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EFFICIENCY OF URBAN FORESTS AND PARKS FOR THE MITIGATION OF CLIMATE CHANGE PRESSURE ON URBAN POPULATION

The article investigates the effectiveness of urban parks and forest parks as tools for mitigating climate pressure on the population in conditions of urbanization. Based on field measurements of air temperature inside green areas and in adjacent open areas, a comparative analysis of their cooling potential was conducted. It was found that the direct difference in air temperature between park areas and dense buildings is not sharply expressed. At the same time, it was found that the key factor in microclimatic comfort is the shading effect provided by woody vegetation. It is concluded that the role of urban forestry in adapting to climate change lies not so much in reducing the overall air temperature, but in transforming the radiation regime and creating spaces for the population protected from direct insolation.

Keywords: urban forest, climate change, heat island, park microclimate, cooling effect.

Rapid urbanization, climate change and increasing anthropogenic pressure have led to a noticeable deterioration of thermal conditions in large cities. One of the most significant manifestations of these processes is the urban heat island effect, which results in higher air and surface temperatures in densely built-up areas compared to suburban and natural landscapes. Elevated temperatures negatively affect human health, increase energy consumption for cooling, worsen air quality and reduce overall comfort of the urban environment. In this context, urban green spaces play an important role by providing ecosystem services such as shading, evapotranspiration, air cooling and regulation of relative humidity. Under conditions of climate change and more frequent heat waves, the study of the microclimatic role of urban green spaces becomes particularly relevant. For Ukrainian cities, especially Kyiv, this problem is of high practical importance due to dense development, limited opportunities for expanding green areas and the need for effective climate adaptation measures.

The aim of the research was to assess the role of urban green spaces in regulating urban microclimate and to substantiate effective shading solutions for improving thermal comfort in densely built-up areas. To achieve this aim, the study of microclimatic parameters such as air temperature and relative humidity in selected urban parks and adjacent built-up areas.

Urban thermal field is known to affect greatly the quality of urban air. Since climate changes are putting on their pressure on urban thermal environment the situation is getting worse with every year. Therefore, the urban thermal environment must undergo continuous control. This is achieved through various methods, including ground-based thermometer networks, vehicle-mounted thermometers, and thermal remote sensing from satellites or aircraft. These measurements are crucial for understanding urban climate, energy balance, and the impact on human comfort and health [1].

Fixed weather stations always include temperature measurement and thus, networks of thermometers are set up across a city and provide continuous, localized data. Thermometers be also mounted on vehicles and driven along specific routes to capture temperature variations over a larger area, though this can be affected by traffic variations and time of day [2]. Remote sensing methods use satellites and aircraft, which have IR sensors and can measure surface temperature over broad areas, providing a large-scale overview of the urban heat island effect [3]. Numerical simulation – can analyze the thermal environment with math models, which can be validated against field measurements to improve accuracy [4].

A well-planned and performed thermometry can reveal limits of the urban heat island and help define its possible causes, like surface materials, lack of vegetation, heat released from vehicles, air conditioning, and industrial activity. Peculiarities of urban geometry, like "canyon effect", contributing to urban heat island, can also be visualized [5].

So, to collect data about the role of urban forests and parks in mitigating climate change effects, nine parks were chosen in Kyiv for thermometry: Nyvky, Syretsky, Bahryany, KPI Park, Fomin Botanical Garden, Shevchenko Park, Vidradny, Orlyatko and Suputnyk. The selection of these green areas was done by the following parameters:

1. Absence of large water bodies – the presence of lakes, ponds or rivers can significantly change microclimatic conditions – in particular, affect air temperature, humidity and the rate of soil cooling during the day. Since the main task of the study was to assess the impact of vegetation on the parameters of the urban microclimate, water bodies could become an additional uncontrolled factor distorting the results.

2. Size and compactness of the territories – relatively small size of the urban forests and parks were chosen to enable the conduction of a full cycle of temperature and humidity measurements at all points of the route without significant changes in weather conditions. This is especially important, because the temperature and humidity characteristics of the air can change even within an hour, and too large parks would complicate the comparability of the results obtained. Moreover, small parts and residual forests are more common in cities than big integral masses of forest and therefore these smaller sites are to carry the burden of cooling in cities.

3. High attendance and social significance – green spaces attracting large number of residents every day will have the greatest impact on the comfortable existence of citizens and shape their perception of the quality of the urban environment. The study of the microclimate of such parks allows us to draw conclusions that will be most relevant for practical decisions in the field of urban planning and the creation of comfortable conditions for the population.

4. Geographical location and diversity of the urban environment – parks from the central part of the city and residential areas were chosen. This made it possible to compare the microclimatic features of green areas surrounded by different types of development: from densely built-up quarters to more open residential areas. This approach helped to find out to what extent the influence of the surrounding infrastructure (tall buildings, transport arteries, industrial facilities) affects the ability of parks to regulate air temperature and humidity.

Thus, the nine selected parks are an example of characteristic urban green zones of Kyiv, which most clearly reflect the effect of vegetation on the urban microclimate. Their study allows not only to compare the effectiveness of different green spaces, but also to obtain data that can be used to justify decisions on expanding and optimizing the network of green spaces in the process of further development of the city.

For each park chosen the points and routes for filed measurements were set. The routes were planned as linear pathways, which reflect the real structure of the parks and the usual paths of movement of visitors as much as possible. The main principle was to cover those parts of the territory that are most actively used by people: central alleys, main walking paths, recreation areas with benches, playgrounds and open lawns. It is in such places that people have the greatest contact with the park microclimate, so the data collected there are of direct practical importance.

Additionally, it was taken into account that the points recorded different types of landscape design: open lawns, areas with dense tree plantations, alleys with a regular arrangement of trees. This allowed us to obtain a comparative picture of the influence of different degrees of shading and density of green spaces on microclimatic parameters.

To evaluate the cooling efficiency of parks and forest parks, it is necessary to determine reference (control) observation points. Their correct location was of key importance, since they reflected the conditions of typical urban development without the influence of vegetation.

The reference points were selected within a 10-minute walk from each of the studied parks to ensure the most similar meteorological conditions during simultaneous measurements and to eliminate the influence of distance. This approach allowed comparing temperature and humidity indicators under the same weather conditions and within the same local climatic region.

The main selection criteria were: absence of green spaces, presence of dense urban development and openness to the sun. Thus, the data obtained provide a clear contrast between the microclimate of the parks and the conditions of the surrounding urban development. This allowed us to objectively assess the impact of green spaces on reducing air temperature and increasing relative humidity, as well as to quantitatively confirm the role of parks as key regulators of the thermal regime in the urban environment.

Field measurements were carried out during two summer months – July and August 2025, which corresponds to the period of the most intense manifestation of the urban heat island effect. It is at this time that the highest average daily temperatures and the greatest solar radiation are observed, which makes the results most indicative for assessing the impact of green spaces on the microclimate.

Measurements were carried out using a portable device for simultaneous measurement of temperature and relative humidity from 12:00 to 16:00, that is, during the period of the highest surface warming and peak air temperature values. This choice of time allows us to most clearly identify the difference between the indicators in parks and in adjacent urbanized areas, since it is during this period that the contrast between "green oases" and built-up areas is most pronounced.

The periodicity of measurements and adherence to a stable time-of-day regime ensured the comparability of the obtained data, and also provided the opportunity to trace the constancy of the identified patterns throughout the entire summer research season.

Field measurements revealed consistent seasonal patterns in air temperature, relative humidity, and the overall cooling capacity of green areas. Across all nine parks, similar microclimatic dynamics were observed, reflecting both natural seasonal processes and the influence of vegetation on local atmospheric conditions. Despite the clear seasonal shift (the closer the autumn is, the lower the thermal stress is. At the same time the presence of green spaces noticeably moderated extremes in temperature – humidity ratio: naturally the dependance is opposite, but the presence of greenery prevented losses of moisture or provided this moisture itself.

On average, all parks provided a temperature reduction of 1–3 °C relative to adjacent built-up areas. In some locations, particularly parks with dense tree canopies such as Nyvky, Syretsky, and Vidradny, temperature differences exceeded 3 °C on the hottest days. Relative humidity within parks was generally 5–15% higher than in the surrounding urbanized environment.

The strength of the cooling effect decreased in August and early September: in many cases, reference temperature differences approached zero or even became negative, meaning that the temperature inside the parks was occasionally higher than in adjacent built-up areas. This phenomenon indicates the gradual evening-out of the city's microclimate at the end of summer.

The results demonstrate that urban green spaces significantly mitigate heat stress in the city during summer months by lowering air temperature and increasing humidity, thus improving thermal comfort. Although the magnitude of this effect varies among parks, all studied green areas act as localized "cooling zones" within densely built urban districts.

Overall, the study confirms that the preservation and expansion of green spaces is essential for improving microclimatic resilience, reducing heat stress, and ensuring long-term urban sustainability in the context of rising temperatures and increasing urbanization.

References

1. Fang, Z., He, H., Mao, Y., Feng, X., Zheng, Z., & Guo, Z. (2023). Investigating an accurate method for measuring the outdoor mean radiation temperature. International Journal of Thermal Sciences, 188, 108219.

2. Zeynali, R., Bitelli, G., & Mandanici, E. (2023). Mobile data acquisition and processing in support of an urban heat island study. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 563-569.

3. Rodríguez, M. V., Melgar, S. G., & Márquez, J. M. A. (2022). Assessment of aerial thermography as a method of in situ measurement of radiant heat transfer in urban public spaces. Sustainable Cities and Society, 87, 104228.]

4. Segura, R., Krayenhoff, E. S., Martilli, A., Badia, A., Estruch, C., Ventura, S., & Villalba, G. (2022). How do street trees affect urban temperatures and radiation exchange? Observations and numerical evaluation in a highly compact city. Urban climate, 46, 101288.].

5. Boiné, K., Demers, C. M., Parsaee, M., & Potvin, A. (2023). Visualization of urban heat and light at the pedestrian level. International Journal of Urban Sciences, 27(2), 301-321.].