Making time for soil
Technoscientific futurity and the pace of care

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Abstract

The dominant drive for understanding soil has been to pace its fertility with human demand. But today warnings about soil's exhaustion and endangered ecology raise concerns that they have been mistreated throughout history. These worries are marked by fears of gloomy environmental futures, prompting us, and specially scientists and soil practitioners to urgently 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: 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 the paper looks for soil ontologies and approaches to human-soil relations that are obscured by this predominant timescape. Discussions about the future of the soil sciences already expose tensions between 'progress as usual' – by intensifying productivity – and the need to protect the pace of soil renewal. However it is in the interrogation of the intimate relation of soil science with productionism, and in the emergence of soil ecology conceptions that emphasise soil as a living community rather than a receptacle for crops, that we could see emerging alternative soil ontologies and human-soil relations paced by a temporality of care. The 'foodweb' model of soil ecology in particular has become a figure of alternative human-soil relations for environmental activists and practitioners, promoting soil care practices that intensify the involvement of practitioners with soil's temporality. Reading these ways of relating to soil ways of making time for '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

The vital role of soils for growing food has bound soil care knowledge to human subsistence economies. Increasingly through successive agricultural revolutions the dominant drive to understand soils has been the pacing of their fertility with intensified rhythms of production. But at the turn of the 21st century, soils regained consideration in public perception and culture amidst concerns that they have been mistreated and neglected. Today, warnings proliferate worldwide about a relatively immediate gloomy future of exhausted fertile land and correlated food crises. Soils remain a resource of value extraction for human consumption 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 soils are thought to be affects the ways it is cared for.

This piece[1] is part of an ongoing research project on transformations affecting human-soil relations 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 paper focuses specifically on relations with time at stake in transformations of human-soil relations 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. Through a focus on the potential transformative character of changes in approaches soil care I try to show how a focus on the articulation of relations of temporality and care can contribute to the recognition and enactment of alternative and/or marginalised temporalities in technoscience by STS scholars, scientists and related environmental actors and activists. My approach to the field of soil knowledge is involved in a feminist politics of care that acts not only to focus attention on practices of care but also as an orientation to engage with the significance of practices and experiences made invisible or marginalised by dominant, 'successful', forms of technoscientific mobilisation. It is also a motivation to look out for, and hopefully foster, ways of improving care in human-soil relations[2]. In this sense, focusing on care is a way of drawing attention to glimpses of alternative liveable relationalities, and hopefully contribute to other possible worlds in the making, or 'alterontologies', at the heart of contemporary technoscience (Papadopoulos, 2011).

The first two sections of the paper situate the argument in an epochal timescape of fear about soil futures. I first read this context through critical approaches in STS and sociology to the understanding of futurity that predominates in contemporary technoscience. 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 next two sections examine conceptual reorientations in the soil sciences with regards to their potential to affect human-soil relations by disrupting the temporality of productionist soil care, and by reconceptualising soil as a living, multispecies, interdependent community. The final two sections focus on exploring practices that involve practitioners with soil temporality. The paper concludes by arguing that these are forms of care time, in practice and experience, that are neither *outside* nor a *slowed down* mode of the timescales of technoscientific futurity. Focusing on making care time does however offer glimpses into a diversity of timelines that, in spite of being made invisible or marginalised in the dominant timescape, can challenge traditional notions of technoscientific innovation.

1. The future of soil in technoscientific timescapes

Today soils are up on the list of environmental matters calling for global care. The Food and Agriculture Organization of the United Nations declared 2015 *International Year of Soils* expressing concerns for this 'finite non-renewable resource on a human time scale under pressure of processes such as degradation, poor management and loss to urbanisation' (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. Human mistreatment and neglect of soils appears as a key theme in calls to reappraise soil's importance in ways that entangle soil's 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 civilisation is on the verge of eating itself" (Ahmed, 2013).

Peak soil – and the correlatives "peak nitrate" and "peak phosphorus"- refer, like other peak forewarnings, to 'economic' breakdowns by which a resource is bound to exhaustion without equivalent efforts to renew as it 'becomes more difficult to extract and more expensive' (Dery & Anderson, 2007). Humanity's vital need for soil supports a sense that the acceleration of its loss might be more worrying than the well discussed peak oil (Shiva, 2008). Countless accounts refer to strains to this resource caused by human population growth, reciting figures approaching ten billion by 2050, warning about famine outbreaks if action is not urgently taken to ensure food security. Yet soil exhaustion is also blamed across the board on industrialised and unsustainable forms of agriculture, therefore many see intensifying food production through technoscientific innovations as a misled perilous response to food security (McDonagh, 2014; Tomlinson, 2011). Human agricultural practices have exhausted soils across the world well before industrialisation (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 recognised factor of climate change, and the intensification of production in 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. In this paper I look at these ongoing transformations through the lens of their temporal dimensions.

Similarly to other environmental warnings – such as the reaching of tipping points, climate change, etc. urging humans to 'Wake Up, Freak out - Then Get a Grip'[3] – 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 left for action is compressed by urgency. I read this 'timescape' (Adam, 1998) as consistent with an hegemony of future-oriented timelines in technoscientific societies that has been illuminated in science and technology studies and sociology from several critical perspectives.

First, technoscientific futurity has been discussed with regards 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, forthcoming; Schrader, 2012). From the perspective of this hegemonic timescape, as faith in modern linear progressivism is increasingly put into question by an environmental crisis, uncertainty prevails; and catastrophic regression seems inescapable (Beuret, 2015)[4]. Secondly, the future orients practices. It acts as the inexhaustible pull of the technoscientific 'expectation', i.e. the socio-affective engine of innovation-driven political economies (Borup, Brown, Konrad, & Van Lente, 2006; Brown & Michael, 2003; Hedgecoe & Martin, 2003; Wilkie & Michael, 2009) – as well as of 'promissory' science (C. Thompson, 2005). Here technoscientific innovation is situated and affected by a shared timescape of futurity typical of late capitalist economies 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 & Papadopoulos, 2014; Papadopoulos, Stephenson, & Tsianos, 2008). Finally, this relates to the 'anticipatory' affective state of technoscientific futurity that Vincanne Adams, Michele Murphy and Adele Clarke have insightfully characterised as one of 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, Murphy, & Clarke, 2009: 247). Technoscience's innovation-driven addiction to novelty fosters uncertainty and expectation about an imminent future that could change it all. While an ongoing sense of urgency and crisis calls to act 'now', the present of action is mortgaged to an always unsure tomorrow. Therefore any meaningful act in the world of promissory capitalism involves taking risks and acting fast. It is not difficult to envision how the sense of urgency and crisis in this timescape thrives at an everyday level. Living in this form of futurity brings the everyday experience of time to a permanent precariousness: the present is diminished, always at the edge of potential change, of a breakthrough into the better or the worse. 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, forthcoming) in the face of uncertain futures is the late capitalism pendant of modernity's impossible efforts to manage and control time (Adam, 1998).

The three lines of critique outlined above characterise 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, 2001). 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 not time but that we *make it* through practices (Dubinskas, 1988; Frank Peters, 2006; Whipp, Adam, & Sabelis, 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, 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.

Secondly, a case for exploring and enacting alternative temporalities is supported by a 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 time scales of ecological relations involve time-frames 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 the long, slow, time of geological processes such as those taking thousands of years to break down rock – that Stephen Jay Gould qualified as 'deep time' (1987) –, and by relatively shorter ecological cycles by which organisms and plants, as well as humans growing food, break down materials that contribute to renew the top soil. In an epoch where all earth timescales seem to become subsumed under grand epochal categories emphasising the impact of human technoscientific progress such as "the anthropocene" (Zalasiewicz, Williams, Haywood, & Ellis, 2011) or of the capitalist politics of some humans, such as "the capitalocene" (Moore, 2014), drawing attention to the temporal diversity and significance of more than human experiences and timescales has ethico-political, practical and affective implications. Here, a focus on experiences of soil care as 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 the way we look at the temporality of science and technology. For instance, by disrupting the 'imaginings of technology' that, as Steve Jackson (2014, p. 227) 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'. In this sense, I will be discussing how approaches to soil care could disrupt 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 to question (see also Papadopoulos, 2014). Here a feminist politics of care in technoscience – akin to Jackson and other's attention to practices of 'maintenance' and 'repair' (Denis & Pontille, 2014) and Anne Marie 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, that are obscured or marginalised – as 'unproductive' – in the dominant futuristic drive.

In the following I will look at how transformations in the ways soil care is conceived might involve questioning technoscientific futurity: a critique of productionism, relating to soil as a living multispecies world, and making time for care time. Before, I further situate the discussion with regards to matters of temporality by highlighting contemporary tensions around the future of soil science in an epoch of ecological breakdown.

2. 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 develops as a distinctive field in the mid-19th century when developments in chemistry, physics and biology coalesce in an interdisciplinary endeavour with research agendas closely intertwined with socioeconomic 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 main scientific figures, paradigms and conceptual shifts (Krupenikov, 1993; Yaalon & Berkowicz, 1997). Only scattered examples can be found in this kind of literature that highlight the entanglement of scientific developments with socioeconomic 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 fertilisers first extracted and imported from the colonised Americas. As these resources became exhausted, fertilisers were developed artificially, propelling soil chemistry through its contribution to industrial manufacturing (Boulaine, 1994). Engaging properly with this complex history, or acknowledge the range of disciplinary perspectives on it goes well beyond the purposes of this paper. What is important to note here is that discussions about the future of soil science in the last twenty years have gone pair with an interest towards historical accounts of the discipline that include a relation with wider socioeconomic contexts (Bouma & Hartemink, 2002). An important story line could contribute to this effort by focusing on how advancements in the field's history have been entangled with 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) offered a powerful account of the dust bowl that shows how this disaster, that still marks the imagination of environmental devastation in the US[5], 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 in scientific and social investment in soils, including an increase of public support of US soil conservation policies as well on 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 of the technoscientific complex that set in motion the so-called Green Revolution accomplished by combining artificial fertilisers, newly developed high-yield seed stocks, and chemical pesticides and leading to intensive cultivation and unprecedented yield. Today, controversies persist about the social and environmental problems related to the Green Revolution (Cleaver, 1972; Shiva, 1991; Paul B. 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 concocting 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' success (The World Bank, 2013) while the concept is kept alive in scientific circles as a privileged response, yet in reformed, more 'sustainable', versions (Sánchez, 2004, 2010), often turning attention to the power of genetically modified crops that could cope with poorer soils.

Historically, social emergency and gloomy uncertainties about soil resources and practices are not new to soil scientists. Fertility, erosion, pollution, nutrient depletion, carbon capture are just some in the series of concerns affecting that modern soil science has been called to remediate with engagement in public and institutional projects of conservation and sustainable agricultural practice. There is however an added aspect to these historical precedents that can be observed by enlarging the frame to consider these scientific responses within the dominant temporal timescape, described above, that frames the future in technoscience. This is particularly important when reading this history through contemporary concerns, that is, when we consider the material implications of technoscientific futurity in environmental and ecological matters. These instances in the history of human-soil relations also can be read by 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 in the case of the green revolution – 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 has been rarely tempered by disasters. In the current context we could consider how the atmosphere of urgency and anxious restlessness about imminent resource exhaustion, seems rather to give impetus to accelerated extension of 'promissory' 'futures' market networks around vital natural resources – thanks to new opportunities of exploitation sometimes even opened by environmental degradation, e.g. oil extraction in newly accessible arctic zones (Johnson, 2010). In the case of soils, these economic moves can be attested in the rush to 'grab' fertile land[6] (Borras, Hall, Scoones, White, & Wolford, 2011): the less there is left, the more valuable an investment 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[7]. Today, scientists are again compelled to mobilise, in a context of global ecological change and possibly disaster, to address increasingly pressing concerns around the state of soils and their capacity to provide. An important theme across these discussions emphasises new pressures and challenges for science brought by environmental and food security concerns (Coquet & Ruellan, 2010). 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 & 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 because reducing its philosophy to a focus on 'responding' to society's demands could result in a potentially hazardous 'technology fix' (Churchman, 2010:215).

Alfred Hartemink - a scientist who has dedicated considerable efforts to promote engagement with the disciplines' history and future – is right when he affirms in the quote opening this section he links the scientific enterprise with an imperative to look into the future. Maybe more than any other modern social practice, science is actively and performatively embedded in the dominant progressive, promissory, productivist epochal timescape that constitutes the present and frames tensions and contradictions about expectations. In particular, modern science's inherent progressivism fosters repulse against any notion suspected of 'turning back the clocks'. 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 questionable, but a general ineluctable progression to the new, to the 'breakthrough', does rarely induce questioning. Yet, in spite of the traction of epochal futurity for science, debates and tensions about the discipline's future reveal some frictions. One important theme around which these tensions can be shown to crystallise 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. In the same way they participated to a green revolution in the past and enhanced production, they can do it again with more sustainable practices (Rattan Lal in Hartemink, 2006: 76). This fosters a notion that science can just continue going forwards, as usual, provided it accumulates wisdom. But if, as I have argued, the progressive drive in the dominant technoscientific framework is inherently associated by productionism, this could set soil science to face an 'infernal alternative' (Pignarre & Stengers, 2011): either intensify agricultural gain or the world will starve. Pressured to increase productivity, the response of science to worried publics will have to be, again, epic (Stengers, 1993). Others however 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). However, there is an underlying sense in this idea that an ecological soil science will follow an ecological society, in which 'opportunities are golden for imparting the knowledge and wisdom of soil science' (8, op. cit.). More pessimistic, are others who see a historical failure of soil scientists to convince agronomists of ways to better produce 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 these tensions around the ways to look forward? I believe it is particularly important to examine the assumption of an alignment of soil science with an ecological temporality – as 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 have been resolutely oriented by a typically linear orientation to the future based on producing output and profit through innovation. A logic not moderated, but rather accelerated, in times of anxiety about the future. Environmentally concerned scientists will have to find

ways to resist to these pressures. In this direction, while at the level of epic scientific mobilisation it remains difficult to disentangle science from the technoscientific futurity, I am interested conceptual and practical reorientations in soil science that could be questioning the alignment with predominant forms of technoscientific futurity. In particular, by questioning the productionist ethos that subjects soil care, and more generally, human-soil relations to the extraction of future economic value.

3. Beyond productionism? [8]

> 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)

Speaking about research in the 1970-80s, when sustainability concerns focused on 'maintaining yield' rather than the 'soil system', renowned soil biologist Stephen Nortcliff speaks above of a change in focus. He is not alone. A disciplinary reassessment seems to be taking place with regards to soil science's traditional implication in the wider societal demand of agricultural production. This could be a significant shift in the historical orientation of soil science, summed 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 with regards to the intensification that became the supreme command for farming from the agricultural reform in 17th century Europe onwards, culminating after the 1940s with the industrialization and commercialisation 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 (1994: 61) expressively summarizes productionism as the consecration of the aphorism 'Make two blades of grass grow where one grew before'. Thompson, who argues for an ethics of production, shows that critiques of productionism do not necessarily condemn the harnessing of natural resources to produce food or yield, but the absorbing of agricultural relations within the commercial logic of intensification and accumulation characteristic of capitalist economies. Critics of political economy can come to complement this analysis with the notion that productionism is the process by which a logic of production overdetermines other activities of value (Papadopoulos, 2014; Papadopoulos et al., 2008, emphasis added). Agricultural intensification is not only a

quantitative orientation – yield increase – but also about 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, speaking of productionist relations means that this logic colonises every other relation: that is, everyday life, relations with other species, and politics (e.g. farmer's 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 changes after 1940 with an increase in adding off-farm outputs to the soil, that is, bringing artificial fertilising 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 op. cit, emphasis added) – that is, not so much 'maintain' but *intensify* the nutrient input in soils beyond the rhythm by which crops absorb them. What these scientific developments confirm is the consistent trend in modern management of soils to move away from 'maintenance' and paced renewal of soils' fertile capacities – for instance by leaving parts of the land at times in a fallow state – to the maximisation and pre-emptive accumulation of soil capacity, to advance yield quantity beyond the intrinsic temporality of renewal 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 fix' 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. A notion of remediating worn-out soils is at the heart of the development of soil science since its beginnings and is part of the socio-economic concerns that influence soil studies very early on (Warkentin, 1994: 14). In parallel to productionist practice, numerous soil scientists have been committed to conserving soils and working with farmers to foster ways of caring for the soil that maintain productivity without exhausting it. 'Soil care' is a notion widely used to qualify the treatment and tasks dedicated to practical care of soils (Yaalon, 2000). Today's visible trend in the soil sciences away from a productionist approach can be read as a move in conceptions of soil care stemming from the global realisation of untenable pressures on soil. In science and beyond, the persistent productionist ethos overlaps today with an 'environmental era' starting in the 1970s influenced by a conception of environmental limits to growth that place 'the living earth […] in a central position' (Bouma & Hartemink, 2002: 137). This has marked soil science, many pointing for instance at the unsustainable destruction and deterioration of natural habitats associated with an excessive use of agrochemicals (134). Most socio-historic accounts of the soil sciences since the early 1990s recognise this 'ecological' turn (Warkentin, 1994: 3-4). This trend goes from an emphasis on the multiplication 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).

These moves support a move towards non-productionist human-soil relations. But 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 'discounted' (Adam, 1998: 74) – short-term thinking in a present generation pushes to exploits natural resources at the expense of future generations – and hailed as central. Indeed the 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 as precarious as the future: 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 farmer experiences worldwide living under the pressures of production (Worster, 1979). So though the timescale of soil productionist exploitation might be focused on the benefit of present generations' enrichment, the everyday practices, relations and embodied temporalities of practitioners embedded in this industrious speeded up time are also compressed. At the same time more than human temporal lines, such as the rhythms of soil renewal are subjected to the realisation of this particularly linear timescale. Productionism not only reduces what counts as care – it could be said that it reduces care to a manageable 'conduct' of tasks to follow (Latimer, 2000) – it also cuts the possibility of developing relations of care that fall out of constricted targets, transforming care from a co-constructed interdependent relation into mere control of the *object* of our care. And indeed, it is not only the temporality of humans but also human-soil relations and non-humans' living conditions that are affected by focusing on accelerated productivity. It could be argued that within the productionist model the drive of care has mostly been for the crops (that is, importantly, not necessarily plants, but plants *as commodifiable produce*). Soils have to be taken care of so that crops are abundant. In this utilitarian vision, worn out soils can be 'put back to work' through technologies brought in by soil engineers, be fed litres of artificial fertilisers with little consideration for the ecological effects in a wider landscape, or host enhanced crops that will work around their poverty and exhaustion.

Soil care in a productionist frame is aimed at increasing soil's efficiency to produce for humans at the expenses of all other relations. From the perspective of a feminist politics of care on human-soil relations, this is a form of exploitative and instrumentally regimented care, oriented by the one-way anthropocentric temporality of productive technoscience. The ecosystem services approach looks at the elements involved in an ecological setting or landscape from the perspective of what they offer to humans beyond purely economic value and tries to calculate other sources of 'value' – not necessarily to 'price' them, a distinction important to many advocates of this approach. But, a feminist politics of care would interrogate the understanding of soils that posits them as either functions or services for 'human wellbeing' (Millennium Ecosystem Assessment, 2005).

This interrogation could contribute to the turn away from an intrumentalisation of 'nature' long identified by ecofeminist thinkers as part of its degradation and the evacuation of its agency (Bastian, 2009; Plumwood, 2001). A feminist approach to care would not leave the very logic of 'service' unexamined: *Cui bono?* (Star, 1995), 'service for whom?' could be a question that reveals the limitations of a service approach to transform human-soil relations based on conceiving naturecultural entities as resources for human consumption. As I will discuss in the next section, care questions unilateral relationalities, it requires thinking from the perspective of the maintenance of a web of relations involved in the very possibility of ecosystem services rather than only on how these are of benefit to humans.

Different soil ontologies involve different modes of soil care. In the next section I look into how a conception of soil as a living world within soil science could question further the persistent reduction of soils to input for crop production and other human needs. Introducing a multispecies approach re-interrogates the place of humans and anthropocentric linear temporalities in human-soil relations.

4. Redefining soil as living

Not only has an ecological turn become noticeable at the heart of soil science, but soil ecology research has become more important at the heart of the soil sciences, emphasising the need for understanding relations between biophysical, organic and animal entities and processes (Lavelle, 2000; Lavelle & Spain, 2003). A great number of accounts of the discipline's development in the past ten years expose a connection between the growing significance of the ecological perspective and the moving of the biology of soils 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 attention on lively physico-chemical processes and interactions. Also, soil microbiology has been a crucial part of soil science since its early beginnings and important precursor work on soil biology was always part of the canon (such as Charles Darwin's work on earthworms). It does not mean either that biology and ecology supports *per se* an 'environmental turn' in the discipline, nor definitively that all disciplinary orientations in soil science now are reduced to biology. Yet a changing trend is noticeable in the increased centrality of the significance of 'biota' or fauna, from microbial to invertebrate, and of course of plants, roots and fungi in the very definition of soil. This is attested by the following statement by soil ecologists:

> 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, Crossley, & Hendrix, 2004: xvi, emphasis added)

In this conception soil is not just a habitat or medium for plants and organisms, nor just the 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 aspect 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 realisation 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 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 soil alterations (van Leeuwen, Hemerik, Bloem, & de Ruiter, 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 in soils as part of educational campaigns and soil fertility projects worldwide.[9] Soils are increasingly looked at as 'soil communities'.

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, 2001). A significant issue for a conception of soils that sees soils as living rather than as physico-chemical compounds that act as crop receptacles are the effects of interventions to enhance impoverished soils, however well intentioned. For example the protection of soil structures connects to a mainstream re-evaluation of tillage in agriculture and other technologies that compact soil and alter and destroy fragile and complex soil structures[10]. Also, there are more interventions pointing at how while chemical fertilisers benefit crop yield, soil communities can be permanently destabilised or destroyed, making soils and growers dependent on fertilisers. In other words, merely exploiting soil species for production threatens to destroy the living agents of this very productivity (Tsiafouli et al., 2014). Once again, these re-conceptualisations of soil as living emphasise how productionist practices ignore the complex diversity of soil renewal processes, harnessing its temporalities to the sole aim of speeding up abundant output.

A specifically interesting example is the 'foodweb' concept of soil life that, as I will discuss below, thrives at the boundaries of soil science having become popular in alternative growers' movements. Foodweb models are not new but they became more prominent in soil ecology after the 1990s (Pimm, Lawton, & Cohen, 1991). Foodweb models are valuable for scientists to describe the exceptionally complex interactions between species that allow the circulation of nutrients and energy. They follow predation and eating patterns as well as energy use and processing. Soil foodweb species 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 how one species' waste becomes another one's food (Coleman, Odum, & Crossley, 1992;

Ingham, 2004; Wardle, 1999). Foodweb conceptions of soil interrogate the use of artificial fertilisers, of 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. These notions emphasise a living world below, teeming with life, and fragility.

Soil ecology is of course not a unified domain and while rich in holistic models of life cycles, it is also 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, its ontology, but also the ways humans maintain, repair, foster its liveliness, that is, the agencies involved in a politics of care (Puig de la Bellacasa, 2014). The emphasis on the interdependency of soil communities is particularly interesting from the perspective of a politics of care for which maintaining living webs of interdependent relations is a fundamental feature of successful care (Tronto, 1993). Seen from the perspective of care, interdependent models of human-soil relations could challenge the unidirectional linearity of both productionist and service approaches and a temporality centred in human-crop relations. This is because though care is often a one-to-one practice between 'a carer' and 'a cared for', it is rare that a carer gets back the care that she gives from the same person who she cares for. Reciprocity in good care is multilateral and collectively shared (Kittay, 1999). As argued before, a care approach would not only look at how soils and other resources produce output or provide services to humans: it would involve looking too at how humans are providing for the soil. Thinking multispecies models such as foodwebs through care involves looking at the dependency of the (human) carer from, not so much soil's produce or 'service', but from an inherent relationality that renders soils capable to 'take care' of a number of vital life processes. This is emphasised by how the capacities of soil in foodwebs refer to a multilateral relational arrangement in which food, energy and waste circulate, in non-reciprocal exchanges.

The capacity of exhausted global soils to maintain these relations has become more dependent on the care humans put in them. What the above conception might require is that humans are included more decisively *in* the concept of soil. That is, seeing humans as 'members' of the soil community rather than merely consumers of its produce or beneficiaries of its services. Here, in turn, changing ways in soil care, would affect soil ontology. Coming back to the redefinition of soil as living (Coleman et al. 2004) we would need to would include a rephrasing such as: 'When we view the soil system as an environment for humans, we must remember *that humans have been involved in its creation, as well as adapting to life within it*…'. Though 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 a prevailing one in the scientific literature. Scientific illustrations of the soil foodweb rarely represent humans as part of this relational web – e.g. as producers of 'organic waste' and beneficiaries of the output of plants. This could be connected to the traditional role given to the 'anthropogenic'/human, element in soil scientific literature, where it is generally considered as one 'element' of soil ecosystems and formation processes that 'lies apart' because of the higher impact of its activities in a shorter amount of time than other organisms. The 'human' mostly features as an unbalanced irruption in soil's ecological cycles – or a victim in case of soil pollution – rather than as a 'member' of the soil community (Hillel & al., 2004). Notions of humans as members of soil

communities, or even of humans *being soil*, thrive outside science however – including in how scientists speak of soil (and land) beyond their 'official' institutional work (Hole, 1988; Warkentin, 2006). It could be argued that alternative affective ecologies with soil become obscured within the science. But my interest is in articulating different horizons of practice and modes of relating to soil through the potential to transform human-soil relations. Here, connections with non-scientific ways of knowing soil, whose relevance is also sometimes mentioned by scientists (Tomich et al., 2011), could become even more important in the light of an argument for a shift in soil models from considering soil as a 'natural body' to soil as a 'human-natural' body (Richter & 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).

Reading speculatively scientific conceptions of 'soil as living' – such as foodwebs – for their potential to transform human-soil relations, brings us beyond science. In the next section I look into how practices that engage with soil as a living web are diversifying the ways of making time at the heart of productionist practices and relations. I argue that these promote modes of soil-care that rather than harnessing more than human temporalities, they are intensifying our involvement with them. This brings us back to the arguments relayed at the beginning of this paper for disrupting anthropocentric, progressive and productionist timescapes of restless futurity by taking a diversity of more than human timescales into account.

5. Making time for soil time

Beyond science, scientific ideas of soil as living and foodweb models are explicitly made to speak for alternative soil-care and human-soil relations with implications with regards to dominant productionist futurity. I learned first about this through following the work of Elaine Ingham – a soil scientist specialised in foodwebs who left the university to establish a foodweb-based soil testing business, and continued a career as a celebrated advisor of alternative soil care. Among many of her interventions I pause on a series of online lectures in which she popularises 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[11]. The basic method she recommends to assess soil health is an estimated count of microorganisms such as bacteria to detect the health and the needs of the soil, in order to feed it with the appropriately balanced organic material, such as on site produced compost and 'compost teas' (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 fertilisers: "Jump off the chemical wagon!" she calls in a video advertising her courses.

This discourse mobilises 'science-informed' soil practice as a promise of future output: effortless, chemical free, 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. What these practices primarily speak of is of intensification, not so much of production but of involvement with soils. These modes of soil-care involve practitioners with 'mediations' that make the soil and its living capacities to take care of biological functions, and that would be made invisible by off-site testing practices. It could be said that Ingham is inviting soil practitioners to themselves in the soil and develop 'a feeling for the soil', to paraphrase Evelyn Fox Keller (1984; see also Myers, 2008). This responds well to ecologies familiar in soil practitioner circles where 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, co-mingling with its substance (Watson & Baxter, 2008: 14). And 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?' (op.cit). An affective involvement not necessarily reserved 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'.[12]

But how do these practical modes of soil care that subordinate production to caring involvement also disrupt the timeline of productivist futurity defined in the first section of this paper as dominating contemporary technoscience? First, with regard to epochal progressive futurity and amidst calls for urgent and global responses to food insecurity these small-scaled reorientations of grower's skills are bound to appear as 'turning back the clocks' to a pre-industrial era. Similarly, from the perspective of 'bright and shiny' conceptions of innovation, tasks such as 'counting bacteria' to test soil health recall school science projects. A sense of outdatedness exaggerated by the use of tools like an apple corer and second hand microscope and by how Ingham underplays the need for sophistication. Second, 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 kin to what Patrick Brenishan elicits in his ethnography of fishermen's 'commoning' practices. He exposes modes of management of fishstocks that are at odds with the neo-liberal management of sustainability. Here, alternative engagements with time are at stake that not only evoke a different mode of production, but a different mode of life, including a different relationship to work. This relation of time 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' (Brenishan, forthcoming). In a similar way, the embodied experience of time in these ways of making time for soils alter linear productive practice in ways that remain irrelevant for the predominant 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 counts with 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 trainings to 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, localised interactions etc.) that constitute temporal niches in a particular ecology (Mollison, 1988:28). The imperative of observation is an ongoing one, because each cycle is an 'event': 'diet, choice, selection, season, weather, digestion, and regeneration differ each time [the cycle] happens' (Mollison, 1988, p.: 23). It is in such variation that the possibility for diversity thrives. Soil care practitioners that I have encountered through my research 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 also 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 that requires making time for soil time. And, I argue, can be read as a form of 'care time'. First because of the repetitive character of this ongoing observation of the cyclic returns. 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.[13] Second, because of the way it 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: e.g. 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. It disrupts humans' location as outsider observers or central beneficiaries of objectified services: even if it strongly relies on the role played by humans in landscapes they are part of, humans are not the end destination of the processes that human-soil ecosystems take care of. In other words, for 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* the relation with soil as a significant living world. For instance, all participants somehow embody the time of the cycle by eating, or becoming food/energy for, other participants in a foodweb cycle that involves death and decay[14]. 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 practice 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 of ecological care 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 in soil care, a temporal tuning between humans and multispecies soils could be taking place that, borrowing from Carla Hustak and Natasha Myers (2013), wouldn't be not so much a "co-evolution" but an 'involutionary momentum', that is, an occasion for a new relational arrangement between species that could further involve them with each other.

6. The pace of care time

Human-soil relations are pervaded by their ancestral status as providers of food and the futurity of a temporality subjected to obtaining yield. Increasing production remains on top of the agenda, it is likely that agricultural intensification and chemical fertilisation will be the immediate response to food security alarms by dominant agribusiness and policy makers worldwide. The processes approached in this paper question the dominant treatment of soils: from tensions in soil science around the imperative of progress "as usual", to moves away from productionism and finally conceptions of soil as living and correlating 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 and of technoscientific mobilisation. Yet while these experiences of care time could disrupt the futuristic drive, they are not disentangled of technoscientific time.[15] Following Dimitris Papadopoulos we can rather argue that these practices are also technoscientific, but committed to making alternative ontologies from within (Papadopoulos, 2014). Also, feminist visions of care emphasise 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 & Bertoni, 2014). Care is political, messy and dirty, not an innocent category, even less in technoscience (Donna Haraway, 2011; see also Michelle 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 paper is marked by a feminist politics that brings attention to ethico-political questions such as who cares for whom and what forms of care are prioritised at the expenses of others – e.g. who provides the ecosystem 'service' and for whom and sees in care a struggle for living possibilities. In that sense, what I have tried to argue in this paper is that an orientation to the articulations of temporality and care in human-soil relations contributes to questioning the prioritisation of technoscientific anthropocentric futurity by making visible alternative timescapes and enriching our temporal imaginings.

In this spirit I conclude by discussing the relation of these timescapes with 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 paper as the predominant technoscientific timescape at the levels of epochal, practical and embodied dimensions of time.

From the perspective of embodied time, care time disrupts restless futurity. A focus on care elicits and re-evaluates affective dimensions, embodied traffics at the heart of the work of maintenance of ecological interdependent relationalities that is at stake in human-soil ontologies. I have shown how these involvements involve temporal adjustments of timescales with soil care that emphasise cyclic, present embedded time**.** This is supported by feminist sociologies of caring practices that expose care as everyday mundane maintenance, repetitive work, requiring regularity and task reiteration (for a recent STS perspective see Mol, 2008; Mol, Moser, & Pols, 2010). But anybody who has been involved in caring for children, pets, elderly friends… knows that the work of care takes time and involves making time of a particular kind. Care time is not necessary pleasant. It can be tiresome and involve a lot of hovering around, adjusting and readjusting 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, it thickens it too with a myriad of demanding attachments. Even when care is compelled by an urgency – like is the case with soil practitioners anxious about the breakdown of soil ecologies and fears around climate change – a certain distance from feelings of emergency and fear as well as temporal projections of futurity needs to happen in order to focus and get on with caring well, with the repetitive tasks of everyday caring maintenance necessary to these relations. So while the probability and repetition of ecological cycles does not preclude uncertainty and restless anxiety about unexpected events (one only needs to think of weather, pests, disaster etc.) expected repetition – e.g. reliance in the cyclic 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' (Paul B. Thompson, 1995). Feminist approaches to care show how the work of reproduction and maintenance of life has traditionally been considered neglectable with regards to value-creating work. The same process can be read from a temporal perspective. When all spheres of practice are colonised by the productionist logic, care time is devalued as 'unproductive' (Adam, 2004, p. 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. Yet, 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 penalise its practice, acts of care can be considered as a space of resistance (Singleton & 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, maybe the most powerful obstacle to these forms of making time for soil at the heart of predominant futurity, is that these ways of making time for care time in human-soil relations 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 paper will be suspected of nostalgia for an idealised 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, 2015 forthcoming). Common reactions to non-productionist views on agricultural technology point at their irrelevance or inability to tackle the important challenges facing current societies: they cannot feed the world – with the often unspoken correlative argument: they are not 'profitable'. But the fact is that the implicit mode of progressive and linear futurity in usual conceptions of innovation could hardly recognise the reconfigurations of soil care examined in this paper. 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 reveal the overestimated value of the productionist imaginary in innovation (Suchman & 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 is possible without a commitment to the everyday maintenance and repair that supports the work of care (Jackson, 2014) and the continuity of life that is the domain of a present thickened by care.

Permaculture and biodynamic practitioners who engage with foodweb friendly soil care techniques qualify them as innovations while simultaneously explaining that some of the 'new' technologies they implement are a thousand years old and that they integrate knowledge from contemporary indigenous modes of re-eacting 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). And 'new' practices recommended by institutions such as the USDA are following. This re-learning cannot be understood as a nostalgic return to a preindustrial 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. In a sense, it only seems to be possible to read these interventions as innovative in the current dominant timescape by thinking them as untimely. That is, as bringing old, or past, elements into a context in which they then become new with regards 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 these temporal redirections would be to see these forms of engagement as refusals of technoscientific mobilisation that Isabelle Stengers sees

as encouraging a 'slowing down' (Stengers, 2005) – in this case, of the pace of productivist appropriation of soil life as a resource. Yet the 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 as these approaches do by operating differently within technoscience[16]. 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 fertilisation of soils aimed at accelerating yield would be a slowing down element to the development of worms and other essential soil communities; while interventions that stride cyclic rhythms and the pace of soil communities' reproductive capacities foster the proliferation and thriving of their habitats. Attention to these relationalities exposes that what seems slow or backwards when living according to one timeline or timescale might have a different sense in another.

The transformative moves in human-soil involvement approached in this paper 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 growth into 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 rather 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 in perpetuating, maintaining and intensifying the resilience of existing cycles more than in extending or intensifying their productivity, involves a stance with regards to 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 to align 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 – i.e. 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, rather than ratifying the dominant productionist mode of futurity in worlds being made through technoscience.

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[2] 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 the most prominent precursor but in the last five years the notion of care has become more significant within 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).

[3] Title of the animation movie by UK based artist Leo Murray aiming at vulgarising research on climate change: http://wakeupfreakout.org. For a study of how the "eco-catastrophic" imaginary is reorganising ecological practices see (Beuret, 2015).

[4] The title of the 2015 meeting of the British Sociological Association "Societies in transition: progression or regression?" could sadly be an example of a lack of temporal imagination imposed by the logic of linear, unidirectional, progress.

[5] The recent blockbuster movie Interstellar (2014) features a new dust bowl as a mark of life on Earth.

[6] Land Grabbing refers to the appropriation of land by investors to the detriment of local communities: see http://farmlandgrab.org (last accessed 14 May 2014).

[7] In addition to the publications cited in this article see (Landa & Feller, 2010) 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.

[8] Productionism and productivism are interchangeable notions in the literature. Here I opt for productionism unless a cited author does otherwise.

[9] See for instance the 'Soil Biodiversity Initiative. A scientific effort': http://globalsoilbiodiversity.org (last accessed May 2014).

[10] This is visible in an information video for farmers available on the USDA Natural Resources Conservation Services Youtube channel, "The Science of Soil Health: Compaction" that invites to 'imitate Mother Nature' and limit the use ploughing machinery.

[11] http://www.youtube.com/watch?v=HHCVIfu1j_U (last accessed 21 May 2014). http://www.youtube.com/watch?v=IBHzJb0TpxU&feature=mfu_in_order&list=UL; and http://www.youtube.com/watch?v=I5MB7vz6awg&feature=mfu_in_order&list=UL (last accessed 21 May 2014).

[12] "Identifying with soil fauna" http://blog.globalsoilbiodiversity.org/article/2013/10/21/identifying-soil-fauna (last accessed 21 May 2014).

[13] This approach to temporal adjustments resonates with notions of temporal 'alignments' explored in STS with relation to collaborative work (Jackson, Ribes, Buyuktur, & Bowker, 2011) and analysed existentially as a process of "torque" by Geoff Bowker and Leigh Star (1999). Other processes of technoscientific synchronization in naturecultures are researched by Astrid Schrader (2010, 2012).

[14] On the ecoethical importance of multispecies eating together see Haraway (2008) and Kristina Lyons (2013) on the specific embodied foodweb conception of soil practitioners in the Colombian Amazonian plains.

[15] I have learned to appreciate this thanks to Chris Kortright's ethnographic work on 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).

[16] 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 time scale, for which there must be room and to which justice must be done." See: http://slow-science.org (last accessed 21 May 2014).