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Making time for soil: Technoscientific futurity and the pace of care

Maria Puig de la Bellacasa
School of Management, University of Leicester, Leicester, UK

Abstract

The dominant drive for understanding soil has been to pace its fertility with human demand. Today, warnings about soil's exhaustion and endangered ecology raise concerns marked by fears of gloomy environmental futures, prompting scientists and soil practitioners urgently to develop better ways of taking care of soils. Yet the pace required by ecological soil care could be at odds with the predominant temporal orientation of technoscientific intervention, which is driven by an inherently progressivist, productionist and restless mode of futurity. Through a conceptual and historical approach to the soil sciences and other domains of soil knowledge, this article looks for soil ontologies and relations to soil care that are obscured by the predominant timescape. Contemporary discussions of the future of the soil sciences expose tensions between 'progress as usual' – by intensifying productivity – and the need to protect the pace of soil renewal. The intimate relation of soil science with productionism is being interrogated, as ecology attempts to engage with soil as a living community rather than a receptacle for crops. In this context, and beyond science, the 'foodweb' model of soil ecology has become a figure of alternative human–soil relations that involve environmental practitioners in the soil community. Reading these ways of making time for soil as a form of 'care time' helps to reveal a diversity of more-than-human interdependent temporalities, disrupting the anthropocentric appeal of predominant timescales of technoscientific futurity and their reductive notion of innovation.

Keywords

care, ecology, foodwebs, innovation, productionism, soil, soil science, time

Corresponding author:
Maria Puig de la Bellacasa, School of Management, University of Leicester, Leicester LE1 7RH, UK.
Email: m.puig@le.ac.uk

The vital role of soils for growing food has bound soil care knowledge to human subsistence economies. Through successive agricultural revolutions, efforts to harness soil fertility have created intensified rhythms of production. But at the turn of the 21st century, soils gained new consideration in public perception and culture amid concerns that they have been mistreated and neglected, prompting worldwide warnings about a relatively close, gloomy future of exhausted fertile land and correlated food crises. Soils remain a resource for value extraction and a recalcitrant object of scientific inquiry, but they are also increasingly considered endangered living worlds. 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.

This article is part of an on-going research project on how relations with soils might be changing for the inheritors of the agricultural revolutions affected by the breakdown of soil ecologies. My research involves attending to the ethico-political, practical and affective dimensions of concepts and practices of soil care in the sciences and other forms of knowledge. This article focuses specifically on temporalities at stake in transformations of human–soil relations, transformations that question the predominance of technoscientific futurity. The argument is based on a conceptual approach to recent developments in the history of soil science and alternative domains of soil practice. A focus on relations of temporality and care contributes to the recognition and enactment of alternative and/or marginalized temporalities. My approach to the field of soil knowledge is involved in a feminist approach that engages with care as a way to draw attention to the significance of practices and experiences made invisible or marginalized by dominant, 'successful', forms of technoscientific mobilization. This is also a motivation to look out for, and hopefully foster, ways of improving care in human–soil relations.[1] In this sense, focusing on care draws attention to glimpses of alternative, liveable relationalities, and hopefully contributes to other possible worlds in the making, or 'alterontologies', at the heart of contemporary technoscience (Papadopoulos, 2011).

The first two sections of the article situate the argument in an epochal timescape of fear about soil futures. I first read this context through critical approaches to contemporary technoscience's dominant understanding of futurity. The second section looks at debates on the future of the soil sciences and their socio-economic role in an epoch of ecological crisis. The following two sections examine conceptual reorientations in the soil sciences that disrupt the temporality of productionist soil care and that rethink soil as a living, interdependent community. The final two sections explore practices that involve practitioners with soil temporality. The article concludes by arguing that care time, in practice and experience, is neither a *slowed* mode of, nor *outside*, the timescales of technoscientific futurity. Focusing on making care time does, however, offer glimpses into a diversity of timelines that, despite being made invisible or marginalized in the dominant timescape, can challenge traditional notions of technoscientific innovation.

The future of soil in technoscientific timescapes

The Food and Agriculture Organization (FAO) of the United Nations declared 2015 *International Year of Soils*, expressing concerns for this 'finite non-renewable resource on a human timescale under pressure of processes such as degradation, poor management

and loss to urbanization' (FAO, 2013). Soils have also become a regular media topic, with interventions drawing attention to the 'hidden world beneath our feet' (Robbins, 2013) as a new frontier for knowledge and human fascination. Mistreatment and neglect appear as key themes in calls to reappraise soil's importance in ways that entangle its economic, political and ethical value around matters of survival. Recent headlines by environmental analysts in the UK press reiterate this: 'We're treating soil like dirt. It's a fatal mistake, as our lives depend on it' (Monbiot, 2015) or 'Peak Soil: industrial civilization is on the verge of eating itself' (Ahmed, 2013).

Peak soil – and the correlatives 'peak nitrate' and 'peak phosphorus' – refers, like other peak forewarnings, to economic breakdowns by which a resource is heading toward exhaustion without equivalent efforts to renew as it 'becomes more difficult to extract and more expensive' (Déry and Anderson, 2007). Humanity's vital need for soil supports a sense that the acceleration of its loss is more worrying than the widely discussed peak soil (Shiva, 2008). Countless accounts refer to strains on this resource caused by human population growth, warning of famine outbreaks if action is not urgently taken to ensure food security. Soil exhaustion is also blamed across the board on industrialized and unsustainable forms of agriculture, and so many see intensifying food production through technoscientific innovations as a misleading, perilous response to food security (McDonagh, 2014; Tomlinson, 2013). Human agricultural practices exhausted soils across the world well before industrialization (Hillel, 1992), pushing populations to leave behind depleted soils in search of fertile grounds, but in the current global productionist regime, options are shown to be narrowing, as the extension of agricultural land by forest clearing is a recognized factor of climate change, and the intensification of production on available land is destroying the resource. It is likely that the impending loss of soil will affect how the inheritors of agricultural revolutions care for this vital universe.

Similar to other environmental warnings, such as urging people to 'Wake Up, Freak out – Then Get a Grip'[2] in response to climate change tipping points, the temporal emergency in soil breakdown warnings is clear: the time to care more and better for soils is now. The future of soils appears pulled forward by an accelerated timeline towards a gloomy environmental future, while the present time left for action is compressed by urgency. I read this 'timescape' (Adam, 1998) as consistent with a hegemony of future-oriented timelines in technoscientific societies that has been illuminated in science and technology studies (STS) and sociology from several critical perspectives.

First, technoscientific futurity has been discussed with respect to the persistence of a modern paradigm that associates the future with progress, with an ethico-political imperative to 'advance' that remains solidly the orientation of linear, 'progressivist', timelines – while the past acts as a discriminatory signifier of development delay (Savransky, 2012; Schrader, 2012). From the perspective of this hegemonic timescape, as faith in modern linear progressivism is increasingly called into question by an environmental crisis, uncertainty prevails and catastrophic regression seems inescapable (Beuret, 2015). Second, the future orients practices. It acts as the inexhaustible pull of the technoscientific 'expectation', that is, the socio-affective engine of innovation-driven political economies (Borup et al., 2006; Brown and Michael, 2003; Hedgecoe and Martin, 2003; Wilkie and Michael, 2009) – as well as of 'promissory' science (Thompson, 2005). Here, technoscientific innovation is situated and affected by a shared timescape of futurity

typical of late capitalist economies, a timescape that fuels 'pre-emptive strategies' and subjects practices in the present to a productivist ethos, increasingly committed to the speculative extraction of future economic value (Cooper, 2008; Dumit, 2012; Lilley and Papadopoulos, 2014; Papadopoulos et al., 2008). Third is the 'anticipatory' affective state of technoscientific futurity that Vincanne Adams, Michele Murphy and Adele Clarke have insightfully characterized as one of the permanent anxiety 'in which our "presents" are necessarily understood as contingent upon an ever-changing astral future that may or not may be known for certain, still must be acted on nonetheless' (Adams et al., 2009: 247). Technoscience's innovation-driven focus on novelty fosters uncertainty and expectations about an imminent breakthrough - for the better or the worse. Any meaningful act in the world of promissory capitalism involves taking risks and acting fast. In this form of futurity, the everyday experience of time is one of permanent precariousness: an on-going sense of urgency and crisis calls to act 'now', while the present of action is diminished, mortgaged to an always unsure tomorrow. Industriously advancing and producing might give the beat to get practice going, but the continuity of existence is also constantly challenged, injecting drama and fear into everyday doings. The 'hype' (Brown, 2003) characteristic of futuristic, progress-driven innovation is co-dependent with fear of doom and hope for salvation. The restless work involved in managing anticipation and calculation (Clarke, in press) in the face of uncertain futures is the late capitalism counterpart to industrial modernity's impossible efforts to manage and control time (Adam, 1998).

The three lines of critique outlined above characterize different scales, albeit intimately entangled, of a dominant mode of futurity in technoscience: the temporal frame of an epoch still marked by a linear imperative of progress versus fears of regression; the time embedded in practices paced to a productivist ethos; and the experienced, embodied time of restless futurity. What these analyses of temporality show is that the future is crucial in 'constituting' the present of everyday life in technoscience (Michael, 2000). They also expose, and somehow ratify, the intrinsically futuristic character of dominant notions of technological and scientific innovation. Yet there are also motivations to question this ambivalent enthralment with the future.

First, socio-historical critiques of temporality expose how different societies and epochs foster different experiences of time. Looking at temporality from the perspective of everyday experience shows that time is not an abstract category, nor just an atmosphere, but a lived, embodied, historically and socially situated experience (Adam, 1998, 2004). Time is not a given, it is not that we have or do not have time, but that we *make it* through practices (Dubinskas, 1988; Frank Peters, 2006; Whipp et al., 2002; see also Wyatt, 2007). Temporality is not just imposed by an epoch or a dominant paradigm, but rather made through socio-technical arrangements and everyday practices. So, if we accept the possibility of a diversity of practices and ontologies, the progressive, productionist and restless temporal regime, although dominant, cannot be the only one. It is in this spirit that I will be examining how conceptions of soil care might question the primacy of technoscientific futurity.

Second, a case for exploring and enacting alternative temporalities is supported by renewed emphasis on temporal diversity in the social sciences and the humanities. I am referring in particular to interdisciplinary work marked by an ecological critique of linear

and anthropocentric temporalities (Bastian, 2009). Indeed, a diversity of eco-temporalities is revealed when multispecies, more-than-human scales are considered (Bird Rose, 2012; Choy, 2011; Schrader, 2010). Both micro- and macro-timescales of ecological relations involve timeframes different from human lifespan and history (Hird, 2009). These insights are of specific importance to research on human–soil relations and ontologies. Soil is created through a combination of geological processes taking thousands of years to break down rock and by relatively shorter ecological cycles by which organisms and plants, as well as humans growing food, break down materials that contribute to renewing the topsoil. In an epoch being named 'the anthropocene' (Zalasiewicz et al., 2011) to alert us to the impact of human technoscientific progress on the planet or 'the capitalocene' (Moore, 2014) to reflect the effects of capitalist politics, drawing attention to the temporal diversity and significance of more-than-human experiences and timescales has ethico-political, practical and affective implications (Haraway, 2015). Here, focusing on experiences of soil care as an involvement with the temporal rhythms of more than human worlds troubles the anthropocentric traction of predominant timescales.

Finally, engaging with different ways of experiencing time could have additional significance for the way that we look at the temporality of science and technology. For instance, they might disrupt the 'imaginings of technology' that, as Steve Jackson (2014) has suggested, keep the language of innovation for the new 'bright and shiny' and for quasi-teleological achievements 'at the top of some change or process' (p. 227). In this sense, I will be discussing how approaches to soil care could question this vision of innovation. Also particularly important for this purpose is a 'productivist bias' in STS imaginaries of scientific innovation that Jackson also identifies, and calls into question (see also Papadopoulos, 2014). Here, a feminist politics of care in technoscience – akin to Jackson and others' attention to practices of 'maintenance' and 'repair' (Denis and Pontille, 2015) and Annemarie Mol's foregrounding of a 'logic of care' (Mol, 2008) – appears particularly relevant. It offers an inquiry into different modes of 'making time' by focusing on experiences, in this case of soil care, obscured or marginalized as 'unproductive' in the dominant futuristic drive.

In the following, I will look at how transformations in conceptions of soil care could involve questioning technoscientific futurity: a critique of productionism, relating to soil as a living multispecies world, and making time for care time. To begin, I further situate the discussion with regard to matters of temporality by highlighting contemporary tensions around the future of soil science.

Soil science futures in an epoch of ecological breakdown

> For any scientific discipline it is good to look back and make out what has been achieved, how it was done and whether anything can be learned from the past. No doubt that is a respectable activity but it will not yield scientific breakthroughs. If you want to stay in business as a science it is healthier to look forward. (Alfred Hartemink, 2006: vii)

Soil science is a relatively young discipline that only emerged as a distinctive field in the mid-19th century when developments in chemistry, physics and biology combined with research agendas driven by concerns around food production. Yet, until recently the most

important accounts of the discipline's history had been written by scientists adopting a classic 'internalist' perspective addressed to soil scientists and focused on central scientific figures, paradigms and conceptual shifts (Krupenikov, 1993; Yaalon and Berkowicz, 1997). Only scattered examples can be found in this literature highlighting the entanglement of scientific developments with socio-economic contexts, let alone the connections with agricultural capitalism (Moore, 2010). For instance, Jean Boulaine notes how the first agricultural revolution in 17th-century Britain was fuelled by the introduction of off-site natural fertilizers first extracted and imported from the colonized Americas. As these resources became exhausted, fertilizers were developed artificially, propelling soil chemistry through its contribution to industrial manufacturing (Boulaine, 1994). Engaging properly with this complex history goes well beyond the purposes of this article. What is important to note here is that discussions about the future of soil science in the past twenty years have been paired with an increasing interest in historical accounts of the discipline that include a relation with wider socio-economic contexts (Bouma and Hartemink, 2003). An important discussion could contribute to this effort by looking at the entanglement between advancements in the field and moments of crisis affecting soil as resource.

One famous example is the so-called dust bowl phenomenon in the 1930s, by which powerful wind storms carried away the topsoil of intensively farmed land, devastating livelihoods and leading to the displacement of hundreds of thousands in the North American high plains. Environmental historian Daniel Worster (1979) showed how this disaster, which still marks the imagination of environmental devastation in the United States,[3] brought with it an intensified wave of technically enhanced soil exploitation based on agrochemical inputs and innovative irrigation systems. Douglas Helms, historian of the US Soil Conservation Service, shows how the dust bowl had an immediate effect on scientific and social investment in soils, including an increase in public support of US soil conservation policies and the extension of soil surveying and mapping enterprises (Helms, 1997).

Another well-known example is how, in the late 1950s, anxieties about an ever-expanding population and imminent famine, particularly in Asia, contributed to public support for the technoscientific complex that set in motion the so-called Green Revolution, accomplished by combining artificial fertilizers, newly developed high-yield seed stocks and chemical pesticides, leading to intensive cultivation and unprecedented yield. Today, controversies persist about the social and environmental effects of the Green Revolution (Cleaver, 1972; Shiva, 1991; Thompson, 2008). The dramatic consequences for farmers of the destruction of soils and water that followed this wave of agricultural intensification still gather public attention (Weiss, 2012). However, the attraction of a new Green Revolution to respond to current threats to future food security has not faded. It remains a model to 'unlock the potential of agribusiness' (World Bank, 2013); the concept is kept alive in scientific circles in reformed, more 'sustainable', versions (Sánchez, 2004, 2010), often turning attention to the power of genetically modified crops that could cope with impoverished soils.

Historically, social emergency and gloomy uncertainties about soil resources and practices are not new to soil scientists. Fertility, erosion, pollution, nutrient depletion and carbon capture are just some in the series of concerns that modern soil science has been called on to remediate. These instances in the history of human–soil relations also can be

read in terms of how they expose a combination of anxious restlessness about the future – in the face of disasters such as the dust bowl or fears of mass famine – with ambitious responses based on innovations that confirm the technoscientific productionist drive. A posteriori, we can see how the effort of value extraction from the soil rarely has been tempered by disasters. In the current context, the atmosphere of urgency and anxiety about imminent resource exhaustion seems to give impetus to accelerated extension of the promissory futures-market networks around vital natural resources – thanks to new opportunities of exploitation sometimes even opened by environmental degradation, for example, oil extraction in newly accessible arctic zones (Johnson, 2010). In the case of soils, these economic moves can be seen in the rush to grab fertile land (Borras et al., 2011):[4] the less there is left, the more valuable an investment it becomes, and its intensified exploitation is further accelerated.

It is against this background that I read contemporary concerns in soil science around the socio-political role of the discipline.[5] Today, many scientists are again mobilizing, in a context of global ecological change and possibly disaster, to address pressing concerns about the state of soils and their capacity to provide. This is not the only reason why soils are 'back on the global agenda', but it does contribute to a 'renaissance' of soil science as a privileged way of responding to the crisis of soils (Hartemink, 2008; Hartemink and McBratney, 2008). On the other hand, the scientific identity of the field is put at stake. Soil physicist Benno Warkentin asks, 'Can we ensure that soil science as a discipline is not lost in the coming competition of responses to society's needs?' While the 'applied' character of soil science seems uncontroversial, there are arguments to preserve a 'basic' value to soil science: a focus on responding to societal demands could result in a potentially hazardous 'technology fix' (Churchman, 2010: 215).

In the quote opening this section, Alfred Hartemink, a scientist who has dedicated considerable efforts to promote engagement with the discipline's history and future, nonetheless links the scientific enterprise with an imperative to look into the future. Perhaps more than any other modern social practice, science is actively and performatively embedded in the dominant progressive, promissory, productivist epochal timescape. In particular, modern science's inherent progressivism reacts against any suspicion of 'turning back the clock'. As described in the previous section, within such a conception progress is either valued for its gains or feared and blamed for its repercussions. Advances in science can be questioned, but not a general ineluctable progression to the new or to a 'breakthrough'. Yet, despite the traction of epochal futurity for science, debates and tensions about soil science's future reveal some frictions. One important theme around which these tensions can be shown to crystallize today is the challenge to increase agricultural yield while promoting sustainable soil care.

Reflecting on the future of their science, some hold to an inherently progressive vision: soil science will prove 'doomsayers' wrong again. Just as soil science participated in the epic Green Revolution and enhanced production, it can participate in a new Green Revolution with more sustainable practices (Rattan Lal in Hartemink, 2006: 76). Science can just continue going forwards, as usual, provided it accumulates wisdom. Others problematize a seamless vision of soil science's environmental leadership: 'Soil science operates simultaneously in the realms of ecology and of economics, each of which marks time by different clocks' and the future of soils depends on how economics/

society will trade off between sustainability and exploitation (Dick Arnold, in Hartemink, 2006: 7). Here, the underlying narrative implies that an ecological soil science will follow an ecologically progressive society, in which 'opportunities are golden for imparting the knowledge and wisdom of soil science' (p. 8). More pessimistic are those who see a historical failure of soil scientists to convince agronomists of ways to produce better without damaging the environment (Ruellan, 2007).

The field of soil science is vast and transdisciplinary and cannot be reduced to the dynamics I am delineating here. However, across the contemporary literature that addresses the societal role of soil science, most scientists associate the future of the discipline with a commitment to sustainability. So what can be learnt by illuminating tensions concerning ways of looking forward? I believe that it is particularly important to examine the assumption of an alignment of soil science with an ecological temporality – as if it was oriented by a clock somehow 'naturally' marking a different time than unsustainable 'economics' (or the 'social'). This obscures how not only economics but also science has been resolutely oriented by a typically linear orientation to the future based on producing output and profit through innovation. The productionist logic is not moderated, but rather accelerated, in times of anxiety about the future. And if, as I have argued, the technoscientific progressive drive is inherently entangled with productionism, the alternative seems bleak: intensify agricultural gain (and further exhaust soils) or the world will starve. Environmentally concerned scientists will have to find ways to resist to these pressures. In this direction, while at the level of epic scientific mobilization it remains difficult to disentangle science from technoscientific futurity, I am interested in conceptual and practical reorientations in soil science that could question this temporal alignment by questioning a productionist ethos that subjects soil care, and, more generally, human–soil relations, to the extraction of future economic value.

Beyond productionism?[6]

> How things have changed as we have moved into the 21st Century! Whilst maintaining agricultural production is still important the emphasis now is on the sustainable use of soils and limiting or removing the negative effects on other environmental components. (Stephen Nortcliff, in Hartemink, 2006: 105)

Soil biologist Stephen Nortcliff speaks above of a change in focus from research in the 1970s and 1980s, when sustainability concerns focused on 'maintaining yield' rather than the 'soil system'. He is not alone. A disciplinary reassessment seems to be taking place. This could be a significant shift in the historical orientation of soil science, summarized as follows by a soil physicist:

> Soil science does not stand alone. Historically, the discipline has been integrated with all aspects of small farm management. The responsibility of maintaining good crop yield over a period of years was laid upon the soil. Research into soil fertility reflected this production-oriented emphasis during most of the nineteenth century … the focus of their efforts remained, and to a large extent still remains, to benefit overall harvests. (McDonald, 1994: 43)

Guaranteeing yield through production is an essential drive of the agricultural effort. But critical research on agriculture refers to *productionism* more specifically in terms of the intensification that drove agricultural reform in Europe from the 17th century onwards. This culminated in the mid-20th century with the industrialization and commercialization of agriculture and the international expansion of this model through the Green Revolution's assemblage of machines, chemical inputs and genetic improvements. The philosopher of agricultural technology Paul B. Thompson (1995) summarizes productionism as the consecration of the aphorism, 'Make two blades of grass grow where one grew before' (p. 61). Critiques of productionism condemn the absorption of agricultural relations within the commercial logic of intensification and accumulation characteristic of capitalist economies. In other words, productionism is the process by which a logic of production overdetermines other activities of value (Papadopoulos, 2014; Papadopoulos et al., 2008). Agricultural intensification is not only a quantitative orientation – yield increase – but also a way of life. While it seems obvious that growers' and farmers' practices, whether grand or small scale, pre- or post-industrial, would be yield-oriented, productionism colonizes all other relations: everyday life, relations with other species, and politics (e.g. farmers' subjection to the industry–agribusiness complex).

The increasing influence of logics of productionist acceleration and intensification through the 20th century can be read within scientific approaches to soil. One notable example can be found in chemistry's contribution to turning cultivation into a productionist effort. Soil physicist Benno Warkentin explains how early studies on plant nutrition were first based on a 'bank balance' approach by which nutrients assimilated by plants were measured, with the idea that these had to 'be added back to the soil in *equal* amounts to *maintain* crop production' (Warkentin, 1994: 9, emphasis added). But the 'balance' emphasis changed after 1940 with an increase in off-farm additions to the soil, bringing artificial fertilizing materials, external to a site's material cycles and seasonal temporalities, in order to bolster yield. The aim of this increase was to ensure 'availability of nutrients for *maximum growth, and timing for availability* rather than on the total amounts removed by crops' (Warkentin, 1994, emphasis added) – that is, not so much to maintain but to intensify the nutrient input in soils beyond the rhythm by which crops absorb them. These developments confirm a consistent trend in modern management of soils to move from maintenance and repair – for instance by leaving parts of the land at times in a fallow state – to the maximization of soil beyond the renewal pace of soil ecosystems (Hillel, 1992). This makes visible how the tension between production and sustainability at the heart of soil science involves a clash of temporalities: between acknowledging soil as a slowly renewable entity and the accelerated technological solutions required by intensified production.

This is not to say that soil scientists – nor even practitioners who live by the productionist credo – have not taken care of soils. Remediating worn-out soils has been at the heart of the development of soil science since its beginnings and was related to the socio-economic concerns that influenced early soil studies (Warkentin, 1994: 14). Numerous soil scientists have been committed to conserving soils and working with farmers to foster ways of caring for them while maintaining productivity: 'soil care' is a widely

used notion (Yaalon, 2000). Moves to interrogate productionism seem, however, to question conceptions of soil care in the light of a broader societal realization of the untenable pressures on soil. In science and beyond, the persistent productionist ethos overlaps today with an 'environmental era' starting in the 1970s and influenced by a conception of environmental limits to growth that place 'the living earth … in a central position' (Bouma and Hartemink, 2003: 137). This has marked soil science, with many of its researchers, for instance, pointing to the unsustainable destruction and deterioration of natural habitats associated with an excessive use of agrochemicals (p. 134). Most socio-historic accounts of the soil sciences since the early 1990s recognize this 'ecological' turn (Warkentin, 1994: 3–4). This trend has also led to an emphasis on the extension of 'soil functions' (Bouma, 2009) and soil science applications to the consideration of a range of 'ecosystem services' – including aesthetic values – that value soils beyond commercial agricultural needs (Robinson et al., 2014).

What can a critical analysis of the articulation of the temporality of productionism and relations of care contribute to these transformations? In a sense, there is an inherent ambivalence contained in these relations whereby the future is simultaneously hailed as central and 'discounted' (Adam, 1998: 74) – short-term thinking pushes to exploit natural resources today disregarding their future. Yet the overriding temporality of productionist-oriented practices in late capitalist societies remains future-oriented: it focuses on 'output' and on efficient management of the present in order to produce it. This is consistent with how, as described above, restless futurity renders the experienced present precarious: subordinated to, suspended by or crushed under the investment in uncertain future outcomes. Worster's account of the living conditions of farmers who outlived the destructions of successive dust bowls to see the return of intensified agriculture and successful grand-scale farming are also stories of discontent, debt and anxiety, echoing farmers' experiences worldwide living under the pressures of productionism (Shiva, 2008; Worster, 1979). So although the timescale of soil exploitation discounts the future by focusing on the benefit of present generations, the present is also discounted, as everyday practices, relations and embodied temporalities of practitioners embedded in this industrious speeded-up time are also compressed and rendered precarious. Productionism not only reduces what counts as care – for instance to a manageable 'conduct' of tasks to follow (Latimer, 2000) – but also cuts the possibility of developing relations of care that fall out of its constricted targets. Productionism transforms care from a co-constructed interdependent relation into mere control of the *object* of care. It could be argued that within the productionist model, the drive of care has mostly been for crops *as commodifiable produce*. In this utilitarian vision, worn-out soils must be 'put back to work' through soil engineering technologies: fed litres of artificial fertilizers with little consideration for wider ecological effects or made to host enhanced crops that will work around soil's impoverishment and exhaustion. So it is obviously not only human temporalities but also more-than-human that are subjected to the realization of this particular-linear timescale focused on accelerated productivity.

Soil care in a productionist frame is aimed at increasing soil's efficiency to produce for humans at the expense of all other relations. From the perspective of a feminist politics of care in human–soil relations, this is a form of exploitative and instrumentally regimented care, oriented by a one-way anthropocentric temporality. The ecosystem-services approach seems to question productionism by calculating the worth of ecosystems beyond their

purely economic value, albeit not necessarily to 'price' them (a distinction important to many advocates of this approach). However, this understanding of soils still posits them as either functions or services for 'human wellbeing' (Millennium Ecosystem Assessment, 2005). A feminist approach to care would not leave the very logic of 'service' unexamined: 'service for whom?' or '*cui bono?*' (Star, 1995) – exposing the limitations of a logic of service to transform relations that reduce soils to resources for human consumption. An interrogation of this logic focused on re-articulating relations of care and temporality joins the efforts to critique the instrumentalization, degradation and evacuation of more-than-human agency, long identified by ecofeminist thinkers (see, for example, Bastian, 2009; Plumwood, 2001). As I will discuss in the next section, care requires thinking from the perspective of the maintenance of a web of relations involved in the very possibility of ecosystems rather than only from their possible benefits to humans.

In the next section, I consider how conceptions of soil as a living world within soil science, which question further the reduction of soils to inputs for crop production and other human needs, re-interrogate anthropocentric linear temporalities and involve transformations in soil care practice.

Redefining soil as living

As part of the ecological turn, soil ecology research has moved to an important place at the heart of the soil sciences, focusing on relations between biophysical, organic and animal entities and processes (Lavelle, 2000; Lavelle and Spain, 2003). Moreover, a great number of accounts of the discipline's development in the past ten years connect the growing significance of the ecological perspective with the moving of biology to the centre of a field traditionally dominated by physics and chemistry. In this context, it is remarkable how a notion of 'living soil' – once mostly associated with organic and radical visions of agriculture – is now mainstream. This does not mean that soil science traditionally conceived of soils as inert matter. Even conceptions of soil as reservoirs of crop nutrition focus on lively physico-chemical processes and interactions. Also, soil microbiology has been a crucial part of soil science since its early beginnings as well as its important precursor work on soil biology (such as Charles Darwin's work on earthworms). This does not mean either that biology and ecology support environmentalism *per se*, nor that other disciplinary orientations in soil science must now be connected to biology. The noticeable trend is the increased significance of 'biota', from microbial to invertebrate fauna and of course plants, roots and fungi, in the very definition of soil.

> Are living organisms part of soil? We would include the phrase 'with its living organisms' in the general definition of soil. Thus, from our viewpoint soil is alive and is composed of living and nonliving components having many interactions … When we view the soil system as an environment for organisms, we must remember *that the biota have been involved in its creation, as well as adapting to life within it*. (Coleman et al., 2004: xvi, emphasis added)

In this conception, soil is not just a habitat or medium for plants and organisms, nor is it just decomposed material, the organic and mineral end-product of organism activity. Organisms *are* soil. A lively soil can only exist with and through a multispecies community of biota that *makes it*.

One of the most significant aspects of these changes to conceptions of soil is a growing interest in investigating biodiversity as a factor of soil fertility and system stability (Wardle, 2002: 238, 234). This goes beyond biological interest; for instance, the recognition of the importance of large pores in soil structures gives a central place to increased research on soil fauna such as earthworms – the 'soil engineers' (Lavelle, 2000). In the words of a soil physicist, 'as the appreciation of ecological relationships in soil science developed after the 1970s, studies on the role of soil animals in the decomposition process and in soil fertility have been more common' (Warkentin, 1994: 8). More research focuses on the loss of soil biodiversity after alterations (Van Leeuwen et al., 2011) and on the ecological significance of soil health for non-soil species (Wardle, 2002). A number of soil scientists are engaged in drawing attention to biodiversity as part of educational campaigns and soil fertility projects worldwide.[7]

These developments are not disconnected from production concerns. On the contrary, the 'loss of organic matter, diminishment or disappearance of groups of the soil biota, and the accompanying decline in soil physical and chemical properties' are identified as important causes of 'yield declines under long-term cultivation' (Swift, 2003). Significant issues for a conception of living soils concern the effects of interventions to enhance impoverished soils, however well intentioned. For example, the protection of soil structures involves a re-evaluation of tillage and other technologies that compact the soil.[8] Other interventions point to how soil communities can be permanently destabilized or destroyed by fertilizers, making soils and growers dependent on those fertilizers. Exploiting soil species for production threatens to destroy the living agents of this very productivity (Tsiafouli et al., 2015). Once again, re-conceptualizations of soil as living emphasize how productionist practices ignore the complex diversity of soil renewal processes in favour of linear temporalities aimed at speeding up abundant output.

An interesting example is the 'foodweb' concept of soil life that, having become popular in alternative growers' movements, thrives at the boundaries of soil science. Foodweb models are not new but have become more prominent in soil ecology since the 1990s (Pimm et al., 1991). These models allow scientists to describe the exceptionally complex interactions among species that circulate nutrients and energy. The models follow predation and eating patterns as well as energy use and processing. Soil foodweb species can include algae, bacteria, fungi, protozoa, nematodes, arthropods, earthworms, larger animals such as rabbits, and of course plants. They describe not only how species feed on each other but also how one species' waste becomes another's food (Coleman et al., 1992; Ingham, 2004; Wardle, 1999). Foodweb conceptions of soil interrogate the use of artificial fertilizers, pesticides and intensified agricultural models more generally. This is because their web-like, interdependent configuration means that altering or removing any one element can destroy them. Often conceptualized as soil communities, foodweb models emphasize a living world below, teeming with life and yet always fragile.

Soil ecology is, of course, not a unified domain and, while rich in holistic models of life cycles, it is also rich in reductionisms. My interest here is in moves that see soil as a multispecies world because these could affect not only the nature of soil itself but also the ways humans maintain, repair and foster soil's liveliness – that is, the agencies involved in a politics of care (Puig de la Bellacasa, 2014). The emphasis on soil communities is

particularly interesting from the perspective of a politics of care for which maintaining, continuing and repairing living webs of interdependent relations are fundamental features of good care (Tronto, 1993). Seen from the perspective of care, interdependent conceptions of human–soil relations could challenge the unidirectional linearity and anthropocentrism of productionist and service approaches. Thinking living soil models such as foodwebs through care draws attention to the dependency of the (human) carer, not so much in terms of soil's produce or service, but from an inherent web of multilateral relations that render soils capable of taking care of a number of vital life processes (circulating food, energy and waste). A care approach would look not only at how soils and other resources produce output or provide services to humans; it would look also at how humans are providing for the soil community in order to maintain, continue and repair this living web.

The capacity of exhausted global soils to support these relations has become more dependent on the care humans put into them. Here, in turn, changing ways of soil care would affect soil ontology, requiring that humans be included more decisively in the concept of soil, that is, as members of the soil community rather than as mere consumers or service beneficiaries, rephrasing the ecological redefinition of soil as living quoted above to affirm that 'humans are involved in [soil] creation, as well as adapting to life within it …' Although scientists have long spoken of 'soil communities' to refer to the organisms involved in soil's ecology, the idea that humans are part of soil communities is not prevalent in the scientific literature where illustrations of the soil foodweb rarely represent humans – for example, as producers of 'organic waste' and beneficiaries of the output of plants. This could be linked to the traditional role given to the human in soil science, generally considered as one 'element' of soil ecosystems and formation processes that 'lies apart' because human activities have higher impacts in a shorter amount of time than have other organisms. The human mostly features as an unbalanced irruption in soil's ecological cycles – or a victim in the case of soil pollution – rather than as a member of the soil community (Hillel, 2004). This notion, along with others such as humans *being soil*, thrives outside science, however, including in how scientists speak beyond their official institutional work (Hole, 1988; Warkentin, 2006). These alternative affective ecologies become obscured within the science focused on soil as a 'natural body'. However, my interest is in articulating different modes of relating to soil through their potential to transform human–soil relations. Connections between scientific and non-scientific ways of knowing soil, whose relevance is sometimes mentioned by scientists (Tomich et al., 2011), could become more significant in the light of moves to consider soil as a 'human-natural' body (Richter and Yaalon, 2012) and the introduction of new approaches such as 'anthropedology' that broaden soil science's approach to human–soil relations (Richter et al., 2011). But is human repositioning within soil enough to transform soil care?

Reading scientific conceptions of 'soil as living' speculatively, for their potential to transform relations of care, brings us beyond science. In the next section, I look at practices that are diversifying the ways of making time for the soil at the heart of productionist practices and relations. This brings us back to the possibility, set out at the beginning of this article, for disrupting anthropocentric timescapes by taking a diversity of more than human timescales into account.

Making time for soil time

Beyond science, foodweb models and scientific ideas of soil as living are explicitly made to speak for alternative soil care and human–soil relations, with implications for the dominant productionist futurity. I first learned about this by following the work of Elaine Ingham – a soil scientist specializing in foodwebs, who left the academy to establish a foodweb-based soil testing business and continued a career as a celebrated advisor of alternative soil care. Among her many interventions, I focus here on a series of online lectures in which she popularizes a 'biological' notion of soil among practitioners: soil is not 'dirt' – dirt is soil without life, she affirms. Here, she introduces the basics of microbiology to inform accessible soil sampling techniques and subsequent soil testing. From how to choose a second-hand microscope to how to sample soil with a '*really expensive* high-tech piece of equipment called an apple corer', the aim is to get at 'the biology' in soil.[9] The basic method that Ingham recommends to assess soil health is an estimated count of microorganisms to detect the health and the needs of the soil, in order to feed it with the appropriately balanced organic material, such as compost and compost teas produced on-site (Ingham, 2000). Extensively named in soil lovers' worlds as having produced scientific research that improves grower's practice, Ingham's explicit political aim is to liberate farmers from industrial fertilizers: 'Jump off the chemical wagon!' she calls in a video advertising her courses.

This discourse mobilizes 'science-informed' soil practice as a promise of future output: effortless, chemical-free and abundant yield (Ingham, 1999). It could be said that the message works because it still speaks to the production ethos as a shared hope of growers to benefit from abundant produce from a fertile soil. Yet here production is harnessed by good care rather than the contrary, and good care is tied to knowing and appreciating soil life. These practices speak of intensification, not so much intensification of production but rather of involvement with soils. These modes of soil care involve practitioners with the agencies and mediations that make the soil community work, that is, capable of taking care of biological functions – agencies that would be made invisible by off-site testing practices. Ingham is inviting soil practitioners to immerse themselves in the soil and develop 'a feeling for the soil', to paraphrase Evelyn Fox Keller (1983; see also Myers, 2008). Farmers speak of intense affective relations with soils, involving 'commitment, concern and empathy normally reserved for close family members', sometimes transforming testing into 'tasting soil', immersing into it and co-mingling with its substance (Watson and Baxter, 2008: 14). Here again, the life in the soil is a powerful signifier: 'if you can't see the fungi, bacteria and invertebrates and you don't feel inclined or qualified to taste your soil, how do you know it is healthy?' (Watson and Baxter, 2008). Kristina Lyons speaks of the intimate relation of Amazonian farmers with soil through an embodied and sensorial involvement that allows them to become 'one among many actors who labor in the act of living and struggling together'(Lyons, 2014). This is an affective involvement not restricted to marginal circles. In similar ways, a scientist-blogger in the Global Soil Biodiversity project argues that showing images of the organisms to farmers and growers opens the soil 'black box' and invites us to 'identify […] with soil fauna'.[10]

But how do these practical modes of soil care that subordinate production to immersed caring also disrupt the productivist futurity dominating contemporary technoscience?

With regard to epochal progressive futurity and amid calls for urgent and global responses to food insecurity, these small-scaled reorientations of growers' skills are bound to appear as 'turning back the clock' to pre-industrial practices. Similarly, from the perspective of 'bright and shiny' conceptions of innovation, tasks such as 'counting bacteria' to test soil health recall school science projects. Ingham's work projects a sense of outdatedness, exaggerated by the use of tools like an apple corer and second-hand microscope. From the perspective of the embedded temporality of practice, one can wonder why a busy farmer or gardener preoccupied with output constraints would *make time* for these slow, labour intensive tasks, instead of putting soil into an envelope and sending it to a soil testing company. In fact, what we see here is a kin to what Patrick Bresnihan (in press) elicits in his ethnography of fishermen's 'commoning' practices. Bresnihan exposes modes of management of fish stocks that are at odds with the standard management of sustainability. Here, alternative engagements with time are at stake that evoke not only a different mode of production but also a different mode of life, including a different relationship to work. This temporal relation is not focused on 'efficiency', and because of that it seems inconceivable from the perspective of the 'rational calculations of a liberal subject plotting his activities along a more or less individualized and linear trajectory', that is, the perspective of 'management … where the future is organized towards a specific, technically defined goal of biological sustainability' (Bresnihan, in press). In a similar way, the embodied experience of time in making time for soils alters linear productive practice in ways that remain irrelevant from the perspective of the trajectories of futurity in technoscience.

To further illustrate this, I draw upon a discussion of 'time niches' extracted from a popular manual of permaculture, an international movement for alternative ecological design that numbers among numerous foodweb proponents. The author, Bill Mollison, speaks of an embodied immersion in ecological cycles that involves a long period of 'thoughtful and protracted observation' before acting on the land and its processes. This principle, known as 'TAPO', is a rule of technical design and an ethical principle in training in permaculture practice (Ghelfi, 2015). The point of immersed observation is to take the time to 'experience' the specific 'schedules' happening within the arrangement of life cycles (involving species, climate, localized interactions, etc.) that constitute temporal niches in a particular ecology (Mollison, 1988: 28). The imperative of observation is an on-going one, because each cycle is an 'event': 'diet, choice, selection, season, weather, digestion, and regeneration differ each time [the cycle] happens' (Mollison, 1988: 23). It is in such variation that the possibilities for diversity thrive. Soil care practitioners whom I have encountered often speak about similar kinds of immersion in the repetitions of cycles of soil life, by which they learn the needs of the landscape and by which a particular ecological environment also 'learns' and adapts to human practice.

Soil ecologists have long been aware of cycles of interdependent growth and decay in the living soil that articulate multiple temporalities. But the temporal immersion of TAPO is about a rethinking of human ecological practice in its material, ethical and affective dimensions. TAPO requires making time for soil time and, I argue, can be read as a form of 'care time'. First, the repetitive character of on-going observation of soil cycles enables care. Care work becomes better when it is done *again*, creating the specificity of a relation through intensified involvement and knowledge. It requires attention

and fine-tuning to the temporal rhythms of an 'other' and to the specific relations that are being woven together.[11] Second, TAPO's temporal immersion involves human practice in an interdependent, yet diverse, web. Temporal diversity, rather than immediate connection (to nature) or mere control of other rhythms, needs to persist in these tunings and re-adjustments. One form of care does not necessarily work in a different arrangement, nor do different temporalities cohabit in harmony. Different types of soil will need different care and members of the foodweb are often read as competitors.

In terms of human–soil relations more generally, this approach puts practitioners not so much 'in charge' of ecological management and food production, but sees them as attentive members of a specific ecological, soil foodweb community. This disrupts humans' location as outside observers or central beneficiaries of objectified services: even if it strongly relies on the role played by humans in landscapes that they are part of, humans are not the end destination of the processes that human–soil ecosystems take care of. In other words, within these conceptions, 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. All participants somehow embody the time of the cycle by eating or becoming food for other participants in the death and decay cycle.[12] Immersion in the foodweb, therefore, creates specific practical and eco-ethical 'obligations', such as the cyclic return of organic waste (i.e. through composting) (Puig de la Bellacasa, 2010). One care task here is, as gardeners like to put it, to *grow soil* (Bial, 2000) by 'returning the surplus' in order to continue to make soil as much as we consume (from) it. This is an enactment of interdependent care.

Focusing on these forms of immersed ecological care, we see that changing human–soil relations require material, ethical and affective ecologies that thicken the dominant timescape with a range of relational rearrangements. In these relations of care, the present appears dense, thickened with a multiplicity of entangled and involved timelines, rather than compressed and subordinated to the linear achievement of future output. In these transformations, a temporal tuning between humans and multispecies soils could be taking place that, borrowing from Carla Hustak and Natasha Myers (2012), would not be not so much a 'co-evolution' but rather an 'involutionary momentum', that is, an occasion for a new relational arrangement between species that could further involve them with each other.

The pace of care time

Human–soil relations are pervaded by their ancestral status as providers of food and a temporality subjected to increased yield. Increasing production remains on top of the agenda, and it is likely that agricultural intensification and chemical fertilization will be the immediate responses by dominant agribusiness and policy makers to future food security alarms. The approaches described in this article question the dominant treatment of soils: from tensions in soil science around the imperative of progress to moves away from productionism towards conceptions of soil as living and correlated practices of involvement with soil. But these immersions in soil times do not exist in an unpolluted temporality that would sit outside the current crisis. While these experiences of care time could disrupt the futuristic drive, they are not disentangled from technoscientific time.[13]

Following Dimitris Papadopoulos (2014), we could rather argue that these practices are also technoscientific, but committed to making alternative ontologies from within. Also, feminist visions of care emphasize the ethico-political significance of doings of care that inhabit everyday life, not, as many wrongly imply, a separate 'cozy' realm where 'nice' relations can thrive (Abrahamsson and Bertoni, 2014). Care is political, messy and dirty, not an innocent category, and even less so in technoscience (Haraway, 2011; see also Murphy in this special issue; Kortright, 2013; Puig de la Bellacasa, 2012). Care is a necessary everyday doing, but it can also become a moralistic regime of power and control (Ticktin, 2011).

Re-enacting meanings of care as disruptive is therefore an intervention in a fraught and contested terrain. It involves unpacking what is actually done under the name of 'care'. My reading of tensions around notions of soil care in this article is marked by a feminist politics that brings attention to ethico-political questions about such matters as who cares for whom and what forms of care are prioritized at the expense of others – for example, who provides the ecosystem 'service' and for whom. In that sense, what I have tried to argue is that an orientation to the articulations of temporality and care in human–soil relations contributes to questioning the prioritization of anthropocentric technoscientific futurity by making visible alternative timescapes and enriching our temporal imaginings.

In this spirit, I conclude by discussing the relation of these timescapes to predominant notions of futurity and innovation. Reading these ways of making time for soil as 'care time' exposes how they are made irrelevant from the perspective of the progress-oriented, productionist, restless futurity identified at the beginning of this article as the predominant technoscientific timescape at epochal, practical and embodied levels.

At the level of embodied time, a focus on care elicits the affective involvements at stake in maintaining and fostering interdependent human–soil relations. These include adjustments according to cycles, present-embedded time and different ecological timescales. Feminist sociologies of caring practices can support this observation, for they expose them as labours of everyday mundane maintenance, and as repetitive work, requiring regularity and task reiteration (for recent STS perspectives, see Mol, 2008; Mol et al., 2010; Singleton and Law, 2013). But anybody who has been involved in caring for children, pets or elderly kin knows that the work of care takes time and involves making time of a particular kind. Care time can be enjoyable and rewarding, but also tiresome, involving a lot of hovering and adjusting to the temporal exigencies of the cared-for. I have noted earlier how future, urgent, speedy temporality suspends and compresses the present. It could be said that care time suspends the future and distends the present, thickening it with a myriad of demanding attachments. Even when care is compelled by urgency, there is a needed distance from feelings of emergency, fear and future projections in order to focus on caring well. So while the probability and repetition of ecological cycles do not preclude uncertainty and restless anxiety about future unexpected events (one only needs to think of weather, pests, disaster, etc.), expected repetition – reliance on the continuity of life processes – is essential to ecological relations of care.

Care time is also irreducible to productionist time. From the dominant perspective of technoscientific innovation, productivity aims at the economic 'transformation of materials from a less valued to a *more valued* state' (Thompson, 1995: 11). Feminist approaches

to care show how the work of reproduction and maintenance of life has traditionally been considered marginal to value-creating work. The same process can be read from a temporal perspective. When all spheres of practice are colonized by the productionist logic, care time is devalued as 'unproductive' (Adam, 2004: 127) or 'merely' reproductive. In other words, from the perspective of productionism, time consecrated to the reproduction, maintenance and repair of ecological life is wasted time. Against this, a politics of care exposes the importance of the work of care for creating liveable and lively worlds. At the same time, feminists have contested the reduction of care work to traditional economic terms (Rose, 1994). Valuing care by 'efficiency' standards transforms its practice into a managed 'conduct' to be monitored (Latimer, 2000). That is why, in contexts of managerial control that underestimate care's value and even penalize its practice, acts of care can be considered as a kind of resistance (Singleton and Law, 2013). Rather than focusing on demonstrating the productive character of activities of care, affirming the importance of care time means drawing attention to, and making time for, a range of vital practices and experiences that are discounted, or crushed, by the productionist ethos.

Finally, perhaps the most powerful obstacle to these forms of making time for soil is that they could involve transgressing the progressive imperative, the 'Thou shall not regress' commandment of modern science (Stengers, 2012) that feeds the 'innovate or perish' credo. In this timeframe, involutionary immersions in soil times such as those that I have approached in this article will be suspected of nostalgia for an idealized past or for unmediated natural connections – while arguments to become part of the soil community may be depreciated as unscientific spiritual talk (Puig de la Bellacasa, in press). Common reactions to non-productionist views on agricultural technology point to their irrelevance or inability to tackle the important challenges facing current societies – they cannot feed the world – with the often unspoken correlative argument that they are not 'profitable'. Indeed, the implicit mode of progressive and linear futurity in usual conceptions of innovation could hardly recognize the reconfigurations of soil care examined in this article. That is why, as noted by Jackson, foregrounding the importance of care, maintenance and repair to the very material sustaining of the world is a step in challenging teleological, progressive, shiny ideals of innovation. Care time's irreducibility to productive aims could contribute to revealing the overestimated value of the productionist imaginary in innovation (Suchman and Bishop, 2000). Thinking from the significance of caring relations suggests that no output, no growth in the future and, one could say, no innovation or emergence of newness are possible without a commitment to the everyday maintenance and repair that supports the work of care (Jackson, 2014) and the continuity of life.

Permaculture and biodynamic practitioners who engage with foodweb-friendly soil care techniques describe them as innovations while simultaneously explaining that some of the 'new' technologies that they implement are a thousand years old, integrating knowledge from contemporary indigenous modes of re-enacting ancestral ecosmologies. These logics are not completely absent from contemporary soil science, as this soil scientist affirms: 'The ancient wisdom and indigenous technical knowledge about benefits of manuring, reduced tillage, conservation farming and other practices abandoned somewhere on the way, need to be re-learnt' (Rao, in Hartemink, 2006: 116). And 'new' practices recommended by institutions such as the US Department of Agriculture (USDA)

are following. This re-learning cannot be understood as a nostalgic return to a pre-industrial landscape, nor one that chooses to ignore pre-industrial unsustainable relations with soil. The present reconfiguration of human–soil relations for the inheritors of industrial revolutions will have to be *unique* to an epoch and timescape where the re-creation of ecological tradition faces global breakdown. One can read these interventions as innovative in the current dominant timescape by thinking them as untimely – bringing old or past elements into a context in which they then become new with regard to a present situation; one in which some humans are seeking to reconfigure themselves, from soil consumers into soil community members.

Another, less dismissive, reading of the temporal redirections in these forms of engagement could see them as refusals of technoscientific mobilization encouraging a 'slowing down' (Stengers, 2005) – in this case, of the pace of productivist appropriation of soil life as a resource. Yet their qualification as 'slow' could still be misleading here. Advocating slowness as time of a different quality against the speed of innovation and growth in technoscience does not necessarily question the direction of the dominant timeline, which these approaches do by operating differently within technoscience.[14] This brings us to the case for decentring anthropocentric temporality in technoscience. Indeed, if we think of time from the perspective of earthworm communities, artificial fertilization of soils aimed at accelerating yield would be a slowing down of the development of worms and other essential soil communities; meanwhile, interventions that adjust to the pace of soil communities' reproductive capacities foster the proliferation and thriving of their habitats. What seems slow or backwards when living according to one timeline or timescale might, perhaps, have a different sense in another.

The transformative moves in human–soil involvement approached in this article require making time for soil time. The pace required by involved soil care poses the challenge of a relational encounter of different timelines that might affect the notions of the future that dominate in technoscience. In these temporalities of ecological care, growth is not necessarily exponential, nor extensive. This is not only because ecological growth involves cycles of living and dying, but also because what makes an ecology grow manifests itself in the intensification and teeming of involvements between members. Conceived as such, the time of soil is not 'one'; it exposes multifarious speeds of growth becoming ecologically significant to each other. To argue for a disruption of futuristic time through making care time is therefore not so much about a slowing or redirection of timelines but an invitation to rearrange and rebalance the relations between a diversity of coexisting temporalities that inhabit the worlds of soil and other interdependent ecologies.

That is why a politics of soil care that insists on perpetuating, maintaining and intensifying the life of existing cycles involves a stance on technoscientific innovation driven by production intensification and network extension. As current alarms about the future of soils repeatedly warn, modes of network extension that succeed in aligning diverse timelines into the linearity of production put in danger the very existence of a living soil and the species that depend on it. Rather than aligning care time to become workable within the dominant timeline – that is, to become productive – the balance of proof might need to be turned towards current ways of living in futurity: how can technoscientific timescapes of futurity live ecologically with timelines of care? This could be a relevant

question for debates on technoscientific time. Research on temporal imaginings that make time for care time could contribute to the exploration of a multiplicity and interdependence of temporalities.

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Notes

1. Feminist research on practices of care is a large interdisciplinary endeavour that includes sociology of work, ethics and political theory. In the context of science and technology, Hilary Rose (1983, 1994) is a prominent precursor, but in the past five years the notion of care has become more significant within science and technology studies (STS), as this special issue demonstrates. I have proposed an approach to the ethico-political specificity of feminist approaches to care in STS and to care as a politics of knowledge in Puig de la Bellacasa (2011).
2. This is the title of an animated movie by UK-based artist Leo Murray aiming at popularizing research on climate change: http://wakeupfreakout.org. For a study of how the 'eco-catastrophic' imaginary is reorganizing ecological practices, see Beuret (2015).
3. The 2014 blockbuster SF movie *Interstellar* depicts the end of the world as a generalized dust bowl with a worldwide correlative food crisis. It includes accounts inspired by the historical disaster.
4. 'Land grabbing' refers to the appropriation of land by investors to the detriment of local communities. See http://farmlandgrab.org (accessed 14 May 2014).
5. In addition to the publications cited in this article, see Landa and Feller (2009) and Warkentin (2006). In 1982, a working group was set up by the International Union of Soil Sciences that led to the establishment of a commission on the History, Philosophy and Sociology of Soil Science.
6. Productionism and productivism are interchangeable notions in the literature. Here, I opt for productionism unless a cited author does otherwise.
7. See, for instance, the 'Soil Biodiversity Initiative. A scientific effort': http://globalsoilbiodiversity.org (accessed May 2014).
8. This is visible in an information video for farmers available on the US Department of Agriculture (USDA) Natural Resources Conservation Services YouTube channel, 'The Science of Soil Health: Compaction' that invites one to 'imitate Mother Nature' and limit the use ploughing machinery.
9. http://www.youtube.com/watch?v=HHCVIfu1j_U (accessed 21 May 2014), http://www.youtube.com/watch?v=IBHzJb0TpxU&feature=mfu_in_order&list=UL (accessed 21 May 2014), and http://www.youtube.com/watch?v=I5MB7vz6awg&feature=mfu_in_order&list=UL (accessed 21 May 2014).

10. 'Identifying with soil fauna' http://blog.globalsoilbiodiversity.org/article/2013/10/21/identifying-soil-fauna (accessed 21 May 2014).
11. This approach to temporal adjustments resonates with notions of temporal 'alignments' explored in STS with relation to collaborative work (Jackson et al., 2011) and analysed existentially as a process of 'torque' by Geoff Bowker and Leigh Star (1999). Other processes of technoscientific synchronization in nature-cultures are researched by Astrid Schrader (2010, 2012).
12. On the eco-ethical importance of multispecies eating together, see Haraway (2008), and on the specific embodied foodweb conception of soil practitioners in the Colombian Amazonian plains, see Kristina Lyons (2013).
13. I have learned to appreciate this thanks to Chris Kortright's ethnographic work on genetically modified (GM) rice research. He reveals forms of creative and caring labour of scientists working in the development of genetically modified rice plants destined to serve a second green, genetically modified, revolution (Kortright, 2013).
14. See, for instance, the Slow Science Manifesto: 'Don't get us wrong – we do say *yes* to the accelerated science of the early 21st century … However, we maintain that this cannot be all. Science needs time to read, and time to fail … does not always know what it might be at right now … develops unsteadily, with jerky moves and unpredictable leaps forward – at the same time, however, it creeps about on a very slow timescale, for which there must be room and to which justice must be done'; http://slow-science.org (accessed 21 May 2014).

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Author biography

Maria Puig de la Bellacasa is a senior lecturer at the University of Leicester School of Management working across science and technology studies (STS), feminist theory and environmental humanities. Her current research focuses mainly on the ecological and socio-cultural dimensions of the soil sciences and soil knowledge more generally. She has previously published on feminist knowledge politics, care and ecological ethics. Her latest book, *Matters of Care. Speculative Ethics in More Than Human Worlds*, is forthcoming at University of Minnesota Press.