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# Flora of Belgrade surroundings (Serbia) 150 years after Pančić's monograph – a comparative overview

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**ABSTRACT**: Detailed data on the flora of Belgrade and its surroundings, collected by Josif Pančić date from the second half of 19th century. After a long break, the expansion of floristic and vegetation studies of Belgrade territory started in 1950 and has continued till the present day. All the available floristic data, historic and current, for Belgrade territory were taken into account. Comparative diversity analysis of the ancient and the recent vascular flora were carried out and preliminary results are presented in this paper.

**Key words**: Josif Pančić, urban flora, extinct species, threatened species, alien taxa

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## INTRODUCTION

Belgrade is one of the few European capitals with a very long tradition of floristic explorations, due to a great botanist Josif Pančić. Namely, after he first settled in Belgrade back in 1846, Josif Pančić started his investigations of plant life in Belgrade and its surroundings. In the first edition of his capital monographic work "*Flora u okolini Beogradskoj*" (Pančić 1865) he recorded 1057 taxa. Pančić continued his explorations in the area, enriching the list of recorded taxa. As a result the sixth edition of this monograph (Pančić 1892), published four years after Pančić's death, a total of 1156 taxa was recorded. Accordingly, at the end of the 19th century Pančić had established the scientific basis for future floristic and vegetation studies of Belgrade and its surroundings.

After the fruitful Pančić era, lasting almost three decades of the late 19th century, the floristic diversity of Belgrade was studied by a relatively small number of scientists. Apart from the contributions of Jurišić (1901a, 1901b), who noticed some novelties for the flora of the Kingdom of Serbia (in the Belgrade area), as well as Adamović (1904), who recorded new species for the Belgrade flora, the first half of the 20th century was marked by the absence of nature explorations, due to the impact of turbulent historical events. Namely, the first contributions to the plant life of Belgrade were published half a century after Jurišić and Adamović, by: Rajevski (1950), Černjavski (1950), Jovanović (1950), Jovanović & Dunjić (1951), Janković (1953), Gajić (1952, 1954a, 1954b), Borisavljević *et al.* (1955), Gajić (1957), Stjepanović-Veseličić & Čanak (1959). The great scientific enthusiasm of members of the 'Belgrade phytocoenologic school' continued during the sixties and seventies of the 20th century (Gajić 1962; Jovanović & Tucović 1962; Bogojević 1968a, 1968b; Ilić *et al.* 1972; Tomić 1972; Jovanović 1976; Jovanović & Vukićević 1977). Nevertheless, the period after 1980 was characterized by a considerable expansion in floristic and vegetation studies, which lasts till today (Fig. 1). This period was especially marked by the work of the following authors: Jović *et al.* (1981); Radulović (1982, 1984); Blaženičić & Vučković (1983); Jovanović *et al.* (1984, 1985); Obratov (1986); Jovanović (1981, 1985, 1988, 1993, 1994, 1997); Jovanović & Lakušić (1991); Jovanović

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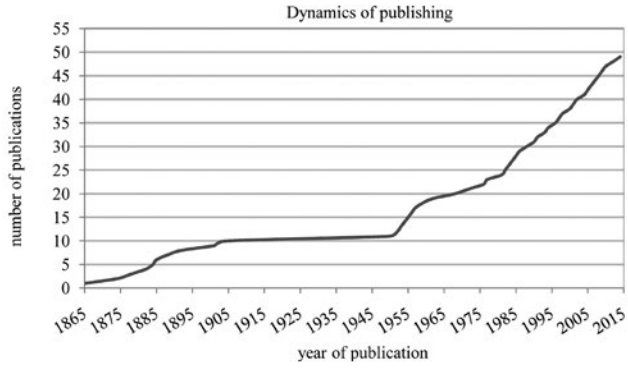


**Fig. 1.** Publishing dynamics of papers dealing with Belgrade's flora and vegetation

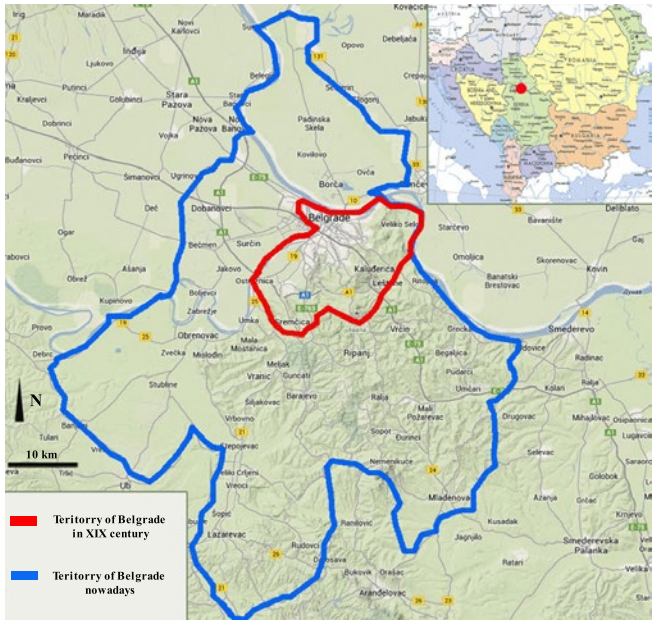


**Fig. 2.** Territory of Belgrade in the 19th century and nowadays

& Bartula (1997); Petrović (1996); Jovanović *et al.* (1998); Obratov-Petković *et al.* (2000); Bartula (2001); Anđelković (2002); Stavretović (2002); Tomanović (2004); Jakovljević & Jovanović (2006); Teofilović *et al.* (2008); Jakovljević *et al.* (2008); Radulović *et al.* (2008); Jovanović *et al.* (2009); Obratov-Petković *et al.* (2009); Stanković (2010); Anastasijević & Anastasijević (2012); Glišić *et al.* (2014), etc.

The main aim of this paper is to bring together all the available floristic data for the Belgrade area and to determine the overall diversity of vascular flora at the present time. We also compare the urban Belgrade flora composition from Pančić's time with records published within the last 60 years. Special emphasis is given to the relationship dynamics between native and foreign, as well as extinct and invasive species.

## MATERIALS AND METHODS

### Study area

Belgrade, the capital city of Serbia, is situated in south-eastern Europe at the confluence of the Sava and Danube Rivers, on the border between the Pannonian Plain and Balkan Peninsula (44°48'52" - 44°50'67" N and 20°31'68" - 20°37'22" E). The city territory covers an area of 322,268 ha, which is 3.65% of the total country area (Fig. 2). The relief of Belgrade is characterized by soft shapes with wide and shallow valleys and spacious rounded hills, mildly descending towards the Sava and Danube Rivers. The highest elevations are on Mt. Kosmaj (628 m), which is situated 50 km south-east of the narrow city core, as well as Mt. Avala (506 m) which is about 15 km away from the city centre. The lowest elevation in the downstream portion of the Danube River within the city area is 71 m. 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 (Đurđić *et al.* 2011).

Today, the city territory is divided into 17 municipalities, where 1,689,000 inhabitants or 22.5% of the total Serbian population live. However, at the end of the 19th century, the territory of Belgrade covered only around 320 km$^2$ with a population of about 20,000 inhabitants (Fig. 2).

### Data sources

Floristic records for the Belgrade territory and its surroundings were gathered from nearly one hundred literature sources, from Pančić's monograph to various floristic and vegetation papers, studies for protection of certain localities and MSc and PhD theses. The analyses encompassed previously-investigated localities and habitat types within the area of Belgrade, from natural (Mt. Kosmaj, Bara Reva, Veliko Blato, Lipovička Šuma, Stepin Lug) and seminatural habitats (Mt. Avala, Ada Ciganlija, Veliko Ratno Ostrvo, Topčider, Košutnjak, riparian area of the lower course of the Sava river), large agricultural areas (Pančevački Rit, Višnjička Kosa), typical park areas (Pionirski and Akademski parks), to ruderal habitats and maintained grasslands (Fig. 3). Besides this, a number of unpublished field records, as well as herbarium data from BEOU (Thiers 2014), were included in the analyses.

Collected data (18,315 records) were incorporated within the unique Information system of the Institute for Natural Protection of Serbia. This database included both native and alien taxa.

The plant species were classified either as native or as alien. Invasive species in the region of Belgrade were determined according to the preliminary national lists of alien neophytes for Serbia (Lazarević *et al.* 2012).

Nomenclature follows the Euro+Med database (http://ww2.bgbm.org/EuroPlusMed/query.asp), and the IOPI database for the families not yet covered by the previous source (http://plantnet.rbgsyd.nsw.gov.au/iopi/iopihome.htm).

## RESULTS AND DISCUSSIONS

A total of 2026 taxa was recorded within the Belgrade territory on the basis of previous floristic studies. However, as the presence of 162 taxa recorded by Pančić were not confirmed in later studies, the actual number of taxa is 1864. The highest proportion was confirmed Pančić taxa, whilst there were 537 records for new taxa not recorded previously. Also, 344 ornamental species were recorded in the study area (Table 1).

Considerable diversity of vascular flora nowadays is characteristic especially for the localities with relatively preserved or partly changed natural habitats (Fig. 3): Mt. Kosmaj (573 taxa - Gajić 1954b; Stanković 2010), Mt. Avala (594 taxa - Borisavljević *et al.* 1955; Obratov 1986), Košutnjak (539 taxa - Ilić *et al.* 1972), Ada Ciganlija (438 taxa - Radulović 1982), River Sava - lower course (352 taxa - Bartula 2001), Stepin Lug (129 taxa - Teofilović *et al.* 2008), Lipovička Šuma (119 taxa - Tomić 1972), Veliko

**Table 1.** A comparative review of vascular flora diversity in Belgrade area (historic and recent data).

| Flora of Belgrade surroundings | N° of taxa |
|---|---|
| Historical data (Pančić 1865-1892) | 1156 |
| Recent data (1950-2014) | 1864 |
| Confirmed taxa | 983 |
| New taxa | 537 |
| Ornamental taxa | 344 |
| Unconfirmed historical taxa | 162 |
| Total | 2026 |

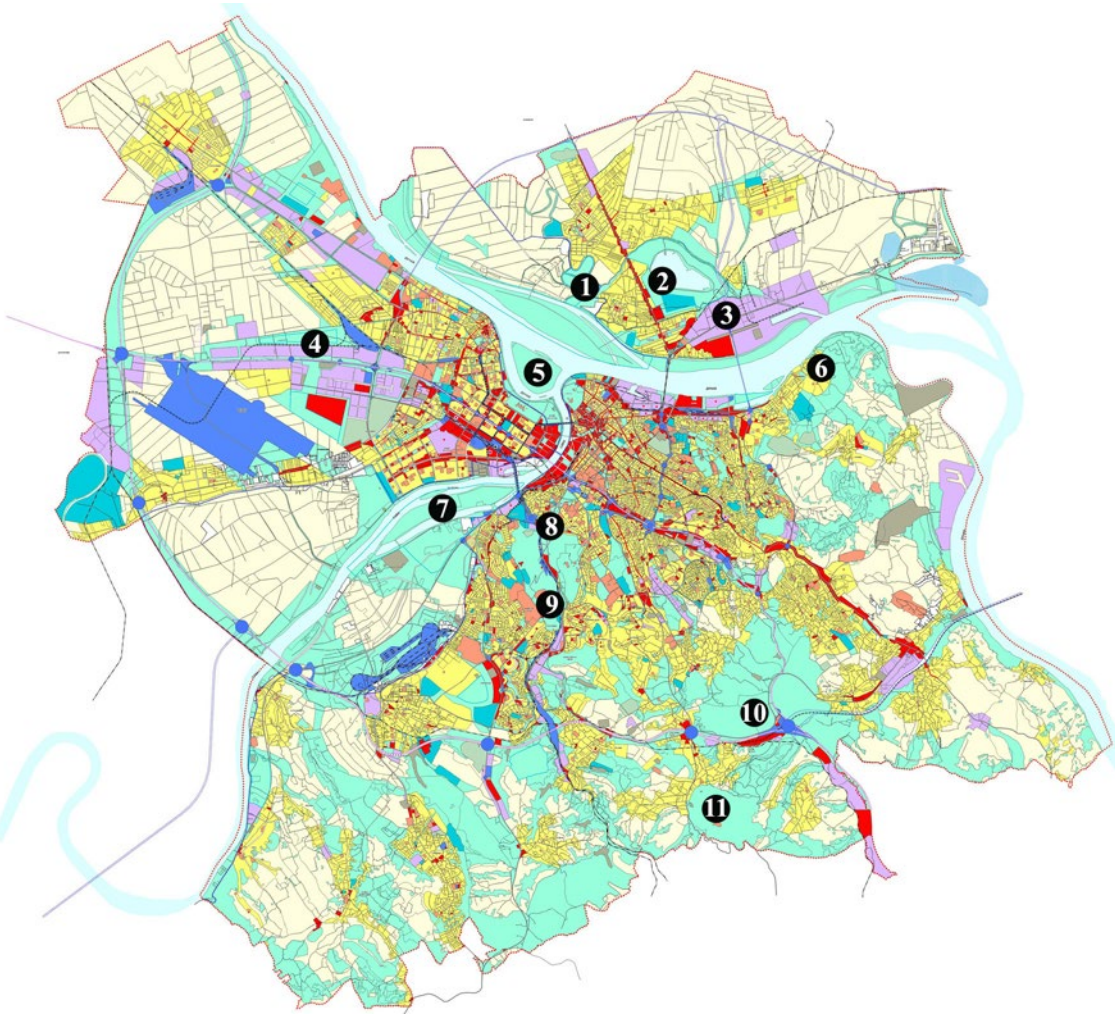


**Fig. 3.** Some recently investigated localities in Belgrade (1 - Pančevački Rit; 2 - Veliko Blato; 3 - Bara Reva; 4 - New Belgrade; 5 - Veliko Ratno Ostrvo; 6 - Višnjička Kosa; 7 - Ada Ciganlija; 8 - Topčider; 9 - Košutnjak; 10 - Stepin Lug; 11 – Mt. Avala)

Ratno Ostrvo (125 taxa - Petrović 1996), Bara Reva (84 taxa - Teofilović *et al.* 2008) and Veliko Blato (69 taxa - Janković 1953; Teofilović *et al.* 2008). Aside from this, high floristic diversity was noticed also at localities dominated by ruderal habitats: Višnjička Kosa (546 taxa - Bogojević 1968; Jakovljević *et al.* 2008), Pančevački Rit (369 taxa – Stanković – Kalezić 2006), Grocka (365 taxa - Jovanović & Bartula (1997), New Belgrade (182 taxa - Stjepanović-Veseličić & Čanak 1959; Mrdaković 1997) and Kumodraž (151 taxa - Obratov-Petković *et al.* 2000). According to Jovanović (1994), 671 taxa of vascular plants inhabit different types of ruderal habitats in Belgrade, while maintained grasslands host 309 taxa (Stavretović 2002).

Comparative study of urban Belgrade flora from Pančić's time and data from the second half of the 20th century till today showed that 162 taxa recorded by Pančić have not been confirmed by recent studies (Table 1). Particularly interesting and scientifically valuable are Pančić's observations on some species found at the time '...only in one place of the atar of Belgrade': *Himantoglossum hircinum* (L.) Spreng., *Orchis papilionacea* L. (=*Anacamptis papilionacea* (L.) R. M. Bateman, Pridgeon & M. W. Chase), *Ophrys scolopax* Cav. and *Iris pumila* L. (,... in Topčider'); *Iris reichenbachii* Heuff., *Crocus reticulatus* Steven ex Adam, *Crocus moesiacus* Ker Gawl. (=*Crocus flavus* Weston subsp. *flavus*), *Paeonia peregrina* Mill. ('in Košutnjak'); *Utricularia vulgaris* L., *Galatella cana* (Waldst. & Kit.) Nees, *Lythrum hyssopifolia* L. ('... on Makiš'); *Genista sagittalis* L. ('... between Banjica and Torlak'); *Lathyrus palustris* L., *Hippuris vulgaris* L., *Androsace major* (=*Androsace maxima* L.) (,... in Karaburma around the ponds), as well as *Seseli rigidum* Waldst. & Kit. and *Onosma visianii* Clementi ('... above Slanci'). These species were extinct long ago from the Belgrade area, hence, literature and herbarium data are the only records testifying to their former presence. For example, the hydrologic regime of these specific flood habitats was altered by building up the banks of the Sava and Danube Rivers, as well as the construction of numerous water wells, all of which caused the extinction of many autochtonous species not able to adapt to sudden and drastic changes of ecological conditions. This was particularly the case with the rare insectivorous hydrophytes such as *Aldrovanda vesiculosa* L. and *Utricularia vulgaris* (Jovanović 1996). Except for those, many other hydrophilous and hygrophilous species are now extinct from the Belgrade territory: *Ranunculus lingua* L., *Cladium mariscus* (L.) Pohl subsp. *mariscus, Hippuris vulgaris, Schoenoplectus mucronatus* (L.) Palla, *Groenlandia densa* (L.) Fourr. and others. Today, all the taxa just mentioned are threatened and protected for the territory of Serbia. According to Red data Book of Serbia 1 (Stevanović 1999), 10 species from these kinds of habitat are extinct from the territory of Belgrade, while *Asparagus pseudoscaber* Grecescu has the status of critically endangered and is present nowadays only in the wet meadows of Makiš. At the same time, some plants from these extremely fragile habitats are extinct from the whole territory of Serbia (*Pilularia globulifera* L., *Caldesia parnassifolia* (L.) Parl. and *Achillea ptarmica* L.). In addition, some other disturbed natural habitats (e.g. forests, steppes, forest-steppe ecotone habitats) on Belgrade territory, as well as the plants growing there till recently (e.g. *Eryngium planum* L., *Crepis pannonica* (Jacq.) K. Koch, *Epipactis atrorubens* subsp. *borbasii* Soó (=*Epipactis atrorubens* (Hoffm.) Besser)), share the same fate and are extinct on the territory of Serbia. A total of 227 taxa have the protection status of protected or strictly protected plants (SGRS 5/2010, 47/2011). Amongst them are endangered (EN) and vulnerable (VU) hydrophytes of Belgrade such as *Nymphaea alba* L., *Nuphar lutea* (L.) Sm., *Marsilea quadrifolia* L., *Stratiotes aloides* L., as well as species of the genus *Trapa*.

The number of taxa for which the presence was not confirmed after Pančić's time should not be taken for granted. These plants may not have been noticed after Pančić for various reasons, although their presence could be expected within the appropriate habitats (e.g. *Impatiens noli-tangere* L., *Sedum cepaea* L., *Draba muralis* L., *Gnaphalium sylvaticum* L., *Stachys officinalis* (L.) Trevis., *Lemna gibba* L., *Polygonum amphibium* L. f. *terrestre* (Willd.) S.F.Blake (=*Persicaria amphibia* (L.) Delarbre), *Loranthus europaeus* Jacq., *Paris quadrifolia* L., *Polygala vulgaris* L. subsp. *vulgaris, Rosa rubiginosa* L., etc.). Further, some taxa such as *Pisum sativum* L. subsp. *elatius* and *Pisum sativum* L. subsp. *sativum,* were not mentioned by the more recent scientists with justification, as these were considered as cultivated or ornamental taxa. Besides, some of the taxa have unresolved taxonomic status, and hence could not have been scientifically evaluated: *Rosa belgradensis* Pančić, *R. feurraci* Pančić, *R. transsilvanica* Pančić, *Chenopodium elibium* Pančić, *Potentilla collina* Pančić and others (Stojanović *et al.* 2010).

At this point, on the basis of preliminary results of comparative analyses we can determine with confidence that 50 or more plant species have become extinct from the Belgrade territory since Pančić's time. Whether this number should be higher or not, is to be confirmed by additional field surveys, detailed investigations of other relevant herbarium collections, as well as the critical taxonomic and chorological analyses on potentially extinct taxa.

On the other hand, some new alien species which could not be found in Pančić's period, appeared on the territory of Belgrade. Namely, due to intense urbanisation, many natural habitats have been converted to construction, industrial, agricultural, horticultural or infrastructural areas, enabling a range of alochtonous species and communities to establish themselves. This is particularly the case with the altered wet habitats along regulated and ruderalized banks of the Sava and Danube Rivers, inhabited by numerous invasive neophytes in the last 60 years: *Amorpha fruticosa* L., *Acer negundo* L., *Asclepias syriaca* L., *Symphyotrichum lanceolatum* (Willd.) G. L. Nesom, *Erigeron annuus* subsp.

*septentrionalis* (Fernald & Wiegand) Wagenitz, *Bidens frondosus* L., *Xanthium orientale* subsp. *italicum* (Moretti) Greuter, *Paspalum distichum* L., *Panicum capillare* L., *P. miliaceum* L., *Echinocystis lobata* (Michx) Torrey & A. Gray, *Reynoutria japonica* Houtt., *R. x bohemica* Chrtek & Chrtková, *Elodea canadensis* Michx. and others. According to the preliminary national lists of invasive neophytes (Lazarević *et al.* 2012), 33 invasive plant species were determined on the territory of Belgrade.

The fact that only 20 naturalised neophytes were recorded by Pančić (1892) testifies to the dynamics of composition changes of urban and suburban flora of Belgrade. Some of the invasive woody species nowadays widely-distributed were not present at Pančić's time, such as *Robinia pseudoacacia* L., *Ailanthus altissima* (Mill.) Swingle, *Gleditsia triacanthos* L., *Fraxinus pennsylvanica* Marshall, *Acer saccharinum* L., *Broussonetia papyrifera* (L.) Vent., *Buddleja davidii* Franch., as well as many invasive herbaceous neophytes (e.g. *Ambrosia artemisiifolia* L., *Amaranthus albus* L., *A. blitoides* S. Watson, *A. caudatus* L., *A. cruentus* L., *A. deflexus* L., *A. hybridus* L., *Datura stramonium* L., *Eleusine indica* (L.) Gaertn., *Helianthus tuberosus* L., *Oenothera biennis* L., *Iva xanthiifolia* Nutt., *Veronica persica* Poir., *Phytolacca americana* L., *Solidago gigantea* Aiton, *Matricaria discoidea* DC., *Lepidium virginicum* L. etc.).

Also, some interesting observations of Pančić on places which, as he said, "... should be searched for rarities of our flora to be found" testify in favour of the dynamics of floristic composition changes. After reviewing these localities, it can be seen that Pančić was also investigating the typical ruderal (weed) habitats, in which he found some of the rare plants at the time then being widely distributed in specific ruderal habitat types, such as *Chenopodium murale* L. (=*Chenopodiastrum murale* (L.) S. Fuentes & al.), *Chenopodium rubrum* L. (=*Oxybasis rubra* (L.) S. Fuentes & al.) and *Euphorbia peplus* L. The similar example, ilustrating the dynamics of floristic changes, can be found in comparative studies of specific parts of the city, such as the forest-steppe area of Višnjička Kosa. According to Jakovljević *et al.* (2008), apart from a significant secondary increase of floristic diversity with ruderal and introduced species, the Višnjička Kosa area has suffered a serious loss of the most important elements of the natural flora. The most conspicuous floristic changes pertain to steppe species. Many of them have disappeared: *Anemone sylvestris* L., *Astragalus onobrychis* L., *Crepis pannonica* (Jacq.) K. Koch, *Prunus tenella* Batsch., *Sternbergia colchiciflora* Waldst. & Kit., *Vinca herbacea* Waldst. & Kit., etc.

Nevertheless, the highest number of records confirm Pančić's previously published results (983 taxa). Thereby, the fact to be kept in mind is that Pančić noticed a total of 1156 taxa in an area of 320 km$^2$ (which was the total territory of Belgrade at the end of 19th century), while 1864 taxa are today present within a territory 10 times bigger cc. 3223 km$^2$, presenting at the time urban and suburban areas of Belgrade.

## CONCLUDING REMARKS

Pančić's *Flora of Belgrade surroundings* undoubtedly presents a capital botanical floristic work even today, giving an extraordinary basis and starting point for comparative studies of the dynamics and degree of endangerment and changes in flora of vascular plants within the last 150 years. Preparation of the contemporary monographic work entitled *Flora of Belgrade surroundings - 150 years after Pančić* has become a necessity and a debt to Pančić and his monograph from the distant 1865.

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**REZIME**

# Flora okoline Beograda (Srbija) 150 godina nakon Pančićeve monografije - uporedni pregled

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Detaljni podaci o flori Beograda i okoline datiraju iz druge polovine 19. veka, a prikupljeni su od strane Josifa Pančića. Nakon dužeg zastoja, ekspanzija florističko-vegetacijskih istraživanja na teritoriji Beograda vezuje se za period od 1950. godine do danas. U ovom radu su prikazani preliminarni rezultati analize svih raspoloživih florističkih podataka za ovo područje odnosno uporedni pregled diverziteta vaskularne flore, zasnovan na recentnim i istorijskim podacima.

**Ključne reči:** Josif Pančić, urbana flora, iščezle vrste, ugrožene vrste, strani taksoni