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How Trees Shape Urban Spaces: Multiplicity and Differentiation of the Urban Forest Viewed from a Visual-Spatial Perspective

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Abstract. Background: The field of urban forestry encompasses many dimensions, of which that of visual-spatial perception, addressing the spatial relationship between city and trees, has received little attention. Analyzing the urban forest from a visual-spatial perspective is needed to understand relationships between different components as well as site-specific qualities. Methods: Tree configurations describe the relationship between form and space, determined by the relative disposition of the trees which result from an interaction between design and the development over time. Based on field observations, with the city of Delft in the Netherlands as a case study, 35 generic tree configuration types have been defined. With this “vocabulary,” specific tree configurations and their relations are researched, describing the urban forest from an eye-level perspective as an essential level on which the spatiality of the urban forest can be understood. Results: Unraveling the urban forest components by comparing two emblematic ensembles of tree configurations allows an understanding of their heterogeneity as well as their coherence and dynamics. Conclusions: The relationship of the tree vocabulary with the specific location exposes their role as an ordering structure and a carrier of the identity of Delft, and their differentiation and site-specific qualities, revealing a composition of wooded areas each with their own characteristics, shows both urban and forested areas as equivalent components of an urban forest mosaic. This differentiation can be used as a tool for strengthening relations between the different components as well as diversity and heterogeneity in urban forests.

Keywords. Site Specificity; Tree Configurations; Tree Vocabulary; Visual-Spatial Characteristics.

INTRODUCTION

Trees in the urban realm create spaces for people to live and act, move, admire, work and play. The mosaic of these spaces, and the way they are formed by different species, different configurations, and structures of trees in relation to infrastructure, water, subsoil, and buildings, conveys the diverse experiential, ecological, and functional qualities of what we might call the urban forest. The way these spaces are perceived has many facets, ranging from the physical-visual (dimensions, proportions, structure, texture, transparency) to the ephemeral (atmospheric and symbolic). A specific focus on the visual-spatial perception, the urban forest as seen from a human eye-level perspective, can inform our understanding of the urban forest and its relations to city and landscape, and might reveal the durable role of the urban forest in creating orientation, identity, and structure.

Such an interaction between humans and wooded spaces can only be site-specific, given that tree species, planting types and wooded structures cannot be separated from the place where they stand, with the specific, associated realm of experience. To analyze the urban forest as such we introduce the notion of a “tree language,” a notion that was first coined by landscape architect Frank de Josselin de Jong (2009). Just like every language, a tree language has a vocabulary—the generic, or repetitive, formal components—that allows us to understand and communicate the existing “wooded narratives” of urban environments and to maintain, transform and expand them in relation to what is already there. Such a vocabulary can be considered at different scales: morphological types of tree species, tree configurations and ensembles (coming together of multiple configurations forming a whole, a unified or interrelated group), and wooded structures.

This paper focuses on tree configurations. The city of Delft was chosen as a test case for developing a methodology for analysis, given it is a typical lowland Netherlands city of modest size, with a long history of urban tree planting, and major transformation challenges in terms of expansion and renewal of the housing stock, climate adaptation, health and welfare, livability, and the preservation of identity.

Dimensions of Urban Forestry

Delft is a city of trees. The number of trees in Delft (over 35,000 in its public space) appear to comfortably meet the international definition of forest, which defines that at least 10% of the land area is covered by trees, as do 60% to 80% of cities in temperate regions, according to Rowntree's (1984) estimation. However, an urban forest cannot be judged based on the number of its single urban trees, just as a forest is not defined by the number of its trees. Nor can urban forestry be restricted to the study of separate woods in the urban realm. It is the combined characteristics of the mosaic of species, configurations, and wooded structures in the Delft urban realm that defines the Delft urban forest.

The emergence of the term urban forest (and of urban forestry as a discipline) was motivated by the need for an integral view of the various components of urban green space in relation to tasks in the field of nature, environment, and health (Miller 1997; Konijnendijk et al. 2005). In this development, the urban forest is seen both quantitatively and qualitatively as the backbone of urban green infrastructure. The various scales of urban forestry reveal its multi-dimensionality, impacting the environmental, ecological, socio-spatial, and economic health of cities and urban communities. As such, urban forestry encompasses all these dimensions and assumes their synergy as fundamental to any sustainable urban environment.

In such a young discipline, definitions need developing, refining, and expanding, allowing for variations, differences, and scale relations. The dimension of spatial perception—the perceptual interaction between humans and trees—has received relatively limited attention and is often overlooked. More specifically, visual-spatial perception, the urban forest as seen from a human eye-level perspective, can inform our understanding of the urban forest and its relations to city and landscape. How then, can we understand urban forestry from a visual-spatial perspective?

A specific motivation of elaborating the urban forest from a visual-spatial perspective relates to the particularity of the urban forest, as compared to more conventional forest types. Whereas natural forests can be considered as systems that self-regenerate and largely function without human intervention, the conditions for the urban forest are man-made, and the artificial and the natural meet and engage in ecological, social, and experiential relations. Urban forests need human intervention to function and regenerate. This leads to the question of how management practices can engage with the urban forest by interaction with the specificities and particularities of the existing, rather than imposing generic forest management practices. A broader research question is thus: how can we understand the existing, as a basis for response and interaction?

To address such a question, the full spectrum of wooded urban landscape components needs to be considered. By taking street trees, for example, as serious as their ecologically and perceptually richer counterparts, they can be considered latent, future urban forest components of value. Considering the urban forest as a mosaic that encompasses the full range from single trees to ecologically valuable forest areas in the urban sphere of influence, each with their specific perceptual, environmental, social, and ecological quality, overrides the classical—politically and programmatically determined—dichotomy of city and countryside. This can be helpful in redirecting the thinking about urbanism in general and urban forestry specifically. Thus, the urban forest can be strengthened as a whole, as a mosaic of relationships, and as a spatial framework for human and non-human use, such as recreation and infrastructure, shelter, and food, as well as for ecosystem services, such as mitigating heat stress. To regard the relations, rather than the components, might reveal the urban forest as a carrier of historical continuity, and ecological and environmental functionality.

From Taxonomy to Tree Language

The visual-spatial perspective to urban forestry has its roots in the early 20th century when a group of American landscape architects studied the specific role that plants play in the delineation of space, aiming to free plants from their ornamental and symbolic values. They sought for an understanding of the perceptual qualities of plants (and trees specifically),

combining the knowledge of a volumetric, architectural understanding of space, and an atmospheric landscape experience, “asserting the human body’s importance for the perception of space” (Meyer 2009, p. 119).

Most explicit in this endeavor was James Rose, who developed a taxonomy of plant forms to articulate their spatial effects, which he explained in his book *Creative Gardens* (Rose 1958). He considered plants as analogous to architectural elements but with specific and unique formal properties, which come from their nature as living material. According to Rose, the main difference is their “sense of transparency, [...] of visibility broken by a succession of planes” (Rose 1938, p. 69). He developed a classification that describes plants in terms of the relation between form and space, according to height, form, and spacing. When height is considered in relation to the human body, the defining aspect is whether the tree reaches above or below eye level. Keeping in mind that plants do not remain the same height, “for this classification the heights are those at which the plant will remain for a period of from 10 to 20 years either by itself or with assistance” (Rose 1938, p. 70). A relevant aspect

is brought forward by adding these last words: for a classification that departs from spatial definition it is not relevant whether the plant form is natural or a result of propagation or pruning. In terms of individual plant form, Rose paid particular attention to the quality of transparency. This led to a typology of tree forms divided into 6 formal categories: columnar, suspended, round or oval, horizontal, broad and spreading, and irregular or picturesque. The distinctions between the categories are determined by the proportions of crown and trunk, and the density of the foliage, which in turn is determined by the shape and size of the leaf, the position of the leaves and the degree of branching.

Using the same criteria that defined the formal characteristics of plants, Rose then extended his taxonomy to include the grouping of trees, considering tree form and tree grouping in parallel. Density, or transparency, is influenced by what he called “spacing”—the way individual plant forms are aggregated—as well as by how form and spacing interact, suggesting that the effect of the individual can be maintained or amplified when it is aggregated (Figure 1).

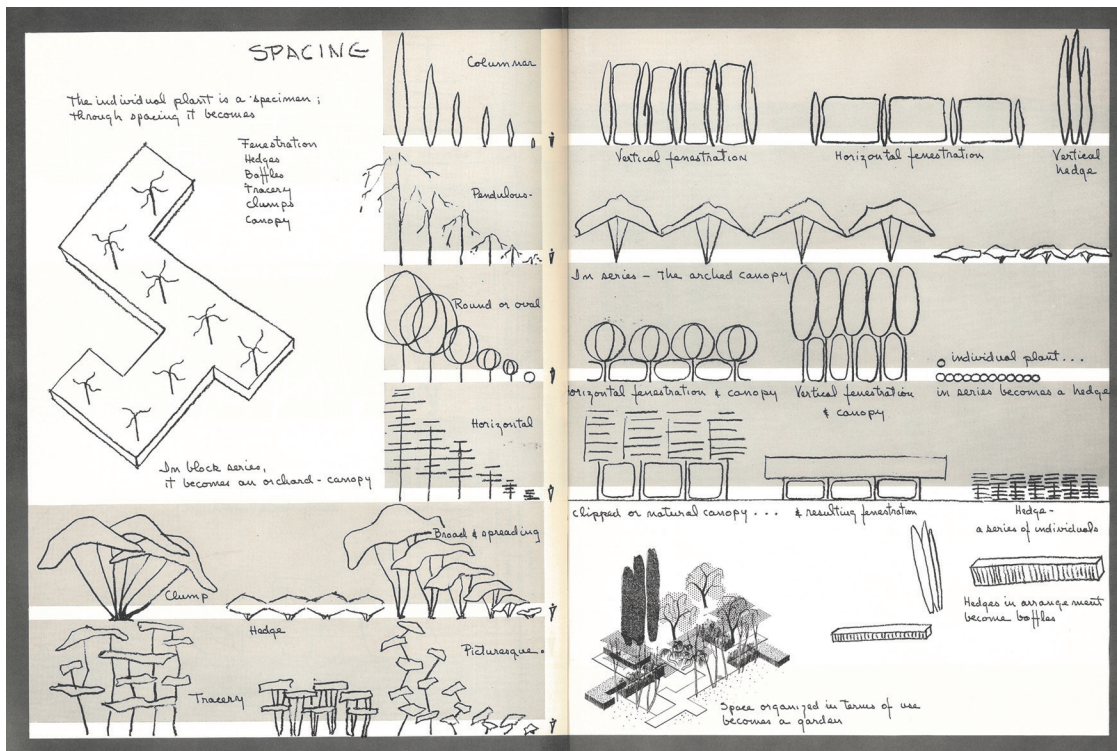


Figure 1. James Rose’s taxonomy of plant spacing (Rose 1958, p. 202-203).

Research into the spatial characteristics of trees received a small revival in the 1980s, expressed amongst others in the teaching by landscape theorists Elizabeth Meyer in the US and Clemens Steenbergen in the Netherlands, which contributed to describing, discussing, and evaluating the spatial effects of tree plantings as urban landscape components. Meyer wrote “How do plants define space? [...] The space between [the canopy] and the ground is a palpable space, a shady place sheltered from the sun and separated from the sky. The character of this space is dependent on many variables, from the shape and texture of the leaf and its darkness of tone to the size and shape of the canopy” (Meyer 2009, p. 125). Steenbergen used notions as screening, transparency, uniformity, continuity, structure, edge profile, and formality to describe different planting images, aiming for a “language” to discuss and transfer any planting form imaginable (Steenbergen 1990, p. 10-11). Meyer and Steenbergen focused on the groupings of trees as landscape components, the scale level between the individual tree and the wooded structure.

In his study, *De bomentaal van Slotervaart* [the tree language of Slotervaart], landscape architect Frank de Josselin de Jong then added to this reading of plant forms and groupings, the dimension of the spatial relations between these components. The research aimed to understand the placement and choice of trees and tree ensembles in the post-war garden cities in order to then let them “speak” in future renewal operations. Noting that the application of trees in Amsterdam varied greatly by neighborhood

and construction period, he introduced the concept of a tree language to enable a comparison and discussion of those variations (de Josselin de Jong 2009).

Exploring a Typology of Tree Configurations

This notion of a tree language, analyzing how the formal characteristics of trees and their configurations and structures define space, as emerged from the work of Rose, Meyer, Steenbergen, and de Josselin de Jong, informed the exploration of the urban forest of Delft. We developed a typology of tree forms, tree configurations and wooded structures, mapping them on different scales to study their spatial relations. The configuration types are summarized in diagrams. Their abstraction overrides the associations typically connected with trees: green color, cloudy shapes, and irregularity, redirecting the attention to the space they define: inside or outside, below or between (Figures 2 and 3).

The maps have the combined databases of all trees under management of the Municipality of Delft and TU Delft as primary source, supplemented by historical documentation and cartographic research. However, the abstract, top-down, and two-dimensional character of such maps does not reflect the three-dimensional, material, and atmospheric realm of eye-level perception. Thus, since the perceivable form is the basis for the tree language, the most important source of information were field observations, conducted by the authors and several groups of students, using visual perception to generate eye-level perspective

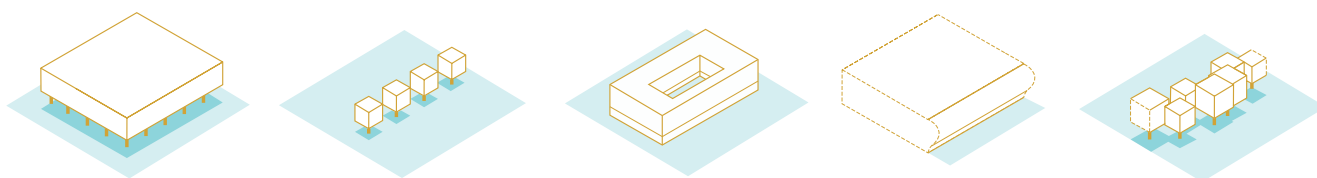


Figure 2. Configuration types of the Verzetstrijdersbuurt: ceiling, colonnade, bosquet, thicket, and curtain.

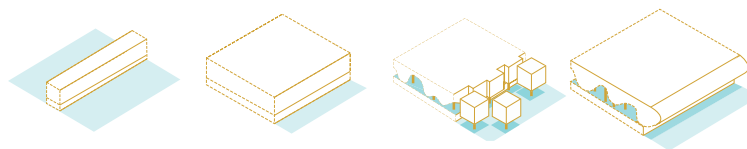


Figure 3. Configuration types of the Delftse Hout: wall, thicket, sandwich vault with crumbled edge, and sandwich vault with pillow edge.



Figure 4. The trees of Delft. By mapping the trees without showing classical topographical indicators such as buildings and infrastructure, the Delft urban forest emerges as carrier of the urban structure. The color range from red to yellow represents the range in tree morphology: from tall and narrow to low and wide. Drawing by Ioanna Kokkona based on Municipality of Delft (2021).

studies that address the spatial relationship between trees and their urban surroundings. Walking and cycling are the most direct way to perceive the environment, not only involving visual experience, but as a multi-sensory, active interaction with the urban landscape.

To understand the role of trees as spatial structures, we mapped the urban forest on the scale of the city. These maps show only trees in public space, without showing classical topographical indicators such as buildings and infrastructure. As a result, they clearly convey the role of the urban forest as a durable carrier of the urban structure, exposing both the unique identities of the different areas as well as their coherence (Figure 4).

How the relations between these configurations constitute the specific Delft tree language is further researched by zooming in on the map and unraveling several ensembles of configurations, in different parts

of the city and created in different time periods. We compare an ensemble in a housing neighborhood and an ensemble in a recreational forest. Programmatically and ecologically, such areas are far apart. Similarly, from a traditional perceptual perspective based on appearance, a housing area and a recreational forest seem incomparable. However, from a visual-spatial perspective they can be compared as equal components of the same mosaic.

A Wooded Spatial Sequence: Verzetstrijdersbuurt

A first example is a sequence of wooded spaces in the Verzetstrijdersbuurt, a neighborhood in the 1960s urban expansion district Buitenhof. Staggered residential buildings are organized around a series of loosely defined courtyards, in spatial sequences perpendicular to the main urban structure. Low fences and sheds surround the courtyards, which are located at the backside of the buildings, so the spatial definition is caused by the tree configurations, rather than by the buildings (Figures 5 and 6).

In the first courtyard a regular grid of *Platanus × hispanica* forms a “ceiling,” covering a grassy area that provides space for sports and play, and framed by a back street and garages. The canopy distinguishes the space underneath from the margin around it (Figure 7). A single row of *Alnus × spaethii* ‘Spaeth’ connects this courtyard to the next. Their canopies remain separate from each other, and the trees remain recognizable as individuals, while also relating to one another as a “colonnade” (Figure 8). In the next courtyard, trees and shrubs form a “bosquet,” enclosing a formal space. Below the trees, a mixed shrub layer forms a closed wall, creating an introverted space for sports and play, open to the sky. The distance between the trees (*Acer campestre*, *Acer saccharinum*, *Alnus glutinosa*, and *Platanus × hispanica*) is quite large, and the wall of shrubs is dominant in defining the space (Figure 9). A “thicket”—trees and high shrubs with overlapping canopies—connects the second courtyard to the water line that divides the neighborhood from the next, and marks a junction in the pedestrian network at a bridge over the water. The thicket is a mix of species: *Acer campestre*, *Populus x canadensis*, *Populus × euramericana*, *Sorbus aucuparia*, and *Tilia europaea*. In terms of spatial experience, use and accessibility, a thicket is complementary to a bosquet: a closed wall from the outside, dense and impenetrable on the inside, and giving shelter to a range of non-human species



Figure 5. Map of the urban forest ensemble of the wooded spatial sequence in the Verzetstrijdersbuurt. Drawing by Ioanna Kokkona, Silvia Viola, and Saskia de Wit.

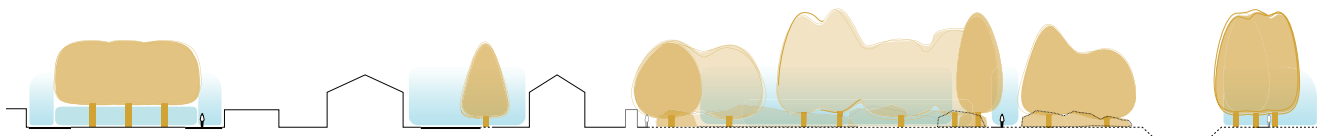


Figure 6. Section of the urban forest ensemble in the Verzetstrijdersbuurt. The blue fields indicate the spaces as defined by the planting configurations. Drawing by Ioanna Kokkona, Silvia Viola, and Saskia de Wit.



Figure 7. Ceiling.



Figure 8. Colonnade.



Figure 9. Bosquet.



Figure 10. Thicket.



Figure 11. Curtain.

(Figure 10). Lastly, a loose and transparent line of alders (*Alnus glutinosa*) and birches (*Betula pendula*) at varying planting distances forms a “curtain,” in dialogue with the dense thicket on the opposite bank. Accompanying the water and footpath, the curtain separates and connects 2 neighborhoods (Figure 11).

An Alternation of Forest Volumes and Open Spaces

In the same period a large recreation area was constructed at the other side of the city. Already in 1921, the Delft Expansion Plan recommended the construction of a large park to the east of the city, “where the quiet, restful view of meadows interspersed with trees will have a soothing and pleasant effect on the walker” (van der Gaag 2015, p. 67). In 1966, this park was elaborated by the municipal department of Public Works in cooperation with landscape architect W.C.J. Boer into the Delftse Hout, a multifunctional recreational area with sports fields, a city camp site, a children’s farm, cemetery, cycling, walking and riding paths, and intensive day recreation with playing and sunbathing areas, arranged around a central recreation lake. The forest masses serve as a backdrop for the recreational fields, and the edges have a different expression, related to the adjacent open space. The northern boundary of the Delftse Hout forms a layered and subtle transition between the centrally organized Delftse Hout and the adjacent pre-war park, Hertenkamp, which follows the orthogonal structure of the agricultural landscape (Figures 12 and 13).

A cycling path along the boundary is framed by 2 almost similar opaque “walls” preventing views to either of the parks on both sides. The walls consist of a mixed planting of several tree and shrub species, planted close together to create a contiguous whole (Figure 14). At the side of the open fields of the Hertenkamp, the wall is autonomous, while at the side of the Delftse Hout, it forms the edge of a volume of trees and tall shrubs with intertwining crests, dense and impenetrable on the inside. Towards the center, the transparent tree species allow enough light in the core of the forest to form an understory of shrubs, but the tree layer of *Fraxinus excelsior*, *Platanus × hispanica*, and *Populus × canadensis* has high crowns, and the tree canopy is clearly separated from the shrub layer below. Towards the central lake this “sandwich vault” gradually transforms into the park-like scattered planting of the sunbathing area,

creating an edge which is an alternation of a “pillow edge” and a “crumbled edge,” providing different degrees of shelter. The pillow edge is a dense and impenetrable edge where tree layer and shrub layer

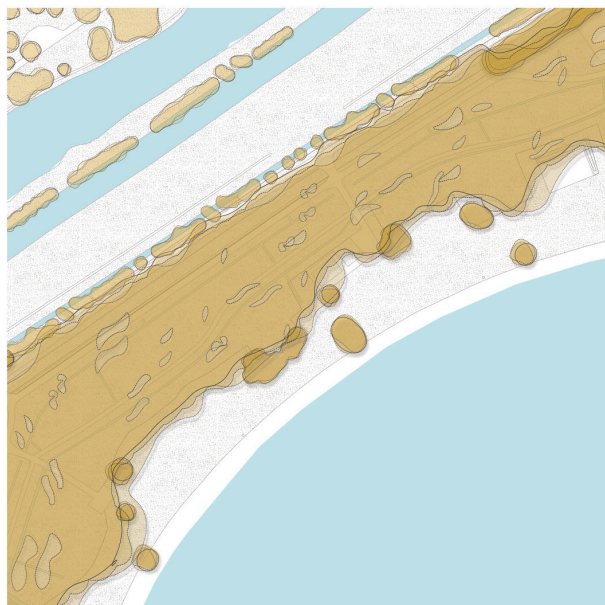


Figure 12. Map of the urban forest ensemble of the layered edge in the Delftse Hout. Drawing by Ioanna Kokkona, Silvia Viola, and Saskia de Wit.

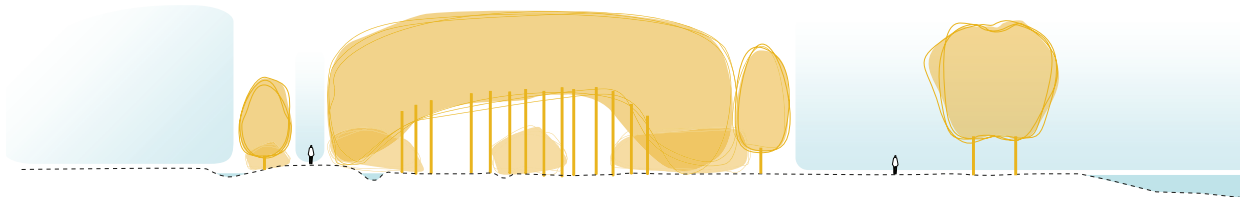


Figure 13. Section of the urban forest ensemble in the Delftse Hout. The blue fields indicate the spaces as defined by the planting configurations. Drawing by Ioanna Kokkona, Silvia Viola, and Saskia de Wit.

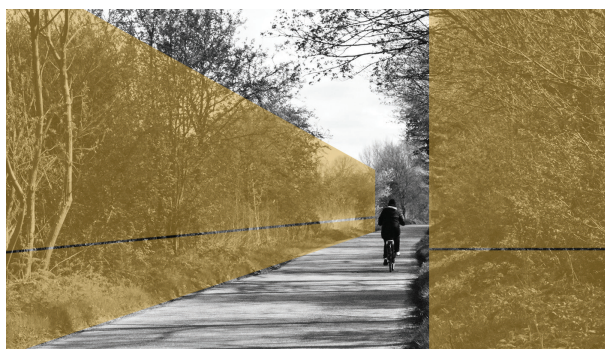


Figure 14. Wall and thicket.

merge, and the tree layer cantilevers over the understory (Figure 15). In the crumbled edge, the sandwich vault is still visible, and free-standing trees in the field echo the dense forest (Figure 16).

Unique Qualities and Heterogeneity

This unraveling of the urban forest components into ensembles of tree configurations allows an understanding of the heterogeneity in a seemingly undifferentiated wooded structure (Delftse Hout), as well as the coherence in a seemingly fragmented one (Verzetstrijdersbuurt).

The green structure in the Verzetstrijdersbuurt, the realm of pedestrians and animals, is separated from the traffic space, a distinction that is elaborated and expressed at the small scale of the ensemble, in the simple colonnade where the green structure meets the traffic structure. A colonnade is the most generic street planting type, usually accompanying the full length of a street. However, in this case its length is limited to the width of the sequence of green spaces, showing a prioritization of the green structure over the car-oriented urban structure.

Also, the sequence shows a gradient from clear to ambiguous, from simple to diverse, and from social to



Figure 15. Sandwich vault with pillow edge.



Figure 16. Sandwich vault with crumbled edge.

ecological, expressing a palette of social and ecological possibilities, as a consequence of the development over time. When planted in the 1960s both courtyards had the same planting pattern: a “carré” of trees around an open center. Over time, the different dimensions, the different relations between tree species and shrubs, and the different maintenance regimes caused this simple planting pattern to transform into diversified spaces. In the northern courtyard the canopy closed and developed into a roof, in the southern one the canopy joined with the underlayer and developed into a wall. The mapping exposes these—probably unintentional—effects instead of the intended generic planting pattern, giving cause to emphasize the unique qualities and heterogeneity through a more diversified management. Already this gives an indication of the relevance of time: the conceived space of the planting patterns has become the perceived space of the configurations, which has gained a richness over time.

Studying the forest of the Delftse Hout from a visual-spatial perspective brings a different quality to light. Here the role of the edges in defining the urban forest is brought to the fore: those parts of the forest that can be seen from the paths and the fields, the places where humans reside. Once we shifted our focus to the forest edges, a wealth of different types emerged, and here also the aspect of the development over time was a determining factor. What had been planted as a continuous forest, developed into a range of different edge types. The wide space of the open fields allowed for the development of a layered forest edge, whereas along the narrow path a straight wall needed to be maintained to allow for space for the

bikes and pedestrians. Over time the continuous maintenance led to a closed canopy, whereas in the center of the forest an open vault developed because the trees rob the understory of light. The wider edge at the side of the fields developed an asymmetrical canopy, protruding over the field. The presence or absence of trees in the adjoining field influenced the canopy of the forest edge, leading to a pillow edge where no trees disturbed the forming of the canopy, and to a crumbled edge where the field trees interacted with the forest trees.

The Urban Tree Configurations of Delft

The systematic translation of the subjective experiences of the different perceivers into the visual-spatial properties of the perceived tree groupings (such as size, shape, dimensions, transparency, uniformity, continuity, planting pattern) provided the data for deducting a typology of tree configurations, translated into the legend of a map of tree configurations of Delft, by grouping them in 4 categories: points, groups, lines, and volumes (Figure 17). The pattern of configurations in the map shows the structure of Delft, dominated by its tree lines that emphasize the canals typical for a lowland city, the fine-meshed warp and weft structure of the postwar neighborhoods, as well as the polder structure that is visible mainly in the east part of the city. The various roles the lines play in different parts of the urban forest are expressed in the combinations they make with the other configuration types. In the city center, where the structure of the lines is that of the canal city, the lines are predominantly complemented by pointed configurations. Where the lines follow the polder structure, they are complemented by tree volumes. And where they form a pattern of warp and weft in the postwar neighborhoods, the main complementary configurations are tree groups.

DISCUSSION: FORM AND PROCESS

Understanding the urban forest as a language, with a visual-spatial vocabulary based on its various dimensions and scales, generates novel insights into specific elaborations from location to location, which can be of critical value to management and transformation. As can be deduced from the analysis of the Delftse Hout and the Verzetstrijdersbuurt, the configurations as we perceive them in this moment result from an interaction between the initial design and the development over time, with its different maintenance regimes, suggesting a basis for guiding diverse

maintenance regimes based on the definition of configuration types.

Taking configurations as the starting point, rather than predictive planting plans, allows for maintenance to take an active role in shaping what is emerging over time, instead of trying to mold the plants to an initial fixed image. Upholding an ensemble of configurations will maintain or enhance the spatial and

historical continuity, while allowing maintenance the freedom and responsibility to replace or add species when this becomes relevant (e.g., due to changing physical conditions such as climate change, disease, or changing insights or visions). Other species from the same spatial category and size can be selected, or species that receive their density and form because of pruning might be replaced by species with a similar



Figure 17. The tree configurations of Delft, categorized in points, groups, lines, and volumes. Drawing by Ioanna Kokkona, and Saskia de Wit based on Municipality of Delft (2021).

natural form and density. Alternatively, species that are more massive or transparent, larger, or smaller can be selected, with an accessory adjustment of the planting pattern to maintain the spatial coherence, thus keeping the configuration intact.

Because plant forms are always growing, developing, and decaying the resulting configurations are in essence intermediate forms, and one configuration might develop into another, each valuable for its own sake. Landscape architect Julian Raxworthy coined the notion of the “viridic,” describing the interrelation between plant growth and form, and its impact on the relation between design and maintenance. What he wrote about individual plants also has implications for the tree configurations in the urban forest: “‘form’ becomes dynamic and changeable and has many more configurations than a single category [...] The implication of this is that all the intermediate states that the [configuration] goes through along the way represent a multitude of emerging and changing qualities all from the same [configuration], each intermediate state valued in design terms as much as the mature condition” (Raxworthy 2018, p. 325). But where for individual plants the intermediate states are everything in between the pot and the mature condition, for configurations there is no distinction between the juvenile and mature condition, and states can be intermediate and mature at the same time, such as the ceiling and the bosquet—both originating from a carré configuration—in the Verzetstrijdersbuurt illustrate.

This interaction between design, plant growth, and maintenance needs to be more explicitly elaborated in further research, including projecting the observed process to the future, with guidelines for expressing and strengthening the existing and potential qualities.

CONCLUSION: CONFIGURATIONS

This research led to the definition of tree configurations: the relationship between form and space as determined by the relative disposition of the components of the shape. The disposition—the pattern of trees in relation to each other—concerns the two-dimensional logic of the planting plan, the system of sizes and proportions. The combination of the spatial characteristics of the components (the trees) and those of the disposition determines the overall perceptual quality.

How trees define urban spaces as a result of their specific and unique formal properties comes from their nature as living material. The formal tree

typology, material characteristics of individual tree species (color, transparency, habitus, relation between crown and trunk, etc.), their age, the influence of the context (climate, soil, etc.), maintenance, and technical and climatic restraints of the situation are relevant when assessing the perceptual qualities of tree-formed space. However, this defines them not only as individual organisms but also as collaborating components of communities or configurations. Each configuration gains their own spatial expression, resulting from the interacting, informing, and changing of individuals because of their interaction. Even the most massive tree species might produce a transparent screen when the planting pattern is spacious enough, while a densely planted group of transparent species may be perceived as a wall. In urban situations it is often overlooked that when several trees are planted together, it is the joint configuration that determines the qualities of the space rather than the qualities of the individual trees, just as in a natural forest, the individual tree form disappears in favor of the forest as a whole.

A single tree configuration defines space in multiple ways, relevant to the position of the perceiving subject, allowing the same grouping to act both as volume and as space. Perceived from a distance, a group of trees acts as a volume in relation to the space outside the group. Perceived from within, the trees create space in between and underneath. As a result, a single configuration might create 1 to 3 spaces: (1) outside: the space next to or around the configuration, with the tree configuration as a boundary or focus point; (2) inside: the space enclosed by the configuration; (3) under/in: the space under the tree canopy. Each of these spaces can be separated or interrelated. A configuration of a single species of trees at equal distances can easily be perceived as defined space when the canopies form a continuous roof. But also naturally developed forest configurations with multiple species, open on the inside and with a dense edge, can form a similarly clearly perceivable space with a “roof” and “walls.”

Based on properties such as size, form, regularity, and transparency, 35 different configuration types could be deducted from the complete range of configurations that occur in Delft. Pointed configurations (solitary, portico, block, tree bouquet) collect, accentuate, and define the surrounding space. Groups (clump, copse, orchard, carré, open carré, ceiling, bosquet)

define the space between the trees, under the canopy, whereas from a distance they are perceived as a unit. Lines (open row, colonnade, curtain, screen, window, wall, double screen, double row, gallery, asymmetrical gallery, tunnel, stoa, multiple screen) are the most characteristic configurations in the Delft urban forest: in the cultural landscape straight rows of trees are among the most important structure-defining elements, and in the urban surroundings the majority of (municipal) trees can be found as street planting. Volumes (scattered, park forest, plantation, thicket, vault, sandwich vault) are wooded areas too large to be perceived as one unity from the outside. They are defined by the relation between core and edge, that goes hand in hand with the spatial distinction between under or in the configuration (the core) and outside it, with the edge of the forest as the boundary. The edge—the transitional zone between forest and open space (wall, screen, curtain, pillow edge, blanket edge, or crumbled edge)—often also constitutes a space in its own right, like a gallery between building and outdoor space.

A comparison to other cities would expand the typology of 35 configuration types that have been derived from studying Delft, to a comprehensive configuration typology: a vocabulary of tree configurations. Trees on private lands also play a role in the spatial definition so these would need to be added in future studies as well.

For a full understanding of the urban tree language the scale of the tree configuration and their ensembles should also be studied in relation to other scales: the different tree species (as shown in Figure 2), individual location characteristics, and the classification of formal tree characteristics on one hand, and the structure, patterns, and densities of wooded areas on the other. Mapping them at the same scale and precision, with the levels of understanding as unique legends with a corresponding grain would expose how they can be understood in relation to each other. Such maps that define and interpret the existing tree structures could reveal an urban forest mosaic composed of wooded areas, each with their own characteristics, reminiscent of the alternation and heterogeneity of more or less diverse, more or less densely wooded areas and open spaces, at different moments of development, that characterize natural forests.

Unraveling the visual-spatial characteristics of the urban forest separate from other perceptual aspects, such as atmosphere or image, allows one to regard

seemingly incomparable urban forest components in mutual relationships and compare them as equal components of the mosaic that is the urban forest. It exposes a tree language that can be understood as a set of rules such as those of grammar, where the relationship between the various scales characterizes the specifics of the urban forest at each specific location. In parallel to linguistic languages, the tree language has a generic vocabulary: the *types* of tree species, configurations, and structures, which can be used to read and write the tree language of specific locations. Naming and describing the different types of configurations as they are perceived from eye level provides a rich palette of spatial qualities, beyond planting patterns and plans. The spatial differentiation provides a framework for a differentiation in perception, use and ecological diversity, and abstracting these into generic types allow for use and comparison between different situations all over the world, regardless of climatic, social, and cultural differences. The configuration types that form the vocabulary each have a particular form and spatiality. The spatial relationship of this vocabulary with the specific location exposes a range of spatial narratives, each unique and specific. The configurations are site-specific and dynamic and can develop a different expression over time or transition from one type into another.

At the city scale, the role of trees as a carrier of the urban structure is brought to the fore. The role of the urban forest as an ordering structure and a carrier of the identity of Delft clearly emerges from the map, revealing a city that can only be Delft. Defining and interpreting the existing tree structures reveals an urban forest mosaic composed of wooded areas, each with their own characteristics, showing both urban and forested areas as equivalent components of Delft as a wooded city. Although these urban forest components are not self-generating natural systems, they show an alternation and heterogeneity of more or less diverse, more or less densely wooded areas and open spaces, at different moments of development, comparable to the diversity in natural forests. At the ensemble scale the interaction between the configurations into sequences or layers reveals the specificity of each location, giving insights for design and transformation that move away from (for example) the hegemony of the traffic-oriented urban structure.

Defining and mapping these types has 2 specific benefits: it highlights the relations as well as the

differentiation and site-specific qualities of the existing urban forest components. This differentiation might then be used as a tool for strengthening relations between the different components, as well as diversity and heterogeneity in urban forests. Discovering the unique implementation of the tree language in each situation can offer a tool that resists uniformity; the specificity of each part of the urban forest can be defined, as a basis for management, care, and further development.

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Résumé. Contexte: Le domaine de la foresterie urbaine englobe de nombreuses modalités, dont celle de la perception visuelle et spatiale, concernant la relation spatiale entre la ville et les arbres, qui a reçu peu d'attention. L'analyse de la forêt urbaine, selon une perspective visuelle et spatiale, est nécessaire afin de comprendre les relations entre les différentes composantes ainsi que les qualités spécifiques d'un site. Méthodes: Les configurations d'arbres résultent de la relation entre la forme et l'espace, déterminée par le positionnement relatif des arbres, découlant de l'interaction entre la conception et le développement au fil du temps. Sur la base d'observations de terrain, avec la ville de Delft aux Pays-Bas comme étude de cas, 35 types de configuration d'arbres génériques ont été définis. Grâce à ce "glossaire", des configurations d'arbres spécifiques et leurs relations sont étudiées, décrivant la forêt urbaine à partir d'une perspective située à la hauteur des yeux comme un outil essentiel afin de comprendre la spatialité de la forêt urbaine. Résultats: Démêler les composantes de la forêt urbaine en comparant deux ensembles emblématiques de configurations d'arbres permet de comprendre leur hétérogénéité ainsi que leur cohérence et leur dynamique. Conclusions: La relation entre le glossaire des arbres et le positionnement spécifique révèle leur rôle en tant que structure ordonnée et porteur de l'identité de Delft, avec leur différenciation et leurs qualités spécifiques de site, révélant un assemblage de zones boisées ayant chacune leurs propres caractéristiques, attestant des zones urbaines et forestières comme des constituantes équivalentes à une mosaïque de forêts urbaines. Cette différenciation peut être utilisée comme outil pour renforcer les relations entre les différentes composantes tout autant que la diversité et l'hétérogénéité des forêts urbaines.

Zusammenfassung. Hintergrund: Der Bereich der städtischen Forstwirtschaft umfasst viele Dimensionen, von denen die visuell-räumliche Wahrnehmung, die sich mit der räumlichen Beziehung zwischen Stadt und Bäumen befasst, bisher wenig Beachtung gefunden hat. Die Analyse des städtischen Waldes aus einer visuell-räumlichen Perspektive ist notwendig, um die Beziehungen zwischen verschiedenen Komponenten sowie die standortspezifischen Qualitäten zu verstehen. Methoden: Baumkonfigurationen beschreiben die Beziehung zwischen Form und Raum, die durch die relative Anordnung der Bäume bestimmt wird, die sich aus einer Wechselwirkung zwischen Design und Entwicklung im Laufe der Zeit ergibt. Auf der Grundlage von Feldbeobachtungen, mit der Stadt Delft in den Niederlanden als Fallstudie, wurden 35 generische Baumkonfigurationstypen definiert. Mit diesem "Vokabular" werden spezifische Baumkonfigurationen und ihre Beziehungen erforscht, die den städtischen Wald aus der Perspektive der Augenhöhe beschreiben und eine wesentliche Ebene darstellen, auf der die Räumlichkeit des städtischen Waldes verstanden werden kann. Ergebnisse: Die Entschlüsselung der Komponenten des städtischen Waldes durch den Vergleich zweier emblematischer Ensembles von Baumkonfigurationen ermöglicht ein Verständnis ihrer Heterogenität sowie ihrer Kohärenz und Dynamik. Schlussfolgerungen: Die Beziehung des Baumvokabulars mit dem spezifischen Standort legt ihre Rolle als Ordnungsstruktur und Träger der Identität von Delft offen, und ihre Differenzierung und ortsspezifischen Qualitäten, die eine Zusammensetzung von bewaldeten Gebieten mit jeweils eigenen Merkmalen offenbaren, zeigen sowohl städtische als auch bewaldete Gebiete als gleichwertige Bestandteile eines städtischen Waldmosaiks. Diese Differenzierung kann als Instrument zur Stärkung der Beziehungen zwischen den verschiedenen Komponenten sowie der Vielfalt und Heterogenität der städtischen Wälder genutzt werden.

Resumen. Antecedentes: El campo de la silvicultura urbana abarca muchas dimensiones, de las cuales la de la percepción visoespacial, que aborda la relación espacial entre la ciudad y los árboles, ha recibido poca atención. Es necesario analizar el bosque urbano desde una perspectiva visual-espacial para comprender las relaciones entre los diferentes componentes, así como las cualidades específicas del sitio. Métodos: Las configuraciones de los árboles describen la relación entre la forma y el espacio, determinada por la disposición relativa de los árboles que resulta de una interacción entre el diseño y el desarrollo a lo largo del tiempo. Sobre la base de observaciones de campo, con la ciudad de Delft en los Países Bajos como estudio de caso, se han definido 35 tipos genéricos de configuración de árboles. Con este "vocabulario" se investigan las configuraciones arbóreas específicas y sus relaciones, describiendo el bosque urbano desde una perspectiva a la altura de los ojos como un nivel esencial en el que se puede comprender la espacialidad del bosque urbano. Resultados: Desentrañar los componentes del bosque urbano mediante la comparación de dos conjuntos emblemáticos de configuraciones arbóreas permite comprender su heterogeneidad, así como su coherencia y dinámica. Conclusiones: La relación del vocabulario arbóreo con la localización concreta expone su papel como estructura ordenadora y portadora de la identidad de Delft, y su diferenciación y cualidades específicas del sitio, revelando una composición de áreas boscosas cada una con sus propias características, muestra tanto las áreas urbanas como las forestales

como componentes equivalentes de un mosaico forestal urbano. Esta diferenciación puede ser utilizada como una herramienta para fortalecer las relaciones entre los diferentes componentes, así como la diversidad y heterogeneidad en los bosques urbanos.