# THE INFLUENCE OF WOODLOTS ON THE PHOTOCLIMATE OF GREEN AREAS AND THE QUALITY OF RECREATION

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**Abstract**
The quality of people's recreation in urban green areas (parks, municipal forests etc.) is remarkably influenced by the availability of sunlight. Especially the intended shaping of woodlots (landscape architecture) can have a very positive local impact on the sense of thermal comfort, diversified sun exposure, etc. The appropriate tree cover can regulate the degree of insolation of the site in the daily and seasonal aspects. The optimal structure of tall green forms (e.g. spatial and age structure, species composition) is the condition to achieve it. Due to the proper spatial arrangement of trees, it is possible to expose places that should be in full sun, keeping other areas in the periodic partial shade. The desired solar exposure can also be obtained by the selection of tree species (tall, low, broadly branched, columnar, etc.), the proper planting density and the distribution of trees regarding other forms of land development (topography, water system, road layout, buildings, etc.). Tree stands with a luminous, loose and airy structure have particular recreational and hygienic values. During recreation in a bright tree stand of parks and forests, the availability of sunlight has long been recognized as having great health-promoting importance due to the increased natural possibility of skin synthesis of vitamin $D_3$ (the so-called "sun vitamin"). Also, with the favourable availability of solar radiation, the therapeutic impact of urban green areas becomes significant, especially during the COVID-19 pandemic.

**Key words:** Parks and municipal forests, recreation, vitamin $D_3$, sun light, luminous stands and woodlots

## Introduction
The quality of places and areas for leisure depends mostly on natural factors (biotic and abiotic), which can significantly contribute to the stimulation or limitation of the human body's feeling of so-called comfort or "well-being". This synthesis of physical, chemical, biological and meteorological stimuli can be defined as the bioclimate. The concept of bioclimate is closely linked to recreation. Hence "recreation bioclimate" should be interpreted as the set of biological variables acting on the quality of recreation, among which greenery, especially trees, is an essential factor. Depending on the area covered and the ecological diversity, tree stands (e.g. in the park) can significantly modify the bioclimatic conditions locally and in neighbouring areas. The decisive factor, in this case, is the structure of tall greenery (spatial, species-specific) achieved by long-term landscaping and nurturing - visually appealing and ensuring favourable recreational bioclimatic conditions, i.e. optimal solar and thermal conditions, air circulation, air composition, etc. The main goal of the publication is to show some chosen aspects of photo-climate inside stands and woodlots concerning the hygiene of the recreation in parks.

## Material and methods
The general goal of shaping and maintaining woodlands and stands in big parks worldwide is strongly connected with the requirements of broadly defined recreation. To follow this goal, the literary review and observations were conducted in chosen reference sites in Europe. The authors present general links between the shaping of the structure of park stands and their potential to provide optimal conditions for the people's recreation. This publication mainly focuses on evaluating solar conditions inside tree stands and the health needs of people in relation to the availability of sunlight during recreation in parks. Conclusions show the vital connection between the favourable availability of solar radiation in urban green areas and its therapeutic impact on the population's health.

## Results
Recent studies confirm that urban green spaces with lush vegetation (e.g. parks, municipal forests, woodlots, etc.) have a remarkably beneficial effect on human health (soma and psyche). Hight self-esteem and life satisfaction, subjective feelings of happiness and easing social tensions are

significantly related to the quality of green spaces [Kuo & Sullivan, 2001, Qing Li, 2010; Dadvand *et al.*, 2015; Derks *et al.*, 2020; Slater, 2020; Soga *et al.*, 2020; Venter *et al.*, 2020; Murray, 2021].
Literature analysis and in-situ research conducted by the authors (several countries in Europe) reveal interesting facts regarding the vital role of shaping tree stands in parks for the quality of recreation. It appears that park tree stands with loose, non-schematic structures are not only visually attractive (referring to the landscape style in garden art). At the same time they present potentially high environmental values and allow to achieve remarkable recreational comfort - Figure 1. [Łukaszkiewicz *et al.*, 2018; Łukaszkiewicz *et al.*, 2018a; Łukaszkiewicz *et al.*, 2018b; Łukaszkiewicz, 2019].

Fig. 1: Luminous, loose woodlots with a canopy cover of max. 40% of the total area creates favourable conditions for recreation and relaxation (bioclimate, thermal comfort). A pine grove on the grounds of Villa Borghese, Rome. Visible passive recreation on the grass under the canopy [photo J. Łukaszkiewicz, 2015]

Although the composition of woodlots with the features of a landscape style (urban and suburban parks, municipal forests) aims to create a picturesque landscape and thus achieve a high aesthetic comfort, the resulting spatial arrangements can be highly comfortable in terms of bioclimatic conditions. Skilful use of various forms of tall greenery in the landscape composition (from compact massifs and clusters, through loose groves to separate forms (groups, clumps) and single trees, displayed in vast, illuminated garden interiors, allows to obtain refined scenery (micro landscapes), included in brightly shaped stands. Especially extensive border zones of such tree stands are beneficial due to bioclimatic conditions and increased biodiversity. The recreational durability there may be improved thanks to skilful planning of spatial structure and species selection. Hence, parks in a landscape style (or those composed to this style in terms of composition) are still trendy not only because of their historical and aesthetic values but also because they remain places of outstanding recreational value, primarily because of the good accessibility of the **sunlight** [Łukaszkiewicz *et al.*, 2018; Łukaszkiewicz *et al.*, 2018a; Łukaszkiewicz *et al.*, 2018b; Łukaszkiewicz, 2019, Fortuna-Antoszkiewicz & Łukaszkiewicz 2021; Bamwesigye *et al.*, 2021].
High greenery can significantly modify the bioclimatic conditions locally and in neighbouring areas depending on the surface size and ecological diversity. In such a case, the greenery structure has got the decisive significance (spatial structure, species structure, age structure) obtained through long-term shaping and maintenance - visually attractive and ensuring optimal light and thermal conditions, ventilation, atmospheric air composition, etc. [Łukaszkiewicz *et al.*, 2018; Łukaszkiewicz *et al.*, 2018a; Łukaszkiewicz *et al.*, 2018b; Łukaszkiewicz, 2019, Murray, 2021].
The therapeutic impact of urban green areas becomes significant - especially during the COVID-19 pandemic - becomes even more apparent when the favourable availability of solar radiation is taken into account [Fortuna-Antoszkiewicz & Łukaszkiewicz 2021; Bamwesigye *et al.*, 2021].
Luminous stands of parks or urban forests with a loose canopy can provide the increased natural possibility of skin synthesis of vitamin $D_3$ (the so-called "sun vitamin"), which is of great health-promoting importance. It is essential, especially when in economically developed countries (e.g. Europe), the so-called "computer generation" (children and adolescents) spent minimal time outdoors, getting little contact with daylight and sun rays. [Webb *et al.* 1988; Wacker & Holick, 2013; Łukaszkiewicz, 2015].
The same is happening among a large part of the adult population due to office / remote work (extended stay indoors) - significantly intensified during the periods of "lockdown" introduced due to the COVID-19 pandemic.

A well-known fact is that staying in the green surroundings allows proper exposure of the human body to solar radiation (ultraviolet B radiation (UVB) - wavelength of 280-315 nm) stimulates the cutaneous synthesis of vitamin $D_3$ in epidermal cells (keratinocytes). It is estimated that skin synthesis can cover 80 - 100% of the daily requirement of the human body for vitamin D. Today it is also known that both the geographical latitude (the angle of the sun's rays), the time of year, time of day and weather conditions have a significant impact on the quality of skin synthesis of the "sun vitamin". For example, in Europe (areas located north of the latitude 30°N), from October to March, skin synthesis of vitamin $D_3$ is ineffective due to inadequate light conditions. In addition, cloud cover and air pollution may temporarily reduce the availability of UVB radiation [Wacker & Holick, 2013; Łukaszkiewicz, 2015].
Among the inhabitants of Central Europe (e.g. Poland), the skin synthesis of vitamin $D_3$ may be effective only from spring to early autumn (from mid-March to the second half of September), between 10:00 - 15:00 (approx. seven hours during the day), that is, in the season and time of the day, ensuring the right angle of sunlight, air temperature conducive to sunbathing and in the predominantly cloudless weather. Under these conditions, exposure of at least 18% of the body surface (i.e. exposed face, neck, forearms, and calves) for approximately 15 min. should provide half of the minimum daily dose of vitamin D for the body [Webb *et al*,. 1988; Wacker & Holick, 2013; Łukaszkiewicz, 2015].
On a social scale, the importance of an adequate vitamin D supply cannot be overestimated - especially during the COVID-19 pandemic. Presently, the "sun vitamin" is regarded as an essential but not a sufficient factor for the proper functioning of the human body's vital physiological pathways of cells. Vitamin D is considered the "enabling" factor: it must be present to enable the physiological processes, but its presence is insufficient to stimulate or trigger them. Therefore the low level of vitamin D supplementation is not a cause of pathology or dysfunction, but it impairs the cellular response to the internal or external stimuli. Hence, vitamin D deficiency is inevitably associated with several pathologies and dysfunctions and increased susceptibility to viruses [Cheng *et al.*, 2003; Baggerly *et al.,* 2015; Holick, 2017; Charoenngam *et al.,* 2019; Pludowski *et al.,* 2019; Charoenngam & Holick, 2020].
For example, in Poland, vitamin $D_3$ deficiency is shared among the studied sub-populations of children, adolescents, adults and seniors. Although the situation improves in the spring and summer months due to exposure to the sun, people's predominant lifestyle and work in cities prompt the consideration of using preventive or intervention strategies to improve the overall health situation, especially during the COVID-19 pandemic [Pludowski *et al.,* 2014; Łukaszkiewicz, 2015; Pludowski *et al.,* 2016; Rusińska *et al.,* 2018; Zemb *et al.,* 2020; Charoenngam *et al.,* 2021].

**Discussion and Conclusions**

The civilization changes in the lifestyle of city dwellers translate into a strongly felt socially - specific for each epoch and time - need for recreation and leisure [Huizinga, 1985]. Currently, also because of the post-pandemic period (COVID-19), it is of great importance to provide high-quality recreational green areas (for everyday and holiday recreation), most often close to places of residence due to the intense pace of life and increasing communication difficulties [Ewing *et al.,* 2008; Canales *et al.,* 2017; Łukaszkiewicz *et al.* 2018a,b; Łukaszkiewicz *et al.* 2021].
The recreational importance of urban parks and forests is connected exceptionally with tall green. Trees can significantly stimulate the feeling of the so-called comfort ("well-being") and influence the "*recreational bioclimate*" ment as a whole of biological factors determining the quality of recreation. Depending on the size of their area and ecological diversity, tree plantings can significantly modify the bioclimatic conditions locally and in neighbouring areas. In such a case, the greenery structure has the decisive significance (spatial layout, species structure, age structure) obtained through long-term shaping and care - visually attractive and ensuring optimal sunlight and thermal conditions, ventilation, atmospheric air composition, etc.
As shown earlier, **sunlight** is essential for the quality and hygiene of rest for people staying in green areas (parks, communal forests). In particular, the targeted shaping of trees (landscape architecture) can have a local very positive effect on sun exposure and the perception of thermal comfort, which determines the quality of rest in a given site. Appropriate woodlot shaping can regulate the degree of insolation of a given area. The prerequisite, however, is the optimal structure of tall green forms (e.g. spatial structure, age structure, species composition). Due to the appropriate spatial structure of tall forms of greenery, it is possible to expose places that should be in full sun, keeping other areas in periodic shade. The desired solar exposure can also be obtained by selecting tree species (tall, low, broadly branched, columnar silhouettes) and the appropriate planting density and the way of arrange trees in relation to other forms of land development (topography, water system, road layout, buildings, etc.).

Our research shows that park tree stands with a less dense, non-schematic structure formed towards achieving high recreational comfort at the same time are beneficial in terms of their favourable availability of solar radiation and its therapeutic impact. During recreation in a luminous stand of parks and forests, the availability of sunlight has long been recognized as having great health-promoting importance.

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**Souhrn**
Kvalita rekreace lidí v městské zeleni (parky, městské lesy atd.) je výrazně ovlivněna dostupností slunečního světla. Zejména záměrné tvarování lesních ploch (krajinářská architektura) může mít velmi pozitivní lokální vliv na pocit tepelné pohody, diverzifikované oslunění apod. Vhodný stromový porost může regulovat míru oslunění lokality z denního i sezónního hlediska. Optimální struktura forem vysoké zeleně (např. prostorová a věková struktura, druhová skladba) je podmínkou k jejímu dosažení. Díky vhodnému prostorovému uspořádání stromů je možné oslunit místa, která by měla být na plném slunci, a ostatní plochy ponechat v pravidelném částečném stínu. Požadovaného oslunění lze dosáhnout také výběrem druhů stromů (vysoké, nízké, široce rozvětvené, sloupovité atd.), vhodnou hustotou výsadby a rozmístěním stromů s ohledem na další formy zástavby (topografie, vodní systém, uspořádání komunikací, budovy atd.). Stromové porosty se světlou, rozvolněnou a vzdušnou strukturou mají zvláštní rekreační a hygienické hodnoty. Při rekreaci ve světlém stromovém porostu parků a lesů je již dlouho uznávána dostupnost slunečního světla, které má velký zdravotně-propagační význam díky zvýšené přirozené možnosti syntézy vitaminu D3 (tzv. "slunečního vitaminu") v kůži. Rovněž při příznivé dostupnosti slunečního záření se terapeutický vliv městské zeleně stává významným, a to zejména v období pandemie COVID-19.

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