ICONARP
International Journal of Architecture and Planning
Received: 30.06.2024 Accepted: 11.08.2025
Volume 13, Issue 2/ Published: 31.12.2025
Research Article *DOI: 10.15320/ICONARP.2025.342 E- ISSN:2147-9380*
ICONARP

Climatic Benefits of Urban Parks: Case Study in a Mediterranean Context

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Abstract

Green spaces make a significant contribution to the climatic comfort of urban dwellers. These contributions can be in the form of cooling in hot summers and heating in cold winters compared to the surrounding built-up areas. These contributions are related to the landscape design of parks to a certain extent. The presence and extension of hard grounds and waters in parks as well as the type, texture and density of plants used determine the level of climatic comfort provided. The present research was conducted in Aydın Kanza Park in the Mediterranean City of Antalya, Türkiye, to determine the cooling and heating benefits of the park, located in a warm climate area. Temperature, humidity, and wind speed were measured once a week all year round at four different locations inside the park (tree-covered, lawn-covered, hard ground, pond-side) as well as at three locations at a distance of 50, 100 and 300 meters away from the park. The findings indicate that Aydın Kanza Park provides 2.4 °C warmer environment in the first four months of the year and 2 °C cooler environment in the following seven months in terms of mean values at midday compared to the built-up area surrounding the park. The findings also indicate that the heating and cooling effect provided by the park continues at a certain distance from the park. However, there is no significant difference between the temperature, humidity, and wind speed values of various locations with different land cover inside the park, which is most probably related to the size of the park.

Keywords: *Climatic comfort, Cooling, Heating, Green spaces, Parks*

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To cite this article: Elma, S., & Ortaçeşme, V. (2025). Climate benefits of urban parks: case study in a mediterranean context. *ICONARP International Journal of Architecture and Planning,* 13 (2), 709-730. DOI: 10.15320/ICONARP.2025.342

INTRODUCTION

Urban open spaces provide physical, environmental, social, and economic benefits to citizens (Woolley, 2003). Thermally comfortable urban open spaces offer high-quality locations to residents and attract them to the outdoors (Nikolopoulou & Lykoudis, 2007; Lin et al., 2012; Lai et al., 2014; Lai et al., 2019b; Lai et al., 2020). Thermal environmental parameters, such as air temperature, humidity, wind speed, and thermal radiation, affect the heat transfer between people and the surrounding Senvironment, and determine people's thermal comfort (Lai et al., 2019a; Zhang et al., 2023).

Urban green spaces such as parks can considerably mitigate the urban heat island effect. An increase in greenspace of 20% above the current level could eliminate between a third and a half of the city's expected UHI effect in 2050 (Emmanuel & Loconsole, 2015). The green vegetation can improve both indoor and outdoor thermal comfort, while at the same time providing multiple environmental services such as carbon storage and reduced air pollution, and act as urban biodiversity hot locations (Feyisa et al., 2014). With the presence of a vegetated surface, evapotranspiration can transform a large portion of incoming solar radiation to the surface, which otherwise would contribute to the underground heat storage and make the ground surface cooler (Ca et al., 1998).

Nonetheless, green spaces are not all the same. They can vary in their structural aspects, depending on their components in terms of trees, shrubs and/or herbaceous vegetation (Nowak et al., 2006). Due to the shading effect trees have on surfaces and/or the cooling effect of the water they transpire, they can also mitigate extreme air temperatures by changing microclimatic conditions on their surroundings (McDonald et al., 2016).

The World Health Organization has recommended that urban residents have access to at least 0.5-1 ha of public green space within 300 m of their home (World Health Organization, 2017). In addition, the Global United Nations Sustainable Development Goal (SDG) 11.7 focuses on the provision of green spaces in a universal, safe, inclusive, and accessible manner (United Nations, 2018; Venter et al., 2023).

The role of green areas in moderating urban climate has been explored all over the world and there is a vast literature on the benefits of green spaces to mitigate the effects of urban heat. However, few of them focus on the design aspect of parks by examining the climatic variables in different locations inside the parks. There are also few studies conducted in the Mediterranean Region, which is to be affected much more by the adverse effects of global warming. What makes different this study from related research is the fact that it focuses on the climatic comfort of the different sectors of the park and also that it deals not only with the cooling but also the heating effects of parks in a Mediterranean context.

DOI: 10.15320/ICONARP.2025.342

METHODOLOGY AND METHODS

The study area is Aydın Kanza Park and its near surroundings in Muratpaşa district of Antalya City, located in the Mediterranean Region of Türkiye. The park, which is located at the intersection of two main transportation axes of the city, namely Yüzüncü Yıl Boulevard and Anafartalar Street, has a size of 1 ha. It is surrounded by a dense urban fabric with 5-7 storey buildings (Figure 1). The reasons for selecting Aydın Kanza Park for this study include the presence of areas with various types of surface cover (wooded, grass, water, hard ground) and also the fact that it is surrounded by dense residential areas. These characteristics enable temperature, humidity, and wind speed measurements in the different parts of the park and in the residential area surrounding the park, and the data obtained can be compared to determine the microclimatic effects of the park.

Within the scope of study, temperature, humidity, and wind speed measurements were made all year round in 2019, once a week and three times a day (morning, 07:00-08:00 h; noon, 13:00-14:00 h; and night, 20:00-21:00 h), at a height of 2 m from the ground level. The measurements were made in four different locations of the park: 1). Tree-covered, 2). Lawn-covered, 3). Hard ground, and 4). Pond-side. In order to determine the extension of cooling and heating effects of the park, measurements were also done at the locations of 50, 100 and 300 m. away from the park (Figure 2). All measurements were done in a time-series basic trial approach with three replicated, split plots trial pattern (Ca et al., 1998; Yüksel 2005; Hamada & Ohta 2010; Xiao et al., 2018). Extech 45160 wind speed, temperature and humidity measurement device was used to record the data. The data obtained were analyzed using SPSS 22 software, and parameters that were statistically significant according to the analysis of variance results were compared using Duncan's multiple comparison test at a 5% significance level. The analysis results were interpreted in the context of the microclimatic contributions of parks throughout the year.

ICONARP – Volume 13, Issue 2 / Published: 31.12.2025

Figure 1. Location of Aydın Kanza Park in Antalya City, Türkiye.

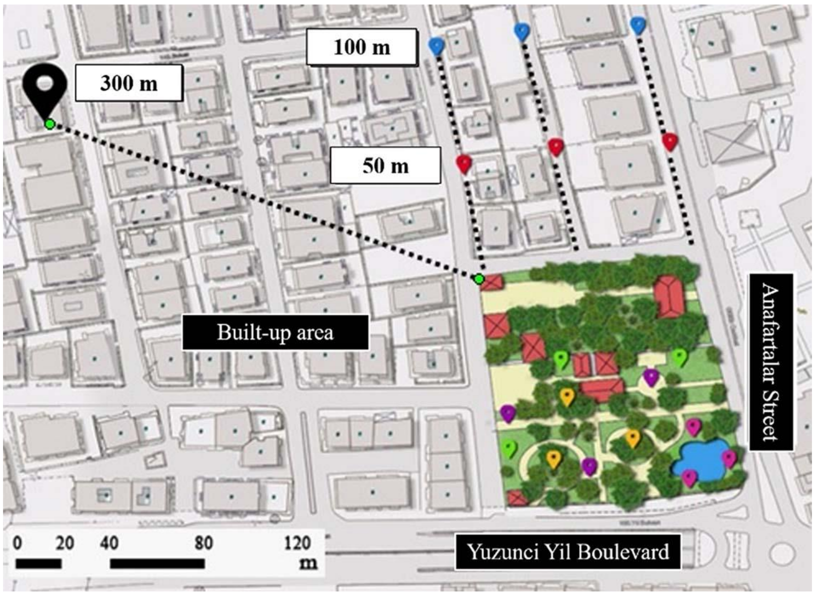

Figure 2. Measurement locations inside and outside of the park.

Table 1. Legend of measurement locations inside and outside of the park.

	Measurement locations in tree-covered part
	Measurement locations in lawn-covered parts
	Measurement locations at the pond-side
	Measurement locations on hard grounds
	Measurement locations at 50 m.
	Measurement locations at 100 m.
	Measurement location at 300 m

DOI: 10.15320/ICONARP.2025.342

DATA ANALYSIS

Antalya has a typical Mediterranean climate, with hot, dry summers and mild, rainy winters. The annual average temperature is 20.2 ° C. The month with the highest average temperature is August at 29.6 ° C, while the month with the lowest average temperature is January at 11.4 °C. The annual average humidity is 60.9%, and the annual average wind speed is 1.9 m/s. General climatic data of the city is given in the Figure 3.

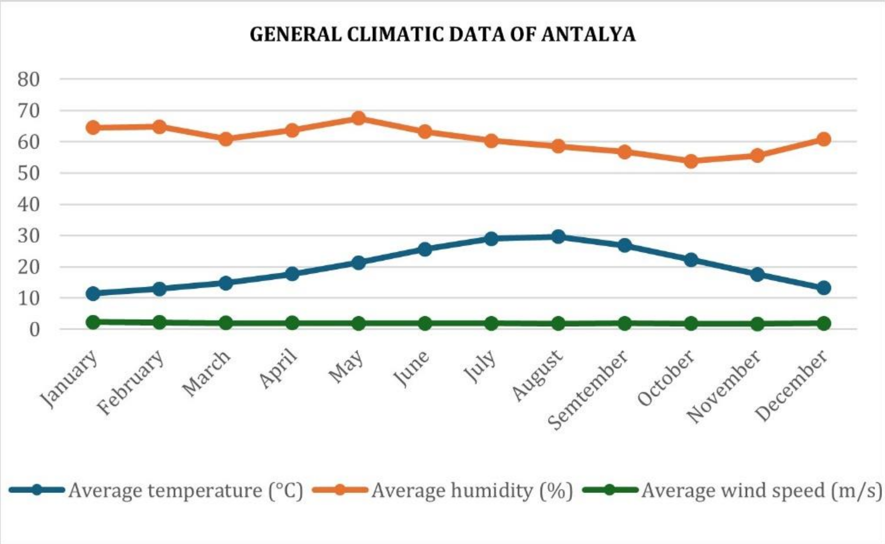

Figure 3. Average temperature, humidity and wind speed values of Antalya.

1. In-park Climatic Values

1.1. Temperatures

The average temperature values according to the month, location and measurement hours and the results of the statistical analysis of data are given in the Table 2.

Table 2. Average temperatures in the park according to the month, location, and hours.

Month	Measurement Hour	Measurement Location				Measurement Hour Average	Monthly Average
		Tree-covered	Grass-covered	Hard ground	Pond-side		
JANUARY	07.00-08.00	8.3 C a [y]	8.4 C a	8.2 C a	8.7 C a	8.4 c	13 k [z]
	13.00-14.00	19.3 A a	20 A a	19.5 A a	20 A a	19.7 a	
	20.00-21.00	11.4 B a	10.9 B a	10.9 B a	11 B a	11 b	
	Meas. Loc. Average	13 a	13 a	12.8 a	13.3 a		
FEBRUARY	07.00-08.00	10.2 C a	10.4 C a	10.5 C a	10.4 C a	10.3 c	**16.1 j**
	13.00-14.00	21.4 A a	21.5 A a	21.3 A a	22.1 A a	21.6 a	
	20.00-21.00	16.9 B a	16.5 B a	16.4 B a	16.7 B a	16.6 b	
	Meas. Loc. Average	16.2 a	16.1 a	15.9 a	16.4 a		
MARCH	07.00-08.00	14.1 C a	14.3 C a	14 C a	14.1 C a	14.1 c	**18.6 h**
	13.00-14.00	23.7 A a	24.2 A a	23.7 A a	24 A a	23.9 a	
	20.00-21.00	18 B a	17.7 B a	17.5 B a	17.7 B a	17.7 b	

ICONARP – Volume 13, Issue 2 / Published: 31.12.2025

	Meas. Loc. Average	18.6 a	18.7 a	18.4 a	18.6 a		
APRIL	07.00-08.00	17.4 C a	17.8 C a	17.4 B a	17.4 C a	17.5 c	
	13.00-14.00	25.7 A a	26.4 A a	25.8 A a	26 A a	26 a	**20.7 g**
	20.00-21.00	18.9 B a	18.9 B a	18.6 B a	18.6 B a	18.8 b	
	Meas. Loc. Average	20.7 a	21 a	20.6 a	20.7 a		
MAY	07.00-08.00	23.5 C ab	24.1 C a	23.4 C ab	23.3 C b	23.6 c	
	13.00-14.00	30.3 A a	30.7 A a	30.2 A a	30.6 A a	30.4 a	**26.5 d**
	20.00-21.00	25.6 B a	25.4 B a	25.2 B a	25.3 B a	25.4 b	
	Meas. Loc. Average	26.5 a	26.7 a	26.3 a	26.4 a		
JUNE	07.00-08.00	27.8 B ab	28.2 B a	27.8 B ab	27.5 C b	27.9 b	
	13.00-14.00	32 A ab	32.9 A a	32.5 A ab	31.6 A b	32.3 a	**29.3 b**
	20.00-21.00	27.9 B a	27.9 C a	28 B a	28 B a	27.9 b	
	Meas. Loc. Average	29.3 a	29.7 a	29.4 a	29 a		
JULY	07.00-08.00	29.8 C ab	30.3 B a	29.9 C ab	29.6 C b	29.9 c	
	13.00-14.00	35 A a	34.8 A a	34.8 A a	34.8 A a	34.8 a	**31.9 a**
	20.00-21.00	31.2 B a	31 B a	31.2 B a	31 B a	31 b	
	Meas. Loc. Average	32 a	32 a	32 a	31.8 a		
AUGUST	07.00-08.00	29.8 C bc	30.4 C a	30 C ab	29.5 C c	29.9 c	
	13.00-14.00	35.5 A a	34.8 A a	35.4 A a	35.5 A a	35.3 a	**32 a**
	20.00-21.00	31 B a	30.9 B a	31 B a	31 B a	31 b	
	Meas. Loc. Average	32 a	32 a	32.2 a	32 a		
SEPTEMBER	07.00-08.00	25.9 C ab	26.8 C a	26.2 C ab	25.5 C b	26.1 c	
	13.00-14.00	31.8 A a	31 A b	31.3 A ab	32 A a	31.5 a	**29.1 c**
	20.00-21.00	29.8 B a	29.4 B a	29.8 B a	29.8 B a	29.7 b	
	Meas. Loc. Average	29.2 a	29 a	29 a	29 a		
OCTOBER	07.00-08.00	23.2 C a	23.7 C a	23.5 C a	23.1 C a	23.4 c	
	13.00-14.00	28.9 A a	29.2 A a	29.1 A a	28.9 A a	29 a	**26 e**
	20.00-21.00	25.7 B a	25.6 B a	25.7 B a	25.5 B a	25.6 b	
	Meas. Loc. Average	26 a	26.2 a	26 a	25.9 a		
NOVEMBER	07.00-08.00	19 C ab	19.2 C a	19.2 C a	18.9 C b	19 c	
	13.00-14.00	26.8 A a	27.5 A a	26.9 A a	27.9 A a	27.3 a	
	20.00-21.00	23.4 B a	23.2 B ab	23.4 B a	23 B b	23.2 b	**23.2 f**
	Meas. Loc. Average	23 a	23.3 a	23.1 a	23.2 a		
DECEMBER	07.00-08.00	13.4 C a	13.3 C a	13.3 C a	12.9 C b	13.2 c	
	13.00-14.00	22 A a	21.2 A a	21.3 A a	21.7 A a	21.5 a	**16.7 ı**
	20.00-21.00	15.5 B a	15.6 B a	15.4 B a	15.3 B a	15.4 b	

DOI: 10.15320/ICONARP.2025.342

	Meas. Loc. Average	17 a	16.7 a	16.6 a	16.6 a		
Measurement Location Annual Aver.		**23.6 ab**	**23.7 a**	**23.5 b**	**23.6 b**		
Measurement Hour Annual Average							
07.00-08.00		**20.3 c**					
13.00-14.00		**27.8 a**					
20.00-21.00		**22.8 b**					
Significance *(p values)*							
Month (M):		<0.001*	^{z} Different averages at 5% significance level according to Duncan test are shown by separate letters. ^{y}: In the sections written in italics (within each month), the uppercase letters show the comparison of the averages in the columns (each measurement hour), and the lowercase letters in the rows (at each measurement location). * It shows statistically significant p values. The underlined values in the table indicate the maximum and minimum values.				
Measurement Hour (MH):		<0.001*					
Measurement Location (ML):		0.027*					
M x MH:		<0.001*					
M x ML:		0.542*					
MH x ML:		<0.001*					
M x MH x ML:		0.654					

The monthly average temperatures vary between 13 °C and 32 °C. The highest monthly average value is in August (32 °C) whereas the lowest value is in January (13 °C). The differences between the morning, midday and evening temperature values in all months are statistically significant, being the midday values the highest and the morning values the lowest. Average annual temperature at midday was 27.8 °C whereas it was 20.3 °C in the morning. The lowest temperature recorded was in the morning of January (8.4 °C) and the highest temperature was at midday of August (35.3 °C).

Regarding the annual temperature averages of different measurement locations, no significant difference is seen with values varying between 23.5 °C and 23.7 °C. When the monthly average temperatures of different locations are compared, no statistically significant difference is seen either. The highest average temperature is in August (32.2 °C) and the lowest one is in January (12. 8 °C), both on the hardgrounds. These values show that the hardgrounds of the park have the highest temperatures in summers and the lowest temperatures in winters.

When the different locations in the park are compared in terms of temperature, it is seen that the differences between months ($p<0.001$), measurement hours in each month ($p<0.001$) and measurement locations ($p<0.027$) are statistically significant. In terms of binary interactions, it is seen that the values of month-to-measurement hour interaction ($p<0.001$), month-to-measurement location interaction ($p<0.542$), and measurement hour-to-measurement location interaction ($p<0.001$) are also statistically significant.

1.2. Humidity

The relative humidity varies between 42.3% and 54%, being the lowest in July and the highest in February. The differences between the morning, midday and evening values in January, March, April, May, June, September, November, and December were found statistically significant, being the evening values the highest and the midday values the lowest. The lowest value was in January at midday (30.7%) and the highest value was in the evening of December (62.8%). No statistically significant difference was found between different measurement hours.

There was not much difference between the annual humidity averages of different locations. The lowest value (49.3%) was recorded in the grass-covered area whereas the highest value (50%) was recorded at pond-side. Regarding the monthly averages, the highest value was in February (54.4%) in the hardgrounds, and the lowest value was in July (41.5%) in the grass-covered area.

When the different locations are compared in terms of relative humidity, it is seen that the differences in the month ($p<0.001$), measurement hour ($p<0.001$) and measurement location ($p<0.001$) are statistically significant. When the values are evaluated in terms of binary interactions, it is seen that the pairwise interactions between month and measurement hour ($p<0.001$) and between measurement hour and measurement location ($p<0.004$) are statistically significant while the pairwise interaction between the month and measurement location ($p<0.787$) is insignificant. When the triple interactions between the months, locations and hours are examined in terms of humidity values, it is seen that the highest value (63%) is recorded at pond-side in the evening of January and at hardgrounds in the evening of December whereas the lowest value (29.3%) is recorded at the grass-covered area at midday in January.

1.3. Wind speed

Monthly averages of different locations and hours vary between 0.1 m/sec and 0.6 m/sec. The highest and lowest monthly averages are seen in June (0.6 m/sec) and December (0.1 m/sec), respectively. The difference between morning and evening values in the eleven months except September was not statistically significant and was lower than the midday values. In September, the difference between the morning, midday and evening was found to be statistically significant, being the highest value (0.8 m/sec) at midday and the lowest value (0 m/sec) in the morning. Looking at the measurement time averages, the lowest value (0 m/sec) was recorded in the evenings of January, April, May; mornings and evenings of February, March, October, November; and only mornings of September. The highest value was at midday (1.4 m/sec) in June.

There was not much difference between the annual wind speed averages of different locations. When the monthly averages are compared, no statistically significant difference is seen between the values of all months. The highest wind speed value (0.8 m/sec) was recorded at the pond-side in June, whereas the lowest values (0.1 m/sec) were recorded at the tree-covered area in October as well as in three-covered, grass-covered and hardgrounds in December.

When the different locations are compared in terms of wind speed, it is seen that the differences in the month ($p<0.001$) measurement hour

DOI: 10.15320/ICONARP.2025.342

(p<0.001) and measurement location (p<0.001) are statistically significant. When the values are examined in terms of binary interactions, it is seen that the pairwise interaction between month and measurement hour (p<0001) is statistically significant, while the pairwise interactions between month and measurement location (p<0.625) and the measurement hour and measurement location (p<0.294) are not.

2. Analysis of In-park and Out-of-park Climatic Data

The differences between the temperature, humidity and wind speed values measured inside as well as outside of the park were examined to see the microclimatic effects of Aydın Kanza Park. For this purpose, the "whole park or in-park" data was created first by calculating the averages of all measurement values from different locations in the park. Then, the in-park values were compared with those of the three locations outside the park (50th m, 100th m and 300th m).

2.1. In-park and out-of-park temperatures

Measurements shows that the expected micro-climatic effects of Aydın Kanza Park are mostly achieved at midday. In the months of January, February, March and April, in-park temperatures are higher than those of out-of-park at midday.

According to both the general climatic data of Antalya and the data measured in this study, January is the coldest month of the year, and the midday temperatures is 3.2 °C higher in the whole park than the farthest location from the park at 300 m (Figure 4). In other words, Aydın Kanza Park provides a 3.2 °C warmer environment in the coldest month of the year. The park is still warmer than the farthest location in February, March, and April with 2.6 ° C, 2.0 °C and 1.9 ° C, respectively.

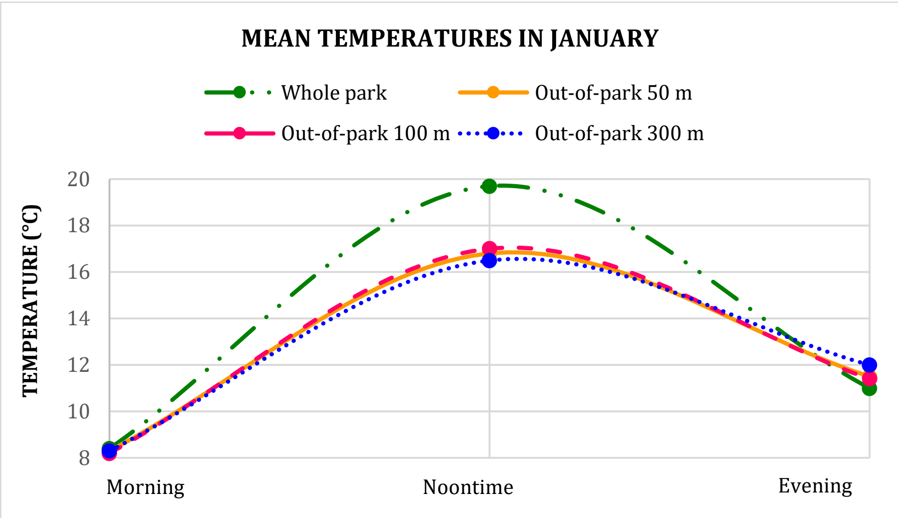

Figure 4. In-park and out-of-park mean temperatures (°C) in January.

Starting from May, the park becomes cooler than the surrounding environment. From May to November, midday temperatures of the park are lower than those of out-of-park. According to both the general climatic data of Antalya and the data measured in this study, August is the hottest month of the year, and the midday temperatures is 3.6 °C lower in the whole park than the farthest location from the park at 300 m (Figure 5). In other words, Aydın Kanza Park provides a 3.6 °C cooler environment in the hottest month of the year.

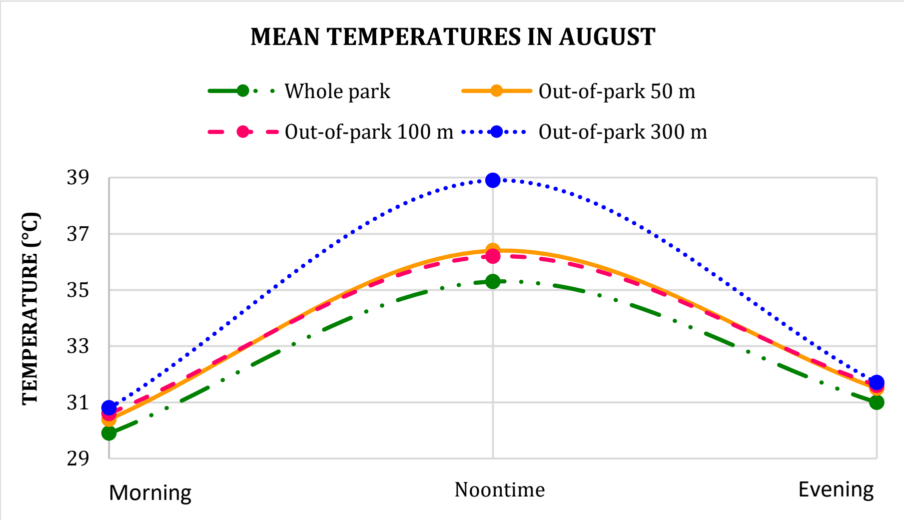

Figure 5. In-park and out-of-park mean temperatures (°C) in August.

The temperatures values according to the month, location, and hours inside and outside of the park, and their statistical analysis results were given in the Table 3.

Table 3. Average temperatures inside and outside of the park according to the month, location, and hours.

Month	Measurement Hour	Measurement Location				Measurement Hour Average	Monthly Average
		In-park	Out-of-park 50 m.	Out-of-park 100 m.	Out-of-park 300 m.		
JANUARY	07.00-08.00	8.4 C a y	8.3 C a	8.2 C a	8.3 C a	8.3 c	**12.4 k z**
	13.00-14.00	19.7 A a	16.8 A b	17 A b	16.5 A b	17.5 a	
	20.00-21.00	11 B c	11.5 B b	11.4 B b	12 B a	11.5 b	
	Meas. Loc. Average	13 a	12.2 a	12.2 a	12.2 a		
FEBRUARY	07.00-08.00	10.3 C b	10.4 C b	10.3 C b	10.7 C a	10.4 c	**15.5 j**
	13.00-14.00	21.6 A a	18.9 A b	19.7 A b	19 A b	19.8 a	
	20.00-21.00	16.6 B a	16.2 B b	16.2 B b	15.7 B c	16.2 b	
	Meas. Loc. Average	16.1 a	15.2 a	15.4 a	15.1 a		
MARCH	07.00-08.00	14.1 C c	14.5 C b	14.4 C bc	14.9 C a	14.5 c	**18.3 h**
	13.00-14.00	23.9 A a	22.5 A ab	22.7 A ab	21.9 A b	22.8 a	
	20.00-21.00	17.7 B a	17.7 B a	17.8 B a	17.9 B a	17.8 b	
	Meas. Loc. Average	18.6 a	18.3 a	18.3 a	18.2 a		
APRIL	07.00-08.00	17.5 C a	17 C ab	16.7 C b	17.2 C ab	17.1 c	**20.5 g**
	13.00-14.00	26 A a	24.9 A a	25.5 A a	24.1 A a	25.1 a	

DOI: 10.15320/ICONARP.2025.342

	20.00-21.00	18.8 B b	19.3 B a	19.5 B a	19.4 B a	19.3 b	
	Meas. Loc. Average	20.7 a	20.4 a	20.6 a	20.2 a		
MAY	07.00-08.00	23.6 C c	24.2 C b	24.2 C b	25.2 C a	24.3 c	
	13.00-14.00	30.4 A b	31.7 A ab	32 A a	31.5 A ab	31.4 a	**27.1 d**
	20.00-21.00	25.4 B c	25.6 B b	25.8 B b	26 B a	25.7 b	
	Meas. Loc. Average	26.5 a	27.2 a	27.3 a	27.6 a		
JUNE	07.00-08.00	27.9 B b	28.6 B a	28.7 B a	29.1 B a	28.6 b	
	13.00-14.00	32.2 A b	33.2 A b	33 A b	35.7 A a	33.6 a	**30.3 b**
	20.00-21.00	27.9 B c	28.7 B b	28.7 B b	29.3 B a	28.6 b	
	Meas. Loc. Average	29.3 a	30.2 a	30.1 a	31.4 a		
JULY	07.00-08.00	29.9 C c	30.8 B b	30.9 B b	31.3 C a	30.7 c	**32.8 a**
	13.00-14.00	34.8 A b	37 A a	35.8 A ab	36.6 A ab	36.1 a	
	20.00-21.00	31 B c	31.6 B b	31.8 B a	31.7 B a	31.5 b	
	Meas. Loc. Average	31.9 a	33.2 a	32.8 a	33.2 a		
AUGUST	07.00-08.00	29.9 C c	30.4 C b	30.6 B ab	30.8 C a	30.4 c	
	13.00-14.00	35.3 A b	36.4 A b	36.2 A b	38.9 A a	36.7 a	**32.9 a**
	20.00-21.00	31 B c	31.5 B b	31.6 B a	31.7 B a	31.5 b	
	Meas. Loc. Average	32 a	32.7 a	32.8 a	33.8 a		
SEPTEMBER	07.00-08.00	26.1 C b	26.1 C b	26.2 C b	26.6 C a	26.2 c	
	13.00-14.00	31.5 A b	31.9 A b	31.7 A b	32.5 A a	31.9 a	**29.4 c**
	20.00-21.00	29.7 B c	30.3 B ab	30 B bc	30.5 B a	30.1 b	
	Meas. Loc. Average	29.1 a	29.4 a	29.3 a	29.9 a		
OCTOBER	07.00-08.00	23.4 C b	23.4 C b	23.3 C b	30.8 A a	25.2 b	
	13.00-14.00	29 A b	29 A b	28.9 A b	30.9 A a	29.5 a	**26.8 e**
	20.00-21.00	25.6 B a	25.9 B a	25.7 B a	25.8 B a	25.8 b	
	Meas. Loc. Average	26 b	26 b	26 b	29.2 a		
NOVEMBER	07.00-08.00	19 C c	20.2 C b	19.9 C b	21.8 C a	20.2 c	
	13.00-14.00	27.3 A b	26.9 A b	27.1 A b	28.7 A a	27.5 a	**23.7 f**
	20.00-21.00	23.2 B a	23.4 B a	23.4 B a	23.6 B a	23.4 b	
	Meas. Loc. Average	23.2 a	23.5 a	23.5 a	24.7 a		
DECEMBER	07.00-08.00	13.2 C ab	13.3 C ab	13.2 C b	13.7 C a	13.3 c	
	13.00-14.00	21.5 A a	20.6 A ab	20.4 A b	21.5 A ab	21 a	**16,8 ı**
	20.00-21.00	15.4 B c	15.6 B bc	15.8 B b	17 B a	15.9 b	

719

	Meas. Loc. Average	16.7 a	16.5 a	16.4 a	17.4 a		
Measurement Location Annual Aver.		**23.6 b**	**23.7 b**	**23.7 b**	**24.4 a**		
Measurement Hour Annual Average							
07.00-08.00		**20.8 c**					
13.00-14.00		**27.7 a**					
20.00-21.00		**23.1 b**					
Significance *(p values)*							
Month (M):		<0.001*	[z] Different averages at 5% significance level according to Duncan test are shown by separate letters. [y]: In the sections written in italics (within each month), the uppercase letters show the comparison of the averages in the columns (each measurement hour), and the lowercase letters in the rows (at each measurement location). * It shows statistically significant p values. The underlined values in the table indicate the maximum and minimum values.				
Measurement Hour (MH):		<0.001*					
Measurement Location (ML):		<0.001*					
M x MH:		<0.001*					
M x ML:		<0.001*					
MH x ML:		<0.001*					
M x MH x ML:		<0.001*					

Table 3 shows that the differences in month (p <0.001), measurement time (p <0.001) and measurement location (p <0.001) values are statistically significant. In terms of binary interactions, the pairwise interactions between the month and measurement hour (p <0.001), the measurement hour and measurement location (p <0.001) and the month and measurement location (p <0.001) were statistically significant. Month, hour and location triple interaction (p <0.001) were also found to be statistically significant.

Monthly averages vary between 12.4 ° C and 32.9 ° C, being the highest value in August (32.9 ° C) and the lowest value in January (12.4 ° C). In terms of hourly averages, the lowest value occur in the morning hours of January (8.3 ° C) and the highest value occur at midday of August (36.7 ° C). Except June and October, the difference in temperature values of morning-noon-evening was statistically significant, being the midday values highest and the morning values the lowest. In June and October, the difference in the morning and evening temperatures was not statistically significant and was lower than the midday temperatures.

2.2. In-park and out-of-park humidity

In-park humidity values at midday were found to be lower than those of the out-of-park in the first four months of the year (January to April). According to both general climatic data of Antalya and the data measured in this study, January is the coldest month of the year and the midday relative humidity in this month is 4.1% lower than the farthest location from the park at 300 m (Figure 6). In other words, the park provides a 4.1% less humid environment in the coldest month of the year that softens the cold air felt.

DOI: 10.15320/ICONARP.2025.342

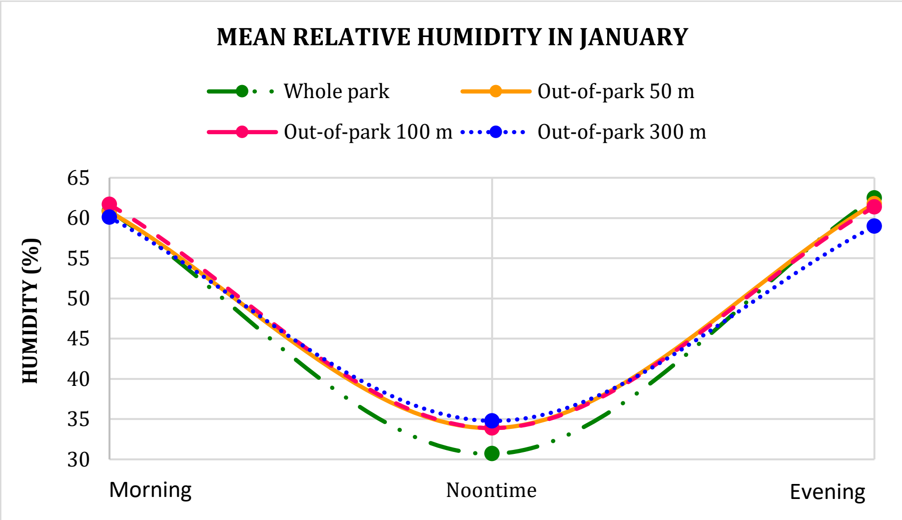

Figure 6. In-park and out-of-park mean relative humidity (%) in January.

In the following eight months from May to December, in-park humidity values are higher than the out-of-park values at all times of the day (Figure 7). In the hottest month of the year (August), the midday humidity in the park is 7.8% more than the farthest location from the park at 300 m. In other words, the park provides a more humid environment in the hottest month of the year, increasing the perceived temperature.

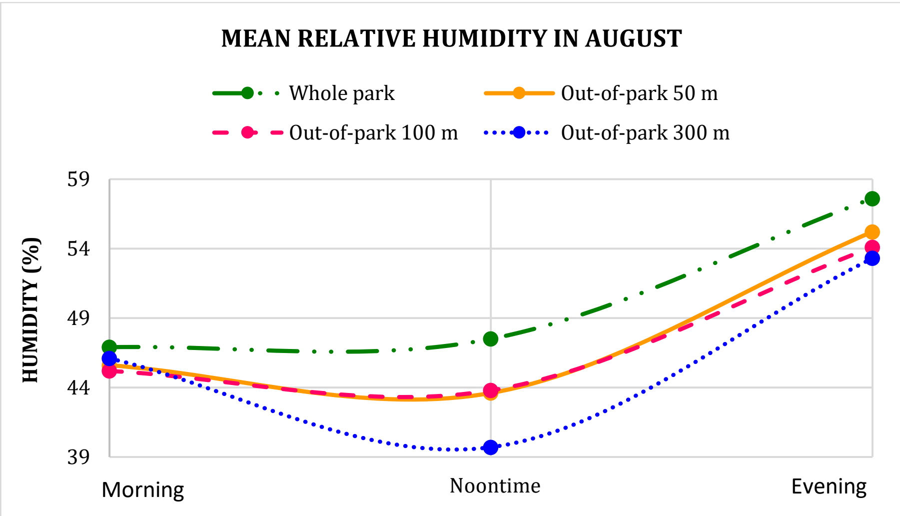

Figure 7. In-park and out-of-park mean relative humidity (%) in August.

When the in-park and out-of-park humidities are compared, it is seen that the differences in month ($p < 0.001$), measurement time ($p < 0.001$) and measurement location ($p < 0.001$) temperatures are statistically significant. In terms of binary interactions, the pairwise interactions between the month and measurement hour ($p < 0.001$), the measurement hour and measurement location ($p < 0.004$) and the month and measurement location ($p < 0.001$) were found to be statistically significant. Month, measurement hour and location triple interaction ($p < 0.001$) were also found to be statistically significant.

The monthly averages vary between 40.3% (July) and 54.4% (February). In terms of the hourly averages, it was observed that the lowest value occurred at midday in January (33.3%) and the highest values occurred in the evenings of both October and December (61.4%).

The difference in humidity values of morning-noon-evening was statistically significant from February to June as well as in August, September, November, and December, being the evening values highest and the midday values the lowest. In July and October, the difference in the morning and midday humidity values was not statistically significant and found lower than the evening humidity. In January, the difference in the morning and evening humidity values was not statistically significant and found higher than the midday humidity.

2.3. In-park and out-of-park wind speed

In-park wind speeds were found higher at 100 m. than the park and other locations at midday and in the evening in the first three months of the year (January, February, and March). In January, the wind speed difference between the park and the 100 m location reaches to 0.5 m/s at midday (Figure 8).

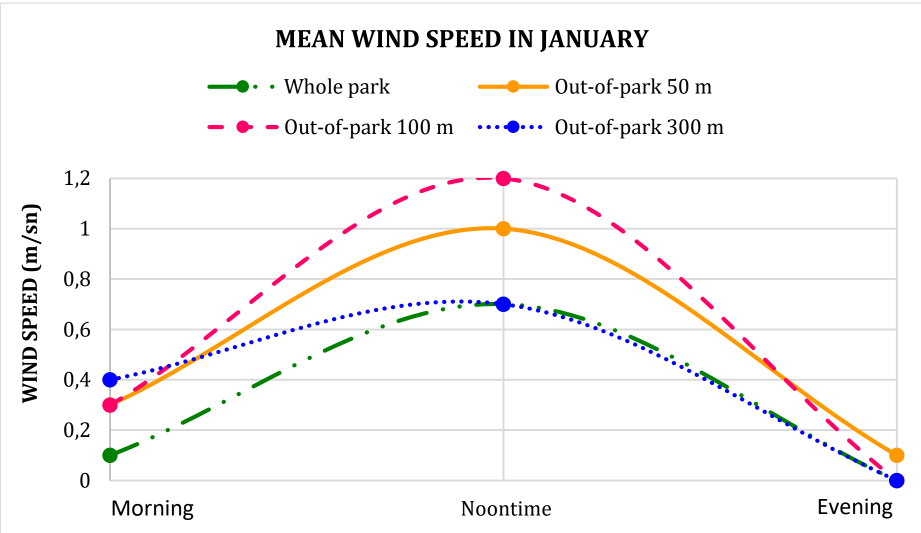

Figure 8. In-park and out-of-park mean wind speeds (m/s) in January.

The mean wind speeds measured at 100 m. are still higher than the park and other measurement locations from April to July and from September to December. The only exception is August in which the highest wind speeds were measured at 50 m location (Figure 9). In June, the wind speed difference between the park and the 100 m location reaches to 0.4 m/s at midday. In general, mean wind speeds are the lowest at 300 m. and the highest at 100 m. The results indicate that the out-of-park wind speeds are higher than the in-park wind speeds. The fact that the 100 m. location has the highest wind speeds measured is probably due to the wind corridor of a large street opening to this location.

DOI: 10.15320/ICONARP.2025.342

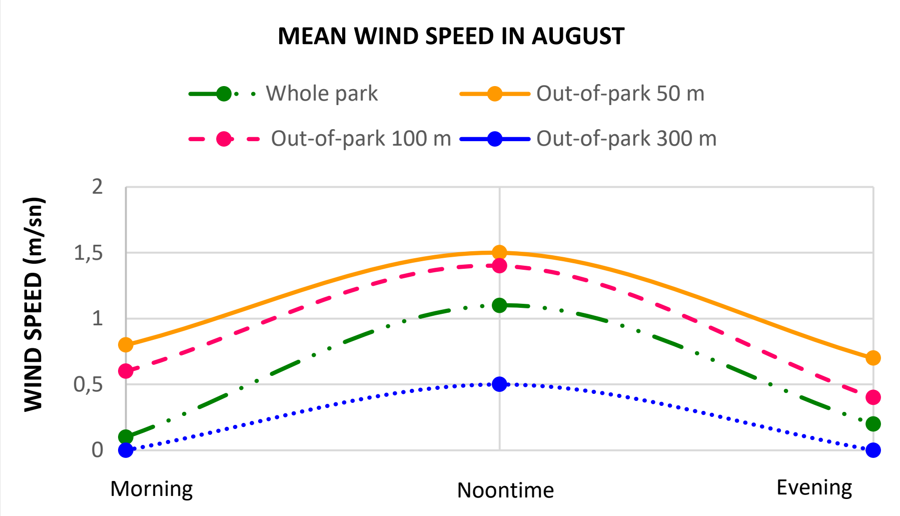

Figure 9. In-park and out-of-park mean wind speeds (m/s) in August.

When the in-park and out-of-park wind speeds are compared, it is seen that the differences in month (p <0.001), measurement time (p <0.001) and measurement location (p <0.001) values are statistically significant. In terms of binary interactions, it was determined that the pairwise interactions between the month and measurement hour (p <0.001) and the measurement hour and measurement location (p <0.004 were statistically significant while the interaction between the month and measurement location (p <0.001) was not. Month, measurement hour and measurement location triple interaction (p <0.001) were also found not significant.

Monthly averages vary between 0.2 m/s and 0.6 m/s. The highest values occurred in June with 0.6 m/s while the lowest one occurred in December with 0.2 m/s. When the wind speed data are analyzed in terms of the hourly averages, it is seen that the lowest value occurred in the evening in January (0 m/s) and the highest values occurred in the evenings of both March and September (1.3 m/s).

DISCUSSION

Scientific research has demonstrated the microclimatic contribution of urban green spaces to the quality of life in urban areas. Studies conducted in India (Jha et al., 2024) and Sweden (Eliasson & Svensson, 2003) have shown that there are temperature differences of up to 8.3 ° C and 9 ° C, respectively, between green areas and their surroundings. A study conducted in France found that the cooling effect of parks was at its maximum during the night hours (16:00-00:00) in the summer months (June-August) and that the cooling effects varied between 1 and 5 ° C (Haeffelin et al., 2024). Some studies have suggested that having more open spaces in parks provides greater cooling during the summer nights, while the presence of dense vegetation provides greater cooling during the day. Based on these findings, the 'savannah approach,' which combines grassy areas and woody vegetation, has been proposed as the optimal solution for cooling (Kraemer & Kabisch, 2022; Arzberger et al., 2024).

The cooling effect of a park was found to exceed 300 m during daylight hours in a study conducted in Nagoya, Japan (Hamada & Ohta, 2010). In Hong Kong, Cheung and Jim (2019) found that 10% increase in tree cover causes a decrease of 0.052 °C in the buffer zone with a diameter of 20 m. Studies have also found that climatic benefits are associated with the size of green spaces (Upmanis et al., 1998, Yu & Hien, 2006). The study in Gothenburg, Sweden, showed that parks with a size of 2.4 ha, 3.6 ha and 156 ha had cooling effects of 1.7 ° C, 2.6 ° C and 5.9 ° C, respectively (Upmanis et al., 1998). The study in Singapore found that two parks of 12 and 36 hectares had a cooling effect between 2.0 °C and 2.3 °C (Yu & Hien, 2006).

In the context of landscape design parameters (grass, 10 m tree, 20 m tree, hard ground, water trunk and building), studies have been conducted to show that urban green spaces can help alleviate thermal comfort (Hwang et al., 2015, Yan & Dong, 2015, Sun et al., 2017) . It has been found that the most important factor affecting the moderation of thermal comfort is tall and large deciduous trees (Sun et al., 2017; Kaçmaz Akkurt & Şemsiyeci 2024) and the shade provided by these trees is effective in lowering temperatures (Hwang et al., 2015) in an urban context. It showed that all landscape parameters in three categories, including spatial and temporal variations in air temperature and their land cover characteristics, site geometry and spatial location, can effectively improve the urban thermal environment on an annual basis (Yan & Dong, 2015). Zhu et al. (2023) conducted a study in a historical region of China where the green space presence is 46.6% and the building density is 17.8%. Two case models were created in which the amount of green space was kept constant, and the building density was increased to 29.9% (Case I), and the amount of green space was kept constant and the amount of green space was reduced to 29.1% (Case II). A thermal comfort calendar was created for the base case and two case cases. When the thermal comfort calendars of the three cases were compared, it was determined that the thermal environment of the base case was the best and the thermal environment of Case II was the worst, especially at 12:00. Yücekaya and GünAydın (2022) stated that besides the cover characteristics of green areas, plant species and planting spacings are also important. In their study, they showed that the area created by planting coniferous plants at 4 m intervals had a higher cooling effect than the area consisting of only broad-leaved plants and both coniferous and broad-leaved plants**.** In a study conducted by Tülek et al. (2024) on the ecosystem services provided by woody plants in Çankırı Urban Park, it was revealed that the identified species contribute significantly to the ecosystem in terms of climatic benefits, pollination, erosion control, recreation and education, improvement of soil and air quality, and habitat provision.

The results obtained from this study support the findings of previous research. The results revealed that Aydın Kanza Park, which is a small Mediterranean park, provides a warmer environment in the first four

DOI: 10.15320/ICONARP.2025.342

months of the year (from January to April) and a cooler environment in the following seven months (from May to November). There is a balancing in

December. The park provides a 3.2 ^{o}C warmer environment at midday in January, the coldest month of Antalya, and a 3.6 ^{o}C cooler environment in August, the hottest month of the city.

The heating effect provided by the park in the first four months is between 1.9 ^{o}C and 3.2 ^{o}C while the cooling effect it provided in the following seven months was varying between 1 ^{o} C and 3.6 ^{o}C. Average midday heating and cooling effects of the park according to the farthest location where no more climatic effect of the park is assumed were calculated as 2.4 ^{o}C and 2 ^{o}C, respectively. This indicates that the average heating effect of the park is higher than its

average cooling effect.

The results show that the heating and cooling effect provided by the park continues at a certain distance from the park. When the midday temperatures measured at 300 m are compared to those of 50 m and 100 m, it is seen that the temperatures at 50 m and 100 m are higher than those of 300 m in the first five months of the year (January to May). Five months' average warmer temperature provided by the park was calculated as 0.4 ^{o}C and 0.7 ^{o}C at 50th and 100th meters, respectively. In the meantime, the average cooling of the park in the seven months (June to December) of the year was calculated as 1.4 ^{o}C and 1.6 ^{o}C at 50th and 100th meters, respectively. These results indicate that the cooling effect of the park in its near surroundings is two to three times more than its heating effect.

The measurements in the different locations inside the park showed that there were not significant differences between the climatic values of different land covers. When we look at the average temperatures in August, which is the hottest month in Antalya, it is seen that the temperatures are equal, except for the hard grounds, which were found 0.2 ^{o}C warmer. The reason why the temperature values of locations with different land covers are so close to each other can be explained by the small size of the park (only 1 ha).

As stated before, the results obtained from this study support the findings of previous research on this subject. In their studies on some Israeli parks, Shashua-Bar and Hoffman (2000) found an average 2.8 ^{o}C cooling effect at midday in July-August. The average cooling effect of Aydın Kanza Park for the same two months was 2.7 ^{o}C, which is very close figure to that one obtained in Israel, a country in the Mediterranean region. Similarly, in a study on a Belgian city park, Toparlar et al. (2017) revealed that the park has a cooling effect of 3.05 ^{o}C in June. In Aydın Kanza Park, this value was found to be 3.5 ^{o}C in the same month. The results obtained from the Ca et al.'s (1998) study in and around a park in Tokyo are also quite similar to the results of this study, too. The temperature of the grass covered area in Tokyo Park was found to be 2 ^{o}C lower than the asphalt and concrete covered surface around the park in

August, whereas the temperature of the grass covered part of Aydın Kanza Park was found 1.8 ◦ C lower than the location covered with the concrete surface at 300 m distance. As in this study, the highest air temperature in the grass area of a park in Tokyo was measured at midday and the lowest air temperature in the morning. Relative humidity was also found to be lower at midday than in the evening as in the park in Tokyo.

The heating and cooling provided by parks at different times of the day were also investigated. Xiao et al. (2018) studied daytime temperatures in the green areas of Suzhou, China, in July. They found that the temperatures reach to the highest level between 12:00 and 14:00; that they start decreasing from 14:00 onwards; and that the cooling effect in the hottest time slot of the day is between 5.2 ◦ C and 7.3 ◦ C. In addition, they revealed that the humidification effect of parks in the hottest time slot of the day is between 20.6% and 25%. The results of Aydın Kanza Park study also showed that the temperature values reach to the highest level between 12:00 and 14:00 and start to decrease after 14:00. The cooling effect of Aydın Kanza Park was found between 1 ◦ C and 2.2 ◦ C in the hottest time slot of the day in July. The humidification effect of Aydın Kanza Park was determined between 3.7% and 4.4% in the hottest time slot of the day in July. Xiao et al. (2018) also investigated the in-park temperature differences. In Wenxing Park, the tree-covered area inside the park provided the most cooling effect, followed by the grass-covered area, the green area near the water and the hard grounds. When the results of both studies are compared, it is seen that Aydın Kanza Park provides lesser cooling environment than the parks studied in China. This can be explained by the fact that the study conducted in China covers relatively large parks, the smallest of which is two times larger than Aydın Kanza Park and that there is strong relationship between the size of the park and the cooling effect provided.

The microclimatic effects provided by the parks can also been felt up to a certain distance. In his study, Şimşek Kuşçu (2016) investigated the microclimatic effects of some parks in İstanbul, Türkiye, and found a temperature difference of 5.08 ° C at 50th m, 7.11 °C at 100th m and 7.14 °C at 150th m. In this study, considering the mean values in August, which is the hottest month in Antalya, the temperature differences were found to be 0.7 ◦ C, 0.8 ◦ C and 1.8 ◦ C at 50th, 100th and 300th meters, respectively. The results from both studies are similar in terms of relative increase from the park, but quite different in terms of figures. This could be related by the fact that Şimşek's study is based on satellite data and represents the mean temperature values of many bigger parks and that this study is based on the actual measurements in a small park.

Most studies focus solely on the cooling effect of parks, and this effect is investigated during the summer months. The first distinguishing feature of this study apart from others is that it looks at not only the cooling effect of an urban park but also its heating effect. The second distinguishing feature is that the cooling and heating effects were studied

DOI: 10.15320/ICONARP.2025.342

not only during a specific period of the year but throughout the entire year.

CONCLUSION

The results of the present study show the importance of climatic benefits provided by urban green spaces. The climatic comfort provided by city parks and other green areas is even more important in warm climates like the Mediterranean. It was concluded that the park size is an important factor for a higher climatic benefit. Small parks like Aydın Kanza still provide climatic comfort to urban dwellers to a certain extent, but that would be much higher in bigger parks. Small, isolated green areas, which are not evenly distributed in the urban fabric, will not fulfil the functions expected from them, especially in terms of providing climatic comfort and mitigating the negative effects of urban heat islands. In order for the cooling effect of different design areas in the park to be clearly distinguished from each other in the hot climate character, these areas should be designed without breaking down too much. Considering the above-mentioned criteria, it is seen that wooded areas, grass area, pond edge and hard ground area come respectively in terms of cooling. In order for a park to provide the best climatic comfort, it is important to design the wooded area as maximum and the hard ground area as minimum, to protect perennial trees, and to use species with high leaf density. In order for parks and other green areas to fully fulfil the social, cultural, ecological and climatic functions expected from them, they must be planned within a system in urban planning, in accordance with certain standards and in sufficient size, and their regular distribution in the urban texture.

ACKNOWLEDGEMENTS/NOTES

This article is produced from the master's thesis ''Parkların Mikroiklimsel Etkilerinin Aydın Kanza Parkı (Antalya) Örneğinde İncelenmesi '' conducted at Akdeniz University.

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Resume

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DOI: 10.15320/ICONARP.2025.342