Check for updates

European Journal of Soil Science

WILEY

European Journal of Soil Science

OPINION OPEN ACCESS

The Language of Soil: Learning the Lessons From Climate Change

Karolina Trdlicova[1] | Roy Neilson[2]

[1]Department of Social, Economic and Geographical Sciences, The James Hutton Institute, Craigiebuckler, UK | [2]Department of Ecological Sciences, The James Hutton Institute, Dundee, UK

Correspondence: Karolina Trdlicova (karolina.trdlicova@hutton.ac.uk)

Received: 23 June 2025 | **Revised:** 20 August 2025 | **Accepted:** 21 August 2025

Funding: This work was supported by Horizon Europe Mission Soil (101112869), UKRI (10068004) and the Scottish Government Rural and Environment Science and Analytical Services Division (KJHI-D3-1).

Keywords: climate communication | soil communication | soil ecology | soil education | soil health | soil literacy | soil monitoring

ABSTRACT

The issues of both soil health and climate change can be characterised as a so called 'wicked problem'. We adopt this shared characteristic as a rationale for applying lessons from climate change communications to suggest an appropriate 'language of soil' that should be deployed to effectively communicate the pertinent issue(s) of soil health. Using six recognised examples of climate change communication pitfalls, we illustrate why inciting a sense of dread around soil and why setting 'soil health' deadlines are not helpful strategies to promote positive action on soils. We also discuss the value-action gap and the way in which it applies to soil communication and why it is important to avoid the 'trap' of the knowledge deficit model. Finally, we stress the importance of communicating actions rather than knowledge as well as the importance of 'credible' soil health communicators.

1 | Introduction

> *Language is like soil. However rich, it is subject to erosion, and its fertility is constantly threatened by uses that exhaust its vitality. It needs constant re-invigoration if it is not to become arid and sterile.*
> Elizabeth Drew, author, critic (1887–1965)

Soil is a multifunctional fundamental building block of life (Creamer et al. 2022) that due to its slow formation is considered a non-renewable resource. Nevertheless, anthropogenic mediated activities such as intensive use of agricultural soils (Powlson et al. 2011) and increased urbanisation (Prăvălie et al. 2024) coupled with a changing climate (IPCC 2023) have resulted in degraded soils globally (Winowiecki et al. 2025), biodiversity loss (Guerra et al. 2021) and reduced soil organic matter (De Rosa et al. 2024). As a result, several calls to action highlighting the importance of soil have been made (Banwart 2011; Minasny et al. 2017), although arguably the pace of change to ameliorate negative impacts on soil has been extremely slow. Moreover, it is recognised that soil has a key role across all planetary boundaries (Kopittke et al. 2021), the importance of such has engendered calls for soils or more specifically, soil degradation, to be included within the planetary boundary framework (Kraamwinkel et al. 2021). Here we explore whether the language and vocabulary used regarding soil health, that is, the capacity of soil to function as a vital living ecosystem that sustains plants, animals and society, should be reflected upon to enhance future societal action to protect global soils and draw from learnings of climate change communication.

Climate change and soil health can be characterised as so called 'wicked problems,' that is, problems which cannot be solved but

Karolina Trdlicova and Roy Neilson shared first authors.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2025 The Author(s). *European Journal of Soil Science* published by John Wiley & Sons Ltd on behalf of British Society of Soil Science.

Summary

- Effective communication is needed to effect positive societal action for soil protection.
- Soil health communication should avoid messages of hopelessness and not focus on tipping points.
- Communicators should be mindful of the value–action gap and not invoke the knowledge deficit model.
- Soil health communicators should exhibit caution in their use of language and consider nuance.

can only be continually addressed and re-addressed (Asayama et al. 2019). The re-visiting of these 'wicked' problems necessitates a continuous effort to communicate their importance and the consequences of failing to adequately address them to diverse audiences. We argue that this shared 'wicked' characteristic provides a solid rationale for comparing the ways in which both climate change and soil health are communicated. It is widely accepted that soil health is impacted by climate change; thus, one could argue that the same issue is being communicated. However, as there are efforts to communicate the importance of soil using a soil literacy approach (e.g., Johnson et al. 2020; Johnson et al. 2023; Lundström et al. 2025; Morillas et al. 2025), there is merit to consider climate change and soil health communication as distinct.

There is not a universally agreed definition of soil literacy (Katikas et al. 2024) as it is closely tied to the concept of soil health which, notwithstanding the EU Mission Soil definition of soil health (Veerman et al. 2020), has several definitions and theoretical constructs (Harris et al. 2022). However, soil literacy has been loosely considered as a popular awareness about the importance of soil, and the acquisition of practical knowledge of how to achieve good soil health (European Commission Directorate-General for Environment 2021). This ambiguity over terminology provides opportunity for new definitions to emerge and for these definitions to be potentially narrow and ineffective. Based on examples from climate change communication literature, we focus on six aspects of communication (Figure 1) that highlight the way in which we can use the climate change communication experience as a guide to shape a future soil literacy approach.

We initially focus on the issue of 'doomism' or 'climate despair' and question whether an in-depth knowledge about the state of the climate or indeed the state of soil health is desirable, especially when it could lead to feelings of despair or hopelessness, which do not lead to desired behavioural change or action. Thereafter, we consider the issue of communicating 'tipping points' or setting climate or soil health 'deadlines' and discuss their effectiveness as a communication tool and whether they should be a part of a soil literacy approach. Moreover, we discuss the value-action gap and reflect on whether using soil literacy as a tool to change societal values around soil is sufficient and build on the literature around climate change which suggests otherwise. We outline the knowledge-deficit model and why it is likely an ineffective tool in science communication and argue that the sole aim of increasing knowledge is an insufficient soil health communication strategy. We also discuss the importance of communicating the 'right actions' as opposed to the 'right knowledge' and finally stress the importance of credible soil health communicators.

FIGURE 1 | An outline of the six aspects of soil communication with examples of best practice (in blue) and poor practice (in yellow).

13652389, 2025, 5, Downloaded from https://bssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

1.1 | Dreading the State of the Soil

One of the issues that climate change communicators have had to contend with is that, sometimes, acquiring knowledge of climate change does not deliver the desired outcome of inspiring positive action (e.g., Naustdalslid 2011; O'Brien 2013; Hengst-Ehrhart 2019; Colombo et al. 2023). Rather, it can inspire feelings of despair or to feelings of existential dread (Wray 2023). There are those, referred to as 'doomists' (Johnstone and Stickles 2024), who believe that the planet is condemned and there is nothing that can be done to mitigate climate change or lessen the consequences of global warming (McManus 2023). This is also closely related to the feeling of 'climate hopelessness' that considers climate change as an insurmountable problem with futile response options (Frumkin 2022). It is therefore incumbent upon the global soil community to reflect upon whether positive messages are being communicated to incite action to protect soils and mitigate the impacts of anthropogenic activities. There is also a tendency to communicate the issues of climate change, and more recently soil health, in a way that accurately depicts the importance and urgency by adding a negative emotion to the messaging, such as '*we should all be worried*' (Bloodhart et al. 2019). However, communicating with negative emotions does not hinder a change in behaviour, but it does not promote it either (Bloodhart et al. 2019). Such a communication strategy may be effective with certain groups, that is, groups that already feel negatively about climate change or soil health, which matches their emotions. However, those who already have a perception of climate change or poor soil health as something negative are also most likely not the target groups for those communication efforts.

There are those who neither perceive climate change nor soil health as 'issues' nor have associated negative feelings. Such a demographic mostly prefers messages without an emotional undertone (Bloodhart et al. 2019) that focus on being 'factual' as opposed to 'negative'. Thus, when communicating soil health, the deliberate intention or inadvertent nuance of inciting negative emotions should be avoided, even though it may be appropriate given the state of soils.

Thus, both the negative feelings of dread and of impending doom are not conducive to effecting positive action. Although, some (e.g., Nguyen 2025) argue that whilst the feeling of despair is not conducive to action, it is an appropriate reaction to learning about climate change (or soil health) and is proportional to the lack of agency that individuals have to fight either the structural issue of the climate crisis or global soil degradation. However, there is considerable agreement that inciting feelings of dread should be avoided where possible (e.g., Weintrobe 2012; Hathaway 2017; Sandberg 2024). A strategy to mitigate feelings of despair is to focus on communicating either solutions or direct actions (Baudon and Jachens 2021; Nutkiewicz et al. 2023). Applying these learnings to how soil health is communicated is therefore key when engaging in mapping the state of soil and then communicating these findings with the hope of inciting soil protection among stakeholders including the public. Moreover, such nuanced and careful communication should be done in tandem with the provision of specific actions to improve soil health (Raupp et al. 2024; Burdun et al. 2025), avoiding the trap of dread induced action paralysis.

The ABC of Soil Literacy (Johnson et al. 2020) notes that the awareness of the multifunctionality of soil and raising awareness that it is a non-renewable resource can lead to environmentally conscious behaviours that, for example, improve soil health or prevent soil erosion. However, the extent to which knowledge gained of how soils function can effect change is questionable, as there is little or no support from climate change communication that suggests knowledge acquisition and increasing awareness results in positive action (e.g., Naustdalslid 2011; Hengst-Ehrhart 2019; Colombo et al. 2023). It is therefore reasonable to assume that increasing awareness of, for example, soil erosion, soil degradation and soil contamination has potential to incite similar feelings of helplessness with concomitant inaction. Johnson et al. (2020) further suggests that the greatest gap in soil literacy is the connection to the knowledge of different soil competencies. However, this could be overcome by soil competencies being taught in both secondary and tertiary education using well-established knowledge transfer infrastructures (Johnson et al. 2020). Yet, in an UK context, the most recent review of skills needed in the environment sector (NERC 2012) highlighted skills associated with communicating uncertainty and soil science as lacking, the latter exacerbated by so few University degrees offering teaching in soils. More widely, there is a conscious effort to enhance soil literacy and soil education through actions supported by, for example, the EU Mission Soil, the European Soil Data Centre, UN-FAO and the International Union of Soil Sciences.

1.2 | Dangerous Deadlines

One of the adopted strategies to communicate the urgency for the need to tackle climate change has been to stress the nearing time scales, that is, 'climate deadlines' or climate tipping points, in other words specific points in the future that signify a development or a stage in climate breakdown. However, the extent to which this has been an effective communication strategy has been questioned (Asayama 2021).

Asayama et al. (2019) highlights the focus on the common (mis-)interpretation of the 2018 IPCC Special Report that an increase in global warming of 1.5°C resulted in 'only 12 years left' to stop climate change. Those authors asserted that this (mis-)interpretation was firstly not accurate, and secondly not helpful. Furthermore, Asayama et al. (2019) argue that this was not a good climate change communication strategy though the intention may have been to stress the urgency of the situation to mobilise action. Thus, deploying a similar strategy in soil health communication would arguably be equally as unhelpful. Whilst there has not been significant effort to try to quantify the 'deadline for saving soil' there have been some reports, that for example have tried to calculate and communicate how many 'harvests are left' (Ritchie 2021), as well as reports which try to establish soil 'tipping points' (Nikolaidis 2011; Crawford et al. 2024).

Asayama et al. (2019) suggest the setting of such deadlines does not lead to the desired outcome of an increased urgency resulting in positive action. This is for several reasons. In our daily lives, we often seek extensions to deadlines, therefore setting a

13652389, 2025, 5, Downloaded from https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

climate or soil health deadline might seem as something that is negotiable. Sometimes, negative emission technologies are discussed as technologies which could buy more time or even 'reverse the clock.' It is hard to think of an equivalent, which could 'reverse time' when it comes to soil health, erosion or degradation. Kopp et al. (2025) suggest that focusing on 'tipping points' is ineffective, in that they distract from urgent climate actions as opposed to incite it. Broadly, recent literature (e.g., McHugh et al. 2021; Patterson et al. 2021; Kopp et al. 2025) when considering the language of the climate 'emergency' call for more nuance as to how and in which context language should be used. We believe that such findings are of equal importance regarding the language of soil.

Finally, inappropriate deadline setting could result in widespread cynicism and undermine the scientific community (Asayama et al. 2019), as setting such deadlines creates an illusion of a 'cliff-edge'. Therefore, trying to establish or set any kind of soil health 'deadline' is not a productive communication strategy, as protecting or maintaining soil is not as simplistic as 'just' meeting a deadline. Soil literacy, we therefore suggest should not include the communication of soil 'tipping points' or suggest that there is a deadline by which soil health should be achieved.

1.3 | The Value-Action Gap

'*Thus, it is not a shortage of rational argument derived from the annals of philosophical ethics that is the root of insufficient action regarding the need to immediately begin the process of minimizing anthropogenically caused climate change. The sources of inadequate action must be sought elsewhere*' (Kretz 2013).

Katikas et al. (2024) note that connecting soil literacy to societal values, interest and concerns is key and should be pursued as part of efforts to increase soil literacy. Societal interests that drive change can be several. In the first instance, they can be economic, in that poor global soil health often coupled with a changing climate can affect food supply and prices. Moreover, soil is an irreplaceable part of our many valued green spaces, which benefits society both economically as well as holistically and through other intangible co-benefits such as improved mental and physical health and overall wellbeing (Callaghan et al. 2021).

Whilst focusing on changing societal values around soil may be a sufficiently robust strategy to elicit behaviour conducive to maintaining good soil health, climate change communication literature often focuses on the so called 'value-action' gap that typically results in inaction or less than favourable outcomes. One of the challenges of effectively communicating climate change with the aim to incite action, is to find a way to overcome this 'value-action' gap (Kollmuss and Agyeman 2002), which is also referred to as the 'attitude-behaviour' gap or 'intention-behaviour' gap (Sheeran 2002). This is the recognised gap or discrepancy between societal values and actions, in other words, even those who care about the environment and have expressed concern about climate change do not take action to protect the environment or mitigate climate change. This is because an individual's environmental knowledge is also influenced by different factors, including cognitive, affective, and cultural factors which in turn feed into how they make sense of climate information and how motivated they are to act based on this information.

This gap between caring, knowing and acting, is not unique to climate change, thus, it is reasonable to assume that similar challenges will occur when trying to incite positive action on soil by increasing soil literacy. The basic purpose of communication effort is to achieve some type and level of social engagement and action. However, Whitmarsh (2008) and Whitmarsh et al. (2021) both highlighted the gap between public communication and the lack of observable behavioural change, and Steg (2023) demonstrated that interventional campaigns on climate change targeted to the public only produced at best, modest behavioural change.

Although there is a need to further educate and therefore in general increase scientific (or soil) literacy, it is too simplistic to argue that it is solely a lack of education, or insufficient information or understanding (Moser and Dilling 2011) of climate change or soil health that is a barrier to positive action. It is also too simplistic to assume that if these gaps were filled and higher education levels attained, that this will lead to an automatic change in behaviour with a concomitant increase in soil health. Previous communication campaigns assumed that simply informing and educating people about climate change would suffice to change beliefs and attitudes, which in turn would mobilise audiences for action. However, the apparent disconnect between societal concerns and attitudes about climate change (e.g., Bouman et al. 2021; Whitmarsh et al. 2021; Franco and Ghisetti 2022) and the extent of their climate-mitigating behaviour, the so-called 'attitude behaviour gap', contradicts this assumption.

1.4 | Soil Literacy and the Trap of the Knowledge Deficit

Katikas et al. (2024) established that the lack of a consistent understanding of soil leads to difficulties in defining soil health and ultimately what it means to be soil literate, and by extension, what it is to either be soil illiterate or be lacking in sufficient soil knowledge. This knowledge deficit approach (Simis et al. 2016) has been used frequently in climate change communication. Such an approach assumes that the gap associated with a concern for a particular (environmental) issue, such as soil health, between scientists and 'the public' stems from a deficit in knowledge. Moreover, the assumption extends to the belief that this gap can be simply bridged by knowledge transfer, and this new knowledge acquisition will ultimately lead to a convergence of minds resulting in behavioural change (Abunyewah et al. 2020). This linear model of knowledge transference leading to agreement and concomitant action (Grant 2023) has been criticised for its simplistic understanding of the relationship between scientists and the public (Simis et al. 2016), because it views the 'public' as a 'monolith' which lacks sufficient knowledge. Applying such a model much criticised in the climate change communication literature (McDivitt 2016) to soil is therefore problematic and should be avoided. However, it is not clear what knowledge should be transferred, because of a lack of a common vocabulary, and use of obtuse language as a

13652389, 2025, 5, Downloaded from https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

direct consequence of the varying definitions associated with soil such as soil health (Katikas et al. 2024). Moreover, different audiences have different perceptions and understandings of soils based on their existing connectedness. The way in which soils have come to be known, represented, and understood to a broad range of audiences is diverse thus, any 'deficit' is nuanced. Also, Pearce et al. (2015) suggest that the future challenge for communicating environmental issues is to effectively communicate both uncertainty and the severity of the issues at hand during times of relative stability.

Thus, if the scientific message is communicated in a simple enough language, it is assumed that the knowledge deficit gap can be bridged. However, in some respects, soil science has a lesser tendency to establish such a clear dichotomy between scientists and the 'public,' as there is extensive literature acknowledging the expert soil knowledge of certain audiences such as farmers who are seen as a distinct group from both scientists and the public (Kuria et al. 2019; Bagnall et al. 2020; Irvine et al. 2023).

1.5 | A Little Less Conversation, a Little More Action, Please

Ultimately, we challenge the assumption that we must first communicate the issue of soil health and establish a good baseline of understanding, before we can expect individuals to take positive soil action (De Meyer et al. 2020). Instead, we propose a focus on changing beliefs *through* action. Adopting the concept of fostering 'climate agency' (Verlie 2018; Toivonen 2022; Cunha et al. 2025) and translating to soil scenarios would support individuals in their personal understanding and belief regarding soils, enabling and empowering individuals to take positive action and in doing so develop 'soil agency'. This is supported by De Meyer et al. (2020) who noted that once involved in positive action, the values and beliefs of individuals change through self-persuasion. Also, those individuals who had persuaded themselves to take part in positive action are those most motivated to engage with environmental information (De Meyer et al. 2020). We can therefore assume that people who have engaged in positive action regarding soil health will also be more susceptible to accepting soil health information. However, it is unsafe to assume that increasing awareness, raising concerns, or even inciting fear of soil inaction are the necessary societal triggers for widespread action on soils. Thus, to increase soil literacy, wherever possible it is important to provide opportunities for positive soil health action. Such opportunity to take positive action could subsequently trigger the self-persuasive process of caring about soil, leading to acceptance of soils being societally important which in turn, results in increased soil literacy.

1.6 | Credible Messengers—Do as I Say Not as I Do

When communicating the issue of soil health, attention should be made to who the key communicators are and whether they display behaviours consistent with the messaging that they are communicating. Sparkman and Attari (2020) reported that in a climate change communication context, communicators are often judged if there is an inconsistency found between their climate change mitigation advocacy and their own behaviour and lifestyle. Thus, to be seen as a credible and trusted communicator on soils, advocates should display behaviours in their day-to-day lives consistent with their messaging (Sparkman and Attari 2020). However, there is reluctance to have overt and demonstrable climate positive behaviour among public servants and politicians for fear of negative reactions from the media, political rivals and certain public demographics (Westlake et al. 2024). Moreover, Goodwin and Dahlstrom (2014) suggest that only through making themselves 'vulnerable' by engaging and re-engaging with doubtful audiences do climate scientists gain trust. Here, we argue this also applies to soil scientists who must extend trust to all audiences to earn it, which in turn ultimately generates credibility and trusted voices on soils. Thus, only a trustworthy and credible messenger can convince doubtful members of society to take appropriate positive action on soils.

Furthermore, the tension between advocacy and objectiveness is a recognised barrier in early career researchers who wish to participate in scientific communication (van Eck 2023). This presents learned societies, (e.g., national soil societies) with an opportunity to support and empower the next generation of soil scientists by providing targeted *communication training* to deliver positive messages that seek to incite positive action for the protection and maintenance of soils in addition to the current, but nevertheless essential, more traditional training such as skills in soil classification.

2 | Conclusion

Here we consider the benefit of comparing how the complex and inter-related issues of soil health and climate change are communicated and identify where application of learnings from the latter to the former is important to maximise societal action on soils.

We conclude that communicating soil health or increasing soil literacy should go beyond efforts to simply increase knowledge but should rather aim to grow soil connectedness and aim to change societal values around soil. However, even a change in values around soil might not lead to a change in behaviour. The goal of soil health communication efforts should therefore be to incite positive behaviour that helps ensure the health of soil for future generations, which is a more complex endeavour than *'just'* increasing literacy, or indeed changing values. It is therefore an imperative to focus on who specifically the target audience is and who is communicating to them. We therefore urge individuals who are active in any aspect of soil communication to exhibit caution in their use of language and be fully cognisant of the intended action that their message seeks to convey.

Moreover, the definition of soil literacy must extend beyond knowledge acquisition; it should consider the value-action gap as well as being mindful that an in-depth literacy of a 'wicked' problem such as soil health needs to be communicated alongside solutions as not to incite feelings of despair with consequent inaction. Moreover, we also contend that a definition of soil literacy should encompass varying forms of knowledge and that

13652389, 2025, 5, Downloaded from https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

there may not be a single effective way to communicate soil health, and that one state of soil knowledge or soil literacy may not effectively be achieved. Furthermore, soil health communicators should not assume an implicit knowledge deficit across a range of audiences and be cognisant that based on climate change communication, establishing or promulgating perceived unattainable deadlines set by others results in societal inaction. This is pertinent given recent calls for soil protection to be subject to legal frameworks (Alblas et al. 2025).

We also argue for a more specific communication focus on soil health *action* and *behaviours* as opposed to current models of only seeking enhanced knowledge acquisition and suggest that focusing on action first can lead to an increase in soil literacy with subsequent knowledge gain.

Author Contributions

Karolina Trdlicova: conceptualization, writing – original draft, writing – review and editing, resources, methodology. **Roy Neilson:** conceptualization, writing – original draft, writing – review and editing, resources, funding acquisition, project administration.

Acknowledgements

Both authors received funding from the Horizon Europe Mission Soil project, *Engaging citizens in Soil Science: The Road to Healthier Soils* (GA. NO. 101112869), co-funded by UKRI (GA NO. 10068004). R.N. also received funding from the Scottish Government Rural and Environment Science and Analytical Services (RESAS) through *Healthy Soils for a Green Recovery* (KJHI-D3-1), as part of the 2022-2027 Strategic Research Programme.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

References

Abunyewah, M., T. Gajendran, K. Maund, and S. A. Okyere. 2020. "Strengthening the Information Deficit Model for Disaster Preparedness: Mediating and Moderating Effects of Community Participation." *International Journal of Disaster Risk Reduction* 46: 101492. https://doi.org/10.1016/j.ijdrr.2020.101492.

Alblas, E., A. Edlinger, J. Helfenstein, et al. 2025. "Bridging Law and Soil Science to Promote Soil Health." *European Journal of Soil Science* 76: e70127. https://doi.org/10.1111/ejss.70127.

Asayama, S. 2021. "Threshold, Budget and Deadline: Beyond the Discourse of Climate Scarcity and Control." *Climatic Change* 167: 33. https://doi.org/10.1007/s10584-021-03185-y.

Asayama, S., R. Bellamy, O. Geden, W. Pearce, and M. Hulme. 2019. "Why Setting a Climate Deadline Is Dangerous." *Nature Climate Change* 9: 570–572. https://doi.org/10.1038/s41558-019-0543-4.

Bagnall, D. K., W. A. McIntosh, C. L. Morgan, et al. 2020. "Farmers' Insights on Soil Health Indicators and Adoption." *Agrosystems, Geosciences & Environment* 3: e20066. https://doi.org/10.1002/agg2.20066.

Banwart, S. A. 2011. "Save Our Soils." *Nature* 474: 151–152.

Baudon, P., and L. Jachens. 2021. "A Scoping Review of Interventions for the Treatment of Eco-Anxiety." *International Journal of Environmental Research and Public Health* 18: 9636. https://doi.org/10.3390/ijerph18189636.

Bloodhart, B., J. K. Swim, and E. Dicicco. 2019. "Be Worried, Be Very Worried: Preferences for and Impacts of Negative Emotional Climate Change Communication." *Frontiers in Communication* 3: 63. https://doi.org/10.3389/fcomm.2018.00063.

Bouman, T., L. Steg, and G. Perlaviciute. 2021. "From Values to Climate Action." *Current Opinion in Psychology* 42: 102–107. https://doi.org/10.1016/j.copsyc.2021.04.010.

Burdun, I., M. Myllymäki, R. R. E. Artz, et al. 2025. "Satellite Data Archives Reveal Positive Effects of Peatland Restoration: Albedo and Temperature Begin to Resemble Those of Intact Peatlands." *Environmental Research Letters* 20: 084037.

Callaghan, A., G. McCombe, A. Harrold, et al. 2021. "The Impact of Green Spaces on Mental Health in Urban Settings: A Scoping Review." *Journal of Mental Health* 30: 179–193. https://doi.org/10.1080/09638237.2020.1755027.

Colombo, S. L., S. G. Chiarella, C. Lefrançois, J. Fradin, A. Raffone, and L. Simione. 2023. "Why Knowing About Climate Change Is Not Enough to Change: A Perspective Paper on the Factors Explaining the Environmental Knowledge-Action Gap." *Sustainability* 15: 14859. https://doi.org/10.3390/su152014859.

Crawford, J., A. Bacq-Labreuil, C. Hasan, et al. 2024. "Soil Is in a Self-Organised Critical State With a Tipping Point Driven by Carbon." *Research Square*. https://doi.org/10.21203/rs.3.rs-4631437/v1.

Creamer, R. E., J. M. Barel, G. Bongiorno, and M. J. Zwetsloot. 2022. "The Life of Soils: Integrating the Who and How of Multifunctionality." *Soil Biology & Biochemistry* 166: 108561. https://doi.org/10.1016/j.soilbio.2022.108561.

Cunha, J., J. Martins, J. C. Núñez, G. Vallejo, and P. Rosário. 2025. "Adolescents' Agency Toward Climate Change: Development and Validation of Scales for Individual, Proxy, and Collective Modes." *Frontiers in Psychology* 16: 1532409. https://doi.org/10.3389/fpsyg.2025.1532409.

De Meyer, K., E. Coren, M. McCaffrey, and C. Slean. 2020. "Transforming the Stories We Tell About Climate Change: From 'Issue' to 'Action'." *Environmental Research Letters* 16: 015002. https://doi.org/10.1088/1748-9326/abcd5a.

De Rosa, D., C. Ballabio, E. Lugato, M. Fasiolo, A. Jones, and P. Panagos. 2024. "Soil Organic Carbon Stocks in European Croplands and Grasslands: How Much Have We Lost in the Past Decade?" *Global Change Biology* 30: e16992. https://doi.org/10.1111/gcb.16992.

Franco, C., and C. Ghisetti. 2022. "What Shapes the "Value-Action" Gap? The Role of Time Perception Reconsidered." *Economia Politica* 39: 1023–1053. https://doi.org/10.1007/s40888-022-00282-8.

Frumkin, H. 2022. "Hope, Health, and the Climate Crisis." *Journal of Climate Change and Health* 5: 100115.

Goodwin, J., and M. F. Dahlstrom. 2014. "Communication Strategies for Earning Trust in Climate Change Debates." *WIREs Climate Change* 5: 151–160. https://doi.org/10.1002/wcc.262.

Grant, W. J. 2023. "The Knowledge Deficit Model and Science Communication." In *Oxford Research Encyclopedia of Communication*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190228613.013.1396.

Guerra, C. A., R. D. Bardgett, L. Caon, et al. 2021. "Tracking, Targeting, and Conserving Soil Biodiversity." *Science* 371: 239–241. https://doi.org/10.1126/science.abd7926.

Harris, J. A., D. L. Evans, and S. J. Mooney. 2022. "A New Theory for Soil Health." *European Journal of Soil Science* 73: e13292. https://doi.org/10.1111/ejss.13292.

13652389, 2025, 5, Downloaded from https://bssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Insitute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Hathaway, M. D. 2017. "Overcoming Fear, Denial, Myopia, and Paralysis." *Worldviews* 21: 2175–2193. https://doi.org/10.1163/15685357-02002100.

Hengst-Ehrhart, Y. 2019. "Knowing Is Not Enough: Exploring the Missing Link Between Climate Change Knowledge and Action of German Forest Owners and Managers." *Annals of Forest Science* 76: 94. https://doi.org/10.1007/s13595-019-0878-z.

IPCC. 2023. *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Core Writing Team, H. Lee, and J. Romero. IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647.

Irvine, R., M. Houser, S. T. Marquart-Pyatt, et al. 2023. "Soil Health Through Farmers' Eyes: Toward a Better Understanding of How Farmers View, Value, and Manage for Healthier Soils." *Journal of Soil and Water Conservation* 78: 82–92. https://doi.org/10.2489/jswc.2023.00058.

Johnson, K. L., D. Philip, and C. Engels. 2020. *The ABC of Soil Literacy-Evidence From Ghana, South Africa and Zimbabwe'. Project Report*. Durham University. https://dro.dur.ac.uk/31775/.

Johnson, K. L., W. Stone, L. Dominelli, et al. 2023. "Boosting Soil Literacy in Schools Can Help Improve Understanding of Soil/Human Health Linkages in Generation Z." *Frontiers in Environmental Science* 10: 1028839. https://doi.org/10.3389/fenvs.2022.1028839.

Johnstone, C., and E. Stickles. 2024. "Navigating the Climate Change Minefield: The Influence of Metaphor on Climate Doomism." *Frontiers in Communication* 9: 1380092. https://doi.org/10.3389/fcomm.2024.1380092.

Katikas, L., A. Krzywoszynska, K. Naciph Mora, and R. Roca Vallejo. 2024. "Preliminary Assessment of the Knowledge Gaps Related to Soil Literacy." *Soils for Europe* 1: e118883.

Kollmuss, A., and J. Agyeman. 2002. "Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-Environmental Behavior?" *Environmental Education Research* 8: 239–260.

Kopittke, P. M., N. W. Menzies, R. C. Dalal, et al. 2021. "The Role of Soil in Defining Planetary Boundaries and the Safe Operating Space for Humanity." *Environment International* 146: 106245.

Kopp, R. E., E. A. Gilmore, R. L. Shwom, et al. 2025. ""Tipping Points" Confuse and Can Distract From Urgent Climate Action." *Nature Climate Change* 15: 29–36. https://doi.org/10.1038/s41558-024-02196-8.

Kraamwinkel, C. T., A. Beaulieu, T. Dias, and R. A. Howison. 2021. "Planetary Limits to Soil Degradation." *Communications Earth & Environment* 2: 249.

Kretz, L. 2013. "Hope in Environmental Philosophy." *Journal of Agricultural and Environmental Ethics* 26: 925–944.

Kuria, A. W., E. Barrios, T. Pagella, C. W. Muthuri, A. Mukuralinda, and F. L. Sinclair. 2019. "Farmers' Knowledge of Soil Quality Indicators Along a Land Degradation Gradient in Rwanda." *Geoderma Regional* 16: e00199. https://doi.org/10.1016/j.geodrs.2018.e00199.

Lundström, C., E. Wärm, M. Caggiano, and M. Gallego. 2025. "Good Examples of Soil Education for Youth to Increase Soil Literacy." (Version 2). Zenodo. Report. https://doi.org/10.54612/a.2bqc5135bc.

McDivitt, P. 2016. *The Information Deficit Model Is Dead. Now What? Evaluating New Strategies for Communicating Anthropogenic Climate Change in the Context of Contemporary American Politics, Economy, and Culture*. University of Colorado at Boulder.

McHugh, L. H., M. C. Lemos, and T. H. Morrison. 2021. "Risk? Crisis? Emergency? Implications of the New Climate Emergency Framing for Governance and Policy." *WIREs Climate Change* 12: e736. https://doi.org/10.1002/wcc.736.

McManus, P. 2023. "Living With Anthropogenic Climate Change: Learning From Environmental History to Question Narratives of Doom, Hope, and Crisis." *Geographical Research* 61: 525–530.

Minasny, B., B. P. Malone, A. B. McBratney, et al. 2017. "Soil Carbon 4 per Mille." *Geoderma* 292: 59–86. https://doi.org/10.1016/j.geoderma.2017.01.002.

Morillas, L., J. Roales, and S. Munzi. 2025. "Cultivating Soil Literacy Through Citizen Science." In *Soil Ecology and Ecosystem Services*, edited by T. Dias, A. Bertolazi, A. Ramos, and C. Cruz, 377–394. Diálogo Comunicação e Marketing.

Moser, S. C., and L. Dilling. 2011. "Communicating Change Science." In *The Oxford Handbook of Climate Change and Society*, edited by J. Dryzek, R. B. Norgaard, and D. Schlosberg, vol. 161. Oxford University Press.

Naustdalslid, J. 2011. "Climate Change – The Challenge of Translating Scientific Knowledge Into Action." *International Journal of Sustainable Development and World Ecology* 18: 243–252. https://doi.org/10.1080/13504509.2011.572303.

NERC. 2012. Skills Review. https://webarchive.nationalarchives.gov.uk/ukgwa/20220214165229mp_/https://nerc.ukri.org/skills/postgrad/policy/skillsreview/2012/.

Nguyen, A.-Q. 2025. "In Defence of Despair About Climate Breakdown." In *The Philosophy of Environmental Emotions: Emotions: Grief, Hope, and Beyond*, edited by O. Beran, L. Candiotto, N. Forsberg, A. Fredriksson, and D. Rozen, 246–266. Routledge.

Nikolaidis, N. 2011. "Human Impacts on Soils: Tipping Points and Knowledge Gaps." *Applied Geochemistry* 26: S230–S233.

Nutkiewicz, L., A. Habib, M. Duenas, L. Ruiz, G. H. Anderson, and K. L'Engle. 2023. "Encouraging Youth Activism to Combat Climate Change and Reduce Eco-Anxiety." *International Public Health Journal* 15: 353–370.

O'Brien, K. 2013. "Global Environmental Change III: Closing the Gap Between Knowledge and Action." *Progress in Human Geography* 37: 587–596. https://doi.org/10.1177/0309132512469589.

Patterson, J., C. Wyborn, L. Westman, M. C. Brisbois, M. Milkoreit, and D. Jayaram. 2021. "The Political Effects of Emergency Frames in Sustainability." *Nature Sustainability* 4: 841–850. https://doi.org/10.1038/s41893-021-00749-9.

Pearce, W., B. Brown, B. Nerlich, and N. Koteyko. 2015. "Communicating Climate Change: Conduits, Content, and Consensus." *WIREs Climate Change* 6: 613–626. https://doi.org/10.1002/wcc.366.

Powlson, D. S., P. J. Gregory, W. R. Whalley, et al. 2011. "Soil Management in Relation to Sustainable Agriculture and Ecosystem Services." *Food Policy* 36: S72–S87. https://doi.org/10.1016/j.foodpol.2010.11.025.

Prăvălie, R., P. Borrelli, P. Panagos, et al. 2024. "A Unifying Modelling of Multiple Land Degradation Pathways in Europe." *Nature Communications* 15: 3862. https://doi.org/10.1038/s41467-024-48252-x.

Raupp, P., Y. Carrillo, and U. N. Nielsen. 2024. "Soil Health to Enhance Ecological Restoration and Conservation." *Journal of Sustainable Agriculture and Environment* 3: e70022.

Ritchie, H. 2021. "Do We Only Have 60 Harvests Left?" From *Our World in Data* [Preprint]. https://ourworldindata.org/soil-lifespans.

Sandberg, O. M. 2024. "The Gravity of Our Situation: On Acrophobia and Eco-Paralysis." In *Elemental-Embodied Thinking for a New Era*, edited by L. Škof, Sashinungla, and S. Thorgeirsdottir, 119–134. Springer International Publishing. https://doi.org/10.1007/978-3-031-42119-8_8.

Sheeran, P. 2002. "Intention—Behaviour Relations: A Conceptual and Empirical Review." *European Review of Social Psychology* 12: 1–36.

Simis, M. J., H. Madden, M. A. Cacciatore, and S. K. Yeo. 2016. "The Lure of Rationality: Why Does the Deficit Model Persist in Science Communication?" *Public Understanding of Science* 25: 400–414.

13652389, 2025, 5, Downloaded from https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Sparkman, G., and S. Z. Attari. 2020. "Credibility, Communication, and Climate Change: How Lifestyle Inconsistency and Do-Gooder Derogation Impact Decarbonization Advocacy." *Energy Research & Social Science* 59: 101290. https://doi.org/10.1016/j.erss.2019.101290.

Steg, L. 2023. "Psychology of Climate Change." *Annual Review of Psychology* 74: 391–421.

Toivonen, H. 2022. "Themes of Climate Change Agency: A Qualitative Study on How People Construct Agency in Relation to Climate Change." *Humanities and Social Sciences Communications* 9: 1–11. https://doi.org/10.1057/s41599-022-01111-w.

van Eck, C. W. 2023. "The Next Generation of Climate Scientists as Science Communicators." *Public Understanding of Science* 32: 969–984. https://doi.org/10.1177/09636625231176382.

Veerman, C., T. Pinto Correia, C. Bastioli, et al. 2020. *Caring for Soil Is Caring for Life – Ensure 75% of Soils Are Healthy by 2030 for Healthy Food, People, Nature and Climate – Interim Report of the Mission Board for Soil Health and Food*. Publications Office of the European Union. https://doi.org/10.2777/918775.

Verlie, B. 2018. "From Action to Intra-Action? Agency, Identity and "Goals" in a Relational Approach to Climate Change Education." *Environmental Education Research* 26: 1266–1280. https://doi.org/10.1080/13504622.2018.1497147.

Weintrobe, S. 2012. "The Difficult Problem of Anxiety in Thinking About Climate Change." In *Engaging With Climate Change: Psychoanalytic and Interdisciplinary Perspectives*, 33–47. Routledge.

Westlake, S., C. Demski, and N. Pidgeon. 2024. "We Can't Be Too Saintly: Why Members of Parliament in the United Kingdom Are Reluctant to Lead by Example With Low-Carbon Behaviour." *Energy Research & Social Science* 117: 103717. https://doi.org/10.1016/j.erss.2024.103717.

Whitmarsh, L. 2008. "Are Flood Victims More Concerned About Climate Change Than Other People? The Role of Direct Experience in Risk Perception and Behavioural Response." *Journal of Risk Research* 11: 351–374.

Whitmarsh, L., W. Poortinga, and S. Capstick. 2021. "Behaviour Change to Address Climate Change." *Current Opinion in Psychology* 42: 76–81. https://doi.org/10.1016/j.copsyc.2021.04.002.

Winowiecki, L. A., H. Linden, S. Alexander, et al. 2025. "Multistakeholder Engagement to Scale Soil Health Globally: The Coalition of Action 4 Soil Health." *European Journal of Soil Science* 76: e70128. https://doi.org/10.1111/ejss.70128.

Wray, B. 2023. *Generation Dread: Finding Purpose in an Age of Climate Anxiety*. Experiment.

13652389, 2025, 5, Downloaded from https://bsssjournals.onlinelibrary.wiley.com/doi/10.1111/ejss.70188 by James Hutton Institute, Wiley Online Library on [09/09/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License