soilcraft | a necessary fiction

Stevie Koepp

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Gundula Proksch
Thaisa Way
Afroditi Psarra

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Abstract

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Stevie Koepp

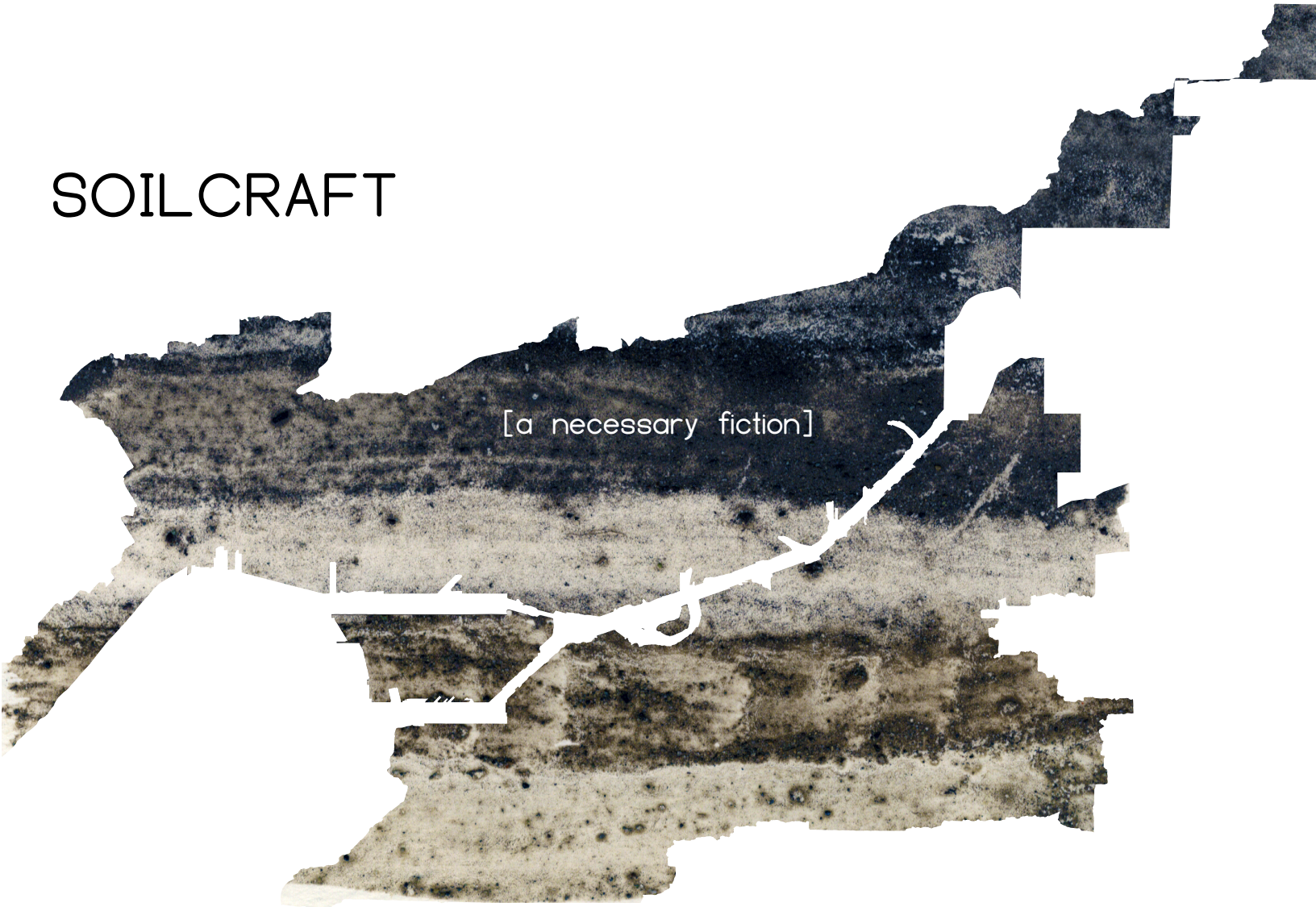
Co-chairs of the Supervisory Committee:
Professor Gundula Proksch, Department of Architecture
Professor Thaisa Way, Department of Landscape Architecture

Committee Member:
Afroditi Psarra, Center for Digital Arts and Experimental Media

This thesis employs design fiction as a practice to suspend belief and present alternative urban soil futures. A recent expansion of classification by soil scientists to better describe and qualify industrial soil types as technosols provides the point of departure for this project. Mixed methods inform the construction of diegetic prototypes to enhance the biological function of technosols, set within a series of wastescapes located in the urbanized Duwamish watershed. The hybrid nature of these soils presents a critical entanglement– development builds or degrades soils, which in turn, nourish or poison the more-than-human city. Research into alternatives ask, what if the built environment was organized to put organic residuals into constructed soils in service of transformative soil biota? Design artifacts build proposals from this what-if scenario to open up and discuss the potential of technosols. Outcomes include an installation entitled, *toward biotechnosols*, a speculative operation manual for the care of damaged soils, and a series of conceptual apparatuses for the production and cultivation of technosols. Research concludes that technosols could and should be cultivated to transform urban materials, bodies, and space as an alternative to throughput waste– a necessary fiction supporting the mutually beneficial coexistence of human and non-human life in the Duwamish and on this planet.

keywords: technosols, soil biota, wastescapes, design fiction

SOILCRAFT



stevie koepp // march/mla 2019

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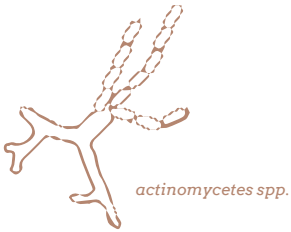
Technology is not neutral. We're inside of what we make, and it's inside of us. We're living in a world of connections – and it matters which ones get made and unmade.

Donna Haraway, author of *The Cyborg Manifesto* in an interview with *Wired* magazine (1997)



actinomycetes spp.

[FRAME]

[SHOW]

[SHIFT]

contents

figures

preface

Soil is an oddly unfamiliar, living matrix supporting the multitude of city life. The World Reference Base for Soils extended classification in 2006 to include urban soil types, termed technosols to describe their semi-synthetic origin. Developing rapidly in biological assemblages qualified by garbage, technosols demand the production of novel narratives to imagine what they will become and to whom they belong. Can speculative proposals for soil building cultivate an ethic of flourishing in the more-than-human city? This thesis engages soil to better understand what working practices reframe environmental values governing action.

What if building nourished urban soil as an alternative to waste?

What do people care most about in the world they inhabit?
How do they use and assign meaning to that world?
How does the earth respond to their actions and desires?
What sort of communities do people, plants, and animals create together?
How do people struggle... for control of the earth, its creatures, and its meanings?
And on the grandest scale: what is the mutual fate of humanity and the earth?
Good questions all, and starting points for many a story ....

William Cronnon, A Place for Stories: Nature, History, and Narrative

[FRAME]

towards necessary fiction

1,00
EARTH
0,75
OCEAN
0,25
DRY
0,125
WHERE WE CAN LIVE AND GROW CROPS
0,03
DEVELOPED AREA
TOPSOIL (<0,005)
TECHNOSOLS
PHYS
GEO
BIO
EXISTING QUALIFIERS
WASTESCAPES
KEY SOIL ATTRIBUTES
MICROBIOTA
CARBON CYCLING

background

Soil scientists broadly agree that a critical aspect of meeting the requirements of healthy soils everywhere is increasing soil organic matter—dead, mostly dead, and living materials.[1] As soil ecosystems are transformed from carbon sinks to sources for the first time in the geological history of our planet, climate scientists fear a positive feedback loop of increasing microbial $C0^2$ production induced by increasing moisture and warming.[2] As the earth's largest carbon pool (3x the capacity of the biosphere), soil management must store more carbon within the topsoil than at present by cultivating plant-microbe interactions.[3,4,5,6,7] Although urban soils represent only a fraction of land worldwide, they present a significant opportunity to alter practices. Urban soils are in immediate contact with urban waste residuals, that have been demonstrated to accelerate soil carbon storage through specific microbial interactions and humification processes.[8] Problematically, soil cultivation practices are –for the first time in human history— entirely separate from processes of city making.

In Seattle, deindustrialization has left the southern communities with a mass of leftover wastescapes qualified as "surplus" by the City of Seattle. Like "Dirt," which etymologically

Fig. 1 (left): Plotting topsoil, technosols and biogeophysical pathways

seattle surplus public properties

means "matter in the wrong place,"[9] such places are anomalies in a growing city distancing itself from discarded things. These sites can be described as *terrain vagues* –multifunctional, surprisingly biologically and socially diverse spaces of ambiguous purpose, boundary, ownership and use.[10] According to Ignasi de Solà-Morales, a terrain vague is most valuable to society in its state of constant flux, lacking definition. The history and present realities of such sites disrupt our technological sense of productivity. What has historically been economically productive was biologically destructive. Now life flourishes where industry is in decay but is threatened by sell-off and redevelopment. Many of these sites are home to both human encampments and wildlife. What is the future of such broadly accessible spaces in a growing city? The vitality of such sites can be cultivated for the benefit of marginalized urbanites - human and non-human. On such sites, the soil is a problem but also a solution – supporting a diversity of life offering a multiplicity of unseen benefits including remediation and sequestration. But how can we revive and rebuild urban soil resources when we've lost an awareness of soil in the city and may not even realize it is alive? What are the stories we tell about soil as a medium—its past, future, and present?

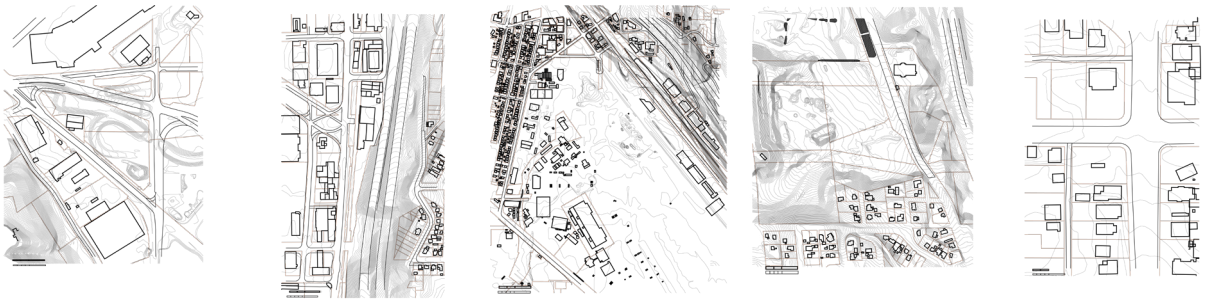


Fig. 2 (left): Seattle's surplus and vacant property map, from: https://data.seattle.gov/
Fig. 3 (above): Five surplus at site scale, GIS files downloaded from: https://data.seattle.gov/

definition of terms

[Apparatus] The things collectively in which preparation consists, and by which its processes are maintained; equipment, material, mechanism, machinery; material appendages or arrangements[11]

[Culture] The distinctive ideas, customs, social behavior, products, or way of life of a particular nation, society, people, or period

[Biogeochemical] Of or relating to biogeochemistry; spec. designating the cycles in which chemical elements and compounds are transferred between living organisms and the environment

[Building] the art or business of assembling materials into a structure[12]

[Design Fiction] a hybrid, hands-on practice operating in a murky middle ground between ideas and materialization, between science fact and science fiction; a way of probing, sketching and exploring ideas by modeling, crafting things, and telling stories through objects[13]

[Diegetic Prototype] cinematic or fictional depictions of future technologies demonstrating to large public audiences a technology's need, viability and/or benevolence (from design fiction)

[Infrastructure] resources (such as personnel, buildings, or equipment) required for an activity

[Soil] a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants. (NRCS)

[Interface] a point where two systems, subjects, organizations, etc. meet and interact. [14]

[Productivity] *Ecology*. The rate of production of new biomass by an individual, population, or

community; the fertility or capacity of a given habitat or area. [15]

[Production] a. The action or an act of producing, making, or causing anything; b. he action or process of making goods from components or raw materials; the manufacture of goods for sale and consumption [16]

[Urban Form] the spaces, places, and boundaries that define urban life; new resources, new technologies, new ways of doing business, the migration of peoples, and shifts in politics and culture all have their part to play in the building and altering of urban form[17]

[Technology] the application of scientific knowledge for practical purposes, especially in industry. (Early 17th c. from Greek tekhne 'art, craft' + -logia) [18]

[Technosol] Soils dominated or strongly influenced by human-made material; from Greek technikos, skillfully made.[19]

[Terrain vague] (Ignasi de Sola-Morales) Open vacant, leftover, undeveloped urban spaces of ambiguous purpose and ownership, uncertain in terms of boundaries and interim in terms of use[20]

[Vitality] The ability or capacity on the part of something of continuing to exist or to perform its functions; power of enduring or continuing[21]

critical stance

The abundance and diversity of urban life is critical in an increasingly urban world, and soil provides the building blocks. Design, as an interdisciplinary art, provides an opportunity to confront the toxic complexity of technosols in support multispecies justice— proposed by Ursula K. Heise as a model for linking justice for human communities with that of non-human species.[22] Bringing together art and science for the purposes of cultural production, design can oscillate across scale and discipline to craft meaning, guiding action to sustain the thin living soil surface which all earthly communities depends upon.

Citing Rosalind Krauss' 1979 essay, *Sculpture in the Expanded Field*, James Corner describes landscape as a place where site and materiality provide "an experimental laboratory, a cultural testing ground to be directly engaged and experienced."[23] I aim to situate my own work within this expanded territory, grappling with the contradictions and overlap between architecture, landscape, and art practice. Krauss' notion of "site constructions" are most relevant to this thesis project, used to describe the intersection of 3 axes between architecture and landscape, opposite of formal sculpture.[24] In her essay she uses Robert Smithson's exploration of entropy in the *Partially Buried Woodshed* (1970) at Kent State to describe this position. My focus is similarly situated in time-dependent processes of weathering but instead emphasizing syntrophy— the coming together of organized processes and life.

How do we shift our attention back to the fantastic matrix of life underneath parks and pavements? Large American cities are perhaps the first urban developments to lack clear cultural connections to soil, maintained historically through soil-based relationships to agriculture and spiritual associations with fertility. Nevertheless, the memory of soil cultivation remains below our feet. In an expedited process of building and eroding—or, pedogenesis—

urban substrates reflect time and place, archiving the weathered artifacts of cultivation and waste. Hypothetical excavations of Seattle's urbanized Duwamish/Green River corridor would reveal the accumulation of fluvial deposition, the nutrient-rich midden piles of tribal settlement, the workings of immigrant market farmers, and the PCB laden silt of factory processes. Core samples would contain centuries of management and cultivation capped by a comparatively recent period of industrialization. Despite urban soil's contaminated complexity, studies have demonstrated its surprising aptitude for ecological function – carbon sequestration, water quality regulation, and a productive diversity of biological life. How will the city relate to our finite soil resources in the digital age? Future visions show glittering skyscrapers free of the earthly surface, glowing hydroponic pink with sterile green foliage. I'm interested in what a grunge brown future rich with fecundity and intermingling life may look like. The project at hand employs narrative to reconnect city with soil, a relationship demanding more imagination than currently afforded in design practice.

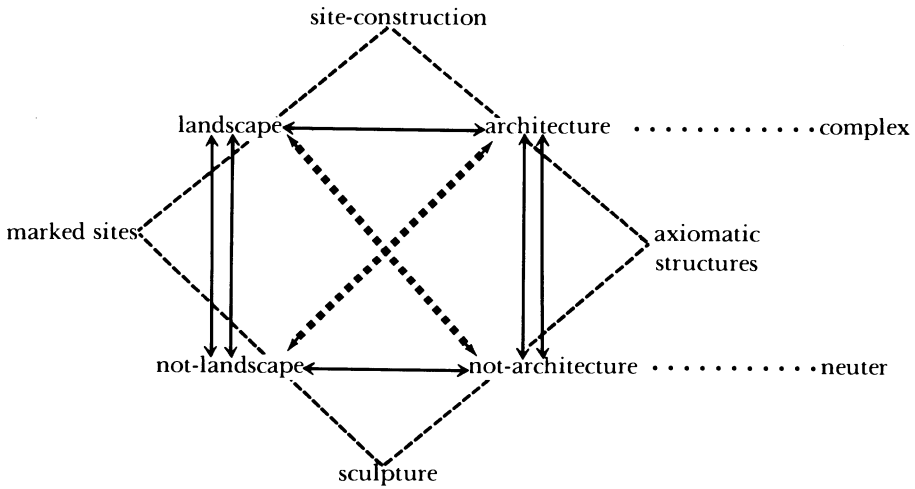


Fig. 4 (above): Rosalind Krauss' expanded field, from: Rosalind Krauss, "Sculpture in the Expanded Field," October 8 (1979). 41.

basis for research

Technosols embody a critical entanglement: urban waste builds soil life and the properties of soil, in turn, nourish or destroy the living.

Response + objectives>> The study at hand confronts the entanglement between soil and waste by providing alternative futures for marginal, leftover soil-based places. Fictional what-if scenarios are proposed to test abundant, hybrid environmental identities in a messy, contaminated, and rapidly urbanizing city. Post-industrial brownfields represent the damaging effects of technology distanced from and biological and ecological processes. Near-future proposals can reimagine these spaces to contest the sanitization and erasure of soil life and histories. Design fiction provides a response to the layered complexity of urban soil and waste/wastescapes. As a generative design practice, it offers an opportunity to provide thoroughly researched and provocative alternatives through the production of visual artifacts and what if scenarios to frame discussion. Fictional apparatuses heal and augment ecological damage to position post-industrial brownfields as ideal sites for soil care. This response offers approaches to process-oriented design and opens up possibilities amidst rigid urban realities. In forming future-oriented narratives around waste and soil biota, this thesis projects aims to impart within the environmental design fields an ethic of care and responsibility for all urban life including awkward, neglected, microscopic communities. Here the role of fiction and narrative in design is explored to bring greater attention to urban soil ecology and access design priorities. In practice and thought, the complexity and diversity of urban soil provides an opportunity to rescale and reassemble marginal landscapes as multifunctional spaces. Engaging the hidden and microscopic life of soil through fiction directs design toward new scales of influence while experimental infrastructures shift spatial expectations.

Scope + limitations >> Methods informing this project are for the purpose of speculation. Analysis and synthesis draws from site histories, soil science, and microbial interactions to provide iterative design thinking for urban soil and waste. Research positions this topic for continued investigation through open narratives to undo restrictive dichotomies between soil and culture and grow new perceptions. Intuitive and tacit knowledge guides design, and microbe-dependent soil processes are explored only to the extent that they may support carbon-based waste cycles, biological abundance and diversity. Soil-based agriculture is not considered at depth beyond the improvement of soil ecosystems to support urban life broadly. Building from María Puig de la Bellacasa's notion of soil care framed in *Matters of Care: speculative ethics in more than human worlds*, this study assumes soil care is reciprocal and beneficial to both humans and soil biota. Soil biota hold agency, and technologies of maintenance and repair can bring people closer to soil life.[25] References to contamination rely on source information and is not a primary focus of site intervention. Responsive technologies such as environmental sensors and systems are explored in a limited, conceptual sense. Design is limited to provocation, leveraging the suspension of belief to use it as a medium for communication, debate and discussion.

Thesis >> Urban soil is a critical medium for design addressing the environmental ethics of waste. *Soilcraft* describes both a process and a series of performative artefacts engaging carbon cycling in scalable, technic-organic assemblages. Research poses the following questions: broadly, what working practices situate environmental ethics to reimagine urban soil; and specifically, what if building nourished soil? Design fiction can bring the properties of technosols and emerging technology together through fictitious prototypes to discuss preferable futures -- what can and should be possible as measured through the implications of "what-if."

research design

Research into near-future narratives for soil employs mixed methods in the development of diegetic prototypes. A diegetic prototype is a functional artefact situated within a fictional narrative to suspend belief about change and evaluate a technology's need or viability. A series of diegetic prototypes at 3 scales—art installation (soil 1:1), design drawing and representation (human @1:10 to urban @ 1:1000), and physical models (1:100) are produced to explore and discuss alternatives to wasteful urban soil practices.

FRAME >> ***frame discussion***

- Literature review – to contextualize inquiry

SHOW >> ***show stories***

- Towards Biotechnosols – Digital art to focus and conceptualize the project
- Making Ground – A soil-based timeline to contextualize, historicize and refine thinking
- Site analysis— Photograph, map, draw and interpret WA ecology brownfield soil reports

SHIFT >> ***shift technology***

- Five fictional proposals for constructed soils d
  conditions, agents, and apparatuses:
    - SITES : mine, yard, plant, shop and substation
    - EXISTING QUALIFIERS: tidalic, spolic, urbic,
    - KEY ATTRIBUTES: moisture, temperature, organic matter, nutrients, structure
    - POOLS + FLUXES in the carbon cycle
    - AGENTS: synthesizers, fixers, decomposers, grazers, and mutualists
    - APPARATUSES: tetraform, specularia, mushmesh, earthbot + nemaknit
- Physical and graphic prototypes represented in handbook with poster zine inserts

inquiry: what if building nourished soil?

proposition: a "what if" scenario bringing urban soil and emerging technology together to discuss preferrable futures -- what can and should be possible as measured through the implications of fictional scenarios

question: what working practices reframe environmental ethics addressing urban soil and waste?

Fig. 5: Making fiction-- a framework

Methods

Mixed methods in this work include literature review, site and historical analysis, categorization, and diegetic prototyping. A preliminary literature review on urban soil and environmental design was conducted to establish a framework for critical discussion and identify possible gaps for continued research. Based on these findings, an approach to investigating possible futures for soil was laid out. A historical analysis in the form of a visual timeline links major cultural events, tribal narratives, and geology in the production and development of Seattle's soils and their capacity to support urban life. A diversity of material fueled this investigation, ranging from the primary texts of immigrant farmers to publications on glacial land formation by regional geologists.

The primary method of investigation in this project is prototyping. The thesis project begins with the presentation of constructed prototypes through digital art and ends with the physical and illustrated representation of apparatuses producing hypothetical future soil types. Prototyping and micro-testing are appropriate methods for positioning the task of soil recovery as an ongoing, iterative process subject to further investigation. It also serves to engage intuitive knowledge—a historically appropriate way of knowing related to soils and their care. Design representation and drawing depict speculative narratives to support the diegesis, presenting microbe-dependent soil processes and soil biological diversity as urban form makers. Various approaches and exercises related to, and nested within, the above methodologies include installation, photography, graphic narrative, creative writing, maquettes and design review.

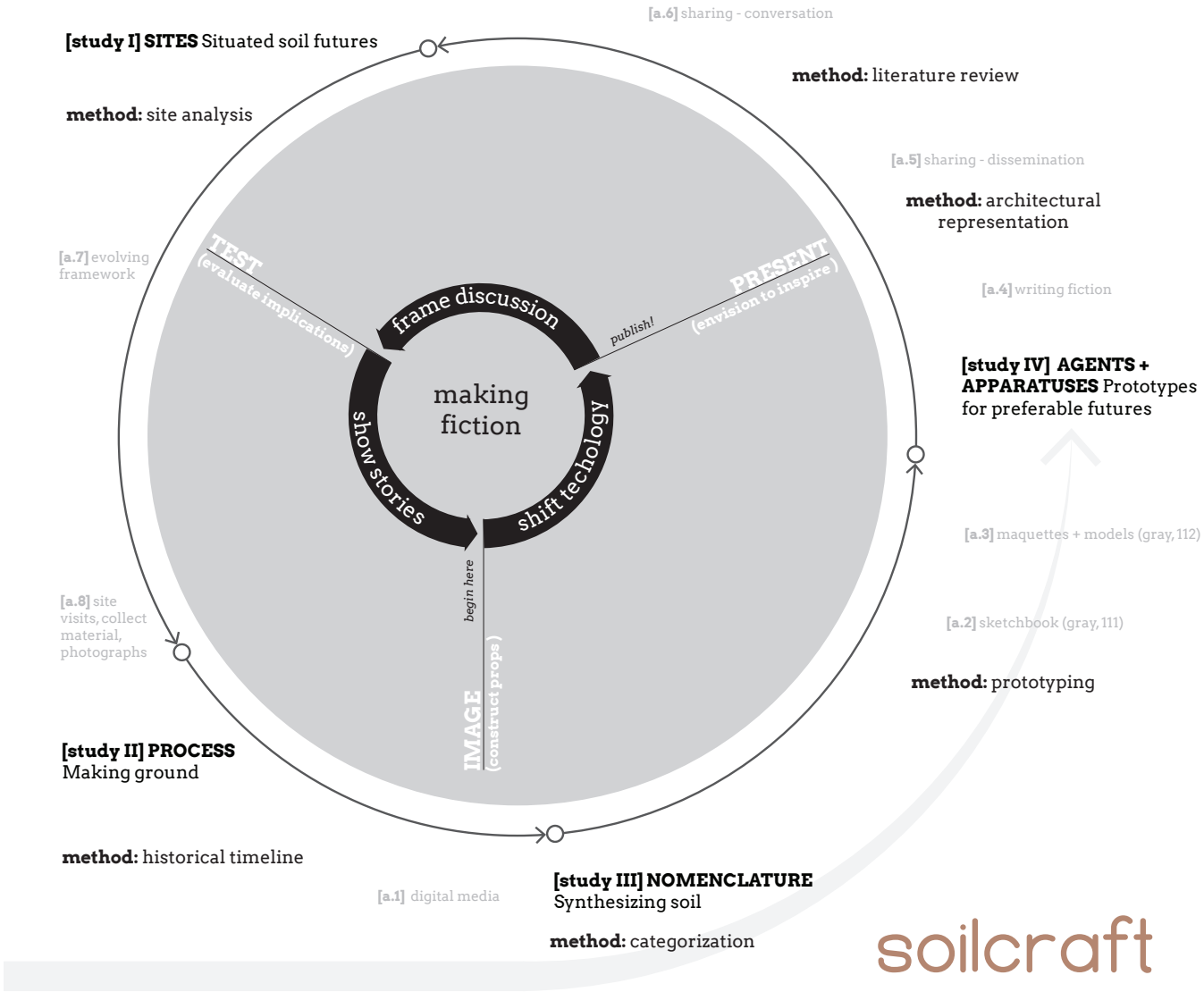


Fig. 6: Making fiction-- mapping methods

literature review

topic: technosols, design, and wastescapes
research gaps: soil fiction – or, future-oriented design for soil; also, design narrative engaging technological and environmental ethics relating to soil

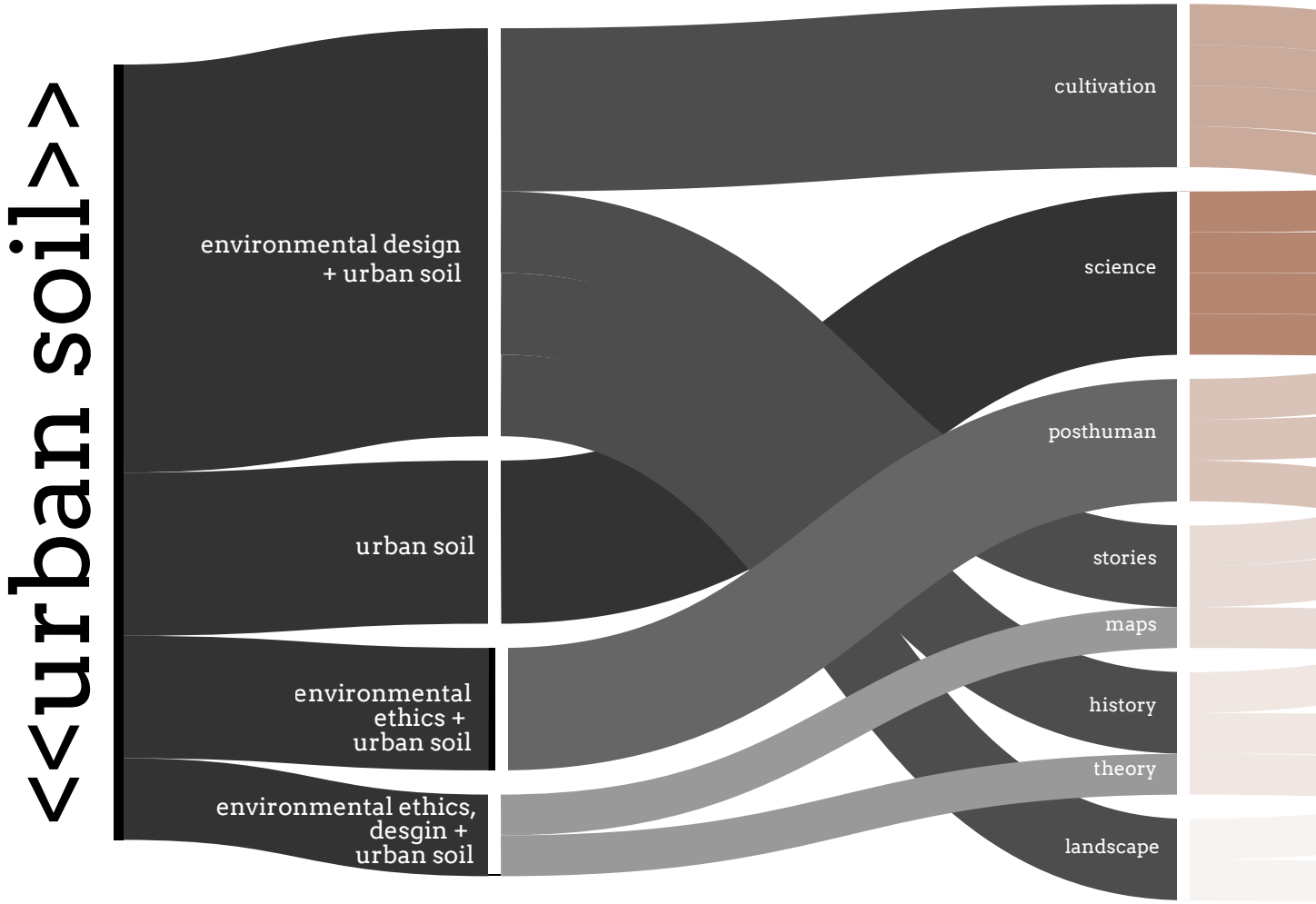


Fig. 7: Mapping the literature


Potteiger, Matthew, and Purinton, Jamie. Landscape Narratives : Design Practices for Telling Stories. (1998). 14
Chris J. Cuomo, Feminism and Ecological Communities an Ethic of Flourishing. (1998). 19
Heise, U. K. "Terraforming for Urbanists." (2016). 12
Dumbarton Oaks Colloquium on the History of Landscape, Food and the City : Histories of Culture and Cultivation (2015). 16
Rattan Lal, Urban Soils, ed. B. A. Stewart, First edition. ed. (2017). 2
Haraway, "Species Matters, Humane Advocacy in the Promising Grip of Earthly Oxymorons." (2011) 20
Sally Brown, Kristen McIvor, and Elisabeth F. Snyder, Sowing Seeds in the City (2016). 3
Sophie Leguedois et al., "Modelling Pedogenesis of Technosols." (2016). 4
David Rossiter, "Classification of Urban and Industrial Soils in the World Reference Base for Soil Resources," (2007). 5
Zev Naveh, "Ten Major Premises for a Holistic Conception of Multifunctional Landscapes,"(2001). 7
André Viljoen, Continuous Productive Urban Landscapes : Designing Urban Agriculture for Sustainable Cities, (2005) 8
Branden Born, "A Research Agenda for Food System Transformation through Autonomous Community- Based Food Projects,"(2013). 9
Gundula Proksch, Creating Urban Agriculture Systems : An Integrated Approach to Design (2017). 10
P. Crowe and K. Foley, "Patrick Geddes as Social-Ecologist: A Century of Mapping Underused Spaces in Dublin," (2016). 13
P. Koohafkan, Forgotten Agricultural Heritage: Reconnecting Food Systems and Sustainable Development. (2016). 17
Dawson, Julie, and Alfonso Morales. Cities of Farmers : Urban Agricultural Practices and Processes. (2016). 11
Nathan McClintock, "Why Farm the City? Theorizing Urban Agriculture through a Lens of Metabolic Rift," (2010). 15
Kongjian Yu and Mary Padua, The Art of Survival : Recovering Landscape Architecture (2006). 6
Puig de la Bellacasa, María. Matters of Care : Speculative Ethics in More Than Human Worlds. (2017). 18

Design for technosols and wastescapes has a growing body of scholarship. Future oriented design and ethics for hybrid soils represent a significant gap in current research. There are few working practices to situate technological and environmental priorities for novel soil systems. A closer examination of the relationship between urban soil, waste, and design is needed, supporting the opening of possibilities for diverse and multifunctional soils and sites. This review brings together soil science, design practices, and conversations from the environmental humanities to understand practices to build ethical urban soil relationships.

This literature review seeks to better understand the state of urban soils (what we know and/or can know), approaches to design for urban soils (how to apply knowledge), and lastly, the future of urban soils (where do we go from here?) Current literature on the topic of urban soil describes an unusual living assemblage of the human and non-human world, representing an unmatched medium for technological and cultural experimentation. The nature of soil bridges art and a myriad of sciences— biological, physical, chemical and ecological. Craft traditions have historically supported and shaped affective human-soil relationships, as have experimental urban design visions. The implications of research into urban soil and its transformative potential is expansive and exciting, countered by the fear and risks posed by its destruction and contamination.

[urban soil science + practice]

In "Dirt: The Erosion of Civilization," by David Montgomery asserts that how we treat the soil, is fundamental to the health and survival of humanity worldwide.[26] He emphasizes that fertile soil worldwide is being converted to sterile dirt and describes a catastrophic peak soil event dwarfing the impact of peak oil. Soil Scientist Rattan Lal echoes Montgomery's call to action,

linking climate change, extinction, political instability and poverty to soil mismanagement.[27] In *Urban Soils*, Lal and his colleagues connect urban places directly to the future of the living pedosphere, describing cities as hotspots for biogeochemical cycles. Providing an in depth survey of urban soil science, Lal and his colleagues position cities as ideal locations for developing and testing novel ecosystems to enhance sustainability.[28] Their work establishes a myriad of possible co-benefits of improved urban soil practices including carbon (C) sequestration, reduced urban heat island effect, habitat for wildlife, improved human health, and waste recycling.[29]

shifting taxonomies>> A forward-looking area of study is the continued development of classification and identification[30]. The formation or pedogenesis of urban soils , classified as Technosols by the 2006 classification by the World Reference for soils, shifts taxonomies in soil science in order to better model processes and breakdown the complex material identify of urban substrates. [31,32] Including human-altered, "technosol" assemblages in expanding taxonomic systems merits a new consideration of a vital material.

If technosols are a technological and biological product of waste, how could, or should, we build future urban soils? A consortium of soil biologist began research into this topic in 2010, as part of the "The BIOTECHNOSOL Project," studying the biodiversity and function of constructed soils in post-industrial brownfields.[33] Suggesting a new soil order, the expression recognizes the role of soil biota as essential actors in "technosols."[34] This hybrid horizon of soil science provides rich opportunities for acknowledging the performative role of soil in urban environments and its agency.

microbiology >> The study of microscopic life and biomes is rapidly expanding field in understanding interdependent biological diversity in the city and in soil. Soil microbes play an

important in the transformation of organic matter and these interactions have been researched extensively by soil biologist Elaine Ingham. Studying the role of soil microbes in landscape, she has divided the various organisms in soil in to functional groups based on their relationship to food webs – grazers, photosynthesizers, shredders, mutualists, predators, and so on. Ingham focuses on the reliance these organisms have on organic matter in the soil and points the addition of organic matter as the easiest way to support soil diversity. Anne Bilke, co-author with Montgomery, entitled *The Hidden Half of Nature* makes a similar argument, linking microbial health and diet to human health and diet. She explains how feeding the soil supports critical biodiversity supporting all of human and non-human health and well-being on our planet.[35] The work of scientist Sharon Doty at the University of Washington focuses on the role of plant-microbial interactions and draws attention to the bioremediation of toxic substrates regionally and globally.[36] Her work demonstrates that not only can microbes sometimes directly alter soil environments but can support plant health to remediate harmful contaminants better together.

A few specific ways that microbial actors facilitate remediation in contaminated sites based on the work of various researchers in this area include: 1to *accumulate* and *extract* persistent organic pollutants like PCBs with algae; 2) to resist phytotoxicity of to pioneer species (ie. alder and cottonwood) that *phytostabilize* and *hyperaccumulate* heavy metals like arsenic with probiotic bacteria (Roy, Khasa, and Greer 2007);[37] 3) to *immobilize* and *degrade* physically harmful contaminates like asbestos with fungi;[38] 4) to *metabolize* abundant hydrocarbons like PAH in anaerobic conditions with archaea;[39] and 5) to *indicate* where volatile contaminates like Trichloroethylene can be *phytotransformed* with nematodes.

While remediation with powerful microbial organism provides ecological solutions for the reversal of damage and correction of harm done to non-human species, it is not the focus of this thesis conceptually. As a rich field of study intersecting with research into and methods of

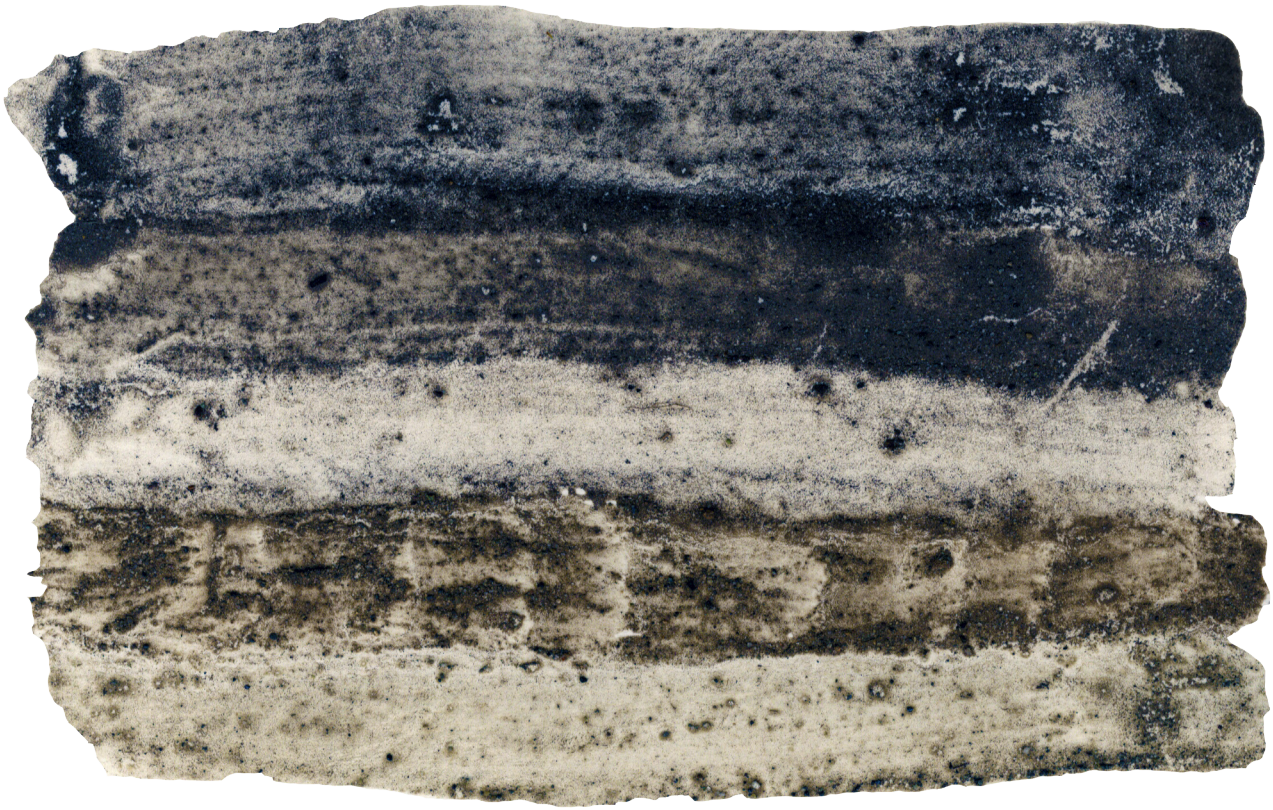


Fig. 8: ***Soil sample/carbon study II,*** exploring the properties of soil through painting

cultivation, remediation and restoration rarely attempts to provide a substantial role for human actors and culture in care for environments. It favors land sparing versus sharing, a never-ending controversy in conservation that has roots in the American conservation movement. This literature review decisively focuses on land sharing and cultivation to explore urban soil assemblages, which have been drastically altered and influenced by human settlement. In the city, transformative, unseen interactions that begin with microbes reopens concepts of earth sharing and cultivation—of what, for whom, and to what ends.

cultivation and production>> Urban agriculture (UA) is the dominant source of literature addressing the social and ecological implications of urban soil technology and management. This represent an area of study overlapping widely with the work of environmental design. A definition from the Merriam Webster dictionary describes agriculture as the art, science and practice of soil cultivation.[40] That said, works on design for soil-based UA is broadly focused and mixed with building integrated agricultural topics. For the study at hand, building integrated works may be relevant to urban soil cultivation as expanded definitions for technosol include unorthodox soil types, such as synthetic rooftop soil mediums (termed "isolatic technosols" for their removal from the ground plane). Lal explores this activated grey space in *Urban Soils*, with a chapter focused on rooftop gardening. Other relevant topics in urban agriculture relate to soil at the urban scale, including: agricultural urbanism,[41] continuous productive urban landscapes,[42] [43] edible landscapes,[44] urban permaculture,[45] and most directly connected to the research at hand, brownfields as sites for urban cultivation.[46] Several other fields such as planning and public health are interested in what soil-based practices can offer communities.[47] "Seeing Beyond the Kale," by Co-authors Kristen Reynolds and Nevin Cohen identify environmental and social justice as a significant gap in UA research. They call for the greater interrogation of structural racism, sexism, heteronormativity, and classism in urban agricultural research.[48]

Although this thesis does not address any of these issues head on, subverting expectations for cultivation and care aims to seed counterhegemonic practices. In related thinking, researcher Nathan McClintock, turns our attention towards Metabolic rift [49] as a rationale for farming in the city, citing Marxist ecological thought and the material primacy of working earth. McClintock speculates that the distance between consumption and production have had disastrous social and ecological consequences and that addressing many issues could begin with soil cultivation to rescale urban metabolism and de-commodify land. Most notably, McClintock describes soil cultivation in the city as a means to eschew alienation through the recycling of organic wastes and frame humans as one of many organisms acting within cyclical biophysical systems.

wastescapes>> Industrial places marked by contaminated waste soils are a contested but common place for soil-based cultivation in dense urban areas. Such sites bring together inorganic waste at the material scale with waste on an urban scale, at and within its margins. Cultivation methods typically shift to manage dangerous toxins. The potential for cultivating vacant, contaminated and underutilized spaces in the city is particularly well studied.[50] The production of food/fiber/energy crops on brownfields, vacant land, and publicly managed areas is a major subject within in soil-based agriculture in existing literature. Darrin Nordahl questions the current practices of land management in the city and reevaluates how varied public open spaces can provide a multiplicity of benefits to the city. A review entitled "Vacant lots to vibrant plots" focuses on the transformation of underutilized spaces to productive ones, reporting the positive benefits and negative consequences of conversion. The study concludes that the rhetoric and expectations of efforts should revolve around the social, health and environmental values of conversion more than supplementary incomes and food provisions. Despite the dangers, brownfields also present the opportunity of exception to private ownership.

In *Terrain Vague: Interstices at the edge of the pale*, editors Mariani and Barron have compiled a series of writings exploring the way in which "vague" interstitial spaces are critical performative spaces of becoming.[51] "Underutilized" places between places serve the city in their potentiality, informality, accessibility, and flexibility. In the introduction, Barron attributes his use of the term Terrains Vagues to the open architect-and-artist collective Stalker, calling for "spaces of confrontation and contamination between the organic and the inorganic, between nature and artifice" that "constitute the built cities' negative, the interstitial and the marginal , spaces abandoned or in the process of transformation." (1996) Barron challenges our negative connotations of waste, derelict, and leftover spaces when we consider their management and

care. Like Nordahl, contributor Karen Franck seeks to tie together spaces with public or an apparent lack of ownership as "a complex domain of places and possibilities."[52] In the lack of ownership and assigned use, these spaces demand care but need to avoid uses that restrict the site's ability to accommodate a diversity of human and non-human users. Farnck examines how important this quality is to preserve flexible urban spaces and believes vacant spaces serve as a model for the "openness" that must be preserved in cities, unconsumed by sole ownership, single use and human use.

waste materials>> McClintock's recontextualization of metabolic rift points towards another key connection between design and urban soil – the potential of UA to perform as a direct sink for urban waste streams. Montgomery also directs attention towards waste management as a critical link to soil in urban systems.[53] Urban planner and agricultural researcher Alfonso Morales would agree, establishing in his work that the potential for urban composting remains untapped.[54] Industrial agriculture disconnected the flow of urban waste from the city to the farm, replacing food scraps and night soil with artificial fertilizers and nutrients manufactured with petrochemicals. Lal, Montgomery, and Morales join others in soil science establishing waste as an increasingly critical link between urban places and soil. Soil scientist Sally Brown similarly urges researchers to focus on the positive contributions wide ranging organic wastes could provide, switching the public health focus on disease and disposal towards beneficial use.[55] Soil's capacity for carbon cycling and storage specifically is supported by Brown's work on soils and climate change. Brown positions urban soil as a significant and effective carbon sink based on long term studies.[56]

This unexpected function of urban soil is one of many hopeful unique attributes that are increasingly well documented. Urban soils demonstrate an underestimated capacity for carbon storage[57] in paved or "sealed" conditions,[58] a higher biological quality than other soil

types,[59] and the same pedogenic processes as non-technical soils,[60,61] The ecological function of managed urban soils is explored at depth in "Sowing Seeds in the City," edited by Brown, McIvor, and Synder with a focus on the possibilities of nutrient cycling in soil formation.[62] An urban scale example of this exchange is the French-intensive method of the 1800s which utilized compost and wastes of the city to grow perishable vegetables within the city borders.[63]

The product of such exchanges was once so significant that soil classification has been developed to identify the agricultural soils that continue to remain as "anthrosols," soils distinguished by the different means in which human cultural practices have shaped regional soils. For instance, French-intensive soils may be described as "hortic" to describe the qualities of a soil layer built up from kitchen scraps. In the southern continent, "Pretic" soils describe the dark black earths of Amazonian people practicing terra preta, or the mixing of manure and charcoal to enhance production while "Plaggic" soils indicate the addition of grassy biomass in northern Europe as a source of organic matter. "Anthraquic" soils (anthra – human and aqua --water) were formed through human methods in wet cultivation and moisture management, such as in paddy soils. Lastly, "terric" soils describe existing wetland soil with modified mineral materials to modify chemical properties.[64] These five definitions for anthrosols offer clues forward, exemplifying the kind of modified soils humans are capable of producing from waste as an alternative to technosols.

science + art >> Art and craft have a long history of engaging human-soil relationships, establishing value and meaning to guide human actions. Edward Landa, a soil scientist who has written extensively about soils as they relate to environment and technology, has co-edited a book entitled Soil+ Culture to chronicle the ways in which artists, philosophers and architects have perceived and presented critical aspects of soil in their work and cultural productions. In "THE SOIL UNDERFOOT: Infinite Possibilities for a Finite Resource," Landa

teams up with researcher G.J. Churchman to echo Montgomery's concern for the future of soil and provide further historical anecdotes of caring for common soil resources. The book seeks to forge greater care for soil by establishing soils as a source of meaning. An academic diversity of contributors energize the topic in a compilation of musings on the nature of soil futures, values, and traditions. They explore how soil has been used throughout human history to paint, dye, make, grow, and manufacture. A chapter entitled "Picturing Soils" examines how the artworld has provided aesthetic experiences of soil reaching beyond science and popular culture to gain entry, inspire stewardship, and grow value. Toland and Wessolek provide a list of contemporary artists working in soil as a medium, across practices: paint, transfer, photography, archival, drawing, land art, and social practice. The intersection between soil science and social practice provides the groundwork for new directions in design. *Soil Kitchen* (2011) by Future Farmers art collective samples soils across Philadelphia's brownfields, Mel Chin's *Operation Paydirt* (2006-ongoing) imagines a future free of childhood lead-poisoning and artist collective Kultivator seeks to give back to the soil we collectively deplete in *Guerilla composting*, *Feedback Berlin* (2010). A chapter entitled "Seeing Soil," connects soil to storytelling through filmmaker Deborah Koons Garcia documentary, *The Symphony of the Soil* (2013). The film celebrates the processes and elements of soil formation across 4 visual "acts" to provide a compelling narrative for lay audiences. A chapter on "Sustaining the Genius of Soils" by Garrison Sposito addresses Georgic aesthetics, a cultural phenomenon growing an appreciation for the soil care. A rich undertaking, the most compelling section of the book focuses on soils and future as we can now see and model the complexity of soils in ways that have never before been possible.

Looking back, the distance between soil science and artistic cultural production is an artificial disciplinary divide. Soil scientists have used art to describe complex ideas. Charles Darwin and Vasily Dokuchaev used drawing to understand the process of pedogenesis in soils, drawing

highly layered substrates to reflect change overtime.[65] Research on nematodes brings up speculative visual studies of nematodes from the early 1900s by scientist rendering dragon-like worm monsters to capture the imagination of its audiences. Science has also inspired art. The well-known science fiction series, Dune was written by Frank Herbert while researching the use of grass to stabilize sand dunes with soil scientists from the USDA along the Oregon coast. [66] The value of bringing art and soil science is perhaps best summed up by Lal's in his science-focused Urban Soils, terminating with a chapter on "Enhancing Awareness about the Importance of Urban Soils." They advocate for the restoration of affective bonds with soil, suggests that "The use of all senses (observe, listen, touch, taste, and smell) evokes feelings and creates emotional bridges." A paradigm shift starting with culture and building from present and past human-soil relationships is possible and necessary towards preferable ecological outcomes.

[soil ethics]

Environmental humanism, a focus of the 21st century, explores the territory of ethics through narrative and creative modes of inquiry. While Aldo Leopold provided a land ethic guiding environmental thought through the last half century, the environmental humanities is exploring new ethical territory posed by the complex challenges facing our planet. Building from cultural studies and ecocriticism, the environmental humanities responds to two major intellectual turns in environmentalism – the first being posthumanism—"a move to de-center the liberal human subject in relation to other species, machines, objects, and systems." The second is "a growing dissatisfaction with declension narratives—doubt about the accuracy and public appeal of stories of nature's decline under the impact of modern societies."[67] Work in this area is led by theorists and writers such as William Cronnon, Bruno Latour, Donna Haraway, Leo Marx and others seeking to redefine and cross-examine environmental narratives shaping evolving concepts of nature. The field has been producing a growing body of material

exploring technological and environmental ethics related, conveniently, to the unseen, awkward, overlooked, and material realities of natural environments. This is fertile ground for locating ethics to inform design for contaminated, unnatural, soils. Locating appropriate ethics for living soils and microbial beings leads to the work of environmental philosopher Chris Cuomo, who applies the Aristotelian concept of flourishing to include all life forms in "Feminism and Ecological Communities: An Ethic of Flourishing." Here she outlines the ways in which values governing action can work to preserve the dynamic charm and valuable unfolding of nonhuman life. She describes dynamic charm as an attribute of all life, defining it as the internal ability to adapt and resist change, as well as a quality that attracts and delights.

Together with environmental narrative, an ethic of flourishing presents an alternative lens to interacting with soils. *Matters of Care: Speculative Ethics in more-than-human worlds* by Maria Puig de la Bellacasa --an interdisciplinary researcher from the university of Warick crossing science and technology studies with the environmental humanities-- builds from Cuomo's thought to outline and ethic of soil care to support such flourishing. Bellacasa dedicates her 5th and final chapter to the topic of soil care. She echoes Lal in his call for emotional bridge building between soil and culture, writing, "The search for glimpses of a transformative ethos in human–soil relations moves us beyond science and its applications to the articulations of alter native affective ecologies and technoscientific imaginaries to which science participates but not necessarily drives." She summarizes the crisis in global soil health outlined in the previous section of this review, and addresses soil as a new material frontier for confronting questions of how technology should respond to unprecedented environmental destruction. Bellacasa directs attention to the multispecies food web as a model for confronting critical temporalities in a necessary reconceptualization of soil. As a system of interdependent needs, she believes foodwebs embody entangled human eco-ethical obligations of care. Focused on the phenomena of one species waste becoming another species food and citing the work of

Elaine Ingham on microbial actors, she positions reciprocity as a focal point in building ethical human-soil interactions. Bellacasa takes a feminist approach throughout the piece, building from the work of sociologist and feminist theorist Susan Leigh Star in asking *Cui bono?* in the context of soil, or, *for whom* are interactions beneficial?[68]

In the case of connected webs of soil-human existence, humans care for soil and soil takes care of humans. In line with feminist thought, the author is skeptical of productivist technoscientific futurity privileging new, bright and shiny over patina, maintenance and repair[69] as well as rhetoric upholding production over reproduction. To conclude her thoughts on soil and care, she urges for an insistence in perpetuating, maintaining, and intensifying the life of existing cycles in innovation and technologies that have endangered the existence of living soil and all species dependent upon it, suggesting that linear technological futurity should rescale and reassemble itself to fit the cyclical timeline of soil care. Langdon Winner's *Do Artifacts Have Politics?* reinforces Bellacasa's point that there are two contrasting approaches to technology. Building from earlier writing on the topic, Winner maintains that technologies are not simply aids to human activity, but powerful forces acting to reshape that activity and its meaning."[70] He situates artefacts such as bridges and chemical fertilizers as biased objects, [71] quoting Lewis Mumford in a declaring two types of technology—one authoritarian and the other democratic. Returning to urban soils that are technic in origin, the work of these writers lay groundwork for tracing the values governing soils material artifactuality.

[soil + environmental design]

By positioning design as a normative practice, by Robert Mugerauer and Lynne Manzo place responsibility on designers in *Environmental Dilemma: Ethical Decision Making* to engage and identify ethics within the context of design practice. A significant area of overlap between

environmental ethics and existing environmental design practice is the reproduction of narrative. Two specific strategies Mugerauer and Manzo provide that have a strong basis in narrative are 1) the opening of new perspectives and 2) the undoing of dichotomies.[72] Landscape architects have been providing rationales for the former through the integration city and cultivation as early as Olmsted in the mid 1800s. A self-proclaimed yeoman, the father of the profession built an urban livelihood on what he considered a rural art form.[73] Similarly, the German landscape architect Lebrecht Migge (early 1900s) proclaimed "All city waste to the land. Unify city and land. We should create our own "earth.""[74] Architectural Historian David Haney, a scholar of Migges work, identifies him as the most overtly political landscape architect on record, seeking a modern revolution of self-sufficiency free from capitalist systems, starting with gardens. Migge connected ideas of home and soil in his work, and connected technology to soil through the possibilities of intensive farming in the city. In fact, he argued for the mechanization of soil and drew detailed diagrams of systems connecting household, waste, and garden. A contemporary landscape architect who shifts narratives in his work connecting the spirit of cultivation to political and social systems is Konjian Yu. In *The Art of Survival*, Yu urges landscape architects to abandon the high art of capital and nobility in favor of the farmer's art of tending the land.[75]

The ethics of undoing dichotomies is also clear in the work of landscape architects in building parks and recreational spaces from contaminated post-industrial landscapes. Gasworks park in Seattle designed by Richard Haag provides a prominent example of this through the integration of petrochemical wastescape with playscape.

Several landscape architecture firms have utilized urban soil in their work to open new perceptions as Mugerauer and Manzo urge, approaching soil as a performative, process oriented medium through investigations of time, transformation, section, and flora. DIRT (for "dump

it right there") represents a critical practice in landscape architecture that is focused on maintaining histories of working landscapes and industrial pasts through the visual presence of debris. The firm was led by Julie Bargmann, a leader in the reclamation of brownfields and post-industrial sites in the US. Bargmann's current work spans discipline and scale, varying widely in context to include quarries, railyards, and factories. One of the most dynamic pieces she's been a part of is *Big Mud*, a collaboration with Mel Chin (mentioned previously) in his operation *Pay Dirt*. The project is an experiment in art and science, and design intervention includes the mapping of neighborhood lead concentrations across New Orleans neighborhoods to locate the active ingredients in lead-free soils (ie missisippi river sediments), and treatment prototypes spanning the scale of small scale sideyard "mudcakes" to extra large regional "mud depots." Landscape Architecture firms Reed Hilderbrand and Halvorson Design Partnership have taken great care to open new perceptions about soils and change over time. An ongoing investigation of soil health in Boston's urban parks studies "the state of city soils" to illustrates 7 soil profiles and how they've developed over a timespan of 6-45 years. The way in which landscape architects have utilized section drawings to explore soilscapes is evocative and imaginative of process, an early example being Ian McHarg's influential Dune Community Types, from Sea and Survival, 1969 depicting the ground plane overtime intersected by ecological communities and limiting factors such as soil moisture and salinity. A recent example of an evocative section-based integration of soil, section, and process is scape's "oyster-tecture" project for MOMA's rising water competition which imagines landform accumulating overtime through the growth of aquaculture.

In contrast to landscape, modern architecture has largely distanced itself from soil with a very recent turn towards the biological. Soil in modern architecture was marginalized – it became a surface firm enough to support a building, sealed, and/or removed to make way for a foundation. German Architect Heirich Jennes has contributed a chapter to *Soil and Culture* titled "Soil,

Subsoil, Priming and Architectural Design" in which he explores the relationship between architect and soil across cultures and over time. He describes architecture that is built from soil, becomes soil, is replaced by soil (gardens), and finally, architecture revolutionized and reimagined by soil. In this final portion of his contribution he cites anarchist soil mounds built in the French revolution inside and between structure as "soil productions" to compete with monumental architecture. This final discovery moves his work towards material explorations between hard and soft surfaces. Urban agriculture is a way in which many architects are beginning to return their gaze to the topic of soil. Constantin Petcou and Doina Petrescu are French architects behind an innovative and tactical social practice project named *R-URBAN* to connect waste streams and production towards greater urban resilience. Workac is an inventive practice that reimagines sustainable systems of architecture and agriculture at the urban scale, bound by soil-based systems. Architectural practices have also turned towards ecological systems and biology at the detail scale in exciting new ways to inform materiality and experiment with what are typically soil-based lifeforms. Ecologic studio plays in algae cultivating BioCities, Fibrous Structures, and systems-based cybergardens; Dirk Hebel and Philippe Block's MycoTree tests mushroom building components and insulation to offer

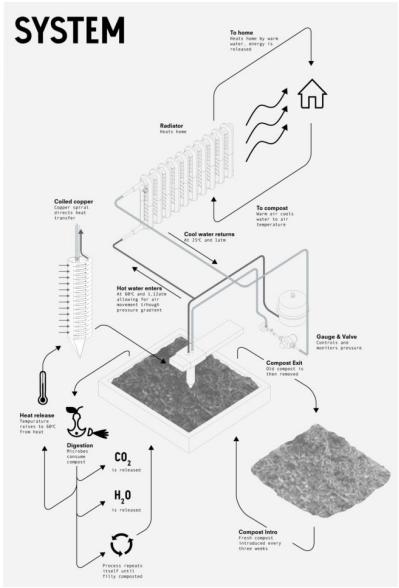
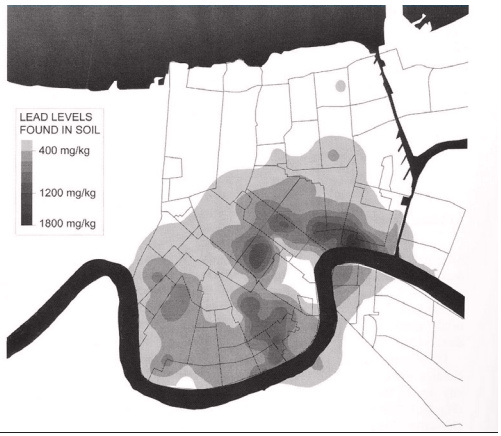


Fig. 9 (above left): Festival of Reason, 1793. ***The Goddess of Liberty and the flame of Reason.*** Unattributed. "Fête de la Raison le décadi 20 brumaire de l'an 2 de la République française..." 9.5 x 15 cm. (Bibliothèque nationale de France)
Fig. 10 (above right): R-Urban, prototype for compost heat capture, from http://r-urban.net/en/prototypes/
Fig. 11 (below): Julie Bargmann, Big Mud, from Pickett, Steward T., et. al. ***Resilience in Ecology and Urban Design : Linking Theory and Practice for Sustainable Cities***. Future City ; v. 3. Dordrecht ; New York: Springer, 2013.



alternatives to biologically toxic materials; and the BiotA Lab at University College London's Bartlett School of Architecture has explored bioreceptive concrete to form habitat for tiny lichen and cyanobacteria photosynthesizers from everyday surfaces in the urban realm.

When urban planning addresses soil, it does so at the systems scale. The work of planner-ecologist Patrick Geddes may not have integrated soil as it's sole focus but spoke from a biological and evolutionary appreciation that celebrated cities connected to soil-based processes. In his final lecture in 1919, he famously stated "by leaves we live… the world is mainly a vast leaf colony, growing on and forming a leafy soil, not a mere mineral mass..."[76] Researchers Philip Crowe and Karen Foley examine Geddes' involvement with the production The Dublin Inquiry Map (1914), to locate derelict spaces and buildings for alternative use. Working with volunteer women's groups to complete the work, Crowe and Foley attribute Gedde's effort recognized that people had a natural right to land and that wealth inequality was core to environmental issues. Geddes noted that vacant land should be reclaimed in the public interest, and trusted that communities could and would care for urban land, and that they should have the opportunity. One of the most interesting contributions Geddes appeared to have on the field is an ability to cross scales, which the field of urban design may continue to contribute today.

Bridging architecture, landscape, urban planning, and art, urban design can build from each field's contribution in re-assigning value to soil in the city. The etymology of design goes back to the Latin de+signare, marking out, setting apart, giving significance by assigning it to a use, user, maker or owner.[77] How does a current and historic practice of "marking out" places for soil cultivation provide a reference for the meaningful management of urban soils? While soil science offers critical guidance to the management of global and local ecosystems, and environmental ethics guide values, an interdisciplinary practice with a foundation in environmental design offers opportunities to work at the seams of all three spheres – waste and

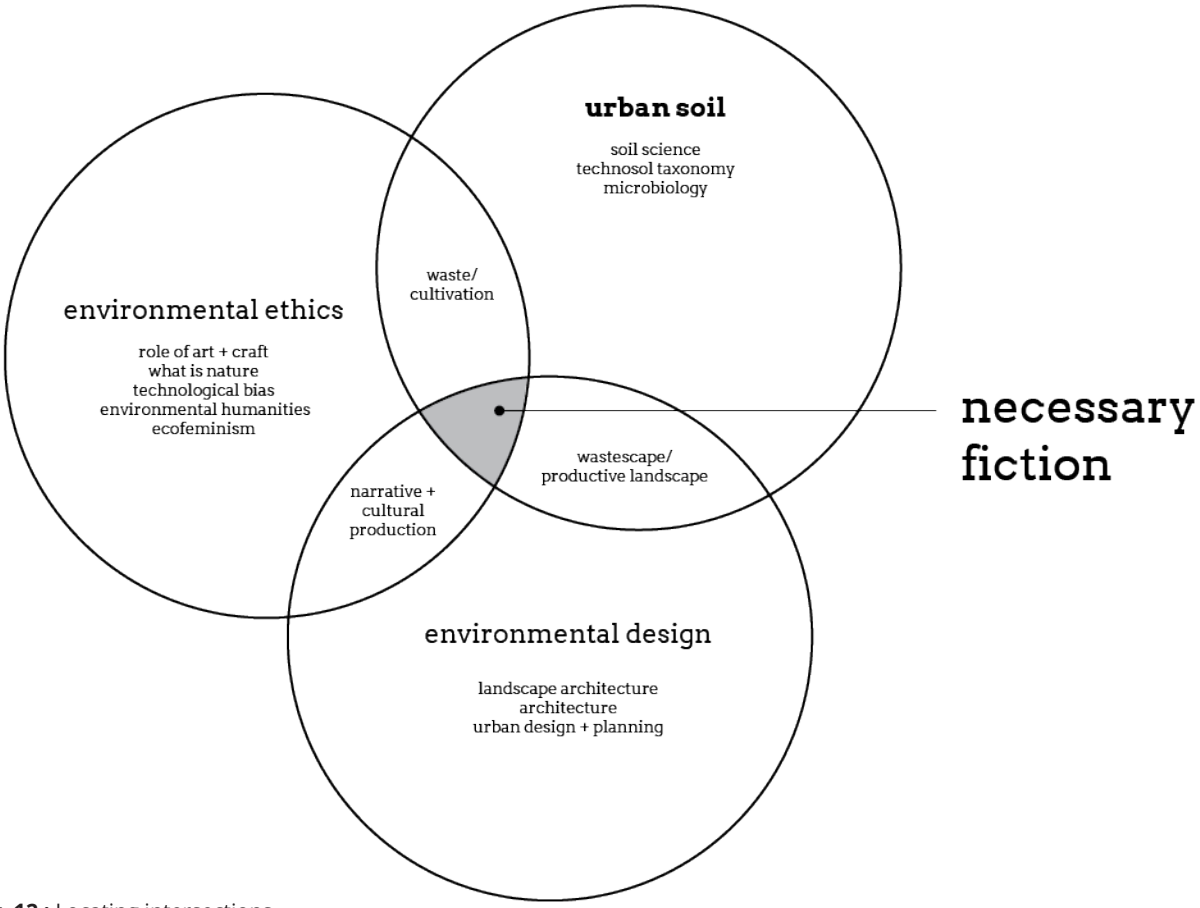


Fig. 12 : Locating intersections

wastescapes, productive landscapes and cultivation, narrative and cultural production— and find focus in creating necessary fiction to confront the destruction of topsoil and habitat as alternatives to inear technological processes of urbanization. Existing work in this area has set the foundation for practice-led experimentation to grow living soil's role and value in damaged urban places.

[Fiction as Necessity]

While design has responded to the current state of soils, a significant gap in work and research is imagining the future of urban soils. Engaging future – what could or should happen—is a product of narrative and ethics. As with other complex issues, a renewed interest in future-oriented design practices may be relevant to the technological and environmental dilemma posed by waste and urban soil. ***Fiction*** is a critical design practice permitting thought experimentation beyond immediate constraints. In a speculative practice, fiction provides a medium to imagine life on a damaged planet and test futures. "Necessary Fiction" is a term utilized by Potteiger and Purinton *In Landscape Narratives, Design Practices for Telling Stories* to describe both the restoration of wastelands and constructed conceptions of home. Both uses imply that fiction has a unique role in producing the built environment. Fiction can simultaneously reflect tangible realities but feed our imagination to reinforce, challenge, and shape lived experience.[78] Fiction becomes necessary when it makes the world habitable. The authors write:

We live within worlds of stories, and we use stories to shape those worlds. In history, fiction, lived experience, myth or anecdote, stories tell of origins, explain causes, mark the boundaries of what is knowable, and explore the territories beyond. As we remember, interpret, plan and dream through stories, they give form to the transience of experience.[79]

Fiction is a way of making-do with reality while creatively borrowing from past and possibility. As a novel approach to bringing fiction into practice, design fiction provides an approach to the production of narratives to shape storied worlds and confront the challenges presented by possible futures. Urban soils are a model for probable future soil ecosystems and earthly threats to biodiversity. Urban waste is a human-induced problem that threatens the inhabitability of our cities and our planet. What stories may start out on the important work of redefining ethics governing action towards less wasteful patterns of city-making? Can we think fictitiously about

waste to combat the earthen monsters of our own creation? How can fiction inform design for soil, and what meaningful, shapeshifting narratives can we tell about soil and waste scapes? The intersection of soil and fiction represents an exciting and exceptional opportunity for the inter-disciplinary field of urban design.

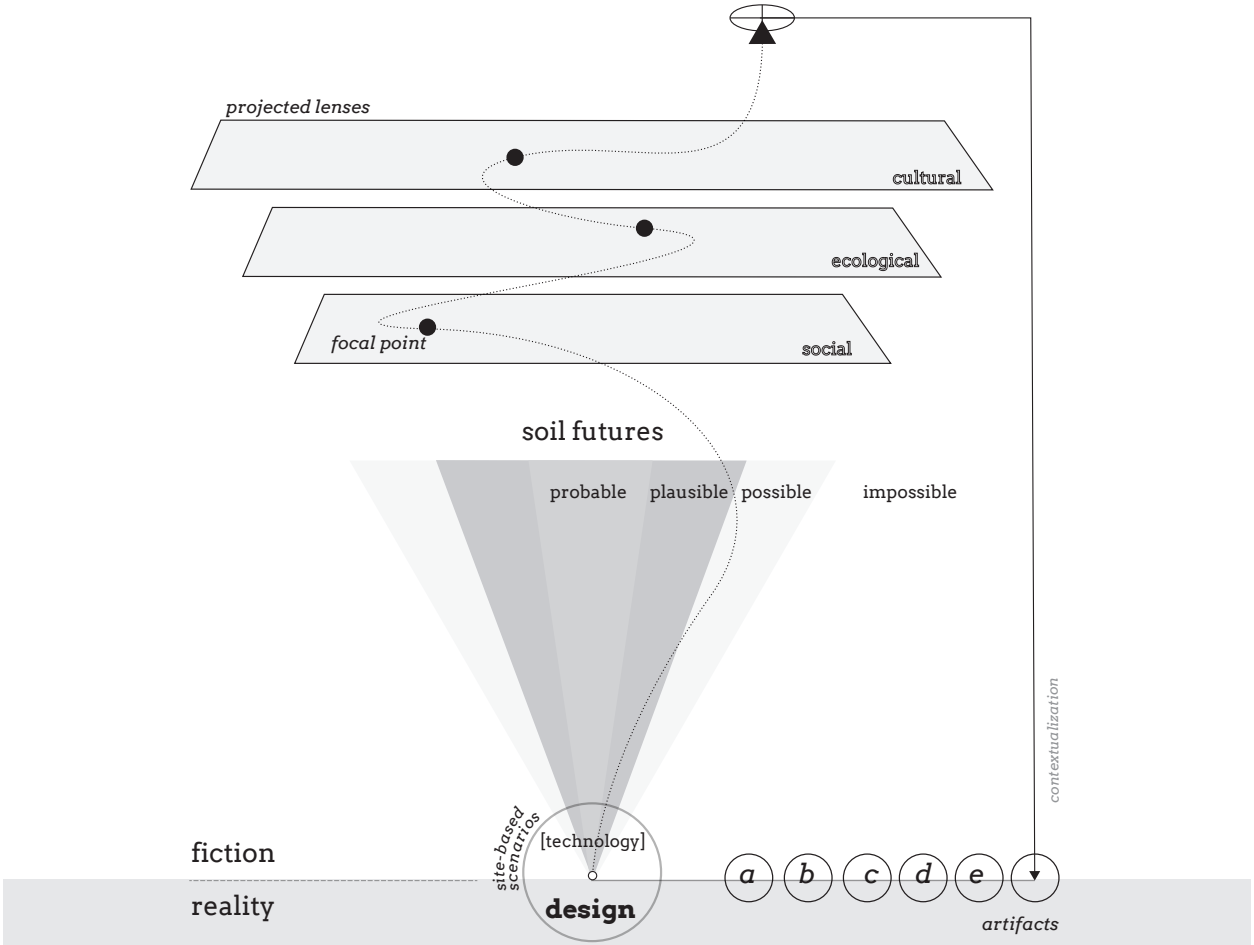


Fig. 13 : Mapping the speculation, redrawn and reinterpreted from the Extrapolation Factory, https://extrapolationfactory.com

conceptual framework

Urban soil forms a critical contact zone for creative intervention. In *Species Matters*, Donna Haraway extends linguist Mary Louise Pratts definition of a "contact zone," from *Imperialist Eyes*, to describe interactions between human and non-human subjects "constituted in and by their relations to each other," within radically asymmetrical power relationships.[80] She connects this concept of experiencing otherness to that of the ecotone, a place where edge effects contain "assemblages of biological species from outside their comfort zones," forming "interdigitating edges" rich with "ecological, evolutionary, and historical diversity." [81] As designers, a framework of entanglement is key to imagining what the space "where species meet" may look like, and how we may begin to reconcile difference by means of staying with the challenges. Haraway argues that life on this planet must respect and respond to companion binaries such as "animal/human, nature/culture, organic/technical, and wild/domestic," to advert mutual, and final destruction.[82] The project at hand imagines how urban life can get along with its hybrid realities, becoming with and belonging to one another within the cities left-over spaces.

Design fiction and speculative design provide overlapping and emerging approaches to making sense of complex interactions and their possible future consequences. As outlined by Anthony Dunne and Fiona Raby in "Speculative Everything," speculation is an opportunity to open up rigorously researched and informed alternatives to hegemonic beliefs and behaviors. Design for the future questions the present and imagines how things could be different-- avoiding simple, unified solutions to a better physical world. Assumptions are challenged and one of a million tiny, non-hierarchical utopias is presented.[83] Design fiction builds from a rich history in science fiction, defined by Bruce Sterling, as cited in speculative everything as "the deliberate use of diegetic[13] prototypes to suspend disbelief about change or "artifacts from the future." [84] In this thesis, a series of what-if scenarios are employed through physical and graphic artifacts

to engage Technosols. Everyday pools and exchanges of human and non-human wastes are visualized and augmented by experimental structures and devices operating between city and pedosphere. Fiction is researched, directed, and informed. The overall objective, consistent with Dunne and Raby's approach, is that design becomes a tool for critique, debate, and critical thinking about urban soil and cultivation.

Design in the framework of this thesis project is generative, ephemeral, performative and hands-on. The conditions of actual physical sites provide context for narratives aimed at raising questions and stimulating curiosity about urban soil, and opening possibilities for technologies that foster an ethic of multispecies flourishing. I've attempted to better understand the capacity for life in real and constructed soil through iterative prototyping and design. The synthesis of this work is a series of scalable apparatuses to manage and cultivate the urban terrain. Storytelling is dialectical, building with microbial others that dwell in Haraway's "historically situated multispecies compost."

relevant theory

Theory builds from posthuman feminism to explore non-man/human centered ontologies[85] and new materialism to embrace indeterminacy, flux, and "messiness" in the material primacy of production and reproduction of physical life.[86] Haraway argues that humans, animals, microbes and technologies have always formed hybrids and as only 10% of our cells contain the human genome, we have never really been entirely human and owe much to our tiny companion species - bacteria, protists and fungi.[87] In a chapter named "posthuman feminist theory" from the *Oxford handbook of Feminist Theory*, Braidotti examines how Haraway's posthuman condition discredits western dominated anthropocentric thinking and promotes a disruptive, critique of binaries such as nature/culture, human/machine, and male/female.[88] Although posthuman is an umbrella term capturing different movements and schools of thought, Haraway's thinking is distinct in blurring of distinctions between human and non-human, as outlined in Haraway's 1985 work, the *Cyborg Manifesto*. Here, where moving beyond human boundaries as a singular, historical focus on mankind opens up new possibilities for an "ecologically accountable, feminist, classless, sex-egalitarian, and anti-racist society."[89]

With a posthuman orientation, New Materialism embraces indeterminacy, flux, and "messiness" to restore agency to living and non-living, non-human things.[90],[91] As an evolution of Haraway's posthuman feminism, new materialism also opposes the transcendental and humanist (dualist) traditions setting man apart and above the rest of life and matter on earth.[92] Coined by Manuel DeLanda and Rosi Braidotti in the second half of the 1990's and espoused by scholar Karen Barad claims that "Matter feels, converses, suffers, desires, yearns and remembers."[93] In an article characterizing the nested scholarship of posthumanism and new materialism, Francesca Ferrando stresses the dissolution of binaries like science and culture—she emphasizes that biology is culturally mediated, and culture is materialistically

constructed.[94] Both of these points are relevant to a reconsideration of urban soil, to open up possibilities through a more imaginative framework than soil science alone can provide.

Together, feminist posthumanism and new materialism provide a theoretical basis in which human culture is constituted through interaction with nonhuman living and non-living others. This supports a foundation for human interaction with the microbial world through cultivation to form techno-cultural worlds of making. Through Haraway's concept of companion species, narratives of soil building to feed, cultivate and revive the urban soil matrix promise more than the production of agricultural products—they seek to dismantle hegemonic, capitalist systems starting with the tiniest urban inhabitants. New materialism represents an evolution of Assemblage Theory (Delueze and Guattari), a discourse that has clear linkages to urban design and processes of city making.[95] Manuel Delanda is a leading interpreter in the school of thought, describing wholes as insufficient in understanding aggregates dependent on connections and capacities versus individual properties. As in new materialism and post-human thought, assemblage is useful in establishing non-human agency and interpreting non-hierarchical relationships. In "The city as assemblage: dwelling and urban space" Geographer Colin McFarlane examines the concept in terms of the city to establish dwelling as a process and secondly, for conceiving the spatiality of the city as processual, relational, mobile, and unequal.[96] Architectural theorists Hesam Kamalipour and Nastaran Peimani place Deleuze and Guattari's concept of "Becomings" from *A Thousand Plateaus: Capitalism and Schizophrenia* (1987, 241–242)) within urban studies to describe a place for new, unfixed relations in city building processes. Urging urban process versus product, becomings provide a touchpoint for incrementality, temporality, and temporaility in the city. [97] This theoretic work provides fertile ground for scenario building and imagination about soil.

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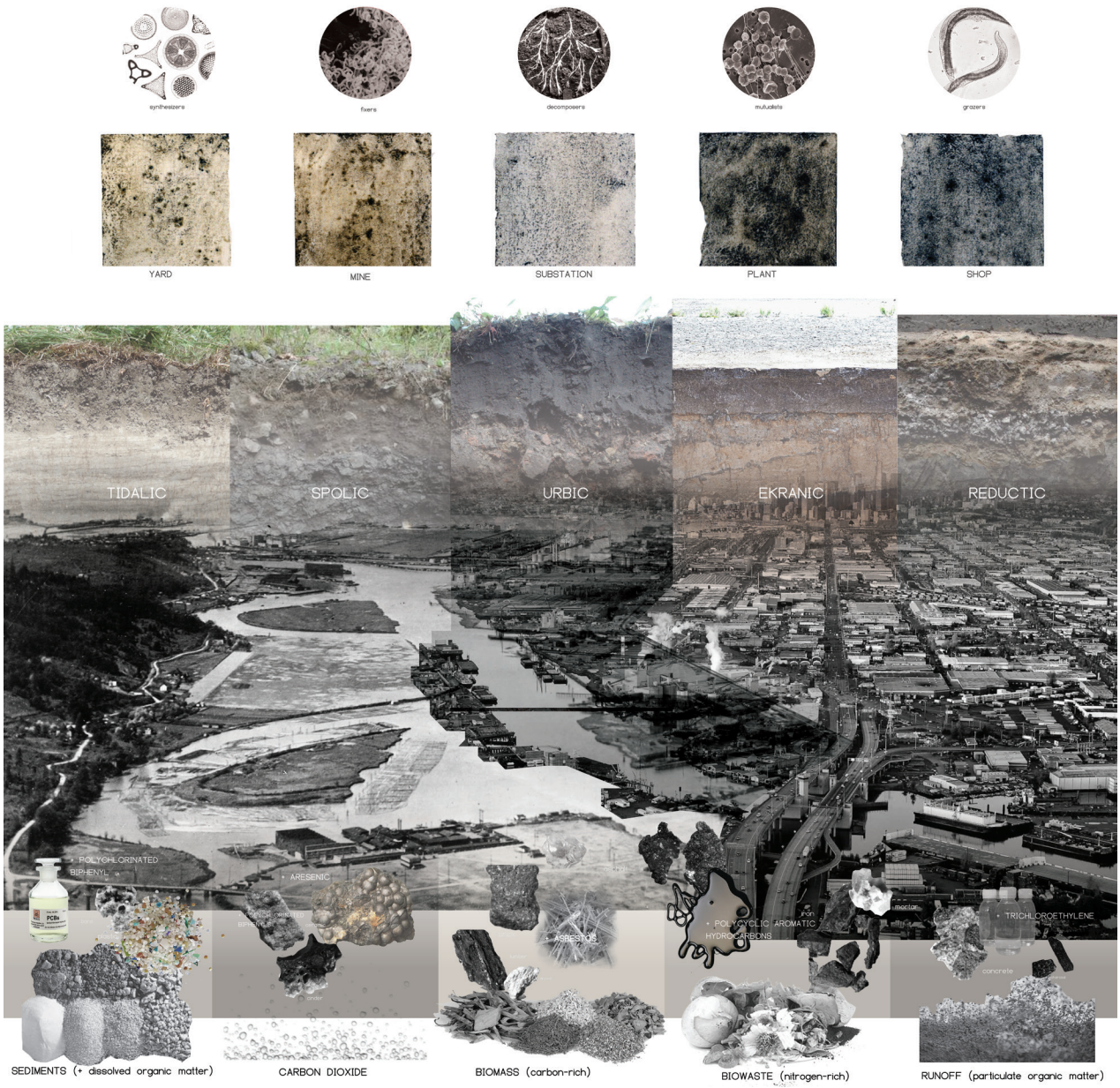
analysis + synthesis


synthesizers
fixers
decomposers
mutualists
grazers
YARD
MINE
SUBSTATION
PLANT
SHOP
TIDALIC
SPOLIC
URBIC
EKRANIC
REDUCTIC
+ POLYCHLORINATED BIPHENYL
+ ARSENIC
+ ASBESTOS
+ POLYCYCLIC AROMATIC HYDROCARBONS
+ TRICHLOROETHYLENE
concrete
SEDIMENTS (+ dissolved organic matter)
CARBON DIOXIDE
BIOMASS (carbon-rich)
BIOWASTE (nitrogen-rich)
RUNOFF (particulate organic matter)

connecting ideas, tools + practices

Mixed methods were utilized in the synthesis the of five speculative proposals introduced in the 3rd and final section of the thesis project. A series of studies aim to ground this speculation in reality. Each study seeks to understanding what aspects of technosols are most important, employing the best approach at hand. A preliminary study and analysis of 5 sites locate the project and introduce real-world constraints to ground the fiction. Digital art was used to breakdown nomenclature and gain a tacit understanding of the capacity for life in constructed soils. A historical timeline was used to grasp the key attributes of disturbed soils their regeneration, and regional relationships between humans and soil over time. Finally, the hands-on construction of prototypes and apparatuses map a fictional symbiotic material world across soil horizons.

study I. SITES > situated soil futures

study II. PROCESSES > making ground

study III. NOMENCLATURE > synthesizing soil

study IV. AGENTS + APPARATUSES > prototypes for preferable futures

Fig. 14 (left): Connecting waste, landscape, soil types, and actors


ELEVEN

study I. SITES – *situated soil futures*

Technology accidentally produced Seattle's industrial soil types –an examination of the consequences of industrial waste may indicate how can technology in the built environment can build future soils intentionally. If the science fiction concept of terraforming could be applied to these damaged sites, what sort of conditions may help or hinder the process? Mapping sites within the urban watershed elucidates new connections between soil and culture.

site selection>> Five sites from the State of Washington department of ecology designated brownfields were selected based on varied **contamination levels** (highest, high, medium, low, none); their ranking from Megan Horst's **"Growing Green"** (2008) study summarizing the criteria for urban gardening (high, medium, low); **historical or cultural relevance** of past industrial and/or agricultural use; and finally, **geological classification** city soil layer to select (Qvt/ hardpan, Qvrl, Qal, Qw, m/fill).

analysis >> Methods in mapping begin to connect disassociated sites within the urbanized watershed through the evolution of soil type from geological parent materials – river sediment, glacial till, peat and volcanic sands. Sites are connected by overlapping geologic material and man-made open space boundaries – the designation of pubic greenway, gardens and surplus sites.

Fig. 15 (left from top to bottom): Site photographs - yard, mine, plant, substation, and shop

findings>> The past is present in the material makings of each site—the limits of human alteration can be traced, river bends inscribed, and the movement of water represent a force superseding human influence. The five sites become places to practice living on a damaged planet—toxic impurities in an ailing but dynamic landscape. Mapping suggests that the ingredients for repair reside within the watershed itself across layers of change through time. Most importantly, unknown "terrain vagues" isolated by surface maps seamlessly belong to the greater geology, with a specific role and function within a more-than-human landscape. In conclusion, a geological map of the watershed supports urban imaginaries to underpin more-than-human forms and functions.

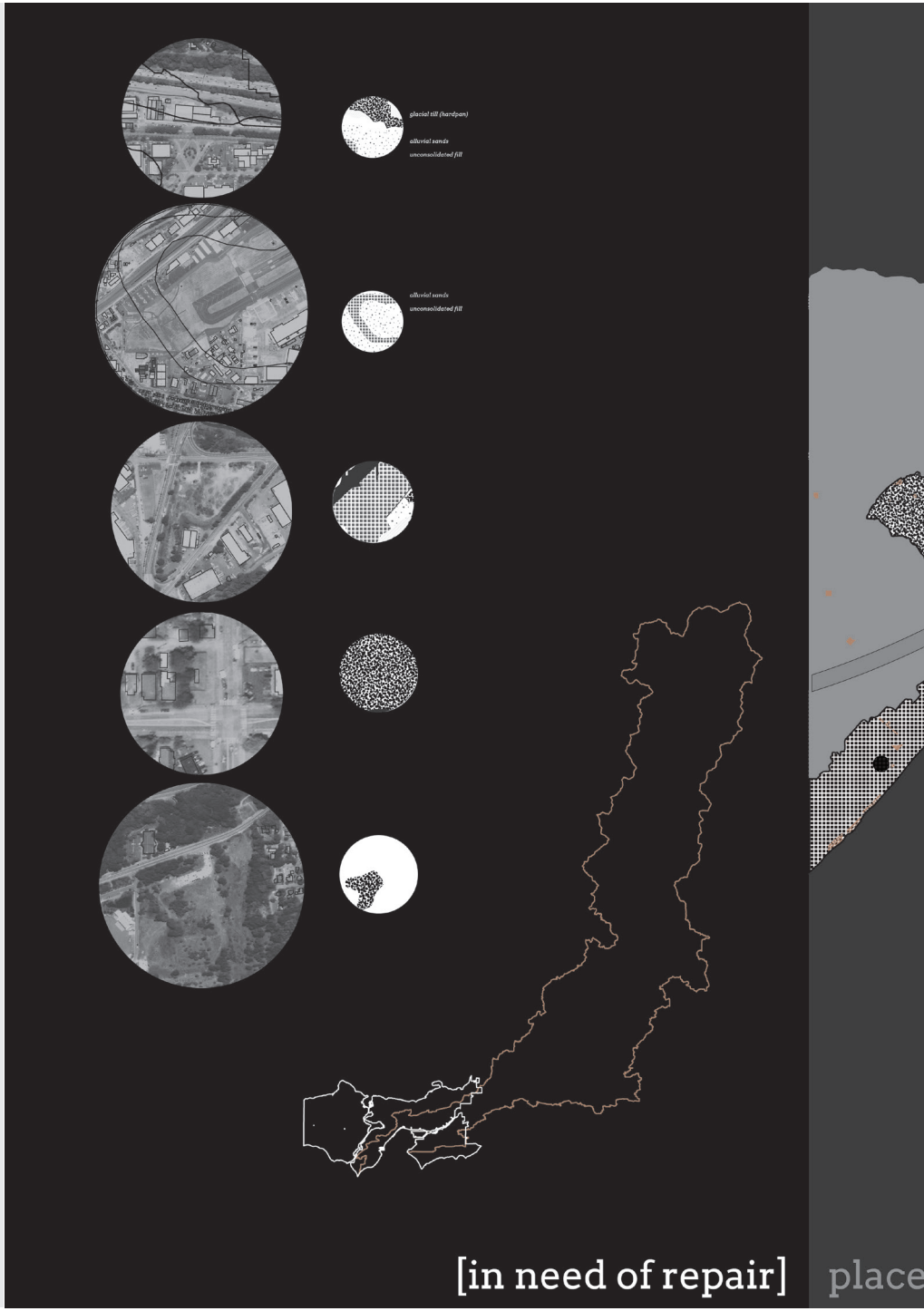
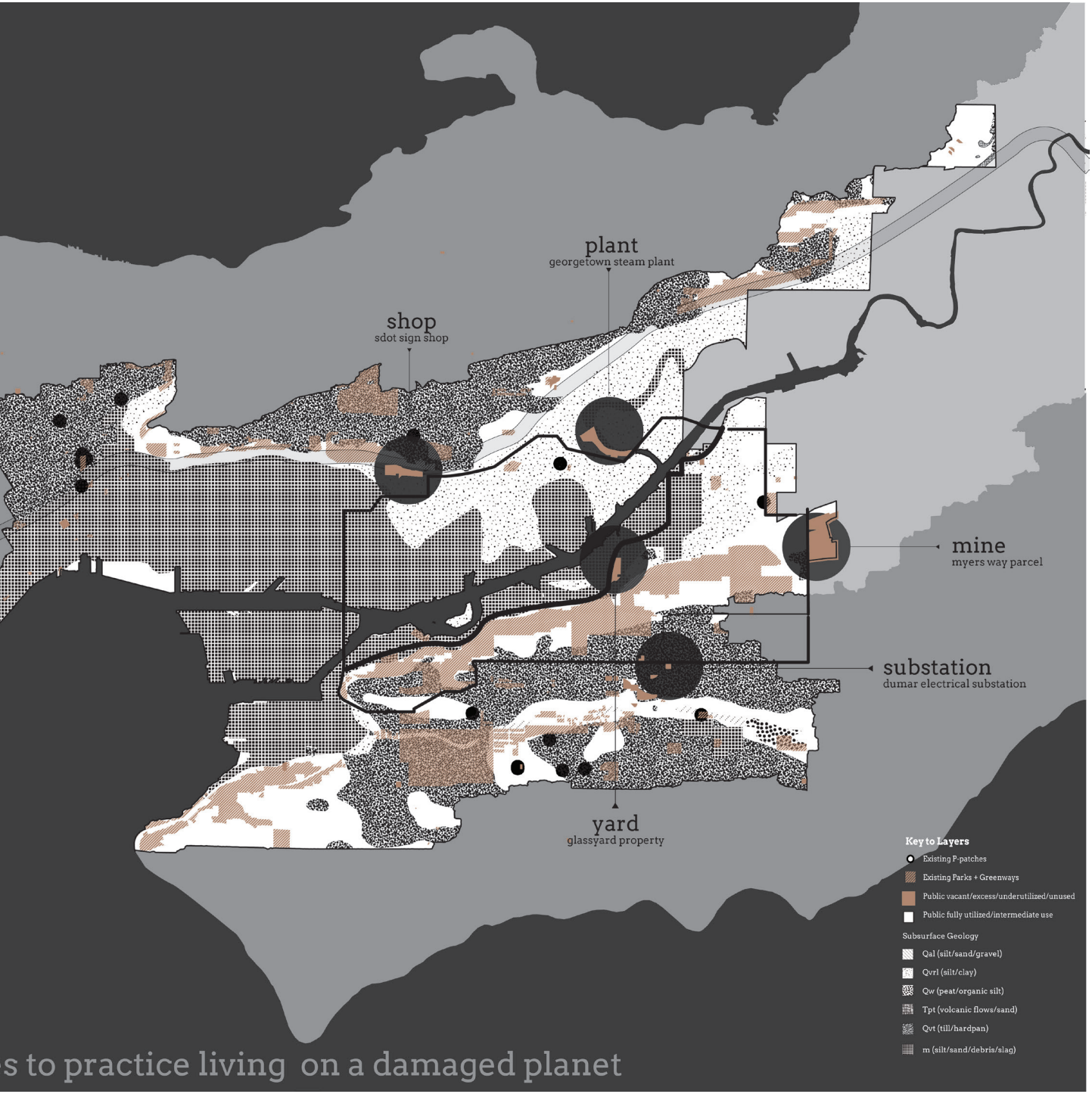


Fig. 16: SIte analysis mapping geology, political boundaries, and open space



s to practice living on a damaged planet

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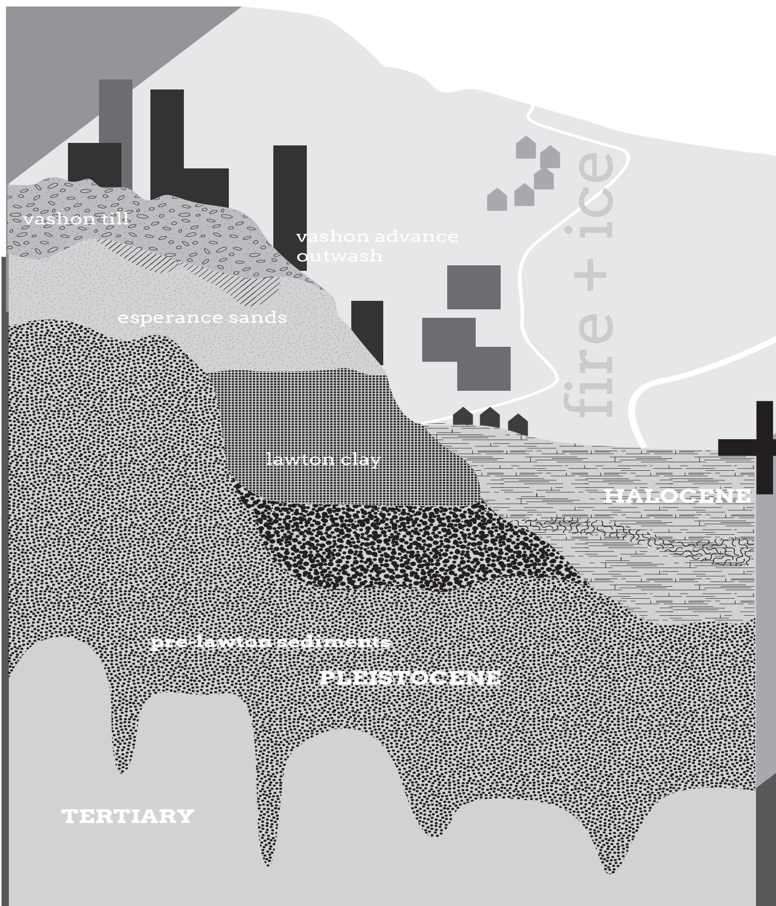
making ground

andisols, entisols — inceptisols, histosols — anthrosols — technosols

fig. a: geological time



hill cross-section

fig. a: **Ideal hillslope**, *from: Johannessen and MacLennan. "Beaches and bluffs of Puget Sound." (2007).*

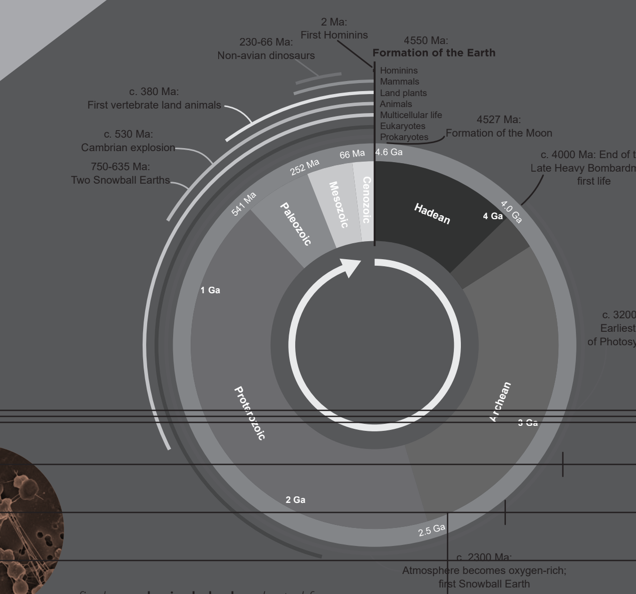
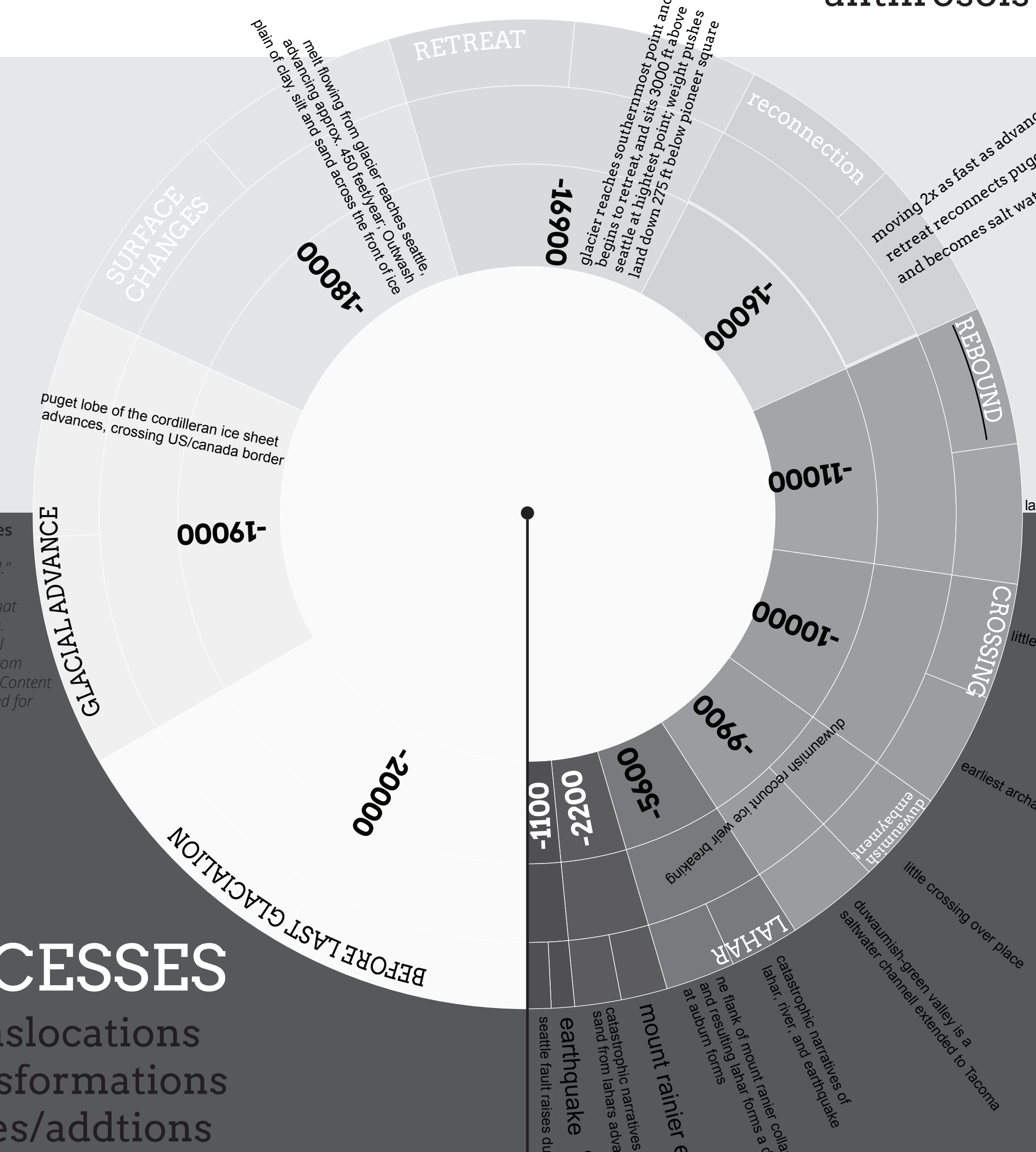


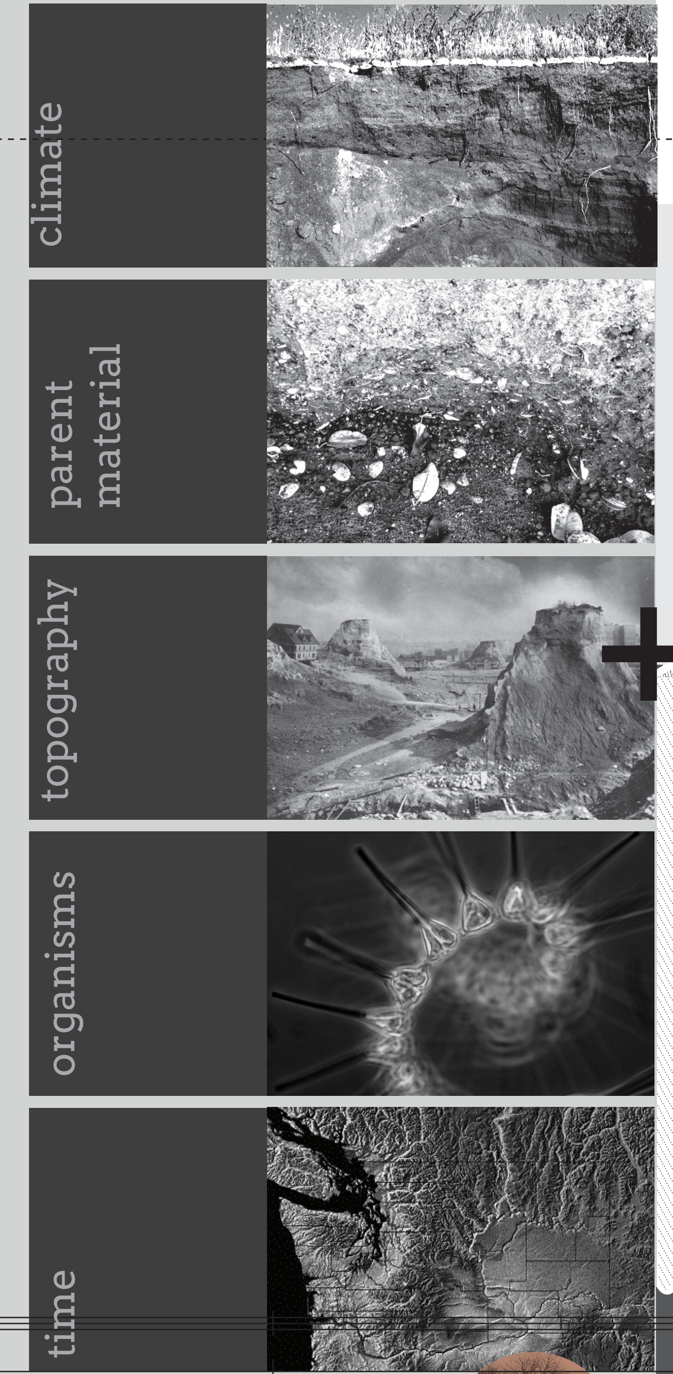
fig. b: **geological clock**, *adapted from: https://commons.wikimedia.org*

fig. c: **glaciation stories** *content from: "20,000 Years in Puget Sound." From glaciers to volcanoes to earthquakes, witness the processes that have shaped the Puget Sound landscape. (YouTube). Production by Amir Sheikh. Model developed by Ralph Haugerud with assistance from Harvey Greenberg. Edit and titles by Britta Johnson. Content assistance by Brian Atwater. Courtesy of WSDOT. Created for*



PROCESSES

translocations
/transformations
losses/addtions



FACTORS

COMPOSITION

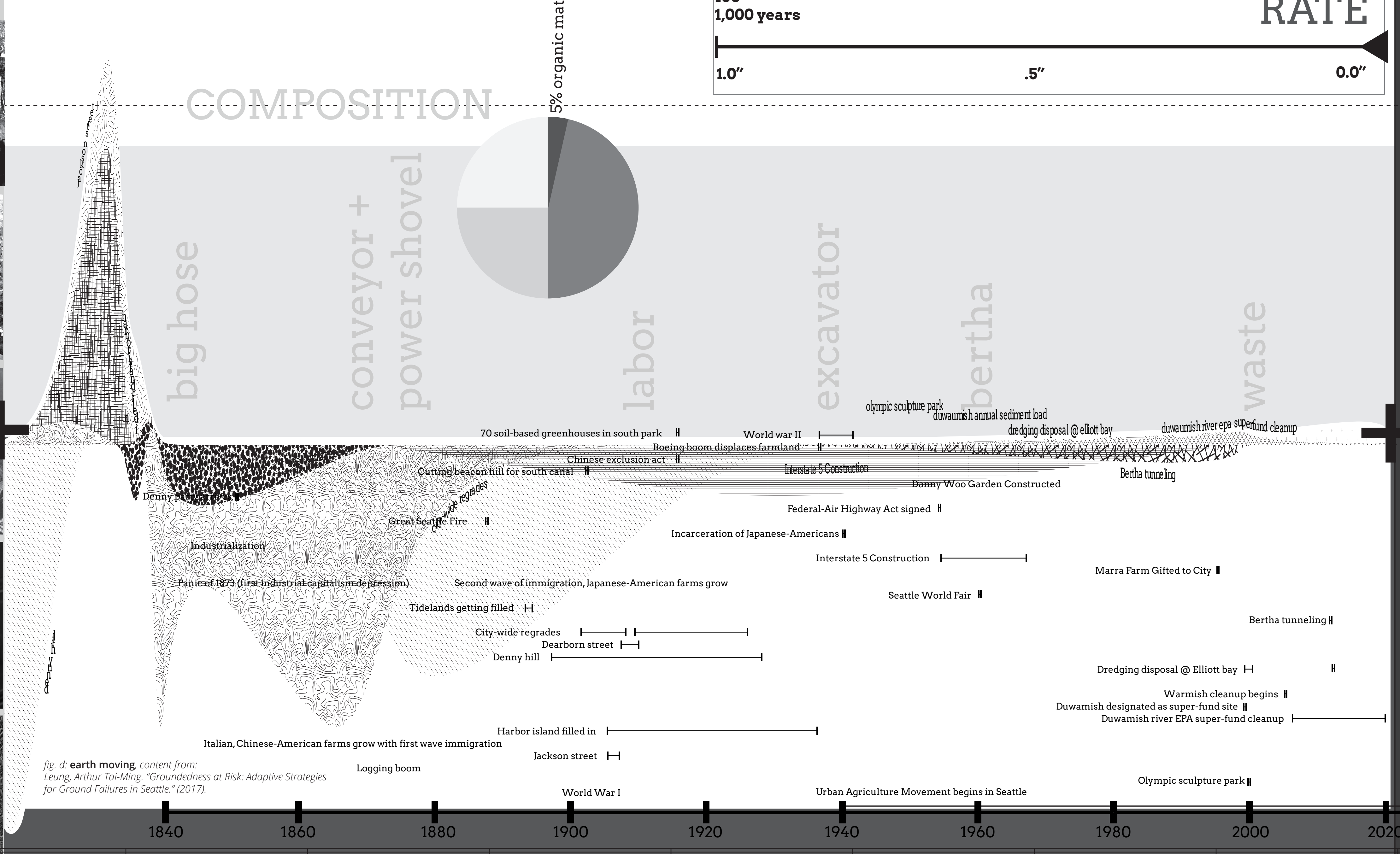


fig. d: **earth moving**, *content from: Leung, Arthur Tai-Ming. "Groundedness at Risk: Adaptive Strategies for Ground Failures in Seattle." (2017).*

RATE

100-
1,000 years

1.0" — .5" — 0.0"

20 years
200 hundred
20 thousand
66 million
4.543 billion

technosols

principal qualifiers	supplementary qualifiers
Ekranic Linic Urbic Spolic Garbic Isolatic Leptic Subaquatic Reductic Hyperskeletic	Alcalic/ Dystric/ Eutric Andic Anthraquic/ Irragric/ Hortic/ Plaggic/ Pretic/ Terric Archaic Arenic/ Clayic/ Loamic/ Siltic Aridic Calcic Cambic Carbonic Densic Dolomitic/ Calcaric Drainic Fluvic Folic/ Histic Gleyic Gypsic Gypsiric Humic/ Ochric Hyperartefactic Immissic Laxic Lignic Mollic/ Umbric Novic Oxyaquic Raptic Relocatic Salic Sideralic Skeletic Sodic Protospodic Stagnic Sulfidic Tephric Thionic Toxic Transportic Vitric

Isolatic (il) (from Italian isola, island): having, above technic hard material, above a geomembrane or above a continuous layer of artefacts starting ≤ 100 cm from the soil surface, soil material containing fine earth without any contact to other soil material containing fine earth (e.g. soils on roofs or in pots).

Ekranic (ek) (from French écran, shield): having technic hard material starting ≤ 5 cm from the soil surface (in Technosols only).

Linic (lc) (from Latin linea, line): having a continuous, very slowly permeable to impermeable constructed geomembrane of any thickness starting ≤ 100 cm from the soil surface (1).

Spolic (sp) (from Latin spoliare, to exploit): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) artefacts containing ≥ 35% (by volume) industrial waste (mine spoil, dredgings, slag, ash, rubble, etc.) (in Technosols only) (2).

Garbic (ga) (from English garbage): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) artefacts containing ≥35% (by volume) organic waste (in Technosols only) (2).

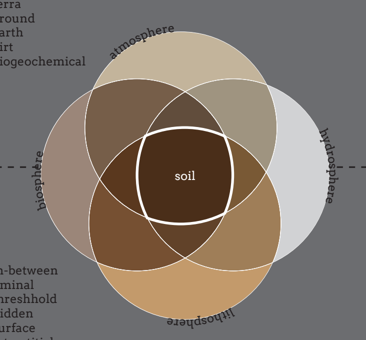
Urbic (ub) (from Latin urbs, city): having a layer ≥ 20 cm thick, within ≤ 100 cm of the soil surface, with ≥ 20% (by volume, weighted average) artefacts containing ≥ 35% (by volume) rubble and refuse of human settlements (in Technosols only) (2).

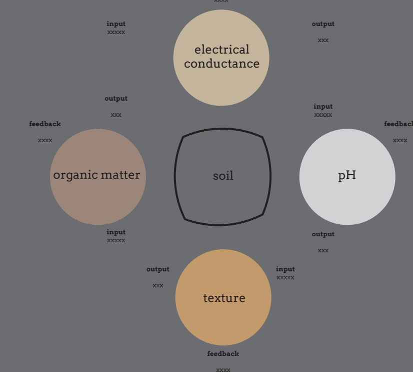
Hyperskeletic (jk) (from Greek hyper, over, and skeletos, dried out): having < 20% (by volume) fine earth, averaged over a depth of 75 cm from the soil surface or to continuous rock, technic hard material or a cemented or indurated layer starting >25 cm from the soil surface, whichever is shallower.

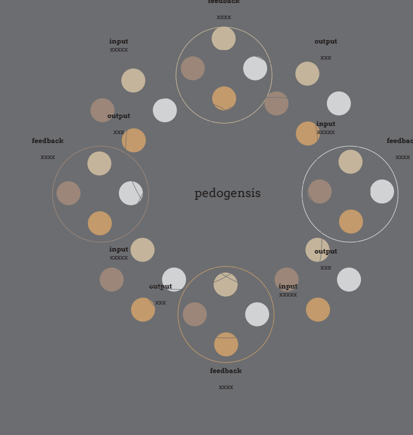
Reductic (rd) (from Latin reductus, drawn back): having reducing conditions in ≥ 25% of the volume of the fine earth within 100 cm of the soil surface, caused by gaseous emissions, e.g. methane or carbon dioxide, or caused by liquid intrusions other than water, e.g. gasoline (5).

fig. e: **technosols**, *content from: FAO of the United, Nations. "World Reference Base for Soil Resources, 2006 : A Framework for International Classification, Correlation and Communication*

- moisture
- structure
- organic matter
- temperature
- nutrients







KEY ATTRIBUTES + METRICS

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study II. PROCESS – *making ground*

While maps situate soil in space, a historical timeline functions to place soil in historical development of the city. It spans geological time to connects existing qualities of soils to ancient climatic events, tribal storytelling, agricultural modulation, microbial transformation and industrialization toward a common unknown trajectory. Painting a picture of soil history is important in framing the future development of urban soils. The timeline focuses on the dynamic milieu of actors and apparatuses embodied by soil development.

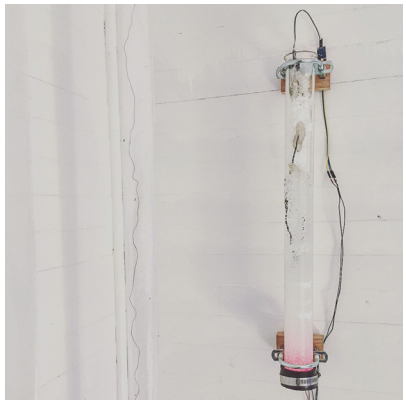
analysis and findings >> The timeline illustrates the confluence of time, organisms, topography, parent material, and climate in the making and unmaking of urban soil types. On a scale of geologic times, non-human organisms—algae, archaea, bacteria, fungus, and microfauna prove to be extremely long-lived, well adapted actors in the formation of soil. This grounds the concept of the posthuman in reality, to decenter humans the study of soil systems in framing the creative project.

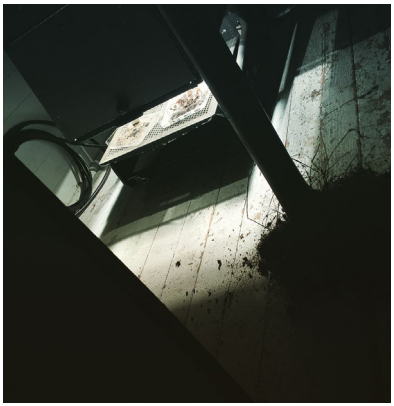
The timeline begins with a typical hillslope cross section showing the geological parent materials from which soils in the urbanized Duwamish weather through processes of translocation, transformation, loss and addition. Time becomes material in the section, as deposits from the Pleistocene era (ending 11,700 years ago) and the earlier tertiary period (ending 2.6 million years ago) marked in section.[1]

Since the 1850s, Seattle’s landscape has experienced extreme topographical modulation by European-Americans and industrialization, which can be quantified as individual events.[2] A graph of the cut and fill shows the biggest modifications of surface occurred more than 100 years ago, begging the question of what has developed of these highly disturbed soils since. Dialing back the clock 10,000 years, major topographic change caused by lahar and climatic events dwarf human alteration. Looking back just 20,000 years, the valley is drastically altered and buried by glacial advance, retreat, and rebound.[3] The Coast Salish people have stories that tell this history[4] through a mythology of earth spirits describing the movement of ground along the Seattle fault and through the Duwamish valley— double headed serpent spirits known as

an a'yahos [5] were associated with shaking from both land and sea. The connections between oral history and geological events set a precedent for the use of narrative to relate daily urban experience and soil qualities.

conclusion >> The visualization ends with an orientation towards the future and a list of "technosol" definitions from the world reference base for soils. These qualifiers are relevant to finding a way forward from the current state of urban soils, beginning with a more complete understanding of urban soils and their composition. How will soils weathered from bricks and mortar or concrete develop over time? Similarly, how can isolated rooftop and container soils function to support microscopic food webs, ultimately supporting broader ecosystems? A historical analysis of urban soils presents more questions than answers, functioning to open up soil storylines and locate possibilities in an easily overlooked part of the city.





study III. NOMENCLATURE > *synthesizing soil*

Art provided a critical engagement with the new definitions for urban soil types from the World Reference Base for Soil Resources (WRB). *Growing Home/Towards Biotechnosols* (2018-19) was installed twice in the production of this thesis project to engage public audiences in speculative aspects of soil building and cultivation. The first installation was May 2018 at the Grocery Studios in South Beacon Hill (pictured here at left and below) as part of a group exhibition, "Machines of Becoming." The second installation was May 2019 in the Gould Hall Gallery.

Analysis>> For the first of the two installations, samples were collected from each of the actual sites, cultured, and projected alongside a series of future soil samples to explore each site's capacity to sustain life. The work invited viewers to interact with the constructed samples, taking readings by placing a hand on the capacitive surface of the sample tubes. This would generate a responsive pitch mapping soil conductivity, a broad indication of soil productivity (see figure 8). Technic definitions from the WRB were described in literature displayed at the event and each soil sample represented a progression from 5 different unique qualifiers: tidalic, spolic, urbic, ekranic, and reductic. These five qualifiers were chosen as they best described the soil present at each of the 5 original sample locations—the yard, mine, substation, plant, and shop.

Fig.17 (left): ***Growing Home/Towards Biotechnosols*** as installed spring 2018
Fig.18 (below): Tuning, testing, and building the soil samples

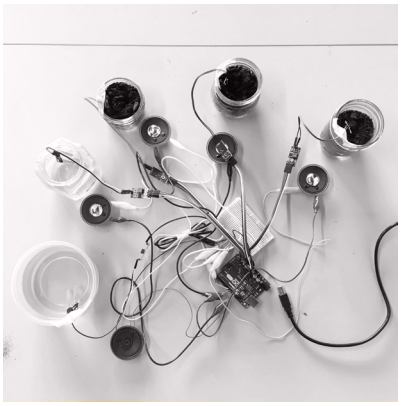


Fig. 19: ***Growing Home/Towards Biotechnosols*** as installed spring 2018

The second installation focused on the biological aspect of soil development, incorporating invented nomenclature for each sample to provide ground for future soil imaginaries. "Biotechnosol" is a term coined by a consortium of French soil biologists studying the biodiversity and function of constructed soils in post-industrial brownfields.[6] Suggesting a new soil order, the expression recognizes the role of soil biota as essential actors in "technosols,"[7] or, soils named for and dominated by artificial materials and urban wastes.

In both installations, the samples function as diegetic prototypes referencing a fictional world of soil building. The samples ask the audience to evaluate and discuss the merits or consequences of novel soil building. The process of naming and categorization also brings into question the technologies producing each distinct soil type, and what technologies may produce new soil types. Furthermore, the ground for fiction is produced by this material engagement with the artificial nature of urban soils

Conclusion>> *Growing Home/Towards Biotechnosols* functioned within the broader context of the thesis project in several important ways. First, it developed the project scope, grounding the work in the conceptual aspects of nomenclature and naming. This surfaced as an important aspect of the work during a search for information on the areas soil types—Seattle's soils are categorized in municipal and statewide databases as "Urban Soils" lacking distinction in origin, history, character and quality across the city. The artwork and thesis project function as a response to the void created by unnamed soils.

Second, art was used as research to answer the open-ended question of "what type of soils may develop from technosols?" Such a question may be answered in traditional science, but artistic investigation functions to locate and synthesize important, related questions—for instance, who are the actors, what are the processes, and what if the humans conceptually reinserted themselves in everyday processes of soil-making?

Lastly, art functioned as a point of public engagement in the overall thesis project. The role of dissemination, discussion, and storytelling is fundamental to design fiction and its function. Art became a tool in this way, providing an immersive experience of alternative realities.

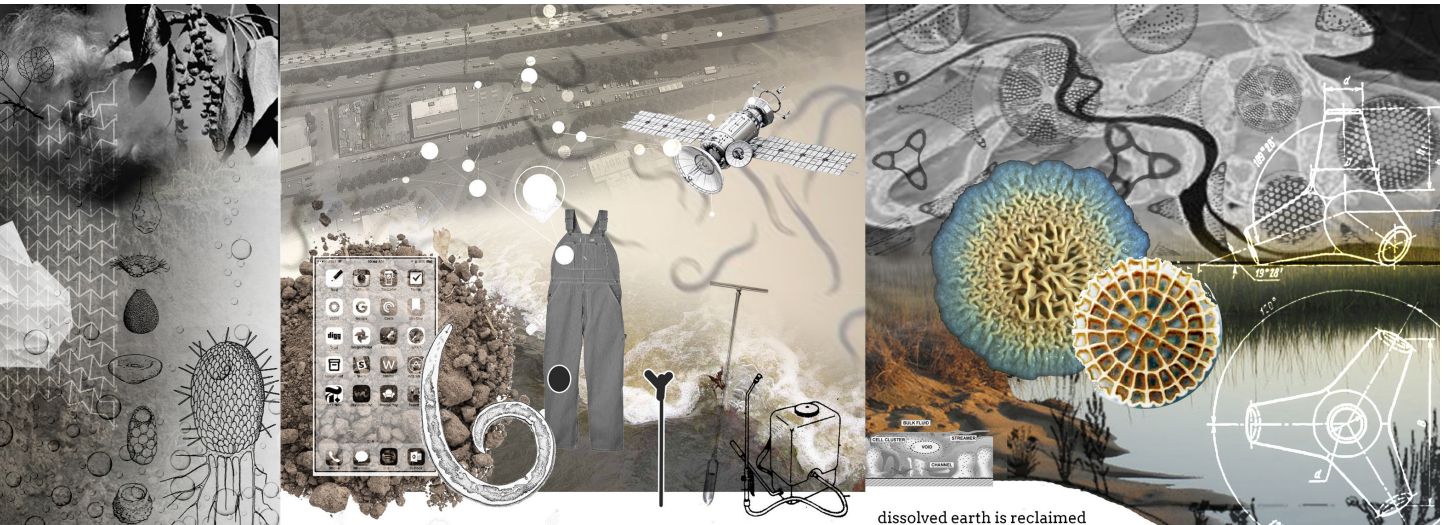
together process	soil microbiota	drawing us together	holding distance	co-benefit
CONVERT	SYNTHESIZERS: **algae,** diatoms, cyanobacteria	convert dissolved carbon* into possible biofuels and **precipitate** useful materials	form slimy biofilms	Persistant organic pollutants like PCBS are *accumulated* and extracted with algae **
SEQUESTER	DECOMPOSERS: **actinomyces**, protists	consume CO2, decaying plants, decaying matter - emissions + **sequestered carbon** in cellulose materials	geosmin, producing earthy smell + associations	Heavy metals such as lead/arsenic are *phytostabilized* by pioneering alnus and *hyperaccumulated* by black cottonwood; Bacteria supports rhizosphere health to help absorb toxins (Roy et. al., 2007)
TRANSFORM	SHREDDERS: **saprophytic fungi**	recycle the dead- **convert biomass** waste (lignocellulosic) into usable materials	distaste for aesthetics of decay	Aspestos *immobilized* in the fungi, petrochemicals *degraded* by fungi
PROCESS	MUTUALISTS: bacteriodetes, **methanogens**, nitrosomas, psuedonomas	the consumption of organic excreta; valuable, pre-digested material and nutrients (N,P) to support other soil life, syntrophy or **cross-feeding**	some are pathogens	PAHs *adsorbed* by organic matter, and *degraded* in environments where microorganisms live and *metabolize* contaminates; anaerobic enviroments are possible sites for removal (Cea-Barcia et al., 2013)
LINK	FEEDERS: beneficial **nematodes**- plant grazers, bacterial grazers, and predators	thrive in an abundance of organic matter and carbon-rich litter (biochar?), acting as a water quality and **micro-environment indicator** (Ingham)	some are pests	nematodes are excellent *bioindicators* of multiple toxins, including TCE which can be located and *phytovolatized* by plants

Fig. 20 (above): Charting an entanglement
Fig. 21 (below): A series of conceptual collages used to develop apparatus prototypes

study IV. AGENTS + APPARATUSES >> *prototypes for preferable futures*

To build speculation from the soil samples, a series of apparatuses were constructed to support the imaginative makings of novel soil types. As open prototypes, each apparatus builds from existing soil processes and attributes, to catalyze microbial interactions growing topsoil. Rather than function independently as architecture, each apparatus builds unique material assemblies collaboratively with microbial agents to structure, aerate, pile, print, and surface imaginary horizons of urban soil.

Mapping the fiction>> Connections between humans and soil microbiota were charted to understand relationships between the primary actors in soil building. Aspects drawing us together and holding distance were considered, as well as the potential co-benefits of collaboration in soil making (see figure 22). Storytelling devices were considered thereafter, developing character, conflict and plot through writing exercises to situate the entanglement



res
gulate soil respiration

NEMATODE TALK *a network of wearable and environmental devices connect human and nematode to build and monitor community wellbeing*

dissolved earth is reclaimed
through artifical marshlands formed
by dredge-block sills seeded with diatoms

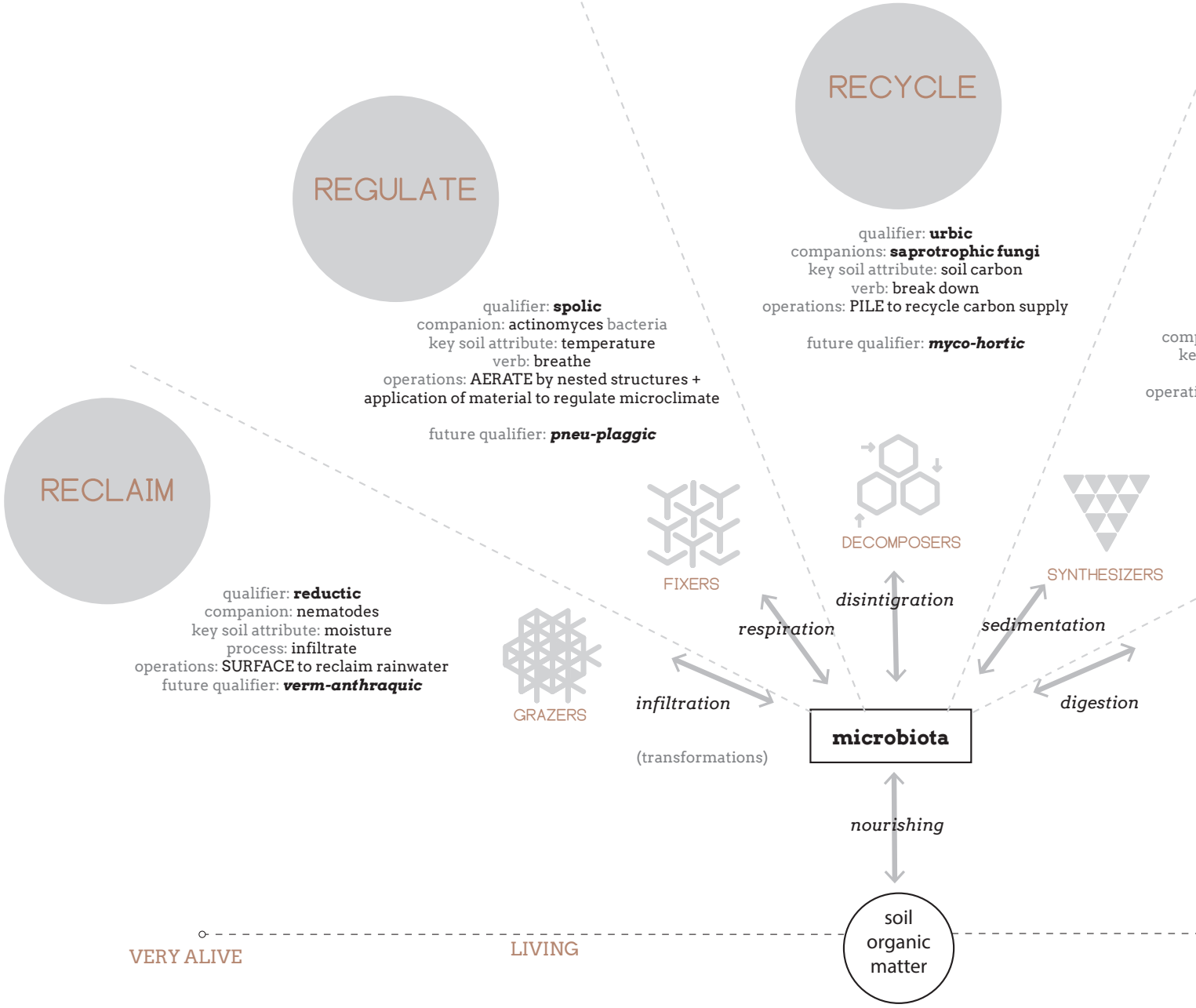
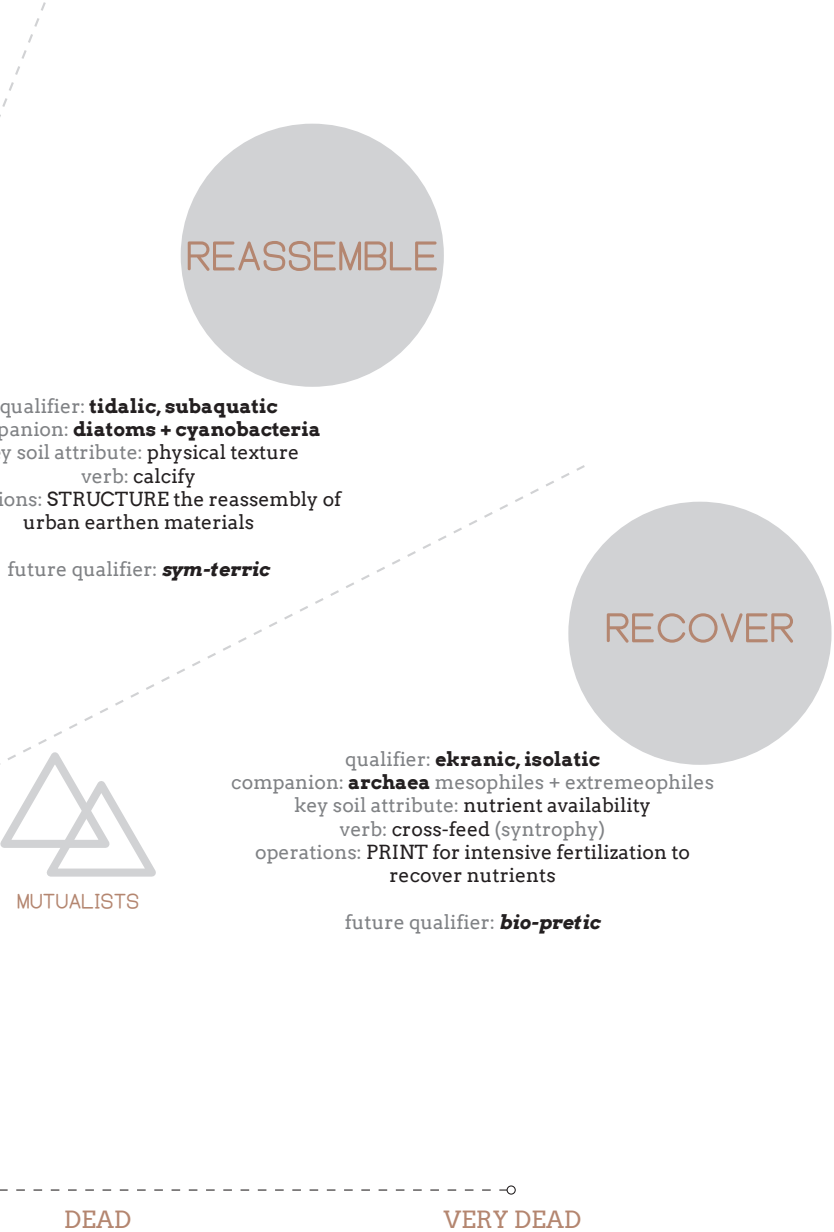


Fig. 22: Mapping a narrative



parallel to lived experience and produce a compelling narrative.

Outcome>> Emerging from this groundwork, a series of devices for soil improvement developed though drawing, collage, writing, and modeling. The protypes respond to the most critical aspects of soils identified in literature review, historical research, and site analysis to build soil biota abundance and diversity. Key soil attributes affecting this aspect of soil health were a focus of intervention, focusing on the perpetual integration of organic waste residuals into the urban soil matrix. Structures responding to and modifying soil pH, temperature, carbon, nutrients, and moisture were envisioned to augment, mediate, accumulate, move, and connect material assemblies within post-industrial wastescapes to nourish, enhance and encourage soil life.

summary

Instead of reporting original findings, the creative project performs research to synthesize material, and stitch together known information. This is the product of this thesis—"soilcraft" describes both a process for the hands-on production of design fiction, and a world crafted from speculative proposals for constructed soil types and their related apparatuses.

In this research, literature, history, soil science and art work in tandem to knit a storyline across the rapidly expanding topic of urban soil. While the science is foundational, history and oral tradition supports scenario building by demonstrating perpetual more-than-human forces in soil formation. Intuitive process of art making function to leverage associative thinking in the service of new creative possibilities - such as the integration of geotextiles, nematode bioindicators and the internet of things. Working across digital and hands-on modes of production also worked to produce a intricate but tangible narrative.

Overall, design does not bring resolution to the topic but rather opens it up and provoke further inquiry. One of the most significant discoveries made through analysis and synthesis of material is the value of maintaining complexity in design. What was most important in the process of soilcraft was that the audience was even talking about soil at all— the topic managed to invoke curiosity and spark wonder. This can be connected back to the three-part process outlined in the first part of the thesis— frame discussion, show stories, and shift technology— to understand storytelling as more than an educational device in design. Storytelling is a means to compel an audience or group of stakeholders towards care and consideration. Stories make people feel things and that matters.

endnotes

-

1 Jim Johannessen, *Beaches and Bluffs of Puget Sound*, ed. Andrea MacLennan, District United States. Army. Corps of Engineers. Seattle, and Partnership Puget Sound Nearshore (Seattle, Wash.]: Seattle, Wash. : Seattle District, U.S. Army Corps of Engineers, 2007).

2 Arthur Tai-Ming Leung, "Groundedness at Risk: Adaptive Strategies for Ground Failures in Seattle" (Harvard University Graduate School of Design, 2017). Citing information from: United States Environmental Protection Agency (EPA) Region 10, "Proposed Plan:Lower Duwamish Waterway Superfund Site" (February 28, 2013) and Washington State Department of Transportation, 2016, http://www.wsdot.wa.gov/Projects/Viaduct/Faqs.

3 20,000 Years in Puget Sound From glaciers to volcanoes to earthquakes, witness the processes that have shaped the Puget Sound landscape. (YouTube). Production by Amir Sheikh. Model developed by Ralph Haugerud with assistance from Harvey Greenberg. Edit and titles by Britta Johnson. Content assistance by Brian Atwater. Courtesy of WSDOT. Created for Milepost 31.

4 Coll Thrush, *Native Seattle Histories from the Crossing-over Place*, ed. Coll-Peter Thrush, Native Seattle (Seattle: Seattle : University of Washington Press, 2014).

5 R. S. Ludwin et al., "Serpent Spirit-Power Stories Along the Seattle Fault," *Seismological Research Letters* 76, no. 4 (2005).

6 Cortet, J. et. al.. "The BIOTECHNOSOL Project: Biological Dynamics and Functioning of a Constructed Technosol at the Field Scale." Proceedings of the 19th World Congress of Soil Science: Soil Solutions for a Changing World, Brisbane, Australia, 1-6 August 2010. Working Group 3.3 Soils in Urban and Industrial Areas, 2010, 64-65.

7 Food Agriculture Organization of the United Nations. World Reference Base for Soil Resources, 2006: A Framework for International Classification, Correlation and Communication. 2006 ed. World Soil Resources Reports; 103. Rome: Food and Agriculture Organization of the United Nations, 2006.

[SHIFT]

building soil fiction

design for diegesis

A diegetic prototype is device frequently used in film and science fiction to suspends disbelief and evaluate the benefits and consequences of a technology or object that doesn't yet exists. It is a way of showing, not telling stories. To facilitate the diegesis or, the presentation of that which occurs within the world of the story, an operations and maintenance manual describing care for damaged soils presents an alternative to current urban soil realities and relationships. As a speculative design artefact, it proposes five constructed soil types and their related soil-building apparatuses. The work crosses scale to connect microscopic processes to urban form and encourage a reassembly of material values.

[note: for best viewing results switch to “single page view”]

operations

+

maintenance

for the cultivation of damaged soils

HOW TO USE THIS MANUAL

This is an operations manual providing guidance towards the productive and beneficial function of soil-human assemblages. Motivated by the transformation of waste by soil, an urban insurgency has coalesced to reclaim and revive exploited soils. To subvert the oppression, sterility and exclusivity of the capitalist city they' ve made alliances with the tiny awkward unseen urbanites-- microbial synthesizers, fixers, mutualists, decomposers, and grazers. Literature and stories about soilcraft -- the skilled science, art, and practice of cultivation-- continue to grow, and the slogan "build soil not towers" has initiated a multi-species collaboration in the construction of urban topsoil. Diverse and creative practices in agriculture combined and soil science have informed a practice of soil building, a much faster process than biogeophysical weathering. New technologies and devices evolving from traditional implements catalyze the process, incubating critical lifeforms and facilitating the guardianship of expendable material, space, and bodies. Utilize this manual to cultivate damaged soils from wastescape in the reproduction of novel urban soil types.

URBAN SCALE @ 1:1000 or 1"=80'
zoom(x2) 1:500 or 1"=40' // zoom(x4) 1:250 or 1"=20'

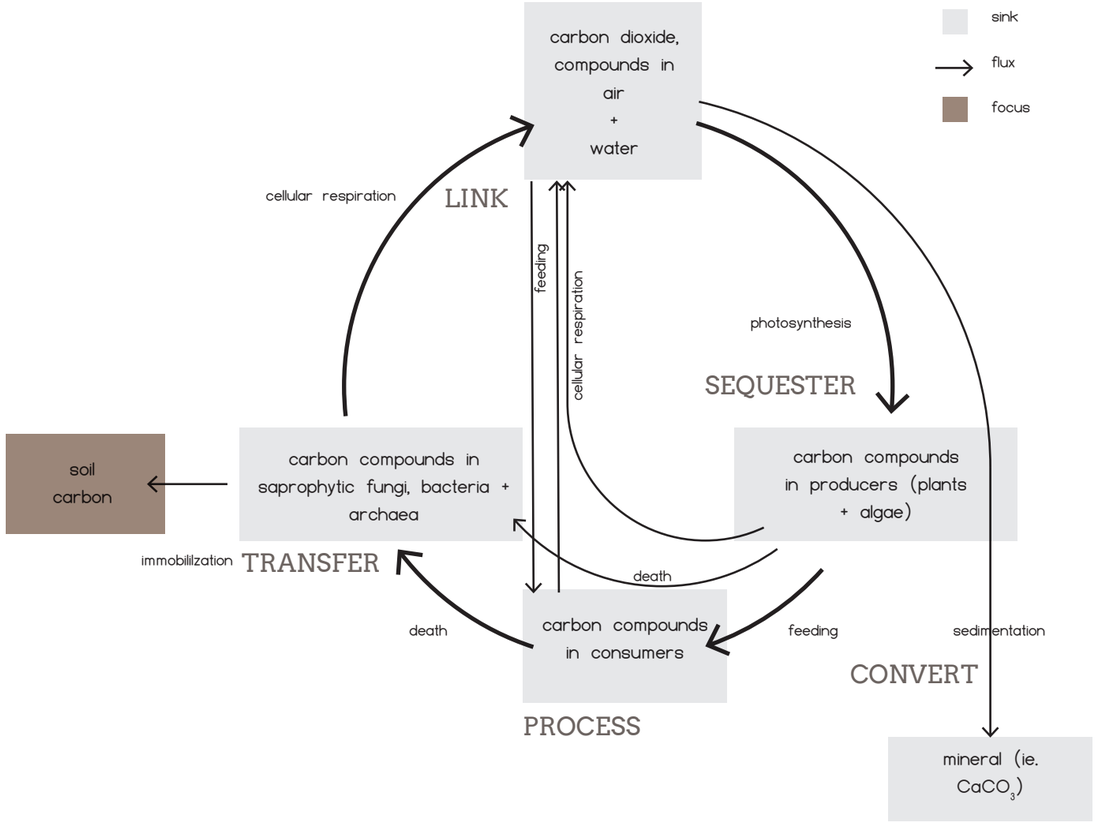
SOIL SAMPLES @ 1:1
BORINGS @ 1:4

HUMAN SCALE @ 1:100 or 1/8"=1'-0"
zoom(x2) 1:50 or 1/4"=1'-0" // zoom(x4) 1:25 or 1/2"=1'-0"

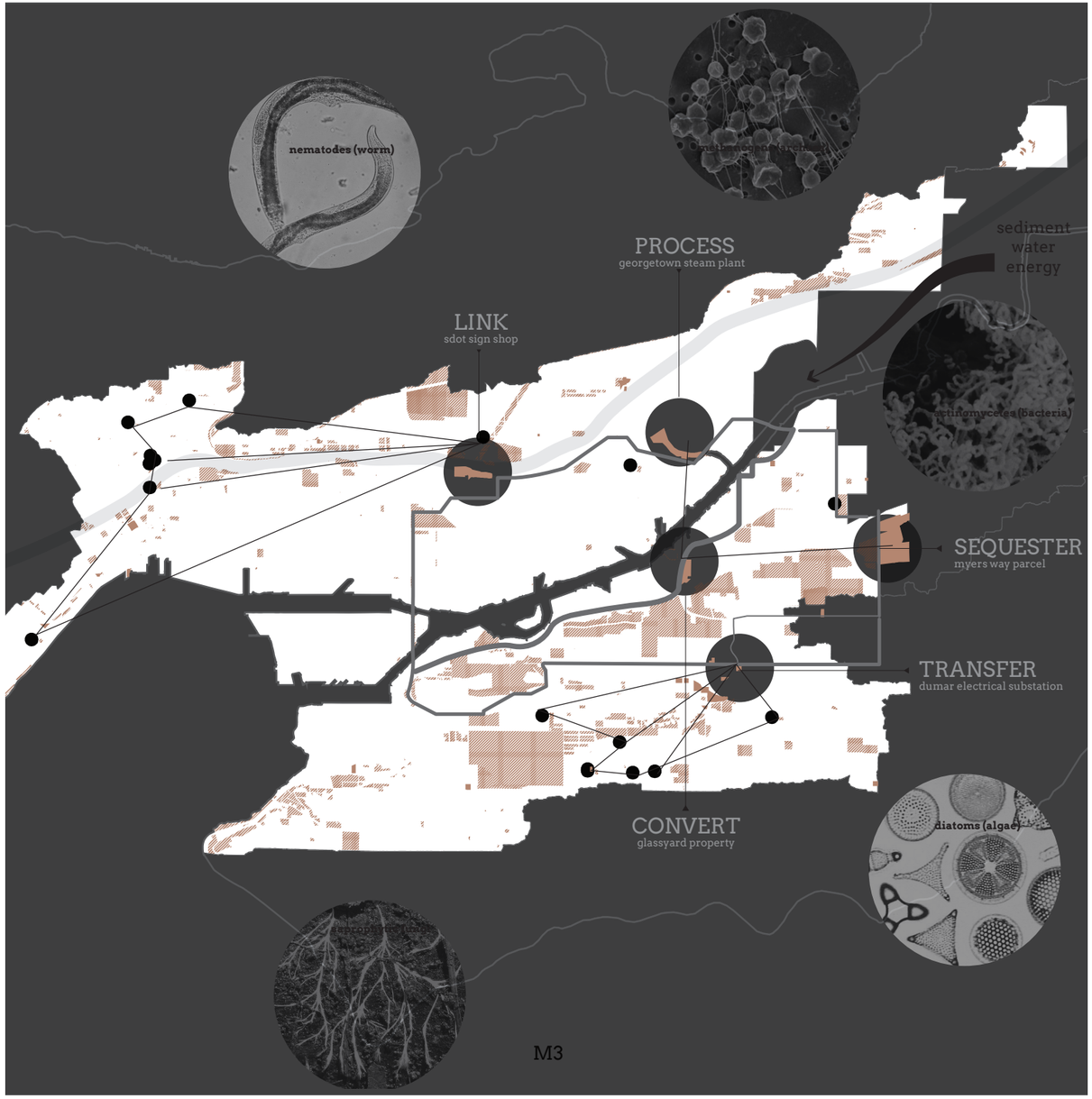
MICROBIOTA @ 1000:1 or 1 µm(micrometer)=.3937"
MICROAGGREGATES @ 100:1 1 mm(millimeter)=3.937"

THE CARBON CYCLE

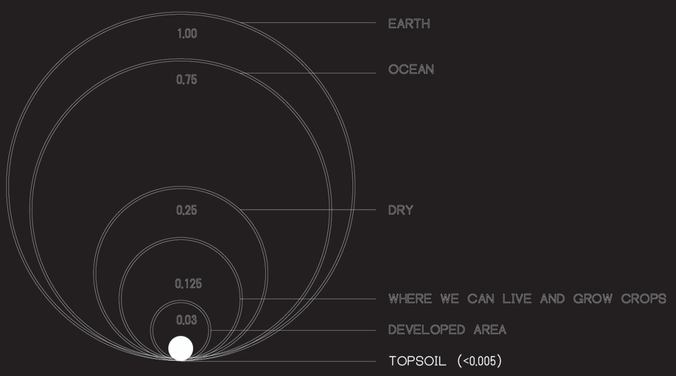
Across the urbanized watershed, transform carbon-based compounds into living soil in support of urban ecosystem abundance and biodiversity. A co-benefit of recycling organic matter in place with microbes will be carbon storage.



M2



M3



TECHNOSOLS

PATHWAYS

CHEM
GEO
BIO

06-08 WASTE

PCBs
ARSENIC
ASBESTOS
PETROCHEMICALS
TCE
08. TOXINS

YARD
MINE
SUBSTATION
PLANT
SHOP
07. WASTESCAPES

DISSOLVED CARBON
ATMOSPHERIC CARBON
BIOMASS
BIOLOGICAL
PARTICULATE CARBON
03. WASTE/INPUTS

05A TAXA

TIDALIC
SPOLIC
URBIC
EKRANIC
REDUCTIC
06A. QUALIFIERS (EXISTING)

MICROBIOTA

02-04 ECOLOGICAL

pH/MINERAL
TEMPERATURE
SOIL CARBON
NUTRIENTS
MOISTURE
02. KEY ATTRIBUTES

SYNTHESIZERS
FIXERS
DECOMPOSERS
MUTUALISTS
GRAZERS
03. AGENTS

CONVERT
SEQUESTER
TRANSFER
PROCESS
LINK
04. TRANSFORMATIONS

01 OPERATION

STRUCTURE
AERATE
PILE
PRINT
SURFACE

00 APPARATUS

TETRAFORM
SPECULARIA
MUSHMESH
EARTHBOT
NEMAKNIT

05B TAXA

SYMTERRIC
PNEUPLAGGIC
MYCOHORTIC
BIOPRETIC
VERMANTRAQUIC

SOIL QUALIFIERS (FUTURE)

structure
aerate
pile
print
surface

FUTURE QUALIFIER:

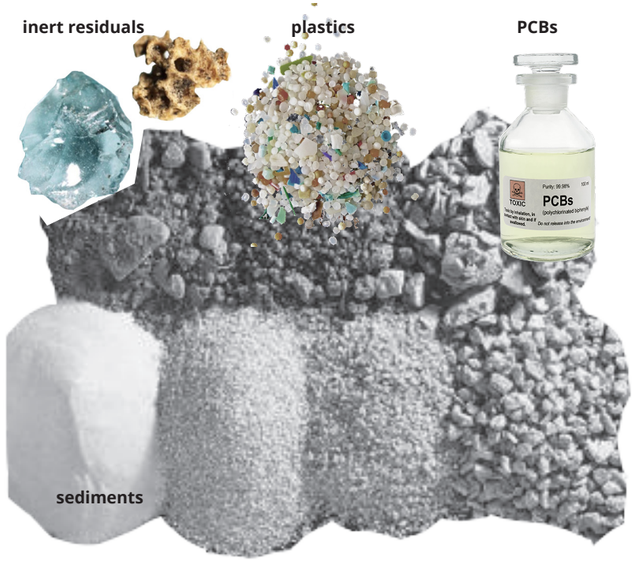
SYMTERRIC

sym- greek) together, terr- earth

definition: symbiotically formed mineral layer from marsh

RELATED QUALIFIERS: terric (anthrosols), tidalic, subaquatic (technosols)

INPUTS: urban sediments, dissolved carbonates, inert materials (sand, concrete, industrial wastes), and persistent organic pollutants like PCBs



HOW TO BUILD SYMTERRIC SOILS

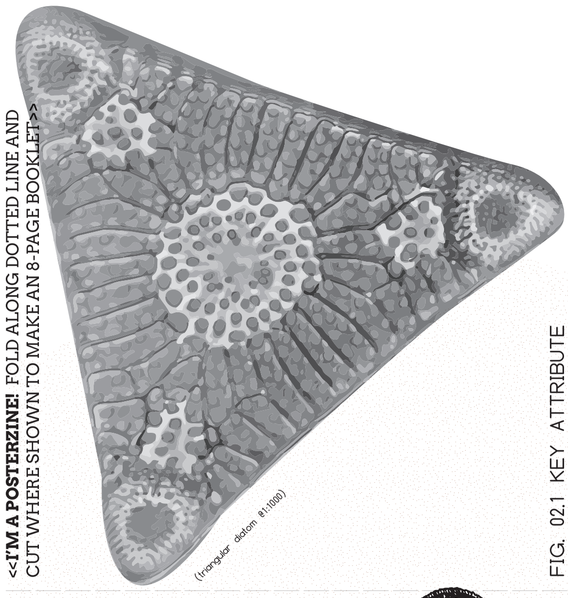
Seed TETRAFORM in newly formed tidelands to encourage microbes. As filtering mechanisms respond to tidal turbidity, biofilms will grow to transform river sediments into silicaceous and calcacious materials, building shoreline, balancing wetland pH, and isolating PCBs.

TETRAFORM: biofilter collecting dissolved carbonates and inert sediments to feed algae + cyanobacterial synthesizers

<<**I'M A POSTERZINE!** FOLD ALONG DOTTED LINE AND CUT WHERE SHOWN TO MAKE AN 8-PAGE BOOKLET>>

tetraform

APPARATUS FOR BUILDING SYMTERRIC SOILS



(triangular diatom @1:1000)

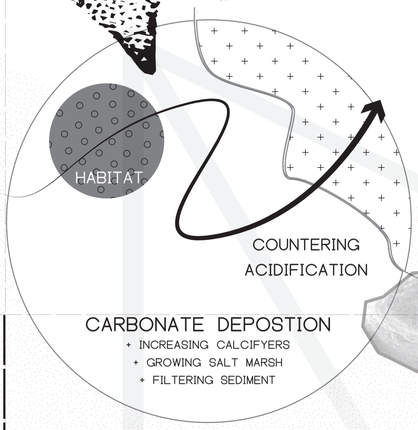
FIG. 02.1 KEY ATTRIBUTE

[pH + INORGANIC MINERALS] CONTROL THE ABILITY OF SILICAFYING AND CALCIFYING ORGANISMS TO SUSTAIN LIFE. THE DIATOM ENGINEERS A SILICA FRUSTULE FROM CO_2. THESE STRUCTURES ACCUMULAE AS DIATOMACEOUS EARTH.

FIG. 03. AGENT: SYNTHESIZER

SOCIABLE, INDUSTRIOUS ORGANISMS SEEKING HABITAT

DIATOM AND CYANOBACTERIA MEET TO MATERIALIZE SUNLIGHT BETTER TOGETHER



CARBONATE DEPOSTION

+ INCREASING CALCIFYERS
+ GROWING SALT MARSH
+ FILTERING SEDIMENT

(clay micrograph)

FIG. 04.1 TRANSFORMATIONS

THE ORGANISMS [CONVERT] DISSOLVED CARBON INTO MINERAL STRUCTURES, GROWING AN ARCHITECTURE OF OOZE TO CATALYZE THE PROCESS

(silt micrographs)

ANCIENT MICROBIAL MATS CATALYZED THE FORMATION OF DRY EARTH FROM WETLAND

FIG. 01.1 OPERATION

[STRUCTURE] SURFACES FOR MICROBES, AND THEY WILL MINERALIZE LANDFORM

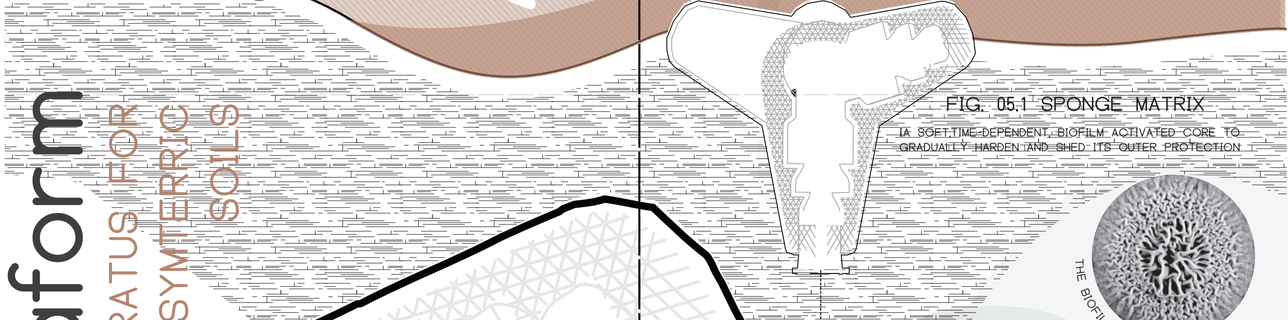


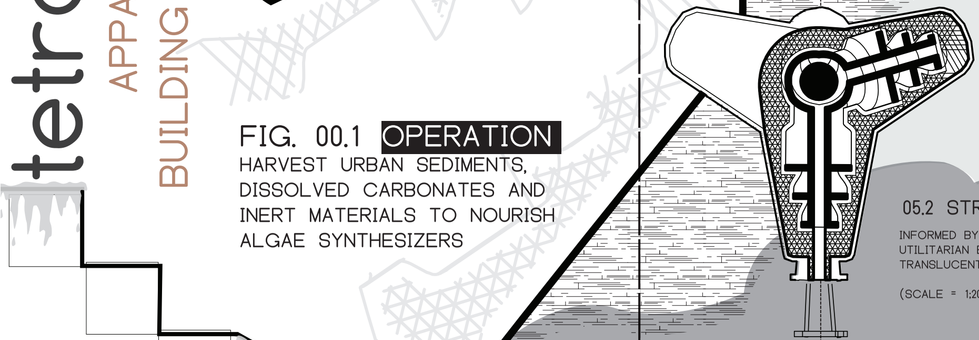
FIG. 05.1 SPONGE MATRIX

[A SOFT,TIME-DEPENDENT, BIOFILM ACTIVATED CORE TO GRADUALLY HARDEN AND SHED ITS OUTER PROTECTION

THE BIOFILM FLOURISHES

FIG. 00.1 OPERATION

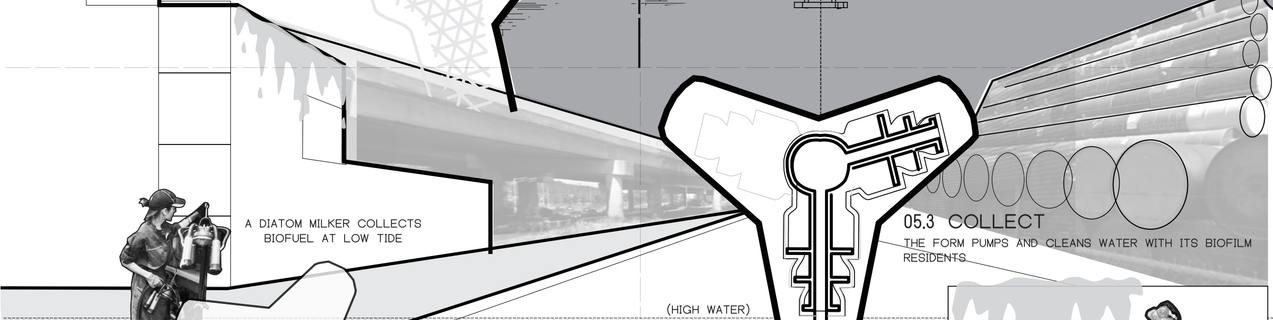
HARVEST URBAN SEDIMENTS, DISSOLVED CARBONATES AND INERT MATERIALS TO NOURISH ALGAE SYNTHESIZERS



05.2 STRUCTURE

INFORMED BY DIATOM MORPHOLOGY AND BORROWED FROM UTILITARIAN BANK STABILIZATION STRATEGIES- A FLEXIBLE, TRANSLUCENT FRUSTLE CONTAINS THE INTERIOR MECHANISMS

(SCALE = 1:20)



A DIATOM MILKER COLLECTS BIOFUEL AT LOW TIDE

05.3 COLLECT

THE FORM PUMPS AND CLEANS WATER WITH ITS BIOFILM RESIDENTS

(HIGH WATER)

(LOW WATER)

05.4 EXPIRED FORMS ACCUMULATE

PCBS ARE CALCIFIED IN STRUCTURES + BROKEN DOWN

...AN INDUSTRY OF OOZE THRIVES

05.5 BEYOND BIOFOUL

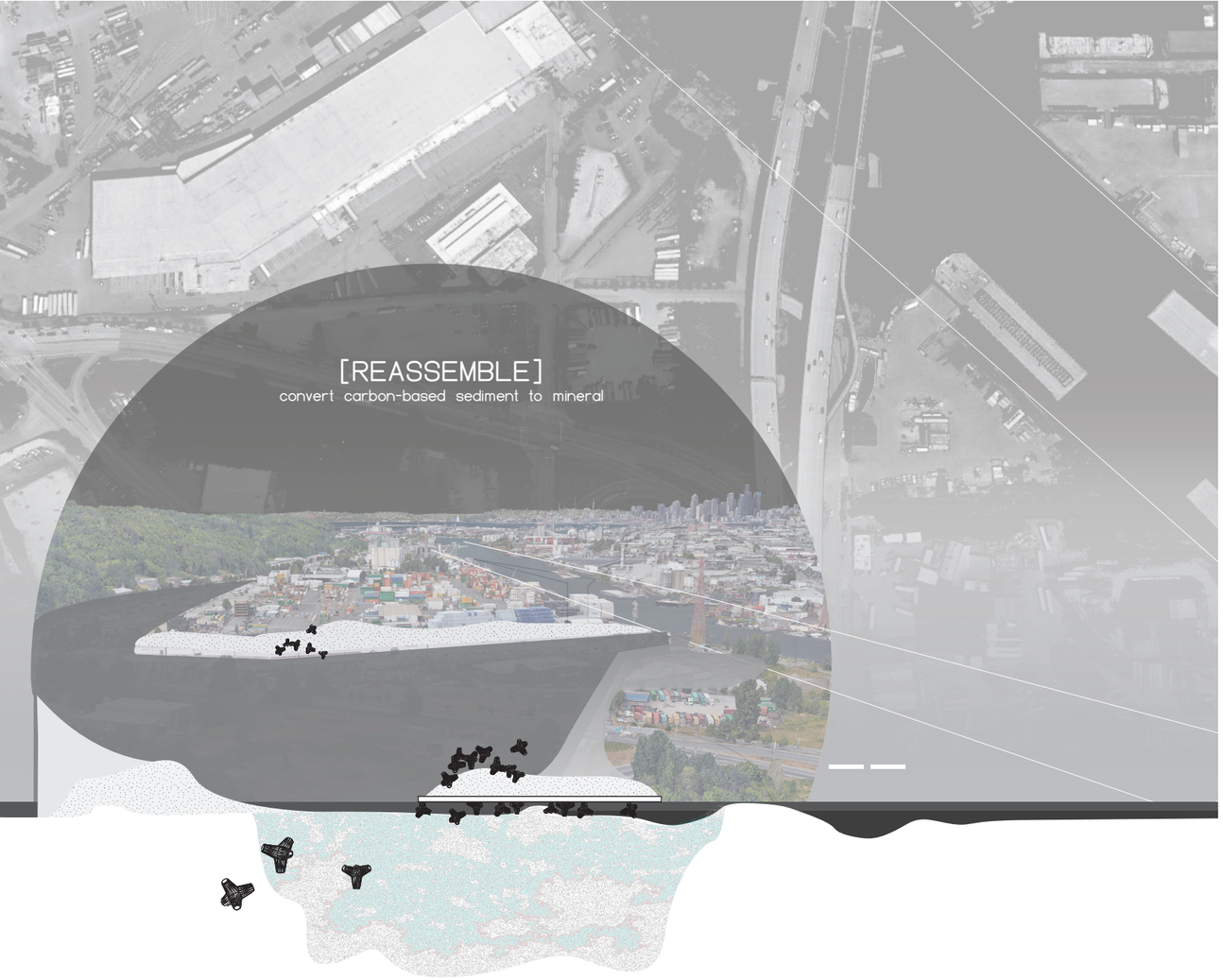
ALGAE IS HIGHLY DESIRABLE IN THE URBAN ENVIRONMENT

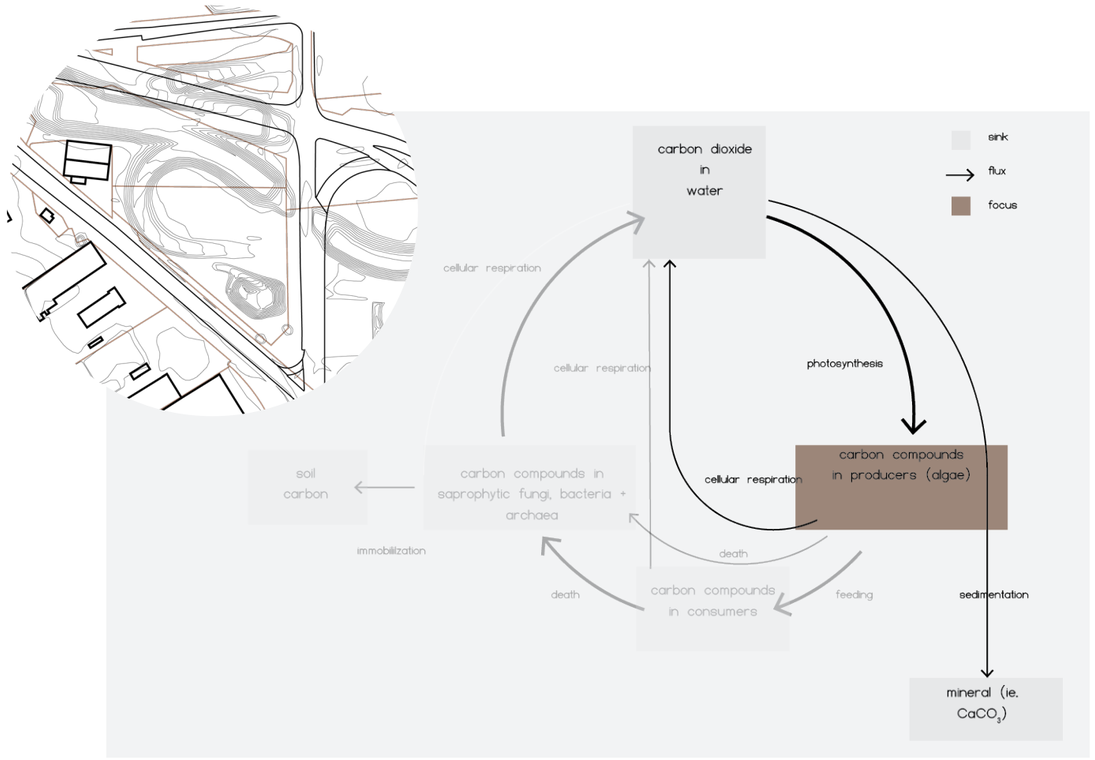
FIG. 05.0

FUTURE QUALIFIER: SYMTERRIC ← EX. QUALIFIER: TIDALIC

>> SYMBIOTICALLY FORMED MINERAL LAYER FROM MARSH

[I]

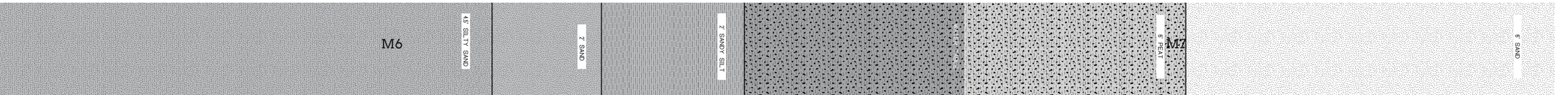




location: yard / trophic level 1 // water + sediment

existing qualifier: TIDALIC

>> SYMTERRIC HORIZON



FUTURE QUALIFIER:

PNEUPLAGGIC

pneu- air, plaggen - fibrous roots and humus

DEFINITION: constructed through the bacterial transformation of air + cellulose

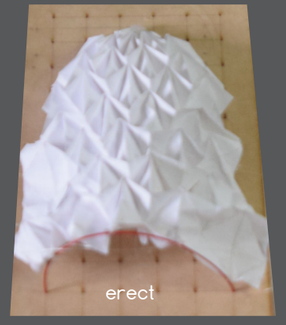
RELATED QUALIFIERS: plaggic (anthrosols produced by the addition of grass and fiber to poor mineral soils), spolic (technosol, contaminated mine soils)

INPUTS: urban carbon dioxide (transportation, construction, land-use emissions), plant + bacterial based cellulose, heavy metals (ie. arsenic)

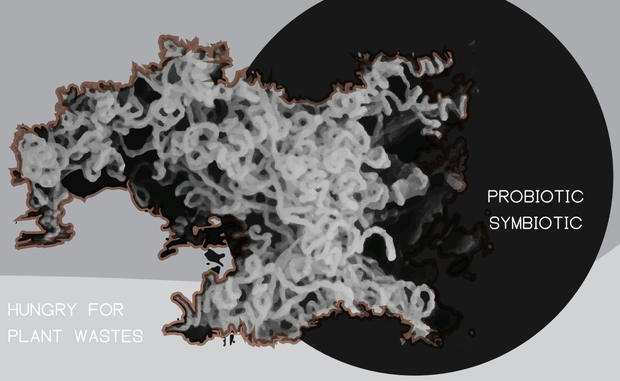
HOW TO BUILD PNEUPLAGGIC SOILS

Erect breathing, nested grow structures to regulate atmospheric exchanges and multiply pro-biotic bacteria in response to root zone temperatures; as inoculated canopies expire, they will aerate, mulch ans fertilize sandy soils.

SPECULARIA: cloth structures harvesting urban emissions to support microbe-plant interaction with bacteria fixers



AN EXCHANGE OCCURS BETWEEN LAND + ATMOSHPERE



FIX NITROGEN, GET CARBON FIX NITROGEN, GET CARBON, FIX....

FIG. 03.1 **AGENT:** FIXER

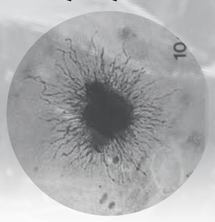
FRANKIA : A BACTERIUM FROM THE ORDER ACTINOMYCEtALES RESPONSIVE TO THE NEEDS OF OTHER SPECIES - A PIONEERING PROTECTOR OF ALDER AND COTTONWOOD

FRANKIA INVADES ROOTS AND BUILDS NODULES TO THE BENEFIT OF THE HOST

ACTINORHIZAL MORPHOLOGY INFORMING BREATHING INHABITABLE STRUCTURES

SANDY SOILS ARE NUTIRENT POOR --BACTERIAL AGENTS FACILIATE PLANT PHOTOSYNTHEISIS AND PROVIDE IMMUNITY TO TOXINS

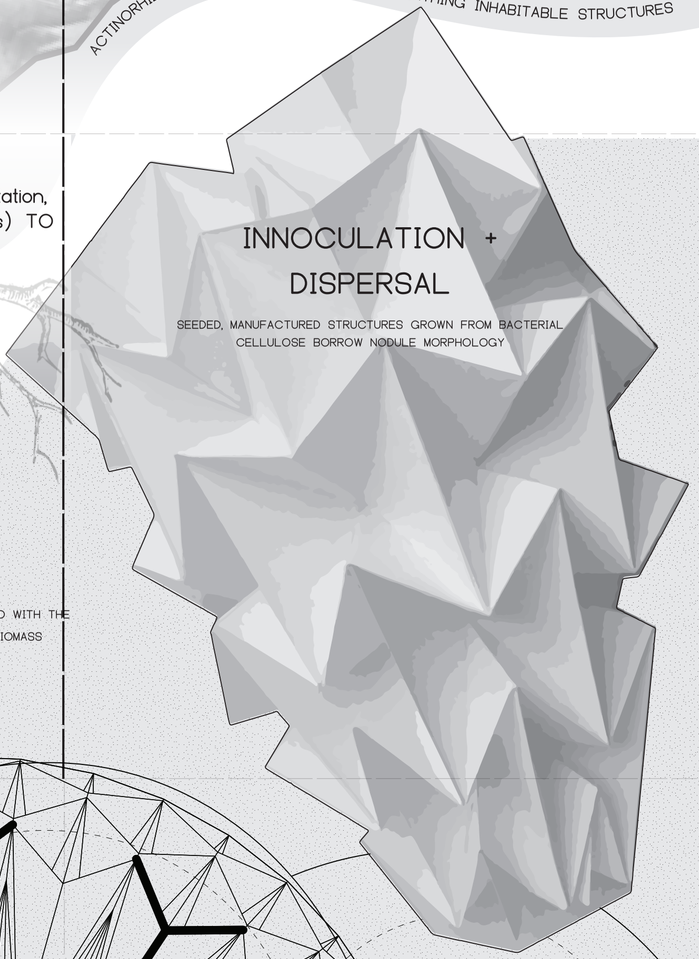
A PROPOGULE ARRIVES



specularia [FOR BUILDING PNEUPLAGGIC SOILS]

FIG. 00.1 **APPARATUS**

HARVESTING URBAN AIR (transportation, construction, and land-use emissions) TO NOURISH BACTERIA



BACTERIAL CELLULOSE GROW STRUCTURES INNOCULATED WITH THE ACTINORIZAL AGENT FACILITATE THE PRODUCTION OF BIOMASS

A CLANDESTINE MICROBE IS TAKING HOME IN THE SOIL, BUILDING COMMUNITIES FROM THE ROOTS UP

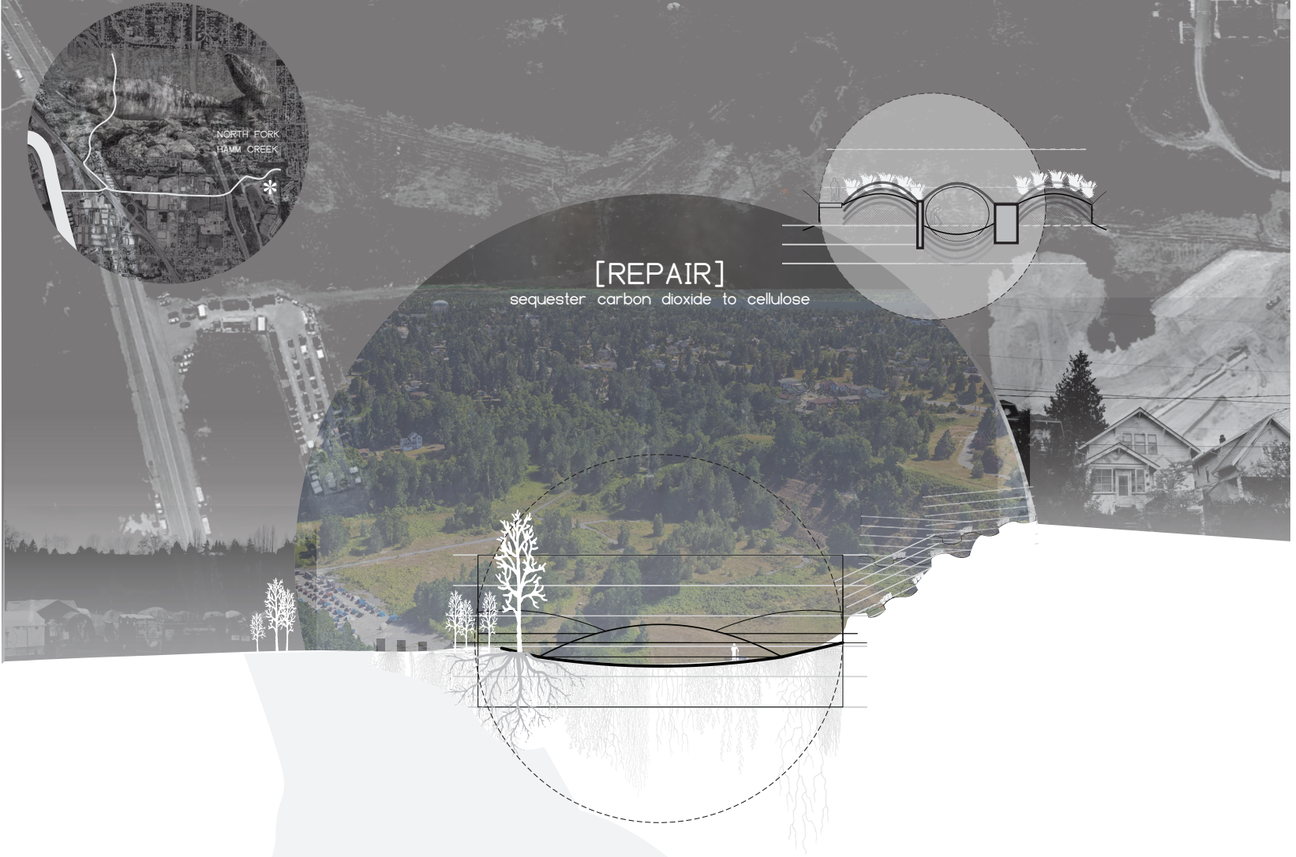
MAKING SPACE
GROWING MORE MORE MORE

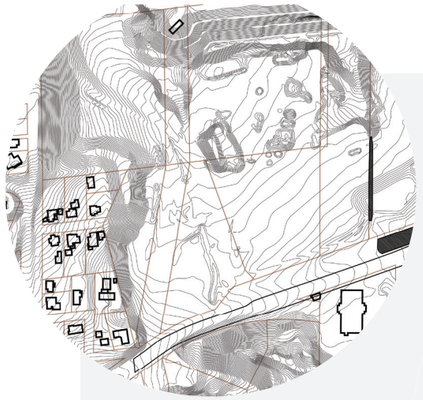
A CONSOTIA OF ACTINOMYCES WILL BREAKDOWN AND CONSUME THE STRUCTURE WITHIN 3 YEARS OF DEPOLOYMENT...

FIG. 05.0

FUTURE QUALIFIER: PNEUPLAGGIC ⟵ EX. QUALIFIER: SPOLIC

[II]





location: mine / 2nd trophic level // atmosphere

existing qualifier: SPOLIC

>> PNEUPLAGGIC HORIZON

M10

SAND WITH SILT
(GLACIAL ADVACE
OUTWASH)

M11

WATER TABLE

7 SILTY SAND (FILL)

FUTURE QUALIFIER:

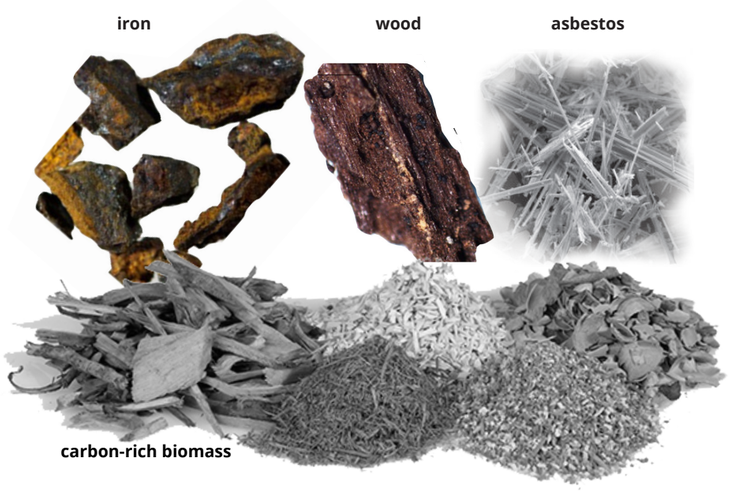
MYCOHORTIC

myco- relating to fungi, hort- horticultural

def: resulting from the saprophytic transformation of household waste

RELATED QUALIFIERS: hortic (anthrosol, kitchen soils), urbic (technosols containing the rubble of human environments)

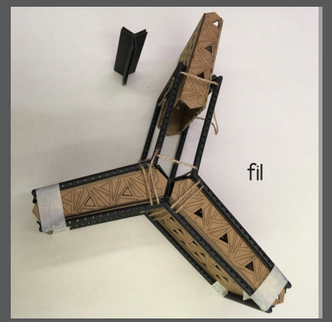
INPUTS: discarded objects (packaging, post-consumer waste, furniture, building materials), carcinogen materials (ie.)

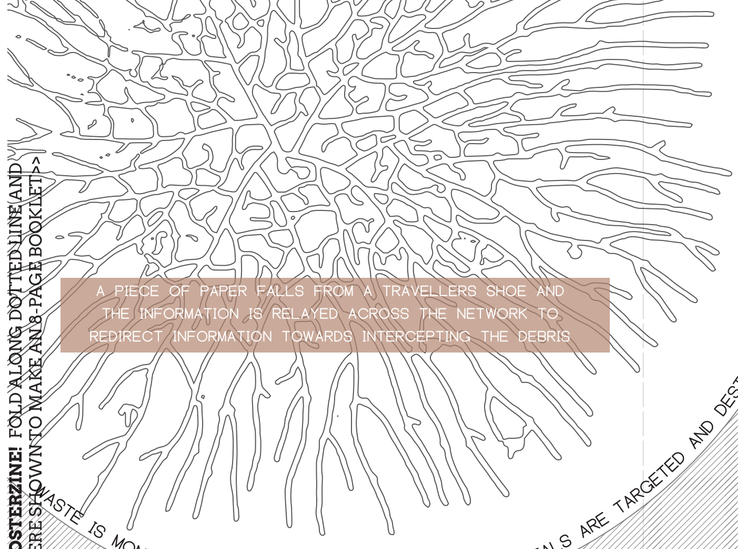


HOW TO BUILD MYCOHORTIC SOILS

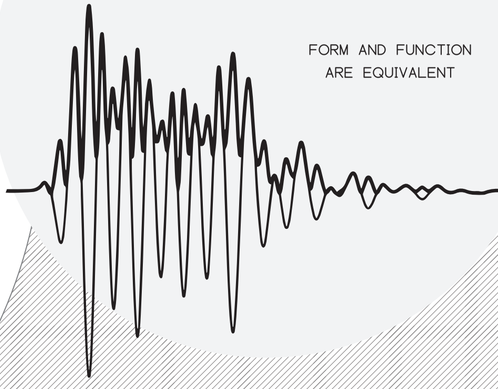
Fill and bail MUSHMESH forms with carbonaceous refuse and mycelium spawn to fuel mushroom growth; sort/stack/ fill modules and maneuver as saprophyte or human requires. Toxins such as asbestos will be metabolized in the process.

MUSHMESH: structural modules containing carbon-rich waste to feed microbial decomposers





A PIECE OF PAPER FALLS FROM A TRAVELLERS SHOE AND THE INFORMATION IS RELAYED ACROSS THE NETWORK TO REDIRECT INFORMATION TOWARDS INTERCEPTING THE DEBRIS



FORM AND FUNCTION ARE EQUIVALENT

<<**I'M A POSTERZINE!** FOLD ALONG DOTTED LINE AND CUT WHERE SHOWN TO MAKE AN 8-PAGE BOOKLET!>>

WASTE IS MONITORED BY THE SYSTEM - HAZARDOUS MATERIALS ARE TARGETED AND DESTORYED

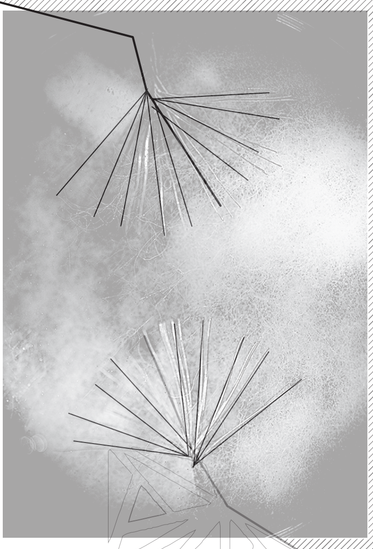
FIG. 03.
AGENT: DECOMPOSER

AN INTELLIGENT SAPROTROPH SEEKS CARBON, CARFULLY SURVEILLING THE ENVIRONMENT

FORMS ARE BUILT IN RESPONSE TO THE SYSTEMS NEEDS, AND THE HUMAN SYMBIONT HARVESTS THE FRUITING BODIES OF THE INNOCULTATED STRUCTURES

FIG. 04.1 TRANSFORMATIONS

THE ORGANISM IMMOBILIZED CARBON, [TRANSFERING] ORGANIC MATTER TO SOIL CARBON STORAGE IN THE HUMUS LAYER



MANUFACTURED ELEMENTS INTERFACE WITH MYCELIUM TO COMMUNICATE

mushmesh

[FOR BUILDING MYCOHORTIC SOILS]

FIG. 00.1 APPARATUS

to harvest DISCARDED OBJECTS (packaging, post-consumer waste, furniture, building materials) and NOURISH FUNGI

OPERATION: FIND + STORE CARBON

THE MUSHMESH GROWS

Satisfied, the synthe-

THE MYCELIA ARE WATCHING

←[OPEN ME]

RESIDENTAL SOIL AND KITCHEN GARDENS GROW FOOD FROM SPENT MEDIUM AS IT ACCUMULATES

TOXIC RESIDUES LIKE ASBESTOS FEED THE SAPROPHYTE AND CARBON-BASED WASTE BECOMES SOIL CARBON

SURFACE SYMBIONTS ARE INFORMED OF THIER PERFORMANCE

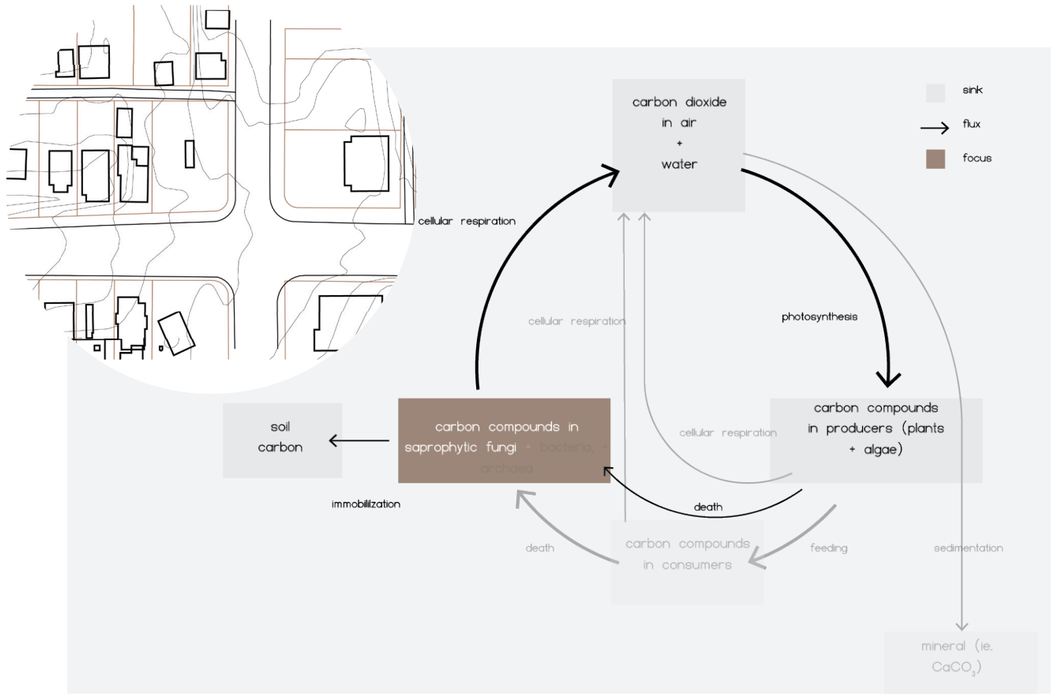
WASTE IS OBSOLETE

tized, [...] growing the biotic community at-large.

FIG. 05.0

FUTURE QUALIFIER: MYCOHORTIC ← EX. QUALIFIER: URBIC

[III]



location: substation/ 2nd trophic level // compounds in fungi

>> MYCOHORTIC HORIZON

existing qualifier: URBIC

SAND WITH SILT
(GLACIAL ADVACE
OUTWASH)

WATER TABLE

7' SILTY SAND (FILL)

FUTURE QUALIFIER:

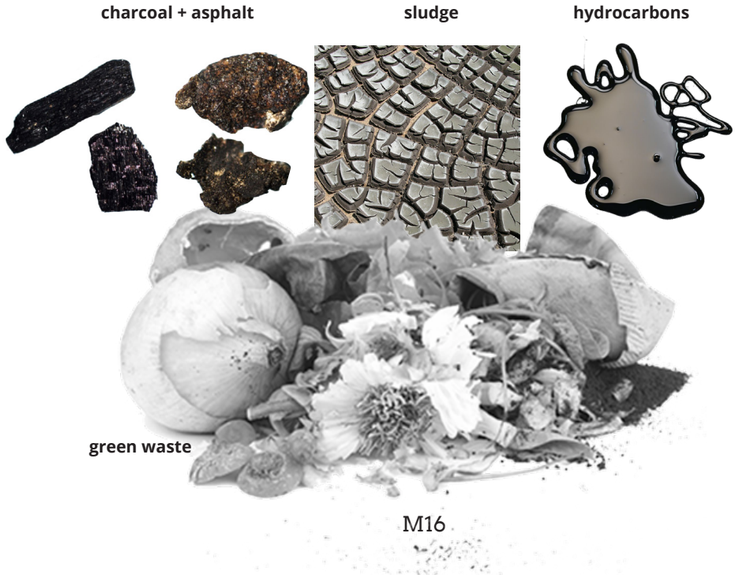
BIOPRETIC

bio- life, pret- rich

DEFINITION: DARK EARTH OF BIOLOGICALLY PRODUCED WASTE

RELATED QUALIFIERS: pretic (anthrosols, dark, amazonian terra preta of manure and charcoal), ekranic (technosols, paved)

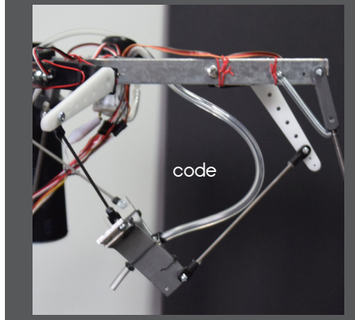
INPUTS: urban biodegradables (discarded food, biological waste/excreta), Polycyclic aromatic hydrocarbons (PAHs), petroleum products

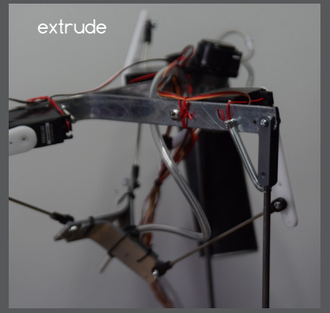


HOW TO BUILD BIOPRETIC SOILS

Collect and digest raw material in holding tanks, heat up and polymerize with filler. Feed extruded material into an EARTHBOT printing mechanism to distribute widely and artfully. Asphalt and petrochemicals will be degraded by persisting mutualistic anaerobes.

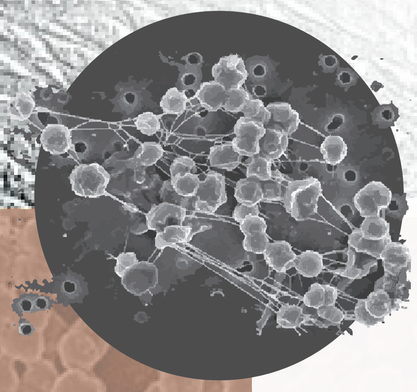
EARTHBOT: additive manufacturing device for the deposition of anaerobically digested, nutrient-rich green waste + biosolids





SYNTROPOHY
(Greek) syn meaning together, trophe meaning nourishment

FIG. 03.1 AGENT: MUTUALIST
A MISUNDERSTOOD, ANTI-AUTHORIATARIAN EXTREMOPHILE



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EVERYTHING EATING SOMETHING

USEFUL BIPRODUCTS: BIOGAS + HEAT

DEPOSIT

producing a tasty soil conditioner

$CH_3COOH \rightarrow CH_4 + CO_2$

METHANOGENESIS (final stage of digestion)

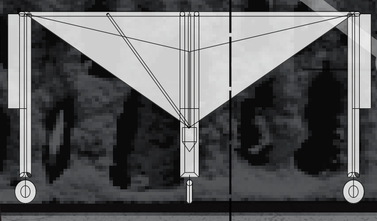
Then other bacteria produce acetate in acetogenesis

Bacteria produces alcohol through fermentation

RAW WASTE

earthbot
[FOR BUILDING BIOPRETIC SOILS]

FIG. 00.1
APPARATUS
HARVESTING URBAN BIODEGRADABLES (discarded food, biological waste/excreta, petroleum products) TO NOURISH ARCHAEA



DIGEST

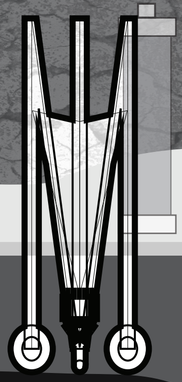
HYDROLOSIS
ACIDOGENESIS
ACETOGENESIS
METHANOGENESIS

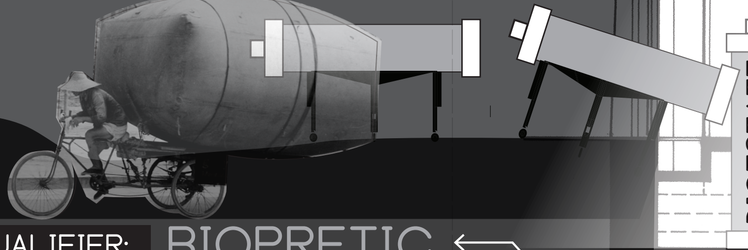
THE METHONOGEN HAS EVOLVED THROUGH INTERDEPENDENCY TO THRIVE IN DIFFICULT PLACES LIKE THE HUMAN GUT, LANDFILLS, MARSHES AND TAR PITS.

IT CAN LIVE INSIDE ASPHALT AND CONCRETE

A DEPLOYABLE UNIT FOR ADDITIVE MANUFACTURING OF FERTILE SUBSTRATES

PROCESS + MIX





DIGESTATE

[IV]

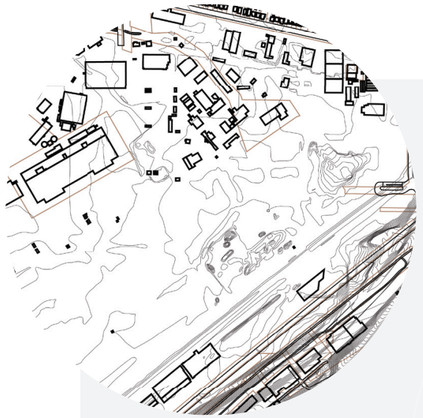
FIG. 05.0

FUTURE QUALIFIER: BIOPRETIC

>> DARK EARTH OF BIOLOGICALLY PRODUCED WASTE

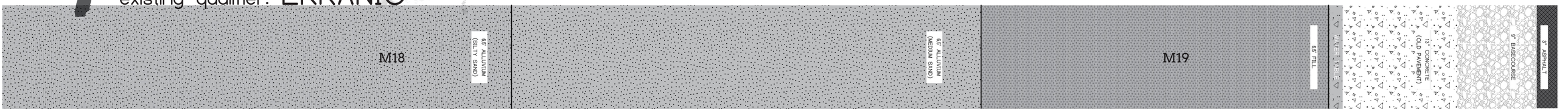
EX. QUALIFIER: EKRANIC

existing qualifier: EKRANIC



location: plant / 2nd trophic level // terrestrial consumers

>> BIOPRETIC HORIZON



FUTURE QUALIFIER:

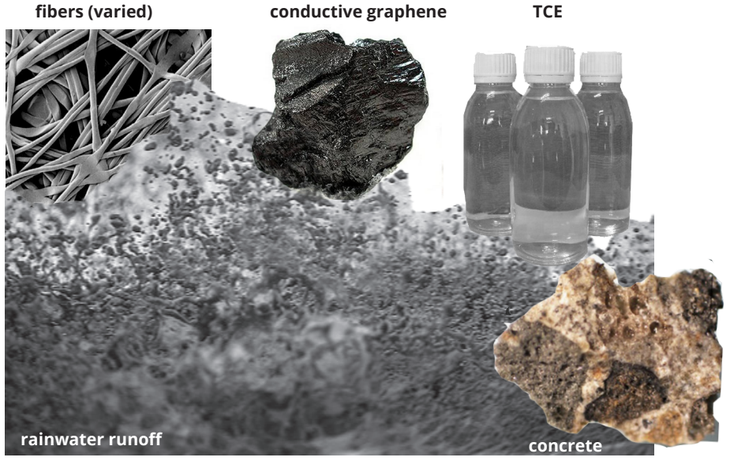
VERMANTHRAQUIC

verm- worm, anthro- human

a surface horizon modified by rainwater and worm-to-human communication networks

RELATED QUALIFIERS: anthraquic (anthrosols), reductic (reducing fluid or gaseous conditions)

INPUTS: urban rainwater (particulate carbon, sewage, debris), Trichloroethylene (TCE) + other volatile organic compounds



HOW TO BUILD VERMANTHRAQUIC SOILS

Position NEMAKNITS to collect data for the production of custom geotextiles matching highly variable site conditions. Infiltrate rainwater and organic residuals where needed. Nematodes will locate volatile toxins to target for phytovolatization.

NEMAKNITS: smart geotextiles retaining moisture and organic particulates to track and nourish grazing nematode diversity

<<I'M A POSTERZINE! FOLD ALONG DOTTED LINE AND CUT WHERE SHOWN TO MAKE AN 8-PAGE BOOKLET>>

IT LOOKS FOR A PLACE WHERE ORGANIC MATTER IS SUFFICIENT TO SUPPORT A LARGE DIVERSITY OF ITS KIND. MORE DIVERSE COMMUNITY OF NEMATODES = HEALTHY SOIL, PLANTS, + PEOPLE

A LIVING CARBON CONDUIT

THE FREE-LIVING NEMATODE

FIG. 03.1 **AGENT:** GRAZER

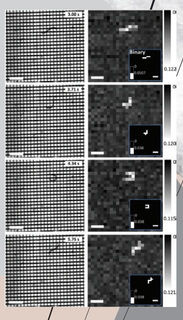
PERSISTENT + UBIQUITOUS, THE FREE-LIVING NEMATODE CONNECTS FLORA TO FAUNA - IT IS A CRITICAL LINK IN URBAN FOOD WEBS

THE MICROSCOPIC WORM MOVES CARBON THROUGH THE SOIL ECOSYSTEM BY FORAGING FOR TASTY BACTERIA, DEAD ROOTS AND PATHOGENS

KNITS PRESERVE SURFACE MOISTURE

A WELL-CONNECTED WANDERER OF THE THIN FILM OF MOISTURE HELD BY SURFACE TENSION BETWEEN SOIL AGGREGATES

MICROGRIDS DETECT NEMATODES BY SPECIES



1.0
.80
.60
.40
.20
.00

Steinernema carpocapsae

HUMANS TAP INTO NEMATODE TALK TO MEASURE DOC (DISSOLVED ORGANIC CARBON), TO BETTER UNDERSTAND THE QUALITY AND QUANTITY OF RAIN WATER IN THE URBAN ENVIRONMENT

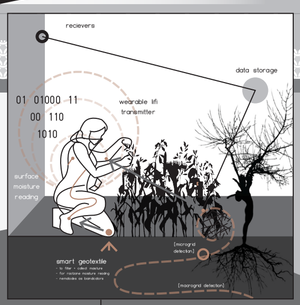
nemaknit

[FOR BUILDING VERM-ANTHRAQUIC SOILS]

FIG. 00.1 **APPARATUS**

HARVESTING URBAN RAINWATER (PARTICULATE CARBON, SEWAGE, DEBRIS)TO NOURISH WORMS

DRAPING FOR H2O CAPTURE



SMART-KNIT GEOTEXTILES GROW SOIL MOISTURE FOR NEMATODE HABITAT AND CONVEY DATA ABOUT URBAN CARBON FLUXES

ROOFTOP SYSTEMS

HUMAN-WORM MOISTURE COOPERATIVES

SPONGY BITS FOR H2O COLLECTION

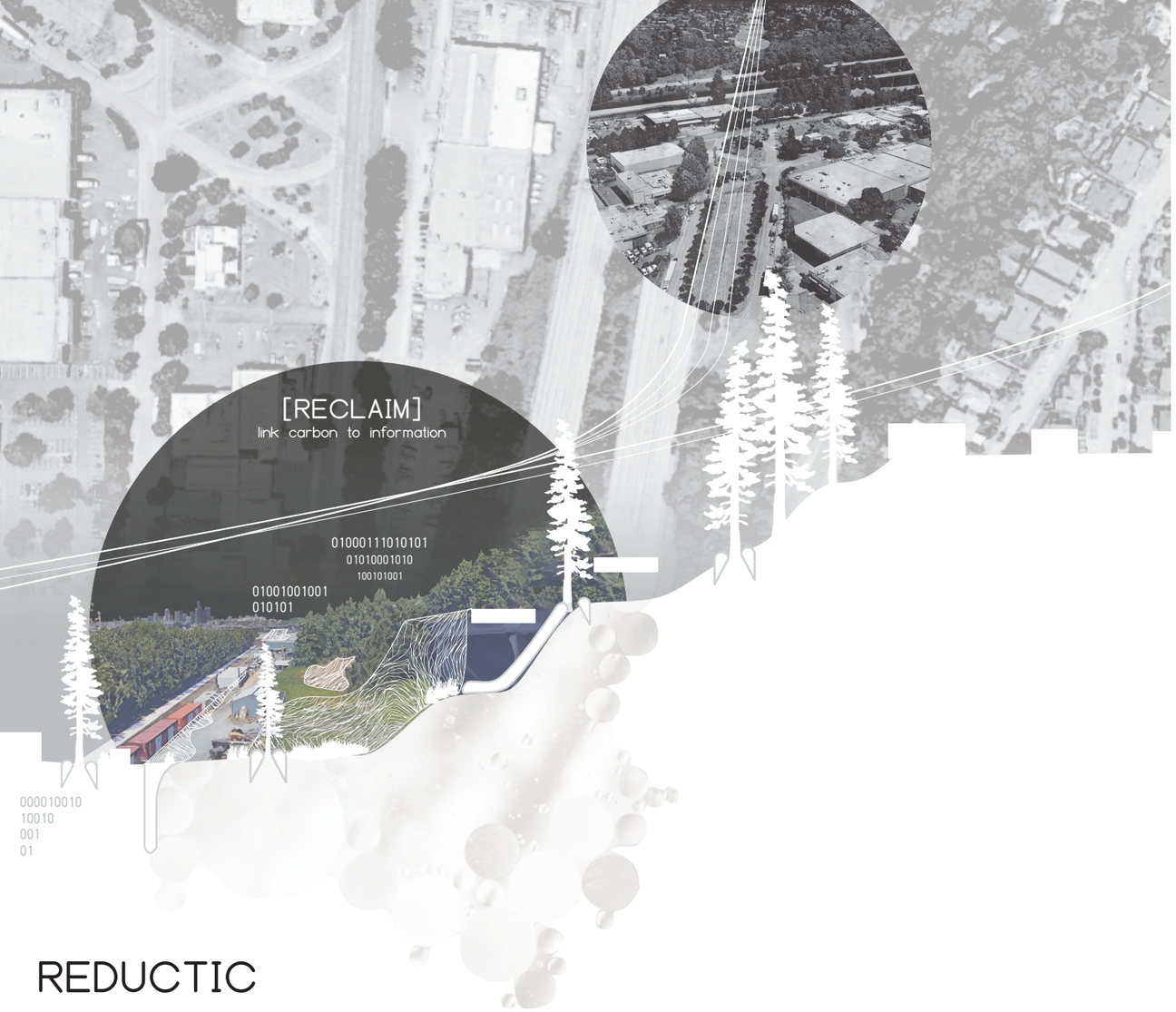
PERCULATIION + TREATMENT

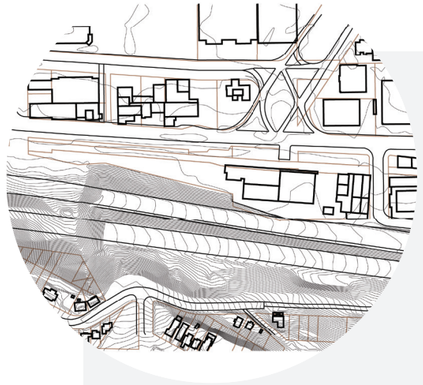
(DEEP PROBES)

FIG. 05.0

FUTURE QUALIFIER: VERMANTHRAQUIC ← EX. QUALIFIER: REDUCTIC

[V]

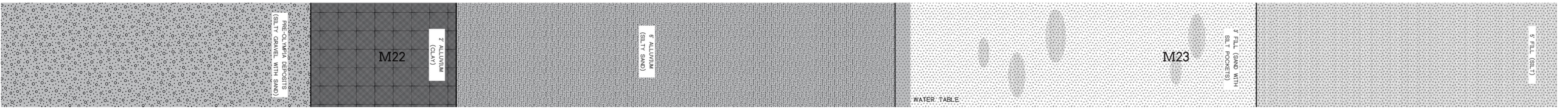




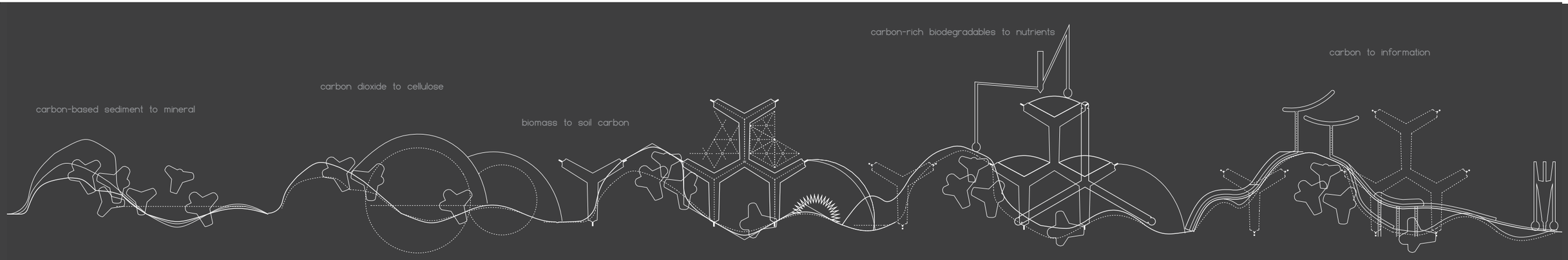
location: shop/ 3rd trophic level// soil consumers

REDUCTIC

>> VERMANTHRAQUIC HORIZON



TO CONCLUDE Organize the apparatuses to construct novel ecosystems across the Duwamish and beyond. Redefine what is disposable and reclaim waste in the more-than-human city through multifunctional spaces for soil reproduction. Inscribe collaborative horizons of soil building in the DNA of earth's thin living layer to be buried, washed out, and exhumed by time.



URBAN SOIL COULD

REASSEMBLE REPAIR RECYCLE RECOVER RECLAIM

MATERIALS, BODIES, AND SPACE TO SUSTAIN MULTISPECIES COMMUNITIES

[note: for best viewing results switch to “two page view”]

reflection

A literature review on the topic of environmental design and urban soil demonstrates that design practices to shift ethics addressing waste and soil represents a significant gap in research. Preliminary research into creative approaches demonstrates narrative as an engaging method for revealing the unseen and making new connections between human experience(s) and environment. Coming from art, science fiction, and interactive design, design fiction provides a possibility-oriented approach. Research into the intersection of urban soil and design fiction confront an entanglement between waste and building technology. I hypothesized that a speculative design practice can foster an ethic of multispecies ecological flourishing through imaginaries of care for discarded and marginalized soils. To test this, I developed diegetic prototypes from research into soil science, culture, and history. Work was situated around a simple, speculative question: what if urban form nourished soil? The anticipated outcome was the facilitation of discussion and debate to rescale and reassemble through-put waste culture. By engaging the anthropological nature of urban soils, speculative landscape narratives have the power to posit transformative human-soil relationships. Prototypes (maquettes, soil samples, and an operations manual) explore existing and future technologies to compel an audience towards care and consideration of the thin living surface shared by all earthly things. Hypothetical soil horizons and apparatuses animate a matrix of material and microbes to rescale the decline of soil life towards approachable action. The purpose of storytelling is two-fold: fiction is a necessary action, and necessary action is fiction. This work suspends belief to solicit care for soil, but also make-believes there can be abundance in decline. Overall, soilcraft is a response to anthropologist Anna Tsing's call for "the arts of living on a damaged planet"— the cultivation of practical healing and improbable collaborations in the face of terrible destruction and poverty.[1],[2] If building nourished soil, design would achieve the nearly unimaginable coupling of material human technology and more-than-human survival.

summary of findings

[1] Design fiction is an instrumental practice for changing environmental and technological ideas

- Speculation can create experiences of alternative technologies
- Interdisciplinary methods form immersive, believable experiences (examples: drawing, prototyping, digital fabrication, projection, graphic storytelling)
- Fictional landscape narratives employ formal and informal design artifacts

[2] Building can and should nourish soil

- What-if thought experiments clarify what is hypothetically possible
- Art and design to shift ethics governing environmental and technological action is critical
- Can and should are important design questions

[3] Storytelling in design is more than didactic or visionary – it creates meaning

- Design pedagogy must advance methods to shift ideas and attitudes
- Narrative production can be supported through generative modes of inquiry and tools of representation

[4] Urban soil is a critical topic in design studies addressing waste

[5] Narratives about soil can facilitate multispecies justice in more-than-human cities

Discussion >> This thesis has demonstrated the use of design representation and digital fabrication in the service of experimentation and process-driven outcomes versus solution-oriented products. It has also demonstrated several possible ways in which environmental art and design can creatively and purposefully work in the production of alternatives to dominant paradigms.

A genre of soil fiction creates possibilities for hybrid systems to reconcile human alienation from ecosystems. As cities represent a rapidly urbanizing world where most of the world's waste begins, urban soil is fundamental. The dynamism of species interactions and feedbacks in soil provides a vibrant space for interdisciplinary art-based practice to refute the human/nature divide and dream of technological alliances with non-human others. Art and design must craft narratives to spark curiosity, open futures, and inform decision making.

Contribution >> This thesis has engaged urban soil to better understand what working practices reframe technological and environmental ethics and posthuman relationships. Open-ended soil fiction draw technologies that extend the resiliency of non-human caretakers—beneficial fungi, bacteria, nematodes, archaea, and algae. The products of this thesis are intended to activate the field of design as a practice to inspire and innovate technology, invite imagination and spark curiosity around the critical topic of soil systems, place multispecies environmental justice as the responsibility of art and design, provide alternative environmental narratives to ecological imperialism, and ultimately, rescale and reassemble the city's relationship to waste in soil ecosystems. The greatest hope for this work is that it will invite further speculation on an underimagined resource.

Recommendations for future work>> The primary audience of this work has been scholars and educators in landscape, architecture and digital arts. The reach of the work can be extended through physical and digital media to a broader community, to invite and encourage the interrogation of technology and waste in growing cities. Collaborations with and contributions from scientists and tradespersons (farmer, compost specialist, soil scientists) to reimagine human-soil interactions would multiply the value of similar work. The research completed in this thesis also aims to serve as a tool for pedalogical process. A curriculum in landscape architecture could engage digital art to manufacture immersive, emancipatory worldmaking to assemble democratic, environmentally just technologies. Iterative design for multispecies communities may invent mutually beneficial ways of life on this planet. All-in-all, *soilcraft* is positioned as an open, ongoing investigation. Physical prototypes are required to address the specific needs of non-human user groups and stakeholders, followed by testing and evaluation to inform responsible soil building.

endnotes

1 Anna Lowenhaupt Tsing, *Arts of Living on a Damaged Planet* (Minneapolis: Minneapolis : University of Minnesota Press, 2017). G1-G12.

2 Donna Jeanne Haraway, *Staying with the Trouble : Making Kin in the Chthulucene* (Durham: Durham : Duke University Press, 2016). 136.

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appendix

APPENDIX A. Sketchbook entries and drawings from various aspects of the project

10/11/2018

SITE ISSUES/CONTAMINANTS

- arsenic
- fibers - asbestos
- halogenated solvents (TCE)
- petrochemicals (PAH)
- PCBs

KEY ATTRIBUTES

- moisture/infiltration
- temperature
- carbon
- nutrients
- physical texture

EMERGING TECHNOLOGIES

- environmental controls - sensors/actuators
- self regulating structures
- transgenic, genetically engineered plants for: - improved phytoremediation
  - carbon sequestration
  - biofuels
  - adaptation to climate change
- seeing more with sampling/mitigation methods
- 3D printing · automation · AI, traceability

EVA PLEASE

- CO_2 ↑ and climate change
- loss of species, diversity
- human health
- loss of env. identity
- landscape neutral w/o agency

KEY PROCESSES

- sedimentation
- infiltration
- decomposition
- respiration
- fertilization

PAST INDUSTRIAL INFRASTRUCTURE

- mine
- quarry and landfill
- agriculture (plantations)
- substation
- steam plant

MICROBES

- diatoms (algae)
- bacteria in rhizosphere (endophytes) (actinomycetes + proteobacteria)
- saprophyte fungi
- nematodes
- extremophiles - methanogens + nitrosomas

urban agriculture gets weird?

Fig. a: Connecting waste, landscape, soil types, and actors

6X

Near Science fiction for Urban Soil to explore shifting environmental reality

INTERVENTIONS

becoming and belonging in urban nature

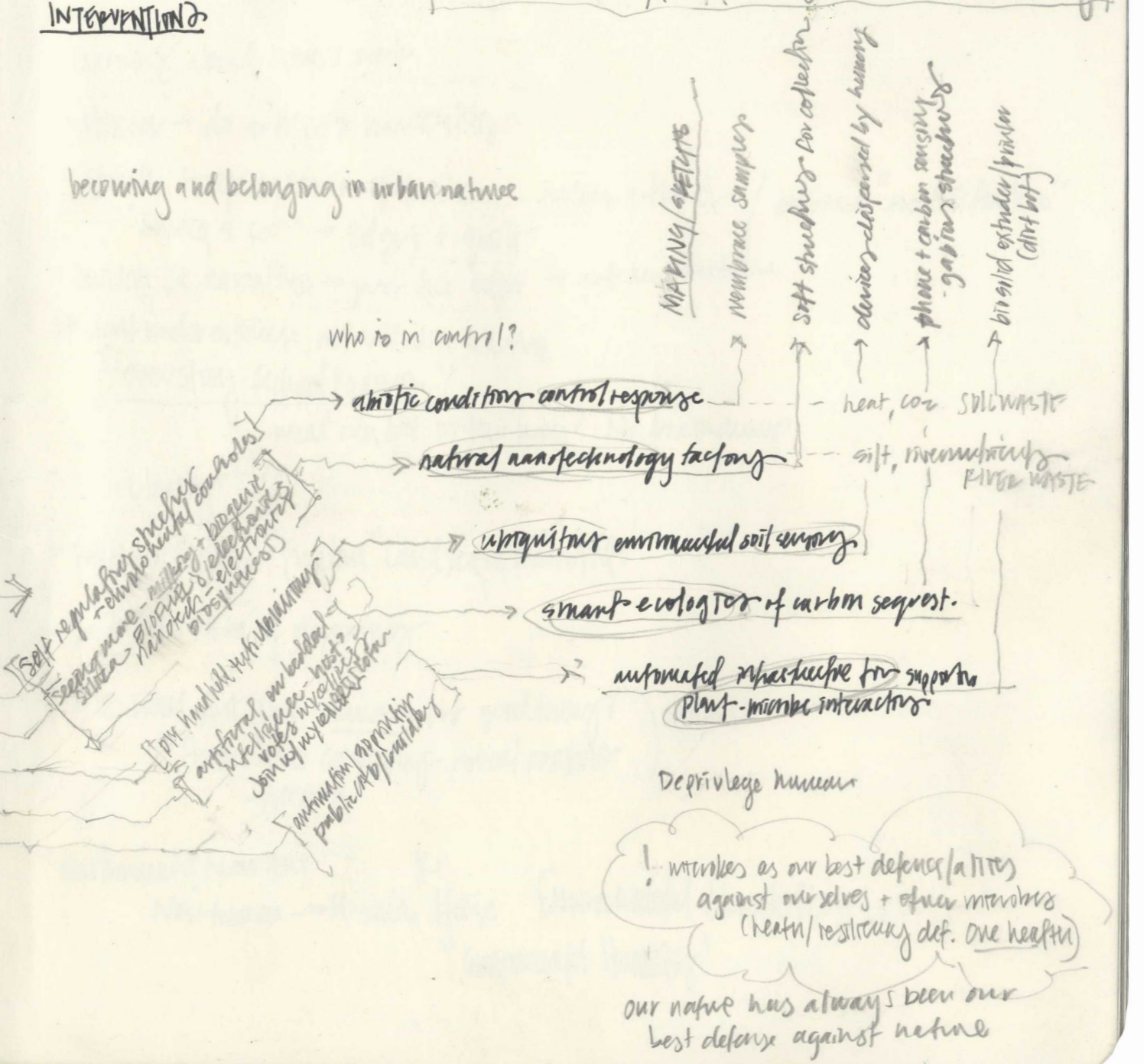
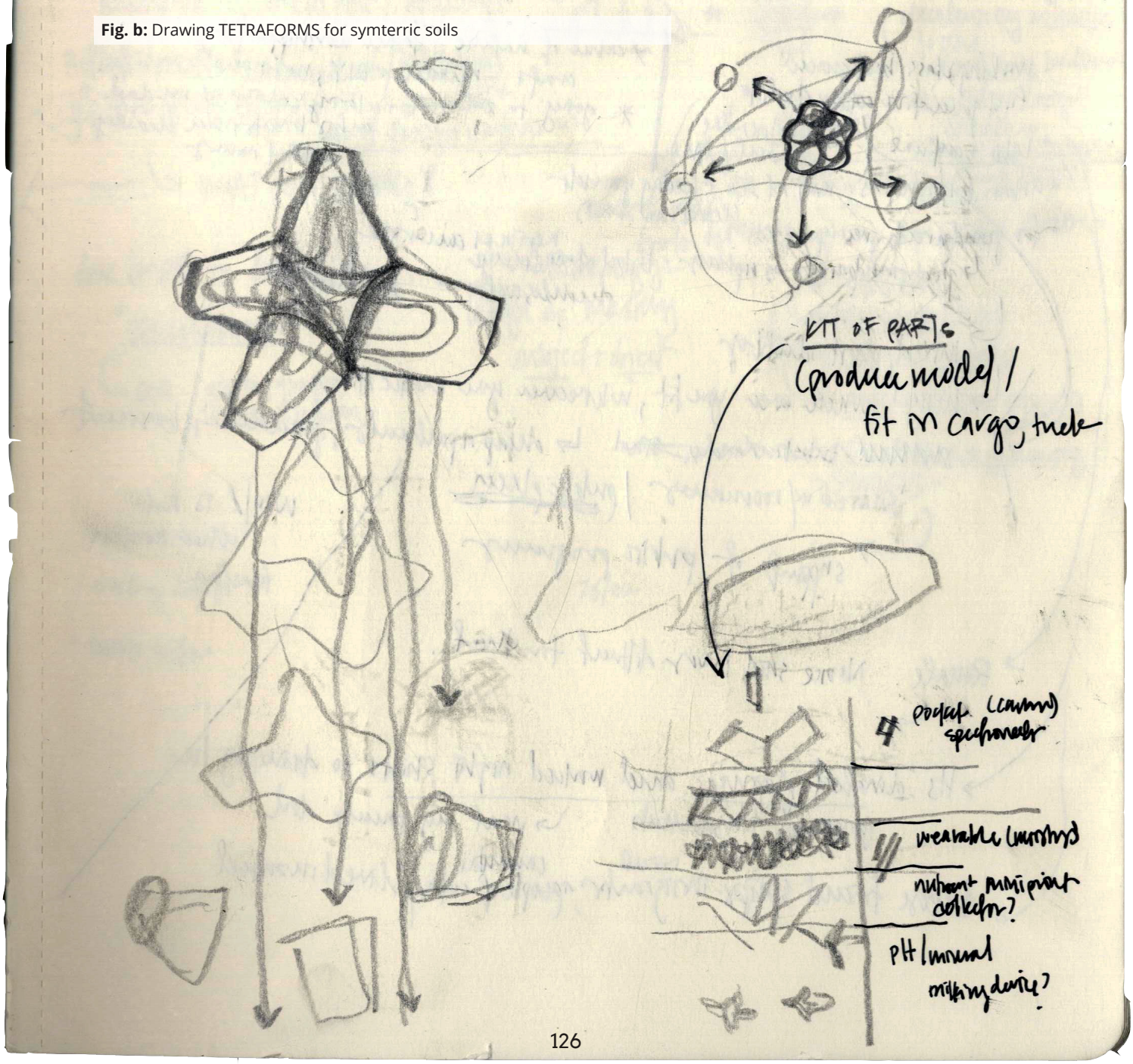


Fig. b: Drawing TETRAFORMS for symterric soils



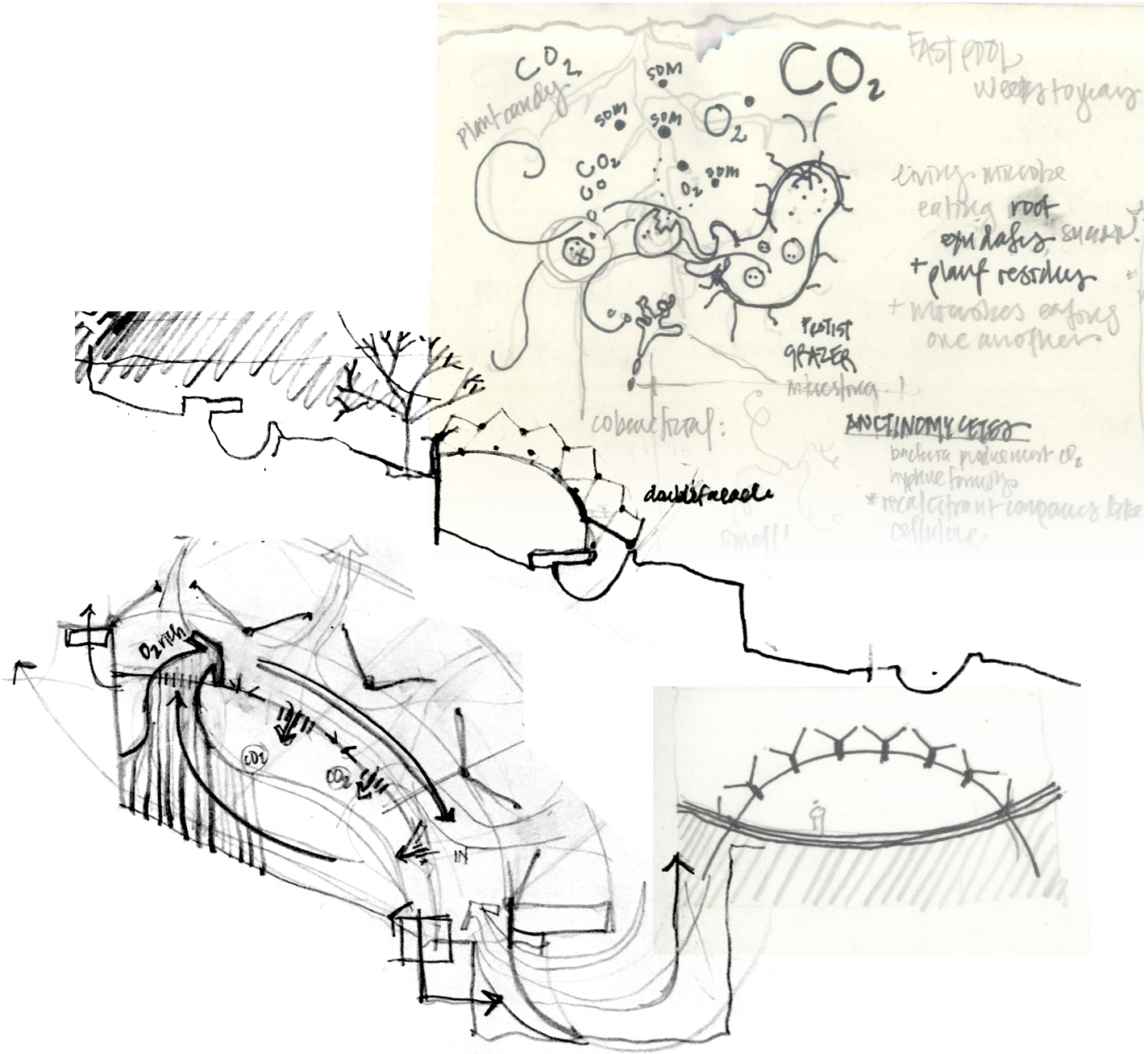
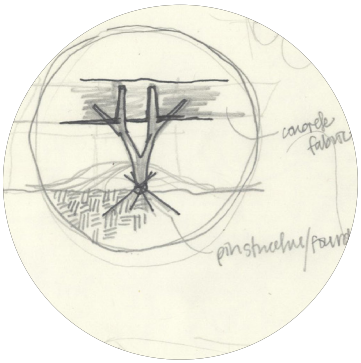
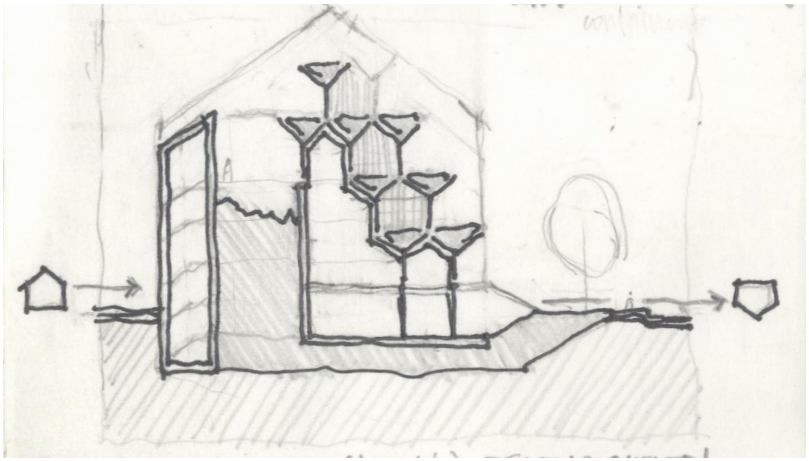


Fig. c: Drawing SPECULARIA for pneuplaggic soils, and diagramming abiotic and biotic interactions





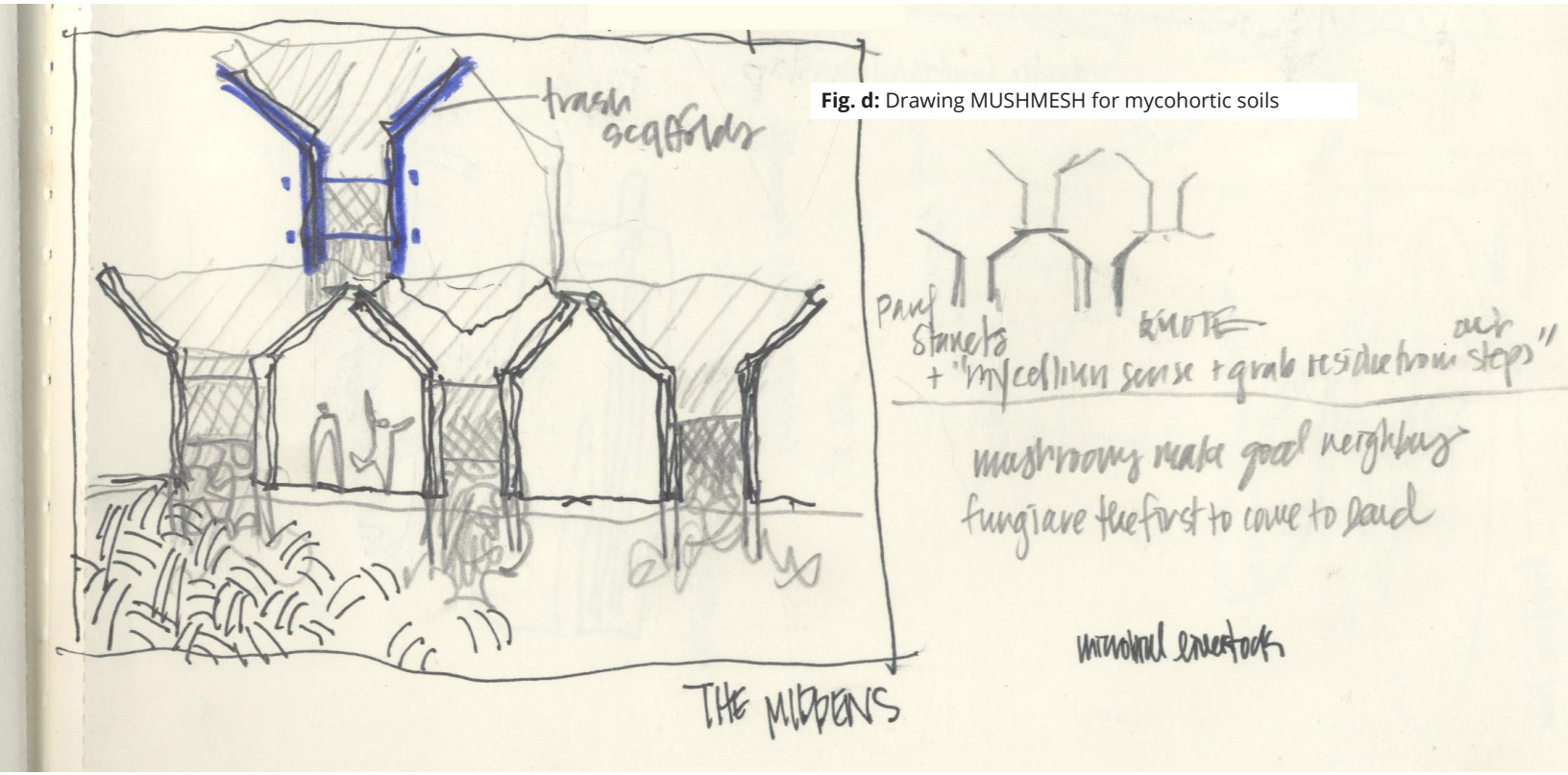


Fig. d: Drawing MUSHMESH for mycohortic soils

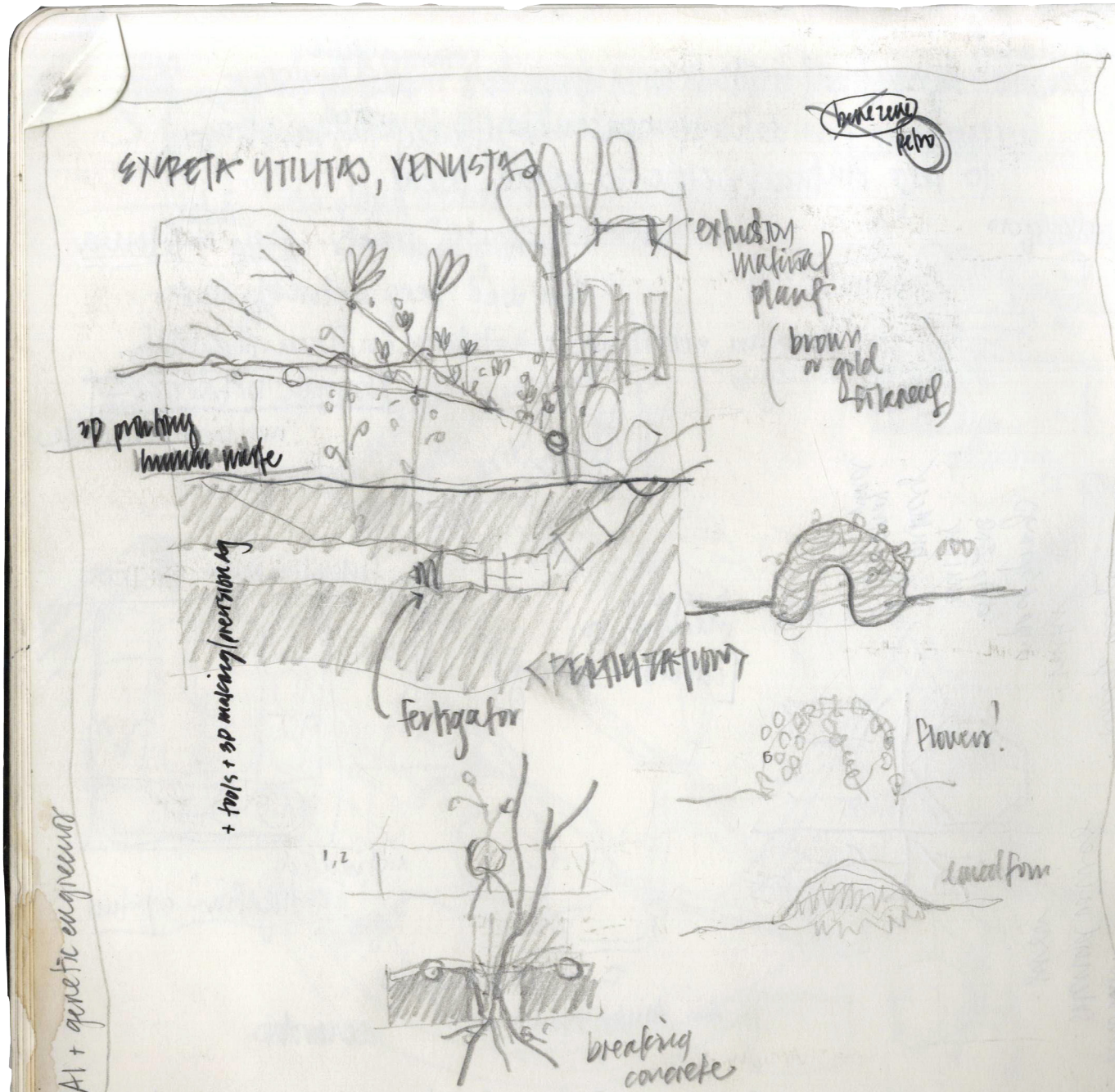


Fig. e: Drawing EARTHBOTS for biopretic soils

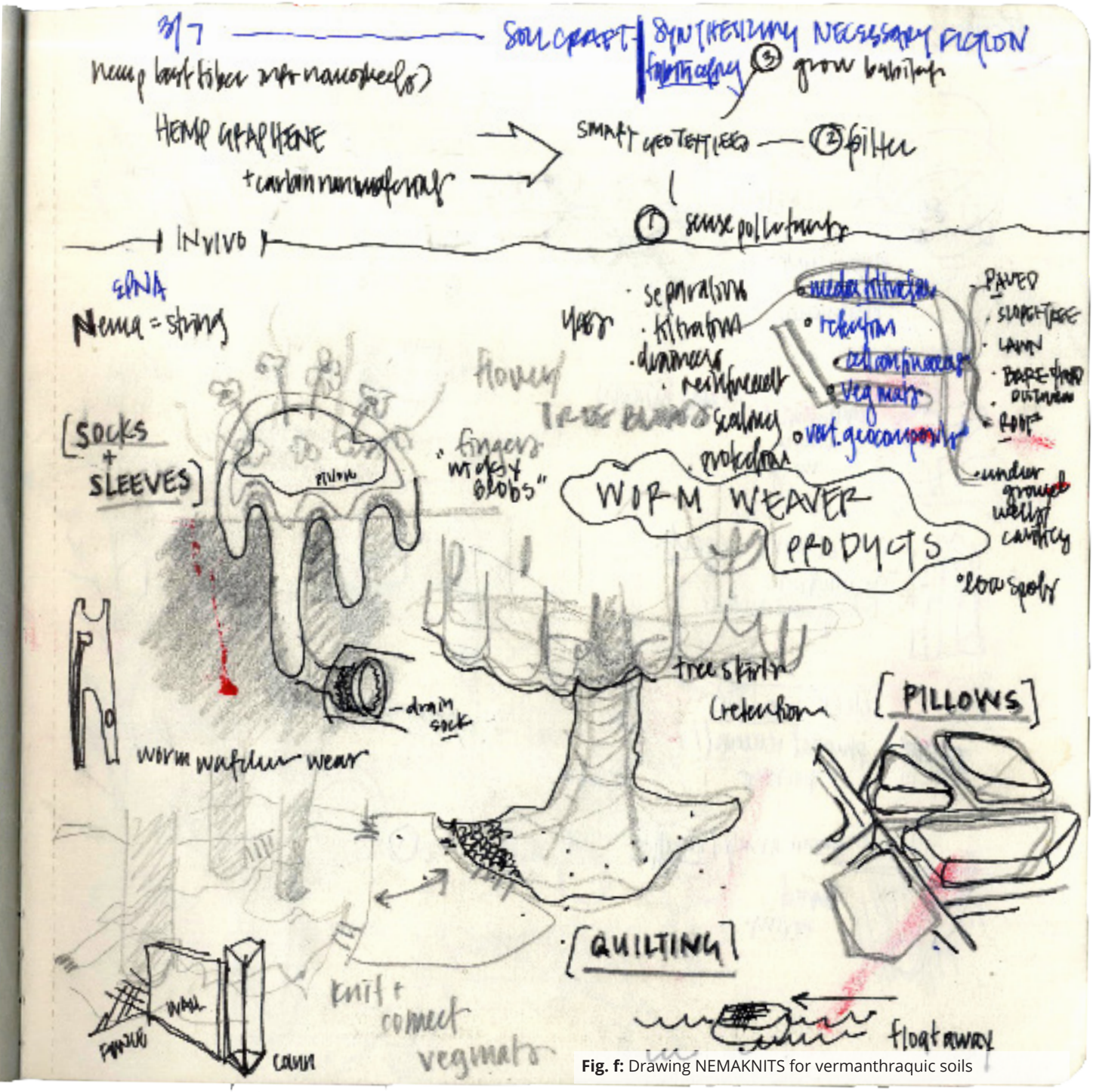


Fig. f: Drawing NEMAKNITS for vermanthraquic soils

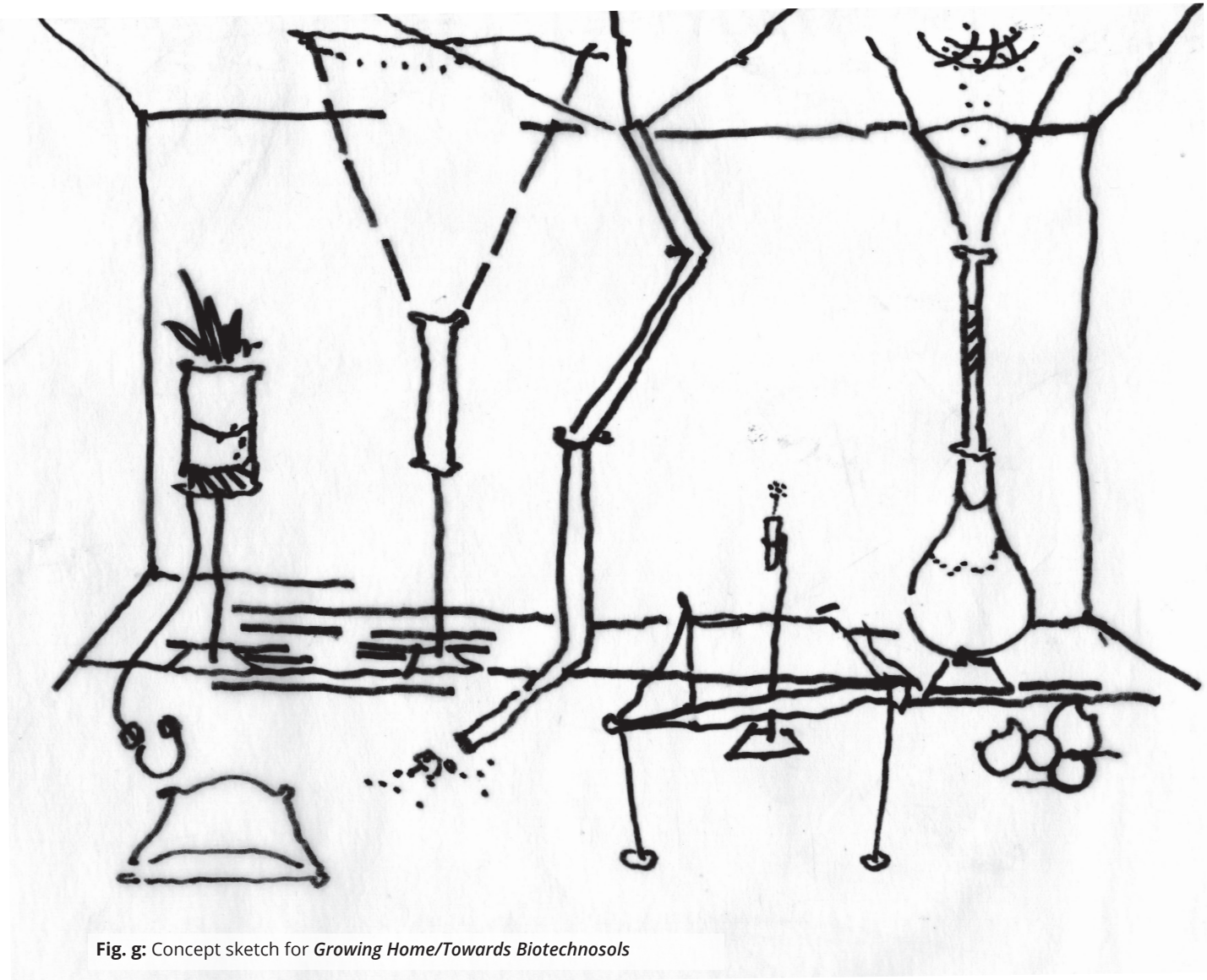


Fig. g: Concept sketch for ***Growing Home/Towards Biotechnosols***

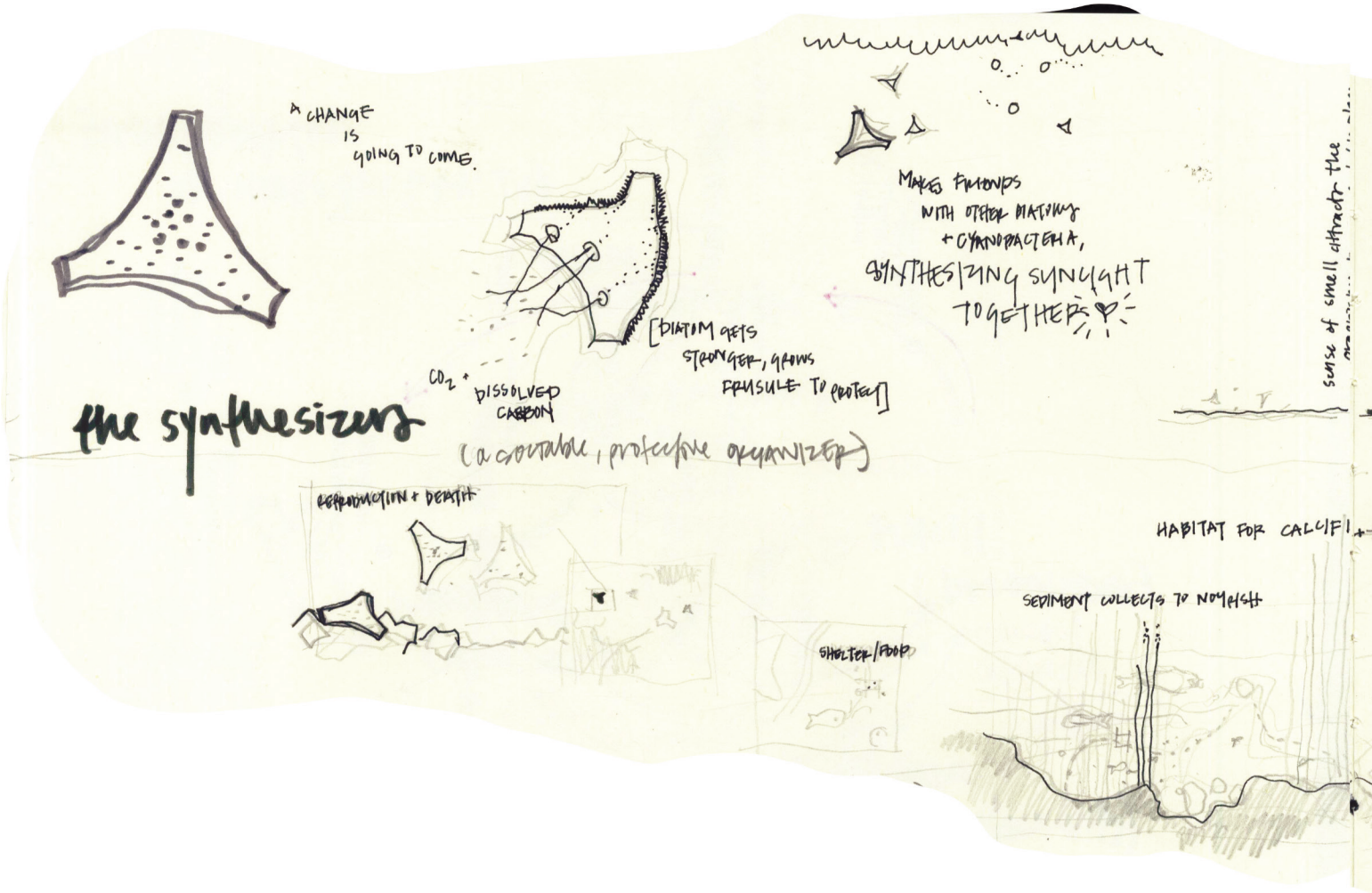
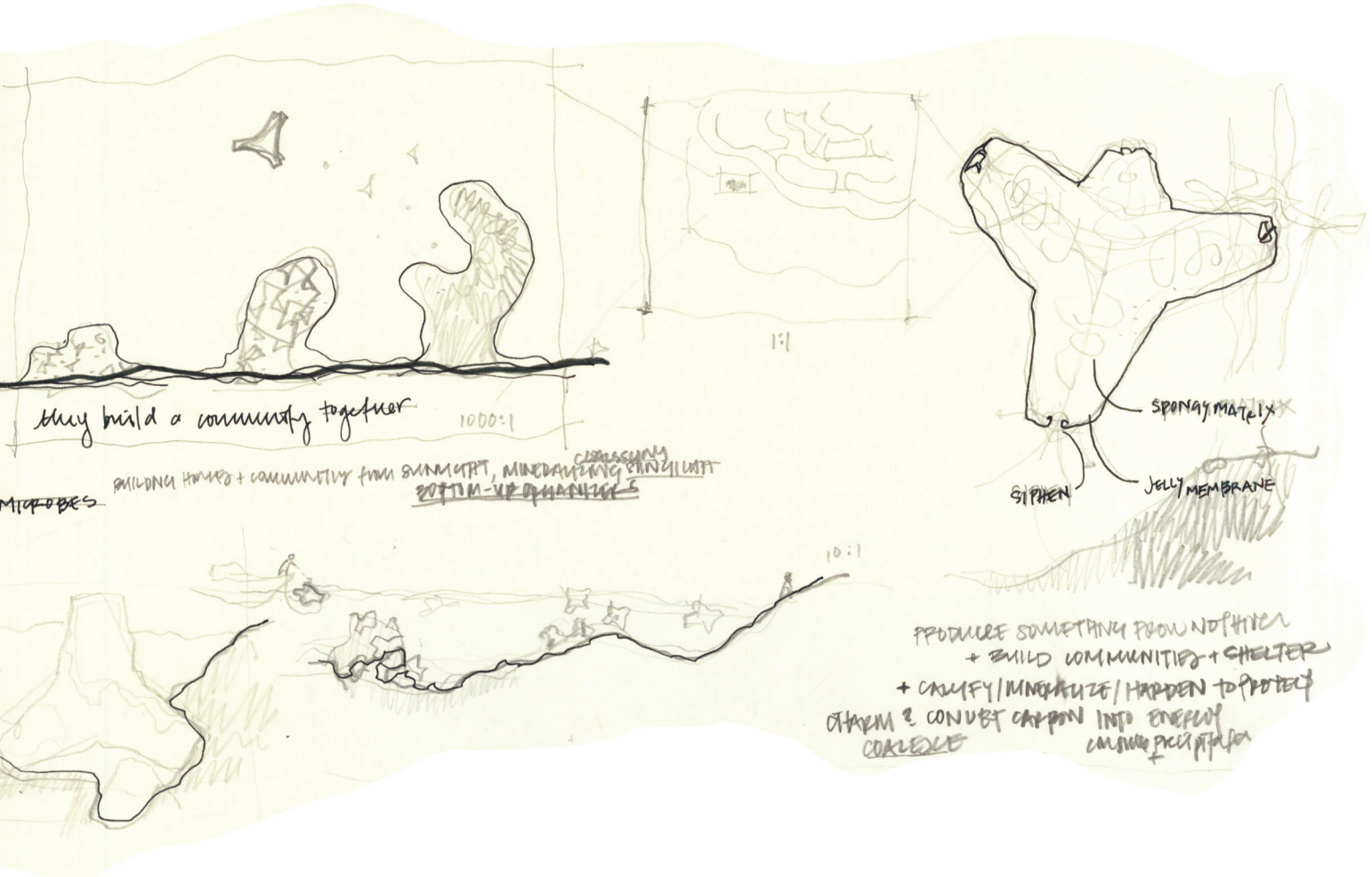


Fig. h: Developing a narrative for synthesizers and tetraforms through graphic storytelling


they build a community together
1000:1
MICROBES
BUILDING HOMES + COMMUNITY FROM SUNLIGHT, MINERALIZING CARBONATE
BOTTOM-UP
1:1
SPONGY MATRIX
SIPHEN
JELLY MEMBRANE
10:1
PRODUCE SOMETHING PROMOTHICA
+ BUILD COMMUNITIES + SHELTER
+ CALCIFY/MINERALIZE/HARDEN TO PROTECT
CHARM & CONVERT CARBON INTO ENERGY
COALESCE

APPENDIX B. ***Towards Biotechnosols***, audiovisual installation, Gould Gallery (May 2019)

pneuplaggic

mycohortic
biopretic

APPENDIX C. Final presentation format, Architecture Hall Room 042, June 3rd, 2019