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Damp beech forests on calcareous tufas in the Parsęta River basin (Western Pomerania)

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Abstract: Damp beech forests in the Parsęta River basin (Western Pomerania) constitute a rare and unique type of beechwood community in post-glacial landscape of the Pomerania region. They grow on calcareous soil of pararendzina type formed from calcareous tufas and are characterized by the presence of two orchids *Cephalanthera rubra* and *Neottia nidus-avis* accompanied by many rare and endangered plant species occurring in habitats rich in calcium.

Key words: damp beech forest, calcareous tufa, *Fagus sylvatica-Mercurialis perennis* community, *Cephalanthera rubra*, *Neottia nidus-avis*, Parsęta River basin, Western Pomerania

1. Introduction

Damp beech forest is a rare and peculiar type of beechwood community observed so far only at a few sites in the Pomerania region. It occurs in specific habitats, on damp soil rich in nutritious elements and calcium carbonate. That community is floristically diverse, with abundant lowest undergrowth in which rare species are observed, for example those belonging to *Orchidaceae* family (Celiński 1962; Danielewicz & Pawlaczyk 2004). Typical damp beech forest habitats are located in the area of lower ground, in morainic uplands, usually in lower parts of ravines, near springs, streams or lakes.

In the Debrzyca River basin near Drzewiany (Parsęta drainage area), damp beech forests developed in the area of broad spring complexes, on pararendzina soil formed from calcareous tufas. The aim of this study was to determine the phytosociological characteristics of damp beech forests against the hydrogeological background.

2. Material and methods

The analysed phytosociological material was collected in 2000-2007 within the framework of research on spring ecosystems in the Pomerania region (Osadowski 2010). Altogether 10 phytosociological releves were taken according to the Braun-Blanquet method. Phytosociological terminology used in this study is after W. Matuszkiewicz (2005) and J. M. Matuszkiewicz (2005), nomenclature of vascular plants after Mirek *et al*. (2002), nomenclature of moss species after Ochyra *et al*. (2003) and liverworts after Szweykowski (2006). Hydrogeological characteristics of the study area was determined with the help of geological maps of Poland in scale 1: 50 000 (sheet Bobolice) as well as hydrogeological maps of Poland in scale 1: 50 000 (sheet Bobolice) and hydrographic maps of Poland in scale 1: 50 000 (sheet Polanów). Identification of soil in the studied area was performed according to Wanic (in press). In the phytosociological table, the modified Braun-Blanquet method (1964) was applied for the degree of coverage.

3. Results and discussion

3.1. Hydrogeological background and geomorphological effects of groundwater outflows

The area covered with damp beech forest is located near Drzewiany village in the Bytów Lake District (Kondracki 2002) (Fig. 1). Beechwoods grow in a deep subglacial channel valley in which nowadays the Debrzyca River flows (the Radew River valley, the Parsęta River basin). The valley cuts across morainic

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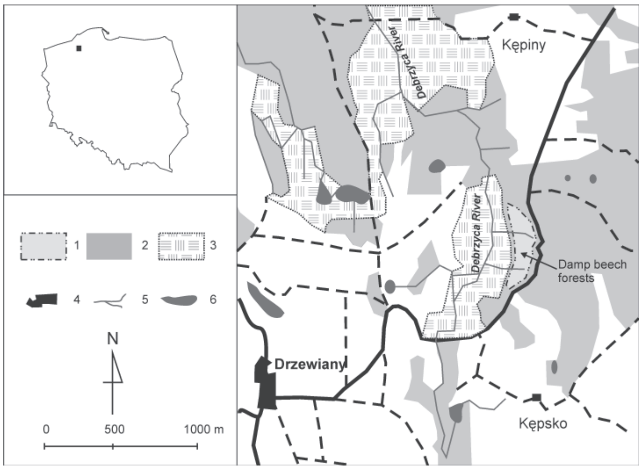

Fig. 1. Location of damp beech forests near Drzewiany
Explanations: 1 – damp beech forests, 2 – forests, 3 – meadows, 4 – buildings, 5 – rivers, 6 – lakes

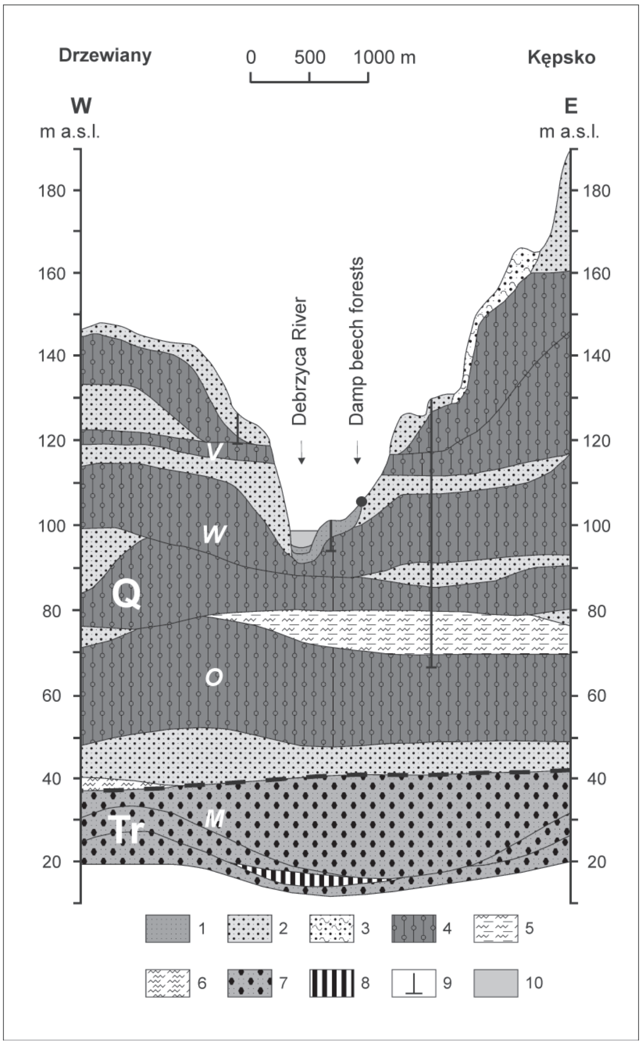

Fig. 2. Geological cross-section along the line Drzewiany-Krępsko with the location of damp beech forests in the Debrzyca River valley near Drzewiany (Marszałek & Szymański 2005, generalised)
Explanations: lithology, 1 – sands, 2 – sands and gravels, 3 – silty sands and gravels, 4 – till, 5 – clayey silts, 6 – sandy silts, 7 – quartz sands, silts, clays with brown coal in places, 8 – brown coal, 9 – boreholes, 10 – waters; stratigraphy, Tr – Tertiary, Q – Quaternary, S – San Glacial, O – Odra Glacial, W – Warta Glacial, V – Vistula Glacial

uplands, which are built from glacial sands with silt and gravel (Pomeranian Phase). During the ice-sheet recession, the valley was the drain for thawing waters and caused the substitution of tills of the Pomeranian Phase with glaciofluvial sand-gravel deposits (Marszałek & Szymański 2005) (Fig. 2). Those intermorainic glaciofluvial sands and gravels are locally exposed in the slopes of the Debrzyca River valley. Its scarps are varied with numerous small valleys and erosion cuts filled with diluvial deposits. The first groundwater level near Drzewiany is at the depth of about 1 m. In the footslope zone, the groundwater level varies between 2 and 5 m (Kaniecki 2006).

Considerable depth of the valley and high hydraulic gradients favoured the drainage of groundwater. The eastern slope of the Debrzyca tunnel valley is covered with numerous groundwater outflows (springs) which drain the intermorainic stratum with glaciofluvial deposits (Kreczko & Prussak 2004). Their outflow efficiency ranges from 2.8 to 26.9 dm^3 s^{-1} (Osadowski 2010).

The eastern slope of the valley, at sites with intensive groundwater outflows, is covered with spring mires. Their development (including calcareous tufa deposits) was favoured by the supply of groundwaters rich in calcium. The main sources of calcium carbonate were the glacial and fluvioglacial deposits which contained up to a dozen or so percent of $CaCO_3$ (Osadowski *et al.* 2009). The move of outflows, changes in flow velocity or the increase of groundwater level triggered off the erosion processes and, as a result, stopped the accumulation. The erosion of spring mires exposed the accumulated calcareous tufas which, in the course of time, became the substrate for vegetation. The erosion of spring mires may be caused by natural factors (lowering of groundwater level, changes in outflow efficiency, increase in the flow velocity of water courses) or past anthropogenic factors (for example, river melioration). As a result, the desiccated calcareous tufas became the substrate for pararendzina soil (Wanic in press). This soil in the area covered by damp beech forests is characterized by neutral or slightly alkaline reaction (pH 6.6-8.0). Higher values of pH are connected with considerable amount of calcium cations which originated from calcareous tufa.

3.2. Community physiognomy and structure

Damp beechwoods cover small fragments of the Debrzyca eastern footslope zone between Kępsko and Kępiny (Fig. 1). The tree stand is very thick (70-100%, 89% on average) and predominated by *Fagus sylvatica* (Table 1). Sporadically, the following species occur:

Table 1. Community of damp beech forest on calcareous tufas near Drzewiany (Parsęta River basin)

Cl. *Querco-Fagetea* Br.-Bl. et Vlieg. 1937
O. *Fagetalia sylvaticae* Pawł. in Pawł., Sokoł. et Wall. 1928
All. *Fagion sylvatica*e R.Tx. et Diem. 1936
Sub. All. *Galio odorati-Fagenion* (R.Tx. 1955) Th. Müller 1992
Comm. *Fagus sylvatica-Mercurialis perennis* (=*Mercuriali-Fagetum* Cel. 1962)

Serial number of relevé	1	2	3	4	5	6	7	8	9	10	Constancy	Coefficient of coverage
Date: day/month (all in 1998)	29/6	1/7	2/7	2/7	29/6	29/6	30/6	29/6	29/6	29/6		
Coverage of tree layer a [%]	70	100	90	80	100	100	70	90	90	100		
Coverage of shrub b [%]	10	5	5	1	0	0	10	40	15	20		
Coverage of herb layer c [%]	100	90	90	80	90	80	80	100	100	100		
Coverage of moss layer d [%]	1	0	25	20	10	1	5	20	10	5		
Relevé area [m^2]	400	400	400	400	600	400	400	400	400	400		
Number of species in relevé	46	34	54	37	52	34	41	52	56	38		
D. Community												
Neottia nidus-avis	+	+	1.1	+	+	+	+	.	+	.	IV	85
Alliaria petiolata	2a.1	2a.1	+	+	.	.	1.1	1.1	1.1	.	IV	360
Mercurialis perennis	2a.1	2b.3	2a.3	2a.3	+	+	.	.	.	.	III	505
Cephalanthera rubra	.	.	.	.	.	.	.	+	+	1.1	II	60
D. Sub. All. Galio odorati-Fagenion												
Poa nemoralis	1.2	+	1.2	2b.3	1.2	+	1.2	2a.1	2a.1	2a.1	V	710
Galium odoratum	1.1	2a.1	2b.1	2a.1	1.1	2a.1	.	2a.1	2a.1	2a.1	V	900
Festuca altissima	2a.2	1.2	1.2	1.2	2b.3	1.2	.	2b.3	2a.1	1.2	V	850
Milium effusum	1.1	.	+	.	+	+	.	+	2a.1	1.1	IV	220
Scrophularia nodosa	+	+	+	+	+	.	+	1.1	.	.	IV	80
Ch. et D. Sub. All. Cephalanthero-Fagenion												
Campanula persicifolia	+	.	+	+	+	+	+	+	+	+	V	45
Polygonatum odoratum	.	1.1	1.1	+	1.1	1.1	.	1.1	1.1	+	IV	310
Vicia sylvatica	.	.	.	+	+	.	+	+	.	1.1	III	70
Campanula rapunculoides	.	.	.	.	.	.	1.1	+	+	1.1	II	110
Astragalus glycyphyllos	.	.	.	.	.	.	.	+	.	.	I	5
Ch. et. D. All. Fagion sylvaticae												
Fagus sylvatica a	4.5	5.5	5.5	4.5	5.5	5.5	4.5	5.5	5.5	5.5	V	8000
Fagus sylvatica b	+	+	.	+	.	.	.	1.1	1.1	1.1	III	165
Fagus sylvatica c	1.1	2a.1	2a.1	1.1	1.1	1.1	1.1	.	1.1	2a.1	V	600
Dentaria bulbifera	+	1.1	1.1	1.1	1.1	+	.	.	+	+	IV	220
Mnium hornum d	.	.	.	2a.3	1.3	+	+	1.3	.	+	III	215
Ch. O. Fagetalia sylvaticae												
Aegopodium podagraria	2a.1	1.1	1.1	+	1.1	+	2a.1	2a.1	2b.3	2b.3	V	860
Pulmonaria obscura	1.1	2a.1	1.1	1.1	1.1	+	1.1	2a.1	1.1	1.1	V	555
Actaea spicata	1.1	+	+	+	1.1	+	+	1.1	1.1	+	V	230
Campanula trachelium	+	.	+	+	+	1.1	+	+	+	+	V	90
Galeobdolon luteum	2a.1	1.1	2a.1	1.1	1.1	.	2a.1	1.1	2a.3	.	IV	600
Ranunculus lanuginosus	1.1	+	1.1	.	+	.	1.1	1.1	1.1	+	IV	265
Stellaria holostea	1.1	1.1	.	.	+	.	2a.3	1.1	1.1	2a.1	IV	405
Viola mirabilis	1.1	1.1	1.1	.	1.1	1.1	.	.	1.1	1.1	IV	350
Daphne mezereum	1.1	.	+	.	.	1.1	.	1.1	1.1	1.1	III	255
Carex sylvatica	.	.	+	.	2a.2	+	.	1.2	+	+	III	170
Acer pseudoplatanus b	1.1	1.1	.	.	.	.	.	2b.1	1.1	1.1	III	525
Atrichum undulatum d	.	.	2a.3	2a.3	1.3	.	1.3	2a.3	.	.	III	400
Epilobium montanum	+	.	+	+	.	.	+	+	.	.	III	25
Stachys sylvatica	.	.	+	.	+	+	.	+	+	.	III	25
Impatiens noli-tangere	2b.3	1.1	.	.	.	.	+	1.1	.	.	II	305
Acer pseudoplatanus c	1.1	1.1	.	.	.	.	.	.	1.1	1.1	II	200
Lathyrus vernus	.	.	+	1.1	1.1	1.1	.	.	.	.	II	155
Viola reichenbachiana	.	.	+	+	.	.	.	1.1	1.1	.	II	110
Circaea lutetiana	1	1.1	.	.	.	.	.	+	+	.	II	110
Adoxa moschatellina	1.1	.	+	+	.	.	1.1	.	.	.	II	110
Paris quadrifolia	.	.	.	.	+	.	+	.	+	+	II	20
Corydalis cava	2a.1	1.1	+	.	.	.	.	.	.	.	II	155
Phyteuma spicatum	+	.	1.1	.	.	.	.	1.1	.	.	II	105
Dryopteris filix-mas	.	.	.	.	+	.	+	.	+	.	II	15
Stellaria nemorum	.	1.1	.	.	.	.	.	.	1.3	.	I	100
Ch. Cl. Querco-Fagetea												
Hepatica nobilis	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	V	500
Melica nutans	1.1	.	1.2	+	+	1.1	1.2	1.1	1.1	1.2	V	360
Brachypodium sylvaticum	1.2	1.1	1.2	.	1.1	1.2	.	2a.3	2a.3	2b.3	IV	650
Anemone nemorosa	.	.	1.1	.	2a.1	2b.3	1.1	1.1	2a.1	2a.1	IV	650
Carex digitata	+	.	1.1	.	1.2	1.2	.	1.2	1.2	+	IV	260
Acer platanoides c	.	+	1.1	1.1	+	.	.	+	+	+	IV	125
Euonymus europaeus	+	+	+	+	+	.	+	+	+	.	IV	40

Serial number of relevé	1	2	3	4	5	6	7	8	9	10		
Corylus avellana b	.	+	+	.	.	.	1.1	+	1.1	2a.1	III	215
Hedera helix	.	.	+	.	+	+	.	1.1	+	1.1	III	120
Corylus avellana	+	.	.	.	+	.	.	.	+	.	II	15
Accompanying												
Oxalis acetosella	1.1	+	+	.	1.1	1.1	.	1.1	1.1	1.1	IV	310
Sorbus aucuparia	.	+	+	.	1.1	1.1	+	+	+	+	IV	130
Maianthemum bifolium	.	.	+	.	1.1	1.1	+	1.1	1.1	.	III	210
Mycelis muralis	.	.	+	1.1	+	.	+	+	+	.	III	75
Geranium robertianum	.	+	.	.	1.1	+	+	.	+	.	III	70
Veronica chamaedrys	+	.	+	.		.	.	1.1	+	.	II	65
Luzula pilosa	.	.	+	+	+	.	.	+	.	.	II	15
Brachythecium rivulare d	1.3	.	1.3	.	.	.	.	.	.	+	II	105
Alnus glutinosa a	.	+	.	.	1.1	.	.	.	1.1	.	II	105
Galeopsis tetrahit	+	.	.	.	.	.	+	+	.	.	II	15
Geum urbanum	+	.	+	.	+	.	.	.	.	.	II	15
Myosotis sylvatica	+	.	+	+	.	.	.	.	.	.	II	15
Rubus idaeus	.	.	+	.	.	.	.	+	+	.	II	15
Stellaria media	.	.	.	+	+	.	+	.	.	.	II	15
Sambucus nigra	.	+	.	.	+	.	.	.	+	.	II	15
Viburnum opulus	+	.	.	.	.	.	.	+	+	.	II	15
Fissidens taxifolius d	.	.	.	.		+	.	.	.	+	II	15
Quercus robur a	.	.	.	2a.1	.	.	1.1	.	.	.	I	150
Cardamine impatiens	.	.	1.1	1.1	.	.	.	.	.	.	I	100

Sporadic: *Betula pendula* (a): 7(+); *Brachythecium mildeanum* (d): 9(1); *Carex remota* (c): 5(+), 9(+); *Carpinus betulus* (a): 7(1); *Crataegus laevigata* (c): 9(+); *Crataegus monogyna* (b): 7(+), (c): 1(+); *Dicranella heteromalla* (d): 8(+); *Dryopteris dilatata* (c): 1(+); *Equisetum hyemale* (c): 6(+), 10(+); *Equisetum palustre* (c): 10(+); *Galium aparine* (c): 7(+), 9(+); *Hylocomium splendens* (d): 9(+); *Hypnum cupressiforme* (d): 5(+), 6(+); *Lapsana communis* (c): 5(+); *Myosotis palustris* (c): 2(+); *Plagiomnium rostratum* (d): 3(2a); *Plagiothecium nemorale* (d): 3(+); *Pohlia nutans* (d): 8(1); *Porella platyphylla* (d): 10(+); *Primula veris* (c): 7(+); *Quercus robur* (c): 7(+); *Rubus plicatus* (c): 5(+); *Sambucus nigra* (b): 1(1), 2(+); *Stachys palustris* (c): 1(1), 2(+); *Urtica dioica* (c): 1(+), 7(+); *Veronica officinalis* (c): 8(+); *Alnus glutinosa* (c): 6(+)

Ch.Cl. *Querco-Fagetea*: *Acer platanoides* (a): 4(1); *Acer platanoides* (b): 2(+); *Ajuga reptans* (c): 1(+), 9(+); *Convallaria majalis* (c): 6(+), 8(+)

Ch.O. *Fagetalia sylvaticae*: *Carpinus betulus* (b): 7(1); *Carpinus betulus* (c): 3(+), 7(+); *Eurhynchium striatum* (d): 4(+); *Polygonatum multiflorum* (c): 7(+); *Tilia cordata* (a): 3(+), 4(+); *Ulmus glabra* (b): 3(1), 4(+); *Ulmus glabra* (c): 3(+), 9(+); *Veronica montana* (c): 5(+), 9(+)

Alnus glutinosa, *Quercus robur*, *Betula pendula*, *Carpinus betulus*, *Tilia cordata* and *Acer platanoides*. In the undergrowth, weakly developed (0-40%, 11% on average), *Fagus sylvatica*, *Acer pseudoplatanus* and *Corylus avellana* occur moderately often, while *Carpinus betulus*, *Ulmus glabra*, *Acer platanoides*, *Sambucus nigra* and *Crataegus monogyna* are observed sporadically. The moss layer is also poorly developed and covers 0-25% of the studied plots (10% on average). *Atrichum undulatum* and *Mnium hornum* occur moderately often, while *Brachythecium rivulare* and *Fissidens taxifolius* more rarely. The remaining moss species occur sporadically and are typical of beech forest (*Dicranella heteromalla, Plagiothecium nemorale*, *Eurhynchium striatum*). Special attention should be paid to a liverwort species *Porella platyphylla* which prefers high concentration of calcium.

The herb layer is well developed and covers from 80 to 100% of the studied plots (91% on average). Among species typical of damp beechwood, the following plants were observed: *Mercurialis perennis*, *Alliaria petiolata, Neottia nidus-avis* and *Cephalanthera rubra*. Römer (1912) reported there also the presence of *Cypripedium calceolus*. A characteristic feature of the herb layer is a permanent or frequent occurrence of sciophyte species, typical for the suballiance *Galio odorati-Fagenion*, the alliance *Fagion sylvaticae* and the order *Fagetalia sylvaticae*. Some lobes are grassy with higher share of *Festuca altissima* and *Brachypodium sylvaticum*. In the undergrowth, particularly at drier places located higher on the valley slope, also some sun-loving species occur, which are diagnostic for the suballiance *Cephalanthero-Fagenion* (for example, *Astragalus glycyphyllos Campanula persicifolia, C. rapunculoides, Polygonatum odoratum* and *Vicia sylvatica*).

Altogether 101 plant species were observed in the studied damp beech forests: 88 vascular plant species and 13 moss species. The number of taxa in the lobes varied between 34 and 56 (44 taxa on average). The following species, rare and endangered in the Pomerania region were recorded: *Neottia nidus-avis*, *Cephalanthera rubra, Actaea spicata*, *Cardamine impatiens*, *Corydalis cava*, *Daphne mezereum*, *Dentaria bulbifera*, *Viola mirabilis* (Żukowski & Jackowiak 1995; Markowski & Buliński 2004; Zarzycki & Szeląg 2006) and endangered liverwort *Porella platyphylla* (Ochyra 1992). As for the upland plant species, *Veronica montana* (Zając 1996) occurred in the studied area.

3.3. Phytosociological affiliation

Systematic depiction of damp „orchid" beech forests in the early post-glacial landscape of the Pomerania region is still unsettled. Tentatively, they were classified as damp beechwood *Fagus sylvatica-Mercurialis perennis* belonging to the suballiance of *Galio odorati-Fagenion* and as the Kashubian orchids beechwood *Fagus sylvatica-Cypripedium calceolus* belonging to the suballiance of *Cephalanthero-Fagenion* (Herbich & Pawlaczyk 2004; W. Matuszkiewicz 2005). In the latest phytosociological approach (Ratyńska *et al.* 2010), the damp beech forest was qualified for the alliance *Galio-odorati-Fagenion* as the association *Mercuriali-Fagetum*.

That specific type of damp beech forest was for the first time identified in Germany (Kaiser 1926, for Moor 1952). In Poland, it was found in the Puszcza Bukowa and classified as the association *Mercuriali-Fagetum* (Celiński 1962) on rich and damp soil formed from lake deposits. Orchid beech forests in the Kaszuby Lake District were described as *Carici-Fagetum* on chalky soil of pararendzina type formed from lake chalk (Fałtynowicz & Machnikowski 1982) and on highly eroded slopes with exposed tills rich in calcium carbonate (Herbich 1982, 1993, 1994, 1998). Damp beech forests near Drzewiany grow on chalky soils of pararendzina type formed from calcareous tufa (spring deposits). Depending on substrate humidity and the presence of orchids, they were tentatively classified to the *Mercuriali-Fagetum* (No. 1-6, Table 1) or *Carici-Fagetum* associations (No. 7-10, Table 1) (Osadowski 2000).

W. Matuszkiewicz (2005) underlines that species of *Orchidaceae* family growing in orchid beech forests show relatively wide phytosociological amplitude. Therefore, the identification of orchid beechwood should not be based only on the presence of orchids but on their characteristic species composition. The cited literature indicates that the beechwood near Drzewiany should be entirely classified as the damp form of *Fagus sylvatica-Mercurialis perennis* community (=*Mercuriali-Fagetum*) because, in the studied vegetation lobes, the shade-loving and hygrophilous species predominated over xerothermic species preferring high calcium concentration. Moreover, the species characteristic for the suballiance *Cephalanthero-Fagenion* (except for *Campanula rapunculoides* and *Astragalus glycyphyllos*) are present in almost every patch.

3.4. Ecological importance and need of protection

Damp beech forests near Drzewiany belong to very rare and peculiar types of forest ecosystems, with numerous legally protected, rare and endangered plant species. That area is also unique thanks to the high concentration of springs and the presence of pararendzina soil formed from calcareous tufas. The most important threat for damp beechwoods is forest economy which does not respect the habitat peculiarity (forest cutting, interference in hydrological system). Due to unique phytocoenotic and landscape values as well as hydrogeological background, the discussed area needs urgent protection in the form of a nature reserve.

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