EVOLUTION OF MICROCLIMATE EFFECT OF AN URBAN PARK OVER THEIR BUILT ENVIRONMENT

[1*] *María Angélica Ruiz,* [1] *María Florencia Colli,* [1] *Claudia Fernanda Martínez,* [1] *Erica Norma Correa Cantaloube*
[1] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Centro Científico Tecnológico CCT – Mendoza, Instituto de Ambiente, Hábitat y Energía (INAHE), Av. Ruiz Leal s/n, Parque General San Martín, Mendoza, CP: 5500, Argentina

*Corresponding author e-mail: aruiz@mendoza-conicet.gob.ar

ABSTRACT

Arid cities suffer the effects of urban heat island (UHI), with negative impacts on the environment, people and economies. Urban greening is a strategy for mitigating UHI. However, vegetation demands high scarce resources in cities on dry land. Hence, it is necessary to rethink the relationship between green spaces and its surrounding built environment. This work´s objective is to evaluate the impact of Mendoza´s Parque Central (Argentina) on the air temperatures of its built environment, taking as a measure the park cool island intensity (PCI) in the 2007-2017 period. Parque Central has a strategic value for the urban development of a residential area with a medium to high construction density. Methodologically, two monitoring campaigns were carried out during the summer periods of 2007-2008 and 2016-2017. In each campaign, temperature and relative humidity sensors were installed in the area. Satellite images from Landsat 7 were analyzed and the NDVI and NDBI indices were determined. The results indicate that over 10 seasons, the park's maximum NDVI has increased more than 8 times, while the maximum PCI intensities have increased 2.31 times.

Keywords: Urban Parks, Heat Island Mitigation, Park Cool Island, Digital Satellite Image, Built Environment.

INTRODUCTION

Greening is an efficient strategy for the adaptation and mitigation of the UHI and urban warming phenomena [1]. In particular, urban parks form the so-called Park Cool Island (PCI), which can effectively alleviate the negative influences of urban heat islands. However, it is important to highlight that in arid zones, urban greening demands a certain amount of water in a place where this resource is scarce. For this reason, it is necessary to plan the features of built-up areas around the park in order to guarantee their sustainability in terms of management, natural resource consumption, and thermal benefits. Thus, the objective of this work is to evaluate the impact of an urban park in the city of Mendoza, Argentina — Parque Central— on the air temperatures of its built environment, taking as a measure the intensity of park cool island. In addition, we analyzed the evolution of its cooling effect over time (ten years) in relation to the evolution of the park and the surrounding urban areas characterized by means of satellite image indices.

MATERIALS AND METHODS

Mendoza´s Parque Central is the fourth green space on the surface of the city (approximately 14 hectares). It is located in the northwest area of the province capital (32° 52' 37.08" S and 68° 50' 28.03" W), in a residential area with medium to high construction density (2-4 m^3/m^2). It has a strategic value for urban development, given the numerous uses and artistic, sport, social and cultural activities provided. But several of those specimens incorporated in 2006 did not adapt to the environmental conditions of the growing site. At present, the most tolerant have been consolidated, integrating forested or aligned groups with the development of a dense vegetation cover (canopy) that provides important shading.

Two monitoring campaigns were developed during the summer periods of 2007-2008 and 2016-2017. In each campaign, temperature and relative humidity sensors of type HOBO H8-003-02 and UX100-003 (HOBO®; Onset; Cape Cod, MA) were installed, recording every 15 minutes. Two of them were located within the park in well differentiated structures: meadow and forest. In addition, four sensors were installed around the park (North, East, South and West) at an average distance of 450 m from the edge. Finally, a sensor was located in the center of the city.

Landsat 7 satellite images from 10/1/2008 and 1/18/2017 were analyzed in order to study the green areas, together with the evolution of their surroundings, and to evaluate their impact over the microclimate. NDVI [2] and NDBI [3] indices were determined as well. The QGIS software was used to process satellite images. The images were calibrated, corrected and projected onto POSGAR 2007–Argentina 2.

The definition of hourly PCI is the difference in air temperature between the surrounding urban areas and the park:

$$PCI = Tu - Tp \quad (1)$$

where, Tu is the hourly average temperature of urban surroundings (North, West, South and East), and Tp is the hourly average temperature inside the park (meadow and forest).

RESULTS AND DISCUSSION

In Mendoza´s Parque Central, the increase in NDVI denotes the consolidation of biomass (Table 1), but the maximum temperature differences decrease from 2007-2008 to 2016-2017, during maximum temperature occurrence. This reduction shows the impact of urban growth throughout the period. The NDBI shows that along ten years the quantity of built up areas has increased in all directions around the park. The maximum values of NDBI have increased in a range of 1.52 to 1.95 times. As the building mass increases, the thermal inertia of the environment increases as well and temperature differences with the cold structures within the park —the forests— decrease in the hours of sun. Based on [4] results, the cooling effect of the park would be expected to increase. However, this has not been the case, demonstrating that the thermal benefits of the park have been governed by the densification of its surroundings.

Table 1. NDVI values for Parque Central and NDBI values for each area of influence.

	NDVI		NDBI							
	2008	2017	NORTH POINT		SOUTH POINT		EAST POINT		WEST POINT	
			2008	2017	2008	2017	2008	2017	2008	2017
Minimum	-0.20	0.02	-0.25	-0.25	-0.18	-0.21	-0.22	-0.26	-0.18	-0.30
Average	-0.05	0.26	-0.01	-0.01	-0.01	-0.01	-0.02	-0.04	-0.01	-0.02
Maximum	0.07	0.57	0.16	0.26	0.15	0.23	0.19	0.37	0.16	0.27

The cooling effect of the forest is more susceptible to the increase of NDBI than that of the meadow. In the South point the variation of the maximum NDBI has been the lowest whereas the cooling effect caused by the park is the greatest. On the contrary, the East point shows the highest increase in maximum NDBI and the lowest cooling effects.

Respect to PCI, during the 2007-2008 season, the maximum PCI is 1.3 ºC, being relatively stable throughout the day. During the 2016-2017 summer, the maximum values of PCI occur during noon: the park is up to 3.0 ºC colder than the urban surroundings. Although the cooling effects of greenspace are well known, the understanding on the roles of landscape inside and outside parks in PCI features is still not deeply explored.

CONCLUSIONS

This research highlights the challenges of reconciling the thermal benefits of an urban park placed in an arid zone with the built environment growth.

The forest structure is 37% cooler than the surroundings in 2016 vs. 2008. In contrast, the maximum PCI recorded between the meadow structure and its surroundings represents a 62% increase in its cooling effect.

Based on NDVI values, the forest area consolidation and the park evolution have allowed a more efficient behavior of the meadow structure, despite the temporary increase in anthropic pressure on the park, evidenced by the NDBI.

Over 10 seasons, the park's maximum NDVI has increased more than 8 times, while the maximum PCI intensities have increased 2.31 times. The high increase in vegetation is not directly proportional to the cooling effect of this urban park.

The cooling profile of the park has changed. NDVI and PCI grew but the evolution of the surroundings (measured as NDBI) has modified the role of the park as a thermal regulator. The thermal benefit of the park has moved from the night to the afternoon hours.

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Para: "cmartinez" <cmartinez@mendoza-conicet.gob.ar>
CC: mehmetezan@gmail.com
Responder a: "Mehmet Akif Ezan" <mehmet.ezan@deu.edu.tr>

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