THE DESIGN OF NATURE: CONSIDERING NOVEL ECOSYSTEMS

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INTRODUCTION

The merger of technology and biological matter is currently evolving in many different levels. The dichotomy between biological and technological is shifting boundaries and there is no longer a clear division between things, which emerge from nature and things that are designed by humans. Design and engineering principles and methods are increasingly appearing in a growing number of areas, e.g. due to possibilities to manipulate and modify biological matter. This kind of evolving development is also re-framing our relation to nature and what we understand with the term *natural*. Natural is being swallowed by technological on the level of material aspects, but also concerning our expectations and perception of nature.

"One can claim that the standardization of images, paper and inks in contemporary societies has produced a certain way of seeing. A comparable standardization in biological research can be seen through epistemic artifacts such as model organisms. For example, the fruit fly, Drosophila, is a model organism used in genetic research. The general expectation is that discoveries and knowledge gained from model organism will provide insight into the workings of other organisms. In the author's and associates artistic project *The Fly Printer: Prototype No.3* (Fig. 1) a standard biological model organism is used for replacing a standard part of our common printer technology. The work points to a divide between the engineered and the organic. The biological and the cultural are reunited in this apparatus as a possibility to break through a common way of depicting the world, trying to find different surfaces and using strange apparatus to insist in the interstice of visibility" (Beloff & González Valerio 2014. The excerpt is from the text discussing the work *The Fly Printer: Prototype No.3*).

The author's artistic projects and research are focused on the merger of the physical world, biological organisms and information and communication technologies. The author proposes a perspective into the merger between technological and biological as an evolving entity with many different kinds of actors, which together form an ecosystem that is comparable to scientists' definition of an ecosystem in nature. The author contextualizes her recent projects in this paper through investigation into ideas concerning the design of nature by introducing ecologists' concept of novel ecosystem. In the described projects it becomes visible how strongly our world is influenced by perspectives from technology and how embedded design and engineering approaches are in our thinking – not only concerning the technological but also towards the natural.

NOVEL ECOSYSTEMS

An ecosystem in biological terms is defined to be comprised of community of diverse organisms and their environment, including non-living components. In a recent introduction to the *Anthropocene Project* by Haus der Kulturen der Welt in Berlin, Scherer & Klingan write: "Nature as we know it is a concept that belongs to the past. No longer a force separate from and ambivalent to human activity, nature is not an obstacle nor a harmonious other. Humanity forms nature. Humanity and nature are one, embedded from within the recent geological record." [1] Following their statement on nature being no longer a force separate from human activity, one can also see that in this technological development plays a crucial role.

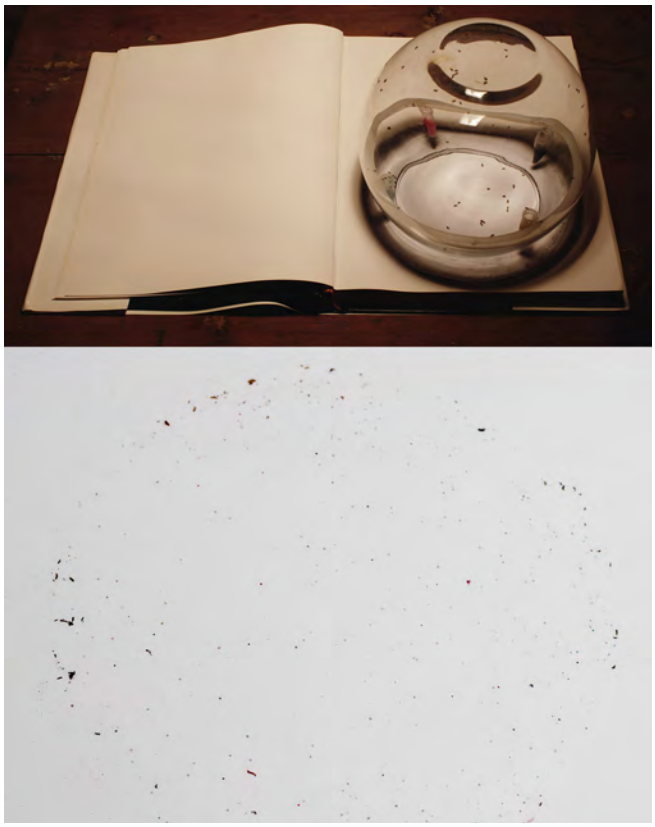

Fig. 1. *The Fly Printer: Prototype No. 3*, 2014, Beloff & González Valerio, fruit flies, glass, paper, inks, yeast.

The ecologists distinquish between few different ecosystems based on human impact. Intentional impact is visible, e.g., in agriculture, forestry and mining, in which humans have designed purposeful plans for utilization of natural resources that are typically directed towards production of goods. This is typically called a human-used ecosystem. In this kind of ecosystem technology is traditionally heavy machinery used primarily for transformation and maintenance of the land. Today these production methods are also getting connected to information technology via location-based and mobile technologies employed e.g. by agriculture.[1]

Another interesting example of intentional impact on environment that is enabled by networked technology is the project conducted by The Natural History Museum of Helsinki University[2] that was based on citizen participation. Since the beginning of the 21st century, the city of Helsinki has experienced an increase of so-called city bunnies, which has been claimed to be an effect of people releasing their pet bunnies into nature. The city initiated a citizen science monitoring of the bunnies and since 2005 the Helsinki citizens have been able to submit bunny sightings online. The obtained results led to a realization that the bunny population in Helsinki was several thousands bunnies, which was considered problematic due to the increasing amount of damage to the city parks and other human-designed plantings. As a solution to the problem the city bunnies have been hunted down since 2010; they are fed to suitable predators in the Helsinki Zoo, advertised as local eco-food. This example presents a case of ecology where a specific (invasive) species is being restricted and maintained to return the environment closer to what is believed to be its previous "historical" state. One could say that this is one form of nature preservation where previous state is considered worth of restoring. A similar kind of thinking is also inherent in various land conservation efforts, including nature reserves.

The management of land e.g. with the purpose of reproducing the "historical" state of the specified ecosystem. However, the interests of the author is specifically in the concept of *novel ecosystem*, which is defined by Hobbs, Higgs and Hall. [2] The *novel ecosystem* is an area in nature or land, that has been impacted by human actions either intentionally or inadvertently in a way that it has developed a clear difference to its past "historical" state in its species variety. However it only develops to a novel ecosystem when it is left without any human management. Typical examples would include agricultural fields, sand pits or other extensive land use that has been abandoned and the land has been left without further maintenance. *Novel ecosystem* can also emerge, for example, when an evolving situation with invasive species is not restricted and maintained, in comparison to the previously described example of the invasion of city bunnies in Helsinki, but the species in their new environment are left proliferating without restrictive actions.

Also indirect human impact, such as climate change, can cause an emergence of *novel ecosystem*. In other words, *novel ecosystems* are the response of the biosphere to human influence. [3] The author's interest in the concept of *novel ecosystem* was triggered by an underlying idea of the *design of nature* and its relation to evolution; how it seems no longer meaningful to consider separately what is "natural" and given and what is "artificial" and constructed by humans. Sacha Kagan writes: "Historically, the evolution of human cultures has been co-determined by ecological contexts. But in return, cultures have also been modifying "nature," co-determining the further evolution of the ecosystems in which human societies establish themselves." [4] *Novel ecosystems* are formed by biological nature set free and taking over abandoned land that has been formerly impacted by humans. These ecosystems are also an integral part of our culture and our current mindset. The following section presents an interesting case of a *novel ecosystem* that has emerged as an effect of unintentional human activity.

A CASE STUDY

In 1942 a Second World War airplane, a German Junker, crashed onto the hills of Kilpisjärvi in the subarctic area of Finland. Today the location is marked on hiking maps as a site of interest and on the spot is a small signpost with information about the event. The interesting aspect is that when one looks at the site today, over 70 years ago, the crash site is clearly visible and looks as if the crash could have happened few months ago.[3] In contrast to the surrounding vegetation a couple of meters away, the crash site is burned and bare and splattered by melted and rusted plane parts (which are gradually disappearing with visitors.) It is obvious that during the last 70 years the site has not recovered in a way one could expect.

This place presents one kind of case for a *novel ecosystem* to emerge; a location that has experienced human influence but it is not actively maintained. In this specific case the human impact has been sudden and unintentional, yet the development of technology has played a major role in it, which for its part has impacted the emergence of this particular *novel ecosystem.* The author's interest in this location was triggered by two things; the fact that a small-scale violent impact on environment is still visible at a site like the crash would have happened few months ago and secondly, with a question: What is there when there seems to be nothing?

Mike Davis, an American author, writes in his book *Dead Cities: And Other Tales* about the impact for natural environment of the Second World War bombing on the urban areas in London that inadvertently created possibilities to observe urban nature set free. [5] The scientists were especially interested in the urban wastelands, such as abandoned railway tracks and other rubble areas caused by destruction. From WWII onwards, the city of Berlin has been continuously under observation by ecologists, which used the destruction sites in West Berlin as their primary fieldwork sites for the study of the development of urban flora and fauna. [6] This work became the foundation of the scientific study of urban wastelands and abandoned land, often called *ruderal ecology*; in which the term *ruderal* is based on the Latin word for rubble (rudus)[4] and it refers to a plant that grows on waste ground. Davis writes how scientists were realizing that a violent event such as war, fire, bombing could act as a catalyst for a rapid expansion of previously rare alien species resulting in the creation of new urban flora. In reference to London he claims the following: "The botanical census of bomb sites in the City and the East End revealed a new pattern of urban vegetation adapted to fire, rubble and open space. Uncommon natives and robust aliens dominated this unexpected "bomber ecology." [5] Similarly, based on the decades long studies on Berlin as an urban environment,

ecologists and activists have recently claimed that urban wastelands are valuable ruderal biotopes, which display dense varieties of species. [6] It is interesting that this kind of violent human-induced impact, which is possible in a technologically developed era, sterilizes the ground and further enables it to support and develop a completely new kind of flora and fauna for the site. These kinds of emerged urban margins and wastelands are random cases for *novel ecosystems* in urban area, however, only as long as they are left without management and any design plans, even without plans for preservation of the environment.

Returning to the over 70-year old crash site in Kilpisjärvi; what about this spot? This crash site has gone through a violent impact which, according to the scientists' claims, should enable new species to inhabit it. The crash site clearly shows visible differences to the surrounding undamaged environment, but at the same time there seems to be nothing new or old growing there. The author & company[5] have collected soil samples from the crash site which have been later sequenced in a science laboratory[6] using metagenomic sequencing technique.

The genomic sequencing technologies have gone through radical development and transformation during the recent decade. In the latter part of the 20th century, genes became a dominant idea about species' evolution. In the traditional gene sequencing individual organisms are extracted from environment, cultivated in a lab and the genetic information is sequenced from the defined individual species. However, the scientists realized that just 1% of the organisms taken from environment survived the laboratory cultivation; 99% were not surviving. Metagenomics is research on genetic material that is recovered directly from environmental samples. This technique was developed to be able to sequence large communities of microorganisms as a whole, which would not survive the cultivation in vitro. In metagenomic sequencing one takes a sample of soil (or water) without extracting and separating individual species; the matter and the whole community of organisms is sequenced in one go. The vast amount of data obtained contains a collection of short gene sequences, which are fed into software detecting the recognized sequences and producing a chart of possible species in that environment. The potential interests of scientists on these kinds of *novel ecosystems* are usually focused on a possibility of discovering novel microorganisms. For example, there is a fair amount of recent interest in extremophiles, which are microorganisms that can survive in extreme environments. These microorganisms potentially produce enzymes capable of functioning in extreme and harsh conditions, which may further lead to profitable[7] industrial applications.

When looking at the larger picture of environmental metagenomics, it becomes very obvious how important one's environment is for one's survival. Another interesting aspect for the author is how metagenomic research bypasses through its method and technology the idea of an individual species. Andreas Weber has written in his account on concepts of nature, culture and politics: "The emerging, more holistic paradigm of biological regulation and identity now holds that the identity of biological subjects is often not that of one species alone: the majority of organisms must be viewed as "metabiomes" consisting of thousands of symbiotic, mostly bacterial species, according to recent research." [7] Even if the researchers later aim at mapping recognized gene sequences to construct more complete image of possible species in the sampled environment, this kind of sequencing method itself bypasses the idea of individual species. In comparison to traditional gene sequencing that targets separated individual species, in metagenomics the genomic data is produced from an environmental sample that contains various different species. This sample with its organisms is sequenced as such without prior separation of individual species. One can say that this kind of metagenomic data has no fixed point of termination, such as a completed genome sequence of an individual organism. There is no end and no clearly bordered and defined individual species; the borders of an individual start blurring. Individual no longer matters as a single or entire organism, rather individual organism blends with its environment and community.

Interesting comment was made in a discussion between the author and an expert[8] on environmental metagenomics on the amount of data, which is so large that according to the expert it is possibly cheaper to store it in the biological matter at the moment; in other words in the organism itself rather than in a digital data storage. The author's on-going artistic research on the case study of Kilpisjärvi crash site has one large challenge ahead: what now? How to interpret the data, which is received in the form of a phylogenetic tree and what does it actually mean? And what does it mean from the perspective of an artist?

TECHNO-ORGANIC ECOSYSTEM

A project by the author, the *Appendix* (2011), is a networked tail designed for a human. The idea for the work was to explore how technological networks enable new kinds of connections and relations to the natural environment, as well as arbitrary human constructed systems. The *Appendix* is designed to become part of the user's physiological body, however, the movements of the *Appendix*–tail are triggered and controlled by the real world events that are external and not controlled by the user. The horizontal direction of the tail movement is determined by the direction of the Helsinki city transport tramway no. 3 in real time and the vertical movements are triggered by the current wave height data from the Baltic Sea. These connections were intentionally selected to have no predefined purpose or self-evident meaning for the user. Rather, the *Appendix* aims at constructing a situation in which it is possible to investigate techno-organic connections that merge the user's body and the environment into a single entity.

Eric Kluitenberg has written about a concept of *techno-ecologies* according to which technology can no longer be understood standing in opposition to biological and social relationships. The technological ecologies emphasize our connectedness to our

environment and our dependence on the available resources. “They become ecologies in which social relationships are deployed, not just with other human beings, but also with other organisms and even inanimate objects.” [8]

Fig. 2. *The Appendix*, 2011, Beloff, electronics, textile, wood, horse hair, plastics, network connection.

Following a similar line of thought the author is investigating an ecosystem, which is the merger of physical world, biological matter, technology and networks. This ecosystem includes various kinds of entities: living actors, such as humans, non-humans (plants, animals, mushrooms, micro-organisms, etc.), but also novel technologically manipulated organisms, such as ones based on synthetic biology or gene manipulation. Furthermore, this kind of ecosystem contains actors that are non-living in biological terms, but which have life-like properties or behaviour, e.g. artificial life organisms and evolutionary systems and intelligent robots. It can be considered as a *novel ecosystem* that is evolving in many different layers at the same time. One can claim that in our current societal and living conditions the formation of this kind of ecosystem has passed the point of no return; it no longer has a possibility to return to its previous or original state. One can see various indicators of this merger of digital, technological and organic matter. The commonly visible are, for example, the mediation of our environment through the use of networks, ubiquitous computing and various sensor technologies, including the wide use of mobile phones, GPS-modules, webcams for environmental observation and the recent increase in the use of drones. But similarly the *novel ecosystem* is present and visible in the field of life sciences and developments in synthetic biology. These various aspects are forming our current environment and also our expectations are evolving together with changes in the environment.

This investigation into these kinds of *novel ecosystems* is an attempt to frame various technology driven developments that include or concern of biological and living organisms. It also points to the underlying ideas of the author’s artistic research and projects. The author’s recent interests are focused on entities, which are mergers of technological data based components and physical, often living, components. In the author’s projects these entities are seen as structures that are based on connections, rather than constructed singular objects with clear borders. These projects speculate on the transforming relationship between an enhanced human and an enhanced environment. Many of the author’s recent works have been anchored to Gregory Bateson’s statement from 1969 that the unit of survival in the biological world is an organism plus its environment. [9] The author considers Bateson’s statement in our contemporary environments and within the conditions afforded by the merger of technological and organic ecosystems.

A Bioreaktor by L. Beloff & M. M. Borch (2014, in-progress) is a project born in the intersection of art, design, biology and technology. It is constructed as a symbiosis between a human and microbial fuel cell consisting of microbes and algae. The initial starting point for the project was one of the key questions of our future: energy. However, instead of aiming at influencing the human behavior towards more a sustainable way of using energy or proposing plausible solutions for the future, this project is focused on the underlying perception about energy and life as a symbiosis within its surroundings. Following Salminen and Vaden’s writings, it is almost impossible to think about energy as an object or material; its effects are perceivable (or sensible) but itself “energy seems to name at the same time something internal, immaterial and spiritual and something material, concrete and physical.” [10]

Microbial fuel cells have recently generated a lot of interest among the energy production industry. With this project the quest was not about maximizing the effectiveness of energy production, but rather the question was how small microbial fuel cell makes sense and what happens when one (a human) will become a life support system for it. The work consists of a wearable microbial fuel cell, which contains oxygen-producing algae and soil bacteria in the same closed system. The human is a necessary component for the flow of water within the system. Additionally, the system will produce digitized data about the current status of the whole ecosystem. On the one hand, the project challenges our perception of production and consumption of energy. On the other hand, the project explores concretely the formation of an ecosystem with dependencies which contains networked technology, microorganisms and a human.

Multiplicity of relations is one of the key conditions for the recent projects by the author. This is seen in the extension of the works through connections and relations to the real world, which reach beyond their immediate material presentation. These produced artifacts do not represent, but their existence as well as the users’ presence is tightly intertwined into the concept of ecosystems as a merger of technological and organic.

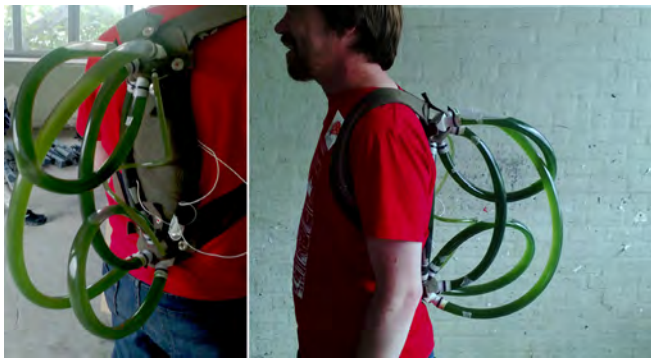

Fig. 3. *The Bioreaktor*, 2014 in-progress, Beloff & Borch, algae, bacteria, plastic, electronics, textile.

CONCLUSION

We are increasingly becoming aware of the transition which our world and we are experiencing towards a new idea concerning the concept of nature and the meaning of the term *natural*. Our approach to biological nature is gradually being coloured with perspectives from design and engineering. Today, not only material things but also living organisms are designed on computers and produced or modified in laboratories. Equally, our technological devices form an elemental part of our current world. During the last decade, these everyday devices have extended and transformed concepts such as time, presence and distance. Andreas Weber writes in reference to various scientists and theorists: "organisms are no longer seen as machines competing with other machines, but rather as a natural phenomenon that "creates" and develops itself in a material way while continuously making and expressing experiences." [7] The on-going merger of technological and biological matter seems not possible without treating the living matter with a similar perspective to that which we use for the development of technology. Technological development always implies an intention, which is typically directed towards creating purposeful functionality. What does it mean when a similar kind of intentionality is present in the molecular level manipulation of biological matter? How does our relation to the biological or natural, world change with technology-based developments and with new possibilities to observe and connect to nature through technology?

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ENDNOTES

1. E.g. Mobile Agriculture Research: http://floatlearning.com/2012/08/float-mobile-learning-research-report-shows-how-mobile-agriculture-has-arrived-in-north-america [accessed 6.10.2013]
2. Also other institutions are conducting surveys of invasive species in Finland using citizen science methods, e.g. Ministry of Agriculture and Forestry.
3. The author is part of a working group investigating the multi-layered story of the site: Oron Catts, Laura Beloff, Kira O'Reilly, Kathy High, Andy Gracie, Astrida Neimanis , Antti Tenetz. The project was initiated within Field_Notes workshop organized by Finnish Bioart Society http://bioartsociety.fi
4. https://www.wordnik.com/words/ruderal [accessed 24.10.2014]
5. Oron Catts, Laura Beloff, Kira O'Reilly, Kathy High, Andy Gracie, Astrida Neimanis , Antti Tenetz
6. With the help of Professor Nils Peder Willasen at the University of Tromsø.
7. The scientists use the term bio-prospecting for potential commercially driven interests.
8. Tromsø, January 2014; a discussion between Nils Peder Willasen, Oron Catts and the author, Laura Beloff.