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Endangered flora of Gdańsk Pomerania – its distinctiveness and diversity

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Abstract. Gdańsk Pomerania is a region characterized by unique physiographic features and diverse flora. This region, as many other areas, is subject to numerous accelerating transformations. The occurrence of numerous species on their range edges and on isolated stands, e.g. mountain and xerothermic grassland species, was an important criterion in the development of a regional red list of vascular plants of Gdańsk Pomerania (Markowski & Buliński 2004). On this list, 648 species of vascular plants, which constitute about 39% of the regional flora and 26% of all Polish flora, are considered to be endangered at various levels. In total, 47 species have been declared extinct in the aforementioned region (RE), 39 taxa are considered as critically endangered (CR) and 109 – as endangered (EN). Further 222 plant species are classified as vulnerable (moderately endangered) (VU), 124 have low risk categories (NT or LC) and there are 107 taxa of unknown threat, due to lack of sufficient information (DD). The aim of this work was to synthesize endangered components of Gdańsk Pomerania vascular plant flora for their better recognition and characterization. Among the species varying in threat degrees, the authors identified species protected by law and endangered in Poland as well as globally. In addition, the participation of species diagnostic of individual phytosociological units was verified. Also, the share of taxa representing various geographical elements was indicated.

Key words: regional red list, vascular plant species, regional floristic specificity

1. Introduction

Gdańsk Pomerania (Fig. 1), due to its geographic location and geological history, is characterized by rich physiographical and floristic diversity. The abrasive influences of the suboceanic and subcontinental climate are reflected in a high number of taxa, which represent different geographic elements. The spatial diversification of the flora, the presence of mountain, xerothermic, dune, fertile deciduous forest and halophylous species as well as a rich variety of lake and river flora constitute a great value of this area.

The flora of Gdańsk Pomerania is relatively well-documented. The first extensive research on the local flora was conducted by German researchers at the end of the 19th and beginning of the 20th century, e.g. Abromeit *et al.* (1898-1940). The first important work published by Polish scientists was Zygmunt Czubiński's publication concerning geobotanical problems of Pomerania (Czubiński 1950). Further botanical works broadened our knowledge of regional floristic diversity. They intensified after the establishment of an academic centre in Gdańsk with various Polish botanists, including Hanna Piotrowska (Latałowa 2006-2007). These studies are still being conducted, allowing us to update and broaden botanical knowledge of the regional flora.

Both numerous anthropogenic transformations to which Gdańsk Pomerania has been subjected, and the fact that the regional flora consists of numerous species on their range edges and on isolated stands, e.g. mountain and xerothermic grasslands species, were important criteria in the development of a regional red list of vascular plants of Gdańsk Pomerania.

The list of rare and threatened components of Gdańsk Pomerania flora was published in 2004 (Markowski & Buliński 2004). It consists, altogether, of 648 plant

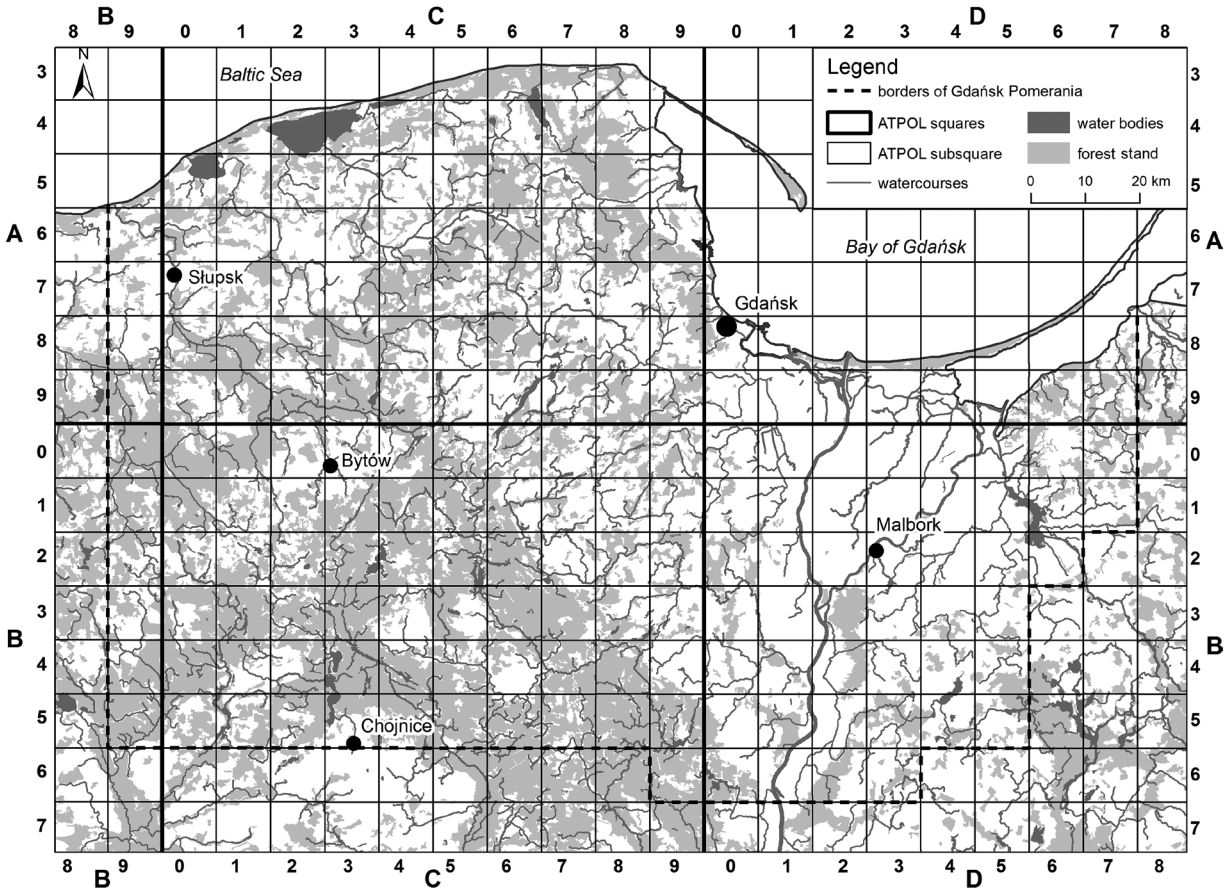


Fig. 1. Gdańsk Pomerania area

species, of which 195 taxa are considered as highly endangered. This group constitutes 30.1% of the entire analysed flora (categories RE – 47 species, CR – 39, EN – 109) (Fig. 2). Vulnerable species (VU) form the greatest share (34.3%) – 222 taxa. Species of a lower threat risk consist of 124 taxa making up 19.1% of the considered flora (NT – 116 spp., LC – 8 spp.) and the rest 16.5% is taken by species of unknown threat, which is due to lack of sufficient information (DD – 107 spp.).

The aim of this work was to synthesize endangered components of Gdańsk Pomerania vascular plant flora for their better recognition and characterization. This is related to the ongoing work on the regional red book of vascular plant species.

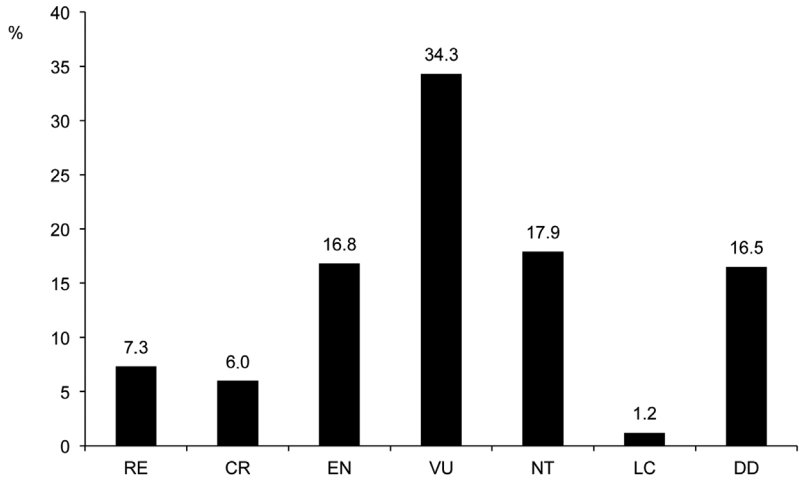


Fig. 2. Percentage of species in various threat categories included in the regional red list of plant species (Markowski & Buliński 2004)
Explanations: RE – regionally extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT – nearly threatened, LC – least concern, DD – data deficient

2. Material and methods

The species included in the red list of vascular plants of Gdańsk Pomerania (Markowski & Buliński 2004) were analysed in terms of their contemporary protection status (Regulation 2014) and threat category in Poland (Kaźmierczakowa *et al.* 2016), as well as globally (The IUCN 2018). The share of species, which are diagnostic of individual phytosociological and socio-ecological units (Kącki *et al.* 2013) was also verified. In addition, the share of taxa representing various geographical elements was indicated (Zając & Zając 2009). The categories of threat to which we refer in this work are adopted from Markowski and Buliński (2004): RE – regionally extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT – nearly threatened, LC – least concern, DD – data deficient.

3. Results

Vascular plant species of Gdańsk Pomerania included in the study of Markowski and Buliński (2004) constitute about 32% of the total regional flora (Markowski & Buliński 2004) and about 22% of all Polish flora (Mirek *at al.* 2002).

About thirty percent of valuable components of the regional flora (195 species) are protected by law (Regulation 2014), of which 134 are strictly protected and 61– partially protected (Fig. 3). It is noteworthy that species with the highest threat categories are often strictly protected: approximately half of the regionally extinct (RE) and critically endangered (CR) species are included in this form of protection, while among endangered species (EN) – one third. Among partially protected species, the largest group are mainly vulnerable species (VU). In this group, however, extinct species in the region of Gdańsk Pomerania were also found, e.g.: *Anemone sylvestris*, *Asplenium septentrionale*, *Orobanche coerulescens*, *O. purpurea* or *O. ramosa*.

Over 46% (346 taxa) of the threatened components of Gdańsk Pomerania flora are mentioned in the latest edition of the Polish national red list of vascular plants (Kaźmierczakowa *et al.* 2016) (Fig. 4). However, differences between categories assigned to species reveal regional specificity of Gdańsk Pomerania. Part of the species with a high threat category (CR, EN) in Poland are closely related to the region described, and are, therefore, less threatened there (VU). Among them, there are taxa occurring in habitats characteristic to Gdańsk Pomerania, like: lobelia lakes – *Lobelia dortmanna*, *Littorella uniflora*, *Luronium natans* and *Myriophyllum alterniflorum*, peatlands – *Drosera anglica* and *D. intermedia*, or coastal dunes – *Atriplex littoralis* and *Linaria odora*. At the same time, other species are considered to be regionally extinct (RE) or critically endangered (CR) in Gdańsk Pomerania, although they are vulnerable (VU) or nearly threatened (NT) on national scale. In many cases, this is due to lack of adequate habitats for those plants. Examples of xerothermic grassland or mountain species such as: *Adonis vernalis*, *Asplenium septentrionale*, *Stipa capillata* and *Tofieldia calyculata* deserve mention. One should also mention a group of species relatively widespread in Poland and, therefore, not included in the national red

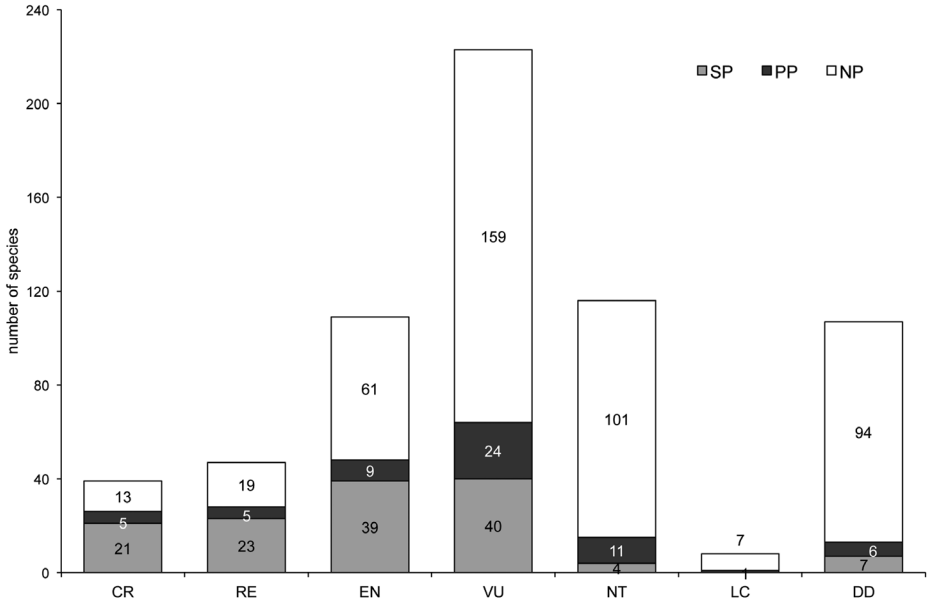
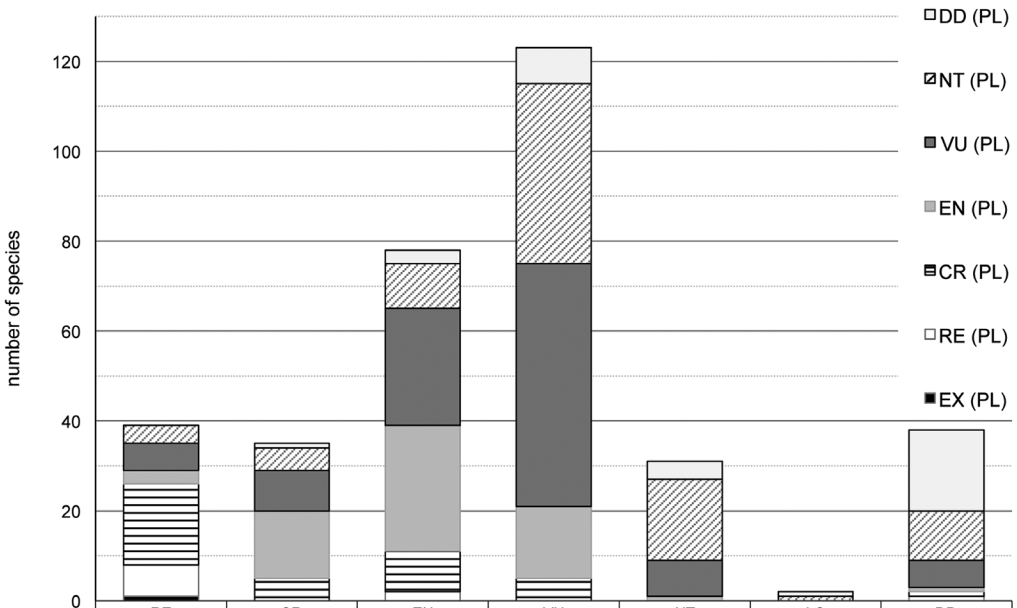


Fig. 3. Number of endangered species from the red list of Gdańsk Pomerania (Markowski & Buliński 2004) with regard to the law's protection of taxa in Poland (Regulation 2014)
Explanations: NP – species not protected, PP – species partially protected, SP – species strictly protected by law; categories of threats see Fig. 2



	RE	CR	EN	VU	NT	LC	DD
DD (PL)	0	1	3	8	4	1	18
NT (PL)	4	5	10	40	18	1	11
VU (PL)	6	9	26	54	8	0	6
EN (PL)	3	15	28	16	1	0	1
CR (PL)	18	5	9	5	0	0	1
RE (PL)	7	0	2	0	0	0	1
EX (PL)	1	0	0	0	0	0	0

Fig. 4. Participation of endangered species from the red list of Gdańsk Pomerania (Markowski & Buliński 2004) in relation to the classification of taxa endangered in Poland (Kaźmierczakowa et al. 2016)
Explanations: PL – categories from the Polish red list (Kaźmierczakowa *et al.* 2016), EX – extinct, RE – regionally extinct, CR – critically endangered, EN – endangered, VU – vulnerable, NT – near threatened, DD – data deficient

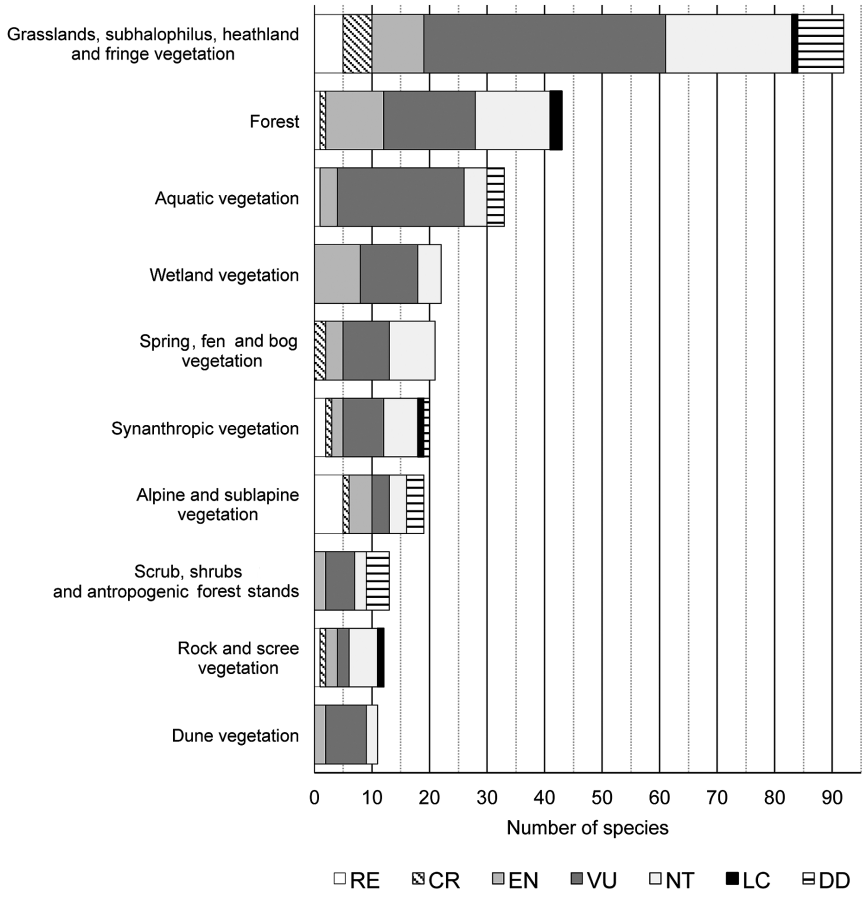


Fig. 5. The share of species diagnostic of individual socio-ecological groups in different threat categories from the red list of Gdańsk Pomerania

list but, at the same time, highly endangered in Gdańsk Pomerania (with categories RE – 8 taxa and CR – 5 taxa), e.g. *Anemone sylvestris*, *Asplenium viride*, *Cerastium sylvaticum*, *Cirsium rivulare*, *Cruciata laevipes* and *Gymnocarpium robertianum*. Again, this indicates regional specificity of the area described. Other species not included on the national red list are: EN – 30, VU – 99, NT – 85, LC – 6, and DD – 69 taxa.

Among regionally endangered flora, 121 species (slightly over 22%) are also considered to be at a lower threat risk on a global scale. They represent three categories of threat (NT, LC, DD) according to the IUCN Red List of Threatened Species (The IUCN 2018). However, the most numerous group are species with the LC category (115 spp.).

Of the Red List of Gdańsk Pomerania vascular plant species, 44% are characteristic of various phytosociological units. In total, the most numerous group consists of species diagnostic of grasslands, subhalophilus, heathland and fringe vegetation (92 spp.) (Fig. 5). Among this group, regionally extinct (RE) and highly endangered (CR) species have a relatively high share (10 taxa). Species characteristic of halophilous meadows (*Salicornia europaea*), intermittently wet meadows (*Gentiana pneumonanthe*) or xerothermic grasslands (*Stipa capillata*, *S. joannis*) can be given as examples here. A group of species recognized as diagnostic of forest vegetation (43 taxa) is also numerous. The remaining groups are relatively smaller. Other highly endangered species (categories RE or CR) belong to the: alpine and subalpine vegetation (6 taxa, e.g. *Arnica montana*, *Swertia perennis*), synanthropic vegetation (*Anagallis foemina*, *Lolium remotum* and *Orobanche pallidiflora*), forest vegetation (*Adenophora lilifolia* and *Asperula tinctoria*), rock and scree vegetation (*Gymnocarpium robertianum* and *Asplenium septentrionale*), spring, fen and bog vegetation (*Gentianella uliginosa* and *Pinguicula vulgaris* subsp. *vulgaris*) and aquatic vegetation (*Pilularia globulifera*).

In regional flora, due to sea shore presence, dune habitat species are important, 11 of which are present on the Gdańsk Pomerania red list. Among them, endangered species (EN) such as *Elymus farctus* subsp. *boreali-atlanticus* occur. Dune taxa with lower threat categories and relatively numerous sites in the region are e.g. *Cakile maritima*, *Festuca polesica*, *Lathyrus japonicus* subsp. *maritimus*, *Linaria odora* and *Salsola kali* subsp. *kali*.

In addition, approximately 5% of the Gdańsk Pomerania valuable flora species are diagnostic of highland communities, including scree cliffs, subalpine and alpine grasslands. These taxa are found only in a few locations and are specific elements of the regional flora (Markowski 1986). Due to the lack of typical habitats in this lowland area, they appear most commonly in anthropogenic habitats (rock embankments, walls and buildings, e.g. *Asplenium ruta-muraria*, *A. trichomanes*, *Cymbalaria muralis*) and sites with specific microclimatic conditions, such as eroded river valleys and moist slopes of northern exposure (e.g. *Huperzia selago*, *Poa chaxii*).

In terms of phytogeography, in the analysed group of components of Gdańsk Pomerania flora, species classified as Holoarctic elements are dominant (Fig. 6). Within this group, the following sub-elements: Eurotemperate, Circum-Boreal and Euro-Siberian, have the largest share. Among them, the participation of species with a specific threat category reflects general trends prevailing in the whole region (e.g. a large number of endangered, vulnerable and near-threatened species). Species belonging to the Amphi-Atlantic and Arctic-Alpic sub-element form only a small part of the list. These species mostly occupy high threat categories in the region (RE, CR, EN).

The Amphi-Atlantic sub-element, together with Pontic-Pannonian species are an important and specific feature of the endangered flora of Gdańsk Pomerania. Those species reach their range edges here, e.g. Amphi-Atlantic species: *Carex demissa*, *Erica tetralix*, *Rhynchospora fusca*, and within Pontic-Pannonian species: *Adonis vernalis*, *Hieracium echioides* or *Veronica vindobonensis*.

Other important species in the region described are those classified as Circum-Boreal and Arctic-Alpic sub-elements, e.g.: *Carex chordorrhiza*, *C. pauciflora*, *Nuphar pumila* or *Rubus chamaemorus*, which are also considered to be relic species in Pomerania.

4. Discussion

The red list of vascular plants for Gdańsk Pomerania (Markowski & Buliński 2004) is a list commonly used in practical activities in the field of nature protection. It is highly valuable, which is due to the fact that it concerns regional flora, and, as it is well known, the scale of species threat changes with respect to the size and habitat diversity of a given area. Numerous regional red lists have been created for different parts of our country, for example: a red list for Lower Silesia (Kącki *et al.* 2003), Greater Poland (Jackowiak *et al.* 2007), Lublin region (Cwener *et al.* 2016), Małopolska Upland (Bróż & Przemyski 2009), Western Pomerania (Żukowski & Jackowiak 1995) or Kuyavian-Pomeranian region (Rutkowski 1997).

Differences between the national list (Kaźmierczakowa *et al.* 2016) and the list for Gdańsk Pomerania (Markowski & Buliński 2004) indicated in the results show the need for the existence of regional lists. These regional lists are an important tool for environmental management on a regional scale, as well as in planning

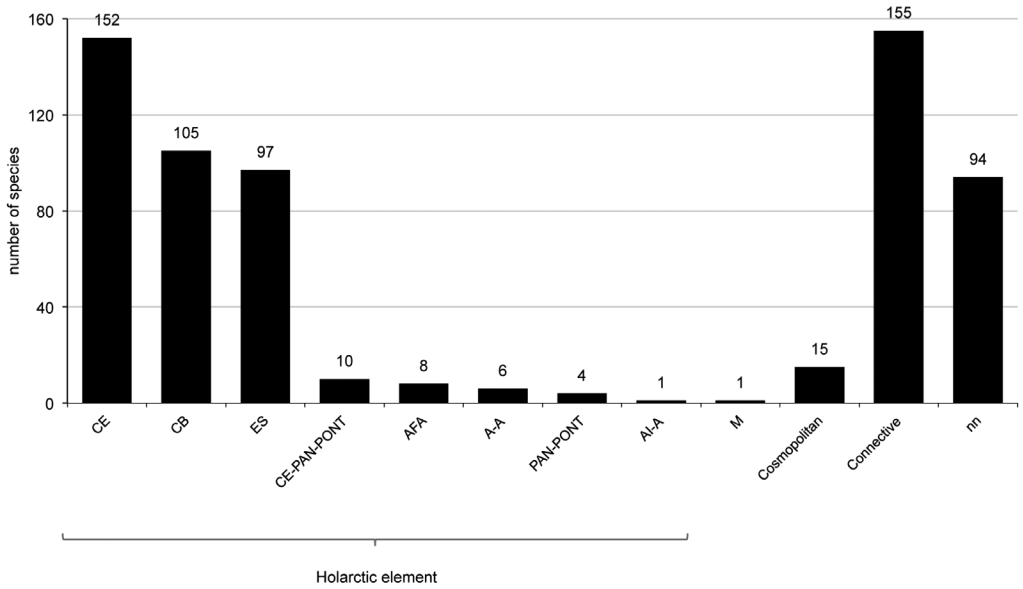


Fig. 6. Geographical element and sub-element contribution to the rare and endangered flora of Gdańsk Pomerania
Explanations: CE – European-temperate sub-element, CB – Circumboreal sub-element, ES –Euro-Siberian sub-element, CE-PAN-PONT – European-temperate sub-element and Pontic-Pannonian sub-element, AFA – Amphi-Atlantic sub-element, A-A – Arctic-Alpine sub-element, PAN-PONT – Pontic-Pannonian sub-element, Al-A – Altaic-Alpine sub-element, M – Mediterranean element, nn – species not classified

protection of plant genetic resources (Olaczek & Ławrynowicz 1986). However, in order to make it possible to compare regional lists, it is necessary to use uniform threat categories assigned according to similar assessment criteria, which was already postulated, among others, by Kącki *et al.* (2003).

In relation to the red lists of vascular plants for regions neighbouring with or partially including Gdańsk Pomerania, the degree of local flora threat is similar between Gdańsk Pomerania (Markowski & Buliński 2004) and Western Pomerania (Żukowski & Jackowiak 1995), 39% and 34%, respectively. The flora of Kuyavian-Pomeranian region is slightly less threatened – 25% of the species that form the local flora are included on the red list (Rutkowski 1997). The same pattern can be observed for species with the highest threat degree (EX/RE, CR, E/EN, V/VU); for Gdańsk Pomerania this number is 30%, for Western Pomerania – 38%, and for the Kuyavian-Pomeranian region – only 11%.

The group of endangered or rare plant species in Gdańsk Pomerania consists of the total of 195 taxa protected by law (Regulation 2014). However, at the time when the Gdańsk Pomerania red list was being prepared, a different regulation (Regulation 2001) was in force. One of the most important changes that occurred due to the introduction of the new regulation was that the total number of species protected by law is now greater: 195 in comparison to 116 species protected according to the 2001 Regulation. In particular, the number of species under partial protection increased significantly: from 6 to 61. In addition to quantitative changes, there were changes in quality. On the one hand, 25 species had their status changed from strictly protected to partially protected. Among this group, there were species with a high regional threat level, like: *Anemone sylvestris* (RE), *Cimicifuga europaea* (EN), *Pedicularis sylvatica* (EN), *Platanthera chlorantha* (EN). On the other hand, there was a group of highly endangered species in the region of Gdańsk Pomerania that was not protected at the time of the red list preparation, but is strictly protected now. It includes: 7 regionally extinct species (RE), 9 species with CR category and 17 endangered species (EN). Overall, changes in the list of protected species should be considered as positive.

As far as the share of species diagnostic of individual socio-ecological groups is concerned, in the case of Gdańsk Pomerania red list, there are mainly species characteristic of vulnerable habitats such as: oligotrophic lakes, bogs, wetlands, dunes as well as habitats occurring infrequently in the region, like mountain species. However, it should be noted that there is also a relatively numerous group of synanthropic species included on the red list of Gdańsk Pomerania. For many years, this group was not included when the red list was under preparation. Relatively recently, attention has been paid to the process of deterioration of these species and their habitats. Red lists dedicated especially to this group of plants were published, e.g. a list prepared by Warcholińska (1986-1987), Warcholińska (1994), Zając *et al.* (2009) or Anioł-Kwiatkowska and Szczęśniak (2011).

Altogether, 14 years have passed since the list of endangered and threatened vascular plants of Gdańsk Pomerania was published. On the one hand, during that

period, negative anthropogenic impacts in the region of Gdańsk Pomerania, as in other parts of the country, have been intensifying. This, as well as natural processes of flora transformation, contribute to the decline in the number of valuable species (e.g. Afranowicz 2006, 2007; Herbichowa & Herbich 2006; Budyś 2008; Lazarus & Wszałek-Rożek 2016) and, as a result, the threat status of many species is changing. On the other hand, current research reveals new locations of rare species, such as: *Carex chordorrhiza* (Kujawska & Afranowicz-Cieślak 2013), *Cephalanthera rubra* (Olszewski 2010), *Cirsium rivulare* (Naczk & Kazimierski 2011), *Elymus farctus* subsp. *boreali-atlanticus* (Górski *et al.* 2015), *Hammarbya paludosa* (Bloch-Orłowska 2005), *Rhynchospora fusca* (Budyś *et al.* 2004), *Saxifraga hirculus* (Gdaniec 2010; Gdaniec & Markowski 2010; Gdaniec & Schütz 2010) or even those recognized earlier as extinct: *Orchis mascula* (Bąk *et al.* 2014), *Orobanche purpurea* (Nowakowski *et al.* 2011), *Salicornia europaea* (Wszałek-Rożek 2009). Both of these phenomena make it necessary to update red lists.

The present level of regional flora recognition is still insufficient, especially in unprotected areas and areas intensively exploited by man. Therefore, further research that will bring the current information up-to-date and allow a more comprehensive analysis of the flora is needed. This was the main priority for the authors of the paper in starting their work on the Red Book of Gdańsk Pomerania flora. It will certainly provide new and more detailed information on the current state of Gdańsk Pomerania flora, while – at the same time – allow for a more accurate assessment of the extent of its transformation and threats.

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