

# HISTORICAL OVERVIEW OF THE DELIBLATO SANDS AFFORESTATION

## POVIJESNI PREGLED POŠUMLJAVANJA DELIBLATSKE PJEŠČARE

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### SUMMARY

Deliblato Sands is one of the largest sandy areas in Europe. Given that developing of vegetation on the sand is a slow process, followed by human activities that devastate the plant cover (grazing, deforestation), the free-moving sand on Deliblato Sands existed until the 18th century. Unbound sand hindered the development of agriculture in the entire southern Banat region, so it was necessary to start a more intensive process of restraining sand masses. The afforestation of this area began in 1818 and is still ongoing. In the process of afforestation, nine periods can be recognized that differ in relation to afforestation/reforestation techniques, the choice of species or the organizational structure of the forestry units (and countries) of the area of Deliblato Sands belonged throughout history. The most significant results in the binding of free moving sand were achieved by the application of black locust (*Robinia pseudoacacia* L.) seedlings with juniper scrub (*Juniperus communis* L.) laid down on open sandy areas and sowing different species of grass between the rows of seedlings. This technique has been applied since the IV afforestation period (1878-1898). The largest areas were afforested in the V period (1898-1918), when parts of Deliblato Sands were formally protected for the first time in history as areas of importance for the preservation of biodiversity. The species most used in afforestation are black locust (*Robinia pseudoacacia* L.), Scots pine and black pine (*Pinus sylvestris* L., *Pinus nigra* J. F. Arnold), poplars (*Populus* sp.), and some shrubby (e.g. *Juniperus virginiana* L.) and herbaceous species (e. g. *Ammophilla arenaria* (L.) Link, *Festuca vaginata* Willd., *Leymus arenarius* (L.) Hochst., *Carex arenaria* L.). Today, *Robinia pseudoacacia* L. is most common tree species on Deliblato Sands and it occupies almost a third of the entire area.

**KEY WORDS:** stabilization of sand, vegetation on sand, continental sand dunes, black locust

### INTRODUCTION UVOD

Sandy landscapes are mostly found on sea and ocean shores, but such habitats can also exist in continental areas. In general, they arise due to the accumulation of sedimentary alluvial material in the flood zones of large rivers. In Europe, continental sandy areas are linked to the last major

relief modifications that took place in the glacial periods of the Quaternary Era (Bohn, 2000). Once formed, the continental unbound sands were moved and carried by winds across great distances, until vegetation partially covered these expanses in the early postglacial period. During the postglacial period, the sandy areas of Europe were partially covered by forest (Walter and Straka, 1970). However, due to deforestation (Hejcman et al., 2013), secondary grassland

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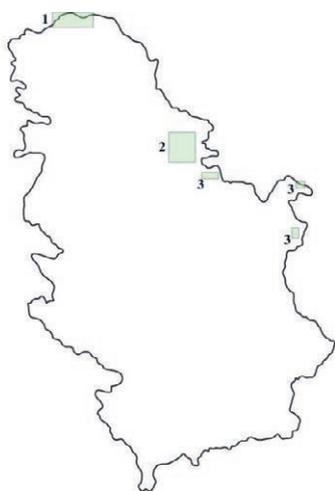
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communities started to form on those surfaces (Leuschner and Ellenberg, 2017a). The vegetation of the entire Europe, and therefore of the continental sand dunes, has been under great anthropogenic influence since the Neolithic Era. Devastation in the sandy regions led to the gradual degradation of autochthonous vegetation and open sands appeared. This process intensified in the Middle Ages, and the damage was further exacerbated by widespread deforestation and livestock grazing (especially by sheep and goats). Through these practices, throughout history, humans have facilitated re-expansion of sandy material and movement of dunes (Ellenberg, 2009).

Sandy habitats are populated by sparse vegetation with relatively rapid successive changes in plant cover (Mucina et al., 2016). Thus, throughout the history of sandy vegetation, periods of progression and regression frequently alternated. As this type of habitat is often threatened by the development of agriculture and modern society in general, it has undergone significant changes in the last few centuries (Edwards et al., 2007; Butorac and Panjković, 2013; Leuschner and Ellenberg, 2017b).

Inland sand dunes in Serbia are distributed along the Danube River. According to the geographical location, they can be divided into three groups—the Subotica-Horgoš Sands with the Selevenj wastelands, the Deliblato Sands and a series of sandy habitats along the right bank of the Danube from Ram to Kladovo, and downstream to the mouth of Timok River (Butorac et al., 2002; Figure 1). Most authors concur that the inland sand dunes in Serbia were formed at the end of the Pleistocene, i.e., about 11,000 years ago. Regardless of whether the sand was brought by river



**Figure 1.** Sandy habitats in Serbia: 1-Subotica-Horgoš Sands and Selevenjske pustare; 2-Deliblato Sands; 3-Sandy habitats in the area from Ram to Kladovo

**Slika 1.** Pješčana staništa u Srbiji: 1-Subotičko-Horgoška pješčara i Selevenjske pustare; 2-Deliblatska pješčara; 3-Pješčarska staništa na području od Rama do Kladova

flows, the water mass of the Pannonian Sea or the wind, the prevailing scientific stance is that the southeasterly wind Košava has played a key role in the geomorphology and relief of sands in Serbia and the Deliblato Sands in particular (Wesely, 1853; Cholnoky, 1910; Bulla, 1938; Milojević et al., 1949; Marković-Marjanović, 1950; Bukurov, 1953, 1955; Rakić et al., 1980/81; Menković, 2013).

### Research area characteristics – *Karakteristike područja istraživanja*

The Deliblato Sands is located in the central part of southern Banat, extending in the southeast–northwest direction, whereby the broader area covered by sand almost 600 km<sup>2</sup> (Menković, 2013). This is the largest sand-covered region in Serbia, as well as in Europe. It is of ellipsoidal shape and extends from the Tamiš valley to the Danube River. The main feature of the Deliblato Sands relief are the dunes, which extend in the southeast–northwest direction and are up to 1 km long, with their height above sea level ranging from 80 m on the Danube riverbanks, to 197 m in the extreme northwest. As the area is devoid of any springs and surface watercourses, water availability in the topsoil is low due to the high sand permeability, which allows precipitation to sink to the water-bearing layers. Groundwater is located at depth of 2–10 m in the southeastern and 100–150 m in the northwestern parts of Deliblato Sands, respectively.

A 30–50 m thick sand layer covers the previously blown loess plain (Menković, 2013). The soil of Deliblato Sands is aeolian alluvium, mostly comprising agenic or young genetic soil (Bura, 1969). The primary substrate is sand, covered by shallower or deeper horizons with 0–7% humus content (Pavlović et al., 2017). Sand composition is dominated by calcium carbonate, as indicated by the presence of lime tiles and concretions. The soil has basic (pH = 7.30–8.50) character, and the humus and moisture content in the substrate determine the types of vegetation in different parts of the Deliblato Sands.

In the Deliblato Sands area, the influences of the moderate-continental climate of the Pannonian Plain, the climate of the Southern Carpathians, and the sub-Mediterranean climate via the South and Great Morava valleys are intertwined, leading to the average annual temperature of 12.5 °C (RHMZ, Meteorological Station Banatski Karlovac, 2018). The amplitude of annual temperature variations is higher than in the surrounding area, as the sandy substrate heats up and cools down quickly. Consequently, in summer, the temperature can reach 60 °C on the sunny dunes with southern aspect, whereas it does not exceed 45 °C on those north facing slopes (Butorac and Panjković, 2013). The air temperature is the lowest in January (−4.4 °C), while the average temperature in July and August is around 24 °C,



**Figure 2.** “Flying sand” was a feature of most sandy areas in Serbia – Deliblato Sands, 1945 (Matvejev, 1973)

**Slika 2.** „Leteći pijesak” bio je obilježje većine pješčanih područja u Srbiji – Deliblatska peščara, 1945. (Matvejev, 1973)



**Figure 3.** Current appearance of the Deliblato Sands – a mosaic of different vegetation types (Čuk, 2019).

**Slika 3.** Sadašnji izgled Deliblatske pješčare – mozaik stepске, grmolike i šumske vegetacije (Čuk, 2019)

declining to 16–18 °C in the growing season. The average annual precipitation in the Deliblato Sands area is 664.15 mm. Its climate is primarily governed by the southeasterly wind Košava, which is cold and dry during winter, early spring and late autumn. According to Kadović et al. (2004) and Ali Bohajar (2015), in this region, the average temperature increases by 0.50–0.75 °C every 100 years, while total annual precipitation exhibits a slight (5%) positive trend. Changes in measured parameters clearly indicate the present trend of climate change, and global warming which can directly or indirectly affects biodiversity.

**Table 1.** Recent plantations on Deliblato Sands

**Tablica 1.** Površine recentnih plantaža nasada na Deliblatskoj pješčari

Type of forest stand	Area (ha)
Poplars	31.29
<i>Fraxinus americana</i> L.	19.60
<i>Robinia pseudoacacia</i> L.	10,821.29
<i>Pinus sylvestris</i> L.	1,150.76
<i>Pinus nigra</i> J. F. Arnold	1,441.54
<i>Pinus sylvestris</i> L. and <i>Pinus nigra</i> J. F. Arnold	2,008.71
<i>Juglans nigra</i> L.	32.99
<i>Populus carolinensis</i> Moench	1.95
soft deciduous trees	25.82
other conifers	325.38
other deciduous trees	25.12
Poplar clone I – 214	23.64
Poplar clone “Robusta”	2.38
hard deciduous trees	851.31
<i>Ulmus</i> sp.	4.51
<i>Fraxinus ornus</i> L.	1.94
<i>Tilia tomentosa</i> Moench	37.45
<i>Quercus robur</i> L.	0.68
<i>Fraxinus angustifolia</i> Vahl.	5.72
<i>Juniperus virginiana</i> L.	0.59
TOTAL	16,812.67

### Deliblato Sands vegetation formation – Formiranje vegetacije Deliblatske pješčare

In all sandy areas in Serbia, successional stages of vegetation took a long time to develop. The process commenced with the germination of seeds blown by the wind from both surrounding and more remote areas. These pioneering stages of vegetation mainly comprised therophytic plant species, with low coverage and diversity. This initial vegetation is of key importance for the binding of sand masses and the development of soil on sand because it creates favorable conditions for the growth of perennial plants that form the next stages of vegetation on sand. The appearance of steppes, forest-steppes and forests on sands was accompanied by the expansion of the daily needs of the surrounding population. Due to the excessive exploitation of plant cover, the sand was released again, and was blown into the air and moved by wind. Efforts to mitigate these adverse outcomes were mostly unsuccessful. Under the threat of sandstorms, “flying sand” buried the crops and dried up the orchards and vineyards, the local population felt defeated and eventually moved away (Pančić, 1863). Unbound “flying sand” lasted until the middle of the 20th century (Figure 2).

Today, on all natural sand accumulations in Serbia—almost no free sand remains (Figure 3). The Deliblato Sands are covered by set of phytocenoses developed in different micro-ecosystems—from sandy, steppe, pasture, shrub, forest and meadow, to numerous anthropogenic stands—that form a mosaic. Sand vegetation is present only in fragments, mainly in the central part of the Reserve. The largest areas under steppe vegetation are located in the north-western part and in narrow belts or fragments within the central and peripheral parts, together with the remnants of oak and linden forests (*Quercus-Tilietum tomentosae* Stjepanović-Veseličić 1953.) or individual trees of these species (*Tilia tomentosa* Moench, *Quercus robur* L. or *Quercus pubescens*



**Figure 4.** Share of different habitat types and forest plantations on Deliblato Sands today

**Slika 4.** Udio različitih habitata i šumskih nasada na Deliblatskoj pješčari danas

Wild.). Hygrophilous forests and meadows are thriving on the “low sand” in the eastern part of Deliblato Sands. Forest plantations with foreign species are dominant in the Deliblato Sands landscape today and are primarily formed by *Robinia pseudoacacia* L. and pine (*Pinus sylvestris* L. and *Pinus nigra* J. F. Arnold) cultures (Table 1, Figure 4.).

### The history of the Deliblato Sands afforestation – *Povijest pošumljavanja Deliblatske pješčare*

The sand moved and formed into dunes until the end of 18<sup>th</sup> century. In that time, vegetation that used to cover most of the current area was destroyed (Wessely, 1873). In the end of 18<sup>th</sup> century land reclamation activities and



**Figure 5.** The map of Deliblato Sands created as a part of the first secret military survey carried out in 1763–1787 (<http://mapire.eu/hu/map/firstsurvey>).

**Slika 5.** Karta Deliblatske pješčare nastala u prvom tajnom vojnom izmjeru 1763-1787. (<http://mapire.eu/hu/map/firstsurvey>)



**Figure 6.** The map of Deliblato Sands created as a part of the second secret military survey carried out in 1806–1869 (Timár et al., 2006, <http://mapire.eu/hu/map/secondsurvey>).

**Slika 6.** Karta Deliblatske pješčare nastala u drugom tajnom vojnom izmjeru 1806-1869 (Timár et al., 2006, <http://mapire.eu/hu/map/secondsurvey>)

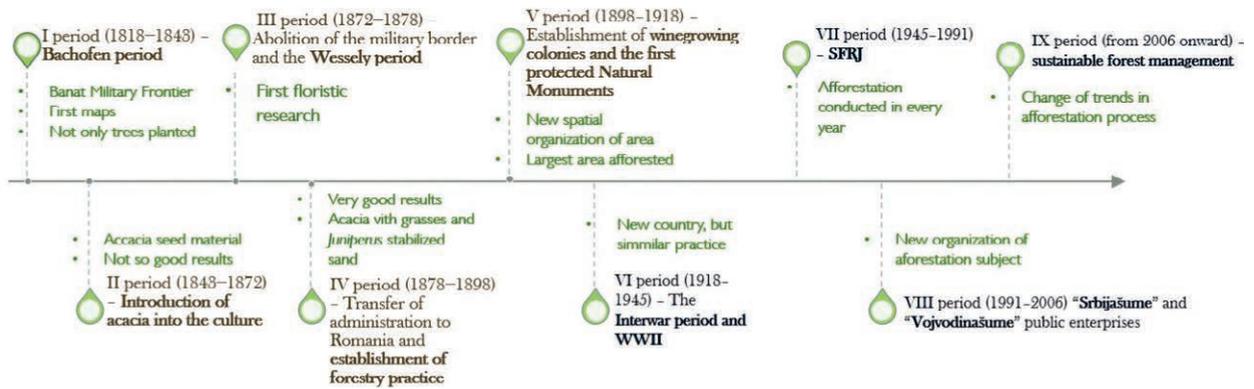


Figure 7. The timeline of the 204 years of afforestation on Deliblato Sands

Slika 7. Razdoblje od 204 godine pošumljavanja Deliblatske pješčare

afforestation started in order to stop process of moving sand.

In 1764, a military border (Banat Military Frontier) was established in this area, with the aim of defending the Habsburg Monarchy against the Turks. The first military maps of the area were made in 1787, and the Deliblato sands was shown as an area of bare sand, without any vegetation. (Figure 5).

However, according to Wessely (1873) and Ajtay (1902), this map was inaccurate, as the area also comprised larger forest complexes, as indicated by arrow fragments and forest game remains found around its perimeter (Ajtay, 1912). This view is supported by the presence of calcified forms which resemble roots in shape (calcium carbonate was deposited in the cavities created by the rotting of oak roots). Because of deforestation and irrational use of pastures, a strong desolation occurred on the Deliblato Sands territory in the 18th century. In 1777 and 1778, when the Turks invaded southern Banat, parts of the Deliblato Sands forests were burned and cut down, the settlements were destroyed, and the local population fled. As a result, additional sandy areas were opened and were spread by Košava to the surrounding agricultural areas (Bura, 1969; Milenković et al., 2018). A strong hurricane that raged through southern Banat, Deliblato Sands and the surrounding area in 1816 further exacerbated sand spreading. According to some reports, the sand from Deliblato Sands was carried by the wind to Vienna and Pest.

A few years prior (1810), the Court Military Council ordered a survey of the Deliblato Sands with the view of its afforestation. In this period, a second secret military survey was carried out, which resulted in a more detailed map of the area (Figure 6).

Afforestation process of the area began in 1818 and was executed in several stages that differed in the methodology adopted, the selection of species for sand stabilization, and the management strategy (Figure 7, Table 2).

- The first afforestation period (1818–1843) – Bachofen period:

Forestry expert Franz Bachofen was entrusted with the task of calming the “flying sand” and creating a plan for binding sand based on the experiences in northern Germany, France and Hungary (Stjepanović-Veseličić, 1953). Bachofen established that 16,800 ha of the total 40,660 ha area Deliblato Sands was covered by unbound sand (Bura, 1969). Bachofen was appointed as the Director of the Military Border Forests with headquarters in Bela Crkva, and from 1818, based on his proposal, the afforestation process began (Bura, 1969; Sekulić and Šljivovački, 1980). Bachofen carried out the afforestation process successfully until 1843. During this time, all grazing and logging was prohibited, while around 5,000 ha was afforested with *Pinus sylvestris* L., *Betula verrucosa* Ehrh., *Populus alba* L., *Populus nigra* L. and psammophilous grasses—*Ammophila arenaria* (L.) Link, *Leymus arenarius* (L.) Hochst., and *Carex arenaria* L. (Stjepanović-Veseličić, 1953; Table 2.). However, many of these species were not an adequate choice. For example, *Ammophila arenaria* (L.) Link is a characteristic species of the coastal sands of Europe. Thus, when planted on continental sands, especially calcareous sands, it tends to quickly disappear (Ellenberg, 2009). Afforestation with poplars was carried out while covering the sand with straw, corn and reeds.

- The second afforestation period (1843–1872) – Introduction of black locust (*Robinia pseudoacacia* L.) into the culture:

In this period, the Court Military Council entrusts the afforestation process to Kristen, the manager of the newly established Business Administration for Forest Activities with headquarters in Deliblato. During this period, forest operations were intermittent and often unsuccessful. The most significant commitment was the acquisition of black locust (*Robinia pseudoacacia* L.) seeds in 1853, which led to the

**Table 2.** List of most common planted species in all afforestation periods on Deliblato Sands (1818–2022)**Tablica 2.** Popis zasadenih vrsta u svim razdobljima pošumljavanja Deliblatske pješčare (1818–2022)

Afforestation period	Planted tree and shrub species	Planted herbs	area (ha)
I (1818–1843.)	<i>Populus alba</i> L. <i>Populus nigra</i> L. <i>Populus tremula</i> L. <i>Populus pyramidalis</i> = <i>Populus nigra</i> L. subsp. <i>nigra</i> <i>Populus x canadensis</i> Moench <i>Populus alba</i> var. <i>bachofenii</i> (Wierzb. ex Rochel) Wesm. <i>Cotinus coggygria</i> Scop. <i>Quercus</i> sp. <i>Betula verrucosa</i> Ehrh. = <i>Betula pendula</i> Roth var. <i>pendula</i> <i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L.	<i>Ammophila arenaria</i> (L.) Link <i>Leymus arenarius</i> (L.) Hochst. <i>Carex arenaria</i> L.	5,000
II (1843–1872.)	<i>Robinia pseudoacacia</i> L. <i>Populus</i> sp. <i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L. <i>Quercus robur</i> L.	<i>Festuca vaginata</i> Willd. <i>Echinops banaticus</i> Schrad.	4,648
III (1872–1878.)	<i>Populus alba</i> L. <i>Populus nigra</i> L. <i>Populus tremula</i> L. <i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L.		470
IV (1878–1898.)	<i>Robinia pseudoacacia</i> L. <i>Populus</i> sp. <i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L. <i>Quercus robur</i> L. <i>Ailanthus altissima</i> (Mill.) Swingle <i>Morus alba</i> L. <i>Juglans nigra</i> L.	Mixd grasses seed material	3,505
V (1898–1918.)	<i>Fraxinus americana</i> L. <i>Juglans nigra</i> L. <i>Prunus padus</i> L. <i>Quercus robur</i> L. <i>Robinia pseudoacacia</i> L.		6,396
VI (1918–1945.)	<i>Robinia pseudoacacia</i> L. <i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L.		2,400
VII (1945–1991.)	<i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L. <i>Juglans nigra</i> L. <i>Robinia pseudoacacia</i> L. <i>Populus carolinensis</i> Moench. <i>Populus</i> sp. <i>Tilia tomentosa</i> Moench <i>Juniperus virginiana</i> L.		4,180
VIII (1991–2006.)	<i>Juniperus virginiana</i> L. <i>Robinia pseudoacacia</i> L. <i>Populus carolinensis</i> Moench. <i>Populus</i> sp.		728
IX (od 2006.)	<i>Pinus nigra</i> J. F. Arnold <i>Pinus sylvestris</i> L. <i>Juglans nigra</i> L. <i>Robinia pseudoacacia</i> L.		41

introduction of this species into the culture, but the strategy failed in binding loose sand due to afforestation in lines (Bura, 1969). As the local population did not always comply with the ban on forest cutting and grazing, considerable damage was caused to the landscape. During this phase, which lasted until the abolition of the Banat military border in 1872, 4,648 ha area was covered by new forest (Milenković et al., 2018).

- The third afforestation period (1872–1878) – Abolition of the military border and the Wessely period:

In 1872, the Deliblato Sands falls under the administration of the Ministry of Finance (Bura, 1969). The Military Ministry from Vienna sends Joseph Wessely to conduct detailed studies of the area and improve the “flying sand” stabilization process. In 1873, Wessely returns to Vienna and publishes his field research on “European flying sand and its cultivation” (Wessely, 1873), which became the basis for the subsequent Deliblato Sands afforestation. During this period, 470 ha were covered with poplars (*Populus alba* L., *Populus nigra* L., *Populus tremula* L.) and pines (*Pinus nigra* J. F. Arnold, *Pinus sylvestris* L.) (Milenković et al., 2018; Table 2.).

- The fourth afforestation period (1878–1898) – Transfer of administration to Romania and establishment of forestry practice:

In 1878, all afforestation operations were placed under the jurisdiction of the Forestry Administration in Orșova with the directorate in Lugoj (a small town in the Austro-Hungarian Empire, until 1918 when it became part of Romania). This was the first time in the history of Deliblato Sands that only foresters were engaged in sand binding efforts, which led to the greatest results. A new method of binding sand was established and applied in 1883, whereby juniper scrub (*Juniperus communis* L.) was laid down on open sandy areas, black locust (*Robinia pseudoacacia* L.) was planted and different species of grass were sown. This sand binding technique was the most successful and largely eradicated the “flying sand”. *Robinia pseudoacacia* L., *Populus* sp., *Pinus* sp., were mostly planted, along with *Quercus* sp., *Morus* sp., *Juglans nigra* L. (Bura, 1969; Table 2.), which covered 3,505 ha (Milenković et al., 2018). At the end of this afforestation phase, some parts of Deliblato Sands were designated for pastures.

- The fifth afforestation period (1898–1918) – Establishment of winegrowing colonies and the first protected Natural Monuments:

From 1898 onward, all work on Deliblato Sands is conducted by the Ministry of Agriculture – Department for Colonization. Due to the appearance of the grapevine pest

phylloxera (*Dactulosphaira vitifoliae* Fitch), which ravaged the vineyards on Vršački Breg, viticulture production was transferred to Deliblato Sands (as phylloxera cannot survive on sandy soil), whereby vineyards were formed on its peripheral parts (Palfi, Emanuelovac, Vekerle, Šušara and Mramorački vineyards). As vine cultivation on sandy soil requires extremely high effort with considerably reduced yield, most of these colonies were abandoned after a couple of decades. In this period, the state-owned 25,054 ha of land was set aside, and was given its current name “Deliblato Sands.” By 1907, most of the fields were stabilized and forestry activities were intensified, resulting in Deliblato Sands becoming highly profitable and the most organized state-owned enterprise in Hungary at the time.

In this phase, forest management plans were prepared for the Deliblato Sands. In the 1908–1912 period, the entire property was encircled by a border trench and pillars and was divided into 606 × 948 m sections (57 ha surface area), surrounded by fire protection pits extending in the southeast–northwest direction (denoted as letters A–S) and in the southwest–northeast direction (labelled as numbers 1–34). As this type of terrain organization facilitates management, it has been maintained to this day. In first 100 years of afforestation (1818–1918), 20,019 ha were cultivated, 12,189 ha of these surfaces were under forest, of which 7,040 ha covered by black locust, 4,869 ha by poplars and hardwood species, and 280 ha by pines (Milenković et al., 2018). Although black locust was most prevalent, it was often planted in inadequate habitat, which led to the emergence of lower-quality forest. In 1912, five sections of forest management

were set aside as Natural Monuments—the first protected areas within the Deliblato Sands. Throughout this period, the range of ecosystem services expanded considerably, including an increase in grazing areas, greater use of wild herbaceous species, introduction of bee pasture, and establishment of wells, shelters, observatories and a metrological station.

- The sixth afforestation period (1918–1945) – The Interwar period and WWII:

In this historically very turbulent period, the creation of Kingdom of the Serbs, Croats, and Slovenes in 1918, and later the Kingdom of Yugoslavia, marked a new forestry era. After the First World War, the Forestry Administration was established, which continued the tradition of afforestation, although the activities were restricted to felling existing forests. By the Second World War, around 2,400 ha were afforested, mostly using black locust (*Robinia pseudoacacia* L.), and pines (*Pinus nigra* J. F. Arnold and *Pinus sylvestris* L.) (Milenković et al., 2018; Figure 8; Table 2.).

- The seventh afforestation period (1945–1991) – period after the WWII:

During and immediately after the Second World War, Deliblato Sands were once again devastated by excessive exploitation, resulting in the re-emergence of free sands. In the Yugoslav period, focus was given to the state modernization. Forest exploitation for timber production was very intensive, in order to provide timber for construction sites, factories and export. In this period, in Deliblato Sands fo-



**Figure 8.** Black pine planting in Deliblato Sands after WWI (Public enterprise “Vojvodinašume” archives)  
**Slika 8.** Sadnja crnog bora poslije I Svjetskog rata na Deliblatskoj peščari (arhiv javnog poduzeća „Vojvodinašume”)

rest areas of *Pinus nigra* J. F. Arnold and *Pinus sylvestris* L. were reforested and expanded (Letić and Malešević, 2005; Milenković et al., 2017; Table 2.). By 1987, the area under pine trees had increased to 5,916 ha, which aggravated the risk of potential fires. In the 1948–2017 period, 267 forest fires were recorded in this area, destroying 11,943 ha of forest (Milenković et al., 2018). The largest fires were recorded in 1972, 1990, 1996 and 2007 (Milenković et al., 2017).

After the WWII, federal and republican decrees on the organization of forestry were passed, and nine large forest holdings were created in Serbia that managed the public forests. Since 1948, the previous practice of forest use has been changed and exploitation has been separated from forest cultivation. Since 1950, a new Law on Forests was implemented, according to which the management of forests was transferred to regional holdings. In 1951, the forestry of Vojvodina was placed under the jurisdiction of the Provincial Government. Forest Management in Bela Crkva with its three forest administrations - Banatski Karlovac, Deliblato and Bela Crkva - was given the responsibility for afforestation, management, and later use of forests within Deliblato Sands. The Planning Elaborate issued in 1952 further mandated annual afforestation and reforestation on 200 ha, for which *Pinus nigra* J. F. Arnold and *Pinus sylvestris* L., *Juglans nigra* L., *Robinia pseudoacacia* L., *Populus carolinensis* Moench., *Tilia tomentosa* Moench and *Juniperus virginiana* L. were predominantly used. In this period, 4,180 ha is afforested.

In this period, a more intensive poplar production began in Serbia. Intensive poplar and willow plantations were mostly located on sites of natural willow and poplar forests, as well as areas covered by other forest tree types.

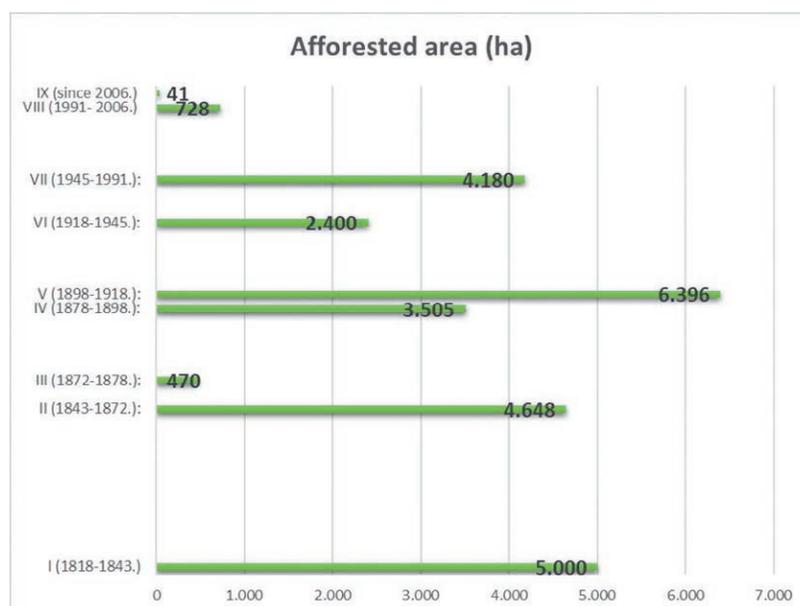
- The eighth afforestation period (1991–2006) – The period marked by “Srbijašume” and “Vojvodinašume” public enterprises:

In 1991, with the passing of the amendment of the Law on Public Enterprises and the Law on Forests, forestry operations in the Republic of Serbia were centralised and taken over by the Public Enterprise “Srbijašume”. Public forests and areas were placed under state ownership, and 27 forest units were established to facilitate their management. Under this new framework, the Deliblato Sands was located within the “Banat” Forestry Holding in Pančevo.

In 2002, in accordance with the Decision of the Provincial Government of Autonomous Province of Vojvodina (Official Gazette of APV no. 7 of 20/05/2002), all forest areas at the AP Vojvodina territory were placed under the jurisdiction of a newly founded public company “Vojvodinašume” with headquarters in Petrovaradin. Forestry Holding “Banat” in Pančevo is still one of the three organizational units of this company. During this period, about 728 ha were reforested (Figure 9.) and scientific research on Deliblato Sands was intensified, with the aim of elucidating its biodiversity, as well as addressing the problems faced by forestry (seedling withering, parasite infestation, raising and maintaining forests on sands, etc.).

- The ninth afforestation period (from 2006 onward) – Period of sustainable forest management:

In 2006, Public enterprise “Vojvodinašume” started the process of certification of forests under its management, which implies the application of clearly defined international standards in the implementation of sustainable forest manage-



**Figure 9.** Afforested areas in 204 years on Deliblato Sands

**Slika 9.** Pošumljene površine Deliblatske pješčare u posljednje 204 godine

ment, i.e., forest management in an economically profitable, ecologically acceptable and socially equitable manner, in accordance with the FSC (Forest Stewardship Council) program. As part of this practice, “Vojvodinašume” is obliged to replace stands of non-native species with autochthonous ones, which represents a significant step forward in the planning and management of forest habitats, especially within protected areas. This strategy, in principle, contributes to the promotion of the richness and diversity of flora, but also to the control of invasive species associated with non-native species. The conversion of non-native species cultures within the Deliblato Sands just started. So far, only degraded plantations of pines, black locust and black walnut are improved on 41 ha. Species replacement in non-native plantations is planned on over 1,000 ha for the period until 2029. (Public enterprise “Vojvodinašume”, 2020). Conversion refers to stands of *Pinus nigra* J. F. Arnold, *Pinus sylvestris* L., *Robinia pseudoacacia* L. and *Populus* sp. as well as mixed stands of hard or soft hardwoods. In the ninth period, the smallest area was afforested (Figure 9).

### Concluding remarks – Zaključna razmatranja

After 204 years of forestry practice, Deliblato Sands is currently an overgrown and stabilized sandy area, from which free sand has been almost eliminated. Its landscape is dominated by forest habitats, followed by shrubby and grassy phytocoenoses. Over the years, *Robinia pseudoacacia* L.—planted with the intention of stabilizing the sand dunes—has spread spontaneously along with the autochthonous scrub vegetation. Today, *Robinia pseudoacacia* L. forests represent the largest forest units in this area. On the one hand, the intensive afforestation practice has mitigated the issue of spreading sand masses. On the other hand, it has threatened the survival of sandy and other non-forest habitats, and thus the specific biodiversity. Maintaining the balance between the need to control and exploit nature and the preservation of endangered habitats is certainly the most important task for the experts in the field of forestry and nature protection. The change in forestry strategy aimed at the replacement of non-native forests is a significant novelty of the current practice and will undoubtedly contribute to the preservation of the natural ecosystems of the area.

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## SAŽETAK

Deliblatska peščara jedna je od najvećih peščara u Europi. S obzirom da je obrastanje pijeska spor i dugotrajan proces, praćen ljudskim aktivnostima koje devastiraju biljni pokrov (ispaša, sječa šuma), površine ogoljenog pijeska na Pješčari zadržane su sve do 18. stoljeća. Rastresiti pijesak kočio je razvoj poljoprivrede u regiji cijelog južnog Banata, te je trebalo krenuti u intenzivniji proces obuzdavanja pješčane mase. Pošumljavanje ovog područja počelo je 1818. godine i još uvijek traje. U procesu pošumljavanja može se prepoznati devet razdoblja koja se razlikuju u odnosu na tehnike pošumljavanja, izbor vrste te organizacijski ustroj šumarskih jedinica kojima je područje Pješčare povijesno pripadalo. Najznačajniji rezultati postignuti su u vezivanju rastresitog pijeska korištenjem sadnica bagrema (*Robinia pseudoacacia* L.) u kombinaciji s grmovima borovice (*Juniperus communis* L.) položenih među redove sadnica i uz sisanje različitih vrsta trava. Ova tehnika primjenjuje se od IV. razdoblja pošumljavanja (1878-1898). Najveća područja pošumljena su tijekom V. razdoblja pošumljavanja (1898.-1918.), kada su dijelovi Pješčare prvi put u povijesti formalno zaštićeni kao područja značajna za očuvanje biološke raznolikosti. Vrste koje su najčešće korištene u pošumljavanju su bagrem (*Robinia pseudoacacia* L.), bijeli i crni bor (*Pinus sylvestris* L., *Pinus nigra* J. F. Arnold), topola (*Populus* sp.), a zasađene su i neke grmolike (npr. *Juniperus virginiana* L.) i zeljaste vrste (npr. *Ammophilla arenaria* (L.) Link, *Festuca vaginata* Wild., *Leymus arenarius* (L.) Hochst., *Carex arenaria* L.). Danas je u Deliblatskoj peščari bagrem najzastupljenija vrsta, zauzima skoro trećinu cjelokupne površine.

**KLJUČNE RIJEČI:** stabilizacija pijeska, pješčarska vegetacija, kontinentalne pješčane dine, bagrem