of approaches to human engagement with soil, including through attention to soil ethics and care and to the soil as a biosocial entity.

## 2. Methods

Using keywords associated with each of the three NCP under review (table 1), Google Scholar and Web of Science were searched for scholarship on soil, focusing on exemplars and most cited works, particularly those explicitly dealing with soil, rather than studies that briefly mentioned soil amid a range of other NCP or ecosystem services. Rather than a systemic review, specific examples that illustrated a range of benefits and values have been highlighted, with an eye to incorporating literature from varied parts of the world and dealing with different types of ecosystems and soil properties. The focus remained on indicative approaches that particularly fit an NCP framing, not on being exhaustive with regard to the extensive history of literature on soils. The review also zeroed in directly on the soil itself, not indirect associations, such as the outcomes of poor soil management (e.g. famine) that might affect NCP, or NCP that derive indirectly from things that grow in soil (e.g. from forests or food). This review should therefore be seen as suggestive of the directions and emphasis of the historical and current literature on soil that coincide with 'intangible' NCP categories, requiring a broad-brush approach rather than a systematic examination of this wide field.

## 3. Soils and NCP 15: learning and inspiration

NCP 15 concerns how elements of nature have set the conditions for learning and other creative endeavours, including art, technology and other 'inspirational' benefits.

### (a) Learning and education

Learning about soil has a long history, given that it has been an object of study since at least the ancient Greeks, who often combined observations of physical properties with reflections on the relational value of soils to humans [16]. The formal discipline of soil science emerged in the nineteenth century, centred on such key figures as Russian Vasily Vasil'evich Dokuchaev and German Justus von Liebig, who worked in fields and laboratories, respectively, to determine the composition and histories of soil formation, and whose 'technocratic' approaches came to dominate the field to the exclusion of more relational approaches [16]. However, soil science as a discipline has in the past two decades centred on new interests in planetary change [17], reframing the field towards a conjoining of both technical and more socially oriented research foci.

Learning about soil has also long existed outside of formal science settings as well, such as through work in community gardens, remediation sites, farms and events like the UN World Soil Day, providing opportunities for co-production of knowledge between experts and laypeople. For example, the French Observatory of Living Soils has promoted joint scientist–farmer work to map soil microbiology across a network of farms [18], contributing to the idea that humans help facilitate 'living' soil. Research on indigenous knowledge systems has also shown that learning about soil can be a source of ethical guidance on how human beings should behave within and towards nature in many cultures [19]. In particular, ethnopedology as a field has focused on identifying and understanding these soil knowledge systems unique to different cultural groups and often reflecting relational values within them [20].

### (b) Inspiration in art, film and literature

Inspiration from soil can be seen in the ways in which artists have used soil, both as a spark for creativity and as a medium itself [21]. The first surviving pictorial art was made using soils and charcoals, then pigments like red and yellow ochre made from iron oxides, while the clay was first used to produce both functional and artistic pottery [22]. Soils have also been subjects of art, with many modern artists like Cézanne, Gauguin and Dubuffet drawing attention to the diversity and beauty of earth [23]. The later Land Art practitioners of the 1960s (including Robert Smithson, Ana Mendieta and Walter de Maria) emerged in an era of rising environmental awareness and used monumental components


**Figure 1.** Contemporary artists using soil as a medium. (*a*) *Yusuki Asai, yamatane, 2014*. Asai uses local soil to paint murals in exhibition spaces and then washes them away. (Photograph by Nash Baker.) (*b*) *Dineo Seshee Bopape, sa____ke lerole, (se lerole ke ____), 2016*. Bopape digs and collects soil for her exhibitions in the location where it will be displayed. (Photograph by Charles Benton.) (*c*) *Truong Cong Tung, Across the Forest, 2018*. Soil cores were pulled from drilling machines used to reach groundwater to irrigate coffee plantations in Tung's native land. (Photograph by Galerie Quynh.)

of the natural environment (including soil) as a way of rejecting formal art galleries [24].

The ways in which soil as an artistic medium often reflects social or relational values can also be seen in contemporary artists engaging with soil (figure 1). These include Claire Pentecost, whose work shapes soils into ingots, representing soil's considerable value, while Yusuke Asai paints 'earth murals' (figure 1*a*) from local soils where he is exhibiting to demonstrate the contextual rootedness of soil. Truong Cong Tung has used soil to dye fabric and to fill galleries with the smell, representing conflicts over the environmental change in Vietnam (figure 1*b*), while Dineo Seshee Bopape, a South African artist, represents gender and language within her earth installations (figure 1*c*). These and other artists have been featured in a recent book on soil and art, with the literature in this field substantial and growing [25], and this soil-attentive art has in turn raised awareness of threats to soil health [26].

Soil has also been an inspiration for literature, such as Frank Herbert's sci-fi book *Dune* [27] and its sequels and film, which were inspired by his working on a soil conservation and dune stabilization project in the 1950s in Oregon [28]. Other soil-related novels include John Steinbeck's *The Grapes of Wrath* [29], in which mismanagement of topsoil in Dust Bowl Oklahoma drives mass migration that in turn shapes the future history of California [30], while Emile Zola's *The Earth* [31] and Pearl Buck's *The Good Earth* [32] take soil as either a key metaphor for their protagonists or the situations in which they find themselves. There has even been an entire poetry school focused on soil and earth, the 'geological school' associated with the Leningrad Mining Institute, again demonstrating the potential links between inspiring both science and art through soil [33].

### (c) Inspiration through technology and design

Unlike in art, there has been comparatively less attention to soil and ideas of 'inspiration' in other fields, such as technology or design. Soil processes themselves are often imitated in human actions, such as composting, and many popular agro-ecological practices to improve soils, such as no-till or cover crops, are essentially a form of biomimicry [34]. Scientists have also used inspiration from Anthrosols, soils created by humans (such as the high carbon Amazonian dark earths known as *terra preta* and *terra mulata*), to guide research and application on new technologies such as biochar [35]. Other examples of using soil to both inspire design and provide a physical medium include housing styles using rammed earth walls, adobe, and compressed earth bricks, which often confer adaptive benefits like cooling or passive solar generation [36].

## 4. Soils and NCP 16: physical and psychological experiences

NCP 16 relates to obtaining physical and psychological benefits from being in or around nature.

### (a) Physical benefits

While the literature on physical benefits from nature is extensive, the soil is usually only the ground from which these benefits emerge, and there is little research specific to soil itself. Research on green spaces has noted that physical experiences of being in nature often result in more exercise and mobility, reduced weight, reduced stress and blood pressure, and improved diet [37]. The overall literature does not, however, make much distinction regarding the interactions with soils leading to such improved health outcomes.

While recreation has been one of the most important cultural ecosystem services identified, there is less attention to physical recreation and tourism specifically built around the soil. Although spectators may not see the direct connection, many sporting experiences rely heavily on well-managed soils, affecting everything from ball rebound on clay tennis courts and cricket pitches to drainage of football fields [38], demonstrating that soil is often a taken-for-granted background to many important and enjoyable human experiences. Beyond a few designated 'geoparks' that have unique soil types, such as bogs and peats in Scotland that are well-integrated into tourist visits and hikes [39], or the practice of 'mudlarking', exploring sedimented riverbanks or other places for traces of antiquities, there is little formal recreation around the soil. In fact, the physical benefits that people may receive from recreating as tourists can result in soil compaction and damage, as is reported in some heavily visited sites [40].

### (b) Psychological experiences

The mental health benefits from experiencing nature, ranging from urban green spaces to practices known as 'forest bathing', have been widely recognized [41,42]. Without soil such benefits would not be possible, but much of the literature is not direct in terms of explaining soil's specific relevance, indicating a potential gap in research. Ecopsychology as a field has also drawn attention to the approach of treating individuals with psychotherapy that encourages stronger ecological identities [43]; again, however, there is little specific reference to the soil in and of itself in this field.

Gardening is the outdoor practice that makes the most direct reference to working with soils to derive psychological benefits; for example, digging in soil may provide mental health benefits by relieving stress, a phenomenon noted in both older and younger populations. In one study of allotment gardeners in Tokyo, those actively gardening had better self-reported mental health than their non-gardening neighbours, in addition to higher levels of social interaction [44]. In a study of school children who participated in garden projects, parents reported less stress and higher self-esteem [45], yet how working with the soil itself generated mental health benefits remains a gap. Additionally, food can provide psychological comfort, and there are cultural practices of direct soil consumption associated with geophagy worldwide that are perceived by practitioners to potentially provide some mental or health benefits [46,47].

## 5. NCP 17: supporting identities

NCP 17 focuses on the ways in which religious, spiritual, symbolic and social identity and experiences can be derived from nature, and thus is a very broad category covering many potential interactions with soil.

### (a) Soil and identities

Soil has been metaphorically and linguistically linked to human identity from the earliest times; for example, the name Adam from the Biblical creation story derives from the Hebrew word adama, meaning earth, while our species name of *homo* comes from a related word for humus in Latin [48]. Other major world philosophies have echoed these ideas of earth as giving life to humans or as forming the basis for existence; for example, the five elements of wuyung philosophy in the *I Ching* refer to earth (tǔ), which was associated with balance and harmony [49]. There are numerous ways in which metaphors around soil have formed the basis of cultural and national identities. The phrase 'native soil' often describes basic characteristics of a society; for example, the phrase *xiangtu* in Chinese combines the words for countryside and earth to present a metaphor for China's rural and agrarian roots [50]. The concept of 'blood and soil' originating in nineteenth-century Germany has much darker meanings, used to mythologize rural lives, racial purity and connections to homeland, a metaphor later adopted by other genocidal regimes [51]. Ethnic divisions and conflicts among self-described 'sons of the soil' and those perceived as outsiders have led to numerous atrocities in history [52].

The development of ethics surrounding soil is a far more positive way in which human identity has been linked to caring for the earth. For example, Aldo Leopold's land ethic described a type of reciprocal relationship with soil, in which care for the land is part of caring for people [53]. Studies have shown that relations with soil can be important in shaping many farmers' identities; for example, farmers' sense of place can influence how they address stewardship of their soils [54], while social cohesion can be shaped by judgements about how other farmers manage soil [55]. Attention to how values and identities shape relations to soil are particularly useful because they can impact whether farmers adopt soil conservation practices [56], help determine who might use soil data or benefit from extension services [57] and can move the discussion beyond the simple economic benefits of better soil management [58].

Gender is also another identity linked to and potentially shaped by soil relations, embodied by metaphors like 'Mother Earth'. Women can have unique soil knowledge, often resulting from specific cultivation practices, experiences resulting from gendered divisions of labour, or beliefs more focused on 'caring' [59,60]. There is also some evidence that women's soil use practices may be more sustainable than men's; in one study, men's labour was associated with excess fertilizer use and soil compaction in Hungary [61], while in another example, rich anthropogenic African 'dark earths' were traced to women's practices of mixing cooking residues (e.g. charcoals or palm oils) with soil [62]. Given that gender affects soil management through various channels, ranging from land tenure, choice of crops, access to marketing and other realms, this argues for more attention to gender in soil science and farmer extension, particularly because women tend to be underrepresented in soil education programs [63]. Further, when gender-blind interventions to improve soil properties have been introduced, this can affect women's land rights, access and use, leading to conflicts [64,65].

### (b) Soil and religious practices

Soil has also been fundamental to many religious and cultural worldviews. Humans have long worshipped deities representing soil fertility and productivity, from Gaia and Demeter in

ancient Greece, the Celtic god Danu and Māori beliefs regarding Papa-tū-ā-nuku, the earth mother [66]. The Japanese and Chinese words for 'earth' are derived from ideas of land spirits that resided in soil, and the symbol for the word 'earth' is itself represented as a horizon of soil (土) [67]. There are significant religious buildings dedicated to soils and earth, including temples devoted to Shintoism in Japan and the Altar of the Earth and Heavens in Beijing [66]. Christianity also has many Biblical references to soil or dust as being the composite material of which man is made. Other diverse religious and cultural practices and rituals worldwide have been shaped by soil, from mound building by early inhabitants of North America and continued rituals by their descendants [68] to the many significant burial practices and rituals involving soil [69]. Such religious practices have often focused on themes of stewardship, care and reciprocity with nature [47].

### (c) Soils and social justice

Soils have an important role to play in symbolic discussions of social and environmental justice as well, as racism and disempowerment have left many communities facing soil degradation. For example, the numerous benefits of community gardening noted previously have been tempered by the realization that many urban soils are contaminated, often because of environmental injustices around siting of polluting industries [70]. Injustices in soil science, such as the national soil survey process in the early twentieth century that excluded non-white farmers in the USA [71], have also been documented. Concerns about the inequitable consequences of the commodification of agriculture, soils and other resources have influenced the work of activists like Vandana Shiva, whose well-known tract *Soil Not Oil* [72] highlights the pitfalls of industrialized agriculture, while the ways in which soil has been used to further the development of capitalism and widening economic divides have been the subject of another recent book [73]. The potential injustices of soil carbon markets that could marginalize communities through 'green grabs' have also been a recent topic of concern [74]. Much of this attention to the social consequences of inequal access to the benefits of soil emerges from the field of political ecology, which traces the ways in which structural forces shape environmental change [75], and the growth of the field is often traced to Piers Blaikie's ground-breaking book on land degradation [76]. Subsequent work has continued to show the ways in which marginalized peoples are often blamed for soil erosion, rather than the practices of the powerful [77,78].

## 6. Discussion: the values of NCP framings

The literature on the 'social' NCP and their non-material benefits has revealed a wide variety of practices, ideas, imaginaries and identities linked to the soil around the world. The literature also reveals useful linkages to some of the NCP explored in the rest of this special issue; for example, artists featuring soil have brought attention to biophysical soil health and the need for restoration practices [79]. Yet despite the prominence given in religions, philosophies and art, intangible NCP linked to soil are often overlooked in research. Unlike forests or wildlife, for which extensive studies of non-material benefits have emerged [80,81], soil all too often remains in the background, only the substrate from which other benefits arise or as the material underfoot in human activities, like recreation. Such gaps argue in favour of extending NCP-focused studies to ensure that cultural and intangible benefits, and the ways in which values shape soil management, receive further attention. Two areas where an NCP framing can help draw attention to soil–human interactions and expand research in useful directions are outlined below, which reflect recent relevant scholarship on relational values, knowledge production and soil materiality.

### (a) Reframing soil relations through culture and care

Recent studies have proposed ways to draw more attention to soil's enormous role in planetary health, from serving as a repository for carbon to harbouring rich biodiversity [57], and one suggestion has been to reframe attention to the soil through a security lens in particular [82]. Yet such studies of 'soil security' have neglected some of the NCP dimensions reviewed here. Similarly, improving the monetary valuation of soil ecosystem services, as some have proposed, is likely to miss the values embedded in the intangible NCP that are potentially of importance [83]. Instead, a reframing around the holistic concept of NCP might assist in recognizing that soil has been fundamental to human spiritual and intellectual flourishing. Improved understanding of the cultural elements of soil interactions, including the concept of 'care', appear useful in this regard, and can help make the case for attention to the multiple benefits and plural values of soil.

Indigenous knowledge could be particularly helpful in understanding these interactions, given that these systems often see soil management as a way to engage in larger reciprocal relations with nature [84]. Examples include practices in West Africa around the incorporation of termites into soil management, rather than their eradication, recognizing their positive role as a 'partner' to the farmer in improving soil fertility [85]. Indigenous knowledge systems could provide resources to improve management and understanding elsewhere, ranging from soil erosion prevention to integrated agro-ecological management [86]; such intimate knowledge and attention often allow for pinpointing interventions needed for soil health, rather than reliance on science and technology alone [87].

Critical assessments of how knowledge around soils is produced have shown that researchers also play a large role in stabilizing the concept of what 'soil' is and what it does for humans [88], and the different ways scientists and farmers both engage and relate to soil often shape divergent outcomes in terms of priorities for management [89]. In other words, how we understand soil shapes how we design policies for it; this argues for additional explorations of the ways in which different types of soil knowledge can lead to practices that can help tackle the soil degradation crisis [90]. For example, identification of the multiple ways different communities think of soil can help shift attention away from a focus on yield and production alone in favour of attention to ethics and care [91,92], and the linkages between soil and human experiences and selves outlined in NCP 17 highlight how identities can shape these values [15,54,58]. Given the many threats to soil discussed elsewhere in this special issue, understanding the ways in which soil-conserving values can be fostered is a useful contribution of an NCP framing [93,94].

### (b) Soil as a co-constructed and biosocial entity

Across all three examined NCP, one common theme was the ways in which soil can be seen as an encapsulation of nature and culture together, or as a co-constructed and 'biosocial entity'. Such approaches are in contrast with many current conceptualizations to soil; for example, the European Commission recognizes social benefits from soil including as a 'physical and cultural environment for humans and human activities' and an 'archive of geological and archaeological heritage', but these definitions reflect a one-way relationship of soils servicing human needs, rather than acknowledging the co-construction of soil from human actions and relationships [95].

One framing of a more biosocial relationship with soil is through the lens of 'relational materiality' [96]. Rather than simply rendering services to people, soil in this way of thinking is considered active matter that is shaping and being shaped by society [15]. Relational materiality stresses the agency of soils and the symmetry of relations: soils are both generated by human attention and in return generate their own reactions (i.e. politics, identities or ideas) [97]. As noted previously, concepts of relationality with soil are often deeply embedded in many indigenous ontologies, as well as material practices of soil creation or amendment [98]. Some authors have proposed that the current era of the Anthropocene calls for a new recognition of the *anthro* in soil studies (e.g. an anthropedology), which could focus not only on human impact on soils, but how new soils like 'Anthrosols' and 'Technisols' are being created through the impacts of a warming climate or the emergence of new microorganisms [99].

Thinking of soil as a biosocial entity could also lead to new conversations about how to treat soils as other than inert matter. As one example, helping farmers 'see' differently through heuristic and aesthetic strategies that emphasize the multispecies worlds embedded in soil could improve agricultural practices for both better soil and farmer health [94]. In another trend, recent conversations around the rights of nature have been extended to the idea of that there should be 'rights of soil', whereby threats to soil health and functionality should be approached not just from technical or financial interventions, but legal and cultural ones. Eminent soil scientist Rattan Lal has recently proposed that 'soil degradation, pollution, and depletion is a moral and ethical wrong that must be stopped' in recognition of the living components of soil and the right of those components to flourish [100].

## 7. Conclusion

Through this review, it is clear that soils provide a widespread range of non-material benefits; indeed, it is hard to see any aspect of human civilization that does not have some link to soils, whether in the ways we grow food, the scope of our imaginations, or the aesthetics of our creative worlds. At the same time, these cultural and relational values have clear ties to understanding and improving material properties of soil: identities of farmers may influence their farming practices, thereby expanding or shrinking soil carbon stocks, while art and aesthetics around soil can build support for restoration efforts that would improve soil health and supply of other NCP like water quality. Overall, the conceptual framing of 'nature's contributions' affords a broad examination of these issues and highlights the variety of ways that humans value and understand soil. Approaching soils from an NCP lens helps illuminate the fact that soils have played a large role in human creative endeavours, are the root of significant relationships to the environment, and can be conceptualized as a bridge linking culture and nature together. Continuing efforts are needed to expand on these foundations and push further attention to learning, inspiration, physical and psychological benefits, and social identities in relation to soil, particularly around the promising concepts of soil care and biosocial relations.

Data accessibility. This article has no additional data.

Competing Interests. I declare I have no competing interests.

Funding. This study was supported by National Science Foundation (grant no. 1853759).

## References

1. IPBES. 2019 *Summary for policymakers of the global assessment on biodiversity and ecosystem services*. Bonn, Germany: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. See https://ipbes.net/news/ipbes-global-assessment-summary-policymakers-pdf.
2. Pascual U *et al.* 2017 Valuing nature's contributions to people: the IPBES approach. *Curr. Opin. Environ. Sustain.* **26–27**, 7–16. (doi:10.1016/j.cosust.2016.12.006)
3. Milcu AI, Hanspach J, Abson D, Fischer J. 2013 Cultural ecosystem services: a literature review and prospects for future research. *Ecol. Soc.* **18**, 44. (doi:10.5751/es-05790-180344)
4. Díaz S *et al.* 2018 Assessing nature's contributions to people. *Science* **359**, 270–272. (doi:10.1126/science.aap8826)
5. Haines Y, Potschin RMB. 2018 *Common international classification of ecosystem services (CICES) V5.1 and guidance on the application of the revised structure*. Copenhagen, Denmark: European Environment Agency.
6. Himes A, Muraca B. 2018 Relational values: the key to pluralistic valuation of ecosystem services. *Curr. Opin. Environ. Sustain.* **35**, 1–7. (doi:10.1016/j.cosust.2018.09.005)
7. West S, Haider LJ, Masterson V, Enqvist JP, Svedin U, Tengö M. 2018 Stewardship, care and relational values. *Curr. Opin. Environ. Sustain.* **35**, 30–38. (doi:10.1016/j.cosust.2018.10.008)
8. Stenseke M. 2018 Connecting 'relational values' and relational landscape approaches. *Curr. Opin. Environ. Sustain.* **35**, 82–88. (doi:10.1016/j.cosust.2018.10.025)
9. Gould RK, Lincoln NK. 2017 Expanding the suite of Cultural Ecosystem Services to include ingenuity, perspective, and life teaching. *Ecosyst. Serv.* **25**, 117–127. (doi:10.1016/j.ecoser.2017.04.002)
10. Smith P, Keesstra SD, Silver WL, Adhya TK. 2021 The role of soils in delivering Nature's Contributions to People. *Phil. Trans. R. Soc. B* **376**, 20200169. (doi:10.1098/rstb.2020.0169)
11. Brevik EC, Cerdà A, Mataix-Solera J, Pereg L, Quinton JN, Six J, Oost KV. 2015 The interdisciplinary nature of soil. *Soil* **1**, 117–129. (doi:10.5194/soil-1-117-2015)
12. Brevik EC, Pereg L, Steffan JJ, Burgess LC. 2018 Soil ecosystem services and human health. *Curr. Opin. Environ. Sci. Health* **5**, 87–92. (doi:10.1016/j.coesh.2018.07.003)
13. Jónsson JÖG, Davíðsdóttir B. 2016 Classification and valuation of soil ecosystem services. *Agric. Syst.* **145**, 24–38. (doi:10.1016/j.agsy.2016.02.010)
14. Comberti C, Thornton TF, de Echeverria VW, Patterson T. 2015 Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems.

*Global Environ. Change* **34**, 247–262. (doi:10.1016/j.gloenvcha.2015.07.007)

15. Friedrichsen CN, Hagen-Zakarison S, Friesen ML, McFarland CR, Tao H, Wulfhorst JD. 2021 Soil health and well-being: redefining soil health based upon a plurality of values. *Soil Secur.* **2**, 100004. (doi:10.1016/j.soisec.2021.100004)
16. Brevik EC, Hartemink AE. 2010 Early soil knowledge and the birth and development of soil science. *Catena* **83**, 23–33. (doi:10.1016/j.catena.2010.06.011)
17. Brevik EC *et al.* 2018 Trends in undergraduate soil science education at selected universities in the USA from 2009 to 2013. *Soil Sci. Soc. Am. J.* **82**, 295–306. (doi:10.2136/sssaj2017.10.0346)
18. Granjou C, Phillips C. 2019 Living and labouring soils: metagenomic ecology and a new agricultural revolution? *Biosocieties* **14**, 393–415. (doi:10.1057/s41292-018-0133-0)
19. Barrera-Bassols N, Zinck JA, Ranst EV. 2006 Symbolism, knowledge and management of soil and land resources in indigenous communities: ethnopedology at global, regional and local scales. *Catena* **65**, 118–137. (doi:10.1016/j.catena.2005.11.001)
20. Winklerprins AMGA. 1999 Insights and applications of local soil knowledge: a tool for sustainable land management. *Soc. Nat. Resour.* **12**, 151–161. (doi:10.1080/089419299279812)
21. Feller C, Landa ER, Toland A, Wessolek G. 2015 Case studies of soil in art. *Soil* **1**, 543–559. (doi:10.5194/soil-1-543-2015)
22. Ugolini F. 2010 Soil colors, pigments and clays in paintings. In *Soil and culture* (eds E Landa, C Feller), pp. 67–82. Dordrecht, The Netherlands: Springer.
23. Jenny H. 1968 *The image of soil in landscape art old and new*. Vatican City, Italy: Pontificiae Academiae Scientarium Scripta Varia.
24. Boettger S. 2003 *Earthworks: art and the landscape of the sixties*. Berkeley, CA: UC Berkeley Press.
25. Toland A, Noller JS, Wessolek G. 2019 *Field to palette: dialogues on soil and art in the anthropocene*. Boca Raton, FL: CRC Press.
26. Lewin MF, Gathorne-Hardy F, Adams C. 2015 'Curating the convivial' for soil culture at Create. *Geohumanities* **1**, 433–441. (doi:10.1080/2373566x.2015.1109470)
27. Herbert F. 1965 *Dune*. Philadelphia, PA: Chiltern Press.
28. Landa E. 2010 In a supporting role: soil and the cinema. In *Soil and culture* (eds E Landa, C Feller), pp. 83–105. Dordrecht, The Netherlands: Springer.
29. Steinbeck J. 1939 *The grapes of wrath*. New York, NY: Viking Press.
30. Heavilin BA. 2017 A sacred bond broken: the people versus the land in *The Grapes of Wrath*. *Steinbeck Rev.* **14**, 23–38. (doi:10.5325/steinbeckreview.14.1.0023)
31. Zola E. 1887 *La Terre* (The Earth). Paris, France: Charpentier.
32. Buck P. 1931 *The Good Earth*. New York, NY: John Day.
33. Belasky P. 2010 'Pochveniks'—'The Poets of The Soil': the Geological School of 20th Century Poetry in Leningrad, USSR (St. Petersburg, Russia). In *Soil and culture* (eds E Landa, C Feller), pp. 173–204. Dordrecht, The Netherlands: Springer.
34. Stojanovic M. 2019 Biomimicry in agriculture: is the ecological system-design model the future agricultural paradigm? *J. Agric. Environ. Ethics* **32**, 789–804. (doi:10.1007/s10806-017-9702-7)
35. WinklerPrins AMGA. 2014 Terra preta: the mysterious soils of the Amazon. In *The soil underfoot: infinite possibilities for a finite resource* (eds GC Churchman, ER Landa), pp. 235–246. Boca Raton, FL: CRC Press.
36. Singh MK, Mahapatra S, Atreya SK. 2009 Bioclimatism and vernacular architecture of north-east India. *Build. Environ.* **44**, 878–888. (doi:10.1016/j.buildenv.2008.06.008)
37. Nicklett EJ, Anderson LA, Yen IH. 2014 Gardening activities and physical health among older adults. *J. Appl. Gerontol.* **35**, 678–690. (doi:10.1177/0733464814563608)
38. Gibbs R. 2014 Sports surface design: the purposeful manipulation of soils. In *The soil underfoot: infinite possibilities for a finite resource* (eds GC Churchman, ER Landa), pp. 351–370. Boca Raton, FL: CRC Press.
39. Gordon JE, Bruneau PMC, Brazier V. 2014 Valuing the soil: connecting land, people, and nature in Scotland. In *The soil underfoot, infinite possibilities for a finite resource* (eds GC Churchman, ER Landa), pp. 337–350. Boca Raton, FL: CRC Press.
40. Shi Q. 2006 The impact of tourism on soils in Zhangjiajie World Geopark. *J. Forestry Res.* **17**, 167–170. (doi:10.1007/s11676-006-0040-2)
41. Kaplan R, Kaplan S. 1989 *The experience of nature: a psychological perspective*. Cambridge, UK: Cambridge University Press.
42. Hansen MM, Jones R, Tocchini K. 2017 Shinrin-Yoku (forest bathing) and nature therapy: a state-of-the-art review. *Int. J. Environ. Res. Public Health* **14**, 851. (doi:10.3390/ijerph14080851)
43. Conn SA. 1998 Living in the earth: ecopsychology, health and psychotherapy. *Hum. Psychol.* **26**, 179–198. (doi:10.1080/08873267.1998.9976972)
44. Soga M, Cox DTC, Yamaura Y, Gaston KJ, Kurisu K, Hanaki K. 2017 Health benefits of urban allotment gardening: improved physical and psychological well-being and social integration. *Int. J. Environ. Res. Public Health* **14**, 71. (doi:10.3390/ijerph14010071)
45. Waliczek TM, Lineberger RD, Zajicek JM, Bradley JC. 2000 Using a web-based survey to research the benefits of children gardening. *HortTechnology* **10**, 71–76. (doi:10.21273/horttech.10.1.71)
46. Abrahams PW. 2010 'Earth eaters': ancient and modern perspectives on human geophagy. In *Soil and culture* (eds E Landa, C Feller), pp. 369–398. Dordrecht, The Netherlands: Springer.
47. Fairhead JA. 2016 Termites, mud daubers and their earths: a multispecies approach to fertility and power in West Africa. *Conserv. Soc.* **14**, 359–367. (doi:10.4103/0972-4923.197613)
48. Montgomery D. 2007 *Dirt: The erosion of civilizations*. Berkeley, CA: University of California Press.
49. Minami K. 2009 Soil and humanity: culture, civilization, livelihood and health. *Soil Sci. Plant Nutr.* **55**, 603–615. (doi:10.1111/j.1747-0765.2009.00401.x)
50. Xiaotong F. 1992 *From the soil: the foundations of Chinese society (A translation of Fei Xiaotong's Xiangtu Zhongguo)*. Berkeley, CA: University of California Press.
51. Kiernan B. 2007 *Blood and soil: a world history of genocide and extermination from Sparta to Darfur*. New Haven, CT: Yale University Press.
52. Fearon JD, Laitin DD. 2011 Sons of the soil, migrants, and civil war. *World Dev.* **39**, 199–211. (doi:10.1016/j.worlddev.2009.11.031)
53. Leopold A. 1949 *A sand county almanac*. Oxford, UK: Oxford University Press.
54. Allen KE, Quinn CE, English C, Quinn JE. 2018 Relational values in agroecosystem governance. *Curr. Opin. Environ. Sustain.* **35**, 108–115. (doi:10.1016/j.cosust.2018.10.026)
55. Wahlhütter S, Vogl CR, Eberhart H. 2016 Soil as a key criteria in the construction of farmers' identities: the example of farming in the Austrian province of Burgenland. *Geoderma* **269**, 39–53. (doi:10.1016/j.geoderma.2015.12.028)
56. Schneider F, Ledermann T, Fry P, Rist S. 2010 Soil conservation in Swiss agriculture—approaching abstract and symbolic meanings in farmers' life-worlds. *Land Use Policy* **27**, 332–339. (doi:10.1016/j.landusepol.2009.04.007)
57. McBratney A, Field DJ, Koch A. 2014 The dimensions of soil security. *Geoderma* **213**, 203–213. (doi:10.1016/j.geoderma.2013.08.013)
58. Braito M, Leonhardt H, Penker M, Schauppenlehner-Kloyber E, Thaler G, Flint CG. 2020 The plurality of farmers' views on soil management calls for a policy mix. *Land Use Policy* **99**, 104876. (doi:10.1016/j.landusepol.2020.104876)
59. Wells BL, Gradwell S. 2001 Gender and resource management: community supported agriculture as caring-practice. *Agric. Hum. Values* **18**, 107–119. (doi:10.1023/a:1007686617087)
60. Schroeder RA. 1999 *Shady practices: agroforestry and gender politics in the Gambia*. Berkeley, CA: University of California Press.
61. Mauro E-D. 2003 Disaggregating local knowledge: the effects of gendered farming practices on soil fertility and soil reaction in SW Hungary. *Geoderma* **111**, 503–520. (doi:10.1016/S0016-7061(02)00279-3)
62. Frausin V, Fraser JA, Narmah W, Lahai MK, Winnebah TRA, Fairhead JA, Leach M. 2014 'God made the soil, but we made it fertile': gender, knowledge, and practice in the formation and use of African dark earths in Liberia and Sierra Leone. *Hum. Ecol.* **42**, 695–710. (doi:10.1007/s10745-014-9686-0)
63. Vaughan K, Miegroet HV, Pennino A, Pressler Y, Duball C, Brevik EC, Berhe AA, Olson C. 2019 Women in soil science: growing participation, emerging gaps, and the opportunities for advancement in the USA. *Soil Sci. Soc. Am. J.* **83**, 1278–1289. (doi:10.2136/sssaj2019.03.0085)

64. Carney J. 1991 Indigenous soil and water management in Senegambian rice farming systems. *Agric. Hum. Values* **8**, 37–48. (doi:10.1007/bf01579655)
65. Carney JA. 1998 Women's land rights in Gambian irrigated rice schemes: constraints and opportunities. *Agric. Human Values* **15**, 325–336. (doi:10.1023/a:1007580801416)
66. Winiwarter V, Blum WEH. 2006 Souls and soils: a survey of worldviews. In *Footprints in the soil: people and ideas in soil history* (ed. BP Warkentin), pp. 107–122. New York: NY: Elsevier.
67. Peng X. 2014 Integrative development between soil science and Confucius' philosophy. In *The soil underfoot: infinite possibilities for a finite resource* (eds GC Churchman, ER Landa), pp. 127–134. Boca Raton, FL: CRC Press.
68. Bloch L. 2020 Animate earth, settler ruins: mound landscapes and decolonial futures in the native South. *Cult. Anthropol.* **35**, 516–545. (doi:10.14506/ca35.4.02)
69. Showers K. 2006 A history of African soil: perceptions, use and abuse. In *Soils and societies: perspectives on environmental history* (eds JR McNeill, V Winiwarter), pp. 118–176. Cambridge, UK: The White Horse Press.
70. Kim BF, Poulsen MN, Margulies JD, Dix KL, Palmer AM, Nachman KE. 2014 Urban community gardeners' knowledge and perceptions of soil contaminant risks. *PLoS ONE* **9**, e87913. (doi:10.1371/journal.pone.0087913)
71. Sant LV. 2018 'The long-time requirements of the nation': the US Cooperative Soil Survey and the political ecologies of improvement. *Antipode* **53**, 686–704. (doi:10.1111/anti.12460)
72. Shiva V. 2015 *Soil not oil: environmental justice in an age of climate crisis*. Berkeley, CA: North Atlantic Books.
73. Mauro SE-D. 2014 *Ecology, soils, and the left: an ecosocial approach*. New York, NY: Palgrave McMillian.
74. Leach M, Fairhead JA, Fraser J. 2012 Green grabs and biochar: revaluing African soils and farming in the new carbon economy. *J. Peasant Stud.* **39**, 285–307. (doi:10.1080/03066150.2012.658042)
75. Andersson E, Brogaard S, Olsson L. 2011 The political ecology of land degradation. *Ann. Rev. Environ. Resour.* **36**, 295–319. (doi:10.1146/annurev-environ-033110-092827)
76. Blaikie PM. 1985 *The political economy of soil erosion in developing countries*. New York, NY: Longman.
77. Showers K. 2005 *Imperial gullies: soil erosion and conservation in Lesotho*. Athens, OH: Ohio University Press.
78. Forsyth TJ. 1996 Science, myth and knowledge: testing Himalayan environmental degradation in Thailand. *Geoforum* **27**, 375–392. (doi:10.1016/S0016-7185(96)00020-6)
79. Denes A, Lal R, Toland AR. 2019 Urban farming: the new green revolution? In *Field to palette: dialogues on soil and art in the anthropocene* (eds A Toland, JS Noller, G Wessolek), pp. 5–18. Boca Raton, FL: CRC Press.
80. Lyver PO, Timoti P, Gormley AM, Jones CJ, Richardson SJ, Tahi BL, Greenhalgh S. 2017 Key Māori values strengthen the mapping of forest ecosystem services. *Ecosyst. Serv.* **27**, 92–102. (doi:10.1016/j.ecoser.2017.08.009)
81. Amberson S, Biedenweg K, James J, Christie P. 2016 'The heartbeat of our people': identifying and measuring how salmon influences Quinault tribal well-being. *Soc. Nat. Resour.* **29**, 1389–1404. (doi:10.1080/08941920.2016.1180727)
82. Bouma J, McBratney A. 2013 Framing soils as an actor when dealing with wicked environmental problems. *Geoderma* **200–201**, 130–139. (doi:10.1016/j.geoderma.2013.02.011)
83. Baveye PC, Baveye J, Gowdy J. 2016 Soil 'ecosystem' services and natural capital: critical appraisal of research on uncertain ground. *Front. Environ. Sci.* **4**, 41. (doi:10.3389/fenvs.2016.00041)
84. González NC, Kröger M. 2020 The potential of Amazon indigenous agroforestry practices and ontologies for rethinking global forest governance. *Forest Policy Econ.* **118**, 102257. (doi:10.1016/j.forpol.2020.102257)
85. Cheik S, Jouquet P. 2020 Integrating local knowledge into soil science to improve soil fertility. *Soil Use Manage.* **36**, 561–564. (doi:10.1111/sum.12656)
86. Barrera-Bassols N, Zinck JA. 2003 Ethnopedology: a worldwide view on the soil knowledge of local people. *Geoderma* **111**, 171–195. (doi:10.1016/S0016-7061(02)00263-X)
87. Sandor J, WinklerPrins AMGA, Barrera-Bassols N, Zinck JA. 2006 The heritage of soil knowledge among the world's cultures. In *Footprints in the soil: people and ideas in soil history* (eds BP Warkentin), pp. 43–83. Amsterdam, The Netherlands: Elsevier.
88. Latour B. 1992 Circulating reference: sampling the soil in an Amazon rainforest. In *Pandora's hope: essays on the reality of science studies*. Cambridge, UK: Harvard University Press.
89. Lyons KM. 2014 Soil science, development, and the 'elusive nature' of Colombia's Amazonian plains. *J. Latin Am. Caribbean Anthropol.* **19**, 212–236. (doi:10.1111/jlca.12097)
90. Counihan C, Tironi M, Kearnes M, Krzywoszynska A, Granjou C, Salazar JF. 2020 Thinking with soils. In *Thinking with soils: material politics and social theory* (eds JF Salazar, C Granjou, M Kearnes, A Krzywoszynska, M Tironi), pp. 1–14. London, UK: Bloomsbury.
91. de la Bellacasa MP. 2015 Making time for soil: technoscientific futurity and the pace of care. *Soc. Stud. Sci.* **45**, 691–716. (doi:10.1177/0306312715599851)
92. Krzywoszynska A. 2019 Caring for soil life in the Anthropocene: the role of attentiveness in more-than-human ethics. *Trans. Inst. Br. Geogr.* **44**, 661–675. (doi:10.1111/tran.12293)
93. Ingram J *et al.* 2016 Communicating soil carbon science to farmers: incorporating credibility, salience and legitimacy. *J. Rural Stud.* **48**, 115–128. (doi:10.1016/j.jrurstud.2016.10.005)
94. O'Brien AT. 2020 Ethical acknowledgment of soil ecosystem integrity amid agricultural production in Australia. *Environ. Hum.* **12**, 267–284. (doi:10.1215/22011919-8142341)
95. European Commission. 2006 Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Thematic Strategy for Soil Protection, COM 231 Final. Brussels, Belgium: Commission of the European Communities. See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52006DC0231.
96. Krzywoszynska A, Marchesi G. 2020 Toward a relational materiality of soils. *Environ. Humanities* **12**, 190–204. (doi:10.1215/22011919-8142297)
97. de la Bellacasa MP. 2020 Forward. In *Thinking with soils: material politics and social theory* (eds JF Salazar, C Granjou, M Kearnes, A Krzywoszynska, M Tironi), pp. 12–15. London, UK: Bloomsbury Academic.
98. Country B *et al.* 2016 Co-becoming Bawaka: towards a relational understanding of place/space. *Prog. Hum. Geogr.* **40**, 455–475. (doi:10.1177/0309132515589437)
99. Kawa N. 2016 *Amazonia in the Anthropocene: people, soils, plants, forests*. Austin, TX: University of Texas Press.
100. Lal R. 2019 Rights-of-soil. *J. Soil Water Conserv.* **74**, 81A–86A. (doi:10.2489/jswc.74.4.81a)