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Caring for soil life in the Anthropocene: The role of attentiveness in more-than-human ethics

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This paper considers the work that attentiveness can and can't do in generating more ethical relations with non-humans. How to build better relations with non-humans has been a central debate in geography and cognate disciplines. These concerns include ethical relations with non-humans who both pervade and create liveable environments, such as soil biota. Scholars have specifically identified attentiveness as key in generating more-than-human ethics. However, how attentiveness may arise, and what work attentiveness may be able to do in generating ethical relations, has not been sufficiently explored. Additionally, soils as relational materialities remain underexplored in social sciences. In this paper, I address these two important gaps in scholarship. Investigating the rising concern with soil biota in conventional English farming, I propose the care network as a way of conceptualising and investigating the ethical potential of attentiveness. As concerns grow about soil degradation, and the dangers this is posing to food production and to human survival, land managers are attending to soil ecosystems as part of caring for their farm businesses. While this attentiveness is producing some transformative effects, its potential is limited by the configuration of the soil care network. As long as soil care is configured primarily as farmers' concern, the potential of attentiveness in generating ethical regard to the needs of soil biota will be limited. In the Conclusions, I suggest ways of expanding attentiveness to soils and of building a wider and practical relational ethic of soil care. I also argue we need more attention in geographic research to attentiveness and care as systemic, unequally distributed, and operating at multiple scales.

KEYWORDS
care, England, farming, microbes, more-than-human ethics, soil

1 | INTRODUCTION

The term Anthropocene originates in the ground, in the discovery of material traces of human activity in the geological record of the planet. This planetary signature is symbolic of the importance of human–non-human relationality to the current understanding of social action. What the Anthropocene makes clear is that "humans cannot survive by stomping on all the others" (Tsing, 2015, p. vii); in order to live *at all*, we need new modes of living *together*.

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Taking the interdependence of human and non-human lives seriously is becoming a more mainstream position. The wide take-up of the ecosystem services framework in policy development (Raymond et al., 2013), for all its shortcomings, signals a certain normalisation of the view of humanity as dependent on and interconnected with a non-human nature. More radical movements, such as the "post-pasteurianism" in food production (Paxson, 2012), or using helminth "gut buddies" to manage human disease (Lorimer, 2017a), explicitly entangle human and non-human well-being through practices of attention and care for hitherto taboo or ignored non-humans, particularly at the microbial scale. Differing in degree rather than in kind, these trends signal the spread of what Lorimer (2017b) calls a probiotic biopolitics, in which care for non-human lives becomes part and parcel of caring for human well-being. Here I wish to extend Lorimer's focus on probiotic biopolitics as particularly concerned with the careful inclusion of previously "dangerous" entities into anthropocentric projects. As he notes, probiotic relationality implies new understandings of danger and pathogeny not as fixed characteristics of particular entities, but as emergent outcomes of particular arrangements, disorder being often the product of arrangements that over-stress purity and separation (2017b, p. 28). Building on this, I suggest a wider reading of the probiotic mode as a way of assembling and governing anthropocentric ecologies through an explicit bringing in of non-human entities as essential to their making and maintenance, without a priori normative categorisations. This results in rationalisation, eradication, and separation giving place to cooperation, adaptation, and care in probiotic environmental governance.

The soil conservation movement is one emerging arena in which the indispensability of non-human lives to the creation and maintenance of human life and its environments is being recognised. Soil biota are being identified by scientists, policymakers, and the farming industry alike as central to ensuring agronomic and ecological futures as the alarm grows around the life-endangering extent of global soil degradation (Food and Agriculture Organization of the United Nations, 2015; Montgomery, 2017; Orgiazzi et al., 2016). Darwin's inquiries into earthworms notwithstanding (Feller et al., 2003), the lively worlds under our feet have only recently become an object of systematic scientific inquiry. These ecosystems are, however, already severely endangered by human land use, with a third of the world's soils classed as degraded by the Food and Agriculture Organization of the United Nations (2015). Healthy soil ecosystems are indispensable to the production of food, and to the broader functioning of all terrestrial ecosystems; without life in the soil, life on our planet's dry surface is also not possible (Ritz, 2014). As a result, forms of land management that would respect and even benefit from the lives of soil biota are being increasingly explored, especially in agriculture (Stockdale & Watson, 2012). In these new forms of soil-centred farming, soil biota are being enrolled in a probiotic mode into a multi-species response to the threats of the Anthropocene. Central to the success of these is a theoretical and practical question: how to attend to and care for soil biota in agrarian practices.

How to respond to more-than-humans and create more flourishing and convivial worlds has been of central interest to geography. In the Anthropocene, and faced with the challenge of soil degradation specifically, this question acquires a particular urgency. Care, as the practical and ethical commitment to ensuring the well-being of others, is a promising way of conceptualising and acting on the interdependence of human and non-human lives (Puig de la Bellacasa, 2017). The non-human care ethic literature and the wider field of more-than-human geographies share a concern with attentiveness as a tool for the expansion of ethics into more-than-human worlds, and for their resulting transformation (Haraway, 2008; Puig de la Bellacasa, 2017; van Dooren et al., 2016). However, how attentiveness may arise, and what work attentiveness may be able to do as a catalyst for and conduit of more-than-human ethics, has not been sufficiently explored. This paper addresses this important gap by exploring the relationship between attentiveness and practices of care for soil biota.

In this paper, I propose the *care network* as a way of conceptualising and investigating the work attentiveness can do in generating expansive and transformative ethics and practices. I investigate the potential of attentiveness as a tool for building a practical more-than-human ethics by examining the role of attentiveness in the emerging practices of soil care in conventional English farming. I argue that thinking care and attentiveness through the care network model allows us to better understand the potential and limitations of attentiveness as a tool for expansion of ethical concern and practical action in more-than-human worlds.

2 | SOIL, THE FORGOTTEN ELEMENT

Soil is yet to take its place as an object of inquiry beyond the natural sciences. To date, the bulk of attention in human geography has been dedicated to the soil as land, i.e., the (governable, ownable, controllable) surface of the Earth. As part of geography's "material turn" (Anderson & Wylie, 2009), the "matter" of water, air, and minerals have started to be opened in productive ways (see e.g., Adey, 2013; Appel et al., 2015; Lavau, 2013). In contrast, in human geography soils have principally been conceptualised as a resource, a "natural thing" belonging to the world of physical science (Bridge, 2009, p. 1219). As a result, scholarship on soils in human geography has predominantly worked from a perspectivist

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standpoint, noting and investigating the consequences of the socially contingent meanings of "soils" and their processes, notably soil degradation (Cudlínová et al., 2016; Orchard et al., 2017; Reed & Stringer, 2016). These inquiries interrogate the role that various knowledges play in soil conservation and management, but leave unexamined the dynamic, socially contingent constitution of soil matter (e.g., Dea & Scoones, 2003; de Bruyn & Abbey, 2003; Ingram, 2008; Klingen et al., 2012; Schneider et al., 2010). While there has been some foundational work in political ecology critiquing the politics of soil science as a particular way of structuring human–soil relations, and the role it plays in relations of domination (Blaikie, 1985; Blaikie & Brookfield, 1987; Engel-Di Mauro, 2014; Marchesi, 2016), the ontological status of soils as a "natural thing" remains a relatively settled matter in the social sciences.

In contrast, I suggest human geography needs to examine the reality of soils not as preceding the mundane practices in which humans interact with it, but rather as *shaped within* these very practices (Mol, 1999, p. 75). This ontological approach to soils as made rather than found was employed by Latour (1999) in his investigation of the stabilisation of soils as an object of scientific practice, and in Lyons' view of soil materiality as connected and dynamic, "less of an isolatable entity than continuous, relational movement" (2014, p. 229). Approaching soil realities as multiple, "sustained, or allowed to wither away in common, day-to-day material practices" (Mol, 2002, p. 6) allows research to ask both what kind of normativities are already embedded in human–soil relations and what possibilities there are for doing things otherwise (Mol, 1999).

The relational materiality of soils is significantly shaped by discourses in the natural sciences, which are currently drawing attention to soils as living ecosystems (Lehman et al., 2015). The development of metagenomics analysis has heralded a new era in soil science in which the microbial is taking centre stage (Fierer, 2017). As a result of the growing recognition of the vital role soil organisms play in most soil functions, the historical and disciplinary divides between the study of soil chemistry, physics, soil biota, and the above-ground ecosystems are becoming more difficult to uphold (Hartemink, 2016). Soils sustain life. But they are not merely lively materials: soils are both lively and *alive*. This inseparability of soil organisms and their environments troubles existing approaches to "taking materiality seriously" in geographical scholarship. Geography has seen on the one hand studies of "matters" – elements and materials (Kirsch, 2013) – and on the other hand engagements with life forms (Lorimer, 2012), from the "big like us" to increasingly more diverse awkward and difficult companion species, including most recently microbial life (Hinchliffe et al., 2013; Lorimer, 2017a). Soils as ecosystems trouble these distinctions between "alive" and "lively," and gesture towards the need to integrate thinking about living beings and material flows in more-than-human and materialist ethics, a move to which this paper contributes. The microbiopolitics (Paxson, 2012) of soils are not just the politics *of soil microbes*, but of soil microbes as part of ethical relational materialities.

3 | MORE-THAN-HUMAN ETHICS AND THE ROLE OF ATTENTIVENESS

3.1 | Relational ethics and the call to attentiveness

How to live well with non-human others is an issue much debated in geography and cognate social sciences. In tackling this question, scholars have increasingly turned away from ethics based on an extension of universal ethical codes to non-human others, and towards a relational ethics. This approach developed in conversation with Haraway's cyborgs (Haraway, 1991) and companion species (Haraway, 2003, 2008), Latour's hybrid collectives (Latour, 2004), Barad's intra-action (Barad, 2007) and Levinas's ethic of encounter. Relational approaches to ethics take human subjectivity and materiality as interdependent with that of non-human others (see Braun, 2008; Lorimer, 2012), with human bodies and environments seen as porous and permeated with, as well as dependent on, non-human forms of life (Diprose, 2002; Hinchliffe et al., 2013), and human societies and economies re-cast as inherently (bio)material (Barker, 2010; Barry, 2013; Moore, 2015; Morton, 2017). The work of assembling the relational materialities that compose this more-than-human world is seen to inescapably implicate ethics, understood as a uniquely human responsibility for the shaping of the worlds that emerge when relations are made (Barad, 2007; Stengers, 2005). As a result, a key question for those concerned with relational materiality and the more-than-human has been how to forge relations that result in worlds which are more convivial (Hinchliffe & Whatmore, 2006), accommodating (Barker, 2008), friendly (Bingham, 2006), and flourishing (Haraway, 2008). The normative demand of this approach derives from the recognition of an interconnectedness of being that is not "romantic or idealist, but mundane and consequential in the little things that make lives" (Haraway, 2008, p. 93).

While seeing ethics as inextricably embedded in relations, relational ethics scholars have asked what situations and affects may make it possible to reconfigure these relations so that better worlds result. A key concern for this literature has thus been understanding the source and characteristics of the "call to ethics" – the "channels along which ethical

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recognition can flow" (Ginn, 2014, p. 533). The affective entanglements between human and non-human bodies have been identified as a particularly important site for such ethical work (Haraway, 2008; Wilson, 2017).

Central to relational ethics is the practice of attentiveness – of attending to the non-human other, of becoming response-able to them. Scholars have identified moments in which ethical relation are forced or triggered through such affects as enchantment (Bennett, 2001), charisma (Lorimer, 2007), or disgust (Ginn, 2014). The central assumption of the relational ethics literature is that such affective moments can be consciously built on so that a more expansive field of relational ethics emerges (Haraway, 2008). The role of attentiveness is to facilitate the emergence of affects in embodied meetings, and to result in "ethical contagion" (Yusoff, 2013) in which relational ethics are extended beyond particular encounters. Attentiveness (also described as curiosity, response-ability, or openness) to non-human others has therefore been often called for (Haraway, 2008; Hinchliffe, 2008), and researchers have explored how people train and may be trained to be attentive and open to being affected by non-humans so that relational ethics is produced (e.g., Desai & Smith, 2018; Despret, 2004; Hansson & Jacobsson, 2014).

The potential of attentiveness in fostering these ethical expansions through encounters has also come under some scrutiny. Critiquing the assumption that embodied encounters between humans and non-humans automatically lead to a positive relational ethics, Pitt (2018) explored how the quality of attentiveness is informed by pre-existing ontological and ethical commitments. With a similar concern about embodiment (including scientifically enhanced embodiment), Yusoff (2013) cautions against the limitations of attentiveness as a conduit of ethics due to its dependence on what I call the *sense-ability* of the non-human, that is its ability to be sensed and made sense of by human beings. She does not discard attentiveness, however, but calls for an exploration of "blind ethics," which demands an attentiveness that is not specific to relations; "an intensified sensibility of an otherwise [which is] wilfully sensible to that which is excluded in a restricted (relational) economy" (2017, p. 97). This approach echoes the role attentiveness is expected to play in the ethics of care, to which I now turn.

3.2 | Attentiveness in the care ethic, and the care network model

The ethic and practice of attentiveness is key to the ethic and practice of care. Following Tronto (1993), care is understood here beyond gender-specific discourses, not as a form of "women's morality," but as a practical and political project: the *necessary ongoing work* of maintenance and repair of the world so that we can live in it as well as possible (1993, p. 103; see also Fisher & Tronto, 1991). Extending thinking care in this way to more-than-human worlds, Puig de la Bellacasa argued we can see care as a condition of all (not just human) life: while not all relations need be relations of care, "for interdependent beings in more than human entanglements, there has to be some form of care going on somewhere in the substrate of their world for living to be possible" (2017, p. 5). She proposed we think of care as tasks that make living better in interdependence, maintaining and repairing a world "so that humans *and non-humans* can live in it as well as possible in a complex life-sustaining web" (Puig de la Bellacasa, 2015, p. 97, my emphasis).[1] Care should not be seen as exclusive to the living elements of the world, but as the totality of practices relating to the living and non-living entities and matters which overall enables life (see e.g., Ureta, 2016).

In the ethic of care, attentiveness is not only an ethical commitment, but, crucially, a practice inherent to the labour of maintaining life. Care demands attentiveness to the needs of the Other as the starting point for what must be done (Tronto, 1993, p. 105). Caring for something or someone means paying attention so as to learn about, act on, and monitor the satisfaction of the needs of the one being cared for. Attentiveness therefore is inherent to care practices as a form of skill (Krzywoszynska, 2016). Attentiveness may be detached from the everyday work of care-giving and encoded in devices, protocols, designs, etc. (although Tronto (1993) argues that such separation may lead to suboptimal care). However, for care to be possible at all, someone at some point has to have paid attention and made commitments to certain needs.

This inseparability of care and attentiveness means that *attentiveness is always already present in care practices*. This attentiveness, I argue, need not be limited to encounters between embodied entities. Rather, a commitment to good care produces a speculative, probing attentiveness which pushes beyond what can be directly experienced by individual bodies. Attentiveness also demands a concern for the interrelations between the primary object/subject of care and other entities and processes on which the well-being of this primary object/subject depends. Care as a practice demands that care-givers attend to *care networks*: the webs of interrelations, connections, and dependencies that affect the life and well-being of the primary object/subject of care. As the root network supports the growth of the tree trunk, the care network is the assemblage of interconnected entities whose existence enables the well-being of the primary object of care. The well-being of the primary object of care thus requires that the needs of the entities comprising the care network are similarly satisfied; they

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too demand care. Their needs are further interdependent on other entities and processes, thus further extending the network of care, in a potentially unlimited way.

A probing attentiveness to the needs of the multiple entities that comprise the care network is enabled through diverse knowledge practices, with individual meetings between embodied entities being only one of the relevant ways of knowledge-making. Exploring the care network is as much an intellectual process as an embodied one, as not all the entities that constitute the care network underpinning the object of our care will be directly sense-able to our individual bodies. Similarly, this learning will be as much a collective as an individual process, displaying an oscillation between joint and individual meaning-making characteristic of communities of practice (Wenger, 1998). Importantly, the exploration of the composition of the care network has the potential to be not only an expansionist but also a transformative form of ethics. As the care network expands, not only are more and more entities included in the field of concern, but the awareness of the needs of those entities can change the very composition of this field, shifting the structure from a pyramidal (primary object/subject of care and all that "serves" it) to a flatter landscape of interconnections.

The care network model is a critical and practice-oriented elaboration of Puig de la Bellacasa's (2017) soil food-web model of care relations. Puig de la Bellacasa introduces the soil food-web as an ecological model that shifts the anthropocentric motivation of caring for soil towards a situating of human activity *within* relations of care/maintenance of life; it "involves looking at the dependency of the (human) carer not so much from soil's produce or 'service' but from an inherent relationality" (Puig de la Bellacasa, 2017, p. 192). However, the speculative inclusive ethos of the food-web risks disregarding exclusions and separations inherent to care as a material, situated process oriented towards particular care outcomes. To put it bluntly, while we may all be ultimately interdependent on a Gaian scale, this cosmic interdependence does not absolve us of the practical work of inclusion and exclusion indispensable to the delivery of care for specific lives/things in specific places, at specific times. While the food-web model seeks to bring all cares together, with the care for one entity necessitating the need for an other, and an other, and an other, the care network concept stays closer to the work of Law (2010) and Mol (2008), who stress that care(s) are always multiple, and often in tension. The creation and maintenance of a "good world"/"good life" for one entity or set of entities inevitably encroaches on the good world or good life of some others.

This more practice-oriented and pragmatic reading of care relationality recognises that *attentiveness is always an attentiveness towards*. While attentiveness in relations of care does have a potential to generate an expansive and transformative ethic, this can be limited by the necessity of achieving care for specific things. In the case of the emerging care for soil life, I argue the care networks retain an anthropocentric orientation making them probiotic (Lorimer, 2017b) forms of care. For Lorimer, a probiotic biopolitics seeks to manage human and ecosystem health by blurring the hygienic separation between human and non-human agents. Instead of seeking to maintain strict boundaries, probiotic approaches see environments and bodies as always already "impure," and seek instead to control this "impurity" in the service of anthropocentric interests. Probiotic approaches thus retain the anthropocentrism of modernity while abandoning its pretence of sharp separations between categories, acknowledging the need for care for non-human agencies as relevant to human well-being.

Probiotic care networks operationalise this principle by explicitly enrolling non-human entities into specific projects of anthropocentric care. The care for the needs of the non-humans is included in the care network so that the interests of the primary objective of care can be satisfied in turn. Probiotic care networks thus explicitly engage in the work of exclusion and separation, as only certain non-humans are allowed "in" to the fold. However, even probiotic care networks are necessarily based on relations of care, and so retain a disruptive ethical potential due to the pull of attentiveness – the demand to attend to the needs of those included in the network. The probing and questing nature of attentiveness creates spaces in which questions about the shape of the care network – about who should be in and out of the care network, and why – can be asked. These present an opportunity for the transformation of the care network, which may be radical.

In the following sections, I investigate the potential of the care network model through an analysis of the emergent practices of care for soil biota in conventional English farming. As life in the soil becomes an object of practical concern for conventional farmers, care for the farm business is being re-configured to include a care for the soil, and for the soil biota. This reconfiguring demands an attentiveness to the needs of soil biota, and a subsequent reflexivity around existing practices from the care-giver. The analysis reveals that the work attentiveness can do in expanding the landscape of ethical relations is shaped by the configuration of the care network.

4 | METHODOLOGY

My methodology is inspired by Mol's (2002) praxiography – that is, the attention to ontologies in the making, and to material and discursive practices that bring them into being. Between 2016 and 2017, I conducted interviews and farm visits

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with 21 English conventional arable land managers (18 farm owners and three farm managers) who self-identified as having an interest in their soils. I chose to focus on arable systems due to the intense engagement with the soil these entail through numerous soil-based operations.[2] I further chose to focus entirely on commercial (i.e., not part-time or "hobby") farmers, and on conventional rather than organic farmers, due to organic agriculture's stress on soil as a significant element of the farming system. The participants were recruited through on-line soil conservation fora, recommendation by farming research organisations, and snowballing. The aim of the study was not to engage a representative sample of the farming community but to gain an in-depth understanding of the ways in which soils become objects of concern and of care for conventional farmers. As a result, my participants were farmers who had dedicated a certain amount of time and resources into changing their land management practices. To ensure a diversity of experiences, I interviewed farmers across a variety of soil types and micro-climates, with three farms situated in the south, four in the east, six in the Midlands, and eight in the north of England. I further interviewed farmers at all points of the spectrum of soil conservation practices, and with a wide range of length of experience with these methods. The least changed farm systems combined ploughing with occasional ventures into soil improvement techniques such as growing grass lays or cover crops. On the other end of the spectrum were those farmers who practised entirely no-plough (no-till) agriculture. The farms were further chosen to represent a diversity of farm sizes, with the two smallest holdings at 75 hectares, and the largest holding at 4,000 hectares; the majority of the farms held between 100 and 400 hectares. The majority of the participants were middle aged; one participant was younger than 30, and two participants were older than 60. All the participants were male.[3]

I conducted initial one-hour telephone interviews to establish basic information about farm size, machinery used, crop rotations, and the farmer's history on that farm. These also started to explore the farmer's interest in, perceptions of, and practices related to soils. This information was then further built on during farm visits, which lasted between two and four hours. During farm visits I combined semi-structured and unstructured interview techniques to engage with the diversity of ways the farmers were relating to their soils. The interviews combined a focus on life-story narratives (e.g., of soil management change), and on specific soil practices. In order to engage with the latter, the visits involved a combination of viewing and discussion of farming machinery, as well as of records of soil analysis and soil maps, on-site interviews about particular fields, and, if practised, observation of farmers' soil assessment. This usually involved the farmers digging shallow soil pits while being asked to narrate their perceptions of the soil's qualities. While I had previous experience of researching farming environments, I completed a week-long course on the basics of soil science and participated in farmer-oriented soil training events to gain in-depth knowledge about agronomic soil quality assessment and related issues. I audio-recorded all the conversations during the farm visits, took pictures of items and places discussed, and video-recorded particular practices (e.g., of soil analysis). I also audio-recorded my own impressions of the field visits. During the visits the farmers acted as expert guides to their relationship with their soils, making it possible for me to participate in an embodied and affective manner in their experiences of making sense of soils through their senses and knowledge practices, and as an element of a material and situated farm system (composed of particular landscapes, weather conditions, machines, material flows, etc.). Crucially these guided farm visits allowed me to participate in situated processes of making sense of very particular realities – particular fields, or even particular sections of particular fields, at particular times. This allowed me to be emotionally present as farmers narrated the tensions and difficulties as well as hopes and successes associated with situated soil relationalities. The interviews and farm visits were transcribed and analysed thematically. In this paper, I focus on the material that explored the practices and discourses of care and attentiveness in relation to soil.

5 | THE MARGINALISATION OF SOILS IN MODERN FARMING

In order to attend to the emergent practices of soil care in contemporary English farming, we need first to take a step back and briefly review the changing role of soils in English agriculture in the modern period, specifically the shift from biological to chemical sources of soil fertility, and the consequent marginalisation of soils as objects of care and attention in farming systems.

The foundations of agriculture are the material transformations that take place in soils and result in the production of plant biomass – food and fibre. Biomass production is linked to soil fertility, i.e., the ability of soils to supply plants with sufficient nutrients, air, and water to enable their growth and reproduction. Farming essentially mines soils by removing nutrients from the fields in the form of a crop (or animal bodies); if the process is repeated regularly, and the nutrients are not replaced, a soil's fertility diminishes. For all sedentary populations without access to a steady off-site flow of nutrients (such as the Nile for the lands of Egypt), the challenge is therefore how to resolve the problem of long-term nutrient loss (McNeill & Winiwarter, 2006, p. 2). Territorial expansion, and the importing of foods from periphery to the centre, is a

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strategy that worked well for a time for the Roman and British empires, while a form of agricultural nomadism, based on a constant westward expansion, was a temporary solution employed by the United States of North America. How to improve the fertility of soil without recourse to external sources of nutrients was an objective of the 17th and 18th British Agricultural Revolution, which saw systematic experimentation with already well-known principles of good land management such as manure applications, cover cropping, liming, and rotations (Stoll, 2002). Importantly, these efforts located fertility in situated interactions between plants, grazing animals, soils, and human labour, creating the ideal of the closed-farm system that today underpins organic farming methods. Soils and their needs – for recovery, for feeding – were seen as a part of what made the farm work. Enhancing soil fertility included a practical care for soil biota, even though this was not recognised as such; the farmers fed soil biota so that these could feed plants in turn.

The marginalisation of soils, and a loss of attentiveness to their needs, is rooted in theories of soil fertility introduced by Justus von Liebig in the mid 19th century. His earth-shattering work *Chemistry and its applications to agriculture and physiology*, first translated into English in 1842, proposed a mineral (rather than organic, or humus-based) theory of soil fertility.[4] Liebig argued that fertility could be seen as a combination of fundamental chemical elements, and that adjusting the chemical balance within soil with mineral additives was all that was needed to maintain its capacity to grow plants (Uekoetter, 2006). Liebig's theories, which still form the basis of agronomic knowledge today, thus located fertility not in soils per se, but in the availability of certain chemicals to plants.

Liebig's enduring legacy has been the perception and performance of soils as merely "a medium for plant growth" (Hartemink, 2016, p. 80). Chemical fertilisation truly took off in the early 20th century, as the post-war industries which produced nitrogen for explosives found a new market in agriculture (Leigh, 2004). Where advances in non-chemical farming systems sought to work with the biological processes within soils to make nutrients available to plants, the adoption of mineral fertilisers essentially by-passed soil processes, creating a direct connection, and indeed a dependence, between plants and chemicals. This practical marginalisation of soils, and particularly soil biota, as active participants in agriculture was further reinforced through a series of linked agronomic developments that together with chemical fertilisation came to form the backbone of modern industrial farming: the mechanisation of field operations from tillage to harvest, and the creation of crop varieties that are highly responsive to nitrogen fertilisation (so called high-yielding varieties). Together, these developments tied fertility to external inputs, and shifted the focus of farming from soil to land – more land, more additives, more yield.

The impact these developments were having on processes within soils, particularly soil life, could be disregarded: as long as there was sufficient soil depth, the combination of chemical additives and machine power made it possible to produce abundant plant life. To exaggerate (but only slightly), soils could be treated as a hydroponic substrate – a primarily physical (not biological) material to which nutrients were applied, and in which plants rooted. Performed as "substrates," soils assumed the status of infrastructure, the "invisible … background for other kinds of work" (Star, 1999, p. 380; see also Puig de la Bellacasa, 2014). Barring cases of pollution or severe erosion, soils could continue fulfilling their "production function" – that is, supporting plant growth – regardless of their health as living ecosystems. This resulting "invisibility" of soils is now much commented on by English soil conservation farmers, who explicitly position their farming practices as a break with the systemic disregard of soils in modern farming systems.

6 | RE-DISCOVERING SOIL LIFE

Whereas attention to soil and concerns about the role soils play in the farm systems used to be the purview of organic or alternative farmers, these debates have now entered the "conventional" mainstream. Large farming conferences such as Cereals or the Oxford Farming Conference, while still dominated by machinery manufacturers and agro-chemical companies, have been dedicating panel time to farmers discussing their experiences of no-tillage, and hosting soil pit demonstrations. This sense of re-discovery of soils as worthy of attention is well expressed by this East Anglian farmer, who told me:

> Jason[5]: I think we've started to take more of an interest in, this sounds daft because we should have been doing it for the last 30 years, but we've been taken much more interest in soil […] [whereas before] we've been concentrating on speed of work and size of machinery and getting it across the land quickly and so on, we now, we've realised that we've hit this sort of yield plateau so our yields have been sort of semi plateauing although not coming down. […] We just started to look at some of the issues we were having and found that actually most of the fixes were involved in improving the soil.

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Jason's self-conscious confession about the years of "ignoring" soils in this excerpt indicates just how deeply ingrained a perspective on soil as a static medium had become in conventional farming. Instead of "moving across the land," approaching soil as an inert substrate to be worked, Jason is one of the many farmers who are now looking under their feet. Jason arrived at a concern with his soil through the care for his farm business, and a desire to enhance its profitability by increasing his wheat yields. He obtained a scholarship to conduct a research project into wheat yield improvement. By interacting with other farmers as well as agronomy researchers during this period of study, Jason learnt that soil can retain water by binding it with organic matter. However, organic matter levels in his fields, as in the rest of the UK (Environmental Audit Committee, 2016), have been falling. To build organic matter in his soil, Jason started growing cover crops: plants that are not grown for sale, and are sown in between the periods when the fields are cultivated with arable crops. He has also stopped ploughing, and now drills the seed directly into undisturbed ground. We travelled from the farm business to crops to water to organic matter. That is the quality of soil which Jason cares about.

There are other qualities of the soil which farmers care about because they matter to the growth of the crops, and so to the care for the farm business. One of them is friability. Seeds germinate best when they can root easily, and when they have access to adequate, but not excessive, moisture. These conditions have to be created, and creating a suitable seedbed can be a significant undertaking, involving multiple passes with different machineries that work at different levels within the soil to break up compacted layers below, and create a level, friable tilth on the surface. Working heavy clay, as in Shawn's fields in southern England, burns a lot of time and a lot of diesel, and the effort does not necessarily translate into desired outcomes. As Shawn recalled during my visit, in his fields creating a seedbed was always a struggle:

> Shawn: There is very little [of a] gap between [the soil] being too wet and getting too dry. So when it's too wet you can't work it or even drive on it cause it just squashes and squidges into lumps. As soon as it starts to dry very quickly, within a day or two days, it then goes to so hard that you can't break it up. […] I used to plough and cultivate it and try and make a seed bed with this sort of, just pure clay really, never very successful.

Inspired by stories of no-till success from the American farming press, Shawn experimented with shallower ploughing, and found this made creating a friable tilth easier. He found that fewer passes with machinery meant his soil was not compacting under the weight of the tractor. Once he stopped ploughing completely, the structure of the soil begun changing. This, he observed, allowed his crops to germinate and grow better, and he also spent less money on diesel, enhancing the efficiency of the farm. And so soil structure became something he attended to, something he started to care about.

6.1 | Extending farm care networks

For these and all the other farmers I spoke with, attention to soils emerged from the practices of caring for the farm as a business. To better care for their farms, Jason and Shawn researched, read, and experimented with ways of improving their farming operations and enhancing their productivity and efficiency in line with the dominant ideals of "good farming" (Burton, 2004). Caring for their farms meant caring for the crop growth; this in turn made them attend to soils, and specifically soil structure and soil organic matter.

Soil structure and soil organic matter are interesting qualities. They are the outcomes of the activity of soil biota, living and dying within the soil; they are not something that farmers can make, only something they can assist with. Soil organic matter (SOM) is made up of living soil organisms, and plant and animal matter at different stages of decomposition; SOM can only be created by soil biota. Similarly soil structure is partly an outcome of the geologically derived characteristics of the soil (soil type, e.g., chalky, clayey), but is also shaped by the activity of soil organisms that create the underground landscape as they go about their lives. Soil macro-fauna such as worms build channels as they burrow, fungi make soil aggregates by sticking particles together. To change the organic matter content of their soils, and to change their structure, farmers must thus make their soils hospitable to the various creatures that inhabit and make soils. This means minimising soil disturbance (i.e., limiting or entirely removing ploughing), adding organic matter (e.g., manure or composts), maximising the time soil is colonised by living roots (e.g., growing cover crops between cash crops), and diversifying plant species grown through more diverse rotations (Stockdale & Watson, 2012, p. xii). These so-called soil conservation methods make soil life an object of care in a very practical sense; its needs for undisturbed shelter and for a variety of food are acknowledged, and the farming system is modified to accommodate these needs.

Through soil conservation farming, the care network that underpins a farm business is therefore extended to include soil biota. Not so much a "becoming soil biota," the engagement between the farmers and soil organisms was fuelled by

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attentiveness – by curiosity and a desire to learn about what practices may result in better care for soil organisms. The needs of soil life, however, are not easily sense-able. Soil biota do not have an individual or collective "face" they could present, or a body the farmers could affectively relate to. While the farmers I spoke with were enthusiastic about digging soil pits or observing worm activity (which they had been exposed to in their consultations with soil-oriented agronomists or soil scientists at farming conferences and meetings), their motivation for caring for soil biota did not derive from such embodied exposure. The idea of "meeting" soil biota through, for example, soil microbiome testing or soil microscopy was often met with polite indifference; as Rick commented, "it's interesting, you learn something, but then, what do you *do* about it?" (my emphasis). This comment indicates the goal-orientation of attentiveness in care networks – and the ways in which attending to soil biota can frustrate this goal-orientation. The temporalities, scales, and complexities of soil ecosystems make them challenging to both sense and make sense of; cause–effect relationships are chronically uncertain, and agronomic sciences struggle, for example, to correlate soil microbiome profiles with specific land management outcomes, such as plant productivity (Dick, 2018). As a result, the care of soil biota the farmers practised was *speculative and hopeful*; following basic principles of good land management, the farmers hoped that creating a hospitable environment for soil microbes would mean "everything will sort of take care of itself," as Richard put it. Another farmer joked, "it's like in that Kevin Costner movie, if you build it they will come," indicating the ghostly nature of the soil biota's demand on farmers' practice.

For the farmers, the knowledge of the soil biota's needs, and of the appropriate ways of responding to those needs, was derived primarily from a participation in evolving communities of practice which involve other farmers as well as researchers and scientists (Krzywoszynska, 2019). Together, these communities (which include farmer groups but also online forums) experiment with and debate the nature of desirable farming systems that work with rather than against soil ecosystems, pondering re-designs of the care networks that make their farm businesses. Attentiveness introduces uncertainty about the make-up of the farm as hitherto routine farming practices are re-assessed from the point of view of soil biota. Shawn, for example, became concerned about the impacts of synthetic nitrogen applications; while nitrogen "makes a crop so lovely […] we know it's damaging the soil life and it's not really a sustainable way to go on." Wheat and rape, which used to be his major crops, had been bred to respond best to synthetic nitrogen inputs; limiting nitrogen applications in the interest of soil biota therefore meant Shawn needed to change his entire business model, abandoning oilseed rape, minimising wheat, and diversifying into beans and linseed. Other important changes introduced by the farmers I spoke with included integrating livestock (and so including pasture in the crop rotation), planting cover crops, and growing herbal lays. Beyond positive effects for soil biota, these interventions created more varied agro-ecological landscapes providing habitat to a wider range of non-humans.

6.2 | Transforming farm care networks: Potential and limitations

New conceptions of what it was that required care when promoting the farm as a productive and profitable business was altering what the farmers viewed as a "farm business" in the first place. Extending the farm care networks to include soil biota was having transformative effects on the make-up of these networks, producing a critique of the productivist framing of current agricultural practices. This is the radical ethical potential of attention in relations of care I want to draw attention to. Through attentiveness to the needs of the soil entities involved in the care network, the very rationale of the care network, the character of the primary object of care, the farm business, was being revisited.

For Shawn, attending to soil biota meant going directly against the predominant logic of care for the farm as continuously growing the most profitable crops. His more diverse rotations were "not very business-like really […] if you worked out the gross margins of each crop I'd still be growing wheat and rape." However, Shawn stressed that taking care of soil biota was changing the temporal orientation of his farm business from extracting the maximum from the soil today towards maintaining a productive soil in the long term. Rick similarly explained that practising soil-biota-oriented farming was "what I would call a sustainable […] not an environmental sense but a sustainable business in a practical sense. We are not looking at the highest gross margin on every crop, what we are looking at is a robust gross margin that will still give us a sustainable business in a 25-year term." For these farmers, attention to soil biota was also shifting the conception of what a desirable farm business may entail, from a focus purely on yield to a broader interest in farm profitability. As Sebastian argued, "if you've got more of a [profit] margin, it doesn't matter if you're not quite selling the same tonnage."

However, this transformative potential of attentiveness did not affect the anthropocentric character of the care network. It was telling that the farmers generally did not refer to soil life or soil organisms, but to "biology," which they saw as replacing "chemistry" in many aspects of farming in the future. The attention dedicated to the soil biota did not concern their intrinsic worth, but related to their role as *farm labourers* (Krzywoszynska, in press). The care for the soil biota was

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expected to be repaid more or less directly to the farmer, not through broader relational networks, as in the food-web model (Puig de la Bellacasa, 2017). Instead, soil biota were expected to take on farm work that had previously been the responsibility of the farmer. For Jason and Shawn respectively, those tasks were providing plants with water and creating a good soil structure for the seeds. Another "job" soil biota were often tasked with was the provision of plant nutrition; farmers linked increased biological activity in soils with greater availability of micro-elements. Weed management was another hoped-for contribution from soil life; its "job" was to improve soil qualities so that they become less favourable to weed populations. Some farmers further argued that lively soils with higher levels of organic matter could help them prevent or reduce nutrient leaching, which occurs as part of fine particle soil erosion. With increasing pressure on farmers to abide by environmental regulations, this was seen as an important benefit; as Peter argued, "if we get our soil management right we will solve the pollution issue without […] legal constraints on farming at all."

The character of the attention to soil life within the farm care networks was, therefore, "probiotic." What was valued about soil organisms was their "abilities to modulate or recalibrate dysfunctional ecologies" (Lorimer, 2017b, p. 36), regenerating exhausted or unproductive soils in the interest of humans who retained full control over the purpose of these ecologies. This finding contradicts Puig de la Bellacasa's assertion that expansion of care from the crop to the soil food-web will result in production becoming subordinate to the immersed relation (2017, p. 200). However, even probiotic relations are care relations and retain the pull of attentiveness, which in turn creates an ethical demand. In the case of soil conservation farmers, this ethical demand was notable as a sense of uncertainty and frustration when the obligation of care for soil biota seemed to demand reconfigurations of the care network that went beyond what the farmers could achieve, at times challenging the very foundations of their farming business.

The difficulties of reconfiguring the care network had to do first with the risks that soil biota as relational beings themselves introduced into the farm. Caring for soil biota goes beyond the practices that involve only the farmer and the land, but introduces a broader range of entities. Cover crops, for example, in addition to supporting soil biota can support other, non-productive or even destructive non-humans. All are not friends of all in the food-web; Terry's over-winter cover crop encouraged a population of slugs that then destroyed the following wheat crop. When we visited the bare field where wheat ought to have been sprouting we dug up plenty of worms; soil health was looking promising. However, Terry was quick to point out:

> I guess the problem is, Anna, that I cannot sell earthworms. You know? Much as earthworms are a key indicator that the soil is healthy, if I've got earthworms but I don't have good crops, then, it's really no good to me knowing I've got lots of earthworms.

The reconfiguration of the farm care network to include caring for the needs of soil biota also introduces temporal challenges. Caring for soil biota requires making time for their needs; this clashes not only with industrialised agriculture's productivist orientation (Puig de la Bellacasa, 2015), but with the way the broader economies of qualities in agro-food chains influence on-farm temporalities. Farmers thus commented on the clash between the needs of the farm business and the needs of their soils in the timing of planting and harvesting. Patrick's farm, for example, derived most of its income from freezing peas; these have to be harvested when the crop reaches specific qualities demanded by the buyers. This may mean sending heavy harvesters into fields sodden with rain, seriously damaging the soil through smearing and compaction. "You can lie down at the gate," Patrick shrugged, "but if they're ready to harvest…."

The spatial challenge posed by the reconfigured care networks was perhaps the most radical. Attending to the needs of soil biota could lead the farmers to question the very basis of their farming business: the suitability of their land for arable farming. Some of Sebastian's fields, for example, had been converted from pasture to arable land as part of the Second World War domestic food production effort. Ploughing up the slopes has resulted in soil erosion, and a notable difference in soil depth and organic matter content, which Sebastian has been trying to counteract with soil conservation methods. Ultimately though, he admits, these fields "shouldn't have really been planted," and the best thing for him to do from the soil's perspective would be to return them to use as pasture. Erik made a similar damning assessment of his fields, whose soils had high sand and silt content. After a heavy rainfall, his soils tend to "slump," with silt fine particles creating an impenetrable film on the soil surface that leads to anaerobic conditions in the soil – an unhealthy lack of oxygen that damages many forms of soil life. Erik felt his soil conservation efforts could only remedy the situation so far. "We're not in an easy part of the world," he said, "we probably should just be growing grass." For Erik and Sebastian, "growing grass" – that is, producing livestock instead of plants – was not a financially viable option. Following the needs of soil biota to a logical conclusion would require them to go bankrupt.

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Attending and trying to respond to the needs of soil biota highlighted the limited agency the farmers had in reconfiguring their farm care networks. This attentiveness, and its ethical charge, thus did not only produce positive affects of interest or enchantment, but also led to a sense of powerlessness and dis-enchantment. As we stood in his devastated field of wheat, Terry commented:

> Sometimes I just think the easy thing to say would be just to say sod it. Let's forget that I ever had an interest in soil heath, and go back just to farming. And it'd make my life a hell of a lot easier. I think it would be a very short-term approach, but it might just make farming much, much simpler.

Terry's comment again highlights the unusualness of including soil biota in conventional farming systems. "Just farming" implies forgetting about the soil, about soil life, and returning to the more usual idea of soils as an inert recipient of chemical inputs, barely a medium between crops and nutrients. His exasperation is also a warning about the consequences of placing the burden of attentiveness and care on the farmer alone. Reconfiguring care networks so that soil biota can be cared for requires a response at multiple scales, as I discuss further below.

6.3 | Redistributing attentiveness: Scales of attentiveness and care

The limits to the reconfigurations of farming care networks discussed above highlight the importance of relations of power in the work of care – not just between the care-giver and care-receiver, but in the broader landscapes that structure what kinds of care are desirable and, indeed, possible.

In farm-scale reconfigurations of the care networks, farmers' continued care for soil biota hinges on the soil biota's usefulness in supporting the continuity of the farm. This, first, makes soil biota easy to dismiss, as in the current petro-chemical agro-food system soil biota is not, strictly speaking, indispensable, as long as the focus is mainly on the productive function of soils. In the short term, it is possible to continue treating soils like hydroponic substrates, "managed" through a combination of machine power and chemical inputs. Even in a post-oil world, or one without agro-chemicals, farm-scale care networks will favour engagements with soil biota that support the perpetuation of the status quo. Such trends are already apparent, with soil life becoming a form of biocapital as research efforts in soil microbiology focus on ways of manipulating the soil microbiome to enhance crop productivity (Chaparro et al., 2012). By focusing on anthropocentric functions, be they exclusively productivity or the broader "ecosystem services" package, these approaches continue to marginalise soil ecosystems as valuable in and for themselves, and as crucial to the survival of more-than-human lives in ways that may be beyond scientific understanding, and that may challenge current land-use decisions.

Truly responding to soil biota demands that we deal with the inextricable question of desirable land use – the ultimate challenge that farmers who "followed" the needs of soil biota came up against. Recognising that soil biota have needs, and that their needs may clash with the demands of current agri-industrial forms of land use, can result in a transformative critique of the current agro-food system. If our eating depends on thriving soil ecosystems, caring for their well-being must be a priority in any agrarian land-use decision. More broadly, thinking about soil biota as actors in a wider life-sustaining web (such as an element of the "critical zone," as Latour (2014) proposes) allows us to recognise their needs as legitimate in themselves, as part of these entities' work of maintaining and repairing their own worlds and sustaining their own life-enabling webs of relations (Puig de la Bellacasa, 2017).

What caring for soils as inextricable from caring for human eating and living demands is a careful coordination of the activities of land-working humans in relation to the activities and needs of soil entities. Practically, following the needs of soil biota – their need to live so that we, too, may continue living – demands we develop approaches to land use, including food production, which start from the needs of the soil. What these may look like is today not clear, and will demand cooperation between land users, land governance, and scientific research. While there is broad agreement around some principles of good land management in arable systems (such as additions of organic matter, crop rotation, and minimal tillage; e.g., Stockdale & Watson, 2012), our scientific understanding of the relationships between land use, soil ecologies, crop productivity, and ecosystem functions, and their scalar and spatial variation, is currently limited. A dialogue around what may count as "needs" of soils, and how to adapt human practices to those needs, is only starting to take shape. What is indisputable is that there is no alternative. We need living soil to sustain life on the planetary surface (Shiva, 2008, p. 6). We need to hear – and heed – the silent call of soil.

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7 | CONCLUSIONS

In the face of ecological and resource crises of the Anthropocene, a pragmatic and anthropocentric form of eco-sociality is emerging, in which caring for human survival and well-being starts to implicate caring for the survival and well-being of non-human entities. Practices of care demand attentiveness to the entities cared for so that their needs can be known and responded to. Scholars of relational ethics have invested much hope in attentiveness as a catalyst for the expansion of ethical relations, with the assumption being that attending to non-humans will produce better relations with them. In this paper, I analyse the potential for and limitations of attentiveness as a pathway for forging better relations with soil biota. Noting the importance of power and scale in shaping the ethical potential of attentiveness in care practices, I argue for a more nuanced understanding of the work that attentiveness can do as a conduit for expanding ethical relations with non-humans.

To explore the ethical potential of attentiveness, I propose the care network model as a pragmatic and practice-oriented tool for conceptualising care relations and tracing the work of attentiveness in specific places. As care-givers seek to better attend to the needs of the primary object of their care, they extend care to other entities on whom the well-being of the primary object of care depends – this produces care networks. Attentiveness in care networks is always an attentiveness *towards*; the reason for attending to the needs of other entities is to better satisfy the needs of the primary object of care. The hope is that attending to the needs of those in the care network will result in a reflexivity about the primary object of care. This is indeed what occurred in the case study discussed here. Attending to soil biota as a way of caring for the farm business has led to a certain re-configuration of both the farm businesses and land use practices. However, the farmers' power to act was also limited. This case study thus illustrates the practical limits to work that attentiveness can do in producing better human–non-human relations.

It is only when caring is more than the obligation of particular individuals, and becomes a systemic project, that the radical potential of attentiveness can be fulfilled. In the case of soil biota, caring for soils is currently configured primarily as the obligation of the individual farmer, whose power to act is constrained. To achieve real transformation of our relations with soil, the obligation for soil care needs to be extended to all the participants in the agri-food system. Beyond food-related land use, we can see all human practices as impacting on and implicating soils. Assessing all our actions in relation to the needs of the soil – taking seriously the notion of Earth citizenship that Shiva (2008) proposes – would be an exciting and radical extension of the soil care network. Acknowledging our rootedness in soils may finally re-position human activity so that we form a symbiotic and not parasitic relationship with the bio-geo-chemical cycles of planetary life.

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ENDNOTES

[1] This thinking of care as a way of creating live-able relations resonates with Hinchliffe's conceptualisation of care as "produced with and as others, and … neither selfless nor only about the self … a gathering together that is not too tight and can thereby work to confirm rather than to assimilate others" (2008, p. 95).

[2] In arable farming different crops are grown in succession on the same parcel of land; this is known as a rotation. The standard crop rotation in England at the moment is wheat, wheat, oilseed rape. Establishing each crop involves a number of soil-related practices, from establishing a seed bed, through seeding, to crop and/or weed spraying, to harvest. As a result arable systems involve the most intense soil–farmer interaction.

[3] The UK overall has a significant gender imbalance in the farming population; 90% of full-time farmers are male (see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/654742/structure-jun2017final-eng-26oct17.pdf).

[4] NB: he was accused of plagiarising the work of another German chemist Carl Sprengel (van der Ploeg et al., 2001).

[5] All participants in this research have been given pseudonyms.

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