The layered urban fabric of Beijing, where the expansion of multi-level municipal roads reflects accelerating urbanisation and squeezed green spaces (image by Yanhan Li, 2025).

LANDSCAPE
REVIEW

Cooling strategies using thermal alliesthesia: a complementary approach to enhancing greenway walking comfort

Yanhan Li, Liang Li, Wenqing Wang, Lanxi Yang and Gillian Lawson

A favourable thermal environment along urban greenways supports public health and sustainability. In dense built-up areas, limited land availability makes it difficult to rely solely on high-quality green spaces for continuous greenway development. Planners are attempting to increase tree canopies along municipal roads, even under less than ideal conditions. The key challenge is how to improve thermal comfort for those walking along these road corridors. Combining a literature review and field investigation, this paper introduces thermal alliesthesia as a perspective that complements physical design. Existing strategies to improve thermal comfort in greenways focus on enhancing static environmental quality. In contrast, 'thermal alliesthesia' emphasises how changing subjective perception can shape thermal experience. The thermal alliesthesia effect can be triggered by variations in the physical environment. Taking Beijing's Second Ring Road Greenway as a case study, this paper proposes route planning and landscape design for urban greenways as strategies to elicit this effect. It describes the detailed design of a representative section of the greenway to demonstrate how this concept can be applied. This approach is adaptable across climate zones, provided designers develop flexible, site-specific solutions. The findings offer practical insights for greenway planning and design in complex urban contexts.

Yanhan Li is a PhD candidate at Beijing Forestry University, PO Box 100083, Beijing 100083, China.
Telephone: +86 152-9553-5935
Email: liyanhan@bjfu.edu.cn

Liang Li is Professor at Beijing Forestry University.
Telephone: +86 138-1009-4918
Email: liliang@bjfu.edu.cn

Wenqing Wang is a PhD candidate at Beijing Forestry University.
Email: wenqingwang@bjfu.edu.cn

Lanxi Yang is a master's student at Beijing Forestry University.
Email: ylx2000fjyl@bjfu.edu.cn

Gillian Lawson is an Associate Professor in the School of Landscape Architecture at Lincoln University, PO Box 85084, Lincoln 7647, Aotearoa New Zealand.
Telephone: +64 3-423-0461
Email:
Gillian.Lawson@lincoln.ac.nz

KEY WORDS
urban greenways; thermal comfort; thermal alliesthesia; greenway planning and design; urban built-up areas

Citation: Li, Y.; Li, L.; Wang, W; Yang, L; Lawson, G. (**2025**) Cooling strategies using thermal alliesthesia: a complementary approach to enhancing greenway walking comfort. *Landscape Review*, 21(2), pp 58–71.
Received: 10 June 2025
Published: 29 October 2025

Introduction

Climate change and heatwaves have become pressing issues globally. Human activities are major contributors to the urban heat island (UHI) effect (Grimmond, 2007), particularly through vehicle emissions and heating, ventilation and air conditioning systems (Chen et al, 2019; Hsieh, Aramaki and Hanaki, 2007; Ribeiro et al, 2021). In response, key strategies to mitigate the UHI effect have focused on reducing reliance on motor vehicles for short trips and minimising heat generated by inefficient air conditioning (Caprì et al, 2016; City of Los Angeles, 2019; Ruefenacht and Acero, 2017). In this context, outdoor walking is increasingly recognised as an effective measure to alleviate urban heat. It is promoted as an important form of non-motorised transport in the United Nations Environment Programme's (2021) *Sustainable Cooling Handbook for Cities*.

Greenways, as linear corridors connecting dispersed green spaces in urban areas, provide important locations for walking (Horte and Eisenman, 2020; K Liu et al, 2016). In particular, as accessible and low-cost locations for walking, greenways can help mitigate social disparities in opportunities for physical activity (He et al, 2021). Accordingly, in China, the development of urban greenways is actively promoted to enhance the public health benefits available through walking.

Environmental quality significantly influences walking behaviour (Qiao and Yeh, 2023), with thermal conditions playing a critical role in people's decisions for or against walking (Audate, Romaric Da and Diallo, 2024; Baobeid, Koç and Al-Ghamdi, 2021). However, in major Chinese cities, the scarcity of land resources makes it challenging to develop greenways on land with desirable landscape and ecological functions, leading planners to repurpose existing municipal roads for greenway construction (Z Liu et al, 2019). For example, in the high-density city of Shenzhen, 56.5 per cent of greenways consist of public infrastructure such as footpaths, trails and motorised roads (ibid), meaning greenways in urban built-up areas often alternate between renovated road segments and high-quality green spaces such as parks. In other high-density cities such as Singapore and New York, urban greenway projects have shown that integration with existing infrastructure is feasible (Gan, 2017; TJ Zhang and Li, 2013), underscoring the importance of prioritising environmental quality during renovation. Realising this potential calls for strategies that meet traffic efficiency requirements while also achieving urban greening and thermal comfort goals.

Currently, many countries and regions have developed policy responses to urban heat. In the Asia–Pacific and Oceania region, northern Australian cities such as Brisbane, Darwin and Cairns face significant heat exposure risks and challenges to walking comfort. Australia has developed a number of action guidelines to address urban heating over the past decade (Osmond et al, 2017; Western Sydney Regional Organisation of Councils, 2021). In recent years, Aotearoa New Zealand has also focused on urban cooling and climate change, adopting several related policy measures (Auckland Council, 2020). These strategies provide comprehensive solutions, such as land use, landscape design, and urban energy consumption.

In urban planning and design, widely adopted heat-mitigation strategies include modifying vegetation, urban geometry, water features and surface materials to achieve certain positive outcomes (Osmond et al, 2017; Western Sydney Regional Organisation of Councils, 2021). Current strategies to improve the thermal environment of greenways primarily focus on optimising landscape design and recommending appropriate times to use them. However, even though walking is a linear, dynamic process, current strategies tend to treat greenways as static and singular spaces. Moreover, due to spatial constraints, existing recommendations for optimising greenways may not apply readily to already constructed greenways in high-density urban areas. In this context, the concept of the 'thermal alliesthesia' effect provides a valuable supplementary perspective, with its emphasis on enhancing thermal comfort by enriching people's dynamic perceptual experience when they are walking.

Pedestrians moving through urban environments experience varying microclimatic conditions, such as changes in wind, solar radiation, and shading. These variations create a more complex thermal experience than stationary activities (J Li, Niu and Mak, 2022; Zhao et al, 2024). While traversing different microclimates, pedestrians experience diverse thermal perceptions and trigger physiological adaptation over short periods (Dzyuban et al, 2022). Moreover, they may experience the 'alliesthesia' effect, subjectively perceiving thermal overshoot before they adapt physiologically (J Li, Niu and Mak, 2023). Research on thermal alliesthesia by Richard de Dear's team at the University of Sydney has provided important theoretical foundations for such applications. The alliesthesia effect associated with transient thermal perception in non-steady-state thermal environments is currently being investigated (Huang et al, 2020). It has been recognised that this phenomenon has the potential to improve walking thermal comfort.

Accordingly, this paper first summarises recent research on enhancing greenway thermal comfort, and then reviews the concept and development of the thermal alliesthesia effect. Using the Beijing Second Ring Road Greenway as a case study, this paper explores strategies for applying this effect to improve thermal experiences while walking in urban greenways. It also describes the design of a representative section of the greenway to demonstrate how this effect can apply in practice. Finally, the paper discusses the potential of the thermal alliesthesia effect in improving the thermal comfort of walking across different regions.

Approach

This paper reports on a study that began with a review of the literature on research into greenway thermal comfort and the thermal alliesthesia effect in building environments. The second part of the study involved a field investigation of the Second Ring Road Greenway in Beijing. Experiential surveys were carried out on 14 selected days in summer, late spring and early autumn from 2022 to 2025. These seasons were chosen as they represent periods of high heat exposure and were most relevant for studying thermal conditions for walking. The survey was conducted at times when pedestrian activity was at its peak, mainly during daylight hours. The surveys covered the full walking route and its connected open spaces to document spatial characteristics and user behaviours. Mapping techniques were then applied to show the current features of the greenway and identify potential areas of concern. Finally, targeted optimisation strategies were proposed based on the thermal alliesthesia effect.

Findings and insights

Current research for enhancing greenway thermal comfort

Scholars have extensively examined factors promoting the use of greenways and strategies to improve them, focusing on connectivity (Z Li et al, 2024; B Xie et al, 2023;), the built environment (He et al, 2021) and amenities (Chi and Lin, 2019). In comparison, thermal comfort has received far less attention.

Existing studies mainly emphasise the role of meteorological factors in thermal comfort while walking and they suggest corresponding design strategies. Li Li and colleagues (2013) explored the impact of 16 surface-material and environmental combinations in Guangzhou's greenways. Their results showed that water-permeable brick, tile, arbours and water were effective for cooling greenways. Later, Lin Liu and colleagues (2022) evaluated the effects of tree density and roadway width on greenway microclimate using ENVI-met simulations and proposed corresponding design strategies. Yuankui Li and colleagues (2024) examined thermal comfort while people were undertaking mild activity in shaded spaces outdoors in hot regions. Based on their finding that thermal stress on greenways was higher during the day and comfort improved at night, the researchers recommended evening use of greenways.

However, these strategies face limitations in urban built-up areas. For example, it is not always feasible to modify footpath widths or adjust tree density along existing municipal roads. Users who rely on greenways for last-mile commuting may lack the flexibility to choose their walking times and may consequently be exposed to higher thermal stress during hotter periods of the day. In addition, current urban planning and design approaches for greenways may pay insufficient attention to how environmental variations influence the walking experience within linear spaces. Therefore, further development of current strategies is needed to better guide planners on effective ways of converting municipal roads into greenways.

The concept and research progress of the thermal alliesthesia effect

Cabanac (1971) coined the term 'alliesthesia', derived from the two words 'esthesia' (referring to sensation) and 'allios' (meaning changed), as a way to describe a shift in sensory pleasure. In the field of the built environment, 'thermal alliesthesia' describes the phenomenon in which an individual already experiences a deviation from their thermal set point, and external thermal stimuli either correct that deviation so that the individual perceives it as pleasurable (positive alliesthesia) or exacerbate the deviation so that the individual perceives it as unpleasant (negative alliesthesia) (Huang et al, 2020; Lai et al, 2020). These studies address variations in thermal perception due to meteorological stimuli such as temperature and wind speed (J Li et al, 2022; Zhao et al, 2024), and the changes in thermal comfort resulting from variations in thermal sensation (S Liu et al, 2021).

Research on this phenomenon began in indoor thermal environments. Richard de Dear's research group systematically studied the physiological and psychological mechanisms of thermal alliesthesia induced by thermal variations (de Dear, 2011; Parkinson, 2016; Parkinson and de Dear, 2017; Parkinson, de Dear and Candido, 2016; Schweiker et al, 2020). Building on this work, they proposed a personal environmental control (PEC) system that applies this phenomenon to interior spaces, aiming to enhance occupant satisfaction while reducing energy consumption (Parkinson, 2016).

Outdoors, current studies primarily focus on characterising changes in thermal perception during dynamic activities in urban open spaces, where microclimatic conditions fluctuate frequently (J Li, 2022; S Liu et al, 2021; Y Zhang et al, 2020). Some of these studies consider thermal alliesthesia during walking activities (J Li et al, 2023; Peng et al, 2022; Vasilikou and Nikolopoulou, 2020; Y Xie et al, 2022). The main aims of such research are to confirm that thermal alliesthesia occurs and to assess its impact on thermal comfort and people's willingness to exercise outdoors. These studies are typically conducted along a continuum of urban settings with complex variations, such as streets, waterfronts and campuses, including both outdoor and semi-outdoor spaces (Dzyuban et al, 2022; J Li et al, 2023; Peng et al, 2022).

Studies show that variable thermal exposures can improve thermal comfort while walking (Dzyuban et al, 2022; J Li et al, 2023). The research of Dzyuban and colleagues (2022) in a hot desert climate provided strong evidence of thermal alliesthesia, with spikes in pleasure ratings triggered by minor reductions in physiological equivalent temperature (PET). The most significant changes in thermal perception occurred at microclimatic transitions, rather than at extreme temperatures. Similarly, a climate chamber study simulating outdoor conditions revealed that the instantaneous thermal sensation significantly decreased for individuals moving from prolonged sunlight exposure to shade, compared with the experience of those remaining continuously in the shade (Zhao et al, 2024). Peng and colleagues (2022) found that, despite the average air temperature along urban walking routes being 3 degrees Celsius higher than in suburban areas, individuals reported feeling less thermally bored and more willing to remain for longer in the inner city. The researchers attributed this finding to the more frequent occurrence of thermal alliesthesia effects from cooling and warming transitions.

These findings indicate that an individual's subjective thermal perception is shaped by comparisons with prior experiences, and the overall thermal experience throughout a walk is shaped by the accumulation of successive transient thermal perceptions. Therefore, consciously creating frequent thermal alliesthesia offers a promising strategy for enhancing the thermal experience of walking along a greenway. This does not imply that urban planners should ignore environmental design improvements; rather, it highlights the potential to strategically use this psychological process to achieve more cost-effective outcomes.

A case study of Beijing's Second Ring Road Greenway

Beijing's Second Ring Road was completed in 1992 as the city's first urban expressway. For many years, it shaped both the spatial structure and the traffic system of China's capital city. Since 2015, parts of the surrounding space have been redeveloped into the Second Ring Road Greenway. The pedestrian route of the greenway extends for about 80 kilometres across four administrative districts, linking moat-side roads, riverside green spaces, and urban infrastructure (figure 1). This marks a broader transition from speed-oriented infrastructure to people-centred, ecological and cultural functions (L Li, 2014; Y Li, 2016).

In 2024, the North Moat River connectivity project removed eight breakpoints along the waterfront path, gradually improving continuity. However, challenges remain. Some roadside land is underused, and in certain locations pedestrians on the greenway cannot easily connect to footpaths in the adjacent urban road system.

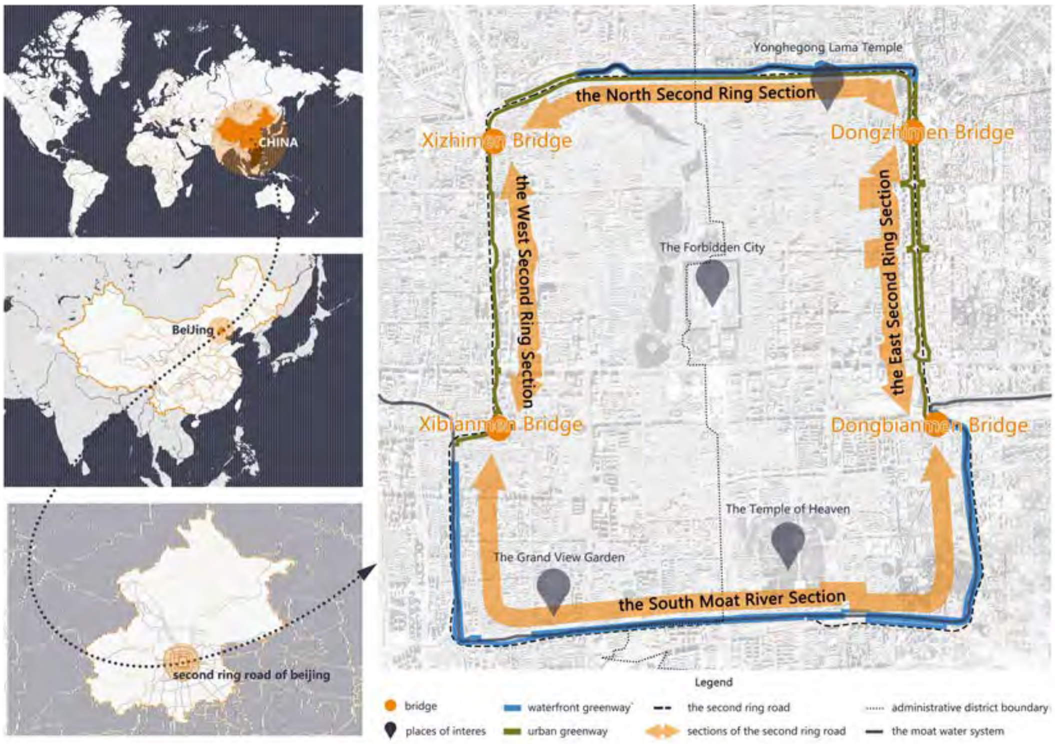

Figure 1. The geographical location and the sections of the Second Ring Road Greenway (image by Yanhan Li and Lanxi Yang, May 2025, adapted from the official website of the Beijing Municipal Forestry and Parks Bureau).

Analysis of the current conditions

The North Second Ring section includes both a waterfront greenway and an urban greenway (figure 2). The waterfront greenway has complex topography, with variations in path width and green space area, connecting a series of themed parks and providing flexible walking routes and diverse landscape experiences. In contrast, the urban greenway consists mainly of shaded walkways and rest areas but suffers from repetitive design and a monotonous landscape character. It reduces both thermal comfort and recreational appeal.

In the South Moat River section, waterfront walkways are provided on both sides of the moat. In some sections along the embankment crest, the greenway route is limited to the municipal road footpaths, while others lack pedestrian pathways altogether. The connectivity between waterfront walkways and embankment-top pedestrian paths or linear parks is poor due to significant elevation differences and insufficient stairs or ramps. The result is to restrict pedestrian access, limiting route flexibility and the overall richness of the walking experience. In addition, the landscape beside the long waterfront walkway lacks spatial and visual variation.

In contrast, the West Second Ring section benefits from broader green spaces adjacent to municipal roads, forming linear parks with varied spatial configurations. The section incorporates themes such as finance and historical Beijing character, offering diverse spaces with a rich range of functions, including shaded walkways, sunlit paths, tree-lined plazas and open squares.

The East Second Ring section features recreational walkways and themed open spaces. On the west side, the walkway widths vary and shading is generally sufficient, with node spaces ranging from open plazas to shaded areas. The northern segment of the east side is densely vegetated, providing ample shade, while the southern segment allows intermittent sunlight through the canopy. Pedestrian overpasses connect both sides.

Figure 2. Current conditions of the Second Ring Road Greenway (image by Yanhan Li and Lanxi Yang, May 2025).

Optimisation strategies

International practices provide useful insights for overcoming such constraints. Singapore's Park Connector Network illustrates how underutilised land – such as drainage buffers, roadside reserves, and spaces beneath viaducts – can be transformed into accessible green corridors with minimal need for new land acquisition. The original spatial conditions of these sites, combined with their redesign, create diverse environmental settings for greenways. The network thus could introduce varied spatial experiences that optimise the thermal alliesthesia effect for pedestrians. This approach demonstrates how strategic reuse of land and the reconfiguration of existing infrastructure can create routes that enhance walking comfort.

Targeted strategies are proposed for each segment of the greenway based on current conditions of the Second Ring Road Greenway. These strategies demonstrate the practical application of the thermal alliesthesia effect in greenway planning and design (see figure 3 for a visual summary).

1. North Second Ring section

To address the monotonous landscape of the urban greenway in this section, diversified design strategies are recommended. Small open plazas with a few trees can create sunlit leisure spaces, while denser planting of broad-leaved trees can establish enclosed, tranquil zones. Shading panels on rest pavilions or pergolas, designed for Beijing's seasonal solar angles, can both provide shade in summer and allow for sunlight in winter. These approaches enrich spatial layering and offer varied thermal experiences for pedestrians.

Localised microclimates along the riverside greenway can be further optimised through strategic planting and micro-topographic adjustments to improve the walking experience. For example, refined planting strategies can be adopted by selecting tree species with varying forms and canopy sizes, combined with a range of planting densities.

2. South Moat River section

Drawing on Singapore's green corridor development experience, roadside reserves and river buffer zones can be fully utilised to enhance the design. In sections with both a waterfront walkway and an embankment-top pedestrian path, more stairs and ramps should be added to enhance vertical connectivity. Clear signage and pavement design can help guide pedestrian flow in a logical manner, enhancing both navigational ease and walking comfort.

In sections with only the waterfront walkway, microclimatic design should consider the river orientation and topography. Sparsely foliated vegetation can be selectively planted in sunlit, well-ventilated areas to reduce shading and allow direct sunlight, balancing sun and shade. Additionally, vertical greening elements can be introduced in certain areas so that shading and plant transpiration improve the vertical thermal environment.

3. East and West Second Ring sections

Without changing the overall layout, it is still possible to improve the landscape quality of existing themed pocket parks. High-albedo or permeable paving materials can reduce heat absorption, and misting fans and dynamic water features like fountains help heat to dissipate through air movement and evaporation.

For the northern segment of the greenway on the west side of the East Second Ring Road, where dense canopy cover creates heavily shaded conditions, selective pruning at appropriate locations may be considered to introduce greater variation in light exposure.

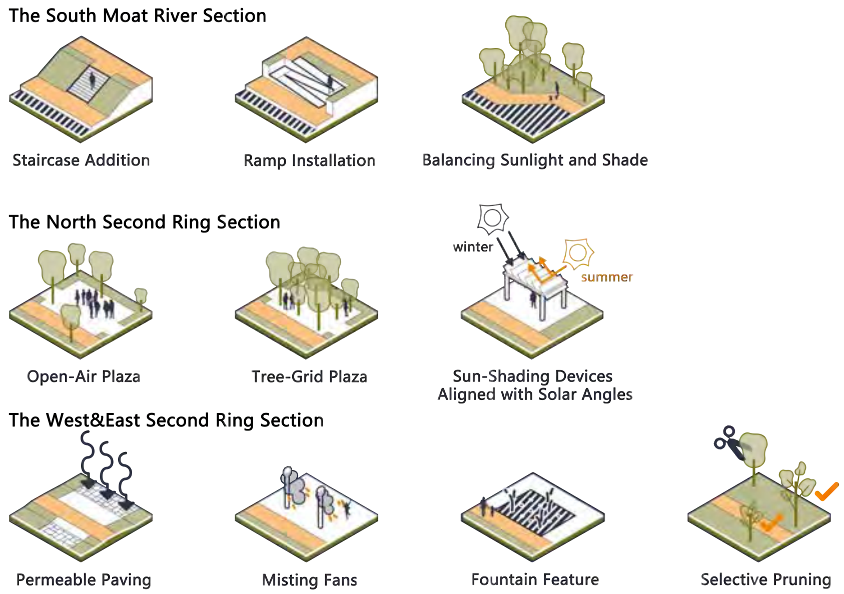

Figure 3. Targeted optimisation strategies using the thermal alliesthesia effect (image by Yanhan Li and Lanxi Yang, May 2025).

Pilot segment: Design informed by thermal alliesthesia

A representative segment of the greenway was analysed to demonstrate how thermal alliesthesia principles can inform design (figure 4). In the proposed design of this segment, the continuity along the municipal footpath, the in-park greenway path and the riverside walkway is enhanced. The route is structured as a sequence of contrasting microclimates to deliberately elicit thermal alliesthesia during walking. In a typical 15–20 minute route, a pattern of alternating 'warm' and 'cool' is arranged: an urban footpath provides the initial warm baseline; a sunlit waterfront forecourt maintains brief radiant exposure; a shaded under-viaduct passage offers rapid relief; an open lawn reintroduces gentle warmth; and a final grove provides shade. The goal is not to maintain a single 'best' temperature, but to create frequent changes in thermal stimuli during the walk to enhance the overall thermal experience. Other routes along this corridor likewise offer diverse conditions capable of inducing this effect.

Design interventions are directly linked to this mechanism. Permeable paving with low reflectance reduces re-radiation and establishes a controllable warm starting point. Shaded corridors beneath the bridge provide cooling. Planting density is varied to adjust the duration of shade, while open squares briefly restore mild warmth. New ramps and stairs connect the viaduct footpaths with the greenway, improving accessibility and allowing users to choose preferred thermal conditions. These measures maintain the primacy of physical improvements – vegetation, ventilation and materials – while using perceptual sequencing to amplify their benefits to the walking experience.

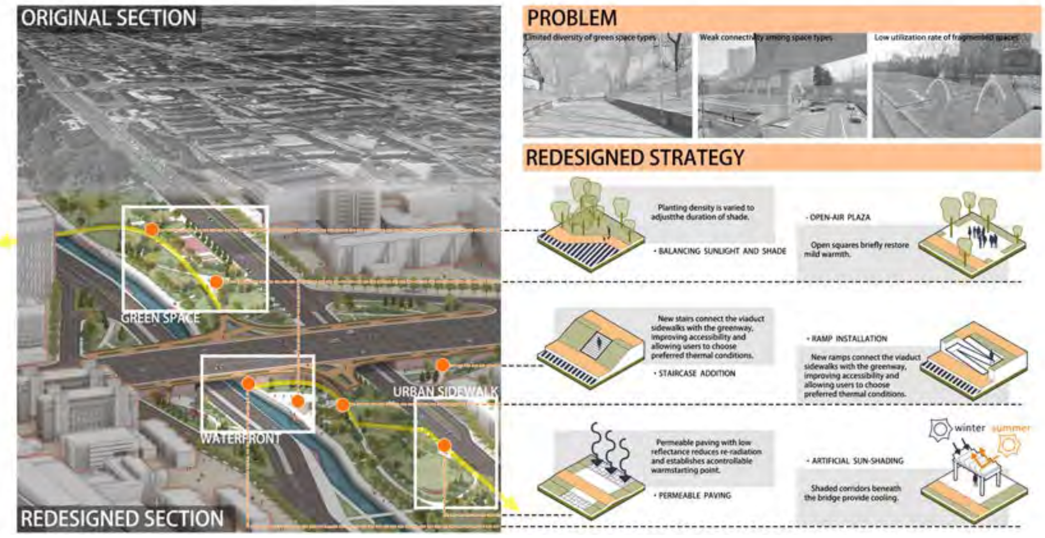

Figure 4. Pilot segment illustrating the application of the thermal alliesthesia effect in design (image redrawn by Yanhan Li and Lanxi Yang, adapted from a project of the research group, August 2025).

Implications

Applying thermal alliesthesia in urban greenway design

Greenways with high-quality environments such as parks tend to provide better thermal comfort (Beele et al, 2024; de Quadros and Mizgier, 2023; Norton et al, 2015). However, given that current trends in urban renewal emphasise sustainability and the optimisation of existing built environments (Almulhim et al, 2024), planners are increasingly exploring ways to integrate urban roads into greenway networks, including in areas with less favourable conditions, in particular poor drainage and narrow spaces. Improving these areas calls for innovative strategies, rather than strategies that rely solely on ideal locations.

In environments with varying microclimatic conditions, the dynamic thermal experiences along a route can contribute to a more nuanced and, at times, more satisfying thermal experience. Planners and designers should create greenway environments that introduce thermal alliesthesia by deliberately varying microclimatic conditions at a small scale, which in turn enhances pedestrian comfort and encourages greater greenway use.

Achieving these kinds of greenways requires introducing physical variations along the corridor, which can be accomplished through two strategies: route planning and landscape design. Route planning should incorporate contrasting landscape features – such as municipal streets and parks – to create thermal transitions. For longer greenway sections, the design should aim for varied landscapes to avoid repetitive design language, which might limit thermal alliesthesia.

Effective use of existing urban spaces, combined with landscape interventions, lays the foundation for high-quality greenway networks. In this process, integrating design strategies informed by thermal alliesthesia helps to capitalise on the psychological benefits of dynamic thermal comfort alongside physical improvements. This approach complements rather than replaces traditional landscape and infrastructure measures, offering a practical and cost-effective way to expand greenway networks in real urban settings.

Global applications of thermal alliesthesia in urban greenways

Growing awareness of urban heat has brought the issue to the forefront of the global planning and policy agenda. At the same time, many cities are advancing greenway initiatives that strengthen active transport networks while supporting public health, such as New York's recent Greater Greenways plan (New York City Department of Transportation et al, 2025).

Against this backdrop, acting on the opportunity to create thermally comfortable greenway environments becomes particularly important.

Supported by the case study of an existing greenway in Beijing, this paper proposes planning and design strategies to enhance thermal comfort by harnessing the thermal alliesthesia effect. This concept has broad international applicability. Introducing it to diverse environments requires flexible, location-specific solutions based on climatic characteristics, urban spatial forms and climate-responsive guidelines.

As a concept that complements physical design, thermal alliesthesia provides a new perspective to improve subjective thermal comfort for people walking outdoors. In this way, the effect has the potential to indirectly reduce motorised travel and support strategies for mitigating the intensifying challenge of urban overheating. This paper therefore recommends integrating this effect into frameworks for responding to heat globally.

Conclusions

A well-designed thermal environment along greenways can promote outdoor exercise such as walking, which benefits public health and sustainable urban development. In urban renewal, planners increasingly need to repurpose existing municipal roads and adjacent underutilised spaces as part of greenway systems, even under less than ideal conditions. Therefore, a key challenge is how to improve thermal comfort for pedestrians along these interwoven greenways. Meeting this challenge requires innovative design strategies.

Current strategies to improve thermal comfort in greenways focus on improving environmental quality. The thermal alliesthesia effect expands the potential strategies available by highlighting how changes in subjective perception have a role in shaping thermal experience. This effect can be induced by varying microclimatic conditions.

Using the Beijing Second Ring Road Greenway as a case study, this paper has explored specific methods of applying the thermal alliesthesia effect to improve thermal comfort in urban greenways. The main approach it recommends is to create diverse thermal environments through route planning and landscape design. A detailed design of a representative section of the greenway demonstrates how these strategies can be applied. Moreover, this approach can be adopted more widely across different places and climates, with designers developing flexible solutions suited to their given location.

The concept of thermal alliesthesia provides a valuable additional perspective on enhancing pedestrians' thermal comfort. It offers new insights for planners and designers into ways to improve greenways as community spaces for walking and other socio-physical activities.

About the authors

Yanhan Li

Yanhan Li is a PhD candidate at Beijing Forestry University, specialising in landscape microclimates and outdoor thermal comfort. Her current research focuses on outdoor thermal comfort evaluation, influencing mechanisms and prediction, as well as microclimate simulation and climate-responsive landscape design.

Dr Liang Li

Liang Li is a Professor at the School of Landscape Architecture, Beijing Forestry University, and serves as Associate Dean of both the School of National Park and the School of Ecology and Nature Conservation. His research focuses on green infrastructure, ecological network planning and design, and community and public health.

Wenqing Wang

Wenqing Wang is pursuing a PhD at Beijing Forestry University, specialising in landscape microclimates and the thermal perception of the elderly. Her current research focuses on the field measurement, simulation and prediction of thermal comfort.

Lanxi Yang

Lanxi Yang is a master's student at Beijing Forestry University (thesis phase). Her current research focuses on machine learning-driven thermal comfort assessment, including predictive modelling frameworks and adaptive design optimisation mechanisms, with cross-disciplinary applications.

Dr Gillian Lawson

Dr Lawson specialises in landscape pedagogy, landscape visualisation and landscape sociology in Australia, Aotearoa New Zealand and other Asia-Pacific countries, and on water and plants as catalysts for improving the adaptation of our cities to climate change. Her work has focused on the sociology of education, social practices in public and private open spaces, green infrastructure and waterfront communities in landscape planning and design.

Funding: This work was supported by the Beijing Municipal Social Science Foundation (Grant No. 23YTB039).

REFERENCES

Almulhim, A.I.; Sharifi, A.; Aina, Y.A.; Ahmad, S.; Mora, L.; Filho, W.L.; Abubakar, I.R. (**2024**) Charting sustainable urban development through a systematic review of SDG11 research. *Nature Cities*, 1(10), pp 677–85. DOI: 10.1038/s44284-024-00117-6.

Auckland Council (**2020**) *Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan*. Accessed 27 May 2025, https://ourauckland.aucklandcouncil.govt.nz/media-centre/2024/december/heat-islands-in-the-city/?utm_source=chatgpt.com.

Audate, P.P.; Romaric Da, S.M.A; Diallo, T. (**2024**) Understanding the barriers and facilitators of urban greenway use among older and disadvantaged adults: a mixed-methods study in Québec city. *Health & Place*, 89, art 103340. DOI: 10.1016/j.healthplace.2024.103340.

Baobeid, A.; Koç, M.; Al-Ghamdi, S.G. (**2021**) Walkability and its relationships with health, sustainability, and livability: elements of physical environment and evaluation frameworks. *Frontiers in Built Environment*, 7, art 721218. DOI: 10.3389/fbuil.2021.721218.

Beele, E.; Aerts, R.; Reyniers, M.; Somers, B. (**2024**) Spatial configuration of green space matters: associations between urban land cover and air temperature. *Landscape and Urban Planning*, 249, art 105121. DOI: 10.1016/j.landurbplan.2024.105121.

Cabanac, M. (**1971**) Physiological role of pleasure. *Science*, 173(4002), pp 1103–07. DOI: 10.1126/science.173.4002.1103.

Caprì, S.; Ignaccolo, M.; Inturri, G.; Le Pira, M. (**2016**) Green walking networks for climate change adaptation. *Transportation Research Part D: Transport and Environment*, 45, pp 84–95. DOI: 10.1016/j.trd.2015.08.005.

Chen, S.; Hu, D.; Wong, M.S.; Ren, H.; Cao, S.; Yu, C.; Ho, H.C. (**2019**) Characterizing spatiotemporal dynamics of anthropogenic heat fluxes: a 20-year case study in Beijing–Tianjin–Hebei region in China. *Environmental Pollution*, 249, pp 923–31. DOI: 10.1016/j.envpol.2019.03.113.

Chi, W.; Lin, G. (**2019**) The use of community greenways: a case study on a linear greenway space in high dense residential areas, Guangzhou. *Land*, 8(12), art 188. DOI: 10.3390/land8120188.

City of Los Angeles (**2019**) *L.A.'s Green New Deal Sustainable City pLAn 2019*. Accessed 27 May 2025, https://plan.mayor.lacity.gov/gnd-nc-toolkit.

de Dear, R. (**2011**) Revisiting an old hypothesis of human thermal perception: alliesthesia. *Building Research & Information*, 39(2), pp 108–17. DOI: 10.1080/09613218.2011.552269.

de Quadros, B.M.; Mizgier, M.G.O. (**2023**) Urban green infrastructures to improve pedestrian thermal comfort: a systematic review. *Urban Forestry & Urban Greening*, 88, art 128091. DOI: 10.1016/j.ufug.2023.128091.

Dzyuban, Y.; Hondula, D.M.; Vanos, J.K.; Middel, A.; Coseo, P.J.; Kuras, E.R.; Redman, C.L. (**2022**) Evidence of alliesthesia during a neighborhood thermal walk in a hot and dry city. *Science of the Total Environment*, 834, art 155294. DOI: 10.1016/j.scitotenv.2022.155294.

Gan, Q.F. (**2017**) A Study on the Planning and Design of Greenway – Based on the Study of Greenway in Shenzhen. Master's thesis, Beijing Forestry University, Beijing, China. DOI: 10.26949/d.cnki.gblyu.2017.001149.

Grimmond, S. (**2007**) Urbanization and global environmental change: local effects of urban warming. *The Geographical Journal*, 173(1), pp 83–88. DOI: 10.1111/j.1475-4959.2007.232_3.x.

He, D.; Lu, Y.; Xie, B.; Helbich, M. (**2021**) Large-scale greenway intervention promotes walking behaviors: a natural experiment in China. *Transportation Research Part D: Transport and Environment*, 101, art 103095. DOI: 10.1016/j.trd.2021.103095.

Horte, O; Eisenman, T. (**2020**) Urban greenways: a systematic review and typology. *Land*, 9(2), art 40. DOI: 10.3390/land9020040.

Hsieh, C.-M.; Aramaki, T.; Hanaki, K. (**2007**) Estimation of heat rejection based on the air conditioner use time and its mitigation from buildings in Taipei City. *Building and Environment*, 42(9), pp 3125–37. DOI: 10.1016/j.buildenv.2006.07.029.

Huang, T.; Niu, J.; Xie, Y.; Li, J.; Mak, C.M. (**2020**) Assessment of 'lift-up' design's impact on thermal perceptions in the transition process from indoor to outdoor. *Sustainable Cities and Society*, 56, art 102081. DOI: 10.1016/j.scs.2020.102081.

Lai, D.; Lian, Z.; Liu, W.; Guo, C.; Liu, W.; Liu, K.; Chen, Q. (**2020**) A comprehensive review of thermal comfort studies in urban open spaces. *Science of the Total Environment*, 742, art 140092. DOI: 10.1016/j.scitotenv.2020.140092.

Li, J. (**2022**) Dynamic effects of frequent step changes in outdoor microclimate environments on thermal sensation and dissatisfaction of pedestrian during summer. *Sustainable Cities and Society*. DOI: 10.1016/j.scs.2022.103670.

Li, J.; Niu, J.; Mak, C.M. (**2022**) Study of pedestrians' mixed thermal responses when experiencing rapid and simultaneous variations in sun and wind conditions in urban continuums. *Sustainable Cities and Society*, 87, art 104169. DOI: 10.1016/j.scs.2022.104169.

Li, J.; Niu, J.; Mak, C.M. (**2023**) Influences of variable thermal exposures on walking thermal comfort in hot summer: physio-psychological responses. *Building and Environment*, 239, art 110346. DOI: 10.1016/j.buildenv.2023.110346.

Li, L. (**2014**) Research on Urban Road Landscape under the Background of Urban Development: Taking Beijing Second Ring Road as an Example. Doctoral dissertation, Beijing Forestry University, Beijing, China.

Li, L.; Zhao, L.H.; Chen, R.C.; Zhou, X.Q.; Xu, L.W. (**2013**) Field measurement on the thermal environment of greenway in Guangzhou. *Applied Mechanics and Materials*, 368–70, pp 666–69. DOI: 10.4028/www.scientific.net/AMM.368-370.666.

Li, Y. (**2016**) City-greenway Functional Evaluation and Research of Construction in Greenway along the Beijing Second Ring Road Case. Master's thesis, Beijing University of Agriculture, Beijing, China, June 2016.

Li, Y.; Zhai, Z.; Tian, Y.; Fang, Z.; Jiang, X.; Mao, Y.; Zheng, Y. (**2024**) Differences in human thermal and physiological responses under corridor and greenway in summer in Guangzhou. *Case Studies in Thermal Engineering*, 61, art 105049. DOI: 10.1016/j.csite.2024.105049.

Li, Z.; Lu, Y.; Xie, B.; Wu, Y. (**2024**) Large-scale greenway exposure reduces sedentary behavior: a natural experiment in China. *Health & Place*, 89, art 103283. DOI: 10.1016/j.healthplace.2024.103283.

Liu, K.; Siu, K.W.M.; Gong, X.Y.; Gao, Y.; Lu, D. (**2016**) Where do networks really work? The effects of the Shenzhen greenway network on supporting physical activities. *Landscape and Urban Planning*, 152, pp 49–58. DOI: 10.1016/j.landurbplan.2016.04.001.

Liu, L.; Cai, Y.; Jin, L.; Zhu, Y.; Gao, Y.; Ding, Y.; Xia, J.; Zhang, K. (**2022**) Landscape pattern optimization strategy of coastal mountainside greenway from a microclimatic comfort view in hot and humid areas. *Urban Climate*, 46, art 101297. DOI: 10.1016/j.uclim.2022.101297.

Liu, S.; Nazarian, N.; Hart, M.A.; Niu, J.; Xie, Y.; de Dear, R. (**2021**) Dynamic thermal pleasure in outdoor environments – temporal alliesthesia. *Science of the Total Environment*, 771, art 144910. DOI: 10.1016/j.scitotenv.2020.144910.

Liu, Z.; Lin, Y.; De Meulder, B.; Wang, S. (**2019**) Can greenways perform as a new planning strategy in the Pearl River Delta, China? *Landscape and Urban Planning*, 187, pp 81–95. DOI: 10.1016/j.landurbplan.2019.03.012.

New York City Department of Transportation; New York City Department of Parks and Recreation; New York City Economic Development Corporation (**2025**) *Greater Greenways*. Accessed 31 August 2025, https://www.nyc.gov/html/dot/html/pr2025/new-york-city-releases-major-greenway-plan.shtml.

Norton, B.A.; Coutts, A.M.; Livesley, S.J.; Harris, R.J.; Hunter, A.M.; Williams, N.S.G. (**2015**) Planning for cooler cities: a framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. *Landscape and Urban Planning*, 134, pp 127–38. DOI: 10.1016/j.landurbplan.2014.10.018.

Osmond, P.; Sharifi, E.; Hatvani-Kovacs, G.; Bush, J.; Fox, J.; Bartesaghi Koc, C.; Pollard, B., Dunford, S.; et al. (**2017**) *Guide to Urban Cooling Strategies*, Low Carbon Living CRC. Accessed 27 May 2025, https://www.lowcarbonlivingcrc.unsw.edu.au/research/program-2-low-carbon-precincts/rp2024-guide-urban-cooling-strategies.

Parkinson, T. (**2016**) Thermal Pleasure and Alliesthesia in the Built Environment. PhD, University of Sydney, Sydney, Australia. Accessed 24 September 2025, https://ses.library.usyd.edu.au/handle/2123/16021.

Parkinson, T.; de Dear, R. (**2017**) Thermal pleasure in built environments: spatial alliesthesia from air movement. *Building Research & Information*, 45(3), pp 320–35. DOI: 10.1080/09613218.2016.1140932.

Parkinson, T.; de Dear, R.; Candido, C. (**2016**) Thermal pleasure in built environments: alliesthesia in different thermoregulatory zones. *Building Research & Information*, 44(1), pp 20–33. DOI: 10.1080/09613218.2015.1059653.

Peng, Z.; Bardhan, R.; Ellard, C.; Steemers, K. (**2022**) Urban climate walk: a stop-and-go assessment of the dynamic thermal sensation and perception in two waterfront districts in Rome, Italy. *Building and Environment*, 221, art 109267. DOI: 10.1016/j.buildenv.2022.109267.

Qiao, S.; Yeh, A.G.-O. (**2023**) Understanding the effects of environmental perceptions on walking behavior by integrating big data with small data. *Landscape and Urban Planning*, 240, art 104879. DOI: 10.1016/j.landurbplan.2023.104879.

Ribeiro, F.N.D.; Umezaki, A.S.; Chiquetto, J.B.; Santos, I.; Machado, P. G.; Miranda, R.M.; Almeida, P.S.; Simões, A.F.; et al. (**2021**) Impact of different transportation planning scenarios on air pollutants, greenhouse gases and heat emission abatement. *Science of the Total Environment*, 781, art 146708. DOI: 10.1016/j.scitotenv.2021.146708.

Ruefenacht, L.A.; Acero, J.A. (Eds.) (**2017**) *Strategies for Cooling Singapore: A Catalogue of 80+ Measures to Mitigate Urban Heat Island and Improve Outdoor Thermal Comfort*, Singapore: Cooling Singapore. DOI: 10.3929/ethz-b-000258216.

Schweiker, M.; Schakib-Ekbatan, K.; Fuchs, X.; Becker, S. (**2020**) A seasonal approach to alliesthesia: is there a conflict with thermal adaptation? *Energy and Buildings*, 212, art 109745. DOI: 10.1016/j.enbuild.2019.109745.

United Nations Environment Programme (**2021**) *Beating the Heat: A Sustainable Cooling Handbook for Cities*, Nairobi: UNEP. Accessed 27 May 2025, https://www.unep.org/resources/report/beating-heat-sustainable-cooling-handbook-cities.

Vasilikou, C.; Nikolopoulou, M. (**2020**) Outdoor thermal comfort for pedestrians in movement: thermal walks in complex urban morphology. *International Journal of Biometeorology*, 64(2), pp 277–91. DOI: 10.1007/s00484-019-01782-2.

Western Sydney Regional Organisation of Councils (**2021**) *Urban Heat Planning Toolkit*, Blacktown NSW: Western Sydney Regional Organisation of Councils. Accessed 27 May 2025, https://wsroc.com.au/projects/project-turn-down-the-heat/turn-down-the-heat-resources-2.

Xie, B.; Pang, Z.; He, D.; Lu, Y.; Chen, Y. (**2023**) Effects of neighborhood environment on different aspects of greenway use: evidence from East Lake Greenway, China. *Journal of Transport Geography*, 106, art 103488. DOI: 10.1016/j.jtrangeo.2022.103488.

Xie, Y.; Wang, X.; Wen, J.; Geng, Y.; Yan, L.; Liu, S.; Zhang, D.; Lin, B. (**2022**) Experimental study and theoretical discussion of dynamic outdoor thermal comfort in walking spaces: effect of short-term thermal history. *Building and Environment*, 216, art 109039. DOI: 10.1016/j.buildenv.2022.109039.

Zhang, T.J.; Li, Z. (**2013**) Multi-objective greenway network in high-density cities: the park connector network in Singapore. *City Planning Review*, 37(5), pp 67–73. Accessed 24 September 2025, https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFD2013&filename=CSGH201305014.

Zhang, Y.; Liu, J.; Zheng, Z.; Fang, Z.; Zhang, X.; Gao, Y.; Xie, Y. (**2020**) Analysis of thermal comfort during movement in a semi-open transition space. *Energy and Buildings*, 225, art 110312. DOI: 10.1016/j.enbuild.2020.110312.

Zhao, H.; Zhao, L.; Zhai, Y.; Jin, L.; Meng, Q.; Yan, J.; Wu, R.; Brown, R.D. (**2024**) The impact of dynamic thermal experiences on pedestrian thermal comfort: a whole-trip perspective from laboratory studies. *Building and Environment*, 258, art 111599. DOI: 10.1016/j.buildenv.2024.111599.