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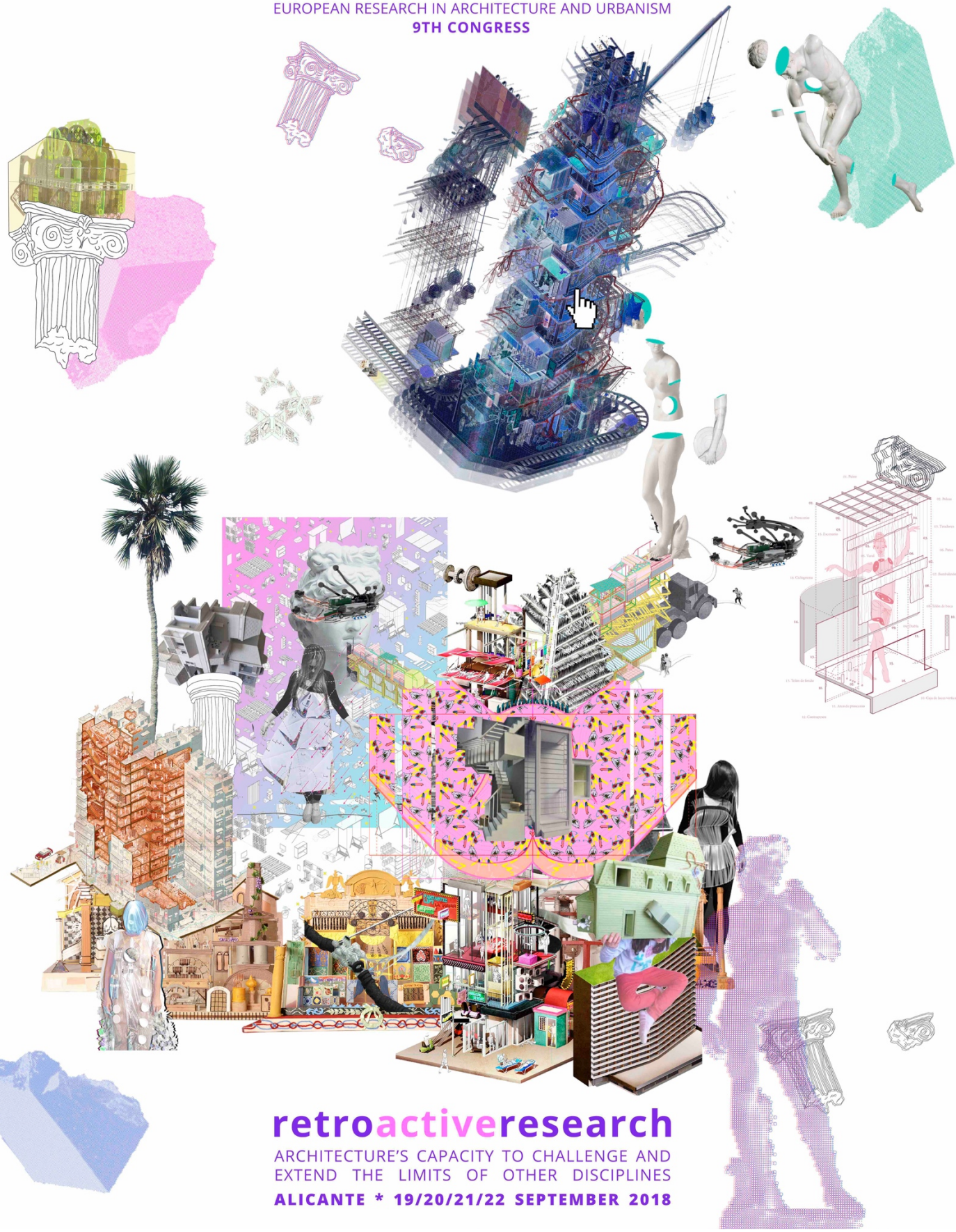
EUROPEAN RESEARCH IN ARCHITECTURE AND URBANISM

9TH CONGRESS



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ARCHITECTURE'S CAPACITY TO CHALLENGE AND EXTEND THE LIMITS OF OTHER DISCIPLINES

ALICANTE * 19/20/21/22 SEPTEMBER 2018

CONGRESS PROCEEDINGS

EURAU18 alicante
RETROACTIVE RESEARCH
CONGRESS PROCEEDINGS

ISBN: 978-84-1302-003-7
DOI: 10.14198/EURAU18alicante

Editor: Javier Sánchez Merina

Titulación de Arquitectura

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Resilient Urban Green Infrastructure

Nature-based solutions through multi-functional planting designs

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Synopsis

In urban environments, vegetation is constantly under a wide range of stress factors that undermine the plant species making them more susceptible to diseases and pests attacks. To achieve and maintain a healthy and effective green infrastructure, it is increasingly urgent to find nature based solutions to deal with this problem, as the use of pesticides is more and more legally limited. The aim of this research was to contribute to solve phytosanitary problems of vegetation in the urban context with planting designs that improve species diversity and include plant species attractive to beneficial insects. The research was focused on street trees to provide guidelines for the planting design within the UGI and within the street context. An extensive literature review provided a conjoint of species and guidelines which could be applied, either to reduce pest levels or to prevent future attacks.
Regarding the planting design within the UGI context, a new and more diverse selection of street trees can be proposed to break the connectivity among pests and diseases without compromising the beneficial connectivity of the UGI.
Regarding the planting design within the street context, diversity can be integrated below the street trees using additional layers of vegetation and using plant species that can attract beneficial insects by providing host plants and, consequently, several nectar and pollen resources and refuges for unfavorable climatic conditions.
Although this research was focused on street trees, results can also be extended to other urban green spaces in the future. Healthy plant species are imperative to maximize the UGI performance and its capacity to deliver services. The inclusion of target species in the urban environment to prevent phytosanitary problems or to improve the overall phytosanitary condition of the vegetation can be one step ahead for the future of more resilient cities.

Key words: Urban green infrastructure, planting design, nature based solutions, biological control, street trees.

1. Introduction

The Urban Green Infrastructure (UGI) must be healthy and resilient to be able to efficiently deliver the services that we all need. This can be a difficult task because in urban environments vegetation is constantly under a wide range of stress factors (e.g. pollution, higher temperatures, compacted soil, etc.) that undermine plant species making them more susceptible to diseases and pest attacks (Gerstenberg et al., 2016). This problem can be particularly relevant for street trees. First, street trees are more exposed to extreme environments and urban pressure. Additionally, street trees are important ecological elements that connect the UGI, so if the trees have phytosanitary problems these important links can be compromised and act as vectors of diseases and pests. Therefore, to achieve and maintain a healthy and effective UGI, it is increasingly urgent to find nature based solutions to deal with this problem, as the use of pesticides is becoming legally limited.

The impact of pesticides in the environment and human health demanded the search of alternative methods to control pests. Biological control ascended as a way of limiting the damage caused by a pest through the deliberate introduction of its natural enemies (The RHS, 2002). Insects that are natural enemies of pests are usually denominated beneficial insects and can decrease pests' population. Besides the fact that biological control is cheaper than other methods, it is not harmful for plants and human beings. This method is being developed and improved in the agriculture field, but we believe that it can also be useful in the urban context, particularly to deal with the most common pests that attack ornamental plants. According to Pauleit et al. (2002), aphids were listed as the most common pests that affect the urban vegetation and, for that reason, this research was focused on this specific pest. Aphids are sucking insects that develop in the leaves and suck the sap from the plant, provoking several negative side effects such the decrease of the plant's vigor and the production of honeydew (The RHS, 2002).

Traditionally, Landscape Architecture planting designs select species based preferentially on their aesthetic characteristics. New and multi-functional selecting criteria based both on the ornamental and ecological value of plant species, using, for instance, biological control knowledge, can be the answer to (re)create healthy plant communities. This way, the aim of this research was to contribute to solve phytosanitary problems of vegetation in the urban context with planting designs that improve species diversity and by including plant species that attract beneficial insects. The research was focused on street trees to provide guidelines for the planting design within the UGI and within the street context.

2. Methods

This research started with a literature review to find which are the natural enemies of aphids and which are the plant species that attract these natural enemies. Then guidelines for the planting design were explored at two levels: 1) planting design within the UGI context and 2) planting design within the street context.

3. Results and Discussion

Several insects such as ladybugs, hoverflies and lacewings are natural enemies of aphids (Coutinho, 2007). The following table (Fig. 1) displays a short version of the information collected in the literature review (Gupta et al., 2012; Kopta et al., 2012) regarding plant species that can attract these natural enemies.

Scientific name	Family	Plant type	Native	Exotic	Natural enemies' attractiveness		
					Ladybugs	Hoverflies	Lacewings
Abelia x grandiflora	Caprifoliaceae	Shrub					
Achillea millefolium	Asteraceae	Perennial					
Anethum graveolens	Apiaceae	Annual					
Armeria maritima	Plumbaginaceae	Perennial					
Calendula officinalis	Asteraceae	Annual					
Euryops chrysanthemoides	Asteraceae	Shrub					
Helichrysum italicum	Asteraceae	Shrub					
Lobularia marítima	Brassicaceae	Annual					
Lavandula angustifolia	Lamiaceae	Shrub					
Malva tournefortiana	Malvaceae	Perennial					
Rosmarinus officinalis	Lamiaceae	Shrub					
Spiraea cantoniensis	Rosaceae	Shrub					
Sambucus nigra	Adoxaceae	Shrub					
Teucrium fruticans	Lamiaceae	Shrub					
Viburnum tinus	Adoxaceae	Shrub					

Figure 1.

3.1. Planting design within the UGI context

Street trees design often results in uniform rows of a single species (Gerstenberg et al., 2016). Besides, usually more than 50% of the trees planted in the streets belong to only a restrict number of genera (e.g. Platanus sp., Tilia sp., Populus sp.). Although this uniformity is very useful for Municipalities and considered visually attractive by people, it may also represent an ecological concern. Species diversity is extremely important for the resilience of the urban vegetation and particularly to improve the resistance of trees regarding pests and diseases (Pauleit et al., 2002). This way, the selection of species needs to be rethought to address this problem and needs to consider which trees are more susceptible to pests and diseases. For instance, the Plane (Platanus sp.) is frequently present in streets and reported as one of the most susceptible to pests in Southern Europe (Pauleit et al., 2002).

Fig. 2 illustrates a new and more diverse selection of street trees that can be proposed to break the connectivity among pests and diseases without compromising the beneficial connectivity of the UGI. This way, streets can have various species of trees that are interspersed in the urban fabric, forming a pattern that can be replicated throughout the UGI.

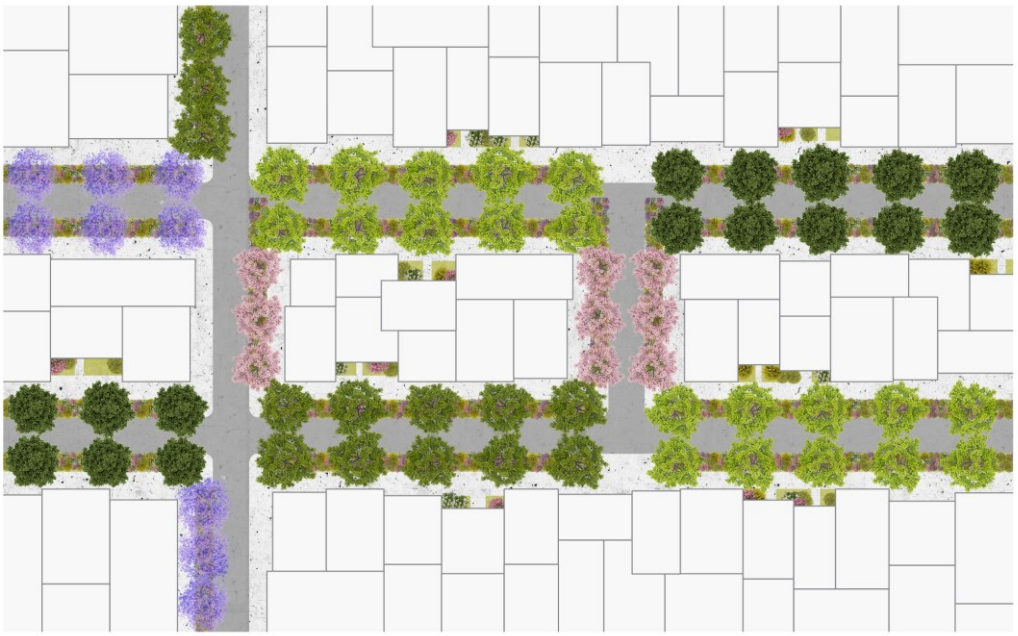

Figure 2.

3.2. Planting design within the street context

Within the street context there is also ways of improving the phytosanitary condition of street trees. Firstly, it is essential that the tree is installed with enough space to grow. An accurate implementation of trees in the tree pits or in green spaces along the sidewalk can also mitigate the negative stress factors that make vegetation more vulnerable. Moreover, diversity can also be integrated below the street trees using additional layers of vegetation (shrubs and herbaceous species).

Fig. 3 illustrates a diverse set of plants that can be installed below the street trees, using the plant species that can attract beneficial insects (Fig. 1). Flowering shrubs and herbaceous such as Helichrysum italicum, Lavandula angustifolia and Spiraea cantoniensis have high ornamental value and can increase biodiversity levels. Besides, these species will promote the presence of beneficial insects by providing host plants and, consequently, several nectar and pollen resources and refuges for unfavorable climatic conditions (Alignier et al., 2014).

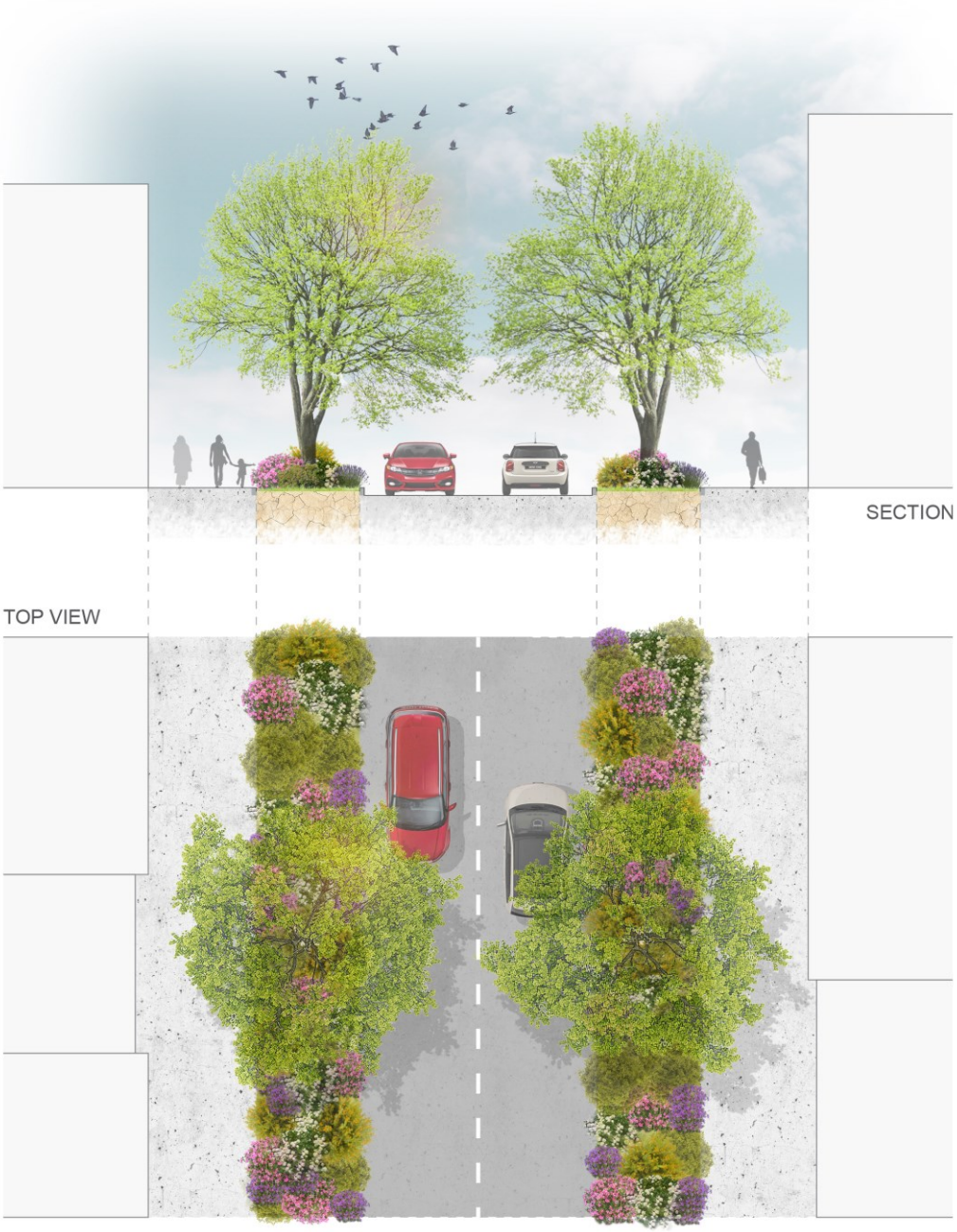

Figure 3.

4. Conclusions

Although this research was focused on street trees, results can also be extended to other urban green spaces in the future. Healthy plant species are imperative to maximize the UGI performance and its capacity to deliver services. Evidences from literature review can better inform the design process. The inclusion of target species in the urban environment to prevent phytosanitary problems or to improve the overall phytosanitary condition of the vegetation can be one step ahead for the future of more resilient cities.

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Biography

Catarina Patoilo Teixeira. Catarina Patoilo Teixeira graduated in Landscape Architecture (2014) and completed the master's degree in Landscape Architecture (2016) at the School of Sciences of the University of Porto. Currently, she is attending the first year of the doctoral degree in Landscape Architecture, at the same institution, with a PhD grant funded by the Portuguese Agency for Science and Technology (FCT). Additionally, she is a Ph.D. Student on the Research Group "Landscape Planning, Design and Management" of the Research Centre in Biodiversity and Genetic Resources (CIBIO-InBIO). Her PhD research project addresses interesting and urgent themes and aims to understand the constraints and opportunities associated with Novel Urban Ecosystems (ecosystems that are emerging as a result of human-induced environmental changes), namely the role they can play in the creation of adaptive strategies for more resilient cities in the future.