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COMMENTARY

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Approaching soil health from a practitioner perspective – Placing practices before indicators for Australian cotton and other producers

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Abstract

Soil health, how it is defined and characterized, has long been a topic of debate, but its importance has never been in doubt. The FAO has provided a unifying definition of what soil health is, but uncertainty remains as to how it will be measured. While finding suitable soil health indicators remains challenging, there is growing pressure from external drivers on land managers to demonstrate they are valuing their soil health. With these issues in mind, the Australian cotton industry developed a soil health framework with the potential to address both competing demands. Taking a lead from the human health management, which focuses on prevention through promotion of adoptable healthy activity principles, and incorporating principles from the existing soil frameworks, we conceived one that is relevant to Australian cotton farmers. The outcome promotes beneficial but non-prescriptive land management practices, which have mechanisms in place to financially reward growers for adoption and facilitates industry monitoring. The Soil Health Framework, also has potential for other agricultural sectors and represents a solution to the current impasse over soil health assessment.

KEYWORDS

cotton, soil framework, soil health, soil management, sustainability

1 | INTRODUCTION

Soil is arguably one of the most important resource on this planet. It represents a finite resource, which develops slowly over time, but can be lost to erosion or pollution events in seconds. The importance of soil to the human populous is recognized globally by bodies such as the FAO, who on the 5th December each year encourage us to celebrate World Soils Day. The 5th December 2022 commenced the international year of soil, where our food begins, serving as an important reminder that we are all reliant on this one planetary resource.

Soil, as a resource, comprises a complex living ecosystem upon which the productivity and health of plants, animals and humans are reliant (Doran, 2002). Given this importance of soil to the health of life on this planet, it is perhaps unsurprising that there exists a history of attempts to quantify and define the health of this soil (Harris et al., 2022; Jian et al., 2020; Kibblewhite et al., 2008). However, many of these attempts to define soil health do not consider the functions of soils in our environment for purposes other than food and fibre production (Janzen et al., 2021). Soils' role in underpinning construction, providing raw materials, preserving our history, filtering our water, transforming our wastes and providing habitat for a phenomenal biodiversity are equally important to many who are not directly producing crops or animals. With all of these functions in mind many turned to the words of Doran and Zeiss (2000), 'the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health' as a means to encapsulate what soil health means. Twenty years later, in an attempt to resolve some of the ambiguity around what soil health is, the FAO Intergovernmental Technical Panel on Soils (ITPS) defined soil health as, 'the ability of the soil to sustain the productivity, diversity, and environmental services of terrestrial ecosystems' (FAO-ITPS, 2020).

A unifying definition only addresses what soil health is. How we measure and monitor it remains elusive, partly due to the spatial heterogeneity and temporal variation in many measurable potential soil health parameters. To address this, many have turned to the concept of developing indicators of soil health that are a reflection of function, and not a direct measure of it, to address this challenge (Bagnall et al., 2023; Ritz et al., 2009; Schloter et al., 2003; Yeates, 2003).

1.1 | Indicator requirements

Meadows (1998) provided guidance as to the criteria good environmental indicators should meet, but satisfying all of these criteria remains challenging when we consider the complexity and heterogeneity of soil biology diversity and function. Doran and Zeiss (2000) proposed a smaller suite of soil indicator criteria, whilst also highlighting the issues with current methods to satisfy these. More recently Harris et al. (2022) have suggested that a new theory about soil health could lead to an approach to measure aspects of the soil that create a soil health framework. However, the amount of work needed to address these criteria across large scale and varied environments would be prohibitive for most to undertake. This becomes even more evident when the size of sampling number needed to give confidence in the data is considered (Gyawali et al., 2023). Further, it is uncertain if these measures have meaning to the farmers and land managers intended to adopt this level of assessment and underlying measurement (Romig et al., 1995).

Defining soil health and its indicators is only one part of improving soil health. Effectively communicating soil health to those responsible for soil management must be part of the process (Doran, 2002; Lobry de Bruyn & Abbey, 2003; Lobry de Bruyn & Andrews, 2016). Establishing definitions for soil health has largely been an academic endeavour and we would propose that this may be part of the reason for land managers' ambivalence towards science-derived determination and indicators of soil health. To develop soil health indicators and metrics that are relevant for the growers we interact with, we ask them what soil health is. The results, across a range of events, locations and food and fibre systems is that soil health is a myriad of possible functions to our farming communities (Figure 1). Finding indicators to address all of these or to be compatible with each member of every audience is therefore likely to remain problematic, even if science or national policy dictates what soil health indicators are.

Again, our approach limits the focus to agricultural systems, at the expense of the wider environment. Indicators need to be representative of the entire soil system (Sieriebriennikov et al., 2014), consider physical, chemical and biological factors (Doran & Zeiss, 2000; Lu et al., 2020) and focus on soil functions not just soil properties (Ritz et al., 2009). Agriculture widely utilizes crop yields or animal productivity as an indicator for productivity, however, sustainability of both crop and animal yields requires maintenance of soil quality (Buckerfield et al., 1997). The quality and health of soils has been linked with microfauna and flora activity, abundance and diversity (Jian et al., 2020; Pankhurst et al., 1995). However, these associations are neither always obvious or not strictly adhered to (Fierer et al., 2021; Pankhurst et al., 1995). Buckerfield et al. (1997) and Woodman et al. (2008) suggest that macroinvertebrates (e.g. earthworms, termites and ants) are generally regarded as suitable candidates for use as bioindicators – as they appear to be relatively easy to sample, highly responsive to stresses and are important contributors to nutrient cycling, soil structure and connectivity of the soil food web. However, a focus on just macroinvertebrates may well be too simplistic a system to capture the status of such a diverse and heterogenic medium as our soils. Another challenge to these proposed indicators is the apparent lack of comparable monitoring of agricultural to dynamic environmental sites, which may obscure the true drivers of any measured change, whilst also assuming that the biology of both ecosystems was originally similar (Lobry de Bruyn, 1999).

1.2 | Drivers for soil health establishment and monitoring

To maintain or restore soil health, assessment and monitoring needs to be undertaken (Porazinska et al., 1999; Sieriebriennikov et al., 2014). Government policy has been the proposed mechanisms by which this would occur

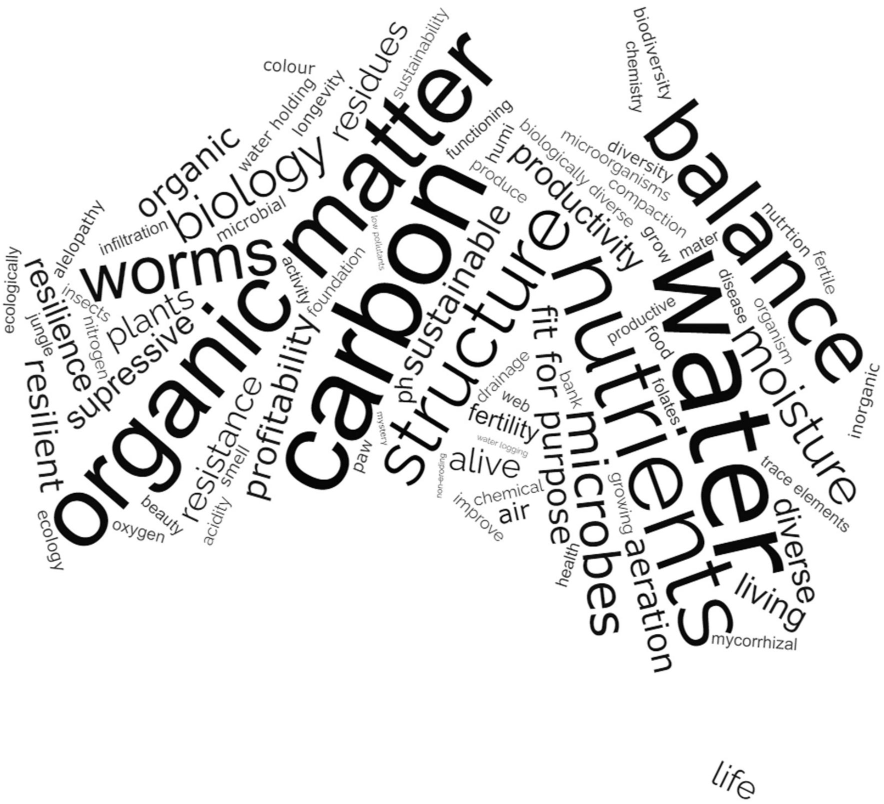

FIGURE 1 Word cloud generated from responses of ~370 farmers at 10 workshops between 2019 and 2023, covering a range of enterprises in New South Wales, Queensland, Tasmania, Western Australia and the Northern Territories in response to the question, 'Soil Health Is?'. Words are sized based on number of responses using https://www.wordclouds.com/.

(Baritz et al., 2021; Department of Agriculture Water and the Environment, 2021a; Honeycutt et al., 2020; Ito et al., 2015; Ritz et al., 2009), but for Europe this might be about to become a legal requirement under the Soil Health Law (Köninger et al., 2022). Although it is unclear as to what the EU Soil Health Law will deliver and how it will be implemented, one facet that appears to be commonly touted is that it is likely to mandate beneficial land management practices, which could be linked to financial incentives.

The Australian cotton industry undertook its first environmental assessment in 1991, making it the first Australian agricultural commodity to do so. The environmental status of the industry has been monitored over the intervening three decades (Cotton Australia, 2022; Roth, 2011) and now directly informs the 'Planet. People. Paddock'-aligned strategic plans of Cotton Research and Development, the Australian cotton research funding body, and Cotton Australia, the industry's peak body and voice in Australia. Other implications from the environmental assessments have included the development of a best management practices (BMP) programme, known locally as *my*BMP (Roth, 2011). The farming practices captured and monitored in the *my*BMP programme have facilitated the capture of data to support the Australian cotton industry's improvement in pesticide use (Knox et al., 2006; Wilson et al., 2018) and improvements in water management (Roth et al., 2013). Data in areas like these facilitate engagement with the global cotton textile markets and associated accreditation schemes.

Some of the schemes, such as Better Cotton, recognize the importance of soil as a finite resource and central to the continued production of this important global commodity. As a result, growers that have adopted management practices associated with improvement of their environment, which includes the soil, can potentially access additional financial reward through Better Cotton and similar schemes.

As part of its commitment to continuing to improve its social licence, sustainability and environmental impact, the Australian cotton industry's *Planet. People. Paddock.* sustainability framework manages nine topic areas; workplace, well-being, productivity, economic contribution, greenhouse gas emission, native vegetation, water, pesticide use and soil. As part of *Planet. People. Paddock.*, the cotton industry has developed a soil health framework, largely in response to external pressures and a need to clarify soil health for growers and customers of Australian cotton.

2 | MATERIALS AND METHODS

2.1 | Lessons from human health

To develop a soil health framework for the Australian cotton industry we needed an outline of what was to be addressed that would engage with farmers (Lobry de Bruyn et al., 2022). We wondered if there were any lessons that could be directly inferred from our approach as a society to human health. For decades the cost of human health interventions had resulted in the promotion and adoption of healthier lifestyles, to reduce the likelihoods of numerous costly diseases (Poterba, 1996; United States. Public Health Service, Office of the Surgeon General & United States, Office of the Assistant Secretary for Health, 1979). This commitment to prevent disease, and its associated costs and impacts, through the promotion of healthier activities, extends as far as informing policy and to evaluating the risks of climate change (Adegoke & Wright, 2013; Reddy, 2019). This approach as a society to human health with promotion of lifestyle activity and choice, rather than regular costly testing and absolutes for specific diseases in a diverse population, offered insight into not only how we might approach soil health, but also as to how we might promote its importance and monitor its condition.

With a decision to pursue healthy soil management options, over specific indicators, direction as to the nature of how we might develop the content of the framework was required. With the development of the framework occurring during COVID, we were regularly reminded of the importance of Maslow's hierarchy of needs, regarding human health. However, only the base level of physiological needs (e.g. breathing, water, food, shelter, clothing and sleep) appeared to have any potential fit to soil (Maslow, 1958; Maslow & Lewis, 1987). Maslow's approach to human well-being takes a fragmented and hierarchical approach to our health and well-being, but if either chunked up to the bare essentials or simply read at the lowest requirement, there is general consensus that food and shelter satisfy our base needs. At this level, we have something to offer soils, especially given the recognized importance of soils in protecting an incredible biodiversity and driving biogeochemical cycles that our food and fibre production, and even human existence, is reliant upon. It also fits neatly with earlier and accepted descriptions of soil as a 'living system' Doran and Zeiss (2000), which allows us to more easily communicate the 'food and shelter' principles of soil health to land managers in language they are familiar with.

At this stage we looked at what was being promoted for soil health elsewhere in the world. Which of these systems offered something that aligned closely to our recognized criteria and whether we could map the agricultural practices that we knew were linked by science with improved soil properties (Figure 2).

2.2 | Framework development

The first aspect of the framework was to set a series of overarching goals that were simple enough to follow and understand, but not simplistic in their design, due in part to the level of education of the Australian growers (Cotton Australia, 2021; Lobry de Bruyn & Abbey, 2003). Of the schemes we looked at, the USA's USDA soil health

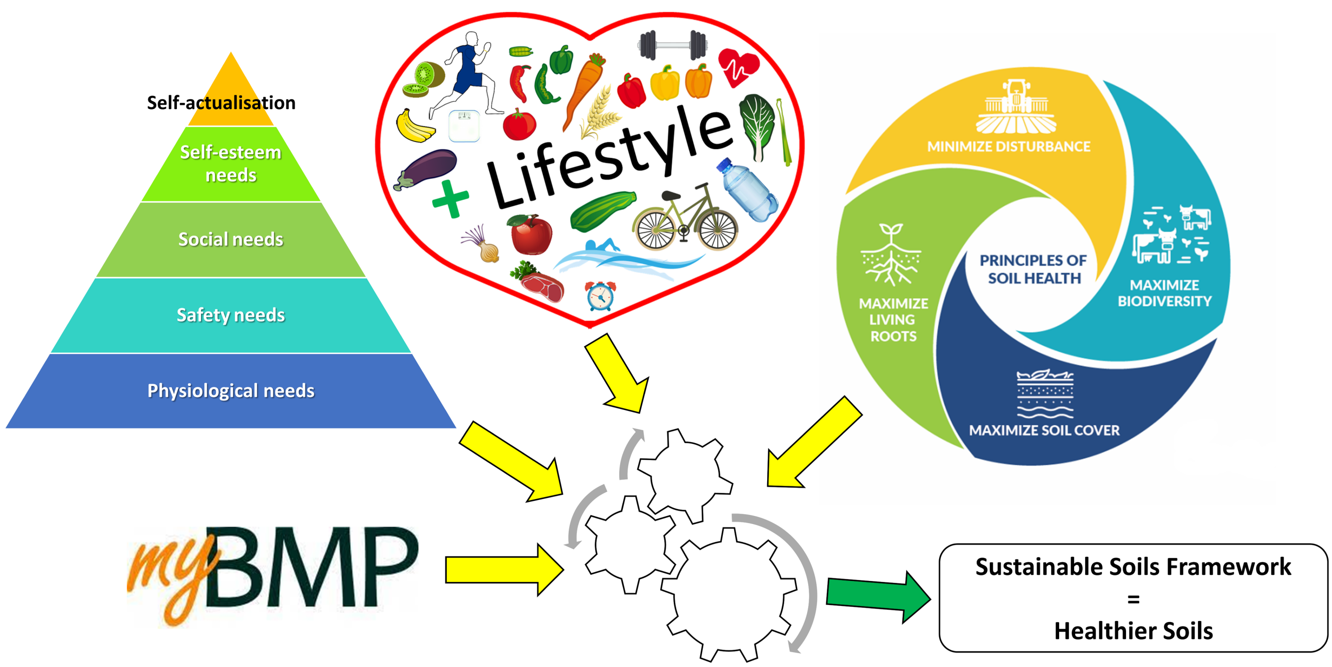

FIGURE 2 A schematic presentation of the process and major contributors (*my*BMP, Maslow's hierarchy of needs, lifestyle over intervention, USDA's Principles of Soil Health©) to the drafting of a soil sustainability framework for the Australian cotton industry with a view to capturing and promoting improvement of the industries soil health.

principles seemed to be the most closely aligned with what we believed, in our expert opinion, was needed and achievable (Honeycutt et al., 2020; Natural Resources Conservation Service, 2021; Toor et al., 2021). Merging with aspects from the base physiological needs of Maslow's hierarchy, from a soil rather than land managers perspective, refinement of the overarching aims from four to two was undertaken and as a result the provision of habitat (shelter) and food became our two guiding principles. These in turn gave rise to four soil management practices, known to either improve soil habitat or with greater potential to feed its biology or both, each of which aligned with three to five common (but not intended to be an exhaustive list of) on-farm practices known to support soil health (Doran, 2002; Toor et al., 2021). Under these we imposed the flow-on improved soil properties and associated changes in soil function from these land management practices (Figure 3).

3 | RESULTS AND DISCUSSION

3.1 | Framework delivery

Delivery of the framework to cotton growers was to be undertaken primarily by CottonInfo, a dedicated research extension team supported by the cotton industry. CottonInfo routinely organize and deliver workshops, field days, conference presentations and write for the industry specific grey literature. These form the major part of CottonInfo's engagement pathways and were employed as the primary mechanisms to deliver the soil health framework.

In theory the outcome or practice change adoption does not directly result in a need to measure the flow on effects to specific soil indicators, which may take years to materialize (Powlson et al., 2011; Rhoton, 2000). Instead, the existing grower and support services (consultant) surveys, which are conducted annually, already ask about the adoption and use of these practices by growers. This level of monitoring therefore provides no further impost on growers already following best management practices associated with improved sustainability, but does allow the Australian cotton industry to gauge the status of soil health promoting practices and by inference the farmed soils' health at a range of scales. Alignment of the practices with the industry's *my*BMP programme also allows for those that either have or later adopt these practices to move to the higher levels of the scheme, undergo farm audit and potentially access a premium payment for the cotton they produce under the existing programmes – a win–win scenario.

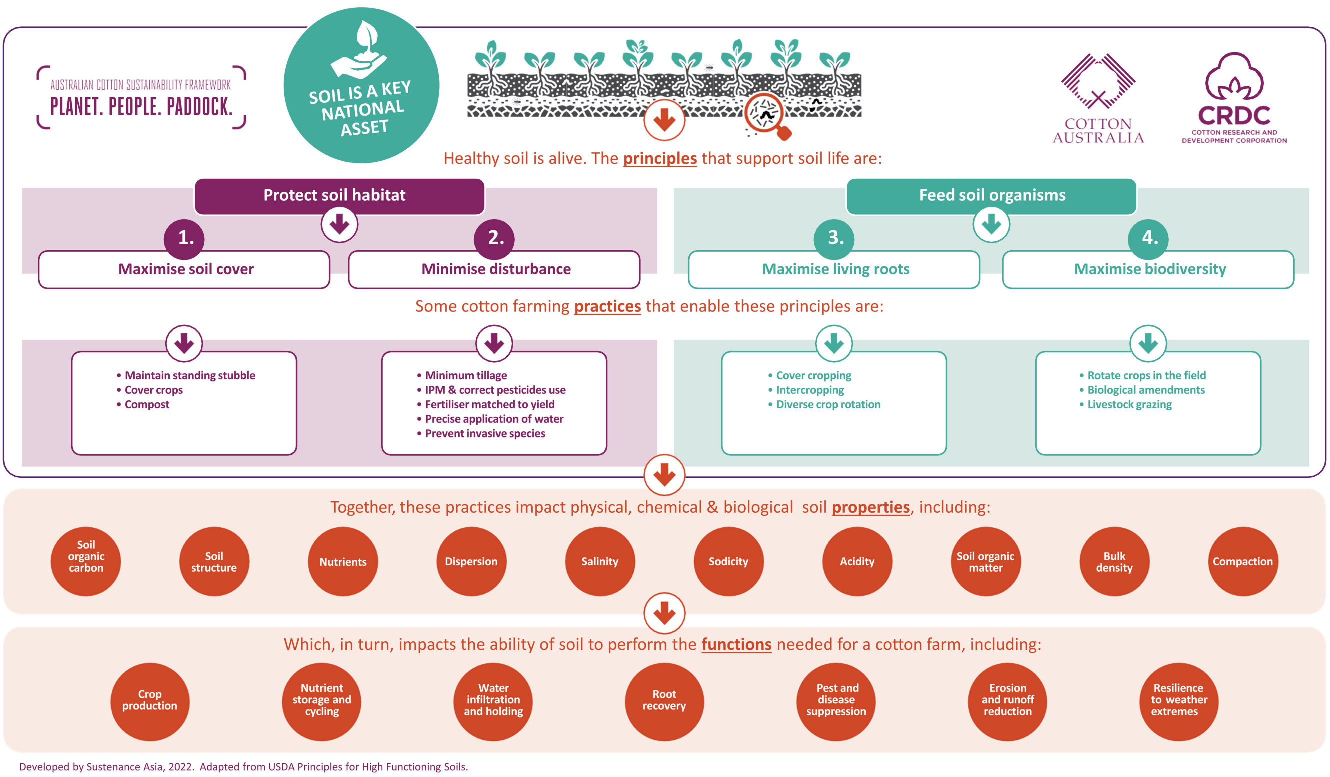

FIGURE 3 The Sustainable Soils Framework for the Australian cotton industry. Based on the two fundamental principles of shelter and food, from which are derived potential land management practices, which are known to be beneficial for soil health. Status is monitored based on practice adoption levels within the existing grower surveys.

3.2 | Altruistic not prescriptive

Another consideration was to promote adoption of these beneficiary practices, as beneficiary rather than prescriptive. Agriculture has a history of failure where change has been enforced, some of which are historic (Jones, 1962; Knox et al., 2011), while others have occurred within the current decade (Nordhaus & Shah, 2022; Teng et al., 2022). Our experience is that farmers are highly motivated and capable of change, but some are lacking the opportunity to bring about a behavioural shift either due to financial or climatic constraints. Providing encouragement, rational discussion and a chance to bare witness to the outcomes of early adoption by others we believed will likely result in increased adoption rates (Dessart et al., 2019). In addition, the most knowledgeable individuals regarding field, farm and local climatic limitations are the current landholder, so allowing their local knowledge and experience to determine which practices to implement and where should foster adoption.

3.3 | Adoption through *my*BMP over carbon and regenerative focus

To reach as wide an audience as possible, we avoided either politicizing the framework or preferencing any particular type of farming over another, although supportive of as many types of farming as possible. The proposed practices were also not badged as being either supportive of carbon or regenerative farming, for the purposes of extension to growers for the following reasons.

There is evidence that putting the farming system first can improve soil carbon or organic matter stocks, which is desirable but not the primary focus of this work (Magdoff & Weil, 2004; Moinet et al., 2023). Although some farmers may find themselves adopting schemes and methods that fit either the Australian emissions reduction fund or other carbon trading schemes, receiving carbon market payments for any additional carbon is unlikely for many cotton producers due to a range of risks and practical issues surrounding soil 'carbon farming' (Powell et al., 2017). In addition, although most of the promoted practices should improve soil organic matter and carbon returns, it remains doubtful that, given climatic variation, these would persist over the 25 year time periods required at present (Osanai et al., 2020a, 2020b). The Australian cotton industry encourages growers to approach carbon sequestration schemes with extreme caution, promoting 'carbon for soils and not soils for carbon' (Moinet et al., 2023).

Although this framework was proposed against the requirement for soil health improvement, we did not feel the need to label the practices as regenerative, because practices such as minimum tillage, maintaining ground cover, integrated pest management, cover and rotational cropping already exist with various levels of adoption in the industry's *my*BMP programme and we envisage that grower familiarity with the *my*BMP programme will improve adoption. However, the growing interest in regenerative farming, both generally in agriculture and within the textile industry (Gordon et al., 2022; Textile Exchange, 2022), would not preclude these practices from complying with the meaning of regenerative to service the needs of the industry supply chain. It should be noted that most regenerative practices have been around for a while under the conservation agriculture banner (Giller et al., 2021), under LandCare farming (Youl et al., 2006) and agroecological ideals (Conway, 1987; Ryan & McClymont, 1996). The final step was to provide the functional rationale for the proposed adoption practices and the delivery of the improvements in soil properties and functions that farmers would benefit from as evident in the proposed framework (Figure 3).

4 | CONCLUSION

While debate at the national level remains over which indicators will be implemented to monitor soil health, the principles and practices that promote beneficial and sustainable soil management for the land manager are relatively well established (Norris et al., 2020; Toor et al., 2021; Yang et al., 2020). Existing data captured in annual grower and consultant surveys already provides an insight into the existing levels of adoption of our proposed soil health framework's practices. As such, future monitoring of practice change will be possible through the continuation of these industry surveys, without further impost on farmers' valuable time. Both the current and future data could be explored at a range of scales and granularity, thus enabling potential impediments, most adopted options and areas where further assistance might be needed to be identified. Again, like with human health, where serious issues are encountered, the framework does not impose any impediment to local interventions and, potentially costly, remediation. However, the framework does allow an industry overview of how much of our landscape is either being appropriately managed, according to the capability of the soil, or improved, and by default the state of our soils' health, assuming that a well-managed soil is either healthier or at less risk of degradation. In addition, the promoted practices do not offer any challenges to being of use in other production aspects of either the farm or across the many production systems that exist within Australia. As such, this framework provides potential to inform similar activity across industries, state and federal governments as Australia continues to develop its approaches to soil health through the National Soil Strategy (Department of Agriculture Water and the Environment, 2021b).

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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