

New records of protected, threatened, and rare vascular plant species in the Lower Bug Valley (eastern Poland)

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Abstract. We present new localities and verified published records of protected, rare, and threatened vascular plant species in the Mazovia region, mostly in the left-bank part of the Lower Bug Valley (Dolina Dolnego Bugu). Some localities are in the Wołomin Plain (Równina Wołomińska) and the Siedlce Plateau (Wysoczyzna Siedlecka). The analysed species occur in various natural and semi-natural habitats, such as xerothermic and sandy grasslands, floodplain meadows, wetlands, bogs, and forests. Data were collected during field research carried out in 2021-2023. In the left-bank part of the Lower Bug Valley, 45 species of protected plants were recorded, but also red-listed or regionally rare plants (90 species in total). They include 16 species are under strict protection, 29 under partial protection, and 35 species are rare in the region. Some of the localities described earlier by other authors were found again or verified. In the Lower Bug Valley, there are almost all plant associations known from Mazovia, including the extremely valuable boreal *Sphagno girgensohnii-Piceetum*, protected in the “Jegiel” reserve. There are also oak forests on the edge of the Siedlce Plateau. The valleys of the Bug and its tributaries are dominated by areas of cultivation, arable fields, meadows, and forests. Some species considered to be common in other regions are rare in the Bug river valley, e.g. *Hepatica nobilis*, *Asarum europaeum*, *Isopyrum thalictroides*. This is because their habitats are sparse or degraded. However, some other species, rare in other regions, are common in the study area, e.g. *Allium angulosum*, *Euphorbia lucida*, and *Hierochloë odorata* on floodplain meadows, *Salvinia natans* in oxbow lakes, and *Arctostaphylos uva-ursi* in pine forests and sandy grasslands. The only locality of *Blechnum spicant* in this part of Mazovia was found in this study. The species is characteristic of montane forests and fir-spruce forests. Two localities of *Diphasiastrum tristachyum* were recorded, in typical habitats of this species: heaths formed after forest fires.

Key words: Bug river, vascular plants, distribution, protected plants, river valley, floodplain meadow

1. Introduction

The distribution of protected, threatened, and rare plant species in the Lower Bug Valley (Dolina Dolnego Bugu) is poorly studied. In this mesoregion, comprehensive research on the flora of the Bug river valley was presented by Faliński *et al.* (2000) in the “Geobotanical atlas of the Bug Valley” and by Ciosek *et al.* (2002-2004) in the “Protection Plan for the Bug River Landscape Park”, whereas Kalinowski (2012, 2013, 2014) studied the neighbouring mesoregion Podlasie Bug Gorge (Podlaski Przełom Bugu). The “Geobotanical atlas of the Bug Valley” provides data on the distribution of 1123 species of vascular plants, including alien ones that occur spontaneously and those that have escaped from cultivation. The records of rare and protected vascular plants in the

Natura 2000 area “Wydmny Lucynowsko-Mostowieckie” (PLH 140013) are comprehensively described by Ciosek (2000, 2003) and the lichens by Jastrzębska (2010). The segetal flora was studied by Skrzyżczyńska & Rzymowska (2001) in mesoregion Podlasie Bug Gorge. Few sites of protected, rare, and threatened plants were later described by Dembiczy *et al.* (2014) and Marciniuk *et al.* (2018). The flora of the “Mokry Jegiel” reserve near Sadowne was investigated by Wierzba *et al.* (2008) and “Podjabłońskie” reserve near Kosów Lacki (Wierzba & Marciniuk 2003). Of the numerous tributaries of the Bug river, the flora of the Liwiec river system is the best described. The flora of the edge of the Liwiec valley in the Jadów commune was inventoried by Kot *et al.* (1990). The flora of agroecosystems of river valleys, including the Liwiec, was studied by Ługowska (2020). Field

research was carried out using the transect method in only 2 locations: near Stachów (FC8066) and Zawiszyn (FC9101). In the northern parts of the mesoregions of Węgrów Lowland (Obniżenie Węgrzowskie) and Siedlce Plateau (Wysoczyzna Siedlecka), Głowacki *et al.* (1990) conducted research on rare species, which resulted in the development of the “The Red List of vascular plants of South Podlasie Lowland”. The flora of vascular plants in the Liwiec valley, from Łochów to the mouth of the Bug river in Kamięńczyk, was described by Szulc (2023). Plants of synanthropic and semi-natural habitats of the Bug valley and adjacent areas were described by Ciosek (1985a), who provided also materials for the flora of Podlasie and Mazovia (Ciosek 1985b, 1990) and the vascular flora of the Natura 2000 area “Wydmy Lucynowsko-Mostowieckie” (Ciosek 2000, 2003). The research of Ćwikliński *et al.* (1987), Ćwikliński & Głowacki (1990, 1995), Głowacki (1984, 1990, 1995), Głowacki & Stańczuk (1984), Głowacki & Celińska (1990), and Głowacki *et al.* (1990) contributed markedly to the recognition of the flora of this area. Most of the historical bibliographic data from the Bug river valley area, from the 18th century to 1999, were revised by Ciosek (2000).

In this study, mapping the distribution of plants in the Bug river valley, our major aim was to find and document new sites. The study also provided an opportunity to verify the sites presented in the past by other authors, which are described below. Additionally, the research contributed to the identification and localization of many rare vegetation units, including habitats listed in the Council Directive 92/43/EEC (1992) on the conservation of natural habitats and of wild fauna and flora, for example: 2330 – inland dunes with open

Corynephorus and *Agrostis* grasslands; 7110 – raised bogs; 4030 – dry heaths; 6410 – *Molinia* meadows (All. *Molinion caeruleae*); 6440 – *Cnidium* meadows (All. *Cnidium dubii*); and 91D0 – bog woodland.

2. Material and methods

The research covered primarily the left-bank part of the Bug valley, which is located entirely in the geographical mesoregion of the Lower Bug Valley (Kondracki 2002). Additionally, some of the investigated sites are located on the northern edge of the Siedlce Plateau and in the eastern and north-eastern parts of the Wołomin Plain (Równina Wołomińska). These areas are close to the Lower Bug Valley, with forests and numerous tributaries of the Bug and their valleys. Particularly well-recognized woodlands are the Kamieniec Forest (Puszcza Kamieniecka) and Miedzyń Forests (Lasy Miedzyńskie). The designated research area based on the digital terrain model covers 1140 km². Within the designated area there are 28 ATPOL squares (10 km × 10 km), numbered starting from the number 0 (Zajac 1978), and 1443 smaller squares (1 km × 1 km), of which about 50% have been surveyed (Fig. 1).

In the research area there are almost all forest associations known from Mazovia, including the extremely valuable boreal spruce forest *Sphagno girgensohnii-Piceetum* protected in the “Jegiel” reserve. There are also thermophilous oak forests (*Potentillo albae-Quercetum petraeae*) on the edge of the Siedlce Plateau and mineral hills. The valley of the Bug and its tributaries is dominated by floodplain meadows (Cl. *Molinio-Arrhenatheretea*), croplands, sandy grasslands as well as oxbow lakes and wetlands in former river beds.

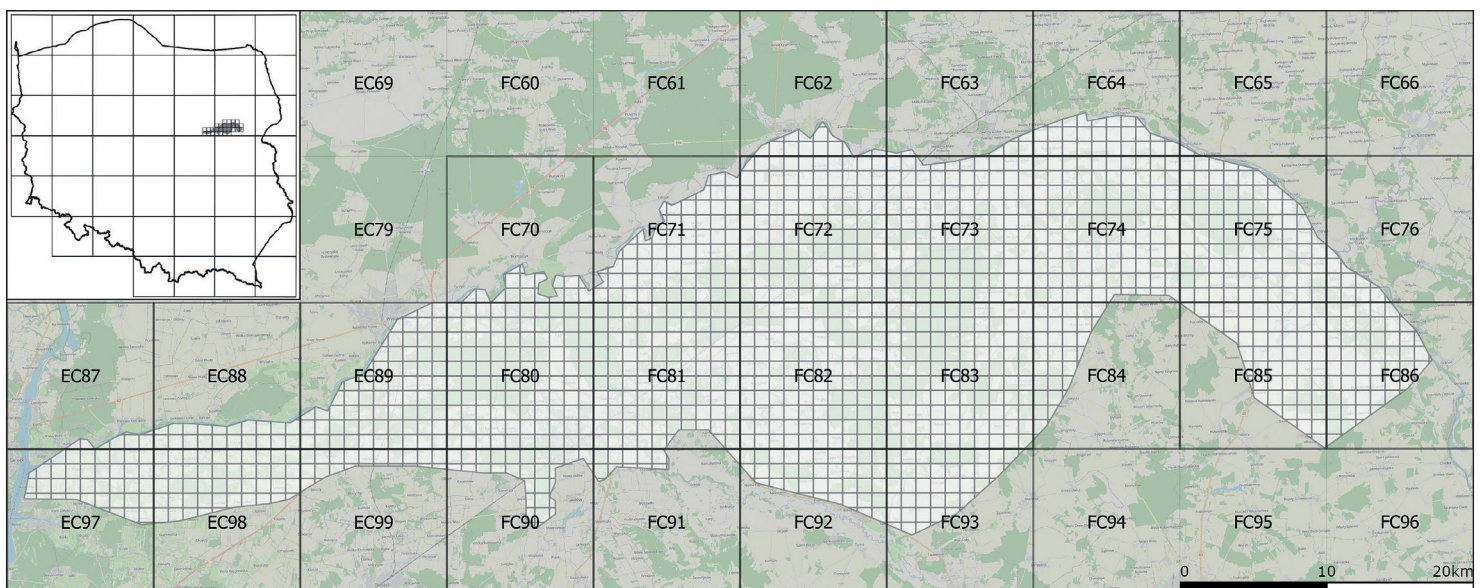


Fig. 1. Location of the research area on the ATPOL grid (10 km × 10 km)

We collected available information on locations of species that are protected (Rozporządzenie 2014), threatened according to the “Polish Red List of ferns and flowering plants” (Kaźmierczakowa *et al.* 2016) or regionally rare. In 2021-2023, the occurrence of these taxa was verified in the field but also previously undescribed sites were searched for, using transects and field routes (total distance 5000 km). The date of the last observation of a given species, its location, as well as the status and size of the local population were recorded. Because of the very large size of the research area and the related predominance of forests, grasslands and croplands, most of information was obtained from such habitats. All the habitats are included in the present publication, while records of species of habitats covering small areas will be published after detailed research, e.g. in peatlands or oxbow lakes. The precise location was recorded using a Garmin GPSMap64ST GPS device, and data were collected using QGIS software. The species nomenclature was adopted according to the concept of Mirek *et al.* (2020). The list of species was compiled alphabetically according to the following scheme:

- (1) species name;
- (2) number of the basic ATPOL square (10 km × 10 km) and specification of positions in smaller ATPOL squares (1 km × 1 km);
- (3) type of protection: PP – partial protection; SP – strict protection;
- (4) threat category according to the Polish Red List (Kaźmierczakowa *et al.* 2016): EN – endangered; CR – critically endangered; NT – near threatened; VU – vulnerable; DD – data deficient, so it is difficult to determine the risk of extinction;
- (5) species rare in the region, marked with the letter R;
- (6) description of sites: location, population size, habitat;
- (7) verified sites, reported earlier by other authors, were marked with asterisks (*) and references were provided.

3. Results and discussion

3.1. List of species

To facilitate localization of villages and nature reserves, the name of commune (c.) is given in brackets.

Allium angulosum L.; PP

In western and central parts of Lower Bug Valley, very common in floodplain meadows but less common eastwards. Most numerous in squares: EC88, 89 / FC62, 70, 71 (Fig. 2A).

Andromeda polifolia L.; PP

FC80: 64 – 1 km N of Załącze (Jadów c.), 4 m², moist pine forest / FC81: 07 – valley of Dzieciołek river,

NW of “Czaplowizna” reserve (Łochów c.), a few m², swampy birch forest; 25 – W part of “Wilcze Błota” reserve (Łochów c.), a few m², moist pine forest; 28 – in ecological site No. 479, ca. 1.5 km NE of Ostrówek Węgrowski (Łochów c.), several dozen m², peatland; 30 – 2.5 km N of Gwizdały (Łochów c.), several dozen m², moist pine forest / FC82: 00 – N of Topór (Stoczek c.); 2 patches ca. 6 m² each, pine swamp forest.

Androsace septentrionalis L.; VU

FC71: 90 – flood barrier NW of Wywłoka (Łochów c.), from several dozen to several hundred individuals in different years, sandy grassland / FC70: 89 – flood barriers, ephemeral populations.

Anthericum ramosum L.; R

FC72: 90 – Kozie Góry dunes, NE of Topór (Stoczek c.), few individuals at a dune base / FC90: 27 – 1 km NW of Jadów, several dozen individuals at a dune base.

Aquilegia vulgaris L.; PP

FC74: 33 – SW of Garnek (Ceranów c.), moraine hill, few individuals; 44 – 1.9 km NE of Tosie (Kosów Lacki c.), several individuals in a forest clearing.

Arabis glabra (L.) Bernh.; R

Rarely on floodplain meadows, most numerous around Treblinka (Małkinia Górna and Kosów Lacki c.). FC73: 65, 66, 75, 76.

Arabis hirsuta (L.) Scop.; R

FC71: 27, 28, 35, 36 – flood barriers between Wilczogęby (Sadowne c.) and Wywłoka.

Arabis planisiliqua (Rchb.) Pers.; DD

FC80: 14 – near Nadkole (Łochów c.), banks of Liwiec river, several individuals.

Arctostaphylos uva-ursi (L.) Spreng.; SP, NT

EC89: 75, 76, 85, 86, 87 – most numerous stands in Mazovia in Natura 2000 area “Wydmy Lucynowsko-Mostowieckie” (*) Ciosek (2003), Wiśniewski (2012) / FC72: 61, 89, 90 / FC73: 74, 83, 85, 91, 92, 94 / FC80: 00, 05, 16, 42, 44, 53, 54, 64 / FC82: 09 / FC83: 02, 13, 31, 32, 41, 44, 45.

Asarum europaeum L.; R

FC74: 34 – E of Garnek (Ceranów c.), edges of alder forests, many sites / FC82: 87 – ca. 1 km NE of Majdan (Stoczek c.), moist forests in Lubicza river valley.

Asparagus officinalis L.; R

EC89: 17 – N Skuszew (Wyszków c.), dry meadow / FC63: 98 – dry meadows N of Rytele Święckie (Kosów Lacki c.) / FC70: 91, FC80: 00, 01 – 2-km section of Bug river valley from Kamieńczyk to Suwiec (Wyszków c.), dry meadows.

Astragalus arenarius L.; NT

FC72: 58 – 0.8 km W of Orzełek (Sadowne c.), a few individuals, sandy grassland on a dune / FC76: 60 – 1 km



Fig. 2. Chosen protected and endangered species occurring in the Lower Bug River Valley (eastern Poland)

Explanations: A – *Allium angulosum*, B – *Blechnum spicant*, C – *Diphasiastrum complanatum*, D – *Iris sibirica*, E – *Pedicularis palustris*, F – *Polemonium caeruleum*, G – *Salvinia natans*, H – *Succisella inflexa* (photograph by A. P. Szulc)

NE of Białobrzegi (Sterdyń c.), several dozen individuals in dry grassland on a riverside slope.

Blechnum spicant (L.) Roth; PP

EC89: 76 – in Natura 2000 area “Wydmy Lucynowsko-Mostowieckie”, 1 specimen, moist deflation basin with dominant birch, (*) Wiśniewski (2012) (Fig. 2B).

Centaureum erythraea Rafn; PP

FC70: 88 – N of Szumin (Łochów c.), flowering clump 0.2 m², humid roadside / FC76: 70 – ca. 700 m N of Matejki (Sterdyń c.), several dozen m², floodplain meadow.

Chimaphila umbellata (L.) W. P. C. Barton; PP, NT

FC72: 30 – 0.6 km S of Sojkówek (Sadowne c.), 8 m² in moderately moist forest on a dune; 82 – 1 km NE of Zieleniec (Sadowne c.), a few m², forest stand of ca. 40-year-old pines in a former sand mine / FC73: 40 – 1 km SW of Złotki (Sadowne c.), 4 m², pine forest / FC80: 30 – 2 km E of Tumanek (Wyszków c.), 25 m², pine forest; 43 – close to road DK62 Wyszków – Łochów (Wyszków c.), 2 patches of 1 m² and 10 m² in an ecological site; 79 – 1 km NE of Kaliska (Łochów c.), 1 m², roadside in a mixed forest / FC81: 00 – 1.3 km NW of Jerzyska (Łochów c.), 5 m², roadside, pine forest / FC82: 19 – 1.4 km N of Stare Lipki (Stoczek c.), 2 m², roadside, pine forest / 27 – 2 km NW of Stare Lipki (Stoczek c.), 3 populations of 4 m² each, pine forest / FC83: 33 – 600 m SE of Lipka-Podborze settlement (Stoczek c.), a few m², pine forest / EC89: 86 – Natura 2000 site “Wydmy Lucynowsko-Mostowieckie”, 1 km E of Mostówka, near Mostówka-Anastazew road (Zabrodzie c.), a few individuals on a roadside, 20 m², (*) Ciosek (2003) / FC80: 34 – 0.5 km S of Loretto (Wyszków c.), roadside 6 m², pine forest.

Comarum palustre L.; R

EC89: 35, 45 – NE Deskurów (Wyszków c.), former river bed, wet meadow / FC72: 96 – ca. 1.4 km S of Kołodziej (Sadowne c.), degraded raised bog / FC80: 49 – ca. 1.2 km NE of Gwizdały (Łochów c.), edge of a raised bog / FC83: 49 – N of Chruszczewka Szlachecka (Kosów Lacki c.), large population, raised bog.

Cystopteris fragilis (L.) Bernh.; R

FC80: 09 – on windthrown spruces in “Jegiel” reserve (Łochów c.), boreal spruce forest on peat (*Sphagnum girgensohnii-Piceetum*), on stumps.

Dactylorhiza majalis s.l. (Rchb.) P.F. Hunt et Summerh.; PP, NT

EC89: 46 – S of Drogoszewo (Wyszków c.), ca. 200 m² in a floodplain meadow / FC72: 67 – N of Kołodziej-Rybie (Sadowne c.), a dozen or so specimens in wet meadows / FC74: 13, 14, 24 – ca. 1 km NE of Garnek (Ceranów c.), most numerous, hundreds of individuals in meadows along a stream.

Daphne mezereum L.; PP

FC72: 44, 45 – infrequent in “Mokry Jegiel” reserve (Sadowne c.) in alder forests, (*) Wierzba *et al.* (2008) / FC74: 23, 33 – around Garnek (Ceranów c.), in alder forests and at base of a moraine hill / FC82: 89 – “Moczydło” reserve (Stoczek c.), many individuals in an area of 600 m² in moist mixed forest.

Dianthus arenarius L.; PP, NT

EC89: 86 – Mostówka (Wyszków c.), N of a railway station, on deforested slopes of a dune (near railway tracks), (*) Ciosek (2003) / FC71: 89 – base of a dune W of Krupińskie (Sadowne c.), 0.2 m², pine forest / FC72: 90 – Kozie Góry dune (Stoczek c.), ca. 1 m², sandy grassland / FC80: 62, 70 – between Tryce and Gać settlements (Zabrodzie c.), several patches on dune slopes / FC81: 00 – on a slope of Dębowa Grzęda dune, S of Wywłoka (Łochów c.), 0.2 m², pine forest / FC82: 12 – ca. 0.7 km S of Księżyzna (Stoczek c.), dune ridge, ca. 1 m².

Diphysastrum complanatum (L.) Holub; PP, VU

Found at 73 sites, occupying from 1 m² to several hundred m², most numerous in squares: FC7383, FC7384, FC7394.

EC89: 87 / FC70: 94 / FC72: 54, 57, 72, 73, 90 / FC73: 51, 83, 84, 85, 92, 93, 94 / FC74: 26, 27, 36, 37 / FC80: 05, 06, 42, 43 / FC81: 01, 10, 21 / FC82: 00, 16, 17, 27, 28 / FC83: 02, 03, 12, 31, 32, 33, 41 (Fig. 2C).

Diphysastrum tristachyum (Pursh) Holub; SP, EN

EC89: 86 – Natura 2000 area “Wydmy Lucynowsko-Mostowieckie”, 30 m², (*) Wiśniewski (2012) / FC72: 53, 54 – E of Sadowne, former forest fire site and young pine forest stand, several dozen m².

Diphysastrum zeileri (Rouy) Holub; SP, DD

FC74: 27 – ca. 1.5 km NW of Ceranów, several dozen m²; 02 – ca. 1.5 km E of Nowe Lipki (Stoczek c.), several dozen m².

Drosera rotundifolia L.; SP, NT

FC82: 89 – “Moczydło” reserve (Stoczek c.), several hundred individuals, raised bog / FC83: 49 – N of Chruszczewka Szlachecka (Kosów Lacki c.), several dozen flowering individuals, raised bog.

Dryopteris cristata (L.) A.Gray; R

FC83: 49 – N of Chruszczewka Szlachecka (Kosów Lacki c.), several dozen individuals, raised bog.

Epipactis helleborine (L.) Crantz; PP

Common, in some habitats numerous populations, in almost every ATPOL square.

Equisetum hyemale L.; R

FC76: 70, 71 – 1 km N of Matejki (Sterdyń c.), several hundred m² in a 45-year-old pine forest stand / FC81:

40, 41 – E of Burakowskie (Łochów c.), a few individuals in oak-hornbeam forests, 63 – ecological site No. 486, E Łochów, several hundred m² in moist pine forest.

Euphorbia lucida Waldst. & Kit; NT

Quite often on floodplain meadows and banks of oxbow lakes, numerous populations in squares FC70 and FC71.

Festuca polesica Zapał.; NT

FC72: 53 – ca. 0.5 km E of Kuźnica near Sadowne (Sadowne c.), about a dozen clumps, wildfire place on a dune top, accompanying *Diphasiastrum tristachyum*.

Galium schultesii Vest; R

FC83: 02 – 1.5 km E of Nowe Lipki (Stoczek c.), thermophilous oak forest (*Potentillo albae-Quercetum*).

Gladiolus imbricatus L., SP, NT

FC70: 84, 85 – N of Rafa (Wyszków c.), large population in floodplain meadows.

Goodyera repens (L.) R. Br.; SP, NT

FC74: 36 – ca. 1.5 km NW of Ceranów, a few m², mixed coniferous forest / FC83: 32 – 1 km E of Nowe Lipki (Stoczek c.), 0.2 m², pine forest.

Gymnocarpium dryopteris (L.) Newman; R

FC72: 90 / FC82: 01 – oak-hornbeam forests on NE slopes of “Kozie Góry” dunes (Stoczek c.), Ugoszcz river valley.

Gypsophila fastigiata L.; R

EC89: 78, 79 – 1 km NW of Podgać (Zabrodzie c.), several dozen clumps at base of a dune / EC98: 26 – N of Dąbrówka (Dąbrówka c.), numerous patches at a dune base / FC73: 92 – 2 km NE of Nowe Lipki (Stoczek c.), several dozen clumps / FC82: 12 – ca. 0.7 km S of Księżyzna (Stoczek c.), dune ridge, ca. 1 m².

Helianthemum nummularium (L.) Mill. ssp. *nummularium*; R

Rarely on grasslands throughout research area; most numerous populations in squares FC7086, FC7670.

Helichrysum arenarium (L.) Moench; PP

Common on sandy grasslands, in most ATPOL squares.

Hepatica nobilis Schreb.; R

FC72: 70, 90 – oak-hornbeam forests in lower part of Ugoszcz river valley (Stoczek c.) / FC82: 01 – oak-hornbeam forests in that valley; 87 – ca. 1 km NE of Majdan (Stoczek c.), oak-hornbeam forests in Lubicza river valley / FC81: 41 – E of Burakowskie (Łochów c.), oak-hornbeam forest / FC73: 28 – “Bojarski Grąd” reserve (Kosów Lacki c.), oak forest.

Hierochloë australis (Schrad.) Roem. et Schult.; PP, VU
FC83: 03 – ca. 2 km E of Nowe Lipki (Stoczek c.), acid mixed oak forest on dunes.

Hierochloë odorata (L.) P. Beauv; PP, VU

Quite numerous on meadows in Bug river valley, most abundant in squares FC70 and FC71.

Huperzia selago (L.) Bernh. ex Schrank et Mart.; PP, NT
FC74: 24, 25 – 2 sites of 0.5 m² each in ecotones at base of mineral islands in alder forests with blackcurrant (*Ribo nigri-Alnetum*), E of Garnek settlement (Ceranów c.) / FC81: 41 – NE of Burakowskie (Łochów c.), 4 sites of ca. 0.5 m² each in moist oak-hornbeam forest and one on a clump in an alder swamp forest / FC83: 40 – ca. 0.4 km NW of Wycech settlement (Stoczek c.), ca. 1 m², alder forest with blackcurrant in Ugoszcz river valley.

Hydrocotyle vulgaris L.; R

FC80: 49 – ca. 1.2 km NE of Gwizdały (Łochów c.), edge of a raised bog / FC81: 66 – ecological site No. 489, E of Łochów, numerous, raised bog.

Iris sibirica L.; SP, VU

FC70: 84, 85 – N of Rafa-Kamieńczyk (Wyszków c.), largest site: ca. 8 ha, floodplain meadows / FC71: 72 – N of Brzuza (Łochów c.), ca. 2000 flowering shoots, floodplain meadow and a mineral island; 80 – N of Brzuza (Łochów c.), 5 flowering shoots, floodplain meadow; 81 – N of Brzuza, several dozen flowering clumps, moist willow thicket (Fig. 2D).

Isopyrum thalictroides L.; R

FC82: 87 – ca. 1 km NE of Majdan (Stoczek c.), oak-hornbeam forest in Lubicza river valley.

Jovibarba sobolifera (Sims) Opiz; SP, VU

EC89: 86, 97 – E of Mostówka (Zabrodzie c.), at base of largest dune in Kamieniec Forest, several hundred individuals / 53 – 1 km W of Deskurów (Wyszków c.), 2 populations 0.5 m² each, grasslands; 46 – W of Tumanek (Wyszków c.), several dozen individuals on a dune, (*) Wiśniewski (2012) / FC72: 31 – Sojkówek (Sadowne c.), a former Evangelical cemetery on a dune, a small clump on a partly shadowed grassland.

Lathraea squamaria L.; R

FC81: 41 – ca. 1 km W of Burakowskie (Łochów c.), 2 populations with a dozen or so inflorescences each, wet oak-hornbeam forest / FC82: 01 – 1.5 km SW of Zieleniec (Stoczek c.), a dozen or so inflorescences, moist oak-hornbeam forest.

Lathyrus palustris L.; PP

FC62: 91 – near floodbanks NE of Płatkownica (Sadowne c.), several dozen individuals in a floodplain meadow / FC71: 36 – ca. 1.3 km NE of Rażny (Sadowne c.), several dozen individuals on a floodplain meadow, 54 – E of Rażny, most numerous individuals around overgrowing oxbow lakes.

Ledum palustre L.; PP

Numerous populations in moist pine forests, swamps, and peatlands throughout research area.

Libanotis pyrenaica (L.) Bourg.; R

FC70: 84, 85 – grasslands, N of Rafa (Wyszków c.), numerous individuals.

Lilium martagon L.; SP

FC83: 02 – 1.5 km E of Nowe Lipki (Stoczek c.), several dozen flowering individuals in oak forest / FC74: 33 – numerous individuals confirmed in moraine hill in Garnek settlement (Ceranów c.), oak forest (*Potentillo albae-Quercetum*) (*) Głowacki (1984), Wierzba & Marciniuk (2003).

Limosella aquatica L.; NT

Rarely on alluvia along whole length of this river section.

Lycopodium annotinum L.; PP, NT

Numerous in moist coniferous forests, edges of peatlands, and alder forests throughout research area.

Lycopodium clavatum L.; PP, NT

Numerous in pine forests and heathlands throughout research area.

Matteuccia struthiopteris (L.) Tod.; PP

FC72: 77 – ca. 0.5 km N of Kołodziej-Rybie (Sadowne c.), several dozen individuals in riparian forest near “Mokry Jegiel” reserve (Sadowne c.), probably of anthropogenic origin.

Melampyrum cristatum L.; SP, VU

FC70: 84 – N of Rafa, several dozen individuals; 88 – N of Szumin (Łochów c.), several dozen individuals / FC76: 70 – ca. 700 m N of Matejki (Sterdyń c.), a dozen or so m², floodplain meadow.

Melittis melissophyllum L.; PP

FC83: 02 – 1.5 km E of Nowe Lipki (Stoczek c.), several dozen flowering individuals in oak forest (*Potentillo albae-Quercetum*) / FC74: 33 – numerous individuals confirmed in moraine hill in Garnek settlement (Ceranów c.), oak forest (*Potentillo albae-Quercetum*) (*) Głowacki (1984), Wierzba & Marciniuk (2003).

Menyanthes trifoliata L.; PP

EC89: 72, 73 – 0.6 km SW of Ślubów (Wyszków c.), several dozen m², oxbow lake and drainage ditches / FC71: 91 – N of Brzuza (Łochów c.), several m², emergent vegetation in a former river bed.

Mercurialis perennis L.; R

FC74: 34 – several m², edge of alder forest, 1 km E of Garnek settlement (Ceranów c.).

Neottia nidus-avis (L.) Rich.; PP

FC74: 35 – ca. 2.3 km SE of Garnek settlement (Ceranów c.), dozens of individuals along a forest road.

Nymphaea alba L.; PP

Species present in every basic square (10 km × 10 km) of ATPOL grid, in oxbow lakes with open water surface.

Orthilia secunda (L.) House; R

FC73: 41 – ca. 0.3 km S of Złotki (Sadowne c.), a few m², thickets in an abandoned gravel pit; 66 – 2.2 km SW of Wólka Okrąglik (Kosów Lacki c.), a dozen or so m², aspen thickets in an abandoned gravel pit / FC75: 23 – S of Natolin (Ceranów c.), 2 m² on a dune slope; 45 – mixed forest N of Kiełpiniec (Sterdyń c.) / FC80: 05 – 1 km N of Nadkole (Łochów c.), 1 m², excavated dune in pine forest; 79 – 1 km NE of Kaliska (Łochów c.), 2 m², ditch in mixed forest / FC81: 00 – 1.5 km SW of Brzuza (Łochów c.), 2 m², mixed forest / FC82: 27 – ca. 1.5 km W of Stare Lipki (Stoczek c.), several m², dune ridge in pine forest / FC83: 02 – 1.3 km E of Nowe Lipki (Stoczek c.), several m², mixed forest; 33 – 0.6 km SE from Lipka-Podborze settlement (Stoczek c.), a dozen or so m², pine forest / FC82: 27 – ca. 1.5 km W of Stare Lipki (Stoczek c.), a dozen or so m², dune ridge in pine forest.

Ostericum palustre Besser; SP, NT

FC73: 27 – single individuals in floodplain meadows in N part of “Bojarski Grąd” reserve (Kosów Lacki c.).

Oxycoccus palustris Pers.; R

FC81: 28 – ecological site No. 479, ca. 1.5 km NE of Ostrówek Węgrowski (Łochów c.), several hundred m², peatland and swamp forest / FC82: 78, 79 – ecological site No. 496, W of Miednik (Stoczek c.), numerous and extensive populations of several dozen m², peatland / FC83: 49 – N of Chruszczewka Szlachecka (Kosów Lacki c.), numerous in a raised bog.

Paris quadrifolia L.; R

FC82: 87 – 1 km NE of Majdan (Stoczek c.), numerous patches in moist oak-hornbeam forest.

Pedicularis palustris L.; PP, VU

FC71: 27 – SW of Wilczogęby (Sadowne c.), several dozen m², emergent vegetation; 82 – ca. 1 km N of Brzuza (Łochów c.), several dozen m², wet meadows (Fig. 2E).

Phleum hubbardii D. Kováts; R

FC71: 81 – 0.5 km N of Brzuza (Łochów c.), a dozen or so individuals.

Phyteuma spicatum L.; R

FC74: 24 – 0.5 km E of Garnek settlement (Ceranów c.), several dozen flowering specimens on a mineral island in alder forest with blackcurrant.

Polypodium vulgare L.; R

Regionally rare, forming small patches, from 0.5 m² to 25 m². EC89: 27, 36, 46 / FC71: 91, 92 / FC72: 63, 82 / FC73: 40 / FC74: 26, 44 / FC76: 60, 70 / FC80: 09 / FC81: 00, 21, 31 / FC82: 48, 67.

Polemonium caeruleum L.; SP, VU

FC72: 36 – ca. 1 km S of Kocielnik settlement (Sadowne c.), several dozen individuals in an overgrowing wet meadow, 47 – ca. 1 km E of “Mokry Jegiel” reserve

(Sadowne c.), several hundred individuals, mineral elevations in wet meadows (Fig. 2F).

Primula veris L.; R

FC70: 84 – 0.5 km N of Rafa settlement (Wyszków c.), numerous patches on grasslands.

Pulmonaria obscura Dumort.; R

FC70: 84 – 0.5 km N of Rafa settlement (Wyszków c.), numerous patches in moist oak-hornbeam forest (*Tilio-Carpinetum*).

Pyrola chlorantha Sw.; PP

FC73: 83 – ca. 3 km NE of Nowe Lipki (Kosów Lacki c.), 10 m², pine forest burnt by wildfire / FC82: 27 – ca. 1.5 km NW of Stare Lipki (Stoczek c.), 1 m², pine forest.

Pyrola minor L.; PP

FC72: 82 – 0.5 km N of ecological site “Wydmy Zielonickie” near Sadowne, several m² in pine forest in a former sand mine / FC75: 23 – S of Natolin (Ceranów c.), 2 m² at a dune base.

Pyrola rotundifolia L.; PP

FC73: 36, 37 – ecological sites No. 593 and No. 600 “Grząskie” near Poniatowo (Kosów Lacki c.), many very large populations in wet thickets, edges of alder forests / FC81: 07 – 1.5 km S of Czaplowizna settlement (Sadowne c.), 1 m², moist oak-hornbeam forest; 41 – 1 km W of Burakowskie (Łochów c.), a few m², wet oak-hornbeam; 51 – 0.7 km SW of Burakowskie, over 100 m², thickets in a former sand mine / FC82: 99 – “Turzyniec” reserve (Stoczek c.), a few m², ecotone between oak-hornbeam forest and alder forest with blackcurrant / FC90: 07 – 0.5 km SW of Urle railway station (Jadów c.), 0.5 m², forest roadside.

Ranunculus cassubicus L.; R

FC82: 01 – 1 km NE of Topór railway station (Łochów c.), oak-hornbeam forest; 87 – NE of Majdan (Stoczek c.), wet oak-hornbeam forest in Lubicza river valley.

Salsola kali L. ssp. *ruthenica* (Iljin) Soó; R

EC89: 86 – Natura 2000 site “Wydmy Lucynowsko-Mostowieckie” (Wyszków c.), several individuals on sand, dune excavation near railroad.

Salvinia natans (L.) All.; SP

Present in every basic square (10 km × 10 km) of ATPOL grid in Bug valley and increasing in number and range, (*) Krechowski (2010) (Fig. 2G).

Sanguisorba officinalis L.; R

EC89: 73 – ca. 0.4 km SW of Ślubów (Wyszków c.), several individuals / FC89: 17 – 0.75 km N of Skuszew (Wyszków c.), single individuals in floodplain meadows, 19 – moist embankment of S8 expressway, Skuszew, several individuals.

Scorzonera humilis L.; R

FC72: 53 – ca. 0.5 km E of Kuźnica near Sadowne, 1 m², roadside, pine forest / FC74: 27 – 1.5 km N of Ceranów, numerous individuals, pine forest roadsides / FC81: 21 – SW of Jerzyska (Łochów c.), 1 m², dune slope / FC90: 27 – 1 km NW of Jadów, a dozen flowering individuals in a mixed forest on a dune.

Scutellaria hastifolia L.; VU

FC70: 88 – N of Szumin (Łochów c.), scattered in meadows, 92 – W of Kamieńczyk (Wyszków c.), 4 m² in meadows.

Sedum reflexum L.; R

FC73: 66 – 2.2 km SW of Wólka Okrąglik (Kosów Lacki c.), numerous small patches in a former gravel pit.

Silene tatarica (L.) Pers.; NT

Riverside grasslands and thickets. EC89: 09, 10, 53 / FC62: 85 / FC63: 98 / FC70: 89 / FC80: 14.

Succisella inflexa (Kluk) Beck; SP, NT

FC81: 31 – 1 km N of Burakowskie (Łochów c.), several dozen m², wet meadow in Struga river valley / EC89: 20, 30 – ca. 1 km E of Skuszew (Wyszków c.), dozens of individuals in wet meadows / FC72: 80 – wet meadows in Ugoszcz valley, 0.5 km S of Krupińskie (Sadowne c.) / FC75: 65, 66, 75, 76 – former river bed S of Kiełpiniec (Sterdyń c.), several hectares in wet meadows, very large populations (Fig. 2H).

Thalictrum aquilegifolium L.; R

FC73: 27, 28 – numerous individuals confirmed in “Bajarski Grąd” reserve and its surroundings (Kosów Lacki c.) (*) Głowacki (1984), Wierzba & Marciniuk (2003).

Thesium ebracteatum Hayne; SP, VU

FC74: 33 – moraine hill in Garnek settlement (Ceranów c.), ca. 200 m², specimens infected with a fungus, *Puccinia thesii* (Desv.) Chaillet.

Trifolium montanum L.; R

FC83: 03 – ca. 1.5 km E of Nowe Lipki (Stoczek c.), forest roadsides in oak forests (*Potentillo albae-Quercetum*).

Ulmus minor Mill. var. *suberosa* Rehd.; R

FC71: 53 – ca. 2.2 km N of Brzuza (Łochów c.), several m², high bank of an oxbow lake / FC75: 15 – ca. 2 km NE of Natolin (Ceranów c.), edges of riparian forests / FC82: 87 – 1 km NE of Majdan (Stoczek c.), several dozen individuals on oak-hornbeam forest edge in Lubicza river valley.

Utricularia vulgaris L.; NT

FC70: 84 – 1 km N of Rafa (Wyszków c.), oxbow lake.

Verbascum phoeniceum L.; PP, NT

FC73: 65, 66 – gravel pits, grasslands, and oak forests near Treblinka (Kosów Lacki c.), large populations.

Viola stagnina Kit.; SP, VU

FC71: 81, 91 – N of Brzuza (Łochów c.), wet meadows / FC75: 66 – S of Kiełpiniec (Sterdyn c.), wet meadows.

3.2. Comparison of localities

Meadows occupy the largest area in the Bug river valley and along its numerous tributaries. They are chiefly intensively used hay meadows of the order *Arrhenatheretalia elatioris* or (on low-lying river terraces) floodplain meadows of the order *Molinieta-lia caeruleae*. The most valuable communities are meadows with *Cnidium* and *Molinia*, rich in rare and threatened species. Four stands of *Iris sibirica* were found within the floodplains. Three of them are located on former river deposits and mineral hills (“grądziki”), while one is located in a former river bed. Only one locality of *Gladiolus imbricatus* was noted, whereas *Gratiola officinalis* was not found, despite frequent records of this species several years ago. Two areas with small populations of *Viola stagnina* and four with *Succisella inflexa* were recorded. One of the localities of *S. inflexa* is a large population in partly intensively used meadows, where it occurs in an area of at least 15 ha. We did not find *Polemonium caeruleum* at the sites recorded earlier in the “Mokry Jegiel” reserve (FC7246) according to Wierzba *et al.* (2008). These populations probably disappeared because the meadows were overgrown by thickets of trees and shrubs. About 1 km north and west of the reserve, there are 3 sites with several dozen to several hundred specimens, including many fruiting ones. *Dianthus superbus* and *Epipactis palustris* were not recorded, even though these species are often found in the Podlasie Bug Gorge, especially in the vicinity of Korczew (FD07). There are also very large populations of *Ostericum palustre* near Korczew, but only a few individuals were found in the research area, close to the “Bojarski Grąd” reserve (FC7327). *Allium angulosum* is quite common in floodplain meadows. The localities reported by Dembicz *et al.* (2014) in square FC70 persist and in some places the species occurs in patches. Populations of *A. angulosum* were also recorded in other ATPOL squares; along the entire length of the studied section of floodplain meadows of the Bug river, the species is numerous and not threatened. Most individuals were found in an area of 15 ha, ca. 2 km west of Kamieńczyk (Wyszków commune). *Euphorbia lucida* and *Lathyrus palustris* turned out to be equally common species in the study area. However, the frequency of occurrence of the mentioned species decreases in the eastern part of the valley. Only 3 localities of *Dactylorhiza majalis* were found, while no localities of *D. incarnata* (L.) Soó and *D. maculata* (L.) Soó. Other rare species recorded in meadows and former riverbeds are: *Arabis planisiliqua*, *Centaureum*

erythraea, *Menyanthes trifoliata*, *Pedicularis palustris*, and *Sanguisorba officinalis*.

In the Bug river valley, grasslands are also common on alluvial deposits, high banks, and mineral hills called “grądziki”. Among the rich flora of these habitats, we found new localities of *Iris sibirica* (mentioned above, including a site with hundreds of flowering individuals), *Libanotis pyrenaica*, *Melampyrum cristatum*, *Primula veris*, and *Scutellaria hastifolia*. It is very interesting that *M. cristatum* was classified as extinct in the “Polish Red List of Plants” (Zarzycki & Szelağ 2006). Fortunately, its populations (although small) contain from several dozen to hundreds of individuals every year. Large areas are covered by grasslands on flood embankments. The grasslands are well developed due to frequent mowing as part of the maintenance of flood protection infrastructure. In the section between the towns of Wywłoka and Wilczogęby, small populations of *Androsace septentrionalis*, *Arabis glabra*, and *Arabis hirsuta* can be found. *Dianthus carthusianorum* (not red-listed) is abundant in grassland habitats, especially in the eastern part of the valley, and rare in its western part. New localities of *Verbascum phoeniceum* were found exclusively on the edge of the moraine of the Siedlce Plateau. Only 2 sites were known earlier in the Lower Bug Valley (Ciosek 1985a), but have not been confirmed recently. Present in grasslands, but in scattered locations, are: *Asparagus officinalis*, *Astragalus arenarius*, *Helianthemum nummularium*, *Sedum reflexum*, *Silene tatarica*, *Phleum hubbardii*, while in sandy grasslands, *Salsola kali* was found.

The first localities of *Salvinia natans* in the Lower Bug Valley were published by Krechowski *et al.* (2010) in squares FC70 and FC75. Previously, closest to the study area, it was observed by Ćwikliński *et al.* (1987) in the Węgrów Depression (Obniżenie Węgrowskie). Currently, this species can be considered as widespread and quite frequent in the Bug river valley, but its population size is smaller than those observed further downstream, in the sections of the Bug and Narew rivers close to Zegrze Reservoir (Zalew Zegrzyński). As a result of a significant slowdown of river flow, *S. natans* dominates in the pleuston (i.e. organisms that live on the water surface) in reedbeds, inlets, etc., and forms large, floating patches. In the largest, open-water oxbow lakes, populations of *Nymphaea alba* are common. Shallow or small oxbow lakes are completely overgrown by floating hydrophytes, such as *Stratiotes aloides* L. and various species of duckweed, very often *Wolffia arrhiza* (L.) Horkel ex Wimm. In only one oxbow lake a large population of *Utricularia vulgaris* was found. Along the entire length of the examined section of the river, small stands of *Limosella aquatica* were located, growing on sandy alluvia that are destroyed every year by river swells.

Arctostaphylos uva-ursi is numerous in dry pine forests and its largest population is in the Natura 2000 area “Wydmy Lucynowsko-Mostowieckie”, covering 427.76 ha. This habitat is a disappearing heathland of the Atlantic type, at a site of a large forest fire in 1993. The area was included in the network in 2004. Its flora is well recognized and known mainly as the heathland with the largest population of *Arctostaphylos uva-ursi* in this part of the country. Research on the vascular flora of this area was conducted by Ciosek (2000, 2003), but since the publication of his studies, the area of heathlands has decreased significantly due to the natural succession of pine, birch, and bird cherry. Some localities of the species mentioned by Ciosek disappeared or were not reconfirmed after 2010 during Wiśniewski’s (2012) unpublished research, but localities of extremely rare species were discovered. In “Wydmy Lucynowsko-Mostowieckie” we found seemingly the only locality of *Blechnum spicant* in this part of Mazovia. This species is characteristic of montane forests and fir-spruce forests. In the Polish lowlands, it occurs in large numbers only in Kashubia, Pomerania, and Lower Silesia. The nearest recorded locations of this fern are near Skierniewice and Biała Podlaska Kurowski (1986) & ATPOL. This discovery gives hope for finding this very rare fern in other, similar habitats in the Bug river valley. Within the study area, stands of other fern species were also found: *Matteuccia struthiopteris* (roadside in riparian forest, probably of anthropogenic origin) and *Cystopteris fragilis* (stumps in boreal spruce forest on peat). Two localities of *Diphasiastrum tristachyum* were recorded. The only locality in the area of “Wydmy Lucynowsko-Mostowieckie” is in a typical habitat of this species – a wild fire area – but is gradually disappearing (private forests). Currently, in its place there is an early form of coniferous forest with a pine stand that is over 20 years old. The second site is located east of Sadowne (forest district Łochów), with 2 populations 100 m apart. The first population is within a treeless wildfire zone (several years after the fire), while the second one is in a 20-year-old pine stand. Several clumps of *Festuca polesica* accompany this species at the fire site. Additionally, 2 localities of *D. tristachyum* with characteristics similar to *D. zeilleri* were also found, in forests on the edge of the Siedlce Plateau. In contrast, as many as 73 sites of *D. complanatum* were recorded. Its populations vary in size from 0.5 m² to over 200 m². They occur in various habitats, from dry coniferous forests (*Cladonio-Pinetum*) to mixed acidophilus oak forests. A large number of sites found are the result of cooperation with the Łochów and Sokołów Forest Districts; many of these populations have been secured thanks to the designation of so-called “ecological sites” (a form of partial protection). Despite the large area of swamp forests in the Kamieniec Forest (Puszcza Kamie-

niecka), only 10 localities of *Andromeda polifolia* were recorded, and the largest population is located in a raised bog overgrown with birch in ecological site No. 479 in Łochów forest district. Most parts of swamp forests are currently drying out as a result of lowering groundwater level. A small number of *Chimaphila umbellata* localities (21) and species of the *Pyrola* genus were found. This is probably due to intensive forest management combined with ploughing the land, because they were found almost exclusively in old forests and along forest roads. *Orthilia secunda* (11 sites) shows a similar tendency, and a large population in the gravel pit in Treblinka-Obóz near Wólka Okrąglik disappeared after the removal of aspen thickets. The least common of the *Pyrola* genus are *P. chlorantha* (2 sites) and *P. minor* (2 sites). Localities of *P. rotundifolia* are not numerous but safe due to their inaccessibility in humid habitats. Despite the vast areas of coniferous forests, no stands of *Pulsatilla patens* (L.) Mill. were found in the research area. However, small clumps of this species (some of them blooming) have been preserved on the other side of the Bug river, in the Biała Forest (Puszcza Biała). There are also no reports of its current occurrence in the left-bank part of the Bug river valley from foresters, naturalists or local residents. *Polypodium vulgare* turned out to be a rare species, as only 30 localities were recorded. It was most often found on steep slopes of dunes and in substitute communities in forest habitats. It was also considered as a very rare species according to Ciosek (1990) in the area of the Biała Forest, adjacent to the Lower Bug Valley from the north. He found only 2 small populations of this fern. Low numbers of localities of the following species are also worth noting: *Goodyera repens* (2 sites), *Scorzonera humilis* and at the base of the dunes *Gypsophila fastigiata* (4 sites each), *Jovibarba sobolifera*, *Equisetum hyemale* (5 sites each), and *Dianthus arenarius* (6 sites).

Oak-hornbeam forests cover small plots and are often transformed or even degraded. Some forest species common in other regions turned out to be rare in the study area: *Isopyrum thalictroides*, *Paris quadrifolia*, *Pulmonaria obscura* (1 site each), *Asarum europaeum*, *Gymnocarpium dryopteris*, *Ranunculus cassubicus*, *Anthericum ramosum*, *Lathraea squamaria* (2 sites each), and *Hepatica nobilis* (5 sites). Large and known populations of *Melittis melissophyllum*, *Lilium martagon* and *Thalictrum aquilegifolium* were confirmed in the Natura 2000 area “Dąbrowy Ceranowskie” and in the “Bojarski Grąd” reserve, respectively Głowacki (1984) and Wierzba & Marciniuk (2003). New large populations of *Lilium martagon* and *Melittis melissophyllum* were found in the vicinity of Nowe Lipki. The sites are located in thermophilous oak forest and oak-hornbeam forest substitute communities on the northern slopes of a vast dune located on the edge of the

Siedlce Plateau. The only localities of *Galium schultesii*, *Hierochloë australis*, and *Trifolium montanum* were also found there, whereas the only localities of *Aquilegia vulgaris*, *Neottia nidus-avis*, and *Phyteuma spicatum* were recorded in the Ceranów Forests (Lasy Ceranowskie). The occurrence of *Trollius europaeus* was confirmed in the “Biele” reserve and its surroundings. The population of *Aruncus dioicus* in the “Sterdyń” reserve persists, especially since the Sokołów Forest District has actively protected this site by removing the undergrowth.

The largest population of *Drosera rotundifolia* in the past was observed in the “Ślize” reserve near Jadów. Unfortunately, not a single individual has been found for years, because the *Sphagnum* patch dried out and is now overrun by reeds. The activity of a large population of European beaver (*Castor fiber*) probably also had a negative impact, as it destroyed ca. 50% of the forest in some places by digging channels and corridors through it. A large population of *D. rotundifolia* is protected in the “Moczydło” reserve near Stoczek. The site of this species found north of Chruszczewka Szlachecka is threatened in the long run. The raised bog is located in a basin surrounded by arable fields. Numerous individuals of *Dryopteris cristata* and large populations of *Menyanthes trifoliata*, *Ledum palustre*, and *Oxycoccus palustris* were also found in this peatland. Due to the destruction by drainage and the disappearance of most of the raised bogs, only 4 sites of *Oxycoccus palustris* were found, of which the 3 larger populations bloom and bear fruit en masse. An equally rare species is *Hydrocotyle vulgaris*, found in one site on the outskirts of a raised bog, and *Comarum palustre*, found only in a few peatlands. Ćwikliński *et al.* (1987) found *Hydrocotyle vulgaris* in a peatland 2 km away from the newly discovered site, but the presence of this species was not confirmed there during our research.

The local populations of *Daphne mezereum* described by Wierzba *et al.* (2008) in the “Mokry Jegiel” reserve (FC72) are not numerous; only in the alder forests near Ceranów (FC74) does this species appear more often. It also grows at many sites in the “Moczydło” reserve. Nine localities of *Huperzia selago* were found in various habitats, both in clumps in alder forests and in wet oak-hornbeam forests. In the town of Garnek near Ceranów (FC7433) there is a small moraine hill on the edge of the Bug valley. The top of the hill is covered with thermophilous oak forest (*Potentillo albae-Quercetum*), and on its slopes there are grasslands with *Thesium ebracteatum*, which occurs in an area of ca. 200 m². Interestingly, many specimens are infected with a rare species of monophagous fungus *Puccinia thesii* (Desv.) Chaillet. Also *Trifolium rubens* L. was recorded in this grassland in the past, but was not found during our research. In the Bug river valley, *Ulmus minor* var. *suberosa* grows at 4 sites on the edges of poplar-willow riparian thickets and meadows.

A few species that are partly protected or red-listed are common in the study area. Some of them occur in forests, e.g. *Epipactis helleborine*, *Helichrysum arenarium*, *Hierochloë odorata*, and *Lycopodium clavatum*. In the Bug river valley, wet forests cover a large area, which is why the populations of *Lycopodium annotinum* and *Ledum palustre* are numerous and not threatened there.

Over the last several decades, the Bug river valley has undergone slight transformations. Grassland management in flood plains still dominates. The problem is that these lands are increasingly being converted into arable land. The cause for this are financial reasons and the decreasing frequency of flooding, making the land available from early spring for cultivation. The greatest changes in this respect concern the flood areas cut off from the river by embankments, especially in the section from Małkinia to Nur. Corn fields reach right up to the embankments. The construction of these embankments itself was not without harm to nature. The sand and gravel needed for their construction came from digging out “grądziki”, i.e. hills scattered in the meadows near the construction area. Few of them have been preserved to this day, including the “grądziki” in the “Bojarski Grąd” reserve. At the same time, a system of pumping stations, locks, and embankments was built, extending far up the smaller rivers that flow into the Bug river.

Another reason for the progressive loss of grassland habitats is the disappearance or limitation of animal grazing. Plant succession is progressing on high, former sandy pastures, and large patches of poor pine forests and juniper forests appear. After the political transformations in 1989-1990, small farms limited the activity and intensity of plant production, which resulted in the formation of fallow lands. Larger farms (20 or more ha of agricultural land) increased their share in agricultural production. This was due to the rise in land ownership and production intensity (Jóźwiak 2004). In 1990-2017, there was a slight (15.2%) increase in the area of meadows and a significant (75.5%) decrease in the area of pastures. These declines occurred mainly until Poland joined the EU structures in 2004, as then the loss of land use was relatively small (Roszkowska-Mądra 2020). On fragmented lands, there was a mosaic of different types of land use that allowed plants to flower and disperse seeds. This is now often impossible in large-scale plantations that are focused on high productivity. The survival of some species in floodplain meadows is also threatened by too intensive mowing, at inappropriate times. Many plants are unable to produce fruit and seeds in such conditions. This problem most strongly affects annual species, such as *Melampyrum cristatum*, but in the case of perennial plants it results in a lack of dispersal in a given year and the inability to conquer new areas. Another habitat-destroying practice observed

by the authors is levelling debris in meadows, bringing soil from outside flood areas, fertilization, and seeding alien grass mixtures. Such meadows become habitats dominated by several grass species, including *Lolium multiflorum* Lam.

Every year, more and more areas are lost due to the construction of new roads and asphaltting of roads leading through meadows and other green areas. Recently, 3 major communication investments have been made: a bridge over the Bug river was built on the S8 route and 2 bridges in Małkinia were rebuilt. The construction of another bridge near Drohiczyń will begin soon. The earthworks, construction of embankments and access roads result in the loss of valuable habitats, filling of oxbow lakes, and regulation of the river in the construction section.

Inappropriate policies of institutions responsible for spatial development plans and managing agricultural areas also contribute to the disappearance of habitats. The lack of appropriate decisions results in the “development” of green and floodplain areas, including the unlimited expansion of summer settlements infrastructure. In each such case, it involves enclosing the property with fences, littering the surroundings, and introducing alien and invasive species. An increasing problem is the division of large areas into many smaller plots and building makeshift huts.

An increase in the number and area covered by alien and invasive species is observed in the study area. For now, they are not a major problem, except for a few species in small areas. The mowing of meadows does not allow excessive expansion of *Solidago gigantea* Aiton and *S. canadensis* L. populations. Their largest populations are observed in unmown areas between the river and the flood embankments. An increase in the number of sites of invasive species was observed in river areas for *Echinocystis lobata* (F. Michx.) Torr. & A. Gray, *Rumex confertus* Willd., *Reynoutria japonica* Houtt., and *R. sachalinensis* (F. Schmidt) Nakai. In forests, there is a visible growth of patches of *Erechtites hieracifolia* (L.) Raf. ex DC., *Padus serotina* (Ehrh.) Borkh., and *Robinia pseudoacacia* L.

Clear-cutting combined with ploughing the land is also associated with the disappearance of many forest species. Most of the localities of *Chimaphila umbellata* and *Arctostaphylos uva-ursi* were found only on the sides of forest roads, currently used or recently abandoned. These were the only places not exposed to destruction in the case of clear-cutting. Therefore, cooperation with forest districts to establish partly protected ecological sites is extremely important.

The growing threat to some species in the research area is evidenced by the increase in the number of red-listed species, which is also confirmed in our research.

In the 1990s, the Polish Red List (Zarzycki & Szeląg 1992) included a group of rare species, marked with the R symbol, which did not appear in later editions. Only since 2016 has a group of near-threatened (NT) species appeared on the Polish Red List, numbering 19 taxa (Kaźmierczakowa *et al.* 2016). Most of them occur in habitats of the highest concern, and knowing this will help to protect these habitats in the future.

The list below shows the number of protected and rare taxa found in this study, based on various Red Lists and other classifications:

- 12 species included in the Polish Red List by Zarzycki & Szeląg (1992);
- 15 species included in the Polish Red List by Zarzycki & Szeląg (2006);
- 34 species included in the Polish Red List by Kaźmierczakowa *et al.* (2016);
- 57 species included in the Red List for the South Podlasie Lowland by Głowacki *et al.* (1990);
- 35 species rare in the study area in 2023 according to our evaluation;
- 45 species under strict or partial protection in 2023 according to Polish law (Rozporządzenie 2014).

4. Conclusions

In total, in the left-bank part of the Lower Bug Valley, 90 species of protected plants, taxa included in the Polish Red List by Kaźmierczakowa *et al.* (2016), and regionally rare ones were recorded. Among them, 16 species are under strict protection and 29 under partial protection. The group of red-listed plants represents 4 categories: DD (2 spp.), NT (19 spp.), VU (12 spp.), and EN (1 sp.). Besides, 35 species are considered rare in the region by our research team (Fig. 3). The collected data allowed us to estimate the resources of rare and protected species on the left side of the Bug valley. The surveys also show the scale of threat and changes in the distribution of the mentioned taxa over the last 30 years. A noticeable loss of habitats or of their area has been observed and is progressing. Due to anthropogenic reasons, this applies in particular to the expansion of human settlements (especially summer recreation areas), replacement of meadows by croplands, improper drainage, cessation of mowing meadows and the methods of their use (change of mowing cycles, reseeding of cultivated grass varieties), but also too intensive forest management. Natural reasons include a drastic decrease in groundwater level (hydrological drought), absence of annual floods of rivers, and the warming of climate. All the above-mentioned factors cause the disappearance of rare and protected species, which is well illustrated by the increase in the number of red-listed taxa recorded in the study area. The most visible is the significant increase in the number of taxa

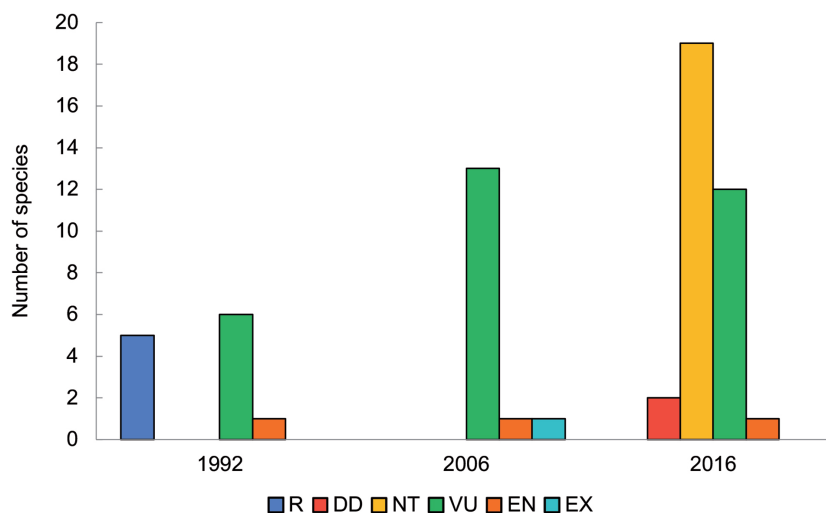


Fig. 3. Changes in the number of red-listed taxa in individual threat categories according to Zarzycki & Szelağ (1992, 2006) and Kaźmierczakowa *et al.* (2016)

Explanations: R – rare; DD – data deficient; NT – near-threatened; VU – vulnerable; EN – endangered; EX – extinct

classified as NT. However, a species considered extinct or lost in 2006 – *Melampyrum cristatum* – turned out to be numerous and its new localities will probably be found in the future (like for other species from the list). During our research, it was impossible to reach many parts of the study area and the above list certainly does not cover all species and locations. Due to inaccessibility, many wetland habitats (especially oxbow lakes) were not checked, so the research will be continued.

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