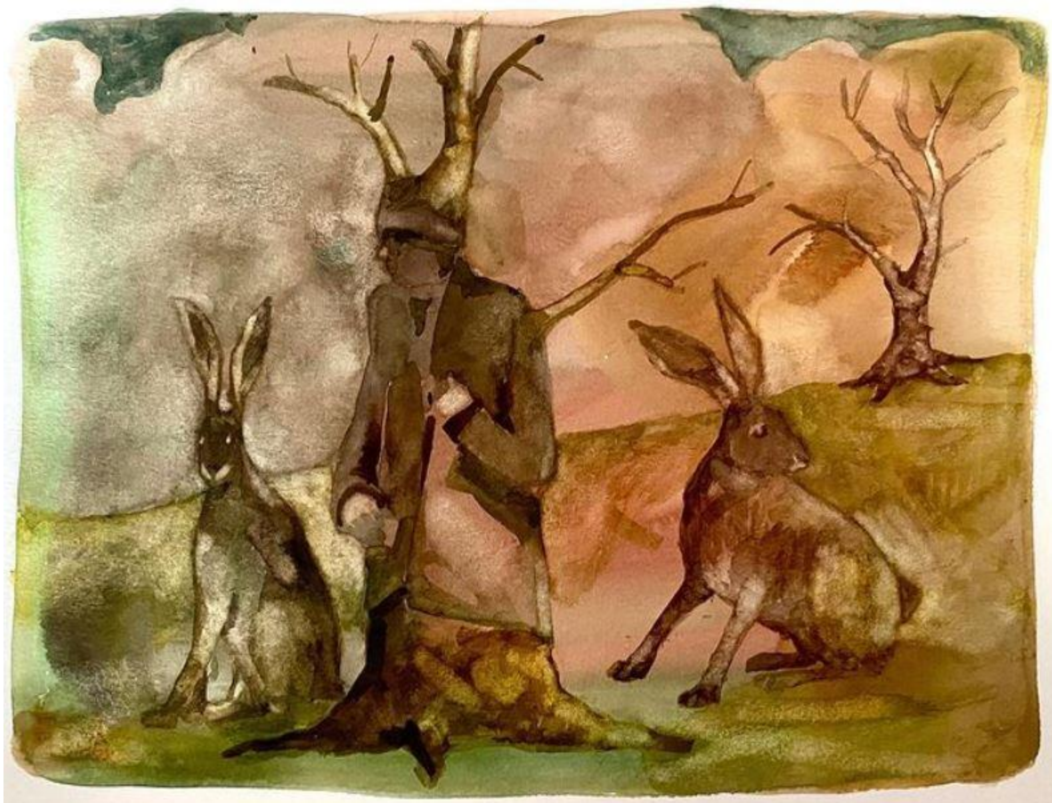
As the Soil, So the Human:

Narratives of Ontological Entanglement and Soil Management in Regenerative Agriculture



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Abstract

Regenerative agriculture is a diverse, highly contested, and rapidly developing sustainable agriculture movement. It has been lauded for its transformative potential, and criticized for its incoherence and susceptibility for corporate co-option. At the heart of regenerative agriculture is an effort to engage with soil life rather than bypass it; this ethos and the messiness of the movement indicate that a range of novel human-soil relations may emerge within this space. Semi-structured interviews were conducted with members of intermediary organizations – research institutes, consultants, and NGOs, among others – that are active in promotion and advocacy for adoption of regenerative practices in order to explore these changing human-soil relations. Interviews focused on conceptualizations of soil (life), forms of analysis and knowledge production around soils, regenerative soil management, and the larger goals of regenerative agriculture, including addressing climate change and improving the economic situation of farmers. Results were subject to narrative analysis, which indicated that respondents acknowledged the fact that soils are living, rather than inert substrates reducible to chemical and physical criteria. Soil biology was understood and engaged with to different extents, and a wide range of analytical tools were used to scrutinize soil, including microscopy, genetic testing, measurement of soil organic carbon, among others. Overall, narratives indicate that a wide range of human-soil relations can be identified within regenerative agriculture, including care, exploitation, and relatively novel mechanisms of commodification and financialization of soil life through the development of soil carbon credits. Further, results indicate that this variation is produced by differences in human approaches to understanding, analyzing, and managing soil life; different approaches to producing knowledge about soils facilitates the creation of different kinds of relations. Building on the narratives, it is argued that the human should be theoretically (re)centered in the social science study of regenerative agriculture and human-soil relations, in order to maintain a uniquely human sense of responsibility to address, among other challenges, climate change. Similarly, the role of alternative ontological outlooks on soils and nature in food system transformation is discussed.

Contents

1 Introduction

Regenerative agriculture is a system that broadly aims to build soil health and 'regenerate' agroecosystems (Kasam and Kasam, 2021). Some commonly employed regenerative practices include no-till, cover cropping, crop rotations, crop-livestock integration, and various forms of high-intensity rotational grazing (Giller et al, 2020). No-till practices can protect against erosion, increase accumulation (or at least decrease the rate of loss) of soil organic carbon (SOC), and improve water infiltration and retention (Magdof and van Es, 2009). Crop rotations and cover crops can increase levels of soil organic matter (SOM) and generally support more diverse microbial communities that can in turn reduce pest pressure (ibid). There is considerable debate in the scientific literature about rotational grazing, but some farmer-advocates of the method claim it can produce benefits to SOC accumulation, soil biology, nutrient cycling, and farm profitability (e.g., Brown, 2018; Sheppard 2013). These methods are common features of regenerative agriculture, but in practice there is a diversity in application and arrangement of the different methods. Overall, it is often argued that many methods must be used concurrently to produce benefits. If this is done, then regenerative agriculture can theoretically present a win-win for profit and planet (LeCanne and Lundgren, 2018); this hypothetical win-win is a key feature of popular narratives of regenerative agriculture.

Regenerative agriculture has seen an explosion in popularity amongst farmers and in the popular media since 2014/15 (Giller et al, 2021), reaching an apogee with the Hollywood film *Kiss the Ground*. The usage of the term predates the recent surge in popularity by decades, with the notion first put forward by the US-based Rodale Institute in the early 1980's. Early definitions emphasized the importance of increasing, rather than decreasing, soil depth, fertility, and integrating soil flora and fauna into soil regeneration processes (Rodale, 1983; Harwood, 1983). The early discussions of regenerative agriculture also emphasized the role of "intimate relationships" between humans and nonhuman components of the system (Harwood, 1983). Further, an assertion was made that regenerative agricultural practices could result in increased profit and yield, rather than the decreases typically associated with other environmentally conscious agricultural systems, such as organic agriculture (Rodale, 1983; Harwood, 1983). These definitions set the stage for many of the main themes that can be observed in the modern regenerative agriculture movement(s): soil as the prime object and site of intervention for producing positive ecological outcomes, the importance of developing more "intimate" connections with the farm system and its non-living/human components, and the assertion that regenerative practices can resolve trade-offs between profitability and environmental sustainability.

Today, there is considerable uncertainty and debate about what constitutes regenerative agriculture (e.g., Giller et al, 2021; Schreefel et al, 2020). A number of studies have been undertaken to highlight key points made by proponents of regenerative agriculture and move towards determining a clear definition (Schreefel et al, 2020; Newton et al, 2020). Schreefel et al present a tentative unifying definition of regenerative agriculture, in which it is "an approach to farming that uses soil conservation as an entry point to regenerate and contribute to multiple ecosystem services", and that above all "the soil is the base" (2020). This definition highlights the centrality of soil and soil conservation methods in regenerative agriculture, but it does not provide much additional clarity in terms of what practices are involved in regenerative agriculture or how to measure its purported impacts.

Starting from a sociological perspective, Burns has defined regenerative agriculture as a “farmer-led social movement” (Burns, 2020), and there is no doubt that there is considerable farmer-led interest in regenerative agriculture. However, in addition to being a famer-led movement with a growing presence in popular media, part of why the notion of regenerative agriculture has received so much recent attention is due to significant private investments made by major players in the agribusiness industry. Cargill, Nestle, General Mills, Danone, and other major players have made commitments to make significant investment into regenerative agriculture in their supply chains (Cargill 2020a, 2020b; Nestle, 2021; General Mills, 2019; Danone, 2021). This has caused some commentators to express concern about the potential co-option and dilution of regenerative agriculture, which could severely limit its transformative potential (e.g., Kloehn, 2021; Fassler, 2021).

Much of the debate and investment in regenerative agriculture has been galvanized by strong claims about the potential benefits of regenerative agriculture. Regenerative agriculture, it is argued, can sequester carbon in the soil, and therefore contribute to climate change mitigation efforts (Lal, 2018; Toensmeier, 2016). The Rodale Institute – which pioneered the term – published two influential white papers in 2014 and 2020 that present particularly grand claims regarding the mitigation potential of regenerative agriculture (Rodale Institute, 2014; Moyer et al, 2020). The 2020 white paper makes the claim that global adoption of regenerative practices would sequester “more than 100% of current anthropogenic emissions of CO_2” (Moyer et al, 2020). There is considerable debate about the validity of these claims in general (e.g., Giller et al, 2020), and Amundson et al argue that, from a soil mass-balance perspective, the prospect of literal regenerative agriculture is physically impossible (2015). There are also ongoing debates with respect to the purported benefits of specific practices such as no-till (Powlson et al, 2014; Paustian et al, 2016) or rotational grazing (Garnett et al, 2017; Briske et al, 2008); the Rodale Institute’s white papers and reverberations of the claims made therein have contributed to the growth of interest and investment in regenerative agriculture, nonetheless.

One of the key developments building on such claims concerns the development of methods to derive, verify, and trade soil-based carbon credits. Microsoft famously purchased 100,000 carbon credits (approximately 100,000 Gt CO_2eq; the sale was worth around 2 million USD) from a subsidiary of the Land O’Lakes farmer cooperative in the USA (Ellis, 2021). A similarly large purchase of carbon credits by Microsoft from an Australian ranch was facilitated by the start-up Regen Network (Condon and Thackray, 2021). Rabobank in the Netherlands has developed a carbon marketplace, called Acorn, and has been involved in developing and facilitating the exchange of agriculture-based carbon credits with organizations such as ReNature, a prominent NGO in the regenerative agriculture space (Manning, 2021). Much of the corporate investment in regenerative agriculture thus seems to be predicated on the potential to benefit (environmentally and/or financially) from emerging soil carbon markets.

Many emerging soil carbon markets are voluntary markets. As such, there is no standardized methodology used for developing and verifying soil-based carbon credits. Further, there are inherent challenges with measuring soil carbon (Paustian et al, 2016; Powlson et al, 2014), and as such a range of methodologies, from physical soil samples to modelling techniques to remote sensing tools are employed by different projects (Smith et al, 2019). (Carbon)plan, a think tank that evaluates the scientific legitimacy of carbon removal programs, assessed 17 SOC measurement methodologies that are currently in use in voluntary carbon markets (2021). Their assessment found that 13 of the 17 methodologies – including Regen Network’s – required either no physical soil sample or site visit whatsoever or an inadequate number of samples to calibrate modelling or remote sensing tools (2021). This represents a legitimacy problem for regenerative agriculture and connects to some of the larger debates that are underway within the movement.

Central to many of the challenges that regenerative agriculture is facing is the interaction between measurement and context. Many proponents of regenerative agriculture emphasize the importance of context (e.g., Kassam and Kassam, 2021; Danone, 2021), but little is said about how to determine the context in which a given method will and won't be beneficial, which results in confusion and precludes realization of positive ecological outcomes (Giller et al, 2021). Related to this is an ongoing debate about whether to define regenerative agriculture in terms of its practices or its measurable outcomes.

The Rodale Institute, with it's pioneering regenerative organic certified (ROC) framework, epitomizes a practice-based definition of regenerative agriculture. The ROC framework incudes criteria based on practices, such as no-till and cover cropping (ROC, 2021). One challenge with this approach is how to use one certification scheme to evaluate farms in diverse ecological settings. Grazing methods, for example, may have radically different requirements and outcomes in different contexts (Garnett et al, 2017). A solution to this problem is to define (and certify) regenerative agriculture based on ecological outcomes. Climate Farmers, a Germany-based NGO promoting regenerative practices, recently held a 'congress' in which a regenerative agriculture manifesto was developed. In the manifesto, a strong case is made for outcome-based definitions, stating that they "embrace the diversity of pathways towards regenerating in different contexts" and that "outcomes should be clear indicators which reflect the full potential of the given context" (Climate Farmers, 2021). The challenge with an outcome-based definition, however, is the need for precise, quick, and cheap measurement of outcomes.

Regenerative agriculture is an ambiguously defined system of agriculture that has seen interest and participation from a wide range of actors, from small-scale farmers to massive agribusiness corporations. As such, there is considerable uncertainty regarding what it means, how its impacts can be measured, and whether it can be a positive transformative force for the global food system. The remainder of this section will explore a common feature of regenerative agriculture: the centrality of soil, and, increasingly, soil life.

1.1 Soil (life) in regenerative agriculture

A key aspect of regenerative agriculture, particularly evident in popular and social media, is an ontological reframing of soils as living ecosystems rather than as inert substrates governed exclusively by chemical and physical properties (Puig de la Bellacasa, 2015; 2019). Woody Harrelson eloquently introduces this reframing of soil in *Kiss the Ground:* "I went to years of college, and I took soil science. I didn't know. I really did not know how the soil worked. *It's alive"* (emphasis added). Shifting the emphasis to the biological components of soil and soil functions represents a movement from working the soil to working *with* soil life. Many regenerative farmers are putting soil life at the centre of their analysis and management as they acknowledge that "[i]n order to live *at all,* we need new modes of living *together"* (Krzywoszynska, 2019; emphasis in original).

Stressing the need to recentre soil *life* in our analysis and understanding can be found coming from many diverse and disparate actors in the regenerative agriculture space. On a Climate Farmers Academy page on soil health, it is stated that "[a]s humans we might feel disconnected from [soil] microbes but we have to realize that they are the backbone of our ecosystems, and dare I say of our economy" (de la Serna, n.d). Soil health is defined in the Rodale Institute's Regenerative Organic Certified (ROC) scheme as:

> "[T]he continued capacity of soil to function as a *vital living ecosystem* that sustains plants, animals and humans. Soil isn't an inert growing medium, but rather is teaming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem." (ROC, 2021, emphasis added).

The *Global Soil Biodiversity Atlas* unequivocally claims that "the role that living organisms play in soil development cannot be overstressed" (as cited in Krzywoszynska, 2020, pp. 229). Terra Genesis International, an NGO avid in promoting regenerative agriculture, stresses the importance of "a mega-diversity of microbiology" for regenerative systems (Soloviev and Landua, 2016). Regeneration International, another prominent organization advocating for regenerative agriculture defines regenerative agriculture as "farming and grazing practices that, among other benefits, reverse climate change *by rebuilding soil organic matter and restoring degraded soil biodiversity"* (2017, emphasis added). "The word humans", states Gabe Brown, an outspoken farmer-advocate in a World Economic Forum promotional video, "comes from the word humic, which means soil. We need to realize that soil is part of us" (World Economic Forum, 2019). Many more examples of the foregrounding of soil life can be found in popular and social media concerning regenerative agriculture[1].

The shifting emphasis on soil life within regenerative agriculture can be linked to developments in the soil sciences. The soil sciences have acknowledged the fact that soils contain living organisms, but only in the last few decades as the irreducibility of these organisms and ecosystems to their chemical and physical characteristics become apparent. Puig de la Bellacasa describes this shift to thinking of soils as living in the soil sciences, and notes that is often marked by the increasing use and significance of the term soil "biota" to refer to all manner of soil organisms (2015). She states that the changing science on soil moving towards the notion that "[o]rganisms *are* soil. A lively soil can only exist with and through a multispecies community of biota that *makes it"* (ibid, emphasis original). These developments in soil science have been linked to, for example, the growing emphasis on the concepts of soil health and soil functions (i.e., ecosystem services) in the scientific literature (ibid).

These shifting conceptions in regenerative agriculture can also be linked to the growing political importance of soils, particularly as related to the climate crisis. During her ethnographic work in Colombia, Lyons studied state soil scientists as they participated in a national year of soils, one of the aims of which was to spread awareness about the importance of soil biology (2020). Similarly, the UN designated 2015 the international year of soils, and has continued to release promotional materials and publications regarding the importance of soil life since. Prior to World Soil Day in 2020, the FAO released a report entitled *State of Knowledge of Soil Biodiversity,* which states that "soil biodiversity provides a wide range of biological functions which are key attribute [*sic*] of a sustainably managed soil", and that

[1] And elsewhere in popular discourses. Puig de la Bellacasa (2019) provides an overview of representations of soil life in artistic projects, for example.

"soil biodiversity […] is at the heart of the alignment of several global agendas such as the UN Sustainable Development Goals (SGDs)" (FAO, 2020).

Schreefel et al were correct in stating that "soil is the base" of regenerative agriculture (2020), but for many it is soil *life* that is the base. This reframing of soil as living is not universal within regenerative agriculture but is a persistent and common theme. Further, the techniques and strategies used by regenerative farmers create new ways of interacting with and managing soils and, to some extent, a new appreciation for the complexity of soils of which biology is an intractable component. However, the diversity of methods for measuring and estimating SOC stocks and fluxes in the literature and being developed by industry participating in voluntary markets represents – in addition to a major challenge for regenerative agriculture practitioners, farmers, organizations, and policymakers – a range of methods for scrutinizing soil biota. Therefore, we have a range of methods in use that abstract, objectify, and eventually financialize soil biota. This is, perhaps, in sharp contrast to the ontological reframing of soils as living that can be found throughout the regenerative agriculture movement.

1.2 Problem statement

Regenerative agriculture is an emergent movement in sustainable agriculture. It is poorly defined, and proposed definitions are highly contested. A cannon of typical practices is associated with regenerative agriculture, but there is considerable uncertainty regarding the universality, transferability, and exclusivity of these practices. Further, there is a disparate range of actors involved in regenerative agriculture, from small-scale farmers to NGOs to 'conventional' agribusiness players. What unifies the diverse movement is the primacy of soil and the aims of relating to the environment in a better way through changing human-soil relations. Through new ways of relating to soils (and through them to the environment), it is argued, the food system can be transformed to be more resilient and can contribute to mitigating carbon emissions.

The aim of this study is therefore to investigate the diverse ways that people in the regenerative agriculture space derive knowledge about and interact with soils. Sensory and embodied ways of interacting with and knowing soils are regularly promoted within the regenerative agriculture space. Regenerative practices – such as no-till and rotational grazing, among others – are increasing in popularity as they are construed as ways to protect or take 'care' of soil life. But, as noted, there is considerable uncertainty regarding the ecological impact of these practices and, in the new context of using agriculture to address climate change, the classic agricultural refrain is again reiterated: you can't manage what you can't measure. As such, a range of tools and methodologies based on the objectification and reduction of soils are also being utilized under the moniker of regenerative agriculture. This study explored these and other diverse ways of knowing and interacting with soils – old, new, and in between – that exist within the regenerative agriculture space and contribute to understanding how human-soil relations are changing in this space and what this could mean for the future of regenerative agriculture

1.3 Roadmap

Chapter 2 will provide a discussion of the theoretical background used for this thesis. The research primarily engages with and takes as a starting point social theory in the so-called nonhuman (or ontological) turn. Chapter 2 will provide an overview of these approaches, specifically in the context of the study of soil and soil conservation, and situate the project within larger debates about the analytical and political quality of nonhuman turn theories. Building from this theoretical background, chapter 3 will outline the central research question and sub-research questions, and discuss how the key methodology, semi-structured interviews, will be used to answer these questions. Chapter 3 will further discuss the positionality of the researcher, and provide background information on interview respondents and their respective organizations. Chapter 4 will analyze data derived from the interviews in detail, and focus specifically on how narratives presented in these interviews address the central- and sub-research questions. Chapter 5 will expand the analysis, contextualize interview data with respect to broader political and theoretical themes, and discuss the role of alternative ontological outlooks (on soil) in regenerative agriculture's project to transform the food system. Finally, chapter 6 will summarize these findings and discuss limitations and areas for future research.

2 Theoretical Background

A handful of social scientists have explored changing human-soil relations in the context of agriculture and the soil sciences. This project aimed to contribute to this growing body of literature by taking regenerative agriculture as a case study of a site of changing ontological outlooks on and ways of relating to soils. Many proponents of regenerative agriculture, as we have seen, reframe soil as living compared to as an inert, non-living substrate. This idea is characterized in different ways by various proponents of regenerative agriculture and regenerative agricultural methods. However, considering the ambiguous and contested definition of regenerative agriculture, the strong emphasis on soil and associated ontological reframing can be understood as a common – if not necessarily universal – and in some cases foundational precept of the movement(s). This is in contrast to narratives of soil as inert substrates primarily characterised by their physical and chemical qualities that has long been dominant in conventional agriculture (Puig de la Bellacasa 2019; Krzywoszynska, 2019).

This chapter will proceed by first reviewing relevant literature on the changing dynamics and forms of human-soil relationships, primarily in the context of agriculture but also including research on soil scientists. The study of changing human-soil relations will then be situated in broader discussions of the nonhuman turn and academic efforts to 'recentre' nonhuman life. Finally, a case will be made for the suitability of using regenerative agriculture as an entry point to explore changing human-soil relationships in particular, and through this changing human-nonhuman/human-nature relationships more generally.

2.1 Human-soil relations in social science literature

Maria Puig de la Bellacasa has conducted research with soil scientists, farmers, gardeners, artists, and others in her exploration of changing conceptions of and ways of relating to soils (2015; 2019). The basic premise of her work is that "modes of soil care and soil ontologies are entangled: what soil is thought to be affects the ways in which we care for it, and vice versa" (2015). Her writing has a relatively optimistic tone, often focusing on the notion that changing conceptions of soil can lead to different, better ways of caring for soils.

Part of Puig de la Bellacasa's research on changing human-soil relations involved fieldwork with Dr. Elaine's™ Soil Food Web School. The school (which now has a strong online presence and materials) teaches budding regenerative farmers to think of and interact with their soil as complex, multispecies communities that are temporally and spatially dynamic (Puig de la Bellacasa, 2015). Therefore, the soil food web on different plots of land must be dealt with as unique and place-based, which invites close interaction with and attention to soil biota. Puig de la Bellacasa argues that "within these conceptions of soil, to properly care for the soil humans cannot be only producers or consumers in the community of soil making organisms but must work, and be, *in* relation to soil as a significant living world" (2015, emphasis original). Through changing ontological conceptions of soil, we can interact with soils in more caring and attentive ways.

Puig de la Bellacasa also investigates changing human-soil relations from the perspective of affective interactions. She does this by studying artists exploring alternative soil ontologies, changing discourses and public communications in the soil sciences, and practitioners of soil conversation methods (2019). In this analysis, the role of collapsing the human-nature dualism in human-soil relations is emphasized. These different forms of engagement with soils – through art, through changing scientific conceptions, or directly with the soil at a garden or farm – can influence the way we conceive of soils and thus how we interact with them. "Stories that spiritualize the soil […] relinquish the identity boundaries of Anthropos for an experience of cosmic intimacy" which can result in better care for soil life (ibid).

Anna Krzywoszynska's research on changing human-soil relations centres on farmers and their practices. She studies conventional (not organic) farmers in the UK who are employing regenerative practices to conserve and build soil health and focuses on the way these farmers talk about, interact with, observe, analyze, and manage their soils and soil biota. Similar to Puig de la Bellacasa, her entry point is to conceptualize soil biota as an object of care and attentiveness for farmers (Krzywoszynska, 2019). By considering soil as living and being attentive to their needs, farmers are engaging in acts of care of soil biota. She considers soil biota as part of a 'care network', rather than as an isolated object of care. This, Krzywoszynska argues, will help to "understand the potential and limitations of attentiveness as a tool for expansion of ethical concern and practical action in more-than-human worlds" (2019).

The limit of attentiveness emerged quickly in Krzywoszynska's research. She, following from Lormier (2017, as cited in Krzywoszynska, 2019), considers the form of care for soil biota that she has witnessed to be *probiotic* (Krzywoszynska, 2019). This means that care for soil biota is not performed for the sake of the soil biota, but for expected benefits that a cared-for soil will provide to the main object of the farmers' care: the farm enterprise. While describing soil management in productionist agriculture, Puig de la Bellacasa states that "the drive of care has mostly been for crops as commodifiable produce" (2015). Krzywoszynska's farmers may be grappling with new ontological conceptions of soil, but the 'drive' of their care seems largely unchanged.

Soils are 'cared for' as productive and resource-making entities (Krzywoszynska, 2019). This leads Krzywoszynska to theorize soil biota as being enrolled as *labourers* in the process of 'improving' soils; that is, rendering them productive in capital accumulation processes (2020a). In order to do this, Krzywoszynska diverges from Marx's nature-culture dualism (which considers labour to be a uniquely human activity). This allows her to conceptualize soil biota as being recruited in capitalist relations in much the same way that human labourers are (2020a), which in turn builds on the notion of probiotic care for soil biota and shows clearly how (the products or activities of) soil biota enter into the capitalist economy. Importantly, Krzywoszynska makes the distinction that the enrollment of soil biota in accumulation processes is still indirect; it is based on soil biota rendering soils as such productive and the *products* of soil biota's activities (crops) are then commodified, not the soil biota itself (2020a).

The subjects of Krzywoszynska and Puig de la Bellacasa's research are, almost exclusively, people embedded in western scientific traditions of understanding, speaking about, and managing soils. Kristina Lyons, her ethnographic study centred in the southern Amazon of Colombia, introduces some non-western conceptions of soils in the context of changing human-soil relations (2020). Her research focuses on both indigenous farmers in the province of Putomayo – who carry on and take inspiration from traditional ways of knowing and managing soils – and state soil scientists struggling to find the balance between reframing soils as living and promoting them as productive resources (ibid).

Heraldo, a key farmer-informant for Lyons' research, does not send soil samples for laboratory analysis:

> "[the decision] is not just a question of reducing costs and external dependencies […] it emerges from the ontological differences between treating soils as artificial strata, or at best a natural body that can be routinely chemically manipulated, and interacting with soils as living worlds that are inextricable from their ecological relationalities" (Lyons, 2020, pp. 33).

The ontological reframing of soil, in this instance, results in farmers like Heraldo seeking different kinds of relationships (including no relationship) with sources of external expertise concerning soils. This dependence on external expertise is (more or less) replaced with the traditional practice of "cultivating eyes for her [la selva/the 'jungle']", which aims to "produce a different kind of human, a human that becomes one with the selva's agroecological and territorial conditions" (Lyons, 2020, pp. 90). Cultivating 'eyes for her' is largely based on the practice of *lecturaleza,* which can roughly be translated as "reading nature" (ibid). *Lecturaleza,* importantly, "does not depend on an ideal of an object 'out in nature'" and is instead about following the processes and actors/organisms within nature (ibid, pp. 92). This produces a fundamentally place-based and temporally contingent agroecological knowledge: cultivating eyes for her is not about producing generalizable agricultural advice, but about paying close attention to and learning from the processes of nature. The ontological (re)framing of soils as living is a fundamental aspect of Heraldo and others' approaches to farming and is observed in conjunction with a coherent epistemology (cultivating eyes for her) and methodology (*lecturaleza*) (ibid).

Farmers such as Heraldo are not the only people in Lyons' work who are grappling with alternative conceptions of soils. Much of Lyons' research follows various state soil scientists and agronomists, largely centered around the efforts to promote the Colombian campaign for the "year of the soils" in 2009 (2020). Lyons focuses on how these scientists are working with the growing prevalence of soil biology in the soil sciences and agronomy. In recent decades, increasing attention has been paid to the role of soil biota, compared to the historical predominance of chemical composition and physical structure. As this is ongoing, funding for soil biology dwindles, and the various roles of soil biologists are increasingly subsumed into the roles inhabited at universities and research institutes by agronomists, physicists, and other non-biologists (Lyons, 2020). There is a movement in the soil sciences to emphasize biology, and a concurrent countermovement reducing institutional funding and support for state soil biology/ists. This results in a tension among state soil scientists,

> "between acknowledging what I [Lyons] came to think of as *soil as living system,* situating its ecological conditions of existence and rights to health for its own sake, and employing *soil as labourer* – the preoccupation with ensuring its economically productive capacities, future-oriented ecosystem services, and monetary value" (Lyons, 2020, pp. 51, emphasis original)

Treating soils as a living system reflects recent scientific advances in soil science/biology. However, presenting soil as a resource whose "labour" can be made productive is necessary for securing funding and public interest in soil (life). Parallels can be drawn here between Lyons' soil scientists and practitioners of regenerative agriculture. Both are working to find a balance between appreciating soils as living and promoting the productive, quantifiable, and financializable benefits of soils in order secure funding and the future for their ideas and practices.

The authors above have made important headway in the study of changing human-soil relations. In particular, the work of Krzywoszynska (2019, 2020a) levies an empirical challenge against the notion that "knowing soils better could enable better care" (Puig de la Bellacasa, 2019). This moves attention to how shifting conceptions of soil are taken up and adapted in relation to existing tools, methodologies, institutions, and economic imperatives that are based on more traditional scientific ontologies of soil as inert. Heraldo and other non-conventional farmers studied by Lyons had clear epistemologies and methodologies to support their ontology of soil as deeply complex and alive (2020). Farmers and other proponents of regenerative agriculture, for the most part, instead are largely reliant on traditional scientific methods of knowing and relating to soil and their associated ontological assumptions concerning soils.

2.2 Soils and the nonhuman turn

This section will situate the study of changing human-soil relations – in the context of regenerative agriculture and more generally – in recent discussions and critiques of the nonhuman turn in the social sciences (e.g., Büscher, 2021). The way that Puig de la Bellacasa, Krzywoszynska, and Lyons engage with and centre soils in their research partly emerges from the nonhuman turn. The core propositions of the nonhuman turn, as interpreted by Büscher, are "an emphasis on ontological entanglement and relationality, a concern to (re)distribute agency away from humans, and questioning of distinction and distinction making mechanisms" (2021). Investigation of how humans are reconceptualizing and changing their ways of relating to soils can be informed by and, ideally, contribute to broader discussions of the nonhuman turn in social theory.

Soils present a particularly compelling "object" for study of changing human-nonhuman dynamics. In their sheer complexity and dynamism, soils defy ontological delineation (Lyons, 2020). It is extremely challenging, if not impossible to clearly separate the living and non-living components of soils, let alone different populations of microbes, fungi, bacteria, and so on. Based on this ontological opacity, soils can be construed as a metonym for the environment as a whole. It is challenging to draw ontological lines between living and nonliving components of the earth system as a whole: so too for soils. Through changing relations to soil, proponents of regenerative agriculture seek to change the human-nature relationship in general. Soil is both the site through which we could have a positive impact on the environment, and in its complexity is representative of the challenges of fully and precisely understanding it and the impact of human actions on it. Thus, how we approach improving our relationships with soil can be seen as a microcosm for how we might approach changing our relationship with the environment as a whole.

Investigating human-soil relations in this light can connect in particular to recent critiques of the nonhuman turn, levied by, among others, Malm (2018), Foster (2016), and extended and nuanced by Büscher (2021). A key criticism presented in this debate is that the nonhuman turn, while analytically useful in many instances, can fail to make *consequential* distinctions (e.g., between culture/society and nature, between human, non-human, and non-living forms of agency) that are necessary to act to address modern environmental crises (Malm, 2018; Büscher, 2021). Inability to inform or even inhibition of effective political action is problematic for the nonhuman turn as it has emancipatory political objectives itself (Büscher, 2021). The political objectives of nonhuman turn scholars are similar to the objectives of proponents of regenerative agriculture that reframe soils as living: figure out how to foster symbiotic, convivial relationships between humans, nonhumans, and the environment in general.

Büscher (2020) proposes a few analytical shifts that could help move nonhuman turn theory forward in a productive way. One of these is a shift from emphasizing the more-than-human (that is, ascribing agency and analytical centrality to nonhumans and historically marginalized humans) to a dialectic between the more-than-human and less-than-human (Büscher, 2021). Less-than-human here refers to actions or processes that marginalize, objectify, alienate, or otherwise "diminish" both nonhumans and humans (ibid). This, it is argued, will help move attention towards how particular forms of entangled human-nonhuman relationships historically emerge as opposed to solely emphasizing *that* humans and nonhumans are entangled (ibid). It is important to highlight the deep interrelatedness between, for example, humans and soils. In order to inform effective action, however, this analysis needs to move beyond highlighting that interconnectedness to understanding how and why particular human-soil relationships (exploitative, caring, objectifying, etc.) develop and change throughout history.

Krzywoszynska's (2020a) discussion of the enrollment of soil biota as labourers provides a clear example of this more-than-/less-than-human dialectic. The changing emphasis on soil life, conceptualization of soil as living, and acts of caring for soil represent the more-than-human side of the dialectic. Krzywoszynska's discussion of how this emphasis on soil life results in those biota being enrolled in accumulation processes and being cared for only in the larger endeavour to care for the farm business represents the less-than-human turn. Through this enrollment, soil biota are objectified, manipulated, and otherwise appropriated into capitalist relations. Growing scientific and public discourse around soil life prompted farmers to adopt soil conversation methods and to starting to think of soils as alive, but these methods were adopted in a particular socioeconomic and cultural context. This led to farmers to experience wariness and uncertainty towards their new strategies of knowing soils (Krzywoszynska, 2020b) and to incorporating their "care" for soils into their lifelong pursuit of economic objectives (Krzywoszynska, 2020a). This dialectic could be a useful starting point for analyzing different movements in regenerative agriculture to recentre and reframe soils as living on the one hand, and to enroll soil life in the pursuit of profit, productivity, and accumulation on the other.

Another of Büscher's proposed analytical shifts: instead of decentering the human in all instances, we should "de- or re-centre [the human] as appropriate based on the consequentiality of distinctions" (2021). The regenerative agriculture space is an appropriate research site for exploring the "consequentiality of distinctions" between humans and nonhumans (soil life), to work to understand if this is a context in which humans should be de- or re-centred. Practitioners of regenerative agriculture are engaged in attempts to ontologically reframe soils as living, operate based on functional distinctions between soil life and themselves, and are potentially implicated in a number of "dehumanizing" actions towards soil life. Büscher's proposed shifts of viewing more-than-/less-than-human actions dialectically, and de- or re-centering the human based on context can therefore be a valuable starting point for analyzing the messiness of regenerative agriculture.

2.3 Nature: immanence, transcendence, and political change

The main subject of this thesis is the human relationship with soil life *as a proximal nature.* By blurring the ontological distinctions between humans and soil life in an agroecosystem, narratives about regenerative agriculture are challenging the nature-culture dichotomy. As such, a discussion of how to theoretically approach any distinction or lack thereof between nature and society/culture is warranted. This work draws primarily on Kate Soper's (1995) book, which asks the ostensibly simple question: *What is Nature?*

Soper, critically, maintains a 'realist' conceptualization of nature, because, she argues, this is "the only responsible basis from which to argue for any kind of political change […] there is no reference to that which is independent of discourse except in discourse, but [I] dissent from any position which appeals to this truth as a basis for denying the *extra-discursive reality of nature*" (1995, pp. 8, emphasis added). We must, at least, act as if nature is "really out there" in order to effect political change, regardless of our epistemological beliefs. This position is more salient now than at the time of Soper's writing given the accelerating urgency with which climate action is needed; an issue directly connected to regenerative agriculture's growth as a movement. Soper goes on to offer a definition of the nature that is really out there:

> "The term 'nature' refers to everything which is not human and distinguished from the work of humanity […] nature is opposed to culture, to history, to convention, to what is artificially worked or produced, in short, to everything which is defining of the order of humanity" (Ibid, pp. 14).

This "indispensable" distinction, from Soper's perspective, is not contradictory to a perspective of ontological entanglement / interconnectedness with nature; indeed, this is an extension of Soper's 'realist' position: "nature is in this sense both that which we are not *and* that which we are within" (ibid, pp. 21, emphasis original). This double movement of distinction and subsumption produces what Soper dubs the "paradox of humanity's simultaneous immanence and transcendence" (ibid, pp. 49). She treats each side of this paradox in turn:

> "To insist on our naturality [immanence], it seems, is to pay too little heed to those exceptional powers and capacities through which we have exercised an ecologically destructive dominion over Nature, but without which there can also be no question of overcoming this alienation […] To insist, on the other hand, on our super-naturality or essential separation from Nature [transcendence] is to sever us too radically from the material context of existence, to conceptualize human nature in idealist terms (by viewing its essence as 'mentalistic' or 'spiritual'), and to open the way to a purely conceptual or subjectivist – and hence ecologically irrelevant – resolution of the problem of alienation" (ibid, pp. 49).

Neither side of the paradox is entirely true, and, more critically, neither side provides a substantial basis for political action to address the "alienation" from nature. As such, a realist acceptance of the paradox is necessary to move forward.

This thesis follows Soper, and adopts a 'realist' perspective towards the nature of nature. Soil, soil life, and nature more generally exist independently of our perception of and discourses about them, though they are all affected by humans in countless ways. It is the position of the researcher that the narratives about soil life analyzed refer to a reality that exists outside of those narratives. "It is true that we can make no distinction between the 'reality' of nature and its cultural representation that is not itself conceptual, but this does not justify the conclusion that there is no ontological distinction between the ideas we have about nature and that which the ideas are about" (Soper, 1995, pp. 151). Further, this project holds the position that any distinction between humans and nonhumans does not negate the notion of ontological immanence / entanglement, and vice versa.

2.4 Regenerative agriculture as a site of changing human-soil relations

Puig de la Bellacasa has argued that "knowing soils better could enable better care" (2019). The proposed research, in part, aims to problematize this claim. The cutting edge of soil biology uses methods that are based on ontologies of soil as observable, knowable objects, and many of the common indicators of soil life represent profound abstractions from soil organisms and communities. Furthermore, many organizations working in the regenerative space use methods that are decidedly not at the cutting edge ((Carbon)plan, 2021). There is little doubt that knowing soils better could enable *different forms of* care, but whether or not this enables *better* care is not clear. Some of the evidence from Krzywoszynska's research with UK farmers clearly suggests that this is not necessarily the case.

A particularly interesting aspect of the regenerative agriculture space in this context is the widespread interest in soil-based carbon credits. Krzywoszynska (2020a) asserts that soils themselves are not being commodified; the commodity is instead the products of their 'labour'. Trade of soil-based carbon credits could represent a more direct form of objectification and financialization of soil life than does the trade of agricultural commodities. Creation of these carbon credits can involve the use of a range of different methodologies and tools, from remote sensing to blockchain, which represent a huge diversity in ways of knowing soil life. Efforts to develop soil-based carbon credits are, of course, not the only way that people and organizations in the regenerative agriculture space are entering into new ways of relating to and knowing soils. However, the potential for more direct commodification of soil life inherent in this makes it a valuable case to explore to build on existing work on changing human-soil relations.

This research aimed to explore organizations and practitioners of regenerative agriculture that are operating in the midst of Büscher's less-than/more-than-human dialectic with respect to their relations to soil, as Krzywoszynska's farmers evidently are. New ontologies of soil are emerging and circulating in the regenerative agriculture space, but there is as yet no coherent epistemology and methodology to support these new conceptualizations. This thesis explored these changing conceptions of soil and how they are being combined with tools and methods used to derive knowledge about and manage soils. This, hopefully, provided insight into how human-soil relations are changing in the space, as well as provide some insight into what these changing relationships mean for the future of regenerative agriculture, and its potential to deliver positive environmental and economic outcomes.

3 Research Design and Methods

3.1 Research subjects and sampling methods

The research is focused on intermediary organizations, such as NGOs, extension services, or private companies that are active in promoting and disseminating knowledge about regenerative agriculture. The organizations approached for participation self-identified as working with regenerative agriculture (or at least explicitly refer to 'regenerative' methods as such) and were involved in some transfer of knowledge or expertise about regenerative agriculture to farmers. This could take the form of publishing of online training materials and resources, conducting soil analysis and providing recommendations, facilitating entry into soil carbon (or PES) markets, or other forms of engagement. Preference was given to organizations working both with farmers and emerging carbon markets, but organizations not involved in such projects were also included.

These intermediary organizations have been chosen due to their position in the gray space in regenerative agriculture. That is, they act as intermediaries between the corporate and farmer-led interests in regenerative agriculture and often act to directly connect these two "sides" of the movement. Emails were sent to prospective respondents, and snowball sampling was used to include a diversity of members of the chosen intermediary organization(s) others in their network. Finally, a diversity of organizations – in terms of their public perspectives and approaches to regenerative agriculture and soils – were contacted to ensure a diversity of perspectives are included in the analysis. In spite of this, this study did not aim to provide a statistically representative picture of the different narratives of soil life in regenerative agriculture. Instead, the objective was to highlight specific perspectives of those working within the space, and to connect these perspectives to larger discussions of regenerative agriculture and the study of human connections to nature.

In the following section, a brief summary of the organizations for which each respondent works is given in order to provide context about their work and approach to regenerative agriculture. The names of interview respondents are not given, partly to ensure privacy and partly because it would not add to the analysis of their narratives.

3.2 Summary of interview respondents

Semi-structured interviews were conducted with members of eight organizations within the regenerative agriculture space. Respondents and their organizations were concentrated in North America and the EU, though some of the organizations worked internationally (for example, reSOILutions). Given that each organization had different mandates and approaches, and each respondent held different positions within their organizations, not all themes were touched on to the same level of detail for each interview. The researcher's interview guides and approach were tailored to highlight each particular respondents' positionality. This section will provide a brief background of each organization interviewed and the specific respondents' roles within these organizations. Table 1 provides a summary of each respondent and their organization.

Table 1. Respondent designations and organizations

Respondent #	Organization
R1	Rodale Institute
R2	Understanding Ag
R3	EarthFort
R4	Soil Food Web
R5	Nori
R6	Climate Farmers
R7	reSOILutions
R8	RegenerativeSkills

3.2.1 The Rodale Institute

The Rodale Institute, widely regarded as originating the concept of regenerative agriculture (in addition to previously coining the term organic agriculture), is largely at the centre of the regenerative agriculture movement in the US. In addition to running long-term field trials comparing regenerative/organic and conventional systems, they provide a range of services to farmers from consulting to webinars. Further, the Rodale Institute has developed a pioneering certification for regenerative agriculture systems, discussed in chapter 1.

3.2.2 Brown Ranch / Understanding Ag

Understanding Ag is a US-based regenerative agriculture consultancy project, providing a range of consulting services for farmers aiming to transition. It was established in partnership with a number of prominent regenerative farmers. This interview touched on educational and consulting activities, as well as on the respondent's perspectives as a farmer.

3.2.3 EarthFort

EarthFort, heirs to the former Soil Food Web lab, provide a range of testing services to farmers, including a soil life test. They also provide two products, a microbial inoculant, and a type of food for soil microbial communities. EarthFort also provides educational and consulting services.

3.2.4 The Soil Food Web

The Soil Food Web is Dr. Elaine (TR) Ingham's organization, which has long been a prominent player in promoting the importance of soil biology in agricultural systems. Now, the organization is engaged in a wide range of activities promoting regenerative practices, close attention towards soil biology, and a holistic approach to agricultural soil management. They provide webinars, online courses, and a wealth of lectures and panelists featured in, for example, the annual Soil Regen Summit.
A farming consultant for the Soil Food Web was interviewed for this project. The consultant engages directly with farm management and planning, and conducts agronomic analysis on site.

3.2.5 Nori

Nori is a pioneering carbon market that is focussing on soil-based carbon credits in the US, and one of the most prominent players within this space. [some raw data – volume of credits onboarded, etc., maybe some general goals]. Nori issues carbon credits based on data concerning farm practices, which are then fed into a USDA-approved process model operated by an associated organization, Soil Metrics. A member of the supply team, which assists with farmer enrollment into their carbon credit program, was interviewed for this project.

3.2.6 Climate Farmers

Climate Farmers is a Berlin-based organization that promotes and provides training for regenerative agriculture, as well as working to develop a carbon credit program that includes remuneration for co-benefits, such as to biodiversity and water retention (Climate Farmers, n.d.). Climate Farmers is developing the Climate Farmers academy, an online source for information on regenerative practices. Further, they host a range of 'skill-sharing' workshops, and (at the time of writing) are in the process of running two pilots for their *Pioneer Program,* which is geared towards conventional farmers looking to transition to regenerative practices. Each of the two iterations of the pioneer program has followed a slightly different structure. The first program was based on Richard Perkins' *Regenerative Agriculture Masterclass;* the second was based on Regrarian's *Scales of Permanence* approach, which was largely influenced by Yeoman's keyline approach and Mollison's Permaculture design manual. The pioneer program can also serve as an onboarding process for farmers participating in the carbon credit program.

3.2.7 ReSOILutions

ReSOILutions provides biological analysis, transition planning, and some biological treatments for regenerative agriculture projects, with most work done in parts of Latin America. The respondent from reSOILutions was moving on to new projects at the time of the interview. Those projects, which centered around Johnson-Su Bioreactors for making concentrated compost, were also discussed in this interview.

3.2.8 Regenerative Skills

The host of the Regenerative Skills podcast, acted as an assisting consultant for one round of Climate Farmers' *Pioneer Program.* In addition to this, Regenerative Skills provides individual consulting/coaching services to transitioning farmers, as well as hosting a podcast which features many prominent experts within the regenerative agriculture space. This is a valuable entry point into expert information on regenerative agriculture systems, as well as providing an entry point for certain farmers.

3.3 Main research question and sub-questions

This research aimed to explore changing ways of conceptualizing, deriving knowledge about, and interacting with soils as living (or not) in the regenerative agriculture space. Further, the researcher aimed to situate human-soil relations in the context of the broader objectives of regenerative agriculture, such as transformation of the food system, developing more sustainable (indeed, regenerative) systems of agriculture, improving farmer profitability, or any others. Therefore, the main research question is: *how and to what end are human-soil relations changing in the regenerative agriculture movement(s)?*

This main research question will be complemented by the following sub-questions:

- How are soils and soil life conceptualized by members of intermediary organizations and others in their network?
- How is knowledge about soils derived and used in different ways (to inform management, access financial capital, etc.) that can influence farmers' practices and conceptualizations of soils?
- What is the connection between different ways of conceptualizing, deriving knowledge about, and managing/interacting with soils and the broader goals of regenerative agriculture?

3.4 What is ontology? Disambiguation and orientation of the researcher's interpretation

From the theoretical discussion presented in chapter 2, largely drawing from the so-called nonhuman (or ontological) turn (NHT) in the critical social sciences, *ontology* emerges as a central concept. As such, a closer investigation of what exactly is meant by this term in the literature and how it is being deployed in this research is warranted prior to moving on from the central research questions.

As highlighted by Viveiros de Castro (2015) and Graeber (2015), there is variation concerning what exactly ontology means, and how social scientists can and should approach studying it. The classical usage of the term *ontology* can be most clearly traced back to Hollowell's paper *Ojibwa Ontology* (1960), and can be thought of as "a discourse (logos) *about* the nature of being" (Graeber, 2015). From this perspective, a different ontology (discourse on the nature of being) has no necessary or direct influence on reality; reality is 'out there' regardless of how a discourse about it is constructed. Ontology follows (often circuitously) from reality, but ontology does not determine the nature of reality. This is in contrast to a newer concept of ontology – more often adopted by NHT scholars such as Viveiros de Castro – in which (human) ontologies are in fact *constitutive* of different realities (2015; Graeber, 2015). This means that, when Hallowell's *mishoomis* (grandfather) informant states that a rock "can be" a person in certain circumstances, we should not interpret this as meaning that the Ojibwa man simply *thinks or believes* that the rock is animated as person; rather, we should interpret Hallowell's respondent as *existing in a separate reality* in which a rock *is* in fact a person.

Graeber (2015) argues that the key distinction between these two conceptualizations of ontology – as a discourse on the nature of being or as constitutive of separate realities – is rooted in an epistemic fallacy, or the conflation of the questions "does the world exist?" and "is it possible for me to have definitive knowledge of this world?". Many in the nonhuman turn reject the possibility of definitive knowledge of reality (an epistemological claim), and jump from this to a rejection of the notion of the existence of a single reality (an ontological claim). Graeber goes on to assert that the impossibility of complete knowledge is, in fact, one of the defining features of reality: "[the ontological turn] makes it effectively impossible for us to recognize one of the most important things all humans really have in common: the fact that we all have to come to grips, to one degree or another, with what we cannot know" (2015).

This research aims to avoid the epistemic fallacy, and strictly employs a 'classical' definition of ontology, as a discourse about the nature of being [of soils]. The central research question could thus be reframed as: *how and to what end are discourses on the nature of soil (life) changing within the regenerative agriculture space, and what influence does this have on material relationships between humans and soils*? Further, the research does not reject wholesale the notion that ontological constructions can materially produce/effect reality. However, the focus is on the *mechanisms* by which ontology influences materiality (through science, knowledge production, emotion, management, finance, etc.) as opposed to any direct or necessary causal link, such as those critiqued by Graeber (2015). A key argument of this thesis is that believing that a soil is lively or inert will not make it so. But such beliefs can lead us to *act* in ways that will make it so, over time.

3.5 Methods

The thesis made use of two key methods: semi-structured interviews and the analysis of online materials. Interview guides for the semi-structured interviews were developed based on the central and sub research questions, and adapted to fit the position and experience of specific respondents. For example, some interviews focused closely on soil analysis, others on the economics of adopting new practices, and so on; the main objective was to highlight each respondents' expertise and perspectives. Semi-structured interviews were the substantive part of the research, though engagement with and use of online materials has played a key role throughout this project. Given that narratives – specifically those produced by intermediary organizations – are the main object of this research, weeding through and attempting to understand the excess of material online concerning regenerative agriculture was one of the major components of the development of the proposal. Further, as discussed above, this project's aim was exploratory, and a representative sample was neither sought nor attained. Therefore, in order to expand the discussion beyond narratives identified in interviews, a handful of additional online materials will be included in the broader analysis in chapter 5. These materials, all produced by interviewed organizations or others directly within their networks, were chosen selectively and conservatively, based on their explicit relevance to the discussion in chapter 5. Many of these additional sources were explicitly referenced by interview respondents.

3.5.1 Semi-structured interviews

Semi-structured interviews were used to maintain a balance between focusing on topics relevant for research – soils – while allowing the respondent to contribute to guiding the discussion. This enabled the researcher to highlight the individual voice of each respondent while reporting and analyzing the data. Such methods are particularly suitable for this investigation of regenerative agriculture due to the high level of diversity of perspectives that can be found in the space. Further, the semi-structured interview guide that was developed lent itself to being adapted to different research subjects outside of the intermediary organizations themselves as well as organizations with different perspectives and activities.

Informed consent forms were prepared, and communicated to, each interviewee prior to conducting the interview. All informed consent forms were returned to the researcher and saved on the researcher's personal hard drive. Interviews were conducted online – on the platform of the respondent's preference – and recorded subject to consent of the respondent. Recordings were kept on the researcher's personal hard-drive and shared only with the thesis supervisor.

3.5.2 Online materials

Many of the intermediary organizations interviewed in this research project have significant online presences. They are engaged in the production of webinars, troves of resources, promotional resources, lectures and seminars, and other information that serves to promote and/or educate about regenerative agriculture. Many of these resources are geared directly towards budding regenerative farmers, and some cater to a more general audience. Engagement with these online materials was a key part of development of the thesis proposal and also provide valuable data for expanding on final analysis of the interview data. Online materials – websites, recordings, etc. – were used to feed-into the development of interview guides and in the development of chapter 1. Selected online materials will enter into the discussion (chapter 5) to connect the narratives to broader discussions in regenerative agriculture. The focus will be on publicly available materials produced directly by intermediary organizations that will be interviewed, as well as sources explicitly mentioned by interview respondents.

3.6 Narrative analysis

Interviews were recorded and transcribed using otter.ai software. Transcripts were then compared to the initial recording to amend any mistakes made by the otter.ai software. Following this, two formal rounds of coding – done by hand - took place. In the first round, interviews were coded individually, shortly after being recorded and transcribed. In this round, the starting coding elements were developed based on the broad sub-research questions – such as conceptualizations of soil as living or inert, physical sample-based methodologies for understanding soil, remote-sensing-based methodologies for understanding soil, regenerative agriculture and farmers' financial situations, regenerative agriculture and climate change, etc. – and then refined and adapted as the researcher worked through each interview. This combination of inductive and deductive coding served to focus the analysis on the research questions while still giving analytical weight to the perspectives of individual respondents. Once all interviews had been completed and coded once, a second round of coding was done; for this round, all interviews were coded in relatively quick succession to elicit stronger connections between the interviews. The coding elements developed by the end of the first round were used as a starting point, and were refined and streamlined in order to better account for the data as a whole, as opposed to the data in one specific interview. The first round of coding was aimed to analyze in depth the perspectives of individual respondents, and the second round was aimed primarily at identifying synthesis and linkage points between/amongst the narratives.

Narrative analysis was then used to understand how different narratives about soils are constructed, deployed, translated, and in relation to other narratives within the regenerative agriculture space. The conversation between different narratives, or different narratives concerning the same subject (e.g., soils as living or soils as substrate) was of particular interest.

3.7 A note on the researcher's positionality: towards a 21st century *Anishinaabe* perspective

This research has been inspired and motivated, in part, by the researcher's indigenous (Canadian) ancestry. The researcher's grandmother was born on the *Mnjikaniing* First Nations (*Anishinaabe*) reserve in southern Ontario, and subsequently left and revoked her status[2] to escape what, at the time, amounted to little more than a postcolonial hellscape. This put her descendants into a cultural interstice familiar to many 'acculturated' American Indians. This separation precludes the possibility of 'purity' or direct representation on the part of the researcher. Rather, the researcher makes no presumption of expertise regarding *Anishinaabe* philosophy/mythology, and instead is focussed on exploring *Anishinaabe* ideas, first, as part of a broader (i.e., not Eurocentric) intellectual exploration of 'alternative' ontologies of soil/nature, and, second, as an opportunity for the researcher to explore his (grandmother's) culture in a deep, topical way. Growing up with regular stories about our connection with nature was a key source of inspiration for this research. This personal history led directly to raising questions regarding what it means to relate to nature in a different way, and how to foster convivial human-nature, human-soil relationships.

The *Anishinaabe* perspective on the world is permeated by a profound respect for nature and its inhabitants, as well as with a robust understanding of the fallibility (and often stupidity) of human beings. The main character of much of *Anishinaabe* mythology – and of some of the stories that lulled the researcher to sleep as a child – was *Nanabozho,* a classic trickster-type figure. *Nanabozho,* though technically only half human, was the first of us to walk in the world. The world he walked through was already full, and his first tasks were not of creation (as in *genesis*) but of observation, naming, and striving for understanding. A deep understanding of the activities of different plants and animals observed by *Nanabozho* was critical because replication of these strategies was the only way that humans would be able to survive in this world. There is a powerful idea here: above all else, humans are students and the nature of our interaction with / observation of nature is largely (and unidirectionally) pedagogical (e.g., Simpson, 2014). A second powerful idea is the nature of the names *Nanabozho* gave to things. *Anishinaabemowin* (the *Anishinaabe* language) is primarily *verb-based,* which means that the agency and tendency of things are contained within their names. For example, the marten's name translates literally as *"the absence of eggs".* Names denote relationality.

One objective of this research/discussion is to attempt to understand what, if any, insights *Anishinaabe* philosophy can provide to the context of changing relationships between humans and soils or other

[2] Under the Canadian *Indian Act,* "status" or a status card confer the legal rights associated with being indigenous.

parts of nature. *Anishinaabe* philosophy is well-established, coherent (if battered by centuries of colonialism), and is based on a profound sense of connection to (or being-in) nature that many proponents of regenerative agriculture strive towards. From a theoretical perspective, one of the advantages of *Anishinaabe* philosophy is that it is “notably not humanist nor posthuman, but emerge[s] as something entirely different” (Manning, 2017). Perhaps *Anishinaabe* (or other indigenous) philosophy can help to understand *how* to reframe and reorganize our relationship to nature within the regenerative agriculture space and more broadly. Such ideas could be powerful tools in thinking through the complexity of such relationships as well as sticking points such as establishing ‘consequential distinctions’ between humans and non-humans (Büscher, 2021). To summarize, the researcher’s *Anishinaabe* descent has been a key source of inspiration for this research project, and the discussion will engage with some key ideas from *Anishinaabe* philosophy [section 5.5] as possible options to improve or, at least, better understand the changing human-soil relations that are developing within the regenerative agriculture space.

4: Results and Analysis

The presentation and analysis of results will begin by discussing respondents' conceptualizations of soils, and the extent to which soils were considered to be living, inert, or somewhere in between, as well as discussing their perspectives on the differentiation between agricultural and "natural" soils, such as those found in relatively undisturbed forest or grassland ecosystems. Following this, the discussion will move on to explore how respondents approached the relationships between humans and soil life within their narratives, and how this may vary based on their approaches to analyze soil and their objectives with soil management, be it to produce crops, sequester carbon, derive profit, or other objectives. Finally, the chapter will discuss forms of analysis of soil life. The key forms of analysis that will be discussed are microscopy techniques, general biological indicators and methods, standard chemical and physical testing, and methods to measure soil organic carbon (SOC). Within the discussion off each form of analysis, the uses of that knowledge (in soil or business management), the types of relations that particular forms of data enable or preclude, and the political and scientific life of knowledge will be discussed where relevant.

4.1 Conceptualizations of soil

Respondents were not asked to directly offer a personal definition of "soil", and potential definitions and their points of intersection/contradiction were identified implicitly throughout the narratives. Overall, respondents' narratives exhibit a degree of ambivalence towards the nature of soil and the role of soil life in regenerative agriculture systems. This reflects some of the contradictions and challenges facing the regenerative agriculture movement as a whole.

As discussed in chapter 1, the so-called ecological turn in soil science has been vital in informing the regenerative agriculture movement's perspective on soil. R1 explained that, although the recent foregrounding of biological processes was an important development that has influenced regenerative agriculture, soil scientists of previous generations were not ignorant of the importance of biology.

> "[I]f you look at the, you know, the textbook for soil science from 50 years ago, you could find that a long time ago people were, you know, talking about the five soil forming factors already including the prior parent materials, climate, topography, time, and biology... Biology was regarded as one of the five soil forming factors from a very long time ago." (R1)

The historical consideration of biology as a soil forming factor indicates that conventional approaches to agriculture are not based on a lack of appreciation for the importance of soil biology, but due to the belief that we can replace the functions of soil biology, and the associated facts that relatively little was known about soil biological processes.

Knowledge of soil microbiology and its role in key soil functions has deepened considerably in recent decades. Through this, we have come to understand the inherent challenges and trade-offs related to attempting to bypass the soil microbiome, largely related to the myriad and complex functions soil life performs, including for soil formation. R1 elaborates on the way soil biology contributes to soil formation:

> “Microbes […] perform these biogeochemical cycles that, you know, turn the carbon in the atmosphere into the organic carbon in the soil, interact with the soil mineral particles and perform the function. So, the cycle of carbon – nitrogen has been accelerated by the microbes or by the… by the biology […] ever since, there has been living things in the soil. So, now, if we… if we look at the millions of years of time, we just look at a short cycle, then we can find that the biological interactions are really the key for soil forming or soil formation”.

Biology, here, is implicated in the very existence of soil. Many of the respondents’ conceptualizations centered around the notion that being alive was an immutable characteristic of soils. R3 firmly stated that, “whether you know it or not, the soil is alive”. Another respondent expressed this through the rise in the concept of soil health:

> “The reason that we are using this term, soil health, more than soil quality right now, in the last, I think, ten years, is because health refers to the state of living things, while quality may make people only think about, you know, physical and chemical aspects of an object. Soil health refers more to a living organism or living system.” (R1)

Some of the narratives – in particular R2, R3, and R4 – highlighted the connection between human health and soil health. R2: “very few people in this world have tasted nutrient dense food. What we have today is not food, it's food like substances […] a mere fraction of the phytochemical nutrients that was once in the soil can now be produced because of the dysfunction of our soil ecosystem”.

R4, a consultant for the Soil Food Web with a non-agricultural background, described the awe that they felt when first learning about the soil microbiome and the Soil Food Web’s composting techniques. These feelings of “happiness and contentment” evoked by working with the soil had a scientific basis. The *M vaccae* bacteria, which is “in higher concentrations in compost” (R4) was found to stimulate serotonin levels in human (O’Brien et al, 2004; Kennedy, 2012). These narratives of the nexus between human health and soil health indicate that healthy soils benefit human health through mechanisms beyond (and inclusive of) the provision of nutrient dense food. R3 draws the connection deeper: “[t]he soil informs the human microbiome, which in turn has been shown to inform our physical, mental, and emotional health. As the soil, so the human” (R3). Deep, innate interconnections between soil life and human life are portrayed as ontological (as an innate characteristic of existence) for both humans and soils.

Only one respondent – R5, from the US soil carbon protocol and marketplace, Nori – did not engage with ideas directly concerning life within the soil. However, this was not due a lack of appreciation or understanding of the role of biology in soil functions, but instead due to Nori’s orientation within the space. Nori, unlike some other organizations within the regenerative agriculture space, does offer prescriptions to farmers. Instead, they model the impact of regenerative farming system on SOC stocks, and convert that into a tradable credit. This model estimates the effect of “practices changes instead of […] what’s actually in the soil” (R5). This narrative, critically, does not discount the functional importance of soil microbiology and thus engages with “non-living” conceptualizations of soil simply by not engaging in detail with biological components.

Overall, the living and dynamic nature of soil ecosystems was a key feature of conceptualizations of soil in the interview narratives; this corroborates the claim put forward in chapter 1, that the regenerative agriculture movement has a significant conceptual break with productivist agriculture in the rejection of an inert, predominantly chemical and physical conceptualization of soils. However, the narrative importance of this living nature was given different emphases by different respondents. Some focused on the specific organisms, populations, and biological processes that define soils, while others engaged with the notion of living soils on a purely conceptual level, recognizing the importance of biology to overall soil function but without reference to specific organisms or biological mechanisms. The level of specificity with which the living character of soils is conceptualized has important implications for and connections with narratives concerning the (active) role that soil life plays in regenerative agriculture systems and on the forms of analysis used to produce knowledge about soils.

Agricultural and "natural" soils

One specific theme that emerged in the interview narratives was the differentiation between agriculture and "natural" soils, with natural soils being those found generally in forest and grassland ecosystems. The results of the Rodale Institute's field trials have shown clearly that natural soils exhibit higher levels of microbial activity and biomass than agricultural soils (R1). R1 briefly discussed research indicating that SOC pools had different compositions – in terms of their origins – in agricultural soils as compared to forests, grasslands, and other natural soils. This is not due to a relative overabundance of microbes in agricultural soils, but due to the dearth of plant material added. This indicates a fundamental, observable difference between agricultural and natural soils in terms of the origins of their SOC pools.

Another key point of differentiation that was brought up concerns the composition of functional groups, illustrated primarily with fungal:bacterial ratios. This was further connected to the process of succession in soil ecosystems, which is generally prevented from going to its natural climax in agriculture [sections 4.3.1 and 4.3.2]. Agricultural soils have distinct compositions compared to natural soils, and agricultural soils would not adequately provide the key soil function of primary productivity if their composition of functional groups was the same as in "natural" soils (R1, R3, R4).

Finally, R3, asserted that there are key differences between agricultural and natural soils based on biodiversity, genetic diversity, and the presence and virulence of different soil pathogens. One aspect of R3's work is the production of a potent bio-inoculant, which will introduce beneficial microbiology to degraded soils. A number of variables led R3 to source the base (living) material for this inoculant from structurally unstable "not quite peat" that is removed from the ground to allow building in some parts of Alaska. One critical factor was the need to have a consistent product in order to acquire USDA approval and sell the product; this would have been a major challenge without consistent source material (eg, by using compost). Due to the remote source and long Alaskan winters, this material has been more or less untouched for "10,000 years" (R3). When R3 first looked at this material under the microscope:

> "I tested it and said, "Oh my God, this is amazing biology" […] We've had it genetically tested, we usually do that every couple years, we do the genetic analysis, and it's got… I forget, now, it's been a while since I looked at the list, but it's several 1000 genus of bacteria and fungi. In the material, and, you know, yeah, and there's no disease, you know, because this stuff isn't coming out of a place where there's actual agriculture, most of the diseases in agricultural is not natural."

This points to the significant, long-term effects that human agriculture has had on soil microbiomes. Over the long history of human agriculture, we have had profound influences on specific species, the selection for and incubation of pathogens, and have likely had an irrevocable impact on the genetic structure of the soil microbiome. While the untouched nature of this soil biology is not the only reason R3 uses it as a source of their inoculants, it does speak to the blurry distinction between agricultural and natural soils; the former evidently defined by the long history of negative human impact and ongoing human interference.

4.2 The role of soil life in regenerative agricultural systems

Most respondents were directly asked a question to the effect of, "what is the role of soil life in regenerative agriculture programs?'', which provided a clear starting point in their narratives for their perspective on soils and soil life in general. In response to this question, R6 stated "that's all it is, right?'.

Most respondents acknowledged the importance of biology of soil functions, but some also argued that the emphasis placed on biology in regenerative agriculture circles could be overstated. R7 claims that, in spite of the importance of soil biology, "it's an error to start thinking that your system can sustain itself, just with the soil biology". R8 nuances this view, giving examples of plants living in conditions with practically no soil biology, such as a tree growing out of the edge of a cliff. R8 goes on to argue that the presence of biology in soil is not a matter of life and death for plants, but between a soil being able to support plants that can simply survive compared to those that can "thrive and create for complex ecosystems".

One function performed by soil biology, which contributes to the creation of complex and thriving ecosystems, is the conversion of organic nitrogen, which is not bioavailable to plants, into a bioavailable inorganic form; this process is vital for the effective use of organic amendments (R1). From the perspective of producing food, feed, fibre, and fuel in agriculture, the outcomes of these soil functions – for example, nutrient availability – must be provided to plants one way or another. R1 discussed how a key difference between conventional and regenerative systems is the decision to bypass or engage soil microbial communities in the provision of these services to plants:

> "In the conventional or, you know, chemical based agriculture, *the mindset is that we can bypass the microbial process*, the interactions, the association between plants and microbes, and soil fertility. We can just feed the plants by the synthetic fertilizer that we apply every year. So that… that's successful in you know, boosting the yields. But it also has a profound impact on soil microbes and soil life. So in that way, the microbes they don't get, you know, they don't get to work with the plant roots to perform the long existing the biogeochemical process. So there's… there are the forgotten communities in the soil." (emphasis added)

Conventional agriculture is based, from this perspective, on the belief that humans could directly provide nutrients and other requirements to plants without the involvement of microbial communities. High input, mechanized agricultural systems were enabled, in part, by this belief or "mindset". This narrative of regenerative agriculture, in contrast, rejects this notion and considers direct engagement with soil life to be the more effective strategy for caring for crops and other plants.

One respondent, R4, discussed how effective engaging with microbes can be for providing for the needs of crops: “if you feed the microbes, your microbes are going to feed your crop, and they are a lot better at that than we are”. Another shares a similar perspective. R1 discussed that we are coming to understand

> “that soil biology is the key or one of the most important factors to the formation of soil. And one people can… have a big impact on. For your other soil forming factors, for example, topography, or parent materials, there’s not much we can do about them. But for soil biology, that people can have a big impact on, especially in agriculture.”

Soil biology, from this perspective, has unique abilities to relate symbiotically with plants and that humans have not been able to equal in the conventional approach to agriculture. In addition to its effectiveness in providing for the needs of plants, one of the advantages of focusing on soil biology is its responsiveness to human intervention.

R1 discussed two treatments – an organic, legume-based system with no external inputs, and an organic system with manure inputs – used in the Rodale Institute’s field system trials, which compare organic and conventional systems, and how they differ in terms of biological activity.

> “The tillage intensity is lower in the organic manure system, the soil is not disturbed for that period of time. So […] it was a time that, you know, this biological process was slowed a little bit in soil, too. So more conservative. While in our organic legume system, when you have this intensive four-year, crop rotation, organic grain crop rotation […] you kind of have accelerated the biological process”

Different approaches to management stimulate or constrain the soil microbiome, which reaches different equilibrium levels of activity under different regenerative, organic, or conventional management regimes. The impact of human management on the soil microbiome, for R1, can be exemplified with the so-called carbon dilemma: “to hoard or to use” soil carbon, either for sequestration or production. The organic manure system involves less disturbance and lower intensity production, enabling higher levels of SOC to be stored within the soil. The legume system, in contrast, involves higher frequencies of disturbance and intensities of cultivation; the higher production it the outcome of soil carbon being put to use by the more-active microbial communities. Humans, in the narrative presented by R1, play a crucial role in guiding and creating enabling environments for soil life to function and in guiding soil life to function in specific ways.

R4 expands on the notion of creating an environment in which soil life can function. In general, R4’s narrative argued that soil life functions better if left to its own devices than actively managed. Whatever agricultural problems one might have, “nature already has an answer”. Further, “[microbes] multiply much quicker in the soil than I can get them to multiply in a compost pile”. These statements indicate that, while biological functions can be influenced and guided by humans, we are not able to fine-tune our management but rather push the system in a general direction. “I give them [soil organisms] the ingredients to do the work” states R4, “I just *plan* it out” (emphasis added). This narrative highlights the power of soil organisms to produce different functions independently of active management, but humans still play a critical role in creating an enabling environment for soil organisms. The element of planning is a key point of distinction between soil organisms and humans in this narrative. Humans and soil life are able affect and have effects on each other, but only humans are able to perform the long-term planning brought up by R4 in their relatively hands-off approach to soil management.

R3 discusses the how soil life can be guided to provide certain outcomes or functions for humans:

> “when you interact with the soil in a way that… where you acknowledge that it's alive, it's a living thing, a living being in a way, you know, not like a dog or a cat but similar, you know, you got to take care of them and they provide you with something […] it's the same with the soil, you're taking care of that living system, and then it will take care of you.”

Soil management, as presented here, is not about bending soil life to our will but about engaging with it as a living thing that must also be cared for. What or who initiates this reciprocal relationship of caring? Some respondents pontificated on how humans can help or inhibit the function of soil microbiology. R1 describes that “processes are somehow accelerated by human land use or intervened by human use significantly, dramatically, by, you know, by changing the physical structure of the soil, or by, you know, adding or decreasing amounts of organic matter into the soil, by disrupting or improving the soil microbial communities”. The impact of human intervention of soil biological processes cannot be overstated, argues R1, who goes on to assert that humans should be considered sixth soil-forming factor because “interactions between the parent materials obtained, you know, topography and climate and soil organisms: these have been significantly accelerated or affected by humans”. Many of the narratives point unequivocally towards humans as the initiators of positive human-soil relationships in the context of regenerative agriculture, as well as holding the power to guide the specific outcomes of the activity of soil microbiology.

In general, respondents’ narratives tended to hold on to, at least implicitly, the notion that humans have a central role as managers and decision-makers within regenerative agricultural systems. This was done while at once emphasizing the deep interconnections between humans and soils and without downplaying the ability of soil organisms to affect us and the agroecosystem in unique ways. This point was eloquently summarized by R3:

> “the soil informs the human microbiome, which in turn has been shown to inform our physical, mental and emotional health. As the soil, so the human. Making the assumption that this is indeed some form of truthful relationship, then it stands to reason that *ensuring a living soil must be an imperative activity of humans*, our very existence is at stake and one way to overcome this threat to the species is to embrace our interdependence on the soil and to strive to allow all the benefits thereof to be fully expressed into the world” (emphasis added).

This excerpt highlights the perspective that soils are not innately living, but *become* and can be kept alive - living soils are produced and exist within temporal and spatial boundaries – and that humans have the capability and existential responsibility to ensure the living nature of soils. Overall, respondents understood that soil life plays a fundamental role in regenerative agricultural systems. However, respondents were also consistent in depicting that role as dependent on human management interventions. Soil life is central to the regenerative agriculture program, but some of these narratives firmly indicate that human decisions are what puts soil life in this central role or, as in conventional agriculture, bypass the soil microbiome entirely.

4.3 Knowledge production

Respondents discussed a wide range of indicators, tests, and other forms of analysis that are used to better understand – and thus, in some cases, better manage – soil and soil life. As R1 pointed out, technological and scientific advances have enabled us "to study […] the diversity and the populations in the soil, of the soil microbes in the soil performing those functions. We knew they were there, you know, decades ago, but now we started to know more what they're doing".

Types of analysis of soils differed greatly in terms of the level of detail/precision/accuracy with which they scrutinized soil, the motivations for selecting them, and their intended uses. Further, as will be discussed below, there are many different methods for calculating certain indicators (such as SOC) that are used in different contexts.

This section will discuss indicators and methods for analysis of soil in four broad categories, based on associations presented in the interview narratives. As the categorization of these methods was based on the narratives, there is some overlap. For example, microscopy (4.3.1) can be used to estimate F:B ratios (4.3.2).

In addition to discussing the methods themselves and their connection to soil management, respondents discussed the political, scientific, and economic aspects and applications of different methods and forms of data; these aspects of the narratives on knowledge production will also be presented within the following section where relevant.

4.3.1 Microscopy

Microscopy is a key technique used frequently by the Soil Food Web (SFW), and can be used for many applications. Microscopes can be used to identify particular species, to count the number of individuals in a given species and thus determine a range of population related indicators, such as the presence/absence of natural predators and pest species (R4). In its specificity, microscopy is one of the only techniques that can allow researchers and practitioners to focus on a specific, individual microorganism. Other methods, as will be discussed below, can provide indication of population composition and dynamics, but do not allow easy scrutiny of "individuals" within the soil microbiome.

R4 of the Soil Food Web uses the microscope in their work most prominently. They employ microscopy for the common purpose of determining the presence, absence, and abundance of different organisms. However, another key way in which R4 uses the microscope in their work is to expose their clients to the living world beneath their feet, as well as to the veritable wasteland that conventional agriculture produces in the soil. R4 describes the effects of farmers visually engaging with soil life:

> "when I go talk to farmers, I take… a presentation with me, but I also take my microscope, and I let them see what the life in the soil looks like for them. And it's like a gateway drug. Once they see what they [soil microorganisms] really look like, and what is missing, it kind of opens their hearts to wanting to take care of them… first wanting to, and then they still don't know how to

> exactly. But then the next question comes, of course: 'how can we take care of the life in the soil?'".

Further, R4 will bring samples of a rich compost and a healthy soil to compare with a farmer's own soils under the microscope. "Wherever you look on the slide [of compost], there's a load of life. And that's what's so impressive… when they look at their own soil, the lack of life, the shocking lack of life". Use of the microscope can create soil organisms as living, visual objects for farmers, thus opening them up to caring and affective relationships; witnessing the microbial desert of conventional soils adds an element of tragedy to this affective engagement, pointing to the notion that the production or destruction (regeneration or degradation) of lively soils is based on the actions and decisions of the farmer. In this context, this notion encourages farmers to develop management strategies that will benefit the life in their soils.

In addition to using the microscope to facilitate a visual connection, R4 shows farmers how to differentiate between healthy and unhealthy soils, and how to identify key populations and understand the mechanisms by which they keep each other in check, thus developing a deeper understanding of the intricate dynamics of soil ecosystems. For many of R4's clients, often conventional farmers aiming for a transition,

> "conditions have already selected for the bad guys [microorganisms] to be dominant. So I show them the root feeders that are eating their crops, that are destroying the crops. But I also show them what the defense system should look like […] there are nematodes that will eat the root feeders, there are fungi that will eat the root feeders, so we need to get the defense system back in."

R4's use of the microscope is a pedagogical tool that is used to inform farmers about the living nature of their (present or aspirational, depending on the starting point) soils and also to elucidate some of the basic ecological dynamics that take place is the soil. Critically, this pedagogy forms a connection between the farmer and soil life through the heart and eyes; the embodied character of this knowledge is contrasted with chemical testing reports, which many of R4's clients do not engage with in a deep way and rather treat as instructions for what to apply on their fields.

Microscopy techniques allow researchers and farmers to come into close contact with specific soil organisms, species, and populations. Microscopy, from some perspectives, assists with the ability to influence and fine-tune these characteristics of the soil microbiome (R4). Further, use of the microscope can facilitate a critical *visual* interaction (or engagement) between humans and soil, which may have implications for the emotional character of the relationship that farmers have or are developing with soil life.

As noted, the value of microscopy has been promoted most fervently by Dr. Elaine Ingham and her Soil Food Web. These techniques were discussed by respondents from the SFW, and from Earthfort and reSOILutions, both of which have connections to the SFW. The Rodale Institute, where Dr. Ingham formerly served as chief scientists, does not employ microscopy techniques to the same extent as other organizations. Data derived from microscopy has a scientific and practical life: it is analyzed, interpreted, and ultimately used to influence management decisions on the farm. But all of these data (derived from microscope techniques and otherwise) also have a political life: it has the potential to be used to influence opinions and policy, to secure funding, and to contribute to the scientific literature. R1:

> “I think it really depends on what purposes are, you know, of the research project. For example, if your goal was to, you know, publish [a] peer reviewed publication, you have to find, you know, the most scientific way… rigorous data collection to quantify the soil microbial boundaries […] but if your goal is to, you know, to showcase to farmers how we do that and just to provide a very rough estimate of the soil microbes, maybe the microscope is a good way to work with the farmers in extension activities.”

Microscope techniques, while they have pedagogical and affective potential, do not produce data that lends itself to strategic deployment in scientific or political debates. Part of the reason for this is the imprecise nature of data derived from microscopy:

> “Our standard deviation [when using microscope-based direct counting] was plus or minus 20%. When you’re doing it with the human eyes, because you get tired, like if you’re human, and sometimes you see bacteria that’s not bacteria, sometimes you count fungi that’s not there, or you’re counting and it’s not there and you’re counting it anyway […] a really high degree of technical expertise, a very expensive microscope [is needed] to do the work.” (R3)

This highlights another key challenge of microscopy techniques: in addition to their relative imprecision, microscopy techniques are time consuming and thus costly.

Due to the time costs and imprecision of microscopy techniques, R7 primarily uses these techniques as a general guidepost rather than a rigorous method from which strong conclusions can be drawn. “[A] lot of people are doing counting and checking how many bacteria to fungi and everything. Personally, I don’t do that. I just check it in a microscope, see what’s there, what’s missing, and that’s it […] either my plants grow or not” (R7). The perspective here is partly based on a belief that farmers are not able to fine-tune soil biology, but simply set it in the right direction. Regardless of what is measured and how it is measured, “the answer is always the same, which is… add compost, basically. Why do you bother testing in the first place […] just put good compost there.” (R7)

Microscopy is an important technique because it opens up access to the soil microbial world, rendering its characters visible and thus creating the possibility for tangible, embodied connections between farmers and soils. However, the time costs and high degree of uncertainty associated with these measurements preclude using these data for precise management interventions (R3). Though R7 iterated this point most clearly, many respondents discussed that their main response to microscope data was simply to add more microbiology, through compost or other means (R7, R4, R3). Further, microscopy techniques do not produce data that can be used in scientific arguments about the sustainability and/or productivity of regenerative agriculture systems, and thus cannot be used to meaningfully contribute to scientific or policy debates regarding regenerative agriculture (R1). Finally, the connection between microscope data (e.g., counts or the presence/absence of specific species) is, at best, tenuously linked to specific soil functions such as carbon sequestration or productivity. As such, there is no clear pathway by which such data could be meaningfully commodified, precluding any economic impetus to engage with these data.

4.3.2 Other biological indicators and analyses

Microscopy can be used to estimate population sizes of different functional groups, and therefore to derive the fungi:bacteria (F:B) ratio, one of the most important biological indicators discussed: “the fungal to bacterial ratio is one of those foundational pieces of the whole biological soil plant interaction movement” (R3). Above all, F:B ratios are indicative of the microbiome’s stage of ecological succession. R4 explains:

> “So early successional, you'll find a lot of bacteria. And then all the way on the other side is old growth forest like pine forests, stuff like that, they'll have the majority of their soil will be dominated by fungi. And then somewhere in the middle, you need both, and most of our vegetables and whatever it is that we grow for [...] human food is around that balancing of enough bacteria and enough fungi is because you need both of them. But if you are intensive with your land management practices, you know, you rip open the fungal hypha all the time, and they have no chance of survival, so they'll disappear. But if you want to keep them, then you need to have some living mulch, meaning you need living roots living plants. So, we need an understory cover crop that will always be able there to feed the microbes.”

In general terms, early and mid-successional soil ecosystems are defined by microbial dominance, or extremely low F:B ratios. As succession unfolds, the ecosystems become dominated by fungi and exhibit high F:B ratios. So-called “natural” ecosystems such as forests and grasslands typically have late-successional, fungal-dominated soil ecosystems (R1), epitomized in the rich mycorrhizal networks found in old growth forests.

The F:B ratio has important implications for crop cultivation. R3 discusses that

> “If you’re growing annuals […] you kind of want it to be in this general range of slightly more bacterial than fungal, if you're growing perennial grasses, you want it to be kind of balanced and a little bit more fungal. And then as you move up in succession, and you get into more and more complex systems, you know, you get into woody perennials, they want it to be two to three times as much fungi, you get into trees, you know, they want it to be five to 10 times as much fungi.”

The precisely optimal F:B ratio for a specific crop is highly variable based climate, temperature, soil type, and other factors, on but only “within a small band of variability” (R3). As such, the key managerial application of data on F:B ratios is not to inform precise applications (as with study of chemical soil fertility management) but inform interventions that simply guide the system in a general direction. Optimization past this “small band” will yield relatively insignificant improvements. The key function of F:B ratios as presented in these narratives, then, is to give insight into the overall state of the microbial ecosystem.

Methods of estimating population sizes – and thus F:B ratios – could be improved in terms of their levels of uncertainty and susceptibility to human error. R3, when discussing methods to estimate quantities of specific functional groups, stated that some estimation methods:

> “[haven’t] changed in 100 years. The best way to get nematodes out of soil is put them wrap them in a filter, put them in a funnel of water, and let them swim to the bottom and siphon

> them off and pull them out and count them in, identify it. And then protozoa is the most probable number of methods. So it's a dilution plate method, where we prepare the sample and then we do serial dilutions. And then based on presence or absence at those different dilutions, we can basically create a most probable number for protozoa" (R3)

The older methods are still appropriate for particular indicators, such as for measuring nematode and protozoa populations. However, in other contexts, R3 broke from the tradition of relying heavily on microscopy-based count data while maintaining a critical perspective on the efficacy of more modern or high-tech methods. For example,

> "You can do genetic testing and identify them to species if you really need to do that. But you can't enumerate them that way. So… and that's one of the limitations that we're finding with testing is, our direct methods are great for telling us how much bacteria and fungi are there. But they don't tell us what species are there. So then you'd have to do genetic sequencing to figure out the species. But then DNA sequencing and the meta genomic stuff, it doesn't tell you how much, it doesn't tell you a population density, it just tells you relative abundance of the DNA sequences that they found."

Further, DNA sequencing methods are "expensive and time consuming" (R3, R7), which is a further barrier to their use. F:B ratios and other data about specific populations and organisms are clearly valuable variables for monitoring the state of the soil ecosystem, but the narratives depicted these as not useful past a certain level of precision. Overall, the approach to using these data was to garner general insights about the current state of the soil microbiome and inform interventions meant to push the microbiome in a general direction (for example, towards higher fungal dominance to support perennial or tree crops).

4.3.3 Standard chemical and physical indicators and tests

Respondents exhibited different levels of engagement with standard chemical and physical soil tests. For the purposes of this thesis, standard chemical and physical tests include quantities of macro and micronutrients, structure, compaction, water infiltration, porosity, pH, cation exchange capacity (CEC), among others: essentially, any metric that is not explicitly measuring soil biology or a connection to soil biology. Critically, this broad category is inclusive of the standard metrics that farmers would receive and base fertilizer and pesticide applications on; such indicators are at the centre of conventional agricultural systems and agronomy. Narratives from the interviews touched on the use of these indicators, but did not discuss them in the same level as detail as biological indicators (above) or SOC (below). From the respondents who discussed standard soil testing, three key reasons why they are employed were highlighted.

First, chemical and physical indicators were used to assess how these variables could affect soil biology. The focus, in contrast to a traditional agronomic approach of reduction to chemical and physical variables, does not take indicators such as pH in terms of its direct connection to yield, but rather in terms of how they influence the relational properties of soils. R1 discussed compaction as a key physical soil characteristic, because "healthy soil should have 50% of pore space filled with water and air. If your soil is compacted, and you have less of these pore spaces, so there is less room for microbes to live and to reproduce and to perform their function". Similarly, R3 uses "EC[3] and pH measurements […] we look at them from the perspective of, 'how does that affect your microbiology?' Not from, 'how does it affect your nutrient availability?'" R3 went on to argue that the purpose of standard soil testing is simply to understand

> "what's going on in the soil [in order to give] us a perspective. But it is not the end result that we're with testing, you know, currently they [farmers] test so that they know how much fertilizer to put out. Right? That's like… No, we test to figure out what's going on in your soil, so that you know how to properly manage your decisions throughout the course of the growing season."

R4 motivates a similar example based on aiding farmers in understanding the impact of different fertilizer applications on the microbial community.

> "They [bacteria] respirate nitrate, NO_3; the fungi respirate ammonium, NH_4. In the middle, you need both of them as plants need both of them. And so that's why it's so important to understand what balance is […] understanding that, [farmers] quickly understand the fertilization thing that they've done is usually nitrate, NO_3. So, they have pushed their systems back in succession, towards early succession […] by thinking about how they've got there, they can also think about how we can get away from it." (R4)

Chemical and physical indicators are measured and analyzed to better understand the environment in which soil organisms live and function. This can help to elucidate, to farmers, the specific impacts of conventional agricultural practices and the processes by which regenerative practices could benefit the microbiome and specific, beneficial microorganisms.

Second, standard soil analyses are employed to illustrate, primarily to conventional farmers, the benefits of regenerative systems compared to conventional systems. This function was primarily highlighted by R2 in the context of direct communications to farmers. R2, a farmer and educator, uses

> "a Haney test, and a PLFA test[4]. And I use those just in my teachings. But realize I don't add anything. So to me, they am not going to say they're meaningless, but they're not going to change my, my production model. Because I know that it's all about nature. But I take… collect those just so to use them to show other people."

The purpose of these data, in this case, is to make the logic of a regenerative farming system comprehensible to farmers operating within the conventional tradition.

R4, finally, also discussed another pedagogical use of standard soil testing. As a consultant, R4 works closely with farmers who regularly receive standard soil tests and associated recommendations. Most of these farmers, R4 claims, treat these tests as instruction guides that require no critical thought, only execution. "The chemical report, you know, spits out a lot of numbers. And it doesn't make any sense to you unless you understand how the ratios work," but most farmers "don't understand it. They'll just do

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[3] Electrical conductivity, a measure of salinity

[4] The Haney Test measures standard micro and macronutrients (N, P, K, etc.) as well as specific pools of N and C that are available to microbial populations (Cates, 2020); the PLFA test measures different types of phospholipid fatty acids which can be indicative of different soil organisms and populations (Brinton, 2020).

what [the chemical reports] tell them to put on the land" (R4). Teaching farmers how to interpret and critically engage with these tests can enable them to be more active participants in guiding the ecological system: "I want [farmers] to be able to understand that chemical reports alongside with getting familiar with their own microscopy, because it's easy to monitor your system" (R4). This use of knowledge produced by standard soil tests aims, ultimately, to make farmers able to analyze their soils at the level described above by R3, where chemical and physical data are used to better understand the biological condition of the soil. Overall, standard soil testing was not rejected by most respondents, but was considered of secondary or complementary importance to biological indicators discussed above.

4.3.4 Soil Organic Carbon

Soil Organic Carbon (SOC) is one of, if not the most important metrics within the regenerative agriculture space. From the farmer's perspective, "people are really interested in carbon markets, because they're seeing that people are getting paid for them [regenerative practices]" (R5). Though there are connections between SOC and other soil functions, such a water infiltration and retention, the interviews focused on the economic impetus to emphasize carbon: "carbon is cool, because you can sell it right now" (R8). This economic impetus does come with obstacles because, as highlighted in chapter 1, there are considerable challenges related to the accurate and precise measurement of SOC.

"Carbon monitoring and verification is very challenging. It's a daunting task," stated R1, "we found soil carbon, highly variable, highly variable. So, it really, you know, requires very accurate soil sampling and measuring to quantify your carbon". One respondent claimed, more firmly, that "the science is not there to accurately measure carbon" (R2). Another pointed out that various fractions of carbon that can be measured and techniques that can be used to measure them, further obfuscating the issue:

> "there's at least ten methods that I know of for measuring carbon. So you've got total organic carbon, you got total carbon, you got loss on ignition, you got derived from organic matter testing, you've got […] viable carbon, organic total, inorganic carbon, all these different things." (R3)

R3 went on to explain how their organization looks "at the living carbon component, based strictly on the biological population of bacteria and fungi, nothing else […] creates another level of resolution for what's going on in the soil". Focusing on this type of carbon allows R3 to have a better understanding of the dynamics of the microbial community, such as the state of ecological succession, and therefore enables better management of these communities. In short, this measurement is portrayed as a more useful measure for engaging with and managing soil microbiology than the total SOC that is more often measured.

Other respondents pointed to the fact that reducing the agricultural system to its effect on carbon could end up as another form of reductionism, with all the challenges that face the conventional system and its focus on yield. R8 states that carbon "is not the only indicator for the health of an ecosystem", and points to the measurement and monetization of co-benefits such as biodiversity and water infiltration as a promising strategy. From this perspective, a strategy such as measuring co-benefits along with carbon would help to avoid a carbon-centric reductionism, where an appreciation and understanding of the complexity of agroecosystems is what is needed to manage them more sustainably.

There are numerous forms of carbon that can be measured in the soil, and each has its particular applications in farm management. However, total SOC is the most common measurement, and respondents discussed remote-sensing, process-based modelling, physical sampling, and other techniques for measuring this fraction of SOC.

Physical Sampling

Physical soil sampling is widely regarded within the scientific community as the gold standard method for estimating SOC. R1 argues that:

> "I think the best method to accurately quantify your soil carbon stock is to… take cores, in the whole soil profile to study using the traditional method: combustion. So, for combustion method to measure your carbon and measure bulk density by using a core. And if you only if you want to focus on the topsoil that top 10cm or top 15cm, that's not going to help because in agriculture system, we have so many things going on with the crop rotations, the tillage practices, and how we overturn the soil."

All of these interventions have complex effects on carbon storage and turnover and can have impacts at different depths. R1 emphasizes the complexity of soil ecosystems and of carbon cycling therein, arguing that the most rigorous methods are needed for accurate and precise measurements of SOC stocks and fluxes.

Further, R1 argues that the more physical samples taken per area or per field the better, as this will help account for the naturally high levels of heterogeneity within the soil: "not all soil is made equal". These high levels of heterogeneity make representative sampling quite challenging, even on small plots of land. In the Rodale Institute Field Trials, "the plots are 20 feet by 300 feet [0.05ha], you know, we still find it very difficult to have very, you know, representative results of the plot" (R1) with results showing high levels of yearly variability. "So, if you have a bigger field, how can you, you know, avoid the variability?" (R1). Taking a sufficient quantity of samples to accurately measure SOC, however, is often prohibitively expensive, which is why estimation techniques based on remote sensing or model-based methodologies are increasingly being used.

Nori, which uses model-based techniques to estimate SOC, plans to incorporate physical soil-sampling protocols into their SOC estimation methodologies in the future. This is partly to help calibrate model estimates, but also because "the scientific community thinks that [physical] soil sampling is better" (R5). A key objective of expanding SOC measurement to include physical sampling is, therefore, to garner greater legitimacy for the protocol amongst the scientific community, and therefore contributing the addressing the larger legitimacy problems in regenerative agriculture [chapter 1].

Model based & remote sensing techniques

R5, working on the supply team for Nori, which hosts a carbon marketplace and issues carbon credits to regenerative farmers, provided a detailed discussion of the process-based model they use to estimate SOC. Nori uses a commercial application of the Comet Farm model, a USDA greenhouse gas inventory tool, which

> "finds carbon sequestration from practice changes, not soil sampling. So there… we don't have farmers who take soil tests for us. But what the model tests for again are those practice changes in… for a switch to regenerative practices. So it could be the diversifying the crop rotation, it could be rotational grazing, it could be tillage to no tillage, or reduction in tillage, cover cropping, things like that. So that's where it's testing, whatever practice change you've made, then, and wherever you are in the United States, it's testing those practice changes in relation to that and your baseline." (R5)

The Soil Metrics model is based on rich and robust datasets that have been produced by the relatively long history of agricultural research institutes and universities in the US (R5), and could pose a challenge to applying similar approaches to measuring SOC outside of the US. Lack of historical and geographically distributed data, which the US agricultural college system has in droves (R5), would make such a model much less accurate and able to account for variation in soil type, biome, or other variables. However, in spite of the robust data that form its foundation, the Soil Metrics "model is limited in some ways". In particular, the model is designed to model only specific crops and arrangements thereof:

> "They [a farmer enrolling into the protocol] diversified their crop rotation when they added soybeans [as a within-row intercrop], but then they added, this is actually a really interesting one, they added rye as a cover crop […] it [the model] actually doesn't pick up all of these crops, it's only picking up the first crop and then the cover crop. And so this actually was showing that they were sequestering about 0.9 tons of carbon per acre. But if it was actually accounting or encompassing all that they were saying, they would have been sequestering more. But the Soil Metrics model is limited to two crops right now and not interplanting crops" (R5)

Therefore, specific models and their specific configurations and capabilities can create (dis)incentives towards specific variations/manifestations of regenerative agricultural systems. In this particular narrative and regarding this model, incentives are created that encourage the adoption of basic regenerative practices – such as no-till, expanded rotations, and cover cropping – within the context of conventional, mechanized grain production. The model, at the present, would be simply unable to accurately measure the SOC stocks within more diverse agroecosystems. R8 extends this criticism, claiming that "predicting the amount of carbon that can be sequestered in these highly complex farming systems" is extremely difficult, and that such agroecosystems are "vastly different from the conventional models that you would want to use as reference for the models." This is exactly the challenge that R5 faced attempting to model changes to SOC stocks in a system employing a simple intercrop.

The economics of SOC measurement

One of the key features of SOC as a metric, in contrast to the indicators and measurements discussed above, is that SOC is commodifiable as a result of its equivalency with carbon emissions and the political impetus to move towards net-zero. In both these interviews and in public discourse, discussions about soil carbon protocols are often filled with wariness due to this fact. In particular, many critics worry that soil carbon credits are a major greenwashing strategy used in lieu of more radical interventions in our food systems. R5 provided one anecdote that provides a counterpoint to this:

> "There was another carbon marketplace that was there [at a conference] to tell people about them. And the first one of the things that he said was, it's not about climate change, because

> you may or may not believe in that. And i was kind of like, 'who believes in [climate change denial]?'. But he said, but there's a demand for carbon. And so I think, though, that over time, the perspective is going to shift and it's not going to be so polarized, and it's going to […] take this more rounded perspective that I can […] care about the environment as a whole, and get a financial incentive. And those two things don't have to be in odds against each other."

A critical piece of this narrative is the cultural context in which different farmers exist. R5, located in the western US, confronts farmers who hold a distinctly American attitude towards land, property, and nature.

> "I was telling him [a farmer] that, you know, you can get paid for these regenerative practices. And so you're getting a financial incentive, and you're also helping the environment […] He's like, 'I don't care about the environment. I care about my own, you know, bottom line.'" (R5)

This farmer exists in a context in which the cultural attitude towards nature and land is based on property relations and is fundamentally instrumental/utilitarian. The financial incentives can, perhaps counterintuitively, help (certain) farmers break through their utilitarian attitudes towards their land and encourage them to engage in more environmentally sustainable practices in spite of their animosity towards environmental issues such as climate change.

The commodification of soil carbon may offer advantages in certain contexts, but also may produce a number of economic challenges for farmers. The current price of carbon and costs of using the tools used to measure and monitor it mean that the market is, generally, only accessible to farmers of a certain scale. R5 illustrated how features of the Soil Metrics model and the contracts that Nori makes with farmers *de facto* excludes farmers below a certain acreage threshold:

> "we're not requiring that you be a certain acreage, but in some way, it does require that because you're paying the verification cost. So if […] you're not getting 3,500 USD in credits, then you're not going to want to go through the program, because you have to pay 3,500 USD in verification costs" (R5).

This size constraint – a common feature of soil carbon protocols – creates incentives towards land consolidation. This factor and the model limitations discussed above exclude particular farming systems and farm sizes from these flows of financial capital, which could have a significant impact on the food system as a whole.

Soil carbon protocols and the regenerative farmers that are engaging with them also face temporal problems. There is no consensus or standard approach regarding for *when* soil carbon credits can be issued. The two organizations involved in soil carbon markets – Nori and Climate Farmers – interviewed for this project took different approaches to this temporal challenge. Nori issues *ex-post* credits for practice changes made within the previous ten years, while Climate Farmers issues *ex-ante* credits for future, planned interventions. Both of these approaches create particular constraints and incentives for farmers, and may be exclusive to some degree. Well-established regenerative farmers, in particular, are excluded from these systems because their carbon is already sequestered, and the temporal dynamics of some protocols may create clear economic incentives to postpone a transition to a regenerative farming system as long as possible. Exploring these dynamics further is beyond the scope of this research; the interviews served to highlight some of the complex economic dynamics that follow from decisions about when to issue credits. These decisions will have important implications for the future of regenerative agriculture and soil carbon markets, and deserves detailed analysis.

4.4 Summary

The interview respondents overall shared a living ontology of soils, and a belief that soils must be engaged with as living and affective organisms (or multispecies arrangements of organisms). While maintaining this perspective, most respondents also clearly positioned humans as the managers of agroecosystems, with unique abilities to understand and influence soil life. Respondents discussed a range of methods for analyzing soil life, and the connection between these different methods and soil management, economics, politics, and science. Certain methods, such as microscopy, contain the potential to facilitate affective, visual engagements that can produce relations of care between land managers and soil biology, but have limited scientific and political utility. Other methods, such as the measurement of SOC, allow soil to be commodified and has the potential to significantly impact the economics of regenerative agriculture with no clear normative outcome. The narratives presented here indicate a wide variation of possible human-soil relations that are presently identifiable and that may emerge in the future, and illustrated how different approaches to analyzing and managing soils can contribute to this variation.

5 Discussion

The narratives analyzed in chapter 4 provide many insights into changing human-soil relations in the regenerative agriculture space. These narratives pointed to the ways in which soils are conceptualized – increasingly as living, but articulated in diverse ways – the way they are analyzed, and how they are enrolled in attempts to realize the various goals of regenerative agriculture. This chapter will expand the analysis of the interviews presented in chapter 4 to connect with larger practical and theoretical discussions about regenerative agriculture, food system transformation, and humanity's place relative to nature.

To begin, some specific forms of human-soil relations that are developing and proliferating within the regenerative agriculture space will be discussed in greater depth. In particular, microscopy techniques will be contrasted with the measurement of soil organic carbon. Further, the potential impacts of the commodification and financialization of soil life and what this – and other interventions in the soil microbiome – means for the nature of our relationship to soil life in regenerative agriculture systems will be explored. Following this, the discussion will return to the nonhuman turn theories introduced in chapter 2. This section will discuss how to approach understanding our position relative to soil life in agroecosystems, as well as the consequential distinctions between humans and soil life and what this means for the theory and practice of regenerative agriculture. Finally, the chapter will conclude with a discussion of the role of alternative ontologies in regenerative agriculture's transformative project. Building on interview narratives, this chapter will argue that humans take a central role as the prime movers of agroecosystems, and as such should be theoretically recentered to better understand the diversity in human-soil relations in regenerative agriculture.

5.1 Microscopy and SOC

The data from these interviews highlighted a number of different approaches to the practice of regenerative agriculture and to understanding soil life. To begin the analysis of these data in connection to larger discussions in regenerative agriculture and the social science investigations of it and other sustainable agriculture movements, two prominent trends regarding the analysis of soil will be contrasted: use of microscopy other direct methods to analyze specific organisms, species, and populations within the soil microbiome; and measurement of soil organic carbon as a key feature in the effort to address climate change.

In some ways, there appears to be friction between these two trends. Microscopy [4.3.1] allows managers to pay close attention to the state of ecological succession in the soil, to population dynamics between beneficial and malign inhabitants of the microbiome, and to locate specific organisms/species within the soil (for better or worse). Through the close understanding of the soil microbiome such techniques allow, managers can alter the state of ecological succession to better suit their crops, provide compost or other forms of inoculation or food to stimulate certain populations, and otherwise understand and thus influence the specific machinations of the microbial ecology. The level of detail with which farmers can intervene in the microbiome will likely increase as scientific knowledge of soil biology continues to improve.

A critical feature of these direct methods, particularly for microscopy, is the establishment of a visual connection between the human manager and the soil life that they are managing. This visual engagement can produce a different kind of farmer (subject/manager) who is capable of and predisposed to caring for the soil; this is part of the theses of Puig de la Bellacasa (2015) and Krzywoszynska (2019), and is reminiscent of how the practice of "cultivating eyes for her" produces a "different kind of human" in Lyons' work on human-soil relations in the Colombian Amazon (2020; section 2.1). The use of methods that facilitate direct scrutiny of specific players within the soil microbiome allows, in addition to more precise ecological management of the soil, for the production of farmers as affective, perceptive, observant, and caring subjects in the agroecosystem.

Knowing nature more closely allows for more and more precisely directed care to be provided to nature. In order to take proper care of microbial communities within our agricultural soils, we must be able to thoroughly understand and monitor specific players, populations, and their dynamics over time. The use of microscopy and other direct methods represent an attempt to reposition ourselves, as managers and analysts, within the agroecosystem. This section will suggest that the proliferation in use and importance of SOC measurements represent, at its core, a similar attempt to restructure the human-nature relationship in agriculture, albeit at a different level of intervention. Further, restructuring the human-nature relationship can be seen as a (the) unifying theme in regenerative agriculture with varying approaches to and philosophies of precipitating food system transformation as the key points of distinction between different trends/factions within the space.

SOC, in contrast to the use of microscopy and other direct biological methods, does not allow for close scrutiny of specific species, population dynamics, or any detailed processes within the soil microbiome. The ontological opacity of soils as such [section 2.2] transfers over to SOC measurements; without measuring these fractions directly, it is impossible to determine the relative proportions of, for example, microbial and plant derived organic carbon. The connection between SOC and microbial activity or some measure of the health of the soil is, basically, correlative and variable. Further, use of SOC measurements alone precludes the possibility of visual – and thus affective / emotional – engagements between agricultural managers and soil life.

Compared to microscopy, measurement of SOC provides fewer possibilities for direct management of soil ecosystems and also does not precipitate affective engagements with and feelings towards soil life. However, the key objective of SOC measurement in regenerative agriculture is not managerial but financial. Narratives discussing both microscopy and SOC measurements acknowledged the fact that the economic system in which farmers are embedded constrains and guides their decision making. As such, facilitating a transition to a regenerative agricultural system is not just about providing new, actionable knowledge to farmers (though this is important, especially for farmers from the conventional tradition) but also about providing an enabling economic/financial environment. The current system, even amongst regenerative farmers, creates at best probiotic relations of care between farmers and soil life (Krzywoszynska, 2020a) in which sustainable, life-affirming intentions are subsumed by the impetus of financial survival.

The objective of SOC measurement is to create an enabling economic environment that will not erode the life-affirming and -stewarding subjectivity of the regenerative farmer. The objective is *unity* between the economic incentives that rendered Krzywoszynska's farmers' care probiotic and the actions/management interventions that create healthy, lively, and functional soils through altering economic incentives.

Microscopy and SOC measurement can then be seen as two relatively discrete manifestations of a single overarching objective of regenerative agriculture: to establish different kinds of relationships with nature through agriculture. Microscopy operates at the level of the individual, working to produce new forms of environmentally conscious, attentive, and observant subjectivities amongst farmers and other land managers. This subjectivity can come into friction with the economic system in which farmers exist, by incentivizing practices that continue to degrade soils, as in the current food system. The challenge with the cultivation of a "different kind of human" (Lyons, 2020) in the context of regenerative agriculture is the reduction of political responsibility to individual farmers who work in a system that incentivizes unsustainable agriculture. Caring, affective subjects may manage the food system in a more convivial way, but this will have limited impact if those subjects are actively working against their economic context in order to be sustainable.

Soil carbon protocols, in contrast, operate at the level of the economic system, ostensibly attempting to resolve the misalignment between incentives produced by the economic system and actions that nurture, care for, or otherwise establish convivial relationships between humans and nature in agriculture. Construing soil carbon protocols in this fairly positive light is meant to highlight the political imaginaries that can be identified in narratives about them, and not to make arguments for their efficacy or in favour of their adoption; such projects are but one possible intervention into the economic side of the food system. There are numerous valid critiques of specific soil carbon protocols and of soil carbon markets in general (eg, (Carbon)plan, 2021). This research remains agnostic regarding the efficacy of soil carbon markets to alleviate climate change, deliver financial capital to farmers, or any of its other stated objectives. This project asserts, simply, that the proliferation of measuring SOC should be understood in similar terms to microscopy: as a form of knowledge production that aims to facilitate the establishment of new, ostensibly better, relationships between humans and nature. In short, these forms of analysis are based on the same kernel of a political imaginary that defines and unifies regenerative agriculture, with one strategy intervening at the level of the individual and the other at the level of the economic system.

5.2 Soil carbon credits and the financialization of soil life

One of the key challenges regarding SOC protocols is potential negative consequences of commodifying soil life. Krzywoszynska's (2020a) conceptualization of soil biota as labourers enrolled in processes of capital accumulation had a strong influence on the development of this thesis project. Of particular interest was the mechanism by which soil life was enrolled into accumulation in Krzywoszynska's conceptual framework. Similar to other authors writing on human-soil relationships (such as Puig de la Bellacasa), Krzywoszynska understands that soil is valuable because of its ability to produce agricultural commodities. These commodities are bought, sold, stored, speculated upon, and soil biota are cared-for so that they will render soil more productive (Krzywoszynska, 2020a). The mechanism of introducing soil life into the economy, critically, is not direct but proximal. Krzywoszynska's metaphor covers the extraction of surplus value from labourers (the removal of nutrients and other organic matter that, in a natural ecosystem, would have returned to the soil) but not the commodification of labour itself (as opposed to simply commodification of the *products* of labour).

Soil carbon credits represent a break from this indirect economic relation. A significant portion of SOC is, was, and will be soil life: C is found in the habitat, food, excretions, and bodies – both living and dead – of soil organisms. SOC, as a commodity, is based on measurable characteristics of the soil *itself,* rather than on discrete products that can be separated and removed from the soil. Productive soils only have relevance for capital accumulation if plants are cultivated in and harvested from that soil; SOC must simply be measured. In the conventional agronomic model, *plant life* was commodified directly (yield), and soil life entered into the equation only through the close entanglement between soil life and plant life. In this new relation, soil life can be commodified directly[5].

This opens up soil life to be affected by and enter into sets of economic relations in new and different ways. In particular, this allows commodified soil life to enter into the increasingly financialized accumulation processes that characterize early 21st century capitalism (Durand, 2014). The two soil carbon projects interviewed for this research – Nori and Climate Farmers – take different temporal approaches to SOC measurement and commodification. Nori provides credits for actions taken in the past, and Climate Farmers for planned actions in the future. The strategies used to make these different iterations of soil carbon protocols work also lays the foundation for further financialization of SOC through the use of options, futures, and other derivative instruments.

Durand (2014) does not assert that increasing financialization will by definition have negative consequences, and instead highlights two specific features of modern finance that can produce detrimental social and economic effects. Early evidence for dispossession – the first feature, drawing on David Harvey's work – based on the financialization of SOC can already be seen in, for example, Microsoft's well-publicized position as the largest owner of farmland in the US (O'Keefe, 2021). Further, the constraints on farm-size imposed by SOC protocols and associated pressure towards farm-consolidation [Section 4.3.4] represents a possible trend towards dispossession as more actors attempt to access liquidity in SOC markets. The mechanism by which the size constraint is imposed is related to the costs, paid by the farmer to the credit issuer, and is representative of the second insidious feature of modern finance highlight by Durand (2014): parasitism. Parasitism in this context can be defined as "the revenues deducted from company profits by entities which themselves stand entirely outside of the production process" (Ibid, pp. 103) and characteristically involves a transfer from non-financial (e.g., the farm) enterprises to financial enterprises (e.g., the carbon credit issuer). Associating these features of modern finance with emerging SOC markets is, as yet, speculative; however, financial dynamics will have

[5] The following point may have some relevance to the mechanics here but was ultimately beyond the scope of this research. When plant life is commodified in a traditional agricultural context, only a fraction (<1) of the body of the plant becomes a commodity. For soil, effectively the 'entire' body is commodified, but the collective 'body' of soil organisms makes up only a fraction (<1) of the measurement. For plant life, the measurement (yield) is a fraction of the body as a whole; for soil life, the body as a whole is only a fraction of the measurement (SOC). More research should be done on this; the key point for the present is that, while the commodification of soil life through SOC is more direct than the yield relation, the measurement of SOC does not establish a systematic or quantitative relationship between soil life and soil carbon. Therefore, commodification of soil life in this form is based on an and *uneven and unsystematic abstraction* which would then have variable effects in different contexts.

increasingly significant impacts on human-soil relationships as these markets become more widespread and the methods for financializing soil life more diverse.

Novel financial relations are already emerging, and increasingly abstract financial instruments are being developed by different soil carbon protocols within the regenerative agriculture space, as many soil carbon protocols are closely connected to the emerging Web3 movement. Many protocols (Nori is one example) are, in addition to developing and deploying methodologies for the measurement of SOC, making extensive use of blockchain technology for the exchange of these credits. Blockchain technology can theoretically be used to add a much-needed layer of transparency to carbon markets in general, to ensure the provenance of particular credits, and provide expanded access to these markets, both for suppliers and buyers. A deeper application of blockchain technology involves the "tokenization" of carbon credits onto the blockchain[6]; tokenized credits can then be put to use for a variety of purposes beyond greater transparency throughout the supply chain. One example of how on-chain credits can be put to use – beyond simply trading – is the overtly political project, KlimaDAO. KlimaDAO is a reserve currency protocol[7] that overtly aims to lock carbon on-chain, creating a supply contraction and thus price inflation in off-chain markets (KlimaDAO, 2022). KlimaDAO hopes that this will force polluters to pay more to offset their emissions – making genuine transition a more economically appealing option for major polluters – as well as delivering more financial capital to farmers through higher prices (ibid). This particular example, while it does have explicitly environmentalist objectives, serves primarily to illustrate the range of possible relationships that could emerge between humans and soil life as a result of the commodification and financialization of SOC.

It is unclear how exactly these increasingly abstract and financialized relationships – many future developments of which are likely based on ideas that have not yet occurred to us – will affect the management of soil life at the farm level. There are, however, a few clues based on the performance of existing soil carbon protocols.

One of the glaring issues facing most soil carbon protocols is that the economics of soil carbon sequestration (low price/tonne) mean that farms must be a minimum size[8] in order to financially benefit. This creates a clear incentive towards consolidation of farms smaller than this threshold, whatever it may be under different protocols using different methodologies, through the exclusion of smaller farmers from access to this source of financial capital. Further, certain methodologies (such as Nori's process-model) incentivize the particular agricultural systems – for example, monocrop production compared to intercropping [section 4.3.4]. In both instances, the way in which SOC is commodified, and which (types of) farm(er)s have access to the flows of financial capital that it produces could have a significant influence on the overall structure of the farming system.

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[6] Tokenized carbon credits are, essentially, NFTs (non-fungible tokens) that are rendered fungible (that is, tradable) through 'bundling' and the accepted equivalency of any given ton of carbon equivalent. In this sense, carbon credits can be thought of as semi-fungible (like bottles of wine).

[7] This means that they are developing a cryptocurrency, KLIMA, whose value is based on reserves with 'real' (that is, real-world) value. KLIMA's reserve base is BCT (base carbon tonne), retired Verra carbon credits brought onto the blockchain by another company, Toucan; the identity between BCT and KLIMA is established and maintained through a liquidity pool built on smart contracts (based on the code developed by OlympusDAO; KlimaDAO is an Olympus "fork"). KLIMA is to the dollar as BCT is to gold under the gold standard, but with an algorithm instead of a central bank managing the relationship.

[8] Generally, around 50 hectares (R5, R6), though this is variable.

Another challenge, related to the issuance of *ex-ante* credits, is that farmers will become locked-in to particular agricultural systems based on the contracts they have signed in order to receive remuneration for their sequestered carbon. It is unclear how this will influence the ability of farmers to adapt their farming systems while in the midst of these contracts. Both of these issues – the impacts of soil carbon protocols on farming practices and consolidation, as well as the effects of contractual lock-in on farmer decision making – are beyond the scope of this project, but deserve close attention as these soil carbon protocols continue to develop and proliferate. Understanding how these protocols influence all levels of the food system is of critical importance if they are to be transformative tools rather than mechanisms of corporate co-option and greenwashing.

The direct commodification of soil life represented by soil carbon credits does not necessarily negate Krzywoszynska's conceptualization of soil life as labourers in regenerative agriculture systems. However, these microbial labourers can be put into new forms of economic and financial relations through the commodification of SOC. It is no longer the outcome of their activity that links them to the human economy, but the simple fact of their existence (past, present, and future). This must be considered when conceptualizing the potential less-than-human turns towards soil life that may be unfolding in regenerative agriculture (of which, commodification of SOC, could arguably be).

5.3 Human-soil relations in the emerging regenerative agriculture space

Narratives analyzed in this project pointed to a number of different ideas about the nature of human-soil relationships in the regenerative agriculture space, including and beyond those related to microscopy and SOC. Exploitation, management, commodification, financialization, care, and non-involvement were all discussed to some extent, though there was considerable overlap between many of these. This section aims to illustrate examples of relations that can be identified within the interview narratives, and through this indicate the sheer number of possible forms of human-soil relations that have and may emerge as regenerative agriculture continues to grow as a movement.

Krzywoszynska's conceptualization of soils as labourers is a clear example of the possibility of exploitation of soil life in a regenerative agriculture system (2020a). In this relationship, the products of soil organisms' activities are appropriated by humans and used for our own benefit, rather than returning the "value" to the soil biology. The soil microbiome has a close, largely symbiotic relationship with plants. Soil organisms provide access to nutrients for the plants, which then return these nutrients to the soil to feed the microbiome. In agriculture, this plant matter is largely diverted away from the soil, representing an appropriation of the products of the soil microbiome's labour.

Although nutrients are extracted from the soil in both conventional and regenerative systems, there are key differences in the role that the soil microbiome plays in these processes. In regenerative systems, the microbiome is enrolled in the process of making the soil resource-ful (Krzywoszynska, 2019); that is, productive. The microbiome's implication in productivity of the soil makes a relation of exploitation possible. Conventional agriculture is based on a belief that we can "bypass" the soil microbiome in the delivery of nutrients to plants (R1). Conventional agriculture has numerous negative impacts on the soil microbiome, but the bypass means that exploitation in this sense is not a feature of conventional systems.

The measurement of SOC to create soil carbon credits represents a distinct, new form of commodification of soil life, and opens up the possibility for many forms of financialization in conventional financial markets and beyond. Further, the commercialization of biological inoculant also represents a new and more direct form of commodification compared to the relation through yield, and is also distinct from the relation through SOC. Given current focus on carbon in regenerative agriculture and elsewhere, it is likely that the SOC relation will the be most prominent of these (semi)-direct commodification relationships, and as such will receive a more thorough treatment here.

Importantly, the interview narratives pointed to a number of possible human-soil relationships emerging from the measurement of different fractions of SOC, and the use of different techniques to measure them. Total SOC can, of course, be commodified and financialized. Biological fractions can be measured to better understand the composition of the microbiome and more directly manage it (R3). Some metrics of soil carbon facilitate the creation of economic relationships with soil life, and other do not. Similarly, the measurement technique can facilitate (or not) the establishment of these economic relations. Physical sampling, though the most scientifically rigorous method (R1) comes with prohibitive costs that would thus preclude the expansion of soil carbon markets. Remote sensing and model-based techniques resolve this economic challenge; the measurement of SOC can have different effects on human-soil relationships depending on how it is measured.

The interview narratives corroborated some of the claims put forth by Krzywoszynska (2019) and Puig de la Bellacasa (2015), who argued that changing one's ontological outlook on soils could produce relations of care and attentiveness. These narratives pointed to the power of visual engagement in particular as galvanizing feelings of care towards soil life. Narratives discussing care towards soil life focused those feelings of care towards different levels. Some directed their care and attention toward the soil microbiome as a whole, while others focused on specific functional groups or species. Applying care to different levels of the microbiome creates additional possibilities of different human-soil (or human-nematode and human-fungi) relations.

Krzywoszynska (2020) pointed towards the possibility of negative (less-than-human) relations emerging in situations of care when care becomes probiotic, and evidence for this was identified within the narratives as well. In particular, anecdotes were provided about the regenerative farmers applying small amounts of pesticides and fertilizers (R3 and R7). These applications were justified based on a deep knowledge of the soil microbiome. This deep knowledge allows for the calculation of a quantity that will have minimal negative impact on the microbiome, and from which the microbiome will be able to recover. Further, the applications were based on a holistic perspective of their system, which indicated that eliminating chemical applications entirely would require more intensive tillage (and negative impact on the soil through that) than their current system allows. Actions that damage the microbiome can exist within a regime of care, and based on some narratives, may be a core component of the long-term sustainability of these relations.

In most of the narratives – as in the above example of pesticide applications – there was a significant amount of emphasis on human management, although this was rarely positioned in contrast to the profound interconnectedness between humans and soil life. One interview in particular, R3, could be interpreted as a clear and practical articulation of embracing Kate Soper's paradox of simultaneous transcendence and immanence (1995). This narrative was characterized by an irreverence for the profound connections between humans and soil life, as well as a clear understanding that the human acts as a manager of soil life in agroecosystems. This position does not deny the affective character of soil biology, nor the key role it plays in most soil processes, but simply acknowledges our unique place in agroecosystems.

While most respondents described farmers as managers of soil life, but one respondent disagreed (R7). This respondent took a largely hands-off approach to soil biological management. "It's less of trying to manage it [soil biology]. It's more like trying to give all the conditions for it to thrive" (R7). In spite of this statement, R7 went on to describe the myriad ways in which they would intervene in and have a direct impact on the soil microbiome, including the development of site-specific compost recipes and seed-coating using biological inoculants. As such, this narrative of non-involvement is more logically interpreted as a management philosophy rather than a literal description of non-management or letting the soil microbiome take charge. However, this does represent a distinct form of management and thus a distinct form of relationship.

The narratives overall pointed to numerous possibilities for human-soil relations within the regenerative agriculture space. These possibilities are largely influenced by different approaches to understanding soils and different (political, environmental, economic) objectives. In general, the narratives pointed towards the human as the main architect of these relations, and as architects we could produce countless types of relationships between ourselves and soil life, reflecting or combining some of the examples discussed above or beyond. In the following sections it will be argued that the approach to understanding soil life, its role in regenerative agriculture systems, and its relation to us, that was presented in these narratives is also theoretically useful for the study of regenerative agriculture and similar movements.

5.4 Responsibility and recentering the human in regenerative agriculture

The variation in human-soil relationships that can be identified within the regenerative agriculture space is, above all, determined by differences in human understanding, analysis, and management of soil life. This conclusion, to some extent, cuts against the grain of the nonhuman turn approach to studying soils (chapter 2.2). This section, following from the interview narratives and from Büscher (2021; section 2.2), will argue that regenerative agriculture is a context defined by "consequential distinctions" between humans and soil life in which the agency of humans should be practically and theoretically re-centred based on these distinctions.

The three core propositions of the NHT are an emphasis on "ontological entanglement and relationality", a move to "redistribute agency away from humans", and the "questioning of distinction and distinction making mechanisms" (Büscher, 2021). These propositions can be compared to the perspectives presented in the interview narratives. The narratives discussed in chapter 4 (especially R3) accept the first proposition wholeheartedly and strongly emphasize our interconnectedness with soils. The approach to propositions two and three is more nuanced, and they are only accepted to a small extent within the interview narratives. For the second proposition, agency is redistributed away from humans to a certain extent. However, the move in these narratives is more to distribute agency *towards* soil life by emphasizing their ability to affect and have an effect on humans and the agroecosystem as a whole. This move, in the narratives presented in these interviews, is not done to diminish or reduce the agency of humans but to emphasize *that* soil life also has some kind of agency. For the third proposition, key distinctions between humans and nonhumans (soil life) are maintained in these narratives. Emphasis is placed on the existential co-constitution of soil life and human life ("as the soil, so the human", R3), and this emphasis blurs *ontological* distinctions (i.e., we are all part of nature). However, practical distinctions are maintained, and it cannot be said that these narratives take at their core questioning distinction and distinction making mechanisms, and instead simply blur the boundaries in the effort to work more closely with nature/soil life. The perspective on these propositions identifiable in the narratives are, to some extent, consistent with some of the analytical fixes that Büscher (2021) proposes for the NHT [section 2.2].

Büscher's first analytical fix for the non-human turn was to shift from an emphasis on the more-than-human to a dialectic of the more-than-/less-than-human, primarily to elucidate how particular forms of human-nonhuman entanglement and of more-than- or less-than-human actions are historically produced. A dialectical perspective can be useful for understanding two key analytical trends in regenerative agriculture, as highlighted in section 5.1. As discussed above, it is important to understand efforts to measure and commodify SOC in light of the larger political imaginary of creating an enabling and financially sustainable environment for farmers, allowing them to manage their agroecosystems in an environmentally sustainable way. The commodification of SOC represents, at a basic level, a clear less-than-human turn in the abstraction and reduction of soil life to a simple, tradable metric. However, this less-than-human turn is performed in a historical context that requires some kind of intervention to overcome the financial barriers for transitioning to regenerative agriculture. Thus, the less-than-human turn is made, ideally, to the long-term end of producing a more-than-human turn based on a historical predicament that precludes, erodes, or inhibits the impetus to take better care of soil life.

Similarly, use of microscopy techniques to closely understand specific soil organisms, populations, and the environments in which they live is a clear representation of a more-than-human turn, emphasizing the activity and needs of specific soil organisms. However, as stated by R8, improving our knowledge of soil biology can increase the possibilities for attentiveness and care, but "there's just as much potential for abuse of this knowledge and looking at it as another way that we can start to control and force our will onto the complexity of living ecosystems." Knowledge is not an isolated object and does not produce normative outcomes in itself; how knowledge is put to use determines normative consequences.

Francis Bacon, often vilified as the originator of the notion that humans have a natural position of domination over nature (for example, Klein, 2014), was also an extremely astute student of nature (Foster, 2000). Foster argues that

> "The notion of the human "domination of nature", while tending toward anthropocentrism, does not necessarily imply extreme disregard of nature or its laws. Bacon himself argued that the mastery of nature was rooted in understanding and following her laws [...] the notions of "mastery" and "sustainability" arose together in the very same Baconian tradition" (ibid, pp. 12).

There is no simple equivalency or necessary causal mechanism between knowledge of and care for nature or non-humans. To amend Puig de la Bellacasa's thesis, "knowing soils better *could* enable better care" (2019, emphasis added), but it could also enable better, more efficient, and precise forms exploitation and manipulation of soil life, as indicated by R8. Just as the less-than-human turn of SOC commodification could, theoretically, result in more-than-human actions towards soil life through the removal of financial constraints, the more-than-human turn of attentiveness towards soil life – epitomized through the use of microscopy techniques – could result in less-than-human interventions based on precise knowledge of soil life. Specific decisions made by specific humans and groups will determine the ultimate outcomes of getting to know soils better.

Büscher's second analytical suggestion for the non-human turn was to move from decentering the human in all instances to strategically de- or re-centering the human based on the consequentiality of distinctions (2021). The relationships developed between humans and soil life in regenerative agriculture systems are defined by consequential distinctions, and humans should be recentered based on these distinctions in this context. The key point of distinction is agency. Interview subjects in this research were clear in their placement of humans as the main drivers of soil regeneration. Soil life may have its own, distinct form of agency, and there is no doubt that it can affect and have an effect on humans through our deep entanglement with them and through their contribution to key soil functions However, in an agricultural context, it is humans alone who have the ultimate power to dictate the context in which soil organisms live; human managers set the conditions under which soil life may express its (their) agency and contribute to the regeneration process (or not).

This point can further be elucidated by exploring a comment one respondent, R7, made in passing:

> "I think you just want to really unleash it [soil life]. I think it's less of trying to manage it. It's more like to give all the conditions for it to thrive […] if we don't intervene for 100 years in one place, it's gonna be a forest again."

Left alone, soil ecological succession, as with aboveground succession, will simply run its course until climax communities are dominate. As discussed in section 4.3.2, late successional soil ecosystems are defined by fungal dominance, which is not conducive to the production of most crops. In general, respondents focusing on succession in soil ecosystems aimed for a rough balance between fungal and bacterial communities. The ultimate purpose of regenerative agriculture is, fundamentally, agricultural. This means that processes of soil regeneration in regenerative agriculture are distinct from natural process (in the sense of having no human involvement) in terms of the type of soil that is produced, and in terms functions that the regenerated soil in turn provides.

Schulte et al's framework, Functional Land Management (FLM), lays out five key soil functions: primary productivity, provision of habitats for biodiversity, carbon storage and regulation, water storage purification and regulation, and nutrient cycling (2015). Critically, Schulte et al highlight that there are inherent trade offs amongst the different soil functions. This point was echoed in R1s discussion of the carbon dilemma, in which there is a trade-off between the carbon storage and primary productivity functions. In a conventional system, primary productivity is seen as the key function which must be maximized. Regenerative agriculture diverts from this, attempting to provide (to some extent) all of the five soil functions, though the key emphasis is often on carbon storage and regulation and primary productivity. Natural ecosystems, such as the forests evoked by R7, provide high levels of, for example, the habitat for biodiversity function, but with the trade-off of reduced primary productivity. Based on the FLM framework and the discussion of ecological succession presented in the interviews, following the process of natural regeneration to its natural conclusion will not produce agriculturally productive soils.

The human need for primary productivity leads us to suspend the successional process and select for the provision of particular soil functions. Further, our position within a given agroecosystem is unique because we have the *capability* to produce and to understand these effects, while billions of soil organisms live out their lives, oblivious to the impacts that we have on their microscopic worlds as well as to the ways in which they can affect us. This capability is the root of our distinct agency, relative to soil life, in regenerative agriculture systems and therefore confers a similarly unique sense of responsibility to humans as managers or stewards. Should regenerative agriculture meaningfully contribute to addressing climate change, it will be as a result of human decisions about how to manage and interact with soil life.

Soil life contains an inherent capacity to sequester carbon and contribute to climate change mitigation, but it lacks the agency to make this potential manifest. Humans have the capacity and responsibility to create environments in which soil life can realize this potential: as R3 put it, acting on this responsibility is an existential imperative. Further, as discussed in section 5.3, the social and economic embedding of different human actors has a profound impact on their ability to employ sustainable (regenerative) soil management. Acting on this responsibility, therefore, is not simply a question of the individual actions of farmers, but also of restructuring the political, social, and economic systems that incentivize, constrain, and otherwise guide individual actions and capabilities. The human's central place in regenerative agriculture systems is based on consequential human/non-human distinctions, and indicates that humans and human systems should be a point of analytical focus in (social science) scholarship on regenerative agriculture, and a point of discursive focus in broader discussions of the movement.

5.5 Transformation towards regenerative food systems: the role of "alternative" ontologies in theory and practice

A question then remains about the role of adopting different ontological outlooks towards soils in regenerative agriculture's broader objective of food system transformation. What function does this new "discourse on the nature of being" (Graeber, 2015) of soils serve in this transformative project? Kate Soper might argue that this discursive work may have little material impact:

> "The relations between the adoption of a particular ontological outlook, and the attitudes one holds towards nature, are much more tenuous than some ecologists seem to suppose; and no ecological set of prescriptions automatically follows from our putting the ontological knife in at one point rather than another" (1995, pp. 175)

This section will diverge from Soper's thesis, albeit just, and argue that the movement of the "ontological knife" can have some impact on our material relations with nature, particularly in the present historical moment.

Toledo identifies "spirituality" – that is, purposeful reflection on the ontological dimension of our relationships with nature – as an unrecognized, but critical, link in agroecology (2022). A distinct sustainable agriculture movement, agroecology can be distinguished from regenerative agriculture through the former's overtly "decolonial and anti-establishment" objectives (ibid). In contrast, regenerative agriculture's key objectives are environmental (addressing climate change) and economic (financial liberation of farmers) without any consistent political or social objectives. In spite of this, insight can still be drawn from Toledo's analysis of spirituality in agroecology, as both agroecology and regenerative agriculture aim to sustainably transform the modern industrial food system.

Toledo's core argument is that agroecology has done significant work on the practice and epistemology (science) of sustainable agriculture, but has not sufficiently addressed or engaged with the ontological/spiritual components of farming. These ontological components are core factors of traditional and indigenous farming systems from which agroecology (and regenerative agriculture) draws significant inspiration from, and Toledo argues that "the merely epistemological dimension cannot be separated from other dimensions that constitute traditional wisdom" (2022). As such, "recognizing and integrating spirituality into agroecological practice would reinforce agroecology as a socially and environmentally liberating activity" (ibid). Ontology is inherently linked to our epistemologies and practices, and therefore has a place in any project seeking food system transformation.

Toledo's discussion concerns the agroecology movement which, compared to industrial agriculture and agronomic science, already has a wealth of spiritual wisdom. Most conventional agricultural soils exist today in a highly degraded state; some warnings claim that, if our rate of soil degradation continues, we will run out of agriculturally productive soils within the next century (FAO, 2015). Conventional soils were referred to as microbial deserts by R4, and conventional agriculture could be considered a spiritual desert with regards to soil life[9]. This degraded state is what makes soil regeneration in an agricultural context possible. From an agronomic perspective, the promise of regenerative agriculture does not lie in what it does, but what it *undoes.* Historical degradation is a precondition for regeneration. For similar reasons, developing alternative "ontological outlooks" or "discourses on the nature of being" of nature can lead to positive material outcomes in the present historical moment. Recall that a core principle of conventional agriculture, from this perspective, is a belief in the human ability to bypass the soil microbiome (R1). In this conceptualization of soils – and under the broader belief in humanity's dominion over nature – there is no ontological basis for a spiritual connection with nature or soils. The degraded "spiritual" state of modern agriculture creates the historical possibility of "regeneration" of an ontological foundation for a spiritual connection to soil life and nature in general, as well as the possibility that this ontological regeneration will contribute directly (materially) to soil regeneration.

Evidence to support this notion can be found in the interview data analyzed in this thesis. The use of microscopy, particularly in a pedagogical context to introduce and familiarize farmers with the soil organisms beneath their feet, can dramatically shift a farmer's perspective on their land and on farm management. Some respondents took the existentially co-constitutive nature of human relationships with soil life as the foundation of their agricultural and scientific practice. Adoption of these ontological outlooks do lead farmers and managers to engage with their soil in different, material ways. This material impact can be curbed or precluded by the socioeconomic contexts in which human actors are embedded – for example through the necessity of staying financially afloat – but material effects can

[9] To be clear, I am not asserting that conventional agriculture is an "ontological desert", but a spiritual one. The conventional approach to agriculture has a robust ontology of soils: one in which soils are inert, nonliving, and can be bypassed in agricultural management. The challenge with this perspective is that there is no ontological *foundation* from which to explore the deeper, fundamental aspects of our relationships with soils and soil life. An ontological outlook that conceptualizes soils are living, lively, and affective provides the ontological foundation for such exploration.

follow from shifts in ontological outlooks, nonetheless. Following from Toledo (2022), the ontological dimension can be viewed as a critical (if not singularly so) component of regenerative agriculture's potential for to affect food system transformation.

Much of Toledo's discussion concerned the indigenous agricultural knowledge, which is usually imbued with spiritual/immanent ontological elements. The difference, according to Toledo, between modern and traditional ontologies of nature is that "the former is separate from the nature of culture and its vision is based on the rational (science), whereas for traditional peoples this separation does not exist and humans appear in a permanent equality in relation to that which is non-human" (2022). The narratives of the human-nature link analyzed in these interviews would align, in general, much more closely to the traditional than the modern ontology as described by Toledo. A challenge, then, is that this ontological shift in regenerative agriculture is a relatively new phenomenon, and does not have established spiritual traditions to draw on (only practical and epistemological traditions, both of which are highly contested). Engaging in serious, direct, and detailed conversations with indigenous peoples could help the regenerative agriculture movement to articulate its ontological position more coherently and thoroughly – both in general and in relation to diverse epistemological and practical perspectives.

Toledo argues that "spiritual beings" (that is, actors who engage deeply with the ontological component of their worldview) share a common core quality, which can be invaluable in an agricultural context:

> "humility. Human beings not only acknowledge that they are powerless, imperfect, limited, and finite, but also recognize their own mistakes […] humility can thus be a key attribute of the practice of agroecology and contrasts with the idea of "ruling over nature" more common to agroindustrial practices" (2022).

This description of humility can be applied to the (re)centering of the human argued for in section 5.4, with one amendment. Humans are not entirely powerless – and in fact wield a great degree of power to influence other actors and process in agroecosystems – but are *ultimately* powerless to the processes of nature, unintended outcomes, and so on. Our unique capacity to impact and understand agroecosystems gives humans a central place in regenerative agriculture relative to soil and other non-human life; humility can be seen as a key characteristic of an ideal human manager in this central role, and it is characteristic that is directly informed by ontological outlook.

Humility and a sense of the fundamental (perhaps ontological) fallibility of human beings is something tangible that agroecology, regenerative agriculture, or other sustainable agriculture movements can draw from indigenous wisdom and practices. Humility can be a strategy for existing within Soper's "paradox of simultaneous transcendence and immanence" (1995). As denizens of this paradox, we are able to understand agroecosystems in extremely fine levels of detail and are able to exert significant powers to influence them; but we are also at the mercy of a larger nature, the actions of other organisms within our systems, and above all, of the fundamental uncertainty of the future. "One of the most important things all humans really have in common," states Graeber (2015), is "the fact that we all have to come to grips, to one degree or another, with what we cannot know". Humility as a principal can help us to balance, on one hand, the inherent fallibility of our knowledge unpredictability of the impacts of our (management) actions with, on the other hand, our unique powers to effect, influence, and understand agroecosystems.

Graeber's invocation of this universal is in critique of nonhuman turn (ontological turn) theory, which, he argues, obscures recognition of this characteristic of human existence. Instead, we need an alternative ontological perspective that does not preclude but encourages recognition of our fundamental fallibility. Some indigenous perspectives and wisdom could help move these discussions forward, both in the study and practice of regenerative agriculture and in discussions of social theory.

Anishinaabe stories provide a compelling template for a human subject, deeply engaged with the ecology in which they live, who wields a unique (relative to non-humans) power to effect and understand that ecology, and who is innately fallible and predisposed to making mistakes and miscalculations of all kinds. As introduced in section 3.7, *Nanabozho* is the trickster-guide of humanity, who taught us much about how to observe and name different actors and process in nature, and thus about how to live properly within nature. Fallibility is another key characteristic of *Nanabozho,* and provides a powerful guide for how to interact with and relate to nature. As a spiritual guide, *Nanabozho's* character partly serves to give us a template for how to come to grips with "what we cannot know" (Graeber, 2015), and the fact that we must act, affect, and have effects on the rest of nature, nonetheless.

Engaging with *Anishinaabe* philosophy – or other indigenous philosophies – could also provide insight into theoretical questions about the relationship between humans and nature. As stated by R8, "the inherent life and the necessity of preservation of health in soil ecosystems has been understood at a spiritual level in a lot of indigenous cultures for a very long time". Recall Hallowell's example of occasionally and contextually animated (living) rocks in *Ojibwe Ontology* (1961), taken up by Graeber (2015) and Viveiros de Castro (2015) [Section 3.4]. Manning, unlike the other commentators an *Anishinaabe* person herself, asserts that Hallowell imposed a distinction – (in)animate – that is incongruent with the internal logic of *Anishinaabe* philosophy (2017, chapter 1). This imposition and Hallowell's informant's subsequent (polite) engagement with the idea of the distinction led to the substance of *Anishinaabe* philosophy being misconstrued. From Manning's perspective – and the perspectives of her *Anishinaabe* family members/informants - it does not matter whether a rock is "really" animate or not. In fact, Hallowell's "question ["are all the stones we see here about us alive?"] might make little sense to the old man for whom everything in existence is alive, for it would not exist otherwise (my mother's teaching)" (Manning, 2017, pp. 6).

Manning describes how an elder told her that "rocks are linguistically inanimate until we interact with them in such a way as to change their status, such as bringing them into the sweat lodge for ceremony" (2016, pp. 7). There are two valuable points in this statement. The first is that rocks may be *linguistically* inanimate in certain contexts, but this does not mean that they are *ontologically* inanimate; for the *Anishinaabe,* being alive is a precondition for all of existence and using such dichotomies offers little insight into *Anishinaabe* wisdom. The second point is the implicit acknowledgement of the impact of humans on nonhumans in the context of our profound entanglement, indicating a deep sense of relationality in conjunction with human/rock distinctions. Once in the sweat lodge, the rock may affect us in many ways, but we are the ones who bring it into this relation. From this perspective, we are always already ontologically connected with nature, and the fact that humans have unique abilities to create and alter specific relations – for better and worse – is in no way contradictory with this basic fact about the nature of reality. Soper's "paradox" is not paradoxical in this view.

The distinctions at the heart of debates about the nonhuman turn – nature/society, human/nonhuman, living/nonliving, animate/inanimate – are meaningful within the western, but not the *Anishinaabe* tradition. Attempting to draw insights from *Anishinaabe* or other indigenous philosophies into these distinctions (or lack thereof) is therefore partly misguided, since these distinctions do not exist within these philosophies as such. Comparing radically different philosophies can be a helpful tool, but indigenous philosophies should be engaged with for the valuable notions internal to them, and not simply for providing novel commentaries on western ideas.

Indigenous perspectives and wisdom can offer useful insights for meaningfully engaging with the ontological dimension of programs like regenerative agriculture. This ontological dimension, though there is no *necessary* causal relationship, can have material environmental impacts in particular circumstances. As such, the ontological reframing of soils and nature in regenerative agriculture does play an important role in its transformative project. However, this effect can be limited and constrained by broader social, economic, and political factors. Thus, a key component of humility is recognition of the powerful influence these factors can have on farmers' ability to sustainably or regeneratively manage their agroecosystems. Adopting alternative ontologies is an important part of regenerative agriculture's transformative project – and an aspect that could be deepened through serious engagement with specific indigenous traditions – but food system transformation will not follow from this alone.

5.6 Conclusions

This thesis has shown that numerous forms of human-soil relationships are developing and scaling-up and -out within the regenerative agriculture movement. These relations are diverse, and this is largely connected to the new kinds and quantities of data that we have about soils and soil life. Soil life plays a central role in regenerative agriculture systems, but there is a consequential distinction between humans and soil life based on humanity's unique abilities to understand and impact agroecosystems. Because of this, humans need to take central discursive and practical place in regenerative agriculture, although this should not downplay the fundamental importance of soil biology.

Evidence from this thesis has indicated that ontological outlooks towards nature/soil can influence how humans impact soil life, and that individual desires to care for soil life is often constrained by economic, social, and political factors. Ontological reframing can, through altering our perception and management of soil life, have a material impact on soil life; these effects are both limited and historically contingent upon the ontological/spiritual desert of modern agriculture. One mechanism through which ontological reframing of nature/soils can have positive effects in regenerative agriculture is through nurturing a sense of humility, and indigenous characters such as *Nanabozho* can provide wisdom for how to thrive within and affect a complex ecosystem with humility. Regenerative agriculture offers great potential for food system transformation, but the ultimate outcomes of the movement – economic, social, political, and environmental – will be based on specific decisions made by specific people and organizations. In order for regenerative agriculture to have positive impacts, we – as agroecosystem managers and participants in the (re)production of the broader social and economic systems in which managers exist – must acknowledge our central place in agroecosystems and act in this position with responsibility and humility. This is critical both for the direct management of agroecosystems and in the administration of the broader socioeconomic structures that constrain, enable, and otherwise incentivize particular forms of agricultural management.

6 Conclusions, Limitations, and Future Research

6.1 Full circle: how and to what end are human-soil relations changing in the regenerative agriculture space?

As a movement, regenerative agriculture offers a radical but messy vision of the future of the food system, with its objectives centered around the goals of delivering positive environmental outcomes and improving economic outcomes for farmers. The movement's diversity – reflected in lively debates concerning the definition of regenerative agriculture, what practices it in/excludes, and how to apply the system to different ecological and socioeconomic contexts – has produced confusion about what exactly constitutes it. Based on this, there are valid concerns about the corporate co-option, dilution, and greenwashing of regenerative agriculture's transformative potential. However, the basic discursive proposition of the movement – that a truly "regenerative" as opposed to extractive or simply sustainable relationship between humans and nature through agriculture is possible – is powerful in itself.

Soil, and specifically the life within that soil, is at the heart of the regenerative agriculture program. The diversity and contestation inherent in the regenerative agriculture movement means that soil is central to regenerative systems in a range of different ways. Soil life can be mobilized to render soils productive, or to sequester a maximum amount of carbon below ground. Specific organisms or plant material of a specific composition can be introduced to engineer the microbiome subject to the requirements of a given crop. In some instances, the microbiome is managed to the smallest level of detail possible, while others treat absolute knowledge of the soil microbiome as neither possible nor desirable, opting instead to employ general best management practices. Further, more direct links between soil life and capital accumulation processes are established through the use of soil carbon credits.

The narratives analyzed in this thesis indicate that what unites these types of relationship or forms of engagement between humans and soil life is that they are all initiated by humans and exist to serve human ends. This does not preclude the possibility of soil life benefiting from these engagements, particularly in the context of a transition away from conventional agriculture. The narratives point, however, to the importance of recognizing humanity's central position as the prime mover and architect of the specific relationships – exploitative, managerial, caring, or otherwise – that we form with soil life. As stated by R3, soil biology and humans are existentially co-constitutive; we depend on each other for our very existence. The nature of the impacts that follow this existential co-constitution, however, are not innate or inherent. Conviviality between humans and soil life is not predetermined or ontological, but rather constructed by specific humans and specific decisions.

The way that we analyze soils, and how the data we produce are used to influence farm management and governance of the food system, directly influences the forms of relations with soil life that we have. Some techniques allow for visual engagements, or close scrutiny of the soil microbiome which can, importantly, result in positive or negative actions towards soil life. This thesis has shown that the case of SOC is particularly illuminating, as the method for measuring carbon and the type of carbon that is being measured enables different forms of relations with soil life. The measurement of SOC can, in particular contexts, enable commodification of soil life, and reducing the agricultural system to its impact on SOC risks ignoring other valuable indicators of the soil microbiome. In other contexts, and using different methodologies, it can be used to make scientific or political claims about regenerative agriculture's contribution to climate change.

The growing importance of soil biology and the associated ontological shifts – framing soils as fundamentally living as opposed to inert, malleable substrates – are critical components of the regenerative agriculture program. However, as pointed out by R8, this increased knowledge and new perspective could be used to influence soil life for better or for worse. A key, then, to engaging with soil life in new ways is to act with a sense of responsibility and humility [chapter 5]. Alternative ontological outlooks on soil can, in particular, have some influence on food system transformation because it provides the foundation for deeper "spiritual" explorations of our connections to nature through agriculture (Toledo, 2022); a foundation that is largely absent from conventional agriculture.

Analysis of the narratives further indicated that taking responsibility and acting with humility must go beyond the individual and individual relations of care, attentiveness, and affectiveness. A key aspect of humility is recognition of the profound constraints imposed on individual actions by the economic, political, and social structures in which individuals live. These structures must be altered or reconstructed in order to enable, incentivize, or at least not actively *dis*incentivize relations of care and attentiveness towards soil life. The narratives analyzed here pointed to soil carbon markets as one possible intervention that could restructure this economic setting, but there are valid concerns about the expansion of carbon markets and many other options to influence the economic setting. A key insight from these narratives is then the importance of combining these two critical aspects – ontological/spiritual and economic/financial – into discussions about food system transformation.

Human-soil relations are changing in numerous ways in regenerative agriculture, aimed to achieve one or both of the goals of environmental sustainability and improving the economic situation of farmers. As our understanding of the soil microbiome improves, and more strategies are developed to financialize soils and soil functions, many more forms of relations between humans and soils are likely to emerge, for better or worse. The narratives analyzed in this research indicate that the future of regenerative agriculture will likely be for better *and* worse in different contexts and with different actors. A major contribution of the movement to mainstream discourses on agriculture is to put the ontological and economic aspects of agriculture into direct conversation, and this will likely have long-term reverberations throughout the food system.

6.2 Limitations

The proposal for this thesis was developed during the height of the Covid-19 pandemic, and, as such, the researcher planned multiple contingencies to be able to adapt to travel restrictions. It was the hope of the researcher to be able to conduct a small amount of participant observation (for example, of a workshop provided to farmers concerning regenerative soil management) in order to complement the semi-structured interviews, but ultimately it was not possible for this to come to fruition and the entirety of the data collection was performed online. We are all adapting to the new rhythm of online work and interaction, but there are important parts of communication that can be lost when using online platforms. Nonverbal communication, informal time to make small-talk prior to or following an interview, and the sense of connection that comes from sharing a space were all missing to some extent from the data collection in this project. It cannot be known what – if any – pieces of data could have been lost in translation as a result of this; exploration of these questions using in-person interviews and/or participant observation could elucidate further insights on the nature of changing human-soil relations and perspectives on soils.

One advantage of participant-observation is that it naturally would have narrowed the focus of the research to one (or a couple) of organizations and their networks. Regenerative agriculture is undergoing a veritable explosion in activity, which new projects, partnerships, and organizations developing and at a breakneck pace. Further, as noted in the introduction, one of the defining features of this movement is its diverse and distributed nature, meaning that a wide range of perspectives and approaches to regenerative agriculture could be found. Focusing specifically on one organizations (and their network) would have reduced the weight of the task of delineating these various perspectives, and could have made the final analysis more sharply focused on a handful of perspectives within a connected bubble. Taking a representative sample of perspectives on soil life in regenerative agriculture was never the objective of this research. Due to the high diversity of projects and perspectives, this project was primarily exploratory in its sampling. Overall, a wide range of respondents representing differing perspectives on many of the key issues in regenerative agriculture (outcomes vs practices and SOC measurement, for example) were included in the study. One key "type" of respondent that would have further benefitted the project is an organization with similar positioning to Nori, but using physical soil sampling to produce carbon credits.

Another limitation of this project was the broad nature of the questions. As the project developed, much more attention was paid to scientific and analytical methods than, for example, communication to farmers. Setting the focus specifically on knowledge production - or, similarly, on soil-carbon credits – could have allowed for a more specific focus within this project. Similarly, the initial sampling objective was to have a large quantity of interviews to try to best capture the diversity of perspectives and positions within the regenerative agriculture movement. The result was an excess of data; an alternative approach based on conducting a smaller number of more in-depth interviews could have additionally added focus to this project. Ascertaining a perfectly representative sample of the regenerative agriculture space is likely all but impossible, as there are as many perspectives as participants (likely even more, if sampling is done over time).

6.3 Looking forward: human-soil relations and regenerative agriculture

As a developing and highly contested movement, regenerative agriculture poses a wealth of future research opportunities. Understanding how "regenerative agriculture" is conceptualized and deployed in different ecological, political, social, and economic contexts will likely be an area of valuable investigation in the future as the movement continues to expand and grow. In particular, the present research hopes to encourage future researchers to take the analysis of changing human-soil relations beyond the level of individual farmers or gardeners to include the social, ecological, economic, and political aspects of the food system as well. Key areas of research could focus on how policy environments influence farmers' ability to care for their land and soil, how sociocultural attitudes towards nature support or create friction with regenerative agriculture systems, or how the economic system could (dis)incentivize particular practices. It would be particularly salient to focus on the trade-offs that emerge from in particular iterations of regenerative agriculture systems, such as the Brazilian high-input no-till systems described by Ofstehage and Nehring (2021).

The present research focused on relatively small intermediary organizations. As discussed in chapter 1, however, much of the growth in the regenerative agriculture movement has been driven by large scale corporate interest and investment. Future research should engage with the corporate version(s) of regenerative agriculture, attempting to understand and clarify how corporate actors define and operationalize regenerative agriculture. Other research could be done to understand how corporate actors encourage/impose regenerative practices along their supply chains, how these practices are selected and how they influence the environment, and how transitions to regenerative agriculture along corporate supply chains influences farmers.

Finally, future research on and practices of regenerative agriculture could benefit from deeper, more serious engagements with indigenous perspectives and traditions. It is often claimed that regenerative agriculture takes significant inspiration from indigenous agricultural systems, though details are rarely given to substantiate this claim. What practices are taken from indigenous traditions, and how and when were/are they adapted to modern farming systems, crops, and business models? From which "indigenous" peoples is this inspiration drawn? Indigenous agricultural traditions and knowledge systems are extremely valuable sources of wisdom on how to farm (and, indeed, live) *with* nature as opposed to against it. As such, indigenous farming systems should be a source of inspiration for practitioners of regenerative agriculture. But this inspiration should be *specific, place-based, and active,* rather than approaching indigenous knowledge as an amorphous fragment of a romanticized past, or taking other homogenizing and/or ahistorical approaches to engaging with indigenous knowledges and peoples.

Part of the value of indigenous perspectives and agricultural traditions is that they are fundamentally place-based, deeply dependent on specific animals, plants, geography, climate, and other features of a place. This echoes the foundational context-dependency of regenerative agriculture. It is claimed that there is no one way to farm regeneratively, because the local conditions determine much of your operations: what is planted, how it is cared for, how the soil is worked, what additions are given, and so on. Drawing on and collaborating with indigenous farmers can therefore provide insight, for non-indigenous regenerative farmers, into specific management strategies in specific places and with specific crops, as well as into place-based / context-dependent approaches to farming in general.

6.4 Looking forward: carbon

Much research can be done on emerging soil carbon markets, especially as significant amounts of financial capital are funnelled into the industry, stimulating a large volume of new projects and protocols centered around soil carbon. There is significant research to be done evaluating the efficacy and accuracy of these different projects, including how they approach key issues such as additionality and permanence, and how different approaches to these issues produces different social, economic, and ecological outcomes. The emergence and growth of soil carbon markets changes the economic incentives that farmers face, and research should be done to determine how exactly this influences sustainability of the food system. Special attention should be given to how these protocols can have effects on farm consolidation and urban/rural dynamics, create (dis)incentives for particular farming systems, and otherwise exclude farmers based on their farm size, region/country, farming system, or other factors.

This research takes an agnostic perspective on carbon credits/markets as economic tools, which will purportedly either facilitate food system transformation or prevent it through greenwashing. What does appear certain, from the researcher's perspective, is that (soil) carbon protocols and markets will continue to develop and attract increasing quantities of capital. Thus, any critical energy would be best directed at ensuring that the markets that do develop are transparent, based on rigorous methodologies, and deliver positive outcomes to farmers. The development of these carbon markets has been set in motion and (probably) cannot be undone; the ultimate impact of these markets on the environment and on the human actors who participate them is not predetermined, and future research can inform political action geared towards making these markets as equitable and sustainable as possible.

Soil carbon markets represent, in general, a new form of economic relation with soil life, and thus with nature. The present research took a small step towards understanding what this direct entry of soil life into capitalism means, and much more research could be done to understand this in greater detail, and to understand how this relation changes under different approaches to the measurement and commodification of soil carbon. Further, many projects involved with soil carbon credits are looking ahead to including compensation for biodiversity and other soil functions. Future research could be done investigation how these projects could further alter relationships between humans and the environment.

Many prominent soil carbon projects operate in a peculiar sociopolitical niche. Some of these projects exist at the intersection between environmental and decentralized finance movements, and are thus at the fringe of each. Future research could be conducted on the technical and political challenges and opportunities that emerge from this marriage. Further, preliminary exposure to this space indicates that it is incubating a radical political imaginary with utopic visions both environmentalist and technocratic, possibly with some distinctly non-leftist, post-capitalist ideas. These spaces will be fascinating research sites for the future study and theorization of sociopolitical projects aimed at 1) creatively leveraging technology to restructure the human-environment relationship, and 2) developing an imaginary of a sustainable future that transcends the capitalism-socialism dichotomy.

6.5 Looking forward: theory

This research aimed to contribute to the ongoing discussion of the nonhuman/ontological turn in the social sciences. The objective of the researcher is not to discredit nonhuman turn theory, but to productively add to the conversation in light of the urgent need for radical action to address the climate, biodiversity, and other socioecological crises. These objectives were, as detailed in chapter 2, largely informed and inspired by the contributions of Malm (2018), Bushcer (2020), and Foster (2016). The discussions of the nonhuman turn presented in these works highlighted the practical bind that nonhuman turn theory gets us into. The present research sought to apply their insights to the case of regenerative agriculture, which provided a basis for understanding the complex uses of different forms of knowledge (chapter 5).

A possible solution to the problems raised by these authors is an acceptance of Soper's paradox of simultaneous transcendence and immanence (1995). The narratives analyzed in this thesis present an image of what existing within this paradox could mean: an acceptance of the profound, ontological interconnections between humans and nature along with an appreciation for humanity's unique position in nature and the responsibility that position affords. Regenerative agriculture as a movement involves both less-than-human and more-than-human actions towards soil life, and these actions are often co-evolving. This made regenerative agriculture a valuable research subject for exploring the possibilities of food system transformation (or other forms of political action) in the context of a deeply interconnected world.

The messiness of regenerative agriculture lent itself to exploring theoretical questions about the connections between humans and nature. Other movements – which have a discursive emphasis on the immanence of human and nature but work actively to influence nature – such as regenerative agriculture could also provide insight into these theoretical questions. Regenerative agriculture and other environmentally oriented movements draw inspiration from indigenous cultures and philosophies. A deep engagement with indigenous philosophy, such as that presented by Manning (2017) could provide valuable outside perspectives on these theoretical questions. Many indigenous cultures, such as the *Anishinaabe,* have long traditions of holding ontological outlooks consistent with Soper's simultaneity paradox. In addition to providing valuable agronomic information and expertise, indigenous peoples could be a source of inspiration for a robust ontology of nature that regenerative agriculture is partly striving towards.

6.6 Conclusion

Regenerative agriculture makes two major contributions to food system transformation. The first is the "ontological reframing of soils" which was the starting point for this thesis, and, as this thesis has shown, may have some material effects. The second major contribution that regenerative agriculture offers is an alternative perspective on the economics of farming. There is a major push to liberate farmers from their financial constraints, and though criticism of some of these interventions is valid, the aim is noble. This is also an aspect of farming that regenerative agriculture engages in much more than many other sustainable agriculture movements: the double-win of agriculture, profit and for the planet. There are economic and financial limits (and care, etc) as evidenced by Krzywoszynska (2020a). There are also very real economic challenges that farmers face, that should be addressed in food system transformation. This is something that many other agricultural movements treat differently from regenerative agriculture; there are real challenges to scaling permaculture in the current economic context, and regenerative agriculture is situated to bypass these challenges endemic to agricultural programs like permaculture. For example, regenerative agriculture can be done in large scale, mechanized, predominantly monocrop systems with low labour input, while this would not fit in permaculture. Regenerative agriculture is similarly positioned to access soil carbon markets more easily than permaculture operations which, due to their high labour inputs and low commercial interest, are often small.

These two ideas – exploring the ontological interrelations between ourselves and nature through agriculture and positing/working towards an economy-environment win-win via agriculture – are, at first glance, contradictory. The former idea leads to more-than-human actions: privileging, appreciating, and caring for soil life. The latter leads to new forms of objectification of soil life, and exposure of soil life to economic forces in new ways. One contribution of regenerative agriculture is bringing these two aspects of food system transformation into direct conversation and apparent contradiction. As discussed in chapter 5, it is useful to view the more-than-human and less-than-human actions towards soil life dialectically, and understand these new forms of human-soil relations – caring and affective, objectifying and exploitative, etc. – as emerging from historical processes. This aides in understanding how and why they have emerged and, more importantly, how to steer the food system towards producing better outcomes. Bringing these (more-than-/less-than-human) actions into contradiction stimulates efforts to resolve that contradiction, such as the expansion of carbon credit programs to include co-benefits. If nothing else, regenerative agriculture has opened up conversations in the mainstream agricultural space about how to live and work better with nature given our ontological connections, how to restructure the economics of agriculture to benefit farmers and incentivize sustainable practices, and, most importantly, how these two projects connect. The economic predicament facing many farmers must be addressed, and Toledo (2022), for example, makes strong arguments for the value of exploring the ontological components of agriculture in transformative projects. Deep transformation of the food system – for the benefit of farmers, the societies they feed, and nature – will require work on both the ontological and economic aspects of agriculture.

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