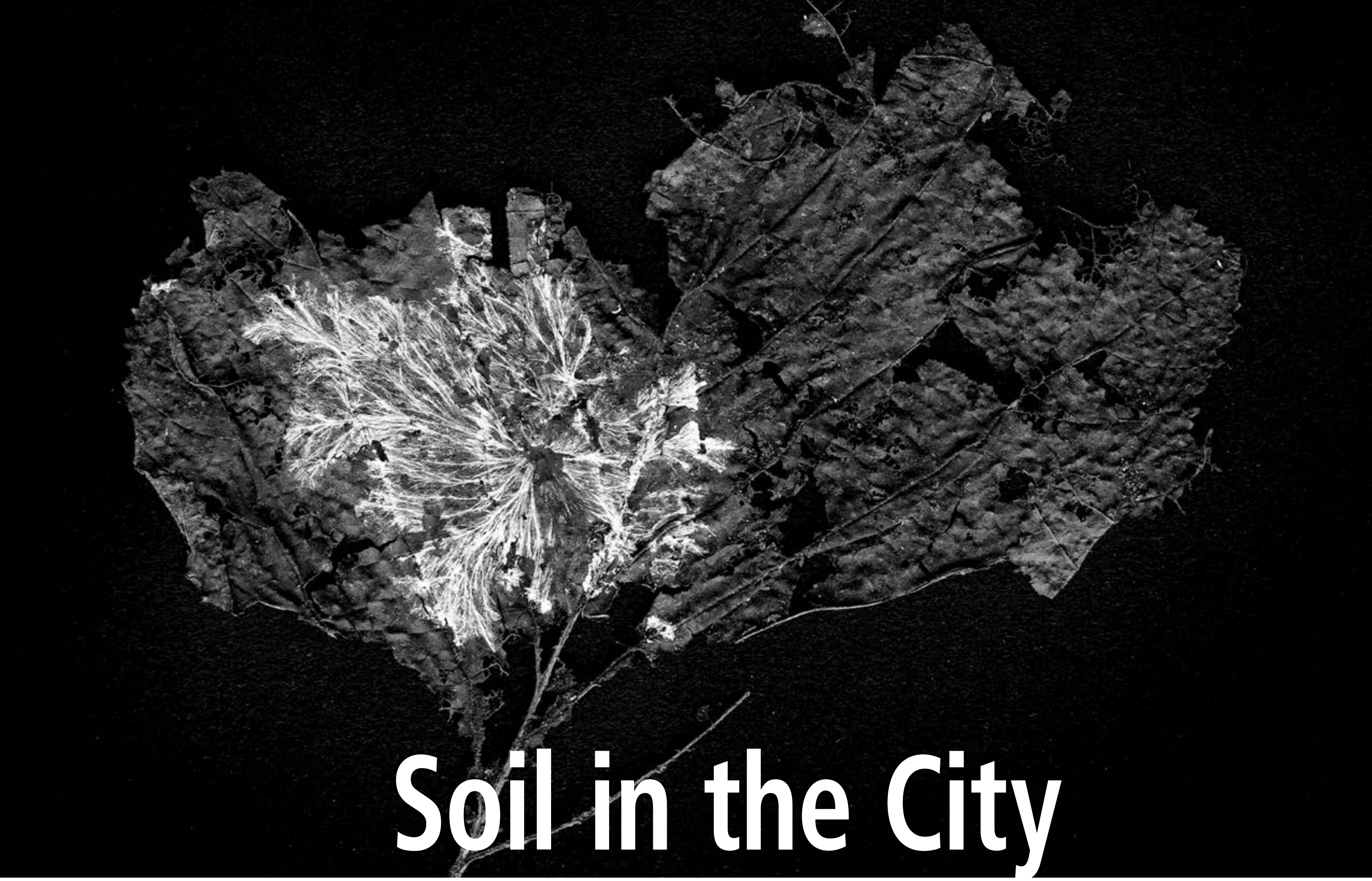

Soil in the City

The Socio-Environmental Substrate

Debra Solomon and Caroline Nevejan

Debra Solomon is an artist and independent researcher, and food forest and urban soil-building expert. Her vision of the urban public space as an ecologically coherent "foodscape" posits a productive, radically greened and socio-natural city. As an artist working in the public space, Solomon has collaborated with local communities since 2009 to produce food-bearing ecosystems in the form of park-like food forests at public locations in Amsterdam and The Hague. In 2010 she founded Urbaniahoeve Design Lab for Urban Agriculture, which means "the city as our farmyard." From 2004 to 2012 she wrote Culiblog.org, a blog about "food, food culture, and the culture that grows our food." Solomon is currently pursuing a PhD on multispecies urbanism with professor Caroline Nevejan and professor Maria Kaika at the Amsterdam Institute of Social Science Research at the University of Amsterdam.

Title image: *En Necromasse, Mycelium,* Debra Solomon. 2015. Screen print on paper, 100 × 70 cm. Mycelium assertively colonizes a dead leaf, metabolizing its nutrients and distributing them to the benefit of the soil community at large.

Dr. Caroline Nevejan is Chief Science Officer of the City of Amsterdam and professor Designing Urban Experience at the Amsterdam Institute for Social Science Research at the University of Amsterdam. Previously she was associate professor in the Participatory Systems Initiative at Delft University of Technology. Specializing in artistic and design research, Nevejan's research takes place in interdisciplinary contexts, focusing on the design of trust in today's globalized and mediated societies. Nevejan was founder/director of Waag Society and program director at Paradiso and lab director at Performing Arts Labs in London, UK. Between 2006 and 2014 Nevejan was a crown member of the Dutch Council for Culture and the Arts. Between 2014 and 2016 she was a member of the supervisory board of *Het Nieuwe Instituut*, which aims to illuminate contemporary subjects related to architecture and design.

Considering that 75% of Europeans and 50% of the population worldwide lives in cities, it is important to ask, Why is urban soil largely absent from soil protection policy recommendations? This question deals with, on the one hand, issues of appraisal, appreciation, and value, and on the other hand, practical, innovative approaches to urban land-use as a countermeasure to land take. This chapter argues that soil is a fundamental element in future ecologies that needs to be addressed in urban theory, methodology, and practice. First, the art installation *Entropical* is discussed, which poses the question of the discrepancy in value creation by soil production versus value creation by mining cryptocurrency. Having identified the lack of soil awareness in today's globalizing world, the chapter describes in detail how future ecologies need to take urban soil as a starting point and how soil is actually part of a social system. The concept of soil ecosystem services seems to offer a foundation for integrating soil into future ecologies and as a basis for policymaking but is unfortunately entangled in economic metaphors and furthermore lacks participatory roles for humans. Exploration of a new paradigm for urban soil is discussed in the presentation of the art project of Urbaniahoeve, an Amsterdam-based foundation.

In cities, large swathes of soil are situated within public space landscaping and "green zones," places more regulated than the soils of conventional farmland and mainstream agriculture. With more than 50% of the world's population living in urban areas and 75% in the European Union,[1] urban soils are a logical starting point to initiate a change in perception of humanity's role in the natural world at large. New systems of valuing are necessary to rethink urban soils, their cultivation, and protection. This chapter explores a new paradigm for thinking about urban soil. Inherent in its argumentation is the notion that art and artistic research has the potential to offer radical realism and contingency[2] and is as such complimentary to scientific research.[3] Both scientific and artistic research are positioned in relation to one another in putting forward a new paradigm in which soil is considered an actor in its own right and which is engaged with human society in a reciprocal manner.

Soil as Value System: *Entropical*

The case study *Entropical*[4] is an artistic research project by Debra Solomon and Jaromil initiated in the International Year of Soils. The exhibition was situated in a glass pavilion in Amsterdam's Amstel Park, as part of the Zone2Source[5] program curated by Alice Smits. *Entropical* reflects Solomon's conceptual roots in the Land Art movement of the 1960s and '70s, in particular artist Robert Smithson's "Non-site" installations from 1969. Smithson, who wrote extensively on the topic of entropy in reference to urban development, displayed rubble from building sites as artistic material.

Metaphorically, the *Entropical* installation and resulting land-art work represent a reconciliation between the prevailing economic, ecological, and agricultural value systems, proposing an alternative "ecology" herein, in which at first human hubris, followed by human nurturing of soil processes position human activities within the soil-producing community underground.

Entropical consists of four art works in which the value and dynamics of the exchange of materials in the biological world is set against the abstract value of algorithms and computer calculations. It questions whether economic value systems can be brought into a direct productive relationship with ecosystem producers such as fungi in a time in which intensive computation is valued more than ecological regeneration. How, for example, could Bitcoin positively affect the rhizosphere, the layer of soil/soil life around the roots of plants?

The collective artworks of *Entropical* play with the concept of "entropy," the second law of thermodynamics, a condition of constant change in which materials and energy are transformed. But the term is also used in cryptography, where it refers to algorithmic processes and abstract information. Entropical therefore inquires into the incentive to produce ecological regeneration and value in an age in which running intensive computation (e.g., "mining Bitcoin") yields far more value than soil production and requisite ecological regeneration.[6]

The exhibition in 2015–2016 comprised the following four works: *En Necromasse*[7] (five screen prints), *Seven Layers*[8] (one screen print), *Resist Exist*[9] (typography on the windows), and in a separate darkened room at the back of the gallery space, the installation *REALBOTANIK*.[10]

En Necromasse depicts one of the soil's most valuable resources: the dead materials known as necromass. The title of the work plays with the notion of soil organisms working as a single community together, en masse. Without ever showing a speck of soil, the screen prints show dead, organic materials in the process of becoming soil, pointing to the economy of topsoil metabolism and production.

En Necromasse, Forest root, Debra Solomon. 2015. Screen print on paper, 100 × 70 cm. The chaotic episode of a fallen tree reveals its root structure, now a habitat for uncountable billions of organisms as it is transformed into an abundant feast for fungi.

En Necromasse, Sporeprint, Debra Solomon. 2015. Screen print on paper, 100 × 70 cm. The spores of the parasitic oyster mushroom leave ghostly fungal drawings.

REALBOTANIK, Debra Solomon and Jaromil. 2015. Installation view with Bitcoin miner, oyster mushroom mycelium growing on screenprinted urban waste cardboard, dimensions variable.

Photo: Daniela Paes Leao.

In the REALBOTANIK installation, screen printed waste cardboard inoculated with oyster mushroom mycelia develops into thick mats warmed by the “waste” heat released by a computer mining blockchains, the technology behind the mining of cryptographic currencies such as Bitcoin. Heat as a by-product of the information and financialization industry is thus recycled in this installation in order to grow nutrients (for humans, for soil organisms, for plants) on cardboard, an abundant, noncontested urban waste material. After the exhibition, the mycelium mats that slowly take shape in the installation are used to restore poor urban soils by inoculating them with fungi as an act of nurturing.

During the two-month exhibition period two workshops were given in which the process of making the traditional Indonesian foodstuff tempeh becomes a metaphor for soil formation. The heat provided by the Bitcoin miner allows the tempeh fungus *rhizopus oligosporus* to grow and bind the (soy)beans together. Just as *Rhizopus* “mines” the beans for nutrients, so do soil fungi mine soil aggregates for nutrients.

REALBOTANIK elaborates on the almost poetical impossibility of a comparison between the abstract processes of value creation in finance and the material value creation of living processes.[11] The title refers to the term “Realpolitik,”[12] reflecting value attributions and technoscience essentialism used to describe resource exchanges within the soil organism and within computer/financial networks and the notable differential between “use value” and “exchange value” in market evaluations.

Next page top:

REALBOTANIK, Debra Solomon and Jaromil. 2015. Special edition Monarch Bitcoin miner warms bags of soybeans and black beans inoculated with *rhizopus oligosporus*, during a workshop in which “tempeh” is a metaphor for soil aggregate. The heat provided by the Monarch miner, allows the *rhizopus oligosporus* mycelium to metabolize the beans, resulting in tempeh.

Photo: Debra Solomon.

Previous page bottom:

REALBOTANIK, Debra Solomon and Jaromil. 2015. Close-up of installation incubator growing oyster mushroom (*Pleurotus ostreatus*) on cardboard stack due to the warmth provided by Bitcoin miner (not shown).

Photo: Daniela Paes Leao.

Soil as Social System: The Socio-Environmental Substrate[13]

To understand how urban soil is a social system, we need to look at the patterns and drivers of land take and soil sealing, as well as examine the status and socio-ecological potential of soils in the city. Urban and periurban space is often built upon what is or was *arable land,* that is, land suitable for food production. Urban sprawl, known in the literature as "urban land take" is the conversion of agricultural land into development and infrastructure. It reduces habitat and other ecosystem services. City soils are frequently paved over, "sealed" under roads, sidewalks, and public squares.[14] "Soil sealing" is a term used extensively in soil reports of the Food and Agriculture Organization of the United Nations, referring to the *disabling* of ecosystem functions so as to impair the soil's ability to perform essential ecosystem services such as water storage or carbon sequestration. Soil sealing is closely connected with "land take."[15] Though *land take* refers to a process that most often occurs outside the city when forests, wetlands, and arable fields are urbanized, it should seem obvious that it is a problem to be taken up in urban planning practice and policy as well as environmental science.

Land take is on the rise. "Urban land use deserves special attention as most human activities are concentrated in cities, and demand for the urban land-use patterns have a particular impact on the environment, for example, through soil sealing or whole sale change of landscapes."[16] But land take is also an indicator for urban growth, and in European Environmental Agency (EEA) assessments it is associated with economic development. Land take strongly indicates an economy that can afford to import its agricultural products, as well as requisite material resources, for example, water and soil nutrients, but also labor, and more abstractly "time spent" from elsewhere.

Soil sealing as a process of urbanization is not only associated with economic growth but also negatively with contemporary forms of colonialism. Soil sealing, in other words, represents not only a loss of "our" soils, but greatly impacts the land use, connected ecosystems, and eco-social functions of soils in other countries. Simply put, when we pave over our farmlands in a spate of "economic development," we are literally implying that we will "be doing our farming elsewhere," by other people, under other conditions. Deforestation and land degradation are often the result. Indeed, the SOER Assessment is clear, "The associated intensification leads to increased environmental pressure on water and soil resources in intensive farmland areas. In addition, abandonment of extensive farmland leads to a loss of biodiversity in the affected areas."[17]

The conversion of forests and grasslands to agricultural land is one of the most important drivers for habitat loss and greenhouse gas emissions worldwide. There are clear links between the use of farmland in Europe and global agricultural trends.[18] Simply put, urban soil sealing is, to no small degree, the equivalent of *soil stealing*. If we are to take an approach that harnesses this rising dynamic to tackle the problem of land take, it behooves us to look at processes of urbanization and the "spoils" of urban resource flows as the resource that they are.[19]

In urban public space, soil is figuratively, but also literally, hidden from view. Urban soils provide the foundation for all of the green landscaping and ecological infrastructure of our cities. Urban landscaping is based on urban soils and the higher the quality of the urban soil, the better its ecosystems can function. Urban soils in urban public green space are still vastly overlooked in policy papers on carbon sequestration and soil fertility, implying that urban soils are not widely considered as potential zones for food production and ecosystem-based adaptation for climate crisis. One reason for this lies in the notion that the larger the surface area, the higher the effect will be, and indeed, the footprint of urban soils is smaller than that of the rural hinterland. But certainly it is not only the physical size of the technical infrastructure of cities and their soils that must change, but also political instruments, municipal maintenance structures and schedules, education, and culture itself.

"Good" management, such as maintaining and building upon the soil's capacity for carbon and water sequestration, preventing erosion, and fostering biodiversity, can be done at all scales and land zone types. The addition of organic materials to urban soils using a combination of mulching and planting techniques[20] requires access to resources readily available, and as yet relatively noncontested in urban settings. Important drivers that positively affect a soil's ability to deliver ecosystem services (e.g., sources of organic material, access to [waste] water) exist in vast and largely untapped quantities in cities. Access to these same resources is usually unavailable in rural and conservation landscapes.[21]

Urban green zones feature "permanent" landscaping that does not require soil disturbance techniques like plowing. Because of a lack of disturbance, urban soils have been documented to contain more carbon sequestration services and higher levels of carbon than under "natural" conditions.[22] Although urban soils and their ecosystems have a considerably smaller footprint than rural and conservation lands, their potential impact in societal and ecological terms may be greater than previously thought, possibly surpassing the impacts of the rural/conservational context.[23]

In fact, the smaller size and fragmented nature of urban soils may even increase efficacy when it comes to the intricacies of project planning, implementation, participation, and the documentation of results at different levels of scale, and the future integration and transfer of innovative practices.

Soil as Economic System: Ecosystem Services

Ecosystem services[24] can be described as the sum total of capabilities and benefits that an ecosystem can provide. To give some examples, a soil ecosystem can provide habitat for soil biodiversity, water-carrying capacity (water sequestration), or can provide plant nutrition and crop health, which directly translates to societal cohesion[25] and human health. Ecosystem services are typically described in terms of four types of services that significantly affect human well-being.[26] From the Millennium Assessment Report, these include, "provisioning services such as food, water, timber, fibre, and genetic resources; regulating services such as the regulation of climate, floods, disease, and water quality as well as waste treatment; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfilment; and supporting services such as soil formation, pollination, and nutrient cycling." From this list one can clearly understand that specific soil ecosystem services have an impact upon other ecosystem services.

Concretely, ecosystem services mean that if European urbanites don't want to pay for and build water drainage treatment plants to process an ever-increasing amount of storm water runoff due to an increasing amount of technically severe rain events in urban areas, it is a priority to ensure that green spaces and their soils, are capable of absorbing that water.

Urban soils are not only capable of sequestering water but also play an extremely important role in *carbon sequestration.* In agricultural contexts, carbon is represented by among other things (a.o.t.) *crop residues,* the woody leftovers of harvested crops, or in the rhizosphere, the food-rich channels of organic material, or the dead matter called *necromass*. Carbon stored in soil (carbon sequestration) not only positively affects soil fertility but is directly linked to positive climate adaptation, because carbon taken up by soil processes and left undisturbed is not released into the atmosphere as CO_2. The good news is that just about any soil, even pitiful urban soils, under proper stewardship and maintenance can be "encouraged" to sequester more carbon.

As convincing as the (Soil) Ecosystem Services Framework first appears, many authors have criticized its philosophical and political weaknesses, especially with regard to its attempts to monetize the values of such services in the marketplace. Among other soil scientists, Phillippe Baveye[27] has pointed out its fraught relationship with economic theory. In scientific communities back in the 1950s, there was a "belief that environmental deterioration … stemmed from the fact that, in large measure, the services provided by natural systems had no readily identifiable monetary value and were therefore entirely overlooked in economic and financial transactions."[28] Despite a sharp increase in publications on soil ecosystem services, "researchers have manifested very little interest in monetary valuation, undoubtedly in part because it is not clear what economic and financial markets might do with prices of soil functions/services, even if we could somehow come up with such numbers, and because there is no assurance at all, based on neoclassical economic theory, that markets would manage soil resources optimally."[29]

A number of alternative frameworks for valuation have challenged the ESS paradigm by focusing on the interdependency between such services, their spatial fluidity which makes values difficult to isolate, their intrinsic worth, and the connectivity between the biotic and abiotic components of the soil. These alternative frameworks include the soil functions concept formulated by Winfried Blum and adopted by the European Union, the Soil Food Web concept developed by Elaine Ingham and cited by the U.S. Department of Agriculture,[30] and more recently, concepts of temporality and care proposed by M. Puig de la Bellacasa.

Particularly the latter proposal by Puig de la Bellacasa[31] hails in an entirely new paradigm, in which soil actors are emphasized rather than soil services. In this view, humans fully join the community of soil producers with mutuality and reciprocity characterized by new roles for all ecosystem actors. In *Making Time for Soil: Technoscientific Futurity and the Pace of Care*, Puig de la Bellacasa describes the nervousness of soil treatment within a future fixated on promissory solutions as so exhausting, that even the process of soil regeneration is situated within the endeavor of reaching the "moment of production." This creates the effect of never actually being in the "temporality" of soil; the time it takes soil beings to make (top)soil. Even Ingham's Soil Food Web[32] concept, with its quantified soil constituents, is criticized by Puig de la Bellacasa for its lack of human actants aside from in the role of extractor, and where there is no caring human hand to serve up organic materials to the Soil Food Web's diverse soil communities. And in fact, if one surveys diagrams offered by other soil conceptualizations such as the soil ecosystem services framework[33] or the soil function(ing)s[34] diagrams, all are bereft of human agency in reciprocal roles of care.

The temporality of care which de la Bellacasa describes and which already forms the practice of many soil building practitioners, agroecologists, permaculturists, and gardeners; of engaging with the living soil community, is what gives Making Time for Soil so much resonance with practitioners-soil builders, as is the case with the Amsterdam-based foundation Urbaniahoeve.

Urban Soil Building as a New Paradigm: The Urbaniahoeve Technosol

In the previous sections soil is explored as value system, as social system and as economic system. The question is raised as to whether a paradigm shift is needed in which soil, including urban soil, is considered to be foundational for ecologies; for value, social, and economic systems; and in a larger sense, for the survival of mankind. The exploration of this new paradigm is practiced by Urbaniahoeve, which is discussed next.

The topsoil of the Urbaniahoeve Food Forest DemoTuinNoord (DTN)[35] is an example of a highly-functioning, nurtured, urban technosol.[36] This ongoing land art piece demonstrates how a change in the perception and management of urban soil can directly and positively affect the city. This anthropedogenic topsoil was developed *in situ* from organic material from the urban waste stream, within a period of just three years and which serves as a model for soil treatment in the public space.[37]

In Urbaniahoeve foodscape projects,[38] like the Food Forest in Amsterdam *DemoTuinNoord*, making time for topsoil production begins simultaneously with planting; applying organic material to the soil, allowing this layer to rot down and suffocate invasive weeds, brambles, and roots *in situ*, and planting through this layer at the onset. The process of adding unrotted organic material is continually attended and sustained. This presoil organic layer is immediately planted in the style of the forest garden,[39] with varied layers and types of vegetation chosen as food for humans and nonhumans alike, and as an aid in the process of topsoil creation. These steps are carefully monitored and repeated, and as previous layers of underlying mulch break down, new ones are added to maintain a blanket cover. The DTN soil is never tilled, nor are the planted beds walked upon, leaving the soil's ever-developing structure beneath the various mulch layers undisturbed.

Because the Urbaniahoeve soil-building methodology does not wait for organic materials to compost before application, the mulch layers provide habitat and food for a much wider range of soil building beings than if, as in other techniques, a layer of rotted compost was first applied. Typical materials of noncontested local urban waste streams comprise the mulching actions: cardboard layers up to 15 cm thick; 30–40 cm of wood chips from the municipal pruning; old blocks of mycelium spawn from a local fungi grower; and generous amounts of coffee grounds from

Topsoil of the Urbaniahoeve Food Forest Ecosystem, DemoTuinNoord, Debra Solomon, and Urbaniahoeve in close collaboration with the soil-building community of the food forest ecosystem. 2011– ongoing. Land art, 1200 m² × 60 cm. View shows spring 2015.

Photo: Debra Solomon.

local restaurants, cafés, and architecture studios. The most important soil amendments are simply what is most at hand.

In 2014 Urbaniahoeve collaborated with University of Wageningen (WUR) soil scientists to measure nutrients and other soil constituents present in the DTN technosol.[40] The levels of available soil nutrients were predictably high but the amount of organic matter present in the soil nearly reached an impressive 15%.[41] This high percentage of organic matter, not typically found in natural soils outside the tropics, is extraordinary considering that this location had just ten years previously been an abandoned and later depaved parking lot, made with the sand used for Dutch urban terraforming projects as its only "parent material."[42] What is especially noteworthy in the WUR soil study of the Urbaniahoeve technosol is this soil's extreme capacity to sequester water. To date, the spongy, black soil (which was not long ago merely sandy fill) is capable of absorbing *virtually* all of the water of the recent year's rainfall events. Instead of impacting urban water infrastructure with surges, the rainwater is safely stored in the soil and food forest ecosystem. This phenomenon is another kind of "banking"; storing and later tapping sequestered water sources during lengthy spring droughts.

Soil Portraits[43]

The WUR soil study provided an initial insight into the development of the Urbaniahoeve topsoil, but the chemical analysis as a technique was not without limitations. Considering that it was merely a snapshot of what was going on in the soil, this form of soil analysis is at the very least financially prohibitive as an observation technique for developing and nurturing (top) soils, in that such processes require frequent monitoring. In the case of

Soil Portrait #26, Debra Solomon, 2016–ongoing. Soil chromatography, soil building, 580 × 580 mm. *Soil Portrait #26* (*SP#26*) is a soil chromatogram sampled from the self-made topsoil produced *in situ* by Solomon, Urbaniahoeve, and in close collaboration with the nonhuman soil-building community of the Urbaniahoeve Food Forest Ecosystem in Amsterdam Noord. *SP#26* depicts a young, well-aerated soil, comprised of a high percentage of partially decomposed organic materials. This illustrates that organic material, even when not completely decomposed, is accessible to many species of soil life present in this highly composed, urban technosol ecosystem.

Soil Portrait #55, by Debra Solomon, 2016–ongoing. Soil chromatography, soil building, 580 × 580 mm. *Soil Portrait #55* (*SP#55*) is a chromatogram of worm humus originating from the carefully "curated" vermicomposter at the Urbaniahoeve Food Forest in Amsterdam Noord. *SP#55* illustrates a young, well-aerated "soil," bursting with soil life, that has an abundance of partially decomposed organic material, and to which sand was recently added as a means of providing roughage for the worms' guts.

the Urbaniahoeve soil ecosystems and the (earth)worm ecosystem of the vermicomposter, both receive an intentionally composed "diet," replete with occasional and voluminous coffee shots and summer treats of comfrey leaf or nettles. Especially in the worm bin, one can bear witness to worms "joyfully" tucking into seasonal sources of nutrition. The ability to monitor the results of this enthusiasm in terms of soil/humus quality is therefore an imperative. A method for monitoring "worm enthusiasm" that is both affordable and technically easy to carry out on a regular basis is soil chromatography.

Soil chromatography[44] is commonly used by farm collectives in the Global South as a means to easily, quickly, and repeatedly check developing soils for changing indicators of soil health such as the presence of organic material, bioavailable nutrients, and soil life. As a data generator, soil chromatography does not quantify nutrient makeup like a chemical analysis, but provides a visual overview with which one can gain perspective into the state of the nutrient contents of any given sample. Most important, soil chromatography illustrates the interaction of soil life within the sample's materials in a visually evocative manner. Lay folk, normally uninterested in the subject of soils and their care, suddenly become fascinated when shown the mandala-like soil chromatograms, particularly the large-scale versions made of the Urbaniahoeve topsoils.

As an artwork, *Soil Portraits* is an ongoing series of large format (289 × 289 and 580 × 580 mm) soil chromatograms first produced during the Mondriaan Foundation's AGALab-Waag Society artist residency in 2016. The series consists primarily of chromatograms sampling the self-made topsoil produced by Solomon and Urbaniahoeve in close collaboration with the nonhuman soil-building community at the Urbaniahoeve Food Forest ecosystem. Solomon worked with Ruben Borge[45] to innovate a technique to make soil chromatograms up to sixteen times larger than the "normal" size used in the field, creating a magnification, primarily of the lightest sampled materials, the soil's organic matter. Produced all over the world by farmers and farm collectives, soil chromatography provides a way of analyzing soils under development in order to establish if the applied methods are effective.

Conclusion and Further Research

This chapter has argued that soil is fundamental to future urban ecologies and illustrated this with two case studies. The art installation *Entropical/REALBOTANIK* shows the discrepancy of value creation between soil, which is fundamental to survival and new financial systems like Bitcoin.

Second, the case study of Urbaniahoeve's Food Forest ecosystem topsoil is discussed, which shows that it is possible to create high-quality topsoil in just a few years' time. New conceptual frameworks of soil ecosystems, consider both the soil's development *in situ* as well as the temporality of reciprocity and care. Adopting methodologies of observation that focus on the (soil) ecosystem as a whole bring into focus the activities and metabolisms of nonhuman members of the soil ecosystem community and produce the necessary feedback to summon sustained observance and nurturing.

Finally the effects of urbanization itself, such as a high level of availability of carbon resources, a lack of soil disturbance in urban greens, and a culture of increased knowledge-sharing practices, offer a unique opportunity that could allow urban soils to flourish and perform necessary ecosystem services. Urban soils are the low-hanging fruit of climate adaptation and food commons production when they are included in spatial planning policy and land-use legislation. Further research needs to investigate how intentional formats and typologies such as those shown here may be scaled-up to provide a means of water and carbon sequestration, food provision, and biodiversity, so as to make urban soil more resilient in order to significantly contribute to climate adaptation needs.

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8. Solomon, Debra, and Jaromil. *Seven Layers*. 2015. Screen print on paper, 100 × 70.
9. Solomon, Debra. *Resist Exist*. Resisteresisteresistere 2015. Typography on windows, dimensions variable.
10. Solomon, Debra, and Jaromil. *REALBOTANIK*. Dec 2015–Feb 2016. Installation with Bitcoin miner, mycelium growing on screen printed waste cardboard, dimensions variable.

11. Roio, Algorithmic Sovereignty.

12. The term "Realpolitik" was coined by Ludwig von Rochau, a German writer and politician in the nineteenth century. Realpolitik appears and is described in his *Grundsätze der Realpolitik angewendet auf die staatlichen Zustände Deutschlands* (1853) to mean: "The study of the forces that shape, maintain and alter the state is the basis of all political insight and leads to the understanding that the law of power governs the world of states just as the law of gravity governs the physical world."

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14. European Environment Agency, *SOER 2010: The European Environment: State and Outlook 2010.* Soil, p. 14–15. Soil sealing happens when agricultural, forest, or other rural land is taken into the built environment. Sealing also occurs within existing urban areas through construction on residual inner-city green zones.

15. Ibid., Landuse, pp. 16, 24, and Soil, pp. 14–15, 23.

16. Ibid., Landuse, p. 16. "In 2000–2006 about 1000 km^2 of land was covered every year by artificial surfaces. Land take for urban area and infrastructure use increased between 1990 and 2000 by 5.7% across Europe, but with unequal distribution. This trend accelerated during 2000–2006—annual land take increased from 0.57% for 1990–2000 to 0.61% for 2000–2006

17. Ibid., Landuse. p. 28.

18. Ibid., pp. 16, 18, 20, 21, 24, 25.

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