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RESEARCH LETTER

Searching for soil: Elucidating public interest in soil and soil conservation from 20 years of internet search trends

Samuel W. Booth

School of Geography, University of Nottingham, Nottingham, UK

Correspondence
Samuel W. Booth, School of Geography, University of Nottingham, Nottingham, UK.
Email: sam.booth@nottingham.ac.uk

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Abstract

Over the last two decades, soil science research has undergone rapid expansion. Understanding public interest in soil science is vital for evaluating dissemination efforts and situating it in the broader environmental discourse. Analyzing Google Trends search data from 2004 to 2023, this study investigates spikes in search volume index (SVI) for soil-related searches and potential influences. Significant spikes in SVI between 2019–2020 and 2021–2022 were observed for a number of soil characteristics and soil conservation searches. Similar spikes were observed for possible influences such as the documentary "Kiss the ground," and SVI related to climate change and carbon sequestration. Notably, SVI for "sustainable development goals" aligned with similar patterns in SVI for "soil health," indicating a possible link between soil interest and the United Nations' sustainability goals. This study underscores the seemingly rising interest in soil science, possibly linked with dissemination events, and broader environmental concerns and policies.

1 | INTRODUCTION

Although specific research focuses may have changed over the decades (Hairiah et al., 2022; Rodrigo-Comino et al., 2020), soil science as a discipline has expanded greatly with increased recognition in policy. In particular, soil and soil processes contribute to a number of the United Nations' sustainable development goals (Lal et al., 2021). This increased recognition is reflected in the amount of research funding provided to soil science research, particularly in Europe, such as through the European Union's research and innovation funding (Arias-Navarro et al., 2023). Globally, dissemination has also increased, from 15,000 journal articles published in 2003 to 42,000 journal articles in 2018, an average annual increase of 1900 articles (Arias-Navarro et al., 2023).

A "soil literate" public can be a powerful force for soils inclusion in policy, so determining public interest in soil is vital (Cline et al., 2006; Johnson et al., 2023). At large scales, this interest is difficult to gauge. The use of the internet for information about nature and conservation is widespread (Fidino et al., 2018; Soriano-Redondo et al., 2017; Soulsbury, 2020), and so surveying soil-specific searches could indicate levels of public interest, possibly linked with successful dissemination efforts. Google Trends is an online tool that allows users to explore and analyze the popularity of search queries submitted to the search engine. It has been used in a number of publications to monitor public interest in nature-related topics (Correia & Mammola, 2023; Phillips et al., 2022; Soulsbury, 2020). This study aims to use Google Trends data to monitor public engagement and interest in a variety of soil/soil conservation topics, as well as a variety of potential influences of this. With a focus on year-on-year changes in interest for soil

Abbreviations: IPCC, Intergovernmental Panel on Climate Change; SVI, search volume index.

topics and their potential influences, this study will attempt to identify significant increases in public interest over the period of 2004–2023 through increased search volume index (SVI) scores and link this to specific dissemination events and/or policy initiatives that may be impacting this engagement.

2 | MATERIALS AND METHODS

2.1 | Internet search trends data collection

Search terms from Google Trends (data source: Google Trends [https://www.google.com/trends]) were analyzed worldwide from January 1, 2004, to December 31, 2023. Terms related to soil characteristics/processes ("soil," "soil carbon," "soil nitrogen," "soil water," "soil erosion," and "soil health"), soil conservation and practices ("soil conservation," "climate change and soil," "regenerative agriculture," "regenerative farming," and "tillage"), and more general climate/environmental searchers or dissemination events that may be potential influences on the interest in these terms ("carbon storage," "carbon sequestration," "climate change," "Kiss the ground," "Intergovernmental Panel on Climate Change (IPCC)," and "sustainable development goals") were searched for in English. Search terms were selected to be relevant combinations of words, reflect broad topics related to soil, in particular those that may be used in policy, documentaries, and other popular media resources, and consider how the general public may approach searching for soil-related information across demographics. The general public here refers to people without specialist knowledge gained from working in soil-related disciplines but may still possess good general knowledge of soil concepts and management. Google Trends data do not represent the total number of searches, but instead the search term's relative popularity compared to other searches within the defined geographic region and time frame. The number of searches for the term within the region/time is divided by the total number of searches within that same region/time, producing relative popularity. The resulting values are then scaled on a range of 0–100, with 100 being the search term with the highest relative popularity, and other values scaled to this. This produces an SVI value at that specific time point. At time scales greater than 5 years, SVI data are returned at a monthly scale.

2.2 | Statistical analysis

From the monthly SVI, yearly averages were produced for 2004–2023. Due to the non-normal distributions of data and interest in year-on-year differences, Kruskal–Wallis tests were conducted for the average yearly SVI of each search term, with year as the factor, and the Benjamini-Hochberg correction for multiple testing was applied to limit occurrences of false significance. Where significant results were returned, the Wilcoxon rank-sum test was conducted to determine the significant variance in relative search popularity between each individual year. All analyses were conducted in RStudio version "ocean storm" (RStudio Team, 2023).

Core Ideas

- Public interest in soil is vital for driving policy change, but gauging this is difficult.
- Google Trends data were used to monitor global searches for soil topics and influences during 2004–2023.
- Searches related to climate change, policy initiatives, and documentaries trended with soil topics.
- Interest in soil is linked to global challenges and influenced by seminal dissemination events.

3 | RESULTS

3.1 | Searches related to soil characteristics and processes

For search terms "soil," "soil carbon," "soil nitrogen," "soil water," "soil erosion," and "soil health," there is a significant difference in average annual SVI (Figure 1a) ("soil": $h = 152.33$, $df = 19$, $p < 0.001$; "soil carbon": $h = 123.51$, $df = 19$, $p < 0.001$; "soil nitrogen": $h = 140.73$, $df = 19$, $p < 0.001$; "soil water": $h = 161.54$, $df = 19$, $p < 0.001$; "soil erosion": $h = 175.53$, $df = 19$, $p < 0.001$; and "soil health": $h = 201.07$, $df = 19$, $p < 0.001$). Following post hoc analysis (p values < 0.05 indicated on Figure 1a by asterisk), there is a significant year-on-year increase in SVI between 2019 and 2020 for all these search terms apart from "soil health." For search terms "soil carbon," "soil water," "soil erosion," and "soil health," there is a significant year-on-year increase in SVI between 2021 and 2022. The SVI for "soil health" increased significantly year over year between 2013 and 2017.

3.2 | Searches related to soil conservation and practices

The average yearly SVI for searches related to soil conservation and related practices, "soil conservation," "climate change and soil," "regenerative agriculture," "regenerative farming," and "tillage," also varied significantly over the study period (Figure 1b) ("soil conservation": $h = 164.02$,

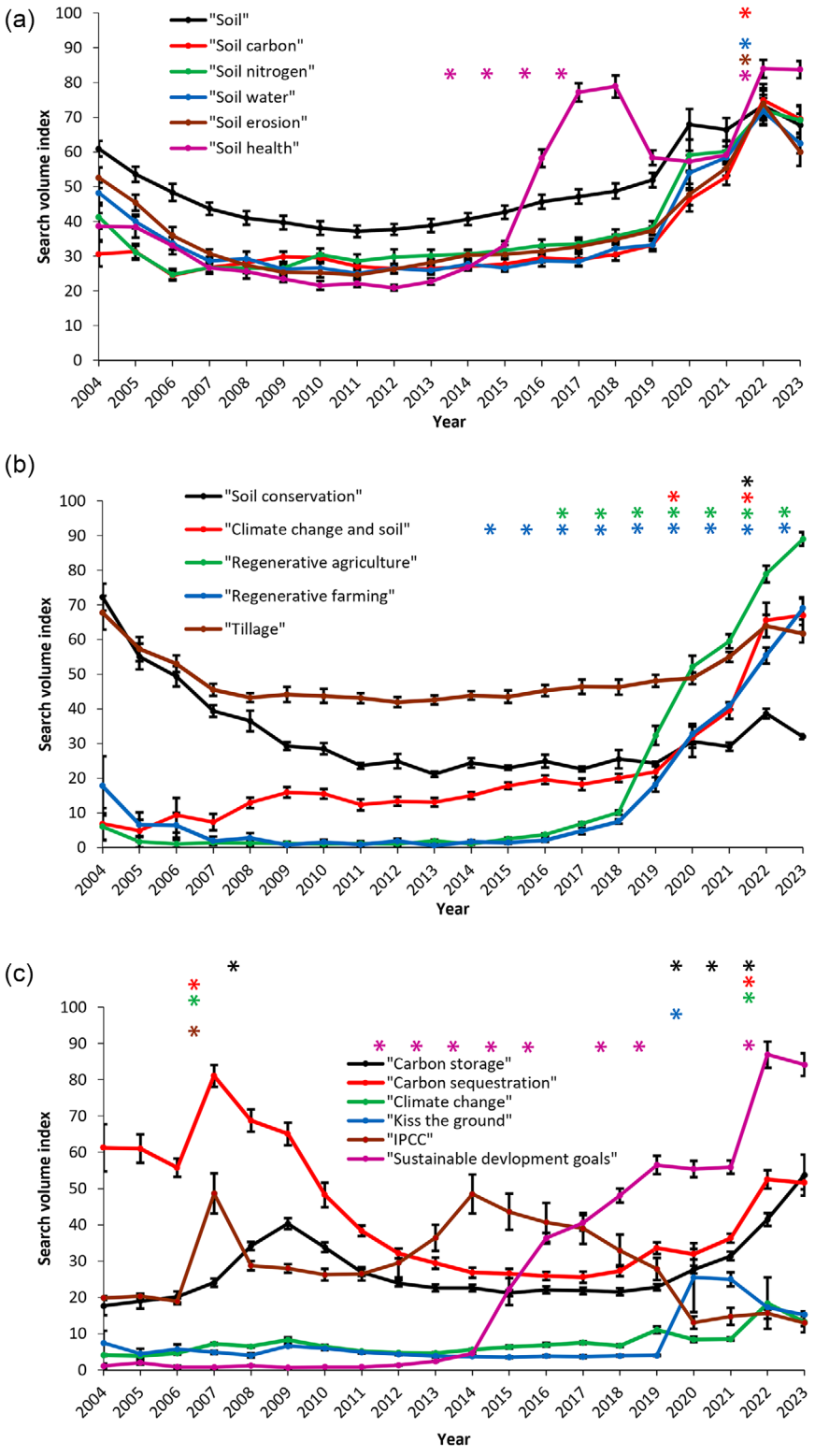

FIGURE 1 Yearly search volume index (SVI) ± 1SE, produced from monthly averages from Google Trends between 2004 and 2023 for the following search terms: (a) "soil," "soil carbon," "soil nitrogen," "soil water," "soil water," "soil erosion," and "soil health"; (b) "soil conservation," "climate change and soil," "regenerative agriculture," "regenerative farming," and "tillage"; and (c) "carbon storage," "carbon sequestration," "climate change," "Kiss the ground," "Intergovernmental Panel on Climate Change (IPCC)," and "sustainable development goals." Colored asterisk location indicates significant increase in SVI between those years for that search term (p values < 0.05 following post hoc analysis).

$df = 19$, $p < 0.001$; "climate change and soil": $h = 147.99$, $df = 19$, $p < 0.001$; "regenerative agriculture": $h = 192.39$, $df = 19$, $p < 0.001$; "regenerative farming": $h = 162.38$, $df = 19$, $p < 0.001$; and "tillage": $h = 99.681$, $df = 19$, $p < 0.001$). Following post hoc analysis (p values < 0.05 indicated on Figure 1b by asterisk), SVI for "regenerative agriculture" significantly increased year on year between 2016 and 2023. SVI for "regenerative farming" significantly increased year on year over a similar time period, between 2014 and 2023. "Climate change and soil" average SVI significantly increased year on year between 2019 and 2020, and between 2021 and 2022. "Soil conservation" average SVI only

significantly increased between 2021 and 2022. Searches for "Tillage" had no significant year-on-year increases in SVI.

3.3 | Searches related to potential influences on soil interest

For the search terms predicted to be potential influences impacting trends in soil and soil conservation interest, all significantly varied in SVI over the study period (Figure 1c) ("carbon sequestration": $h = 188.98$, $df = 19$, $p < 0.001$; "carbon storage": $h = 167.31$, $df = 19$, $p < 0.001$; "climate change": $h = 165.52$, $df = 19$, $p < 0.001$; "Kiss the ground": $h = 123.76$, $df = 19$, $p < 0.001$; "IPCC": $h = 154.69$, $df = 19$, $p < 0.001$; and "sustainable development goals": $h = 201.07$, $df = 19$, $p < 0.001$). Following post hoc analysis (p values < 0.05 indicated on Figure 1c by asterisk), average SVI for search terms "carbon sequestration," "climate change," and "IPCC" increased significantly between 2006 and 2007, with SVI for "carbon storage" significantly increasing between 2007 and 2008. SVI for "carbon storage" also significantly increased between 2019 and 2020, alongside searches for the documentary "Kiss the ground." 2020–2021 likewise saw SVI for "carbon storage" significantly increase. Average SVI significantly increased year on year between 2021 and 2022 for search terms "carbon sequestration," "carbon storage," and "climate change." Apart from between 2016 and 2017, a significant year-on-year increase in average SVI for search term "sustainable development goals" occurred each year between 2011 and 2019, followed by a significant increase again between 2021 and 2022.

4 | DISCUSSION

For terms "climate change and soil," "regenerative agriculture," and "regenerative farming" (Figure 1b), and in all soil characteristic search terms except for "soil health" (Figure 1a), there is a significant year-on-year increase in SVI and therefore interest between 2019 and 2020. The documentary "Kiss the ground" was released in September 2020 throughout much of the world, with a large focus on the contribution of soils to climate change mitigation through increased carbon sequestration from regenerative agriculture practices. Interest in "Kiss the ground" also significantly increased from 2019 and peaked in 2020 (Figure 1c), suggesting a possible link between viewership and increased interest in soil and soil conservation topics. Despite some criticisms of the documentary among researchers, owing predominantly to a lack of reference to specific studies and a possible overpromise of the ease of carbon sequestration increase (Carter, 2022; Paulson, 2021), it was widely praised by critics and audiences (Internet Movie Database, 2024; Rotten Tomatoes, 2024).

Similar to Kiss the ground, SVI for searches focused on "carbon storage" also significantly increased between 2019 and 2020 (Figure 1c) along with a similar trend in "climate change and soil" (Figure 1b). Specifically, when considering searches for "soil carbon," peaks in interest alongside wider climate and carbon storage suggest that soil carbon may be well linked with public understanding of wider climate change and climate change mitigation. Recent work suggests that a majority of people support promoting soil carbon storage as a mitigation method, up to 62%, behind only afforestation and reforestation at 73% (Sweet et al., 2021). Increase in SVI for these terms together as well as high support for mitigation strategies that involve soils, suggests that soil is likely a key component of the public conversation around climate change and its mitigation. There is also a significant increase in SVI's for searches related to climate change and carbon storage/carbon sequestration between 2021 and 2022, along with searches for "soil carbon," "soil water," "soil erosion," and "soil health" (Figure 1a) and all soil conservation and practices except for tillage (Figure 1b). This likewise may suggest that wider public interest in climate change and its mitigation is being well translated into interest in soils place in mitigation strategies. Public climate and carbon literacy are generally increasing (Howell, 2018; Whitmarsh et al., 2011), and so the increased interest in soils as part of this is expected and reflected in the recent significant increases in interest in soil-related topics.

The United Nations' sustainable development goals are a collection of 17 objectives designed to serve as a "shared blueprint for peace and prosperity for people and the planet, now and into the future." Published in 2015, these goals reflect the steps required to have a healthy, prosperous, and sustainable planet for all people and organisms (United Nations, 2015). Soils are intrinsically linked to many of these goals, and sustainable use of soils forms the basis of achieving many of these goals (Lal et al., 2021). "Soil health" has captured policymakers attention in terms of soil conservation, including its use in the sustainable development goals. This is despite disagreement among academics on what constitutes "healthy soil," owing to the unquantifiable nature of measuring the health of a complex system (Baveye, 2021; Harris et al., 2022). Regenerative agriculture/farming is practicing farming in a way that benefits the soil, preserving what is "healthy" and restoring what is degraded, such as through reduced tillage and lower fertilizer use (Sherwood & Uphoff, 2000).

With significantly increased interest in the sustainable development goals observed between 2021 and 2022, similar trends may be expected in searches for "soil health" and "regenerative agriculture/farming." These similar trends are observed (Figure 1a,b), suggesting a good association between the sustainable development goals and promoting soil health through healthy soil management. Focusing on

when the sustainable development goals were published in 2015, significant year-on-year increases in SVI occurred from 2014 to 2019. Similar trends were observed in interest for "soil health" across the same period. Other results similarly suggest wide and increasing public interest in the sustainable development goals since publication, with a stall in interest between 2019 and 2021 due to shifting public focus on the COVID-19 pandemic (Correia & Di Minin, 2023).

It is worth noting that Google searches rely heavily on artificial intelligence (AI), utilizing machine learning algorithms to understand user queries and deliver relevant results. Additionally, AI-powered features such as auto-complete enhance search efficiency by offering suggestions as users type their searches. How AI delivers results, gives suggestions, and autocompletes searches may have influenced increasing SVI over time, but it also potentially offers the opportunity for better tailoring of soil content to meet the requirements for selection by these AI tools. Similarly, although the "worldwide" category was selected for searches, these were only conducted in English, and so may not accurately reflect the variety of searches conducted in countries where English is not the first language, or the full global picture. Ideally, future work utilizing this method looking at the global scale would search in native languages and compare SVI between regions/countries.

5 | CONCLUSIONS

There are significant spikes in SVI in soil and soil conservation topics between 2019 and 2020, and 2021 and 2022. This compares with similar significant spikes in interest for the documentary Kiss the ground, searches related to climate change/carbon sequestration, and the United Nations' sustainable development goals. This suggests that dissemination efforts related to climate change and its mitigation through soil may be translating to increased engagement online with soil-related searches. Similarly, since the publication of the sustainable development goals in 2015, interest measured through SVI in soil characteristics and practices to conserve them has followed similar trends of interest to the goals themselves, particularly searches for "soil health." Interesting future work could focus on breaking down these trends regionally and searching in native languages, linked with research funding, and focusing on the impact of localized dissemination events.

AUTHOR CONTRIBUTIONS

Samuel W. Booth: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; visualization; writing—original draft; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The author declares no conflicts of interest.

ORCID

Samuel W. Booth https://orcid.org/0000-0001-9481-8433

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