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Living Soil

Inside Outside

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As designers and landscape architects at Inside Outside, we have long been captivated by the power of visuals in shaping environmental understanding. We embed research directly within our professional design practice, using visual strategies to explore and communicate complex environmental systems. Through a co-creative design research process, we explored soil as a vital ecosystem within urban landscapes. Across four stages, we focused on making the unseen life of soil visible through layered drawings, developed in collaboration with scientists and other experts. We aim to raise awareness of soil as a complex, living system; its biodiversity and its crucial role in supporting urban resilience. By integrating scientific knowledge with artistic interpretation, we seek to inspire a shift in how soil is perceived and valued within urban design practice.

EXPLORING THROUGH DRAWING

Our interest in Living Soil did not originate from policy, regulation, or scientific data—it began with drawing. As an office rooted in visual and spatial thinking, we, at Inside Outside, became increasingly curious about the unseen worlds beneath our sketches: the layered complexity hidden below every line that marks "ground level".

What if we stopped representing the underground in architectural sections as a uniform grey hatch?
What if we illustrated it true to what it is: an environment teeming with life, activity, interactions, and unpredictability?

These visual questions became the foundation of our design research. If soil is a critical ecosystem, how can drawing make it visible, relevant, and assist in its protection? Through this process, we came to understand soil not as a static background but as a dynamic, relational ecosystem. We believe that strong visual representation can change minds. For soil to be protected, it must first be seen, understood, and appreciated. Therefore, our drawings aim to communicate scientific knowledge accurately, while also engaging broader audiences through an imaginative and accessible visual language. In this sense, our work is both didactic and aspirational: it demonstrates how design research can generate new insights while inspiring a cultural shift in how soil is perceived and valued.

With this vision in mind, we developed a collaborative research process to explore how drawing could make soil's living systems visible. From the outset, we adopted a co-creative design research approach—a method in which we generate knowledge collaboratively through active participation rather than imposing it from a single perspective. This approach brought together scientists, stakeholders, designers, and students in a series of interactive formats, including collaborative drawing sessions and hands-on workshops. These sessions served as platforms not only for sharing knowledge but also for cultivating new insights through interdisciplinary exchange (Figure 1). Our studio lectures provided a foundation of scientific understanding. In these lectures, experts on soil biology and ecology shared insights about the behaviors, roles, and interactions of various soil organisms—including mycorrhizae (fungal networks), springtails (tiny arthropods), worms, and bacteria—within the soil ecosystem. These contributions ensured that our visual explorations were informed by current scientific knowledge and conceptually robust.

Joint drawing sessions translated this knowledge into visual representations to show soil systems spatially and temporally. Interdisciplinary workshops between students and professionals created an experimental arena where ideas could be tested, challenged, and expanded. The collaborative structure between scientific expertise, practical knowledge, and design thinking established a knowledge-sharing network that supported ongoing dialogue and creative exploration while remaining rooted in ecological reality.

Figure 1: One of the Open Ateliers in the Studio (Inside Outside, 2023)

FOUR-PHASE DESIGN RESEARCH PROCESS

Our research unfolded across four iterative phases, each building on the last to explore, understand, and apply knowledge of soil ecosystems in urban design. In each phase, we began with a clear question and aimed for one clearly defined, yet integral, result.

In Phase 1, we visualized a living soil by establishing a foundational understanding of soil biodiversity through collaborative drawing workshops and studio lectures, culminating in a multi-layered illustration that translated scientific insights into visually engaging narratives.

In Phase 2, we examined urban soils and the realities of design, exploring how soils are altered by compaction, paving, and roof gardens. We used co-creative methods to identify regenerative strategies to support biodiversity and to develop preliminary design lessons.

In Phase 3, we applied insights strategically, exploring ecosystem services provided by soil organisms and developing a soil-focused urban design framework.

Finally, in Phase 4, we translated research into site-based experimentation at Schiphol Oost. We developed experimental gardens and visual management tools to test regenerative soil strategies in real-world conditions, fostering hands-on learning and creating scalable approaches for urban soil stewardship.

PHASE 1: VISUALIZING A LIVING SOIL
Establishing a foundational understanding of soil ecosystems

In this phase, our goal was to create a detailed illustration showing the rich biodiversity of healthy loamy-sand soil with a high groundwater table. A soil condition often observed in Amsterdam, where historical peatlands were overlaid with thick sand layers to support urban development.

At the heart of our process were the collaborative drawing workshops, or Open Atelier, which served as both knowledge exchange and design laboratories. These were enriched by studio lectures with specialists who deepened our understanding of underground ecosystems, and provided insight for the following questions:

How do we make the invisible soil life visible?
How do we reveal the beauty of the underground world?
How can we visualize the unpredictability of natural processes?

The answers emerged through layered drawings — visual translations of scientific insight and artistic interpretation. These drawings became tools, prototypes, and provocations. With scientific input, we developed a large composite cross-section that revealed a vibrant soil ecosystem with the water table about 1 meter below the surface (Figure 2). The illustration portrayed a dynamic profile with microbes, fungi, nematodes, three species of earthworms, beetles, ants, roots, and a single mole (Figure 3). Each group contributes to soil health in distinct ways: microbes decompose organic matter and cycle nutrients; fungi form symbiotic relationships with plant roots; nematodes help control microbial populations; earthworms aerate and structure the soil; and macrofauna, like moles and beetles, mix soil layers and disperse seeds. We were fascinated to learn how much of this activity is concentrated within the top 30 centimetres of soil; the very layer most vulnerable to urban development.

Through visual storytelling, we aimed to foster emotional and intellectual awareness. Our drawing was never intended as a strict scientific diagram. Rather, it served as an educational, narrative artwork —an accessible invitation into a typically invisible world. Now, this drawing is circulating widely. It was presented at the Architectuurcentrum Amsterdam (ARCAM) in 2023 (Figure 4), during the International Architecture Biennale Rotterdam (IABR), in the exhibition 'Ramification' at the Kunsthaus Luzern in 2024 and won the Architecture Drawing Prize 2025. It is also used as an educational tool at the Naturalis Biodiversity Center, Yuverta, and the Amsterdam Academy of Architecture and will be exhibited in Sir John Soane's Museum in 2026. Teachers, ecologists, planners, and policy advocates use the drawing in their work. It has moved from studio walls to museums, exhibitions, and municipal presentations. Most importantly, it has sparked new conversations: soil is more than just a foundation; it is a complex, living ecosystem that supports countless forms of life.

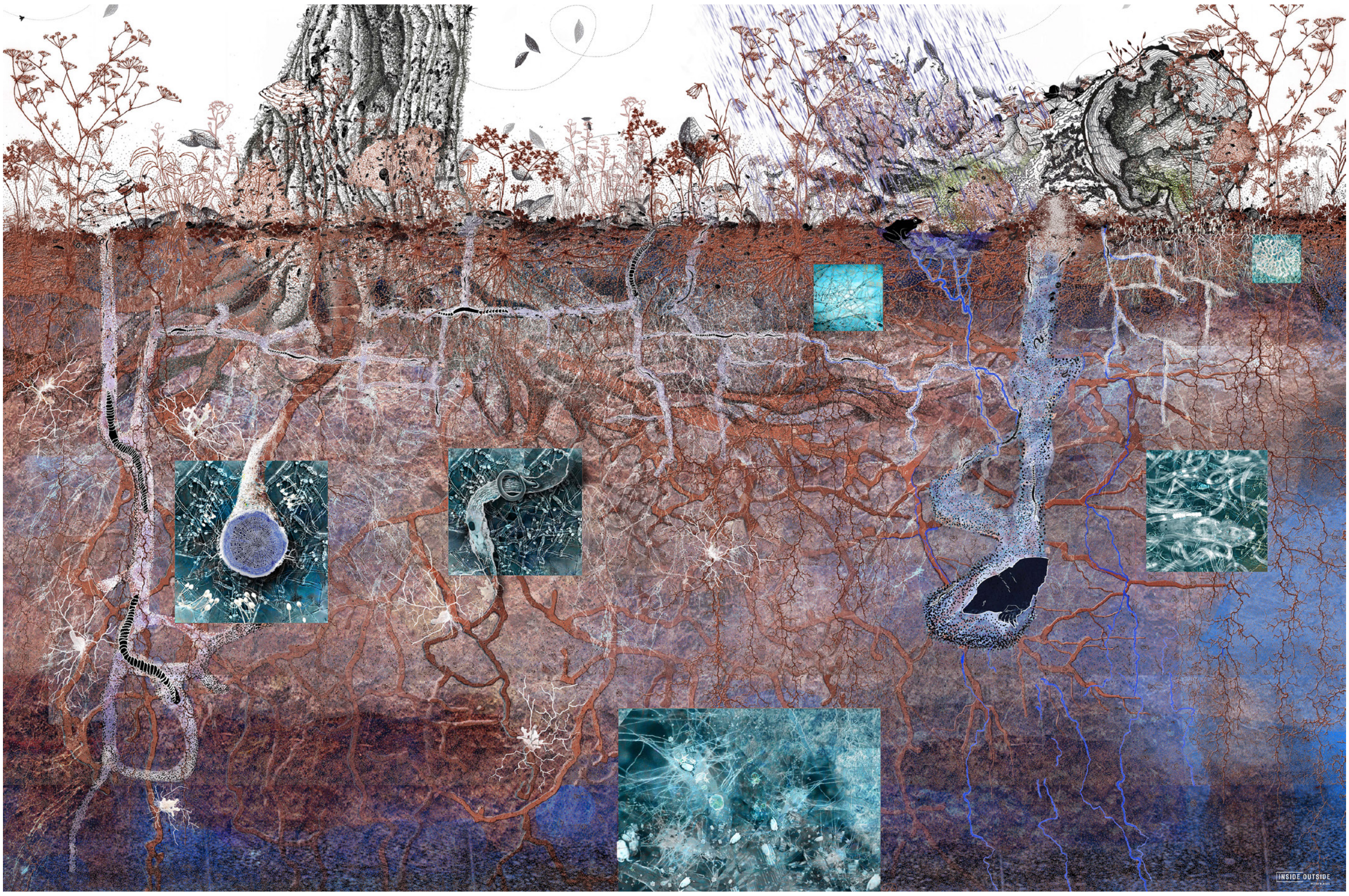


Figure 2: Living Soil Visualization Phase 1
(Inside Outside, 2023)

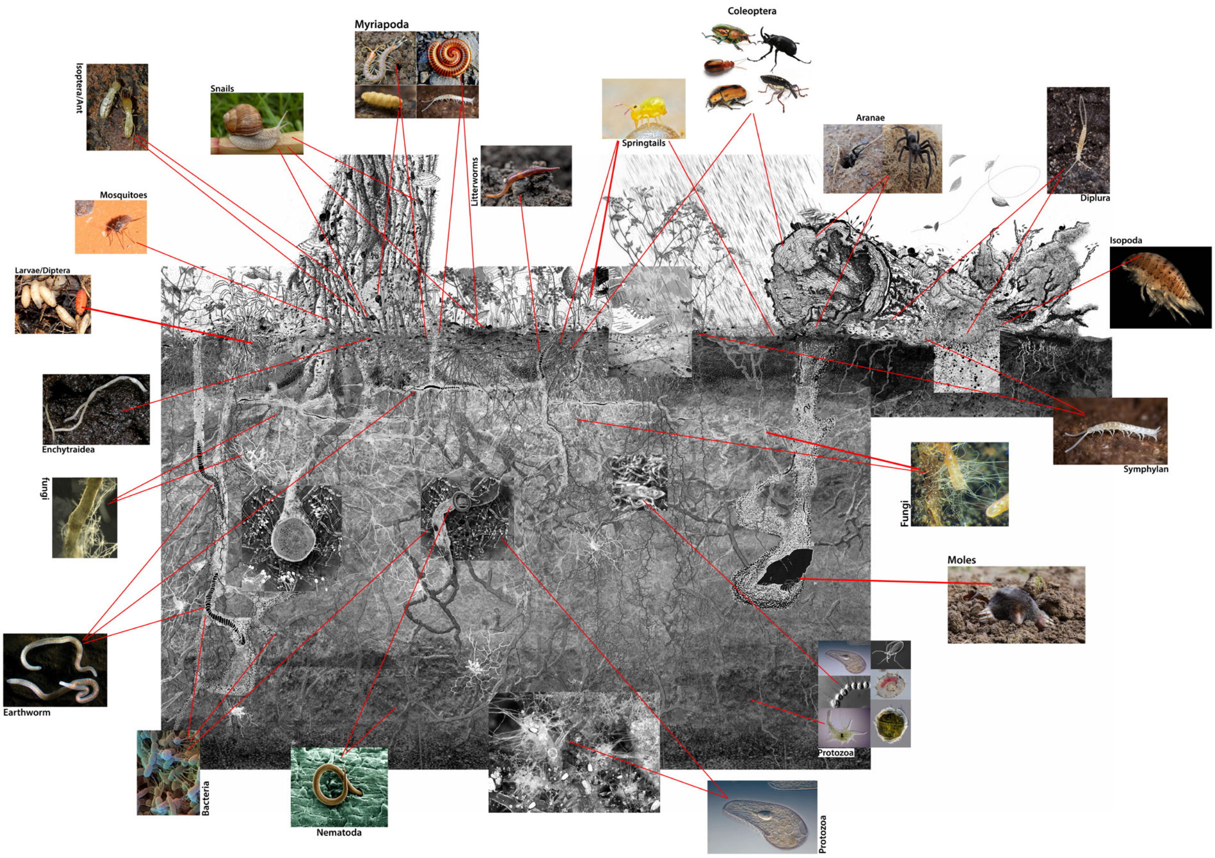


Figure 3: The main chracters of the underground habitat
(Inside Outside, 2023)

Figure 4: "Living Soil: A visual language for urban soil biodiversity"
(Exhibition at Arcam, Inside Outside, 2023)

PHASE 2: URBAN SOILS AND THE REALITIES OF DESIGN
From diagnosis and observation to early design lessons

In this phase, we examined urban soils, which are often heavily compromised—polluted, compacted, or sealed. Our guiding question for this phase was:

How do urban conditions affect soil life, and what strategies can support biodiversity in cities?

Through further iterations of an Open Atelier, drawing sessions, and lectures by biologists (Figure 5), we studied the most common urban soil conditions in Amsterdam's public and private green spaces: compacted soils, paved surfaces, poor soils, isolated soil patches, green roofs, and nutrient-rich soils. Many building sites had been filled with two to three meters of sand, resulting in biologically impoverished conditions. By developing cross-sectional drawings, we visualized the interactions between organisms and their environments. This revealed not only the negative impacts of urban development but also opportunities for ecological restoration (Figure 6 & 7). We encountered soil life outside mature or undisturbed soils. To our surprise, we also engaged with soil life in unexpected places — beneath pavements, on green roofs, and in undisturbed green pockets. Yet soil life defies single metrics and is more than just a foundation. It exists as a complex, interdependent system shaped by and supporting countless forms of life.

Working closely with soil experts, we translated these insights into design strategies. Field observations, cross-sectional drawings, and co-creative workshops highlighted the crucial role of natural "ecosystem engineers" such as earthworms and moles, whose activity improves aeration, water absorption, root growth, and overall soil health. In addition to a new integrated soil drawing of the diverse soil conditions, we developed urban design principles. These principles focused on favoring the diversity of planting. This can be achieved by minimizing paving with permeable construction materials or avoiding deep sand infills to limit drainage problems. Isolated soil patches should be connected to create continuous ecosystems, while local and native plant species adapted to the regional soil and climate were recommended, including groundcovers, perennials, shrubs, and trees. Other principles pointed towards the need to encourage spontaneous vegetation and seasonal variation, allocating space and time for natural processes such as decomposition, self-seeding, and succession.

Something that is often overlooked is the role of soil maintenance and monitoring, alongside above-ground aesthetics. To enhance social engagement, we proposed accessible green spaces involving local communities in the care and monitoring of these spaces, while promoting educational and recreational activities that connect people with soil and biodiversity.

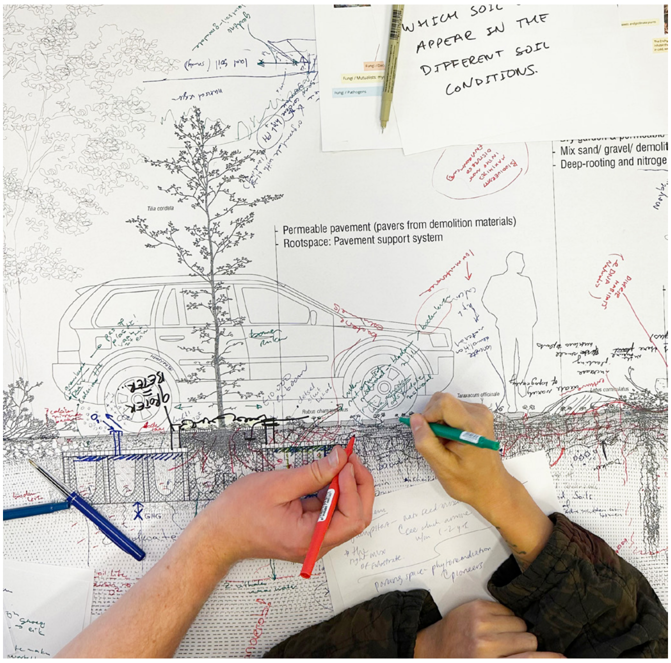


Figure 5: Third Open Atelier 15-11-2023
(Inside Outside, 2023)

Figure 6: In-process soil visualisations for "Marktkwartier", Amsterdam
(Inside Outside, 2025)

PHASE 3: THE ROLE OF SOIL LIFE IN URBAN DESIGN
Strategic application: Towards a Soil-Based Urban Design Framework

Building on observations and practical lessons from Phase 2, we asked ourselves:

How can these insights inform city design?
Do soil organisms help mitigate climate change, manage stormwater, clean pollution, support biodiversity, and enhance human well-being?

Ultimately these questions lead to the framing of Phase 3 for which the guiding question is as follows:

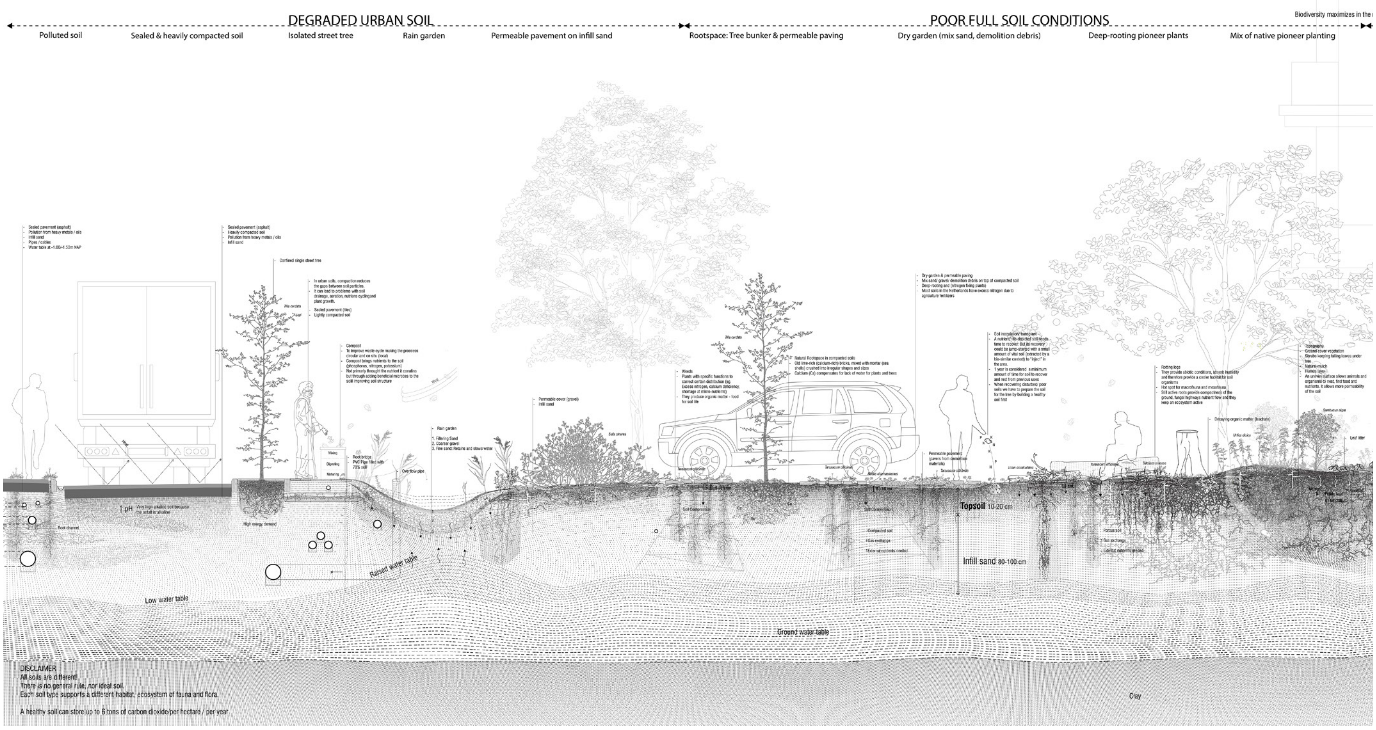
How do soil organisms contribute to ecosystem services, and how can design actively support them in urban landscapes?

Healthy soils teeming with diverse organisms - microbes, mesofauna, macrofauna, and even megafauna - provide critical ecosystem services essential for urban resilience and sustainability. Each group of soil organisms plays a unique role in maintaining environmental stability and enhancing the quality of urban green spaces. Their behaviours—how they live, move, and process organic matter—directly contribute to climate regulation, water management, pollution remediation, and the support of biodiversity. Specific design decisions can therefore positively influence soil life, thereby enhancing ecosystem services across urban landscapes. To do so, we investigated the challenges and potentials for soil life within different urban soil conditions found in Phase 2, being: degraded urban soils, poor, full soils, natural full soils, and artificial soils.

'Degraded Urban Soils' - such as compacted soils under asphalt or street profiles -, street trees struggle due to limited rooting space, compaction, and disrupted microbiomes caused by high pH from asphalt. These factors reduce soil biodiversity, particularly fungi. Therefore, in these soils, design decisions should be oriented towards the creation of rain gardens that can support microbes and macrofauna —which break down pollutants and increase infiltration. Design decisions in these soils should also facilitate connecting isolated soil patches as a means to restore urban soil vitality.

'Poor Full Soils' - such as post-industrial sites or permeable parking areas -, there is a high level of compaction and disrupted ecological communities. Rather than simply adding nutrients - which may favor invasive species - biodiversity is better supported by restoring soil structure, retaining organic material onsite, and planting deep-rooting native species adapted to nutrient-poor conditions. These strategies help re-establish microbial and faunal communities, enhance soil porosity and water infiltration, and support native species.

'Natural Full Soils' - such as urban parks with mature vegetation-, rich soil life remains vulnerable to urbanization and pollution. When intact, such soils store carbon,



retain water, and improve root health. Mesofauna and macrofauna enhance aeration and porosity, supporting overall ecological function.

'Artificial Soils' -such as rooftops or planters over garages-, soil life is often shallow and restricted. Water limitations, extreme microclimate, and inappropriate planting can hinder growth. By connecting them to adjacent ecosystems, but also by using strategies such as layered and multi-stem planting or water storage crates, these environments can still support thriving soil life, sometimes attracting surprising visitors such as moles.

Building on the former insights, we developed a soil-focused roadmap to guide urban landscape projects across diverse contexts, from streetscapes and parks to rooftops and post-industrial sites (Figure 8). The roadmap is structured around four interconnected action areas:

1. Site Analysis: Detailed mapping and analysis of soil structure, compaction, moisture regimes, and flora and fauna to identify where actions such as decompaction, organic matter addition, or soil profile reconstruction can restore biological activity.
2. Design Strategy: Site-specific measures supporting soil organisms and ecological processes, such as including rain gardens and bioswales to capture and infiltrate stormwater, green roofs with water retention and sufficient substrates for microbes and fauna, and planting designs promoting root diversity and symbiotic fungi.
3. Maintenance: Adaptive soil care reinforcing living systems such as periodic aeration, mulching to support nutrient cycling, monitoring mesofauna and earthworms, and allowing spontaneous vegetation in low-use areas.
4. Community Involvement & Education: Participatory programs where local residents, maintenance staff, and students observe soil health, learn about key organisms, and contribute to long-term stewardship and ecological monitoring.

When applied to specific urban sites, the roadmap enables practical actions that improve soil carbon storage, enhance water retention and infiltration, reduce pollutants via microbial processing, and maintain habitat connectivity for soil fauna. Grounding strategies in local conditions and monitoring biological responses ensure tangible ecological and social outcomes.

These insights prompted a shift, broadening our practice as well as the design- from illustrative research to applied, testable designs. Recognizing soil organisms as active agents of ecosystem resilience, we developed landscapes that deliberately support their activity and survival, paving the way for Phase 4, where these strategies are implemented and evaluated in the field.

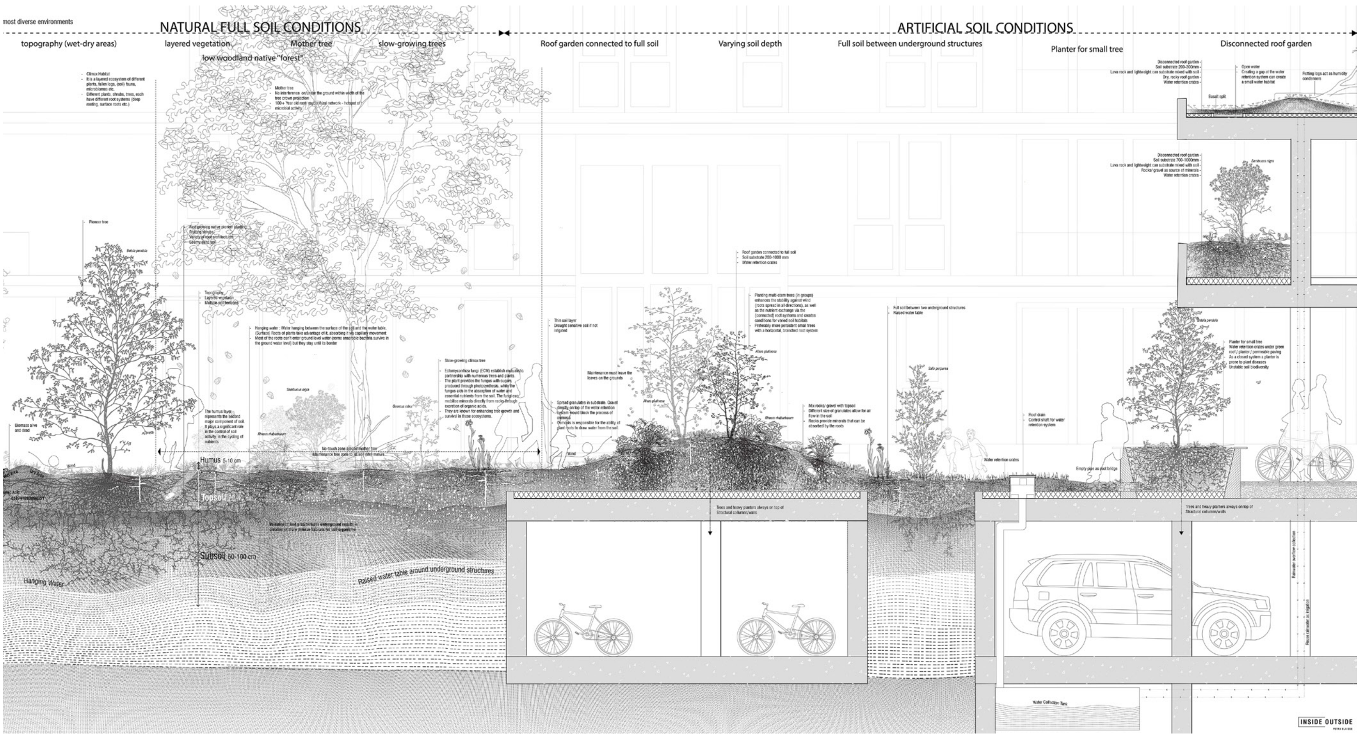


Figure 7: Section Living Soil study on urban soil conditions Phase 2 (Inside Outside, 2024)

Figure 8: In process soil visualizations for "Adam Ademt", Strandeiland, Amsterdam (Inside Outside, 2025)

PHASE 4: FROM INSIGHT TO ACTION - TESTING THE GROUND
Translating knowledge into site-based experimentation and design application

As part of our ongoing effort to translate research into practice, we developed a pre-packed approach to test our ideas and knowledge about soil biodiversity in a real-world context (Figure 9). Schiphol Oost -a generic business park and aviation area within Amsterdam Airport Schiphol- was chosen as the pilot site, given our existing involvement in its future landscape design. We saw great potential to improve conditions through thoughtful maintenance and regenerative strategies. The project is collaborative and multidisciplinary: while Inside Outside leads design, Yuverta students working in the green environment contributing to the ecological monitoring and vocational training; and Schiphol's Technical Management Team does the project coordination ensuring alignment with operational constraints.

With the support from our client, Schiphol airport, this project combines practical learning with applied research by connecting passionate young students and maintenance staff to investigate opportunities for enhancing biodiversity and ecological resilience within a highly managed urban environment (Figure 10). The primary goal of the Schiphol Oost Pilot Garden project is to improve ecological performance, strengthen soil health, support water retention, and foster biodiversity — all while respecting aviation safety protocols. The project also aims to raise awareness of soil life and promote regenerative maintenance practices benefiting both the landscape and the community. The selected site is a dry, compacted open area with young birch trees. This allows testing strategies across specific microclimatic and soil conditions, increasing the transferability of findings to other urban contexts. The pilot garden provides a controlled setting for experimentation while reflecting typical conditions across Schiphol. Within this context, interventions such as soil decompaction, organic amendments, and native planting can be tested to assess their effect on soil biodiversity and function. The findings offer practical guidance for managing soils in comparable areas while accounting for operational constraints.

Our design strategy builds on key insights from earlier phases: the presence of mesofauna correlates with overall soil health, and compacted soils inhibit microbial function and root development. Many urban soils are artificially constructed and disconnected from the subsoil, limiting the continuity required for complex soil food webs to establish. Experimental garden objectives include: reducing soil compaction in local loamy clay; increasing organic content through mulch and adaptive planting;

encouraging spontaneous vegetation development in less controlled zones; and mimicking natural successional dynamics to foster long-term diversity. As a result, the pilot garden is a dynamic environment. Seasonal shifts, time-based growth, and natural colonization are built into the design process, so success is evaluated ecologically - through soil texture, moisture retention, faunal presence, and overall vitality.

This garden is not just a physical site but also a pedagogical space. Designers, maintenance staff, students, and other stakeholders engage directly with soil as a living system. Dissemination occurs through hands-on participation: workshops and guided site visits demonstrate soil decompaction, mulching, adaptive planting, and fostering spontaneous vegetation. Participants observe ecological processes in action - how mesofauna and microbes interact with roots, how organic matter decomposes, and how water infiltrates differently under varied treatments. Visual aids, diagrams, and monitoring data are displayed onsite to illustrate changes and outcomes, while seasonal updates and hands-on activities encourage iterative learning. Observing how soil responds over time helps participants develop a shared understanding of regenerative care. Knowledge is further shared through workshops, educational programs at the secondary school Yuverta, and presentations for planners and community groups, extending the lessons beyond the garden boundaries.

A REGENERATIVE DESIGN FUTURE STARTS BELOW GROUND

Over four phases, Living Soil evolved from a drawing experiment into a holistic design research framework bridging science, art, and urban practice. Phase 1 taught us that to protect something, we must first make it visible. Phase 2 revealed that soil health in cities is shaped by human choices. Phase 3 gave us the arguments for soil sensitive design and the necessary tools. Phase 4 demonstrated how even small interventions can lead to actionable insights when tested and monitored and that regenerative urban design begins underground. Soil biodiversity and vitality are essential for climate adaptation, water management, ecological health, and human well-being. These insights prompted a shift in our practice —from illustrative research to applied, testable designs. By recognizing soil organisms as active agents of ecosystem resilience, we developed landscapes that deliberately support their activity and survival.

As designers, our role is to craft spaces and narratives that help others see and value the life beneath their feet and, above all, create a vision for the future. In the face of biodiversity loss and climate uncertainty, this vision is urgent: Soil is not a backdrop. It is the foundation of all living systems. It is time we design as though our cities depend on it - because they do.

Figure 9: Compacted Soil, Schiphol Oost (Inside Outside, 2025)

Figure 10: Yverta 1st and 2nd year students soil-testing (Inside Outside, 2025)

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