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URBAN TREE AVENUES – MORPHOLOGICAL CHARACTERISTICS AS A FACTOR IN TREES SELECTION

URBANI DRVOREDI – ODABIR DRVOREDNIH VRSTA NA OSNOVI MORFOLOŠKIH MJERA

M. Dobrilovič

ABSTRACT

The knowledge about plant material and its applicability is an important factor in achieving quality in landscape design. It manifests itself in the appropriate selection of plant species for individual design solutions.

Nowadays we can observe the selection of plants based on fashion; measures defined by creation of a certain space characteristic are omitted. The main problem is that in the literature the plant species are frequently treated individually and arranged according to the visual effect of each plant. In order to satisfy the needs of design practice for this research, it was necessary to ascertain the hidden designer potential of each plant, which is not identical with the pleasing effect of the plant. This is how the central problem is formulated in this research: to determine the selection criteria (of plant species), arising from the visual characteristics of the plants and, based on these criteria to determine the suitability of plants to create visual effects of a tree avenue. In this sense we can stress the importance of proving the connection between morphological properties of the plants and the characteristics of tree avenues, which are formed by these very plants. The subject of this research is plant material, 193 trees, systematized according to their size, shape, habitus, texture, colour, as well as the seasonal appearance of individual characteristics. We established criteria for the selection of morphological properties of the trees that allowed us to achieve a certain visual character of a tree avenue. The process of plants selection is shown on a concrete example, whereby certain design demands determine the choice of adequate plants. For the final selection of plants it is necessary to add criteria arising from eco-physiological needs of the plants and from technological demands.

Key words: landscape architecture, tree avenues, urban places, tree morphology, selecting species

SAŽETAK

Odabir biljnih vrsta često se temelji na ukusu i modnom dobu, više nego na skupu karakteristika odabranih s ciljem stvaranja određene prostorne važnosti. U literaturi biljne vrste se često obrađuju individualno i raspoređuju prema vidljivim učincima pojedinih biljaka. Kako bi se zadovoljile potrebe projektanata u praksi, bilo je potrebno istraživanje biljnih vrsta s ciljem identifikacije skrivenog potencijala biljnih vrsta za design. U tom smislu ljepota pojedinačne biljke podređena je prostornim potencijalom biljne vrste. Osnovni razlog iztraživanja bio je zato: utvrditi kriterije za odabir biljnih vrsta, na osnovi vidljivih obilježja biljaka i na osnovi toga odrediti prikladnosti vrsta za stvaranje vizualnih učinaka drvoreda u širem urbanom prostoru. U tom kontekstu važno je pokazati dosljednost između morfoloških karakteristika biljaka i vidljivog značenja drvoreda kao krajobraznog elementa. Predmet istraživanja je biljni materijal: 193 različite vrste stablašica raspoređene su prema veličini, obliku, habitusu, teksturi, boji i razdoblju pojavljivanja pojedinih svojstava. Predstavljene su mjere za odabir morfoloških karakteristika biljnih vrsta s kojima možemo postići točno odabrani prostorni učinak drvoreda. Proces odabira biljaka prikazan je na određenom slučaju. Na bazi određenih zahtjeva dizajna odabrane su odgovarajuće drvoredne vrste (stablašice). Za konačni odabir biljnih vrsta potrebno je dodati dodatne daljne kriterije na bazi ekofizioloških potreba biljaka i tehnoloških kriterija.

Ključne riječi: oblikovanje krajobraza, urbani prostor, drvored, morfologija drveća, odabir biljnih vrsta

INTRODUCTION

The knowledge about plant material and its applicability is an important factor in achieving quality in landscape design. It manifests itself in the appropriate selection of plant species for individual design solutions.

In nature the distribution and expansion of plants is determined by biotic factors (soil, climate and fauna) whereas in a designed landscape people represent the main factor. Here the plants become material, and people choose, arrange and remodel according to their needs and wishes.

In the past – and it is often so even nowadays - the selection of plants usually rested upon individual taste and fashion dictates of the period, rather than starting from and following directives determined by the objective of creating a certain space characteristic.

The primary elements or rather 'building blocks' of a designed landscape are called landscape elements. They can be vegetation (lawn area, tree avenue) or non-vegetation (water and sand areas, buildings) (Ogrin, 1996). Examining the relevant literature (Zion, 1970, Robinson, 1992, UCONN Plant Data Base of trees, shrubs and vines, 2005, Wyman, 1956) it was ascertained that the research on plant suitability as regards the construction of vegetational area phenoena had been fairly fragmentary. Merely a few basic elements have been treated, such as hedges and ground-cover plants. The procedures of selection are non-transparent and quite inadequate for the use in a serious design.

Therefore the main research problem can be seen as determining criteria for the selection of plant material**,** arising from the visual properties of the plants and, based on these criteria, subsequently determining the suitability of plants as to their capacity to create visual effects of vegetation areas. Rather than dealing with all the vegetation elements this paper focuses on vegetation areas. It is in this light that the objective is set - examining the morphological properties of plant species with the aim to establish a means of selection of plant species suitable for the construction of vegetation areas.

THE TREE AVENUES – THE LINE VEGETATION ELEMENT

The line vegetation elements behave in a cultivated region as zones of riverine vegetation, boundaries and are a consequence of differences in the use of space. In a formed region belong to the line vegetation structures tree avenues, cut palisades, free-grown and cut hedges, plantings in the form of zones etc.

Figure 1, 2. Linear structure of vegetation (avenue, clipped avenue, palisade) (Park Citroen, Pariz, Jardin Atlantique, Pariz)

Slika 1, 2. Linijske vegetacijske strukture (drvored, šišan drvored i linijski potezi (Park Citroen, Pariz, Jardin Atlantique, Pariz)

If we examine in detail the procedure of the formation of tree avenues we realize, that it is distinguished from natural line structures by a regular arrangement of trees in a fixed direction. As one of the earliest acts of the regional formation the procedure is evident from illustrations of the first tree avenues in Egypt, when the line of regularly arranged trees was created by a larger number of tree species. The procedure of the regular arrangement was followed by a reduction of species that mostly led to the use of one single tree species (Ogrin,1993). The development of the formation procedure is evident from the illustrations of the tree avenues in the Garden of high officials of the sovereign Amenhotep III. in Thebes around 1400 B.C.

Tree avenues determine the direction and the frame of space, define the areas, divide the surface elements, and direct the views. As spatial and view guidance they condition the orientation and the feeling of safety in space, even more, they are the carriers of messages (such as, the lines of tree avenues in the baroque gardens). In the history of the regional formation they first appeared in

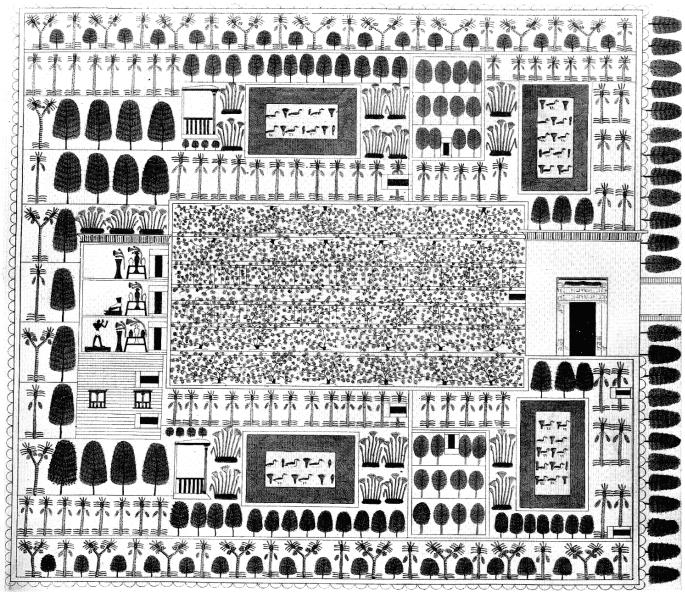


Figure 3. The garden of High Official at Thebes, 1400 b.c. (Cliford, 1962: 33)

Slika 3. Vrt u Tebi, 1400 p.n.e. (Cliford, 1962: 33)

the Egyptian culture, where water canals were bordered by trees. As regional elements tree avenues have been preserved until today. Besides space forming and the symbolic role their ecological role is also important (creating microclimate conditions, the passage of animals...), that is why they are an important element for the construction of the green system of cities. Among all the other line structures they are most appropriate for creating rhythm and sequence in space.

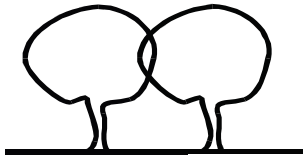
Deriving from the Butina definition of the line (Butina, 2000: 44) as a series of oriented points we can come to a conclusion that the suitability of vegetation species for the creation of a tree avenue derives from the suitability of the species for the creation of the vegetation point. If a certain vegetal species is suitable for the creation of the point elements, then it can also create the line structure – the tree avenue. It has to be pointed out, that plants are not abstract

points, as in dense arrangements the reciprocal effects can be produced, that can be seen in the strong shading and in the destruction of certain plants. That is why besides the appearance of the plant it is important to take into consideration its ecological limitations or needs.

The characteristics of species, used for the construction of tree avenues are:

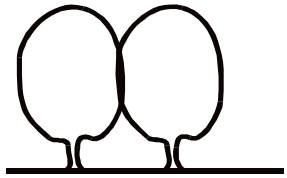
- Good levelling within the species (established genotype),
- Do not spread with root offshoots and other vegetative reproductive modes,
- The regularity of the shape of the treetop, bush (is not as important characteristic as the selection of the plants appropriate for vegetation point, because of the line characteristics the identification of rhythm and repetition is more important as the identification of the individual unit... The line can also be created with the trees that have irregular habitus. In this case we create a compact and levelled line structure by dense planting.),
- homogeneity, levelling of the core of the vegetation volume (this characteristi is especially important when selecting the species for a tree avenue),
- clear division of fenophases of the development of the plant (flowers are equally arranged on the plant, the plant flowers at the same time on all parts and deflowers quickly),
- tolerate well different intensity of lighting (an important characteristic when selecting species for the free-grown and cut hedges, palisades),
- tolerate well the trimming (an important characteristic when selecting species for cut hedges and palisades),
- tolerate well the trimming (an important characteristic for creating palisades),
- tolerate well city climate, salt in the soil, dust, hard ground, temperature oscillation, drought (for public parks in the cities and roadside plantings).

In a wider space the tree avenue makes a defined spatial structure, and at the same time forms a proper (sub) space, that is very important in terms of experience. By a negative space we understand the space between the ground and treetops (the interior of the tree avenue). The form of this space depends on the tree species (size, shape, and habitus), density and the way of planting (Walker, 1991). Further on only some forms of the negative space of tree avenues are shown.



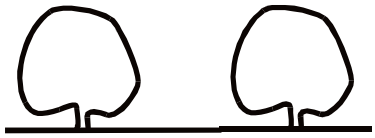
- the space profile in the rectangular shape

  Treetops are dense, the rhythm of trunks is well expressed, and the visual field is wide. The tree species that are appropriate for such tree avenues have tall, levelled and smooth trunks and ball-shaped, wide ball-shaped, dome-shaped and compact treetops. Appropriate habitus are irregular, upright and wide spread.



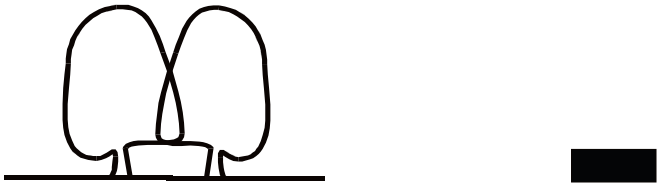
- the space profile in the shape of letter 'T'

  Treetops are dense, the rhythm of trunks is well expressed, and the visual field is wide. The tree species that are appropriate for such tree avenues have tall, levelled and smooth trunks and egg-shaped treetops. Habitus is regular, upright and spread or irregular, upright and spread.



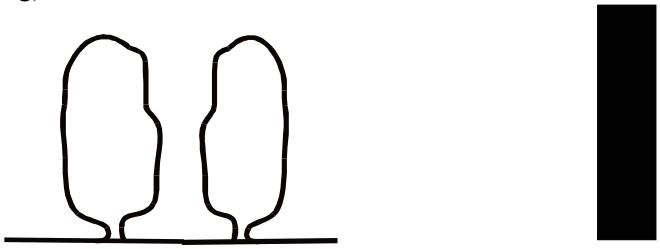
- the space profile in the shape of letter 'T' with the emphasised central side

  Treetops are not dense; the rhythm of trunks is not expressed well. The visual field is limited to the ending of the tree avenue. The tree species that are appropriate for such tree avenues have short trunks, ball-shaped, dome-shaped or cone-shaped treetops, regular and upright or irregular, upright and widely spread habitus.



- the space profile in a rectangular shape with emphasised width

  Treetops are dense, the rhythm of trunks is expressed, and the visual field is limited by low treetops. The tree species that are appropriate for such tree avenues have lower trunks, long framing branches, the shape of the treetop stands out, bow-shaped, habitus is irregular, upright and sloping (descending).



- the space profile in the rectangular shape with the emphasised height

  Treetops are not dense, the rhythm of trunks is not expressed very well, and the visual field is limited to the real ending of the tree avenue. The tree species that are appropriate for such tree avenues have low trunks, short branches and offshoots that are equally arranged on the extension of the trunk. The treetop is slightly pointed (the cone-shape of the treetop) or flat (cylinder-shape of the treetop). Habitus is regular or upright.

MATERIAL AND WORK METHOD

The subjects of this research project are plant species designed for greening public spaces. They are chosen on the basis of assessing their hardiness, their resistance to urban climate, to diseases and pests, the cost of maintenance and their design potential.

The research encompasses autochthonous species (Kotar and Brus, 1999), suitable for the use in public places and foreign species or sorts of trees which are wide-spread in our country and fulfil the user's demands (Šiftar, 2001, Bruns Pflanzen,1997).

The principal goal of the research is to define appropriate criteria for plant species selection in order to achieve the desired effect of the tree avenue. In order to achieve this it was first necessary to establish the connection between the morphological and the visual properties of the plants in the tree avenue (height, form, texture, colour and similar) and to determine which morphological properties of the plants affected the desired character of the avenue.

As far as the work method is concerned it is imperative to emphasize that the aspect here treated as far as the knowledge of plants is concerned, covers a fairly unknown ground and does not provide well-established methods of research. Therefore further on the work process is introduced in some detail. It was necessary to systematize all plant species (the research subject matter) according to their visual properties (size, shape, habitus, texture, and colour) and the properties determined by their seasonal appearance (e.g. foliage colour – autumn, colour of blossoms – spring …). All plants were classified on the basis of data obtained by observing visual properties in situ, and subsequently comparing them with findings of other authors. This was followed by a meticulous analysis in terms of visual properties (size, shape, colour, texture, durability of foliage). Next step was the setting of criteria for the selection of morphological plants by means of which we could achieve the desired visible characteristic feature of the tree avenue. In order to help establish the afore-mentioned connections, a scheme is demonstrated in which the grey colour designates those morphological plant properties by which the character of tree avenues is defined.

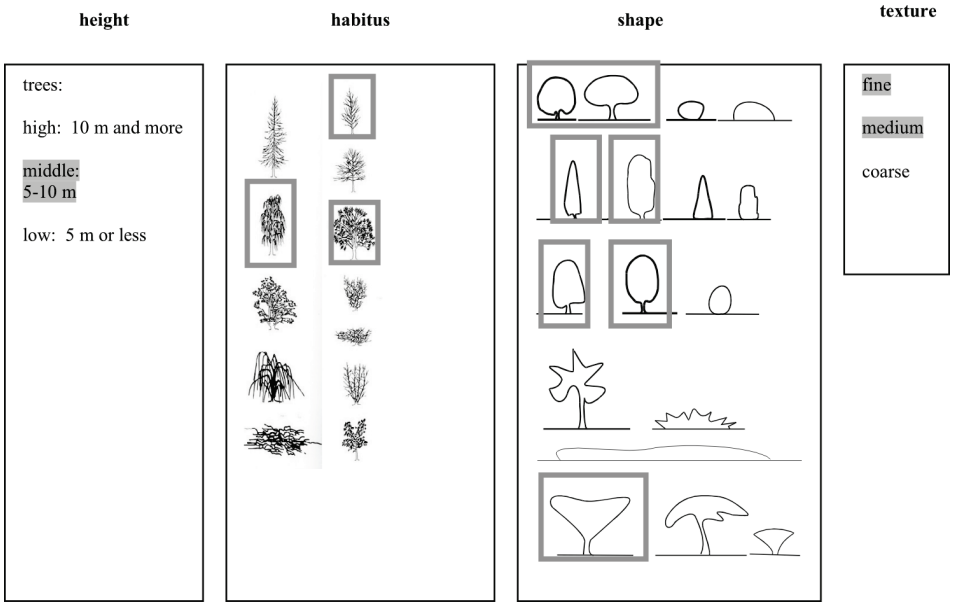


Figure 4. Morphological characteristics of plants used for tree avenues

Slika 4. Morfološke karakteristike stablašica prikladnih za izgradnju drvoreda

The next step is the selection of plant species according to the desired visual effects of the avenue. The selection process is introduced by means of a concrete example and represents one of the results of this research. The suitability of plant species for the construction of tree avenues is determined according to the following criteria: size, foliage durability, shape, habitus, and colour (leaf, blossom, shoot). The criteria are introduced gradually, each added criteria representing a new level or rather combination of morphological properties. We consider the most suitable those species that conform most optimally to all levels of selection and all combinations of criteria.

RESULTS AND DISCUSSION

Results of this research are presented in two condensed paragraphs:

1. Systematizing the plant species according to their morphological properties; this comprehensive part of the results is not shown in the article. It is, however, of great importance for the process of selection itself. By the same token it represents an autonomously applicable outcome, since the elaborate complex classification enables us to look for adequate plants with regard to their visual properties (size, shape, habitus, texture, and colour) and seasonal appearance.
2. The process of plant selection itself in terms of the effect that a plant species is capable of expressing when appearing as a constituent part of a certain vegetational element.

The selection of plant species in terms of desired visual effects of tree avenues will now be demonstrated on a concrete example. Prior to the selection of certain plant species a distinct design goal (or respectively a pre-formulated design request) for a certain visible effect of the landscape element is presented. Thus, for example, by making a certain choice we wish to find the best possible plant species for the construction of a tree avenue whose visual effects are defined by its height, form, texture, colour and the time when a certain effect will be visible.

Example: tree avenue

The expected properties (design requirements): tree avenue height 5-10 m, deciduous, treetops are dense, the interior of the tree avenue (negative space) in the tube-shape, dense arc, the texture of leaves medium, colour green, uncut treetops.

Stipulating morphological properties of adequate plant species:

- size: *tree(5-10 m)*
- foliage durability: *deciduous*
- shape: *rounded to oval, high domed, closed crown*
- habitus: *informal, upright, widely spreading, hanging slightly*
- texture - leaf: *medium*
- colour - leaf: *green*

Definition of criteria for selection and a list of species that conform to these criteria:

1.Size - foliage durability

Acer platanoides
Acer platanoides 'Cleveland'
Acer platanoides 'Faassen's Black'
Acer pseudoplatanus
Acer rubrum
Acer saccharinum 'Pyramidale'
Aesculus hippocastanum
Alnus cordata
Betula papyrifera
Betula pendula 'Fastigiata'
Carpinus betulus 'Fastigiata'
Corylus colurna
Fagus sylvatica 'Asplenifolia'
Fagus sylvatica 'Dawyck'
Fagus sylvatica 'Dawyck Purple'
Fraxinus excelsior
Gleditsia triacanthos 'Skyline'
Juglans regia
Malus baccata
Malus triloba
Populus alba
Populus alba 'Raket'
Populus nigra 'Italica'
Populus simonii
Pterocarya fraxinifolia
Quercus palustris
Quercus robur
Quercus rubra
Robinia pseudoacacia 'Pyramidalis'
Salix alba
Sophora japonica
Tilia cordata
Tilia platyphyllos
Tilia x intermedia 'Pallida'
Acer negundo
Abies nordmanniana
Acer platanoides 'Schwedleri'
Acer saccharinum
Ailanthus altissima
Betula ermanii
Carpinus betulus
Castanea sativa
Fagus sylvatica
Acer platanoides 'Royal Red'
Fagus sylvatica 'Atropunicea'
Fagus sylvatica 'Dawyck Gold'
Fagus sylvatica 'Pendula'
Fraxinus excelsior 'Altena'
Gleditsia triacanthos 'Shademaster'
Liriodendron tulipifera
Malus tschonoskii
Paulownia tomentosa
Populus balsamifera
Populus alba f. pyramidalis
Populus x berolinensis
Prunus avium
Quercus frainetto
Quercus petrea 'Columna'
Quercus robur 'Fastigiata'
Robinia pseudoacacia 'Bessoniana'
Robinia pseudoacacia 'Unifoliola'
Salix alba 'Tristis'
Tila x euchlora
Tilia cordata 'Erecta'
Tilia tomentosa

2. Size - foliage durability - shape

Acer negundo
Acer platanoides 'Faassen's Black'
Acer pseudoplatanus
Acer saccharum
Ailanthus altissima
Fagus sylvatica
Fagus sylvatica 'Atropunicea'
Juglans regia
Pterocarya fraxinifolia
Quercus rubra
Salix alba 'Tristis'
Tila x euchlora
Acer platanoides 'Emerald Queen'
Acer platanoides 'Royal Red'
Acer saccharinum
Aesculus hippocastanum
Carpinus betulus
Fagus sylvatica 'Asplenifolia'
Fraxinus excelsior
Malus baccata
Quercus robur
Salix alba
Sophora japonica
Tilia cordata
Tilia tomentosa

3. Size - foliage durability - habitus – shape (crown)

Acer negundo
Acer pseudoplatanus
Acer saccharum
Ailanthus atissima
Fagus sylvatica
Fagus sylvatica 'Atropunicea'
Juglans regia
Pterocarya fraxinifolia
Quercus rubra
Sophora japonica
Tilia cordata
Acer platanoides 'Faassen's Black'
Acer saccharinum
Aesculus hippocastanum
Carpinus betulus
Fagus sylvatica 'Asplenifolia'
Fraxinus excelsior
Malus baccata
Quercus robur
Salix alba
Tila x euchlora
Tilia tomentosa

4. Size - foliage durability - habitus – shape (crown and trunk)

Acer negundo
Carpinus betulus
Fagus sylvatica 'Asplenifolia'
Juglans regia
Quercus robur
Acer saccharum
Fagus sylvatica
Fagus sylvatica 'Atropunicea'
Malus baccata
Sophora japonica

5. Size - foliage durability - habitus - shape (crown and trunk) – texture (leaves)

Acer negundo
Carpinus betulus
Fagus sylvatica 'Asplenifolia'
Malus baccata
Acer saccharum
Fagus sylvatica
Fagus sylvatica 'Atropunicea'
Quercus robur

6. Size - foliage durability - habitus- shape (crown and trunk)- texture (leaves) - color (leaves)

Acer negundo
Acer saccharum
Carpinus betulus
Fagus sylvatica
***Fagus sylvatica* 'Asplenifolia'**
Malus baccata
Quercus robur

The dense, medium height tree avenue with the tube-shaped interior, is best completed by the species *Acer saccharum* and *Carpinus betulus*. Both species have low trunks, dense and compact treetops and tolerate well dense planting the condition in the tree avenue. They tolerate well the salt in the soil, which is an important characteristic of tree species. Branches on the exterior side of the tree avenue with older plants are slightly curved and create a visual protection. We get a similar effect if we use a beech tree (*Fagus sylvatica, Fagus sylvatica* 'Asplenifolia'), but because of the overshadowing of the first framing branch they may develop higher and that is why the effect of 'tubes' is smaller. In communal planting oak develops (*Quercus robur)* a flat, tall trunk and a small treetop (Erker, 1957: 82), which eliminates it from the species appropriate for creating the required spatial effect. Due to the eco- physiological unsuitability we can also eliminate *Acer negundo* (it does not tolerate well the overshadowing)**.**

CONCLUSION

The method used and described here for the selection of plant species represents a novelty in the field of landscape design. By means of this research it was ascertained that the manner of selecting plants according to their visual properties is appropriate. For a final selection it is necessary to add to the morphological criteria some other criteria, which are formulated on the basis of eco-physiological needs of each plant (lighting, temperature, soil conditions) and technological demands (cultivation requirements).

Therefore it is imperative to emphasize the relativity of such plant selection, as evident from the above commentary, relating to a concrete example of choosing appropriate plants. The results of the research are applicable on different levels. By using the data gained in the research (systemizing the plant species according to their visual properties) we can find species that belong to certain size classes, shapes, colours, and textures. The data can be combined arbitrarily in order to search for cross-section multitudes that in essence represent combinations of morphological properties. The data and the above mentioned systematizations are not presented in this paper, due to the extensiveness of the material.

Alongside the selection criteria it is also important in which order or rather sequence the criteria, upon which the selection of plants is based, are applied. Which criteria are to be included and in what order, largely depends on the design goal. The paper demonstrates the process of selection of plant species suitable for tree avenues. In a similar way suitable plants for other landscape elements can be chosen.

The presented process of selection is not applicable only in landscape architecture. It can be equally useful in selective breeding, since it can help determine the need for a particular shape, habitus, colour … In terms of its informative quality it can be applied by tree planters, horticultural experts and may also be seen as a welcome aid in the education of landscape architects and horticultural experts.

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Adresa autora - author´s address:
Marko Dobrilovič, Ass. Ph.D.B.Sc
Univ. of Ljubljana,
Biotehnical Faculty,
Landscape Architecture Department,
Jamnikarjeva 101,
Ljubljana, SI-1111

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