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# Effects of Tall Buildings on Visually Morphological Traits of Urban Trees

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**Abstract:** The visual morphology of trees significantly impacts urban green micro-landscape aesthetics. Proximity to tall buildings affects tree form due to competition for space and light. The study investigates the impact of tall buildings on six visually morphological traits of eight common ornamental species in urban micro-landscapes in Beijing, with the distance and direction between trees and buildings as variables. It found that as trees grow closer to buildings, most angiosperms show increased crown asymmetry degree and crown loss, and reduced crown round degree and crown stretch degree (i.e., *Sophora japonica* L. and *Acer truncatum* Bunge saw a 52.26% and 47.62% increase in crown asymmetry degree, and a 20.35% and 21.59% decrease in crown round degree, respectively). However, the pattern of crown morphological changes in gymnosperms is poor (the closer the distance, the lower the height-to-diameter ratio of *Pinus tabuliformis* Carr., while the height-to-diameter ratio of *Juniperus chinensis* Roxb. significantly increases). In terms of orientation, gymnosperms on the west side of buildings have a greater crown asymmetry degree. It suggests that planting positions relative to buildings affect tree morphology. Recommendations include planting *J. chinensis* closer to buildings but keeping angiosperms like *Fraxinus velutina* Torr., *S. japonica*, and *A. truncatum* more than 3 m away to ensure healthy crown development.

**Keywords:** urban trees; visually morphological traits; tall buildings; aesthetic quality



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## 1. Introduction

As an important part of urban ecosystems, urban trees play an irreplaceable role in regulating the carbon–oxygen balance, alleviating heat island effects, and beautifying local environments. In recent decades, buildings in cities have become taller with the continuous urbanisation, and people's demand for green landscapes has become more and more urgent [1]. Compared to herbs and shrubs in urban green spaces, arboreal species, with their tall stature and stable landscape creation, serve as the primary focus and visual centre of space [2,3]. Therefore, the visual characteristics presented by urban trees in their external morphology have a significant impact on people's aesthetic experience [4].

Studies related to the aesthetic quality of individual urban trees have showed that the visual features of tree crown morphology [5,6], coordination between trunk and crown [7], and even trunk posture [8] are closely related to landscape aesthetics. Although the results of research on different tree species and traits are not completely consistent, most people prefer to appreciate tree landscapes with larger size, full and stretched crowns, and coordinated trunk–crown ratios [9,10]. This indicates that such visual features are more in line with the aesthetics of the majority.

However, the visually morphological traits of trees depend on the spatial structure of the living environment and are closely related to the available spatial and light resources around them [11–13], Microenvironmental factors and anthropogenic disturbances can also lead to issues such as lopsided or narrow crown morphologies in trees [14,15]. For single trees that are close to tall buildings, the occupation of spatial resources and the obstruction of light resources by buildings are the main influencing factors for the construction of tree visual forms [16]. Currently, there are no reports on the effects and extent of the impact of tall buildings on the visual morphology of trees.

Therefore, the study focuses on eight common green ornamental tree species in Beijing, including *Pinus bungeana* Zucc. ex Endl., *F. velutina*, *S. japonica*, *Koelreuteria paniculata* Laxm., *Ginkgo biloba* L., *P. tabuliformis*, *J. chinensis*, and *A. truncatum*. With the distance and relative orientation between trees and buildings as variables, the research focuses on exploring the following questions: (1) What changes in the visually morphological traits of trees are caused by the occupation of spatial and light resources by tall buildings? (2) To what extent do these morphological traits change, and are there differences among different tree species?

## 2. Materials and Methods

### 2.1. Research Site

Beijing is located in the north of the North China Plain, with geographical coordinates ranging between 115°25′–117°30′ E and 39°28′–41°05′ N. The terrain is high in the north-west and low in the southeast. With four distinctive seasons, summer is hot and rainy, winter is cold and dry, and spring and autumn are short, so it is a typical warm temperate continental monsoon climate. The average annual temperature is 10–12 °C, and the average precipitation is 600–620 mm. There are significant differences in precipitation in different time and space, with the most precipitation concentrated from June to August, which is more abundant in mountainous areas. The entire urban area of the Fifth Ring Road in Beijing is composed of artificial plant communities, mainly consisting of large park green spaces, affiliated green spaces, and protective green spaces [17]. By early 2024, the urban green coverage rate in Beijing reached 49.8%, and the per capita park green area reached 16.9 $m^2$ [18].

In September and October 2023, the paper studied 18 communities between the Fourth Ring Road and the Fifth Ring Road in Haidian District, Beijing (Figure 1). A total of 233 solitary trees of urban green space that are close to buildings, were investigated as research objects. Basic information of each construction area is shown in Table 1.

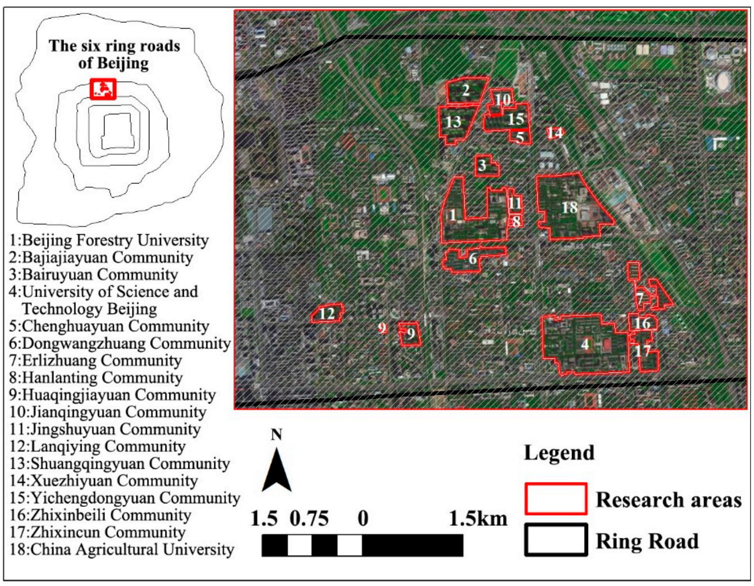


**Figure 1.** The research area of the study.

**Table 1.** Basic information of research area.

| Research Area | Building Average Height (m) * | Main Tree Species | Number of Trees |
|---|---|---|---|
| Beijing Forestry University | 20 | *P. bungeana*, *F. velutina*, *J. chinensis*, et al. | 41 |
| Bajiajiayuan Community | 50 | *F. velutina*, *S. japonica*, et al. | 8 |
| Bairuyuan Community | 40 | *K. paniculata*, *P. tabuliformis*, et al. | 10 |
| University of Science and Technology Beijing | 23 | *K. paniculata*, *A. truncatum*, et al. | 14 |
| Chenghuayuan Community | 18 | *F. velutina*, *J. chinensis*, et al. | 5 |
| Dongwangzhuang Community | 18 | *G. biloba*, *J. chinensis*, et al. | 20 |
| Erlizhuang Community | 20 | *F. velutina*, *P. tabuliformis*, *J. chinensis*, et al. | 12 |
| Hanlanting Community | 35 | *F. velutina*, *G. biloba*, et al. | 5 |
| Huaqingjiayuan Community | 40 | *F. velutina*, *K. paniculata*, et al. | 6 |
| Jianqingyuan Community | 18 | *F. velutina*, *A. truncatum*, et al. | 12 |
| Jingshuyuan Community | 25 | *S. japonica*, *G. biloba*, et al. | 8 |
| Lanqiying Community | 40 | *S. japonica*, *K. paniculata*, *A. truncatum*, et al. | 13 |
| Shuangqingyuan Community | 45 | *F. velutina*, *S. japonica*, et al. | 17 |
| Xuezhiyuan Community | 18 | *G. biloba*, *P. tabuliformis*, *J. chinensis*, et al. | 10 |
| Yichengdongyuan Community | 35 | *F. velutina*, *P. tabuliformis*, *A. truncatum*, et al. | 16 |
| Zhixinbeili Community | 20 | *S. japonica*, *J. chinensis*, et al. | 7 |
| Zhixincun Community | 25 | *F. velutina*, *P. bungeana*, et al. | 7 |
| China Agricultural University | 30 | *P. bungeana*, *S. japonica*, *G. biloba* et al. | 22 |

Note: * The average height of building is the mean of the building heights in the surveyed area of the study.

### *2.2. Tree Survey Methods*

Within the confines of the 18 designated architectural zones, the selection criteria for the target trees were based on their proximity to tall structures, specifically within a 9 m radius, and the absence of spatial competition from other individuals. To mitigate the morphological variability associated with the juvenile phase of tree development, the study exclusively considered trees with a diameter at breast height (DBH) exceeding 10 cm. Comprehensive data collection was conducted on each target tree, encompassing both arboreal and environmental parameters. The methodologies employed for data acquisition are delineated as follows:

(1) Arboreal Parameters: The DBH of the target trees was ascertained using a standardised DBH measuring tape, and the stature of the target trees was quantified employing a Blume-Leiss clinometer [19]. The crown spread in the cardinal directions (east, west, south, and north) was determined using a combination of a tape measure and a laser rangefinder [20].

(2) Environmental Parameters: The vertical extent of the surrounding structures was ascertained in correlation with the number of building floors, utilising the same Blume-Leiss clinometer. The horizontal distance between the tree's centroid and adjacent tall structures was measured with a laser rangefinder, with due attention to the cardinal orientation of the structures. Photographic documentation of the target trees and their immediate spatial context was achieved using a Nikon D7100 camera (Nikon, Tokyo, Japan), positioned at a height corresponding to eye level (1.7 m) for a horizontal perspective [21].

### *2.3. Visually Morphological Traits Indicators*

Based on the characteristics of visually morphological traits of urban ornamental tree species and previous research conclusions [22,23], the study selected six visually morphological trait indicators, including the Crown asymmetry degree (CAD), to represent the visual characteristics of tree crown and tree form in terms of morphology. The names, calculation methods, and aesthetic meanings of each indicator are shown in Table 2.

**Table 2.** Visually Morphological Traits Indicators.

| Name | Calculation Formula | | Aesthetic Meanings |
|---|---|---|---|
| Crown asymmetry degree (CAD) | CAD = $max\left(\frac{We}{Ww}, \frac{Ww}{We}, \frac{Wn}{Ws}, \frac{Ws}{Wn}\right)$ | (1) | Reflects the maximum degree of crown deviation from the centre of the tree. |
| Crown loss rate (CLR) | CLR = $CV_m/CV \times 100\%$ | (2) | Reflects the maximum extent of local crown loss. |
| Crown round degree (CRD) | CRD = $CW/CL$ | (3) | Reflects the completeness of tree crown development. |
| Crown stretch degree (CSD) | CSD = $CW/H$ | (4) | Reflects the radial spread of the crown and the coordination between the trunk and the crown. |
| Ratio of crown-diameter (RCD) | RCD = $CW/DBH$ | (5) | Reflects the radial coordination degree between the crown and the trunk of the tree. |
| Ratio of height-diameter (RHD) | RHD = $H/DBH$ | (6) | Reflects the overall coordination between the radial and axial aspects of the tree. |

Note: $W_e$, $W_w$, $W_s$, $W_n$ are the crown widths (m) of trees in the east, west, south, and north directions; $CV_{\mathrm{m}}$ is the volume of the missing part of the tree crown ($m^3$); $CV$ is the volume of the tree crown in a complete state ($m^3$); $CW$ is the crown width (m); $CL$ is the crown length (m); $H$ is the height of the tree (m); $DBH$ is the diameter at breast height (cm).

Based on the reality, the crown shapes of trees are divided into three types: spire shaped, oval shaped, and cylindrical shaped [23–26], and their crown volumes are calculated separately. The calculation formulas for crown width and crown volume are as follows:

$$CW = (W_e + W_w + W_s + W_n)/2 \quad (7)$$

$$CV_{\text{Spired-shape}} = \pi(W_e + W_w) \times (W_s + W_n) \times CL/12 \quad (8)$$

$$CV_{\text{Ovate-shape}} = \pi(W_e + W_w) \times (W_s + W_n) \times CL/8 \quad (9)$$

$$CV_{\text{Cylindrical-shape}} = \pi(W_e + W_w) \times (W_s + W_n) \times CL/4 \quad (10)$$

### *2.4. Data Analysis*

The data were obtained on 233 object trees located close to tall buildings from 18 building areas. Based on the two groups of gymnosperms and angiosperms, we have selected a total of eight tree species, with four species from each group. The gymnosperms include *P. bungeana*, *G. biloba*, *P. tabuliformis*, and *J. chinensis*, while the angiosperms include *F. velutina*, *S. japonica*, *K. paniculata*, and *A. truncatum*. The number and basic information of the target trees for each tree species are shown in Table 3.

**Table 3.** Basic information of target trees for different tree species.

| Type | Species Name | Number of Trees | DBH (cm) | Height (m) | Average Crown Width (m) |
|---|---|---|---|---|---|
| Gymnosperms | *P. bungeana* | 24 | 12.0–30.9 | 4.0–9.0 | 1.68–3.43 |
| | *G. biloba* | 35 | 12.5–30.2 | 7.3–11.9 | 1.50–4.03 |
| | *P. tabuliformis* | 30 | 13.6–32.0 | 4.0–9.7 | 1.93–4.08 |
| | *J. chinensis* | 30 | 11.8–31.2 | 6.0–11.4 | 1.23–3.38 |
| Angiosperms | *F. velutina* | 30 | 10.8–42.0 | 6.7–12.1 | 2.40–7.65 |
| | *S.japonica* | 34 | 14.9–39.8 | 6.1–13.4 | 2.40–7.43 |
| | *K. paniculata* | 24 | 12.3–40.5 | 6.0–12.8 | 2.13–6.68 |
| | *A. truncatum* | 26 | 10.0–37.8 | 4.6–10.9 | 2.08–5.60 |

The research conducted in the campus environments of Beijing, which are ecologically analogous to the settings of the study, has reported an average crown spread of 6.02 m [27], with an approximate unilateral crown spread of 3 m. Consequently, delineated the study into three distinct intervals: 0–3 m (the crown extension on the side adjacent to the building is highly susceptible to contact with the structure, potentially inducing alterations in crown morphology, and the trees are significantly impacted by the shading effects of the building), 3–6 m (the crown extension on the side adjacent to the building has a moderate likelihood of contact with the structure, with a corresponding moderate influence from the building's shading), and 6–9 m (the crown extension on the side adjacent to the building is unlikely to come into contact with the structure, and the trees experience minimal impact from the building's shading), to investigate the influence of proximity to buildings on the visually morphological characteristics of urban isolated trees. Taking *G. biloba* and *A. truncatum* as examples, the visually morphological traits of trees at different distances are shown in Figure 2. To minimise the negative impact of distance differences, when studying the influence of building orientation on the visually morphological traits of trees, only the data of trees within 0–3 m from the building were selected for analysis. Additionally, the visually morphological trait data of each tree species were dimensionless processed to avoid the incomparability caused by differences in indicators.


**Figure 2.** Illustrative diagram of tree visual morphology at different distances. (**a**) *G. biloba* within 0–3 m; (**b**) *G. biloba* within 3–6 m; (**c**) *G. biloba* within 6–9 m; (**d**) *A. truncatum* within 0–3 m; (**e**) *A. truncatum* within 3–6 m; (**f**) *A. truncatum* within 6–9 m.

SPSS 25.0 and R 3.6.1 were used to analyse the data. The creation of sample maps and boxplots was accomplished with ArcMap version 10.6 and SigmaPlot version 14.0, respectively. Given the characteristics of the data, the study selected the non-parametric Kruskal–Wallis test for statistical analysis and applied the All pairwise method for subsequent multiple comparisons. Inverse sine (arcsine) transformation and logarithmic transformation techniques were utilised in the data processing.

## 3. Results and Analysis

### *3.1. The Influence of Building Distance on the Visually Morphological Traits of Individual Trees*

#### 3.1.1. Gymnosperms

The visually morphological traits of gymnosperms mainly respond to building disturbances in terms of CAD, CSD, and RHD (Figure 3). The CAD of the crown deviation index of *P. bungeana* and *G. biloba* showed a significant upward trend with the decrease in building distance ($p < 0.05$), and the maximum CAD values of the crown deviation index of *P. bungeana* and *G. biloba* with a distance of less than 3 m from the building reached 2.35 and 2.22, respectively. The CAD of *J. chinensis* has no significant relationship with the distance from buildings and has remained at a low level, indicating that the crown width of *J. chinensis* has little variability in direction and can maintain a symmetrical crown shape well in green landscapes. The CSD of *P. tabuliformis* at a distance of 0–3 m from the building is significantly higher than the other two groups, indicating that the obstruction of nearby buildings can easily make *P. tabuliformis* appear relatively short and wide in shape. The RHD of *P. tabuliformis* and *J. chinensis* is significantly affected by the distance from buildings ($p < 0.05$). When the distance from buildings is 0–3 m, the RHD of *P. tabuliformis* is lower, and the axial growth of trees is more strongly inhibited than the radial growth. In contrast to *P. tabuliformis*, the RHD of *J. chinensis* that are less than 3 m away from buildings is significantly higher, and their axial growth is stronger than their radial growth. There were no significant differences ($p > 0.05$) in the CRD, RCD, and CLR among the four gymnosperm tree species at different building distances, indicating that gymnosperm tree species can maintain high consistency in radial growth between crown and trunk, and are insensitive to interference from tall buildings in crown integrity.

#### 3.1.2. Angiosperms

Except for the RCD, other visually morphological traits of angiosperms have varying degrees of response to changes in building distance (Figure 4). The CAD of *F. velutina*, *S. japonica*, and *A. truncatum* all significantly increased with the decrease in building distance ($p < 0.05$). Compared with the distance of 6–9 m, the CAD of the three at 0–3 m from the building increased by 28.80%, 52.26%, and 47.62%, respectively. At the same time, the tree crown loss rate of *S. japonica* and *A. truncatum* also significantly increased with the decrease in building distance ($p < 0.05$). The CLR of the two species increased from 7.59% and 6.65% at a distance of 6–9 m from the building to 20.69% and 20.00% at a distance of 0–3 m from the building, indicating that the shading of close-range buildings can easily cause significant morphological changes such as displacement or loss of the tree crown for most angiosperm species. When the distance from the building is 0–3 m, the CRD of *S. japonica* and *A. truncatum* is significantly lower than the other two groups ($p < 0.05$). Among them, the CRD at a distance of 0–3 m from the building is reduced by 17.25% and 20.35% compared to 3–6 m and 6–9 m, respectively, while that of *A. truncatum* is reduced by 19.10% and 21.59%, respectively. This indicates that under the interference of close-range buildings, the radial growth of the crowns of the two tree species is weaker than the axial growth, and the crowns tend to form a thin visual characteristic. As the distance between buildings decreases, the CSD of *S. japonica*, *K. paniculata*, and *A. truncatum* also shows a decreasing trend, indicating that the radial stretch degree of the entire tree may be sensitive to interference from nearby buildings. The RHD of *S. japonica* located less than 3 m away from buildings was significantly higher than the other two groups ($p < 0.05$), indicating that the obstruction of nearby buildings has a certain promoting effect on the axial growth of *S. japonica* and reflecting their strong phototropism. However, the RCD and RHD of *F. velutina*, *K. paniculata*, and *A. truncatum* did not show significant differences at different building distances, indicating that the three angiosperm species can maintain relatively stable trunk-crown coordination under the interference of tall buildings.

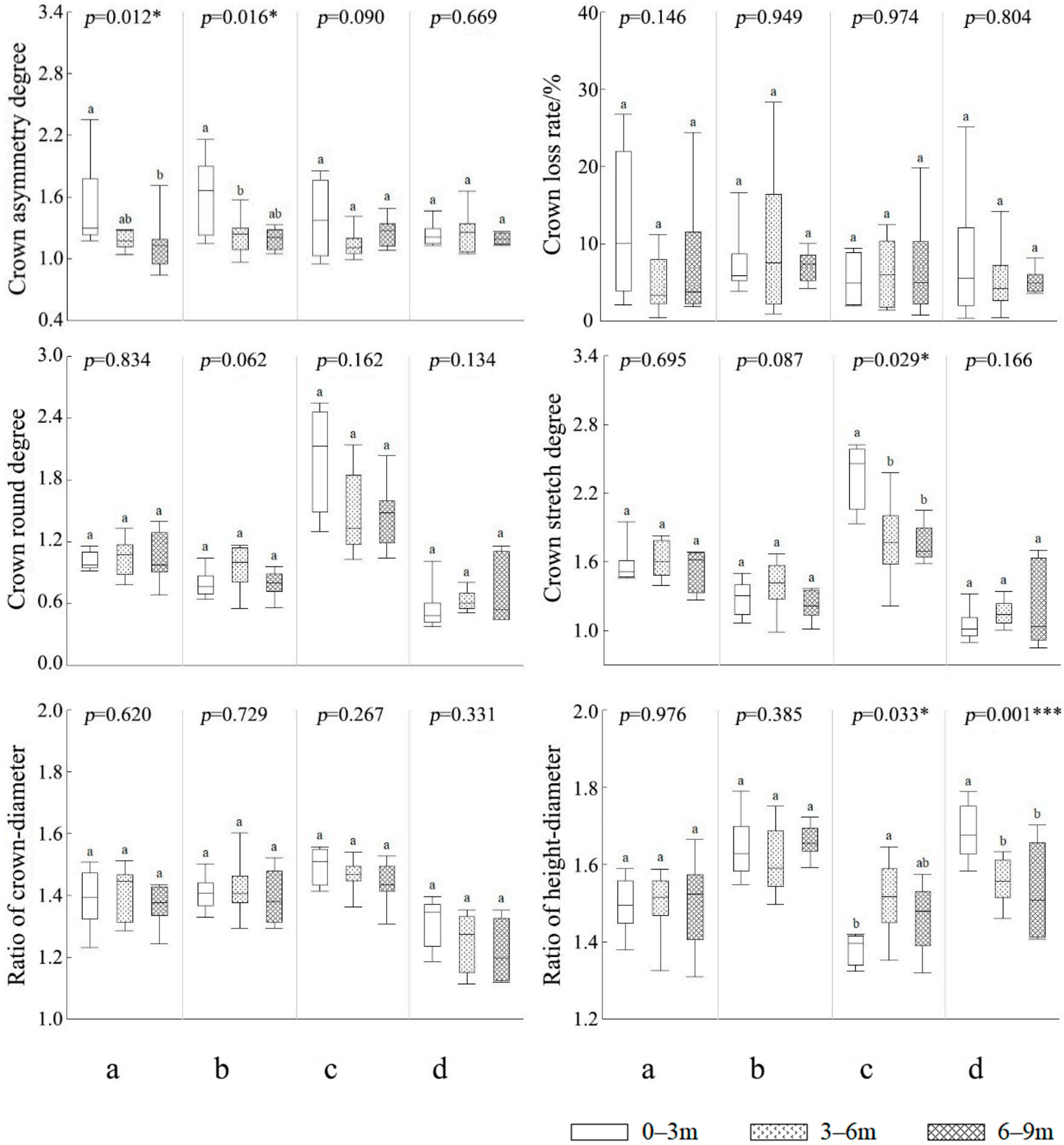


**Figure 3.** The influence of building distance on the visually morphological traits of individual gymnosperm trees (a: *P. bungeana*; b: *G. biloba*; c: *P. tabuliformis*; d: *J. chinensis*). (Different lowercase letters indicate significant differences between different groups. * indicates significant difference $p \leq 0.05$; *** indicates difference significance $p \leq 0.001$).

### *3.2. The Influence of Building Orientation on the Visually Morphological Traits of Individual Trees*

#### 3.2.1. Gymnosperms

Overall, the differences in the survival direction of gymnosperm species within close range of buildings have a relatively small impact on the visually morphological traits of trees (Figure 5). Except for the CAD, the other five visually morphological trait indicators did not respond to changes in the survival direction of trees. The CAD of gymnosperm trees growing on the west side of buildings was significantly higher than that growing on the east side ($p < 0.05$), which may be related to the difference in light intensity between morning and evening in Beijing.

### 3.2.2. Angiosperms

Similar to the research results on gymnosperms, angiosperm tree species are not sensitive to differences in the direction of tall buildings at close range (Figure 6). Angiosperm trees growing on the east, south, west, and north sides of buildings did not show significant differences in six visually morphological traits, including the CAD ($p > 0.05$), indicating that the construction of angiosperm visually morphological traits is not significantly related to the direction of light.

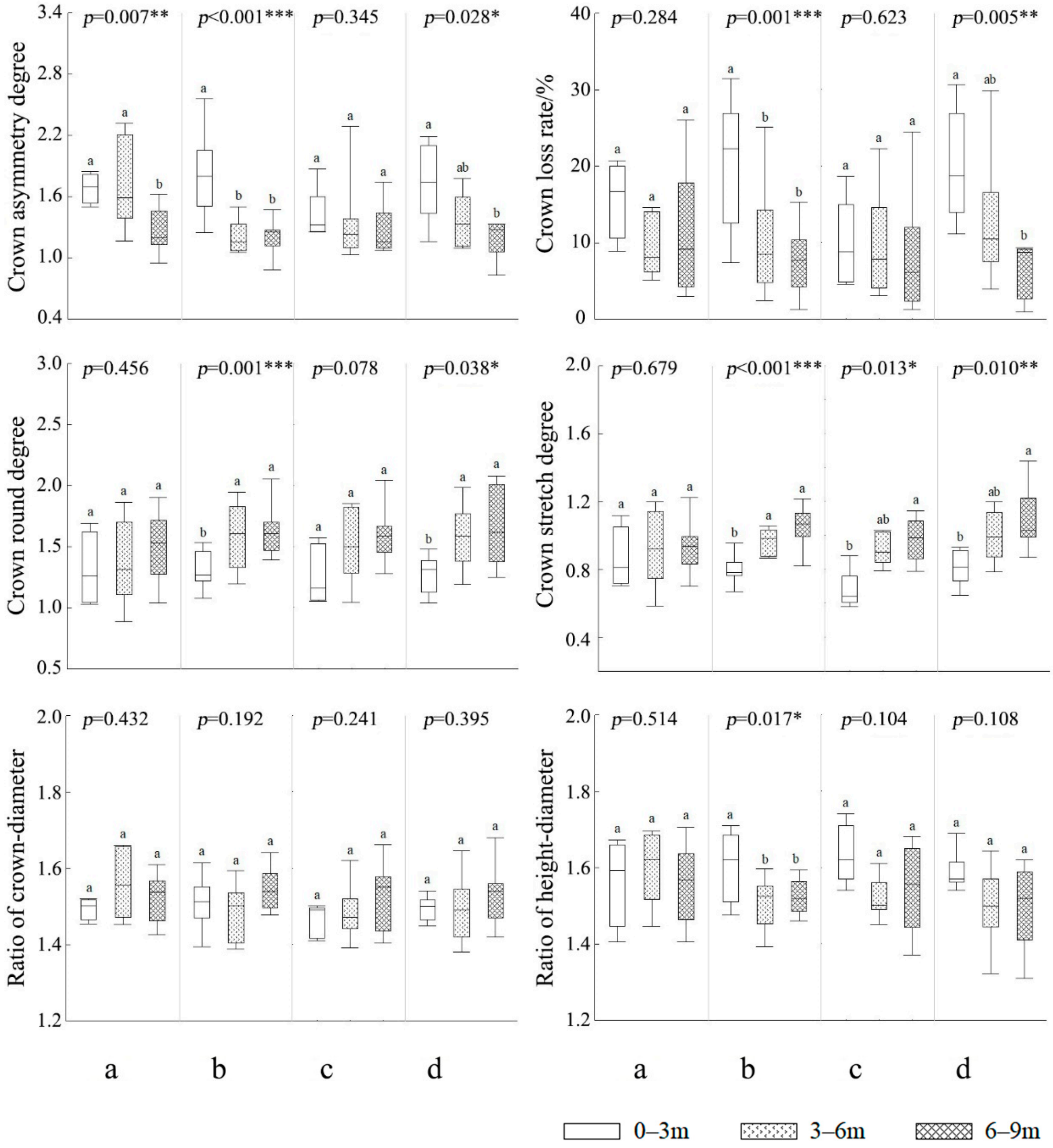


**Figure 4.** The influence of building distance on the visually morphological traits of individual angiosperm trees (a: *F. velutina*; b: *S. japonica*; c: *K. paniculata*; d: *A. truncatum*). (Different lowercase letters indicate significant differences between different groups. * indicates significant difference $p \leq 0.05$; ** indicates significant difference $p \leq 0.01$; *** indicates difference significance $p \leq 0.001$).

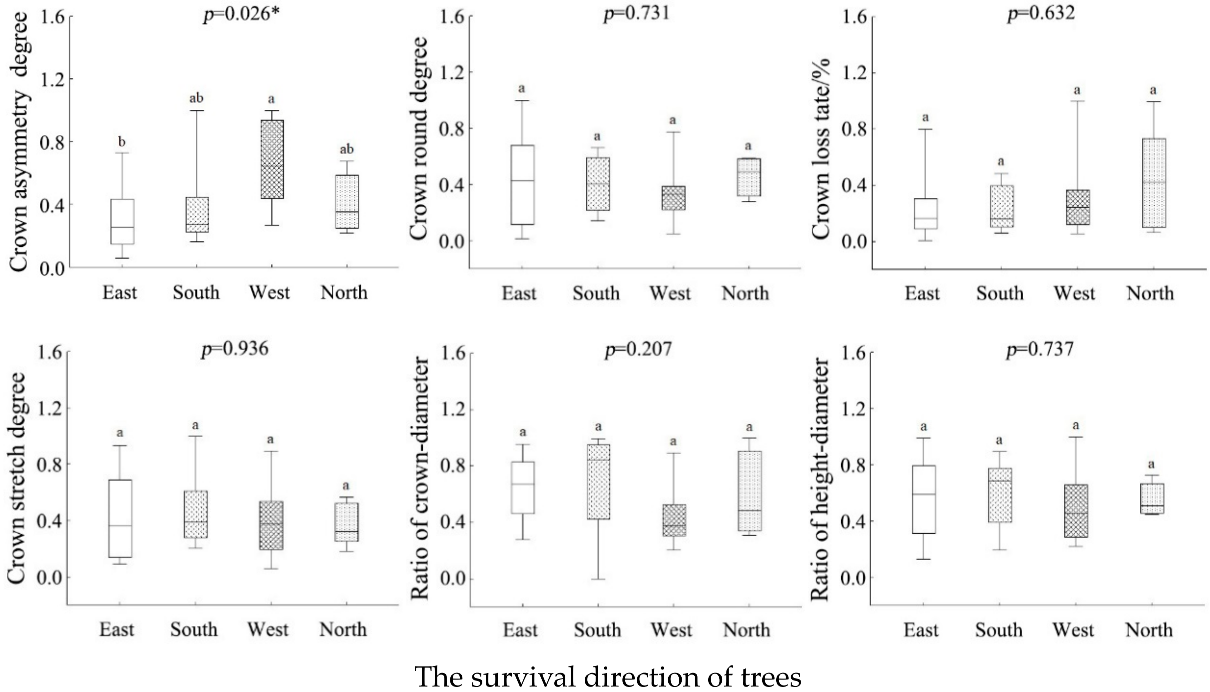


**Figure 5.** The influence of building orientation on individual visually morphological traits of gymnosperm trees. (Different lowercase letters indicate significant differences between different groups. * indicates significant difference $p \leq 0.05$).

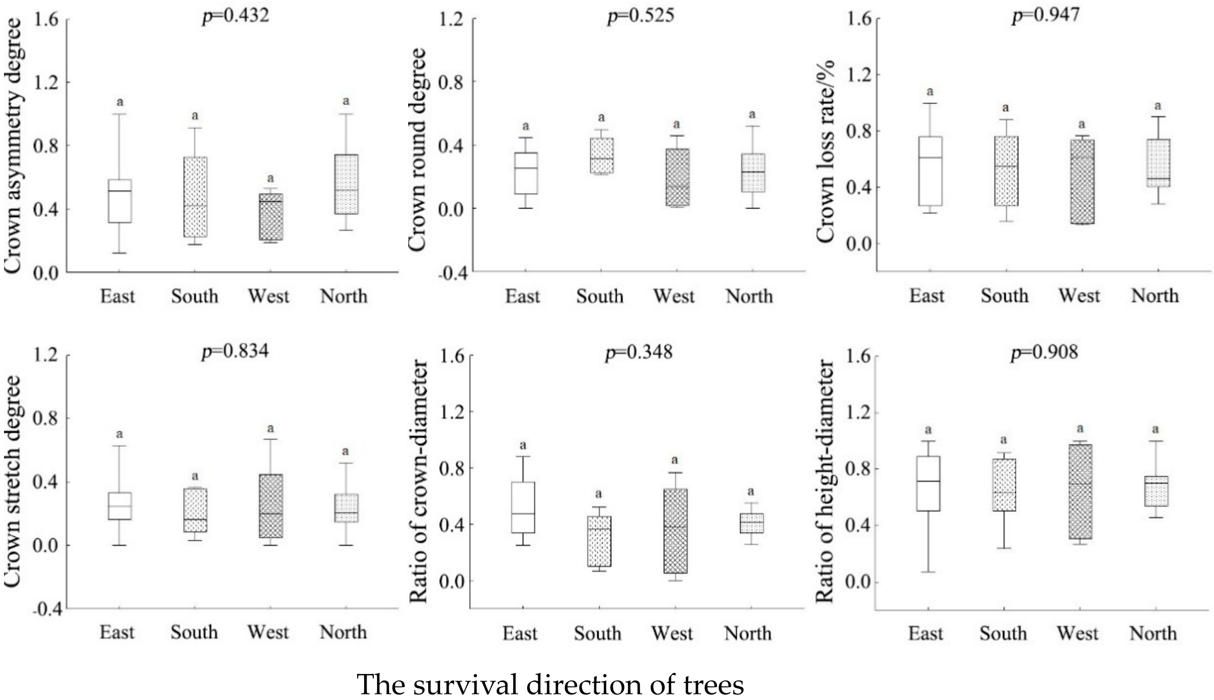


**Figure 6.** The influence of building orientation on individual visually morphological traits of angiosperms trees. (Different lowercase letters indicate significant differences between different groups).

## 4. Discussion and Limitations

### *4.1. Discussion*

In architectural landscape design, the integration of vegetation media is crucial for enhancing diversity and aesthetics, creating a pleasant visual experience [28,29]. By carefully selecting and arranging various plants, designers can create rich landscape layers that not only enrich the visual experience but also help improve the ecological functions and environmental quality of the space. Vegetation not only neutralises the monotonous colours of buildings with its rich colours but also softens the straight lines and sharp boundaries of hard landscapes with its natural form and texture, creating a sense of harmony and balance in the urban environment [30–32]. However, not all tree species are suitable for planting around buildings when constructing urban forest landscapes; the distance and position of planting must be considered [33,34].

Under the influence of high-rise buildings, there are certain differences in the visually morphological characteristics of gymnosperms and angiosperms. Most notably, gymnosperms show more stability in crown loss rate (CLR) and crown round degree (CRD) when the distance to buildings changes, while some angiosperm species show more significant changes, indicating that angiosperms are more sensitive to disturbances and have weaker crown integrity compared to gymnosperms. In terms of the number of changes in visually morphological indicators, angiosperms show stronger changes than gymnosperms, but the trends and degrees of morphological changes vary by species. Among gymnosperms, changes are mainly reflected in the tree coordination of *P. tabuliformis* and *J. chinensis*, while changes are mainly reflected in the crown symmetry of *P. bungeana* and *G. biloba*. For example, the crown stretch degree (CSD) of *P. tabuliformis* within 0–3 m of buildings is significantly higher than other groups, indicating a higher ratio of crown width to tree height. Considering that buildings close to trees occupy more spatial resources, and the crown asymmetry index (CAD) of *P. tabuliformis* near buildings does not significantly differ from other groups, it is believed that the possibility of abnormally increased crown width is relatively small. Changes in CSD are mainly related to individual axial growth. The shading of high-rise buildings affects the normal axial growth of trees, leading to significant changes in indicators reflecting the coordination of trunk and crown. Compared with *P. tabuliformis*, the ratio of height–diameter (RHD) of *J. chinensis* significantly increases under the influence of high-rise buildings, indicating stronger phototropism in axial growth, which reflects different ecological characteristics between the two species. Among angiosperms, *F. velutina* and *K. paniculata* show less response to the distance from buildings, with *F. velutina* mainly showing changes in crown displacement and *K. paniculata* mainly showing changes in crown spread. In contrast, *S. japonica* and *A. truncatum* are more sensitive to the disturbance of high-rise buildings. Under the disturbance of buildings within 0–3 m, the degree of crown displacement and loss in these two species significantly increases, and the crown round degree and stretch degree significantly decrease. It can be seen that some visually morphological indicators of various urban greening tree species show significant differences at different distances. Most indicators are significantly affected within 0–3 m, indicating that buildings at an ultra-close distance of less than 3 m can greatly influence the construction of tree shapes, while the interference of buildings is lower when the distance is greater than 3 m. This may be because the closer the distance, the more obvious the occupation of space around the trees by high-rise buildings, and the stronger the shading of light [33–35], which hinders the normal growth of vegetation crown and trunk morphology. In other words, the narrow spatial environment between buildings can restrict tree growth and damage tree health in terms of tree shape [22].

Research on the degree of influence of buildings on the crowns of common tree species in Beijing can provide a certain basis for the selection of tree species in green space landscapes similar to university environments, such as planting corresponding tree species at different positions from buildings, and reasonable vegetation configuration patterns can greatly ensure the more complete retention of crown morphology for each tree species. For urban green space micro-landscapes, changes in morphological characteristics such as crown morphology can affect the visual perception of species [22]. Urban single-tree landscapes with tall trunks, complete crown development, and coordinated ratios of trunk to crown are usually more attractive for people to watch [9,36], effectively improving the visual ornamentality and the quality of urban green space landscapes. In addition, the higher the degree of crown asymmetry, the more the crown spread degree is reduced, the more it will affect the ecological functions of urban trees, such as cooling and humidifying [34,37,38]. A complete crown shape can ensure the effective functioning of urban green spaces [39], which is of great significance in improving the micro-climate of green spaces, regulating urban environmental quality, and the trend of green species selection in urban forest management. Therefore, exploring the planting position and distance of vegetation around buildings has important reference value in the management of urban green spaces.

### *4.2. Limitations*

In the context of varying environmental conditions, this study examines the influence of the proximity and orientation of tall structures on the visually morphological traits of urban trees. Within urban habitats, particularly in areas of high population density, such as residential neighbourhoods and university campuses, the complexity of the environment precludes the acquisition of a controlled, pristine growth milieu; consequently, this investigation did not incorporate control samples. Beyond the impact of tall buildings, the morphological characteristics of isolated trees, specifically their trunk and crown, may also be subject to anthropogenic interference and microenvironmental features [40,41], which could potentially mitigate the outcomes of this research. Additionally, the present study has focused solely on the differential trends in visually morphological traits and has not extended to an aesthetic quality assessment of tree forms under architectural influence, thus limiting the ability to draw conclusions from a landscape aesthetic perspective. Future research endeavours could benefit from more nuanced quantitative surveillance and simulation of the spatial dynamics between buildings and trees, as well as from integrating human aesthetic appraisals of arboreal landscapes, thereby informing the scientific and comprehensive design of greenery adjacent to structures.

## 5. Conclusions

The influence of tall buildings on the visual morphology of urban trees is mainly related to the distance from the buildings. The closer the trees are to the buildings, the stronger the occupation of spatial resources and the obstruction of light resources around the trees by the buildings, and the more likely the trees change their crown morphology. The response trends of morphological traits for different tree species to the interference of tall buildings are different: Under the influence of close-range buildings, the crowns of *P. bungeana*, *G. biloba*, and *F. velutina* become asymmetric; the overall tree shape of the *J. chinensis* becomes thinner and taller; the crown of the *P. tabuliformis* becomes wide and stretched; the crown of the *K. paniculata* becomes narrow and thin; the crowns of *S. japonica* and *A. truncatum* not only become skewed and missing, but also narrow and thin. In addition, compared to the east side, gymnosperms planted on the west side of tall buildings have a higher degree of crown asymmetry.

Based on the characteristics of tree planting in the building areas and the research results of this article, from the perspectives of safety and aesthetics, it is recommended to plant angiosperm species such as *F. velutina*, *S. japonica*, and *A. truncatum* at a distance of more than 3 m from the building to facilitate the normal development and full expansion of their tree crowns. The distance between *J. chinensis* and tall buildings can be appropriately reduced, which can promote the formation of typical visual features of tall and sharp shapes. However, the distance between the gymnosperm species planted on the west side of tall buildings and the buildings should not be too small to avoid serious crown asymmetry, which not only has a negative impact on the visual quality of the microlandscape but may also cause a safety hazard in strong wind.

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