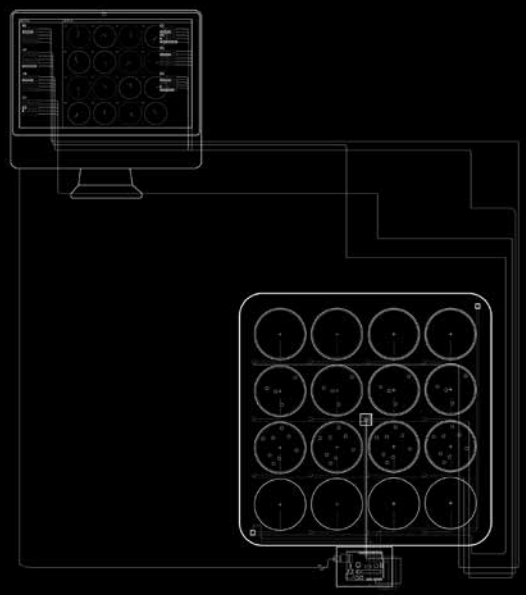
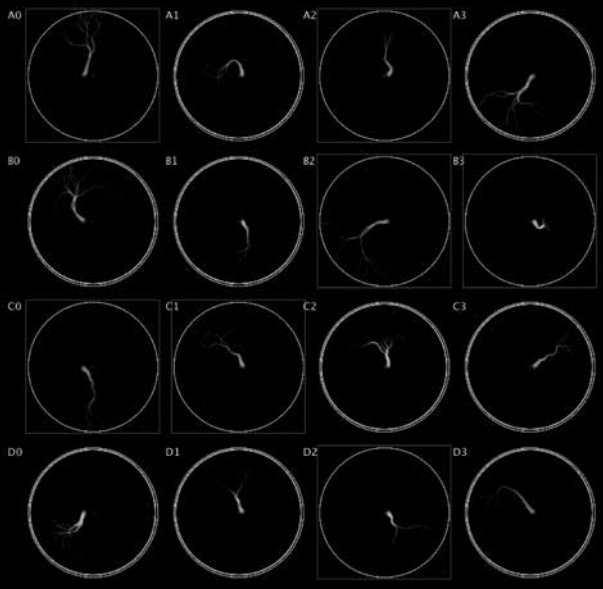
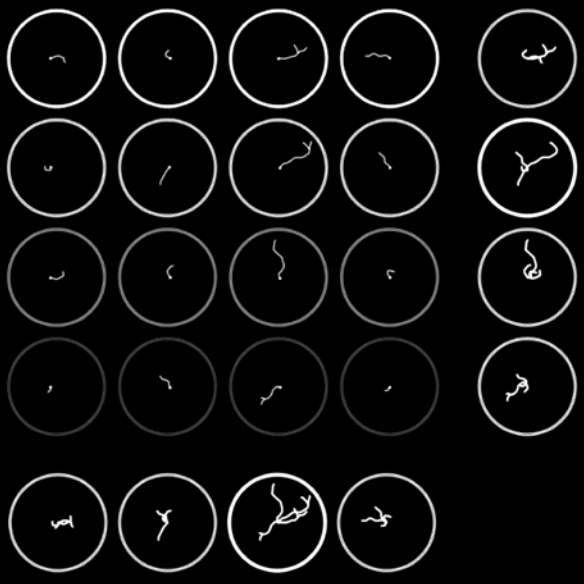






APPARATUS DIAGRAM – ATMOSPHERIC ECOLOGIES EXPERIMENT

DIAGRAM ZARIADENIA – EXPERIMENT ATMOSFÉRICKEJ EKOLÓGIE

Authors Autori: Peter Malaga, Fran Castillo, 2013

APPARATUS

ZARIADENIE

Photo Foto: Peter Malaga, 2013

APPARATUS – DIGITAL SIMULATION

ZARIADENIE – DIGITÁLNA SIMULÁCIA

Authors Autori: Peter Malaga, Fran Castillo, 2013

APPARATUS – DIGITAL SIMULATION

ZARIADENIE – DIGITÁLNA SIMULÁCIA

Authors Autori: Peter Malaga, Fran Castillo, 2013

Microbial Ecologies Exploring Industrial Hemp Behaviour under Artificial Climates (Growing Apparatus)

Mikrobiálne ekológie Výskum priemyselnej konope v umelých podmienkach (v pestovateľskom zariadení)

Peter Malaga, Fran Castillo

Mikrobiálne ekológie (ME) predstavujú teoretický scenár, v ktorom možno skúmať nové robotizované procesy výroby ako rámec výskumu a vývoja bio-artificiálnych systémov. Tieto systémy umožnia regenerovať znečistené a erodované terény, ochraňovať pôdu pred ďalšou eróziou a podporiť zdravý spôsob pestovania s využitím systémov z 3D vlákien.

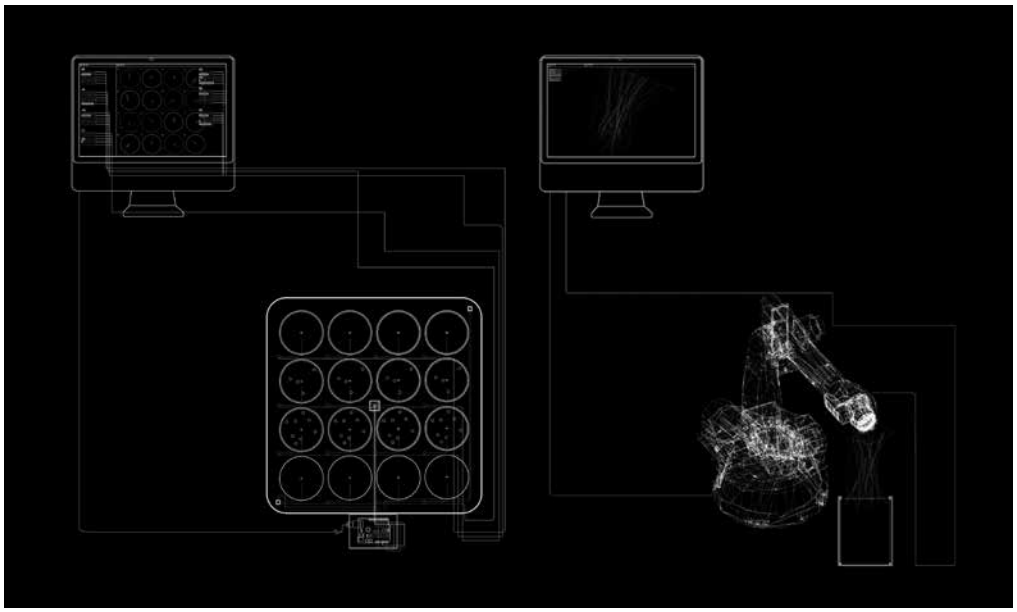
Fytoremediácia je proces, pri ktorom znečistenie absorbujú rýchlo rastúce konopné korene alebo sa toxíny v niektorých prípadoch transformujú na neškodné substancie. Takýmto dekontaminačným procesom sa z pôdy dokázateľne odstraňujú ťažké kovy. Fytoremediáciu použili aj na odstránenie rádioaktívneho stroncia a cézia po černobyľskej jadrovej katastrofe.

Výskum sa zameriava na heterogenitu vláknitých štruktúr v širokom rámci priestorových mierok. Heterogenita a interkonektivita systémov z 3D vlákien vytvára v pôde symbiotický biodiverzný mikrobiotop vhodný pre rôzne populácie mikróbov a vegetačné systémy. Systém, ktorý navrhuje mikrobiálna ekológia, má pre mikrobiálne interakcie ťažiskovú úlohu, lebo je schopný rozšíriť biodiverzitu ekosystémov. Mikrobiálne ekológie sa zameriavajú na vývoj vláknitých štruktúr, na základe ktorých možno v rôznych mierkach určiť zloženie pôdy vhodnej pre mikroorganizmy.

Atmospheric Ecologies

Atmospheric Ecologies (AE) aims to explore new fictional environments in which it becomes possible to reproduce a global climate experiment. AE investigates new interfaces that allow us to simulate artificial climates and enables us to explore how all these invisible (data) artificial microclimates are encoding the plant growth. The research intends to develop a device (growing apparatus) that enables us to increase our knowledge about the implications of using different chemical substances or artificial nutrients and their different compositions during the germination period or in plant growth and simultaneously, based on collected data, developing a digital simulation tool. The simulations will allow the exploration of new ways of visualizing of hemp behaviour. AE will be the framework for researching the link between data that has been codified in the different artificial atmospheres and hemp behaviour. Furthermore, this interface aims to expand the methods of producing citizen science. Our research investigates new ways of materialization of the Hemp Root System by exploring 3D printing techniques. AE will allow us to build 3D Hemp Root Systems under various artificial atmospheres and, consequently, helps visualizing in real time the effect of using different nutrients in hemp seeds or plants.

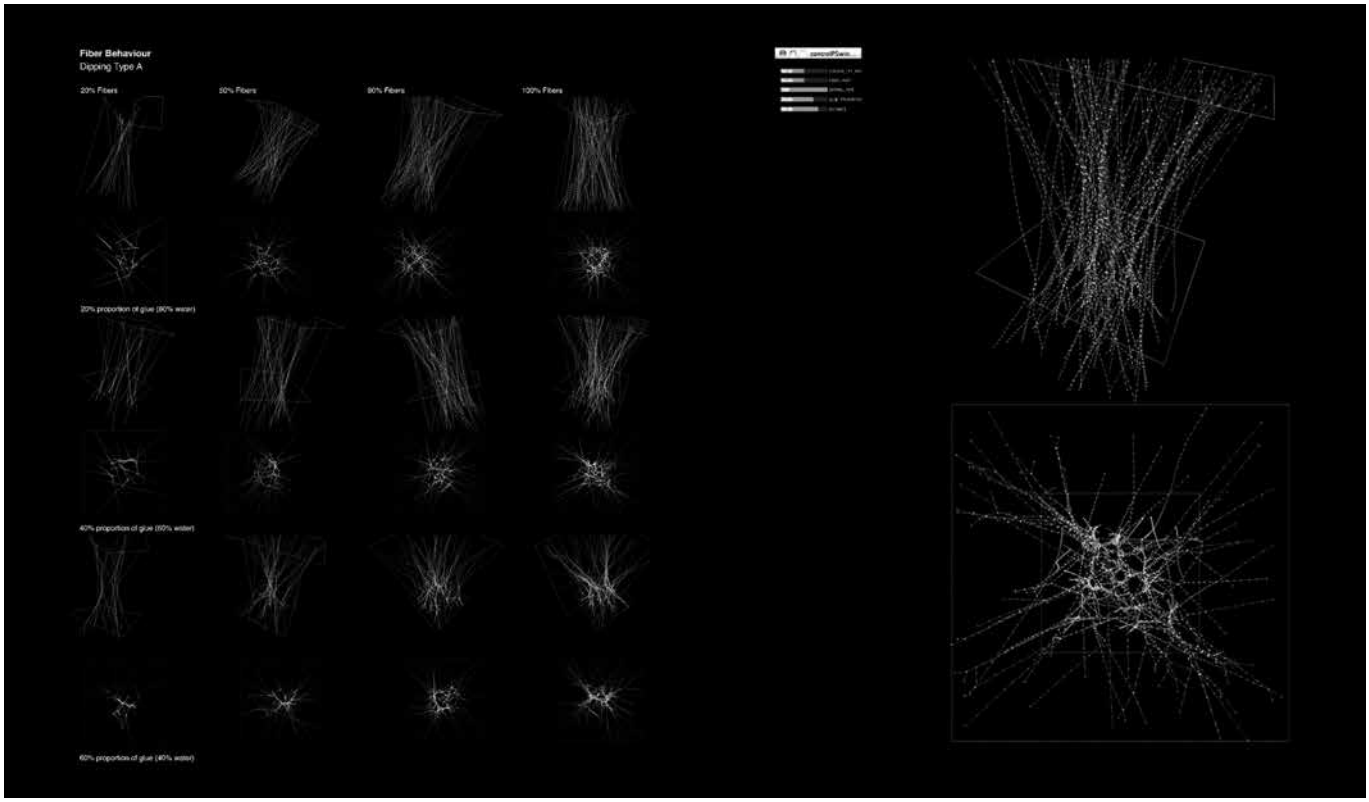
Seed germination is a necessary phase if we plan to explore the growing patterns of the plants from the initial seed stage. The most important part of germination is keeping the seeds moist at all times. Mature seeds are often extremely dry and need to be placed in a significant amount of water. When the seed imbibes water, hydrolytic enzymes are activated, which break down these stored food resources into metabolically useful chemicals.



APPARATUS – ROBOT TRANSITIONS, DIGITAL MACHINES DIAGRAM

ZARIADENIE – ROBOTICKÉ MODULÁCIE, SCHÉMA DIGITÁLNYCH PRÍSTROJOV

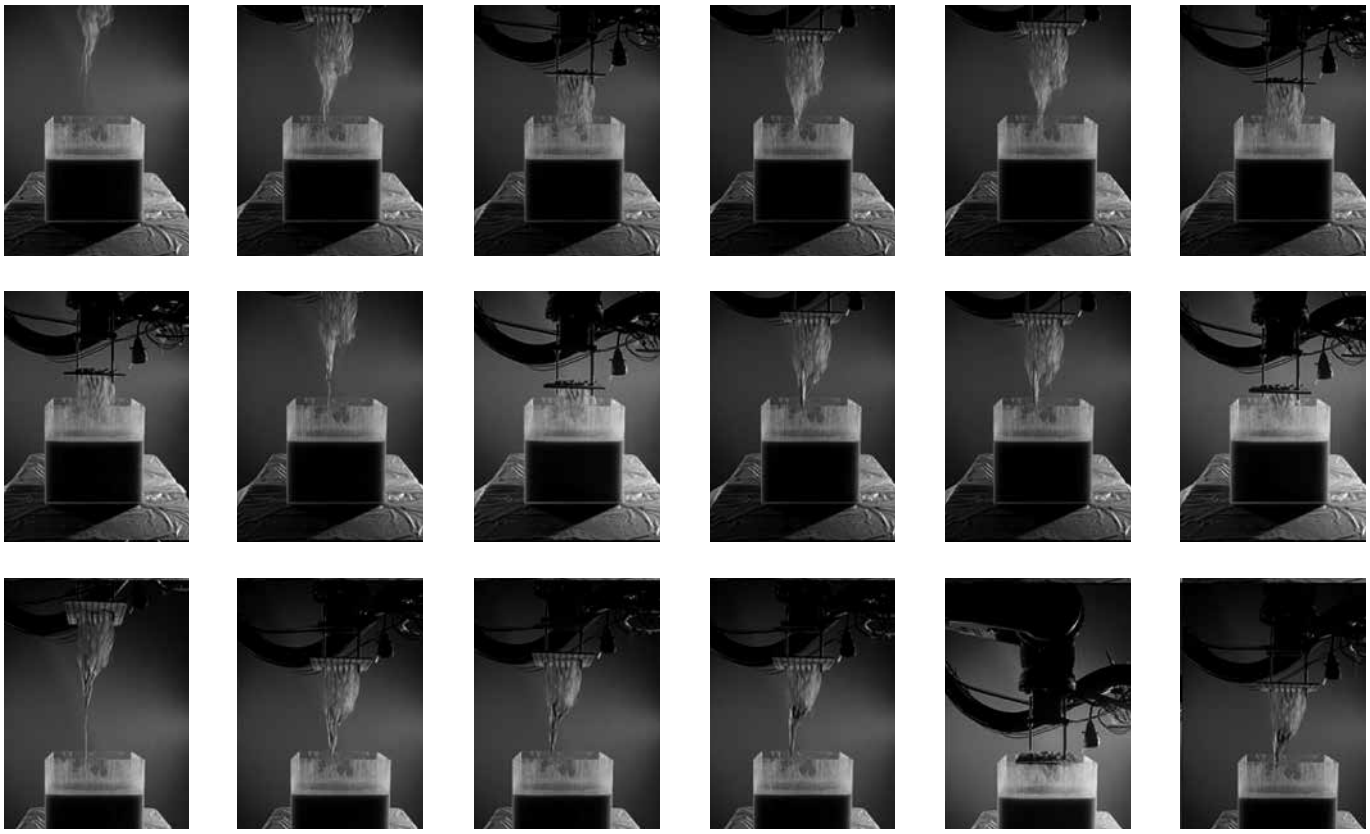
Authors Autori: Peter Malaga, Fran Castillo, 2013



FIBRE BEHAVIOUR – DIGITAL SIMULATION

SPRÁVANIE VLÁKNA – DIGITÁLNA SIMULÁCIA

Authors Autori: Peter Malaga, Fran Castillo, 2013



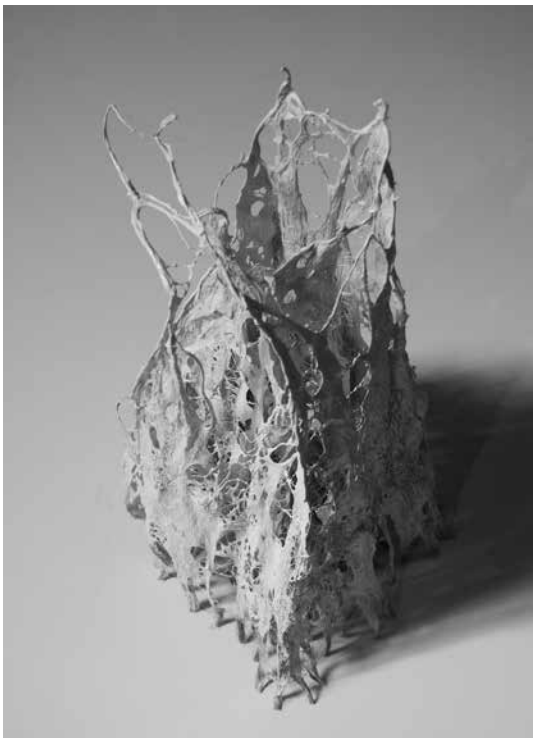
ROBOTIC FABRICATION – DIPPING TECHNIQUES AND MATERIAL TESTS

ROBOTICKÁ VÝROBA – TECHNIKA PONÁRANIA A TESTOVANIE MATERIÁLU

Authors Autori: Peter Malaga, Fran Castillo, 2013

It is necessary regularly to control if there is constantly enough moisture in the soil or alternative material. It is possible to plant in normal soil, vermiculate, artificial soil substratum (Root Gel) or eventually in a Rockwool cube. Once the seed has sprouted, this Rockwool cube can be placed into a larger Rockwool cube, thus eliminating the need for transplanting, which usually weakens the plant if it is not done correctly.

Paper towels can also be used for the germination process. This method works, but paper towels dry out extremely fast! The best way to do this is to place a paper towel in a small bowl (eventually Petri dish) that is saturated with a weak concentration of nutrients and cover the bowl with plastic wrap, so that it keeps the moisture in. Preferably, the bowl should be placed in a damp area and kept out of the light while the seeds are germinating. Covering with paper or another light-blocking material is a good option. Warm temperatures (24 – 32 C) affect cellular metabolic and growth rates and have a large impact on germination success. New seedlings should be given access to bright light from the time they emerge, as the seedling's photosynthesis provides the energy needed for continued growth; the seedling now requires a continuous supply of water, nutrients and light. Main Germination Variables: Moisture, Oxygen, Temperature (24 – 32 C), Dark/Light Cycles, Nutrients.



ROBOTIC FABRICATION – PROTOTYPES V1.0 – PHOTOS

ROBOTICKÁ VÝROBA – PROTOTYPY V1.0 – FOTOGRAFIE

Photo Foto: Peter Malaga, 2013

Prototype V1.0 (Simulation and Robotic Fabrication)

In this phase, we started to define the relations between digital simulations and physical (hemp fibre) behaviour in the process of robotic fabrication. After the set of basic material tests and different crafting methods, we decided to explore the mechanical (robotic) operation of dipping fibres into liquid mixtures and creating solid fibrous 3D structures.

To run simulations at the beginning of the fabrication process was quite speculative when we tried to simulate fibre behaviour under random conditions. However, this approach allowed us to envision in advance the different kinds of material behaviours.

In our first physical experiments, we tried different types of dipping processes and different densities of the liquid mixture with various proportions of the glue and water; after these initial tests we reached the conclusion on the right dipping technique and the proper proportion of the liquid mixture to be used.

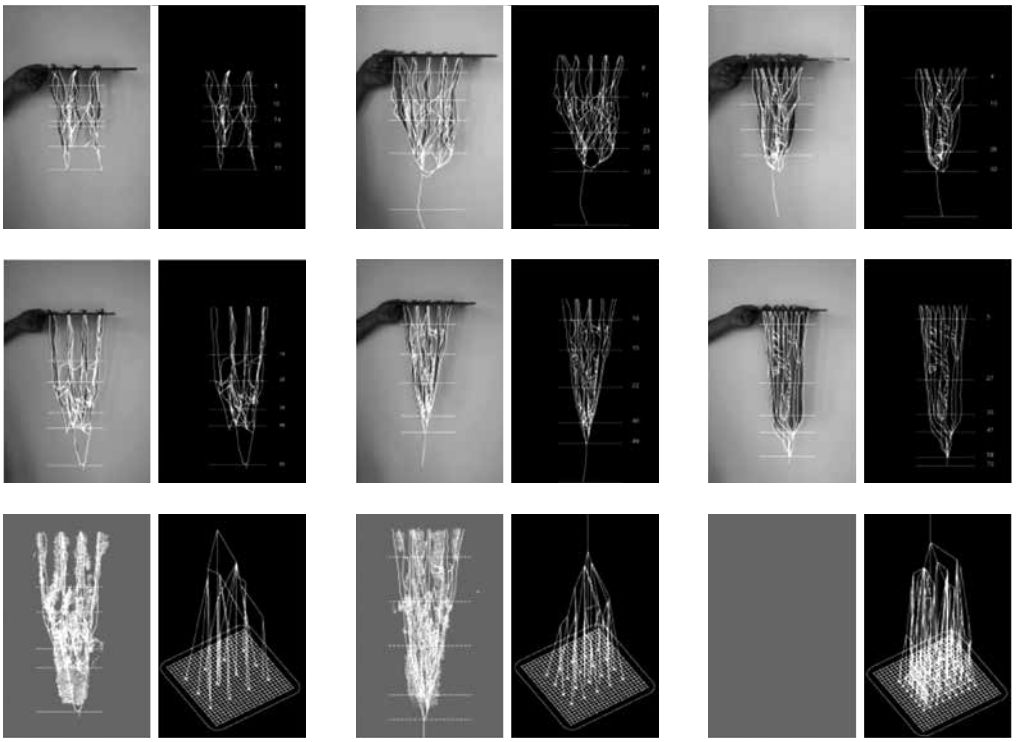
The three different types of dipping techniques as seen in the image are the following: First we dip all the fibres into the liquid material completely and pull them out for a specific time for drying; the process is then repeated various times. However, in this method the fibre would bundle at the very beginning of the process and always have a pointed tip at the end. In the second method, we started dipping the fibre gradually into deeper positions in the liquid material, which gave us better results of fibre bundling and not creating a pointed end; The third method was to dip the fibres completely into the liquid and then again gradually pull them out, which also created a pointy tip. The final proportion of water and glue had to be around 60% water and 40% glue, as with higher-density material the fibres would not dip into the medium quickly, but instead start deforming and piling into stacks on the liquid surface. Various different patterns and fibre densities were also subjected to experiment, and the fibre bundling was observed in different situations.

For the final prototype, after various dipping and drying sequences and proper formation of a defined fibrous structure with water and glue liquid mixture, the glue proportion can be increased or the white paint on the water bases can be added into the liquid material substance to obtain a more solid final structure (final liquid material proportions: 30% water, 30% glue, 40% paint).

ROBOTIC FABRICATION – DIPPING TECHNIQUE AND MATERIAL TESTS

ROBOTICKÁ VÝROBA – TECHNIKA PONÁRANIA A TESTOVANIE MATERIÁLU

Authors Autori: Peter Malaga, Fran Castillo, 2013



Fibre Behaviour Catalogue

After the experience and feedback received from fabricating Prototype v1.0, we prepared a systematic catalogue of material behaviour with different lengths of fibres and various distances between fibre strands for a more precise understanding of the dipping process. We experimented with two different fibre lengths of 30 cm and 50 cm with the grid distances between the fibre strands of 2x2 cm, 4x4 cm and 6x6 cm; in the catalogue, we can see how the fibre bundling changes with different conditions and creates different connections and patterns.

Valldaura Labs (Self Sufficient Lab – Green Fab Lab)

Covering 130 hectares (320 acres), the Valldaura estate has three nuclei: (a) Can Valldaura Nou, the farmhouse and its vicinity, where the main agricultural settlement grew up in the late 19th century; (b) Can Valldaura Vell, the original site of the first Cistercian monastery in Catalonia, subsequently a palace of the kings of the Crown of Aragon, and (c) a third complex, adjacent to the BV-1415 road from Horta to Cerdanyola, which includes the Can Valldaura restaurant and its service area.

Valldaura Labs embodies IAAC's contribution to the management of natural systems and structures and the promotion of diversity, and works in close cooperation with the Collserola Natural Park Consortium, Cerdanyola Town Council and the Barcelona Metropolitan Area in establishing a conservation plan for the environment and the landscape.

"Valldaura Labs has a group of laboratories researching into sustainability and self-sufficiency that aims to be zero net energy consumption in the future".

What can one discover during the survey of Valldaura's complex ecosystem? In this environment, nature intersects with different human activities where history overlaps with contemporary and the fresh emerging ambitions of Valldaura Labs. We discovered that the slope areas are affected by soil erosion (mostly used for vineyards in the past) and we started to think about self-sufficient and environmentally friendly solutions for restoration of these degraded plots as well as about creating a space which interconnects all environmental aspects and supports biodiversity.

After surveying the Valldaura Labs site, we selected a testing plot within the most eroded area. Soil erosion can result from a variety of environmental conditions, so we made some studies for the

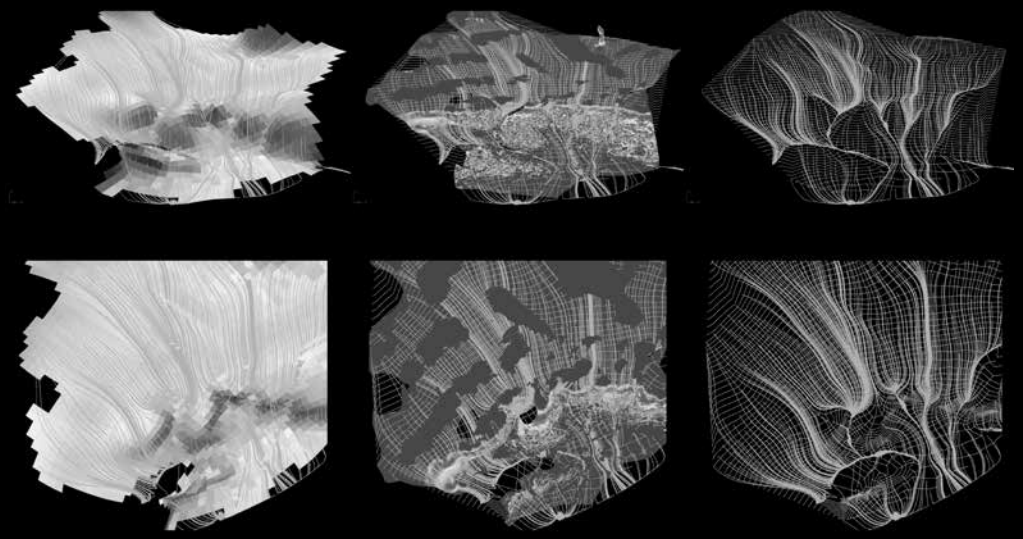
VALLDAURA LABS – TESTING PLOT
LABORATÓRIÁ VO VALLDAURE – TESTOVACIE ÚZEMIE
Authors Autori: Peter Malaga, Fran Castillo, 2013

testing area. We collected and applied environmental data to a 3D digital model of the site, which was previously scanned. The first image explains the solar radiation study, showing that wherever there is higher solar radiation the soil dries up quickly and again causes erosion. The second image shows the slope gradient of the site, from which we can understand the sliding movement of the soil. The third image explains the water flow on the site, since wherever there is a strong flow, the erosion is more likely to occur, so we had to redistribute the water flow by creating a new artificial landscape. Due to this problematic combination of existing environmental conditions, even the micro-organisms in the soil are dying.

Prototype V2.0 (Simulation and Robotic Fabrication)

The research is structured into three main domains:

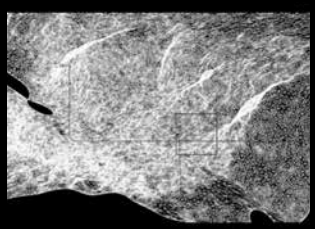
- The Sensor System (SS) as a framework for processing environmental data. The prototype has been developed in Valldaura Labs. This sensing technology is feeding our second dimension (Software Simulation) and parameterizing the virtual prototype. The parameters modelling the software are: water flows, slope gradient and solar radiation. Thus, the fibre pattern is defined according to environmental data processing.
- The Software Simulation (S) is based on a physics engine and explores new ways of simulating fibre behaviour (each string is defined by a number of particles). This variable configures the length of the fibre. The physical media are inferring alteration in the position of the particles in the physical model. The script calculates the distance between particles and when the distance is lower than 5 mm, it starts to interconnect. The parameters that are encoding the virtual prototype are: distance between fibres, lengths of fibres codified by the number of particles per each fibre, fluid properties, dipping time, speed and frequency. The internal logic of simulation is based on rules extracted from the physical experiments in which we tested the fibre behaviour under different dipping techniques, and also different



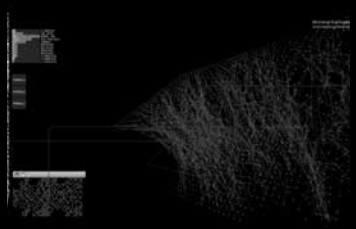
TESTING PLOT DIGITAL MODEL – ENVIRONMENTAL DATA

DIGITÁLNY MODEL TESTOVACIEHO ÚZEMIA – DÁTA PROSTREDIA

Authors Autori: Peter Malaga, Fran Castillo, 2013



SENSORY SYTEM



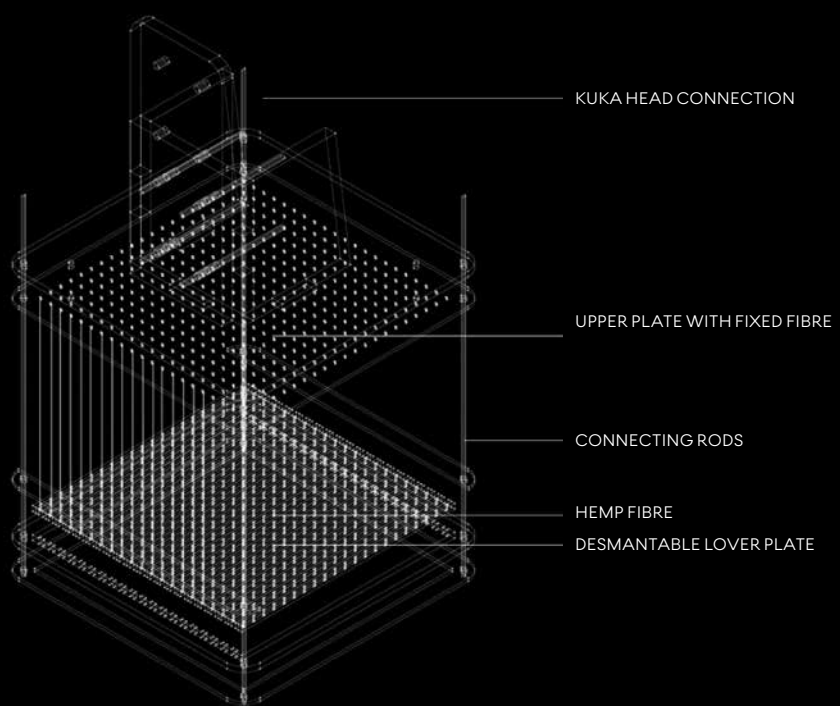
SOFTWERE

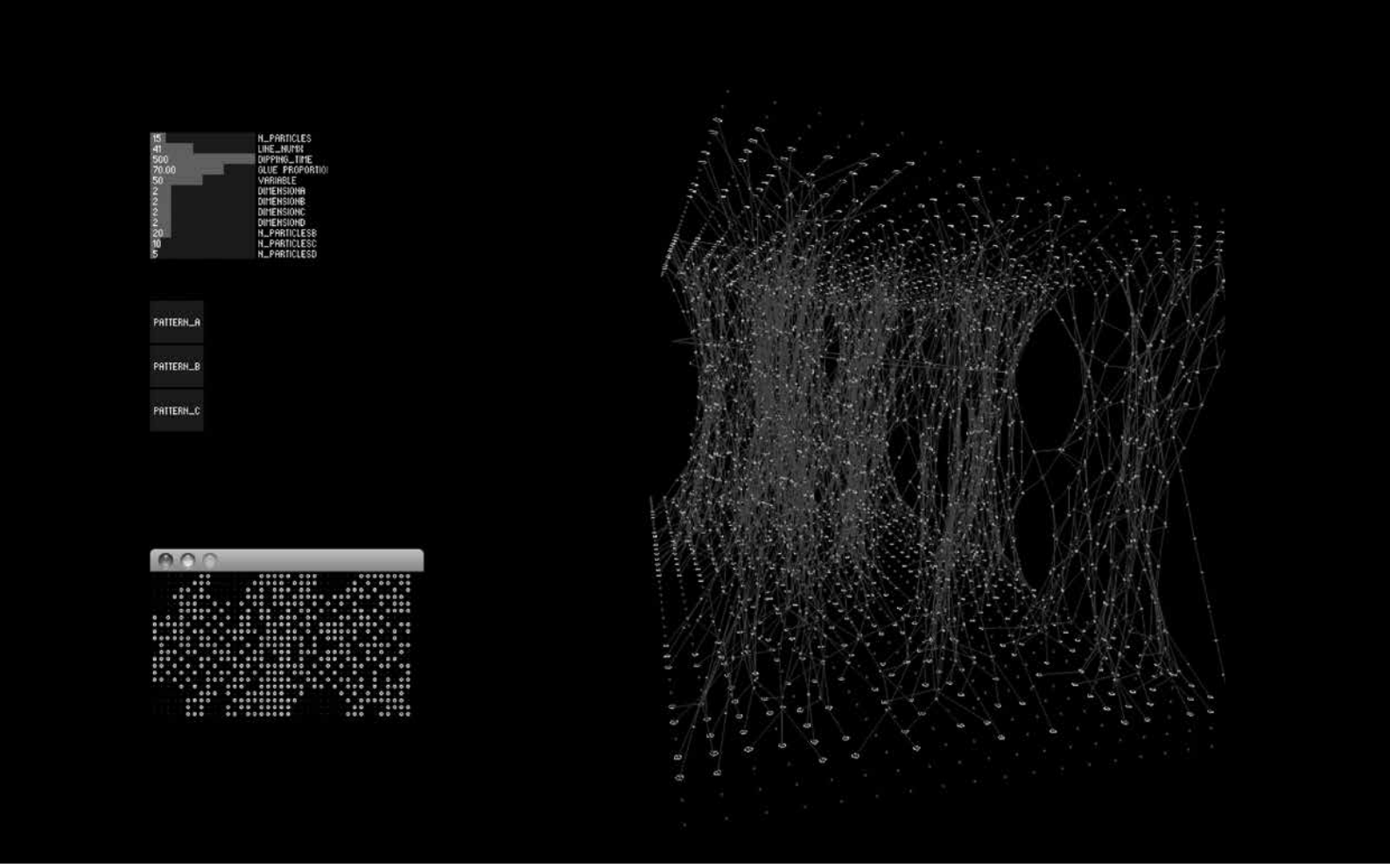
ACTUACTION/FABRICATION SYTEM

ROBOTIC FABRICATION PROCESS – KUKA TOOL

PROCES ROBOTICKEJ VÝROBY – NÁSTROJ KUKA

Authors Autori: Peter Malaga, Fran Castillo, 2013

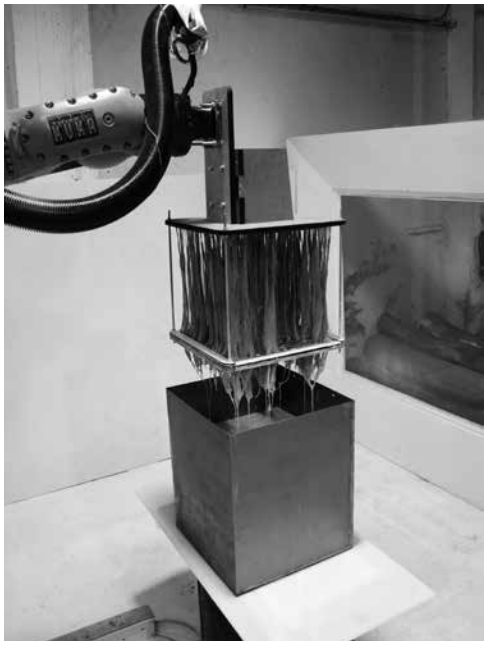




DIGITAL SIMULATION – PROTOTYPES V2.0

DIGITÁLNA SIMULÁCIA – PROTOTYPY V2.0

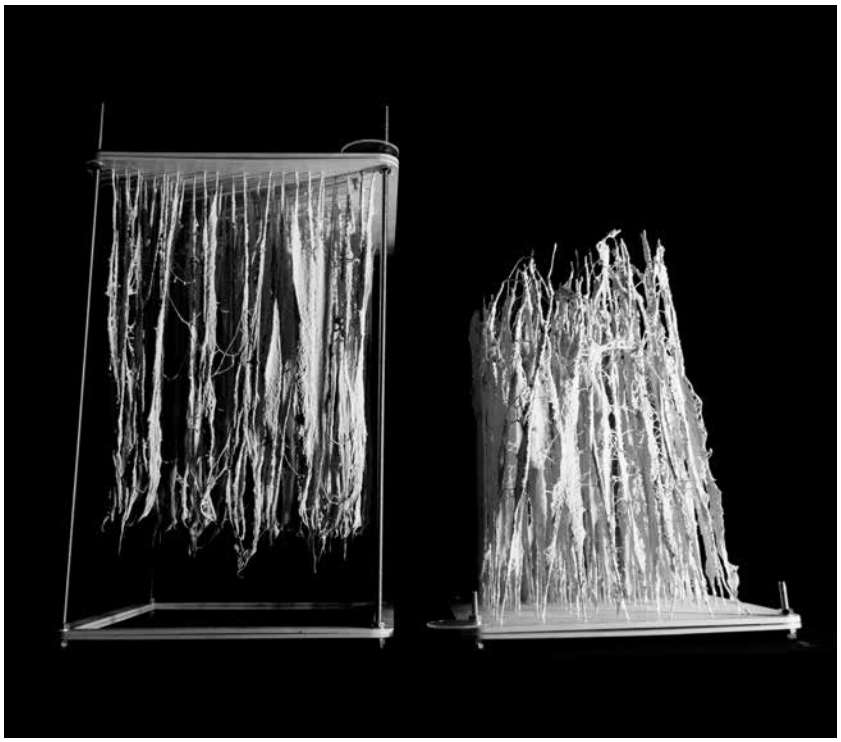
Authors Autori: Peter Malaga, Fran Castillo, 2013



ROBOTIC FABRICATION – PROTOTYPES V2.0

ROBOTICKÁ VÝROBA – PROTOTYPY V2.0

Photo Foto: Peter Malaga, 2013



FINAL PROTOTYPES V2.0
FINÁLNE PROTOTYPY V2.0
Photo Foto: Peter Malaga, 2013

fluid material properties. These material behaviour experiments allow us to understand the emergent fibre behaviour processes. The software explores new ways of form-generation and develops a new system for modelling a complex adaptive environment.

- The Actuation System / Fabrication System (FS). This phase is the physical modelling, through robotic processes, of all datasets that have been processed in the digital simulation. All of these processes are proposing a new hybrid framework for fabricating a bio-artificial ecosystem, which investigates new feedback loops between materials and digital systems. Microbial Ecologies is exploring new robotic fabrication protocols using natural fibre as an environmentally friendly medium for designing microhabitats.

The final experiment of the prototype with the robot was based on the feedback from the software simulations. A specific pattern was created for the specific areas of the plot, which have different coding: the distribution of the fibre, its density and length, which pre-defines landscape form depending on environmental parameters. The dipping technique and the halt timing were all finalised after the various digital simulations were carried out. As we found, the physical final prototypes are very close to the digital simulation. The material used for dipping was primarily water and glue, which toughened the fibres with the desired bundling. Later, paint and gypsum were added to achieve more solid results. The use of gypsum also increases soil sulphur levels when applied on site. (Binder Material Specification: 60 litres of water, 10 litres of glue, 40 litres of paint, 8 kg of gypsum.)

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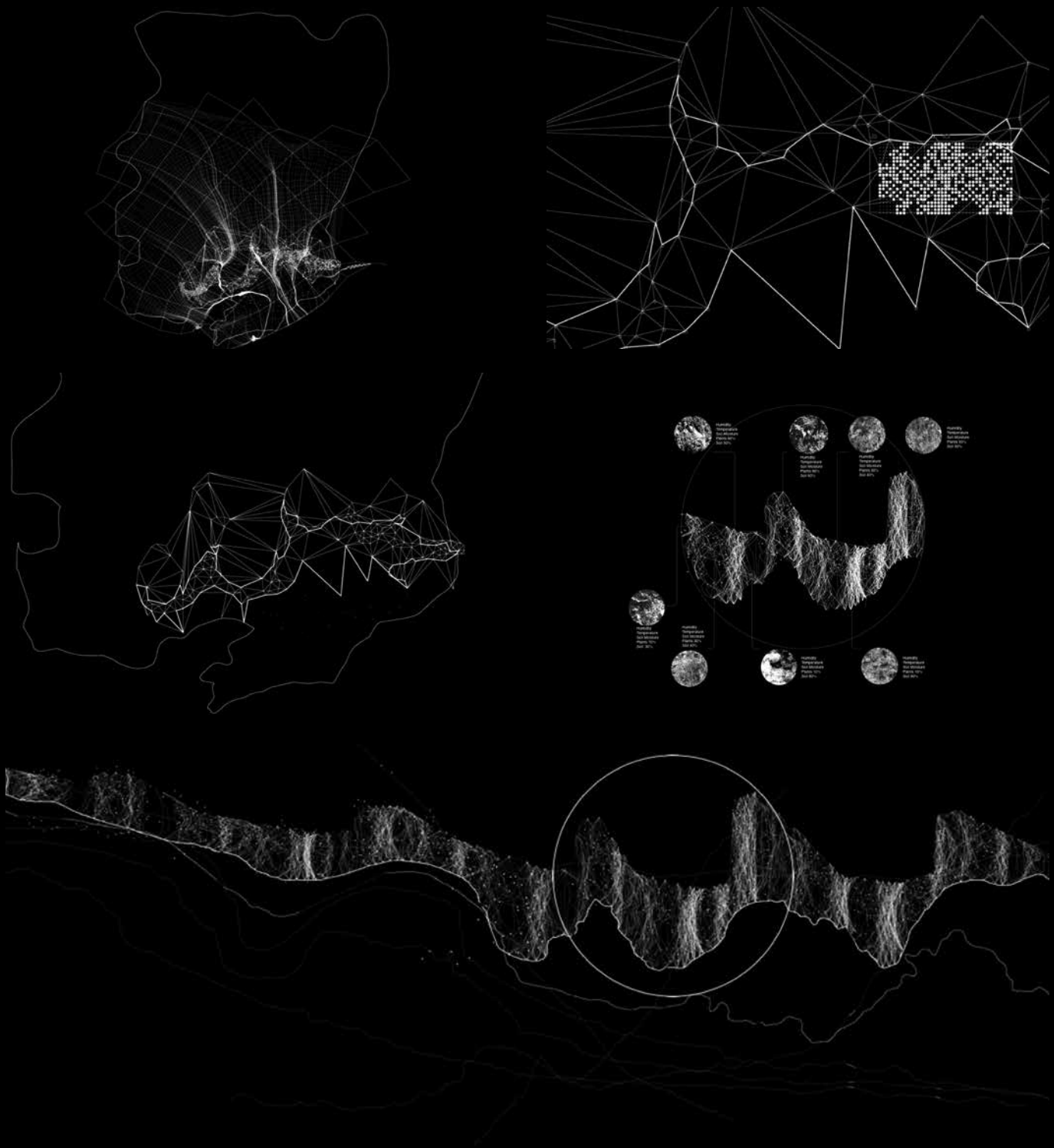
2013

Microbial Ecologies

Microbial Ecologies (ME) is the proposal of a speculative scenario which explores new robotic fabrication processes as a framework for investigating the generation of bio-artificial systems. These systems allow us to regenerate polluted and eroded terrain, protect the soil from further erosion and encourage healthy plant growth using interconnected 3D fibre systems.

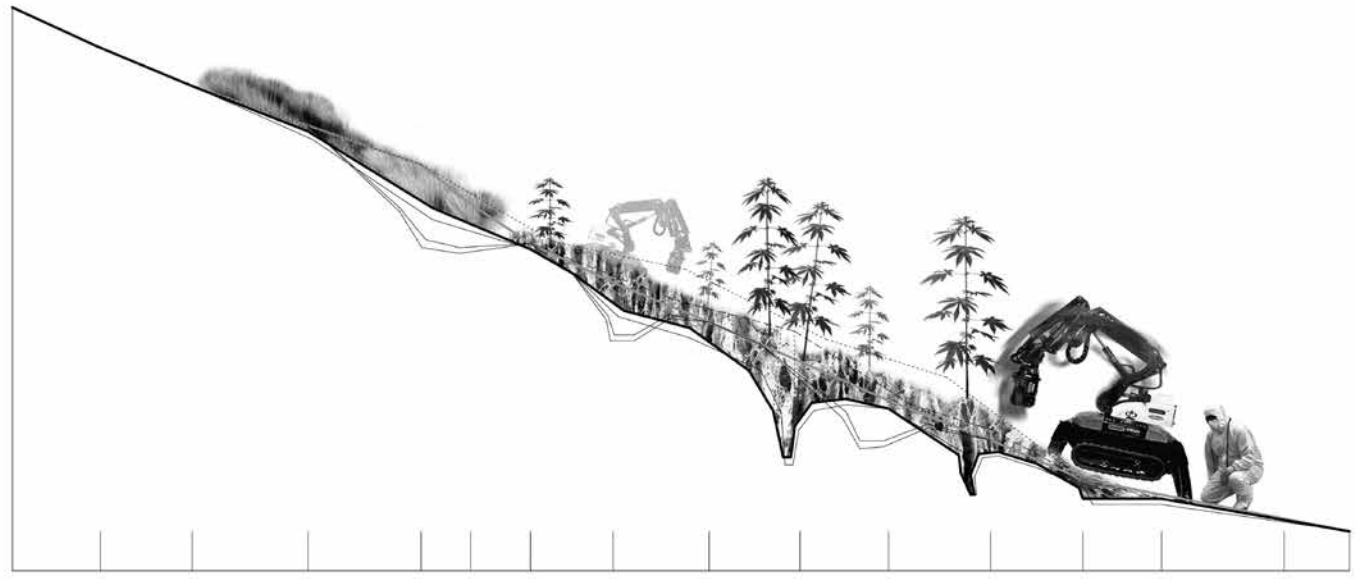
Phytoremediation is a process where contaminants are absorbed by the fast-growing hemp roots or, in some cases, toxins are transformed into harmless substances. This decontamination process has been proven to pull heavy metals from soil. It was also used at the Chernobyl nuclear

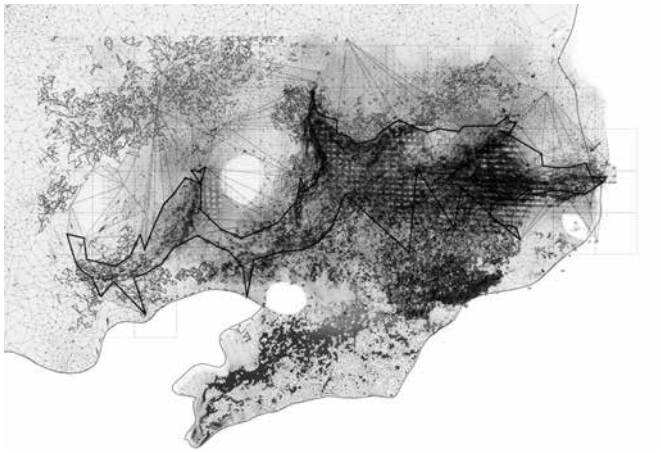


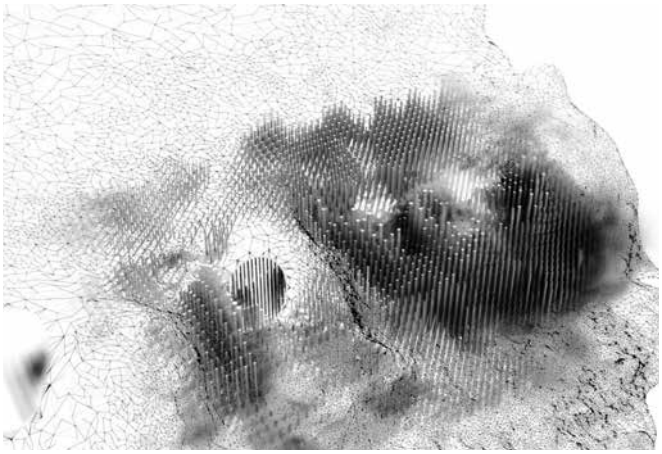
TESTING PLOT – BIO-ARTIFICIAL ECOSYSTEM – MICROHABITATS

TESTOVACIE ÚZEMIE – BIO-ARTIFICIÁLNE EKOSYSTÉMY – MIKROBIOTOP

Authors Autori: Peter Malaga, Fran Castillo, 2013







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disaster site to remove radioisotopes and a variety of other toxins such as radioactive strontium and caesium from the soil, water and air. The research explores the heterogeneity of fibre structures across a broad range of spatial scales. The heterogeneity and interconnectivity of the 3D fibre system within the soil creates a symbiotic bio-diverse microhabitat for the various microbial population and vegetal systems. The system that ME is proposing has a pivotal role in microbial interactions, and therefore can amplify the biodiversity of ecosystems. ME focuses on the development of fibre structures to characterize soil composition on multiple scales that are relevant for microorganisms.

Beside restoration of eroded or polluted areas, the system also provides renewable resources, such as hemp plants that can be harvested for industry (Cybernetic Hemp Garden). Hemp is also one of the faster growing biomasses known, producing up to 25 tonnes of dry matter per hectare per year.