# VASCULAR PLANT BIODIVERSITY OF FLOODPLAIN FOREST IN MORAVA AND DYJE RIVERS CONFLUENCE (FOREST DISTRICT SOUTOK), CZECH REPUBLIC

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## ABSTRACT

This paper presents an evaluation of full-area floristic investigation of floodplain forests in Soutok forest district (Židlochovice Forest State Enterprise) based on an individual forest stand inventory. The study area encompasses 5103 ha of forests, where 1186 segments were inventoried, and 71 223 single records about presence of vascular plant species were done. We found 761 taxa (species, subspecies and hybrids), out of which 655 were herbs, 106 woody plants, 156 were endangered species and 177 adventive species. The average area of a segment was 4.3 ha. The mean number of species per segment was 64.42 in a range of 4– 180.

**Keywords:** biodiversity, vascular plants, floodplain forest, forest district Soutok, Morava and Dyje rivers, Czech Republic

## INTRODUCTION

The area under study is composed not only from valuable floodplain forests (Horák, 1961; Klimo *et al*. 2008; Maděra *et al*. 2011, 2013; Řepka *et al*. 2015) but there occur also the continental floodplain meadows (Vicherek *et al*., 2000) with solitary oak trees (Maděra *et al*., 2007) creating famous landscape character of the area. High abundance of many endangered xylophagous species of insect (Miklín *et al*., 2018, 2017; Miklín & Čížek, 2014; Laštůvka *et al*., 2016), many rare bird species (Machar *et al*., 2018; Opluštil & Čupa, 2012), amphibians (Šebela, 2004; Suchomel *et al*., 2017), invertebrates and other organisms (Hrib & Kordiovský, 2004; Suchomel *et al*., 2017) due to the occurrence of well preserved habitats like large old trees, forest pools, riverine lakes, water channels and close nature floodplain forests, were reasons why a few small scale protected areas, NATURA 2000, UNESCO Biosphere Reserve were established in the area during last decades.

Floristic-oriented studies from the area of the confluence of the Morava and the Dyje rivers have been published only recently. Horák (1961) focused on the typology of floodplain forests, Vicherek *et al*. (2000) dealt with a floristic inventory in map squares regardless of forest or non-forest biotopes, Danihelka *et al.* (1995) and Danihelka & Šumberová (2004) described the distribution of selected taxa in detail.

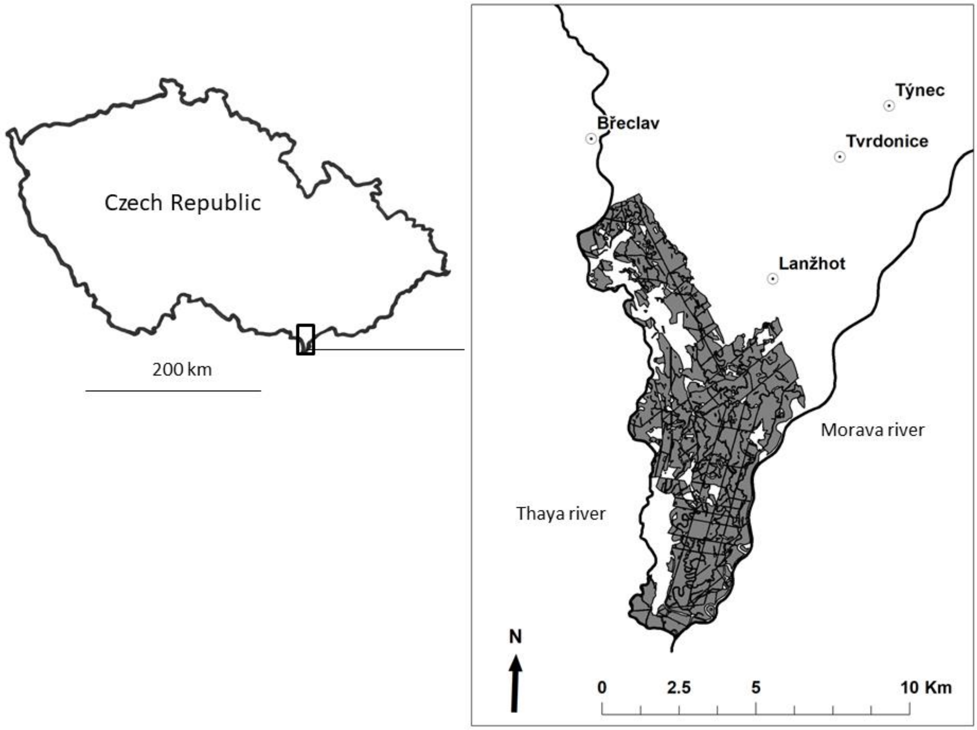
Presented paper is third part of articles concerning to vascular plant biodiversity evaluation in south Moravian floodplain forests. The previous were published by Maděra *et al*. (2011, 2013) for forest districts Valtice and Tvrdonice. The aim of the work is to describe spatial distribution of vascular plants biodiversity in the area as a tool for both, responsible forest management and conservation efforts.

## MATERIAL AND METHODS

### Study area

The area of 5103 ha of floodplain forest in confluence of the Morava and Dyje rivers between towns Lanžhot and Břeclav was inventoried. This is the Soutok forest district, Židlochovice Forest Enterprise, which is a part of state forests managed by Lesy ČR s.p. The Morava and Dyje rivers in the studied area forms large alluvium and the border among the Czech Republic, Slovakia and Austria, respectively (Fig. 1).

**Fig. 1: Study area**




## METHODS

All vascular plants in the area of the Soutok forest district were recorded between 2007 and 2011 down to the level of a segment; each segment corresponds to one stand group (exceptionally, similar groups are put together or non-homogeneous groups are divided). The presence of species in each segment is ticked in a list that includes 263 most common species of herbs in south-Moravian floodplains. Rare species and woody plants are added to the list. We followed nomenclature according to Kubát *et al*. (2002). The occurrence of species growing only at the segment edges (stand adjacent to the forest roads, water channels, clearings and meadows) and dominant species (species of over 40 % cover) are marked differently. The terrain survey needs to be conducted in two aspects: spring (March 20–May 31) and summer (June 1–November 30); also fresh clearings and young plantings were inventoried. The ticking lists are then transferred to a database and further processed. Both, list of alien plant species according to Pyšek *et al*. (2012a) and Red list according to Grulich & Chobot (2017) were used for evaluation of our dataset. The segments after digitalization become a site. The digitalization and creation of the species distribution maps was implemented in the GIS environment (ArcGIS).

## RESULTS

The total study area was 5,103 ha of forest; 1,186 segments were explored and 71,223 records on the presence of vascular plant taxa were taken. According to the records, there are 761 species (and infraspecific taxa and hybrids) in the area, out of which there were 655 herbs and 106 woody plants. The mean size of a segment was 4.3 ha. On average, there were 64.42 taxa (range of 4–180) per segment (most segments containing 40–59 species). The numbers of species within a segment were distributed unequally – there were more segments with lower numbers of species than average (703) and fewer segments with higher numbers (483) (Fig. 2). On average, there were 8.94 species of woody plants and 55.48 species of herbs in a segment. The spatial distribution of the segments with their highlighted significance for biodiversity (the number of species per segment) is illustrated in Fig. 3.

**Fig. 2: Frequency of segments according to containing number of species**

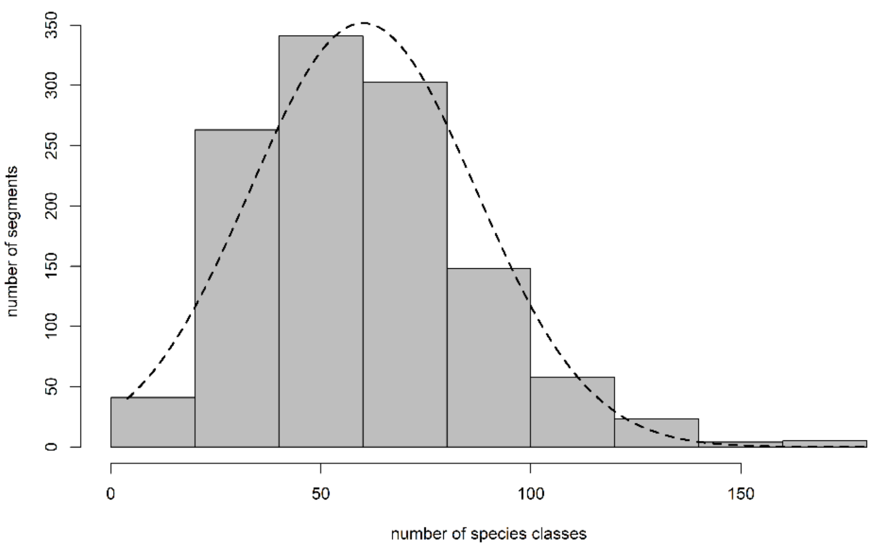
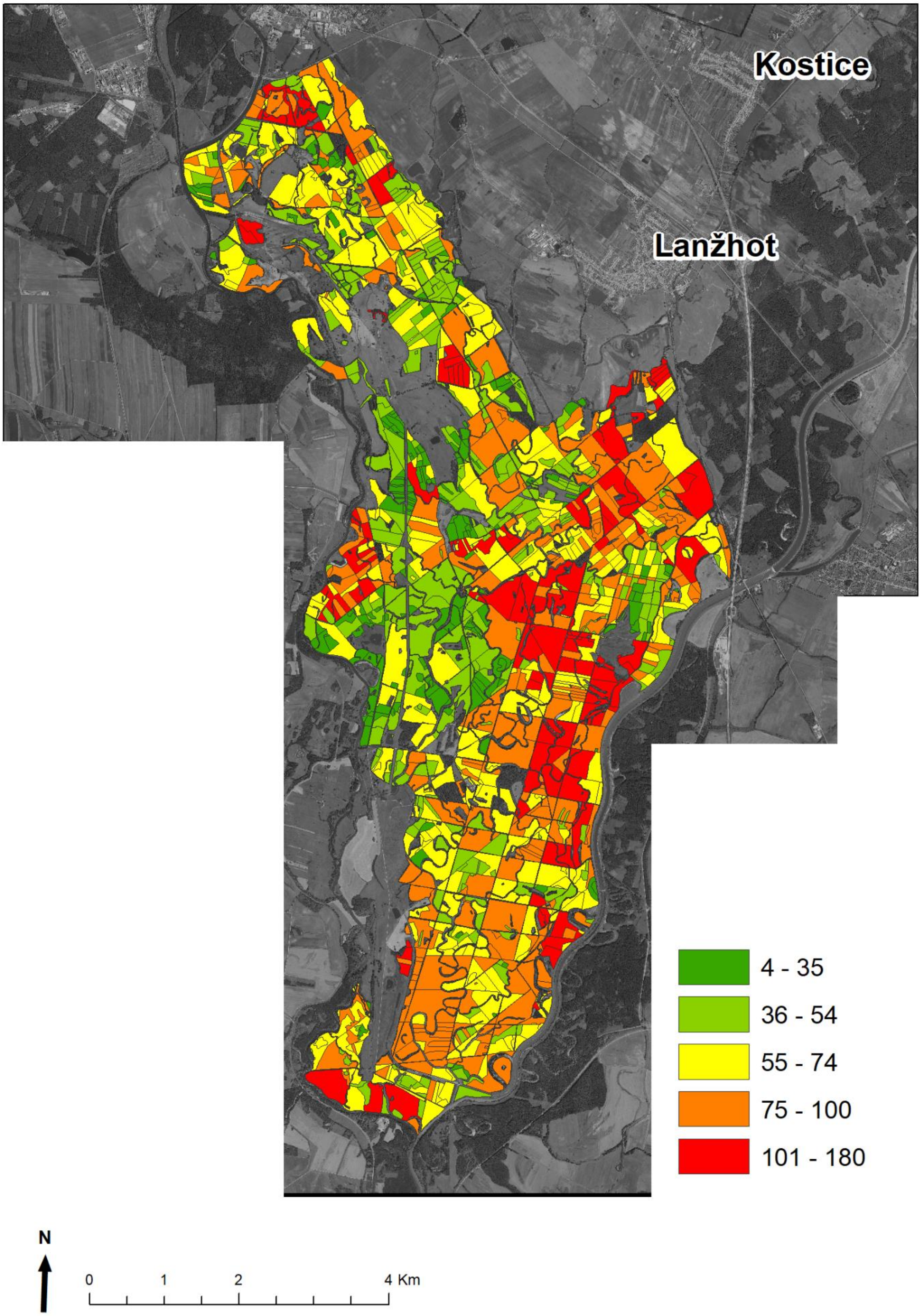


**Fig. 3: Map of the number of all vascular plant species per segment in the study area**



We also examined the frequency of species occurrence (presence of a taxon in segments) in the study area (Table 1). The analysis shows that 126 species (i.e. nearly 17 %) occurred in one segment only, 343 species (i.e. 45 %) were present in 1–9 segments; it means that the species scarcely occurred in the area and were rare. The table also shows that another 251 species (i.e. 33 %) were present in 10–99 segments. These species can be referred to as scattered. 167 species (i.e. 22 %) were present in over 100 segments – these species were abundant. Only 20 species occurred in over 60 % of segments (Table 2) – the species with high stability and diagnostic species of suballiance *Ulmenion* (Chytrý, 2013) only one adventive species is in this group – invasive neophyte *Aster lanceolatus*.

**Table 1: The frequency of species occurrence in the study area**

| Classes of segments number | Number of species |
|---|---|
| 1000 + | 4 |
| 900–999 | 3 |
| 800–899 | 9 |
| 700–799 | 4 |
| 600–699 | 8 |
| 500–599 | 21 |
| 400–499 | 11 |
| 300–399 | 15 |
| 200–299 | 31 |
| 100–199 | 61 |
| 1–99 | 597 |
| 90–99 | 14 |
| 80–89 | 7 |
| 70–79 | 17 |
| 60–69 | 16 |
| 50–59 | 17 |
| 40–49 | 18 |
| 30–39 | 26 |
| 20–29 | 42 |
| 10–19 | 94 |
| 1–9 | 343 |

**Table 2: The species with frequency over 60 % of segments in the study area**

| Species | No. of segments |
|---|---|
| *Ficaria verna* | 1080 |
| *Rubus caesius* | 1065 |
| *Urtica dioica* | 1046 |
| *Acer campestre* | 1003 |
| *Quercus robur* | 968 |
| *Fraxinus angustifolia* | 911 |
| *Carex riparia* | 908 |
| *Symphytum officinale* | 890 |
| *Geum urbanum* | 889 |
| *Glechoma hederacea* | 868 |
| *Rumex sanguineus* | 866 |
| *Aster lanceolatus* | 854 |
| *Phalaris arundinacea* | 839 |
| *Deschampsia cespitosa* | 835 |
| *Brachypodium sylvaticum* | 828 |
| *Lysimachia nummularia* | 816 |
| *Galium aparine* | 782 |
| *Ranunculus repens* | 761 |
| *Iris pseudacorus* | 755 |
| *Viola reichenbachiana* | 733 |

From the perspective of nature conservation, it is interesting to evaluate the proportion of adventive species (based on Pyšek *et al*., 2012a) and endangered species (based on Grulich & Chobot, 2017). Considering merely the number of species (Fig. 4), almost a quarter (23.2 %, i.e. 177 taxa) were various categories of adventive species and 20.8 % (156) taxa were species with various categories of conservation status. However, Fig.5 has a higher information capacity concerning the role of these groups in the study area. It shows the results categorised based on the number of records of the species in the segments. Based on this, the proportion of adventive species dropped to 14.8 % (10,562 records) and the proportion of endangered species to 11.2 % (7,948 records).

**Fig. 4: Proportion of adventive, threatened and others vascular plant species in the study area**

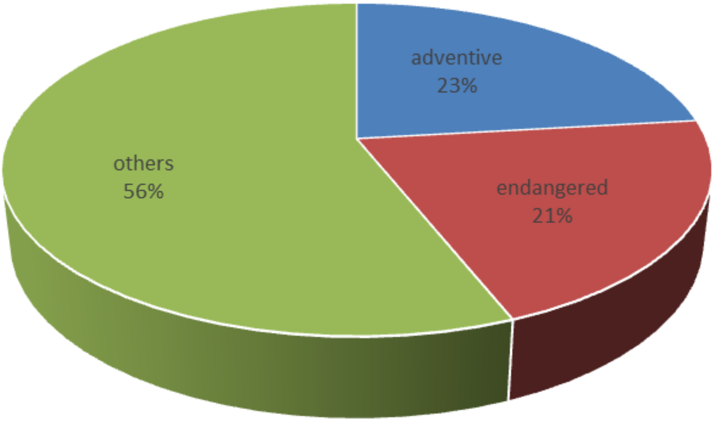
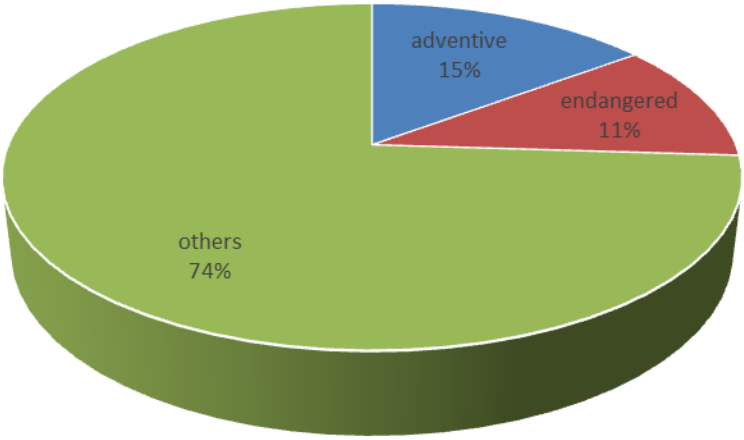



**Fig. 5: Proportion of adventive, threatened and others vascular plant species in the study area according to the number of records**




Within the set of adventive species, archeophytes (54.8 %) slightly prevailed over neophytes (45.2 %); there were 38, i.e. 21.4 % of invasive species in total (Fig. 6, Table 3). On average, there were 8 adventive species in a segment (range of 0–42). Only 27 segments contained no adventive species. There were up to 10 % of adventive species in 440 segments, 10–20 % in 579 segments, 20–30 % in 126 segments, 31–40 % in 14 segments, and no segment contains over 40 % of adventive species. The loading of individual segments by the presence of adventive species is illustrated in the map (Fig. 7), neophytes especially are pictured in the map (Fig. 8).

**Table 3: The abundance of different categories of adventive species (according to Pyšek *et al.*,2012a).** Arch = archeophytes, neo = neophytes, cas = causal, nat = naturalized, inv = invasive

| Adventive species category | all species | | herbs | | woody plants | |
|---|---|---|---|---|---|---|
| | species number | records number | species number | records number | species number | records number |
| arch cas | 4 | 13 | 4 | 13 | 0 | 0 |
| arch nat | 85 | 5235 | 79 | 4821 | 6 | 414 |
| arch inv | 8 | 792 | 8 | 792 | 0 | 0 |
| neo cas | 22 | 164 | 6 | 23 | 16 | 141 |
| neo nat | 28 | 1017 | 24 | 931 | 4 | 86 |
| neo inv | 30 | 3341 | 20 | 2922 | 10 | 419 |

**Fig. 6: Proportion of adventive species (classification according to Pyšek *et al.*, 2012a) in the study area**

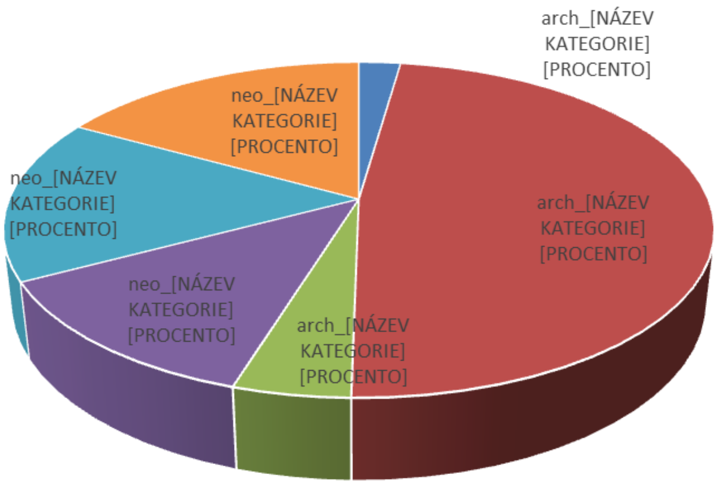


**Fig. 7: Map of the number of adventive species per segment in the study area**

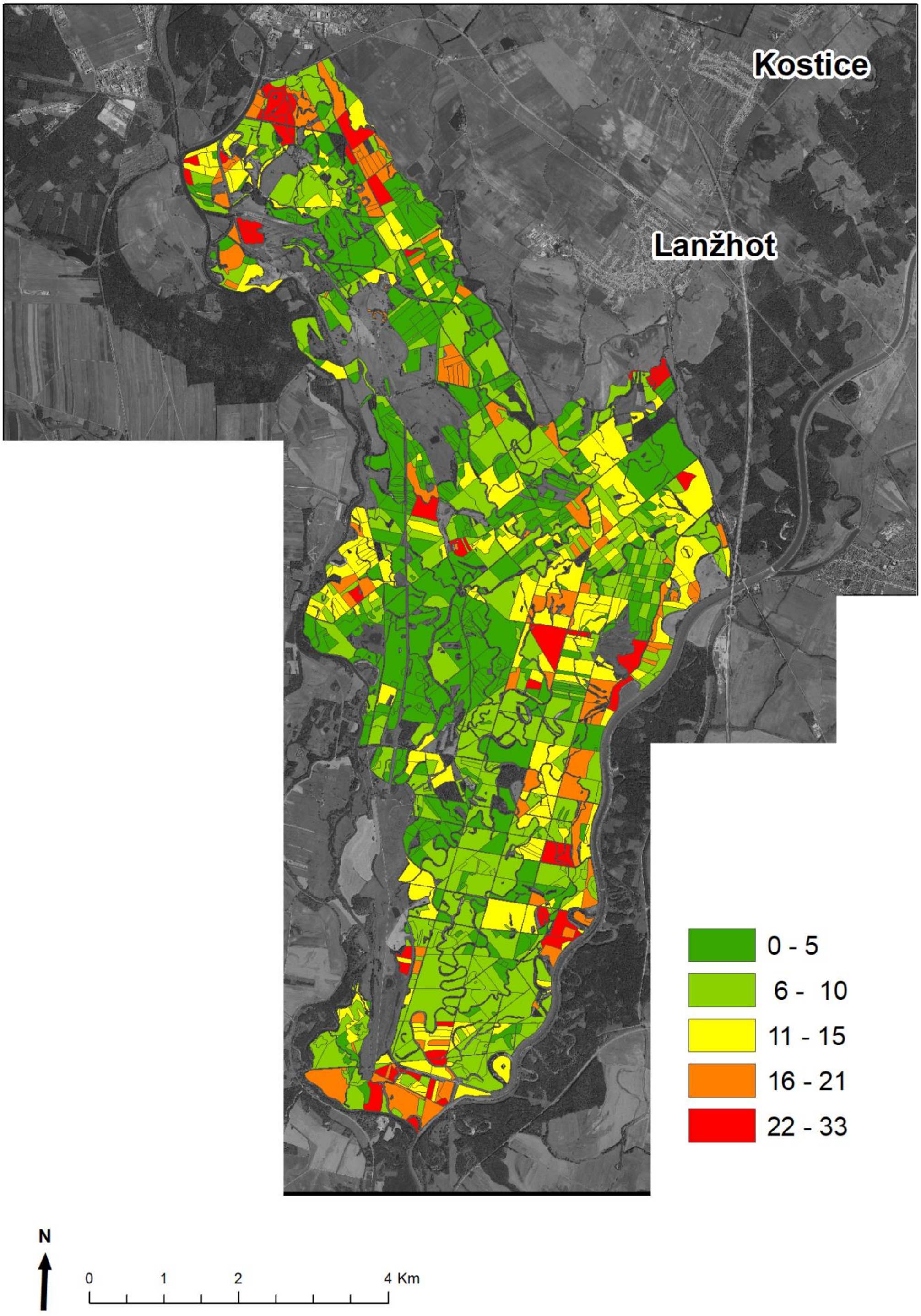
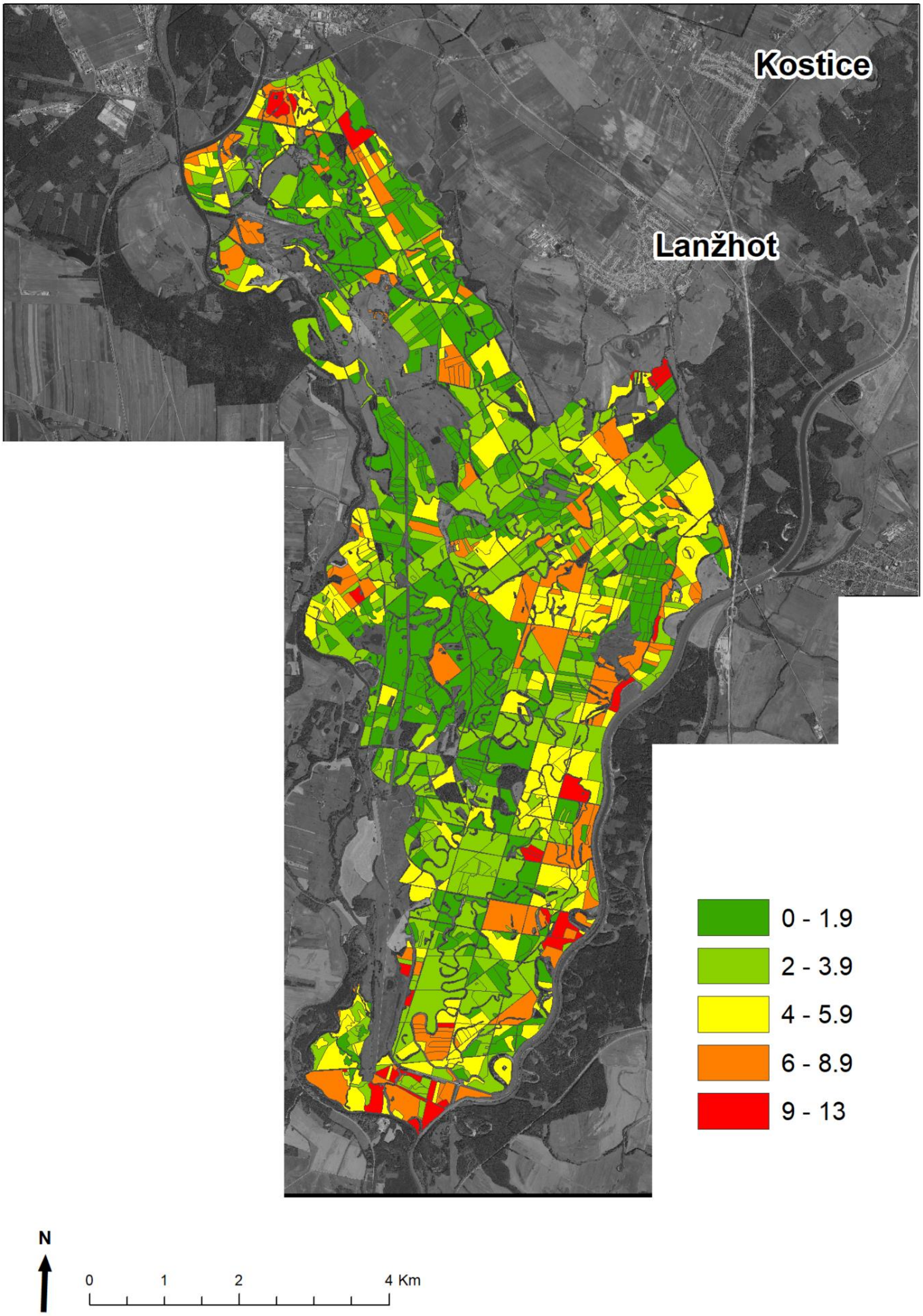


**Fig. 8: Map of the number of neophytes per segment in the study area**



As concerns endangered species, 20.75 % of them were protected by law, the rest were within various categories of the Red List (Grulich & Chobot, 2017). There were 18 critically endangered species, 34 strongly endangered and 44 endangered, the other 60 species were within C4 category – requiring further attention (Fig. 9, Table 4). The analysis shows that the mean number per segment was 5.4 of endangered species (range of 0–24). Endangered species were not present in 20 segments only; there were at least one endangered species in the other segments. Most segments (383) contain 6–9 % of endangered species; 76 segments even over 15 %. The most of endangered species (62.2 %) were present in 1–10 segments and only 11.3 % of endangered species were present in over 100 segments. The spatial distribution of the numbers of endangered species of plants in the segments is shown in the map (Fig. 10). The map in Fig. 11 shows the species of categories C1 (critically endangered) and C2 (strongly endangered).

**Table 4: The frequency of endangered species (according to Grulich & Chobot, 2017) in the study area**

| threat and protection category | all species | | herbs | | woody plants | |
|---|---|---|---|---|---|---|
| | species number | records number | species number | records number | species number | records number |
| §1 | 11 | 237 | 11 | 237 | 0 | 0 |
| §2 | 16 | 240 | 16 | 240 | 0 | 0 |
| §3 | 4 | 30 | 3 | 28 | 1 | 2 |
| C1 | 18 | 283 | 17 | 252 | 1 | 31 |
| C2 | 34 | 1031 | 32 | 919 | 2 | 112 |
| C3 | 44 | 1574 | 42 | 1505 | 2 | 69 |
| C4 | 60 | 5060 | 51 | 2875 | 9 | 2185 |

**Fig. 9: Proportion of endangered species in the study area**

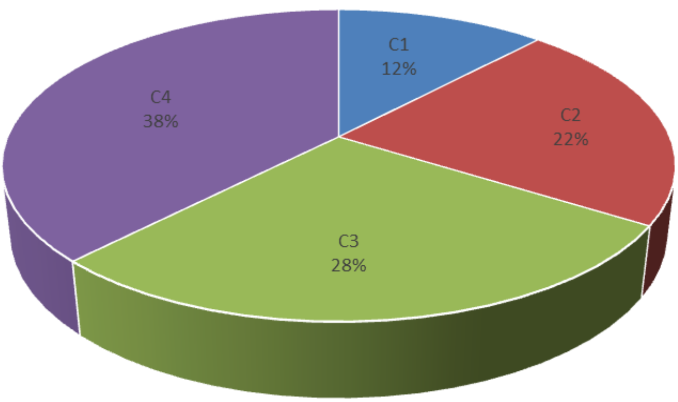


**Fig. 10: Map of the number of endangered species per segment according to Grulich & Chobot, (2017) in the study area**

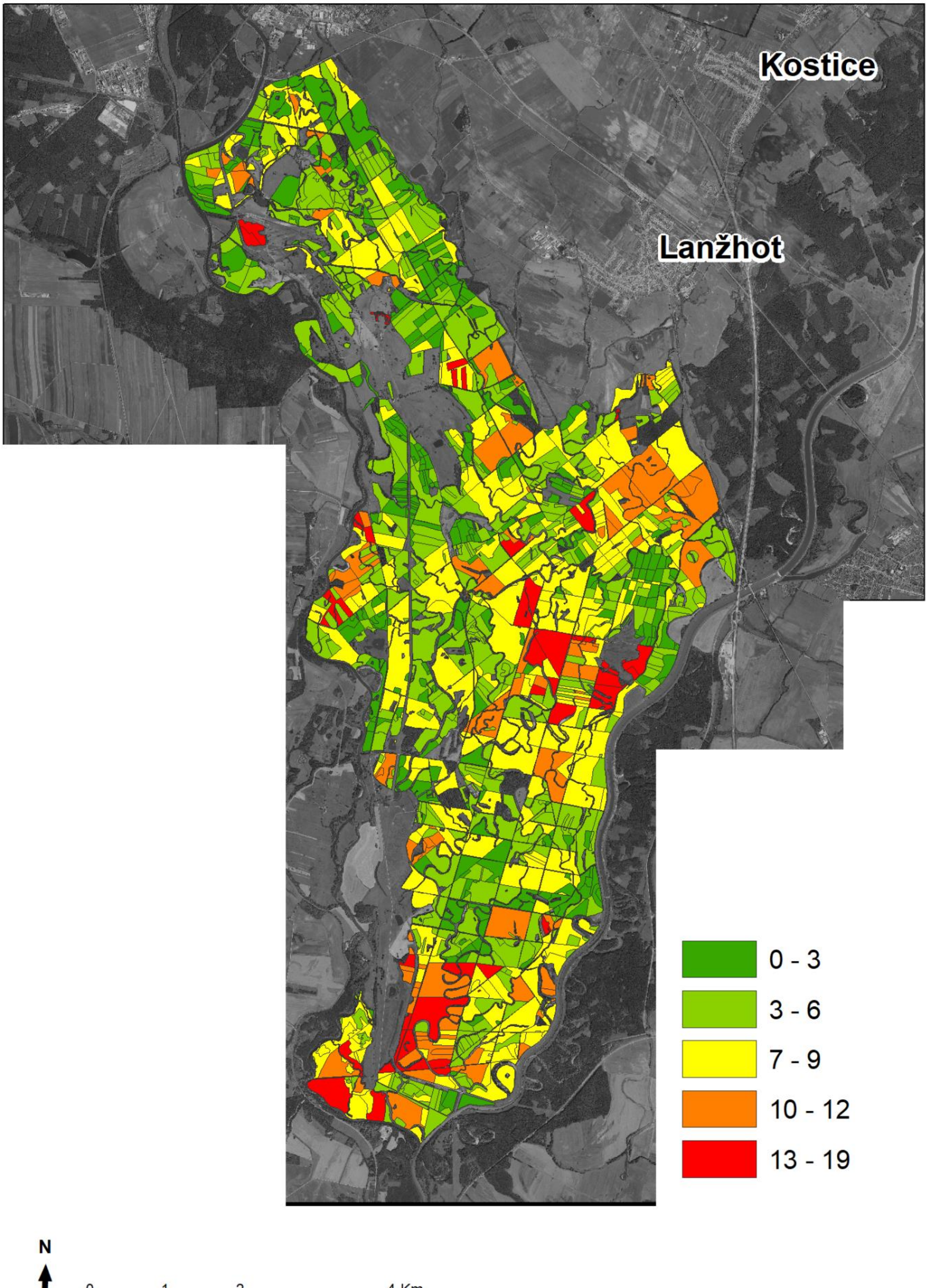
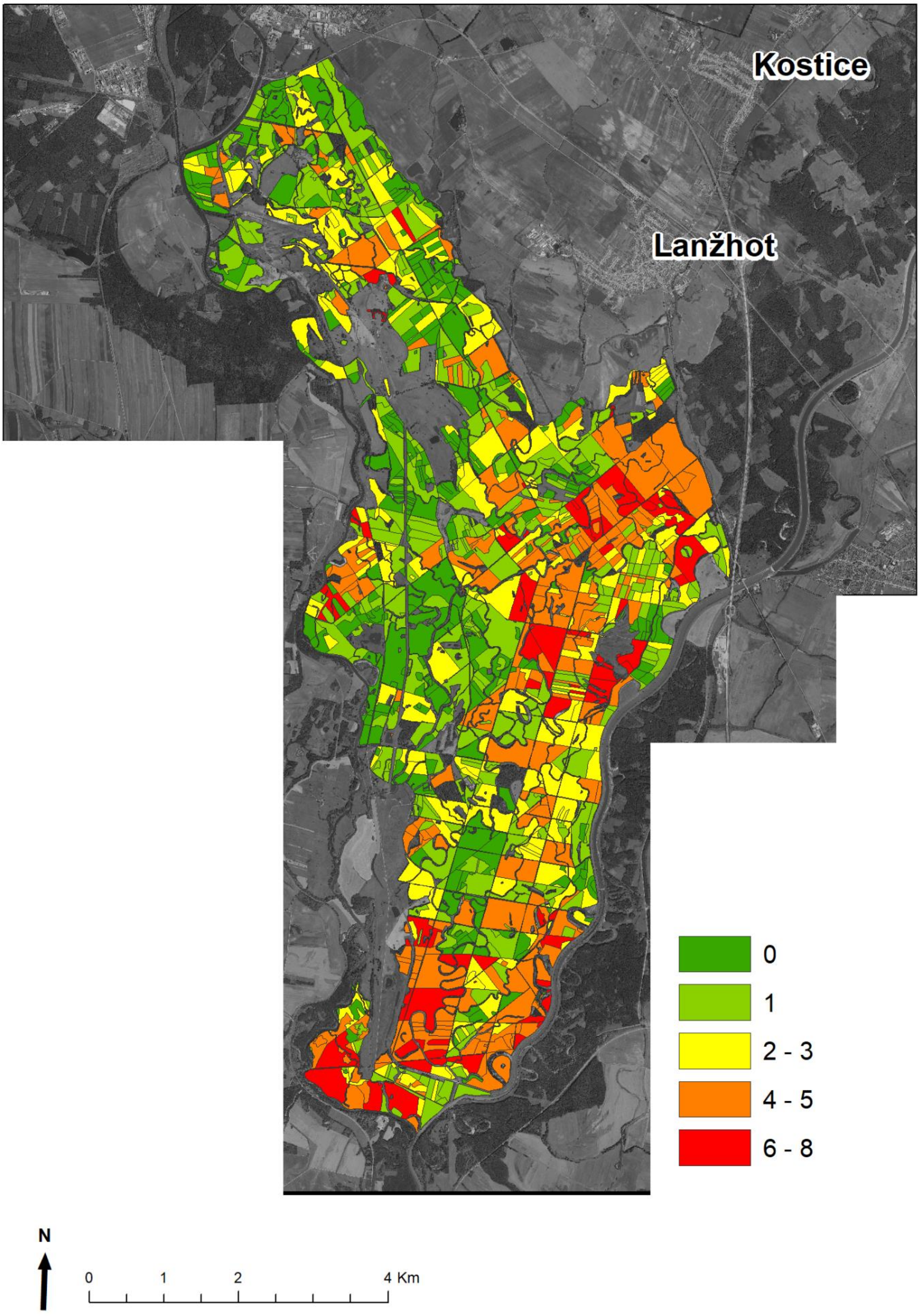


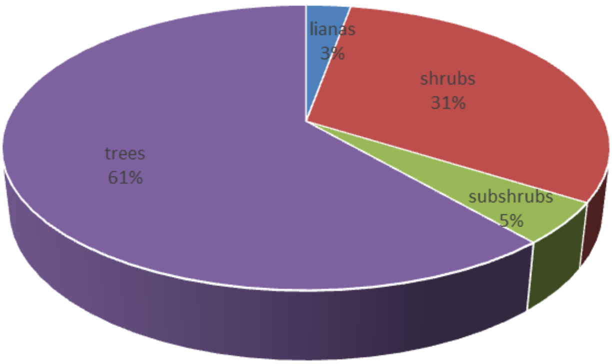
**Fig. 11: Map of the number of critical (C1) and strong endangered (C2) species per segment according to Grulich & Chobot, (2017) in the study area.**



**Diversity of woody plants in the floodplain forests**

As has been mentioned above, we found 106 species, subspecies and hybrids of woody plants in the study area. Based on Úradníček *et al*. (2010), woody plants are not only trees and shrubs but also semi-shrubs (e.g. *Vinca minor*) or woody lianas (e.g. *Vitis vinifera* subsp. *sylvestris*) and shrublets, whose representative has not been found in the area (Fig.12).

**Fig. 12: Proportion of occurrence of life forms of woody plants (according to Úradníček et al., 2010) in the study area.**




Out of the total number of woody plants found in the study area, there were 29 abundant species (occurrence in over 100 segments), 32 scattered species (10–99 segments) and 43 rare species (1–9 segments) – 18 species were recorded in one segment only.

From the perspective of autochthonous origin, 36 recorded species were various types of adventive species (Table 5). There are 10 recorded invasive neophytes, a more significant presence being recorded for both *Acer negundo* and *Populus* × *canadensis* – in nearly 13 % of segments, the other species were spread less (under 3% of segments). Pyšek *et al*. (2012a) also categorised the frequently grown *Juglans nigra* as an occasionally wild-growing neophyte; however, in the conditions of a floodplain forests, where is often planted, we can assume at least a very good naturalisation as it often regenerates naturally – it was recorded in 8.7 % of segments.

**Table 5: The presence of adventive woody plants species in segments (according to Pyšek *et al*., 2012a).**

| Species | number of segments | proportion of segments [%] | adventive species category | |
|---|---|---|---|---|
| *Pyrus communis* | 268 | 22,6 | arch | naturalized |
| *Malus domestica* | 88 | 7,4 | arch | naturalized |
| *Malus × dasyphylla* | 48 | 4,0 | arch | naturalized |
| *Juglans regia* | 4 | 0,3 | arch | naturalized |
| *Prunus insititia* | 4 | 0,3 | arch | naturalized |
| *Prunus domestica* | 2 | 0,2 | arch | naturalized |
| *Juglans nigra* | 103 | 8,7 | neo | casual |

| | | | | |
|---|---|---|---|---|
| *Morus alba* | 11 | 0,9 | neo | casual |
| *Fraxinus ornus* | 7 | 0,6 | neo | casual |
| *Picea pungens* | 4 | 0,3 | neo | casual |
| *Castanea sativa* | 2 | 0,2 | neo | casual |
| *Catalpa bignonioides* | 2 | 0,2 | neo | casual |
| *Gleditsia triacanthos* | 2 | 0,2 | neo | casual |
| *Tilia tomentosa* | 2 | 0,2 | neo | casual |
| *Acer saccharinum* | 1 | 0,1 | neo | casual |
| *Hibicus syriacus* | 1 | 0,1 | neo | casual |
| *Phellodendron amurense* | 1 | 0,1 | neo | casual |
| *Platanus × hispanica* | 1 | 0,1 | neo | casual |
| *Populus candicans* | 1 | 0,1 | neo | casual |
| *Rosa multiflora* | 1 | 0,1 | neo | casual |
| *Thuja plicata* | 1 | 0,1 | neo | casual |
| *Zelkova serrata* | 1 | 0,1 | neo | casual |
| *Aesculus hippocastanum* | 58 | 4,9 | neo | naturalized |
| *Pinus nigra* | 16 | 1,3 | neo | naturalized |
| *Ribes rubrum* | 11 | 0,9 | neo | naturalized |
| *Pseudotsuga menziesii* | 1 | 0,1 | neo | naturalized |
| *Populus × canadensis* | 153 | 12,9 | neo | invasive |
| *Acer negundo* | 152 | 12,8 | neo | invasive |
| *Robinia pseudacacia* | 34 | 2,9 | neo | invasive |
| *Parthenocissus inserta* | 27 | 2,3 | neo | invasive |
| *Quercus rubra* | 19 | 1,6 | neo | invasive |
| *Prunus cerasifera* | 16 | 1,3 | neo | invasive |
| *Fraxinus pennsylvanica* | 12 | 1,0 | neo | invasive |
| *Ailanthus altissima* | 4 | 0,3 | neo | invasive |
| *Amorpha fruticosa* | 1 | 0,1 | neo | invasive |
| *Prunus serotina* | 1 | 0,1 | neo | invasive |

14 species of the woody plants fall within threatened species of some category (Table 6) but only *Cornus mas* is protected by law and it was found in two segments only. Floodplain forests are indispensable biotopes of critically endangered woody species *Populus nigra* (31 segments), endangered species *Malus sylvestris* (68 segments), vulnerable species *Fraxinus angustifolia* (911 segments) and *Pyrus pyraster* (248). There is also a strong population of elms, both *Ulmus laevis* and *U. minor* (517 and 391 segments, respectively). High presence of *Quercus cerris* is due to its artificial plantation in dryer sandy sites.

**Table 6: The presence of threatened woody plant species (according to Grulich & Chobot, 2017).**

| species | number of segments | threat category |
|---|---|---|
| *Populus nigra* | 31 | C1t |
| *Sorbus aria* | 2 | C2b |
| *Quercus cerris* | 110 | C2r |
| *Malus sylvestris* | 68 | C3 |
| *Rosa tomentosa* | 1 | C3 |
| *Cornus mas* | 2 | C4a, §3 |
| *Fraxinus angustifolia* | 911 | C4a |
| *Loranthus europaeus* | 108 | C4a |
| *Pyrus pyraster* | 248 | C4a |
| *Thymus pannonicus* | 3 | C4a |
| *Ulmus laevis* | 517 | C4a |
| *Ulmus minor* | 391 | C4a |
| *Viscum album* subsp. *austriacum* | 4 | C4a |
| *Quercus polycarpa* | 1 | C4b |

**Diversity of herbs in the floodplain forests**

We determined 655 species, subspecies and hybrids of herbs in the floodplain forest herb layer. Out of the total number of herbs found, there were 138 abundant species (occurrence in over 100 segments), 218 scattered species (10–99 segments) and 299 rare species within the study area (1–9 segments) – 107 species were found in one segment only.

From the perspective of autochthonous origin, 141 recorded species were various types of adventive species (Table 7), out of which there were 91 archeophytes and 50 neophytes, 28 invasive species. The more significant invasive archeophytes was *Cirsium arvense* in 56.5 % of segments which was dominant in forest edges and clearings. The most significant and highly aggressive invasive neophytes in the area was *Aster lanceolatus*, whose presence 72 % of segments and frequent dominance in younger and older stands of the floodplain forest presents a problem with almost no solution any more (Řepka & Maděra, 2009a). The other abundant invasive neophytes in the area were *Bidens frondosa* (50 % of segments), *Impatiens parviflora* (29 %), *Conyza canadensis* (26 %), *Erigeron annuus* (19.6 %) and *Echinocystis lobata* (16.2 %) usually grew in clearings and newly established cultures and only the first two mentioned ones penetrated into forest communities.

**Table 7: The presence of adventive herb species in segments (according to Pyšek *et al.*, 2012a).**

| Species | number of segments | proportion of segments [%] | adventive species category | |
|---|---|---|---|---|
| *Xanthium strumarium* | 7 | 0,6 | arc | casual |
| *Panicum miliaceum* | 3 | 0,3 | arc | casual |
| *Triticum aestivum* | 2 | 0,2 | arc | casual |
| *Beta vulgaris* | 1 | 0,1 | arc | casual |
| *Descurainia sophia* | 835 | 70,4 | arc | naturalized |
| *Lapsana communis* | 568 | 47,9 | arc | naturalized |
| *Arctium lappa* | 558 | 47,0 | arc | naturalized |
| *Veronica hederifolia* | 426 | 35,9 | arc | naturalized |
| *Tanacetum vulgare* | 266 | 22,4 | arc | naturalized |
| *Tripleurospermum inodorum* | 205 | 17,3 | arc | naturalized |
| *Setaria pumila* | 175 | 14,8 | arc | naturalized |
| *Sonchus asper* | 126 | 10,6 | arc | naturalized |
| *Capsella bursa-pastoris* | 124 | 10,5 | arc | naturalized |
| *Atriplex patula* | 123 | 10,4 | arc | naturalized |
| *Lactuca serriola* | 115 | 9,7 | arc | naturalized |
| *Lamium purpureum* | 91 | 7,7 | arc | naturalized |
| *Ballota nigra* | 72 | 6,1 | arc | naturalized |
| *Anchusa officinalis* | 70 | 5,9 | arc | naturalized |
| *Sonchus arvensis* | 66 | 5,6 | arc | naturalized |
| *Silene latifolia* subsp. *alba* | 65 | 5,5 | arc | naturalized |
| *Linaria vulgaris* | 62 | 5,2 | arc | naturalized |
| *Chelidonium majus* | 58 | 4,9 | arc | naturalized |
| *Solanum nigrum* | 58 | 4,9 | arc | naturalized |
| *Carduus acanthoides* | 56 | 4,7 | arc | naturalized |
| *Fallopia convolvulus* | 56 | 4,7 | arc | naturalized |
| *Geranium pusillum* | 51 | 4,3 | arc | naturalized |
| *Convolvulus arvensis* | 46 | 3,9 | arc | naturalized |
| *Setaria viridis* | 46 | 3,9 | arc | naturalized |
| *Bromus sterilis* | 40 | 3,4 | arc | naturalized |
| *Bromus hordeaceus* | 38 | 3,2 | arc | naturalized |
| *Viola odorata* | 35 | 3,0 | arc | naturalized |
| *Lamium album* | 32 | 2,7 | arc | naturalized |
| *Sonchus oleraceus* | 30 | 2,5 | arc | naturalized |

| | | | | |
|---|---|---|---|---|
| *Senecio vulgaris* | 28 | 2,4 | arc | naturalized |
| *Veronica arvensis* | 27 | 2,3 | arc | naturalized |
| *Digitaria sanguinalis* | 20 | 1,7 | arc | naturalized |
| *Saponaria officinalis* | 17 | 1,4 | arc | naturalized |
| *Bromus japonicus* | 16 | 1,3 | arc | naturalized |
| *Berteroa incana* | 15 | 1,3 | arc | naturalized |
| *Arctium tomentosum* | 14 | 1,2 | arc | naturalized |
| *Myosotis arvensis* | 13 | 1,1 | arc | naturalized |
| *Vicia villosa* | 13 | 1,1 | arc | naturalized |
| *Vicia angustifolia* | 12 | 1,0 | arc | naturalized |
| *Melilotus albus* | 11 | 0,9 | arc | naturalized |
| *Verbena officinalis* | 11 | 0,9 | arc | naturalized |
| *Lathyrus tuberosus* | 9 | 0,8 | arc | naturalized |
| *Tragopogon dubius* | 9 | 0,8 | arc | naturalized |
| *Bromus commutatus* | 8 | 0,7 | arc | naturalized |
| *Melilotus officinalis* | 8 | 0,7 | arc | naturalized |
| *Sisymbrium officinale* | 8 | 0,7 | arc | naturalized |
| *Thlaspi arvense* | 7 | 0,6 | arc | naturalized |
| *Leonurus cardiaca* s.lat. | 6 | 0,5 | arc | naturalized |
| *Bromus tectorum* | 5 | 0,4 | arc | naturalized |
| *Viola tricolor* | 5 | 0,4 | arc | naturalized |
| *Anagallis arvensis* | 4 | 0,3 | arc | naturalized |
| *Artemisia absinthium* | 4 | 0,3 | arc | naturalized |
| *Chenopodium botrys* | 4 | 0,3 | arc | naturalized |
| *Erodium cicutarium* | 4 | 0,3 | arc | naturalized |
| *Papaver rhoeas* | 4 | 0,3 | arc | naturalized |
| *Vicia sativa* | 4 | 0,3 | arc | naturalized |
| *Armoracia rusticana* | 3 | 0,3 | arc | naturalized |
| *Avena sativa* | 3 | 0,3 | arc | naturalized |
| *Cynodon dactylon* | 3 | 0,3 | arc | naturalized |
| *Lamium amplexicaule* | 3 | 0,3 | arc | naturalized |
| *Microrrhinum minus* | 3 | 0,3 | arc | naturalized |
| *Sambucus ebulus* | 3 | 0,3 | arc | naturalized |
| *Vicia villosa* subsp. *varia* | 3 | 0,3 | arc | naturalized |
| *Crepis capillaris* | 2 | 0,2 | arc | naturalized |
| *Erysimum cheiranthoides* | 2 | 0,2 | arc | naturalized |

| | | | | |
|---|---|---|---|---|
| *Geranium columbinum* | 2 | 0,2 | arc | naturalized |
| *Lithospermum arvense* | 2 | 0,2 | arc | naturalized |
| *Mentha × verticillata* | 2 | 0,2 | arc | naturalized |
| *Atriplex tatarica* | 1 | 0,1 | arc | naturalized |
| *Cichorium intybus* | 1 | 0,1 | arc | naturalized |
| *Crepis setosa* | 1 | 0,1 | arc | naturalized |
| *Euphorbia peplus* | 1 | 0,1 | arc | naturalized |
| *Geranium dissectum* | 1 | 0,1 | arc | naturalized |
| *Hyoscyamus niger* | 1 | 0,1 | arc | naturalized |
| *Lepidium ruderale* | 1 | 0,1 | arc | naturalized |
| *Malva neglecta* | 1 | 0,1 | arc | naturalized |
| *Onopordum acanthium* | 1 | 0,1 | arc | naturalized |
| *Parietaria officinalis* | 1 | 0,1 | arc | naturalized |
| *Veronica polita* | 1 | 0,1 | arc | naturalized |
| *Cirsium arvense* | 670 | 56,5 | arc | invasive |
| *Portulaca oleracea* | 42 | 3,5 | arc | invasive |
| *Echinochloa crus-galli* | 29 | 2,4 | arc | invasive |
| *Eragrostis minor* | 24 | 2,0 | arc | invasive |
| *Atriplex sagittata* | 11 | 0,9 | arc | invasive |
| *Chenopodium pedunculare* | 8 | 0,7 | arc | invasive |
| *Digitaria ischaemum* | 7 | 0,6 | arc | invasive |
| *Conium maculatum* | 1 | 0,1 | arc | invasive |
| *Xanthium italicum* | 16 | 1,3 | neo | casual |
| *Hemerocallis fulva* | 2 | 0,2 | neo | casual |
| *Lycopersicum esculentum* | 2 | 0,2 | neo | casual |
| *Helianthus annuus* | 1 | 0,1 | neo | casual |
| *Phacelia tanacetifolia* | 1 | 0,1 | neo | casual |
| *Phytolacca americana* | 1 | 0,1 | neo | casual |
| *Oxalis fontana* | 364 | 30,7 | neo | naturalized |
| *Galega officinalis* | 178 | 15,0 | neo | naturalized |
| *Trifolium hybridum* | 125 | 10,5 | neo | naturalized |
| *Juncus tenuis* | 48 | 4,0 | neo | naturalized |
| *Chenopodium strictum* | 46 | 3,9 | neo | naturalized |
| *Epilobium ciliatum* | 41 | 3,5 | neo | naturalized |
| *Datura stramonium* | 24 | 2,0 | neo | naturalized |
| *Amaranthus albus* | 15 | 1,3 | neo | naturalized |

| | | | | |
|---|---|---|---|---|
| *Sagittaria latifolia* | 15 | 1,3 | neo | naturalized |
| *Rumex thyrsiflorus* | 13 | 1,1 | neo | naturalized |
| *Chenopodium pumilio* | 12 | 1,0 | neo | naturalized |
| *Erechtites hieraciifolia* | 12 | 1,0 | neo | naturalized |
| *Asclepias syriaca* | 10 | 0,8 | neo | naturalized |
| *Agrostis gigantea* | 7 | 0,6 | neo | naturalized |
| *Senecio vernalis* | 6 | 0,5 | neo | naturalized |
| *Oenothera biennis* | 4 | 0,3 | neo | naturalized |
| *Geranium pyrenaicum* | 2 | 0,2 | neo | naturalized |
| *Rubus armeniacus* | 2 | 0,2 | neo | naturalized |
| *Veronica persica* | 2 | 0,2 | neo | naturalized |
| *Alcea rosea* | 1 | 0,1 | neo | naturalized |
| *Medicago sativa* | 1 | 0,1 | neo | naturalized |
| *Ornithogalum nutans* | 1 | 0,1 | neo | naturalized |
| *Pleioblastus chino* | 1 | 0,1 | neo | naturalized |
| *Xanthium albinum* | 1 | 0,1 | neo | naturalized |
| *Aster lanceolatus* | 854 | 72,0 | neo | invasive |
| *Bidens frondosa* | 593 | 50,0 | neo | invasive |
| *Impatiens parviflora* | 347 | 29,3 | neo | invasive |
| *Conyza canadensis* | 309 | 26,1 | neo | invasive |
| *Erigeron annuus* subsp. *annuus* | 233 | 19,6 | neo | invasive |
| *Echinocystis lobata* | 193 | 16,3 | neo | invasive |
| *Solidago gigantea* | 96 | 8,1 | neo | invasive |
| *Arrhenatherum elatius* | 65 | 5,5 | neo | invasive |
| *Amaranthus retroflexus* | 57 | 4,8 | neo | invasive |
| *Amaranthus powellii* | 44 | 3,7 | neo | invasive |
| *Impatiens glandulifera* | 32 | 2,7 | neo | invasive |
| *Galinsoga parviflora* | 27 | 2,3 | neo | invasive |
| *Helianthus tuberosus* | 24 | 2,0 | neo | invasive |
| *Solidago canadensis* | 14 | 1,2 | neo | invasive |
| *Galinsoga quadriradiata* | 8 | 0,7 | neo | invasive |
| *Sisymbrium loeselii* | 7 | 0,6 | neo | invasive |
| *Ambrosia artemisiifolia* | 6 | 0,5 | neo | invasive |
| *Oxalis dillenii* | 6 | 0,5 | neo | invasive |
| *Reynoutria sachalinensis* | 5 | 0,4 | neo | invasive |
| *Rudbeckia laciniata* | 2 | 0,2 | neo | invasive |

As regards, specially protected and endangered species, there were 142 of them in the study area (Table 8). 40 species within the total number of 505 records in the segments were protected by law.

**Table 8: The presence of endangered herb species (according to Grulich & Chobot, 2017).**

| species | number of segments | threat and protection category | |
|---|---|---|---|
| *Leucojum aestivum* | 142 | C1b | §1 |
| *Cardamine parviflora* | 12 | C1b | §1 |
| *Pulicaria dysenterica* | 5 | C1b | |
| *Hierochloë repens* | 2 | C1b | §1 |
| *Clematis integrifolia* | 1 | C1b | §1 |
| *Cyperus michelianus* | 1 | C1b | §1 |
| *Juncus atratus* | 1 | C1b | §1 |
| *Trapa natans* | 1 | C1b | §1 |
| *Viola elatior* | 56 | C1t | §1 |
| *Pulegium vulgare* | 9 | C1t | |
| *Pulicaria vulgaris* | 9 | C1t | |
| *Xanthium strumarium* | 7 | C1t | |
| *Lathyrus palustris* | 2 | C1t | §1 |
| *Crepis setosa* | 1 | C1t | |
| *Nymphoides peltata* | 1 | C1t | §1 |
| *Scorzonera laciniata* | 1 | C1t | |
| *Stratiotes aloides* | 1 | C1t | §2 |
| *Leonurus marrubiastrum* | 238 | C2b | |
| *Scutellaria hastifolia* | 93 | C2b | §2 |
| *Cicuta virosa* | 78 | C2b | |
| *Verbascum blattaria* | 67 | C2b | |
| *Cnidium dubium* | 28 | C2b | |
| *Sium latifolium* | 24 | C2b | |
| *Euphorbia lucida* | 18 | C2b | §1 |
| *Thalictrum flavum* | 15 | C2b | §2 |
| *Lycopus exaltatus* | 10 | C2b | |
| *Iris variegata* | 7 | C2b | §2 |
| *Teucrium scordium* | 6 | C2b | §2 |
| *Hydrocharis morsus-ranae* | 5 | C2b | |

| | | | |
|---|---|---|---|
| *Iris graminea* | 5 | C2b | §2 |
| *Scirpoides holoschoenus* | 5 | C2b | |
| *Senecio sarracenicus* | 5 | C2b | §2 |
| *Epipactis albensis* | 3 | C2b | §2 |
| *Lythrum hyssopifolia* | 2 | C2b | |
| *Lythrum virgatum* | 2 | C2b | |
| *Ophioglossum vulgatum* | 2 | C2b | §3 |
| *Muscari neglectum* | 1 | C2b | |
| *Ornithogalum boucheanum* | 1 | C2b | |
| *Sonchus palustris* | 1 | C2b | |
| *Stellaria palustris* | 1 | C2b | |
| *Viola tricolor* subsp. *curtisii* | 1 | C2b | |
| *Carex strigosa* | 235 | C2r | |
| *Carex fritschii* | 2 | C2r | |
| *Parietaria officinalis* | 1 | C2r | |
| *Carex melanostachya* | 38 | C2t | §2 |
| *Althaea officinalis* | 11 | C2t | |
| *Gratiola officinalis* | 9 | C2t | §2 |
| *Viola pumila* | 3 | C2t | §2 |
| *Viola stagnina* | 2 | C2t | §2 |
| *Senecio erraticus* | 349 | C3 | |
| *Carex divulsa* | 264 | C3 | |
| *Cardamine dentata* | 236 | C3 | |
| *Barbarea stricta* | 178 | C3 | |
| *Lotus tenuis* | 56 | C3 | |
| *Cucubalus baccifer* | 45 | C3 | |
| *Euphorbia palustris* | 40 | C3 | §2 |
| *Pseudolysimachion maritimum* | 37 | C3 | |
| *Corydalis pumila* | 32 | C3 | |
| *Carex curvata* | 30 | C3 | |
| *Silaum silaus* | 30 | C3 | |
| *Dipsacus laciniatus* | 26 | C3 | |
| *Erysimum diffusum* | 21 | C3 | |
| *Galanthus nivalis* | 15 | C3 | §3 |
| *Leersia oryzoides* | 14 | C3 | |
| *Trifolium fragiferum* var. *fragiferum* | 13 | C3 | |

| | | | |
|---|---|---|---|
| *Verbena officinalis* | 11 | C3 | |
| *Hottonia palustris* | 11 | C3 | §3 |
| *Carex distans* | 10 | C3 | |
| *Gagea minima* | 10 | C3 | |
| *Thalictrum lucidum* | 10 | C3 | |
| *Bromus commutatus* | 8 | C3 | |
| *Achillea pannonica* | 8 | C3 | |
| *Myosurus minimus* | 8 | C3 | |
| *Centaurium pulchellum* | 6 | C3 | |
| *Iris sibirica* | 6 | C3 | §2 |
| *Linaria genistifolia* | 5 | C3 | |
| *Scilla vindobonensis* | 5 | C3 | §2 |
| *Chondrilla juncea* | 4 | C3 | |
| *Cyperus fuscus* | 3 | C3 | |
| *Allium angulosum* | 2 | C3 | §2 |
| *Hesperis sylvestris* | 2 | C3 | |
| *Hyoscyamus niger* | 1 | C3 | |
| *Carex supina* | 1 | C3 | |
| *Ficaria calthifolia* | 1 | C3 | |
| *Gagea pusilla* | 1 | C3 | |
| *Lactuca quercina* | 1 | C3 | |
| *Lathyrus latifolius* | 1 | C3 | |
| *Muscari comosum* | 1 | C3 | |
| *Najas marina* | 1 | C3 | |
| *Silene otites* | 1 | C3 | |
| *Veronica catenata* | 1 | C3 | |
| *Carex riparia* | 908 | C4a | |
| *Aristolochia clematitis* | 530 | C4a | |
| *Veronica hederifolia* | 426 | C4b | |
| *Galega officinalis* | 178 | C4a | |
| *Veronica montana* | 123 | C4a | |
| *Cerastium lucorum* | 92 | C4a | |
| *Allium ursinum* | 89 | C4a | |
| *Myosotis sparsiflora* | 71 | C4a | |
| *Galium rivale* | 64 | C4a | |
| *Carex buekii* | 58 | C4a | |

| | | | |
|---|---|---|---|
| *Cardamine matthioli* | 55 | C4a | |
| *Serratula tinctoria* | 31 | C4a | |
| *Aethusa cynapioides* | 29 | C4a | |
| *Nuphar lutea* | 20 | C4a | |
| *Vicia dumetorum* | 20 | C4a | |
| *Bromus japonicus* | 16 | C4a | |
| *Veronica scutellata* | 14 | C4a | |
| *Dianthus armeria* | 13 | C4a | |
| *Verbascum chaixii* subsp. *austriacum* | 13 | C4a | |
| *Galium mollugo* | 11 | C4b | |
| *Batrachium aquatile* | 10 | C4b | |
| *Carex otrubae* | 8 | C4a | |
| *Centaurium erythraea* | 8 | C4a | |
| *Peucedanum oreoselinum* | 8 | C4a | |
| *Berula erecta* | 7 | C4a | |
| *Petrorhagia prolifera* | 7 | C4a | |
| *Butomus umbellatus* | 6 | C4a | |
| *Inula salicina* | 6 | C4a | |
| *Melica transsilvanica* | 6 | C4a | |
| *Isopyrum thalictroides* | 4 | C4a | |
| *Lavatera thuringiaca* | 4 | C4a | |
| *Cynodon dactylon* | 3 | C4a | |
| *Bolboschoenus* sp. indet. | 3 | C4a | |
| *Galium elongatum* | 3 | C4a | |
| *Geranium sanguineum* | 3 | C4a | |
| *Malva alcea* | 3 | C4a | |
| *Primula veris* | 3 | C4a | |
| *Pseudolysimachion spicatum* | 3 | C4a | |
| *Scrophularia umbrosa* | 3 | C4a | |
| *Corydalis intermedia* | 2 | C4a | |
| *Corynephorus canescens* | 2 | C4a | |
| *Omphalodes scorpioides* | 2 | C4a | |
| *Euphorbia esula* subsp. *riparia* | 2 | C4b | |
| *Cerinthe minor* | 1 | C4a | |
| *Anthericum ramosum* | 1 | C4a | |
| *Dianthus pontederae* | 1 | C4a | |

| | | | |
|---|---|---|---|
| *Listera ovata* | 1 | C4a | |
| *Neottia nidus-avis* | 1 | C4a | |
| *Polystichum aculeatum* | 1 | C4a | |
| *Schoenoplectus lacustris* | 1 | C4a | |
| *Viola mirabilis* | 1 | C4a | |

## DISCUSSION

Floodplain forests often represent a high biodiversity area in the European landscape (Ward *et al*., 2002). The species richness of certain organisms, such as vascular plants, often far exceeds that in adjacent upland habitats (Naiman *et al*., 1993; Tabacchi *et al*., 1996; Stohlgren *et al*. 1998). Concerning to the vascular plants, the study area isn´t exception, we found 761 species (591 excluding adventive species) in area of 51 km$^2$ what corresponds to about a fifth of the flora of the Czech Republic. Many authors confirm the high importance of floodplain forests for vascular plant species diversity maintenance (Tab. 9). Schnitzler *et al*. (2007) summarised available articles focused on the diversity of riparian forests across the whole of Europe and recorded 1,380 species.

**Table 9: Overview of studies focusing on vascular plant diversity of floodplain forests**

| Locality | Number of species | Size of area | Source |
|---|---|---|---|
| Forest district Valtice, Thaya River, Czech Republic | 656 | 16 km$^2$ | Maděra *et al*. (2011) |
| Forest district Tvrdonice, Morava River, Czech Republic | 612 | 22 km$^2$ | Maděra *et al*. (2013) |
| northern Croatia | 437 | | Trinajstič *et al*. (2005) |
| Current and Jacks Fork Rivers, North America | 269 | | Lyon & Sagers (1998) |
| Adour River (SW France) | 1,396 | | Tabacchi *et al*. (1996) |
| Pantanal wetland, Brazil | 2000 | 150,000 km$^2$ | Pott *et al*. (2011) |
| Seine, France | 334 | 20 plots 1 km$^2$ | Ernoult *et al*. (2006) |
| NE Wisconsin, USA | 162 | 417 plots 1 m$^2$ | Goebel *et al*. (2006) |
| Danube River | 165 | | Mölder *et al*. (2011) |
| Sado and Guadiana, Portugal | 45 (only woody plants) | 70 river sections of 2 km | Santos (2010) |
| Estonia | 372 | 1600 plots 1 m$^2$ | Paal *et al*. (2007) |
| Current River and Jacks Fork River, SW Missouri, USA | 339 | 94 plots | Lyon & Sagers (1998) |
| Cypress Creek NWR, Illinois, USA | 193 | 80 plots 1 m$^2$ | McLane *et al*. (2012) |
| Ill, Rhine, Loire and Allier | 106-157 | | Schnitzler (1997) |
| Rhine | 37 (only woody plants) | | Trémoliéres *et al*. (1998) |

Řepka *at al*. (2015) recorded a total of 732 herb and 121 woody species in whole area (89 km$^2$) of the floodplain forests of Forest Enterprise Židlochovice (Forest Districts Tvrdonice, Valtice and Soutok) demonstrating their immense importance for biodiversity of vascular plants.

History of forest management in the study area is crucial for understanding of the highly valuable current state. In the Middle Ages, coppice forests with 7 year rotation are described and coppices with standard are documented, too (Nožička, 1956). The forests were used for livestock grazing (especially pigs) due to acorn production. The ”modern forest management” began under the Lichtenstein family ownership in the middle of the 18th century (Hrib, 2004). The conversion of coppice forest to high forest started by using the way of alternate forestry (agroforestry) system. Man-made natural ecosystems sensu van Maarel (1975) were established this way, forests developed under influence of both, human activities and natural processes. Key human interventions supporting the high level of biodiversity are (i) using of habitat-original tree species (mainly oak, ash and elm) for reforestation, especially oak regeneration is problematic without artificial reforestation (Libus *et al.*, 2010) (ii) diversification of age structure of forests (Řepka & Maděra, 2009b) document that young developmental stages of forests host high diversity), (iii) creation of forest edges as a habitat with high diversity and many endangered plant species (Maděra *et al.*, 2011), (iv) maintenance of water channels bringing water inside the floodplain forests after rivers have been regulated (Vybíral & Hrib, 2000). The most important natural conditions co-creating the floodplain forests are (i) meandering rivers, (ii) high groundwater table and nutrient reach fluvisols and (iii) regular flooding (Klimo *et al.*, 2008).

Human modifications of streams and rivers have caused extensive stream channel and riparian degradation (Meixler & Bain, 2010). Since 1973, the south Moravian floodplain forests were affected by Dyje and Morava Rivers regulation within complex hydrotechnical measures (Jakubec, 1981). The most serious problem of the study area is the absence of natural hydrological regime due to the regulation of main water courses since this time. The variety of riparian plant communities found in natural floodplains is mainly controlled by the flow regime (Poff *et al.*, 1997), which generates physical disturbance and environmental stress on riparian vegetation, ultimately affecting its temporal and spatial dynamics (Shafroth *et al.*, 2002). The dynamic fluvial succession by the absence of natural hydrological regime lead to the increase of occurrence of late-serial stages (the driest types of hard-wood forests) and on the contrary, to the decrease of initial-serial stages. Gonzáles (2010) described progressive area decrease (up to 37 %) of the pioneer forest types (*Populus nigra*, *Salix alba* and *Tamarix* spp.) since the intensification of river regulation in the mediterranean region. In contrast, non-pioneer senescent forests have doubled their surface after river regulation was intensified. The same results were published by Maděra *et al.* (2010) from area under study, 60% of area was occupied by “wet hardwood” floodplain forests communities (*Querci roboris-Fraxineta*) and 30 % of area was occupied by “dry hardwood” floodplain forests communities (*Ulmi-Fraxineta carpini*) before rivers regulations. The rate was opposite after 30 years of development without flooding and decreasing ground water table (Penka *et al.*, 1991). Dams, land-use changes throughout the basin, and construction of flood defences that restrict the main channel have changed behaviour of the Ebro river system which urgently needs a management plan combining both, improvement and risk reduction (Ollero, 2010).

Technical regulations of the water regime within floodplains can also impact on the species diversity of floodplain forests. For example, Trémoliéres *et al.* (1998) compared various sections of an alluvial hardwood forest along the Rhine. Using six plots of about 2,000 $m^2$, they found 63 species (25 woody species) in a flooded floodplain, 121 species (45 woody species) in a floodplain that had not been flooded for 30 years, and 95 species (47 woody species) in a floodplain not flooded for 130 years. Deiller *et al.* (2001) mentioned that the species richness of the extant vegetation increases with the duration of interruption of the floods in the Rhine forest as a result of introduction of flood-intolerant species in the unflooded forest. By contrast, Amanda *et al.* (2005) recorded a 40 % higher number of species in unregulated floodplain of the Yampa river in contrast to the regulated Green River. Other authors also document the changes in species composition and spatial structure of the synusia of floodplain forest herb layer (Vašíček, 1985; Vrška, 1997, 1998; Maděra 2001a, 2001b; Viewegh, 2002; Unar & Šamonil, 2008; Santos, 2010) or in the tree layer (Schnitzler 1994; Trémoliéres *et al*., 1998; Janík *et al*., 2008, 2011, 2016) in dependence on drying of floodplain forests, when flood-intolerant and mesic species can arrive.

High native plant diversity in riparian biotopes is largely associated with natural disturbance, particularly flooding and scour by seasonal and storm related flood pulses, which create regeneration microsites and mediate resource competition among species (Naiman & Decamps, 1997; Naiman *et al*., 1993, 2005). Frequent natural or anthropogenic disturbances, however, can also create conditions conducive to alien plant establishment (De Ferrari & Naiman, 1994; Pyšek & Prach, 1994; Planty-Tabacchi *et al*., 1996; Pyle, 1995; Stohlgren *et al*., 1998). We found 177 adventive species in the study area, it is 23.2 % of all vascular plants creating the floodplain forest communities. Many other authors confirmed the sensitivity of floodplain forests to adventive species invasion (Tab 10).

**Table 10 Comparison of adventive vascular plant species occurrence in floodplain forests in various parts of the World**

| Locality | No of adventive species | Ratio of the total (%) | Source |
|---|---|---|---|
| Allegheny River Islands Wilderness (northwestern Pennsylvania) | 40 | 17.8 | Williams (2010) |
| Mura River (NE Slovenia) | | 15.0 | Košir *et al.* (2013) |
| Cypress Creek NWR, Illinois, USA | | 14.4 | McLane *et al.* (2012) |
| Yampa and Green rivers (northwest Colorado, USA) | | 30.0 | Amanda *et al.* (2005) |
| Upper Danube | | 7.0 | Mölder & Schneider 2011 |
| Middle Danube | | 14.0 | Mölder & Schneider 2011 |
| Lower Danube | | 10.0 | Mölder & Schneider 2011 |
| eastern Oregon, USA | 60 | 14.5 | Magee *et al*. (2008) |

Schnitzler *et al*. (2007) summarised 1,380 species across European riparian forests, 45 (3.3 %) of these were exotic (adventive) species. Pyšek *et al*. (2012b) found that the proportion of neophytes in floodplain forests of the alliance *Alnion incanae* (incl. *Ulmenion* suballiance) was 2.2 ± 2.8 %, in coverage 4 ± 10 %, which is the highest number within the forest communities of the Czech Republic. Our study shows higher average proportion of neophytes in the study area (10.5 %). A number of large-scale studies have confirmed that floodplain forests are one of the most invaded forest habitats (Chytrý *et al*., 2005; Petrášová *et al*., 2013; Řepka *et al*., 2015).

Many exotics found in Schnitzler´s *et al* (2007) study were introduced intentionally either from North America (51 %) or Asia (38 %). The exotics belong to various life-forms: approximately 50 % are grasses (polycarpic perennials, summer and autumn annuals), while the rest are phanerophytes, equally distributed among trees, shrubs and liana life-forms. Most of the exotics are thermophilous and light-demanding pioneer species from warm temperate floodplains. Thirty-two percent are from the *Asteraceae* family. The distribution of exotics in the 177 communities recorded is highly unequal. Twenty-six are present at low levels in very few communities; seven have an intermediate distribution; and twelve (27 %) are abundant in a large range of habitats (in compliance with our results there are for example *Impatiens parviflora*, *Erigeron canadensis* or *Solidago gigantea*). The most important adventive tree species were *Fraxinus pennsylvanica* (Middle and Lower Danube), *Acer negundo* (Middle Danube) and *Robinia pseudacacia* (Upper Danube), which reached considerable proportions in the tree layer. Frequent adventive herb species were *Impatiens parviflora* and *Solidago* *gigantea* (Upper and Middle Danube), *Aster parviflorus*, *Oxalis stricta* (Middle Danube) and *Aster lanceolatus* (Lower Danube). The invasive shrub species *Amorpha fruticosa* was very common on the Lower Danube (Mölder & Schneider, 2011). Also, Chmura & Sierka (2006) in their study of Polish floodplain forests consider *Impatiens parviflora* to be a significant invasive species.

Floodplains are considered vulnerable to exotic species (Hood & Naiman, 2000; Harris *et al*., 2005), due to the combined influence of intensive human exploitation, a high degree of hydrological connectivity that facilitates propagule dispersal and the high spatial and temporal heterogeneity inherent to these systems. Globally, anthropogenic alterations to floodplain hydrological regimes have frequently resulted in riparian species invasions (Richardson *et al*., 2007). Vegetation changes are partially structured by reduced flood frequency favouring increased abundance of exotic, sexually reproducing annuals at drier sites. Sites of low flood frequency are more sensitive to future exotic weed invasion. Flow restoration is predicted to benefit propagule dispersal of species adopting dual regeneration strategies, which are predominantly natives in this system (Stokes *et al*., 2010). The invasion by alien plant species is a major challenge to the conservation and management of riparian areas, which can alter ecosystem structure and function in undesirable ways (Hood & Naiman, 2000; Stohlgren *et al*., 1998). The invasive species capable of becoming dominant are the most dangerous, and in the study area it is *Aster lanceolatus* (Řepka *et al*., 2009a). Brewer (2010) described a similar example: a significant negative effect of species richness on invasive grass *Microstegium vimineum* abundance. According to investigation of Saccone *et al*. (2010), *Acer negundo* showed both a high survival in the shade and a high growth in full light. This species could be an example of adaptive plasticity that certainly represents a competitive advantage over native species. Another example is mentioned by Hanula & Horn (2011); they investigated the effects of the invasive shrub Chinese privet (*Ligustrum sinense*). Pyšek & Prach (1993) named four significant invasive species in riparian habitats of central Europe: *Impatiens glandulifera*, *Heracleum mantegazzianum*, *Reynoutria japonica* and *R. sachalinensis*; none of these has caused a significant problem in the study area.

## CONCLUSIONS

Natural riparian corridors are the most diverse, dynamic and complex biophysical habitats on the terrestrial part of the Earth. Riparian corridors, as interfaces between terrestrial and aquatic systems, encompass sharp environmental gradients, ecological processes and communities. Riparian corridors are an unusually diverse mosaic of landforms, communities and environments within wider landscape. They serve as a framework for understanding of the organisation, diversity and dynamics of communities associated with fluvial ecosystems. Riparian corridors possess an unusually diverse array of species and environmental processes and they should play an essential role in water and landscape planning, in the restoration of aquatic systems, and in catalyzing institutional and societal cooperation for these efforts (Naiman *et al*., 1993).

Unfortunately, floodplains forests belong to the most endangered communities not only in Europe (Wenger *et al*., 1990; Klimo & Hager, 2000) affected by diverse human negative interventions. The most serious are hydrotechnical river regulations (Dynesius & Nilsson, 1994). Meixler & Bain (2010) developed the cost-effective, rapid assessment tools can be used to better manage such areas by identifying the status of habitats for restoration planning and protection. Managers can use these cost-effective strategy development tools to identify candidate reaches for further study and prioritize stream channel and riparian restoration actions over large regions. Our results could serve as an unique basis for such management measures.

Gonzáles (2010) recommended measures principally aimed at recovering some hydrogeomorphic dynamism to guarantee the self-sustainability of the floodplain forest ecosystem. In this sense, according to Comín *et al*. (2005), the most effective restoration approach should focus on the recovery of some hydrogeomorphic dynamism (i.e., channel migration, periodic creation of new barren sites, reactivation of secondary channels, meander cut-offs, renaturalized hydroperiod, etc.) both, at the basin and the reach scale, within the current socioeconomic context. Thus, the ideal hydrogeomorphic regime would not necessarily be the preregulation state but one 'renaturalized', which led to a selfsustainable forest structure at patch and landscape scale, guaranteed their ecological functions and provided services to society (Dufour & Piégay, 2009).

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