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Bridging the gap between theory and design

A proposal for regenerative campus development at the Swedish university of agricultural sciences

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Abstract

Purpose – This paper aims to describe an exploratory research and design process that uses illustrative techniques to bridge the gap between theoretical principles of systems ecology, stakeholder input and a workable physical planning strategy for Ultuna Campus in Uppsala, Sweden.

Design/methodology/approach – Stakeholder interviews provide the empirical basis for this exploratory design process, in conjunction with landscape analysis, and review of previous proposals for campus development. Central principles of self-organizing systems are selected and concretized as visionary hypotheses in a physical context. Preliminary design concepts and plans illustrate sustainable systems while supporting new functional programmatic requirements: housing, industry-research collaboration, transportation and community-integrated landscapes.

Findings – The result is a proposal based on regenerative landscape design, envisioning campus Ultuna as a coherent whole.

Research limitations/implications – A large-scale modern building program is already underway at Ultuna, and rapid urbanization in the surrounding region coupled with projected growth on campus suggests future intensification of university lands. A master plan to be implemented until 2040 is now in the

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preliminary design phase. Ultuna is home to significant cultural and ecological landscapes, and a holistic approach is called for.

Practical implications – Illustrative techniques suggest ways to synthesize knowledge by creating future scenarios that are workable in practice.

Social implications – Global challenges call for designs that enhance environmental and human resources and their capacity to regenerate over time. Sustainability objectives are particularly crucial when envisioning university campuses; the environment serves as a laboratory for researchers, teachers, students and residents of the surrounding community.

Originality/value – This paper describes an innovative process for bridging ecological principles, stakeholder perspectives and practical design strategies for sustainable campuses.

Keywords Campus development, Systems theory, Place attachment, Regenerative design, Illustrations

Paper type Research paper

Introduction: global challenges and university campuses

Global challenges call for designs that enhance environmental and human resources and their capacity to regenerate over time. Sustainability objectives are particularly crucial when envisioning university campuses; which serve as living laboratories for researchers, teachers, students and residents of the surrounding community. Activities on campus foster local place-bonding and build new knowledge; as people are spread throughout the world ideas are dispersed globally.

However, a prerequisite for effective knowledge production and participation in global academia is access to knowledge as well as material and energy resources. University campuses appropriate a range of human and environmental resources, e.g. by using and cycling energy, materials and information, both internally and in relation to external environments (Zhifeng *et al.*, 2014). Consequently, the environmental support area and cultural impact of university campuses is geographically vast, influencing society and environment in both positive and negative ways (Zari, 2015; Zhifeng *et al.*, 2014). Sustainability in university campuses hence calls for site design and planning that maximizes knowledge production, learning, and place-attachment, while mitigating environmental impacts and negative externalities of campus life.

To enable sustainable campus design, the approach applied in this paper draws on a) design criteria for regenerative systems landscapes, and b) future desires expressed by current users, gathered through previous plans and interviews with staff working in the Ultuna campus of the Swedish University of Agricultural Sciences (SLU) in Uppsala, Sweden. To date, campus design in Ultuna has not been based explicitly on sustainability theory. Nor has locally specific opportunities such as landscape functions, research, education and collaboration activities and competences been fully evaluated or included to fully reach its potential in the site.

Whereas the visions expressed by interviewees contributed the empirical basis for design, the design criteria supported the process of turning normative visions into concrete design solutions for the establishment of regenerative landscape functions. Current and future opportunities were incorporated in a holistic design proposal for regenerative campus development, hence rooted both in sustainability theory and local conditions. In practice this entailed design explorations emphasizing connections and potential synergies for the regeneration of human and environmental resources, as opposed to remediating land tenure conflicts and competition.

The design process described in this paper is the result of an iterative process in which multiple proposed plans and empirical accounts from interviews are combined with theory.

With the explicit aim to facilitate incorporation of sustainability goals in design, this approach has recently been proposed by Bergquist and Hedfors (2018) in the form of criteria for regenerative systems landscape design. Using Ultuna as a concrete case for field trials, this paper represents a first attempt to operationalize this approach in a specific site planning context. Hence, specific design intervention possibilities are produced, while contributing more generally to knowledge on the practical application of sustainability theory in university campus development.

Aim and objectives

The aim of this paper is to use illustrative techniques to bridge the gap between theoretical principles of systems ecology and a workable design strategy for Ultuna. The normative objective on this site is to develop the built environment and surrounding green-blue landscapes in a manner that reflects, involves and benefits from research, education, housing, services, entrepreneurship and collaboration; it should be visible in the physical environment and in the management that SLU pursues Science, Education and Collaboration for Sustainable Life [SLU's official vision].

Case study: Campus Ultuna

Campus Ultuna covers an area of about 290 hectares, of which 20 make up the central part where most buildings are located. Apart from SLU the area hosts several other institutions; the National Veterinary Institute of Sweden (SVA), Research Institutes of Sweden (RISE) and Green Innovation Park (GIP) are the most significant. Ultuna is located on Uppsalaåsen (the Uppsala esker), 6 km South of Uppsala city center. It is delimited by the urban district Ulleråker to the North, the main road Dag Hammarskölds väg and urban district Gottsunda to the west, the river Fyris and urban districts Sävja to the east and Sunnersta to the South. This larger planning area is growing rapidly and there are plans to build a transportation link between Sävja and Gottsunda that will go through Ultuna.

A large-scale building program was implemented in the five years; rapid urbanization and growth in the surrounding region and projected growth on campus indicates the need for future development. The campus is expanding to double the number of students as the life sciences grow to address challenges related to food, energy and other natural resources, as wells as the rapidly emerging field of bio-technology. Meanwhile the municipality has signed an agreement with national government to build 33,000 apartments in the Southern part of Uppsala, as a response to the government investing in new train tracks and a tramline. Ultuna Campus has been selected as the main focal area of urban growth.

Ultuna is home to significant cultural and ecological landscapes with archaeological findings of importance from the Bronze Age. With more than 2,000 taxa the flora and fauna of Ultuna is biologically rich, comprising several biotopes, from wetlands and the river Fyris, to fields and dry pasture land, and forest. Within Sweden and the region Mälardalen, Ultuna is part of the city of Uppsala (60 km from Stockholm). Located at the 60th parallel of North latitude, the campus has, for an agricultural university, a unique setting on the border between the nemoral and boreal biomes and has been a center for agricultural study since the 1720s.

Theoretical point of departure for regenerative campus development

As merely sustaining civilization is not enough, McHarg (1998) has argued that we must begin to design regenerative communities and landscapes. Nearly 50 years ago, McHarg (1969) championed an ecological approach to spatial design, rooted in landscape analysis and underpinned by respect for ecological processes. At the same time, planning theorists

began to promote a person-centered, participatory approach to spatial design that considers the role of multiple users and clients in a complex way (Arnstein, 1969; Davidoff, 1965). An ecological approach to design is generally expert-driven and top-down, whereas a participatory approach that gives users a voice in decision-making is considered bottom-up (Sanoff, 1990). The approach to spatial design in this paper attempts to synthesize an analytical ecological design method rooted in systems ecology theory with a human-centered, participatory approach to planning in efforts to balance ecological and social perspectives and enhance opportunities for place-attachment (Manzo and Devine-Wright, 2014; Hester, 2006). Regenerative design is conceived as the re-design of human-environment interactions that heal and amplify ecosystems (Zari, 2015). This aspiration is operationalized using regenerative systems landscape design as developed for urban contexts by Bergquist and Hedfors (2018), a theory based design process that draws on the ecological approach by Murphy (2016) and systems ecology (Odum, 2007). It essentially concentrates on relations between elements, i.e. the spatial organization of structure and non-visible relations that are relevant from a broad systems perspective, as opposed to the detailed design of individual objects and isolated phenomena. Consequently, sustainability is conceived as regenerative functions and qualities that are found at multiple scales, and in physically visible as well as invisible and relational dimensions.

Systems ecology: learning from self-organizing systems

The systems perspective in this paper primarily draws on systems ecologist Odum's (1987, 2007) observations of general patterns in natural ecosystems. As shown by Hall (1995), several studies have found that ecosystems develop processes by which energy and materials flow within and between systems at various scales. As the trial and error process of evolution progresses, eventually a state is reached when resource use is most efficient. Hierarchies emerge where certain organizational patterns have been found universal. One such pattern is self-organization, or *autopoiesis*; the emergent property of system parts (sub-systems) to develop relations in ways that maintain their structure over time, by amplifying endogenous processes as well as the larger scale system(s) in which they are embedded.

In this way, relations develop where connectivity enables resources to flow between sub-systems, and build storages for future use, a process called feedback. In other words, the causal arrangement of several interconnected elements that interact so that each element affects the next, until ultimately feeding back to the first. Positive feedbacks amplify a system¨s capacity to access and make efficient use of resources, i.e. reinforce the system. This relational pattern takes place through selective reinforcement of what works, i.e. functions and relations that increase productivity and efficiency of the system as a whole. Self-organization maximizes the performance of systems in the long run, and can be found in all systems operating far from thermodynamic equilibrium. Self-organization has therefore been proposed as a general system principle (Odum, 1987), and as such provides inspiration for human design that mimics organizational patterns proven successful in nature.

In design, self-organization implies that suitable solutions emerge from dialectical relations that enable positive feedback and reinforcement of the system as a whole. Bergquist and Hedfors (2018) therefore operationalize self-organization as the broad inventory of resources, processes, actors, and potential connections in the specific site selected for design. By doing selective inventories, they propose a deliberate process in which designers consider when and if the physical space obstructs or supports self-organization. As will be shown, this mode of thinking was applied when envisioning regenerative landscape functions and their possible implementation in campus Ultuna.

Criteria for regenerative systems landscape design

In this paper, criteria for regenerative systems landscape design were applied to the concrete case and planning context of Ultuna. A comprehensive overview of the design criteria, and their theoretical underpinnings, is provided in Bergquist and Hedfors (2018). Below they are briefly introduced, and where relevant, exemplified under urban conditions such as those in Ultuna and many university campuses worldwide.

Design for self-organization and provide feedback

Self-organizing systems use and cycle resources, including information and knowledge, in ways that enable beneficial connections and interdependencies. This pattern may be replicated in design, e.g. by integrating a range of human needs and ecosystem functions on a local scale. In addition, positive feedback should also be contributed on larger scales of society and the environment. Ideally, processes are optimized to reduce the need for non-renewable resources, through substitution by internal resources and regenerative processes at multiple scales.

Create ecotones

By creating patchy transitions between elements, structures and functions, synergetic connectivity increases. One strategy is to entwine built (static) and living (dynamic) elements so as to support each other instead of competing. Particularly in urban contexts, the most prominent structures of the built environment are often static, such as roads and buildings. To create a mutually supportive and integrative patchwork, dynamic elements need to be mapped, and sometimes added through design. Hence, static and dynamic elements can be overlapped and mixed to reinforce each other. Ideas might include new recreation networks and programs that reinforce campus facilities and research programs. Buildings can be incorporated into green-blue infrastructure networks of surrounding landscapes.

Internalize resource use

Internalizing resource use has the potential to counteract negative externalities: the displacement of detrimental environmental impact and resource use. By optimizing connections, e.g. using greenery for shade, blue-green structures for runoff and waste water management, transforming lawns to food production areas, re-use of building materials or building sites, resource use can be internalized and made more efficient and renewable. This is a responsible way of arranging human–environment interactions that contribute ecosystem services by maximizing the potential of locally available and renewable resources.

Facilitate regenerative processes

To internalize resource use, local regenerative processes should thus be facilitated. Prioritizing regenerative process of e.g. dynamic green-blue elements–photosynthesizing plants and water bodies–also promotes recreational values.

Enabling diversity and multi-functionality

Design regenerative processes to enhance place-attachment and local resource regeneration. For example, the design of creek buffers and wetlands should enhance storm water management and improve water quality through natural filtration, providing ecological

regeneration while enhancing recreation opportunities that increase human access, knowledge-gathering and place-bonding.

In conclusion, site-specific regenerative systems landscape design is thus a deliberate process of identifying and designing structures and elements based on their potential to provide positive feedback, generate multi-functionality, regenerate and self-provide human and environmental resources.

Methods

To ensure a design direction rooted in knowledge and activities on campus, local visions of a desired campus future were gathered prior to developing the preliminary design concepts in this paper. During the course of 18 months in 2017-2018, this was done in two ways: interviews with staff involved in research and teaching in SLU and a review of multiple plans submitted over the previous decade by a range of actors. Followed by landscape analyses, the work was then concluded by design explorations aiming to reconnect the empirical accounts to theory. Consequently the work presented in this paper is delimited to the time period during 2017-2018, emphasizing design opportunities identified at that time, and operationalized for the specific site of campus Ultuna. However, since the design approach is rooted in the theoretical criteria for regenerative design, the results may offer inspiration also for other campus projects, i.e. as an example of sustainable campus design based on the practical application of sustainability theory in campus development.

Interviews with faculty members

Interviewees were selected in their capacity as key persons in a range of academic subjects, e.g. waste management, life cycle assessment, economics, animal health and welfare, soil sciences, landscape architecture and urban design. In total, 14 interviews were carried out with individuals representing seven departments. Interviews lasted 1-1.5 h and were semi-structured, meaning questions were open-ended and focused on the following themes:

- renewable energy;
- climate impacts and mitigation strategies;
- sustainable mobility;
- food production and consumption practices; and
- waste and water management.

Under these headings, interviewees were asked to describe their research and teaching activities and reflect around its potential for improvement by integrating research and teaching in planning and management of the built environment. Consequently, conversations started off by identifying research frontiers and possibilities, followed by formulating concrete ideas under the following headings:

- Desired goals that are both feasible and ambitious.
- Infrastructure needs – facilities, buildings, land, technology and other physical resources required to attain specified goals.
- Practical solutions that could be tested on campus, and evaluated through research, teaching and collaboration.
- Possibilities for co-management through integration with research and teaching curricula.

Review of multiple plans

In addition to interviews, more input was sought on multiple perspectives for the future campus. Examination of plans prepared by diverse users provided various perspectives on future goals for the campus. Half a century ago, Davidoff (1965) theorized that the creation of "plural plans" would offer multiple perspectives on desired futures, and foster deliberation. The strategy was intended to counter top-down planning conducted without public input. Plural planning is seldom used as a practical design strategy, as deliberations are encouraged prior to the development of physical plans (Forester, 1999). However, At SLU and in the surrounding municipality, numerous plans have already been developed over several years, providing distinct views of Ultuna's future as expressed by a variety of user groups. These include designs for specific landscape elements, e.g. constructed wetlands and an arboretum, zoning diagrams describing plans for the entire campus, developer's submissions for projects on lands adjoining the university, architectural designs for proposed housing developments and new research/industry facilities, and city planning documents outlining strategies for parks, green linkages and transit infrastructure.

Landscape analysis

Next, an analysis of the existing conditions on campus was conducted. This involved multiple field visits, tours of facilities and grounds, and a review of the history of the campus, from its archaeological roots to the most recent building program. A plan showing the existing campus was illustrated to provide a base for future design interventions. Near-future developments in the surrounding municipality, either approved or planned at the time (such as an approved building program for new housing developments on the North and western edges of the campus) were also analysed and illustrated to demonstrate changes that would occur in the near future.

Design interventions

The expressed desires obtained from user groups and actors were evaluated based on principles of regenerative landscapes and sustainable urban form, and assessed in relation to the suitability of the particular site conditions and cultural context of the existing Ultuna landscape. Opportunities for interventions and future plans were identified, mapped and illustrated. In this paper, these possibilities are presented as results.

Results

Narratives obtained by interviews provided objectives that were given physical form by the production of sketches that captured the essence of the future desire. Next, an analysis of strengths and weaknesses of the multiple plans was conducted, and future scenarios that support goals for sustainable form and regenerative landscapes were adopted as objectives for the next phase of generating plans.

Narratives – identification of opportunities that contribute to vision

Food: A majority of the interviewees had opinions and ideas related to food practices. One suggestion was to expose current food production on campus, and adding new facilities such as greenhouses for integrated aquaculture and horticulture (aquaponics) and small-scale animal husbandry. To spur curiosity and increase public exposure, local food production could be located centrally and expand from primary production to experimental kitchens for food innovation, processing and gastronomic experience in new restaurants. Other aspects related to food were waste as a potential resource for circular food production.

A normative goal was formulated as a "zero vision for food waste". This could be achieved by reducing food waste and also by reusing food scraps as a biological resource to agriculture and in research laboratories, e.g. as an input to composting. A specific project mentioned in this context was basic research on composting procedures in which fly larvae are used to convert organic waste into animal feed (larvae) and organic fertilizer (treatment residue). Other similar strategies include ethanol production from discarded bread, as well as separating sanitary waste flows (urine and faeces) to recycle nutrients to agriculture.

Energy: Many argued that SLU should set higher standards for energy use than what is required by current legislation and certification schemes. The ambition was formulated as the aspiration to become energy "prosumers" [100 per cent self-sufficient in renewable energy]. For example, this could be achieved by a policy to install solar panels on every roof. Such measures could also offer pedagogical opportunity to display the energy system, evaluate and experiment with new renewable energy systems, such as urban wind power and bioenergy.

Parks: Ultuna's knowledge park, "Kunskapsparken", is renowned and appreciated by many and was identified as an important legacy to build on and develop in the future. The park is currently used as a plant library for research and teaching, and integrated in management of the outdoor environment. It was suggested to copy and expand such a holistic approach to research, teaching and landscape management, so as to encapsulate also other green-blue structures throughout the Ultuna area, e.g. the river valley, wetlands, farmland and pastures, but also by adding new functions such as apple groves to attract pollinators. In addition to preserving and reinforcing current landscape values, such a strategy made explicit would add new aesthetic values as well as biodiversity gains and shade for regulating indoor temperature. Other potential values include new opportunities for storm and flood water management and climate change mitigation.

Farmland: Some of the interviewees expressed a desire for new test- and demonstration facilities dotted out around campus, particularly for integrated waste management and food production. Some initiatives are already underway, and it was stressed that both conventional and organic solutions should be allowed and contrasted to remain truly exploratory and transparent to spur constructive dialogue rather than polarization. Such an approach would primarily aim to display, compare and contrast alternative solutions for sustainable agriculture, e.g. by community outreach; citizen participation and organizing public debate around future practices. As a management strategy, agricultural activities on campus also offer opportunity for monitoring and improving carbon capture and storage capacity in plants and soils.

Buildings: As the future is uncertain, most of the interviewees had difficulties forecasting needs for additional infrastructure and buildings. However, a central reasoning was the importance of flexible spaces, e.g. building envelopes with changeable interior, and spaces where specific land use can easily switch as new opportunities and needs arise. Technical infrastructure was easier to pinpoint, e.g. in terms of equipment and piping required to sort and separate waste flows, as well as monitoring and documenting flow data for use in research. Such infrastructure would also enable management where nutrients are recycled in practice, e.g. by installing alternatives to WC. Another central aspect related to buildings was to use wood as a renewable construction material in future constructions.

Strategic goals: A central target shared by most interviewees was for Ultuna to develop towards 100 per cent self-sufficiency in both energy and food, e.g. through local production and provisioning from SLU managed farms, complemented by external food procurement from national producers. The UN sustainability goals concretized for Ultuna were also

mentioned as a desired strategy for operationalizing sustainable development in the local context.

Social life and recreation: Sustainable mobility was another issue discussed during interviews. Proposed strategies for reducing idleness and car dependency was to activate staff and students by promoting outdoor recreation and mobility (walking and cycling) in the river valley. Another was to organize "meaningful exercise", e.g. the opportunity to exercise by participating in park management and animal care. A concrete idea was to create parkour facilities, possibly combined with goats that share the need for activation and social interaction.

Broader landscape perspectives: included transitioning from single purpose land use towards multi-functionality and polyculture practices for diverse landscapes and green values, which in turn would facilitate stronger connection between people and the locale. This aspiration included the creation of new spaces for gardening and socializing, e.g. community gardens and greenhouses connected to new housing planned in the area. Other desires were more informal meeting places that are available and vivid also outside of office hours, e.g. cafés, restaurants and public squares.

Summarizing desires expressed in multiple plans

Particularly, SLU, Akademiska Hus and Uppsala municipality have already been developing numerous plans that provide distinct views of multiple desired futures. The multitude of visions expressed by a variety of user groups is illustrated in Figure 1. In general terms, the desires illustrated by staff or found in official planning documents fell into three broad thematic categories: restoration and protection of greenbelts and blue corridors, expansion of research and industry facilities and housing, synergies within the institutions and with the municipality.

Protection of greenbelts: As identified in the Uppsala master plan, protection and enhancement of green belts and blue wedges is a strong consideration for regional planning. Green linkages have been highlighted on the North side of campus, South of Ulleråker (Figure 1A). A large park has been suggested for the South side of campus, in addition to a neighborhood park on the east side of campus abutting the river (Figure 1D) Contributing to these greenbelt zones, an arboretum has been proposed on the North side of campus (Figure 1B) and a restored wetland area is proposed on the South side adjacent to the Fyris river (Figure 1C).

Expansion of housing and research/industry facilities: A primary reason for the work on the Ultuna master plan stemmed from an imperative from Uppsala municipality to address a severe housing shortage in the region. On-campus, plans for housing had already been proposed on a variety of sites. Off campus, the first phase of a high-density development has been approved on the North side of campus in Ulleråker, and a second phase has been proposed that directly abuts Ultuna campus (Figure 1G, H). SLU lands on the west side of campus were recently sold to the municipality to accommodate medium to high density development, now under construction, with additional housing in the planning phase (Figure 1I).

In addition to housing, the establishment of a Green Innovation Park has commenced, with several locations identified for a large scale building program aimed at industry-academic collaboration (Figure 1K, L). Additional research facilities are expected to be added over time; a new equestrian research facility has been proposed but no drawings are currently available.

Increasing synergies and connections: Linkages and physical connections have been suggested by municipal plans; such as improved rail, bus, tram, road and cycling linking the city of Uppsala with the Ultuna Campus. There are plans for a new rail station to improve

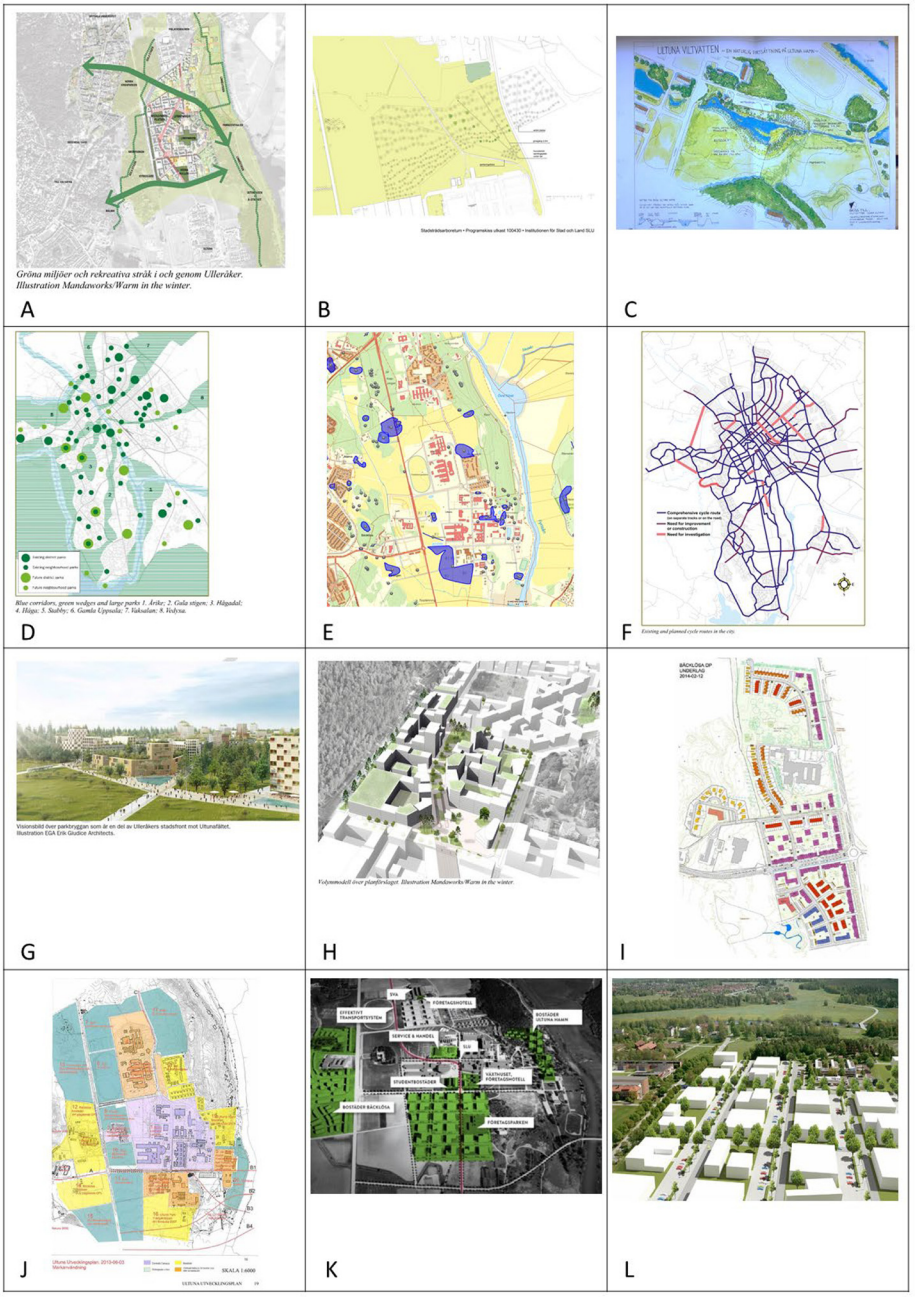


Figure 1.
Example of multiple plans currently developed by main actors in the Ultuna area

linkages between South Uppsala and Stockholm. Municipal proposals include a new bridge across the river Fyris and although no formal decision has currently been taken (Figure 1F), numerous locations for the bridge appear in different variations of campus plans.

Cultural values and recreation: Recreation trail systems are currently being enhanced, with signage programs planned for Linnaeus walks that connect with an established trail system in Uppsala. A signage program is being developed to orient residents and visitors to local landscapes and the stories behind the cultural landscape features, such the knowledge garden, and Ultuna's significant archaeological sites (Figure 1E).

Landscape analysis

Traditionally, many campuses were developed using an "ivory tower" model of academic isolation. This symbolic separation between the University and the community is evident in SLU's land use planning. The planning tradition of locating university campuses on large tracts of open space was intended to create a focussed research environment, and authentic rural environment for studies of agriculture and ecology. However, the ivory tower model has drawbacks because the campus is disconnected from social fabric of the surrounding neighborhood. Forging connections between campuses and communities builds stronger "town and gown" relationships, supports social bonding and promotes knowledge-sharing (Lederer, 2007). The SLU campus is isolated from surrounding residential areas, and there is a lack of urban amenity, student housing, and social liveliness, especially during evenings and weekends. In addition to green space for restoration, an urban-feeling campus also contributes to students' wellbeing and social connectedness: "the 'well-designed' campus was conceptualized as a mixed, compact, well-connected, well-structured, inhabited, green campus in an urbanized setting" (Hajrasouhila, 2017, p. 168).

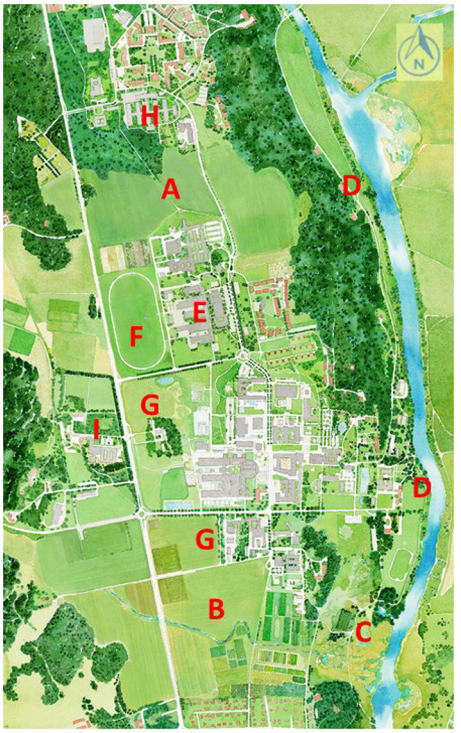
Under-used green areas that create social isolation may hamper SLU's potential to create an active, urban campus. The lands on the west side of campus that line the main arterial road are not functioning well as greenbelts (Figure 2F, G); in future, such lands will have a reduced ability to provide habitat because of new residential development, while excessive space isolates people at campus from the neighboring communities.

On the other hand, abundant green spaces offer recreational values and contribute to regional green-blue infrastructure. Agricultural research and teaching programs also require significant tracts of land, and animals make use of green spaces for recovery from surgery at the Veterinary hospital, particularly grazing lands for horses. Still, from a wider perspective, large tracts of land are currently underused which implies plentiful opportunities for design interventions and future development. The spatial analysis of the area is illustrated in detail in Figure 2.

Proposed design interventions

Greenbelts and blue corridors: Green linkages and blue corridors provide rich opportunities for human-environment interactions, and for regenerative ecological functions. Desires expressed about sustainable farming practices, food production and waste-to-energy issues are conceived as critical functions and qualities that merit spatial allocation. Enhanced greenbelts are proposed on the North and South side of campus to create east to west connections with the river including other synergetic values (see Figure 3a b), and to major forest patches in the region.

The North greenbelt is not compatible with development plans to remove a large patch of forest from the South side of Ulleråker. However, it aligns with linkages proposed in municipal plans, and landscape planning concepts such as the arboretum plan (Figure 1B). An arboretum could also accommodate community participation, with shared facilities and



Notes: Areas for enhancing Green-Blue infrastructure: A. Forest patch and agricultural fields on north side of campus align with location of key east-west linkages identified on Uppsala city plan; B. Agricultural lands on south side of campus provide east-west open space linkages, recreation areas, and lands for research; C. Wetland area on southeast side of campus requires restoration and enhancement; D. Lands along the river Fyris provide habitat for wildlife, and recreation space for students and community; Areas with underused lands suitable for infill: E. Demolition planned for former Veterinary Hospital; F. Horse track with grass expanse and grazing lands; G. Lands on west side of campus rented for crop production; Areas with future housing planned and approved by Uppsala Municipality: H. New housing project to be constructed at "Ulleråker" on the north side of campus; I. "Backlösa" Development planned on west side of Dag Hammarskölds väg (under construction in 2018)
Source: Campus Landscape Analysis (2017)

Figure 2.
Spatial view of the campus area

Figure 3.
Green linkages and blue corridors in the North (A) and South (B) fringes of campus Ultuna

Notes: A. Green-blue corridors are protected and enhanced, providing habitat and migration corridors for wildlife, recreations and experiential learning opportunities for students and community members; B. Riparian buffers within agricultural lands are established to enhance stormwater management, regenerate natural systems and provide recreation, place-bonding and knowledge-sharing opportunities

land management, space for food production and research and greenhouses possibly using waste heat from nearby incineration facilities. Figure 4 outlines such a multifunctional ecotone between the Ulleråker housing district and North campus Ultuna. A transect of the same area is illustrated in Figure 5.

The South greenbelt is not compatible with large-scale zoning of development blocks, previous housing studies adjacent to sensitive areas along the river, or bridge and road plans that carve through lowlands and marsh areas as seen in Figure 6.

On the other hand, the South side greenbelt aligns with municipal plans for a large urban park, as well as proposed wetland (re)construction (Figure 1C), and strengthens farmland research and development, such as a pollinator research facility, new orchards and storm water management. The creation of vegetative buffers along dikes turns underused waterways into a patchwork of integrated green-blue structures that

Figure 4.
Ecotone between the Ulleråker housing district and North campus Ultuna

contribute new multi-functionality in the form of biodiversity values, recreation, mobility and aesthetics.

Regenerative forests are suggested that enhance connectivity and provide spatial opportunities for development of forestry-related research and bioenergy production. Incorporating trail systems and recreational functions enhances community integration and reduces idleness.

Expansion of research facilities and housing: Two previous on-campus plans for housing have been rejected because siting has been deemed too sensitive; proximity to sensitive cultural landscapes, archaeological lands, ecologically sensitive forests, river and wetlands, or to legal buffer zones, e.g. SVA incineration facilities. The land use zoning approach to locate large blocks of housing on the South side is also problematic because the sprawling land use pattern positions new housing far from the center of campus, and removes large portions of agricultural research lands and open space (Figure 1J). Similarly, plans for a Green Innovation Park follow a model for development that places large blocks of buildings dedicated to a single function in one large area (Figure 1K). New development that lacks sensitivity to the pedestrian scale and place-identity of Ultuna, such as the generic architecture proposed for Ulleråker (Figure 1G), lacks authenticity.

Figure 5.
The ecotone displayed as a transect; the upper view shows current land use, and the lower highlights potential multi-functionality by weaving together Ulleråker and North campus Ultuna

Figure 6.
South side greenbelt

Having said this, there is significant room to grow at Ultuna. To develop and maintain an active, liveable and regenerative campus, development in housing and research/innovation facilities is desired. However, simplistic zoning solutions are unlikely to foster liveliness. Planning for extensive development requires a nuanced approach that strives to create synergies between people, nature and the built environment. Figures 7 and 8 exemplify this mode of thinking in physical design of specific sites throughout Ultuna.

In terms of locating integrative design interventions to create lively mixed-use areas, under-used lands that are unlikely to contribute to research programs or regional ecosystem health should be repurposed and used first, such as demolition sites and other spaces in between current functions and zoning. Vacant lands within the central campus area, and structures that are under-used or are coming to their end-of-life cycle should be investigated for potential removal or transformation to increase densities in future. Design solutions that take advantage of small-scale infill and adaptive-reuse require a nuanced approach to the specific site conditions. Figures 9 and 10 convey such a development trajectory for the central and Southwestern parts of Ultuna.

Research and innovation facilities and housing could thus be added with an infill approach that is sensitive to key campus functions. Development can be planned for larger

Figure 7.
A new wellness center is integrated with recreation areas for students, community members and animals.

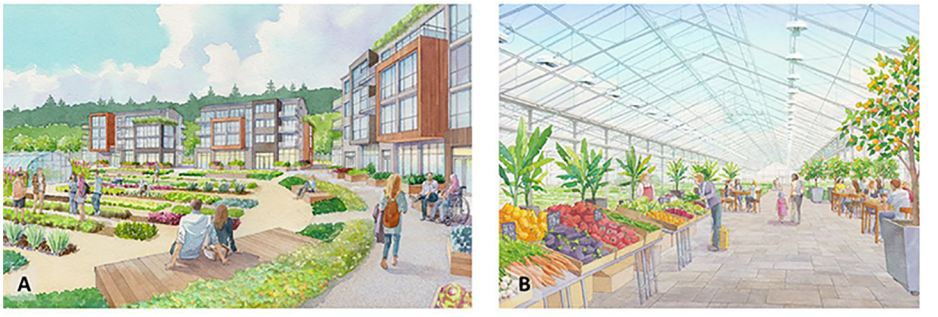


Figure 8.
Examples of site-specific design interventions to enable a regenerative, active, liveable campus Ultuna

Notes: A. Housing concepts illustrate potential for sustainable construction techniques. Integration of communities gardens suggests an opportunity for synergies between dwelling, learning, and social interaction; B. Campus facilities such as a proposed greenhouse and market combine research and innovation while building spaces for increased liveliness and social connections

Figure 9.
Central campus area

Notes: A. Central campus area in 2017. Previous veterinary hospital has now been abandoned due to asbestos contamination in walls; B. Central campus area projected for 2020 showing lands available for infill: anticipated demolition site; C. Master plan proposal showing infill approach: Innovation Park proposed on location of former hospital. Additional facilities to share lands with horse track

Notes: A. Central campus area in 2017. Underused lands separate the campus from the main arterial road; B. Central campus area projected for 2019 showing new housing (currently under construction) on west side; C. Master plan proposal showing infill approach: New housing to connect university with community

Figure 10.
Central/Southwest campus area

areas and also on smaller scales for smaller mixed-use facilities, experimental buildings and alternative housing projects. Although essential grazing lands, agricultural research areas and recreational areas that support key functions (fields for horses, field trials for carbon sequestration, horse racing track that supports new equestrian research), there is substantial space for new development. The design explorations presented above, and rooted in the criteria for regenerative design, illustrate the potential of such an approach in revealing multiple possible connections and synergies that would regenerate human and environmental resources in the area.

Discussion and conclusions

The criteria for regenerative landscape design worked as a guide in the process of siting and designing specific elements and activities in Ultuna. As such, the results derive from a process of weighing concrete opportunities in Ultuna against normative and theoretical sustainability aspirations. The scenarios illustrated in response to interviews describe activities that can be placed at specific locations on campus, to maximize the potential for regenerative ecological and human processes.

Recreation, knowledge-sharing and restoration of riparian buffer strips is imagined in the South agricultural lands, in response to analysis of existing un-buffered creek conditions in the agricultural fields on the South side of campus. In this way, opportunities for place-attachment are created in new riparian ecotones that allow residents, students, staff and other groups to bond with local landscapes while participating in regenerative processes.

The river Fyris is imagined as a recreation landscape providing sustainable mobility, and supporting key wildlife migration corridors in the Uppsala region. Scenarios for new housing show landscapes that are integrated with food and bioenergy production, while providing opportunities for social interaction and learning. Renewable materials and connections to green infrastructure is suggested by wood construction, solar roof panels, ground level and roof-top gardens. SLU's focus as a veterinary and agricultural institution is reinforced in illustrations; scenarios describe multi-functional areas where people interact with animals; "meaningful exercise" is supported by new sports facilities and health clinics. Greenhouses provide places for innovators and researchers to grow food, while also providing spaces for education, social learning and interaction.

The opportunities illustrated in plans underscore a key sustainability principle: protect and enhance green-blue infrastructure, and locate new facilities in existing built-up areas. Previous plans for an arboretum on the North side and a wetland construction on the South-east side support regenerative functions of greenbelts, and these ideas are incorporated into plans. Other plans showing very large blocks of new buildings, new roads and a bridge in sensitive agricultural and wetland zones on the South side are rejected. Instead, an infill approach is illustrated for new construction; a new Innovation Park is located on the site of a former facility now abandoned, and additional campus facilities are located within built-up areas. New housing is located in underused fields that currently sever the campus from the new residential developments that are being built to the west.

Though locally specific, the design interventions outlined above are all examples of how a design approach can be structured with the explicit ambition to merge site-specific concerns and opportunities, with theories on what constitutes a sustainable, or rather, regenerative university campus. It is clear that there is much to be gained by involving staff and students in campus design, to realize the full potential of both local knowledge

and ecological resources. Too often in the planning process, desires for a more sustainable future remain as abstract goals or general statements. These illustrations are provided to bridge the gap between theoretical ideas about regenerative landscapes, and a workable planning strategy for campus Ultuna. While it remains to be seen if the opportunities explored in this paper will be turned into reality, current joint efforts and collaboration between SLU, landowners and other key actors in Ultuna suggest opportunities for such a future in Ultuna.

References

Arnstein, S. (1969), "A ladder of citizen participation", *Journal of the American Institute of Planners*, Vol. 35 No. 4, pp. 216-224.

Bergquist, D. and Hedfors, P. (2018), "Design criteria for regenerative systems landscapes", *Nordic Journal of Architectural Research*, Vol. 30 No. 3, pp. 107-133.

Davidoff, P. (1965), "Advocacy and pluralism in planning", *Journal of the American Institute of Planners*, Vol. 31 No. 4, pp. 331-338.

Forester, J. (1999), *The Deliberative Practitioner: Encouraging Participatory Planning Processes*, The MIT Press, Cambridge, MA.

Hajrasouhila, A. (2017), "Campus score: measuring university campus qualities", *Landscape and Urban Planning*, Vol. 158, pp. 166-176.

Hall, C. (1995), "What is maximum power?", in Hall, C. (Ed.), *Maximum Power. The Ideas and Applications of H.T. Odum*, University press of CO, Boulder, CO.

Hester, R.T. (2006), *Design for Ecological Democracy*, MIT Press, Cambridge, MA.

Lederer, J. (2007), "University, downtown, and the mid-size city: an examination of the roles of university in downtown revitalization within the context of community-university partnerships", Waterloós Institutional Repository, UWSpace, available at: http://hdl.handle.net/10012/3039 (accessed 9 04 2018).

McHarg, I. (1969), *Design with Nature. Garden City*, Natural History Press for the American Museum of Natural History, New York, NY.

McHarg, I. (1998), *To Heal the Earth: selected Writings of Ian L. McHarg*, Island Press, Washington, DC.

Manzo, L. and Devine-Wright, P. (2014), *Place Attachment: Advances in Theory, Methods and Applications*, Routledge, New York, NY.

Murphy, M. (2016), *LA Theory. An Ecological Approach*, Island press, Washington, DC.

Odum, H. (1987), "Living with complexity", *The Crafoord Prize in the Bioscience. Crafoord Lectures*, The royal Swedish academy of science, Stockholm.

Odum, H. (2007), *Environment, Power, and Society for the Twenty-First Century: The Hierarchy of Energy*, Columbia University Press, New York, NY.

Sanoff, H. (1990), *Participatory Design: Theory and Techniques*, Bookmasters, Raleigh, NC.

Zari, M. (2015), "Ecosystem services analysis: mimicking ecosystem services for regenerative urban design", *International Journal of Sustainable Built Environment*, Vol. 4, pp. 145-157.

Zhifeng, Y., Yan, Z., Shengsheng, L., Hong, L., Hongmei, Z., Jinyun, Z., Meirong, S. and Gengyuan, L. (2014), "Characterizing urban metabolic systems with an ecological hierarchy method, Beijing, China", *Landscape and Urban Planning*, Vol. 121, pp. 19-33.

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