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Towards a Social-Ecological Urbanism: Co-Producing Knowledge through Design in the Albano Resilient Campus Project in Stockholm

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Abstract: If we are to promote urban sustainability and resilience, social-ecological knowledge must be better integrated in urban planning and design projects. Due to gaps in the two cultures of thinking that are associated with the disciplines of ecology and design, such integration has, however, proven to be challenging. In mainstream practice, ecologists often act as sub-consultants; they are seldom engaged in the creative and conceptual phases of the process. Conversely, research aiming to bridge the gap between design and ecology has tended to be dominated by a relatively static and linear outlook on what the design process is, and what it could be. Further, few concrete examples of the co-production of ecological and design knowledge exist. In this paper, we give an account of a transdisciplinary design proposal for Albano Resilient Campus in Stockholm, discussing how design—seen as a process and an assemblage of artifacts—can act as a framework for co-producing knowledge and operationalizing concepts of resilience and ecosystem services. Through a design-based and action-oriented approach, we discuss how such a collaborative design process may integrate ecological knowledge into urban design through three concrete practices: (a) iterative prototyping; (b) generative matrix models; and, (c) legible, open-ended, comprehensive narratives. In the conclusion, we sketch the contours of a social-ecological urbanism, speculating on possible broader and changed roles for ecologists, designers, and the associated actors within this framework.

Keywords: social-ecological urbanism; design theory; resilience; ecosystem services; transdisciplinary; prototyping and co-design

1. Introduction

In the light of unprecedented global urbanization [1,2] functioning ecological systems are increasingly being highlighted as critical for human survival [3,4]. Creating better links between the disciplines of urban design and ecology, as well as thinking in terms of an 'ecology for cities' in an integrated and systemic manner, is essential if we are to move toward a more sustainable future [5]. In ecological science, this insight has led to a growing interest in cities, where ecologists are beginning to revisit their role in relation to the urban design discipline [6,7]. From an earlier position that concentrated almost solely on ecological systems in non-urban areas (and in line with the previous "Balance of Nature" paradigm), ecology has begun to move towards a more dynamic, non-linear, and complex understanding of the interconnectedness of ecological and social systems [8–10]. Central concepts in this new school of thinking include ecosystem services (which understand humans

as co-creating, as well as benefiting from, nature) and resilience (which refers to the capacity of a system to absorb and utilize shocks, reorganize, and then continue to develop without losing fundamental functions) [11]. This shift in thinking sees humans resituated from being outside ecosystems—as polluters or as benevolent resource managers—to being integrated within them, as stewards "navigating" the system from within, e.g., [12].

In urban planning and design, where there has been a call for improved integration of ecological knowledge for decades now, see, for example, [13], a corresponding resurgence in ecological ideas and ecological thinking can also be noted (for an overview of this recent development, see, [14]). Within the emerging fields of landscape urbanism, e.g., [15,16] and later ecological urbanism [17], landscape, and ecology are discussed and are tested as integrative, generative, and inseparable parts of cities and as key for sustainable development. Important here are also the increasing interest on these topics in the social sciences, not least social psychology. A central contribution in this context is the work in social ecology that aims to integrate studies of humans' social interaction with their physical environment in a broad interdisciplinary approach [18].

Within urban planning, the concept of "social-ecological resilience" promises the development of new theory and tools that may, more accurately and realistically, capture and conceptualize complex urban processes [19]. The heightened level of resolution and detail embodied in resilience theory can, it has been suggested, produce synergies and win-win situations in contested planning situations [20], and offer alternatives to preservationist ideals within urban green space conservation and planning [20–24]. In this context, ecosystem functions and processes—rather than a single species or habitat—become the target of management, regeneration, and even creation [23,25], which must be incorporated and built into urban planning and design in order to maintain the resilience of a given urban system.

Despite this potential, few tangible examples exist with respect to how novel ecological theory can be integrated in actual, hands-on planning and urban design projects [26–28]. Contemporary, mainstream urban planning and design practices have tended to only incorporate ecological issues in the prescriptive and preventive aspects of projects, commissioning ecologists as consultants to produce inventories before, or environmental assessments after, the development of design proposals [6,29]. The contribution made by ecologists in contemporary planning projects therefore often concerns the collection and classification of data about existing situations and seldom adopts more future-oriented perspectives [30]. Moreover, interdisciplinary engagement is still lacking in academic research and academic discourse [7]. This is unfortunate, as a broad interest and even outspoken urgency exists in relation to both more socially integrative ecological understanding within urbanism, e.g., [19,31] and the development of a "transformative design-ecology nexus" [26].

In response to this gap, this paper explores strategies for facilitating more integrated social-ecological approaches within urban design processes, referring to an urban design project in the Albano area in Stockholm, Sweden. This site, which is situated within the National Urban Park in Stockholm, has for many years been characterized by conflict and controversy; recently, calls have been made for its development, in order to transform it from a desolate, post-industrial brownfield site into a hub for academic research and teaching. Importantly, the City of Stockholm has kept a high profile in environmental sustainability over a long time, going back to the first United Nations (UN) conference on the environment held in Stockholm in 1972. These ambitions were perhaps crowned by the development of the urban district Hammarby Sjöstad in the decades around the Millenium, which reached broad international renown for its' ground-breaking sustainability work, and was instrumental for Stockholm being the the first city to be awarded the European Green Capital title in 2010. More specifically, the National Urban Park in Stockholm has been a central object of study for the kind of urban social-ecological dynamics, central to the project presented here [32].

Although a proposal for development of the Albano area was put forward by Stockholm University and the property developer Akademiska Hus, the group in which the authors of this article took part chose to present an alternative idea under the title of Albano Resilient Campus

(hereinafter referred to as the ARC project/process). The original members of the group were central to the development of the ARC proposal. Beside the authors of this article, who all self-identify as urban designers and architects, this group included urban ecologists and resilience scholars (please see acknowledgement for further details on the original members). The project adopted a transdisciplinary perspective, conducting a series of workshops in which professionals and researchers from the fields of systems ecology, natural resource management, political ecology, urban design, architecture, and landscape design, as well as planners, developers, local interest groups, and Non-Governmental Organizations (NGOs), all participated.

Our central concern in this paper is to exemplify and discuss how a collaborative design process of the kind utilized in the ARC project can contribute to sustainable urban development. In particular, we aim to explicate how such a process can contribute to the integration of social-ecological theory in urban design by bridging disciplinary boundaries (here primarily between ecologists and designers), as well as integrating non-expert knowledge. We see this process as integral to what we conceptualize as "social-ecological urbanism". Our specific questions are: How can ecological knowledge become an integrated, active and generative part of urban design and planning projects? How can knowledge traditions be bridged in design processes through the promotion of transdisciplinarity? Which particular tools, techniques, and strategies do we see the need to develop further?

The paper is divided into six parts. Following this introduction, our methodological approach is presented and positioned in relation to the existing literature that addresses the disciplinary specificity of design and its capacity for generating integrative knowledge. In the third and fourth sections, the ARC process and its primary methodological orientations are outlined. Outcomes are then discussed. The final section summarizes the specific lessons that are learnt from the ARC process in terms of its contribution to a social-ecological urbanism framework.

2. Method: Bridging Gaps through Collaborative Design-Based Approaches

This paper documents a transdisciplinary design process, detailing that process for a wider audience and demonstrating the complex, iterative development of the ARC project as it evolved over time and in relation to the emerging ecological and social conditions on the site. As such, this paper can be read as an account of an interdisciplinary method; our method in constructing that account is also interdisciplinary, although it relies on practices of scientific writing, rather than the design-based, narrative, and participatory methods deployed in the ARC process (these, in turn, are documented in Section 4 of this paper).

Despite decades of efforts, work continues on frameworks for cross-fertilization between disciplines in order to bridge the gaps between knowledge traditions and unite scientific and experience-based knowledge [33–37]. The urge to develop more integrative approaches is hardly new, but has gathered momentum within both practice and academia in recent decades. Briefs for urban planning and design competitions now increasingly demand diversely assembled teams; similarly, calls for research grants now often require the crossing of disciplinary boundaries. However, in-depth integration of different research traditions and disciplines continues to prove challenging [34,35]. Although many processes claim to be set up in an integrative manner, the different fields involved in fact often work parallel to one another and seldom cross over or challenge each other. As Tress and colleagues state, truly inter-and transdisciplinary approaches involve the crossing of subject boundaries in order to create new knowledge and integrative theory. In this process, disciplines need to "readjust their concepts and methods and, as a consequence, a new commonly shared axiom is developed at a level above that of the individual disciplines involved" [35] (p. 486).

Bridging the knowledge traditions between ecology and urban design represents a particularly difficult challenge, since the two disciplines maintain disparate epistemological traditions [10,15,38] and cultures of thinking [7]. The field of ecology, on the one hand, originates almost exclusively in the natural sciences, and the profession has been dominated by instrumental perspectives that involve corrective measures related to restoration, and techniques of description and prescription [15,27].

The epistemological background of the design professions, on the other hand, draws from a far wider range of sources—both the natural and social sciences, as well as aesthetic and artistic practices [39]. Despite this inherent eclecticism, many scholars agree on the need to acknowledge the disciplinary specificity of design [39–41], and in past decades, the capacity of design as a knowledge-generating process has been highlighted in the fields of architecture and urbanism, see for instance [42–47]. This discussion is particularly developed in relation to the "co-design" discourse, e.g., [48,49].

Design theorist Nigel Cross describes design as a "third culture", alongside science and the humanities. In Cross' work, we find an interpretation wherein science is described in terms of a culture of analysis of the natural world with concern for "truth"; the humanities are portrayed as a culture of evaluation of human experience, expressing a concern for "justice", and design is described in terms of a culture of synthesis of the artificial world with a concern for "appropriateness" [41] (p. 2). Any such reductive characterization can of course be debated. Naturally, all these cultures indulge in all three forms of knowledge, but often one form of knowledge seems more dominant in each culture than the other, and Cross' description helps in understanding the decisive divides between these cultures and how we might begin to bridge them. Backed by this line of thought, one could argue that design, seen as a third culture, constitutes a neglected field within academia in spite of its tremendous impact. One reason for this neglect lies in the very different degrees of institutional support and status that is tied to the epistemological foundations of the three cultures. While science has developed analytical theory and the humanities discursive theory (together more or less constituting the academic world of knowledge), design primarily rests on generative theory, which is a much looser concept [50]. The architectural theoretician Bill Hillier describes generative theories as "theories of possibility", as opposed to the "theories of actuality" that is found in science [51].

Generative and solution-oriented approaches that, in the words of Herbert Simon, are concerned not only with "how things are" but also "how things ought to be" [52], become especially urgent in light of the escalating, multifaceted, and complex problems that societies currently face [44,53,54]. In relation to the "wicked problems", as addressed by urban design and planning [55], scholars have particularly highlighted the potential of design-based approaches to reconceptualize human-environment relations [44,47,53]. The distinctive ways through which designers think and work—described in terms of "designerly ways of knowing" [56], "design thinking" [57], and "design intelligence" [58]—have thus been lauded for the ability to synthesize various fields of knowledge, to project such knowledge in creative and forward-looking designs, and to explore unexpected potential [44].

Within the context of landscape ecology, there has been an increased interest in the potential role of the design process as a link and mediator between ecology and planning. Childers et al. [26] state that the challenges that societies increasingly face cannot be adequately met if "urban design and ecology continue to be practiced as separate fields" (p. 3776). Nassauer and Opdam [59] have highlighted the collaborative design process as a potentially useful link—a common ground—through which scientists and practitioners can both "conceptualize innovations" and bring scientific knowledge into society and decision-making. Here, designs, broadly conceptualized in terms of processes of "knowledge innovation" ([59] drawing on [60]), can produce possibilities to integrate ecological knowledge into real, hands-on planning situations and in research. Grove et al. [31] seek to raise the potential of processes of co-design and the co-production of knowledge through project teams, arguing that these processes challenge more traditional interactions between scientists and decision-makers. Felson and Pickett [61] also recognize the potential of design as a link and mediator between ecology and planning. They emphasize the experiment as a common denominator, arguing that both disciplines use experimentation, albeit in different ways, stating that: "While ecologists develop experiments as a means to an end—to obtain quantitative data through simple and efficient manipulations—designers use experimentation primarily as a creative and exploratory tool" (p. 549). Felson and Pickett propose taking advantage of this area of overlap between the professions and suggest that urban design projects may act as ecological experiments in urban systems. They argue that in the same way that designers use the creative process as an essential tool for bringing together complex factors into cohesive designs,

ecologists could "piggyback" on such processes and utilize them for the integration of experiments into cities. This could, potentially, as further highlighted by Felson and Pollak [62], make ecological research more public, inventive, and visible. The Presidio Project in San Francisco is raised by Felson [6] as an example wherein the design process acted as a framework for integrating ecology and design.

This article draws and builds upon these important scholarly works. However, we also argue, in agreement with Grose [7], that this literature is dominated by a relatively static and linear understanding of what design (and the design process) is and could be. Although Childers et al. [26] and Grove et al. [31] acknowledge the importance of an iterative, non-linear design process, they do not expand on how this may, in more precise ways, transpire. Thus, whilst we acknowledge that there is no single "design method" [7], and that design is always situated and site-specific (e.g., [63]), we also hold that various methods support integration to varying degrees and that some methods are more useful than others. By unpacking the ARC process in light of an emerging social-ecological urbanism methodology, we wish to provide general insights into, and particular examples of, where the integrative capacity of the design process lies.

3. An Account of the Albano Resilient Campus Design Process

The ARC process was the result of a collaboration between four primary actors: the School of Architecture at the Royal Institute of Technology in Stockholm (KTH); the Stockholm Resilience Centre (SRC); the Beijer Institute of Ecological Economics (Beijer); and the architecture and urban design firm KIT. Throughout the process, local interest groups and NGOs (under the umbrella organization Association of the Ecopark), were also involved, along with the property developer Akademiska Hus (a public company owning, developing and managing all facilities for higher education in Sweden), Stockholm University, Stockholm Municipality, the architecture firm BSK, and the design bureau SERVO. The collaboration, undertaken between 2009–2013, took the form of a series of workshops, in which iterative, recursive prototyping was paralleled by critical reflections on outcomes. Vigilant discussions within the group, collaboratively formulated written reflections, as well as transparent documentation (e.g., through notes, e-mails, sketches, diagrams) were all important methods. Thematic workshops (including mini-lectures) were organized; shared readings were made in relation to key literature from the different fields; and outreach workshops with key stakeholders and activist groups connected to the site were also held. Some of the first steps in the process included: repeated visits to the site both as a group and individually; studies of existing and previous plans for the area (including comprehensive plans and on-going pre-plan inquiries for Albano); analysis of existing ecological studies of the park; and, photographic analyses of site conditions and mappings of the various stakeholders and interest groups active in the park at the time. The project in this way followed a transdisciplinary methodology [35] and used a Research Through Design (RTD) approach with emphasis on the process of design over the more traditional accent of design as a product [46].

The spark that formed the starting point for the ARC process was a response to the proposed plan for the expansion of Stockholm University at the Albano site in Stockholm. The plan, which was the result of an invited competition organized by Stockholm University and Akademiska Hus, stirred up mixed feelings at Stockholm Resilience Centre. Many researchers felt that the proposal, which constituted a rather traditional campus plan reliant on freestanding buildings set amidst a grass lawn, did not reflect the direction and scope of the center regarding social-ecological planning and sustainable urban development. In reaction to this, the PatchWork group was formed in September 2009, with the idea of creating a parallel design proposal in order to stimulate a debate on the potential of the Albano area. The proposal Albano Resilient Campus (ARC) took shape, and was presented at a conference entitled "Green Urbanism in Albano", which was hosted by Stockholm Resilience Centre in the same year. Through this exposure, the proposal won further interest and the support of a number of key actors, resulting in the developer Akademiska Hus commissioning the group to develop an official "vision program document" in 2010 [64], and later the co-authored book, *Principles of Social-Ecological Urbanism* [25].

As opposed to several of the previous transdisciplinary co-design processes in urban contexts that have been captured in scientific studies lately, e.g., [65,66] decision makers (e.g., governmental and private/public sector stakeholders) were not involved in the initial stages of the engagement process, but were rather enrolled in the process as the project grew and gradually gained momentum. In this sense, the ARC project, resembled more of an activist "shadow project" at first, although, importantly, the initiative was not "bottom-up" in a traditional sense but came from academia. As the project grew, key actors (both governmental and private/public sector stakeholders) were enrolled and participated in the co-design process. Later in the process, however, and in conjunction with the project being taken up more formally in the planning process through our group's advisory role in the detailed planning process the municipality of Stockholm replaced the project manager, which became a set-back for the project. As a result, and as noted by Pulkkinen many of the "original systemic ideas, combining urban form and ecological processes, were cut off or partially changed in the planning process, which resulted in a different emphasis in the detailed plan" [67], (p. 299). To date, the actual material influence of the project still remains to be seen, and in this paper we have therefore chosen to presents some of the main characteristics of the PatchWork group's original concept. During the course of the project process, the work has been utilized and exposed in different contexts, and the ARC project has also served as a model for several municipal workshops in Sweden and was presented at Expo 2010 in Shanghai. The principles that make up the SEU approach have also served as a basis for the 2015 Nordic Case Competition and 2016 Nordic City Challenge and are the subject of several Masters-level and PhD studies e.g., [67–69]. The PatchWork group has also had an advisory role in the continued detailed planning process and the work has served as student literature and as a basis for studio workshops at several universities.

For the members of the PatchWork group, the ARC proposal was seen as an opportunity to develop and deepen existing collaborative work between the universities on the topic of integrating ecology and design, e.g., [20] and to test this work on the Albano site. The theoretical basis for the process was especially found within two fields: first, ecosystems theory (including resilience, social-ecological systems, and ecosystem services); and, second, spatial morphology, especially as developed in space syntax theory. (Spatial morphology combines the qualitative study of individual urban forms, such as streets, squares and buildings typical for urban morphology [70] and the quantitative approach of spatial analysis that rather look at cities as spatial systems [71]. In Space syntax, this takes the form of analysis of street systems by way of network analysis, which has proven efficient in capturing pedestrian movement in the street system. In turn, this produces public spaces with co-presences of different size that create certain social and economic conditions [51,72]). The main steps of the ARC process are described and discussed below. Whilst the linear format of an academic article requires that these steps be presented one after the other, in reality, they were undertaken in parallel.

3.1. Site Analysis and the Formation of an Alternative Brief

The site, which is situated on former industrial land in the northeast part of Stockholm, has long been an object of conflict and controversy in the local planning debate [73]. The area, which consisted of gravel, dirt, and paved slabs at the time, was primarily used for temporary parking and storage. However, Albano's strategic location right at the edge of the inner city between the city's three major universities (Stockholm University, Royal Institute of Technology, and Karolinska Institutet) and within the The National Urban Park (NUP) (Figure 1), made the site not only the subject of extraordinary development potentials, but also an important potential link in the city's large-scale green infrastructure. Altogether, the NUP, protected by law since 1995, makes out a 27 km^2 stretch of land that includes vast and diverse areas of meadows, forests, lakes, and streams, with a high biodiversity of common and rare species [21,74]. Furthermore, the park has been associated with a highly mobilized network of civic associations, which played a pivotal role in the early 1990s in creating a constituency for the area and in articulating and protecting the values later enshrined in the law [73,75].

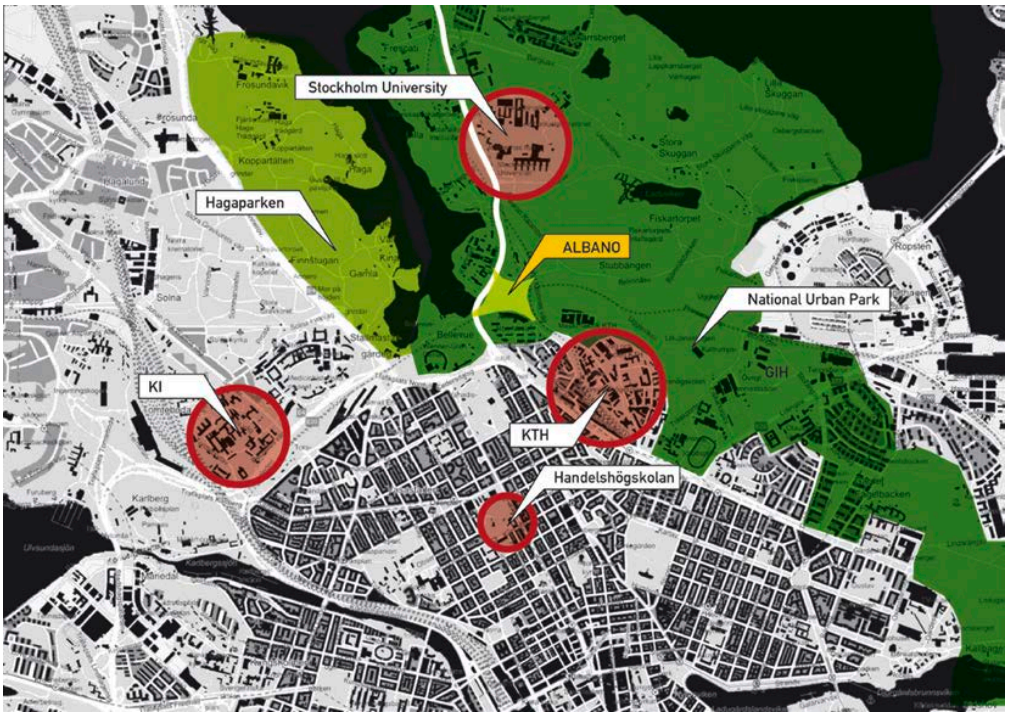


Figure 1. Albano is situated within the National Urban Park and could strengthen both important social and ecological linkages. The site is also located centrally in relation to several important academic centers and has potential to become one of the main gateways between the city and the National Urban Park.

In 2007, the property developer Akademiska Hus initiated the process of seeking permission to build in the park and, together with Stockholm University, organized an invited architectural competition. The competition brief called for a building mass of 100,000 m^2, including teaching venues, offices, research facilities, and housing for students and researchers. The PatchWork design team used this brief both as a point of departure and a goal for the proposal. Given this highly contested site, the group decided to reformulate the brief and explore if and how an even more connected urban fabric could be combined with a maintained, or even strengthened, ecological infrastructure at the site and its surroundings.

3.2. Building Resilience in Ecological and Social Services

Parallel to the site analysis, we started mapping the social and ecological services present in the landscape surrounding the site, while also suggesting potential new services. At first, we mainly focused on ecological services like seed dispersal and pollination, water retention, biodiversity, noise reduction, and air filtration. The small-scale farming heritage of the area is still present in several patches in allotment gardens, and we saw these as attractive for pollinating insects, and thus important in future planning. Services of a more social nature, as generated by the urban fabric and its systems, were also listed, including attractiveness, recreation, safety, and publicness. The selection of "urban system services" was made in relation to the challenges and potentials identified at the site, in particular the aim of creating an urban node and academic meeting place. Unlike ecological services that have been universally categorized, the criteria we used was based on discussions in the group and in consultation with the participating actors throughout the workshops. Having brought both types of services to the table, we realized that a simple distinction would not be possible: in urban locations, ecosystems become intermingled with social/urban systems, and, in turn, also generate social/urban services. Despite this insight, we found it useful to try to separate these two categories initially, using

resilience thinking—in particular, the interacting resilience principles developed by Folke et al. [76] of learning and memory, disturbance, diversity, and self-organization—in order to discuss ways of managing and developing both, in combination.

3.3. Designing for Adaptive Co-Management and Learning

Adaptive co-management is a central concept within resilience science, which formed a key theoretical base for our work on the project [12]. Our aim was to create an alternative spatial proposal that could support a fine-meshed management structure on the site, which in turn needed to fit within the current ownership structure of the site. As a first step, the property was divided into a number of units to which different actors would be assigned property rights (Figure 2a–f). This is one way of facilitating increased civic participation and stakeholder involvement in the active management of the green spaces. The co-management of ecosystems requires that solutions be developed over time and adapt to environmental fluctuations. Managers must, we reasoned, have the possibility to renew plans as they learn about how the system works. Hence, we discussed both, how to use the theory of adaptive co-management in the design process of the campus and also how the landscape itself would be an arena for adaptive co-management and learning for future generations.

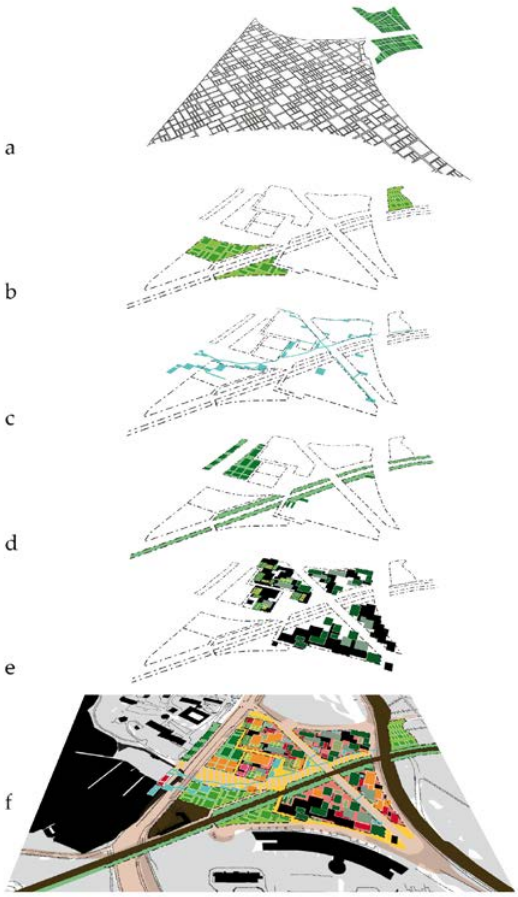


Figure 2. (**a**–**f**) Illustrating the division of land in units to which actors are assigned property rights. Programs could include: allotment gardens (Figure 2b); wetlands (Figure 2c); or showcase gardens that could announce the entrance to the park and serve an important educational purpose. Further experimental "test bed gardens" and "climate change gardens" (Figure 2d) could serve as areas where researchers tied to the University could study and monitor urban ecology and the implication of climate change. These units, or patches, would also extend up on the roofs, sometimes accessible to people and sometimes providing more secluded spaces for disturbance-sensitive habitats (Figure 2e). Figure 2f shows synthesis.

3.4. Spatial and Institutional Design Components

Six design components were formulated in response to an emerging set of challenges that were identified by the group: three spatial components (*Green Arteries*, *Performative Buildings*, and *Active Ground*) and three institutional components (*Property Rights/Rules*, *Local Knowledge*, and *Social Networks*). These are briefly described below.

Although Albano is centrally located between three universities, the area is poorly integrated in the city's mobility systems, including walking and bicycling infrastructures. This complicates the aim of creating an urban node and academic meeting place. Similarly, in ecological terms, the site constitutes a weak link between the western and eastern parts of the NUP. In response to these challenges, the design component *Green Arteries* (Figure 3a–c) was put forward as a network of corridors intended to connect ARC with central routes in the larger urban fabric and unite the two green areas of the park. One such suggested artery lay in a proposed transformation of a freight railway into a public tramline that would connect new development nodes via an east-west axis. Parallel to the tracks, a public park for pedestrians and bicycles was proposed that would also serve as an ecological dispersal corridor. Another proposed artery was the transformation of the highway Roslagsleden into a tree-lined public street, thereby extending the existing esplanade that unites several inner-city parks with the surrounding landscape and Stockholm University in the north.

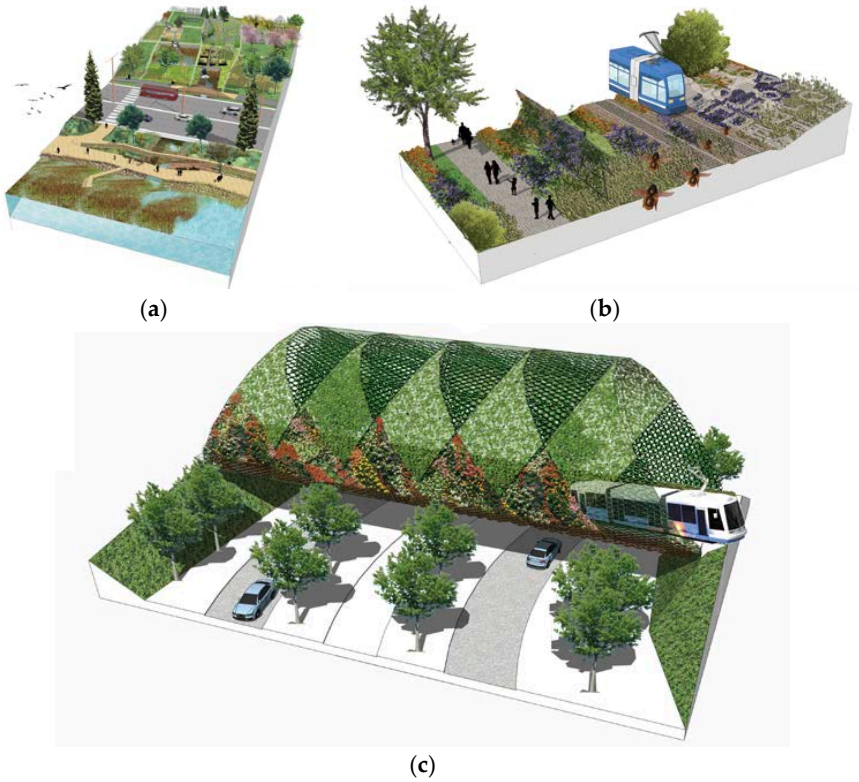


Figure 3. (**a**–**c**) The elongated public space of the proposed Green Arteries shifts in character in response to surrounding conditions. In one section, a system of ponds, ditches, and wetlands passes under the main road, connecting the lake with the cultured patches of the Albano site (Figure 3a). In the suggested Railway Park, the tracks are paralleled by a public park with bands of experimental gardens, making it a potentially high-quality dispersal corridor for pollinating insects, small mammals, and birds. Large-scale graphic patterns in the gravel are designed to facilitate orientation for bees (Figure 3b). Where the railway park bridges the motorway, an ecoduct is planned that is made of double layers of metal mesh that can hold soil. The tube is planted with flowering plants to attract butterflies and other pollinators, like a meadow folding back on itself. The ecoduct provides a new entrance to the area and a manifestation of the new development (Figure 3c).

Performative Buildings (Figure 4a–c) are buildings that not only facilitate the particular uses they are designed for in the university program, but which also support other services, such as: establishing social and ecological links; constituting a gateway between the city and the NUP; offering shelter and/or feeding areas for organisms; treating air; or, providing knowledge about the area's cultural history. Perhaps more than anything else, the role of the performative buildings in the ARC proposal was to challenge the traditional division between categories of "building" and "landscape".

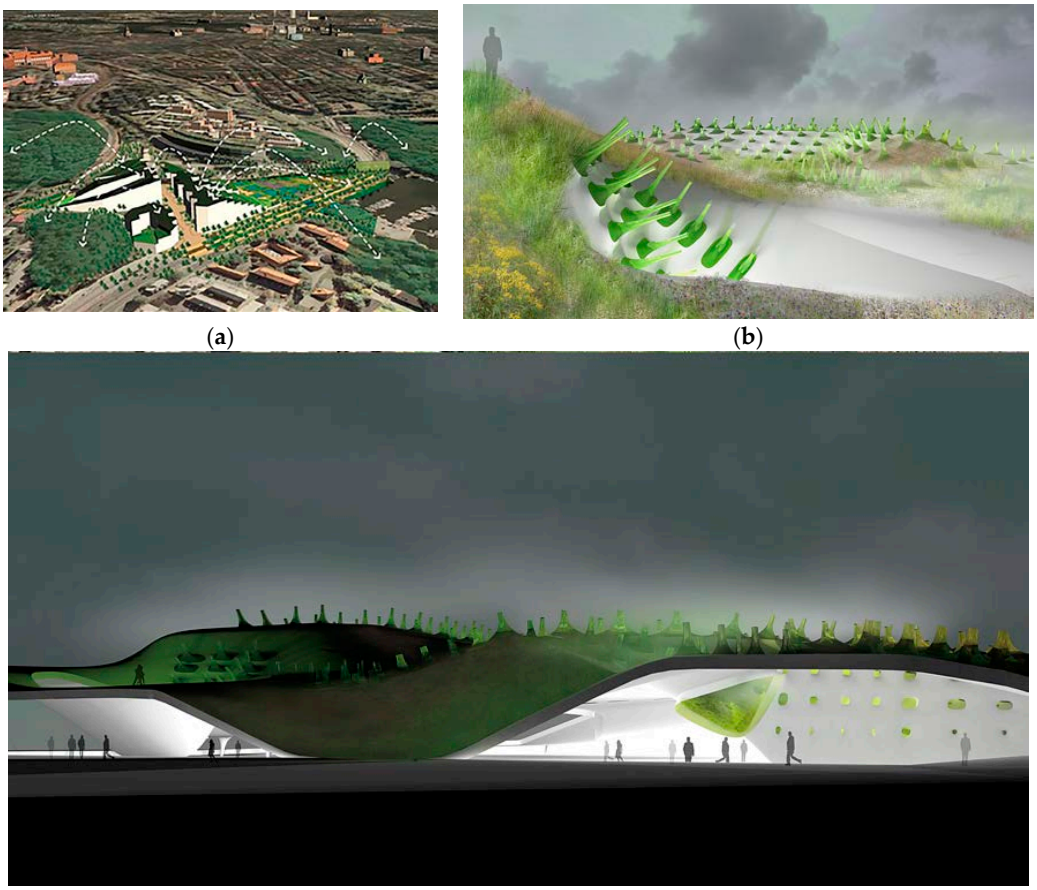


Figure 4. (**a**–**c**) To the right: Performative Buildings function as stepping stones for birds and other flying organisms. To the left and below are extracts from the project "Hydrophile: Hydrodynamic Green Roof", by SERVO through design partners Ulrika Karlsson and Marcelyn Gow, in collaboration with Jonah Fritzell and ecologist Tobias Emilsson © SERVO. This proposal was a part of a research project that used the ARC process as a framework for exploring innovative solutions for green roofs.

As an extension of the landscape, the proposed building mass would provide urban experiences and connect the universities in a north-south direction. In this way, it would not act as a barrier between the east and west side of the park for either birds, insects and amphibians, or pedestrians and bicyclists. The roofs of the buildings were envisioned as vegetated in order to potentially serve as habitats for plants and animals and to function as "stepping stones" for birds and insects (Figure 4a). A variation in soil depth and degrees of dryness, moisture, shade, and sun was proposed in order to create conditions for different habitats and blur the boundary between surface and building (see Figure 4b,c and proposal by SERVO).

The third spatial component, *Active Ground*, responded to the challenge of making the ground surface of the campus not only function as a public space, but that would also promote and support the development of ecological and social diversity. In this context, we specifically explored strategies

for taking advantage of the knowledge and engagement built into local organizations and stakeholders tied to the park. A structure was proposed that could support a fine-meshed management structure made up of a number of units characterized by different property and user rights. Ecologically, diversity creates opportunities for a multitude of different habitats (environments suitable for different plant and animal species), and although access to suitable habitats does not necessarily mean that an organism will be present, it does increase the probability. From a social perspective, a fine-meshed management structure distributes opportunities to and responsibility for managing the area. A multitude of managers also increases the number of people visiting the area for various reasons, which in turn may contribute to a greater diversity in public space.

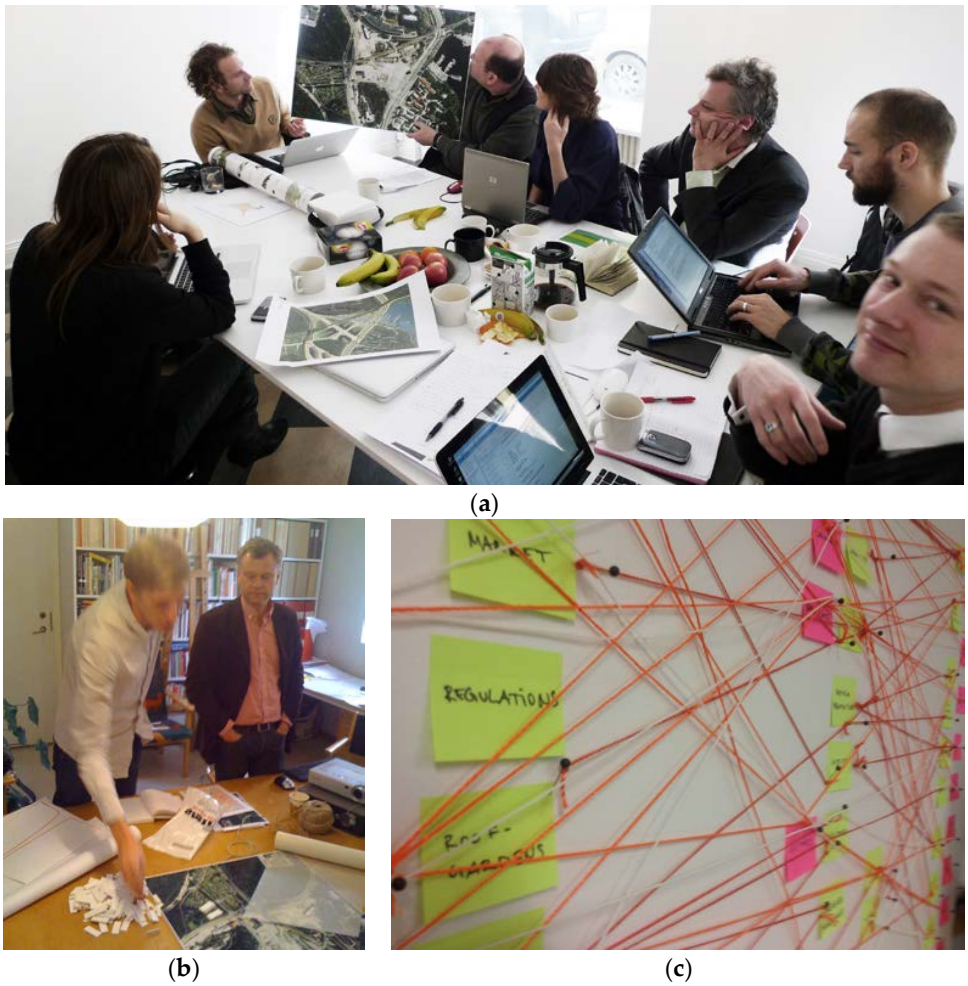
Linked to the vision of creating conditions that are related to *Active Ground*, as well as the lens of adaptive co-management described above, the vision also included design for social institutions for upholding social-ecological diversity and learning about local social-ecological system over time, e.g., [77]. Albano is situated in an area owned by the Swedish state, but it was suggested that the implementation of a more multifunctional land-use and distributed ownership/user structure could hypothetically promote biodiversity [25]. As the area already had a well-developed structure of management responsibilities, we proposed changes to user rights rather than ownership rights [25]. User rights are tightly linked to particular properties or management units and thus to the component *Active Ground*. By clearly dividing the units, a diverse set of user rights could be given to different managers, determining a different action space for each manager. The location and shape of each unit and the user rights assigned to it needed, we argued, to be congruent; certain activities, after all, require certain amounts of space, and some locations are more or less suitable for certain activities [64].

In Stockholm, user contracts have been used for park management for a long time and we saw an opening for the framework to be applied to other organizations. Thus, it was considered to be essential that the contracts were written between Akademiska Hus and the manager of each site. Users in this context could include e.g., residents, learning institutes, boat clubs, allotment garden associations, daycares, and others. User participation builds on collaboration between landowners, organizations, and associations, wherein the user would take on a greater responsibility for management [25]. This may lead to a higher quality of maintenance, we proposed, and (through greater diversification) to multifunctional land-uses, which can, at least potentially, promote biodiversity [25].

Social networks were also used as a design component. Beyond occasional encounters, social networks are understood as patterns of stable and mutual relations between actors [78]. Here, the focus was to create and sustain social networks of actors in and around the new Campus area that could facilitate knowledge-creation and knowledge-transfer in order to manage local (or wider) landscape and social-ecological processes [23]. While social networks emerge organically from interaction between actors and cannot be designed as such [23], factors that can facilitate conducive social network structures can be designed [25,64]. The ARC proposal therefore included the physical design of a venue for meetings and a specific governance forum made up of land-owners and tenants that meet across the year. Together, these were conceived of as serving to promote not only a "culture of collaboration" [25], but also the building of an institution to promote social learning and linking social-ecological knowledge across spatial and temporal scales [21], including the emergence of "scale-crossing brokers" to promote such knowledge integration [23].

4. Methods Developed during the Albano Resilient Campus Process

The previous section has detailed the design process that was involved in the ARC proposal, and the present section will reflect on the numerous methodological orientations that emerged whilst undertaking that process. We reflect upon these methods here, particularly with respect to their utility in future practice. In particular, we discuss notions of prototyping, the use of generative matrix models, and ways of working with comprehensive narrative, all of which we locate at the heart of a fledgling social-ecological urbanism (Figure 5).



(**a**) (**b**) (**c**)

Figure 5. (**a**–**c**) Workshops with the PatchWork group. (**a**) With a limnologist and Nature Conservation officer from the Museum of Natural History, and a landscape architect and founding member of the design bureau SERVO during work with ARC in 2010; (**b**) At the City planning office at Norrköping in 2011 spreading the experience to other cities; (**c**) From a student workshop at Chalmers University of Technology in 2011 showing interactions between proposed services and actors on a selected site. (Photos by Jonas Torsvall).

4.1. Iterative and Recursive Prototyping

The working method that evolved within the PatchWork group was based on recurrent meetings and workshops at regular intervals and with design sessions in between, where the designers from KIT and KTH concretized the discussions into sketches, diagrams, and models that then formed the basis for the next group meeting. Consequently, the analysis phase took place in parallel with design iterations and theoretical exploration. In preparation for each internal workshop within the PatchWork group and prior to each outreach occasion, e.g., at the conference, the stakeholder workshops, the vision program document [64], tentative ideas and conclusions were gathered into a comprehensive sketch proposal. The resulting new iteration or prototype then became the basis for new discussions and further alterations, which were incorporated into new designs. In this way, the various components or sub-sections of the process (presented earlier in the paper)—site analysis, social and ecological services, spatial and institutional design components; and, resilience theory as an overarching and guiding concept—were allowed to interact in a dynamic manner through feedback loops that came to be incorporated in the next prototype (Figure 6).

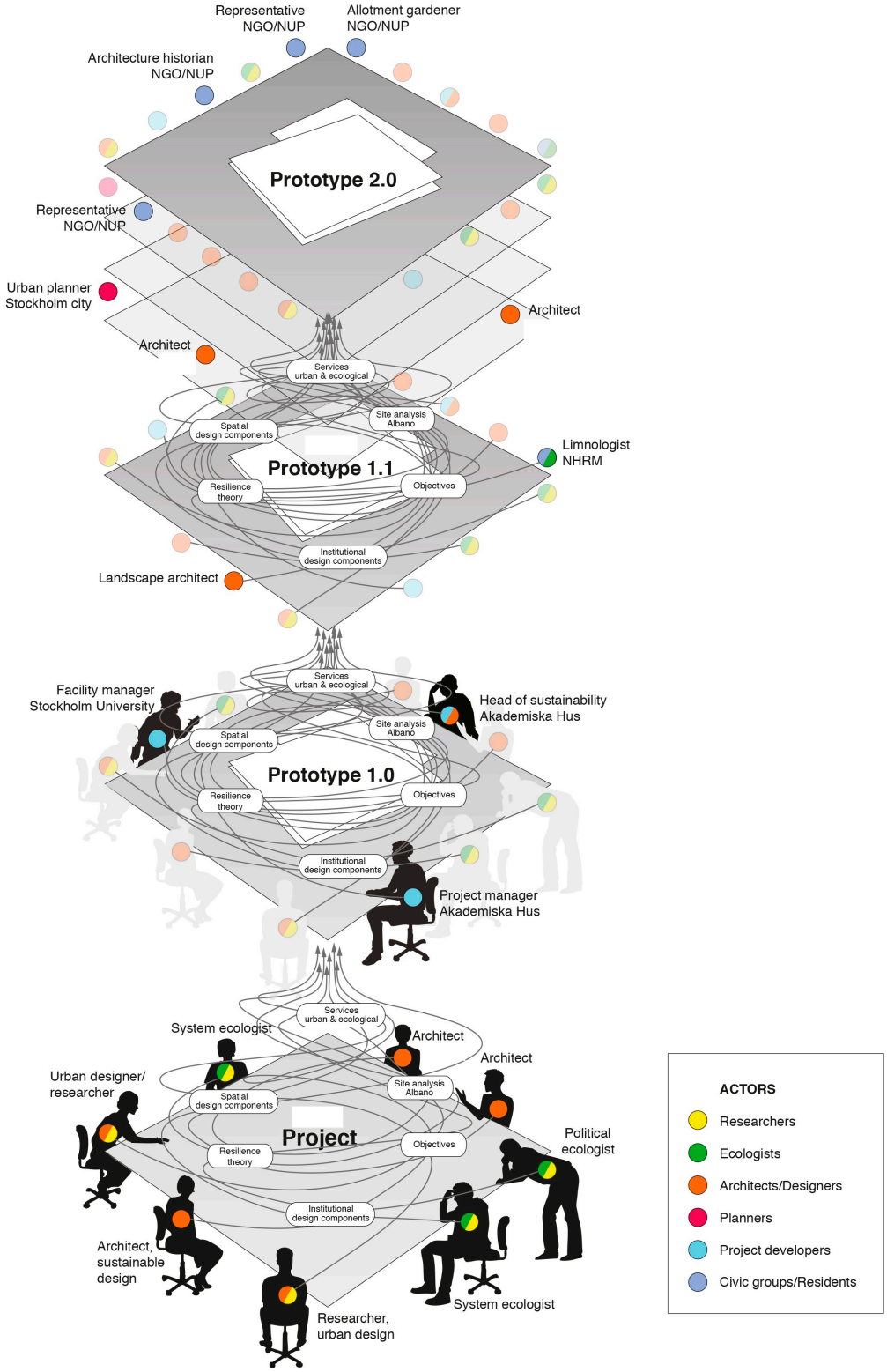


Figure 6. The transdisciplinary design process of the ARC project. The different parts of the process occurred in parallel. Each part informed the other in what could be described as a messy, quickly shifting, back-and-forward movement, in which the understanding of the site and the theoretical foundations deepened as a shared understanding of the project emerged. In preparation for each internal workshop and presentation, the project was assembled into a "unified whole" that was then yet again disassembled and allowed to evolve in an iterative process.

In this context, the prototype is a tool that can be understood according to the definition provided by Floyd [79], and Runberger [43,80]: not primarily as a "first of their kind"—a forerunner or template for later examples to follow—but rather as a transformative object of investigation that allows for experimentation, communication, and feedback. The prototype can in this sense be seen both as a series of artifacts or "assemblies around which research and design work can be organized" [80] (p. 10), but also a verb in the form of prototyping [81]. Iterative prototyping has, during the past decade, gained increased attention in the context of participatory, and collaborative design, see [81] for an overview, and has been brought forward for its quality to "evoke a focused discussion in a team, because the phenomenon is 'on the table'," [82] (p. 6). As work on the ARC project progressed, the PatchWork group began to reach out to external actors and to include them in the workshops as co-creators. At one such occasion, for instance, a Nature Conservation Officer from the Museum of Natural History and a landscape architect and founding member of the design bureau SERVO participated. The question was raised as to whether and how a wetland that was tasked with performing a number of water-related services could be constructed on the site and how it should be best managed. These aspects were consequently introduced into the prototype in the form of an outlined management structure with the Museum of Natural History as steward of the wetlands. On another occasion, members of the Association of the Ecopark were invited to express their views on the latest prototype. Here, one representative stressed the importance of pedestrian access to the park across the highway, as well as sight lines of cultural historical value from the opposite side of the lake. Another participant and member of the local allotment garden association realized that they could expand their activities while taking a more experimental direction. These aspects were then brought into the next prototype, making the process increasingly well-informed and established.

4.2. The Use of Generative Matrix Models

Another methodological approach that defined the ARC process lay in the use of generative matrix models. These models allowed us, for instance, to explore the integration of institutional and spatial components (shown on the vertical axis in Figure 7) and ecological and social services (shown on the horizontal axis in Figure 7), filtering the design components discussed previously through a variety of potential services. While not all of the services were represented in each component, the goal was to find as many synergies and overlapping opportunities as possible. Each design component was filtered through the matrix, with the matrix acting not as a checklist but rather as a mechanism to raise the level of creativity by increasing the complexity and dynamics of the components that were "on the table", helping to generate designs that could cater to a multitude of aspects.

The generative matrix approach allowed us to explore how the Green Arteries could not only provide more traditional urban services such as accessibility through paths, roads, and public transport, but also act as places for knowledge exchange and publicness and support services, such as water treatment, pollination, recreation, biodiversity, and air treatment through a series of site-specific speculative design experiments (see Figure 3a–c). Likewise, with Performative Buildings and Active Ground, the matrix approach helped us to explore and imagine interaction between multiple social and ecological systems, scales, and processes over time. In their speculative proposal "Hydrophile", SERVO took this approach further by developing a bioscience innovation center with a performative hydrodynamic vegetated roof scape augmented with systems for percolating water through soil substrates (Figure 4b,c).

Design theorist and practitioner Linda Pollak points toward the merits of matrix models when analyzing and designing urban ecological landscapes [83]. Her study of competition entries for the remaking of the Fresh Kills landfill in New York into a park revealed that over half of the projects—including the winning scheme "Lifescape" by James Corner Field Operations—utilized a type of matrix to represent the project [83]. Mathematically, a matrix is a tool for managing complexity, and Pollak argues that in urban design projects, the matrix can make out a similar useful method to calibrate the relationships between parameters in a dynamic way. The matrix differs from a grid:

while a grid can "hold many kinds of information but does not interact with its content or set up such content to interact with itself, a matrix is conceived in dynamic terms: engaging the action of each term on others in what becomes a set of dynamic relationships" [83] (p. 102). In the ARC process, the matrix allowed for us to explore the relation between spatial/institutional design components and social-ecological services and processes in a dynamic, generative way. Services are in this way not static, but can be added throughout the process as designs reveal their necessity and possible potential. This performative aspect is key and distinguishes the generative matrix model from, for instance, methods that are rooted in Ian McHarg's "creative fitting" for evaluating a site's suitability for different types of development [84,85]. In her analysis of "Lifescape", Pollak recognizes these different approaches as a "transformation of the matrix from a tool for classification of complexity into a springboard for figuration" [83] (p. 114).

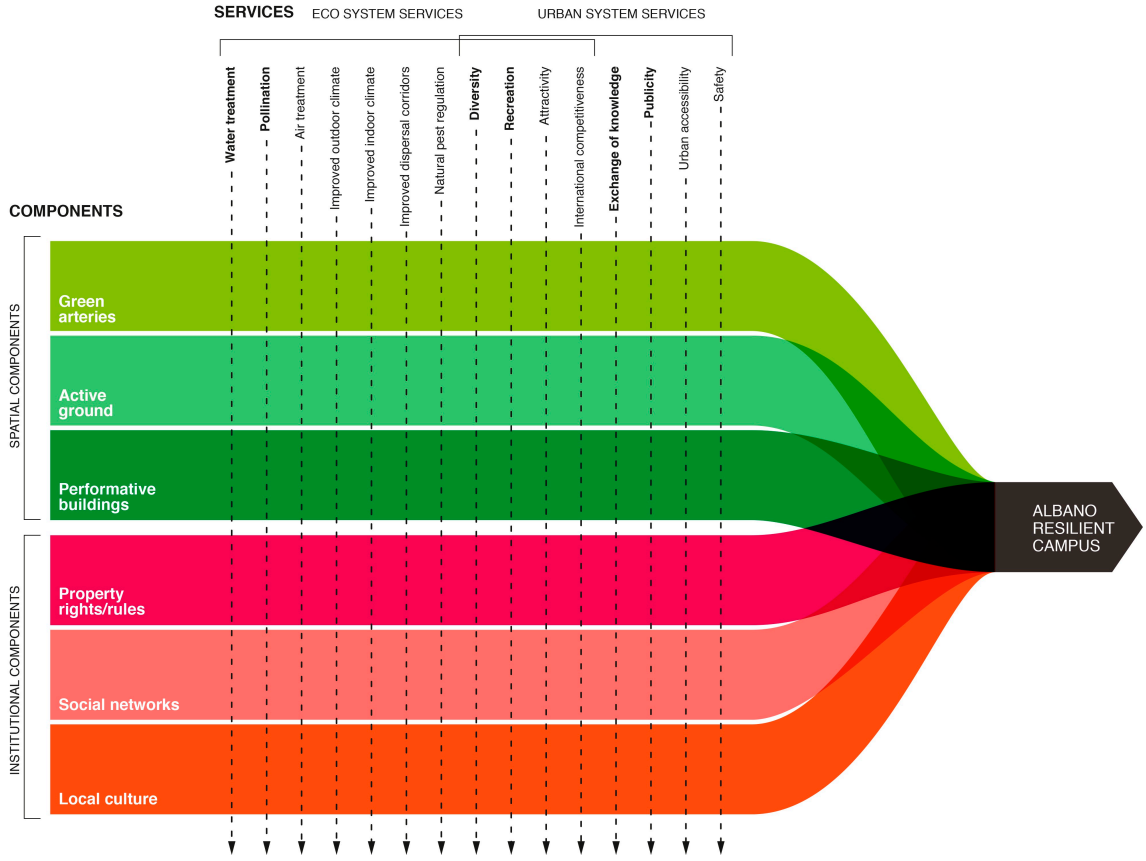


Figure 7. A matrix between on the one hand, both ecosystem services and urban services and on the other hand, both institutional and spatial design components, which visualized the complex of potential overlaps and supported novel design solutions.

4.3. Comprehensive Narratives

A third reoccurring methodological approach that is present throughout the participatory design process was the framing of ecological research into what we conceptualize as comprehensive narratives. The over-arching narrative related to how social-ecological resilience theory challenges the dichotomy between city and nature, offering an alternative view where social and ecological processes are integrated and interdependent. In addition, several sub-narratives existed that illustrated particular issues and made abstract scientific discourses tangible.

One such story was the example of the forgetful bird, based on a study conducted in the NUP by researchers from Stockholm Resilience Centre [86]. Every year the Eurasian Jay (Garrulus glandarius)

creates caches of acorns for the winter, some of which it ultimately does not eat. These "forgotten" acorns eventually germinate, becoming new oak trees. The oak is a symbol for the park, referring to the area's rich cultural history as an oak plantation that was intended to provide the royal navy with material for ship building. Renewing and maintaining the large stock of oak trees in the huge park over the years was a costly affair, and the bird has functioned as a gardener, doing the job for free. The twist of the story is that the bird depends on dense stands of conifers to hide its nest and avoid predators. In other words, one way to promote long-term regeneration of the oaks is to make sure that there are large, well connected areas of conifers.

Another reoccurring narrative was that of the early-rising queen bee. Resilience theory tells us that a diversity of actors spread the risks of losing important ecosystem services over time. Taking pollination as an example, it is important to ensure there are healthy populations of honey bees, but also that the gene pool of wild bees (e.g., bumble bees) is sustained. In wild bee communities, the queen wakes up early in the spring, before the other bees. Starving after a long winter in hibernation, it is crucial that she can find fast access to food, such as early blooming vegetation. The planting of early-flowering willow trees may increase the survival chance of wild bee communities, and thus the chance of a more diverse range of pollinators. In the ARC proposal, salix plants were proposed to be planted along the railway in proximity to areas with holes and gravel suitable for nesting and hibernation of bees. These areas were designed with large-scale graphic patterns to facilitate orientation for the bees (Figure 3b).

Throughout the ARC process, these stories and others that also were based on ecological research became a type of recurring narrative, which was first told within the group and later retold at outreach seminars and public presentations. Runberger [80] emphasize precisely this potential in the prototype to function as "the basis for a design narrative, in which multiple authors can co-create the series of events" (p. 22), i.e., what Stappers calls a type of "prop" that can carry activities and tell stories [87]. Sandercock in turn emphasizes how narratives can be "powerful agents or aids in the service of change, as shapers of a new imagination of alternatives" [88] (p. 18).

5. Discussion

5.1. Collaborative, Prototypical and Matrix-Oriented Design Methods Reveal Potentials

Throughout the ARC process, we found that the methodological techniques of prototyping and matrix modeling allowed for different parts of the design process to interact through dynamic feedback loops that constantly re-informed the design. In contrast to more phase-oriented traditional urban design processes, which tend to assume a strictly linear ordering of development steps [89], generative prototyping, performative matrices and comprehensive narratives introduce communication and feedback. Both social and ecological knowledge (expert and non-expert/local/experience-based) was in this way integrated into the process on an ongoing basis. Furthermore, this more open-ended, iterative, and recursive approach allowed us to jointly reformulate the problem setup—each new transformative prototype, or design iteration, also altered our perception of the site, its prerequisites, and hence our objectives (Figure 6). In this way, ecological knowledge was integrated, as ecologists took part not only in mapping and inventorying existing ecological properties of the site, but also in projecting ecological possibilities and "future natures" [30]. This allowed the ecologists the rare chance to re-negotiate the problem set-up and the brief.

If we return to the notion of design thinking or design intelligence [58], the prototype in this context constitutes a specific type of "intelligence" that may serve as a transitional object that generates multiple possible solutions and initiates change [43]. This technique thus has a focus on, not only what will happen (given certain assumed parameters), but also what could happen. Reflecting Bill Hillier's distinction between the theory of possibility and the theory of actuality, we here see a methodology of possibility rather than of actuality [51]. A prototypical approach involves an open and unrestricted exploration, wherein the formulation of the problem—and hence also the objectives—can change

during the course of the journey. In this sense prototypes (and likewise certain types of scenario techniques, e.g., what Börjeson et al. have conceptualized as "explorative scenarios" [90]) focuses and combines the exploratory and the generative, the analytical and suggestive. In other words, as stated by Runberger, "both answers and raises questions" [80] (p. 24).

The prototypical and matrix-oriented approach also shifts focus away from the more traditional question of 'what does it look like?' to the more generative and performative question of 'what can it do?'. In our experience, asking this latter question led to the discovery of unexpected potential and synergetic overlaps that were not apparent at first glance. This more performative take on urban planning and design is also one of the defining characters of landscape and ecological urbanisms in for instance the early work of Stan Allen, e.g., [91] and James Corner [15]. Cross, citing Akin [92], states that "one of the unique aspects of design behavior is the constant generation of new task goals and redefinition of task constraints" [41] (pp. 78–79). Bringing this argument further, Janssens [44] notes that such restructuring of the problem setup "enables designers to break free from the initially given problem and reveal unexpected potential" [44] (p. 184). Adding a more diverse and complex set of social-ecological parameters to what was already "on the table" may result in a greater number of more time-consuming challenges for the designer, but it also increases the potential for overlaps and for identifying positive synergies. More transformative and open-ended design-based approaches—what Childers and his colleagues [26] conceptualize as the "transformative urban design-ecology nexus"—can in this sense challenge the dichotomy between "nature" and "city" that still characterizes linear urban planning procedures.

5.2. Designerly Mediators Function as "Touchstones" Activating a Diverse Range of Stakeholders

The ARC process was thus iterative and recursive. The techniques of testing and speculation used included input from many stakeholders in a number of phases of the process, and these inputs influenced each other and the process at large. As we moved back and forth between analytical and suggestive modes of practice, we were able to constantly re-examine the problem in a way that informed the design as it was being worked upon. Design theorist Catharina Dyrssen has referred to this as a "double capacity" that is inherent to the process of design, whereby quick shifts between innovation and analysis occur [93]. On a similar note, Miss [94] uses the spiraling, continuous movement of the double helix to conceptualize the potential exchange and shared development of ideas between scientists and designers working collaboratively on projects. Donald Schön, in turn, has depicted this back and forth movement inherent to design as a "reflective conversation with a situation", and a process in which the designer "shapes the situation, in accordance with his [or her] initial appreciation of it, the situation 'talks back,' and he [or she] responds to the situation's back-talk" [95] (p. 79). That which is being created is thus both intimately linked to the designer, but at the same time, as the design evolves, it becomes placed outside of her or him. The design then partly becomes autonomous and an actor in itself, even generating its own questions and further topics of inquiry.

This is exactly what we saw happening in the ARC process. Throughout the process, the distinct design proposals that emerged were used as designerly mediators or "touchstones". These were used to pinpoint key issues and potentials, and to create a common understanding of (and narrative for) the site and its place in the broader context of the city. In this sense, the ARC project did not provide a "solution" in a traditional sense, but rather attempted to produce a transformative model that could potentially enable multiple, sometimes conflicting, actors to identify points of conflict and convergence. Brodersen et al. [81] note precisely this potential quality in experimental collaborative design, indicating that a "radicalization towards an imaginative place of co-creation provides participants with an extended space for imagining future practices" (p. 19). Indeed, this creates a new role for design which is not about "frictionless futures", but rather about "staging sociomaterial conditions for controversial issues in ways that facilitate contradictions, oppositions, and disagreement through direct engagement" [96] (p. 153).

In retrospect, the participatory aspect with non-experts could have been taken much further to include a wider range of actors and greater experimentation with co-design tools. However, even

though these first tentative attempts, we found that gathering around concrete, but not-yet-finalized, designs stopped participants from falling into routinized positions and adopting the habitual dualisms of city/nature or academia/practice. Instead, we tried to avoid situations in which participants felt that they had to defend their specific interests and areas of expertise, and rather to embark on joint learning processes, exploring possible key points of interest and hidden possibilities together.

5.3. Legible yet Open-Ended Narratives

The integration of new, open-ended, complexity-based ecological theory in urban design poses challenges, possesses potential and calls for new design methodologies [10,83]. These methods need not only to make way for that open-endedness, but also to make that complexity legible for a multitude of stakeholders [97]. In the ARC process, this dance between complexity and legibility became a central challenge: how could our emerging proposal (which was based on uncertainty, dynamism, and change, and predicated on resilience thinking) convince decision-makers, land developers, and activists to invest time, finances, and support into a design process with an unpredictable final outcome? How could the idea of change be translated into a vision and a central narrative that could be sturdy enough to convince not only official agencies, developers and building companies, but also the large number of NGOs and other constituents connected to the park? The ARC process thus needed to be able to incorporate change and uncertainty into the identity and legibility of the campus area. As a response, and instead of trying to hide or disguise the patch-like structure of the plan, we suggested that the cohesiveness of the project could in fact be built around this very "patchiness". In this sense, each individual plot of land could change over time—perhaps one experimental garden plot would "fail" one year, or another would be neglected by its owner for a period of time—but the Albano area at large would still convey a unified identity that is built on a diverse, vibrant, and changing mix of land uses and actors.

This search for legibility, however, also took place at a parallel, meta-level of the project: throughout the process, we used sketches, narratives, and diagrams to make our thoughts and perspectives legible to others within the group (see Figures 7 and 8). These clarifications, or even amplifications, helped us to project a common narrative and to establish joint ownership over the project. In their co-design framework, Brandt, Binder, and Sanders [98] tie the iterative cycles of making artifacts (i.e., through prototyping) to that of telling and enacting, stating that:

> People make artefacts and then readily share their stories about what they made. Taken in isolation the artefact may say very little or remain highly ambiguous. In fact, this ambiguity is intentional, as it generates opportunities for creativity, expression and discussion. The meaning of the artefact is revealed through the stories told about it and the scenes in which it plays a role [98] (p. 7)

In the ARC process, we found that, as the proposal was developed and the number of stakeholders grew, the main narrative was expanded to include a wider range of perspectives. Erixon Aalto & Ernstson [99] propose that in order to assemble a multitude of actors, agendas, and sub-narratives, narratives need to be inclusive (open, broad, and general), yet specific (with a distinct character and direction). Similar observations are made by Binder and his colleagues [96] in relation to participatory design experiments, in which "the invitation" emerges as particularly important. The invitation, they state, could be seen as a:

> Delicate matter of proposing alternative possibilities just clearly enough to intrigue and prompt curiosity, and, on the other hand, to leave enough ambiguity and openendedness to prompt the participants' desire to influence the particular articulation of the issue [96] (p. 162)

Within the context of collaborative, design-based processes such as that pursued in relation to the ARC project, we propose that the narrative itself can indeed be seen as an invitation to co-produce knowledge. In this sense, narratives or stories do not just provide pedagogical keys into ecological

system thinking, but they also link various views to spatial perspectives that in turn may be relevant to planners and urban designers. Ideally, and in extension, narratives that are legible and inclusive becomes invitations not only to co-produce knowledge, but also to help persuade decision-makers (who may not have been direct participants in the process), to use the knowledge which has been accumulated. In the ARC process, however, this is yet too early to say.

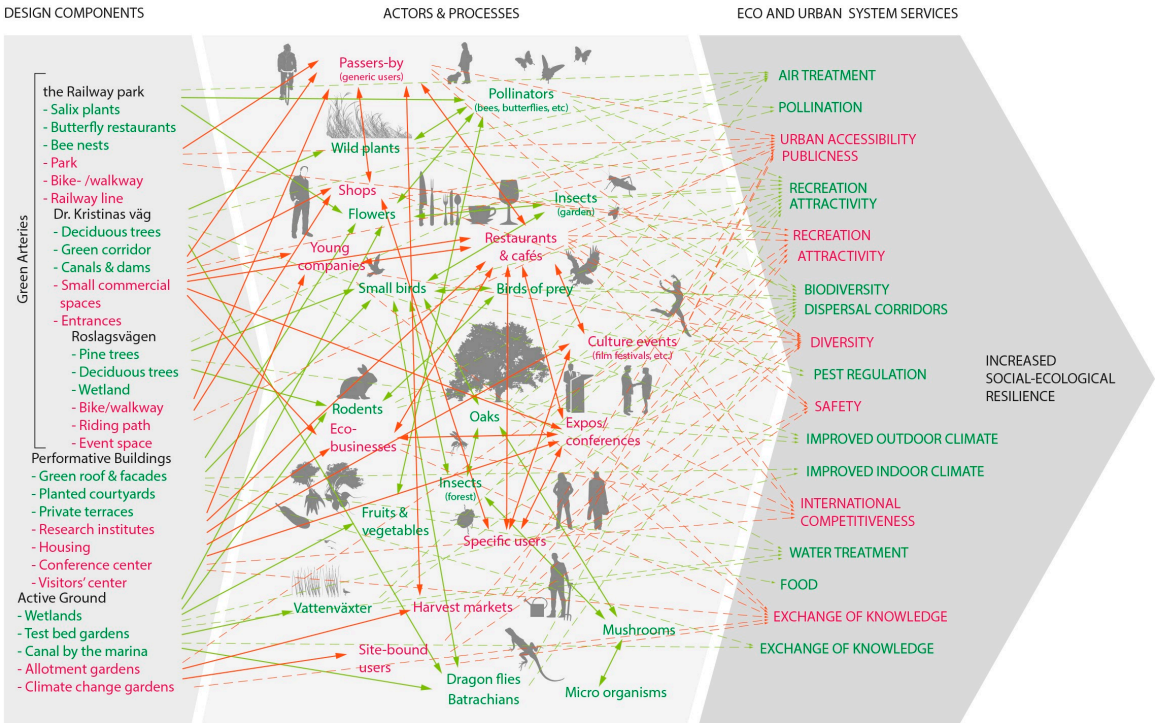


Figure 8. Various design components create conditions for certain actors and processes that in turn generate a number of services (listed to the right). An initial separation is made into categories of ecological and social processes, although these are dynamically interconnected in reality.

Comprehensive narratives such as "the forgetful bird" or "the queen bee" are two examples of an alternative approach to including more strategic, creative, and active aspects of ecology in urban planning and design. They also show the complexity of ecology: it may, they suggest, be more strategic to influence an earlier aspect in the ecological chain than a later, albeit more visible, factor (for instance, by supporting the long-term presence of oak trees by planting conifers, or safeguarding important pollination functions through planting willows). In complex and large-scale projects, a challenge exists in finding ways to create identity and legibility that are not based on a singular vision and comprehensive scheme [83,97]. The ARC project shed light on the power that co-design tools, such as transformative prototyping, matrix models, and comprehensive narratives can play for integrating multiple perspectives and creating a joint ownership and trust amongst participants. However, drawing from our experience of how the process evolved, one could also speculate that such collaborative processes can potentially function in an *excluding* rather than *including* manner for actors that enter the process in later stages, which is what occurred in the ARC process as the project became formalized in the detail planning process. Transdisciplinary, situated co-design processes, in which knowledge is collaboratively produced and comprehensive narratives and legibility is built jointly might in this sense be potentially vulnerable in situations where key actors and decision makers are replaced. In light of these insights, one could indeed argue that our process would most likely have benefitted from including decision-makers at an even earlier stage.

6. Conclusions: Towards a Social-Ecological Urbanism

The paradigmatic shift which has occurred in ecological science and theory indeed opens up for potentially more dynamic, complexity-embracing and social-ecologically integrated approaches within urban planning and design, as well as for a related reinvigorated dialogue between ecologists and designers [10]. To be able to proceed and develop more integrated social-ecological approaches to urban planning, urban design, and urban management, however—and to truly shift focus on not only an ecology in, but also for cities [26]—we firmly believe that new analytical and generative frameworks are needed in order to bridge gaps between professions and advance transdisciplinarity. To give impetus to this task, we put forward four guiding principles in closing that we see as essential to the methodology of social-ecological urbanism (SEU).

First, SEU emphasizes the integration of social-ecological expert knowledge and research in various phases of planning and urban design processes (from vision statement, the formulation of a brief, conceptual and creative phases, and post-construction and monitoring). Responding to the call for more "actionable science that links science and decision making based on social–ecological knowledge" [31] (p. 1), established research fields are to be integrated in such processes, and new research topics thereby also generated. Drawing on our experiences from the ARC process, we found that the flat, nonhierarchical set-up of the process in which researchers and designers participated on equal terms, in combination with the use of prototypical and generative matrix-oriented design methods, allowed for the integration of knowledge on a continuous basis, in which feedback loops constantly re-informed the design. Furthermore, we found the process of "translating" or amplifying abstract scientific knowledge and findings into comprehensive narratives, to be useful not only in creating a sense of co-ownership in the project (across disciplinary boundaries), but also in making our results legible to a wider audience.

Second, SEU stipulates the integration of non-expert, experience-based, and local knowledge by engaging stakeholders (e.g., NGOs, local organizations, and small-scale enterprises), both in collaborative design processes and in decentralized management. In her study of the ARC process, Pulkkinen conceptualizes this aspect of SEU as a "systemic design for a learning system" and further suggests that it is through this "learning and co-evolving between the site and the actors [that] it is possible to follow up the interaction and adjust to the changing conditions" [67] (p. 304). In this sense, the project is not finished when built, but rather sets a framework for future management. In the ARC process, we explored such a management structure in which citizens, groups, and organizations could take on a larger and more active role. Although this approach could have been taken much further, it allowed for us to identify goal conflicts between stakeholders, facilitating their potential reconciliation at an early stage. This however calls for critical reflection upon who in fact has the agency to participate in the production of urban space and who is possibly excluded, thus highlighting the fact that any operational interpretation of resilience requires that the concept be specified in relation to questions such as "resilience for whom?" and "of what?" [20,100]. In the ARC process, there were for instance a selection made by us to include park interests through the umbrella organization Association of the Ecopark, and although it includes a large number of sub-organizations, some interests were undoubtedly bound to be overlooked or misrepresented. This highlights an awareness of the importance of the invitation in participatory processes, and of the related aspect of design iterations being able to carry comprehensive, poignant, distinct, yet open-ended and inclusive narratives.

Third, SEU specifically strives to integrate production of social-ecological services within planning and urban design. As a point of departure, SEU proposes a shift in emphasis from the primary question "What will it look like?" to also "What will it do?"—i.e., which ecological and social/urban services should this particular development provide? This presupposes a mapping of existing and surrounding conditions whilst also acknowledging that the form and structure of ecological as well as urban environments determine the outcome of services produced, and further, that environments can be designed and configured to better serve the desired purposes. In the ARC project, the dynamic matrix models proved a useful tool in both mapping and idea generation concerning services, actors and

components, which were then materialized in the sketches for green arteries, active ground and performative buildings and also in the institutional designs.

Fourth and finally, SEU, in particular, through the integration of uncertainty and dynamism predicated on resilience thinking, open for a necessary rethinking of roles, for those scholars and practitioners involved in complex social-ecological urban and urbanizing environments. As Grose has noted [101], for ecologists, engaging in design processes more actively might challenge the role of the researcher as observer and calls for new ways of working with incomplete data by "enabling speculation, articulation of desired ecological outcomes, and a qualitative approach to data and noise in systems" [7] (p. 73). For designers, in turn, the trajectory into more inter-and transdisciplinary processes of co-design implies, as Munthe-Kaas and Hoffmann note, that "there is no one designer and no one form of knowledge and expertise", but rather a host of designers acting as managers or "navigators" in collaborative design processes [49] (p. 5). However, and drawing from our experience of the ARC process, this approach should not be mistaken for a neutral facilitation or impersonal coordination of complexity. Rather, the disciplinary specificity of design professions—as experts in synthesizing complex factors, in working with narrative, aesthetics and "materials" such as built form and spatial structure in the case of urban design—should be seen as assets that could be put to use as powerful co-authoring tools. Importantly, rethinking roles to promote integration often requires a willingness to step out of one's comfort zone [7,102] and a capacity to critically reflect on doing "business-as-usual-research" [102] (p. 429).

In summary, we concur with what Steiner and colleagues so aptly describe as the need for "professionals from various disciplines [to] demonstrate a mutual respect for and a willingness to listen and learn from one another, with the objective of optimizing ecological function toward resolving environmental issues from local to global scales" [28] (p. 360). Although such processes are often both resource demanding and time-consuming [37], and indeed prove challenging in terms of bridging gaps between professions and understanding each other's cultures of thinking [7], as we found in the ARC process, we believe that continued development of such processes is necessary to continue to explore and pursue in order to promote urban sustainability and resilience in the long term.

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