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ID 1509 | UTILIZING SPATIAL AND LANDSCAPE PLANNING TO PROMOTE ECOLOGICAL CONSERVATION ON UNIVERSITY CAMPUSES

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ABSTRACT: Universities globally have committed themselves to behaving as responsible citizens in addressing global ecological challenges through physical planning and management of their campuses. At the Technion – Israel Institute of Technology, a comprehensive, two-year planning effort was made to revise the vision and physical plans of the main university campus in Haifa to meet emerging 21st century challenges facing the academic community. Defining and addressing ecological challenges was integral to this effort and an ecological advisory team worked closely with campus planners to envision an ecologically sustainable campus. This paper reflects upon this process, from its first stages of problem definition and goal setting, through a multifaceted ecological survey and the integration of architectural and urban planning students into the planning process, to production of the final statutory zoning plan and strategic master plan. The study highlights the particular challenges of a campus that sits on the interface between urban and natural ecosystems and one that demands rapid development with a concurrent desire to preserve ecological integrity. Conclusions highlight the universality of the ecological responsibilities and challenges that universities face, suggest general strategies for exploiting the planning process towards ecological sustainability goals, and advocate for the integration of students into campus design activities.

1. INTRODUCTION

The role of the university, as often defined in terms of its responsibilities towards larger society, is to prepare students to be socially responsible global citizens (Harkavy, 2006), to produce knowledge for addressing global social, economic and ecological (i.e. sustainability) challenges (Alshuwaikhat and

Abubakar, 2008; Finlay and Massey, 2012), and to act as a socially-responsible institution (Alshuwaikhat and Abubakar, 2008; Viebahn, 2002). As teaching and research institutions, the knowledge produced within university campuses should be applied for the benefit of humankind. As such, since the 1990s, universities have looked inward to their own campuses in order to reshape them as exemplary models for sustainability, particularly within the environmental realm (Alshuwaikhat and Abubakar, 2008; Finlay and Massey, 2012). Among the many sustainability criteria are the institution's commitment towards distinctly ecological priorities of preserving biodiversity and ecosystem integrity. However, the relative emphasis of ecological priorities varies greatly from being a central facet of university objectives to, more often, a relatively minor element.

Even among environmental considerations, ecological priorities are relatively minor. The Association for the Advancement of Sustainability in Higher Education's Sustainability Tracking, Assessment & Rating System (STARS) awards an institution's efforts conserving endangered species or environmentally sensitive areas, or general environmentally sustainable grounds management (Association for the Advancement of Sustainability in Higher Education, 2014). But while these ecological considerations are explicit in the STARS criteria, they are only a few of over 60 criteria that include all aspects of sustainability, from educational curriculum and research, to campus and community engagement, to university operations, and planning and administration (AASHE2014). As such, the university sustainability literature that focuses on biodiversity is only a small part of the overall oeuvre. In comparison, much of the literature focuses on ecosystem flows, including carbon and water cycles as expressed in energy use, architecture, and transportation. Representative of this phenomenon is the University of Massachusetts, Amherst, which dedicated a revision of its master plan to sustainability issues, which dealt almost exclusively with energy use and greenhouse gas emissions. Biodiversity, when mentioned, is in reference to the role of vegetation in carbon sequestration. The program includes additional foci including food and waste management and a management focus on runoff water including creation of wetlands and ponds for multiple benefits, including biodiversity (Pavlova-Gillham et al., 2015).

The current research deals exclusively with the ecological aspects of campus design. Ecological, in this sense, focuses on biota and ecosystem processes on campus, and in particular, the protection of biodiversity, the long-term provision of ecosystem services and positive intervention in ecosystem processes (e.g. ecological integrity). There are three reasons why universities should be particularly concerned with ecological challenges. The first, as noted above, is their stated commitment to good citizenship and global and regional sustainability. The second is the plethora of scientific knowledge and a fitting venue for its application, making it efficient for university faculty to "act locally". Finally, university campuses occupy a significant amount of land in multiple ecosystem types, and therefore their physically planning can have a profound impact on ecological characteristics of their region. For example, the University of Michigan has historically occupied between 8 and 10% of the total land area of Ann Arbor, Michigan (Brinkman, 1981).

University campuses vary widely with regard to their physical locations vis-à-vis cities, with some being distinctly urban with few open spaces, while others are located along a gradient between the built and the non-built environment, encompassing natural and semi-natural ecosystems (e.g. Cornell University, 2008). The sheer spatial size of campuses and their population leads some planners (e.g. Sasaki, 2009) to compare them to, and plan them as, small cities. Additionally, many universities possess satellite properties that serve as nature reserves, botanical gardens, and biological field stations. These satellite properties, while crucial for fulfilling the universities' ecological goals and responsibilities, do not face the same planning dilemmas as the central campuses with their multiple, often competing, development goals. The present work addresses the main core campus of universities, where most of the research, education and administration takes place.

This paper documents efforts to integrate ecological considerations into an urban university campus, the Technion – Israel Institute of Technology. We describe a two-year process in which an ecological advisory team worked in parallel to a larger multi-disciplinary planning process of the university's physical environment. As noted, the paper addresses a somewhat neglected consideration – ecology, in terms of biodiversity and ecosystem integrity, which is generally subsumed within the larger university sustainability literature. We suggest that the process of physical planning affords a novel and productive opportunity to integrate ecological considerations into the priorities and objectives of the university, although the process also reveals the challenges in prioritizing ecological considerations.

2. ECOLOGY AND THE TECHNION PLANNING PROCESS

The Technion – Israel Institute of Technology was founded in 1924 and the Faculty for Architecture (later Architecture and Town Planning) was among its first departments. The university campus was located in the Hadar neighborhood of Haifa, and was moved in 1954 to a 130-hectare piece of land on a steep hillside adjacent to Haifa's Neve Sha'anan neighborhood. According to aerial photographs, the land on which the Technion was built consisted primarily of heavily grazed, Mediterranean chaparral – shrubs and annual plants – that was later forested with Stone pines and Aleppo pines (Pinus pinea and Pinus halepensis, respectively), which were popular forestry trees through most of Israel's history (Fig. 1 and 2; Tal, 2013). The topography of the campus influenced the architectural designs. Three wadis (dry riverbeds that run only following winter rains) run through the campus from south to north, two of which are on the borders of the campus and one running through the center. Early plans of the campus envisioned the central wadi as a green stripe and pedestrian pathway through the campus, and building was avoided in this area (Fig. 3). Between 1965 and 2012, four additional campus master plans were utilized. The most recent plan allowed for 50 hectares of built space. Today, the southern (upslope) portion of the campus consists of a planted pine woods, while a 2 hectare plot in the northern area of the campus is designated, since 1982, as an ecological garden.

In 2012, the institution commissioned a new master plan, and turned to its Building and Maintenance Division and to the Faculty of Architecture and Town Planning to complete the task. The new planning committee was headed by architects, landscape architects, and planners, and was supplemented with a wide range of subject-area advisors, including faculty experts in transportation, ecology, environmental psychology, education and others. Technion graduate students were also integrated into the planning staff as both advisors and research assistants. The committee had three objectives: a strategic master plan for creating the vision of the Technion, a statutory, zoning land-use plan, and a plan for real-time project interventions (Assif et al., 2015).

The strategic master plan is a vision statement that aims to "enhance [the campus'] unique spatial characteristics as a home base for its faculty, staff, students and visitors, and to lead the campus towards better integration in its urban and natural contexts" (Assif et al., 2015; p.13). It requires (and received) the approval of the institution's Board of Governors. The zoning code is a statutory document that requires approval by city and regional planning committees and that designates permitted land uses within the Technion. The intervention and involvement plan "takes immediate action to reflect and fulfill components of the strategic plan in real time (Assif et al., 2015; p.13).

In recognition of the planning committee's emphasis on ecological sustainability (which was, as yet, only vaguely defined), the committee provided support and resources to support a multi-phase ecological assessment of the campus in order to receive ecologically-sound recommendations.

3. THE ECOLOGICAL ASSESSMENT OF THE TECHNION CAMPUS

The ecological assessment team divided its work into four parts: 1) review of ecological planning on university campuses (grey literature review of university planning documents) and defining the "ecological campus" concept based on ecological principles, and examples and precedents from other universities; 2) assessment of the biodiversity and ecosystem services found in the Technion campus, and assessment of the potential for their conservation and improvement; 3) review of administrative structures for supporting ecological planning, and 4) development of an ecological vision for the Technion campus, including guidelines and recommendations on how to integrate this vision into the masterplan and actual development of the campus.

3.1 REVIEW OF ECOLOGICAL PLANNING ON UNIVERSITY CAMPUSES: COMPACT, CONNECTED, CONSERVED

There was little available in the English-language academic literature with regard to particular ecological guidelines in campus planning and development[1]. There is, however, abundant material within the grey literature, including reports and planning documents from university campuses that have emphasized the importance of ecological conservation and provide guidelines for campus planning and management. Therefore, we relied mainly on grey literature (reports and planning documents from university campuses) and websites that were dedicated to these issues. Our objective was to glean the main ecological principles that have been integrated into such plans and gain a clear view of the "state of the art". Our starting point was several reviews and ranking of universities published in online news websites[2]. We expanded the information obtained from these sources through an internet search for several relevant keyword combinations (campus* + ecolog* + plan* + university*). The master plans of some universities were readily available, while other institutions had websites presenting plan essentials and related activities.

Our review of university precedents for ecological planning revealed three main principles that were common in many universities as reflected in their planning documents: (1) compact development (Fig. 4) – concentrating development in existing core areas; giving precedence to renovation of existing structures; prioritizing development in areas with existing infrastructure; (2) connectivity of open spaces and natural habitats (Fig. 5) – this often includes a classification or hierarchical division of the campus into units based on multiple criteria such as land cover, hydrology, topography, and land use; and (3) conservation of high quality and key natural habitats (Fig. 6) – this can include conservation of large areas as preserves or reserves, undertaking ecological reclamation and restoration projects, and taking steps to improve the ecological value of habitats, also in the developed areas (e.g., vegetation soil and water restoration, prioritizing native species in gardening and landscaping, monitoring and treating invasive species, avoiding the use of pesticides and herbicides. These three themes are exemplified in the University of Wisconsin (UW), Eau Claire Master Plan whose vision headings are “connected and engaged,” “green and open,” and “compact and integrated” (Campus Master Planning Team, 2011). It is important to note that in most cases, including UW Eau Claire, that while these three themes are consistent with ecological objectives, ecology is not the primary focus of the themes, but rather they are associated to social, transportation and educational goals (see below).

3.1.1 COMPACT

Due to the severe impact of urban development on biodiversity (Hansen et al., 2005; McKinney, 2002), compact urban development is recommended across the planning and ecology literature in order to slow the impact of urban development and conserve open spaces for their ecological value. Compact and high-density development is recommended in many campus master plans as serving multiple economic, social and environmental goals. The most common of these is creation of walkable and public-transit oriented campus centers, but also include efficient use of infrastructures, catalyzing social and scholarly interactions, defining a clear campus boundary and identity, and preservation of open spaces elsewhere in the campus (Campus Master Planning Team, 2011; Cornell University, 2008; Sasaki, 2009; University of Idaho, 2000). Most of these campus plans refer to a compact academic center, while the built environment (research parks, athletic complexes, residential areas) extend beyond this center, suggesting that ecological considerations are not the primary driver of compact development.

3.1.2 CONNECTED

Connectivity between habitats is a predominant theme of the conservation ecology and planning literature (Pulliam and Johnson, 2002; Zipperer et al., 2000). Networks of open spaces are discussed in some university planning documents in terms of ecologically connectivity (Sasaki, 2009). But more often they are promoted for sense of place, integrative design with the built environment, aesthetics, providing coherence

[1] Curiously, the largest proportion of this small literature comes from Chinese case studies. These sources have English-language abstracts, but are rarely available in English-language journals.
[2] http://grist.org/article/2009-08-20-top-20-green-colleges/full;http://collegestats.org/2009/10/the-nations-greenestuniversities-top-10-eco-friendly-colleges; http://www.princetonreview.com/green-guide.aspx

and green connectivity between the built environment, and their role as a social and recreational venue in the natural environment (Brook Mcllroy Planning & Urban Design, 2003; Campus Master Planning Team, 2011; Carol R Johnson Associates Inc, 2012; Cornell University, 2008; Sasaki, 2009; The University of Warwick, 2007; UMass Amherst Campus Planning Division, 2012; University of Idaho, 2000). These plans often note the ecological relevance of open space connectivity for ecological reasons, though they give far less attention to the ecology per se than to the other justifications.

Another aspect of ecological connectivity concerns the connection of a campus to prominent features of the natural environment, including rivers and other water bodies, university ecological reserves (see below) and natural landscapes. The Master Plan for the University of Wisconsin, Eau Claire, for example aims to use campus planning to better integrate and connect the campus to The Chippewa River and Little Niagara Creek (Campus Master Planning Team, 2011).

3.1.3 CONSERVED

The third guideline, conservation of open spaces of high ecological value, is touted for multiple reasons, including, but not limited to, the goal of preserving biodiversity and important habitats. The preservation and expansion of green infrastructures is a very prominent theme among campus planning documents(e.g. Campus Master Planning Team, 2011; Sasaki, 2009; University of Idaho, 2000), although here, too, the emphasis is on human uses of green spaces and then only sometimes (and briefly) in connection to biodiversity or habitat conservation. Prominent reasons for preserving and expanding green spaces on campuses include providing recreational spaces for the campus community, emphasizing connectivity between built spaces, strengthening the connection between the campus and local communities and enhancing the cultural relevance of the institution (Sasaki, 2009; Skidmore Owings & Merrill LLP, 2008). Water bodies, including wetlands, riparian areas and waterfronts, sometimes receive mention for their biodiversity value and potential for restoration (e.g. The University of Warwick, 2007), In addition to physical planning, campus master plans emphasize the importance of landscape planning and its role in obtaining ecological objectives. Tree plantings are a commonplace recommendation. Some campus master plans are accompanied by a landscape vision and detailed operational instructions, such as that of University of Tennessee, Knoxville (a urban campus), which promotes the use of native plants for purposes of biodiversity enhancement and ecological health (Carol R Johnson Associates Inc, 2012). Native plants are also suggested for water conservation (e.g. University of Utah).

3.2 BIODIVERSITY AND ECOSYSTEM SERVICES SURVEY OF THE TECHNION CAMPUS

We conducted two biodiversity surveys in the Technion campus, one for the fall season (August-September 2014) and one for the spring season (March-May 2015). Each survey assessed the species richness of five taxonomic groups in randomly selected locations throughout the Technion campus. In order to select the sites for the survey we superimposed the map of the Technion with a 30 x 30 meter grid and selected randomly 31 cells. These cells represented the range of land cover types found in the Technion – including entirely undeveloped areas (no structures or paved surfaces) onto areas with partial to nearly complete artificial cover (90-100% structures, paved roads etc.). In both seasons the surveyors visited and surveyed the same sites. The five groups were: medium-sized and large mammals (using trap cameras), bat (using bat detectors), plants, butterflies and birds (the latter three through direct observation).

The main findings of these surveys were that the Technion Woods, a forested plot in the southern, up-slope campus is unique in comparison to the rest of the campus, including species not found elsewhere in the campus such as wild boars (Sus scrofa), golden jackals (Canis aureus), rock hyrax (Procavia capensis), chukar partridge (Alectoris chukar), and a red-listed (endangered) plant species Myrtle (Myrtus communis). We concluded that the presence of these species only in this area is a result of its being a part of a large tract of natural and semi-natural areas found to the south of the Technion that lay on the fringes of Haifa's developed area (i.e., the rural-urban interface). Overall, the species richness found in the Technion was representative of urban areas and similar to that found in a biodiversity survey conducted in Haifa in 2012.

An ecosystem service assessment of the Technion campus was conducted in 2014-2015. The assessment consisted of the three steps: (1) A team of expert assessors conducted preliminary fieldwork to determine the presence and quantity of the various ES in the built and forested areas of campus. The team adopted the ES outlined by the Israel National Ecosystem Assessment (INEA) for reference; (2) 27 interviews with representatives of the various campus stakeholder groups (e.g. faculty, students, administrators, visitors) aimed at defining "high priority" ES, and; (3) a matrix of high priority ES was developed and analyzed in terms of value and connection to underlying ecosystem processes. The team analyzed the provision of high priority ES as affected by different campus development plans relative to the current state.

High priority ES, as defined in the stakeholder interviews were primarily cultural services. Among them, relaxation was the most commonly noted, with "existence value and biodiversity" receiving the second most attention. An additional unique benefit that emerged in the interviews is the importance of nature in giving a campus "prestige and status", as the natural components of the campus are seen to attract both donors and students. This finding would later play an important role in connecting tree cover to the overall image of the campus that planners chose to develop. The only regulating ES that received considerable attention, and thus considerable weight when assessing the services, was the air quality improvement. No provisioning services were noted by the interviewees. The research team used the ES inventory to assess how different campus development scenarios would increase or decrease the provision of these services, thereby affecting wellbeing of the campus community.

3.3 ADMINISTRATIVE STRUCTURE

Since we were considered not only with the ecological principles needed to protect and embellish biodiversity and ecosystem integrity on campus, but also with the administrative means for implementing ecological recommendations, we also queried the literature and selected universities regarding the administrative structure of institutions who have implemented sustainability programs. We reviewed available literature and conducted interviews with staff at eight American universities to learn about the administrative processes by which these universities initiated and incorporated sustainability into their decision-making processes. Ecological priorities are included under the broader umbrella of "sustainability" objectives. While we found many campuses that emphasized carbon, water and waste policies, very few explicitly noted ecological objectives, and among them ecology (wildlife conservation or ecological integrity) was rarely a primary objective. We also investigated the administrative structure of the Technion to identify key personnel who might be willing, able, and empowered to help us turn a conversation about sustainability into action.

Most campuses that prioritize environmental sustainability have dedicated sustainability offices on campus. A sustainability office works closely with ground and maintenance on campus, usually directed by an administrative committee. Committees are divided into subunits, each with a specific sustainability focus, e.g. water, food, buildings, transportation, etc. Each of these schools has a written sustainability plan, either incorporated into a master plan or as a standalone document. Campuses also make significant efforts to publicize their environmental efforts and educate the campus community.

4. DEVELOPMENT OF AN ECOLOGICAL VISION FOR THE TECHNION CAMPUS – GUIDELINES AND RECOMMENDATIONS

The ecological advisory team concluded its work by formulating guidelines and recommendations to the planning team. The recommendations were based on the two prior stages – the lessons learned from other universities and the findings of the surveys conducted in the Technion. These recommendations were divided into three:

a. Recommendations in accordance with the three presiding themes of ecological campus planning: compact development, connectivity of open spaces, and conservation of high ecological quality land. In this regard, it was recommended that the southern forest patch (The Technion Woods) and the ecological garden serve as the primary open spaces on campus and that building be avoided in these areas. Moreover, the central wadi would serve as a green belt connecting the

two areas. These recommendations were indeed adopted and reflected in the campus statutory zoning plan (Fig. 7).

b. Recommendations that are based on intensity of land use – low intensity (the Technion Woods and the Ecological Garden), interstitial spaces, and the built environment. For primarily open/natural areas, the advisors recommended a management policy emphasizing both biodiversity potential and cultural ecosystem services. The team recommended thinning the forest in accordance with the advice of biodiversity surveyors to encourage the growth of annual plants and shrubs, thereby increasing diversity of plants and animals, as well as developing a low-impact infrastructure for human use (pathways, picnic areas, educational signage) and a longterm socio-ecological research platform (Mirtl et al., 2013). Interstitial spaces between buildings and in the central campus emphasize ecological gardening. Landscaping, in which the use of native species are emphasized, has been emphasized as a crucial mechanism for university campuses to conserve and enhance biodiversity (Kermath, 2007). We developed two simple rules of thumb for campus gardeners which would be easily remembered and which reflect the overall findings of the biodiversity survey. First, we recommended managing gardens to increase habitat availability for birds, bees, butterflies and bats. Second, we recommended that all plant choices for campus gardens fit at least two of three criteria: (1) Be a local species to Mount Carmel; (2) Be an aesthetically pleasing species, and (3) Be a species that can provide habitat for a target species from the taxa noted above[1]. Finally, recommendations for buildings and their immediate surroundings included the development of green roofs and walls and the placement of nesting boxes and bird feeders.

c. Recommendations for specific projects for increasing the potential for campus biodiversity and for cultural ecosystem services. These recommendations were diverse and included the restoration of the central campus wadi, the establishment of the forest education and research site, improving access to the Ecological Garden, employing a professional gardening team for the campus that also had experience in ecological gardening, and coordinating ecological goals with those of transportation, education and energy. Indeed most of the recommendations here have synergies with other campus goals including resource conservation, strengthening the physical image of campus, integrating students and staff from different faculties and more.

5. ECOLOGICAL CAMPUS PLANNING IN THE CLASSROOM

Scholars note the importance of connecting the content of university courses with the sustainability goals of the institution, as well as preparing a cadre of young adults who are intellectually equipped to address global environmental challenges (Alshuwaikhat and Abubakar, 2008; Kermath, 2007; Koester et al., 2006). A curriculum that emphasizes sustainability is considered a crucial component of an overall university sustainability plan. Further, the natural physical space of universities provides opportunities for outdoor education, and in particular for ecological education. This pedological resource is noted generally in campus planning documents (e.g. Cornell University, 2008) and more specifically in others, such as the development of outdoor classrooms for ecological education (Campus Master Planning Team, 2011). Kermath (2007) cites the use of the physical planning process as an excellent mechanism for educating landscape architects and planners about ecologically sustainable landscape planning.

Even prior to the beginning of the campus planning process at the Technion, the physical campus was used as a focal study object for ecology courses for landscape architecture students. Each year, graduate students in this mandatory course were required to assess the ecological challenges of the broader region (e.g. habitat degradation and loss, invasive species proliferation, species extinctions) and then propose a design intervention in the university that would address their selected challenge. Students were allowed to focus at any scale they selected, from campuswide to a single building or small patch of ground. They chose challenges as diverse as habitat preservation for both common and endangered species, restoration of campus streams, and increasing the ecological literacy of students and campus visitors. They were directed to the Landscape Architecture Foundation “Landscape Performance Series”[2] projects

[1] These criteria allow for the possibility of use of exotic species if, and only if, they provide habitat for other species of interest. We allow for this possibility due to the fact that butterfly surveys of the campus found that the diversity of that taxon was low, even for an urban environment. The butterfly surveyor suggested using (exotic, though not invasive) plants to attract particular native species of butterflies.

[2] https://landscapeperformance.org/

that received accolades for addressing ecological challenges through design for inspiration and ideas. While the students' work was intended for purely for educational purposes, when the course instructor was approached to act as ecological advisor to campus planning, he was uniquely equipped with a reservoir of studentinspired ideas for implementation. Further, several students were recruited to work on the plans, as well. As a result, several ideas directly inspired by students found their way into both the master and the statutory plans. In this way, successive generations of students acquired theoretical experience in campus planning, while learning about the potential for university campuses to serve as exemplars of ecological conservation in the urban environment.

6. DISCUSSION

In this work we show that spatial and master planning of campuses can be an effective mechanism for advancing the ecological goals of the institution, particularly when ecological goals are synergistic with a suite of other goals, including connectivity, creating spaces for learning and social activity, and creating an outdoor environment that reflects the university's cultural identity.

Many of the recommendations above were integrated into each of the three planning products at the Technion Campus (The strategic master plan, the new zoning code and the active intervention plan). The presence of multiple ecological concerns and objectives in the master plan document suggests that, with some initiative, ecological objectives can be raised and pursued with the support of the plan, which has been approved by the institution's board of governors.

University campuses are often considered small cities (Alshuwaikhat and Abubakar, 2008; Finlay and Massey, 2012), although they can be divided into the larger environment in which they are nested, whether it be urban, agricultural or natural (undeveloped) or some combination thereof. Reconciling the place of the Technion in a heterogeneous environment was a central feature of the planning process. The most significant contributions of the ecological assessment to the outputs of the planning process were (1) the inclusion of the Technion Woods, the Ecological Garden and the central wadi into an "Ecological-Historic Corridor" in the statutory zoning plan, and (2) the definition of the image of the Technion as a "ForestCity" with its emphasis on the significance of tree cover in the strategic master plan.

Kermath (2007) noted that the simultaneous emphasis on cultural and natural heritage on university campuses can have a synergistic impact on both social wellbeing and ecological conservation. The Technion campus image, as described in the master plan, is one of a city within a forest and the plan is enthusiastic in its endorsement of the value of forest cover and its benefits for both academic life and the environment. Alongside this image is the fact that the campus itself is nestled in the midst of a city and hosts a large population of students, staff and visitors. Rather than emphasize the potential conflict between these two images (city and forest), the master plan adopts the "ForestCity" image as a new and unique concept tailored for the Technion campus. As a ForestCity, the Technion plans aim to preserve a central greenspace and enhance the tree and plant cover throughout the campus – in the preserved areas, the interstitial spaces and integrated into the buildings themselves.

Nearly a decade ago, Alshuwaikhat and Abubaker (2008) noted that most universities, despite environmental proclamations and commitments, approached sustainability in an ad-hoc and limited way, often focusing on a limited number of environmental parameters (this point is re-emphasized by Finlay and Massey, 2012, and others). Our analysis suggests that ecological conservation receives only limited attention in most university plans, and then usually in relation to other social, economic or environmental objectives. Most plans focus primarily on energy, water and waste cycles with the objectives of conserving resources and reducing waste (Finlay and Massey, 2012). These are perceived by planners and consultants as "low-hanging fruit" that are economically beneficial in addition to their environmental benefits, and are therefore common first steps since they can be justified financially. We suggest this is positive and desirable, but it does not allow for realizing the full potential of university campuses to be positive actors in ecological conservation. Arguably, universities that address energy, water and waste flows are addressing ecological systems from an ecosystem perspective, considering their local to global scale impact with regard to greenhouse gas emissions, and energy and water consumption. Some university plans discuss landscaping in terms of hydrological flows or [generalized] habitat creation or protection. However, very few of the outline plans we reviewed here addressed species- and habitat-level

ecological conservation considerations as recommended in the ecocity model (Finlay and Massey, 2012) and has been attempted in the Technion plans.

Sustainability, in the broad sense, also receives prominent attention within the master plan. As is common in most of the university planning documents reviewed here, the Technion plan expresses commitment to environmental management of resources, including energy efficiency, waste reduction, and water conservation. However, as a result of the active participation of an ecological advisory team and the positive reception to its recommendations by the planning team, ecological conservation also plays a significant role in sustainability goals. As such, the master plan directs “increased emphasis on the harmonic relationship between the campus community and the unique ecology of Mount Carmel” (Assif et al., 2015; p.86), and sets as a planning goal “preserving and nurturing the unique natural environment in which the campus is situated” (Assif et al., 2015; p.87)

The strategic decision to develop the campus image as a “ForestCity” ensures the maintenance of green landscapes within the campus, but does not alone assure ecological objectives beyond those associated with green infrastructures, such as cultural ecosystem services, carbon sequestration, shade, etc. Biodiversity must be addressed through specific directives regarding habitat creation and restoration and species choices for gardening and forestry. While ecological conservation is one of many considerations driving planning objectives at the Technion, ecological considerations received greater emphasis in its strategic and statutory zoning plans than is typical of the university planning documents reviewed here, and certainly more than they had in past Technion planning documents. This was made possible through collaboration between planners and an ecological advisory team, through the sponsorship of biodiversity and ecosystem service assessments, and through extensive discussion, coordination and integration of ecological considerations final planning documents. The integration of students into the planning process via academic courses created a win-win situation, provided planners and ecological advisors with ideas, models, and research, while providing students with hands-on experience and the gratification of seeing some of their analyses and ideas work their way into final planning documents.

7. FIGURES

Figure 1: Aerial photograph of Technion campus, circa 1962

Figure 2: Aerial photograph of Technion campus, circa 2012

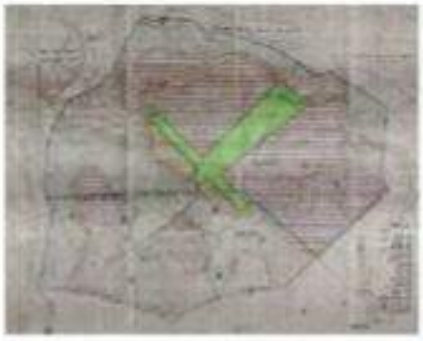

Figure 3: Campus development plan (“Klein plan”, 1950s)

Figure 4: Examples of compact campus planning. From left to right: University of Idaho (University of Idaho, 2000),Purdue University (Sasaki, 2009), and the University of Utah (Skidmore Owings & Merrill LLP, 2008).

Figure 5: Examples of connectivity in campus planning. From left to right: Cornell University (Cornell University, 2008), University of Idaho (University of Idaho, 2000), and Purdue University (Sasaki, 2009).

Figure 6: Examples of preservation of quality habitat in campus planning: From left to right: Purdue University (Sasaki, 2009) and University of Wisconsin, Eu Claire (Campus Master Planning Team, 2011).

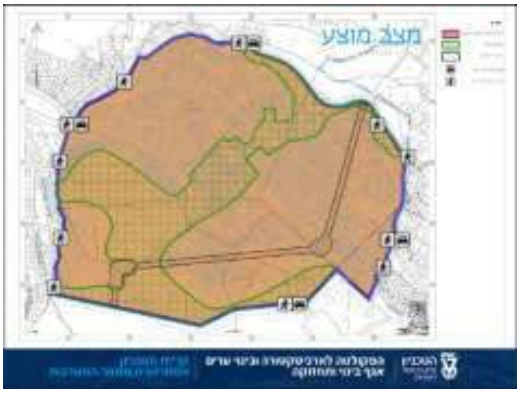

Figure 7: The Technion Campus statutory zoning plan. The Technion Woods (lower left), the central wadi, and the ecological garden (upper center) are to be conserved as open spaces, each with a unique recommended management plan.

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