Nordisk Arkitekturforskning
The Nordic Association of Architectural Research

Proceedings Series 2018-1

ON URBAN HARD SURFACES

Figure A. *Chlorophyta / graffiti [Kværnerbyen Oslo 59°54'13.2"N 10°47'12.6"E],* ink print on paper. Artwork for the Drawing Biannual Oslo, 2016. Artwork: Elin T. Sørensen 2016 © BONO. Photo: Knut W. Alsén.

ON URBAN HARD SURFACES

Elin T. Sørensen

ABSTRACT

This academic essay presents some angles to an arts based doctoral study, where one aim is to fuse methods from the arts, landscape architecture, and science for the sake of arriving at visionary urban design propositions. In respect to the discourse of artistic research, the aspiration is to shed light on the underlying forms of knowledge particular to the field of arts and landscape architecture. Thus, the study evolves around the artist/architect as societal actor, skilled in critical, aesthetic, and poetic thinking. An anticipated contribution is to elucidate mentioned traits that are of relevance to the advancement of architectural research per se, as well as to educational practice. What is at stake is the development of legitimate and relevant scholarly activity.

Moreover, the essay addresses the cultural and biological enrichment of urban hard surfaces through a transdisciplinary approach; specifically, through the possible establishment of *biologically active* urban covers – for the pleasure of people as well as ecological functions. Here notions such as *green building envelopes* and *eco-engineering* are introduced. Moreover, in order to achieve new cognition through work with form and space, the study initiates a series of *living labs*. The artwork "*Mosses/circuits*" is the study's first outdoor-laboratory proposal, where mosses in combination with microhabitat reliefs inspired by electronic circuit boards are the main ingredients. In this fashion, the work addresses interrelationships between nature, technology, and human values.

KEYWORDS

Artistic research, transdisciplinary practice-based exploration, urban hard surfaces, urban living labs, microhabitat-experiments, eco-engineering

Cite this article: Sørensen, E. T. (2018). On urban hard surfaces. *The Production of Knowledge in Architecture by PhD Research in the Nordic Countries. Proceeding Series 2018:1*. Editors: Anne Elisabeth Toft & Magnus Rönn. Nordic Academic Press of Architectural Research. Pp. 411-441. 978-91-983797-2-3. ISSN 2535-4523. Pp. 458.

The series is ranked at level 1 in Norway and Denmark.

Figure B. *Tortula acaulon* is a minute (1–2 mm high) ephemeral moss with immersed capsules. This example was growing along with Bryum lanatum, in a backyard porch under a barbecue grill in New Mexico. Photo: Russ Kleinman & Karen Blisard (photomicrograph 400x of cross section of mid leaf, March 2015. Accessed from: https://wnmu.edu/academic/nspages/gilaflora/t_acaulon2.jpg.

PROLOGUE

FASCINATION | **DEEP GREEN**

When little, I was a dreamer … and a particularly attractive setting for this preferred imaginative mode was the atmosphere attached to mosscapes, as for instance discovered on forest floors. Miniature universes; lining up between curbstones, or as green shapes that made boulders look soft. Folded tinder fungus, lichens, and the many mushroom caps made up a community of small forest people. Walking barefoot – it was as if they tickled my skin. The ground felt like a cold and damp cushion, into which each step would sink slightly under the body weight. I remember the somewhat thick, heavy smell of the wood floor's moist soil, and of entering a silence – as if the soft green layers protected against sharp, unpleasant noise. Moreover, there was the touching of rotting tree stumps and wood smouldering between the fingers. I was aware neither of the ecological value of these decaying habitats, nor of the intricate underworld of mycelia: its interconnected communication via biochemical cascades or signal pathways such as the woodland's fungus Internet. Mosscapes revealing colour gradients from deep green to black, from velvety and friendly to dark zones behind curtains of hanging roots. Moss carpets, ornaments with stars, trumpets, and folds. I was a child absorbed by the forest floor's fairy-tale scenography, imagining that I could collect the dewdrops containing rainbows and bring them home.

> Bryophytes are small, non-vascular plants, such as mosses, liverworts and hornworts. They play a vital role in regulating ecosystems because they provide an important buffer system for other plants, which live alongside and benefit from the water and nutrients that bryophytes collect. Some bryophyte species are amongst the first to colonise open ground. Bryophytes are also very good indicators of habitat quality as many plant species in this group are sensitive to levels of moisture in the atmosphere, which are lower in disturbed habitats because there is less shade.[1]

INTRODUCTION

The following text was developed in the context of the seminar *Knowledge Production in Architecture by PhD Researchers in the Nordic Countries*, organized by the Nordic Association of Architectural Research. Accordingly, the text presents some sides of a doctoral project which is being carried out at the Faculty of Landscape and Society, at the Norwegian University of Life Sciences (NMBU). The study has two points of departure: first, an interest in the interface between arts, landscaping, and science as a way to arrive at visionary urban designs; and second, an interest in reaching a deeper understanding of the city as habitat, and possible interactions between people, ecology, and urban form. The study's main theme, thus, is the potential for cultural and biological enrichment of the dense inner city. The theme connects to overall concerns about urban resilience and the so-called *Green shift*, which imply great societal changes concerning climate impact and environmentally friendly restructuring of cities.[2]

Particularly, this article focuses on the possible treatment of urban hard surfaces by so-called biologically active covers – for the pleasure of people as well as for environmental benefits. In this, notions such as microhabitats and green building envelopes, together with strategies such as eco-engineering, are introduced. The attempt is to concretize the mentioned strategies by presenting the study's ongoing practical endeavours, exemplified by using urban sites as outdoor laboratories. The artwork *"Mosses/circuits"* is the study's first living-lab proposal, where mosses in combination with reliefs inspired by electronic circuit boards are the main ingredients (section IV will provide closer look at this work). These site-specific investigations are based on the mentioned coupling of ecology with urban form, again by seeking to fuse methods from the arts, landscape architecture, and science. They are inherently transdisciplinary.

> The idea of an expressive component in research is important to the architectural industry, thus possibilities of expressing the qualitative aspects of the world and adding something new to the existing through experiments and proposals is characteristic for the field. Research is "coloured" by traditions and professions, and research in architecture should be coloured too, taking into consideration that the practice of architects stretches from natural science and sociology to art and that the most important way in which the architect achieves new cognition is through work with form and space – drawings, models and completed works.[3]

ARTISTIC RESEARCH: INVESTIGATION THROUGH PRACTICE

This article presents some angles of an arts based doctoral study, in its initial phase. The work follows a practical and processual path typical for architectural creation, as is pointed out in the above quotation. Compared to the academic and scientific tradition, architectural and artistic research are the younger branches – characterized by Professor Halina Dunin-Woyseth, Oslo School of Architecture and Design, as "hybrid modes in the continuum from scientific research to creative practice".[4]

In the *OECD Glossary of Statistical Terms*, research is defined as "any creative systematic activity undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications".[5] According to the Norwegian Artistic Research Programme, artistic research should include dimensions, such as a sound basis in artistic practice, that provide for new artistic perspectives and contributions to the development of the field. Furthermore the candidate should be committed to articulating and reflecting on methods and work processes; promote critical dialogue within one's own discipline and with other relevant disciplines; and make results accessible to the public.[6] Catharina Dyrssen, professor of architecture and design methodology, elaborates on architectural research as being "not pure, often contradictory and vague, impossible to regenerate, open for interaction, logical thinking intertwined with associative and intuitive conceptualisation".7 Hence, an arts based approach may be seen as "breaking boundaries" of "established behaviour", such as the research methods and traditions from the natural sciences and the humanities. Naturally, their similarities and differences are debated in this context, as for example by Birger Sevaldson[8] and *The Routledge Companion to Research in the Arts*.[9] In respect to this discourse, the study associates with design theoretician Nigel Cross's concept of "designerly ways of knowing, thinking and acting", and his statement that "designers should concentrate on the underlying forms of knowledge particular to themselves".[10] Maarit Anna Mäkelä, Associate Professor in the Department of Design at Aalto University, Helsinki, discusses his emphasis on the experience of the "work performance" when she addresses designerly results in the form of artefacts as embodying design-knowledge.11 Hence, artefacts can be seen as transmitters of research as much as written language. Correspondingly, Jørgen Hauberg, Vice Dean at The Danish Academy of Fine Arts School of Architecture, claims that this particular research branch arises from design: "from the proposal, model or experiment to the generalisation and rationalisation by consciously extracting rules about the object of the research process."[12]

In the doctoral study presented here, part of the exploration is done by way of self-reflection, where data are drawn from the author's experience as a practicing visual artist and landscape architect (since 1996 and 2008 respectively). Architectural experience is harvested through the part-time PhD position in combination with freelancing in the mentioned fields. Altogether, the work address artistic and aesthetic skills – specifically the critical, analytical, and not least poetic approaches. These are aspects that seems less present in more "conventional" landscape design work, which, however, have potential to arrive at more vital and even economically sustainable results.

In order to establish a professional merit true to both field- and site-specific concerns, contributions to the advancement of architectural research are of great importance. What is at stake is the development of legitimate and relevant scholarly activity. Thus, the study aims at articulating some angles of view on landscape architectural research, where an inquiry through design practice sets the scene.

THE SUGGESTION IS OF UNPOLISHED WRITING

> Essay (v.) from Latin exigere "drive out; require, exact; examine, try, test", apparently meaning here "to weigh". Also "short, discursive literary composition", first attested in writings of Francis Bacon, probably in imitation of Montaigne. The suggestion is of unpolished writing (etymonline.com/word/essay)

The PhD study's written, visual, and practical outcomes follow an essayistic path, such as a dialogic structure; with a process-oriented open form – testing trains of thought by experimental, associative, and critical approaches.[13] Jo Bech-Karlsen describes this approach as tracing the "travel of thoughts". He sees experience as the main "fodder" to such travels: the vantage point, from which the writer combines her knowing of the world with the reflections of others through a sequence of reflective steps.[14] The so-called father of the essay, Michel de Montaigne (1533–1592), characterizes this dialogic structure as "replanting': through complementary exchange between the writer's own accomplishments and existing literature, insight is sown and eventually unfolds in experiential transactions between the receiver/reader and sender/writer.[15]

Along these lines, both in the urban design experiments and the PhD's written outcome I seek to cultivate an *essayistic approach*. Whereas academic texts tend to use visual input illustratively, and as such tend to place the textual at the top of the hierarchy, an essayistic form gives room for an equal integration of various narrative agents. As for visual representation, the essay correlates with the sketch as well as the collage, where the assembly of elements such as pictures, text, or movie clips forms a connected whole – similar to the montage, where the mix of narrative elements collectively bring forth the message. The essay allows for "collisions" of ideas, concepts, and images stitched together rather roughly. In comparison, academic papers may be perceived as a collage of scholarly voices, too, however sometimes edited quite artlessly. Be it as it may, the strategy of "unpolished writing" has served as an inspiration for this particular text, by seeking to demonstrates the "digestion" of existing literature, and its juxtaposition with quotations (the scholarly voices) with visual input and personal reflections.

URBAN ESSAYS: THE SITE AS LABORATORY

As each site is a story in itself, comprising for instance people, physical conditions, and the tensions between them – the above-mentioned approach is assumed applicable to place making and site transformation.

Like natural processes, the city too is in a state of perpetual change. Thus, urban transformation and development should provide many occasions for research and experimentation. In order to achieve new cognition through work with form and space, the study initiates the mentioned *living-lab concept*. By concrete experiments adapted for specific urban milieus, the intention is to harvest insights on some benefits of nature-based solutions. The test sites specifically focus on the properties of the dense inner city's hard surfaces, and with the above-mentioned essayistic approach as the explorative frame. As the opening of this text, and likewise the mentioned ongoing artwork *"Mosses/circuits"*, is based upon a long-standing fascination with mosses – mosses play an essential role in the suggested outdoor experiment.

GUIDING CONCEPTS FOR LOOKING AT, DECHIPERING AND TREATING CITYSCAPES

> Urban ecology is an amalgamation of several disciplines, and is closely aligned to the relatively new discipline of landscape ecology. Today, urban ecologists are trained in and utilize terminology, paradigms and methodologies from a diversity of disciplines such as ecology, human ecology, planning, architecture, geography, economics, political science, engineering, sociology, social work, anthropology, psychology, and health sciences.[16]

In order to comprehend the urbanscape as habitat, the PhD study builds upon the broader field of urban ecology. In this article, the understanding of the latter mainly leans on Jari Niemelä and Jürgen Breuste's *Urban Ecology: Patterns, Processes, and Applications*,[17] the first research-level book to define the field of urban ecology with a focus on the functioning of cities as integrated social-ecological systems.

Herein the introduction entitled "The History of Urban Ecology: An Ecologist's Perspective" accounts for the field's development.18 The author there claims that the discipline of ecology has shown relatively little interest in the "ecology of human settlements". Some biological researchers have even viewed cities as "anti-life", that is, without nature, and thus have considered the city as "undeserving of study".[19]

These are tendencies that, to some degree, still linger within some scholarly perspectives; for example, in the new description system for Norwegian natural resources (NiN), which was tested as part of the present study (see section below). We discovered in it a lack of categories that adequately cover urban environments. According to Mark J. McDonnell, such attitudes connect to the so-called "equilibrium paradigm" which is considered outdated and thus has been replaced by the "non-equilibrium paradigm", a concept that "incorporates recent knowledge of how ecosystems are structured and function".[20] Similarly, Barbara Clucas and John M. Marzluff present human/non-human relationships as a new direction to the field,[21] concluding that a "fuller understanding of urban ecology can be gained by explicitly studying the degree to which humans and nature are linked in reciprocal feedback loops".[22] By this, humans are included as components of ecosystems, and thus human activities are acknowledged as important agents of ecosystem change.

McDonnell brings forth influential contributions to this branch of knowledge. One is UNESCO's *Man and the Biosphere Programme* (MAB), launched in 1971 as an Intergovernmental Scientific Programme that aims to establish a scientific basis for the improvement of relationships between people and their environments.[23] Another is Boyden et al.'s classic *The Ecology of a City and Its People: The Case Study of Hong Kong*, published in 1981.[24] As stated by McDonnell, this work's intellectual framework is still relevant since it provides the first "model for integrating the ecological and sociological dimensions of urban ecosystems".[25] Furthermore, he points at the field developing from a traditional focus on terrestrial environments, to include perspectives that are more diverse – mentioning, amongst others, topics such as marine environments, remnant vegetation, aesthetics and recreation, human health, and urban environments in developing countries.[26]

COMBINING URBAN ECOLOGY WITH "ARTISTIC WAYS OF KNOWING, THINKING AND ACTING"

Blue-green infrastructure is a life-giving and thus an essential part of the urban tissue – broadly defined as "a strategically planned network of high quality natural and semi-natural areas … designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings".[27] Structures and alignment of pathways, parks, and recreation areas in between built environments are of relevance, for instance, to health, well-being, and urban resilience. Specifically, enhanced city performance in relation to natural cycles is a topic

currently discussed within the context of urban densification. With statements such as "evidence base for the effectiveness of nature-based solutions needs to be developed and then used to implement solutions",[28] the Horizon 2020 expert group puts renewed focus on the ecosystem approach within urban regeneration.

As the doctoral project is geared towards landscape design processes that may contribute to enhanced city performance, notions such as *biomimicry* and *eco-engineering* are sources of inspiration (as discussed in paragraph below). The overall line of inquiry relates to proposed strategies concerning transitions from a "poor" into "richer" environments, by way of place making that actively involve transdisciplinary workways. Hence, several of the study's activities are in effect bridging natural science and aesthetic competences – trying to "solve problems" by transdisciplinary efforts and thus better understand the role of landscape architecture. As an example, the focus on urban hard surfaces was sparked by a conversation between a biologist and the author of this article. Immersed in the tsalk, we entered a mutual "thought travel" through a city where the built geometry popped from the ground like towering cliffs, and where the streets appeared like narrow, dried-out canyons. Thus, moving about in a topography of synthetic surfaces, a cityscape transformed in our eyes into possible *urban nature types*, as we imagined the mineral façades corresponding to i.e. *bare rock* or a steep *north-facing cliff*.[29] From this, questions arose concerning this fabricated urban condition – moreover to the durability of the comparison between the cityscape and the cliff ecosystem. Culminating in questions on how we can arrive at "better-performing cities"? For the sake of the latter, urban planners and designers need to understand how ecosystems work in and on the city matrix.

Studying Urban Tissue

Seeking answers to the above questions, a *transect walk* was performed on 18 August 2016. This specific action facilitated an explorative exchange between architectural research and the natural sciences. The latter were represented by Heidrun Asgeirsdatter Ullerud, a PhD fellow and part of the Geo-Ecology Research Group at The University of Oslo.

As a method, the "transect" is borrowed from ecological surveys implying registrations along a predefined line that provides analysis through an environmental gradient. Thus, it allows for studying a delimited area with a larger spatial reference – in this case the transition from Oslo's industrial harbour within the city core via semi-dense residential areas and the suburb towards the Østensjøvannet nature reserve. Moreover, the walk was triggered by a common interest in testing the new classification system *Nature Types in Norway* (hereafter NiN), and its applicability to urbanscapes.

The NiN-system was developed as a commission by the Norwegian Biodiversity Information Centre and was launched in spring 2015 – aiming to establish a common and verifiable survey and description system for all Norwegian natural resources. In short, NiN has its foundation in mapping and describing natural processes, providing detailed categories for a diverse set of nature types. In contrast, NiN classifies the urban landscape based on how humans have used, and thus have imposed, structural changes in natural environments. As an example, the urbanscape is described as nearly 100 per cent "highly modified synthetic substrate".[30] Even though not all categories are considered synthetic, the NiN-system provides little differentiation and ecological information concerning the urban nature context. For instance, NiN includes eighty-five types of bare rock but only one category covering urban built structures. When it comes to biodiversity and well-being, a world covered by highly modified synthetic substrates may associate to a rather "poor" place to linger. Thus, the metaphoric trail of "cliff" and "bare rock" may have a certain relevance. From this perspective, my interest in NiN takes an opposite direction – based upon an assumption that such a nature-type-based descriptive system has the potential to inform nature-based designs. However, this would require the NiN system to develop more differentiated descriptions on the urban-nature context and urban ecological traits.

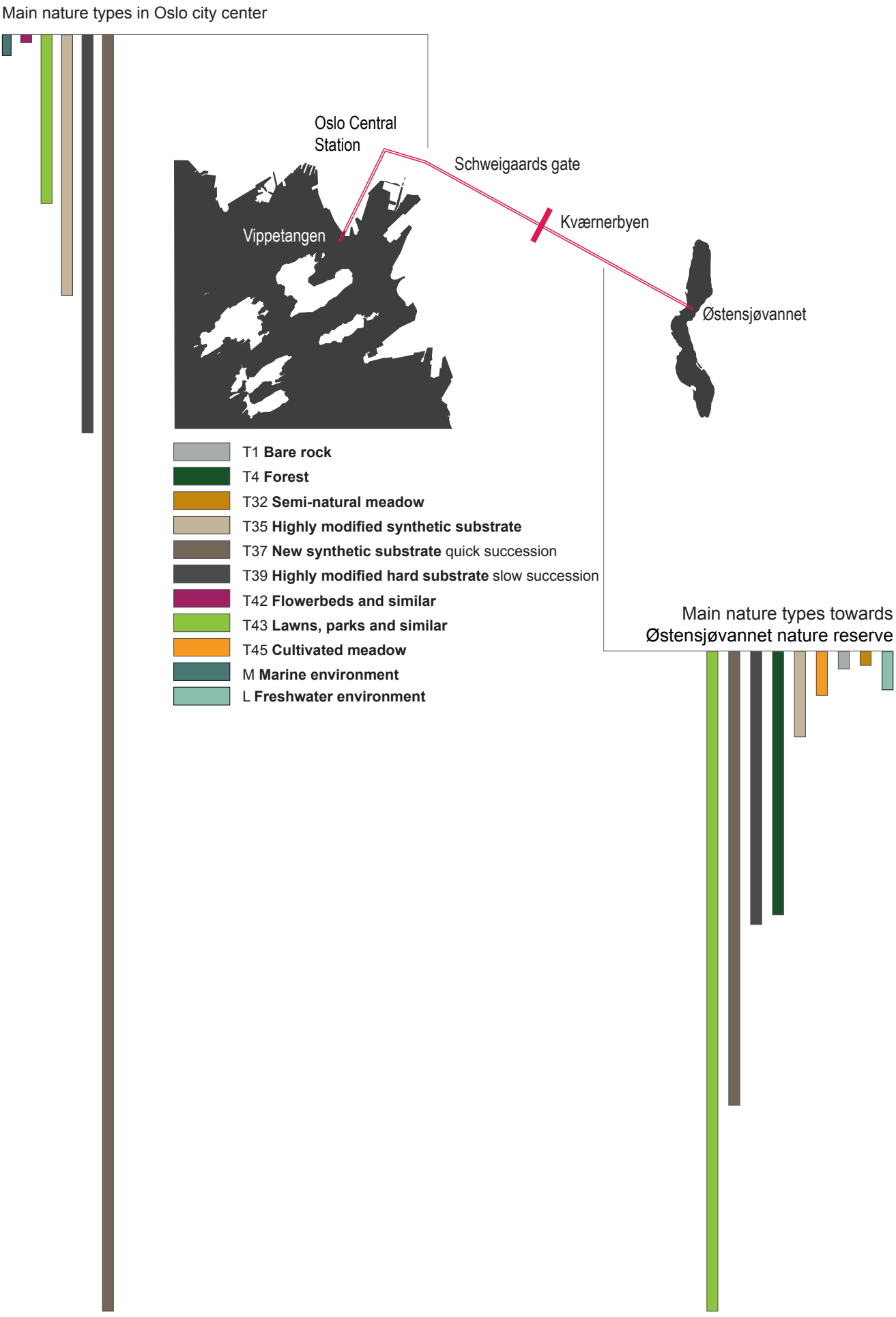

Figure 1. Distribution of nature types, according to the NiN system, along an urban transect. The red line across the transect indicates the contrast between the dense inner city and semi-dense residential areas towards the Østensjøvannet nature reserve. Digital collage: Sørensen & Ullerud 2017 © BONO.

As Figure 1 reveals, the city core has notably fewer categories in comparison to the stretch through the semi-dense residential areas and the suburbs. From this, the question is whether the "urban grey" has received its rightful place in the NiN system.[31] As a suggestion, NiN could develop towards becoming a knowledge base for the definition of urban nature types. Henceforth, these thoughts are further reflected upon in a co-written article on NiN and urbanscapes.

Urban Grey

> It is [an] urgent matter to adequately investigate and evaluate the "urban grey" in its ecological relevance and physical functionality.[32]

Did you ever stumble over loose concrete slabs, and thus have your attention drawn towards these unintentional mosaics? In a sense, hard surfaces "choke" and constrain the urban environment by counteracting and preventing the usually beneficial functions of natural cycles, such as returning freeze and thaw (see Figure 2). Niemelä and Breuste articulate an appearing research gap, thus from their point of view the "Planning of urban grey does not exist or is fragmented at best".[33] Consequently, challenging the function and aesthetic appearance of urban hard surfaces represents a timely topic.

The term *green building envelopes* addresses solutions for countering the negative impacts of hard-tissues typical to urban habitats. Here, adding biologically active material to the urbanscape provides the "dense inner city with surfaces for effective and applied green infrastructure".[34] Accordingly, they put forth the following thought experiment:

> If we imagine that we could replace 30 % of the total sealed areas of cities by offering about 20–25 % of the buildings and making use of about 20–25 % of each building envelope, i.e. façade and roof areas, we could achieve significant benefits to improve the micro-climate in cities.[35]

As the "clean slate" for a better practice, urban hard surfaces are seen as steadfast "habitat templates regardless of where they are found".[36] Thus, strategies related to the enhancement of urban tissue, by for instance facilitating bioactive structures and covers, may apply to a wide range of urban sites.

Figure 2. Photo-note [59°55'45.5"N+10°45'36.0"E, 2016-08].
Photo: Elin T. Sørensen 2016 © BONO.

A New Physical World

> A new physical world is created—the city. However, it is not only a new physical, but also a new ecological, environment.[37]

Breuste points at the surface material properties of, for example, concrete, asphalt, plates, glass not being biologically active. Consequently, this "new" urban tissue fundamentally changes environmental properties such as its thermal characteristics and before-mentioned natural cycles. With negative impacts of climate change and resilience in mind, the water cycle and changes in hydrological processes are well-known debates. Moreover, urban hard surfaces influence both acoustics and air quality.[38]

These Anthropocene habitats are often designed for aesthetic and visual purposes, which have a profound effect on their composition and structure. Correspondingly, the city planners' decision-making processes have an impact on the structure and functions of biological processes in these constructed landscapes.[39] *High aerodynamic surface roughness* is the technical term for the three-dimensional variation of the urbanscape. This phenomenon, together with radiation and the heat budget, the aforementioned emission from traffic, greenhouse gasses, pollutants, and direct heat release comprise a complex surface for all exchange processes.[40] Hence, by its appearance, the urban condition is likened to, for example, canyon-like streetscapes or cliff-like ecosystems – all in all representing rather harsh habitats.[41] Architect and façade designer Tessa Brunette suggests that a better understanding of the mentioned nature types may yield useful guidelines for the creation of more "nature-like" building covers.[42] Similarly, ecologist Jeremy Lundholm points to rock cliffs as rare features in natural landscapes. Thus, the "proliferation of walls in cities represents a significant expansion of habitat for rock specialist species"[43] (see Figure 3).

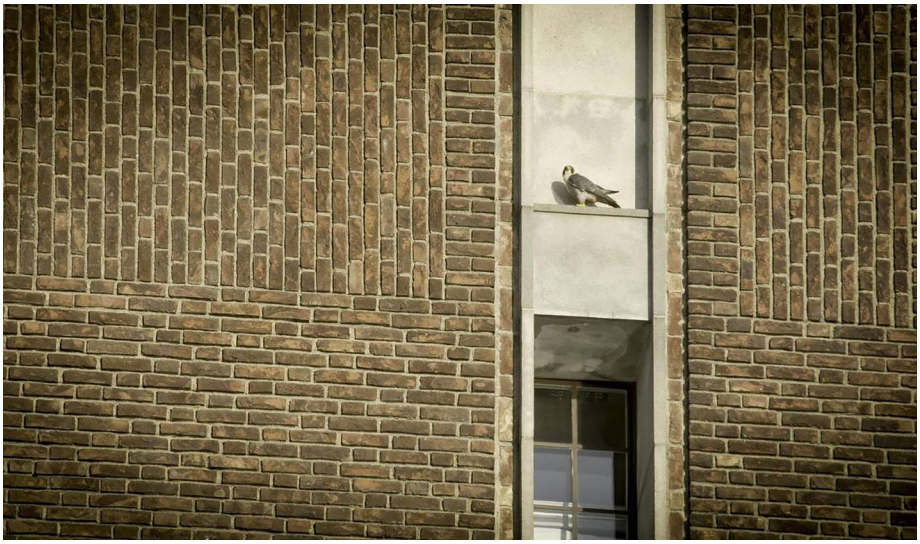

Figure 3. The peregrine (*Falco peregrinus*) resides in Oslo City Hall together with the public officers. Photo: James Ewen. Accessd from: https://www.aftenposten.no/osloby/i/2mov/Krever-hekke-plass-til-vandrefalk-i-radhustarnet.

PASSING ON THE RELAY BATON FROM BIOLOGY

So-called *biomimicry* may provide a constructive approach to the "choked urban skin". The term comprises the Greek *bios* (life) and Latin *mimesis* (imitation) to express a method of teaming up with nature. Biomimicry as innovation strategy seeks:

> Sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The goal is to create products, processes, and policies – new ways of living – that are well adapted to life on earth over the long haul. The core idea is that nature has already solved many of the problems we are grappling with. Animals, plants, and microbes are the consummate engineers. After billions of years of research and development, failures are fossils, and what surrounds us is the secret to survival.[44]

One can say that biomimicry forms a conceptual backdrop to so-called *ecological engineering* as an emerging field integrating "engineering and ecological expertise to create more ecologically-friendly urban environments".[45]

In the name of economy, efficiency, and habit, there is a tendency to apply standardized methods and materials – without paying attention to actual site preconditions, whether social or ecological, as discussed in above sections. Thus, the practical manner in which marine biologist Louise Firth and her team, associated with the Faculty of Science and Engineering at Plymouth University, perform their research inspires the mentioned *living lab* approach. Furthermore, the way these researchers aim at informing engineering by providing input to the enhancement of biodiversity and thus place making encourages transdisciplinary thinking.

In several studies, Firth and her fellow researchers explore and determine patterns of biodiversity on natural rocky shores. The team points out how artificial structures "inserted" into a place tend to differ from the given context and, as an effect of being more homogenous, substantially alter the existing situation. A coastal defence structure, for instance, may change a location from exposed to sheltered, influencing sediment transport and living conditions related to the motion of the waters. Such alterations may result in the colonization of non-native species with an eventual adverse impact on local habitats and species variety. Accordingly, an essential objective is the mimicking of natural surfaces and structures for increased colonization of beneficial marine plants and organisms. From my understanding, many of their practical pieces of advice may as well apply to terrestrial milieus. For example, by increasing the porosity as opposed to the impermeability of surfaces, or by introducing surface rugosity such as pores, pits, and crevices and other structural adjustments that provide for enhanced biodiversity in the city.[46]

In summary, a main concern is the combination of "soft" and "hard" designs that in turn provide us with the services of nature – so-called ecosystem services. The design of microhabitats adapted to beneficial plants and organisms both supplement and correspond to the way architects strive for friendly and thriving environments for people. Concerning biomimetic designs, the researchers Lidia Badarnah and Usama Kadri see the "absence of a systematic selective design methodology that is capable of identifying the relevant systems and then abstracting their strategies and mechanisms" as a major challenge to this practice.[47] Figure 4 and Table 1 exemplify their endeavour to articulate such a methodology.

The Fabulous Traits of Mosses

The thin, green patina of bryophytes (mosses), lichen, and algae belong to early ecological succession, that is, the process by which the structure of a biological community develops over time. As people are crowding in cities, the city gets denser and the space for blue-green structures decreases. Teaming up with algae, lichens, and mosses may be a good idea – embracing the natural graffiti and the benefits of nature's time-tested patterns and strategies.

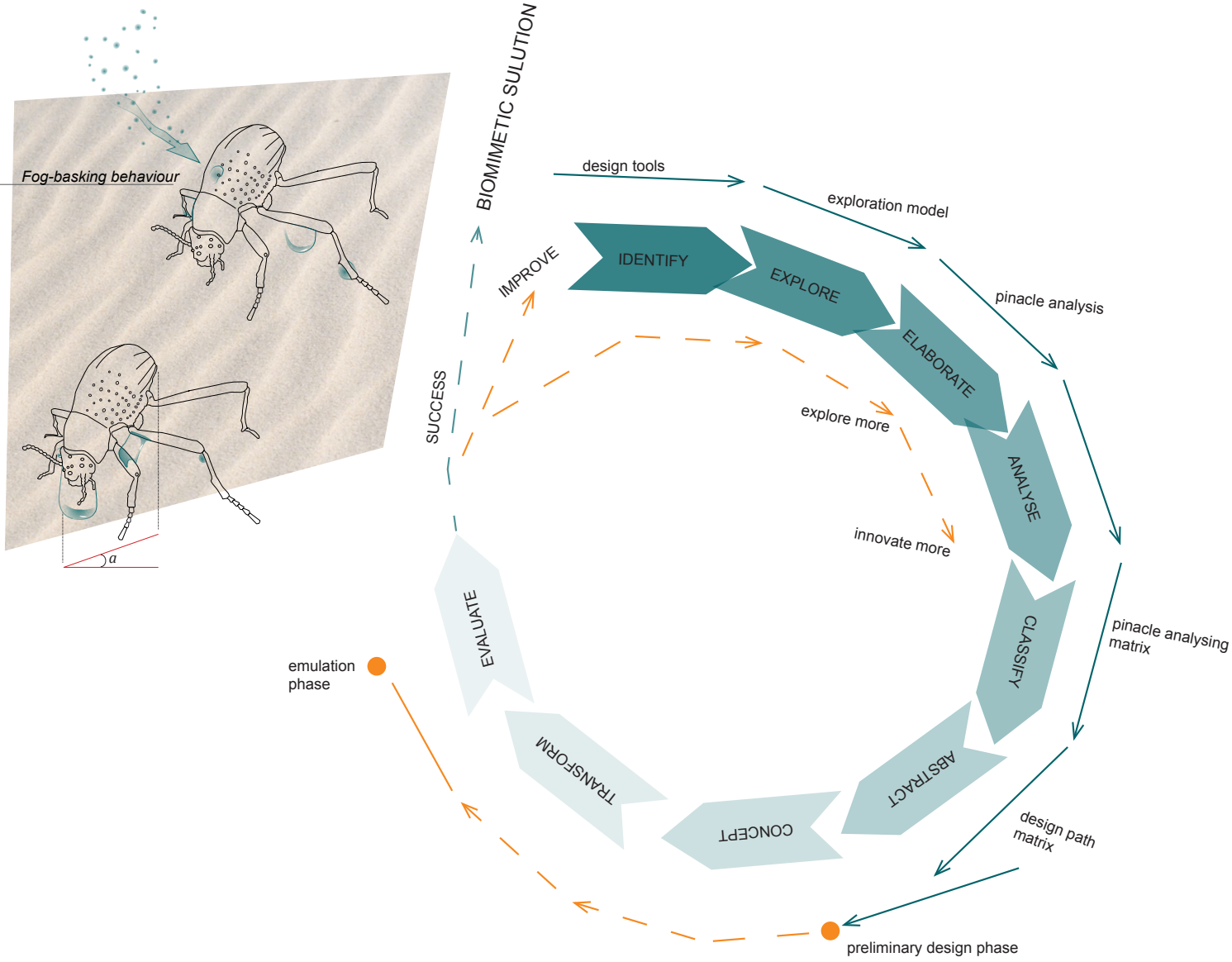

Figure 4. Flowchart for the BioGen methodology, including the various phases to be addressed in order to generate a biomimetic design solution. Digital collage: Elin T. Sørensen 2017 © BONO inspired by Badarnah & Kadri, 2015.

Table 1. Biomimetic analysis; three examples from the analysis summary (Badarnah & Kadri, 2015, p. 127, Table 5).

***Pinnacle's* strategy**	**Mechanism**	**Main principle**	**Main feature**
Namib desert beetle Collects water from fog by condensation on the elytra (hardened forewings of certain insects)	A special arrangement of hydrophilic and hydrophobic areas on the elytra results in attracting water droplets and transporting it to the mouth	Bumpy surface for water attraction	Fog-basking behaviour
Human skin Contains complex vascular system and sweat glands for evaporative cooling	Secreting sweat to the skin surface, removes heat by evaporation	Latent heat transfer	Sweating
Stoma A pore, found in the epidermis of leaves; open and close for gas exchange in response to osmotic pressure in the guard cells	The thick elastic inner walls and thin elastic outer walls of the guard cells, ensure an uneven expansion when inflated, thus result in the opening	Varied elasticity for uneven expansion	Elasticity & expansion

Lundholm mentions the silvery leaf hairs of silver-moss that are likely to increase the reflection of solar radiation from the surfaces on which they grow:[49] a trait that could possibly inspire a biomimetic design. However, with reference to a large number of ecological tests of weed control methods, Lundholm brings forth how mosses on anthropogenic surfaces often are seen as a nuisance. "Similar to their animal counterparts, the rat, the cockroach, and the pigeon, plants attracted to the hard surface habitats that mimic their habitats of origin are not always welcome on structures built to fulfil human purposes."[50] Nonetheless, organisms colonize almost all structures in our environment. Under certain circumstances, special microorganisms may alter the properties of a building's coat and, according to biologist Wolfgang Hofbauer, this might not only have negative consequences but may even be beneficial.[51] Mosses soak up water like a sponge and thus have the ability to store water (water retention). In addition, mosses collect dust, reduce pollutants, function as an air filter, and have a positive influence on acoustics.

> Some of these lineages may actually be adapted to grow on modern building surfaces – and therefore could be used for moss gardening. This could be beneficial for insulation purposes, to reduce air pollution and climate gases (CO_2 scavenging), to increase biodiversity within an area, and, last but not least, for aesthetic purposes: greening cities and visually breaking up expanses of concrete.[52]

In their research, Hofbauer and his colleagues seek to identify selective biocontrol of moss growth. At the Fraunhofer Institute for Building Physics (IBP), the work objective is to both prevent and enhance the growth of microorganisms. Amongst other things, they have built up a living database containing 650 single cultures, 400 strains, and 250 species, together with 1:1 scale test sites for the study of bryophytes in relation to, for instance, outdoor weathering, as well as coatings and surfaces that enhance moss growth.[53]

Likewise, moss experiments take place on the art scene. Figure 5 presents the exploration of moss's ability to deliver renewable energy from photosynthesis, so-called "biophotovoltaics", as well as power to a radio by moss-based "biological solar panels". Back to the scientific context again, Figure 6 is drawn from a study on "active moss biomonitoring". In regard to the latter theme, Angela Ares et al. claim that mosses enable the "simultaneous monitoring of a large number of contaminants with the same sample (i.e. metals, and metalloids, PHAs, radionuclides), and also have other advantages over current methods (e.g. simplicity, reliability, cost effectiveness and the lack of the need of electricity)".[54]

Along these lines, exploring moss's advantages through concrete site experiments in the city has a potential to invert established views and presumptions.

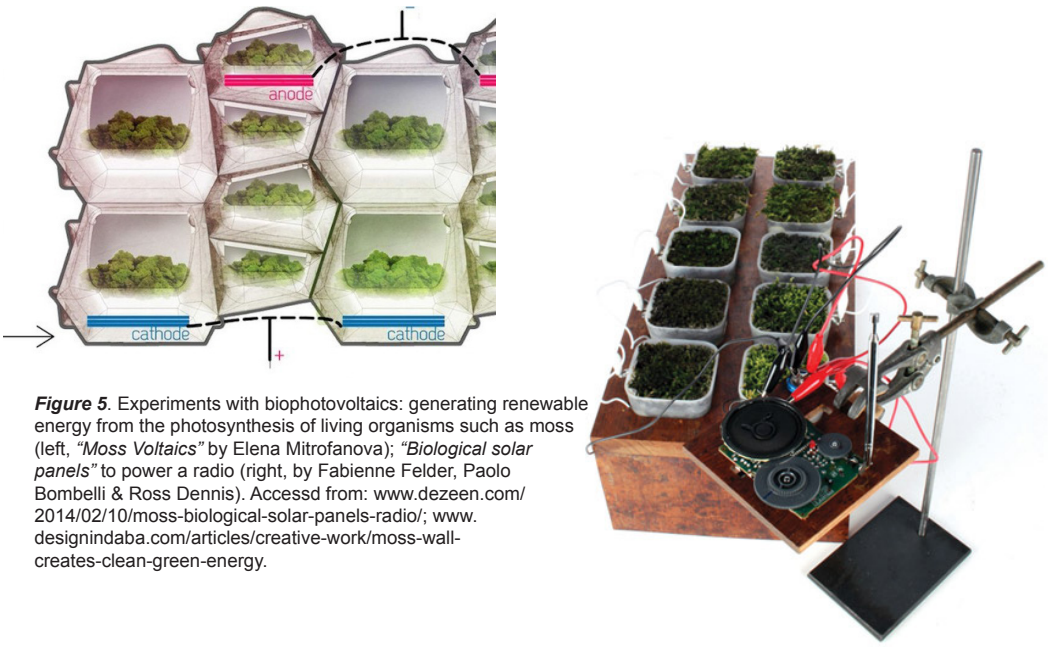

Figure 5. Experiments with biophotovoltaics: generating renewable energy from the photosynthesis of living organisms such as moss (left, *"Moss Voltaics"* by Elena Mitrofanova); *"Biological solar panels"* to power a radio (right, by Fabienne Felder, Paolo Bombelli & Ross Dennis). Accessd from: www.dezeen.com/2014/02/10/moss-biological-solar-panels-radio/; www.designindaba.com/articles/creative-work/moss-wall-creates-clean-green-energy.

Figure 6. Active moss-biomonitoring study for the sake of identifying sources of atmospheric pollution: wetted moss bag during exposure (left); suspended dry moss bags (right). Accessd from: www.envpl.ipb.ac.rs/bio2.htm.

"MOSS/CIRCUITS": ESTABLISHING MOSSES ON A FLUVIAL RETENTION WALL

The microhabitat strategy presented above was taken on in the "*Mosses/circuits*" project, an ongoing study that came to life by devloping aproposal for the development of mosses on a fluvial retention wall, commissioned by the Agency for Urban Environment and Water Management in Oslo. The wall is supporting a newly reopened stream running through the Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS). On the one side, the agency wished to establish mosses in order to prevent graffiti – on the other, to harvest experience on the controlled development of mosses in urban milieus.[55]

The concept is developed as a collaborative piece between the author of this article and the botanist Magni Olsen Kyrkjeeide, researcher at The Norwegian Institute for Nature Research (NINA) – starting out with a couple of straightforward questions:

- How can we facilitate moss growth through the creation of microhabitats, informed by natural habitats, which may work well in the long term?
- How can we turn a conventional retention wall into a contemporary artwork involving living material?

Seeking to test how the urbanscape can function as an outdoor laboratory, the proposal has led to a broader dialogue with other municipal agencies. Our next move is to carry out small scale experiment at NMBU Campus as well as searching for suitable sites for establishing microhabitat experiments in central Oslo.

AT THE INTERSECTION BETWEEN ARTS, LANDSCAPING, AND SCIENCE

By studying mosses in nature, you quickly discover their preference to colonize uneven surfaces. Drawing from this, our contribution deals with creating relief structures that act as moss microhabitats. In the case of the fluvial retention wall, the overall aim was to transform a dull concrete structure into a public attraction well fit for the location within one of Oslo's central research clusters, as Figures 7–8 exemplify. However, in the Norwegian context, there is no documented experience on controlled moss development in urbanscapes. Thus, this project seeks to explore and highlight moss's many qualities – aesthetically, culturally, and environmentally.

The client wished the artwork to reflect activities within the CIENS cluster, which, amongst others, houses the Department of Informatics. The architecture and systems of informatics are part of almost all we do, from leisure to professional activities – and even incerted into our bodies as part of medical progress. As such, this motif has a potential for outreach to a wide audience. Moreover as a visual reference, the circuit board may be interpreted in

multiple ways, as resembling metropolitan infrastructure, graphs of signal currents in biochemical processes, pulse flows in the brain, or even the crack reliefs of mountain walls exemplified. Accordingly, in relation to the reliefs' basic pattern, the design is inspired by electronic circuit boards (pointed out in Figure 7, *"Mosses/circuits"* study #1–2, and in Figure 9).

On the artistic-conceptual level, the synthetic and technical infrastructure will slowly be "taken over" by an organic moss cover – as in an abandoned place. In this fashion, the artwork addresses interrelationships between nature, technology, and human values – even more, in the sense that much technology development relates to nature emulation.

Evidently, artistic and scientific practice is performed through investigative processes. In both cases, not all results are useful. In the case of artworks, the result must express an "extraordinary dimension" – that is, a potential to expand the viewer's perspectives and horizon of understanding. As follows, the art piece should lead the viewer into an aesthetic, sensuous experience and thus provide a new perspective on worldly phenomena. Moreover, the artistic process behind the microhabitats have similarities with the research layout proposed: the application of *moss-growth mixtures* to the relief surfaces are both controlled and improvised, and left to spontaneous succession in order to "see what will happen …".[56]

Factilitating Moss Microhabitats

According to Hofbauer, there are knowledge gaps related to succession as well as ecophysiology such as water, temperature, and light requirements, which are important prerequisites for an efficient management of mosses.[55] Our objective is to study how different mosses establish themselves on the microhabitats in contrast to "clean" control spots, that is, the retention wall's original concrete surface. In this way, different revegetation strategies that work under different growth conditions can be monitored. The microhabitat design thus functions as a fieldwork arena that provides information on how mosses develop, from controlled colonization to spontaneous growth.

By experiments with different *moss-growth mixtures*, we will gain a sense of establishment of successes and failures. The assumption is that many species in a mixture can increase the likelihood that one or more species thrive and establish themselves. On the other hand, the application of single-species mixes to the substrate will provide opportunities to study that particular moss" growth on the suggested *microhabitat reliefs*. Testing with different species on different substrates will provide knowledge on this. Consequently, we may arrive at a basis for comparison of different *microhabitat designs*, with the further growth taking place somewhat uncontrolled. Hence, *"Mosses/circuits"* unfolds as a living piece of art.[56]

Table 2. Success criteria's for moss microhabitats[57] (Kyrkjeeide & Sørensen, 2017; Lundholm, 2011, p. 95).

Time and succession	When it comes to plant development, mosses have a slow growth rate. In addition, spontaneous colonization may take time. Here the application of growth mixtures composed of moss particles mixed with nutrients will facilitate establishment, and thus accelerate growth. Concerning time, it is assumed that at least one growth season is required until any substantial results are achieved. However, growth rate and the development in time before major surfaces are covered with mosses is uncertain and will depend on access to water. In order to document the moss development over time, points for photography will be established where pictures are taken on a regular basis.

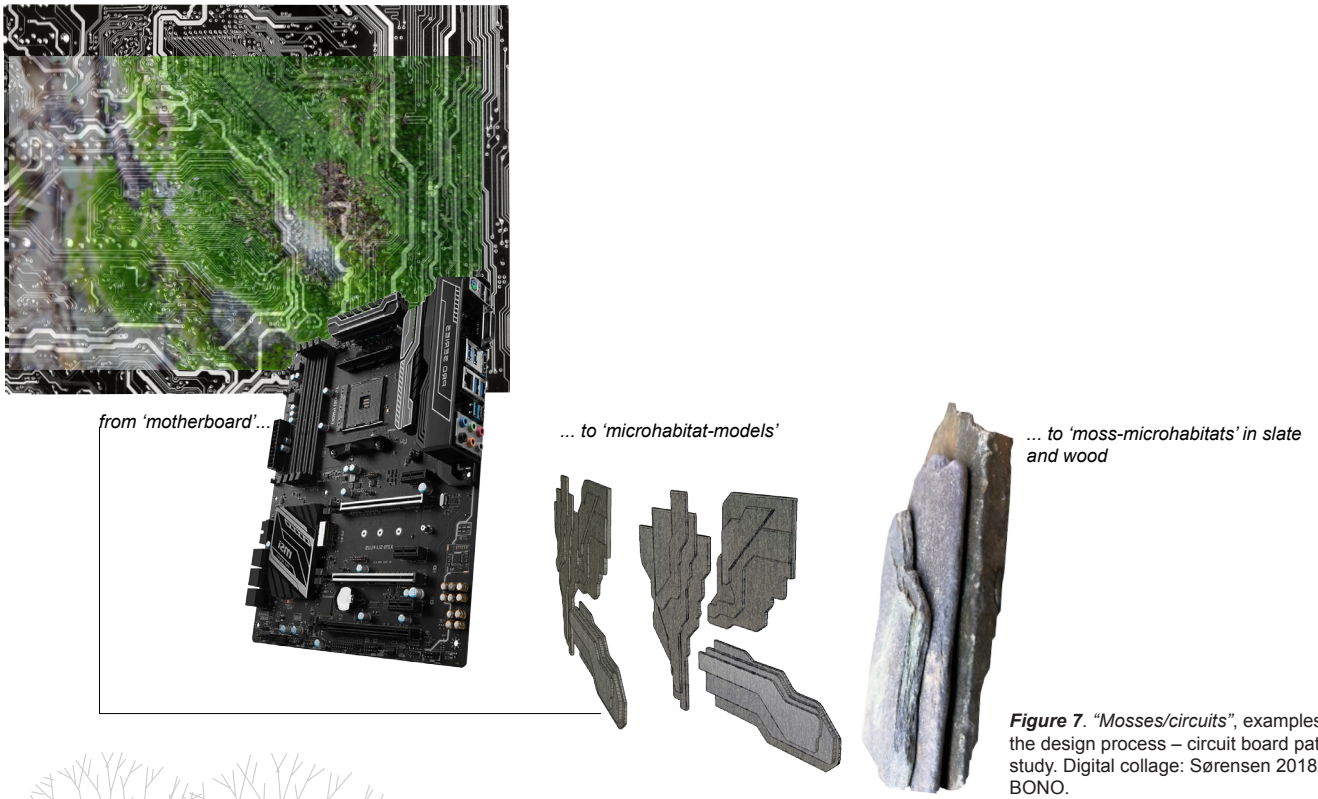

Figure 7. *"Mosses/circuits"*, examples from the design process – circuit board pattern study. Digital collage: Sørensen 2018 © BONO.

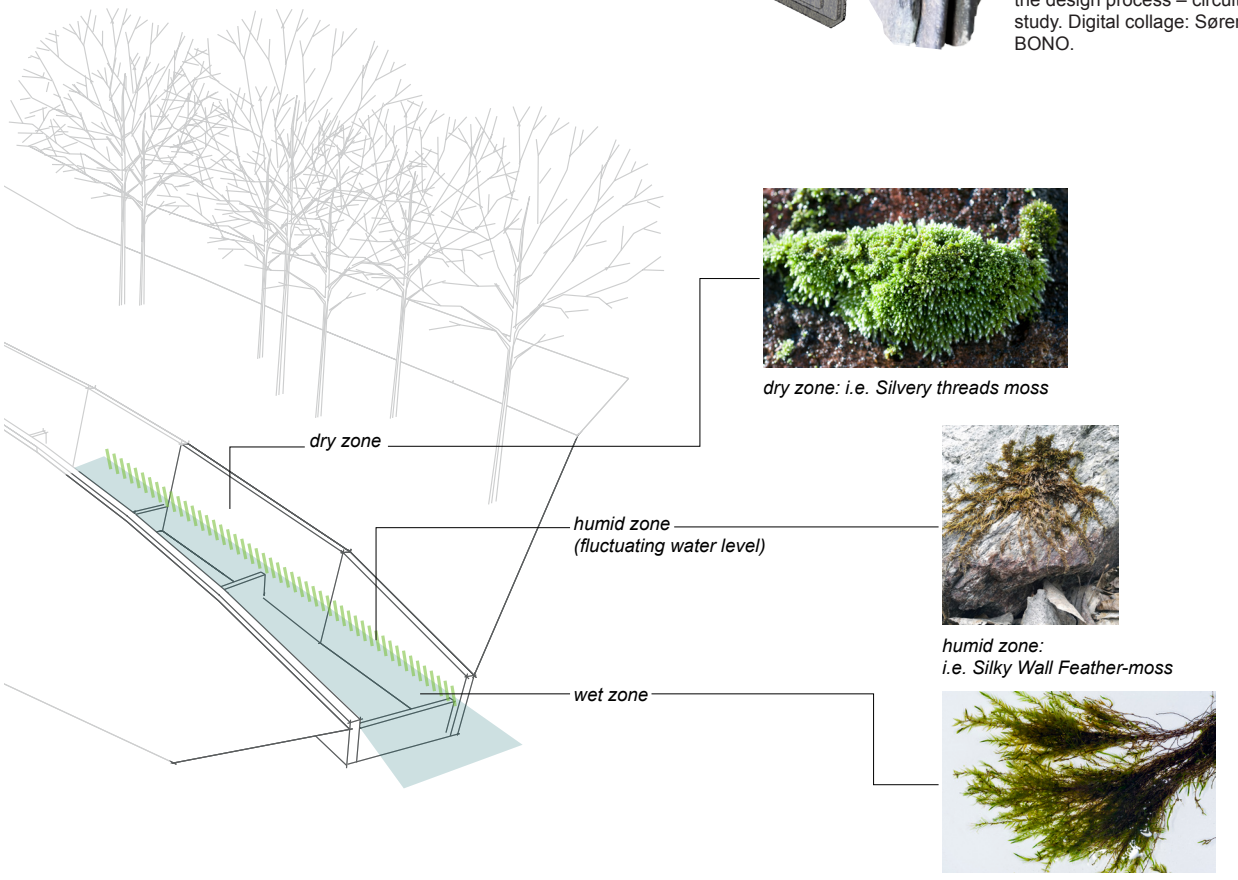

Figure 8. *"Mosses/circuits"*, examples of suggested wall zonation. Digital collage: Elin T. Sørensen 2017 © BONO.

Table 2. Success criteria's for moss microhabitats, continue.

Moisture availability	Mosses are generally divided into two groups, those that tolerate drying out and those that avoid drought. For the retention wall at hand, it is advisable to select drought-tolerant species that thrive directly on rock surfaces. In this way, we ensure that the species applied withstand a stressful environment and periods of drought. Moreover, periods with good water availability and/or high humidity represent optimal growth conditions. In the case of the retention wall, it is located in relation to an urban stream. Thus, it is assumed that "natural watering" from the stream should be sufficient for the mosses established. Here water spray from the stream will provide a more stable water regime. Moreover, the relief structures with angles, cavities, and crevices provide microclimate conditions that are beneficial in terms of moisture.
Structure	In general, irregular surfaces enhance natural colonization. The microhabitat reliefs will thus help the moss particles to establish, in that the spores and vegetative material will not be flushed away from rainfall or for other reasons. In order to harvest experience on the development of different species, we apply a wall zonation for the "moss tapestry", adapted to different growth requirements. On the upper level, we facilitate drought-tolerant species, and at the base aquatic mosses exemplified in Figure 8.
Material composition	The relief structures are suggested to be built in slow-grown pine, slate, and/or in concrete, the latter mixed with more or less lime (as pH adjustment). Variation in materials allows several species to thrive, which will be crucial from a long-term perspective and for the emergence of new species on the wall. Moreover, mosses come with great variation in growth forms and colours: greyish, such as **silver-moss** (*Bryum argenteum*) or brownish red as **great hairy screw-moss** (*Syntrichia ruralis*). Thus, the *Mosses/circuit*s design facilitates for variations in structure as well as colour and contrast as the pattern unfolds**.**

REFLECTIONS AND GAINED INSIGHTS HOW FACINATIONS PUSH EXPLORATIVE WORKWAYS

> Fascinare (v.) from Latin fascinus "a charm, enchantment, spell, witchcraft" as by the power of the eye; to enchant and to charm are to bring under a spell by some more subtle and mysterious power. Sense of "delight, attract and hold the attention of." (etymonline.com/word/fascinate)

The 1983 Nobel laureate for discoveries on mobile genetic elements, Barbara McClintock, claims that her discoveries in plant cytology (the study of the structure of the cell) are due to her ability to acquire a "feeling for the organism" – in which she opens herself up to "what the material has to say". Close identification provided her the insights, later to be synthesized with observation and explanation grounded in more traditional scientific workways.[58] All the same, by daring to immerse herself, and by trusting "hunches" and "keen intuition", McClintock generated new knowledge.

Similarly to how McClintock "feels" and "listens", fascinations work as "mind-openers" and thus serve as important concept-development tools. For example, by paying attention to seemingly insignificant clues (that eventually may even constitute a work's conceptual backbone) – a fascination can be seen as an "empathetic crowbar" providing "design-problem breakthroughs". In the work-process, seemingly insignificant "moments" often trigger a state where so-called *stream of consciousness* may take place. This method is described as an "inner monologue" rendering "a person's chaotic and more or less unconscious thoughts and feelings".[59] With regard to this, fascinations may be likened to keywords in a browser, giving access to consciousness's constant thought-streams and their idea-generating impressions and associations.

Figure 9. Natural microhabitats for mosses, such as silver-moss (*Bryum argenteum*), on boulder rocks by the retention wall. According to Lundholm (2011, p. 97), silver-moss is considered the quintessential urban moss, tolerant to trampling, nitrophilous, and xerophytis – with silvery leaf hairs that likely increase reflection of solar radiation. Silver-moss has nearly global distribution. Photos: Elin T. Sørensen, April 2017 © BONO.

Framing Unruly Imagination

Arriving at landscape architecture from the arts, the combination of the "ungovernable" with strict structuring is of particular interest. Off course, architectural practice may be rebellious, going beyond a "normal" production sequence – towards the visionary and even unrealizable. Conversely, an artistic practice may be dry, factual, and in the worst case uncommitted. However, the limits to architectural projects often stand clearer: on the one side, there are the work's physical borders such as those steering spatial and contextual conditions; on the other, there is the push towards efficiency and market orientation that may result in a repetition of "safe solutions" and business as usual.

The development of a strong conceptual backbone is an essential success criterion to any project. Thus, concerning the cultivation of an "unruly imagination", the ability to trust "imaginative hunches" has to be refined in the creator's experience over time. Such embodied knowledge or so-called *tacit knowledge* is a type of awareness difficult to transfer by means of writing or verbalization, thus more likely to manifest as an insight or intention in the form of a gut feeling. Whether being a scientist or artist, these may be understood as the traits of a creative practice. All the same, through the refinement of artistic authentic thinking and skills, profound critical, analytical, and ethical thinking is cultivated – and none the least poetic perspectives. From my experience, these aspects often strengthen the production outcome, and as such are of great relevance to urban planning and place making.

One may say that design, architecture, or the arts happen in the combination of accessing "what the material has to say", while at the same time interacting with places and situations. In her PhD, landscape architect Rannveig Søndergaard Holm discusses how the researcher "creatively interacting with her material" in investigations is naturally generating nonverbal results.[60] This is a strategy clarified by Mäkelä:

> As an object made by an artist–researcher, the artefact can also be seen as a method for collecting and preserving information and understanding. However, the artefacts seem unable to pass on their knowledge, which is relevant for the research context. Thus, the crucial task to be carried out is to give a voice to the artefact. … In this process, the final products (the artefacts) can be seen as revealing their stories, i.e. the knowledge they embody.[61]

EPILOGUE

The contributions from a self-reflective study may be to better articulate artistic and architectural skills of relevance to the advancement of architectural research per se, as well as to the educational practice. Therefore, architectural research has importance for the development of the profession's role in society.

The crossing of professional boundaries may yield manifold reflections on how to look at and decipher, in this case, the cityscape, through different (disciplinary) lenses. From collaborating with professionals of various kinds – such as water engineers, ecologists, and biologists – my experience is that, besides contributing indispensable professional knowledge, they most often fall short on design competence and aesthetic awareness on a high level. A lack of critical distance to design processes and results is often the missing link between mediocrity and excellence. Conversely, I assume that architects, product designers, and others, in most situations, do not possess adequate insights on all facets of the artefacts produced. Accordingly, taking on the relay baton from applied science to urban design explorations has potential. The PhD fellowship provides an opportunity to experiment with both design expertise and transdisciplinary interaction. Taking such skills to a higher level would better enable the transition from a "poor" urban habitat to enriching a place. Particularly, developing the ecological function as well as the aesthetic appearance of urban hard surfaces.

An emerging hypothesis is that by "listening to" and looking more closely at the urban habitat, the designer may access essentialities. Those are particular clues for the development of liveable and possibly more easily maintained cityscapes, for instance by turning the "urban grey" into biologically active surfaces. This is an approach that requires opening up to what urbanscapes "tell us": its physical properties and people's needs, its ambiences and hidden treasures – as for example the wonders of minuscule moss colonies.

Figure 10. Forest floor/darkness study #1–2 – the atmosphere attached to mosscapes, as for instance discovered on forest floors. Photo: Elin T. Sørensen 2017 © BONO.

NOTES

[1] The Plant List, "*The Bryophytes* (Mosses and liverworts)", 2013, http://www.theplantlist.org/1.1/browse/B/ (all URLs accessed in April 2018).

[2] Norwegian Ministry of Climate and Environment, *Green Shift: Climate and Environmentally Friendly Restructuring* (2014), https://www.regjeringen.no/en/topics/climate-and-environment/climate/innsiktsartikler-klima/green-shift/id2076832/.

[3] (Hauberg 2011: 46)

[4] Halina Dunin-Woyseth, "Making Scholarships: Some Developments towards Field-Specific Research in Creative Fields", Nordic Association of Architectural Research 2016 Symposium, Stockholm, lecture on 19 May 2016.

[5] OECD, *Research and Development – UNESCO: OECD Glossary of Statistical Terms* (2003), https://stats.oecd.org/ and https://stats.oecd.org/glossary/detail.asp?ID=2312.

[6] Board, Norwegian Artistic Research Programme (N. A. R. P.), *Guidelines for The Project Programme 2018* (2017), www.artistic-research.no and http://artistic-research.no/wp-content/uploads/2016/10/The-Project-Programme-Guidelines-2018.pdf.

[7] (Dyrssen 2011: 223)

[8] Birger Sevaldson, "Discussions and Movements in Design Research: A Systems Approach to Practice Research in Design", *FORMakademisk*, 3/1 (2010), pp. 8–35.

[9] Biggs and Karlsson, *The Routledge Companion to Research in the Arts*.

[10] (Cross 1982: 55; Cross 2001)

[11] (Mäkelä 2007: 158)

[12] Hauberg, (2011: 52)

[13] Gerhard Haas, *Essay* (Stuttgart: J. B. Metzler, 1969).

[14] Jo Bech-Karlsen, *Gode fagtekster: Essayskriving for begynnere* (Oslo: Universitetsforlaget 2003), pp. 34 and 107.

[15] Ibid., pp. 96–97 and 116–19.

[16] Mark J. McDonnell, "The History of Urban Ecology: An Ecologist's Perspective", in Jari Niemelä, Jürgen H. Breuste, Glenn Guntenspergen, Nancy E. McIntyre, Thomas Elmqvist, and Philip James (eds.), *Urban Ecology: Patterns, Processes, and Applications* (Oxford: Oxford University Press, 2011), pp. 5–13, esp. p. 5.

[17] Niemelä et al., *Urban Ecology*.

[18] (McDonnell 2011: 5-13)

[19] Ibid., p. 7.

[20] McDonnell, "The History of Urban Ecology", p. 7.

[21] Barbara Clucas and John M. Marzluff, "Coupled Relationships between Humans and Other Organisms in Urban Areas," in Niemelä et al., *Urban Ecology*.

[22] Ibid., pp. 136 and 147.

[23] UNESCO, "Man and the Biosphere Programme" (2017), http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/man-and-biosphere-programme/.

[24] Stephen Boyden, Sheelagh Millar, Ken Newcombe, and Beverley O'Neill, *The Ecology of a City and Its People: The Case Study of Hong Kong* (Acton: Australian National University Press, 1981).

[25] McDonnell, "The History of Urban Ecology", p. 10.

[26] Ibid., (2011: 12)

[27] (European Union 2013: 7)

[28] (European Commission 2015: 6)

[29] Hanna Bjørgaas and Elin T. Sørensen, *Biotopopplysningen#1*, FAGUS Vinterkonferanse: Miljø i det grønne, Arkitektenes hus, Oslo, 2016.

[30] Rune Halvorsen, Egil Bendiksen, Harald Bratli, Anders Bryn, John Bjarne Jordal, Ellen J. Svalheim, Vigdis Vandvik, Liv Guri Velle, and Dag-Inge Øien, "Beskrivelser av utvalgte enheter for kartlegging i målestokk 1:5000 etter NiN versjon 2.0 og artslister som viser diagnostiske arters fordeling langs viktige lokale komplekse miljøvariabler. – Natur i Norge, Kartleggingsveileder (versjon 2.0.3)", in Artsdatabanken (ed.), http://www.artsdatabanken.no (2015).

[31] Elin T. Sørensen & Heidrun A. Ullerud, (2018). Byen — natur eller antinatur? En tverrfaglig refleksjon om by-utvikling med Natur i Norge [NiN]. *Arkitektur N Tema: Landskap og stedsutvikling*, Nr. 2/2018: 54- 63: 9.

[32] (Niemelä & Breuste 2011: 71)

[33] Ibid.

[34] (Carfrae et al. 2016: 7)

[35] (Carfrae et al. 2016: 8-9)

[36] (Lundholm 2011 ibid: 101)

[37] Jürgen H. Breuste, "Ecology in Cities: Man-Made Physical Conditions", in Niemelä et al., *Urban Ecology*, pp. 17–72, esp. (2011: 17)

[38] (Breuste 2011: 17-18)

[39] (Guntenspergen 2011: 75)

[40] (Parlow 2011: 31)

[41] Arnold Darlington, *Ecology of Walls* (1981), Heinemann Educational Publishers; Laura Forrest and Wolfgang Hofbauer, *Hidden Diversity in Unexpected Places: Moss Growth on Modern Building Surfaces*, Royal Botanical Garden Edinburgh (2015), http://stories.rbge.org.uk/archives/17489; Tessa Brunette, *Urban Cliffs for Better City Biodiversity* (2017), http://thoughts.arup.com/post/details/613/urban-cliffs-for-better-city-biodiversity.

[42] Brunette, *Urban Cliffs for Better City Biodiversity*.

[43] Lundholm, (2011: 99)

[44] The Biomimicry Institute, What is Biomimicry? (2015), https://biomimicry.org/what-is-biomimicry/.

[45] (Firth et al. 2014: 123)

[46] (Bohn et al. 2013; Firth et al. 2012)

[47] Lidia Badarnah and Usama Kadri, "A Methodology for the Generation of Biomimetic Design Concepts", *Architectural Science Review*, 58/2 (2015), pp. 120–33, esp. p. 120.

[48] Lundholm, (2011: 97)

[49] (Lundholm 2011: 101)

[50] Wolfgang Hofbauer, Personal Communication with Dr. rer. nat. Wolfgang Karl Hofbauer [Gruppenleiter Biologie Abteilung Bauchemie, Baubiologie, Hygiene at the Fraunhofer Institute for Building Physics IBP] (2016).[51]

[51] (Forrest & Hofbauer 2015).

[52] (Hofbauer 2016 plates 25-28)

[53] Magni Olsen Kyrkjeeide & Elin T. Sørensen, *Mosses/circuits: Establishing Mosses on a Fluvial Retention Wall in Oslo*, Norwegian University of Life Sciences [NMBU]; The Norwegian Institute for Nature Research [NINA], unpublished manuscript (2017).

[54] Ibid.

[55] Hofbauer, *Personal Communication with Dr. rer. nat. Wolfgang Karl Hofbauer.*

[56] Kyrkjeeide and Sørensen, *Mosses/circuits*.

[57] Ibid.; Lundholm, "Vegetation of Urban Hard Surfaces", p. 95.

[58] From Joan Mullin citing Fleckenstein, "Testifying: seeing and saying on world making" (2007) in "Rhetoric: Writing, Reading and Producing the Visual". Biggs and Karlsson, *The Routledge Companion to Research in the Arts*, pp. 152–66, esp. p. 157, Part 2

[59] Helge Ridderstrøm, "Stream of Consciousness", *Bibliotekarstudentens nettleksikon om litteratur og medier* (2015), http://edu.hioa.no/helgerid/litteraturogmedieleksikon/stream_of_consciousness.pdf; Kristian Smidt, "Stream of Consciousness", *Store norske leksikon* (2009), https://snl.no/stream_of_consciousness.

[60] Søndergaard Holm, R. "The Burial Area as Landscape Architecture Variation, Means, Possibilities" (2015). Doctoral thesis # 2015:13. Department of Landscape Architecture and Spatial Planning NMBU.

[61] Mäkelä, "Knowing Through Making", (2007: 157).