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Original scientific paper

THE POSSIBILITY OF CREATING AN EDUCATIONAL TRAIL INSPIRED BY THE MEDICINAL AND USEFUL PROPERTIES OF THE SHRUB SPECIES PRESENT IN THE ARBORETUM OF THE FACULTY OF FORESTRY

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Abstract: *Vegetation supports the life of many other organisms, ensures the development of ecosystem functions, and regulates geomorphological and atmospheric processes. Important coeenobionts of different types of vegetation are medicinal plants. Medicinal plants represent a significant, both biological and economic resource of every country. People use them as a source of active substances that have an important impact on human health, and at the same time they find their application in landscape design because they are characterized by great decorativeness. The aim of this work is the analysis of woody shrub species in order to determine the possibility of forming an educational trail in the Arboretum of the Faculty of Forestry, with a focus on medicinal, aromatic and edible species, as well as the research of existing biomimetic solutions, products and technologies based on plant species present in the Arboretum of the Faculty of Forestry in Belgrade.*

Keywords: educational trail, medicinal and aromatic plants, shrub species, Arboretum of the Faculty of Forestry, biomimetic.

MOGUĆNOST KREIRANJA EDUKATIVNE STAZE INSPIRISANE LEKOVITIM I UPOTREBNIM SVOJSTVIMA ŽBUNASTIH VRSTA PRISUTNIH U ARBORETUMU ŠUMARSKOG FAKULTETA

Sažetak: *Vegetacija podržava život mnogih drugih organizama, obezbeđuje odvijanje ekosistemskih funkcija, reguliše geomorfološke i atmosferske procese. Značajni cenobionti različitih tipova vegetacije jesu lekovite biljke. Lekovite biljke predstavljaju značajan, kako biološki, tako i ekonomski resurs svake zemlje. Ljudi ih koriste kao izvor aktivnih supstanci koje imaju važan uticaj na ljudsko zdravlje, a istovremeno one nalaze svoju primenu u pejzažnom dizajnu jer se odlikuju velikom dekorativnošću. Cilj ovog rada je analiza drvenastih žbunastih vrsta radi utvrđivanja mogućnosti formiranja edukativne staze u Arboretumu Šumarskog fakulteta, sa fokusom na lekovite, aromatične i jestive vrste kao i istraživanje postojećih biomimetičkih rešenja, proizvoda i tehnologija zasnovanih na biljnim vrstama prisutnim u Arboretumu Šumarskog fakulteta u Beogradu.*

Ključne reči: edukativna staza, lekovite i aromatične biljke, žbunaste vrste, Arboretum Šumarskog fakulteta, biomimetika.

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1. INTRODUCTION

Vegetation is a source of basic nutrients, bioactive substances and raw materials for industrial use for mankind. It is generally known that medicinal plants play an important role in human health due to their various beneficial properties and therapeutic effects (Reč, 2014).

In today's time of availability of affordable, commercial herbal preparations, their safety for human health and the potentially harmful effects they can cause with inadequate application are being questioned. In order to use them correctly and efficiently, it is necessary to educate ourrself about plant properties (Ekor, 2014). Plants, animals and entire ecosystems form components of traditional medicine, which is still important in supporting people's health worldwide, particularly in developing countries and remote, isolated areas. Around one third of modern pharmaceuticals have been directly derived from compounds found in the natural world, and many other drugs are designed to mimic natural products (Newman et al., 2020). Around 60 000 species – plants, animals, fungi and microbes – are used for their medicinal, nutritional and aromatic properties (www.cbd.int). A signifcant proportion of pharmaceuticals have been derived from nature: between 1981 and 2019, 185 small molecule drugs were approved to treat cancer, of which 65% were derived from or inspired by natural products (Newman et al. 2020).

Medicinal and aromatic plants not only represent a significant biological and economic resource, a source of active substances that have an important impact on human health, but many of them are characterized by distinct decorative characteristics and have had significant application in the field of landscape architecture and horticulture for centuries.

Decorative plants represent an important element in the urban environment, both because of their aesthetic values and because of their positive impact on the quality of the environment and the health of citizens (Zuo & Zhao, 2014).

Each woody species has a typical crown shape, which is different and is the result of hereditary factors but also the influence of external environmental factors (Ocokoljić & Ninić-Todorović, 2003).

According to estimates, shrubby plant species occupy 45% of the land area on the surface of the planet Earth (Götmark et al., 2016). Shrubs represent an important component of forest ecosystems, stabilize biocenoses and contribute to phytoremediation of forest soil. Shrubs also protect trees from the damaging effects of strong winds and their shoots, seeds and fruits are a source of food for many forest animals. Ornamental shrubs are used in landscape design due to their high aesthetic appeal, and are often planted in parks, green squares and along boulevards (Boyce, 2009).

Many botanical gardens have biomimetic trails with accompanying information boards through which visitors learn about the properties of a particular plant species, as well as how that species found its place in biomimetic, technical applications (Speck & Speck, 2023).

Biomimicry is a word that means "imitation of life". The term "biomimetics" implies the understanding of biological structures and processes and their technological application, method or procedure. Biomimetics is not a mere imitation of nature, neither in a material, functional nor creative sense, but an essential

understanding of natural principles and models, translating them into solving current problems while ensuring the sustainability of the solution (Pohl, 2015, Jović, 2018).

Biomimetics "draws" inspiration from nature and imitates natural structures into systems in order to solve human problems (Bhushan, 2009) and thus plant structures and textures have always been inspirational (Barthlott et al., 2017).

The essence of biomimetics, among other things, is in the imitation of biological mechanisms of nature, which results in their imitation and the development of new nanomaterials, nanodevices and processes. The properties of biological materials and surfaces arise from complex interactions of surface morphology and physical and chemical properties. Desirable molecular properties such as: superhydrophobicity, self-cleaning, reduction of fluid flow resistance, energy conversion and conservation, high adhesion, reversible adhesion, aerodynamic lift, then materials and fibers with high mechanical strength, anti-reflection, structural coloration, thermal insulation, self-healing and sensory-assistive mechanisms some are examples found in nature whose imitation and implementation in the form of new materials would have great commercial importance (Bhusan, 2009).

Biological materials are developed using the information contained in the genetic code. As a result, hierarchical structuring at all levels creates biological tissues as a form of material whose form and structure would be adapted to a specific function and ability to adapt to changes (Fratzl & Weinkamer, 2007).

Arboretum of the Faculty of Forestry in the city of Belgrade represented a research location and a special healing environment with a high variety of species (Vujčić & Tomićević-Dubljević, 2017). The natural heritage Arboretum of the Faculty of Forestry is a green area with a specific purpose and is of exceptional botanical and landscape-horticultural value (University Heritage of Serbia, 2017).

As a Natural Monument, it was declared protected due to the unique, botanically diverse collection of dendroflora in the open space and for the purpose of preserving and improving the gene pool of autochthonous, non-native and exotic dendroflora, as well as rare, endemic and relict species, intended for scientific research and education (Management plan of the nature monument "Forestry Faculty Arboretum" 2021 – 2030) (Figure 1).

Figure 1. *Arboretum of the Faculty of Forestry, University of Belgrade (source: Olga Gajanić)*

It is primarily recognized for its educational and scientific purpose, followed by bio-ecological and sanitary-hygienic as well as cultural and aesthetic purposes (Management plan of the nature monument "Forestry Faculty Arboretum" 2021 – 2030).

The aim of this work is the analysis of woody shrub species in the Arboretum of the Faculty of Forestry in order to determine the possibility of forming an educational trail, with a focus on medicinal, aromatic and edible species, as well as the research of existing biomimetic solutions, products and technologies based on plant species present in the Arboretum of the Faculty of Forestry in Belgrade.

2. MATERIAL AND METHODS

The method of theoretical and field research was applied for the purposes of this work. Theoretical research was conducted through the collection, analysis, and synthesis of data obtained from a wide array of relevant scientific literature and professional studies. To ensure the accuracy and reliability of the information, various electronic database, search engines and specialized reference tools such as Scopus, Web of Science, Google Scholar, Google Earth Pro and scientific literature were used to find data. These tools made it possible to find reliable resources regarding taxonomy, distribution, and potential uses (medicinal, aromatic, and edible) of shrub species. Theoretical data was accompanied by the analysis of case studies of biomimetic solutions, products, and technologies inspired by plant species around the world, especially those in the Arboretum.

Based on data from the Management plan of the nature monument "Forestry Faculty Arboretum" 2021 - 2030 and other existing AutoCAD maps showing the distribution of shrub species present in the Forestry Faculty Arboretum (fields A, B, C, D, E, F, G and I) (Figure 2), field research was conducted that included detailed

photographic documentation of the species, which was used as a visual record, but also for further analysis.

AutoCAD and Photoshop software were used to visualize the graphic conceptual representation of the map of the educational trail.

Figure 2. *Spatial organization of the nature monument "Arboretum of the Faculty of Forestry" (source: Management plan of the nature monument "Forestry Faculty Arboretum" 2021 – 2030)*

3. RESULTS

During the research, 51 shrub species were recorded in the Arboretum of the Faculty of Forestry in Belgrade. Many of them are characterized by distinct decorativeness, and at the same time they are used in traditional and official medicine. The Table 1: Review of decorative, medicinal properties and biomimetic solutions inspired by bushy plant species, shows the most common shrub species present in the Arboretum with a description of their decorative properties, medicinal properties and utility value, as well as existing inspirations for biomimetic solutions. Certain taxa of the plant species *Acer tataricum* L. and *Prunus cerasifera* L. are basically woody species, but have a shrub habit, as is the case in the Arboretum of the Faculty of Forestry in fields B, C and D.

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
Mahonia aquifolium (Mirb. Franco)	Spreading small evergreen shrub with glossy deep green pinnate leaves becoming purplish in winter. Abundant deep yellow flowers in large clusters, followed by black berries.	Rich source of anthocyanins, phenols, and antioxidants, resulting in potential nutritional value (Gunduz, 2013). Used in traditional medicine for the treatment of a wide range of health conditions, such as tuberculosis, periodontitis, dysentery, etc. Has antimicrobial, anti-inflammatory, hepatoprotective, antitumor, antioxidant and analgesic properties (He & Mu, 2015).	Middleton et al. (2024) in their work investigate the wide distribution of matte blue color - UV chromaticity of the fruit of photon effects that occur naturally in epicuticular wax. The reproduction of the structurally colored wax by in vitro recrystallization was performed and the epicuticular wax of the fruits of *Mahonia aquifolium* (Mirb. Franco), which has a high degree of reflection, was extracted (Middleton et al., 2024).
Berberis thunbergii DC. *Berberis juliane* Shneid. *Berberis gagnepainii* var. *lanceifolia* Ahrendt	This plant species is often used as a garden ornamental because in autumn the leaves take on shades of red and orange and the bright red berries persist until the following spring (Brunelle et al., 1996).	Have antioxidant, anti-inflammatory, antibacterial, antifungal, antinociceptive, antihypertensive, antidiabetic activity (Küpeli et al., 2002). Used in traditional medicine for the treatment of heart diseases, digestive complaints and problems with the urinary tract (Bober et al., 2018). The alkaloids berberine, berbamine, palmatine, oxyacanthine, jatrorhizine, magnoflorine and columbamine are present in most species of the genus Berberis (Brázdovlcová et al., 1979).	In their study, Jin et al. (2021) are trying to synthesize a new type of active compound berberine, present in plant species of the *Berberis* genus, for the treatment of asthma, based on nanotechnology.
Taxus baccata L.	Due to its great decorativeness and shaping possibilities, yew is often present in parks, as well as in dendrological collections of botanical gardens around the world.	Taxol is in high demand in the pharmaceutical industry for the preparation of drugs for the treatment of some forms of cancer (Thomas & Polwart, 2003). Used in kidney disease, Alzheimer's, bronchitis, asthma and as an aphrodisiac (Beckstrom-Sternberg & Duke, 1993).	In the field of biomimetics, attention is drawn to the phytochemical properties of certain plants and their mechanical and chemical defense mechanisms against insects. The adaptive mechanism of *Taxus baccata* L. is reflected in the chemical defense it possesses (Koch et al., 2009). Some of these defense strategies are of interest for the development of defense strategies against insect invasions in forests and in other applications. Nature has developed materials, objects and processes that function effectively at both the macro and micro levels (Bhusan, 2009).

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
Philadelphus coronarius L.	*Philadelphus coronarius* L. as an ornamental plant species that grows in the urban environment under constant anthropogenic influence, and is resistant to toxic effects and has a resistance index of 65%, and thus it is classified in the group of plants that are suitable for planting by the roadside or at a distance of 100 meters from the road (Dogadina et al., 2022). Biologically active coumarin is present in extracts of the plant species *P. coronarius* L. (Vaľko et al., 2011). a benzopyrone-based chemical compound that gives the species its scent.	Water extracts of *Philadelphus coronarius* L. flowers are used in traditional medicine and homeopathy. *Philadelphus* sp. are known for their cytotoxic, antibacterial and immunomodulatory effects (Vaľko et al., 2011), also has antiproliferative, apoptotic and antioxidant effects.	
Prunus laurocerasus L.	It is a popular plant species in the field of landscape architecture in temperate regions around the world. It is usually grown as a hedge (Sulusoglu, 2011).	In traditional medicine used for analgesic, antispasmodic, narcotic, sedative effects, treatment of asthma, cough and dyspepsia, while plant extracts showed antifungal antinociceptive and anti-inflammatory activity (Erdemoglu et al., 2003).	Biologically inspired artificial polydimethylsiloxane/polyphenylsulfone (PDMS/PPSU) membranes mimic the hydrophobic properties of natural membranes. Hydrophobicity was achieved by coating the surface sublayer of the membrane using a conventional silicon material, which mimics the character of the epicuticular wax of *Prunus laurocerasus* L. leaves (Jullok et al., 2013).
Prunus cerasifera L.	As an early flowering ornamental species, its application in landscape architecture is significant (Petrov et al., 2024). The color of the leaves is also very decorative.	The study shows that people who have consumed the fruits of *P. cerasifera* for many years have a much lower rate of cardiovascular disease. The fruits are rich in polyphenols, secondary plant metabolites, very effective in the fight against metabolic diseases (Ren et al., 2024).	Current research is based on the use of the *P. cerasifera* species for the biomimetic synthesis of PZO NFs. To obtain zinc, a simple and non-toxic method of obtaining oxide nanofalcates from the reducing agents of *P. cerasifera* pomological extract is applied. It is expected that zinc oxide nanoparticles produced in this way will be widely used in remediation and protection of plants from pathogens (Jaffri et al., 2018).

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
Lonicera tatarica L. *Lonicera ligustrina* var. *pileata* (Oliv.) Franch. *Lonicera x purpusii* Rehder	Some species are highly fragrant and colorful, so are cultivated as ornamental garden plants.	Contains iridoids including secologanin (Hallard et al., 1998) and high content of flavonoids. Has bactericidal properties that inhibit the growth and adhesion of *S. aureus* and *S. epidermidis* strains. *Lonicera* sp. is suitable for the development of new antimicrobial products or strategies to combat medical biofilms (Bubulica et al., 2012).	
Spirea japonica L.	*Spiraea* are shrubby plant species with a very low level of maintenance and a high degree of tolerance but above all they are used for their decorative characteristics, which are widely used for landscaping. The color of flowers and leaves gives the plant decorative properties.	Contains alkaloids and flavonoid glycoside and used as effective therapeutics for inflammation and malaria (Zhang & Wang, 1986). In traditional medicine, the young leaves, fruits, and roots are used as a diuretic, detoxifier, and pain reliever, as well as for the treatment of cough, headache and toothache (Wu, 1984).	
Ligustrum vulgare L.	A bushy, deciduous or semi-evergreen shrub with dark green, lance-shaped leaves and terminal panicles of small, white, pungently-scented flowers in summer, followed by small, shining black berries. Fast growing, if it is clipped regularly it will make a good dense hedge, but will not flower or fruit.	Used in traditional medicine for prevention of cardiovascular disease, chronic inflammation, hypertension, type II diabetes, and cancer (Huang et al., 2019). Contains various bioactive phytochemicals such as phenylethanoids, triterpenes, flavonoids, organic acids, lignans and characteristic iridoids associated with the Oleaceae family (Litewski et al., 2024).	
Pyracantha coccinea M. Roem.	Fire thorn is most often used as an ornamental garden plant, both because of its fast growth and resistance to almost all habitat conditions, and because of its autumn	Has polyphenols with powerful antioxidant properties (Prior & Cao, 2015) and	

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
	and winter appearance. The fruits, after which this species got its name, with their flaming colors represent an accent in the winter landscape (Grlić, 1986).	bioactive compounds such as polyphenols, fatty acids and vitamins (Keser, 2014). Keser in his study shows the presence of phenolic acids and flavonoids significant for the removal of free radicals.	
Deutzia scabra Thunb.	A medium to large-sized, deciduous shrub, growing to 2-3m high. Bears simple, opposite, lanceolate, apple-green, serrated foliage and flattish heads of single, white, star-shaped flowers in spring.	Has antipyretic, diuretic, insecticidal properties and ability to strengthen bone tissue (Yang, 1998). Contains iridoids and flavonoids that affect protection of the gallbladder and stomach, as well as hypoglycemic, antibacterial and anti-inflammatory properties (Gu et al., 2020).	
Junuperus x *pfitzeriana* (Spath) P.A. Schmidt.	*Junuperus* x *pfitzeriana* is an evergreen shrub with thick, upright branches clothed in sharply pointed needles that are light green with shades of blue. Depending on the variety, it works well as a ground cover and can be used for hedges, single or group planting. It requires very little maintenance and belongs to highly resistant varieties.	A precursor of the anticancer drug podophyllotoxin (PPT) with effective antiproliferative properties has been discovered in many species of the genus Juniperus, such as *J.* × *media Pfitzeriana* (Spath) Schmidt (Kusari et al., 2011).	In his study, Kim (2012) provides a detailed description of the surface structure of adult leaves of the plant species *Juniperus chinensis*. The micromorphological characteristics of the stomata and epicuticular waxes are responsible for the xeromorphic nature of the leaves. These results can be used in biomimetics to design hierarchical structures to mimic innate plant properties such as hydrophobicity and self-cleaning effects of the leaf surface.
Cornus sanguinea L.	*Cornus sanguinea* is a deciduous shrub that has oval, green leaves and tiny, cream-white flowers in May and June. In autumn, cornus sanguinea reveals its shiny stems as the golden leaves fall. The shoots begin to take on a yellow-orange hue, and the tips turn red as the season progresses, giving the bush the appearance of flames. It is good for adding color in the winter.	The leaves and fruits contain antioxidants, anti-inflammatory, cytoprotective, analgesic, antidiabetic and anticoagulant activity (Stanković & Topuzović, 2012). It is also used in the treatment of cancer, circulatory problems (such as edema) and diabetes (Tarayre & Lauressergues, 1979).	
Cotinus coggygria 'Royal Purple'	Cottonwood is a highly decorative plant species used to beautify outdoor and public	This plant is used in the Balkans and Anatolia to treat wounds and reduce inflammation, as well as to treat	Studies on the leaves of the plant species *Cotinus coggygria* indicate the possibility of designing textural surfaces with unexpectedly high non-wetting

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
	spaces in modern landscape architecture (Dirr, 1990).	gastrointestinal and respiratory disorders (Ploetz, 2000). In Asian countries, *C. coggygria* is often used against hepatitis and even anemia (Ajaib et al., 2010). *C. coggygria* is very rich in phenolic compounds and shows significant antimicrobial activity (Ivanova et al., 2005).	properties. Herminghaus pointed out that these leaves exhibit superhydrophobic properties (Herminghaus, 2000). Understanding the relationship between surface energy and roughness on the non-wetting ability of a surface has led to the development of numerous biomimetic superhydrophobic surfaces.The surfaces of numerous plants and insects have wetting properties that inspire the development of analogous engineering materials (Tuteja et al., 2007).
Hippophae rhamnoides L.	The oval or lightly roundish fruits grow in compact grapes varying from pale yellow to dark orange.	Has a large number of different bioactive compounds, vitamins, minerals, natural antioxidants, n-3 and n-6 fatty acids and proteins, as well as its antioxidant, cardioprotective properties, antiatherogenic, antidiabetic, hepatoprotective, anticancer, immunomodulatory, antiviral, antibacterial, anti-inflammatory and vasorelaxant effects (Krejcarová et al., 2015).	
Acer tataricum L.	In horticulture and landscape architecture, it is used in individual planting, massifs and rows of trees for streets of narrow dimensions. It is easy to maintain (Vukićević, 1996).		Nave et al. (2021) in their research they test the mechanical properties of maple seeds *Acer* sp. Based on the natural form, they created a 3D print model and tested the rotation speed and compared the properties with each other. It has been shown that natural seeds have better performance and it is planned to continue research on this topic. Plants as natural reservoirs of chemical compounds can be useful for the development of advanced nanomaterials through biomimetic principles (Jaffri et al., 2018).
Viburnum lantana L.	They are often planted in gardens and used in landscape design for their colorful appearance, fragrant flowers, size variation	The bark of *V. lantana* was used in folk medicine as a rubticis and antinociceptive. The genus *Viburnum* is	

Latin name of the species	Decorativeness	Medical characteristics / use in medicine	Inspiration for biomimetic solutions
	and highly ornamental fruits (Clement et al., 2012, Awan et al., 2013).	known to contain triterpenoids (Machida & Kikuchi, 1997) diterpenoids, sesquiterpenes, polyphenols (Fukuyama et al., 1996).	
Laburnum anagyroides Medic.	This species blooms in the spring when there are still not many attractive trees and shrubs. Precisely because of these properties, *Laburnum anagyroides* is recommended for urban plantings and gardens as a highly decorative and useful species for insects during the spring season (Stawiarz & Wróblewska, 2013).	Numerous studies conducted in different countries refer to the poisonous and medicinal properties of this taxon (Greinwald et al., 1990).	
Buxus sempervirens L	*Buxus sempervirens* is an evergreen, densely branched shrub that is often used in horticulture. It grows very slowly, but can reach a height of up to 3 m. The leaves are small and oval, green and shiny. It tolerates pruning well, so it is often used to make a variety of shapes in the garden. In planned gardens, boxwood is most often planted as a frame for rose beds or higher plums.	Boxwood is used as a medicinal plant for the treatment of rheumatism and malaria (Neves et al., 2009). According to the literature, *B. simpervirens* contains characteristic nor-triterpene alkaloids of the nor-cycloartane type in leaves, twigs, flowers and roots (Khodzhaev et al., 1983).	
Chimonanthus praecox (L.) Link	Prized for its attractive and sweetly scented winter blooms, *Chimonanthus praecox* is a decidous shrub that adds beuty and fragrance to the garden when most plants lie dormant.	Used to treat rheumatic arthritis, cough, dizziness, nausea, fever, and contributes to detoxification (Shang et al., 2020). The species is also recognized as a source of natural oil, which can be used in perfumery, cosmetics and aromatherapy (Deng et al., 2004).	
Physocarpus opulifolius (L.) Maxim.	*P. opulifolius* has decorative foliage, clusters of white flowers in spring, and red berries in autumn. Various varieties are used in planting due to compactness of growth, yellow or golden color of the leaves and conspicuousness of large flower clusters.	The bark of *Physocarpus opulifolius* is rich in triterpenoid compounds that show antitumor properties (Liu & Yu, 2011).	

The creation of an educational trail in the Arboretum of the Faculty of Forestry, similar to the model that already exists in many botanical gardens, would aim to enhance visitors' to understanding of the photochemical importance of plant species. Additionally it would emphases the variety of applications of biomimicry, using examples of certain biological models, found within woody plant species of the Arboretum and their possible functional application in different spheres of life. The analysis of the spatial distribution of shrub species within the Arboretum revealed that fields D, E, F, G contain the largest number of impressive shrub species. Consequently, these areas have been identified as the most suitable for the formation of an educational path.

The trail would be further enriched by the installation of strategically placed information boards. On the information boards, significant phytochemical, decorative characteristics, as well as existing biomimetic solutions in various scientific fields related to a certain plant species, would be displayed. The aim is to create an engaging and educational environment where visitors can learn not only about the aesthetic and biological significance of these plants but also their broader impact on innovation.

The conceptual solution of the path of the educational trail which highlights these elements is shown in Figures 3 & 4.

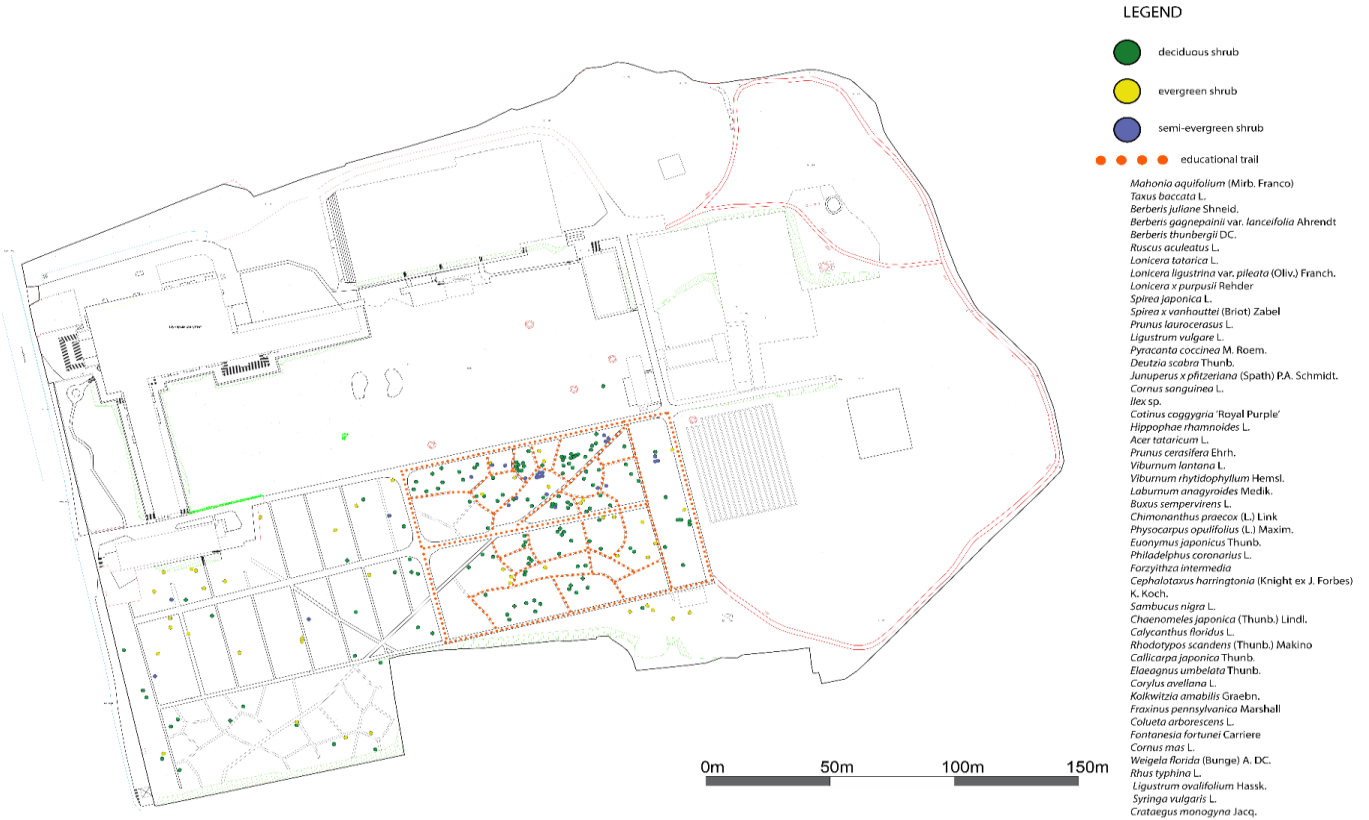

Figure 3. *Conceptual solution of an educational trail inspired by the species of the Arboretum (source: atuhors)*

Figure 4. *Suggested path of the educational trail inspired by the medicinal and useful properties of shrub species in the Arboretum of the Faculty of Forestry - fields D, E, F, G*

Field D: *Mahonia aquifolium* (Mirb. Franco), *Berberis thunbergii* DC., *Lonicera tatarica* L., *Lonicera ligustrina* var. *pileata* (Oliv.) Franch., *Lonicera x purpusii* Rehder, *Pyracanta coccinea* M. Roem., *Deutzia scabra* Thunb., *Cornus sanguinea* L., *Hippophae rhamnoides* L., *Viburnum lantana* L., *Viburnum rhytidophyllum* Hemsl., *Laburnum anagyroides* Medik., *Chimonanthus praecox* (L.) Link, *Philadelphus coronarius* L., Forzyithza intermedia , *Sambucus nigra* L., *Calycanthus floridus* L., *Callicarpa japonica* Thunb., *Elaeagnus umbelata* Thunb., *Kolkwitzia amabilis* Graebn., *Colueta arborescens* L. , *Fontanesia fortunei* Carriere, *Cornus mas* L., *Weigela florida* (Bunge) A. DC., *Rhus typhina* L., *Ligustrum ovalifolium* Hassk., *Syringa vulgaris* L., *Crataegus monogyna* Jacq.

Field E: *Lonicera tatarica* L., *Lonicera ligustrina* var. *pileata* (Oliv.) Franch., *Mahonia aquifolium* (Mirb. Franco), *Taxus baccata* L., *Berberis thunbergii* DC., *Spirea japonica* L., *Spirea x vanhouttei* (Briot) Zabel ,*Prunus laurocerasus* L., *Pyracanta coccinea* M. Roem., *Deutzia scabra* Thunb., *Viburnum lantana* L., *Chimonanthus praecox* (L.) Link, *Physocarpus opulifolius* (L.) Maxim., *Philadelphus coronarius* L., *Sambucus nigra* L., *Chaenomeles japonica* (Thunb.) Lindl., *Calycanthus floridus* L., *Rhodotypos scandens* (Thunb.) Makino, *Callicarpa japonica* Thunb., *Kolkwitzia amabilis* Graebn.

Field F: *Taxus baccata* L., *Prunus laurocerasus* L., *Ilex* sp. , *Viburnum rhytidophyllum* Hemsl., *Euonymus japonicus* Thunb., *Philadelphus coronarius* L.,

Cephalotaxus harringtonia (Knight ex J. Forbes) K. Koch., *Callicarpa japonica* Thunb.

Field G: *Mahonia aquifolium* (Mirb. Franco), *Ruscus aculeatus* L., *Lonicera x purpusii* Rehder, *Viburnum lantana* L., *Philadelphus coronarius* L., *Sambucus nigra* L., *Elaeagnus umbelata* Thunb., *Corylus avellana* L., *Kolkwitzia amabilis* Graebn.

4. DISCUSSION

Many botanical gardens have biomimetic trails with accompanying information boards through which visitors learn about the properties of a particular plant species, as well as how that species found its place in biomimetic, technical applications (Speck & Speck, 2023).

In addition to passive learning, scientists and gardeners offer guided biomimetic tours for interested visitors of all ages, using simple examples to explain functional biomimetic solutions to visitors. They also organize public lectures on numerous biomimetic topics and provide access to scientific and popular scientific publications, organize workshops and lectures for children of different ages, pupils and students (Speck & Speck, 2021, Jacobs et al., 2022).

A notable example is the botanical garden of Freiburg. There is a cactus-inspired pavilion as an illustration of a concrete biomimetic model inspired by the nucleus of the cladode of the cactus *Opuntia* sp. and the stem of the cactus *Carnegiea gigantean* Britton & Rose. Both plant species have a mesh structure, which served as a conceptual solution for the construction of pavilions connected by wooden fiber elements (ICD/ITKEUniversity of Stuttgart, Germany 2020-21, Speck et al., 2023).

The pavilion was built by architects and civil engineers from the University of Stuttgart, Germany, in collaboration with biologists from the University of Freiburg. The Biomimetic Pavilion thus demonstrates the use of natural materials and advanced digital technology in creating a sustainable building inspired by a biological model (Speck et al., 2023).

The formation of an educational path inspired by the medicinal and useful properties of the shrub species present in the Arboretum of the Faculty of Forestry, the area of specific purpose and exceptional botanical and landscape-horticultural value would further emphasize the educational, scientific and cultural function and importance of this natural monument. This type of educational trail would also include displays of various existing biomimetic solutions, products and technologies based on plant species present in the Arboretum of the Faculty of Forestry.

This type of interactive education in the natural environment, both for citizens, would be extremely significant for the students of the Faculty of Forestry, who would gain insight into various ways of applying models from nature through familiarization with various existing biomimetic solutions, which would also serve as inspiration for the creation of new biodesign models.

5. CONCLUSION

Janine Benyus in her book "Biomimicry", which has attracted the attention of many disciplines including biology and design, points out that she considers

nature to be the greatest designer and emphasises the importance of turning to nature and biology to get the answers we need. All the answers lie in nature, it's just important that we know where to look.

Learning from living nature in order to learn about the importance of medicinal and aromatic plants as well as the development of biomimetic technical applications has a special role in botanical gardens and arboretums, which is reflected in educational trails and guided tours.

The continuation of the research would be focused on researching the medicinal and useful values of the remaining dendroflora and herbaceous ground flora of the Arboretum of the Faculty of Forestry, as well as existing biomimetic solutions inspired by those plant species, and in this way it would be possible to approach the design of a comprehensive educational botanical trail that would pass through the entire Arboretum.

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THE POSSIBILITY OF CREATING AN EDUCATIONAL TRAIL INSPIRED BY THE MEDICINAL AND USEFUL PROPERTIES OF THE SHRUB SPECIES PRESENT IN THE ARBORETUM OF THE FACULTY OF FORESTRY

Olga GAJANIĆ, Biljana JOVIĆ, Ivana BJEDOV, Marija NEŠIĆ

Summary

The aim of this work is the analysis of woody shrub species in order to determine the possibility of forming an educational trail in the Arboretum of the Faculty of Forestry, with a focus on medicinal, aromatic and edible species, as well as the research of existing biomimetic solutions, products and technologies based on plant species present in the Arboretum of the Faculty of Forestry in Belgrade. The method of theoretical and field research was applied for the purposes of this work. Theoretical research was conducted through the collection, analysis, and synthesis of data obtained from a wide array of relevant scientific literature and professional studies. growth forms, and distributions of shrubs were studied across different sections of the Arboretum of the Faculty of Forestry in the city of Belgrade (fields A, B, C, D, E, F, G, and I). This field research also included a detailed

photographic documentation of the species, which was used as a visual record and also for further analysis. AutoCad and Photoshop software were used for the graphic conceptual representation of the educational trail. The creation of an educational trail in the Arboretum of the Faculty of Forestry, similar to the model that already exists in many botanical gardens, would aim to enchance visitors' to understanding of the photochemical importance of plant species. Additionaly it would emphaze the variety of applications of biomimicry, using examples of certain biological models, found within woody plant species of the Arboretum and their possible functional application in different spheres of life. This type of intervention would contribute to a better way of using this natural space, not only by students but also by the wider population of citizens. The purpose of guided tours on educational trails in botanical gardens and arboretums is to learn about the importance of medicinal and aromatic plants by learning from nature and getting to know biomimetic technical innovations.

MOGUĆNOST KREIRANJA EDUKATIVNE STAZE INSPIRISANE LEKOVITIM I UPOTREBNIM SVOJSTVIMA ŽBUNASTIH VRSTA PRISUTNIH U ARBORETUMU ŠUMARSKOG FAKULTETA

Olga GAJANIĆ, Biljana JOVIĆ, Ivana BJEDOV, Marija NEŠIĆ

Rezime

Cilj ovog rada je analiza drvenastih žbunastih vrsta radi utvrđivanja mogućnosti formiranja edukativne staze u Arboretumu Šumarskog fakulteta, sa fokusom na lekovite, aromatične i jestive vrste kao i istraživanje postojećih biomimetičkih rešenja, proizvoda i tehnologija zasnovanih na biljnim vrstama prisutnim u Arboretumu Šumarskog fakulteta u Beogradu. Za potrebe izrade ovog rada primenjena je metoda teorijskog i terenskog istraživanja. Teorijsko istraživanje sprovedeno je kroz prikupljanje, analizu i sintezu podataka dobijenih iz obimnog izvora relevantne naučne literature i stručnih studija. Terensko istraživanje podarzumevallo je proučavanje forme rasta i rasprostranjenost žbunastih biljnih vrsta u različitim delovima Arboretuma Šumarskog fakulteta u Beogradu (na poljima A, B, C, D, E, F, G i I), kao i izradu fotodokumentacije koja je korišćena kao vizuelni zapis i materijal za dalju analizu. Za grafički konceptualni prikaz edukativne staze korišćeni su softveri AutoCad i Photoshop. Uvođenje edukativnih staza za cilj bi imao da posetiocima približi fotohemijski značaj biljnih vrsta, kao i raznovrsnost primene biomimikrije na primerima pojedinih bioloških modela, drvenastih biljnih vrsta Arboretuma i njihove moguće funkcionalne primene u različitim sferama života. Ova vrsta intervencije doprinela bi boljem načinu korišćenja ovog prirodnog prostora, ne samo od strane studenata nego i šire populacije građana. Svrha vođenih tura po edukativnim stazama u botaničkim baštama i arboretumima, sprovodi se u cilju upoznavanja značaja lekovitih i aromatičnih biljaka „učenjem" iz prirode i upoznavanjem sa biomimetičkim tehničkih inovacijama.