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Report

Nature conservation in urban conditions: A case study from Belgrade, Serbia

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Abstract: This paper analyses the Serbian nature protection system in Belgrade. Effective protection of natural features in urban landscapes have become increasingly complex due to conversion of natural habitats, high levels of pollution and other forms of deterioration caused by human impact. These anthropogenic pressures vary in type and intensity and depend on the location of protected assets. Through comparative analyses of selected legally protected natural assets in various areas in the city, different features of spatially-functional coexistence and development are noted. According to the results of this research it is evident that various natural protected assets in highly urbanised conditions can sustain theirs primary ecological function and can also develop additional adjusted functions during time.

Keywords: nature conservation, nature protected assets, Belgrade, urban landscape, human impact

INTRODUCTION

The modification of landscape structures and functions by human development is an immutable fact of contemporary society. The main differences between urban and non-urban ecosystems are the type, intensity and frequency of anthropogenic influence. Urban ecosystems are governed by human actions and it is important to consider these actions when studying urban ecology [1]. The spatial disposition, survival and functions of autochthonous ecosystems depend increasingly more on anthropogenic interventions. Their protection is often undertaken too late to prevent the destruction or deterioration of natural assets. Ecosystems have the greatest degree of sensibility to human influences, but this also applies to abiotic natural resources (geological,

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hydrological, etc.) that are situated in urban landscapes. Urban landscapes are a complex mosaic of autochthonous covers (geological, pedological, hydrological, vegetation, etc.) altered by anthropogenic actions and land use.

Typically, cities show a mosaic of habitats with increasing degrees of human impact along a gradient from the outskirts to the city centres [2]. Similarly, Bryant [3] states that "it is clear that habitat diversity and life-support conditions vary greatly along the urban-rural gradient. For conservation purposes, it is important to consider the full spectrum of environmental conditions, from urban core to urban fringe, when planning interventions." Urban land uses are in a state of continuous flux in which change is the norm rather than the exception [4]. Also, from particular interest in research as presented in this paper are landscapes situated on the city edge. As Qviström and Saltzman [5] pointed out for Malmö, Sweden, "a critical analysis of landscape dynamics at the inner fringe can highlight the ways in which time and space are understood within landscape studies."

The main factor determining living conditions in cities is human impact. Increased human densification means that the maintenance and conservation of tracts of natural or semi-natural vegetation will become more difficult in areas of higher human density [6]. With increased human densification, densely built-up areas also expand, causing the loss of biotope structures and the introduction of different species. The effects of urbanisation are more intense in the inner city and this can support specialised urban plant communities [7]. Massive disturbances created by city growth not only destroy the habitats of native species, but also create habitats for the relatively few species that are able to grow in urban and suburban conditions [8], which may lead to urban biotic homogenisation. According to Maurer et al. [9], "for a long time nature conservation in cities has been restricted to relicts of the natural landscape such as wetlands or woods. However, for a more general evaluation of urban land-use types, nature conservation in cities should focus not only on primary natural assets, but also include other important and more or less subjective arguments. All urban land-use types reflect the historic artificial landscape as well as the economic and cultural changes in cities. The vegetation thus represents relicts of historical and botanical heritage."

During the collections of data for our research, one of the problems that appeared was an inconsistency in the defining terminology and in the essential recognition of different features and areas of this type. Löfvenhaft et al. [10] state that the basic problem in the collection of such data occurs due to "poor and/or heterogeneous compilations of ecological data and the terminological confusion leading to multiple meanings for terms such as nature, forest, park, built-up area and green area." For Belgrade, which is the subject of this study, it is obvious that relevant legal documents clearly define the concepts of green areas, forest parks, forests, parks and protected natural assets. However, in official documents and among the public, confusion in the use and essential properties of such terms is present. This clearly results in a remarkably complicated or impossible comparison in an international context, especially in countries where legislation is not compatible with EU regulations and recommendations, as is the case with Serbia.

We aim to present an analytical survey of natural protection in Belgrade, especially from the perspective of spatially-functional coexistence within this environment. For this reason, a comparison of different protected natural assets based on their qualifications to legal protection regimes and locations in the city will be examined, along with the possibility of their sustainable ecological

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existence. For the purpose of comparison within the same legal type, the selection is based on pairs of protected assets which are creation limited mostly by natural versus anthropogenic influences. Our research will attempt to determine whether and to what extent the location of protected assets in a gradient from the city edge to city centre affects their functions.

GENERAL OVERVIEW OF STUDY AREA

The city of Belgrade, capital of Serbia, covers an area of 322,268 ha, which is 3.65% of the total area of the country. The coordinates for Belgrade are: 45°06' N, 44°16' S, 44°27' E and 44°38' W. The highest elevation is 628 m, measured at a distance of 50 km south-east of the narrow city core. The lowest elevation at the most downstream portion of the Danube River in city is 71 m.

Belgrade is situated in south-east Europe at the confluence of the Sava and Danube Rivers, at the boundary between the Pannonian plain and Balkan Peninsula. In Belgrade's territory, Neogene deposits are far more prevalent than Mesozoic formations [11]. Its geographic location and relief characteristics give it a mild-continental climate with an average annual temperature of 12.7°C and annual precipitation of 750 mm.

Due to such geographic conditions, the autochthonous vegetation consists of a mosaic of grass formations in the northern part of the city on the pedological substratum of hydrogenic and chernozem soils, and forest vegetation in which, in a zone from Sava and the Danube River towards the south, associations with dominant species, namely *Salix alba* L. (Salicaceae) and *Populus alba* L. (Salicaceae), alternate with a thermo-mesophilous oak forest zone of the West-Moesian sub-region. The forest associations that were widely distributed in the past with most widespread species such as *Quercus cerris* L. (Fagaceae), *Quercus frainetto* L. (Fagaceae) and *Carpinus betulus* L. (Corylaceae) are now usually only present in various degraded forms [12-13].

Because Belgrade's population history dates in continuity from the 1st century B.C., the autochthonous vegetation cover has been greatly altered by anthropogenic influences, which is of great importance for research on this issue. Today, the city's territory is divided into 17 municipalities, where 1,689,000 inhabitants or 22.5% of the total Serbian population live.

Nature Conservation by Law in Serbia

The nature conservation system in Serbia was created on a legislative basis according to the Law on Nature Protection [14]. The basic unit of protection is known as a protected natural asset, which is defined as a 'preserved area of nature, with particularly great natural values and features which give to the area a permanent ecological, scientific, educational, recreational or other importance. So, being of particular interest, this asset is particularly protected.'

In addition to the general definition, the Law on Nature Protection provides seven different types of protected natural assets, viz. national park, nature park, landscape of outstanding features, natural reserve, special nature reserve, natural monument and natural rarities. Brief descriptions of these types of protected natural assets are shown in Table 1.

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Table 1. Definitions of protected natural assets in order of importance

Protected natural asset	Definition
National park	Large area with highly valuable, well-preserved natural ecosystems, with complex structural or biogeographical features with diverse original flora and fauna, representative physical-geographical phenomena and with cultural-historical value such as an exceptional natural unit important for the country.
Nature park	Area of well-preserved natural water, air and soil, dominant natural ecosystems, and without major degradation changes of landscape; a significant area of preserved nature and healthy environment.
Landscape of outstanding features	Relatively smaller area with vivid landscape features, undisturbed primary values of landscape with a presence of traditional ways of life and cultural heritage; also the protected surroundings of immobile cultural assets.
Natural reserve	An original or minimally altered area of nature of a special composition and features of plant or animal communities within the ecosystem; intended primarily for the preservation of genetic funds.
Special nature reserve	Area with one or more natural values to be particularly protected or natural phenomena to be observed and managed.
Natural monument	Natural object or phenomenon, physically clearly expressed and recognisable with representative geomorphologic, botanical or other features (geological, hydrological, etc.), which, as a rule, ought to be of attractive and remarkable appearance or mode of appearing; also a man-made artificial botanical value (individual trees, arboretum, botanical gardens, etc.) if it has particular importance.
Natural rarities	Plant and animal species or communities whose survival is threatened in their natural habitats or whose populations are quickly becoming extinct or whose habitats are degraded, or species that have narrow distributions or have special ecological, genetic, economical, sanitary or other significance.

Different levels of natural asset values dictate implementation of various management methods and responsibilities for the care, protection and improvement of some natural assets. Accordingly, many requirements are needed for categorisation of protected natural assets in order to improve management of protected areas. Under the Serbian Law on Nature Protection, it is possible to recognise the following categories of protection, i.e. category I: exceptionally important natural assets; category II: very important natural assets; and category III: important natural assets.

The procedure of categorisation and evaluation of protected natural assets is under the jurisdiction of the Institute for Nature Conservation of Serbia, which prepares expert reviews and conducts evaluations and proposes a category for each protected natural asset. The categorisation

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procedure is based on the natural assets' essential features such as authenticity, being representative, relict or endemic, rarity, degree of preservation, functions and importance of assets (ecological, scientific, educational) as well as the level of endangerment to the protected natural assets.

CASE STUDY

Approximately 550,000 ha or 6.19% of the total area of the Republic of Serbia is protected by the Law on Nature Protection. The area covered by this research consists of approximately 5,000 ha of protected areas, which is about 1% of the total protected natural assets in Serbia.

In the research area, the tradition of legitimate nature protection is 40 years old. It was intensified in the last decade (see Table 2), which corresponded to the period of greatest anthropogenic pressure (spatial expansion of the urban zone and a population increase of approximately 100,000 from 1991). Mostly, the data were collected from the national institution for nature protection, Institute for Nature Conservation of Serbia, and were supplemented with empirical data. Table 2 provides a list of legitimate protected natural assets in Belgrade, but it does not include a detailed list of individual protected trees.

According to the Serbian Law of Nature Protection, among natural monuments it is also possible to find individual trees with protected status. In Belgrade, 35 natural monuments of botanical character are registered as protected trees, among which some exotic and decorative species are dominant that do not belong to the autochthonous floristic elements (e.g. *Cupressus arizonica* L. (Cupressaceae), *Liriodendron tulipifera* L. (Magnoliaceae) and *Platanus acerifolia* L. (Platanaceae)—the oldest tree in Belgrade planted in 1839). From the category of autochthonous floristic elements, only a few trees are protected (only nine in the four localities and all are the same species, namely *Quercus robur* L. (Fagaceae). This is evidence of a significant deterioration of the vegetation cover of Belgrade, which has been almost fully destroyed by urban development. Although protected trees will not be a subject of detailed discussion in this paper, their imposing visual prominence in the ambient environmental picture, in addition to explanations of their scientific importance and their need for protection, has contributed to the popularisation of the idea and practice of nature protection even in a highly developed urban landscape such as that of Belgrade.

Among the protected natural assets shown in Table 2 are landscapes of outstanding features and natural monuments with different protection values. Forests and park complexes are dominant, but among them are also three natural monuments of geological importance. Protected assets such as natural monuments of geological significance have exclusive scientific, educational and cultural/historical value and, because of their particularity and on the basis of their area and location, do not have limiting effects on the development of surrounding areas.

We will emphasise two landscapes of outstanding features—Veliko ratno ostrvo and Avala—and two natural monuments—Banjička šuma and Jevremovac Botanical Garden (Figure 1) to elucidate the spatially-functional coexistence of nature conservation and urban development.

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Table 2. Protected natural assets in Belgrade

No.	Protected asset	Area (ha)	Asset type	Year of protection	Main value
1.	Avala	489.13	LOF	2007	Well-preserved mountainous thermo-mesophilous oak forest habitat
2.	Kosmaj	3514.50	LOF	2005	Well-preserved mountainous thermo-mesophilous oak forest habitat
3.	Veliko ratno ostrvo	167.9056	LOF	2005	Ecosystem of typical wetland vegetation and avifauna
4.	Banjička šuma	58.6586	NM	1993	Ornithological site
5.	Miljakovačka šuma	244	NM	2008	Preserved thermo-mesophilous oak forest habitat
6.	Topčider	12.83	NM	2008	Public park site with many protected trees
7.	Košutnjak	267	NM	2008	Preserved thermo-mesophilous oak forest habitat
8.	'Jevremovac' Botanical Garden	4.8183	NM	1995	University botanical garden
9.	Akademski Park	1.4590	NM	2007	Public park site with many protected trees
10.	Pionirski Park	3.6013	NM	2007	Public park site with many protected trees
11.	'Mašin majdan' Senonian shelf	4.5	NM	1969	Rare geological site
12.	Sea Neogene shelf – Kalemegdan	0.006	NM	1969	Rare geological site
13.	Miocene shelf – Tašmajdan	2.5	NM	1968	Rare geological site
14-48.	Protected trees	1.5	NM	1969-	Remarkable trees

Note: LOF = landscape of outstanding features; NM = natural monument

Source: Institute for Nature Conservation of Serbia [15]

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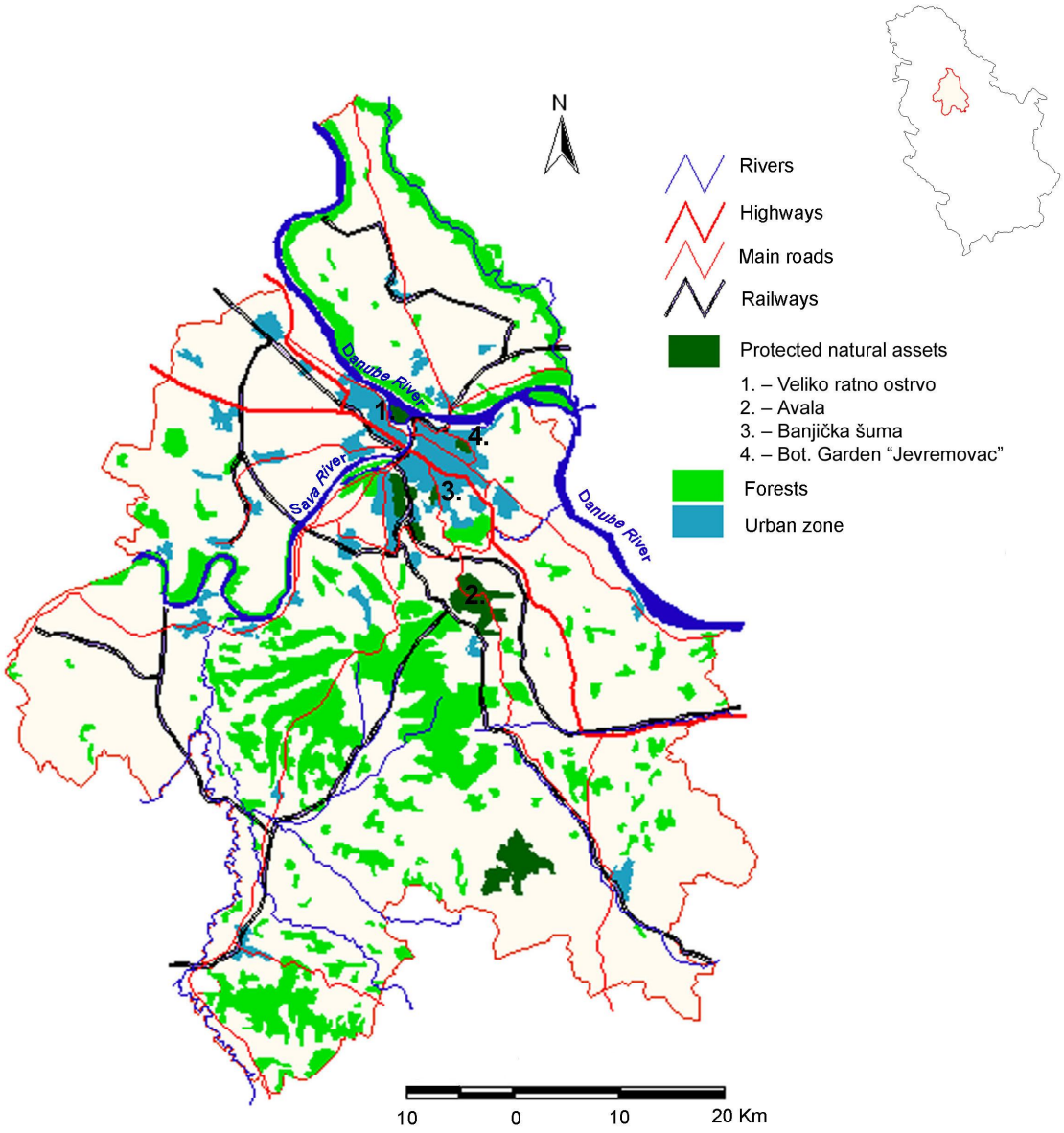

Figure 1. Distribution map of selected protected natural assets in Belgrade area

The Veliko ratno ostrvo (Figure 2) is an area of outstanding features, representing one of the largest areas and the most composite landscape complex with its physical-geographic, biotic and ecological particularities that is protected in Belgrade. It is located in the narrow city centre and it lacks human occupancy. This island originated from the accumulation of fluvial deposits at the mouth of the Sava River next to the Danube. The habitat is of seasonally flooded forest with *Salix spp.* and *Populus spp.* and wetland vegetation. The vegetation supports a rich avifauna on the island with nesting and feeding habitats. The number of birds vary depending on the water level and the season, but the most common species among 160 species seen on this island are: *Egretta garzeta* L. (Ardeidae), *Larus ridibundus* L. (Laridae), *Podiceps cristatus* L. (Podicipedidae), *Ciconia ciconia* L. (Ciconiidae), *Phasianus colchicus* L. (Phasianidae), *Circus aeruginosus* L. (Accipitridae), *Accipiter gentiles* L. (Accipitridae) and *Buteo buteo* L. (Accipitridae) [16].

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Figure 2. Veliko ratno ostrvo at the mouth of Sava River (left) on the Danube (right), 2010

Avala, a landscape of outstanding features that includes a low mountain (506 m) of the same name (Figure 3), is about 15 km away from the city centre. The dominant ecosystem of Avala consists of a mountainous thermo-mesophilous oak forest habitat of the West-Moesian floristic subregion [16]. Almost 70% of the total area is covered by forest within the altitude region of oak and beech habitats with most common species such as *Quercus frainneto* L. (Fagaceae), *Quercus cerris* L. (Fagaceae) and *Fagus moesiaca* (K.Maly) Czeczott (Fagaceae) in association with *Ruscus aculeatus* L. (Gonvallariaceae). Among others, dominant species such as *Tilia tomentosa* Moench. (Tiliaceae) and *Fagus moesiaca* are also found on the Avala mountain. Anthropogenic interventions to increase the forested area and to artificially enrich flora were done more than 100 years ago, with introduced trees such as *Pinus nigra* Arn. (Pinaceae), *Pinus silvestris* L. (Pinaceae) and *Cedrus atlantica* (Endl.) Carr. (Pinaceae) being planted. In this oak and beech habitats, numerous bird species have been found, most notably *Falco tinnunculus*, *Strix aluco*, *Otus scops*, *Buteo buteo* and *Dendrocopos major*. Some species of flora and fauna on Avala mountain, e.g. *Thlaspi avalanum* Pancic (Brassicaceae) and *Strix aluco* L., are protected by Serbian law of natural rarities [17].

Figure 3. Panoramic view of Avala mountain, 2010

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Banjička šuma woodland (Figure 4) is protected as a natural ornithological area and is located approximately 5 km south of the city centre. The forest is dominated with anthropogenic trees, viz. *Quercus robur* L. (Fagaceae), *Acer campestre* L. (Aceraceae), *Populus virginiana* Foug. (Salicaceae) and *Cedrus atlantica* (Endl.) Carr. (Pinaceae), planted in the primary habitat of *Tilia tomentosa* Moench. (Tiliaceae) and *Quercus spp.* during 1948-1950. It has developed into three levels that serve as habitats for 68 bird species, of which 40 are residents, 16 are migrators and 12 are migrants. Four of these species (*Oriolus oriolus, Turdus pilaris*, *Strix aluco* and *Buteo buteo*) are also strictly protected by the Serbian regulation for natural rarities [16].

Jevremovac Botanical Garden is situated in the city centre, where vegetation conditions are unfavourable, i.e. there is high air pollution. This natural monument is a habitat for more than 1,000 outside plant species and an additional 1,000 species in the indoor part of the garden. Since the artificial ecosystems of the botanical garden has specific conditions, it is also a habitat for 25 of the 58 moss species in Belgrade [18].

Figure 4. Banjička šuma, 2009

Figure 5. Jevremovac Botanical Garden, 2009

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Methods

The first step entailed a detailed survey of the literature relevant to this research. This included the flora-vegetation, avifauna and ecosystems. By study of contemporary urban ecology papers, it was concluded that flora-vegetation criteria are crucial in decisions for the enactment of nature protection laws [9, 19-26]. Avifauna diversity and richness were of special importance for protection in the literature [27-31]. The theoretical basis of analysis also included relevant literature [4, 32-41]. We found a few suitable inventories of autochthonous plants and fauna in Belgrade [12-13, 16].

We then did a qualitative comparative analysis. The following criteria were used: qualification to the same type of protected assets on a legal basis, spatial location of assets (centre vs. outskirts), and genesis (slightly altered natural ecosystem vs. initially dominant ecosystems of anthropogenic origin).

The final phase of comparative analysis involved a critical overview of the selected examples with special focus on their spatially-functional coexistence. With that aim in a mind, data about biodiversity and ecosystems as well as disturbances were reviewed.

RESULTS AND DISCUSSION

The result of a comparative analysis performed on two pairs of protected areas that belong to the same category of protected assets is presented in Table 3. The first pair consists of two natural assets that are classified as landscapes of outstanding features, Veliko ratno ostrvo and Avala, and the second pair as protected natural monuments, Banjička šuma and Jevremovac Botanical Garden.

Table 3. Comparison of selected natural assets

Criteria		First pair		Second pair	
		Veliko ratno ostrvo	Avala	Banjička šuma	Jevremovac Bot. Garden
Type of protected natural assets	Landscape of outstanding features	+	+	-	-
	Natural monument	-	-	+	+
Location	Centre	+	-	-	+
	Outskirt	-	+	+	-
Genesis	Natural ecosystem	+	+	-	-
	Disturbed ecosystem	-	-	+	+

During the comparison of the first pair of natural protected assets we found that both have remarkable and unique ecological values (Table 4). The location of these natural protected assets does not affect their ecological and scientific functions. It was also found that location does not influence the existence of limited production activities (e.g. agriculture and forestry) which are allowed by the Serbian law on nature protection.

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Table 4. Functions of selected natural assets

Function	Veliko ratno ostrvo	Avala	Jevremovac Bot. Garden	Banjička šuma
Ecological	+	+	+	+
Scientific	+	+	+	+
Educational	-	-	+	-
Recreational	+	+	-	+
Productional	+	+	-	-
Residential	-	+	-	-

Educational function only recorded for one of these protected assets due to absence of guide service and not to their location. The location of these assets does not influence their recreational function. For Veliko ratno ostrvo the recreation function is limited only to the summer because it is an inaccessible and inhospitable island during the rest of the year (flooded areas, lack of the trails, etc.). A residential function is therefore not applicable here while Avala has this function (mostly rural households) because of its large area. Finally, we can say that the presence of all these functions in the protected assets analysed is not influenced by their location.

These examples belong to the same type of protected natural assets not because of compatible ecosystems or landscape values (wetlands or thermo-mesophilous mountain forest ecosystem), but rather because of the similar magnitudes of urban development suffered by both places. The types of pressure and the forms of autochthonous values at risk are different though. At Veliko ratno ostrvo, the endangering factors are continuous and affect all habitat types directly and equally. Conversely, for Avala the endangering factors are sporadic and directly devastate only forest habitats. We determined that significant functional differences in the analysed examples do not derive from their different spatial connections with the urban core.

A comparison of the second pair shows that both protected natural assets have specific ecological and scientific functions. In the case of Jevremovac Botanical Garden, where allochthonous conditions are suitable for the largest number of plants, the ecological, scientific and educational functions are high. A cultural-historical dimension is also present with Jevremovac Botanical Garden, which was created more than 120 years ago. Banjička šuma also has ecological and scientific functions but lacks educational values as a result of a deficiency in management activities. It is obvious that location does not have any influence on the functions of the second pair of protected assets. Neither of these has productional or residential function. Recreation (walking, tracking, jogging or bicycle riding) is not a common characteristic of Jevremovac Botanical Garden while Banjička šuma is a popular area for the same activities in the local surrounding.

The natural assets of Banjička šuma and Jevremovac Botanical Garden were included in this research because of similarities in their initial phases of genesis since both were planned for a specific purpose relatively recently and have achieved various functions. The primary function of Banjička šuma was the afforestation of devastated land. With time it developed spontaneously from direct management-oriented activities into an optimal habitat for birds. Jevremovac Botanical Garden was operational for more than a century and has become ecological filter in the most urbanised and

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polluted part of Belgrade. In accordance with legal conservation postulates, it has stimulated the protection and improvement of not only the original, autochthonous ecological functions of those sites, but also of those that have developed in dynamic interactions between the abiotic features of the urban environment and the biotic potentials of the same areas.

According to the presented results, it is clear that ecological and scientific functions of all selected protected assets are well exposed and not influenced by location (Figure 6). Such results are expected since improvement of these functions is the primary reason for their legal protection.

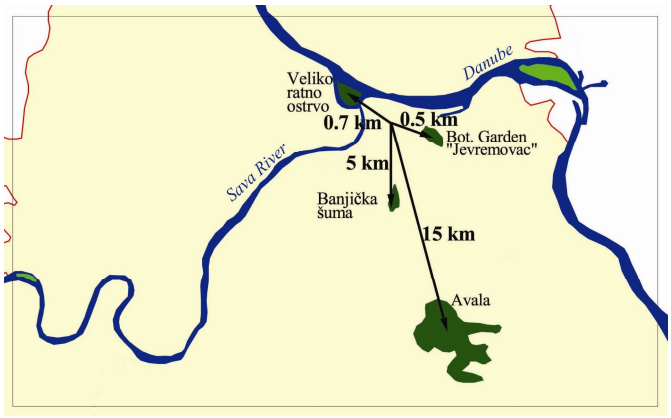

Figure 6. Detail of the study areas with distances from the city centre

Considering this in the time scale, it was observed that for landscapes of outstanding features (Veliko ratno ostrvo and Avala), definite conclusions about changes in their ecological and scientific functions are too early to know. It is evident that some disturbing factors have been minimised. Research on Veliko ratno ostrvo by Šinžar-Sekulić et al. [36] noted that "twenty years ago, 53.2% of the island were agricultural areas, followed by 28.4% of willow and poplar forest. Nowadays, only 6.0% of the island is used for agriculture." By undertaking adequate protection measures, it has been possible to reduce the exploitation of autochthonous habitats and landscapes. Anthropogenic influences are causes of environmental disturbance (intensive fluctuations of ground water level, pollution of surface and ground waters, decrease of area under indigenous vegetation, extermination of avifauna habitats, disturbance of habitat conditions for ichthyo- and herpetofauna, etc.). The specific location of Veliko ratno ostrvo wetlands is at a disadvantage for the regeneration of its ecosystem. Because of its isolation and lack of contact with related ecosystems, the nearest being at least 10 km away, measures to manage this natural asset have been oriented towards the stimulation of the sustainable capacity of the ecosystem. At Avala, minimising clear cutting of forest cover and degradation of biodiversity has been the main reason for the initialisation of protection. Breuste [22], states: "To preserve indigenous vegetation, it is necessary to understand the forces on the processes of urban growth as well as the ongoing landscape changes by agriculture and forestry, and how to deal with this transformation of landscape." This is pursuant to the findings of Zhu and Zhang [25], who emphasised that "in a dynamic context, we see that the eco-regional condition may influence the changing amount of urban forest land during different stages of city growth."

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For the natural monuments, i.e. Banjička šuma and Jevremovac Botanical Garden, where legal protection has been in force for longer than one decade, it is possible to follow improvement of their ecological and scientific values. At the Jevremovac Botanical Garden, according to Jovanović [42], "among other initiatives, a program of ex situ protection of endangered Serbian plant species is being developed with the goal of reintroducing those species to the natural habitats from which they have disappeared." This place also operates as an ecological filter: typical unpolluted air bio-indicators (related to limited values of SO_2 concentration) have been found according to Cvijan et al. [39], who also reported six species of lichens in the Jevremovac Botanical Garden, which represents an isolated island within the 11-km^2 "lichen desert" of Belgrade. As can be seen in Figure 1, the location and elongated shape of Banjička šuma functions as an ecological corridor for the avifauna of southern Belgrade. Such corridors stabilise the survival of mobile habitat-dependent species [27]. These should not be substitutes for the protection of large, intact nature reserves in urban or suburban landscapes [28]. Banjička šuma is situated at the intermediate point along urbanisation gradient and has significant richness of avifauna [35]. According to well-known landscape ecology postulates, small natural vegetation patches serve as stepping stones for species dispersal and provide heterogeneity. In urban conditions, it is more difficult to successfully provide the level of protection available to undisturbed regions of larger areas. We agree with Forman [43] that "small patches provide different benefits than large patches and should be thought of as a supplement to, but not a replacement for, large patches." Diversity of habitat patches is a result of stochastic colonisation events combined with varying degrees of human-induced disturbance [44]. According to Colding [4], it is believed that "ecological land-use complementation may involve the clustering together of a whole range of different green patches in cities to increase available habitat and promote ecological processes." Although Banjička šuma is surrounded by dense urban development and very heavy traffic, the healthy state of this ecosystem indicates that it has resisted negative anthropogenic influences. Whatever the biodiversity quality of the periurban landscape, site-specific actions such as shrub and tree planting, water table restoration and increasing vegetation diversity can change bird diversity and improve the quality of Nature [29].

For a better understanding of the avifauna of Veliko ratno ostrvo and Banjička šuma, it is necessary to undertake future inventory research by using "a habitat island approach which may be a good starting point for bird management in urban landscapes" [30]. Future research on the effects of human disturbance on urban birds should be directed to the analysis of the relationships between human disturbance and tolerance levels for more skittish and rarer species, which are usually the target of conservation efforts. Also, the species composition, habituation levels, visitor loads in urban parks, type of human activities and how the temporal dynamics of visitors (daily and seasonal) may influence bird species' tolerance levels, population persistence and breeding success must be known.

Equally important are the recreational, educational, and productive functions of protected natural assets. Petrosillo et al. [41] noted that protected natural assets in urban areas can "support natural capital and consequently environmental security and human well-being. Natural protected areas can be considered part of the so-called 'critical social natural resource', representing natural areas that are of critical value largely as a result of their social value to local communities rather than any outstanding ecological or scientific value."

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One of the most significant social benefits of nature protection is its role in educating and informing the public. This is particularly important for living in urban conditions as outlined in the results of different studies [32-33, 45]. Unfortunately, the practical confirmation of these findings cannot be found in our study except at the Jevremovac Botanical Garden.

CONCLUSIONS

The spatial disposition, functionality and survival of autochthonous ecosystems and abiotic rarities are increasingly threatened by anthropogenic pressure. Biotic and abiotic assets located in urban landscapes have the highest sensibility and are most threatened by human influence. Now in Belgrade, there are about 50 natural assets of different types that are protected by law and are under some management regime that guarantees their existence and functionality. These protected assets are of different types, structures, values, locations and significance. Through their protection, some level of compliance with the need to preserve the ecological balance and environmental protection and rational nature resource usage are fulfilled amid necessary urban development, society, infrastructure, and productive urban structure.

This report covers four protected assets situated on different locations from the centre to the edge of Belgrade city. It can be concluded that location does not influence the functions of these areas, which are legally protected by the Serbian law on nature protection.

It is expected that the structure of the protected areas will change through future Belgrade development. In the future, these changes should be studied, with special emphasis on the under-developed educational function for which there is high potential.

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REFERENCES

1. J. Breuste, J. Niemelä and R. P. H. Snep, “Applying landscape ecological principles in urban environments”, *Landscape Ecol.*, **2008**, *23*, 1139-1142.
2. H. Sukopp, “Human-caused impact on preserved vegetation”, *Landscape Urban Plan.*, **2004**, *68*, 347-355.
3. M. M. Bryant, “Urban landscape conservation and the role of ecological greenways at local and metropolitan scales”, *Landscape Urban Plan.*, **2006**, *76*, 23-44.
4. J. Colding, “Ecological land-use complementation for building resilience in urban ecosystems”, *Landscape Urban Plan.*, **2007**, *81*, 46-55.
5. M. Qviström and K. Saltzman, “Exploring landscape dynamics at the edge of the city: spatial plans and everyday places at the inner urban fringe of Malmö, Sweden”, *Landscape Res.*, **2006**, *31*, 21-41.

6. K. J. Gaston, "Biodiversity and extinction: species and people", *Prog. Phys. Geogr.*, **2005**, *29*, 239-247.
7. E. Osma, İ. İ. Özyiğit, V. Altay and M. Serin, "Urban vascular flora and ecological characteristics of Kadıköy district, Istanbul, Turkey", *Maejo Int. J. Sci. Technol.*, **2010**, *4*, 64-87.
8. M. L. McKinney, "Urbanization as a major cause of biotic homogenization", *Biol. Conserv.*, **2006**, *127*, 247-260.
9. U. Maurer, T. Peschel and S. Schmitz, "The flora of selected urban land-use types in Berlin and Potsdam with regard to nature conservation in cities", *Landscape Urban Plan.*, **2000**, *46*, 209-215.
10. K. Löfvenhaft, C. Björn and M. Ihse, "Biotope patterns in urban areas: a conceptual model integrating biodiversity issues in spatial planning", *Landscape Urban Plan.*, **2002**, *58*, 223-240.
11. S. Knežević and V. Radulović, "Important geological localities in the Belgrade area", *Geologica Balc.*, **1996**, *26*, 39-44.
12. S. Jovanović, "The Steppe vegetation fragments in the surroundings of Belgrade", *Arch. Biol. Sci.*, **1988**, *40*, 9-10.
13. K. Jakovljević, D. Lakušić, S. Vukojičić, A. Teofilović and S. Jovanović, "Floristic characteristics of Višnjička kosa near Belgrade, Serbia", *Arch. Biol. Sci.,* **2008**, *60*, 703-712.
14. National Assembly of the Republic of Serbia, "Law on nature protection", *Official Gazette RS*, **2009**, *36*, Belgrade, pp. 76-100 (in Serbian).
15. "Official Register of Institute for Nature Conservation of Serbia", Institute for Nature Conservation of Serbia, Belgrade, **2010** (in Serbian).
16. M. Veselinović, V. Golubović-Ćurguz, B. Nikolić, N. Nešić and M. Cvejić, "Some of the protected natuaral areas of the Belgrade region", Proceedings of Conference on "Management of Forest Ecosystems in National Parks and Other Protected Areas", **2006**, Jahorina-NP Sutjeska, Bosnia and Herzegovina, pp.137-143 (in Serbian; English abstract).
17. National Assembly of the Republic of Serbia, "Regulation of natural rarities", *Official Gazette RS*, **1993**, *50*, Belgrade, pp. 2342-2348 (in Serbian).
18. S. Grdović and V. Stevanović, "The moss flora in the central urban area of Belgrade", *Arch. Biol. Sci.,* **2006**, *58*, 55-59.
19. S. Godefroid, "Temporal analysis of the Brussels flora as indicator for changing environmental quality", *Landscape Urban Plan.*, **2001**, *52*, 203-224.
20. M. W. Schwartz, N. L. Jurjavcic and J. M. O'Brien, "Conservation's disenfranchised urban poor", *Bioscience*, **2002**, *52*, 601-606.
21. S. Zerbe, U. Maurer, S. Schmitz and H. Sukopp, "Biodiversity in Berlin and its potential for nature conservation", *Landscape Urban Plan.*, **2003**, *62*, 139-148.
22. H. J. Breuste, "Decision making, planning and design for the conservation of indigenous vegetation within urban development", *Landscape Urban Plan.*, **2004**, *68*, 439-452.
23. D. Oğuz, "Remaining tree species from the indigenous vegetation of Ankara, Turkey", *Landscape Urban Plan.*, **2004**, *68*, 371-388.

24. I. Vähä-Piikkiö, A. Kurtto and V. Hahkala, "Species number, historical elements and protection of threatened species in the flora of Helsinki, Finland", *Landscape Urban Plan.*, **2004**, *68*, 357-370.
25. P. Zhu and Y. Zhang, "Demand for urban forests in United States cities", *Landscape Urban Plan.*, **2008**, *84*, 293-300.
26. S. T. A. Pickett and M. L. Cadenasso, "Linking ecological and built components of urban mosaics: An open cycle of ecological design", *J. Ecol.*, **2008**, *96*, 8-12.
27. L. Hansson and P. Angelstam, "Landscape ecology as a theoretical basis for nature conservation", *Landscape Ecol.***, 1991**, *5*, 191-201.
28. J. Niemelä, "Ecology and urban planning", *Biodivers. Conserv.*, **1999**, *8*, 119-131.
29. P. Clergeau, J. Jokimäki and J. L. Savard, "Are urban bird communities influenced by the bird diversity of adjacent landscapes?", *J. Appl. Ecol.*, **2001**, *38*, 1122-1134.
30. E. Fernández-Juricic and J. Jokimäki, "A habitat island approach to conserving birds in urban landscapes: Case studies from southern and northern Europe", *Biodivers. Conserv.,* **2001**, *10*, 2023-2043.
31. P. Clergeau, S. Croci, J. Jokimäki, M. –L. Kaisanlahti-Jokimäki and M. Dinetti, "Avifauna homogenisation by urbanisation: Analysis at different European latitudes", *Biol. Conserv.*, **2006**, *127*, 336-344.
32. M. L. McKinney, "Urbanization, biodiversity, and conservation", *Bioscience*, **2002**, *52*, 883-890.
33. R. J. Miller and J. R. Hobbs, "Conservation where people live and work", *Conserv. Biol.*, **2002**, *16*, 330-337.
34. K. Daugstad, H. Svarstad and O. I. Vistad, "A case of conflicts in conservation: Two trenches or a three-dimensional complexity?", *Landsc. Res.*, **2006**, *31*, 1-19.
35. E. Fleishman, R. F. Noss and B. R. Noon, "Utility and limitations of species richness metrics for conservation planning", *Ecol. Indic.*, **2006**, *6*, 543-553.
36. J. Šinžar-Sekulić, A. Komarnicki and V. Stevanović, "Changes of habitat types through several decades in the Danube region in Serbia - The case of Veliko ratno ostrvo island near Belgrade", Proceedings 36th International Conference of IAD, **2006**, Vienna, Austria, pp. 322-325.
37. A. Jorgensen and M. Tylecote, "Ambivalent landscapes – wilderness in the urban interstices", *Landsc. Res.*, **2007**, *32*, 443-462.
38. G. W. Luck, "The relationships between net primary productivity, human population density and species conservation", *J. Biogeogr.*, **2007**, *34*, 201-212.
39. M. Cvijan, G. Subakov-Simić and J. Krizmanić, "Monitoring of the 'lichen desert' in the Belgrade area (1980/81, 1991 and 2007)", *Arch. Biol. Sci.,* **2008**, *60*, 215-222.
40. N. Zaccarelli, K. H. Riitters, I. Petrosillo and G. Zurlini, "Indicating disturbance content and context for preserved areas", *Ecol. Indic.*, **2007**, *8*, 841-853.
41. I. Petrosillo, N. Zaccarelli, T. Semeraro and G. Zurlini, "The effectiveness of different conservation policies on the security of natural capital", *Landscape Urban Plan.*, **2009**, *89*, 49-56.

Maejo Int. J. Sci. Technol. **2011**, *5*(01), 129-145

42. S. Jovanović, "Jevremovac Botanical Garden - a unique monument to the nature of Serbia at the eve of the third millennium), *Заштита природе*, **1998**, *50*, 71-78 (in Serbian; English abstract).
43. R. T. T. Forman, "Some general principles of landscape and regional ecology", *Landscape Ecol.*, **1995**, *10*, 133-142.
44. J. Niemelä, "Is there a need for a theory of urban ecology?" *Urban Ecosyst.*, **1999**, *3*, 57-65.
45. M. Stubbs, "Natural green space and planning policy: Devising a model for its delivery in regional spatial strategies", *Landscape Res.*, **2008**, *33*, 119-139.