Ethical Acknowledgment of Soil Ecosystem Integrity amid Agricultural Production in Australia

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Abstract The growing adoption of no-till cropping and other minimal-impact farming practices in recent decades signals a shift in how soil is understood and valued. Eschewing vigorous disturbance, standard in the West (and beyond) since the Neolithic Revolution, farmers instead learn to intervene with the soil profile more sensitively. This article focuses on the concept of soil integrity and its significance for farmers' ethical relationship to soils in everyday practice, using the case study of pasture cropping, an Australian form of agriculture that extends no-till methods to embrace ecological relationships within and beyond the soil. Prioritizing the integrity of soil ecosystems often requires reconceiving what soil is and should be. Soil can be difficult to see as ethically significant partly because it often appears as a granular bulk good, seemingly featureless and fungible. To counteract this, farmers who care for soil integrity use various heuristic and aesthetic strategies to render soil integrity more perceptible and intelligible. The author considers how a keener perception of soil integrity may enable greater attunement toward the soil condition, acknowledgement of soil distress, and thus ethical responsiveness. The article considers this through a broader discussion of phenomenological ethics.

Keywords no-till, soil integrity, eco-phenomenology, environmental ethics, pasture cropping

> To the extent that [soil communities] do not appear as constituents of our world it might seem impossible to concern ourselves with them instrumentally, let alone ethically.
> —Mick Smith, 2011.[1]

More than 4.4 billion tons of soil have been lost to erosion since the colonization of Australia,[2] largely owing to agriculture,[3] and the clearing of vegetation. Topsoil in

1. Smith, "Dis(appearance)," 25.
2. Marston et al., "Waterborne Erosion."
3. Particularly efforts to apply European/ Western farming methods, crop varieties and livestock breeds to distinctly Australian soils, landscapes, and climates.

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Australia is typically fragile, weathered, shallow,[4] and low in nutrients. Large areas are degraded, with low levels of organic matter, while soil compaction, salinization and other issues present major challenges to farmers.[5] Erosion from water moving across bare soil incises streams, carving out 325,000 kilometers of gullies. These watercourses are severed from dynamic interchanges with surrounding landscapes due to their positioning below them.[6] In erosion's aftermath, soil capabilities to support diverse forms of life tend to decline. Hard and bare surfaces remain, resisting plant growth apart from tough biological crusts.

I propose to think through soil integrity in this article. I see soil integrity as the capacity of a soil ecosystem to hold together and maintain distinct structures, so it can perform functions that enable its flourishing, including the ability to support many forms of life. When soils lose integrity, they degrade; individual particles become less connected as part of a relational and physical matrix, impacting soils' structure, biology and functions, and leading to erosion. Their form becomes less cohesive, as the fungi that bind soil particles together in aggregates decline, and the networks of pores that enable aeration become compromised. Important soil functions such as filtering water and holding carbon are degraded, with repercussions for global biogeochemical cycles. As soils simplify in their relations, they become less capable of sheltering plants, fungi, invertebrates, and microorganisms. This can become a vicious cycle, as biological relationships themselves often help render soils more hospitable to life.

Damaging levels of soil disturbance are culturally normalized and even idealized in pastoral tropes of neat and bare ploughed fields observable in paintings and photography; in specialist prescriptions of how the land should appear evident in textbooks and in agronomic advice; and in the standard modes of operation of farm machinery, which often require the construction of a bare soil surface. We can see such norms at work in an advertisement for an Australian bank (fig. 1). The neat furrows of uniform, bare soil extend toward the horizon, showing no signs of life. The text captioning the picture advocates for sustainable soil management. Evidently those responsible for this advertisement do not see the irony at play.

The key issue isn't disturbance per se: moderated scales and intervals of disturbance can enhance processes of renewal in soil, as is the case in other ecosystems.[7] As I discuss further below, farmers caring for soil integrity can become capable judges of appropriate intensities and frequencies of disturbance, given local conditions and the particular characteristics of their agricultural practice. Farmers practicing pasture cropping learn to manage the growth cycles and habits of annual and perennial plants

4. Australian Bureau of Statistics, "Salinity, Assets at Risk."

5. Issues include sodic soils and acid sulfate soils.

6. Marston et al., "Waterborne Erosion."

7. There are many texts in disturbance ecology that explore the impacts of disturbance, for example, Mori, "Ecosystem Management Based on Natural Disturbances."

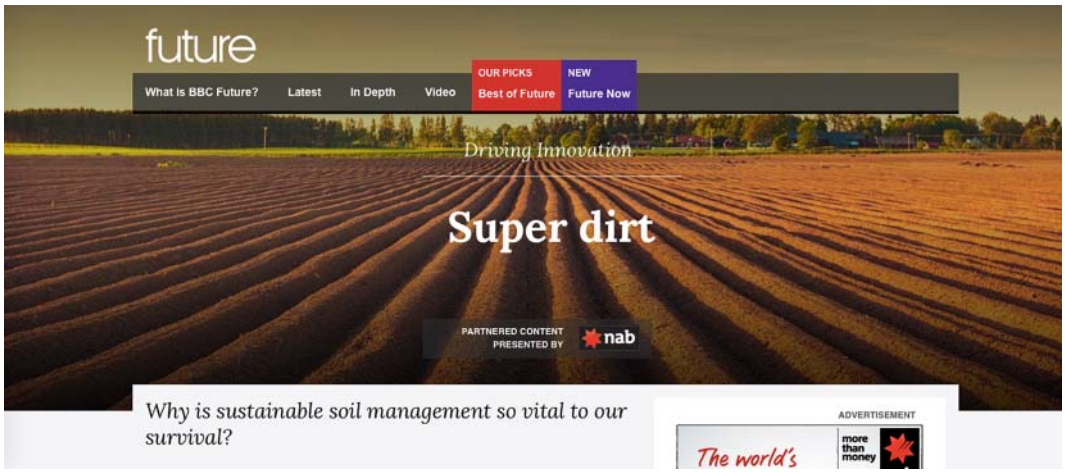

Figure 1. "Super Dirt." Courtesy of the National Australia Bank.

occupying the same terrain so that overall, they work in synergy rather than in competition with one another. They thus attend to the soil ecosystem so that it can support greater complexity and abundance of life. They use grazing animals and minimal till machinery such as scarifiers judiciously to cause levels of disturbance that are nondamaging and even beneficial to the soil.

Drawing upon a fieldwork site visit, farming educational material as well as examining farmer participation in social media during the period 2013–17, I consider how farmers are both contesting the normalized status of ploughing, as they engage with alternative approaches, and becoming sensitive to the multidimensional impacts of their tools upon soil ecosystems.

As they iteratively respond to a range of related entities in agroecosystem assemblages,[8] farmers tend to become more attuned to signs of need and signs of flourishing in soil. The meanings of these signs often become clearer as farmers attend to soil, and as they learn from communities of practice, rather than being pre-given.[9] Recognizing soil's forms of coherence is important, I believe, as the more that soil's integrity and interconnectedness is perceived, the less it can be seen as fungible (and thus objectifiable),[10] the more its patterns can be noted, and thus its condition can be responded to and cared for. Soil can thus be acknowledged as ethically significant.

In thinking through the ethics of our relations with soil I am inspired by phenomenological ethics, following Mick Smith, who sees such approaches as well suited to exploring our relations with soil and the broader more-than-human world, as opposed

8. Anna Krzywoszynska calls the assemblage that becomes evident through such attentive practices a "care network." See "Caring for Soil Life in the Anthropocene."

9. Krzywoszynska, "Caring for Soil Life in the Anthropocene."

10. Nussbaum regards fungibility as one feature of [negative] objectification (of women) in *Sex and Social Justice*, 218–21. I think this connection also holds for soil.

to more formal and abstract systems of ethics.[11] Phenomenological approaches focus on concrete events of relating with one another, attending to the significance of moments when ethics materialize. Rather than starting from abstract first principles (while not discounting the value of such approaches), phenomenological ethics instead focus on how objects come to matter for a perceiver. For Smith, soil's ethical appearance, provoking certain responses from humans, is a key event. At the same time, there are challenges. Soil's multiplicity, heterogeneity, and facelessness present several perplexing issues for embodied and phenomenological modes of relational ethics,[12] let alone ethical theories based on individualist ontologies.[13] Soil not only lacks a face but also lacks a coherent body that is visibly expressive in so-called real time. We cannot rely on gestures, flinches, grimaces, or other body language for our appraisal of soil well-being. Instead soil's expressiveness manifests in other ways, and on much slower timescales, that require skill and care to recognize.[14] Elaborating compelling visual forms and detailed vocabularies for soil's distributed forms of integrity may help us better acknowledge the condition of soil. To this end, useful resources can be obtained from several heuristic forms: the *meshwork* and the *soil food web* as well as images generated by the CT scan to better describe the coherence of soils. As farmers gain a better grasp of soil integrity, and as that integrity is also revealed as contingent, new dimensions of soil flourishing become evident, and the distress of soil ecosystems is rendered ethically acknowledgeable.[15]

Beyond No-Till: The Example of Pasture Cropping

In recent decades, no-till or low-till technologies that minimally impact soil have been widely adopted, across more than 110 million hectares of farmland worldwide.[16] These methods conserve soil integrity through causing minimal disturbance to the soil profile while preparing land for cropping. Conventional ploughs invert and churn soil, breaking up its structures and exposing the subsoil to sunlight, which can dry out and kill delicate fungi as well as oxidizing carbon. Machines for no-till farming very thinly slice through soil, creating enough of a separation of the soil matrix to enable the planting of seeds.

11. Smith, "Dis(appearance)," 26.

12. Smith, "Dis(appearance)," 33.

13. For example, Singer's approach, which requires that subjects of ethics have specific qualities such as sentience. See *Animal Liberation*, 178–79, as well as to a lesser extent Nussbaum's application of the Capabilities approach to sentient animals in *Frontiers of Justice*.

14. This necessitates that we "make time for soil care," as Puig de la Bellacasa has argued. See *Matters of Care:* 195–215. Also see Cristina Grasseni, "Skilled Vision," 41–55.

15. An earlier version of this article looked at soil and ethical acknowledgment using the work of Stanley Cavell (*Must We Mean What We Say*). A similar discussion can be found in my PhD thesis. See O'Brien, "Ethical Relationships to Soil in the Anthropocene."

16. Derpsch, Friedrich, Kassam, and Hongwen. "Current Status of Adoption of No-Till Farming," 1–26.

Numerous scientific studies of soils around the world have shown the value of minimizing soil disturbance for soil functioning. No-till techniques reduce soil erosion,[17] enabling the development of stable soil aggregates,[18] improved water flow, and water retention through soil, maintaining pore continuity and size.[19] Such increased hydration has flow-on effects, reducing the surface temperature of the soil.[20] Minimum tillage increases soil organic carbon and nitrogen compared with conventional tillage[21] as well as the availability of other minerals.[22] Biologically, soils managed under no-till conditions are richer than soils ploughed conventionally. They have significantly higher earthworm populations[23] as well as a higher fungi-to-bacteria ratio.[24] Yet the most common methods of no-till agriculture tend to rely heavily on the use of herbicides such as glyphosate. This can have detrimental impacts upon soil biology, particularly fungi.[25]

Extending no-till methods, some farmers taking up the mantle of "beyond no-till" methods have found ways to reduce their chemical usage, thus better supporting the ecological relations in soil. Pasture cropping is one of these approaches.

I visited Winona, the farm of Colin Seis, at a field day organized by Mudgee Microscope Group, a group of farmers and landholders in the central west of New South Wales who meet regularly to discuss soil health and microbiology.[26] Seis showed us several fields, with recently planted seedlings emerging from them. In figure 2, we see an annual crop, in this case, oats, directly planted into a biodiverse perennial native grass pasture through the use of minimal-impact machinery.

Neighbors Colin Seis and Darryl Cluff developed the pasture cropping method at a time when financial problems made their usual purchases of large volumes of fertilizer and herbicide untenable. Rather than killing native grasses with glyphosate before planting their crops,[27] they decided to leave the grasses alone, and instead planted annual seeds such as barley, oats, rye, and canola directly into the grassy surface. They timed planting to coincide with when the grass was going dormant, so it would not

17. Busari et al., "Conservation Tillage Impacts on Soil, Crop and the Environment," 119–29.

18. See Lal, Reicosky, and Hanson. "Evolution of the Plow over 10,000 Years," 1–12.

19. Benjamin, "Tillage Effects on Near-Surface Soil Hydraulic Properties," 277–88.

20. Rasmussen, "Impact of Ploughless Soil Tillage on Yield and Soil Quality," 3–14.

21. Jacobs, Rauber, and Ludwig, "Impact of Reduced Tillage,"158–64.

22. Ismail, Blevins, and Frye, "Long-Term No-Tillage Effects on Soil Properties,"193–98.

23. In a study lasting six years Andersen found a significantly higher earthworm population under no-till conditions than ploughed conditions. See Anderson, "Corn Root Growth and Distribution," 544–49.

24. Cookson, Murphy, and Roper observed that increased disturbance by tillage led to decreased fungal biomass and increased bacterial biomass. See "Characterizing the Relationships between Soil Organic Matter Components," 763–77.

25. Zaller, et al., "Glyphosate Herbicide Affects Belowground Interactions," 1–8; Dobberstein, "Is Glyphosate Harming Your No-Tilled Soils?"

26. Mudgee Microscope Group is coordinated by a local branch of the national organization Landcare. For more information, see Watershed Landcare (https://watershedlandcare.com). Accessed January 21, 2019.

27. While Seis promotes the use of biologically derived amendments, he occasionally uses agrochemicals. He uses herbicide once during winter to keep weeds down.

Figure 2. Oats emerging from a field of dormant perennial native grasses in Winona, Gulgong, New South Wales, 2013. Courtesy of Anne O'Brien.

compete with the crop for nutrients and water. Sheep lightly grazed the field prior to planting, providing fertilization and a moderate level of disturbance, but not enough to compromise the continuity or the vigor of the living soil matrix. The seeds were planted using a modified scarifier, a machine that slices through the surface and minimally impacts the soil during planting, as shown in figure 3. After depositing the seeds and compost tea[28] into the incision, wheels gently pressed the soil to hold the seed in place.[29]

The presence of a diversity of perennial native grasses throughout the year ensures that the soil surface is protected and the soil ecosystem is fed with sugars, the products of photosynthesis. Each different plant species secretes a unique mix of sugars to attract particular microbes.[30] Most partner with mycorrhizal fungi, which help to build soil structure by excreting carbon polymers that hold together stable aggregates, such as the glue-like substance, glomalin.[31] These fungi tend to proliferate in conditions of minimal chemical[32] and tillage disturbance.[33] Such fungi are key organisms for the generation of soil coherence and integrity as well as for carbon sequestration.

The pasture cropping method produces quite a dramatic change in the physical appearance of the crop. Speaking to farmers, Seis remarked, "It comes up really untidy.

28. Compost tea is a liquid mixture of compost, non-chlorinated water and nutrients, aerated for a specified period (usually around eighteen hours) to propagate beneficial microbes. This mixture is sprayed across the land surface. It acts as an inoculant. Such methods have been particularly promoted by Dr. Elaine Ingham, who leads the Soil Food Web Institute, an organization that trains farmers at several locations around the world.

29. Main, "Machinery for Ecological Thinking."

30. Badri and. Vivanco, "Regulation and Function of Root Exudates," 666–81.

31. Nichols and Millar, "Glomalin and Soil Aggregation," 374–78.

32. Zaller et al., "Glyphosate Herbicide Affects Belowground Interactions," 1–8.

33. Brito et al., "Impact of Tillage System on Arbuscular Mycorrhiza Fungal Communities," 63–67.

Figure 3. Modified scarifier used by Colin Seis to plant annual crops into a perennial pasture, 2013. Courtesy of Anne O'Brien.

Don't show it to your bank manager at that stage [crowd laughter]."[34] Jokes aside, this admission reveals the pressures that farmers are under from financial institutions to farm in visibly conventional ways.

After adopting pasture cropping at Winona in 1999, by 2017 Seis observed the number of native grassland species increasing from nine to sixty. In the soil, fungal biomass increased 862 percent, while bacteria increased 350 percent.[35] Insect biodiversity increased 125 percent, with insect biomass increasing 600 percent. This wasn't a problem for his crop, as a variety of spiders and predatory wasps reduced the numbers of insects that can be crop pests.[36]

Seis achieved carbon bio-sequestration rates of up to nine tons per hectare per annum, a 203 percent increase in soil carbon over ten years, which has translated into significant improvements in the water holding capacity, nutrient dynamics, biodiversity, and resilience to climate stress of the land.[37] In terms of output, Seis reports that harvests tend to be slightly lower than volumes achieved with conventional agriculture, although become comparable with experience.[38] However, the far lower input costs more than compensates for any reduction in harvests.

Beyond-no-till techniques disclose soil integrity as not only a physical property that requires careful movement of machinery but also a property of interspecies relationships between plants, microbes and invertebrates. Plant diversity improves soil structure and therefore, soil functioning.[39] Soil organisms need the energy produced

34. Seis, "Address to Digging Deeper Soil Biology Forum."
35. Seis, "Address to Digging Deeper Soil Biology Forum."
36. Seis, "Address to Digging Deeper Soil Biology Forum."
37. Seis and Seis, "Multi Species Pasture Cropping."
38. Seis, "Pasture Cropping as a Means to Managing Land," 8
39. Gould et al., "Plant Diversity and Root Traits," 1140–49.

through photosynthesis, and congregate in great density in the rhizosphere, the root zone of plants, where plants exude around 30 percent of the energy they produce. Since soil organisms are fed by root secretions carrying energy from photosynthesis, soil ecosystems suffer from losing their proximity to plants. They lose access to major food sources, particularly in the case of microbes that are adapted to the exudates of specific plant species. As Kristin Ohlson explains, "When the ground is bare, that partnership [between soil microbes and plants] is broken,"[40] and the soil ecosystem experiences famine. This is why Seis and Cluff's scientist mentor Christine Jones argues for yearlong green farming [41] so that the soil ecosystem is continually being fed. Pasture cropping demonstrates the importance of intact plant-soil interfaces. Building soil connectivity through continuously feeding a diverse soil ecosystem enables the sharing of nutrients and products of photosynthesis between plants, enhancing interdependence and thus soil integrity.[42]

Representations of Soil Integrity: Bodies and Meshworks

The biological abundance generated by pasture cropping in particular, and the widespread success of other methods of low-till agriculture, demonstrate the way soil holds together as a differentiated and interactive ecological community: its integrity has a bearing on its functionality and flourishing. Yet a relational conception of integrity is counterintuitive because the dominant conceptions of integrity in Western cultures are individualistic and atomistic, oriented towards human bodies (with an emphasis on their outer boundaries) and precious objects. As such it is difficult for many people to understand what it means for soil to be injured, for its integrity to be broken or damaged.

Pointing out likenesses between soil and bodies is a common tactic used by soil educators, scientists, and farmers who advocate for the recognition of both soil's sensitivity and the importance of its interconnected and extended structure. Analogies between soil and skin are well established, at least in scientific understandings of soil. This can be seen in the name of the scientific journal *Geoderma* and numerous soil text books.[43]

Outside of science, there is also a quasi-animistic discourse of soil-as-skin. This can be seen in the backlash to a meme on Facebook that idealizes a bare, ploughed field, shown in figure 4.

The comments on the right side of this picture reveal the articulation of a particular ethical sensibility regarding soil integrity among some land practitioners. One

40. Paul Cox, interview with Kristin Ohlson, "Burying Climate Change."

41. For a compelling description of this process, and the role of continuous plant cover in the production of soil carbon, see Jones, "Building Soil carbon with Yearlong Green Farming," 3–4.

42. Fellbaum et al., "Fungal Nutrient Allocation," 646–56.

43. The term *body* is used in some soil science to describe a particular area of soil with similar characteristics, for example B. A. Needelman, "What Are Soils?," 2. Soil's role on a planetary scale is invoked through metaphor by Kutílek and Nielsen, *Soilh*.

Figure 4. Facebook meme with critical comments, 2017. From the Facebook Agriculture Everyday" page, courtesy of Anne O'Brien.

comment likens the ploughing of the soil surface to ripping off human skin, asking, "How would you like it?" This personifies and sympathetically identifies with the soil, positioning soil as part of a living, integrated and vulnerable system that ought not be disturbed. Unlike scientific discourses of soil-as-body or as skin, this comment more explicitly endorses an understanding of soil as sensitive, and even a locus of experience, a quasi-animistic view that challenges scientific rationalist understandings of objects such as soil. Another commenter questions the evident lack of biodiversity on the bare field, arguing that reversing this situation is the only potential that should be seen in the picture. These interventions are indicative of cultural shifts that are slowly occurring in agriculture away from normalized soil disturbance.

Going further, within science, compelling analogies have been made between human circulatory systems and soil structures, which are important for the circulation of water and nutrients in soils. Figure 5 compares two soil core samples using a computed tomography (CT) scan: one control (left) and another that was driven over by a vehicle over a decade before.[44] The contrast is striking. A single event of heavy downward force from a car resulted in a loss of oxygen and water circulation in those soil zones and in turn, a loss of underground biomass.

The writer quotes a media release from the Soil Science Society of America: "Just as in the human body, this constriction of the soil's circulatory system can have ill effects. Blocked and narrowed pores likely impede the diffusion of air through bulk soil. The dominance of vertical pipes in the compacted soil also suggests that water flows mostly downward, with relatively little reaching the surrounding soil matrix."[45] In this example, the undisturbed form of this soil is described primarily by analogy to the human body, and secondarily to plumbing.[46] This loss of structure would be the

44. Lyseng, "CT Scan Tech Used to Check Soil Health."

45. Lyseng, "CT Scan Tech Used to Check Soil Health."

46. The "pipes" image can be seen as part of a broader analogy between soil and city infrastructure/architecture. Soil as Infrastructure has been discussed by Maria Puig de la Bellacasa. "Encountering Bioinfrastructure," 1–15.

Figure 5. CT scan of soil core samples from depths of 25–45 cm. (Top) Undisturbed soil. (Bottom) Soil disturbed by one occasion of compaction fourteen years earlier is shown in 2013. Courtesy of Lamandé et al.

functional equivalent of crushed ribs or vertebrae, compromising processes of breathing and circulation. This description of the impact of the soil compaction evokes severe injury, revealing soil to be intricately structured and sensitive.

Analogies between soil and bodily forms have both heuristic and moral dimensions. This can be seen in the media release likening the interconnected structures of healthy soil to circulatory and respiratory systems,[47] highlighting both their crucial functions and their vulnerability, commanding respect. However, when bodies are used as moral shortcuts to try to gain respect for soil by analogy to humans, the comparison may buttress anthropocentrism. Such moral extensionism still relies on humanity as the standard of value, promulgating the view that entities in nature are valuable to the degree that they resemble humans. It also bypasses the ethical challenge of becoming

47. The novel aspects of the body-soil metaphor (such as the vessels analogy) is generative whereas the more conventional meanings of the body metaphor (particularly the body as a monistic exclusionary entity) are not so useful. This calls to mind Paul Ricoeur's discussion of novel metaphors and their role in generating new insight. See *The Rule of Metaphor.*

responsive to diverse others through acknowledging their alterity, their otherness, and their particularities.[48]

The integrity of soil is an emergent result of the activity of many different organisms. Soil structure arises as assemblages of substances and biological relations, where the main processes and relations occur outside and between bodies, which may be disrupted at any time.[49] The coherence of an organism in terms of its physical bone, muscular, and skin continuity owes itself largely to endogenous developmental processes (despite the importance of microbiomes). The image of a body, while clear and ethically compelling, doesn't adequately capture the contingency of soil's relations.

Soil integrity is a product and enabler of diverse collaborations between organisms living in or on soil.[50] Tim Ingold's concept of a meshwork[51] is a patterned form created by diverse organisms as their paths of movement intersect. This image aptly captures the distributed quality of soil's coherence. Here Ingold explores the idea as it applies to the ground:

> An analogy might be drawn with a textile, whose surface is not the same as those of all the strands of which it is woven, but is nevertheless constituted by them. It is a mesh or matrix of lines. . . . In places, the ground may be more granular than textural, heaped up rather than knotted, as with sand dunes or stone shingle. But as we have repeatedly observed, a ground that was purely granular—all blobs and no lines—could harbour or nourish no life.[52]

Soil can readily be described as a meshwork assemblage, woven together by organisms, undergoing continuous generation. Integrity can be understood as coherence in the form of patterns, forms and substances that bind entities materially so that they are likely to function in relation. The meshwork lines woven by diverse organisms hold space and create structure.[53] The pore spaces in soil, made possible by its structure, are

48. Further to this, there is a long history of using the body as an organic metaphor to argue that certain ways of organizing social relations are natural because they resemble a division of labor like that of parts of a body. The ancient metaphor of the body politic (such as that used by Aristotle and Plato) is the most common example. We are not dealing with such metaphors here, although the concept of integrity when conceived through a body politic framework may appeal to the role of the skin/ soil as a boundary that helps with defense. There are countless analyses of the body politic metaphor. See for example Rasmussen and Brown, "The Body Politic as Spatial Metaphor."

49. My understanding of assemblages is informed by Manuel Delanda, who sees them as "wholes characterized by relations of exteriority" (*A New Philosophy of Society*,: 10–11). At the same time, a body can be theorized as an assemblage, and many have done so.

50. My thanks to an anonymous reviewer for the summation of my argument here, which I have paraphrased.

51. Ingold, "Bindings Against Boundaries," 1796–1810.

52. Ingold, *The Life of Lines*, 43.

53. Using an architectural metaphor, soil pores are described vividly by soil educator Walter Jehne as "cathedrals," highlighting the way in which the spaces created by the structure provide a space to gather for organisms. See Jehne, "Pedogenesis, Soil Cathedrals, Living Membranes, and Industrial Hydroponics."

crucial and are often overlooked by those who mistake dirt for soil. Pores allow for oxygen diffusion, while increasing soil's sponginess and water holding capacity, making it possible for aerobic organisms to thrive. Spaces may be created by invertebrates, fungi or created through plant root growth. Plant roots have been measured to increase soil macropore volume in soil immediately adjacent to those roots by 700 percent in a little over a week.[54]

Like the image of the meshwork, the image of the soil food web focuses on intersecting lines of trophic relations. The framework presupposes that robust soil has many links, or relations of interdependence, that exhibit a level of redundancy. If one connection is no longer functional, there will be other links that can at least partially perform the function that the previous connection once provided. Beyond that, the food web is a model that invites active participation. Maria Puig de la Bellacasa argues the soil food web has "become, beyond science, a symbol of alternative ecological involvement."[55] It can help construct new worlds, encouraging practitioners to see themselves as *part* of the web (rather than above it), supporting the development of beneficial conditions for the formation of healthy relations in the soil. It is at once a model of the real and of the ideal, helping to concretize and bring into view possibilities for improved relations both within soil and beyond soil.

Perceiving Soil as Ethically Significant

Many indicators of soil integrity have long been imperceptible, insignificant and overlooked by land-based practitioners and laypeople alike. This has meant that it has been difficult to even acknowledge a situation of excessive soil disturbance or degradation, thus few people have taken ethical responsibility for soil. It is often only after witnessing abundant soil ecosystems demonstrating their diverse capabilities (as we can see in the example of pasture cropping) that we might even realize that a soil ecosystem may have been thwarted in the past.[56] By having a grasp of the forms in which an entity such as soil takes when it is flourishing, and the inverse, when it is degrading, we can more clearly see soil distress. Thinking about soil ecosystems, Smith asks, "Who or what 'appear' (in both the sense of 'manifesting itself' and 'seeming to matter') to share the world in ways that call forth our concern[?]"[57] These are particular difficulties for soil, as not only does soil not have much charisma or beauty as conventionally understood but, as discussed, its extended form and the significance of that form is difficult to discern.

54. See Helliwell et al., "The Emergent Rhizosphere," 5.

55. Puig de la Bellacasa, *Matters of Care,* 194–95. The soil food web concept is closely associated with a particular organization, Elaine Ingham's Soil Food Web Institute, which should take significant credit for popularizing the idea. While neither the methods nor the institute exhaust the meaning of the concept, in practice, it is difficult to carve out a separate meaning that is independent from the work of Ingham's Institute.

56. Such thwarting can be understood to be an injustice to soil ecosystems, following David Schlosberg's elaboration of ecological injustice using the capabilities approach. See *Defining Environmental Justice*, 153.

57. Smith, "Dis(appearance)," 25.

Adopting a phenomenological approach, Smith draws from Levinas's ethics, particularly his centering of appearance of the Other as a locus of ethical responsiveness: "There is a sense in which the Other always calls us out of the world with which we are familiar to insist that there is more, infinitely more, than initially appears to be the case, more than we know, see, or understand."[58] Perceiving the soil assemblage (including plants and invertebrates) as an Other, we might be moved to act when we can sense that not all is well. The Other interrupts habitual everyday practice, and we cannot proceed as before. "Such ethical events are, in many respects, beyond our conscious control."[59] For such events to transform us, in Smith's view, does not require mutual embodiment, a face or personhood. But for soil's appearance to prompt any concerning action, it would seem to require that we have enough of a grasp of soil's relationally generated form that we can see that the ecosystem is in distress. We can see here the crucial role that perception and careful attention thus plays in soil ethics.

Learning to perceive soil integrity and becoming ethically responsive to its condition involves paying attention when soil manifests in surprising ways as well as paying closer attention to soil's characteristic patterns; its habits and forms when freely expressed, while developing empirically adequate and aesthetically rich descriptions of these.[60] Supplementing more scientific descriptions, Christine Jones describes healthy soil texture as fragrant and with an appearance like chocolate cake.[61] Similarly, David Montgomery writes, "Fertile soil crumbles and slides right off a shovel. Look closely and you find a whole world of life eating life, a biological orgy recycling the dead back into new life. Healthy soil has an enticing and wholesome aroma—the smell of life itself."[62] Such lively and life-filled descriptions generate a compelling aesthetic vision of shared conviviality across species. As Puig de la Bellacasa writes, "Involvements with soil's animatedness open up to a sense of earthy connectedness that not merely animates and re-affects objectified worlds but both intensifies and complicates a sense of ecological belonging for the humans involved."[63] Describing soil in these sensuous ways, these soil thinkers construct a captivating and enchanting world highlighting the rich experiences that become possible from encountering the diversity, vitality, and integrity of soil ecosystems. Puig de la Bellacasa documents numerous themes that are emerging in public discourse of sensorially rich and enlivened engagement with soil, suggesting that "through the senses . . . we are invited to claim commonness and connection to the materiality we share with soil and other forms of elemental matter."[64] Sensorially

58. Smith, "Dis(appearance)," 35.

59. Smith, "Dis(appearance)," 37.

60. Anna Krzywoszynska discusses a similar process of developing care-based expertise in coming to know what a "good plant life" is ("See What Farmers Know," 294).

61. Frisch, "SOS," 3–4,

62. Montgomery, 1.

63. Puig de la Bellacasa, "Re-animating Soils," 403.

64. Puig de la Bellacasa, "Re-animating Soils," 399.

rich accounts of soil such as these help to build understandings that there is more to soil than its usefulness to humans, and that above all the use of soil does not have to be harmful, disrespectful, or extractive but instead can be part of building ecological integrity through a sensitive construction of interdependent interspecies livelihoods.[65] Such attentive and appreciative practices help to build respect for soil as an end in itself in addition to being valued as a means to an end.

Conclusion

A key precondition for soil care is acknowledging the vulnerable condition of soil and the distributed relationships that constitute soil integrity. When such relationships are damaged, the flourishing of soil is diminished. While numerous social norms regulate human behavior with regard to the integrity of other humans and precious objects (for example, respecting the personal space of other people, or holding porcelain gently), there are few conventions regarding human behavior and the movement of machines when they impact upon soil. Yet an emerging repertoire of soil-sensitive practices and ethics from the new understandings of soil that they generate are helping to change this from the ground up.

Part of the challenge of reconceiving aesthetic and ethical understandings of soil well-being is developing appropriate objects of concern that account for the multiplicity and complex structures of soil ecosystems rather than oversimplifying the condition of soil. While metaphors of soil as a body are used by soil educators and practitioners to impart the ethically charged nature of soil structure, often by analogy to the human, other concepts such as the meshwork and soil food web suggest soil integrity to be a creative product of interdependent biodiverse relations.

Communities of practice in Australia that focus on protecting the integrity of soil structure have developed numerous novel methods of growing crops and raising animals that attend to soil's relations closely and carefully moderate the temporalities and degrees of disturbance that soils experience. Pasture cropping is one of them, providing an example of how changing patterns of soil disturbance can have profound consequences for soil ecosystems. Enabling the development of soil integrity through using modified machinery to more gently impact the soil, the method maintains a biodiverse grassland cover to protect and feed soil ecosystems. This enhances soil's capabilities as more biological relationships are accommodated within its matrix. Allied methods of building soil integrity similar to pasture cropping that emerge from the Australian context include no-kill cropping, natural sequence farming, and keyline systems, which also deserve further analysis.

Soils have long been subjected to injuries that have been naturalized and hidden amid standard practices of agriculture. It can be difficult to know what aspects of soil's appearance to us are spontaneous, and which are artefacts of duress. Even in Australia

65. See Gibson-Graham and Miller, "Economy as Ecological Livelihood."

where settler agriculture is little more than two centuries old, and far younger in many regions, such difficulties abound. The rise of agricultural methods that attempt to work *with* rather than against patterns of growth of soil ecosystems, preserving rather than disrupting their integrity, sheds some light on these questions, revealing patterns and habits of soil flourishing that are usually obscured. Methods of agriculture such as pasture cropping attend to soil as a living ecosystem, helping to render it an entity for which people might become ethically accountable. In reflecting on soil sensitive practices, we are beginning to see what it might mean to respect and build the integrity of soil ecosystems amid production agriculture in Australia, making space for the expression of their diverse capabilities and withholding from actions that injure their extended forms and relations.

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