

## Globe flower *Trollius europaeus* L. in forest and forest edge communities of the northern part of Południowopodlaska Lowland

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**Abstract.** The distribution of *Trollius europaeus* in the northern part of the Południowopodlaska Lowland was described and a phytosociological study made of the localities where it was present between 2010 and 2012. The condition of all sites where *T. europaeus* was historically present was also verified. These field studies reveal that the number of sites of occurrence and the abundance of *T. europaeus* populations have rapidly diminished over recent years. Only 15 populations of the species in the vicinity of 7 sites were confirmed. *Trollius europaeus* is usually considered a species characteristic of moist meadows of ordo *Molinietalia* and in the plant community type, *Polygono bistortae-Trollietum*. In the northern part of the Południowopodlaska Lowland, no meadow sites containing *Trollius europaeus* still remain according to our survey. All the confirmed stands are situated in deciduous forests of class *Quercio-Fagetea* (*Tilio-Carpinetum* and *Potentillo albae-Quercetum*) and moist forest edge communities of ordo *Glechometalia*. The disappearance of all meadow populations is mainly considered a result of intensification of the agricultural use of these habitats. We suggest that the category of threat to *Trollius europaeus* is increased on the regional list from VU to EN, and consolidated with further monitoring and active protection of stands where it is present.

**Key words:** *Trollius europaeus*, forest communities, forest edge communities, Południowopodlaska Lowland

### 1. Introduction

Globe flower *Trollius europaeus* L. (*Ranunculaceae* family) is a Eurosiberian hemicryptophyte. It occurs in Europe (with the exception of the south-western areas) and Western Siberia. Its natural stands are scattered throughout Poland, with particularly large populations occurring in the Lubelszczyzna (Lublin region) (Zajac et al. 2001). At higher altitudes, it is replaced by alpine globe flower (*Trollius altissimus* Crantz), sometimes considered a sub-species of the European globe flower (*Trollius europaeus* subsp. *transsilvanicus*) (Piękoś-Mirkowa, Mirek 2003).

Globe flower has been strictly protected since 1946 (Regulation of the Ministry of Education of Poland of

29th August 1946), when the list of protected plants mentioned was only 29 taxa. According to a recent regulation (Regulation of the Minister of Environment of Poland of 5th January 2012, § 8), an active conservation is required to protect globe flower stands. Although the species has not been included in the *Red List of plants and fungi in Poland* (Zarzycki, Szelağ 2006), it is incorporated in most of the regional lists. In the Opolszczyzna (Opole region) it was considered among the critically endangered species CR (Nowak et al. 2008). In Dolny Śląsk (Lower Silesia) (Kački et al. 2003), Śląsk (Silesia) (Bernacki et al. 2000), central Poland (Jakubowska-Gabara, Kucharski, 1999), Wielkopolska (Grater Poland) (Jackowiak et al. 2007) and in Pomorze Zachodnie (Western Pomerania)

(Żukowski, Jackowiak 1995), the globe flower taxon was classified as vulnerable (VU). Also in the Nizina Południowopodlaska (Południowopodlaska Lowland), it belongs to the same category of threat (Głowacki et al. 2003).

*Trollius europaeus* is considered to be a species characteristic of moist meadows of ordo *Molinietalia* and association *Polygono bistortae–Trollietum* (Matuszkiewicz 2006). It is less frequent in reed beds (Kochanowska, Gamrat 2007) and forests (Kępczyński, Fertsch 1974; Sokołowski 1995; Matuszkiewicz 2002; Zarzycki et al. 2002).

None of the quite numerous historical meadow localities of globe flower in the Południowopolska Lowland has been preserved. The natural stands that have remained are located entirely within or directly adjacent to forest communities.

The paper presents the current distribution of *Trollius europaeus* in the northern part of Południowopodlaska Lowland with phytosociological characteristics of its localities.

## 2. Materials and methods

The study was conducted in the northern part of the Południowopodlaska Lowland, within mesoregions: Wysoczyzna Siedlecka (Siedlecka Upland), Podlaski Przełom Bugu, Węgrowskie Obniżenie and Wysoczyzna Kałuszyńska (Kałuszyńska Upland). The Południowopodlaska Lowland is slightly undulating plateau at an altitude ranging from 150–200 m above sea level. The typical geomorphological forms of its northern part are monadnocks of moraine hills, kames and eskers formed during the warciański ice age (Kondracki 2009). The climate of the area is characterised by a lower average annual temperature by 1°C than in areas further west, and total precipitation of about 550 mm. The study area is located in the Podlasie Lowland and Siedlecka Upland District belonging to the Kraina Mazowiecko-Podlaska (Mazowsze-Podlasie Mesoregion) (according to Trampler et al. 1990).

The list of localities of *Trollius europaeus* in the studied area (Fig. 1) was prepared on the basis of our own materials, with the literature, information on its distribution within the ATPOL grid square system (Zajac et al. 2001), and herbarium cards from the Herbarium of the University of Natural Sciences and Humanities in Siedlce.

The first reports of *Trollius europaeus* occurrences date back to the end of the XIX century (Karo 1871; Drymmer 1895; Błoński 1982). Other data on the globe flower stands in the region have been published since the 70s of the XX century, after the establishment of a scientific center in Siedlce (such as Głowacki 1976, 1977, 1985; Ciosek 1985, Ćwikliński et al., 1987; Ćwikliński and Głowacki 1990, 2000; Krechowski 1997). These localities were verified during the field work carried out by the Authors in 2010–2012. The characteristics of existing populations (location, plant community, size and abundance) are shown in Table 1.

In all existing localities of globe flower phytosociological relevés were made with compliance to the Braun-Blanquet method of (Pawłowski 1972). They were the basis for determining the phytosociological characteristics of a stand. In the forest communities, relevés were performed in two periods: early spring, and in June (globe flower flowering period).

Due to the lack of complete documentation of historical localities (number of individuals, the size of the patch), limited mostly to specify the location and type of community, a long-term dynamic analysis on the population of globe flower was impossible.

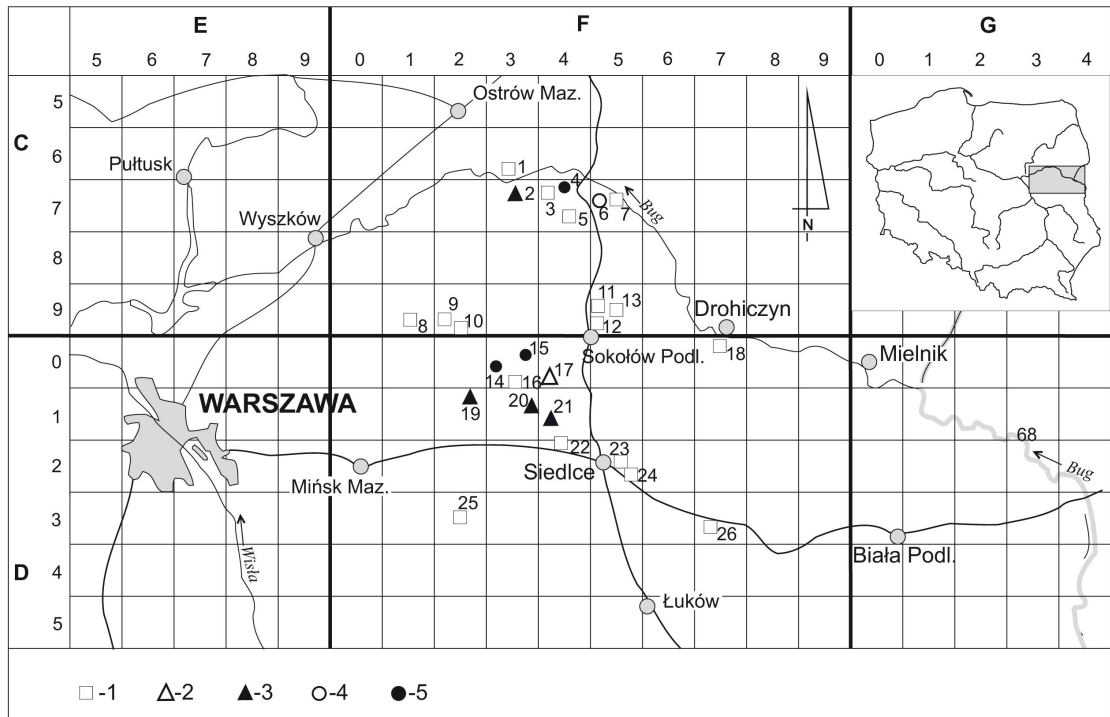
Nomenclature of vascular plant species follows Mirek et al. (2002), while moss naming is taken from Ochyra et al. (2003). Phytosociological classification of species was based on paper by Matuszkiewicz (2006).

## 3. Results

In the northern part of the Południowopodlaska Lowland, *Trollius europaeus* was recorded at 34 sites in the vicinity of 26 towns (Fig. 1). Most of these localities are of historical significance. Currently 15 stands of globe flower, centered around 7 towns, are confirmed (\* - currently existing localities).

Localities of *Trollius europaeus* in northern part of the Południowopodlaska Lowland

Globe flower stands within the study area (Table 2) are located in deciduous forests of ordo *Quercus-Fagetea* with different phytosociological characteristics (relevés. 1–8) and in moist forest edges of ordo *Glechometalia* (relevés. 9–15).



**Figure 1.** Distribution of *Trollius europaeus* L. in the northern part of Południowopodlaska Lowland:

1 – meadow localities existing in the past, 2 – forest edge localities existing in the past, 3 – present forest edge localities, 4 – forest localities existing in the past, 5 – present forest localities.

1. FC 63 Małkinia Mała (Przewóz), Małkinia Górna Commune, moist meadow (Ćwikliński, Głowacki 2000).
2. \*FC 73 Bojary (Bojarski Grąd Reserve), Kosów Lacki Commune, moist forest edge (Ćwikliński, Głowacki 1990).
3. FC 74 Garnek, Cerańów Commune, moist meadow; *leg.* Głowacki 1984 (Zajac et al. 2001)
4. \*FC 74 Noski (Biele Reserve), Cerańów Commune, 2 stands, deciduous forest and mid-forest meadow (Ćwikliński, Głowacki 1990).
5. FC 74 Olszew, Cerańów Commune, meadow (Błoński 1892).
6. FC 75 Antonówka (Majdan), Cerańów Commune, deciduous forest; *leg.* Głowacki 1985 (Zajac et al. 2001).
7. FC 75 Natolin, Cerańów Commune, moist meadow (Ćwikliński, Głowacki 1990).
8. FC 91 Dębiana, Korytnica Commune, meadow (Drymmer 1895).
9. FC 92 Komory, Korytnica Commune, moist meadow; *leg.* Głowacki 1977 (Zajac et al. 2001).
10. FC 92 Korytnica, Korytnica Commune, meadow (Drymmer 1895).
11. FC 95 Jadwisin, Sabnie Commune, moist meadow (Głowacki 1985).
12. FC 95 Lubianki (Sapula), Sokołów Podlaski Commune, moist meadow; *leg.* Jastrzębska 1977.
13. FC 95 Wyrąb, Sokołów Podlaski Commune, moist meadow; *leg.* Głowacki 1989 (Zajac et al. 2001).
14. \*FD 03 Jarnice, Liw Commune, 2 stands, deciduous forest; *leg.* Ciosek 1999.
15. \*FD 03 Ruchna (ur. Ruchna), Liw Commune, 5 stands, deciduous forest (Drymmer 1895, Ćwikliński et al. 1987).
16. FD 03 Szaruty, Liw Commune, moist meadow (Głowacki 1985).
17. FD 04 Śnice, Liw Commune, moist forest edge (Ciosek 1985).
18. FD 07 Starzewice (Przekop Reserve), Korczew Commune, moist meadows (Ćwikliński et al. 1987).
19. \*FD 12 Soboń, Wierzbno Commune, 2 stands, moist forest edge (Krechowski 1997).
20. \*FD 13 Męczyn, Mokobody Commune, 2 stands, moist forest edge; *leg.* Ciosek 1999.
21. \*FD 14 Budziszyn (Mokobody), Mokobody Commune, moist forest edge; *leg.* Ćwikliński 1987 (Zajac et al. 2001).
22. FD 24 Niwiski, Mokobody Commune, moist meadow (Błoński 1892).
23. FD 25 Golice, Siedlce Commune, moist meadow (Karo 1871, Jówko, Głowacki 1976).
24. FD 25 Stok Lacki, Siedlce Commune, moist meadow (Karo 1871).
25. FD 32 Liwiec, Mrozy Commune, moist meadow; *leg.* Głowacki 1988 (Zajac et al. 2001).
26. FD 37 Zawady, Zbuczyn Commune, moist meadow; *leg.* Głowacki 1975 (Zajac et al. 2001).

**Table 1.** Characteristics of present localities of *Trollius europaeus* L.

No.	Object	No. of relevé	Forest address	Community	Geographic coordinates		Station area [m <sup>2</sup> ]	Abundance of population	
					N	E		numer of clumbs	flowering
1	Jarnice	1	6	<i>Tilio-Carpinetum typicum</i>	52,365883	22,021232	10	15	5
		8	4	<i>Potentillo albae Quercetum</i>	52,363258	22,021623	1	1	2-3*
2	Ruchna	2	205c	<i>Tilio-Carpinetum typicum</i>	52,370595	22,100716	3	6	
		4	214c	<i>Tilio-Carpinetum stachyetosum</i>	52,372432	22,108193	15	12	5
		5	216f	<i>Tilio-Carpinetum stachyetosum</i>	52,362393	22,103033	10	6	3
		6	210	<i>Tilio-Carpinetum stachyetosum</i>	52,350336	22,089300	30	dozens	30
		7	212	<i>Tilio-Carpinetum stachyetosum</i>	52,341265	22,081404	30	dozens	28
3	Biele	3	15i	<i>Tilio-Carpinetum typicum</i>	52,647831	22,198603	25	10	0
		9	15 h/i	<i>Ord. Glechometalia</i>	52,648090	22,198421	ca 1000	ca 250	ca 100
4	Soboń	10	237d	<i>Ord. Glechometalia</i>	52,310453	21,893016	15	15	2
		11	237d	<i>Ord. Glechometalia</i>	52,313753	21,901353	5	3	2
5	Bojarski Grąd	12	.	<i>Ord. Glechometalia</i>	52,655894	22,072961	hundreds	dozens	19
6	Męczyn	13	.	<i>Ord. Glechometalia</i>	52,277453	22,089901	1	1	2*
		14	.	<i>Ord. Glechometalia</i>	52,297903	22,066512	25	5	4
7	Budziszyn	15	.	<i>Ord. Glechometalia</i>	52,284792	22,106810	20	12	3

\* flowering sprouts

The first three relevés describe locations within oak-hornbeam forest *Tilio-Carpinetum typicum*. The canopy layer is dominated there by oak *Quercus robur*, while the lower layer by hornbeam *Carpinus betulus* and in the Jarnice location, lime *Tilia cordata*. The understory consists of the trees mentioned above and hazel *Corylus avellana*, rarely other species. In the herb layer, a large share (cover 2–3) have species characteristic of oak-hornbeam forests: *Stellaria holostea* and *Galium schultesii*. There are many species characteristic of class *Quercus-Fagetalia* and ordo *Fagetalia sylvaticae* (such as *Aegopodium podagraria*, *Anemone nemorosa*, *Ranunculus lanuginosus*). The accompanying species characterised by high degree of presence are: *Oxalis acetosella*, *Maianthemum bifolium*, *Dryopteris carthusiana*. A small percentage of species such as *Festuca gigantea*, *Glechoma hederacea*, *Ranunculus lanuginosus* or *Circaea lutetiana*

implies that the patches described represent more humid form of an oak-hornbeam forest. The moss layer, with a relatively high cover (10–20%), consists of *Plagiomnium affine* and *Atrichum undulatum*. Somewhat different is the stand in Biele Reserve (Fig. 3). The distinguishing trait is the lack of hornbeam and linden in the canopy layer and lack of species characteristic of the plant association, *Carpinion betuli* in the herb layer.

Next, four localities of globe flower in Ruchna (described by relevés 4–7) are in a moist sub-association of *Tilio-Carpinetum stachyetosum*, characterised by the presence of the tree species with high humidity requirements. Share of *Alnus glutinosa* and *Fraxinus excelsior* ranges from 1–3 (Figs. 5–7), and from 2–4 (Figs. 4 and 5) respectively. Permanent element of this layer is oak (cover from 1–4). Attention is drawn to the considerable share of *Padus avium* in understory. The herb

layer doesn't exhibit typical floodplain characteristics. It is dominated by species typical of class *Quercio-Fagetea* (*Aegopodium podagraria*, *Anemone nemorosa*) and ordo *Fagetalia sylvaticae* (*Viola reichenbachiana*, *Milium effusum*, *Stachys sylvatica*, *Asarum europaeum*, *Ranunculus lanuginosus*). Species characteristic of associations between *Carpinion betuli* and *Alno-Padion* are few in numbers and achieve little coverage. Mosses coverage, built by *Plagiomnium undulatum* (cover 3) and *Plagiomnium affine* (cover 2), is high in relevé 5 (70%).

The stand in Jarnice, as described in relevé 8, is different and represents *Potentillo albae-Quercetum*. Tree stand of low closure (50%) is dominated by oak, and lacks linden and hornbeam. In the forest floor, apart from the species characteristic of class *Quercio-Fagetea*, ordo *Fagetalia sylvaticae*, and association with *Carpinion betuli*, there can also be thermophilous oak forest species of ordo *Quercion pubescenti-petraeae* (*Campanula persicifolia*, *Hypericum montanum*, *Melittis melissophyllum*, *Potentilla alba*) and edge forest

and xerothermic species of class *Trifolio-Geranietea* and *Festuco-Brometea* (*Melampyrum nemorosum*, *Trifolium rubens*, *Ajuga genevensis*, *Campanula bononiensis*). There is also a large group of accompanying species, unrecorded in other localities of globe flower, among others *Vaccinium myrtillus* (cover 3), *Hieracium floribundum*, *H. lachenalii*, *H. murorum*, *Chamaecytisus ruthenicus*, *Genista tinctoria* and *Digitalis grandiflora*.

Another group of relevés (9–15) describes the globe flower stands located in the close vicinity of the moist deciduous forest edges (Table 2). The common feature of these relevés is the lack of canopy and sparse shrub cover (0–20%). The herb layer is dominated by moist meadows of ordo *Molinietalia*, including: *Ranunculus repens*, *Filipendula ulmaria*, *Lysimachia vulgaris*, *Polygonum bistorta* and species characteristic for the whole class *Molinio-Arrhenatheretea*, such as *Ranunculus acris*, *Alopecurus pratensis*, *Trifolium pratense*, *Lathyrus pratensis* and *Poa trivialis*. Relevés 12–15 are characterised by a high share of fresh grassland

**Table 2.** Phytosociological characteristics of *Trollius europaeus* L. stands

No. of relevé		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Location		Jarnice	Ruchna	Biele, rez.	Ruchna	Ruchna	Ruchna	Ruchna	Ruchna	Biele	Soboń	Soboń	Bojarski Grąd	Męczyn	Męczyn	Budziszyn
Date		2012	2010	2010	2010	2010	2010	2010	2012	2010	2012	2012	2010	2011	2011	2012
Cover of the tree layer	(%)	60	80	40	60	90	70	70	50	.	.	.	.	.	.	.
Cover of the first tree layer	(%)	50	70	40	40	60	70	60	40	.	.	.	.	.	.	.
Cover of the second tree layer	(%)	30	40	10	40	40	.	20	30	.	.	.	.	.	.	.
Cover of the shrub layer	(%)	60	50	20	50	50	70	40	50	.	20	.	.	.	.	10
Cover of the herb layer	(%)	80	70	100	80	100	90	100	100	100	80	90	90	100	90	80
Cover of the moss layer	(%)	20	10	10	20	70	20	30	50	.	.	.	.	.	.	.
Area of relevé	[m <sup>2</sup> ]	200	250	200	250	250	200	200	250	200	25	25	25	25	25	50
Tree stand age		V	IV	V	III	III	V	VI	IV							
Number of species		55	42	60	48	60	41	48	88	47	29	37	40	45	48	50

Trees and shrubs

<i>Quercus robur</i>	a <sub>1</sub>	3	4	2	3	.	4	.	3	.	.	.	.	.	.	.
<i>Quercus robur</i>	a <sub>2</sub>	.	.	1	2	1	.	1	1	.	.	.	.	.	.	.
<i>Quercus robur</i>	b	1	1	.	1	1	1	.	.	.	1	.	.	.	.	.
<i>Quercus robur</i>	c	+	+	+	1	+	+	.	1	.	+	.	.	.	.	.
<i>Carpinus betulus</i>	a <sub>2</sub>	2	3	.	.	1	.	1	.	.	.	.	.	.	.	.
<i>Carpinus betulus</i>	b	2	2	1	.	1	.	.	.	.	.	.	.	.	.	.
<i>Carpinus betulus</i>	c	1	1	.	+	+	+	.	.	1	.	.	.	.	.	.

No. of relevé		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Corylus avellana</i>	b	3	3	1	.	.	2	2	2	.	.	.	.	.	.	.
<i>Corylus avellana</i>	c	.	.	.	.	+	1	1	+	.	.	.	.	.	.	.
<i>Ribes spicatum</i>	b	1	.	+	.	.	.	1	.	.	.	.	.	.	.	.
<i>Ribes spicatum</i>	c	+	.	+	.	2	+	.	.	r	.	.	.	.	.	+
<i>Padus avium</i>	a <sub>2</sub>	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Padus avium</i>	b	.	.	.	.	2	4	2	.	.	.	.	.	.	.	.
<i>Padus avium</i>	c	.	.	.	.	1	3	.	.	+	.	.	.	+	1	+
<i>Alnus glutinosa</i>	a <sub>1</sub>	.	.	.	.	1	2	3	.	.	.	.	.	.	.	.
<i>Alnus glutinosa</i>	b	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+
<i>Alnus glutinosa</i>	c	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
<i>Viburnum opulus</i>	c	1	.	1	+	.	.	.	r	.	.	.	.	.	.	.
<i>Cornus sanguinea</i>	c	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.
<i>Fraxinus excelsior</i>	a <sub>1</sub>	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.
<i>Fraxinus excelsior</i>	a <sub>2</sub>	.	.	.	2	3	.	.	.	.	.	.	.	.	.	.
<i>Fraxinus excelsior</i>	b	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.
<i>Fraxinus excelsior</i>	c	r	.	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Frangula alnus</i>	b	.	.	.	3	.	.	.	1	.	1	.	.	.	.	.
<i>Frangula alnus</i>	c	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.
<i>Picea abies</i>	a <sub>1</sub>	.	.	1	.	.	.	2	.	.	.	.	.	.	.	.
<i>Picea abies</i>	b	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Picea abies</i>	c	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.
<i>Populus tremula</i>	a <sub>2</sub>	1	.	.	.	.	.	.	2	.	.	.	.	.	.	.
<i>Populus tremula</i>	c	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.
<i>Pyrus communis</i>	a <sub>2</sub>	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Pyrus communis</i>	b	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.
<i>Pyrus communis</i>	c	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
<i>Betula pendula</i>	a <sub>1</sub>	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
<i>Betula pendula</i>	a <sub>2</sub>	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Betula pendula</i>	b	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
<i>Betula pendula</i>	c	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
<i>Crataegus monogyna</i>	b	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
<i>Crataegus monogyna</i>	c	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
<i>Daphne mezereum</i>	b	.	+	.	.	+	1	.	.	.	.	.	.	.	.	.
<i>Daphne mezereum</i>	c	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
<i>Sorbus aucuparia</i>	b	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
<i>Sorbus aucuparia</i>	c	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.
<i>Tilia cordata</i>	a <sub>2</sub>	2	.	.	.	.	.	2	.	.	.	.	.	.	.	.
<i>Tilia cordata</i>	b	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Tilia cordata</i>	c	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Occasionally: *Acer platanoides* 5 (c - +), 10 (b 1); *Betula pendula* 4 (b - 2, c - +); *Euonymus europaeus* 5 (b - 1), 6 (c - +); *Juniperus communis* 8 (b - 2, c - +); *Pinus sylvestris* 7 (a<sub>1</sub> - 1); *Rhamnus catharicus* 8 (b - +); *Ulmus minor* 3 (a<sub>1</sub> - 2), 7 (c - 1);

#### Ch. Carpinion betuli

<i>Stellaria holostea</i>	3	2	.	.	2	1	2	2	.	2	+	2	1	1	.
<i>Galium schultesii</i>	3	2	.	.	1	2	.	2	.	.	.	.	.	.	.
<i>Dactylis polygama</i>	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.

#### Ch. Alno-Padion

<i>Equisetum sylvaticum</i>	1	.	1	.	.	+	1	.	1	.	.	+	+	.	.
<i>Festuca gigantea</i>	1	.	1	1	.	1	.	.	+	.	.	.	.	.	.
<i>Circaea lutetiana</i>	.	1	.	.	1	.	1	.	.	.	.	.	.	.	.
<i>Ficaria verna</i>	+	.	.	.	.	.	.	.	1	.	.	.	.	+	.

Occasionally: *Rumex sanguineus* 3, 7 (r); *Stellaria nemorum* 9 (+);

#### Ch. O. *Quercion pubescentis-petraea* – Pa-Q

Occasionally: *Campanula persicifolia* 3,8 (+); *Hypericum montanum* 2 (r), 8 (+); *Melittis melissophyllum* 8 (+); *Potentilla alba* 8 (+);

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Ch. Fagetalia sylvaticae</i>															
<i>Viola reichenbachiana</i>	1	+	1	1	1	+	+	+	1	.	.	+	.	+	.
<i>Milium effusum</i>	+	.	1	+	1	+	2	r	+	.	.	.	.	.	.
<i>Atrichum undulatum</i>	2	1	2	1	.	2	2	+	.	.	.	.	.	.	.
<i>Ranunculus lanuginosus</i>	2	1	2	.	1	+	+	r	1	.	.	.	.	.	.
<i>Scrophularia nodosa</i>	.	.	+	r	.	.	.	+	+	+	.	r	.	r	.
<i>Dryopteris filix-mas</i>	1	+	.	.	.	+	1	.	+	.	.	+	.	.	.
<i>Asarum europaeum</i>	+	.	1	+	1	.	+	.	1	.	.	.	.	.	.
<i>Carex sylvatica</i>	1	+	.	.	.	+	+	.	.	.	.	.	.	.	.
<i>Galeobdolon luteum</i>	+	.	2	.	.	.	3	.	1	.	.	.	.	+	.
<i>Polygonatum multiflorum</i>	1	.	.	.	+	+	+	.	.	.	.	.	.	.	.
<i>Pulmonaria obscura</i>	1	+	.	.	1	.	1	.	.	.	.	.	.	.	.
<i>Ranunculus cassubicus</i>	+	.	.	.	1	+	+	.	.	.	.	.	.	.	.
<i>Sanicula europaea</i>	1	+	.	.	1	.	1	.	.	.	.	.	.	.	.
<i>Impatiens noli-tangere</i>	.	.	+	.	2	.	2	.	.	.	.	.	.	.	.
<i>Phyteuma spicatum</i>	+	.	1	.	.	.	.	+	.	.	.	.	.	.	.
<i>Stachys sylvatica</i>	r	.	.	.	1	.	2	.	.	.	.	.	.	.	.

Occasionally: *Adoxa moschatellina* 3 (+), 7 (1); *Anemone ranunculoides* 7 (2); *Campanula latifolia* 2 (+); *Lathyrus vernus* 3, 10 (+); *Lilium martagon* 1 (+); *Mercurialis perennis* 6 (+), 7 (5); *Paris quadrifolia* 1, 5 (+);

<i>Ch. Querco-Fagetea</i>															
<i>Aegopodium podagraria</i>	4	3	1	2	3	2	3	1	2	.	2	1	1	1	1
<i>Anemone nemorosa</i>	2	1	4	2	2	1	3	2	2	.	.	2	1	1	.
<i>Ranunculus auricomus</i>	+	.	1	1	+	.	.	1	.	.	.	.	.	.	.
<i>Melica nutans</i>	2	.	1	.	.	.	.	2	.	.	.	.	.	.	.
<i>Brachypodium sylvaticum</i>	+	.	.	.	1	1	.	.	.	.	.	.	.	.	.

Occasionally: *Carex digitata* 1, 3 (+); *Poa nemoralis* 5 (+); *Viola mirabilis* 1, 5 (+);

<i>Ord. Glechometalia</i>															
<i>Glechoma hederacea</i>	1	.	1	.	+	.	1	.	1	1	1	+	1	1	1
<i>Geum urbanum</i>	1	+	+	.	.	3	1	r	.	1	+	.	.	.	.
<i>Anthriscus sylvestris</i>	.	.	.	.	.	.	.	.	.	+	1	+	+	1	2
<i>Galium aparine</i>	.	.	.	.	+	.	.	.	.	1	+	.	+	1	1
<i>Geranium robertianum</i>	.	.	1	.	1	.	.	.	+	.	+	.	.	+	+

Occasionally: *Allaria petiolata* 11, 12 (+); *Epilobium parviflorum* 4 (+); *Impatiens parviflora* 10, 14 (+);

<i>Cl. Trifolio-Geranietea, Festuco-Brometea</i>															
<i>Vicia sepium</i>	.	+	1	.	.	.	.	.	+	.	1	.	.	.	.

Occasionally: *Ajuga genevensis* 8 (+); *Campanula bononiensis* 8 (+); *Campanula glomerata* 2 (+); *Clinopodium vulgare* 8 (+); *Galium mollugo* 4 (+); *Galium verum* 8 (+); *Melampyrum nemorosum* 8, 12 (2); *Trifolium alpestre* 8 (+); *Trifolium medium* 4, 11 (+); *Trifolium rubens* 8 (1); *Vicia cassubica* 8 (+);

<i>Ord. Molinio-Arrhenatheretea</i>															
<i>Ranunculus acris</i>	.	.	.	.	.	.	.	+	r	.	1	1	1	+	1
<i>Alopecurus pratensis</i>	.	.	.	.	.	.	.	.	.	1	2	1	1	+	1
<i>Cardamine pratensis</i>	.	.	+	.	.	.	.	.	.	.	.	1	1	1	1
<i>Lathyrus pratensis</i>	.	.	.	.	.	.	.	.	.	.	+	+	1	1	+
<i>Rumex acetosa</i>	.	.	.	.	.	.	.	+	.	.	1	.	+	+	+
<i>Poa trivialis</i>	.	.	.	.	.	.	.	.	.	.	1	1	1	.	+
<i>Trifolium pratense</i>	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+
<i>Plantago lanceolata</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+
<i>Cerastium holosteoides</i>	.	.	+	.	.	.	.	r	+	.	.	.	+	.	+
<i>Poa pratensis</i>	.	.	.	1	.	.	.	.	+	.	.	1	.	+	+

Occasionally: *Avenula pubescens* 11 (+); *Prunella vulgaris* 4 (+), 7 (r); *Vicia cracca* 4 (+), 8 (2);

<i>Rz. Molinieta</i>															
<i>Trollius europaeus</i>	+	1	1	1	1	1	r	+	3	1	+	+	r	+	+
<i>Deschampsia caespitosa</i>	2	2	1	2	2	2	+	+	1	.	.	1	1	1	1
<i>Ranunculus repens</i>	+	1	1	.	+	+	1	.	1	.	2	1	2	+	2

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Filipendula ulmaria</i>	.	.	2	1	1	+	.	.	1	2	3	1	1	1	1
<i>Lysimachia vulgaris</i>	.	.	1	2	+	+	.	1	+	2	+	.	r	1	r
<i>Lysimachia nummularia</i>	1	.	1	+	2	.	1	+	+	.	.	.	1	1	+
<i>Cirsium palustre</i>	.	r	r	.	+	.	.	.	.	+	+	.	.	+	+
<i>Polygonum bistorta</i>	.	.	.	.	.	.	.	+	.	+	2	1	2	+	1
<i>Lychnis flos-cuculi</i>	.	.	.	+	+	.	.	r	+	.	+	1	2	1	1
<i>Cirsium rivulare</i>	.	.	.	.	.	.	.	.	.	.	.	1	1	2	1
<i>Myosotis palustris</i>	.	.	.	.	.	.	.	.	.	.	.	r	+	1	1
<i>Caltha palustris</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
<i>Crepis paludosa</i>	.	.	+	.	.	.	.	.	.	+	.	.	r	.	+
<i>Betonica officinalis</i>	.	+	.	1	.	.	.	1	.	.	.	1	.	.	.
<i>Serratula tinctoria</i>	.	1	.	+	.	.	.	2	.	.	.	.	.	.	.

Occasionally: *Dactylorhiza majalis* 11 (+); *Equisetum palustre* 10 (+); *Galium boreale* 8 (+); *Gallium uliginosum* 9 (+); *Geranium palustre* 11 (2), 14 (+); *Gladiolus imbricatus* 11 (r); *Juncus effusus* 8 (+); *Laserpitium prutenicum* 3 (+); *Lythrum salicaria* 3 (+); *Poa palustris* 10 (2), 15 (+); *Rumex crispus* 15 (+);

Ord. *Arrhenatheretalia*

<i>Achillea millefolium</i>	.	.	.	.	.	.	.	+	.	.	+	2	1	1	+
<i>Taraxacum officinale</i> s.l.	.	.	.	.	r	.	.	r	.	.	.	+	2	2	1
<i>Dactylis glomerata</i>	.	.	.	.	.	.	.	.	r	.	+	2	2	1	1
<i>Campanula patula</i>	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+
<i>Heracleum sphondylium</i>	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+
<i>Leucanthemum vulgare</i>	.	.	.	.	.	.	.	.	.	.	.	r	1	+	.

Occasionally: *Cynosurus cristatus* 8 (r); *Saxifraga granulata* 13 (1); *Trifolium dubium* 14 (+); *Trifolium repens* 13 (1);

Accompanying spp. :

<i>Ajuga reptans</i>	1	1	2	.	+	+	+	1	1	.	+	+	1	.	.
<i>Geum rivale</i>	+	.	2	1	2	.	.	.	2	2	1	1	1	+	2
<i>Veronica chamaedrys</i>	.	1	1	1	+	.	.	1	1	+	2	1	1	1	+
<i>Oxalis acetosella</i>	2	1	2	.	1	+	2	.	1	.	.	+	+	1	.
<i>Maianthemum bifolium</i>	+	2	1	2	+	+	.	2	.	.	.	.	.	1	.
<i>Plagiomnium affine</i>	1	1	1	2	2	1	2	.	.	.	.	.	.	.	.
<i>Dryopteris carthusiana</i>	+	+	+	.	+	+	+	+	+	.	.	.	.	.	.
<i>Agrostis capillaris</i>	+	.	.	1	+	+	.	+	.	.	.	.	.	.	.
<i>Luzula pilosa</i>	+	.	1	+	.	.	.	+	.	.	.	.	.	.	.
<i>Athyrium filix-femina</i>	.	.	+	.	.	1	1	+	+	.	.	.	.	.	.
<i>Fragaria vesca</i>	.	1	1	2	.	.	.	1	+	.	.	.	.	.	.
<i>Rubus idaeus</i>	.	.	2	.	1	2	1	.	.	.	.	.	.	.	.
<i>Urtica dioica</i>	.	1	1	.	+	.	1	.	.	2	.	.	1	.	1
<i>Moehringia trinervia</i>	+	.	.	.	.	.	.	.	+	.	.	+	+	+	.
<i>Anthoxanthum odoratum</i>	.	.	1	1	.	.	.	1	.	.	.	.	1	+	.
<i>Galium palustre</i>	.	+	.	.	.	.	.	.	.	1	+	.	.	+	+
<i>Hypericum maculatum</i>	.	.	.	.	+	.	.	+	+	1	r	.	.	.	.
<i>Convallaria majalis</i>	.	2	.	.	.	+	.	1	.	.	.	1	.	.	.
<i>Viola riviniana</i>	+	.	1	.	.	.	.	.	+	.	.	.	.	.	.
<i>Campanula rotundifolia</i>	.	r	.	+	.	.	.	+	.	.	.	.	.	.	.
<i>Peucedanum palustre</i>	.	.	.	.	.	.	.	.	.	.	+	.	.	+	r

Occasionally: *Calamagrostis arundinacea* 8 (1); *Cardamine amara* 15 (1); *Cardaminopsis arenosa* 12 (1), 13 (+); *Carex acutiformis* 9 (+); *Carex gracilis* 10 (3); *Carex hirta* 8 (+); *Carex montana* 8 (1); *Carex nigra* 8 (+); *Carex ovalis* 8 (+); *Carex pallescens* 4 (1); *Chamaecytisus ratibonensis* 8 (+); *Chamaecytisus ruthenicus* 8 (1); *Cirsium arvense* 11 (+); *Digitalis grandiflora* 8 (r); *Equisetum arvense* 3, 9 (r); *Festuca ovina* 8 (1); *Genista tinctoria* 8 (+); *Hieracium floribundum* 8 (1); *Hieracium lachenalii* 8 (+); *Hieracium murorum* 8 (+); *Hieracium pilosella* 4, 8 (+); *Hieracium polonicum* 8 (1); *Holcus mollis* 7 (1); *Hylacomium splendens* 8 (2); *Iris pseudacorus* 3 (+); *Linaria vulgaris* 12 (+); *Lycopus europaeus* 5 (+); *Melampyrum pratense* 4 (+), 8 (1); *Mycelis muralis* 5 (+); *Phragmites australis* 9 (r), 15 (+); *Plagiomnium undulatum* 5 (3); *Platanthera bifolia* 4, 8 (+); *Pleurozium schreberii* 8 (2); *Potentilla erecta* 4 (1), 8 (+); *Pteridium aquilinum* 9 (+), 12 (1); *Pyrola media* 8 (r); *Pyrola rotundifolia* 4 (+); *Rubus caesius* 10, 15 (1); *Rubus saxatilis* 5 (1); *Rumex confertus* 15 (+); *Rumex conglomeratus* 15 (+); *Solidago virgaurea* 8 (+); *Stellaria graminea* 4 (+), 8 (r); *Stellaria palustris* 10 (2), 15 (+); *Thalictrum lucidum* 9 (r); *Vaccinium myrtillus* 4 (+), 8 (3); *Viola palustris* 6 (+), 15 (r).



species of ordo *Arrhenatheretalia*, including: *Achillea millefolium*, *Taraxacum officinale* s.l. and *Dactylis glomerata*. The forest species with greater degree of presence are: *Aegopodium podagraria*, *Anemone nemorosa* and *Stellaria holostea*. Among the forest edge species (ordo *Glechometalia*), most frequently recorded were: *Glechoma hederacea*, *Anthriscus sylvestris* and *Galium aparine*. From a large group of accompanying species with the highest degree of presence were listed: *Geum rivale*, *Veronica chamaedrys*, *Urtica dioica*, *Oxalis acetosella*, *Ajuga reptans* and *Galium palustre*. The location on the edge of a mid-forest meadow in Biele Reserve (Fig. 9) is distinguished by a number of taxa, typical of deciduous forests (17 species). The location near the village of Soboń (Fig. 10) is characterised by a high proportion of species with high moisture requirements (*Carex gracilis*, *Poa palustris*, *Stellaria palustris*).

#### 4. Discussion and conclusions

According to Matuszkiewicz (2006), globe flower is a species characteristic of moist meadows and association *Molinietalia Polygono bistortae-Trollietum*. Globe flower occurrences in meadow communities are described by Kucharski et al. (1992), Król et al. (1993), Izydorek (1996), Ćwikliński and Jasnowski (1997), Jermaczek (2007) and Dembicz et al. (2011). In the Chociel valley, globe flower is present not only as the association in *Molinietum caeruleae*, but also, (although less abundant), in reed bed associations – *Phragmitetum australis* and *Glycerietum maximae* (Kochanowska 2007). Bacieczko (1996) describes the natural stand of *Trollius europaeus* from Pojezierze Myśluborskie (Myślubórz Lakeland) in the *Juncetum subnodulosi* association. In addition, the literature mentions about the occurrence of the species within forest communities. Matuszkiewicz (2005) writes about the occurrence of *Trollius europaeus* in the north-Podlasie variant of *Potentillo albae-Quercetum* (= *Potentillo albae-Quercetum trollietosum*), known from Knyszyńska and Białowieża Forests. Sokolowski (1995) notes the locality of globe flower in mixed forests of *Melitti-Carpinetum*. The population of this species in riparian phytocenoses *Ficario-Alnetum* and association with *Quercus robur* are studied by Kępczyński and Fertsch (1974).

In the northern part of the Południowopodlaska Lowland localities, *Trollius europaeus* are found exclusively within the forest or forest edge communities. These are the deciduous forests of *Quercus-Fagetea* class with a wide amplitude of humidity ranging from moist oak-hornbeam forests with a share of ash and alder in the stand (Ruchna Reserve),

through typical oak-hornbeam forests (Ruchna and Biele reserves; Jamice), to thermophilous oak forests (Jamice). Other existing stands of *Trollius europaeus* remained within the moist forest edges of ordo *Glechometalia*.

Having it summarised, globe flower is preserved only in relatively little changed forest habitats, which are presumably its original habitat in Europe. Old-growth forests in Europe were in fact nature's woodland pastures, consisting of mosaic of grassland and clumps of trees forming a loose canopy closure (*Quercus robur* and *Q. petraea*, *Corylus avellana*). After abandoning grazing, further development of forest proceeded without herbivores, which in turn resulted in a change of composition of species (expansion of shade-tolerant species such as beech *Fagus sylvatica*, elms *Ulmus laevis* and *U. glabra*, hornbeam *Carpinus betulus*, limes *Tilia cordata* and *T. platyphyllos*, ash *Fraxinus excelsior*) and an increase in stand density. As a result of shading in the undergrowth layer, light-demanding species declined, finding better conditions in the open meadow communities (substitute for oak-hornbeam and floodplain forests). Some of the forest plants (especially light-demanding species) found in this new type of phytocenosis favorable conditions for development. Under extensive agriculture conditions, these species increased their abundance to the point that was considered as being characteristic of meadow. Only the intensification of agriculture has contributed to the gradual disappearance of their stands.

Plant species associated with extensively used meadows, to which the globe flower belongs, are among the most threatened in Europe (Hitchmough 2003; Jögar, Mari 2008). The greatest threats to globe flower stands are: intensive mowing, land use change, fertilization, overgrazing, drainage, secondary succession and digging up specimens for gardens (Nowak 2002; Nowak et al. 2008; Dembicz et al. 2011). Populations located in forest communities are not exposed to such a strong human pressure; therefore the chance of their preservation is much higher, which is very clearly shown by the localities of globe flower in the Południowopodlaska Lowland. In places where an intensification in use of moist meadows was observed, globe flower perished (Małkinia-Przewóz, Garnek, Natolin, Jadwisin, Łubianka, Niwiski, Golice, Stok Lacki) or survived only in neighboring, less intensively managed moist edges of forests (Budziszyn, Soboń, Mokobody Kolonia, Bojarski Grąd). As regards forest localities, only one did not remain: the one situated in the broadleaved forest near Antonówka. Other populations still exist and hold promise for the future.

Only 15 out of the 34 localities of *Trollius europaeus* known in the research area have survived until today, all clustered around seven villages. The abundance of globe flower population for most of the existing localities is decreasing (especially: Soboń, Budziszyn, Ruchna). However, the lack of complete comparative information does not allow for a precise assessment of the dynamics of these populations. On the current list of regionally threatened plant (Głowacki et al. 2003), globe flower taxa is classified as being vulnerable to the point of extinction (VU). Due to rapid decline in the number of stands, the size of the population and the threat of the habitats where the species occur, we should consider changing its threat category into EN (endangered).

Population of globe flower situated outside the Kantor Stary, Biele and Bojarski Grąd reserves should be under legal habitat protection. It is required to implement active conservation procedures related with tree stand thinning, keeping the shrub layer density low and maintenance of existing water relations.

The results thereby lead to the following conclusions:

1. Number of stands and size of population of the European globe flower in the northern part of the Południowopodlaska Lowland decreased significantly in recent years.

2. Localities of globe flower in the study area remained only within the deciduous forests of *Quercus-Fagetea* class (*Tilio-Carpinetum* and *Potentillo albae-Quercetum*) and moist forest edges of ordo *Glechometalia*. Disappearance of all meadow localities is mainly due to the intensification of agriculture in the region.

3. The threat category of the species on the regional list should be increased from VU to EN. It is advisable to extend the monitoring and active conservation on all of the globe flower populations in the region.

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