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Encountering Bioinfrastructure
Ecological Struggles and the Sciences of soil

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Abstract: What humans know about the soil has material implications for the future of life on Earth. This paper looks at how 'soil' is in the process of becoming visible as a living world at the heart of an epoch marked by technoscientific management of the environment. At this time scientific knowledge of the natural world encounters a range of collectives and individuals striving to renew humans' relationships with non human and organic ways of life. Soil is an interesting case for the study of absence: all around yet hardly apparent for many of us. Drawing upon Susan Leigh Star's approach to 'residues' and 'infrastructures' allows soil to appear in all its ecological significance, as the final home to all residues and the dismissed infrastructure of *bios*. The aim of this essay is not only to make soil visible, but to treat its *passing into visibility* as an event in its own right that reveals soil's ambivalent material and cultural value. As ecological visions come to reclaim this mistreated living ecosystem it is not only the knowledge about soil that could be transformed but the soil itself.

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Introduction: revealing the universe beneath

A quote, attributed to Leonardo da Vinci, circulates in networks of soil lovers and bloggers:

> 'We know more about the movement of celestial bodies than about the soil underfoot'.

Resuscitating a sentence dating from the 1500s dramatises the perseverance of our lack of knowledge of the soil, adding credence to contemporary attempts to reinstate the vital value of this underground world. Many of those calls for enriching our knowledge of soil are coming from the margins of science – ecological activism, organic farming etc. What is mostly challenged here is not science per se, but rather scientific approaches that support industrial and intensive ways of knowing and treating the soil. The absent made present here is *soil-as-living*, a relational entity of which humans are part. The space-time of this essay is this emerging presence by which soil passes from background to focus. This is a localised and culturally specific process. It is mostly westerners who are speaking out for a 'novel' awareness of the living world beneath. Others, notably indigenous people around the world, have entertained different relations to the soil for which its liveliness is not necessarily new, even when they have suffered the effects of hegemonic agricultural practice (1996: 113, quoted in Lyons, (forthcoming): 380). Nonetheless, the changes affecting humans' relation to the soil concern a range of collectives and individuals striving to renew human interactions with Earth, its non human inhabitants and organic forms of life, at the heart of a world and epoch marked by technoscientific management of the environment. The aim of this essay is

not only to modestly contribute to this new visibility of soil, but to treat this passing into visibility as an event in its own right.

For this purpose, I am drawing from Susan Leigh Star's work on 'residues' and 'infrastructure' – developed particularly in different collaborations with Geoffrey Bowker and Karen Ruhleder Surely, what comes to mind when we think of residual categories within working infrastructures are mostly human-built technoscientific worlds. But what happens if we immerse into the soil with Star's mode of attention? What kind of 'invisible work' becomes visible? And at what cost? Through this vision the material, cultural, and ecological significance of soil appears not only as the final home to all residues but also as the dismissed infrastructure of *bios*. In what follows, I first discuss the shifting value of soil as 'residue' through contrasting epistemic sites. Soil shifts from container of worlds to a world in itself showing how its worth – from residual to essential – is not fixed. Secondly, the notion of infrastructure acts as a revelatory of the 'working' quality of this universe, opening into the perception of a whole world of invisible labours that are more than human. Star's notions of the residual and the infrastructural help to reveal the importance and effects of soil's shifting worth. When ecological conceptions reclaim this mistreated living ecosystem it is not only the knowledge about soil that could be transformed but the soil itself.

I. Soil as dirt: the residue of all residues

Soil carries many material and literal meanings as well as metaphorical (Landa & Feller, 2010), some of which this article explores. In this section I unfold its material meaning as the home of all residues to start exposing its shifting value. At a basic material-scientific meaning, soil refers to a thin layer of the earth, composed by organic materials or, more precisely of 'remains', such as rock particles. This layer is in itself composed of different layers or 'horizons' – that go from the thin yet nutritious layer of 'humus' to the solid bedrock. This multilayered universe is a 'boundary object' (Leigh Star & Griesemer, 1989) of the interdisciplinary field of 'soil science' that interests physical geographers, agricultural scientists, biochemists, microbiologists and even archaeologists. But it is also an object of attention, concern and care outside the scientific establishment for ecological activists and lay gardeners. Interest and focus varies in this multifarious context. For Star and Griesemer a boundary object is that which allows cooperation between heterogeneous scientific work 'to create common understandings, to ensure reliability across domains and to gather information which retains its integrity across time, space and local contingencies' (Leigh Star & Griesemer, 1989: 387). Their definition of 'scientific work' includes not only what scientists do but also amateurs, humans and animals etc. In that sense, the meaning of soil as a boundary object is not fixed to a sole disciplinary focus. Soil can be treated as a mineral and chemical composition or as a web of living organisms, or both. It also has an informative dimension that justifies an impressive range of planetary projects of information systems, soil mapping, and quality testing. Yet more commonly, the very word carries additional cultural material-metaphorical meanings that are transversal to communities of (scientific) practice. In many cultures for instance, soil is the final 'home' to most residues. In that sense it carries Earth's material memory and that of its creatures. In cultures marked by horror of decay the status of this massive memory storage easily shifts between treasure beholder and trash dump.

This ambiguous perception as well as shifts in focus are illustrated by how archaeologists at the University of Leicester speak of the work of distinction between 'remains' and the soil that hosts them: 'delicate remains are carefully separated from the soil in running water so that they can be identified under the microscope'. Here 'delicate remains' refer to all sorts of residues from past

humans and other creatures. These are valued today as revealers of our ancestors' practices, cultures and natures:

> 'Rubbish pits are also a good source of evidence because they often contain charred remains which do not decay, mixed with animal bones and pottery which can be used to date the material ... pollen samples from a buried soil under the defensive rampart ... will indicate what the area was like just before the Roman defences were constructed'.
>
> Archaeological Services, University of Leicester, 2007

A residue, is a name for that which doesn't fit a particular category scheme, or that which is irrelevant to a data collector (Leigh Star & Bowker, 2007). Bowker and Star show how what becomes 'residue' can be ethically charged, because it involves exclusions from knowledge and thus invisibility and objectification. What is residual depends on focus. In our case, the scientific focus of archaeologists corresponds to what enters in their category of 'evidence', including here, somehow paradoxically, residues that resisted to the dissolution resulting from decay. Soil is, by contrast, the actual result of decay, of remains that didn't resist to dissolution. As residues become 'delicate remains' the remaining soil becomes the container of this evidence – a more or less irrelevant *background*. Its relevance is reduced to how its quality will guarantee better or worse conservation, nonetheless, the indistinct residue that soil has become, once the first selection of remains has been done, can also be a valuable provider of other types of information, for those who can interpret more hidden 'data': 'the soil will be analysed for pollen and seeds by a specialist and this will tell us about the environment at the time the ditches were in use' (Archeological Services, 2007) What will remain soil for archaeologists at work is the utmost residual, that which has escaped categorisation as evidence.

Isn't it like that for most humans as we go about our business? We class things and make irrelevant the ones we do not need to focus on. Is not that they are ontologically absent, but that we become absent minded to them. This lack of awareness does not respond just to 'negative' qualities – disregard for instance, or to immoral erasure - but is also a symptom that to forget, to 'sort things out', is human (Bowker & Star, 1999). And not only human, as Star put it humorously: 'I love the idea of being a residual category to a mountain lion' (Leigh Star, 1995: 3). So let's take the material meaning of residue at face value in its everyday meaning. Soil is where most residues end up, all the unclassifiable in the everyday 'sorting out' of things. It is significant that 'non recyclable' materials - including plastics – can that way become part of categories of 'organic waste'. As a child, when I lost something like a coin, or a toy in the middle of the countryside, I remember thinking that it would become an archaeological object for future people, who would study it to learn about us. But if we look at the category of archaeological evidence with the contemporary notion of ecological living, waste resistant to decay becomes a highly ethically charged category of matter. In short, if it cannot become soil, we have a problem. Civilisations that didn't leave any trace might become the ones to celebrate. The value of well decayed soil shifts when it takes status of host of natural resources – soil being the ground where 'our' food and that of many other beings in this planet grows. Yet still, from these radically dissimilar and somehow incomparable perspectives on soil, it still appears as the home for all residues, what is in question is what residues become once within it, once they are absent to our everyday perception. Here is different types of knowing and perceiving speak to each other. Depending on *who* is looking at the data and *for whom* that work is done some things are considered data and others not. In classification systems, the very category of data exposes that something is 'not data'. Ethical and political issues however

arise when the 'not elsewhere classified', the residual category par excellence, becomes dumped as not interesting (Leigh Star & Bowker, 2007). So more generally, what these considerations point at, is the shifting *value* of soil as the home of all residues and the possible *consequences* of this change for this boundary object and those who depend on it. This brings the actual sciences of soil at the foreground of societal interest, but how is the science of soil, for which soil is not background but focus, affected by this change in culture? And how are different practices involved in this shift?

II. Soil Science: a residual science

Interestingly enough, 'soil science' was developed initially by a gathering of residual topics of different sciences, all concerned by one or other bit of what makes the soil, or can be found in it. Still in 1958, Dr. W. T. H. Williamson asked, in his Presidential Address to the British Society of Soil Science: 'Is there such a subject as soil science, or is there merely ... a 'hot-potch of sciences' applied to the study of soils?' (W.T.H., 1959) Scientific disciplines can start as residual categories. It happens that those who do not fit anywhere else, some of those inhabiting the indefinite 'not elsewhere classified' gather to become something visible as one. In the beginning of the 1960s a science of soils is still struggling for identity by detaching itself from other categories of origin. In the same address, Williamson argues that: 'Application of the techniques of other natural sciences is very necessary, but these should be directed towards the end of explaining soil features recorded in the field, *and not of isolating some problem primarily of interest to these sciences themselves*' (my emphasis). Yet since soil becomes a scientific object in its own right, soil science has been borrowing from multiple disciplines: chemistry, physics, mathematics and applied practices such as 'ecology' or 'geostatistics', with one of the main sites of 'application' being agriculture and issues related to the environment. The field remains heterogeneous, and specialization is strong, so what is accounted for as the history of soil science will depend on who among its participants tells the story and what questions are asked to the soil. And these are not isolated from larger societal and cultural issues.

The relation between soil science and 'society' remains a relatively unresearched one even if the development of this discipline historically resonates deeply with societal concerns. Scientists Johan Bouma and Alfred E. Hartemink (2002) have examined how, in the Dutch context and more broadly Western Europe, this relationship has worked thorough three historical periods. First, a 'production wave (1945-1970)', in which the authors highlight a focus on food production (after the Second World War). The agricultural industry was boosted then by incorporating soil science research into plant nutrition for instance. Bouma and Hartemink also highlight the price of this success: an excess of agricultural production by the early seventies. Also, 'the excessive use of agrochemicals ... had unwittingly polluted soil, water and air, and had contributed to the destruction and deterioration of natural habitats for animals and plants' (Bouma & Hartemink, 2002: 134). This resulted in boosting an interest in 'environmental research' giving way to what they call the 'Environmental Wave (1970-late 1980)'. Finally, in the third wave, starting in the late 1980s, a 'postmodern phase', capitalism has become the 'only major political system'. This phase, they argue, is transforming soil science with the emergence of interdisciplinary, non-traditional and flexible initiatives that involve concerned citizens, policy makers, and non-governmental organisations that *invite soil scientists to participate* not to give solutions within 'problem-solving' modes of operation but in which 'soil science input was derived from discussions in the team and was part of a joint learning experience' (Bouma & Hartemink, 2002: 137). I find their typology particularly interesting in that it highlights for each wave the correspondent level of public trust in science. High in the Post-War period, decreasing by the end of the 1980s, and finally, in this 'third wave', affected by a

changing relationship between science and society: 'the linear model transfer' gives place to a 'much more flexible network structure in which various stakeholders such as citizens, politicians and scientists, work together' (Bouma & Hartemink, 2002: 135).

This late phase is well recognisable from the perspective of the social studies of science – one could argue that scholars in this field have also contributed to develop these new forms of knowledge production (Callon, Lascoumes, & Barthe, 2009). Yet it is not a coincidence that capitalism appears associated to this third wave. We also know that the opening of science to society, like it happened with the 'third mission' of the university, has been in many cases just a way for the opening of science to the markets. But what I am interested in emphasising here is the shift in the developments of the science itself that Bouma and Hartemink would like to see associated with this transformation: more than soil science being just market driven, 'the living earth is placed in a central position, from which are derived the limits within which human societies can develop' (Bouma & Hartemink, 2002: 137). Though they see few activities in this sense in the early 2000s, they do point at the emerging presence of soil as a living entity and how this is happening throughout the initiatives in which scientists are involved in broad interdisciplinary contexts in dialogue with other communities and forms of knowledge. The orientation of a late International Conference on Applied Soil Science (University of Wageningen, 2011) could be also characteristic of these evolutions. Organised around topics such as climate change, food security and biodiversity it puts soil as a living entity at the centre of these issues treated interdisciplinary. Interesting enough one of the keynote speakers at the conference was initially programmed to be Vandana Shiva, the well known Indian ecofeminist activist and researcher.

In this paper I am interested in a plane of analysis that could add insight to the thinking of these phases, by identifying processes by which 'alternative ontological politics' are being created (see Papadopoulos in this volume). The question here is: where are 'constituent' radical politics of matter emerging at the heart of technoscience through the crafting of alternative relationships with the material world (D. Papadopoulos, 2011)? Focused here shifts onto how scientific knowledge about soil is not just *used by* but may well be *produced by* social movements, in a quest to transform ecological relations between different beings sharing the Earth. These are not only so called 'activists' in the traditional sense of the term that alienates everyday practice (Dimitris Papadopoulos, Stephenson, & Tsianos, 2008; TheFreeAssociation, 2011) but just people changing their everyday material conditions, through common 'ethical doings' (Puig de la Bellacasa, 2010). From this perspective, the ongoing redefinition of the object of soil science could be further exploding out of scientific boundaries in a way that is not so much about citizens becoming experts but practices displacing knowledge. The words of these gardeners turned into writers of popular science with a book that explains soil biology to gardeners can give a hint of this process:

> 'What makes this book different from other texts on soil is our strong emphasis on the biology and microbiology of soils – relationships between soil and organisms in the soil and their impact on plants. We are not abandoning soil chemistry, pH, caption exchange, porosity texture or other ways to describe soil. Classic science is covered, but from the premise that it is the stage where the biology acts out its many dramas.... *We think that learning about and then applying soil science (particularly the science of how various forms of life in the soil interrelate – the soil food web) has made us better gardeners*'.
>
> Lowenfels and Lewis (2010, 14)

They distinguish their focus on the soil as a living web of interdependent beings from previous approaches. Their work is just an example of how, while ecological concern is growing at the heart of the sciences of soil, marginal reappropriations of soil science are happening among 'lay people', making change 'from below', as Sandra Harding (2008) would put it. As mentioned earlier,

soil is a particularly rich boundary object for the precise reason that it gathers interests across a broad range of knowledge communities. Yet we can see that it would be inappropriate to oppose 'classic soil science' like an interest in soil as inert matter, versus an ecological lively approach – we know how natural scientists have *a feel* for their living objects whether these are organisms or molecules (Keller, 1984; Myers, 2008). However, the political and affective charge can be different whether we conceive the quality of living for the purposes of scientific interest, for saving resources for humans' food, or for the purposes of the world beneath *for its own sake* – a concern typically voiced by ecological movements. These modes of care for the living can be related, and these overlaps between science and ecology are precisely at the heart of this paper. Before coming to this aspect, I want to address a common cultural and affective space of this transformative relation: an increasingly widespread acknowledgement that soil has been a forgotten, dismissed and shattered element of our ecosystem.

III. Encountering the infrastructure of bios

'People often cannot see what they take for granted
until they encounter someone who does not take it for granted'
(Bowker and Star 1999: 291)

To start approaching the emerging into visibility of a large scale multisite *topos* I find helpful to inquire into soil as the 'infrastructure' of our living ecologies on Earth – to which I refer here as *bios* as a way to emphasise everyday living with nature, rather than a more existentialist and humanist vision of 'Life' as a driving force. Approaching soil as infrastructure makes it appear as a highly lively entity. Not only living memories of exclusions and past organisational settings are archived and processed in it, but this work is only possible through *labours* invisible to most humans: of earthworms, fungi, microorganisms etc. I am drawing here upon Leigh Star's work on infrastructure developed in collaboration with Karen Ruhleder. I find Star's singular modes of attention particular helpful here, precisely because they are not neutral towards invisible labours but are moved by a yearning for social justice in naturecultures.

In 'The Ethnography of Infrastructure' Star looks at the specifics of studying large scale infrastructural objects, coming back through her discussion to a series of characteristics of infrastructure itself as 'ecology'. The most generic characteristic of infrastructure *is to be relational per essence* : 'Analytically, infrastructure appears only as a relational property, not as thing being stripped of use' Star and Ruhleder (1996: 113, quoted in Star, 1999: 380). What is infrastructure from the perspective of one practice, from another perspective is a focus, a topic. Infrastructure speaks about an invisible 'background for other kinds of work' (Star, 1999: 380), but one that gives meaning to the visible work. We have seen how soil as an entity shifts from background to topic and back to background. Following Star's approach, insisting on soil as infrastructure helps to reveal one of its dimensions, one of its modes of existence: that of a basic understated, stabilised, indispensable ground upon which a collective lives and works. In other words, the very gesture of *exhibiting* infrastructure is acknowledging simultaneously, the importance and the invisibility, or silence, of a vital component of a world. In that sense, when asserting that the world of soil has been absent, this requires acknowledging the relational character of this truth. Again we can ask the question *Cui Bono*? (Leigh Star, 1995): *for whom* is the quest to reclaim the soil? And, why has it become important to reclaim soil's significance as the infrastructure of *bios*?

Star's work on infrastructure and residual categories is rooted in mostly often technologically human made material worlds, however – like the above explored attention to the

'residues' – it provides a lens through which to see differently all parts of the everyday. For instance, in everyday urban living, soil is mostly apparent as residue left in cracks between pavements and roads, to which most of us do not even pay attention to. Even when soil is extensively present, like in parks or farms, its importance in the ecosystem is shadowed to the passant by the other creatures of the green spaces that grow from it – most of us will enjoy the beauty of trees, the taste of good vegetables but never give a thought to the ecological continuity of this beauty and taste into the soil that makes it possible. Here it is important to add a 'personal' note. This paper is written by somebody for whom soil has passed from being unimportant inert matter to a lively *beingness* manifesting a world of 'companions' in trouble. This particular experience marks the way in which I understand here the importance of soil and its emerging presence. The vital liveliness of soil is something I 'learned as part of membership' – another characteristic of the different properties of infrastructure: 'Strangers and outsiders encounter infrastructure as a target object to be learned about. New participants acquire a naturalized familiarity with its objects, as they become members' (Star, 1999: 381). In my case, the membership was that of becoming an apprentice of permaculture practices with the trainings of the *Earthactivist* collective[i], which give a prominent place to knowledge of the soil, of its inhabitants and its ecology because caring properly for the soil requires relearning to *know* it as living. In words of one of the leaders and trainers in this organisation, the neopagan ecofeminist witch Starhawk: 'Earth-honoring agriculture would generate abundance, but its primary intention would be not to grow profits, but rather *to grow soil* – living, healthy, complex soil – as a fertile matrix for living, vital, health-sustaining food. To grow soil, we need to appreciate and understand that soil is a living matrix of incredible complexity, the product of immense cycles and great generative processes' (Starhawk, 2004: 161, my emphasis).

Permaculture is just one of the names given to practices by which movements of ecological practice are converging today in a need to attend the health of soil by knowing it better. What these movements have in common is a calling for *planetary* awareness but starting from the *local* level. This also reveals another characteristic of infrastructure: its particular 'reach or scope' always 'goes beyond a single event or one-site practice' (Star, 1999: 381). Infrastructure manifests its existence locally, through our material everyday relationships with it. In that sense, renewed concern with the alarming state of planetary soils is gathering multiple situated perspectives, people for whom soil is at the heart of a practice – some soil scientists, organic gardeners – or the 'soul' of a way of life – indigenous communities fighting to protect a threatened ecology (McIntosh, 2004). For a range of human collectives soil conveys a strong cultural significance as the ground for communities in the most basic everyday meaning. This is a crucial infrastructural quality that could be named also after Star and Rudheler as *Embeddedness*. Embeddedness of infrastructure can be actually understood as a success, making its 'absence' from our thinking a normal quality, more than would be a constant presence: 'Infrastructure is sunk into and inside of other structures, social arrangements and technologies. People do not necessarily distinguish the several coordinated aspects of infrastructure' (Star, 1999: 381). Through passing into awareness however, it reveals new aspects of the world, and because of its relational essence, this affects its ontological quality and that of its 'members'. For instance, would the embeddedness of soil push humans to realise that 'In a sense we are unique, moist packages of animated soil'? (Hole, 1988) – in the lyric words of a soil scientist, also known for his delightful songs about soil. This can be read as a poetic reminder of what the ecofeminist environmental activist and researcher Vandana Shiva has made pretty clear in her recent book *Soil not Oil* (Shiva, 2008). Shiva makes a case to the truth that we are what we eat, and that what we eat is very much given its quality through the health of the soil. For instance, zinc deficient soils, produce zinc deficient food. All these changes on perspective about the soil and our relationship with it can be explained by a global sense of threat but something also very

corporeal, that touches the most bodily aspects of our being. Why is this perception important? Does the affective shift that would make us care more for the soil pass by the acknowledgement that '*we* are soil', that *we are our residues*? Or at least some among us need that. Maybe those who have pretentiously named ourselves after *humus*, the richest part of soil, that sturdy and stable end product of laborious processes of decomposition and decay – from which Latin derives *humanus*, human.

However in researching infrastructure Star's work shows the importance of listening to its invisible workers. In the case of soil these are mostly non humans, the actual processors of decay. The workers of the soil need thus particular spokespersons: but who is bringing up the messages from the soil workers? Who is giving voice to the current breakdown of soil's nourishing capacities? And to say what? But again, making visible is not a neutral affair. A scientific paper on vermiculture technology (i.e. the recruitment of worms for the processing of waste) reveals the invaluable role of earthworms as 'soil managers' (Sinha, Valani, Chandran, Soni, 2011)[ii]. Words matter: thinking of worms as managers reproduces the hierarchies of capitalist productionist culture. Humans remain shareholders, soil's inhabitants the managers of *our* biocapital and our excess surplus. Such a naming contrasts sharply to the approach to worms, fungi, microbial et al... as relatives, as creatures whose existence is not 'for us', but for itself. From the perspective of permaculture ethics, soil is revealed as the habitat of respectable beings that take care of its health: worms, fungi, nematodes, microbes (Starhawk, 2004; Lowenfels & Lewis, 2006). This revelation goes hand in hand with a particular consciousness – or it could be said spiritual wisdom – that soil is itself part of a living organic web of being of which many creatures including humans are part. Here *Worms et al*. are acknowledged as co-creators of our very matter while *composting* is our part of this collaborative and ongoing work of creation. These particular spokespersons of the labours of the soil are here humans striving to break up with a culture of human exceptionalism by changing our practices and consciousness and acknowledge that we humans are part of this ecosystem and we have a role to play that is not that of 'stewards' but more that of *relatives* in what soil scientist Elaine Ingham calls a *foodweb* (Ingham, 2004). The widespread interest in invisible workers of the soil is benefiting from the work of biologists and environmental scientists. Together, these perspectives are contributing to what Bowker (quoted in Star, 1999: 380) calls an 'infrastructural inversion' where the 'backstage of elements of work practice' are brought to the forefront: among these are the ecologies of taking care of excess waste, and of the invisible, non human, workers of the soil that make this possible.

IV. Common soil science

Soil is for many the most important *biotope* on earth, and the most endangered. The fact of the matter is that soil is also resource and thus, in humanist capitalist history, a valuable object of political economy, which as any 'good' in capitalism, becomes rapidly consumed and then trashed. As such, soil it is also a site of what Dimitris Papadopoulos has called a 'politics of matter' in which constituent 'alter-ontologies' are at stake (see Papadopoulos' contribution to this volume). Today, the worrisome state of soil in many places that has made of it a public matter of concern. We could say that this global perspective alone precisely reveals it as the infrastructure of *bios* on Earth. A flow of catastrophic messages is making more visible its vital importance of soil. Here soil is a planetary word, literally, as a constitutive layer of the planet, and also in that it speaks of global ecological threats. Ecologists are warning of a 'peak soil' worst than 'peak oil' (Wild, 2010). The unhealthy conditions of agricultural exploitation are being linked to the most visible planetary disaster: global warming (Shiva, 2008) – and fascination with demise is fuelled by historical studies of how 'using up' the soil has systematically led to the 'erosion of civilisations' (Montgomery, 2008).

This state of global awareness speaks well of a second relative dimension of infrastructure: it 'becomes visible upon breakdown'. In Star's words: 'The normally invisible quality of working infrastructure becomes visible when it breaks... Even when there are back-up mechanisms or procedures, their existence further highlights the non-visible infrastructure'(Star, 1999: 382). The drive to pour chemical fertilisers into the ground to enhance its quality can be seen as one of those 'back-up' mechanisms of the infrastructure that has, pushed many to try convincing fellow humans about the awesome invisible ecologies at play in soil's own fertilising cycles when conditions such as biodiversity are met (Shiva, 2010; 1995). If we understood/acknowledged the infrastructure before it broke down and back up measures kicked in we might be able to avoid some of the devastating effects of infrastructure breakdown. Exposing the stubbornness of the proponents of the 'green revolution' to accept its failures and instead continuing to extend its previous devastations into unexplored land (i.e. Africa), Shiva shows how the promises from ecological salvation coming from Science Inc. (in its alliance with agribusiness) reinforce the never-ending contradiction of science and technology to be called upon to *solve* problems that previous scientific and technological solutions might have created in the first place. Problems keep being read as an 'absence of (proper) technology' (see Bauchspies' contribution in this volume). Meanwhile, movements opposing such logics are dismissed as technophobic, or left to respond to problems formulated in a reductionist way, 'infernal alternatives' (Pignarre & Stengers, 2011: 23) such as: 'GMOs or Africa will starve'.

Technoscience thrives on 'seductive metaphor' – whether by scare and or promise. So do our social movements. Soil carries also cultural meanings that are highly affective. The very word transpires intense material and metaphorical meanings in subjective-objective ways: dirt, erosion and decay as well as source of life. But at the same time that large scale salvation discourse and projects expose how it is a matter of urgency to act at a global level movements such as those promoting permaculture practices expose that people are getting involved in the most domestic level of ethicality, confronting this breakdown in an everyday way: organic agriculturists but also vacant lot gardeners applying themselves to 'heal the soil one garden at a time' (Carlsson, 2008). Permaculture movements are far from being 'against technology' but are calling for technologies that can work *with* nature's patterns (Mollison, 1988) rather than against them, or trying to *master* them (Merchant, 1990). Of course the development of these at a level that could transform scientific practice remains marginal, the mode of production of science today is far from being accessible to the average gardener and the drive of Science Inc. seems unstoppable, including to scientists themselves (Stengers, 2006, 2011). But though biotechnologies working 'with nature's patterns' are yet to be invented it is the point of this paper to insinuate that these could be fostered and that soil sciences might be offering glimpses of a common soil science, attentive to *ordinary* ways of knowing and calls from outside science.

But the need for collaboration between ecological movements and scientific practice into a common soil science comes also with one of the fundamental teachings of looking at soil as infrastructure: it cannot be engaged with from one sole perspective. 'Because infrastructure is big, layered and complex, and because it means different things locally, it is never changed from above. Changes take time and negotiation, and adjustment with other aspects of the systems are involved. *Nobody is really in charge of infrastructure*' (Star, 1999: 382).Who does the *soil* belong to? Of course, soil is a privatised universe, sold as resource. But what happens to local soil, even under a private golf course, exceeds the consequences of its enclosed boundaries. What we eat in the UK has consequences for the state of the soil in Kenya – from where vegetables are imported (Shiva, 2010). From a scientific perspective this is also true: which disciplines need to know about soil, about air, about water? The struggle to close up a list, confirms what contemporary *commoners* are

claiming: some things shouldn't be for sale. This could be what common science means: one that engages with ecological concerns, steps out of traditionally aseptic boundaries of science, and resists the logic by which the 'social relevance' of science fuels for the capitalist appropriation of the material world and the commodification of scientific knowledge. Envisioning soil as the infrastructure of bios supports a double argument for common soil science. Particularly Star's thinking of infrastructure, because it is not only an intellectual endeavour, nor a scholarly epistemic drive to know the unknown worlds but also an effort to attend to worldly struggles at the heart of the production of technoscience in order to hear voices that are made absent. In that sense it invites to go beyond a critique of science and technology, not just to a more benevolent form of description of technoscience, but to foster thinking with scientists who are trying to change the sciences from within.

Conclusions

Like most 'absences' produced by the focus of collective thought, the dismissal of soil is relative. What appears when we look at the wide range of scientific interest in soil, is that it not so much 'soil' that has been absent, but *soil as something to care for collectively,* beyond feeding the human at any price possible. What might seem absent from one practice's perspective, is at the core of another's focus. Thus, the invisibility of soil is not an essential absence, it is relative in that it is perspectival –something is invisible to who does not see it, or something is *made* invisible by who does not want to see. But invisibility does have ontological consequences. Being invisible can change the conditions of existence of the invisible, of those who would not see it, and the relations between them. And that is precisely the heart of the matter: the point is not to make 'visible' what has been rightfully or wrongly made 'absent', but to focus on what happens in and through this irruption into presence. Making something visible is never a neutral affair – *cui bono* would ask Leigh Star, in whose benefit? Like every innovation in the production of knowledge, this very move can change *what* is being made visible. In other words, the soil might never be the same after reappropriations of the science of soil within a quest aiming to benefit all earthlings, not only humans. This is just one of the questions that I have in mind when thinking about the significance taken by soil today. From being a scientific object to some or a matter of fact to other practices, to becoming a matter of concern (an issue for political ecology (Latour, 2004, 2005)), soil has also become a matter of global and local care, a 'being' that is asking to be taken care of, protected and engaged with (Puig de la Bellacasa, 2011). As a consequence, the living web in the soil being, as absence to (our) perspective is not just ignorance to remediate (see Croissant's chapter on this volume for an approach to the uses of 'agnotology'). The ignorance of soil cannot be just treated as an epistemic flaw that better science could just correct. Concentrating on how soil is reappearing within some ecological practices as an emerging presence, and on how this could change the way we live, this paper has taken a specific path into attending to absences and presences particularly marked by the work of Leigh Star, now passed away, but present through memories, deeds and prolongations. Star's ways of thinking absences is about how these can break their silence and alter the present, disrupt the legitimacy of represented worlds by giving voice to the unrepresented, but also opening into new possible worlds. In that sense, commitments to social justice reveal new configurations through attention to worlds that have been forgotten, silenced, or erased. And in doing so, they also aim to do things differently. Here, shifts in epistemological frameworks have to be also affective, not just rational choices about the true and false. The change in ways of knowing we are witnessing is a change of relationship that may well transform the object of knowing itself, in our case, Earth's soil.

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REFERENCES

Archeological Services, U. o. L. (2007). Plants and seeds - investigating ancient rubbish. Retrieved 23-1-2112

Bouma, J., & Hartemink, A. E. (2002). Soil science and society in the Dutch context. *Wageningen Journal of Life Sciences, 50*(2), 133-140.

Bowker, G. C., & Star, S. L. (1999). *Sorting things out : classification and its consequences*. Cambridge, Mass.: MIT Press.

Callon, M., Lascoumes, P., & Barthe, Y. (2009). *Acting in an Uncertain World*. Cambridge, Massachusetts: MIT.

Carlsson, C. (2008). *Nowtopia. How Pirate Programmers, Outlow Bicyclists, and Vacant-Lot Garderners Are Inventing the Future Today!* Edinburgh: AK Press.

Harding, S. (2008). *Sciences from below : feminisms, postcolonialities, and modernities*. Durham, NC ; London: Duke University Press.

Hole, F. D. (1988). The Pleasures of Soil Watching. *Orion Nature Quarterly, Spring*.

Ingham, E. R. (2004). The Soil Foodweb: It's Role in Ecosystems Health. In C. R. Elevitch (Ed.), *The Overstory Book Cultivating Connections with Trees*. Holualoa:Hawaii: Permanent Agriculture Resources.

Keller, E. F. (1984). *A Feeling for the Organism: Life and Work of Barbara McClintock* New York: W. H. Freeman.

Landa, E. R., & Feller, C. (2010). *Soil and Culture*. Dordrecht: Springer Science+Business Media B.V.

Latour, B. (2004). Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry, 30*(2), 225-248.

Latour, B. (2005). *Reassembling the social. An introduction to actor-network theory*. New York: Oxford University Press.

Leigh Star, S. (Ed.). (1995). *Ecologies of Knowledge. Work and politics in science and technology*. Albany: State of New York University Press.

Leigh Star, S., & Bowker, G. C. (2007). Enacting silence: Residual categories as a challenge for ethics, information systems and communication. *Ethics and Information Technology, 9*, 273-280.

Leigh Star, S., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrae Zoology, 1907-39. *Social Studies of Science, 19*, 387-420.

Lowenfels, J., & Lewis, W. (2006). *Teaming with microbes : a gardener's guide to the soil food web*. Portland, Or.: Timber Press.

Lyons, K. ((forthcoming)). Soil Science, Development and the "Elusive Nature" of Colombia's Amazonian Plains. *The Journal of Latin American and Caribbean Anthropology*.

McIntosh, A. (2004). *Soil and soul : people versus corporate power* (Rev. ed.). London: Aurum.

Merchant, C. (1990). *The Death of Nature: Women, Ecology and the Scientific Revolution*. New York: HarperCollins.
Mollison, B. (1988). *Permaculture. A Designer's Manual*. Sisters Creek/Tasmania: Tagari Publications.
Montgomery, D. R. (2008). *Dirt: The Erosion of Civilization*. Berkeley: University of California Press.
Myers, N. (2008). Molecular embodiments and the body-work of modelling in Protein Crystallography. *Social Studies of Science, 32*(2), 163-199.
Papadopoulos, D. (2011). Alter-ontologies: Towards a constituent politics in technoscience. *Social Studies of Science, 41*(2), 177-201.
Papadopoulos, D., Stephenson, N., & Tsianos, V. (2008). *Escape routes. Control and subversion in the 21st century*. London: Pluto Press.
Pignarre, P., & Stengers, I. (2011). *Capitalist Sorcery. Breaking the Spell*. London: Palgrave.
Puig de la Bellacasa, M. (2010). Ethical doings in naturecultures. *Ethics, Place and Environment. A journal of philosophy and geography, 13*(2), 151-169.
Puig de la Bellacasa, M. (2011). Matters of Care in Technoscience. Assembling Neglected Things. *Social Studies of Science, 41*(1), 85-106.
Shiva, V. (2008). *Soil not oil : environmental justice in a time of climate crisis*. Cambridge, Mass.: South End Press.
Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist, 43*(3), 377-391.
Starhawk. (2004). *The Earth Path: Grounding your spirit in the rhythms of nature*. San Francisco: Harper.
Stengers, I. (2006). *La Vierge et le neutrino. Les scientifiques dans la tourmente*. Paris: Empêcheurs de Penser en Rond.
Stengers, I. (2011). Comparison as a Matter of Concern. *Common Knowledge, 17*, 48-73.
TheFreeAssociation. (2011). *Moments of Excess: Movements, Protest and Everyday Life*. Oakland, CA: PM Press.
W.T.H., W. (1959). The discipline of soil science. *Journal of Soil Science, 10*(1), 1-4.
Wild, M. (2010). Peak soil: it's like peak oil, only worse [Electronic Version]. *Energy Bulletin*. Retrieved January 2012 from http://www.energybulletin.net/52788.

[i] See Earth Activist Training. Planting the seeds of change: http://www.earthactivisttraining.org (last accessed January 2012).

[ii] With the subtitle : 'Reviving the Dreams of Sir Charles Darwin'. Referring to a late volume, unpublished at Darwin's death: *The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits.*